Warranty

NTN warrants, to the original purchaser only, that the delivered product which is the subject of this sale (a) will conform to drawings and specifications mutually established in writing as applicable to the contract, and (b) be free from defects in material or fabrication. The duration of this warranty is one year from date of delivery. If the buyer discovers within this period a failure of the product to conform to drawings or specifications, or a defect in material or fabrication, they must promptly notify NTN in writing. In no event shall such notification be received by NTN later than 13 months from the date of delivery. Within a reasonable time after such notification, NTN will, at its option, (a) correct any failure of the product to conform to drawings, specifications or any defect in material or workmanship, with either replacement or repair of the product, or (b) refund, in part or in whole, the purchase price. Such replacement and repair, excluding charges for labor, is at NTN's expense. All warranty service will be performed at service centers designated by NTN. These remedies are the purchaser's exclusive remedies for breach of warranty.

NTN noes not warranty (a) any product, components or parts not manufactured by NTN, (b) defects caused by failure to provide a suitable installation environment for the product, (c) damage caused by use of the product for purposes other than those for which it was designed, (d) damage caused by disasters such as fire, flood, wind, and lightning, (e) damage caused by unauthorized attachments or modification, (f) damage during shipment, or (g) any other abuse or misuse by the purchaser.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

In no case shall NTN be liable for any special, incidental, or consequential damages based upon breach of warranty, breach of contract, negligence, strict tort, or any other legal theory, and in no case shall total liability of NTN exceed the purchase price of the part upon which such liability is based. Such damages include, but are not limited to, loss of profits, loss of savings or revenue, loss of use of the product or any associated equipment, cost of capital, cost of any substitute equipment, facilities or services, downtime, the claims of third parties including customers, and injury to property. Some states do not allow limits on warranties, or on remedies for breach in certain transactions. In such states, the limits in this paragraph and in paragraph (2) shall apply to the extent allowable under case law and statutes in such states.

Any action for breach of warranty or any other legal theory must be commenced within 15 months following delivery of goods.

Unless modified in writing signed by both parties, this agreement is understood to be the complete and exclusive agreement between the parties, superceding all prior agreements, oral or written, and all other communications between the parties relating to the subject matter of this agreement. No employees of NTN or any other party is authorized to make any warranty in addition to those made in this agreement.

This agreement allocates the risks of product failure between NTN and the purchaser. This allocation is recognized by both parties and is reflected in the price of the goods. The purchaser acknowledges that is has read this agreement, understands it, and is bound by its terms.

NTN
Bearing Units

CAT.NO. 2400/E

TECHNICAL DATA INDEX

1. Construction

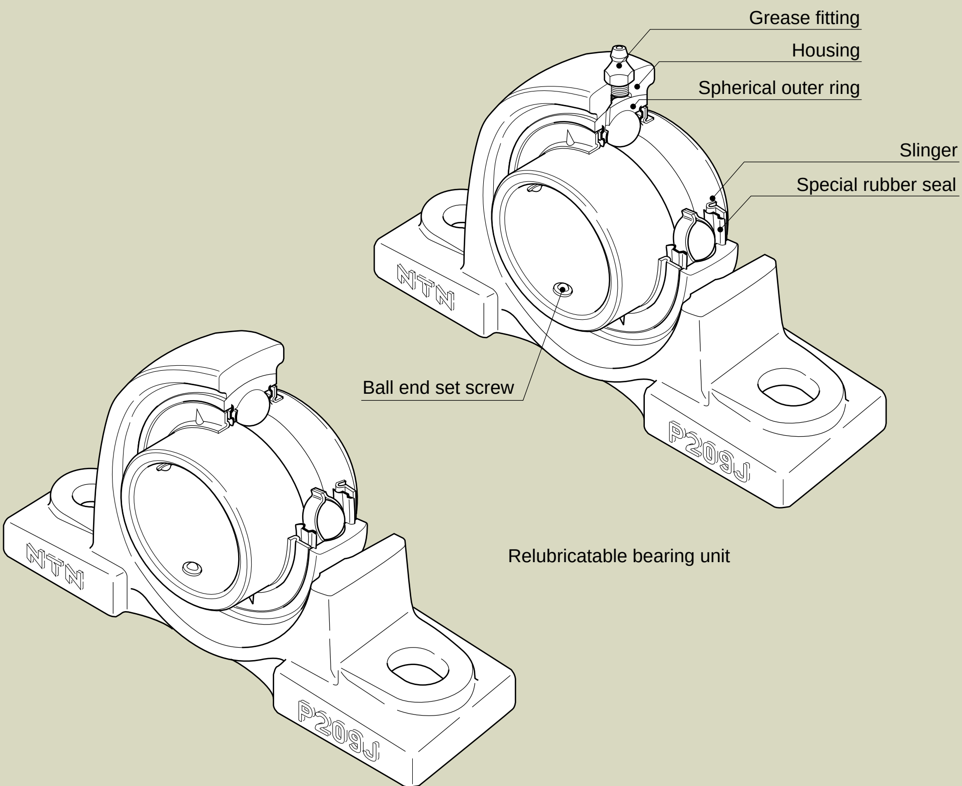
The NTN bearing unit is a combination of a radial ball bearing, seal, and a housing of high-grade cast iron or pressed steel, which comes in various shapes.

The outer surface of the bearing and the internal surface of the housing are spherical, so that the unit is self-aligning.

The inside construction of the ball bearing for the unit is such that steel balls and retainers of the same type as in series 62 and 63 of the NTN deep groove ball bearing are used. A duplex seal consisting of a combination of an oil-proof synthetic rubber seal and a slinger, unique to NTN, is provided on both sides.

Depending on the type, the following methods of fitting to the shaft are employed:

1) The inner ring is fastened onto the shaft in two places by set screws.
2) The inner ring has a tapered bore and is fitted to the shaft by means of an adapter.
3) In the eccentric locking collar system the inner ring is fastened to the shaft by means of eccentric grooves provided at the side of the inner ring and on the collar.



Relubricatable bearing unit

Maintenance free bearing unit

Fig. 1.1

2. Design Features and Advantages

2.1 Maintenance free type

The NTN Maintenance free bearing unit contains a high-grade lithium-based grease, good for use over a long period, which is ideally suited to sealed-type bearings. Also provided is an excellent sealing device, unique to NTN, which prevents any leakage of grease or penetration of dust and water from outside.

It is designed so that the rotation of the shaft causes the sealed-in grease to circulate through the inside space, effectively providing maximum lubrication. The lubrication effect is maintained over a long period with no need for replenishment of grease.

To summarize the advantages of the NTN maintenance free bearing unit:

1) As an adequate amount of good quality grease is sealed in at the time of manufacture, there is no need for replenishment. This means savings in terms of time and maintenance costs.
2) Since there is no need for any regreasing facilities, such as piping, a more compact design is possible.
3) The sealed-in design eliminates the possibility of grease leakage, which could lead to stained products.

2.2 Relubricatable type

The NTN relubricatable type bearing unit has an advantage over other similar units being so designed as to permit regreasing even in the case of misalignment of 2° to the right or left. The hole through which the grease fitting is mounted usually causes structural weakening of the housing.

However, as a result of extensive testing, in the NTN bearing unit the hole is positioned so as to minimize this adverse effect. In addition, the regreasing groove has been designed to minimize weakening of the housing.

While the NTN maintenance free type bearing unit is satisfactory for use under normal operating conditions in-doors, in the following circumstances it is necessary to use the relubricatable type bearing unit:

1) Cases where the temperature of the bearing rises above 100°C, 212°F:
   *–Normal temperature of up to 140°C, 284°F heat-resistant bearing units.
   *–Normal temperature of up to 200°C, 392°F heat-resistant bearing units.
2) Cases where there is excessive dust, but space does not permit using a bearing unit with a cover.
3) Cases where the bearing unit is constantly exposed to splashes of water or any other liquid, but space does no permit using a bearing unit with a cover.
4) Cases in which the humidity is very high, and the machine in which the bearing unit is used is run only intermittently.
5) Cases involving a heavy load of which the Cr/Pr value is about 10 or below, and the speed is 10 rpm or below. or the movement is oscillatory.
6) Cases where the number of revolutions is relatively high and the noise problem has to be considered; for example, then the bearing is used the fan of an air conditioner.

2.3 Special sealing feature

2.3.1 Standard bearing units

The sealing device of the ball bearing for the NTN bearing unit is a combination of a heat-resistant and oil-proof synthetic rubber seal and a slinger of an exclusive NTN design.

The seal, which is fixed in the outer ring, is steel-reinforced, and its lip, in contact with the inner ring, is designed to minimize frictional torque.

The slinger is fixed to the inner ring of the bearing with which it rotates. There is a small clearance between its periphery and the outer ring.

There are triangular protrusions on the outside face of the slinger and, as the bearing rotates, these protrusions on the slinger creates a flow of air outward from the bearing. In this way, the slinger acts as a fan which keeps dust and water away from the bearing.

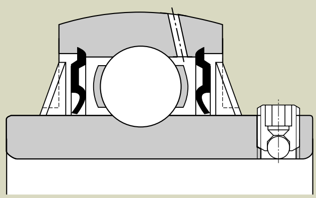


Fig. 2.1

These two types of seals on both sides of the bearing prevent grease leakage, and foreign matter is prevented from entering the bearing from outside.

2.3.2 Bearing units with covers

The NTN bearing unit with a cover consists of a standard bearing unit and an outside covering for extra protection against dust. Special consideration has been given to its design with respect to dust-proofing.

Sealing devices are provided in both the bearing and the housing, so that units of this type operate satisfactorily even in such adverse environments as flour mills, steel mills, foundries, galvanizing plants and chemical plants, where excessive dust is produced and/or liquids are used. They are also eminently suitable for outdoor environments where dust and rain are inevitable, and in heavy industrial machinery such as construction and transportation equipment.

The rubber seal of the cover contacts with a shaft by its two lips, as shown in Fig. 2.2 and 2.3. by filling the groove between the two lips with grease, an excellent sealing effect is obtained and, at the same time, the contacting portions of the lips are lubricated. Furthermore, the groove is so designed that when the shaft is included the rubber seal can move in the radial direction.

When bearing units are exposed to splashes of water rather than to dust, a drain hole (5 to 8 mm, 0.2 to 0.3 inches in diameter) is provided at the bottom of the cover, and grease should be applied to the side of the bearing itself instead of into the cover.

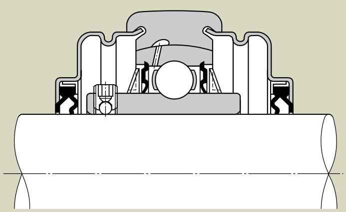


Fig. 2.2 Pressed steel cover

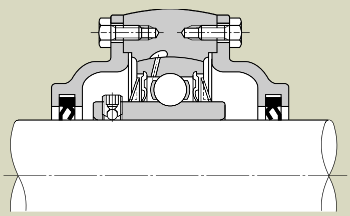


Fig. 2.3 Cast iron cover

2.4 Secure fitting

Fastening the bearing to the shaft is effected by tightening the ball-end set screw, situated on the inner ring. This is a unique NTN feature which prevents loosening, even if the bearing is subjected to intense vibrations and shocks.

2.5 Self-aligning

With the NTN bearing unit, the outer surface of the ball bearing and the inner surface of the housing are spherical, thus alignment of the assembly is automatic. Any misalignment of axis that may arise from poor workmanship on the shaft or errors in fitting will be automatically adjusted.

2.6 Higher rated load capacity

The bearing used in the unit is of the same internal construction as those in NTN bearing series 62 and 63, and is capable of accommodating axial load as well as radial load, or composite load. The rated load capacity of this bearing is considerably higher than that of the corresponding self-aligning ball bearings used for standard plummer blocks.

2.7 Light weight yet strong housing

Housings for NTN bearing units come in various shapes. They consist of either high-grade cast iron, one-piece casting, or of precision finished pressed steel, the latter being lighter in weight. In either case, they are practically designed to combine lightness with maximum strength.

2.8 Easy mounting

The NTN bearing unit is an integrated unit consisting of a bearing and a housing.

As the bearing is prelubricated at manufacture with the correct amount of high-grade lithium base, it can be mounted on a shaft just as it is. It is sufficient to carry out a short test run after mounting.

2.9 Accurate fitting of the housing

In order to simplify the fitting of the pillow block and flange type bearing units, the housings are provided with a seat for a dowel pin, which may be utilized as needed.

2.10 Bearing replaceability

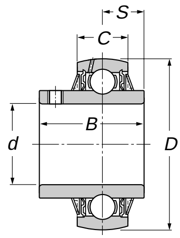
The bearing used in the NTN bearing unit is replaceable. In the event of bearing failure, a new bearing can be fitted to the existing housing.

2.10 Bearing replaceability

The bearing used in the NTN bearing unit is replaceable. In the event of bearing failure, a new bearing can be fitted to the existing housing.

3. Tolerance

The tolerances of the NTN bearing units are in accordance with the following JIS specifications:



3.1 Tolerances of ball bearings for the unit

The tolerances of ball bearings used in the unit are shown in the following tables, 3.1 to 3.5.

Table 3.1 (1) Cylindrical bore (UC, UCS, AS, ASS, UELS, AEL, AELS) Unit: μm/0.0001 inch

Nominal bore diameter *d*				Cylindrical bore						Radial runout
				Bore diameter				Width		
over		incl.		Δd_{mp} Deviations		Δd_s Deviations		ΔB_s, ΔC_s Deviations		K_{ia}
mm	inch	mm	inch	high	low	high	low	high	low	(max.)
10	0.3937	18	0.7087	+18	0	+22	–4	0	–120	15
				+ 7	0	+ 9	–2	0	– 47	6
18	0.7087	30	1.1811	+21	0	+25	–4	0	–120	18
				+ 8	0	+10	–2	0	– 47	7
30	1.1811	50	1.9685	+25	0	+30	–5	0	–120	20
				+10	0	+12	–2	0	– 47	8
50	1.9685	80	3.1496	+30	0	+36	–6	0	–150	25
				+12	0	+14	–2	0	– 59	10
80	3.1496	120	4.7244	+35	0	+42	–7	0	–200	30
				+14	0	+17	–3	0	– 79	12
120	4.7244	180	7.0866	+40	0	+48	–8	0	–250	35
				+16	0	+19	–3	0	– 98	14

Note: Symbols

Δd_{mp}: Mean bore diameter deviation Δd_s: Bore diameter deviation ΔB_s: Inner ring width deviation ΔC_s: Outer ring width deviation

Table 3.1 (2) Cylindrical bore (UR, AR, JEL, REL) Unit: μm/0.0001 inch

Nominal bore diameter *d*				Cylindrical bore			
over		incl.		Δd_{mp} Deviations		Δd_s Deviations	
mm	inch	mm	inch	high	low	high	low
10	0.3937	18	0.7087	+13	0	+16	–3
				+ 5	0	+ 6	–1
18	0.7087	31.750	1.2500	+13	0	+16	–3
				+ 5	0	+ 6	–1
31.750	1.2500	50.800	2.0000	+13	0	+16	–3
				+ 5	0	+ 6	–1
50.800	2.0000	80	3.1496	+15	0	+19	–4
				+ 6	0	+ 8	–2

Table 3.2 Tapered bore (UK, UKS) Unit: μm/0.0001inch

Nominal bore diameter d				Δd_{mp} Deviations		$\Delta d_{1mp}-\Delta d_{mp}$		Vd_p 1)
over		incl.						
mm	inch	mm	inch	high	low	max.	min.	max.
18	0.7087	30	1.1811	+21	0	+21	0	13
				+8	0	+8	0	5
30	1.1811	50	1.9685	+25	0	+25	0	15
				+10	0	+10	0	6
50	1.9685	80	3.1496	+30	0	+30	0	19
				+12	0	+12	0	7
80	3.1496	120	4.7244	+35	0	+35	0	25
				+14	0	+14	0	10
120	4.7244	180	7.0866	+40	0	+40	0	31
				+16	0	+16	0	12

1) To be applied for all radial flat surfaces of tapered hole.
Note: 1. To be applied for tapered holes of 1/12.
2. Symbols of quantity or values.

d_1: Basic diameter at the theoretical large end of the tapered hole
$d_1 = d + \frac{1}{12}B$

Δd_{mp}: Dimensional difference of the average bore diameter within the flat surface at the theoretical small-end of the tapered hole

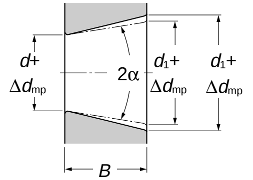
Δd_{1mp}: Dimensional difference of the average bore diameter within the flat surface at the theoretical large-end of the tapered hole

Vd_p: Inequality of the bore diameter within the flat surface

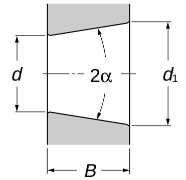
B: Nominal width of inner ring

α: Half of the nominal tapered angle of the tapered hole

α =2°23'9.4"
=2.385 94°
=0.041 643 rad



Tapered hole having dimensional difference of the average bore diameter within the flat surface.



