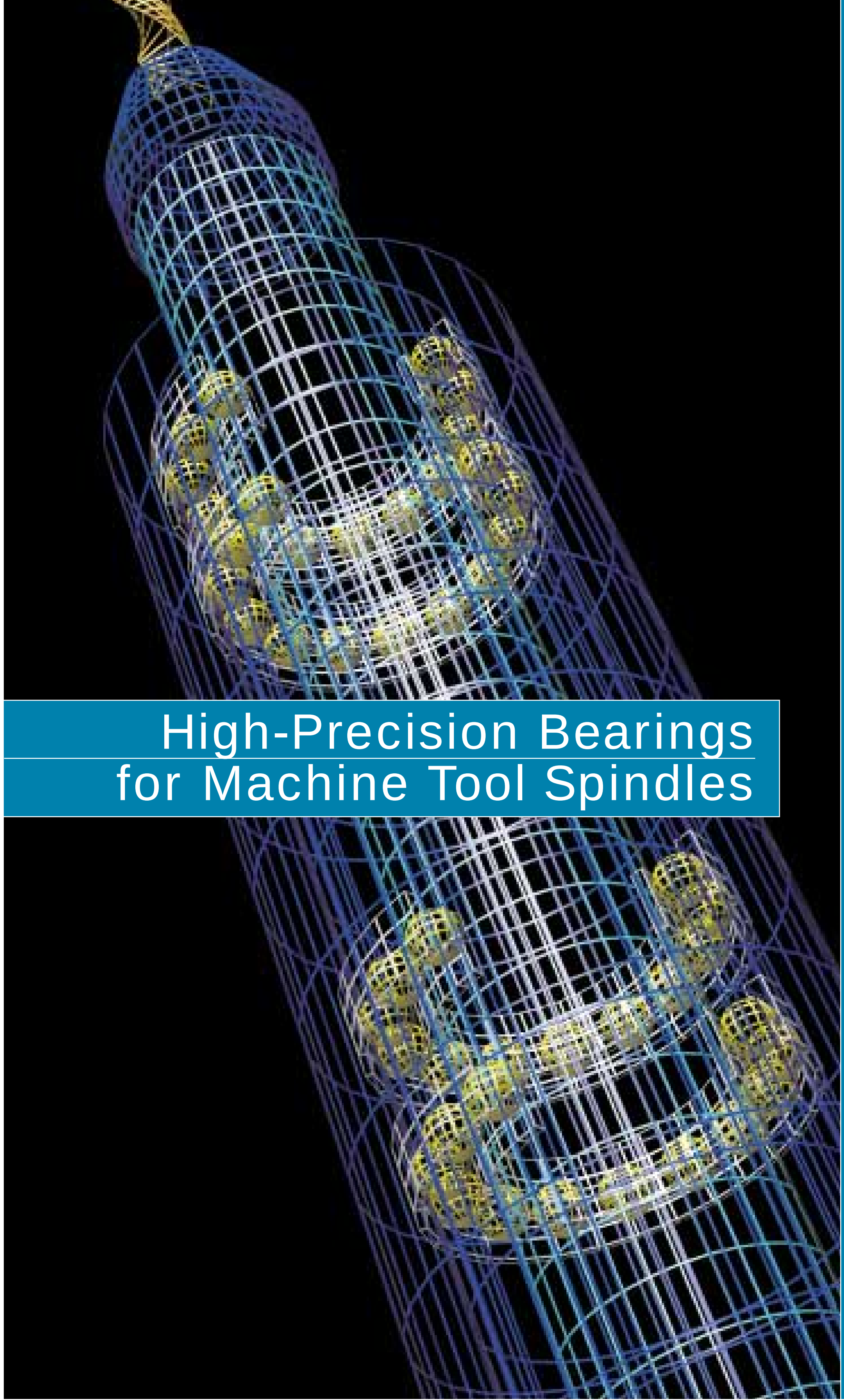
SNR - Industry



High-Precision Bearings for Machine Tool Spindles

SNR INDUSTRY

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SNR INDUSTRY

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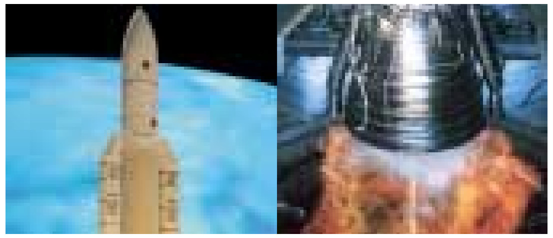
SNR HIGH PRECISION



SNR High Precision is partner to the major aeronautical and space programs: Ariane 5, Airbus, Boeing, Aerospatiale...
The experience and knowledge that SNR has acquired in the field of extreme operating conditions contribute to the performance and high reliability of its products.

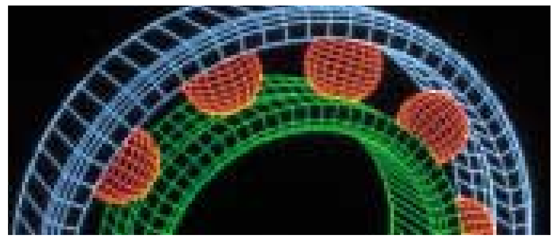
The company's total quality approach is recognized by numerous certifications: manufacturer approvals, ISO 9001, AQAP110, etc.
The quality methods and tools ensure total control over the production process based on the Statistical Process Control and TPM concepts. Production resource management is certified MRP class A.

The industrial resources and manufacturing processes meet the very stringent demands of our customers:
- Production machines capable of achieving ISO 2 precision
- Heat treatment in computer-controlled ovens.
- Assembly in controlled environment or class 100 clean room.

SNR has acquired considerable know-how in the machine tool market through its partnerships with numerous world-renowned manufacturers and with its own experience as a manufacturer and user of high-precision spindle bearings.

Investments in equipment and personnel training guarantee product quality:
- Metrology department with sophisticated measuring equipment in compliance with the French Bureau of Standards (BNM).
- Non-destructive testing performed by certified technicians.
- Computer controlled data loggers at all assembly workstations.

The resources SNR High Precision devotes to Research and Development make it possible to model the operation of the bearing and verify its design by tests:
- Powerful computation resources to take the bearing stresses into account,
- Optimum choice of materials, heat treatments and surface treatments to suit the application.




UTAC
SYSTEMES QUALITE
Diplôme d'Aptitude Qualité
SNR ROULEMENTS
MINISTERE DE LA DEFENSE
DGA
ATTESTATION
SNR ROULEMENTS
BVQI
Certificat de Système Qualité
Attribué à

Contents

SNR, machine tool spindle bearings

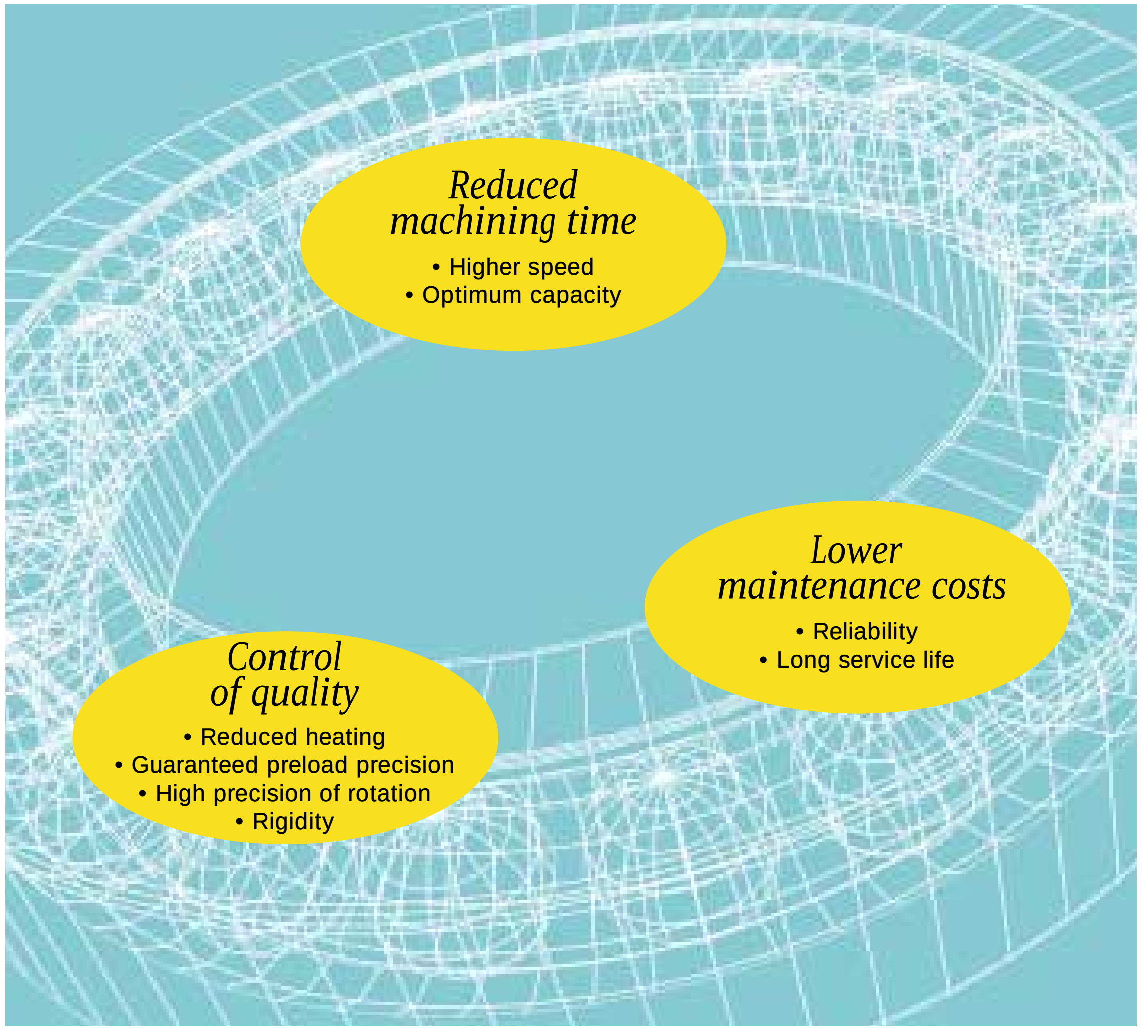
Presentation

Machine tools are constantly evolving to give better productivity and quality control.
The SPINDLE is one of the vital components that helps attain these objectives; it must satisfy several requirements:

- high speed of rotation
- low heat generation
- good rigidity
- high precision of rotation
- long service life

The use of **high-precision angular-contact** ball bearings in spindles has been found to be the best technological means of achieving the desired performance levels.

