7. Lubrication of Bearings

In a bearing, lubrication forms a thin oil film on both the rolling surface and sliding surface to prevent metal-to-metal contact. The benefits of lubricating a rolling bearing can be summarized as follows:

(1) Alleviation of friction and wear
(2) Removal of friction heat
(3) Longer bearing life
(4) Rust prevention
(5) Protection against contamination by foreign matter

To achieve the full lubricating effect, it is necessary to use the lubricating system best suited for design operating conditions; select a quality lubricant; remove dust from the lubricant; and design an appropriate sealing structure to prevent contamination by foreign matter as well as lubricant leakage.

The main spindle of a machine tool usually uses an extremely low volume of lubricant so heat generation from stirring of lubricant is minimal.

Fig. 7.1 summarizes the interrelation among oil volume in a bearing, friction loss, and bearing temperature.

The lubrication methods available for bearings on a machine tool include grease lubrication, oil mist lubrication, air-oil lubrication, and jet lubrication. Each method has unique advantages. Therefore, a lubricating system should be selected that best suits the lubrication requirements.

Tables 7.1 and **7.2** summarize the features of various lubrication methods.

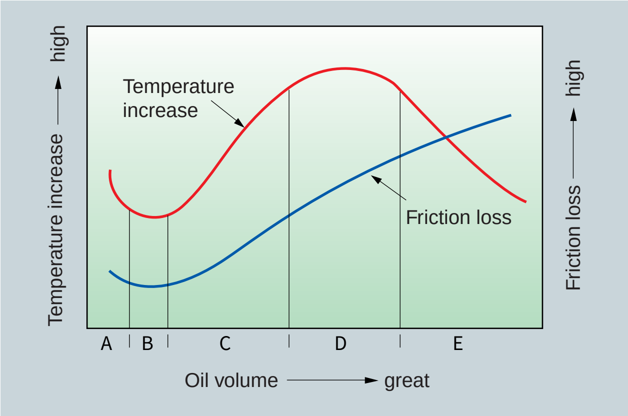


Fig. 7.1

Table 7.1 Oil volume, friction loss and bearing temperature (Fig. 7.1)

Zone	Features	Typical lubrication method
A	With an extremely low oil volume, partial metal-to-metal contact occurs between the rolling elements and raceway surface, possibly leading to abnormal wear and bearing seizure.	——
B	A uniform, non-interrupted oil film is formed. Friction is minimal and bearing temperature is kept low.	Grease lubrication Oil mist lubrication Air-oil lubrication
C	Even with a greater oil volume, heat generation and cooling are in balance.	Circulating lubrication
D	Temperature increase is constant regardless of oil volume.	Circulating lubrication
E	A further increase in oil volume contributes to a significant cooling effect, and the bearing temperature drops.	Forced circulating lubrication Jet lubrication

Table 7.2 Evaluation of various lubricating systems and criteria

Lubrication method Criterion	Grease lubrication	Oil mist lubrication	Air-oil lubrication	Jet lubrication
Handling	◎	○	○	△
Reliability	○	△	○	◎
Temperature increase	△	△	○	◎
Cooling effect	×	△	○	◎
Sealing structure	△	○	○	×
Power loss	○	○	○	×
Environmental contamination	○	×	△	○
Allowable dmn value ❶	140×10^4	220×10^4	250×10^4	400×10^4

Legend ◎ : Excellent ○ : Good △ : Fair × : Poor

❶ The permissible dmn values are approximate values:
dmn: pitch circle diameter across rolling elements [mm] multiplied by speed [min^{-1}]

① Grease lubrication

Grease lubrication is the most common, as it simplifies the main spindle structure more than other lubricating systems. With an adequate amount of quality grease prefilled, this system can be used over a wide The allowable maximum speed of a grease-lubricated bearing varies with the type and size of bearing: with a high-speed angular contact ball bearing, the d_mn value should be 140×10^4 as a guideline. For applications exceeding this range, consult NTN Engineering.

■Grease types

A lithium-based grease, whose base oil is mineral oil, is commonly used as a lubricant for rolling bearings, as it is compatible with the working surface of the bearing. Its operating temperature range is -30˚C to 130˚C.

When the temperature increase must be limited, as with the main spindle of a machine tool, NTN recommends the use of a synthetic-oil-based grease (diester, diester+mineral oil) whose consistency is NLGI grade 1 or 2.