Theoretical tapered hole

Table 3.3 Outer ring Unit: μm/0.0001inch

Nominal outside diameter D				Mean outside diameter deviation ΔD_{mp}		Radial runout K_{ea} (max.)
over		incl.				
mm	inch	mm	inch	high	low	(max.)
30	1.1811	50	1.9685	0	–11	20
				0	–4	8
50	1.9685	80	3.1496	0	–13	25
				0	–5	10
80	3.1496	120	4.7244	0	–15	35
				0	–6	14
120	4.7244	150	5.9055	0	–18	40
				0	–7	16
150	5.9055	180	7.0866	0	–25	45
				0	–10	18
180	7.0866	250	9.8425	0	–30	50
				0	–12	20
250	9.8425	315	12.4016	0	–35	60
				0	–14	24

Note: 1) The low deviation of outside diameter D_{mp} does not apply within the distance of 1/4 the width of the outer ring from the side.

Table 3.4 Distance S between radial plane passing through center of sphere of outer ring and side of inner ring.

Nominal outside diameter d				S Deviations ΔS_s	
over		incl.			
mm	inch	mm	inch	μm	0.0001inch
—	—	50	1.9685	±200	±79
50	1.9685	80	3.1496	±250	±98
80	3.1496	120	4.7244	±300	±118
120	4.7244	—	—	±350	±138

3.2 Tolerances of housings

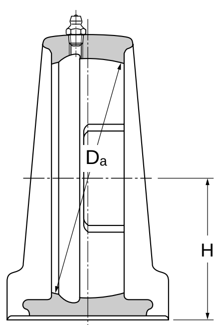
Table 3.5 Spherical bore diameter of housings **Unit: µm/0.0001 inch**

Nominal spherical bore diameter D_a				Tolerance class H7				Tolerance class J7			
over		incl.		ΔD_{amp} Deviations		ΔD_{as} Deviations		ΔD_{amp} Deviations		ΔD_{as} Deviations	
mm	inch	mm	inch	high	low	high	low	high	low	high	low
30	1.1811	50	1.9685	+25	0	+30	–5	+14	–11	+19	–16
				+10	0	+12	–2	+6	–4	+7	–6
50	1.9685	80	3.1496	+30	0	+36	–6	+18	–12	+24	–18
				+12	0	+14	–2	+7	–5	+9	–7
80	3.1496	120	4.7244	+35	0	+42	–7	+22	–13	+29	–20
				+14	0	+17	–3	+9	–5	+11	–8
120	4.7244	180	7.0866	+40	0	+48	–8	+26	–14	+34	–22
				+16	0	+19	–3	+10	–6	+13	–9
180	7.0866	250	9.8425	+46	0	+55	–9	+30	–16	+39	–25
				+18	0	+22	–4	+12	–6	+15	–10
250	9.8425	315	12.4016	+52	0	+62	–10	+36	–16	+46	–26
				+20	0	+24	–4	+14	–6	+18	–10

Note: 1) Symbols
DD_{amp}: Mean spherical bore diameter deviation
DD_{as}: Spherical bore diameter deviation
2) Dimensional tolerances for spherical bore diameter of housing are classified as H7 for clearance fit, and J7 for intermediate fit.

Table 3.6 Pillow block housings (P, HP, UP, PL)
Unit: µm/0.0001 inch

Housing numbers						*H* Deviations ΔH_s
P203	—	—	—	—	—	±150 ±59
P204	—	—	HP204	UP204	PL204	
P205	P305	PX05	HP205	UP205	PL205	
P206	P306	PX06	HP206	UP206	PL206	
P207	P307	PX07	HP207	UP207	PL207	
P208	P308	PX08	HP208	UP208	—	
P209	P309	PX09	HP209	UP209	PL209	
P210	P310	PX10	HP210	UP210	PL210	
P211	P311	PX11	—	—	—	±200 ±79
P212	P312	PX12	—	—	—	
P213	P313	PX13	—	—	—	
P214	P314	PX14	—	—	—	
P215	P315	PX15	—	—	—	
P216	P316	PX16	—	—	—	
P217	P317	PX17	—	—	—	
P218	P318	PX18	—	—	—	
—	P319	—	—	—	—	±300 ±118
—	P320	PX20	—	—	—	
—	P321	—	—	—	—	
—	P322	—	—	—	—	
—	P324	—	—	—	—	
—	P326	—	—	—	—	
—	P328	—	—	—	—	



Note: 1) *H* is height of the shaft center line.
2) This table can be applied for bearing units with dust covers.

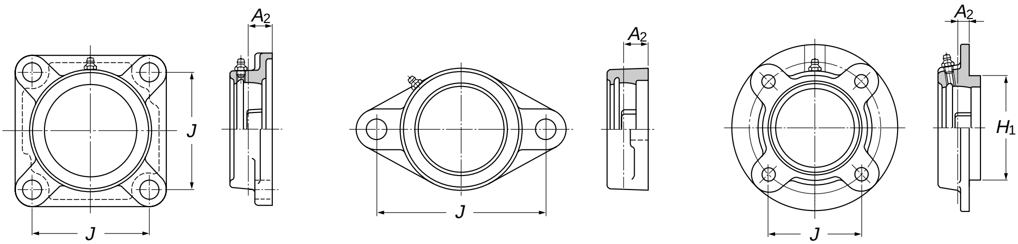
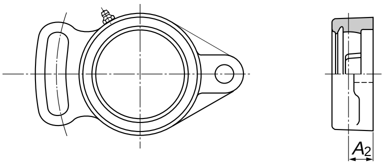


Table 3.7 Flange unit housings (F, FU, FC, FS, FL, FLU, FD) Unit: μm/0.0001 inch

Housing numbers								J Deviations ΔJ_s	A_2 Deviations ΔA_{2s}	H_1 Deviations ΔH_{1s} FC2 high	FC2 low	FS3 high	FS3 low	FCX high	FCX low	Radial runout of spigot joint Δi_s (max.)
—	—	—	—	—	—	—	FD201	±700 / ±276	±500 / ±197	0 / 0	−46 / −18	—	—	—	—	200 / 79
F204	—	—	FC204	—	FL204	—	FD204									
F205	F305	FX05	FC205	FS305	FL205	FL305	FD205					0 / 0	−46 / −18	0 / 0	−46 / −18	
F206	F306	FX06	FC206	FS306	FL206	FL306	FD206					0 / 0	−54 / −21	0 / 0	−54 / −21	
F207	F307	FX07	FC207	FS307	FL207	FL307	FD207			0 / 0	−54 / −21					
F208	F308	FX08	FC208	FS308	FL208	FL308	—									
F209	F309	FX09	FC209	FS309	FL209	FL309	—					0 / 0	−63 / −25			
F210	F310	FX10	FC210	FS310	FL210	FL310	—									
F211	F311	FX11	FC211	FS311	FL211	FL311	—	±1000 / ±394	±800 / ±315	0 / 0	−63 / −25			0 / 0	−63 / −25	300 / 118
F212	F312	FX12	FC212	FS312	FL212	FL312	—									
F213	F313	FX13	FC213	FS313	FL213	FL313	—									
F214	F314	FX14	FC214	FS314	FL214	FL314	—					0 / 0	−72 / −28			
F215	F315	FX15	FC215	DS315	FL215	FL315	—									
F216	F316	FX16	FC216	FS316	FL216	FL316	—							0 / 0	−72 / −28	
F217	F317	FX17	FC217	FS317	FL217	FL317	—									
F218	F318	FX18	FC218	FS318	FL218	FL318	—			0 / 0	−72 / −28					
—	F319	—	—	FS319	—	FL319	—			—	—					
—	F320	FX20	—	FS320	—	FL320	—									
—	F321	—	—	FS321	—	FL321	—					0 / 0	−18 / −32	—	—	400 / 157
—	F322	—	—	FS322	—	FL322	—									
—	F324	—	—	FS324	—	FL324	—					0 / 0	−89 / −35			
—	F326	—	—	FS326	—	FL326	—									
—	F328	—	—	FS328	—	FL328	—									

Note: 1) J is the bolt hole's center line dimension, A_2 is the distance between the center line of spherical bore diameter of the housing and mounting surfaces, and H_1 is outside diameter of the spigot joint.
2) Radial runout of spigot joint is applied for flange units with spigot joints.
3) For FU2 and FLU2 types, tolerances for F2 shall be applied.
4) For FCX and FLX types, tolerances for FX shall be applied.
5) This table can be applied for bearing units with dust covers.



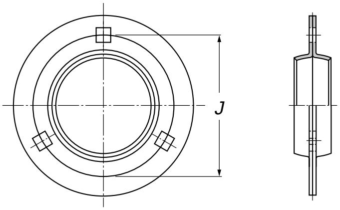


Table 3.8 Flange unit housings (FH, FA, PF, PFL)

Unit: μm/0.0001 inch

Housing numbers	A_2 Deviations ΔA_{1s}	Housing numbers	H_1 Deviations ΔH_{1s}
—		PF203	
FH, FA204		PF204	
FH, FA205		PF205	
FH, FA206	±500	PF206	
FH, FA207	±197	PF207	
FH, FA208		PF208	±500
FH, FA209		PFL203	±197
FH, FA210		PFL204	
		PFL205	
	±800	PFL206	
FA211	±315	PFL207	

Note: 1) A_2 is distance between the center line of spherical bore diameter of housings.
2) J is the bolt hole's center line dimension.

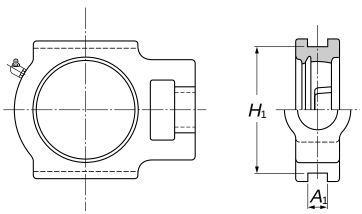
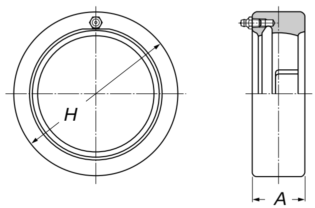


Table 3.9 Take-up unit housings (T)

Unit: μm/0.0001 inch

Housing numbers			A_1 Deviations ΔA_{1s} high	A_1 Deviations ΔA_{1s} low	H_1 Deviations ΔH_{1s} high	H_1 Deviations ΔH_{1s} low	Parallelism of guide (max.)
T204	—	—					
T205	T305	TX05					
T206	T306	TX06	0	+200	0	–500	500
T207	T307	TX07	0	+79	0	–197	197
T208	T308	TX08					
T209	T309	TX09					
T210	T310	TX10					
T211	T311	TX11					
T212	T312	TX12					
T213	T313	TX13					
T214	T314	TX14					600
T215	T315	TX15					236
T216	T316	TX16					
T217	T317	TX17					
—	T318	—	0	+300	0	–800	
—	T319	—	0	+118	0	–315	
—	T320	—					700
—	T321	—					276
—	T322	—					
—	T324	—					800
—	T326	—					315
—	T328	—					

Note: 1) A_1 is the width of guide rail grooves.
2) H_1 is the maximum span of guide rail grooves.
3) This table can be applied for bearing units with dust covers.



Housing numbers			H Deviations ΔH_s C2 high	C2 low	C3 high	C3 low	CX high	CX low	Radial runout of outside surface (max.)	A Deviations ΔA_s
C204	—	—	0	–30	—	—	—	—		
C205	C305	CX05	0	–12						
C206	C306	CX06			0	–35	0	–35	200	±200
C207	C307	CX07			0	–14	0	–14	79	±79
C208	C308	CX08	0	–35						
C209	C309	CX09	0	–14						
C209	C309	CX09					0	–40		
C210	C310	CX10			0	–40	0	–16		
C211	C311	CX11			0	–16				
C212	C312	CX12	0	–40						
C213	C313	—	0	–16						
—	C314	—							300	
—	C315	—							118	
—	C316	—								
—	C317	—			0	–46				
—	C318	—			0	–18				±300
—	C319	—					—	—		±118
—	C320	—	—	—						
—	C321	—			0	–52				
—	C322	—			0	–20			400	
—	C324	—			0	–57			157	
—	C326	—			0	–22				
—	C328	—								

Note: 1) H is the outside diameter of cartridge housings.
2) A is width of cartridge housings.

4. Basic Load Rating and Life

4.1 Bearing life

Even in bearings operating under normal conditions, the surfaces of the raceway and rolling elements are constantly being subjected to repeated compressive stresses which cause flaking of these surfaces to occur. This flaking is due to material fatigue and will eventually cause the bearings to fail. The effective life of a bearing is usually defined in terms of the total number of revolutions a bearing can undergo before flaking of either the raceway surface or the rolling element surfaces occurs.

Other causes of bearing failure are often attributed to problems such as seizing, abrasions, cracking, chipping, gnawing, rust, etc. However, these so called “causes” of bearing failure are usually themselves caused by improper installation, insufficient or improper lubrication, faulty sealing or inaccurate bearing selection. Since the above mentioned “causes” of bearing failure can be avoided by taking the proper precautions, and are not simply caused by material fatigue, they are considered separately from the flaking aspect.

4.2 Basic rated life and basic dynamic load rating

A group of seemingly identical bearings when subjected to identical load and operating conditions will exhibit a wide diversity in their durability.

This “life” disparity can be accounted for by the difference in the fatigue of the bearing material itself. This disparity is considered statistically when calculating bearing life, and the basic rated life is defined as follows.

The basic rated life is based on a 90% statistical model which is expressed as the total number of revolutions 90% of the bearings, in an identical groups of bearings subjected to identical operating conditions, will attain or surpass before flaking due to material fatigue occurs. For bearings operating at fixed constant speeds, the basic rated life (90% reliability) is expressed in the total number of hours of operation.

The basic dynamic load rating is an expression of the load capacity of a bearing based on a constant load which the bearing can sustain for one million revolutions (the basic life rating). For radial bearings this rating applies to pure radial loads, and for thrust bearings it refers to pure axial loads, and for thrust bearings it refers to pure axial loads. The basic dynamic load ratings given in the bearing tables of this catalog are for bearings constructed of NTN standard bearing materials, using standard manufacturing techniques. Please consult NTN for basic load ratings of bearings constructed of special materials or using special manufacturing techniques.