The SNR bearing: its performance



SNR bearing versions

Basic characteristics of angular-contact bearing

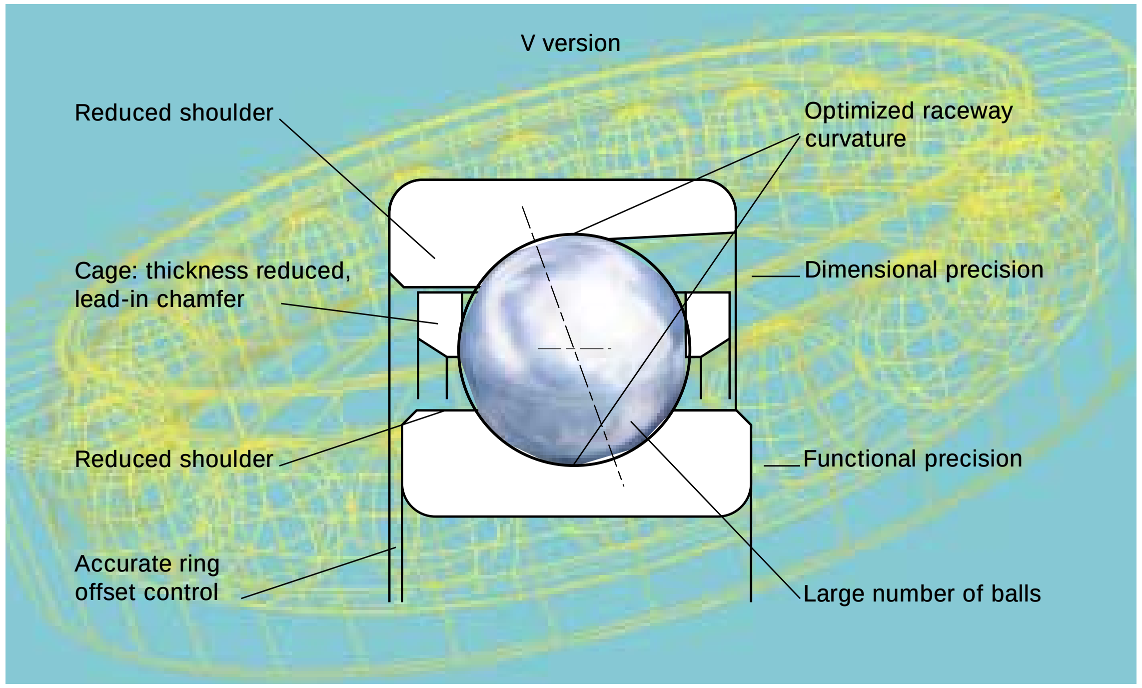
- Rings and balls in very high quality 52100 vacuum-degassed steel
- Two angles of contact: 15° and 25°
- Phenolic resin cage centered on the outer ring
- Three preload grades
- ISO 4 (ABEC 7) precision. Possibility of providing ISO 2 (ABEC 9) precision

Important :
- The majority of SNR ISO 4 precision bearings achieve ISO 2 (ABEC 9) run-out precision.
- SNR achieves a highly accurate control of the offset between the outer ring and the inner ring. This non-standard characteristic determines the preload value, which has a strong influence on the rigidity and hence the behavior of a spindle.

Bearing series and version codes

Series	Version code
719	V
70	V
72	G1

The reasons behind the performance



V version bearings

The **719** and **70** series bearings are the best suited to high rotational speeds. Numerous computer simulations backed up by tests in both our research center and in industrial situations, have enabled us to optimize these two series to obtain the best performance:

- Speed
- Capacity
- Rigidity
- Precision

This research led to the production of the **V** version series by SNR.

These bearings are characterized by an internal geometry which provides:
- improved dynamic behavior
- reduced friction
- limited contact pressure
- enhanced lubrication and cooling

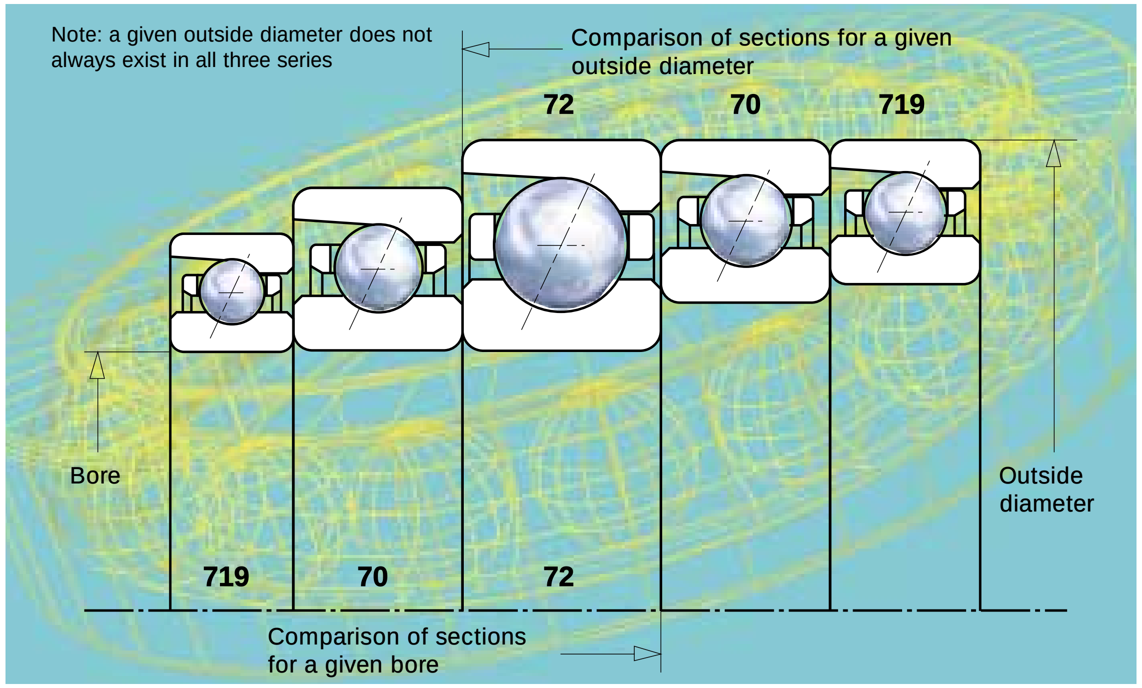
G1 version bearings

The G1 version has been specially developed to meet the specifications of the 72 series, which is typically designed to withstand predominantly high axial loads.

”Hybrid” bearings

Bearing performance can be substantially improved by using ceramic balls instead of steel balls.
The characteristics of SNR ”hybrid” bearings are given on page 22.

Dimensions series

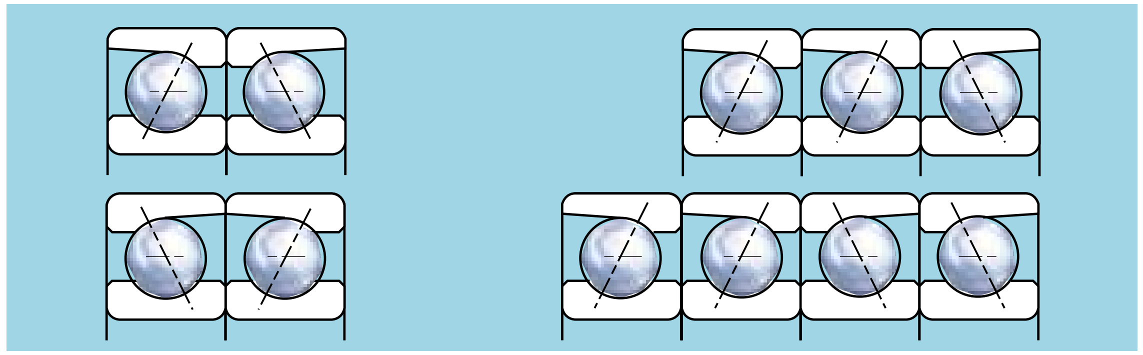


Angular-contact ball bearing technology

Characteristics of a preloaded bearing arrangement

Universal or matched set bearing arrangements

Examples :



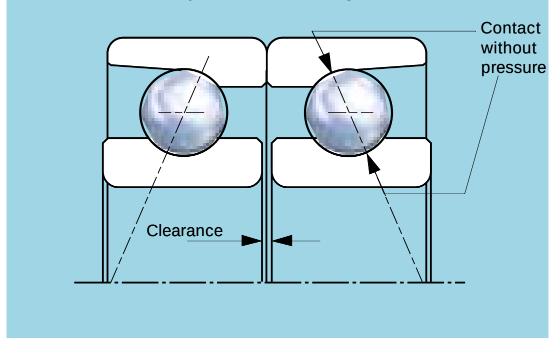
These arrangements can be made with universal bearings or sets matched by us at the factory.
See characteristics of the different versions on page 24.