Table 7.3 lists technical data for greases commonly used for the main spindle of a machine tool.

■Amount of grease required

Usually, a bearing for the main spindle of a machine tool requires a small amount of grease so heat generated by the stirring of the grease during high-speed operation is minimal. As a guideline, the amount of grease used for a main spindle bearing is given below, by type and speed of bearing.

- Angular contact ball bearing
  (d_mn value $\leqq 65\times10^4$); 15% of bearing space
  (d_mn value $> 65\times10^4$); 12% of bearing space
- Cylindrical roller bearing; 10% of bearing space
- Tapered roller bearing; 15% of bearing space

The spaces in the bearings typically used for the main spindle are listed in dimension tables. Determine a fill amount by referring to the relevant dimension table.

Before filling a bearing with grease, remove the rustproof coating from the bearing with clean wash oil and allow the bearing to dry fully. Then, fill and uniformly distribute an appropriate amount of grease in the bearing with an injector or a plastic bag, etc.

Table 7.3 Typical greases for main spindle of machine tool

Grease brand	ISOFLEX LDS18	Multemp PS2	Multemp LRL3	ISOFLEX NBU15	Stabllugs NBU 8EP	MP-1
Thickener	Li soap			Ba complex soap		Urea
Base oil	Synthetic oil	Diester+mineral oil	Synthetic oil	Ester	Mineral oil	Synthetic oil
Base oil viscosity (40˚C) mm^2/S	16	15.3	37.3	20	105	40.6
Dropping point ˚C	＞180	190	208	＞200	220	254
Operating temperature range ˚C	－60～＋130	－55～＋130	－40～＋150	－60～＋130	－35～＋150	－40～＋150
Application	Suitable for ball bearing	Excellent low temperature and friction characteristics	Wider operating temperature range	Most commonly used for main spindle	Suitable for roller bearings subject to large loads	Applied to ULTAGE Series grease-lubricated sealed angular contact ball bearings

② Air-oil lubrication

Air-oil lubrication (also known as oil-air lubrication or oil and air lubrication) is widely adopted for main spindle bearings in order to cope with the higher speed and precision of the main spindles of machine tools and by ensuring more reliable lubrication.

Air-oil lubrication employs a method by which compressed air is used to feed lubricating oil in precisely controlled amounts. Generally, an air-oil lubrication unit is adopted that operates a volumetric piston-type distributor that accurately meters the required minimum amount of lubricating oil and feeds it at optimal intervals controlled by a timer.

■Special features of air-oil lubrication

Air-oil lubrication has the following advantages over conventional oil mist lubrication:

- Accurately supplies a minimal amount of oil.
- Can be adjusted to provide the proper amount of lubricant for individual bearings.
- No limitations exist regarding lubricant viscosity and extreme pressure additives.
- Compressed air helps cool the bearing.
- Variations in the distance and height of lubrication points does not affect lubrication efficiency.
- Health hazards of oil mist are minimized.
- Low consumption of lubricating oil.
- Compressed air can prevent contamination of bearing by coolant.
- The recommended oil viscosity is 10 to 32 mm^2/s.

■Example of an air-oil lubrication unit

Fig. 7.2 shows the structure of an air-oil lubrication unit.

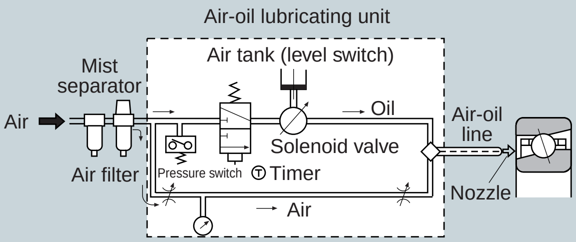


Fig. 7.2 Air-oil lubricating system

■About air-oil lubrication nozzle spacer

Air-oil lubrication requires a specialized nozzle because it feeds an optimal amount of lubricating oil to the inside of the bearing by means of compressed air. (**Fig. 7.3**)

A nozzle with a hole diameter of 1.0 to 1.5 mm and a length 4 to 6 times the hole diameter is recommended.