The relationship between the basic rated life, the basic dynamic load rating and the bearing load is given in the formula (4.1).

$$L_{10} = \left(\frac{C_r}{P_r}\right)^3 \cdots\cdots (4.1)$$

where,

L : Basic rated life of 106 revolutions
C_r : Basic dynamic rated load, N, lbf
P_r : Equivalent dynamic load, N, lbf

The basic rated life can also be expressed in terms of hours of operation (revolution), and is calculated as shown in formula (4.2).

$$L_{10} = 500 f_h^3 \cdots\cdots (4.2)$$

$$f_h = f_n \frac{C_r}{P_r} \cdots\cdots (4.3)$$

$$f_n = \left(\frac{33.3}{n}\right)^{1/3} \cdots\cdots (4.4)$$

where

$L10$: Basic rated life, h
fh : Life factor
fn : Speed factor
n : Rotational speed, r/min

Formula (4.2) can also be expressed as shown in formula (4.5).

$$L_{10h} = \frac{10^6}{60n}\left(\frac{C_r}{P_r}\right)^3 \cdots\cdots (4.5)$$

The relation between rotational speed n and speed factor f_n as well as the relation between the basic rated life L_{10h} and the life factor f_h is shown in Fig. 4.1.

When several bearings are incorporated in machines or equipment as complete units, all the bearings in the unit are considered as a whole when computing bearing life (see formula 4.6). The total bearing life of the unit is a life rating based on the viable lifetime of the unit before even one of the bearings fails due to rolling contact fatigue.

$$L = \frac{1}{\left(\frac{1}{L_1^{1.1}} + \frac{1}{L_2^{1.1}} + \cdots\cdots + \frac{1}{L_n^{1.1}}\right)^{1/1.1}} \cdots\cdots\cdots\cdots\cdots (4.6)$$

where,

L : Total life of the whole bearing assembly h

l_1, L_2, …, L_n : Rated life of bearing 1, 2, …, n, h

In the case where load and the number of revolutions change at regulated intervals, after finding the rated life l_1, L_2, …, L_n under conditions of n_1, P_1; n_2, P_2;…; n_n, P_n; the built-in life L_m can be given by the formula (4.7).

$$L_1 = \frac{10^6}{60n_1}\left(\frac{C_r}{P_1}\right)^3$$

$$L_2 = \frac{10^6}{60n_2}\left(\frac{C_r}{P_2}\right)^3$$

$$\vdots$$

$$L_n = \frac{10^6}{60n_n}\left(\frac{C_r}{P_n}\right)^3$$

$$L_m = \left(\frac{\phi_1}{L_1} + \frac{\phi_2}{L_2} + \cdots\cdots + \frac{\phi_n}{L_n}\right)^1 \cdots\cdots\cdots\cdots\cdots\cdots (4.7)$$

where,

l_1, L_2, …, L_n : Rated life under condition 1, 2,…, n, h

n_1, n_2,…, n_n : Number of revolutions under condition 1, 2, …, n, r/min

P_1, P_2, …, P_n : Equivalent load under condition 1, 2, …, n, N, lbf

ϕ_1, ϕ_2, …, ϕ_n : Ratio of condition 1, 2, …, n accounting for the total operating time

L_m : Built-in life, h

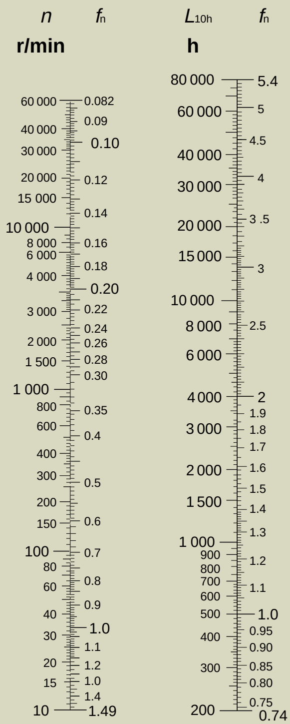


Fig. 4.1 Bearing life rating scale

Service classification	Machine application	Life time L_n
Machines used occasionally	Door mechanisms, Garage shutter	500
Equipment for short perior or intermittent service-interruption permissible	Household appliances, Electric hand tools, Agriculture machines, Lifting tackles in shops	4000~ 8000
Intermittent service machines-high reliability	Power-Station auxiliary equipment, Elevators Conveyors, Deck cranes	8000~ 14000
Machines used for 8 hours a day, but no always in full operation	Ore wagon axles, Important gear units	14000~ 20000
Machines fully used for 8 hours	Blowers, General machinery in shops, Continuous operation cranes	20000~ 30000
Machines continuously used for 24 hours a day	Compressors, Pumps	50000~ 60000
Machines continuously used for 24 hours a day with maximum reliability	Power-station equipment, Water-supply equipment for urban areas, Mine ventilators	100000~ 200000

4.3 Machine applications and requisite life

When selecting a bearing, it is essential that the requisite life of the bearing be established in relation to the operating conditions. The requisite life of the bearing is usually determined by the type of machine the bearing is to be used in, and duration of service and operational reliability requirements. A general guide to these requisite life criteria is shown in Table 4.1. When determining bearing size, the fatigue life of the bearing is an important factor; however, besides bearing life, the strength and rigidity of the shaft and housing must also be taken into consideration.

4.4 Adjusted life rating factor

The basic bearing life rating (90% reliability factor) can be calculated through the formulas mentioned earlier in Section 4.2. However, in some applications a bearing life factor of over 90% reliability may be required. To meet these requirements, bearing life can be lengthened by the use of spatially improved bearing materials or special construction techniques. Moreover, according to elastohydrodynamic lubrication theory, it is clear that the bearing operating conditions (lubrication, temperature, speed, etc.) all exert an effect on bearing life. All these adjustment factors are taken into consideration when calculating bearing life, and using the life adjustment factor as prescribed in ISO 281, the adjusted bearing life can be arrived at:

$$L_{na} = a_1\, a_2\, a_3 \left(\frac{C}{P}\right)^3 \cdots\cdots\cdots\cdots (4.8)$$

where,

L_{na} : Adjusted life in millions of revolutions (10^6) (adjusted for reliability, material and operating conditions)
a_1 : Reliability adjustment factor
a_2 : Material/construction adjustment factor
a_3 : Operating condition adjustment factor

4.4.1 Life adjustment factor for reliability a_1

The values for the reliability adjustment factor a_1 (for a reliability factor higher than 90%) can be found in Table 4.2.

Table 4.2 Reliability adjustment factor values a_1

Reliability %	L_n	Reliability factor a_1
90	L_{10}	1.00
95	L_5	0.62
96	L_4	0.53
97	L_3	0.44
98	L_2	0.33
99	L_1	0.21

4.4.2. Life adjustment factor for material/ construction a_2

The values for the basic dynamic load ratings given in the bearing dimension table are for bearing constructed from NTN's continued efforts at improving the quality and life of its bearings.

Accordingly, a_2 =1 is used for life adjustment factor in formula (4.8). For bearing constructed of specially improved materials or with special manufacturing methods, the life adjustment factor a_2 in formula (4.8) can have a value greater than one. Please consult NTN for special bearing materials or special construction requirements.

When high carbon chromium steel bearings, which have undergone only normal heat treatment, are operated for long periods of time at temperatures in excess of 120°C, 248°F, considerable dimension deformation may take place. For this reason, there are special high temperature bearings which have been treated for dimensional stability. This special treatment allows the bearing to operate at its maximum operational temperature without the occurrence of dimensional changes. However, these dimensionally stabilization-treated bearing, designated "HT", have a reduced hardness with a consequent decrease in bearing life. The adjusted life factor values used in formula (4.8) for such heat-stabilized bearings can be found in Table 4.3.

Table 4.3 Dimension stabilized bearings

Code	Max. operating temperature °C	°F	Adjustment factor a_2
—	100	212	1.00
HT1	140	284	0.87
HT2	200	392	0.68

4.4.3 Life adjustment factor a_3 for operating conditions

The operating conditions life adjustment factor a_3 is used to adjust for such conditions as lubrication, operating temperature, and other operating factors which have an effect on bearing life.

Generally speaking, when lubricating conditions are satisfactory, the a_3 factor has a value of one; and when lubricating conditions are exceptionally favorable, and all other operating conditions are normal a_3 can have a value greater than one.

However, when lubricating conditions are particularly unfavorable and the oil film formation on the contact surfaces of the raceway and rolling elements is insufficient, the value of a_3 becomes less than one. This insufficient oil film formation can be caused, for example, by lubricating oil viscosity being too low for the operating temperature (below 13 mm^2/s for ball bearings); or by exceptionally low rotational speed (n r/min × d_p mm less than 10000). For bearings used under special operating conditions, please consult NTN.

As the operating temperature of the bearing increases, the hardness of the bearing material decreases, Thus, the bearing life correspondingly decreases. The operating temperature adjustment values are shown in Fig. 4.2.

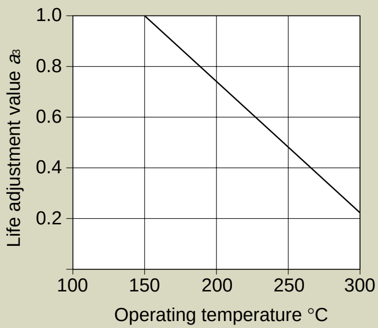


Fig. 4.2 Life adjustment value for operating temperature

4.5 Basic static load rating

When stationary rolling bearings are subjected to static loads, they suffer from partial permanent deformation of the contact surfaces at the contact point between the rolling elements and the raceway. The amount of deformity increases as the load increases, and if this increase in load exceeds certain limits, the subsequent smooth operation of the bearing is impaired.

It has been found through experience that a permanent deformity of 0.0001 times the diameter of the rolling element, occurring at the most heavily stressed contact point between the raceway and the rolling elements, can be tolerated without any impairment in running efficiency.

The basic rated static load refers to a fixed static load limit at which a specified amount of permanent deformation occurs. It applies to pure radial loads for radial bearings. The maximum applied load values for contact stress occurring at the rolling element and raceway contact points are given below.

For ball bearings (for bearing unit): 4200 Mp_a.

4.6 Allowable static equivalent load

Generally the static equivalent load which can be permitted (see section 5.3) is limited by the basic static rated load as stated in Section 4.5. However, depending on requirements regarding friction and smooth operation, these limits may be greater or lesser than the basic static rated load.

In the following formula (4.9) and Table 4.4 the safety factor S_o can be determined considering the maximum static equivalent load.

$$S_o = \frac{C_o}{P_{o\,max}} \cdots\cdots\cdots (4.9)$$

where,

S_o : Safety factor
C_o : Basic static rated load, N, lbf
$P_{o\,max}$: Maximum static equivalent load, N, lbf

Table 4.4 Minimum safety factor values S_o

Operating conditions	Ball bearings
High rotational accuracy demand	2
Normal rotating accuracy demand (Universal application)	1
Slight rotational accuracy deterioration permitted (Low speed, heavy loading, etc.)	0.5

Note: 1) When vibration and/or shock loads are present, a load factor based on the shock load needs to be included in the $P_{o\,max}$ value.

5. Loads

5.1 Load acting on the bearing

It is very rare that the load on a bearing can be obtained by a simple calculation. Loads applied to the bearing generally include the weight of the rotating element itself, the load produced by the working of the machine, and the load resulting from transmission of power by the belt and gearwheel. Such loads include the radial load, which works on the bearing at right angles to its axis, and the thrust load, which works on the bearing parallel to its axis. These can work either singly or in combination. In addition, the operation of a machine inevitably produces a varying degree of vibrations and shocks. To take this into account, the theoretical value of a load is multiplied by a safety factor that has been derived from past experience. This is known as the "load factor".

Load acting on the bearing

=Load factor f_w ×Calculated load

Table 5.1 below shows the generally accepted load factors of f_w which correspond to the degree of shock to which the machine is subjected.

5.1.1 Load applied to the bearing by power transmission

The force working on the shaft when power is transmitted by belts, chains or gearwheels is obtained, in general, by the following formula:

$$T = 9550\frac{H}{n},\ 84500\frac{H}{n} \cdots\cdots (5.1)$$

$$K_t = \frac{T}{r} \cdots\cdots (5.2)$$

where,

- T : Torque, N•m, lbf•inch
- H : Transmission power, kW
- n : Number of revolutions, r/min
- K_t : Transmission force (effective transmission force of belt or chain; tangential force of gearwheel), N, lbf
- r : Effective radius of belt pulley, sprocket wheel or gearwheel, m, inch

Accordingly, the load actually applied to the shaft by the transmission force can be obtained by the following formula:

$$\text{Actual load} = \text{Factor} \times K_t \cdots\cdots (5.3)$$

Different factors are adopted according to the transmission system in use. These will be dealt with in the following paragraphs.

Belt transmission

When power is transmitted by belt, the effective transmission force working on the belt pulley is calculated by formula (5.2). The term "effective transmission force of the belt" refers to the difference in tension between the tensioned side and the loose side of the belt. Therefore, to obtain the load actually acting on the shaft through the medium of the belt pulley, it is necessary to multiply the effective transmission force by a factor which takes into account the type of belt and the initial tension. This is known as the "belt factor".

Table 5.1 Load factors f_w

Load conditions	f_w	Examples
Little or no shock	1 to 1.2	Machines tools, electric machines, etc.
Some degree of shock; machines with reciprocating parts	1.2 to 1.5	Vehicles, driving mechanism, metal-working machinery, steel-making machines, paper-making machinery, rubber mixing machines, hydraulic equipment, hoists, transportation machinery, power-transmission equipment, woodworking machines, printing machines, etc.
violent shocks	1.5 to 3	Agriculture machines, vibrator screens, ball and tube mills, etc.

In the case of power transmission by belts, gearwheels, etc., load factors adopted are somewhat different from the above.

Factors used for power transmission by belts, gearwheels and chains, respectively, are given the following sections.

Table 5.2 Belt factors f_w

Bell type	f_b
V-belt	1.5 to 2.0
Timing belt	1.1 to 1.3
Flat belt (with tension pulley)	2.5 to 3.0
Flat belt	3.0 to 4.0

Note: In cases where the distance between shafts is short, the revolution speed is low, or where operating conditions are severe, the higher f_b values should be adopted.

Gear transmission

In the case of gear transmissions, the theoretical gear load can be calculated from the transmission force and the type of gear. With spur gears, only a radial load is involved; whereas, with helical gears and bevel gears, an additional axial load is present.

The simplest case is that of spur gears. In this instance, the tangential force K_t is obtained from the formula (5.2) and the radial force K_s can be obtained from the following formula:

$$K_s = K_t \bullet \tan\alpha \cdots\cdots\cdots\cdots\cdots\cdots (5.4)$$

where,

α is the pressure angle of the gear.

Accordingly, the theoretical composite force, K_r, working on the gear is obtained from the following formula:

$$K_r = \sqrt{K_t^2 + K_s^2} = K_t \bullet \sec\alpha \cdots\cdots\cdots\cdots (5.5)$$

Therefore, to obtain the radial load actually working on the shaft, the theoretical composite force, as above, is multiplied by a factor in which the accuracy and the degree of precision of the gear is taken into account. This is called the "gear factor" and is represented by the symbol f_z. In Table 5.3 is below, f_z values for spur wheels are given.

The gear factor is essentially almost the same as the previously described load factor, f_w. In some cases, however, vibrations and shocks are produced also by the machine of which the gear is a part. Here it is necessary to calculate the actual load working on the gear by further multiplying the gear load, as obtained above, by the load factor shown in Table 5.1, according to the degree of shock.

Table 5.3 Gear factors f_z

Gear	f_z
Precision gears (tolerance 0.02 mm 0.0008 inch max., for both pitch and shape)	1.05 to 1.1
Gears finished by ordinary machining work (tolerance 0.02 to 0.1 mm, 0.0008 to 0.0039 inch for both pitch and shape	1.1 to 1.3

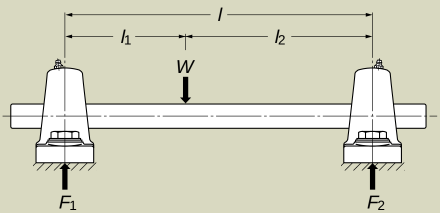
Chain transmission

When power is transmitted by chain, the effective transmission force working on the sprocket wheel is calculated by formula (5.2). To obtain the load actually working, the effective transmission force must be multiplied by the "chain factor", 1.2 to 1.5.