Preload

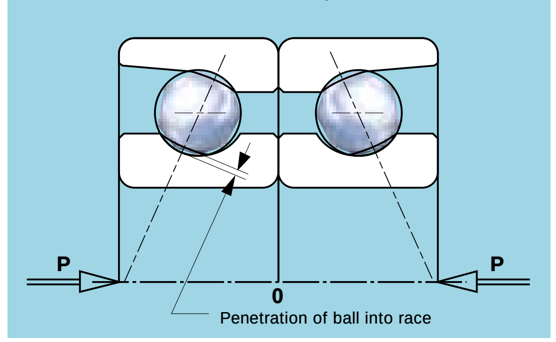
The preload is an important characteristic of the bearing arrangement. It has a direct influence on the permissible levels of load and speed.
The big advantage of the preload is that it gives **predetermined and controlled rigidity** to the arrangement.

Preloading a bearing arrangement effectively applies a permanent axial load to the bearings. This load will cause elastic deformation between the races and balls, resulting in a contact pressure between these components. The axial load is called the preload (P).

Non-preloaded arrangement



Preloaded arrangement



Example: arrangement 7014HVDBJ84

Clearance	: 0.012 mm
Preload (P)	: 1100 N (247 lbf.)
Deflection	: 0.0025 mm
Contact pressure	: inner ring: 960 N/mm² (139,400 psi) - outer ring 840 N/mm² (121,800 psi)

Methods of applying the preload

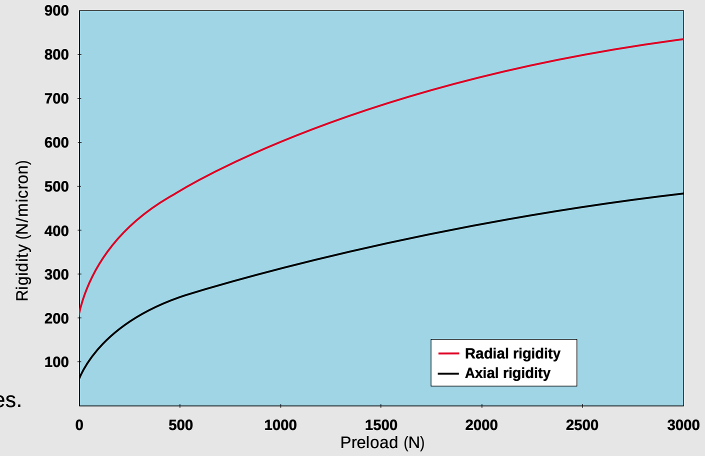
The preload is obtained:
- either by clamping the faces of the bearings in an arrangement
- or by spring systems

Preload grades

SNR has defined three preload grades:
- light preload code 7
- medium preload code 8
- heavy preload code 9

Rigidity

Rigidity as a function of preload
Arrangement 7014HVDB



The rigidity is determined by the preload.
Rigidity increases as the preload increases.

(1 N = 0.2248 lbf)

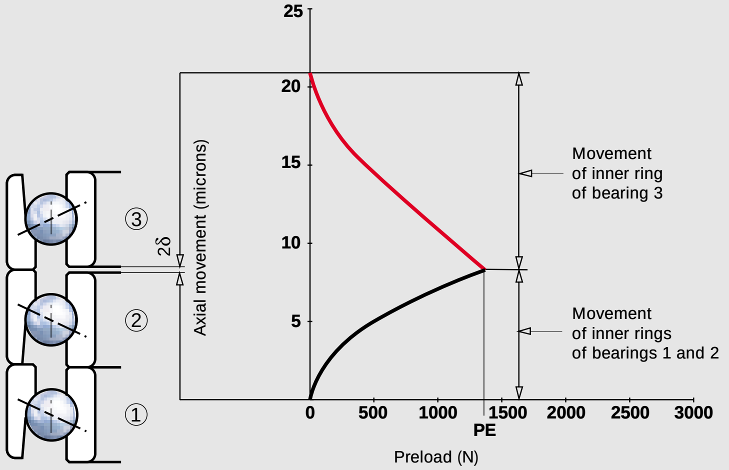
Axial deflection of an angular-contact ball bearing:

When a bearing is subjected to an axial (or thrust) load (Fa), one of its rings moves axially with respect to the other by an amount δa. $\delta a = K(Fa)^{2/3}$

K is the axial deflection constant specific to each bearing. Its value is given in the preload table on page 34.

Application of the preload :

Let's consider the example of a Q16 bearing arrangement with preload P per bearing.
Before the preload is applied, there is a gap 2δ between the inner rings of bearings 2 and 3.
$2\delta = 2K(P)^{2/3}$
If the inner rings are tightened by eliminating the gap 2δ, their movement is shown in the graph opposite. The equilibrium preload of the arrangement equals PE when clearance 2δ is eliminated.

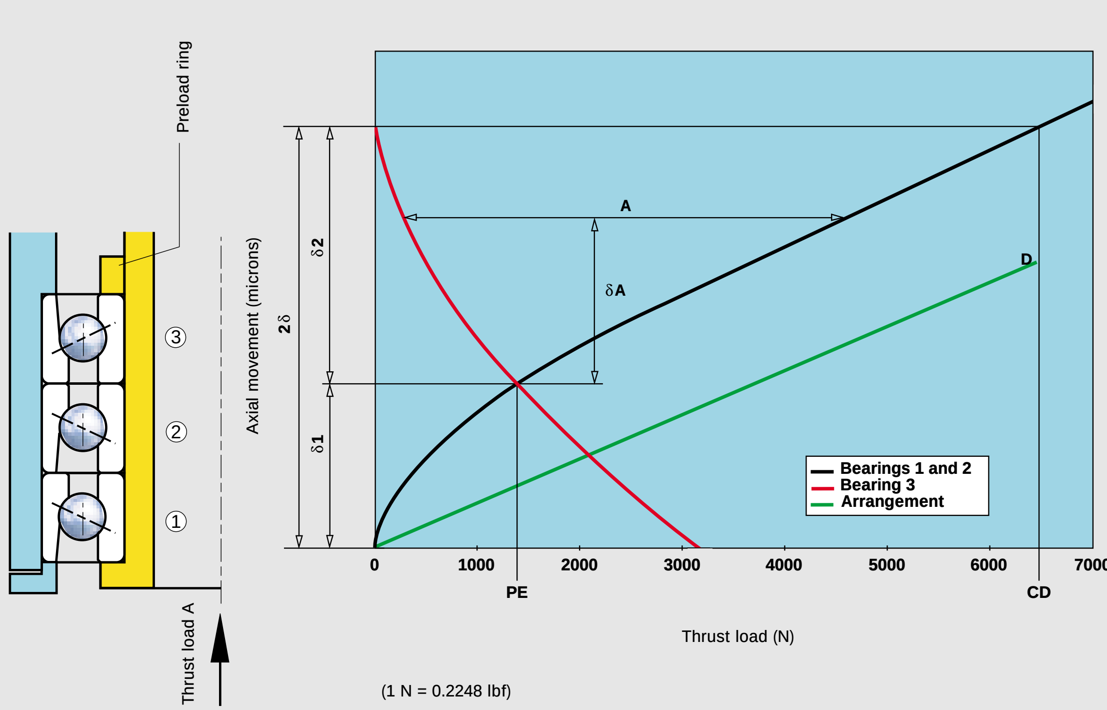


(1 N = 0.2248 lbf)

Influence of an external thrust load:

By applying a thrust load to the preloaded arrangement, bearings 1 and 2 withstand an additional load. Their inner rings move and offset the inner ring of bearing 3 whose load is relieved.

Axial deflection curve of a Q16 bearing arrangement



(1 N = 0.2248 lbf)

The thrust load A induces a displacement of the inner rings δA.
When δA = δ2, the bearing 3 is no longer loaded (beginning of ring separation) and the preload is canceled.

Characteristics:

Axial displacement
Until the preload is canceled, the displacement is equal to δ2. As a first approximation, it is defined by the straight line OD. Beyond point D, the curve is that of the bearings supporting the thrust load A, i.e. bearings 1 and 2 in the above example.

Axial rigidity
The mean rigidity equals CD/δ2 until the preload is canceled.