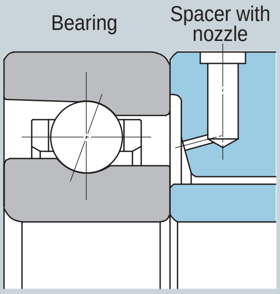


Fig. 7.3 Feed system for air-oil lubrication

■About exhausting method for air-oil lubrication

Air-oil lubrication is a lubricating method in which a large amount of air is used to feed lubricating oil to the inside of the bearing. Therefore, it is essential that the air fed into the bearing be allowed to escape. If the air is not smoothly exhausted, the lubricating oil will remain in the bearing and possibly contribute to bearing seizure. In the design stage, remember to allow ample space on the exhaust side of the bearing in order to increase exhaust efficiency and provide a larger oil drain hole to ensure smooth airflow. In addition, for types that allow for repositioning of the spindle, it is recommended that the shoulder dimensions of all parts be designed to prevent lubricating oil from flowing back into the bearing because of the change in attitude of the main spindle. Unnecessary dimensional differences can contribute to stagnancy of the lubricating oil.

■Recommended targeted position with nozzle

(1) Angular contact ball bearings

Table 7.4 Air-oil/oil mist nozzle spacer dimensions
Note: Spacer dimensions are the same for all contact angles (15°, 25°and 30°).

Bearing No.	θ	*A*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
7900U	15°	14.6	12.4	13.4	18.5	1
7901U	15°	16.6	14.4	15.4	20.5	1
7902U	15°	19.5	17.2	18.2	25	1
7903U	15°	21.5	19.2	20.2	27	1
7904U	15°	26.3	24	25	32.5	1
7905U	15°	31.3	29	30	37.5	1
7906U	15°	36.3	34	35	42.5	1
7907U	15°	41.5	39.2	40.2	50.5	1
7908U	15°	48.1	45.8	46.8	56.5	1
7909U	15°	52.8	50.5	51.5	63	1
7910U	15°	57.3	54.3	55.8	67.5	1.5
7911U	15°	64.1	61.1	62.6	73.5	1.5
7912U	15°	69.1	66.1	67.6	78.5	1.5
7913U	15°	74.1	71.1	72.6	84	1.5
7914U	15°	80.9	77.9	79.4	93	1.5
7915U	15°	85.9	82.9	84.4	97.5	1.5
7916U	15°	91.4	88.4	89.9	103	1.5
7917U	15°	97.4	94.4	95.9	112	1.5
7918U	15°	102.4	99.4	100.9	117	1.5
7919U	15°	107.4	104.4	105.9	122	1.5
7920U	15°	113.9	110	112	131	1.5
7921U	15°	118.9	115	117	136	1.5
7922U	15°	123.9	120	122	141	1.5
7924U	15°	135.4	132	134	155	1.5
7926U	15°	146.9	143	145	169	1.5
7000U	15°	15.4	13.1	14.1	22	1
7001U	15°	18.1	15.8	16.8	24.5	1
7002U	15°	21.3	19	20	27.5	1
7003U	15°	23.3	21	22	31	1
7004U	15°	28.6	25.8	26.8	37.5	1
7005U	15°	33.1	30.5	31.5	41.5	1
7006U	15°	39.6	36.5	37.5	49.5	1
7007U	15°	44.6	41	42	56	1
7008U	15°	50.4	47	48	61.5	1
7009U	15°	55.9	52	54	67.5	1
7010U	15°	60.9	57	59	72.5	1.5
7011U	15°	67.4	63	65	82	1.5
7012U	15°	72.4	68	70	87	1.5
7013U	15°	77.4	73	75	92	1.5
7014U	15°	83.9	78	80	101	1.5
7015U	15°	88.9	83	85	106	1.5
7016U	15°	95.4	90	92	115	1.5
7017U	15°	100.4	95	97	120	1.5
7018U	15°	106.9	101	103	129	1.5
7019U	15°	111.9	106	108	134	1.5
7020U	15°	116.9	112	114	139	1.5
7021U	15°	123.4	117	120	148	1.5
7022U	15°	129.9	122	125	157	1.5
7024U	15°	139.9	133	136	167	1.5
7026U	15°	153.9	143	146	184	1.5

Table 7.5 Air-oil/oil mist nozzle spacer dimensions
Note: Spacer dimensions are the same for all contact angles (15°, 20° and 25°).