5.1.2 Distribution of the radial load

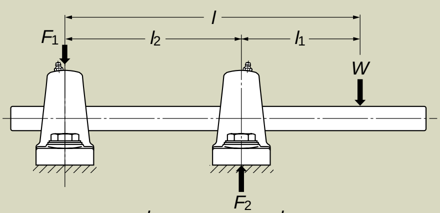
The load acting on the shaft is distributed to the bearings which support the shaft.

In Fig. 5.1, the load is applied to the shaft between two bearings; in Fig. 5.2 the load is applied to the shaft outside the two bearings. In practice, however, most cases are combinations of Fig. 5.1 and 5.2, and the load is usually a composite load, that is to say, a combination of radial and axial loads. Therefore they are calculated by the methods described in the following sections.



$$F_1 = \frac{l_2}{l} \bullet W \qquad F_2 = \frac{l_1}{l} \bullet W$$

Fig. 5.1



$$F_1 = \frac{l_1}{l_2} \bullet W \qquad F_2 = \frac{l}{l_2} \bullet W$$

Fig. 5.2

5.2 Equivalent dynamic radial load

For ball bearings used in the NTN unit, the basic rated dynamic loads C_r mentioned in the table of dimensions are applicable only when the load is purely radial. In practice, however, bearings are usually subjected to a composite load. As the table of dimensions is not directly applicable here, it is necessary to convert the values of the radial and axial lads into a single radial load value that would have an effect on the life of bearing equivalent to that of the actual load applied. This is known as the "equivalent dynamic radial load", and from this the life of the ball bearings for the unit is the calculated. The equivalent dynamic radial load is calculated by the following formula:

$$P_r = X \bullet F_r + Y \bullet F_a \quad \cdots\cdots (5.6)$$

where,

- P_r : Equivalent dynamic radial load N, lbf
- F_r : Radial load, N, lbf
- F_a : Axial load N, lbf
- X : Radial factor
- Y : Axial factor

Values of X and Y are shown in Table 5.4 below.

With ball bearings for the unit, when only radial load is involved, or when $F_a/F_r \leq e$ (e is value which is determined by the size of an individual bearing and the load acting thereon), the values of X and Y will be 1 and 0 respectively, resulting in the following equation:

$$P_r = F_r \quad \cdots\cdots (5.7)$$

Table 5.4 Values of X and Y applying when $\frac{F_a}{F_r} > e$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} > e$	
		X	Y
0.010	0.18		2.46
0.020	0.20		2.14
0.040	0.24		1.83
0.070	0.27		1.61
0.10	0.29	0.56	1.48
0.15	0.32		1.35
0.20	0.35		1.25
0.30	0.38		1.13
0.40	0.41		1.05
0.50	0.44		1.00

Note: C_{or} is the basic rated static load. (See table of dimensions.) When the value of $\frac{F_a}{C_{or}}$ or $\frac{F_a}{F_r}$ is not in conformity with those given in Table 5.4 above, find the value by interpolation.

5.3 Equivalent static radial load

In the case of a bearing which is stationary, rotates at a low speed of about 10 rpm, or makes slight oscillating movements, it is necessary to take into account the equivalent static radial load, which is the counterpart of the equivalent dynamic radial load of a rotating bearing. In this case, the following formula is used.

$$P_{or} = X_o \bullet F_r + Y_o \bullet F_a \quad \cdots\cdots (5.8)$$

where,

- P_{or} : Equivalent static radial load N, lbf
- F_r : Radial load N, lbf
- F_a : Axial load N, lbf
- X_o : Static radial factor
- Y_o : Static axial factor

With the ball bearings for the NTN unit, the values of X_o and Y_o are X_o=0.6; Y_o=0.5.

However when only radial load is involved, or when $F_a/F_r \leq e$, the following values in used:

X_o=1 Y_o=0

Accordingly, the following equation holds.

$$P_{or} = F_r \quad \cdots\cdots (5.9)$$

6. Bearing Internal Clearance

6.1 Bearing internal clearance

Bearing internal clearance (initial clearance) is the amount of internal clearance a bearing has before being installed on a shaft or in a housing.

As shown in Fig. 6.1, when either the inner ring or the outer ring is fixed the other ring is free to move, displacement can take place in either an axial or radial direction. This amount of displacement (radially or axially) is termed the internal clearance and, depending on the direction, is called the radial internal clearance or the axial internal clearance.

When the internal clearance of a bearing is measured, a slight measurement load is applied to the raceway so the internal clearance may be measured accurately. However, at this time, a slight amount of elastic deformation of the bearing occurs under the measurement load, and the clearance measurement value (measured clearance) is slightly larger than the true clearance. This discrepancy between the true bearing clearance and the increased amount due to the elastic deformation must be compensated for. These compensation values are given in Table 6.1.

The internal clearance values for each bearing class are shown in Table 6.3.

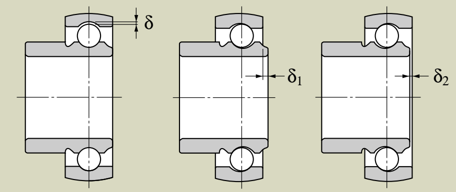


Fig. 6.1 Internal clearance

Table 6.1 Adjustment of radial internal clearance based on measured load **Unit: μm**

Nominal Bore Diameter *d* (mm) over	incl.	Measuring Load (N)	Radial Clearance Increase C2	CN	C3	C4	C5
10	18	24.5	3~4	4	4	4	4
18	50	49	4~5	5	6	6	6
50	200	147	6~8	8	9	9	9

6.2 Internal clearance selection

The internal clearance of a bearing under operating conditions (effective clearance) is usually smaller than the same bearing's initial clearance before being installed and operated. This is due to several factors including bearing fit, the difference in temperature between the inner and outer rings, etc. As a bearing's operating clearance has an effect on bearing life, heat generation, vibration, noise, etc.; care must be taken in selecting the most suitable operating clearance.

Effective internal clearance:

The internal clearance differential between the initial clearance and the operating (effective) clearance (the amount of clearance reduction caused by interference fits, or clearance variation due to the temperature difference between the inner and outer rings) can be calculated by the following formula:

$$\delta_{eff} = \delta_o - (\delta_f + \delta_t) \cdots\cdots (6.1)$$

where,

δ_{eff} : Effective internal clearance, mm
δ_o : Bearing internal clearance, mm
δ_f : Reduced amount of clearance due to interference, mm
δ_t : Reduced amount of clearance due to temperature differential of inner and outer rings, mm

Reduced clearance due to interference:

When bearings are installed with interference fits on shafts and in housings, the inner ring will expand and the outer ring will contract; thus reducing the bearings' internal clearance. The amount of expansion or contraction varies depending on the shape of the bearing, the shape of the shaft or housing, dimensions of the respective parts, and the type of materials used. The differential can range from approximately 70% to 90% of the effective interference.

$$\delta_f = (0.70 \sim 0.90) \bullet \Delta d_{eff} \cdots\cdots (6.2)$$

where,

δ_f : Reduced amount of clearance due to interference, mm
Δd_{eff} : Effective interference, mm

Reduced internal clearance due to inner/outer ring temperature difference:

During operation, normally the outer ring will be from 5° to 10°C cooler than the inner ring or rotating parts. However, if the cooling effect of the housing is large, the shaft is connected to a heat source, or a heated substance is conducted through the hollow shaft; the temperature difference between the two rings can be even greater. The amount of internal clearance is thus further reduced by the differential expansion of the two rings.

$$\delta_t = \alpha \bullet \Delta_T \bullet D_o \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(6.3)$$

where,

δ_t : Amount of reduced clearance due to heat differential, mm

α : Bearing steel linear expansion coefficient 12.5×10^{-6}/°C

Δ_T : Inner/outer ring temperature differential, °C

D_o : Outer ring raceway diameter, mm

Outer ring raceway diameter, D_o, values can be approximated by using formula 6.4.

$$D_o = 0.20(d + 4.0D)\cdots\cdots\cdots\cdots\cdots\cdots\cdots(6.4)$$

where,

d : Bearing bore diameter, mm

D : Bearing outside diameter, mm

6.3 Bearing internal clearance selection standards

Theoretically, in regard to bearing life, the optimum operating internal clearance for any bearing would be a slight negative clearance after the bearing had reached normal operating temperature.

Unfortunately, under actual operating conditions, maintaining such optimum tolerances is often difficult at best. Due to various fluctuating operating conditions this slight minus clearance can quickly become a large minus, greatly lowering the life of the bearing and causing excessive heat to be generated. Therefore, an initial internal clearance which will result in a slightly greater than negative internal operating clearance should be selected.

Under normal operating conditions (e.g. normal load, fit, speed, temperature, etc.), a standard internal clearance will give a very satisfactory operating clearance.

Table 6.2 lists non-standard clearance recommendations for various applications and operating conditions.

Table 6.2 Examples of applications where bearing clearances other than normal clearance are used

Operating conditions	Applications	Selected clearance
Shaft is heated and housing is cooled.	Conveyor of casting machine	C5
Shaft or inner ring is heated.	Anealing pit, Drying pit, Curing pit	C4
Allows for shaft deflection and fitting errors.	Disc harrows	C4
	Combines	C3
Tight-fitted for both inner and outer rings.	Large blowers	C3
To reduce noise and vibration when rotating.	Multi-wing fan of air conditioners	C2

Table 6.3 (1) Cylindrical bore bearings **Unit: mm/0.0001 inch**

Nominal bore diameter *d*				Radial internal clearance															
				C2				CN				C3				C4			
over		incl.		min.		max.		min.		max.		min.		max.		min.		max.	
mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
10	0.3937	18	0.7087	0	0	9	4	3	1	18	7	11	4	25	10	18	7	33	13
18	0.7087	24	0.9449	0	0	10	4	5	2	20	8	13	5	28	11	20	8	36	14
24	0.9449	30	1.1811	1	0	11	4	5	2	20	8	13	5	28	11	23	9	41	16
30	1.1811	40	1.5748	1	0	11	4	6	2	20	8	15	6	33	13	28	11	46	18
40	1.5748	50	1.9685	1	0	11	4	6	2	23	9	18	7	36	14	30	12	51	20
50	1.9685	65	2.5591	1	0	15	6	8	3	28	11	23	9	43	17	38	15	61	24
65	2.5591	80	3.1496	1	0	15	6	10	4	30	12	25	10	51	20	46	18	71	28
80	3.1496	100	3.9370	1	0	18	7	12	5	36	14	30	12	58	23	53	21	84	33
100	3.9370	120	4.7244	2	1	20	8	15	6	41	16	36	14	66	26	61	24	97	38
120	4.7244	140	5.5118	2	1	23	9	18	7	48	19	41	16	81	32	71	28	114	45

Note: Heat-resistant bearings with suffix HT1 or HT2 have C4 clearances.

Table 6.3 (2) Tapered bore bearings **Unit: mm/0.0001 inch**

Nominal bore diameter *d*				Radial internal clearance															
				C2				CN				C3				C4			
over		incl.		min.		max.		min.		max.		min.		max.		min.		max.	
mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
24	0.9449	30	1.1811	5	2	20	8	13	5	28	11	23	9	41	16	30	12	53	21
30	1.1811	40	1.5748	6	2	20	8	15	6	33	13	28	11	46	18	40	16	64	25
40	1.5748	50	1.9685	6	2	23	9	18	7	36	14	30	12	51	20	45	18	73	29
50	1.9685	65	2.5591	8	3	28	11	23	9	43	17	38	15	61	24	55	22	90	35
65	2.5591	80	3.1496	10	4	30	12	25	10	51	20	46	18	71	28	65	26	105	41
80	3.1496	100	3.9370	12	5	36	14	30	12	58	23	53	21	84	33	75	30	120	47
100	3.9370	120	4.7244	15	6	41	16	36	14	66	26	61	24	97	38	90	35	140	55
120	4.7244	140	5.5118	18	7	48	19	41	16	81	32	71	28	114	45	105	41	160	63

7. Lubrication

As bearings in NTN bearing units have sufficient high-grade grease sealed in at the time of manufacture, there is no need for replenishment while in use. The amount of grease necessary for lubrication is, in general, very small. With the NTN bearing units, the amount of grease occupies about a half to a third of the space inside the bearing.

7.1 Maximum permissible speed of rotation

The maximum speed possible while ensuring the safety and long life of ball bearings used in the unit is limited by their size, the circumferential speed at the point where the seal comes into contact, and the load acting on them.

To indicate the maximum speed permissible, it is customary to use the value of *dn* or $d_m n$ (*d* is the bore of the bearing; d_m is the diameter of the pitch circle=(I.D. +O.D.)/2;d_m is the number of revolutions).

Problems connected with the lubrication of bearings are the generation of heat and seizures occurring at the sliding parts inside the bearing, in particular at the points where the ball is in contact with the retainer, inner and outer ring. The contact pressure at the points where friction occurs on the retainer is only slightly affected by the load acting on the bearing; the amount of heat generated there is approximately in proportion to the siding velocity. Therefore, this sliding velocity serves as a yardstick to measure the limit of the rotating speed of the bearing. In the case of a bearing unit, however, there is another large factor that has to be taken into account—the circumferential speed at the part where the seal is in contact.

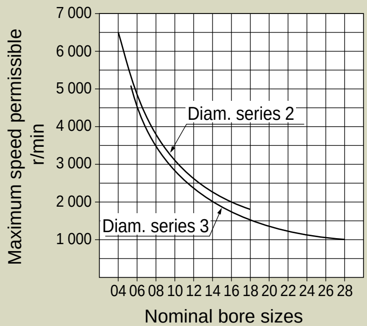


Fig. 7.1

The graph in Fig. 7.1 indicates the maximum speed of rotation permissible, taking into account the aforementioned factors.

There are two common methods of locking the bearing unit onto the shaft—the set screw system and the eccentric collar system. However, in both of these systems high-speed operation will cause deformation of the inner ring, which may result in vibration of the bearing. For high-speed operation, therefore, it is recommended that an interference fit or a clearance fit with a near-zero clearance be used, with a shaft of the larger size as shown later in this manual in Fig. 8.1, Fig. 8.6.

For standard bearing units with the contact type seal, the maximum speed permissible is 120,000/d. Where a higher speed is required, bearing units with the non-contact type seal, are advised. Please contact NTN regarding the use of the latter type. Additionally, it is necessary that the surface on which the housing is mounted be finished to as a high a degree of accuracy as possible. A regularity of within ±0.05mm, ±0.002 inch is required.

7.2 Replenishment of grease

7.2.1 Sealed-in grease

With NTN bearing units, no relubrication is the general rule. The standard self-lubricating type of bearing units contain high-grade lithium-based grease which, being suitable for long-term use, is ideal for sealed-type bearings. They also feature NTN's unique sealing device. Relubrication, therefore, is unnecessary under most operating conditions.

At high temperatures, or where there is exposure to water or excessive dust, the highest quality grease is essential. Therefore, NTN uses its own specially selected brands which are shown in Table 7.1. It is necessary to use the same brand when replenishing grease.

Table 7.1 Brand of grease used in NTN bearing units

Bearing units	Grease			Symbols	Operating temperature range
	Name of grease	Thickening agent	Base oil		
Standard	Alvania grease 3	Li soap	Mineral oil	D1	–15° to +100°C, (+5° to +212°F).
Heat-resistant	Darina grease 2	Non-soap	Mineral oil	HT1D1	Normal temp. to +140°C (284°F).
Heat-resistant	SH44M	Li soap	Silicone oil	HT2D1	Normal temp. to +200°C (392°F).
Cold-resistant	SH33L	Li soap	Silicone oil	CT1D1	–60°C (–76°F) to normal temp.

7.2.2 Mixing of different kinds of grease

Whether or not different kinds of grease may be mixed usually depends on their thickeners. The commonly used criteria are shown in Table 7.2. Properties which are most susceptible to influences from mixing are viscosity, dropping point and penetration. Water and heat resisting properties as well as mechanical stability are also lowered. Therefore, when mixing in a grease which is different to that which is already in use, it is essential that the thickener (soap base) and the base oil be of the same group.