Equilibrium preload (PE)

Arrangements DB-DF	PE = P
Arrangement Q16	PE = 1.36P
Arrangement Q 21	PE = 2P

Separation load (CD)
This is the thrust load that causes unloading of the opposing bearing(s), i.e. bearing 3 in the above example.
CD values:

Arrangements DB-DF	CD = 2.83P
Arrangements Q16-Q21	CD = 5.66P

The characteristic curves of an arrangement can be provided on request. The axial and radial rigidity values of preloaded bearings are given on page 34.

Design definition of machine tool spindle bearings

SNR angular-contact ball bearings are designed to meet the spindle applications of the majority of machine tools: **lathes, milling machines, drilling machines, machining centers, grinding machines**, etc...
These bearings have the ability to support the loads induced by cutting and driving forces, and at high shaft speeds

Their design has been specially developed to optimize performance regarding the following criteria:

- precision of rotation
- dimensional accuracy
- macro and microgeometric deviations
- rigidity
- heat level
- vibration level
- service life

General design rules for spindle bearings

It is vital to draw up specifications that are as complete as possible before starting the study, so that calculations and simulations can be an accurate description of the actual performance to be expected.

Preliminary dimensioning and calculation of spindle bearings permit to define the following parameters:

- the front and rear bearing part numbers:
- dimensions of bearings
- type of arrangement
- contact angle
- preload
- tolerance class
- position of bearings

- lubrication of bearings
- the bearing environment, on which spindle performance partly depends:
- tolerances of parts in contact with the bearings
- sealing

Preliminary dimensioning of spindle bearings

The dimensional constraints of the spindle shaft, the spindle housing and the performance requirements determine a preliminary design.

• Front Bearing(s):

The selection is determined by the speed of rotation and loading conditions.

• Arrangement:
Light to medium load, recommended arrangement: DB.
Medium to heavy thrust load (one direction), recommended arrangement: Q16.
Medium to heavy thrust load (both directions), recommended arrangement: Q 21.

• Contact angle:
The choice depends on the speed of rotation and loading conditions:
15° for a predominantly radial loading
25° for a predominantly axial loading
combined 25°/15° association to increase the separation load.

• Preload:
The preload is chosen from the three standard grades: light, medium, heavy. The selection depends on the maximum speed of the spindle, the desired rigidity and the separation load.

• Verification of speed:
Once the preceding parameters have been chosen, check that they allow the maximum desired spindle speed to be reached.

Each bearing has a maximum speed of rotation called the limiting speed.
The limiting speed of a bearing depends on its design, the type of lubrication, and the maximum admissible heat that this speed would generate. If one of these parameters changes, the limiting speed changes. The limiting speed of a single bearing alone is listed starting on page 29.

For SNR hybrid bearings, this value is increased by 30% (see page 22).

When several bearings are matched in an arrangement, the limiting speed of the bearing alone must be corrected according to the arrangement and the preload, using the following factors.

Speed correction factor

Arrangement	Preload		
	Light	Medium	Heavy
DB	0.80	0.70	0.5
DF-Q16-Q21	0.75	0.65	0.4

Note: These speed adjustment factors are approximate values for information only. If a spindle has to operate continuously near its maximum speed, the heat level reached will have to be checked to ensure that it is compatible with the required machining accuracy.

• Rear bearing(s):

The rear bearing(s) are usually defined as a DB arrangement with a 15° angle and a light preload. Perform the same type of speed check as for the front bearing.

• Position of bearings:

The front bearing must be placed as near to the nose of the spindle as possible to improve radial rigidity. The spacing between the front and rear arrangements depends on the machine design, and in particular on the drive system.

Spindle calculation

Preliminary dimensioning of the spindle bearings must be checked then optimized.
This can be achieved:

• by using a calculation software program adapted to this type of application.
or
• by a methodology that is based on the standard calculations of material strength and bearing life.

Calculation software - simulation

Many years of research have enabled SNR ROULEMENTS to develop a calculation software for checking and optimizing the dimensioning of spindle bearings. These sophisticated methods allow a more comprehensive and precise simulation than the simplified method.
Our CALCULATIONS department is constantly working to refine these resources to meet the increasingly demanding needs of machine tool spindle technology.
This software can model the spindle and its bearings, accounting for the loading, speed, and lubrication conditions. Modeling of the shaft: see below.

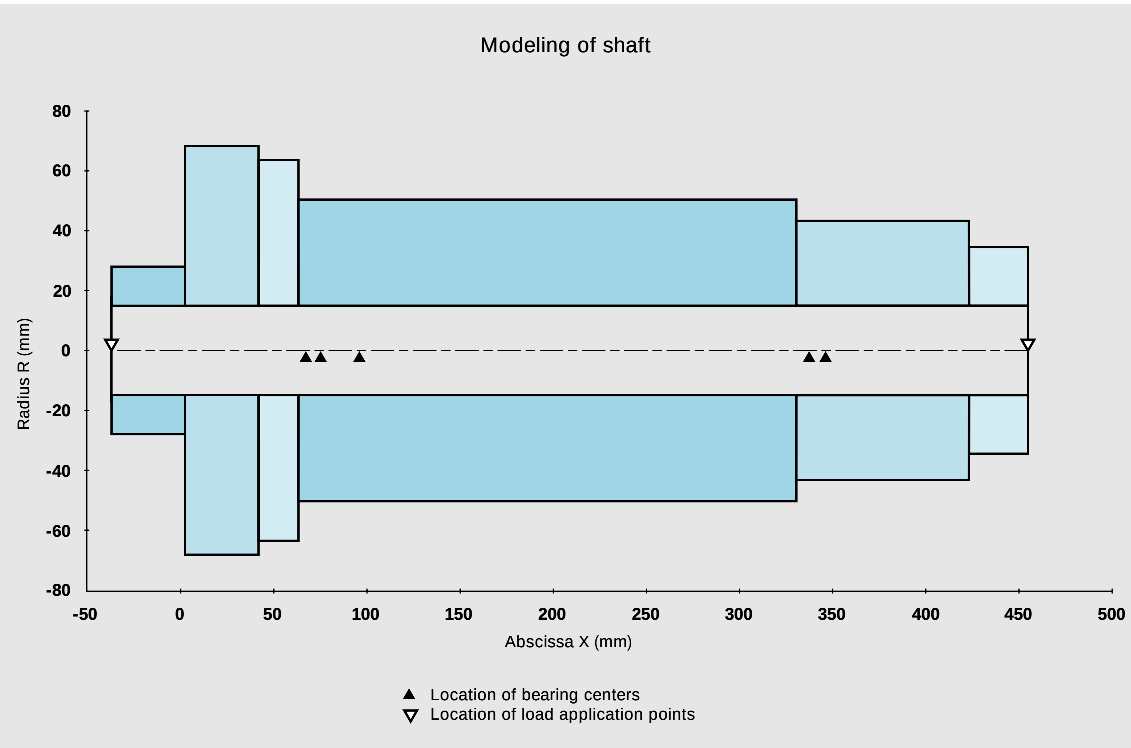
Representation of loading: see following page.

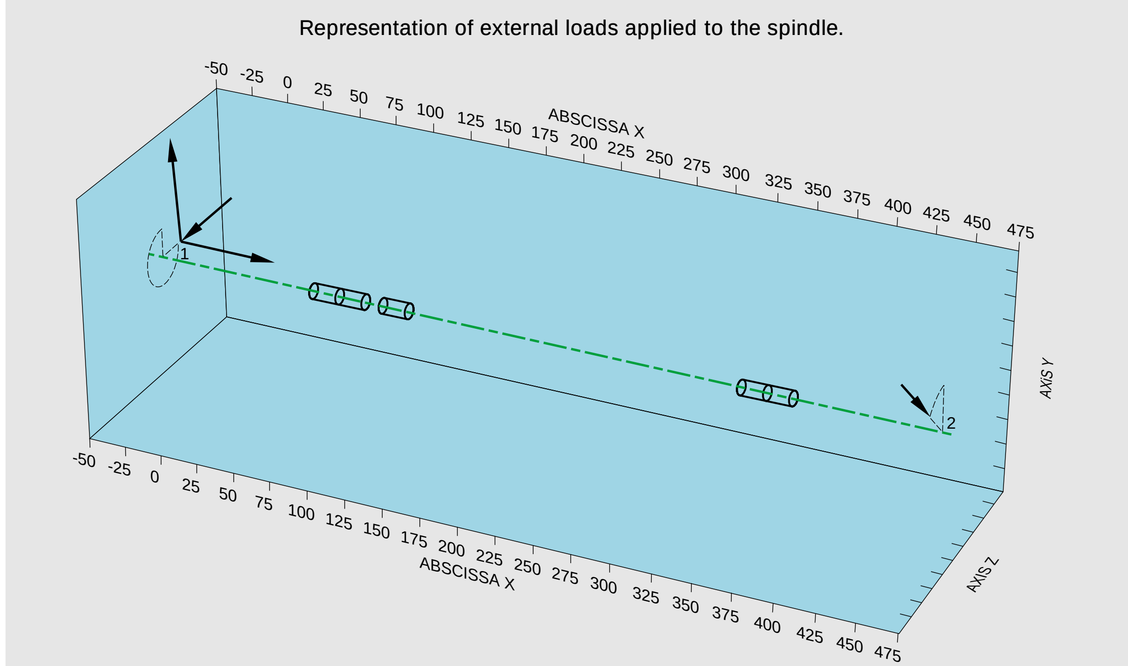
The software simulates the equilibrium of a rotating spindle mounted on bearings and subjected to external loads.
• It thus determines:
- the loads and contact deflections between balls and rings
- the loads applied to each bearing
- the displacement of the inner and outer rings
- the distortion of the shaft
- the axial and radial rigidity at the chosen reference point
• It then calculates:
- the pressures and dimensions of the contact ellipses
- the L10 life of the bearings
- the lubricant film thickness; the life is adjusted if the film is inadequate.