Bearing No.	θ	*A*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
HSE910	12°	59.1	55.6	56.6	65	1.5
HSE911	12°	65.1	61.6	62.6	73	1.5
HSE912	12°	70.1	66.6	67.6	78	1.5
HSE913	12°	75.1	71.6	72.6	83	1.5
HSE914	12°	82.5	78	80	92	1.5
HSE915	12°	87.5	83	85	97	1.5
HSE916	15°	93.1	88.6	90.6	100	1.5
HSE917	15°	100.4	95	97	110	1.5
HSE918	15°	105.4	100	102	115	1.5
HSE919	15°	110.4	105	107	120	1.5
HSE920	15°	116.9	110	112	130	1.5
HSE921	15°	121.9	115	117	135	1.5
HSE922	15°	126.9	120	122	140	1.5
HSE924	15°	139.2	132	134	153	1.5
HSE926	15°	151.4	143	145	167	1.5
HSE928	15°	161.4	153	155	177	1.5
HSE930	15°	175.2	165	167	195	1.5
HSE932	15°	185.2	175	177	205	1.5
HSE934	15°	195.2	185	187	215	1.5
HSE010	15°	61.6	57	59	73	1.5
HSE011	15°	69.7	63	65	82	1.5
HSE012	15°	74.7	68	70	87	1.5
HSE013	15°	79.7	76	75	92	1.5
HSE014	15°	86.9	73	80	101	1.5
HSE015	15°	91.9	83	85	106	1.5
HSE016	15°	99.2	90	92	115	1.5
HSE017	15°	104.2	95	97	120	1.5
HSE018	15°	111.4	101	103	129	1.5
HSE019	15°	116.4	106	108	134	1.5
HSE020	15°	121.4	112	114	138	1.5
HSE021	15°	128.7	117	119	148	1.5
HSE022	15°	135.2	122	126	158	1.5
HSE024	15°	145.2	133	136	167	1.5
HSE026	15°	158.5	143	149	187	1.5
HSE028	15°	170.8	153	160	197	1.5
HSE030	15°	181.5	165	171	210	1.5
HSE032	15°	193.2	175	183	225	1.5
HSE034	15°	207.8	185	197	245	1.5

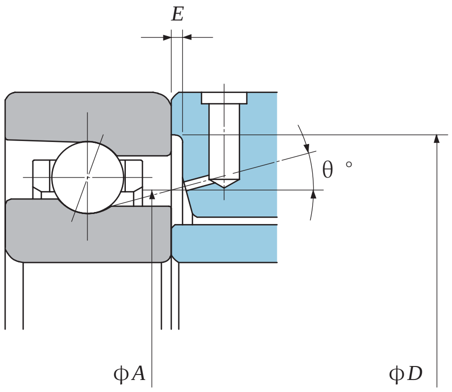


Fig. 7.4 7U, HSE, BNT and HTA types

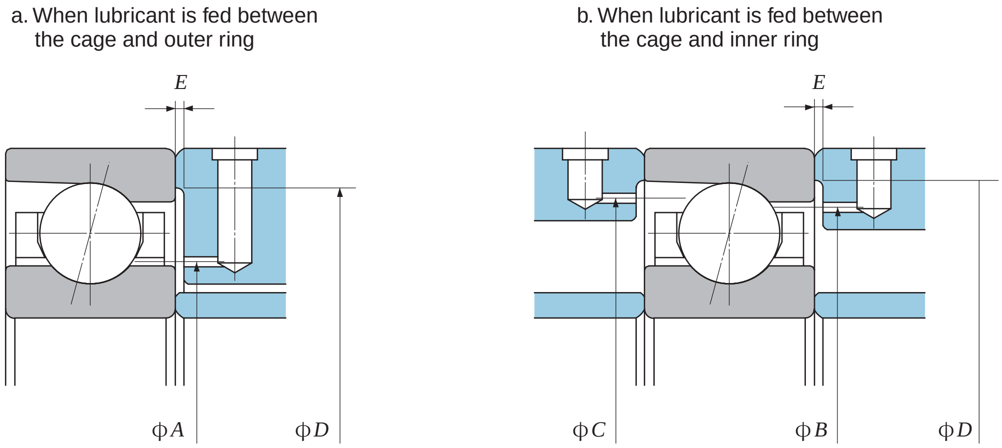
Table 7.6 Air-oil/oil mist nozzle spacer dimensions