When relubricating NTN bearing units, it is advisable to use the brands of grease shown in Table 7.1.

Table 7.2 Mixing properties of grease

Soap base	Ca	Na	Al	Ba	Li
Ca	❍	∆	∆	×	∆
Na	∆	❍	∆	×	×
Al	∆	∆	❍	×	×
Ba	×	×	×	❍	×
Li	∆	×	×	×	❍

❍ Mixing will not produce any appreciable change of properties.
∆ Mixing may produce considerable variations of properties.
× Mixing will cause a drastic change of properties.

7.2.3 Relubrication frequency

Relubrication frequency varies with the kind and quality of grease used as well as the operating conditions. Therefore, it is difficult to establish a general rule, but under ordinary operating conditions, it is desirable that grease be replenished before one third (1/3) of its calculated life elapses. It is necessary, however, to take into consideration such factors as hardening of grease in the oil hole, making replenishment impossible; deterioration of grease while operation of the machine is suspended, and so forth.

In Table 7.3 below are shown standard relubrication frequencies. Irrespective of the calculated life of the grease, this list takes into consideration such factors as the rotational speed of the bearings, operating temperatures and environmental conditions, with a view to safety.

7.2.4 Re-greasing

The performance of a bearing is greatly influenced by the quantity of grease. In order to avoid over-filling, it is advisable to replenish the grease while the machine is in operation.

Continue to insert grease until a little oozes out from between the outer ring raceway and the periphery of the slinger, for optimum performance.

Table 7.3 Standard relubrication frequencies

Type of unit	Symbol	*dn* Value	Environmental conditions	Operating temp. °C, °F	Relubrication frequency	
					Hours	Period
Standard	D1	40,000 and below	Ordinary	–15 to +80, +5 to +176	1,550 to 3,000	6 to 12 mo.
Standard	D1	70,000 and below	Ordinary	–15 to +80, +5 to +176	1,000 to 2,000	3 to 6 mo.
Standard	D1	70,000 and below	Ordinary	+80 to +100, +176 to +212	500 to 700	1 mo.
Heat-resistant	HT1D1	70,000 and below	Ordinary	+100 to +140, +212 to +284	300 to 700	1 mo.
Heat-resistant	HT2D1	70,000 and below	Ordinary	+140 to +170, +284 to +338	300 to 700	1 mo.
Heat-resistant	HT2D1	70,000 and below	Ordinary	+170 to +200, +338 to +392	100	1 wk.
Cold-resistant	CT1D1	70,000 and below	Ordinary	–60 to +80, –76 to +176	1,000 to 2,000	3 to 6 mo.
Standard	D1	70,000 and below	Very dusty	–15 to +100, +5 to +212	100 to 500	1 wk. to 1 mo.
Standard	D1	70,000 and below	Exposed to water splashes	–15 to +100, +5 to +212	30 to 100	1 day to 1 wk.

7.3 Grease fitting

NTN bearing units are, as a general rule, provided with a grease fitting made of brass, as shown in Table 7.4, and a grease gun is used for regreasing, However, button-head and pin types may also be furnished on demand.

Grease fitting dimensions and the designation of applicable bearing units are given in Table 7.5.

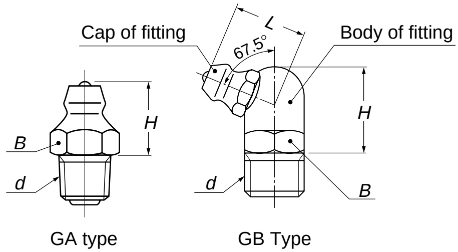


Table 7.4 Grease fitting types available for bearing units

Types of housing	NTN standard grease fitting types
Pillow type	GA type
Flange type	GA type
Take-up type	GB type
Hanger type	GA type
Cartridge type	GA type

Table 7.5 Grease fitting dimensions and designations of applicable bearing units

GA type (Vertical type)

NTN Designation	*d*	*H*		*B*	
		mm	inch	mm	inch
GA-1/4-28 UNF	1/4-28 UNF	8.5	0.335	7	0.276
GA-PF1/8	G1/8	12	0.472	10	0.394
GA-PF1/4	G1/4	14	0.551	14	0.551

GB type (67.5∞)

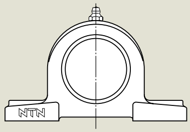
NTN Designation	*d*	*H*		*L*		*B*	
		mm	inch	mm	inch	mm	inch
GB-1/4-28 UNF	1/4-28 UNF	10.5	0.413	9.3	0.366	8	0.315
GB-PF1/8	G1/8	14.2	0.559	13.5	0.531	10	0.394
GB-PF1/4	G1/4	15	0.591	13.5	0.531	14	0.551

Nominal screw size *d*	Series 2	Series X	Series 3
1/4-28 UNF	203-209	X05-X08	305-309
G1/8	210-215	X09-X14	310-315
G1/4	216-218	X15-X20	316-328

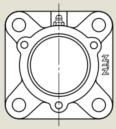
Note: Screw size for the cartridge type is 1/4-28 UNF.
That for C310D1 to C328D1 is G1/8 (PF1/8).

7.4 Standard location of the grease fitting

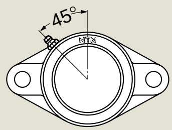
Standard location of grease fitting on the housing for the relubricatable bearing units of each type is illustrated below.



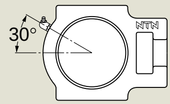
P, PL, PX, S-P, type



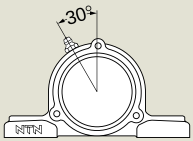
C-F type



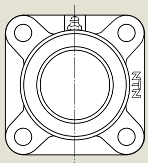
FL, FLU, FLX, S-FL type



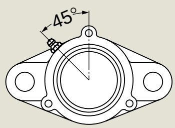
T, TX, S-T type



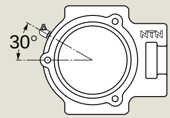
C-P type



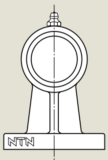
F, FU, S-F (#204•#205), FS type



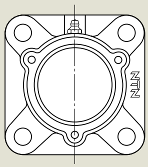
C-FL type



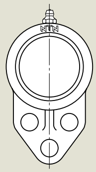
C-T type



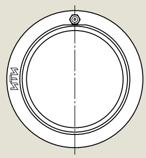
HP type



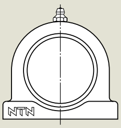
C-FS type



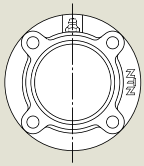
FH type



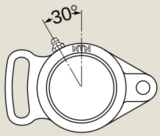
C,Cx type



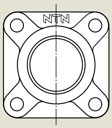
UP type



FC, FCX, S-FC type

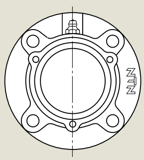


FA type

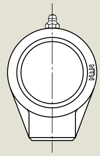


Except #204•#205

F, FU, FX, S-F type



C-FS type



HB type

8. Shaft Designs

Although the shafts used for NTN bearing units require no particularly high standards of accuracy, it is desirable that, as far as possible, they be free from bends and flaws.

8.1 Set screw system bearing units

With set screw system bearing units, under normal operating conditions the inner ring is usually fitted onto the shaft by means of a clearance fit to ensure convenience of assembly. In this case the values shown in Fig. 8.1 are appropriate dimensional tolerances for the shaft.

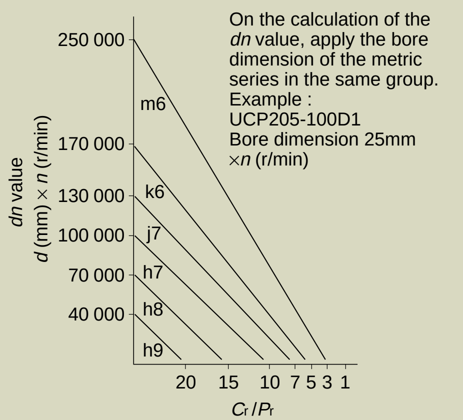


Fig.8.1 Dimensional tolerance for the shaft for set screw system bearing units

Set shafts

Wherever there is a noticeably large axial load, a step shaft, as shown in Fig. 8.2, should, if practical, be used.

For bearing units with cover, it is recommended that the units shown in Table 8.1 be used with shafts of the corresponding diameters, as shown in the same table.

The values of the radii of the rounded corners of these shafts are shown in Table 8.2.

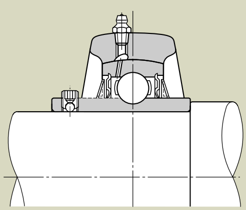


Fig. 8.2

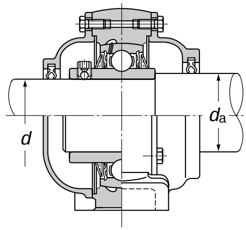


Table 8.1 Bearing units with covers (for use with step shafts) and shaft diameters

A) Metric series

Designation of units		d_a mm
10C-UCP206 to 10C-UCP218	10C-UCT208 to 10C-10UCT217	d+10
10C-UCP305 to 10C-UCP311	10C-UCT305 to 10C-UCT311	d+10
15C-UCP312 to 15C-UCP324	15C-UCT312 to 15C-UCT324	d+15
20C-UCP326 to 20C-UCP328	20C-UCT326 to 20C-UCT328	d+20

Remarks: Designation of bearing units with blind cover.
Example: 10CM-UCP206D1

B) Inch series

Designation of units	d_a inch	Designation of units	d_a inch
ZnC–…206–…	1 1/2	ZnC–…305–…	1 3/8
ZnC–…207–…	1 3/4	ZnC–…306–…	1 1/2
ZnC–…208–…	1 7/8	ZnC–…307–…	1 3/4
ZnC–…209–…	2	ZnC–…308–…	1 7/8
ZnC–…210–…	2 3/8	ZnC–…309–…	2 1/8
ZnC–…211–…	2 1/2	ZnC–…310–…	2 3/8
ZnC–…212–…	2 3/4	ZnC–…311–…	2 3/4
ZnC–…213–…	3	ZnC–…312–…	3
ZnC–…214–…	3 1/8	ZnC–…313–…	3 1/8
ZnC–…215–…	3 3/8	ZnC–…314–…	3 1/4
ZnC–…216–…	3 1/2	ZnC–…315–…	3 1/2
ZnC–…217–…	3 3/4	ZnC–…316–…	3 3/4
ZnC–…218–…	4	ZnC–…317–…	4
		ZnC–…318–…	4

Note: Designations for all units differ from the normal numbering system.
Example 1 Pillow type: ZnC-UCP206-101D1
ZnCM-UCP206-101D1
Example 2 Flange type: ZnC-UCF206-101D1
Znc-UCFL206-101D1
Example 3 Take-up type: ZnC-UCT206-101D1
ZnCM-UCT206-101D1
n indicates serial number in designing from 1 onward.

As an expedient, there may be provided a bored hole on the shaft as illustrated in Fig. 8.3. In this case it is necessary to ensure the accuracy of the relationship between the positions of the housing of the bearing and of the bored hole on the shaft.

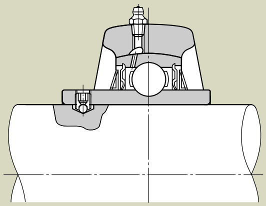


Fig. 8.3

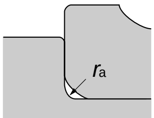


Table 8.2 Radii of the round corners of step shafts

Designation of bearings	$r_{as\,max.}$ mm	$r_{as\,max.}$ inch	Designation of beairings	$r_{as\,max.}$ mm	$r_{as\,max.}$ inch
UC201 to UC203	0.6	0.024	UC305 to UC306	1.5	0.059
UC204 to UC206	1	0.039	UC307 to UC309	2	0.079
UC207 to UC210	1.5	0.059	UC310to UC311	2.5	0.098
UC211 to UC215	2	0.079	UC312 to UC316	2.5	0.098
UC216 to UC218	2.5	0.098	UC317 to UC324	3	0.118
			UC326 to UC328	4	0.157

Relief in the axial direction

Where several bearing units are fitted on the shaft, or where there is a great distance between two bearing units, one of the bearings is secured to the shaft as the “fixed-side bearing” and is subjected to both the axial and radial loads. The other is mounted on the shaft as the “free-side bearing” and is subjected only to radial load, compensating for expansion of the shaft due to a rise in temperature or for any errors in distance between bearings that may have occurred during assembly.

If there is no free-side bearing, the bearings will be subjected to an abnormal axial load, which could cause premature break-down.

Although it is desirable to use a cartridge-type bearing unit for the above purpose (Fig. 8.4), the following method is often employed. As illustrated in Fig. 8.5 (a) and (b), a key way is cut in the shaft, to accommodate a special set screw.

When relief is provided in the axial direction by the use of screwed bolts as above, the dimensional relationships applicable are shown in Tables 8.3 (a) and 8.3 (b) on the following pages.

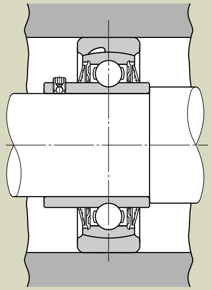


Fig. 8.4

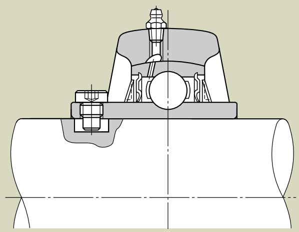


Fig. 8.5 (a)

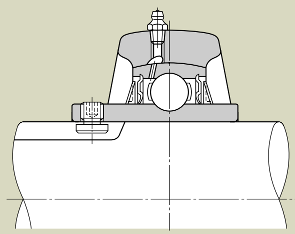
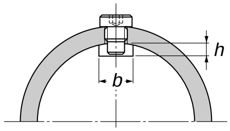


Fig. 8.5 (b)



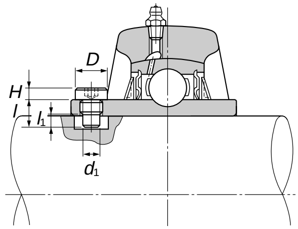
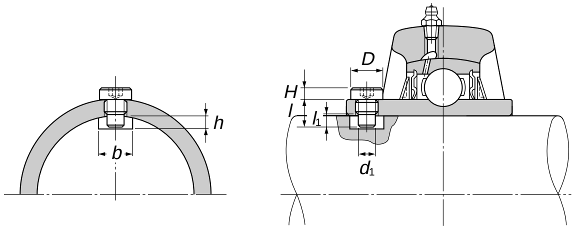


Table 8.3 (a) Screwed bolt system

A) Metric series, applied to metric bore size.