Representation of Shaft Distortion: see following page.

SNR ROULEMENTS is at your disposal to verify and optimize your spindle bearing selections based on your specifications.

Graphic representation of the input data and the results of the SNR calculation software.

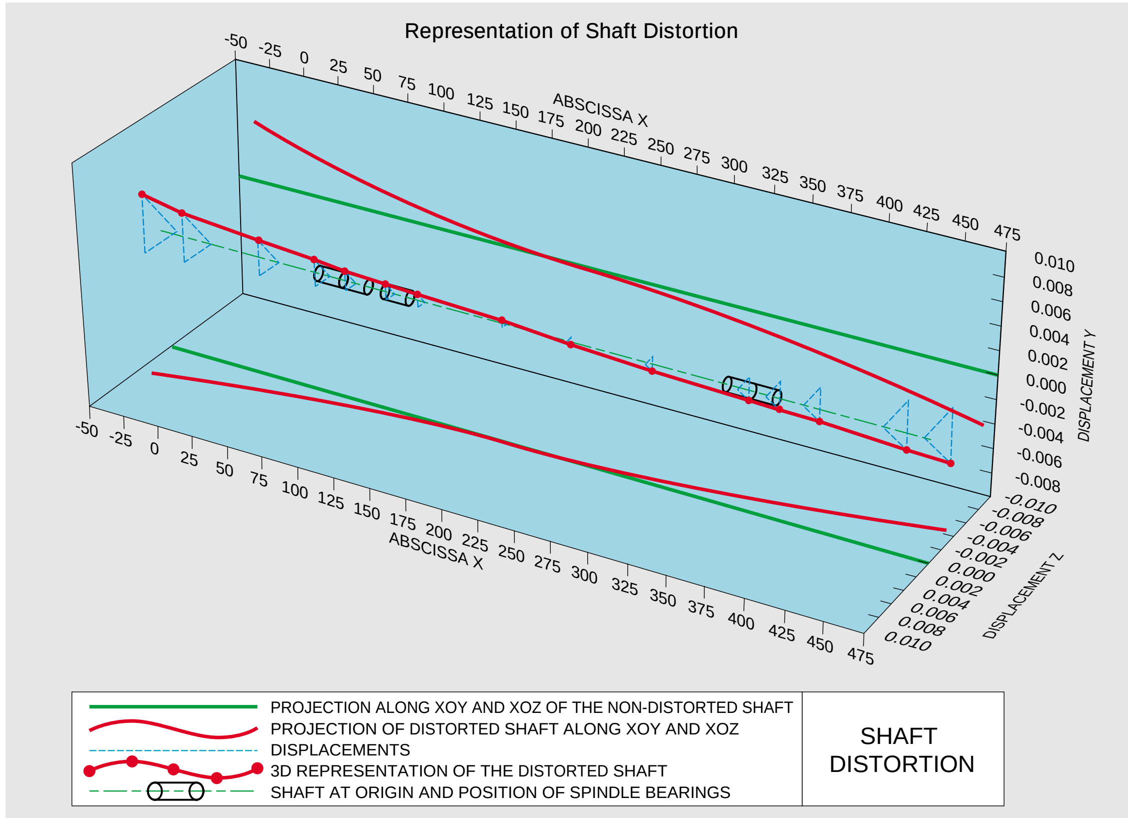




LOAD NUMBER	1	2
CENTERLINE LOCATION (mm)	-40.0	470.0
AXIAL LOAD (daN / lbf)	100.0	0.0
RADIAL LOAD (daN / lbf)	-100.0	-100.0
TANGENTIAL FORCE (daN / lbf)	100.0	0.0
DISTANCE TO AXIS (mm)	30.0	50.0
ANGLE / Y-AXIS (deg)	270.0	45.0

(1 daN = 2.248 lbf)

EXTERNAL LOADS



Simplified calculation method

The service life of the spindle bearings is related to the loss of machining precision (dimensional accuracy, vibration) or abnormal heating.
This loss of precision is due to the superficial degradation of the bearing raceways and balls through wear, contamination, oxidation or breakdown of the lubricant (oil or grease).
The corresponding service life cannot be calculated directly. The only calculation possible is that of the life duration (L10) associated with fatigue of the material. Experience shows that to have a suitably dimensioned spindle, the L10 life must be on the order of 20,000 hours.

Breakdown of the loads on each bearing:
The cutting and feeding loads must be broken down at each bearing using the usual materials resistance methods.

Thrust load
Must be uniformly distributed over each bearing supporting this load. If there are (m) bearings supporting this thrust load:

$Fa = A / m$ (A: thrust load applied to all bearings).

Radial load
Must be uniformly distributed over each bearing of the arrangement. If there are (n) bearings in the arrangement, the radial load applied to each bearing is:

$Fr = R / n^{0,9}$ (R = radial load applied to all bearings)

The calculation of the life of spindle bearings comes down to the calculation of the life of the most heavily loaded bearing.

Equivalent radial load

$P = X\,Fr + Y\,Fa$
The coefficients X and Y are given in the table.
To determine them, one must calculate the ratio Fa / Co then determine e and calculate Fa / Fr and compare it with e.

Co is the basic static load rating (radial).
If the loading varies with different types of machining, the "weighted average" equivalent radial load is calculated using the following equation:

$P = (t_1 P_1^3 + t_2 P_2^3 + ... + t_i P_i^3)^{1/3}$
t_i = duty rates
P_i = corresponding equivalent load

	$\frac{Fa}{Co}$	e	$\frac{Fa}{Fr} \leq e$		$\frac{Fa}{Fr} > e$	
			X	Y	X	Y
	0.015	0.38				1.47
	0.029	0.40				1.40
	0.058	0.43				1.30
	0.087	0.46				1.23
15°	0.12	0.47	1	0	0.44	1.19
	0.17	0.50				1.12
	0.29	0.55				1.02
	0.44	0.56				1.00
	0.58	0.56				1.00
25°	-	0.68	1	0	0.41	0.87

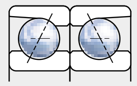
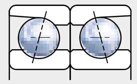
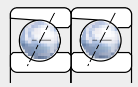
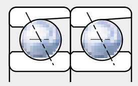
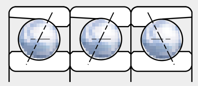
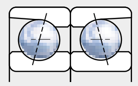
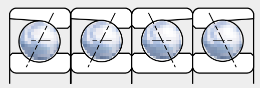
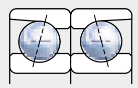
Bearing life:

$$\text{Life L10} = \left(\frac{C}{P}\right)^3 \cdot \frac{10^6}{60\,N} \text{(hours)}$$

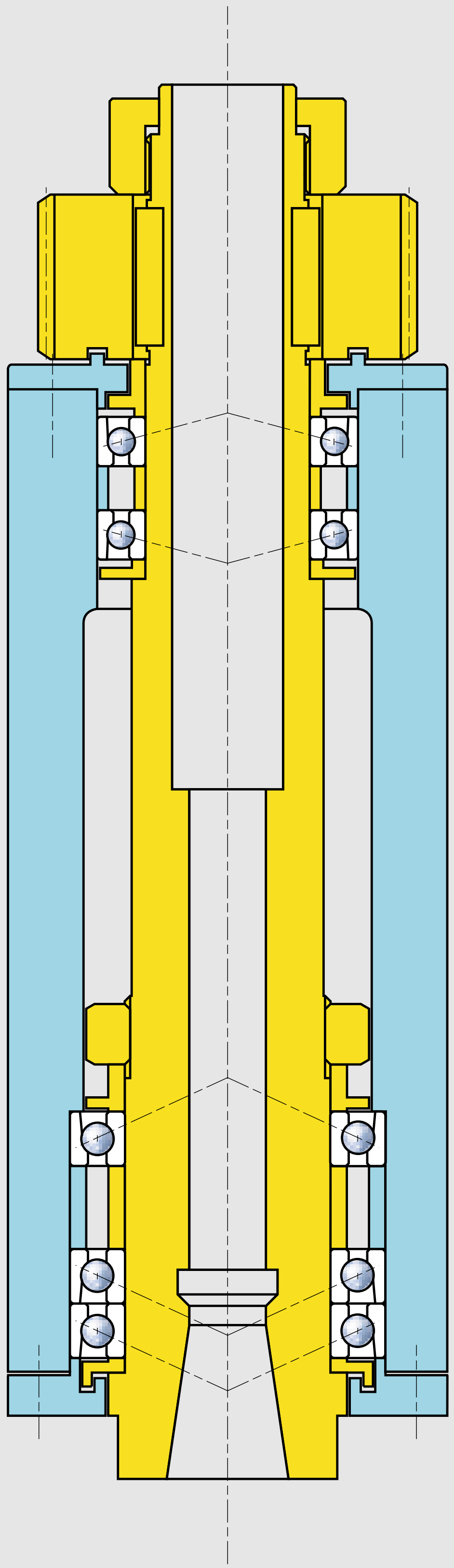
C : basic dynamic load rating (see page 29)
Co : basic static load rating (see page 29)
N : speed of rotation in rpm