Bearing No.	θ	*A*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
BNT900	12°	14.3	12.2	13.2	18.5	1
BNT901	12°	16.3	14.2	15.2	20.5	1
BNT902	12°	19.2	17.1	18.1	24	1
BNT903	12°	21.2	19.1	20.1	26	1
BNT904	12°	26	23.5	24.5	32.5	1
BNT905	12°	31	28.5	29.5	37.5	1
BNT906	12°	35.8	33.5	34.5	42.5	1
BNT907	12°	41.1	38.5	39.5	50	1
BNT908	12°	47.1	44.4	45.4	56	1
BNT909	12°	52.3	49	50	61.5	1
BNT000	15°	15.1	13	14	22	1
BNT001	15°	17.7	15.6	16.6	24	1
BNT002	15°	21	18.6	19.6	28	1
BNT003	15°	22.9	20.6	21.6	30	1
BNT004	15°	28.1	25	26	37	1
BNT005	15°	32.6	30.5	31.5	41.5	1
BNT006	15°	39.1	35.5	36.5	49.5	1
BNT007	15°	44	41	42	56	1
BNT008	15°	49.8	47	48	61	1
BNT009	15°	55.2	52	53	68	1
BNT200	15°	17.5	15.4	16.4	24.5	1
BNT201	15°	18.9	16.8	17.8	26.5	1
BNT202	15°	21.4	19.3	20.3	29	1
BNT203	15°	24.6	22	23	34	1
BNT204	15°	30	26.5	27.5	40.5	1
BNT205	15°	34.8	32	33	45.5	1
BNT206	15°	40.9	37.5	38.5	54.5	1
BNT207	15°	46.6	43.5	44.5	64	1
BNT208	15°	52.5	49	50	71.5	1
BNT209	15°	56.9	54.5	55.5	76.5	1

Table 7.7 Air-oil/oil mist nozzle spacer dimensions

Note: Spacer dimensions are the same for all contact angles (30°and 40°).

Bearing No.	θ	*A*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
HTA920	15°	116.4	110	112	130	1.5
HTA921	15°	121.4	115	117	135	1.5
HTA922	15°	126.4	120	122	140	1.5
HTA924	15°	138.7	132	134	153	1.5
HTA926	15°	151	143	145	167	1.5
HTA928	15°	161	153	155	177	1.5
HTA930	15°	174.9	165	167	195	1.5
HTA932	15°	184.9	175	177	205	1.5
HTA934	15°	194.9	185	187	215	1.5
HTA936	15°	208.1	197	199	233	1.5
HTA938	15°	218.1	208	210	242	1.5
HTA940	15°	232.5	220	222	260	1.5
HTA006	15°	39.5	35.5	36.5	49.5	1
HTA007	15°	44.3	41	42	56	1
HTA008	15°	49.9	47	48	61	1
HTA009	15°	56.1	52	53	68	1
HTA010	15°	61.1	57	59	73	1.5
HTA011	15°	69.3	63	65	82	1.5
HTA012	15°	74.3	68	70	87	1.5
HTA013	15°	79.3	73	75	92	1.5
HTA014	15°	86.4	78	80	101	1.5
HTA015	15°	91.4	83	85	106	1.5
HTA016	15°	98.7	90	92	115	1.5
HTA017	15°	103.7	95	97	120	1.5
HTA018	15°	111	101	103	129	1.5
HTA019	15°	116	106	108	134	1.5
HTA020	15°	121	112	114	138	1.5
HTA021	15°	128.4	117	119	148	1.5
HTA022	15°	134.9	122	126	158	1.5
HTA024	15°	144.9	133	136	167	1.5
HTA026	15°	158.1	143	149	187	1.5
HTA028	15°	170.4	153	160	197	1.5
HTA030	15°	181.2	165	171	210	1.5
HTA032	15°	192.7	175	183	225	1.5
HTA034	15°	207.4	185	197	245	1.5