Designation of bearings	Key way Width b mm	Key way Depth h mm	Designation of bearings	d_1 mm	l mm	l_1 mm	D mm	H mm
UC201D1W5	3.5	3	S5W5×0.8×11	3.5	11	5	6	3
UC202D1W5	3.5	4.5	S5W5×0.8×11	3.5	11	5	6	3
UC203D1W5	3.5	5.5	S5W5×0.8×11	3.5	11	5	6	3
UC204D1W5	3.5	4.5	S5W5×0.8×8.5	3.5	8.5	5	6	3
UC205D1W5	3.5	5	S5W5×0.8×8.5	3.5	8.5	5	6	3
UC206D1W5	4	5.5	S5W6×0.75×10	4	10	5.9	8	3
UC207D1W5	4	5	S5W6×0.75×10	4	10	5.9	8	3
UC208D1W5	6	5.5	S5W8×1×11.5	6	11.5	5.5	10	3
UC209D1W5	6	6	SEW8×1×11.5	6	11.5	5.5	10	3
UC210D1W5	6	6	S5W8×1×11.5	6	11.5	5.5	10	3
UC211D1W5	6	5.5	S5W8×1×11.5	6	11.5	5.5	10	3
UC212D1W5	7	5.5	S5W10×1.25×13.5	7	13.5	6.5	12	3
UC213D1W5	7	5.5	S5W10×1.25×13.5	7	13.5	6.5	12	3
UC214D1W5	7	5.5	S5W10×1.25×13.5	7	13.5	6.5	12	3
UC215D1W5	7	5	S5W10×1.25×13.5	7	13.5	6.5	12	3
UC216D1W5	7	6.5	S5W10×1.25×15	7	15	7	12	3
UC217D1W5	9	6.5	S5W12×1.5×16.5	9	16.5	7	14	4
UC218D1W5	9	6.5	S5W12×1.5×16.5	9	16.5	7	14	4
UC305D1W5	4	6.5	S5W6×0.75×11.5	4	11.5	6	8	3
UC306D1W5	4	5	S5W6×0.75×11.5	4	11.5	6	8	3
UC307D1W5	6	5	S5W8×1×11.5	6	11.5	5.5	10	3
UC308D1W5	7	6	S5W10×1.25×13.5	7	13.5	6.5	12	3
UC309D1W5	7	6.5	S5W10×1.25×15	7	15	7	12	3
UC310D1W5	9	7	S5W12×1.5×16.5	9	16.5	7	14	4
UC311D1W5	9	6.5	S5W12×1.5×16.5	9	16.5	7	14	4
UC312D1W5	9	6	S5W12×1.5×16.5	9	16.5	7	14	4
UC313D1W5	9	7	S5W12×1.5×18	9	18	7.5	14	4
UC314D1W5	9	6.5	S5W12×1.5×18	9	18	7.5	14	4
UC315D1W5	10	7.5	S5W14×1.5×20	10	20	8.5	17	5
UC316D1W5	10	7	S5W14×1.5×20	10	20	8.5	17	5
UC317D1W5	12	9	S5W16×1.5×23	12	23	9	19	6
UC318D1W5	12	8.5	S5W16×1.5×23	12	23	9	19	6
UC319D1W5	12	7.5	S5W16×1.5×23	12	23	9	19	6
UC320D1W5	14	8	S5W18×1.5×25	14	25	9.5	22	7
UC321D1W5	14	7	S5W18×1.5×25	14	25	9.5	22	7
UC322D1W5	14	9	S5W18×1.5×29	14	29	10	22	7
UC324D1W5	14	7	S5W18×1.5×29	14	29	10	22	7
UC326D1W5	16	9.5	S5W20×1.5×33	16	33	11	24	7
UC328D1W5	16	8.5	S5W20×1.5×33	16	33	11	24	7

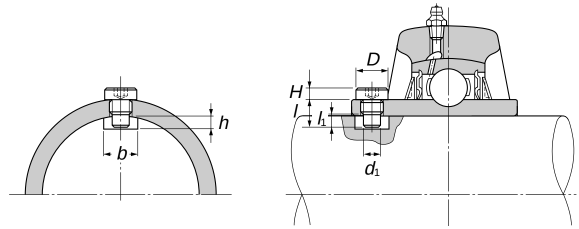
Remarks: The tolerance for the width (*b*) of the key way should preferably be set at the range of 0 to +0.2 mm.



B) Inch series, applied to inch bore size.

Designation of bearings	Key way		Designation of bearings	d_1 inch	l inch	l_1 inch	D inch	H inch
	Width *b* inch	Depth *h* inch						
UC201-008D1W5	0.138	0.118	S7W4.826×32×10.5	0.138	0.413	0.197	0.236	0.118
UC202-009D1W5	0.138	0.177	S7W4.826×32×10.5	0.138	0.413	0.197	0.236	0.118
UC202-010D1W5	0.138	0.177	S7W4.826×32×10.5	0.138	0.413	0.197	0.236	0.118
UC203-011D1W5	0.138	0.217	S7W4.826×32×10.5	0.138	0.413	0.197	0.236	0.118
UC204-012D1W5	0.138	0.177	S7W4.826×32×8	0.138	0.315	0.197	0.236	0.118
UC205-013D1W5	0.138	0.197	S7W4.826×32×8	0.138	0.315	0.197	0.236	0.118
UC205-014D1W5	0.138	0.197	S7W4.826×32×8	0.138	0.315	0.197	0.236	0.118
UC205-015D1W5	0.138	0.197	S7W4.826×32×8	0.138	0.315	0.197	0.236	0.118
UC205-100D1W5	0.138	0.197	S7W4.826×32×8	0.138	0.315	0.197	0.236	0.118
UC206-101D1W5	0.157	0.217	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC206-102D1W5	0.157	0.217	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC206-103D1W5	0.157	0.217	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC206-104D1W5	0.157	0.217	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC207-104D1W5	0.157	0.197	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC207-105D1W5	0.157	0.197	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC207-106D1W5	0.157	0.197	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC207-107D1W5	0.157	0.197	S7W1/4×28×9.5	0.157	0.374	0.217	0.315	0.118
UC208-108D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC208-109D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC209-110D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC209-111D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC209-112D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC210-113D1W5	0.236	0.217	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC210-114D1W5	0.236	0.217	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC210-115D1W5	0.236	0.217	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC210-200D1W5	0.236	0.217	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC211-200D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC211-201D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC211-202D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC211-203D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC212-204D1W5	0.276	0.217	S7W3/5×24×12.5	0.276	0.472	0.224	0.472	0.118
UC212-205D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC212-206D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC212-207D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC213-208D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC213-209D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC214-210D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC214-211D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC214-212D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC215-213D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC215-214D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC215-215D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC215-300D1W5	0.276	0.217	S7W3/8×24×12.5	0.276	0.472	0.224	0.472	0.118
UC216-301D1W5	0.276	0.256	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC216-302D1W5	0.276	0.256	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC216-303D1W5	0.276	0.256	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC217-304D1W5	0.354	0.197	S7W1/2×20×15	0.354	0.591	0.244	0.472	0.157
UC217-305D1W5	0.354	0.197	S7W1/2×20×15	0.354	0.591	0.244	0.472	0.157
UC217-307D1W5	0.354	0.197	S7W1/2×20×15	0.354	0.591	0.244	0.472	0.157
UC218-308D1W5	0.354	0.197	S7W1/2×20×15	0.354	0.591	0.244	0.472	0.157

Note: The tolerance for the width (*b*) of the key way should preferably be set at the range of 0 to +0.008 inch.



B) Inch series, applied to inch bore size.

Designation of bearings	Key way		Designation of bearings	d_1 inch	l inch	l_1 inch	D inch	H inch
	Width *b* inch	Depth *h* inch						
UC201-008D1W5	0.138	0.118	S7W4.826×32×10.5	0.138	0.413	0.197	0.236	0.118
UC305-013D1W5	0.157	0.226	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC305-014D1W5	0.157	0.226	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC305-015D1W5	0.157	0.226	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC305-100D1W5	0.157	0.226	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC306-101D1W5	0.157	0.197	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC306-102D1W5	0.157	0.197	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC306-103D1W5	0.157	0.197	S7W1/4×28×11	0.157	0.433	0.228	0.315	0.118
UC307-104D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC307-105D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC307-106D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC307-107D1W5	0.236	0.197	S7W5/16×24×10.5	0.236	0.413	0.205	0.394	0.118
UC308-108D1W5	0.276	0.157	S7W3/8×24×12	0.276	0.472	0.224	0.472	0.118
UC308-109D1W5	0.276	0.157	S7W3/8×24×12	0.276	0.472	0.224	0.472	0.118
UC309-110D1W5	0.276	0.236	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC309-111D1W5	0.276	0.236	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC309-112D1W5	0.276	0.236	S7W3/8×24×14.5	0.276	0.571	0.264	0.472	0.118
UC310-113D1W5	0.354	0.256	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC310-114D1W5	0.354	0.256	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC310-115D1W5	0.354	0.256	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC311-200D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC311-201D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC311-202D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC311-203D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC312-204D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC312-205D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC312-206D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC312-207D1W5	0.354	0.236	S7W1/2×20×15	0.354	0.591	0.244	0.551	0.157
UC313-208D1W5	0.354	0.276	S7W1/2×20×17.5	0.354	0.689	0.276	0.551	0.157
UC313-209D1W5	0.354	0.276	S7W1/2×20×17.5	0.354	0.689	0.276	0.551	0.157
UC314-210D1W5	0.354	0.256	S7W1/2×20×17.5	0.354	0.689	0.276	0.551	0.157
UC314-211D1W5	0.354	0.256	S7W1/2×20×17.5	0.354	0.689	0.276	0.551	0.157
UC314-212D1W5	0.354	0.256	S7W1/2×20×17.5	0.354	0.689	0.276	0.551	0.157
UC315-213D1W5	0.394	0.295	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC315-214D1W5	0.394	0.295	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC315-215D1W5	0.394	0.295	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC315-300D1W5	0.394	0.295	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC316-301D1W5	0.394	0.276	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC316-302D1W5	0.394	0.276	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC316-303D1W5	0.394	0.276	S7W9/16×18×19	0.394	0.748	0.335	0.669	0.197
UC317-304D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC317-305D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC317-307D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC318-307D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC318-308D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC319-310D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC319-311D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC319-312D1W5	0.472	0.276	S7W5/8×18×21.5	0.472	0.846	0.354	0.748	0.236
UC320-314D1W5	0.551	0.315	S7W5/8×18×24	0.551	0.945	0.354	0.866	0.276
UC320-315D1W5	0.551	0.315	S7W5/8×18×24	0.551	0.945	0.354	0.866	0.276
UC320-400D1W5	0.551	0.315	S7W5/8×18×24	0.551	0.945	0.354	0.866	0.276

Note:The tolerance for the width (*b*) of the key way should preferably ve set at the range of 0 to +0.008 inch.

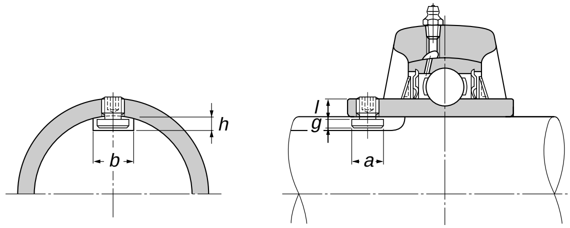
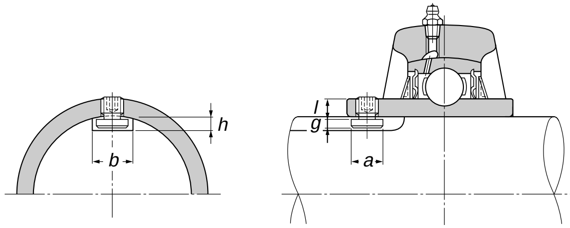


Table 8.3 (b) Key bolt system

A) Metric series, applied to metric bore size.

Designation of bearings	Key way		Designation and size of bolts	*a* mm	*g* mm	*l* mm
	Width *b* mm	Depth *h* mm				
UC206D1W6	6	4	S6W5×0.8×5-1	5.9	3	6
UC204D1W6	7	4.5	S6W5×0.8×5	6.9	3.2	6
UC205D1W6	7	4.5	S6W5×0.8×5	6.9	3.2	6
UC206D1W6	8	4.5	S6W6×0.75×6	7.9	3.2	7
UC207D1W6	8	4.5	S6W6×0.75×6	7.9	3.2	7
UC208D1W6	10	5	S6W8×1×7	9.9	3.6	8
UC209D1W6	10	5	S6W8×1×7	9.9	3.6	8
UC210D1W6	10	5	S6W8×1×7	9.9	3.6	8
UC211D1W6	10	5	S6W8×1×7	9.9	3.6	8
UC212D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC213D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC214D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC215D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC216D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC217D1W6	14	6	S6W12×1.5×11	13.9	4.8	12
UC218D1W6	14	6	S6W12×1.5×11	13.9	4.8	12
UC305D1W6	8	4.5	S6W6×0.75×6	7.9	3.2	7
UC306D1W6	8	4.5	S6W6×0.75×6	7.9	3.2	7
UC307D1W6	10	5	S6W8×1×7	9.9	3.6	8
UC308D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC309D1W6	12	5.5	S6W10×1.25×9	11.9	4	10
UC310D1W6	14	6.5	S6W12×1.5×11	13.9	4.8	12
UC311D1W6	14	6.5	S6W12×1.5×11	13.9	4.8	12
UC312D1W6	14	6.5	S6W12×1.5×11	13.9	4.8	12
UC313D1W6	14	6.5	S6W12×1.5×11	13.9	4.8	12
UC314D1W6	14	6.5	S6W12×1.5×11	13.9	4.8	12
UC315D1W6	16	7.5	S6W14×1.5×13	15.9	5.8	14
UC316D1W6	16	7.5	S6W14×1.5×13	15.9	5.8	14
UC317D1W6	18	8.5	S6W16×1.5×16	17.9	6.5	17
UC318D1W6	18	8.5	S6W16×1.5×16	17.9	6.5	17
UC319D1W6	18	8.5	S6W16×1.5×16	17.9	6.5	17
UC320D1W6	20	10.5	S6W18×1.5×18	19.9	8.5	19
UC321D1W6	20	10.5	S6W18×1.5×18	19.9	8.5	19
UC322D1W6	20	10.5	S6W18×1.5×18	19.9	8.5	19
UC324D1W6	20	10.5	S6W18×1.5×18	19.9	8.5	19
UC326D1W6	22	11	S6W20×1.5×25	21.9	9.5	26
UC328D1W6	22	11	S6W20×1.5×25	21.9	9.5	26

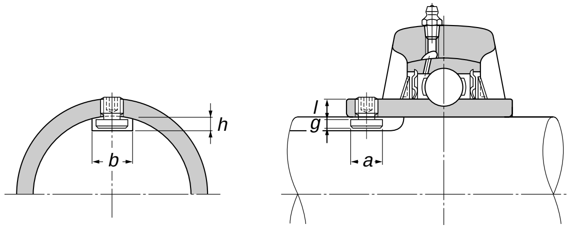
Note:The tolerance for the width (*b*)of the key way should be set at the range of 0 to +0.2 mm.



B) Inch series, applied to inch bore size.

Designation of bearings	Key way		Designation and size of bolts	a inch	g inch	l inch
	Width b inch	Depth h inch				
UC203-011D1W6	0.236	0.157	S7W4.826×32×5-1	0.232	0.118	0.236
UC204-012D1W6	0.276	0.177	S7W4.826×32×5	0.272	0.126	0.236
UC205-013D1W6	0.276	0.177	S7W1/4×28×6	0.272	0.126	0.236
UC205-014D1W6	0.276	0.177	S7W1/4×28×6	0.272	0.126	0.236
UC205-015D1W6	0.276	0.177	S7W1/4×28×6	0.272	0.126	0.236
UC205-100D1W6	0.276	0.177	S7W1/4×28×6	0.272	0.126	0.236
UC206-101D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC206-102D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC206-103D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC206-104D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC207-104D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC207-105D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC207-106D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC207-107D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC208-108D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC208-109D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC209-110D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC209-111D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC209-112D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC210-113D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC210-114D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC210-115D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC210-200D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC211-200D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC211-201D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC211-202D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC211-203D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC212-204D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC212-205D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC212-206D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC212-207D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC213-208D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC213-209D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC214-210D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC214-211D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC214-212D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC215-213D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC215-214D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC215-215D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC215-300D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC216-301D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC216-302D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC216-303D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC217-304D1W6	0.551	0.236	S7W1/2×20×11	0.547	0.189	0.472
UC217-305D1W6	0.551	0.236	S7W1/2×20×11	0.547	0.189	0.472
UC217-307D1W6	0.551	0.236	S7W1/2×20×11	0.547	0.189	0.472
UC218-308D1W6	0.551	0.236	S7W1/2×20×11	0.547	0.189	0.472

Note: The tolerance for the width (*b*) of the key way should preferably be set at the range of 0 to +0.008 inch



B) Inch series, applied to inch bore size.