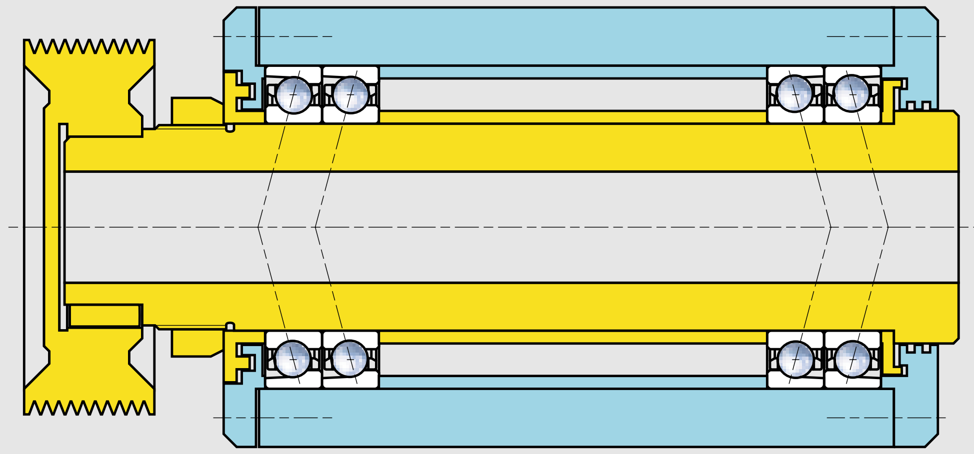
General spindle design

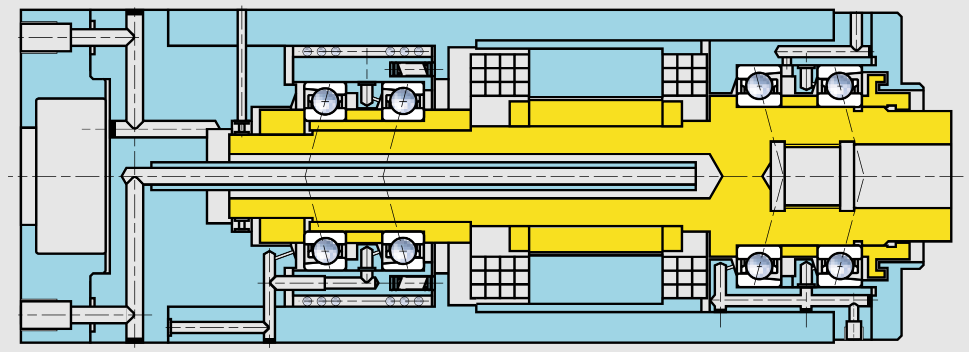
To summarize the advice given in the previous chapters on the machine tool spindle bearing and its environment, we have classified the different types of spindles and defined their usual field of application.
These are the most frequently used configurations; others are possible.

Number of bearings	Arrangement: Front arrangement	Arrangement: Rear arrangement	Field of application
4			Light to medium loads - high speed Arrangement used for boring, milling, drilling units and grinding spindles
			Light loads - very high speed Arrangement frequently used for spring-preloaded bore grinding spindles
5			Heavy loads (thrust, one direction) - moderate speed Arrangement very frequently used for spindles of boring and milling machines, lathes, and boring, milling, drilling units
6			Heavy loads - moderate speeds Good arrangement when the thrust load is applied in both directions Same applications as for preceding arrangement

Assembly Examples







SNR ceramic ball bearings

The use of CERAMIC balls greatly improves bearing performance. These products are commonly referred to as "hybrid" bearings. Their coding is characterized by the prefix CH - Ceramic Hybrid - in front of the part number. Example : CH 70...

Ceramic properties

The ceramic used is a Silicon Nitride: $Si_3 N_4$

Principal properties:

- low density: 3.2 kg/dm^3 (0.1156 lbs/in^3)
- high modulus of elasticity: 310,000 N/mm^2 (45 X 10^6 psi)
- low coefficient of friction
- low thermal conductivity
- low coefficient of thermal expansion
- non-magnetic
- non-conductive
- corrosion resistant

All these properties make it possible in particular to:

- increase the speed of rotation at a given operating temperature
- improve bearing rigidity
- increase bearing life

Performance

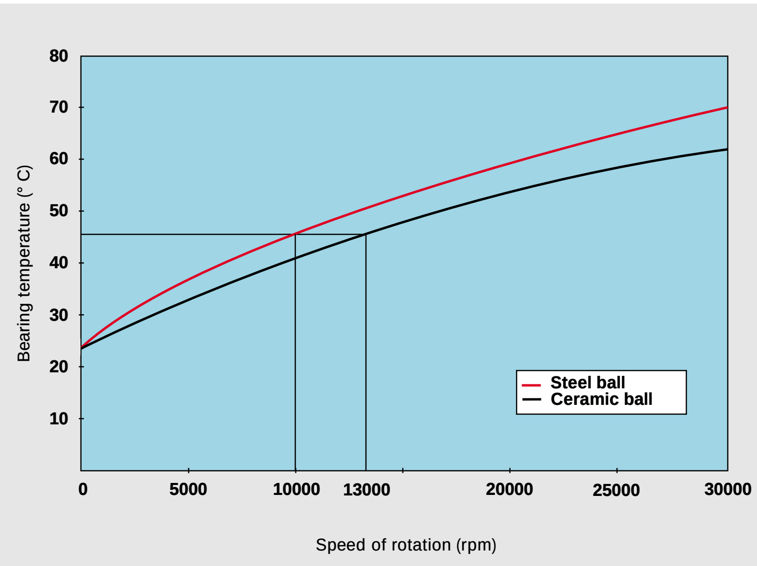
Increase in speed of rotation

Thanks to the properties of the ceramic ball, SNR hybrid bearings generate less slippage and heating than steel ball bearings.
For a given temperature they can therefore operate at higher speeds..

Example of spindle

Front and rear bearings:	CH7009CVDTJ04
Preload (by spring):	550 N (124 Lbf.)
Lubrication:	air-oil

Temperature as a function of rotational speed



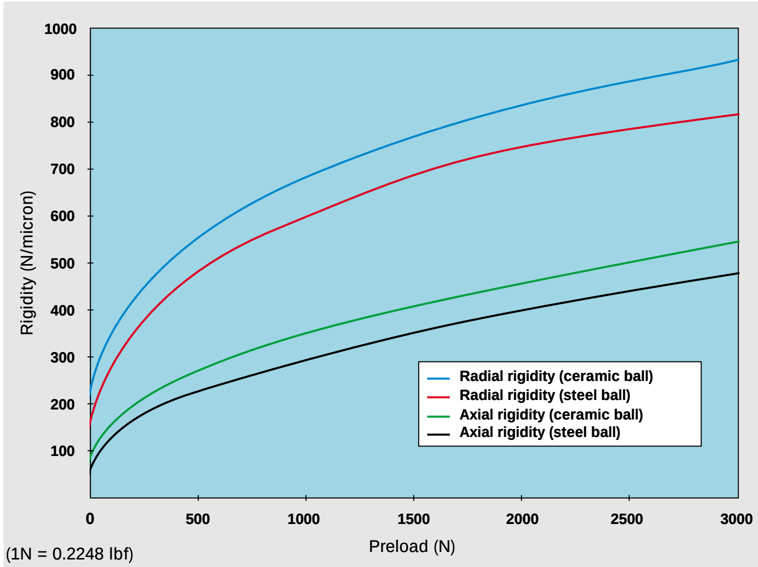
For an operating temperature of 45°C (113°F), the speed of rotation varies from 10,000 rpm with steel balls to 13,000 rpm with ceramic balls.

Tests performed in our research center and results of industrial trials confirm that the "hybrid" bearings allow the operating speed to be increased by about 30% compared with steel ball bearings.

Improved rigidity

The fact that the modulus of elasticity of ceramic is higher than that of steel gives the hybrid bearing greater rigidity under a given preload.

Comparative rigidity of a steel ball bearing and a ceramic ball bearing



The comparative curves confirm that the increase in rigidity is approximately 10%.

Increased bearing life

The lubricity qualities of the ceramic material, and its low coefficient of friction, reduces wear even during periods of marginal lubrication and extends bearing life. The amount of bearing life extension will of course depend on the actual service conditions.

Lubrication

The lubricants used for the 52100 steel bearings can generally be used with hybrid ball bearings. Certain applications might require a specific study to define the recommended lubricant.

In certain situations, the properties of "hybrid" bearings allow grease lubrication to be used instead of air-oil lubrication that was necessary because of the intended speed of rotation. This option can be economically favorable.

Choice of hybrid bearings

The hybrid bearing enables the performance of spindle bearings to be considerably enhanced. A study must nevertheless be carried out to ensure that this solution is technically and economically appropriate. SNR ROULEMENTS is at your disposal to carry out this type of study and help you find the most suitable design.

Identification of bearings

Choice of version

SNR offers several bearing arrangement possibilities

Definitions and characteristics of proposed versions

UNIVERSAL bearing, code U.
Once preloaded, the faces of the inner and outer rings of these bearings are flush (in the same radial plane). Therefore, this bearing can be paired in any arrangement.