a. When lubricant is fed between the cage and outer ring

b. When lubricant is fed between the cage and inner ring

Fig. 7.5 78C, 79C, 70C and 72C types

Table 7.8 Air-oil/oil mist nozzle spacer dimensions

Bearing No.	b. When lubricant is fed between the cage and inner ring					
	B	*C*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
7805C	32.6	33.3	28	29	34	1
7806C	37.6	38.2	33	34	39	1
7807C	42.6	43.1	38	39	44	1
7808C	47.8	48.4	43	44	49	1
7809C	53.2	54.3	48.5	49.5	54	1
7810C	59.5	60.2	54	55	60.5	1
7811C	66.2	67.4	59	61	68	1
7812C	71.7	72.8	64.5	66.5	73.5	1
7813C	77.7	78.7	70.5	72.5	79.5	1
7814C	82.4	83.6	75.5	77.5	84.5	1
7815C	87.8	88.8	80.5	82.5	89.5	1
7816C	92.5	93.6	85.5	87.5	94.5	1
7817C	101	102.5	91.5	93.5	103.5	1
7818C	106	107.3	96.5	98.5	108.5	1
7819C	111	112.4	101.5	104	113.5	1
7820C	115.6	117	106.5	110	118.5	1
7821C	120.7	122	111.5	115	123.5	1
7822C	129.2	131.1	117.5	122	132.5	1
7824C	139.2	141.1	127.5	132	142.5	1
7826CT1	152.3	154.5	139	144	156.5	1.5
7828CT1	162.3	164.5	149	155	166.5	1.5
7830CT1	175.3	177.8	160.5	167.5	180.5	1.5
7832CT1	185.5	188	170.5	177.5	190.5	1.5
7834CT1	198.7	201.5	181	188	204.5	1.5
7928CT1B	171.3	176.9	153	163	179	1.5
7930CT1B	187.2	193.8	165	179	197	1.5
7932CT1B	198.3	201.9	175	190	205	1.5
7934CT1B	208.2	211.9	185	200	215	1.5

7805C〜7834CT1，7928CT1B〜7934CT1B，7200C〜7218C …………B is recommended.
7028CT1B〜7040CT1B，7219C〜7226C ……………………………………A is recommended.
If targeting at A is impossible, B is acceptable. If both A and B are impossible, targeting from C is acceptable.

Table 7.9 Air-oil/oil mist nozzle spacer dimensions

Bearing No.	a. When lubricant is fed between the cage and outer ring			b. When lubricant is fed between the cage and inner ring				Common to a. & b	
	A	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*B*	*C*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
7200C	—	—	—	23	23.8	15.5	17.5	25	1
7201C	—	—	—	24.9	25.8	17.5	19.5	27	1
7202C	—	—	—	28.3	29.4	20.5	22.5	30	1
7203C	—	—	—	32.4	33.7	23.5	26.5	35	1
7204C	—	—	—	38.4	40.2	26.5	31	41.5	1
7205C	—	—	—	43.3	44.7	32	36	46.5	1
7206C	—	—	—	51.1	53	37.5	44	54.5	1
7207C	—	—	—	59.1	61.2	43.5	52	64	1
7208C	—	—	—	65.9	68.3	49	58	71.5	1
7209C	—	—	—	71.3	73.8	54.5	63	76.5	1
7210C	—	—	—	76.4	78.8	59.5	68	81	1.5
7211C	—	—	—	84.6	87.4	66	76	90	1.5
7212C	—	—	—	94.4	97.5	72	85	99.5	1.5
7213C	—	—	—	100.8	104.1	77.5	92	108.5	1.5
7214C	—	—	—	106.2	109.6	83	96	114	1.5
7215C	—	—	—	112.2	115.6	88.5	102	118	1.5
7216C	—	—	—	119.5	123.2	94	109	127	1.5
7217C	—	—	—	128	131.8	100	117	136	1.5
7218C	—	—	—	136.2	140.4	106	125	146	1.5
7219C	119.4	111.5	113.5	144.4	149	111.5	132	155	1.5
7220C	126.1	117.5	120	152.7	157.7	117.5	141	164	1.5
7221C	131.6	122.5	125	159.9	165.1	122.5	148	173.5	1.5
7222C	138.3	129	131	168.5	174.1	129	157	182	1.5
7224C	149.3	141	143	181.5	187.2	141	169	196	1.5
7226C	161.3	152.5	155	193	199.2	152.5	181	210	1.5
7028CT1B	162.9	153	157	183.5	187.4	153	172	197	1.5
7030CT1B	174.4	165	169	196.6	200.9	165	185	210	1.5
7032CT1B	185.7	175	180	209.8	214.2	175	198	225	1.5
7034CT1B	199.2	185	193	226	231.3	185	214	245	1.5
7036CT1B	212.2	197	206	242	248	197	230	263	1.5
7038CT1B	222.2	210	216	252	258	210	240	270	1.5
7040CT1B	235.2	220	229	268	275	220	255	290	1.5