Designation of bearings	Key way		Designation and size of bolts	*a* inch	*g* inch	*l* inch
	Width *b* inch	Depth *h* inch				
UC203-011D1W6	0.236	0.157	S7W4.826×32×5-1	0.232	0.118	0.236
UC305-013D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC305-014D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC305-015D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC305-100D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC306-101D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC306-102D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC306-103D1W6	0.315	0.177	S7W1/4×28×6	0.311	0.126	0.276
UC307-104D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC307-105D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC307-106D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC307-107D1W6	0.394	0.197	S7W5/16×24×7	0.390	0.142	0.315
UC308-108D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC308-109D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC309-110D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC309-111D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC309-112D1W6	0.472	0.217	S7W3/8×24×9	0.469	0.157	0.394
UC310-113D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC310-114D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC310-115D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC311-200D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC311-201D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC311-202D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC311-203D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC312-204D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC312-205D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC312-206D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC312-207D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC313-208D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC313-209D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC314-210D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC314-211D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC314-212D1W6	0.551	0.256	S7W1/2×20×11	0.547	0.189	0.472
UC315-213D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC315-214D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC315-215D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC315-300D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC316-301D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC316-302D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC316-303D1W6	0.630	0.295	S7W9/16×18×13	0.626	0.228	0.551
UC317-304D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC317-305D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC318-307D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC318-308D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC319-310D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC319-311D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC319-312D1W6	0.709	0.335	S7W5/8×18×16	0.705	0.256	0.669
UC320-314D1W6	0.787	0.413	S7W5/8×18×18	0.783	0.335	0.748
UC320-315D1W6	0.787	0.413	S7W5/8×18×18	0.783	0.335	0.748
UC320-400D1W6	0.787	0.413	S7W5/8×18×18	0.783	0.335	0.748

Note:The tolerance for the width (*b*)of the key way should be set at the range of 0 to +0.008 inch.

8.2 Eccentric collar system

As in the case of the set screw system, it is usual under normal operating conditions to fit the inner ring onto the shaft by means of a clearance fit, for ease of assembly.

Fit. 8.6 shows the appropriate values of dimensional tolerances for the shaft.

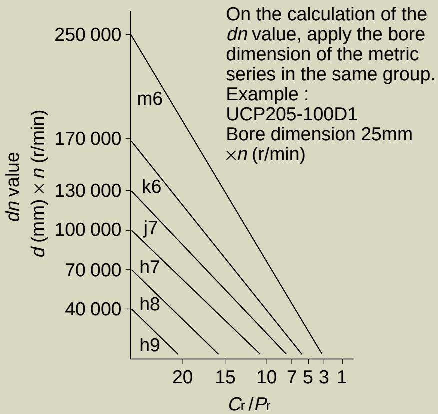


Fig.8.6 Dimensional tolerances for the shaft eccentric collar system bearing units

8.3 Adapter system bearing units

Since in the case of the adapter system, the bearing unit is fastened onto the shaft by means of a sleeve, for dimensional tolerances for the shaft, h9 is applicable under all operating conditions.

9. Handling of the Bearing Unit

9.1 Mounting of the housing

9.11 Pillow block type and flange type

Although an advantage of the NTN bearing unit is that it can be fitted easily and will function efficiently on any part of a machine, attention must be paid to the following points in order to ensure its normal service life.

1) The surface on which the housing is mounted must be sufficiently rigid.

2) The surface on which the housing is mounted should be as flat as possible (The housing should set firmly in its position). Deformation of the housing caused by incorrect mounting will in turn cause deformation of the bearing, leading to its premature breakdown.

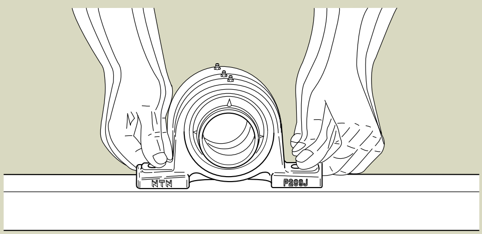


Fig. 9.1

3) It is desirable that the angle between the surface on which the housing is mounted and the shaft be maintained to a tolerance of ±2°.

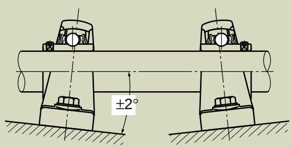


Fig. 9.2

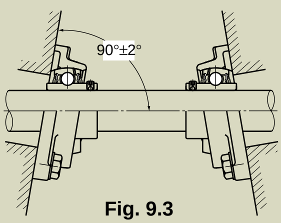


Fig. 9.3

4) The pillow block type and flange type housings are provided with a seat for a dowel for accurate location. For the use of dowel pins, refer to Table 9.1.

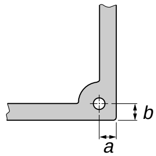
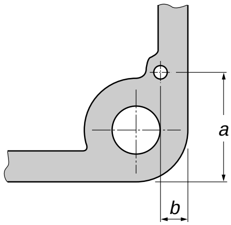
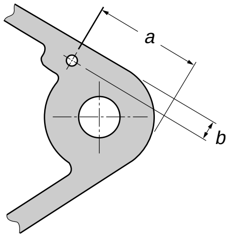


Table 9.1 Recommended dimensions of dowel pins

Designation of the housings		a mm	a inch	b mm	b inch	Recommended pin diameter mm	Recommended pin diameter inch
P203	—	5.5	0.216	5.5	0.216	3	0.118
P204	C-P204	5.5	0.216	5.5	0.216	3	0.118
P205	C-P205	5.5	0.216	5.5	0.216	3	0.118
P206	C-P206	5.5	0.216	5.5	0.216	3	0.118
P207	C-P207	5.5	0.216	5.5	0.216	3	0.118
P208	C-P208	7	0.276	7	0.276	5	0.197
P209	C-P209	7	0.276	7	0.276	5	0.197
P210	C-P210	7.5	0.295	7.5	0.295	5	0.197
P211	C-P211	7.5	0.295	7.5	0.295	5	0.197
P212	C-P212	9	0.354	9	0.354	7	0.276
P213	C-P213	9	0.354	9	0.354	7	0.276
P214	C-P214	9	0.354	9	0.354	7	0.276
P215	C-P215	9	0.354	9	0.354	7	0.276
P216	C-P216	10	0.394	10	0.394	7	0.276
P217	C-P217	12	0.472	12	0.472	10	0.394
P218	C-P218	12	0.472	12	0.472	10	0.394
P305	C-P305	8	0.315	8	0.315	4	0.157
P306	C-P306	8	0.315	8	0.315	4	0.157
P307	C-P307	10	0.394	10	0.394	5	0.197
P308	C-P308	10	0.394	10	0.394	5	0.197
P309	C-P309	10	0.394	10	0.394	5	0.197
P310	C-P310	12	0.472	12	0.472	6	0.236
P311	C-P311	12	0.472	12	0.472	6	0.236
P312	C-P312	14	0.551	14	0.551	6	0.236
P313	C-P313	14	0.551	14	0.551	6	0.236
P314	C-P314	14	0.551	14	0.551	6	0.236
P315	C-P315	17	0.669	17	0.669	8	0.315
P316	C-P316	17	0.669	17	0.669	8	0.315
P317	C-P317	17	0.669	17	0.669	8	0.315
P318	C-P318	17	0.669	17	0.669	8	0.315
P319	C-P319	17	0.669	17	0.669	8	0.315
P320	C-P320	17	0.669	17	0.669	8	0.315
P321	C-P321	17	0.669	17	0.669	8	0.315
P322	C-P322	19	0.748	19	0.748	10	0.394
P324	C-P324	19	0.748	19	0.748	10	0.394
P326	C-P326	23	0.906	23	0.906	12	0.472
P328	C-P328	23	0.906	23	0.906	12	0.472





Designation of the housings		a mm	a inch	b mm	b inch	Recommended pin diameter mm	Recommended pin diameter inch
F204	C-F204	33	1.299	6	0.236	4	0.157
F205	C-F205	35	1.378	6	0.236	4	0.157
F206	C-F206	35	1.378	6	0.236	4	0.157
F207	C-F207	38	1.496	7	0.276	5	0.197
F208	C-F208	40	1.575	8	0.315	5	0.197
F209	C-F209	43	1.693	8	0.315	5	0.197
F210	C-F210	49	1.929	8	0.315	5	0.197
F211	C-F211	49	1.929	8	0.315	5	0.197
F212	C-F212	49	1.929	8	0.315	5	0.197
F213	C-F213	52	2.047	9	0.354	6	0.236
F214	C-F214	52	2.047	9	0.354	6	0.236
F215	C-F215	52	2.047	9	0.354	6	0.236
F216	C-F216	55	2.165	12	0.472	6	0.236
F217	C-F217	55	2.165	12	0.472	6	0.236
F218	C-F218	61	2.402	14	0.551	6	0.236
F305	C-F305	35	1.378	6	0.236	4	0.157
F306	C-F306	40	1.575	6	0.236	4	0.157
F307	C-F307	47	1.850	8	0.315	5	0.197
F308	C-F308	48	1.890	8	0.315	5	0.197
F309	C-F309	48	1.890	8	0.315	5	0.197
F310	C-F310	48	1.890	8	0.315	5	0.197
F311	C-F311	51	2.008	10	0.394	5	0.197
F312	C-F312	51	2.008	10	0.394	5	0.197
F313	C-F313	57	2.244	10	0.394	6	0.236
F314	C-F314	61	2.402	10	0.394	6	0.236
F315	C-F315	65	2.559	8.5	0.335	6	0.236
F316	C-F316	65	2.559	8.5	0.335	6	0.236
F317	C-F317	70	2.756	9	0.354	6	0.236
F318	C-F318	80	3.150	10	0.394	8	0.315
F319	C-F319	80	3.150	10	0.394	8	0.315
F320	C-F320	80	3.150	10	0.394	8	0.315
F321	C-F321	80	3.150	10	0.394	8	0.315
F322	C-F322	90	3.543	10	0.394	8	0.315
F324	C-F324	90	3.543	13	0.512	10	0.394
F326	C-F326	100	3.937	13	0.512	10	0.394
F328	C-F328	108	4.252	13	0.512	10	0.394

Designation of the housings		a mm	a inch	b mm	b inch	Recommended pin diameter mm	Recommended pin diameter inch
FL204	C-FL204	22	0.866	10	0.394	4	0.157
FL205	C-FL205	28	1.102	10	0.394	4	0.157
FL206	C-FL206	33	1.299	12	0.472	4	0.157
FL207	C-FL207	30	1.181	14	0.551	5	0.197
FL208	C-FL208	33	1.299	15	0.591	5	0.197
FL209	C-FL209	38	1.496	15	0.591	5	0.197
FL210	C-FL210	39	1.535	16	0.630	5	0.197
FL211	C-FL211	44	1.732	18	0.709	5	0.197
FL212	C-FL212	54	2.126	19	0.748	5	0.197
FL213	C-FL213	53	2.087	18	0.709	6	0.236
FL214	C-FL214	53	2.087	18	0.709	6	0.236
FL215	C-FL215	55	2.165	21	0.827	6	0.236
FL216	C-FL216	55	2.165	21	0.827	6	0.236
FL217	C-FL217	55	2.165	21	0.827	6	0.236
FL218	C-FL218	55	2.165	22	0.866	6	0.236
FL305	C-FL305	35	1.378	9	0.354	4	0.157
FL306	C-FL306	44	1.732	11	0.433	4	0.157
FL307	C-FL307	43	1.693	13	0.512	5	0.197
FL308	C-FL308	45	1.772	15	0.591	5	0.197
FL309	C-FL309	51	2.008	18	0.709	5	0.197
FL310	C-FL310	55	2.165	15	0.591	5	0.197
FL311	C-FL311	55	2.165	15	0.591	5	0.197
FL312	C-FL312	60	2.362	18	0.709	5	0.197
FL313	C-FL313	59	2.323	24	0.945	6	0.236
FL314	C-FL314	63	2.480	24	0.945	6	0.236
FL315	C-FL315	66	2.598	23	0.906	6	0.236
FL316	C-FL315	72	2.835	27	1.063	6	0.236
FL317	C-FL317	74	2.913	29	1.142	6	0.236
FL318	C-FL318	74	2.913	29	1.142	8	0.315
FL319	C-FL319	80	3.150	30	1.181	8	0.315
FL320	C-FL320	84	3.307	30	1.181	8	0.315
FL321	C-FL321	84	3.307	30	1.181	8	0.315
FL322	C-FL322	84	3.307	36	1.417	8	0.315
FL324	C-FL324	93	3.661	38	1.496	10	0.394
FL326	C-FL326	94	3.701	39	1.535	10	0.394
FL328	C-FL328	102	4.016	40	1.575	10	0.394

9.1.2 Cartridge type

The inside diameter of the housing into which a cartridge type unit is inserted should be H7 under general operating conditions. It should be so furnished as to permit the bearing unit to move freely in the axial direction.

9.2 Mounting the bearing unit on the shaft

9.2.1 Mounting of the set screw system unit

To mount the set screw system bearing unit on the shaft, it is sufficient to tighten the two set screws uniformly.

The construction of the NTN "Ball-End Set Screw" is illustrated in Fig. 9.4 with the pin design that prevents it from becoming loose even when it is subjected to vibrations or impact loads.

If the fit clearance between the inner ring and the shaft is very small, it is advisable, prior to fastening on the screw, to file off that part of the shaft at which the end of the set screw (ball) strikes, by approximately 0.2 to 0.5 mm 0.01 to 0.02 inches, to flatten it, as illustrated in Fig. 9.5.

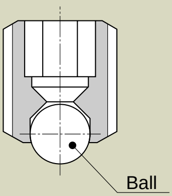


Fig. 9.4

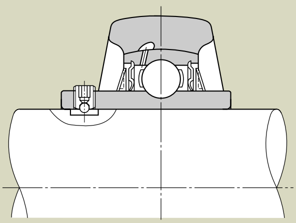


Fig. 9.5

This will facilitate dismounting of the bearing from the shaft should it become necessary.

The method of mounting the unit on the shaft is as follows:

1) Make certain that the end of the set screw is not protruding into the bore of the bearing.
2) Holding the unit at right angles to the shaft, insert the shaft into the bore of the bearing without twisting the bearing. Take care not to strike the slinger nor to subject the unit to any shock (Fig. 9.6).

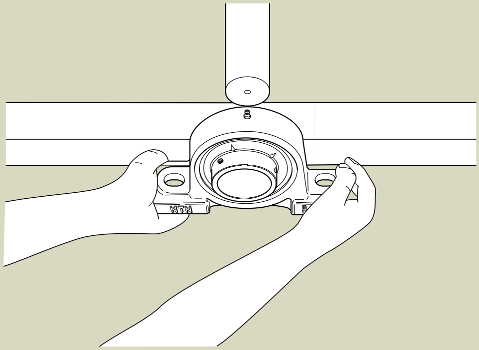


Fig. 9.6

3) Insert a hexagonal bar wrench securely into the hexagonal hole of the set screw, and tighten the two screws uniformly. Use the tightening torque shown in Table 9.2.

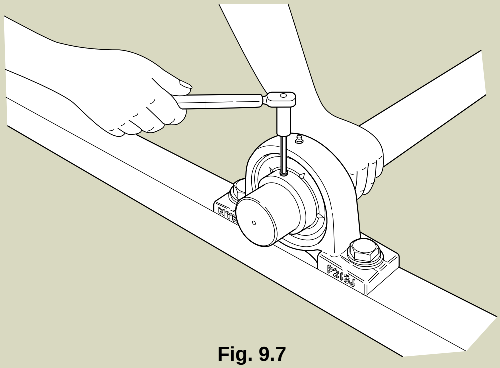


Fig. 9.7

4) Mount the housing securely in position on the machine. Sometimes the order of sets 3) and 4) is reversed.