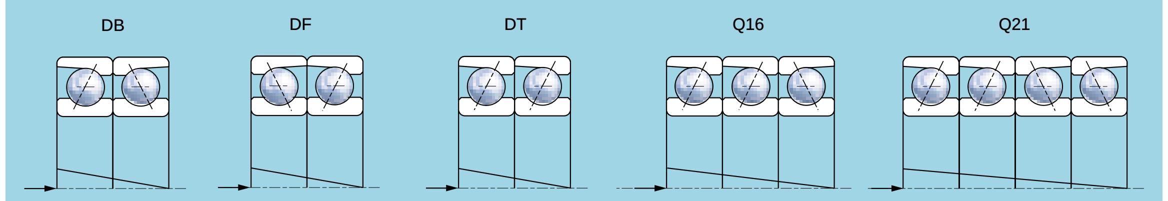
Arrangements of UNIVERSAL bearings, codes DU, Q53, Q54...
Arrangement of universal bearings whose outside diameters and bores are selected to ensure variation from nominal between bearings in a set are no more than half of the ISO standard.

Arrangements of MATCHED bearings, codes DB, DF, DT, Q16, Q21...
These assemblies are matched by SNR at the factory to ensure proper orientation and are not to be mixed with other bearings. They have the following characteristics:

- Matching of preload values
- Variation of outside diameters and bores in an assembly is less than half the ISO tolerance
- Identification of assembly by marking a V across the outside diameter of all bearings in the assembly
- The point of maximum eccentricity is located along the centerline of the V.

These features, in particular the precise preload control, allows greater precision in spindle performance, with higher rigidity and longer life.

Examples of identification codes for matched assemblies:



→ = Direction of maximum machining thrust load applied to shaft

Specific tolerances:
Certain applications may require bearings with bore and outside diameter tolerances that are reduced and centered with respect to the ISO 4 tolerance specifications.
Such bearings are identified by the letter R, as shown in the following coding example: 71912CVURJ74.

CH 719 12 C V U J 7 4 *

Hybrid bearing
(ceramic balls)

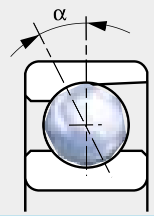
Series
719
70
72

Bore

Code	Dimension
00	10 mm
01	12 mm
02	15 mm
03	17 mm
04 x 5	20 mm
05 x 5	25 mm
.... x 5	etc…

Contact angle α

Code	Angle
C	15°
H	25°



V High-performance bearing
Series 719-70
Laminated phenolic cage
centered on outer ring.

G1 High load capacity bearing
Series 72

*** Special features**
Example:
D = pre-greased bearing

Tolerance classes
(Precision)

Code	Standard ISO	ABEC	DIN
4	4	7	P4
2	2	9	P2

Preload

Code	Designation
7	Light
8	Medium
9	Heavy
X	Special
0	Unspecified

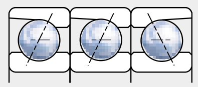
Character preceding the preload and precision functions

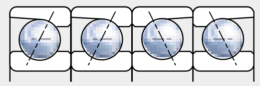
Arrangement codes

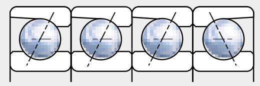
Universal bearing and arrangement of universal bearings

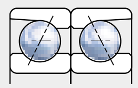
U: Universal individual bearing
DU: Pair of universal bearings
Q53: Arrangement of 3 universal bearings
Q54: Arrangement of 4 universal bearings

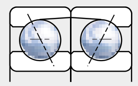
Arrangement of matched bearings: same contact angles

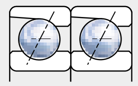
Q16


Q21


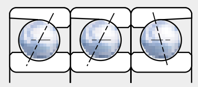
Q18


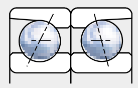
DB


DF


DT


Arrangement of matched bearings: different contact angles

Q30


Q34


Marking and packaging

Bearings

Bearings, or bearing arrangements, are identified by markings on the faces and outside diameters.

Universal bearings

Matched bearing arrangements

1 Part number of bearing or bearing arrangement
2 Location and amount (in microns) of maximum variation from nominal bore and outside diameter, the minus sign is not shown
3 V marked on the outside diameter: indicates the position of the bearings in the proper arrangement and enables the assembly to be oriented at fitting (see recommended fitting practices)
4 Registration number of the arrangement: enables assemblies to be reconstituted if bearings get mixed up.

Each SNR bearing, after being coated with a protection lubricant, is wrapped in a heat-sealed plastic bag and placed in an individual cardboard box. Long-term protection against corrosion is guaranteed if the bearing is kept in its original package.

Universal bearings

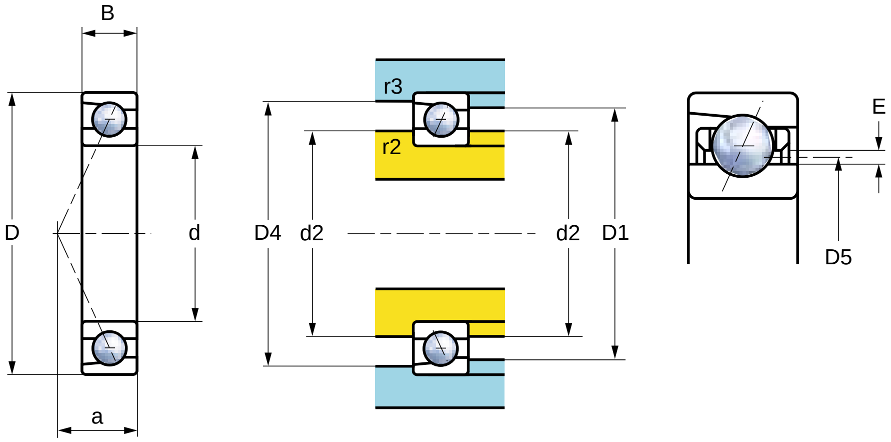
Information shown on package:
• Bearing part number
• Date of packaging
• Maximum variation (in microns) from nominal bore and outside diameter: the minus sign is not shown

Matched bearing arrangements

Where matched bearings are concerned, the boxes of the bearings forming the arrangement are bound together with adhesive tape bearing the caption: "Do not separate".

Information shown on package:
• Arrangement part number
• Date of packaging
• Maximum variation (in microns) from nominal bore and outside diameter: the minus sign is not shown.

Series 719 70 72



Dimensions (mm)			Weight	Series	Shoulder and fillets (mm)					Lubrication opening (mm)	
d	D	B	lbs		D1	d2	D4	r2 max	r3 max	D5	E
10	22	6	0.022	71900	17.8	13.6	18.8	0.3	0.1	14.7	1.10
	26	8	0.040	7000	21.4	14.7	22.7	0.3	0.1	16.6	1.85
	30	9	0.066	7200	24.5	16.0	25.5	0.6	0.3	18.3	2.25
12	24	6	0.024	71901	19.6	15.4	20.6	0.3	0.1	16.7	1.30
	28	8	0.044	7001	23.4	16.7	24.7	0.3	0.1	18.4	1.65
	32	10	0.082	7201	26.0	18.3	27.9	0.6	0.3	20.2	1.85
15	28	7	0.033	71902	24.3	18.7	25.4	0.3	0.1	20.1	1.40
	32	9	0.062	7002	26.9	20.2	28.2	0.3	0.1	21.9	1.65
	35	11	0.097	7202	29.0	21.1	31.3	0.6	0.3	23.2	2.10
17	30	7	0.037	71903	26.6	21.0	27.7	0.3	0.1	22.5	1.45
	35	10	0.082	7003	29.4	22.7	30.7	0.3	0.1	24.5	1.75
	40	12	0.143	7203	33.0	24.1	35.2	0.6	0.3	26.6	2.45
20	37	9	0.079	71904	31.9	25.1	33.2	0.3	0.2	26.9	1.78
	42	12	0.139	7004	35.5	26.6	37.3	0.6	0.3	29.0	2.40
	47	14	0.232	7204	38.6	28.5	41.4	1.0	0.3	31.4	2.85
25	42	9	0.090	71905	37.4	30.6	38.7	0.3	0.2	32.4	1.75
	47	12	0.168	7005	40.1	32.2	42.3	0.6	0.3	34.3	2.05
	52	15	0.282	7205	44.5	34.0	46.9	1.0	0.3	36.8	2.80
30	47	9	0.104	71906	41.9	35.1	43.2	0.3	0.2	36.8	1.73
	55	13	0.247	7006	47.0	38.1	49.5	1.0	0.3	40.5	2.35
	62	16	0.441	7206	52.1	40.4	55.4	1.0	0.3	43.6	3.15
35	55	10	0.165	71907	48.6	41.4	50.4	0.6	0.2	43.3	1.85
	62	14	0.331	7007	53.1	43.2	56.3	1.0	0.3	46.1	2.85
	72	17	0.639	7207	61.0	47.4	64.5	1.1	0.3	50.9	3.50
40	62	12	0.243	71908	55.2	46.8	57.2	0.6	0.2	49.0	2.18
	68	15	0.408	7008	59.0	49.2	61.8	1.0	0.3	51.8	2.55
	80	18	0.816	7208	67.6	52.8	71.8	1.1	0.6	56.9	4.05
45	68	12	0.287	71909	60.7	52.3	62.7	0.6	0.3	54.5	2.15
	75	16	0.529	7009	65.0	54.7	68.6	1.0	0.3	55.6	2.00
	85	19	0.904	7209	72.5	57.4	77.5	1.1	0.6	58.7	1.25
50	72	12	0.298	71910	65.2	56.8	67.2	0.6	0.3	58.9	2.13
	80	16	0.573	7010	70.0	59.7	73.6	1.0	0.3	60.6	2.00
	90	20	1.014	7210	76.9	62.5	82.7	1.1	0.6	63.9	1.43