(2) Cylindrical roller bearings

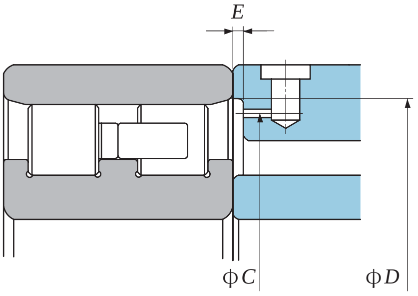


Fig. 7.6 NN30 type

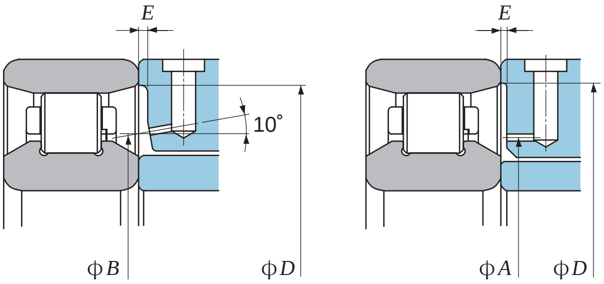


Fig. 7.7 N10HS type

Table 7.10

Bearing No.	*C*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
NN3005	40.3	31	33.8	42	1
NN3006	47	38	40.5	50	1
NN3007	53.5	43	47.0	57	1
NN3008	59.5	48	53.0	63	1
NN3009	66	54	59.5	69	1
NN3010	71	59	64.5	74	1.5
NN3011	79	65	72.5	83	1.5
NN3012	84	70	77.5	88	1.5
NN3013	89	75	82.5	93	1.5
NN3014	98	82	90	102	1.5
NN3015	103	87	95	107	1.5
NN3016	111	93	103	115	1.5
NN3017	116	98	108	120	1.5
NN3018	125	105	117	130	1.5
NN3019	130	110	122	135	1.5
NN3020	135	115	127	140	1.5
NN3021	143	120	135	149	1.5
NN3022	152	127	144	158	1.5
NN3024	162	137	154	168	1.5
NN3026	179	150	171	185	1.5
NN3028	189	160	181	195	1.5
NN3030	202	172	194	210	1.5
NN3032	215.5	183	208	223	1.5
NN3034	232	196	224	240	1.5
NN3036	251	209	243	259	1.5
NN3038	261	219	253	269	1.5

Table 7.11

Bearing No.	*A*	*B*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
N1006HS	—	40.4	37	38	50	1
N1007HS	—	46.5	42	43	57	1
N1008HS	—	51.7	47	48	63	1
N1009HS	—	57.7	52	53	69	1
N1010HS	—	62.7	57	58	74	1.5
N1011HS	—	69.7	63.5	64.5	83	1.5
N1012HS	—	74.8	68.5	69.5	88	1.5
N1013HS	—	79.7	73.5	74.5	93	1.5
N1014HS	86	—	78.5	80.5	102	1.5
N1015HS	91	—	83.5	85.5	107	1.5
N1016HS	97.5	—	88.5	90.5	115	1.5
N1017HS	102.5	—	93.5	95.5	120	1.5
N1018HS	110	—	102	104	130	1.5
N1019HS	115	—	107	109	135	1.5
N1020HS	120	—	112	114	140	1.5
N1021HS	125.9	—	118	120	149	1.5
N1022HS	133.1	—	123	125	158	1.5
N1024HS	143.3	—	133	135	168	1.5
N1026HS	157.2	—	143	145	185	1.5
N1028HS	167.2	—	153	155	195	1.5
N1030HS	179.6	—	165	167	210	1.5
N1032HS	191.1	—	175	177	223	1.5

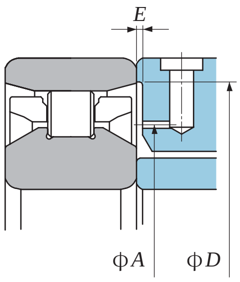


Fig. 7.8 N10HSR type

Table 7.12

Bearing No.	*A*	Outer diameter of inner ring spacer	Inner diameter of outer ring spacer	*D*	*E*
N1011 HSRT6	71.5	63.5	64.5	83	1.5
N1012 HSRT6	76.6	68.5	69.5	88	1.5
N1013 HSRT6	81.5	73.5	74.5	93	1.5
N1014 HSRT6	89.7	78.5	80.5	102	1.5
N1016 HSRT6	101.3	88.5	90.5	115	1.5
N1018 HSRT6	113.8	102	104	130	1.5
N1020 HSRT6	123.8	112	114	140	1.5

③ Jet lubrication

With this lubricating system, a high-speed jet of lubricant is injected into the bearing from the side. This is the most reliable lubricating technique and is typically used on the main spindle bearings of jet engines and gas turbines. It is currently capable of a d_{mn} value of up to approximately 400×10^4.