Table 9.2 Recommended torques for tightening set screws

A) Metric series, applied to metric bore size.

Designation of the bearings of applicable units			Designation of set screws	Tightening torques N • m (max.)
UC201 to UC205	—	—	M 5×0.8 × 7	3.9
UC206	—	UC305 to UC306	M 6×0.75 × 8	4.9
UC207	UCX05	—	M 6×0.75 × 8	5.8
UC208 to UC210	—	—	M 8×1 ×10	7.8
UC211	UCX06 to UCX08	UC307	M 8×1 ×10	9.8
UC212	UCX09	—	M10×1.25×12	16.6
UC213 to UC215	—	UC308to UC309	M10×1.25×12	19.6
UC216	UCX10	—	M10×1.25×12	22.5
—	UCX11 to UCX12	—	M10×1.25×12	24.5
UC217 to UC218	UCX13 to UCX15	UC310 to UC314	M12×1.5×13	29.4
—	UCX16 to UCX17	—	M12×1.5×13	34.3
—	UCX18	UC315 to UC316	M14×1.5×15	34.3
—	UCX20	UC317 to UC319	M16×1.5×18	53.9
—	—	UC320 to UC324	M18×1.5×20	58.8
—	—	UC326 to UC328	M20×1.5×25	78.4

B) Inch series, applied to inch bore size.

Designation of the bearings for the unit to which torques given are applicable			Designation of set screws	Tightening torques lbf • inch (max.)
UC201 to UC205	—	—	No. 10–32UNF	34
UC206	—	UC305 to UC306	1/4–28UNF	43
UC207	UCX05	—	1/4–28UNF	52
UC208 to UC210	—	—	5/16–24UNF	69
UC211	UCX06 to UCX08	UC307	5/16–24UNF	86
UC212	UCX09	—	3/8–24UNF	147
UC213 to UC215	—	UC308 to UC309	3/8–24UNF	173
UC216	UCX10	—	3/8–24UNF	199
—	UCX11 to UCX12	—	3/8–24UNF	216
UC217 to UC218	UCX13 to UCX15	UC310 to UC314	1/2–20UNF	260
—	UCX16 to UCX17	—	1/2–20UNF	303
—	UCX18	UC315 to UC316	9/16–18UNF	303
—	UCX20	UC317 to UC319	5/8–18UNF	477
—	—	UC320	5/8–18UNF	520

Designation of the bearings of applicable units	Designation of set screws	Tightening torques N • m (max.)
AS201 to 205	M5×0.8×7	3.4
AS206	M6×0.75×8	4.4
AS207	M6×0.75×8	4.9
AS208	M8×1×10	6.8

Designation of the bearings for the unit which torques given are applicable	Designation of set screws	Tightening torques lbf • inch (max.)
AS201 to 205	No. 10-32UNF	30
AS206	1/4-28UNF	39
AS207	1/4-28UNF	43
AS208	5/16-24UNF	60

9.2.2 Mounting the eccentric locking collar system unit

In this system, unlike the screw system, the shaft and inner ring are fastened together by fastening the eccentric collar in the direction of the rotation of the shaft. They are fastened together securely, and deformation of the inner ring seldom occurs. This system, however, is not recommended for applications where the direction of rotation is sometimes reversed.

Directions for mounting the unit are as follows:

1) Make certain that the frame in which the housing is to be mounted is suitable to the operating conditions with regard to rigidity, flatness, etc.
2) Make sure that the end of the shaft is not burred and that the end of the set screw in the eccentric collar is not protruding from the interior surface of the collar (Fig. 9.8).

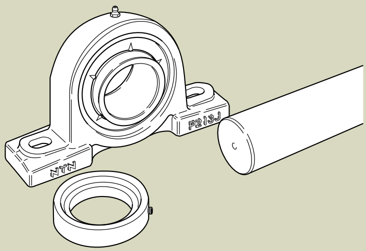


Fig. 9.8

3) Mount the housing of the unit securely onto the frame.
4) Determine the relative position of the unit and the shaft accurately so that the unit will no be subjected to any thrust, and then insert the eccentric collar (Fig. 9.9).

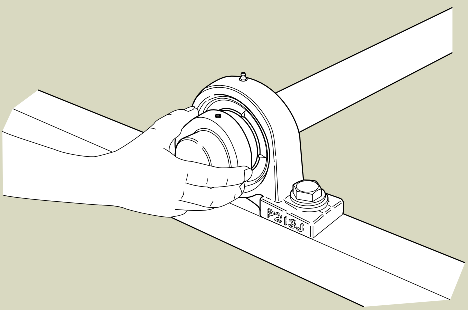


Fig. 9.10

5) Fit the eccentric circular ridge provided on the inner ring into the eccentric circular groove of the eccentric collar, and then provisionally tighten by turning the collar by hand in the direction of the shaft (Fig. 9.10).

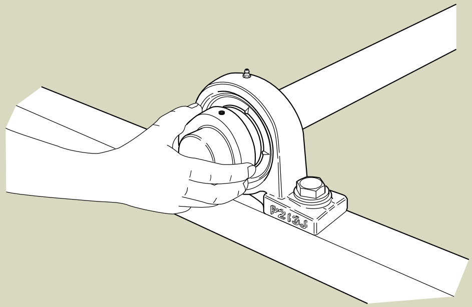


Fig. 9.10

6) Insert a bar into the hole provided on the periphery of the eccentric collar and tap the bar so that the collar turns in the direction of rotation of the shaft (see Fig. 9.11).

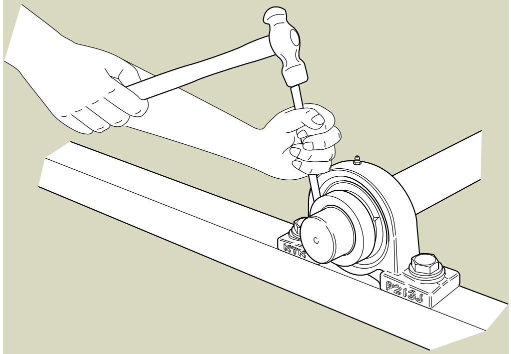


Fig. 9.11

7) Fasten the set screw of the eccentric collar onto the shaft. Recommended tightening torques are given in Table 9.3.

Table 9.3 Recommended torques for tightening set screws of the eccentric collar

A) Metric series, applied to metric bore size.

Designation of the bearings of applicable units			Designation of set screws	Tightening torques N • m (max.)
—	UEL204 to UEL205	AEL201 to AEL205	M6×0.75×8	7.8
UEL303 to UEL307	UEL206	AEL206	M8×1×10	9.8
—	UEL207	AEL207	M10×1.25×12	11.7
—	UEL208 to UEL210	AEL208	M10×1.25×12	15.6
—	UEL211	—	M10×1.25×12	19.6
UEL308 to UEL312	UEL212 to UEL215	—	M10×1.25×12	29.4
UEL313 to UEL314	—	—	M12×1.5×13	34.3
UEL315 to UEL317	—	—	M16×1.5×18	53.9
UEL318 to UEL320	—	—	M20×1.5×25	78.4

B) Inch series, applied to inch bore size.

Designation of the bearings for the unit to which torques given are applicable			Designation of set screws	Tightening torques lbf • inch (max.)
—	UEL204 to UEL205	AEL201 to AEL205	1/4–28UNF	69
UEL303 to UEL307	UEL206	AEL206	5/16–24UNF	86
—	UEL207	AEL207	3/8–24UNF	104
—	UEL208 to UEL210	AEL208	3/8–24UNF	138
—	UEL211	—	3/8–24UNF	173
UEL308 to UEL312	UEL212 to UEL215	—	3/8–24UNF	260
UEL313 to UEL 314	—	—	1/2–20UNF	350
UEL315 to UEL317	—	—	5/8–18UNF	520
UEL318 to UEL320	—	—	3/4–16UNF	700

9.2.3 Mounting of the adapter system unit

When an adapter system unit is used, there is no danger of the fit between the shaft and the inner ring working loose even if it is subjected to impact loads or vibration. Furthermore, straight shafts of h9 may be used under any operating conditions, except where there is a large axial load.

To mount the adapter system unit onto the shaft, the procedure is as follows:

1) Adjust the position of the sleeve so that the tapered part comes to about the center of the bearing. To facilitate the mounting of the sleeve onto the shaft, the opening in the sleeve can be widened using a screwdriver or similar implement. The sleeve should be positioned so that the nut is located on the opposite side form the pulley, etc., for easier handling (Fig. 9.12).

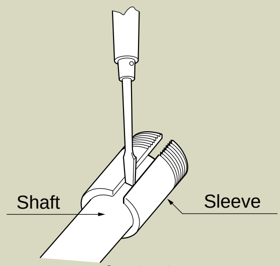


Fig. 9.12

2) Place the bearing unit with the tapered bore properly oriented on the sleeve and abut a cylindrical sleeve against the lock nut side face of the inner ring. Tap the adapter sleeve lightly over its entire periphery, as shown in Fig. 9.13, until a positive contact is made between the bearing and the sleeve.

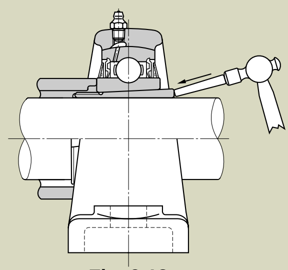


Fig. 9.13

3) Insert the washer and tighten the nut fully by hand.

4) Apply a jig (or screwdriver where no jig is available) to the notch of the nut and tap it with a hammer. Stop tapping after the nut has turned through from 60° to 90°. Be careful no to strike the slinger. Care should also be taken not to over-tighten the nut, as this will deform the inner ring, causing heat generation and seizure.

5) Bend up the tab on the rim of the washer, which is in line with the notch of the nut. This will prevent the nut from turning. The nut must not be turned backwards to bring the notch into line with the tab on the washer.

6) Mount the housing securely in position on the machine.

9.2.4 Mounting covered bearing units

For selection of the shaft, mounting the bearing onto the shaft and fitting the housing follow the same procedure as for standard bearing units. Furthermore, fitting the cover presents no special difficulty, with no need for special tools or jigs.

The procedure for mounting covered bearing units is as follows:

1) Remove the cover from the bearing unit. The steel cover can also be removed easily by hand, but should there be any difficulty due to an over-tight fit, insert a screwdriver or similar tool in a twisting motion, as shown in Fig. 9.14.

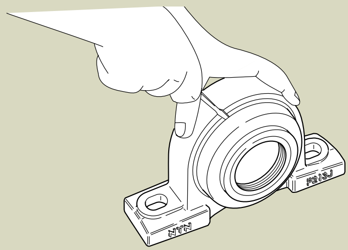


Fig. 9.14

2) In order to augment the dust and waterproofing effects, completely fill the space between the two lips of the rubber seal incorporated in the cover with grease, and apply grease to the inside of the cover, filling about two-thirds of the space. Cup grease is commonly used for this purpose (Fig. 9.15.)

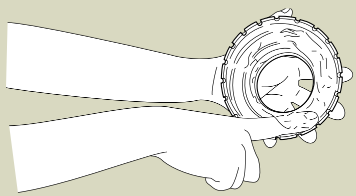


Fig. 9.15

3) First, pass one of the two grease-packed covers along the shaft, and then slide the bearing unit onto the shaft and fix the inner ring fast on the shaft before tightening the bolts holding the housing. Sometimes these steps are reversed for convenience of assembly. It is recommended that the end of the shaft be chamfered beforehand to avoid damaging the lips of the rubber seal.

4) Next take the cover which has been passed along the shaft and press it into the housing as follows: Be careful not to strike the surface of the steel cover directly with a steel hammer but use a synthetic resin or wood block in between. Do not strike only in one place but tap the cover all the way round until it is firmly seated in the housing. (Fig. 9.16). The cast iron cover is fastened with three bolts.

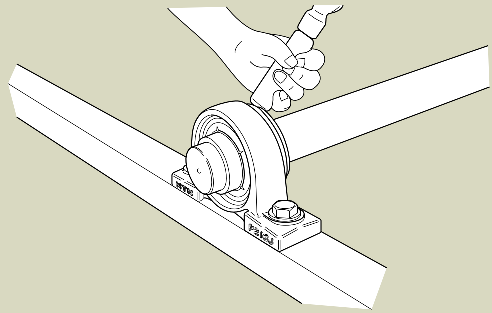


Fig. 9.16

5) Pack the second cover with grease as in step 2 and pass it along the shaft. In the case of a blind cover, the recess of the housing should be filled with grease (Fig. 9.15).

6) Fit the cover into the recess of the housing using the same procedure as detailed in Step 4) (Fig. 9.17).

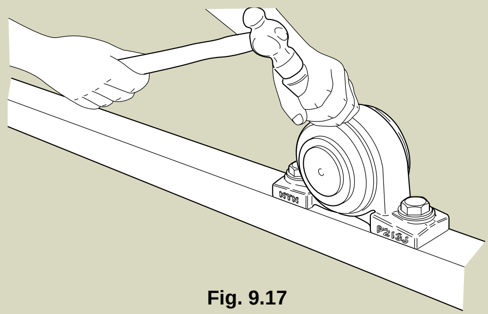


Fig. 9.17

9.3 Running tests

After mounting the bearing unit, check that it has been done correctly.

First, turn the shaft or the rotor by hand to make certain that it rotates smoothly. If there is no irregularity, start up the machine. Run the machine at low speed under no load and gradually bring it up to full operating speed while checking that there are no abnormalities.

Some indications of abnormality or faulty assembly are as follows:

When the shaft is turned by hand a resistance or drag is felt, or the shaft appears to become heavy or light in turn. Or, if the machine is running under power, any abnormal noise, vibration or overheating is evident.

9.4 Inspection during operation

Although the NTN lubrication-free bearing unit does no require refilling with grease while in use, periodic inspections are necessary to ensure safe operation of the unit's most important parts. While the interval between inspections varies from case to case, according to the degree of importance and the rate of operation, it is usually some time between two weeks and a month.

Since the inside of the bearing can be examined only by removing the slinger, seal etc., the condition of the bearing should be judged by checking for the presence of vibration, noise, overheating of the housing, etc., while the machine is running.

9.5 Dismounting the bearing unit

If some abnormality makes it necessary to dismount the bearing unit from the shaft in order to replace it, the procedure used to mount the bearing is followed in reverse order. In this case, special care should be given to the following points:

1) Set screw system units:
   If the set screw is protruding into the bore of the bearing when the unit is withdrawn from the shaft, it will damage the shaft. Therefore the screw should be turned back fully.
2) Adapter system units:
   To remove an adapter system bearing unit from the shaft, raise the tab of the washer, turn the nut two or three turns back, and apply a metal block to the nut and tap it with a hammer. Do this all round the nut, until the sleeve can be moved (Fig. 9.18).
   If the nut is turned back too far and the screws are only slightly engaged, tapping to remove it will eventually ruin the screws.

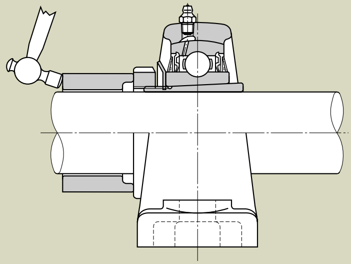


Fig. 9.18

9.6 Replacement of the bearing

If the bearing in the NTN bearing unit needs to be replaced, this can be carried out simply with a plummer block. There is no need to replace the housing, as it is reusable.

The bearing is changed using the following procedure: First, the set screw should be tightened as much as possible. Otherwise, there is a danger that it may catch in the housing when the bearing is tilted.

Next, insert the handle of a hammer or similar tool into the bore of the bearing and twist. Tilt the bearing through a full 90°, and pull it in the direction of the notch on the housing to remove it. To install a new bearing in the housing, follow the same procedure in reverse.