When used as a lubricating system for the main spindle of a machine tool, it can minimize the temperature increase of the bearing. However, the resultant torque loss is great, as a large amount of oil is supplied to each bearing. Therefore, this arrangement requires a powerful motor to drive the main spindle. Low viscosity oil (2-3 mm^2/s) is used.

Fig. 7.9 shows examples of the temperature increase of the same bearing with air-oil lubrication and jet lubrication, while **Fig. 7.10** graphically plots test results of power loss with the same bearing.

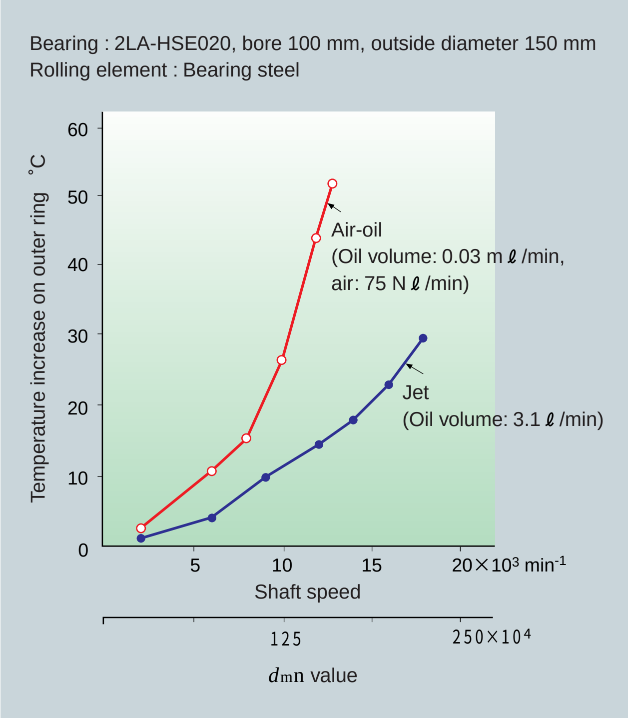

Bearing : 2LA-HSE020, bore 100 mm, outside diameter 150 mm
Rolling element : Bearing steel

Fig. 7.9 Comparison of temperature increase of outer ring with air-oil lubrication and jet lubrication

(The temperature increase with air-oil lubrication is relative to room temperature; the temperature with jet lubrication is relative to lubricant temperature.)

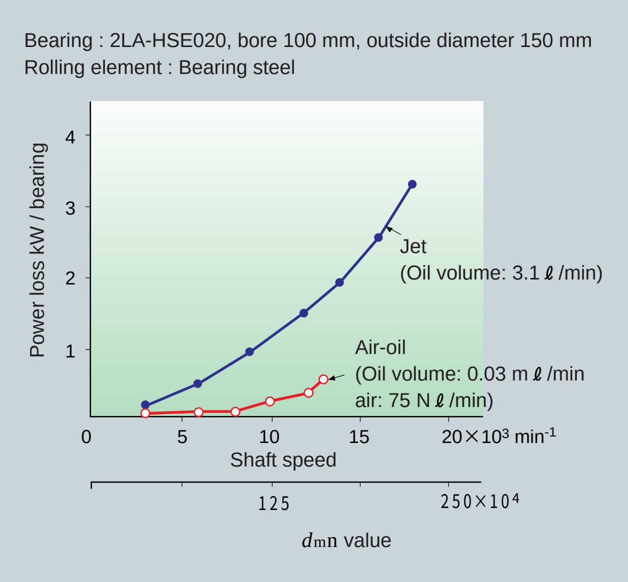

Bearing : 2LA-HSE020, bore 100 mm, outside diameter 150 mm
Rolling element : Bearing steel

Fig. 7.10 Comparison of power loss with air-oil lubrication and with jet lubrication