Series 719 CV 70 CV 72 CG1

Contact angle 15°

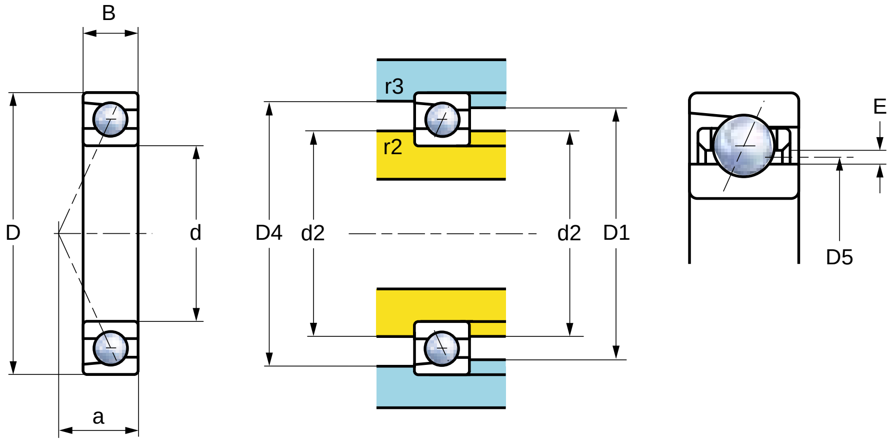
		Basic load ratings in lbf		Max. speed in rpm	
Series C	a (mm)	C dynamic	Co static	Grease	Oil
71900CV	5	690	340	71,000	108,000
7000CV	6	1,280	620	60,000	95,000
7200CG1	7	1,690	830	53,000	82,000
71901CV	5	770	420	64,000	97,000
7001CV	7	1,400	720	54,000	85,000
7201CG1	8	1,940	970	48,000	74,000
71902CV	6	1,150	640	52,000	79,000
7002CV	8	1,580	900	46,000	72,000
7202CG1	9	2,120	1,130	42,000	65,000
71903CV	7	1,190	710	46,000	70,000
7003CV	8	1,670	1,000	41,000	65,000
7203CG1	10	2,610	1,440	37,000	58,000
71904CV	8	1,730	1,100	39,000	60,000
7004CV	10	2,660	1,600	35,000	55,000
7204CG1	11	3,510	2,000	32,000	49,000
71905CV	9	1,870	1,310	33,000	50,000
7005CV	11	2,930	1,940	30,000	47,000
7205CG1	13	3,960	2,500	27,000	42,000
71906CV	10	1,890	1,420	29,000	44,000
7006CV	12	3,760	2,630	25,000	40,000
7206CG1	14	5,490	3,580	23,000	35,000
71907CV	11	2,500	1,910	25,000	38,000
7007CV	13	4,730	3,490	23,000	35,000
7207CG1	16	7,310	4,880	20,000	31,000
71908CV	13	3,310	2,660	21,000	33,000
7008CV	15	4,860	3,780	21,000	33,000
7208CG1	17	8,210	5,630	18,500	29,500
71909CV	14	3,470	2,400	20,000	31,000
7009CV	16	5,560	4,300	19,000	29,000
7209CG1	18	10,330	6,730	16,500	26,000
71910CV	14	3,500	2,550	19,000	28,000
7010CV	17	6,350	4,550	18,000	26,000
7210CG1	19	10,800	7,340	15,500	24,500

Series 719 HV 70 HV 72 HG1

Contact angle 25°

		Basic load ratings in lbf		Max. speed in rpm	
Series H	a (mm)	C dynamic	Co static	Grease	Oil
71900HV	7	650	330	67,000	103,000
7000HV	8	1,240	600	53,000	82,000
7200HG1	9	1,620	800	46,000	72,000
71901HV	7	730	400	61,000	93,000
7001HV	9	1,350	690	48,000	72,000
7201HG1	10	1,870	950	42,000	65,000
71902HV	9	1,090	620	49,000	75,000
7002HV	10	1,510	870	42,000	62,000
7202HG1	11	2,050	1,090	37,000	57,000
71903HV	9	1,150	680	44,000	68,000
7003HV	11	1,580	960	37,000	56,000
7203HG1	13	2,520	1,400	32,000	50,000
71904HV	11	1,640	1,050	37,000	57,000
7004HV	13	2,540	1,530	31,000	47,000
7204HG1	15	3,380	1,910	28,000	43,000
71905HV	12	1,760	1,240	31,000	47,000
7005HV	14	2,790	1,850	26,000	40,000
7205HG1	16	3,800	2,390	24,000	37,000
71906HV	13	1,800	1,330	27,000	42,000
7006HV	16	3,580	2,520	22,000	34,000
7206HG1	19	5,270	3,420	20,000	31,000
71907HV	15	2,360	1,820	23,000	36,000
7007HV	18	4,500	3,330	21,000	31,000
7207HG1	21	6,980	4,660	17,000	27,000
71908HV	18	3,130	2,500	20,000	31,000
7008HV	20	4,610	3,600	20,000	30,000
7208HG1	23	7,880	5,420	16,500	25,500
71909HV	19	3,260	2,270	18,000	25,500
7009HV	22	5,850	4,070	18,000	24,000
7209HG1	25	9,860	6,410	15,000	25,500
71910HV	20	3,300	2,390	17,000	24,000
7010HV	23	5,990	4,430	16,000	22,000
7210HG1	26	10,290	6,930	14,000	20,500

Series 719 70 72



Series 719 CV 70 CV 72 CG1

Contact angle

15°

Series 719 HV 70 HV 72 HG1

Contact angle

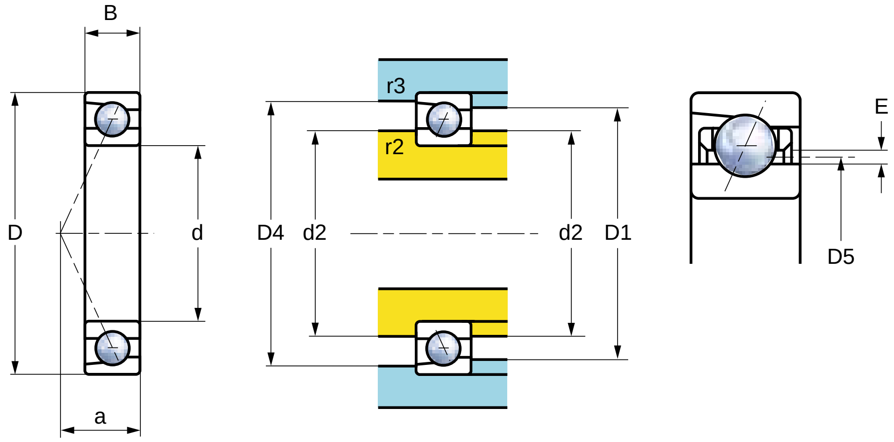
25°

Dimensions (mm)			Weight	Series	Shoulder and fillets (mm)					Lubrication opening (mm)	
d	D	B	lbs		D1	d2	D4	r2 max	r3 max	D5	E
55	80	13	0.397	71911	72.5	62.5	76.0	1.0	0.3	64.5	1.25
	90	18	0.860	7011	80.0	65.0	84.0	1.1	0.6	69.0	2.00
	100	21	1.367	7211	87.0	68.0	92.5	1.5	0.6	72.5	2.10
60	85	13	0.441	71912	77.5	67.5	81.0	1.0	0.3	69.5	1.25
	95	18	0.926	7012	85.0	70.0	89.0	1.1	0.6	73.8	2.00
	110	22	1.786	7212	95.0	75.0	101.5	1.5	0.6	79.5	2.30
65	90	13	0.463	71913	82.5	72.5	86.0	1.0	0.3	74.5	1.25
	100	18	0.970	7013	90.0	75.0	94.0	1.1	0.6	78.8	2.00
	120	23	2.514	7213	104.0	81.0	109.0	1.5	0.6	87.0	2.30
70	100	16	0.750	71914	91.0	79.0	95.0	1.0	0.3	81.5	1.50
	110	20	1.345	7014	98.5	81.5	103.0	1.1	0.6	85.8	2.50
	125	24	2.426	7214	109.0	86.0	116.0	1.5	0.6	91.4	2.60
75	105	16	0.794	71915	96.0	84.0	100.0	1.0	0.3	86.3	1.50
	115	20	1.433	7015	103.5	86.5	108.0	1.1	0.6	90.7	2.50
	130	15	2.646	7215	114.0	91.0	121.0	1.5	0.6	96.4	2.60
80	110	16	0.838	71916	101.0	89.0	105.0	1.0	0.3	91.2	1.50
	125	22	1.874	7016	112.0	93.0	117.5	1.1	0.6	98.0	3.50
	140	26	3.241	7216	122.5	97.5	130.0	2.0	1.0	103.4	2.80
85	120	18	1.213	71917	110.0	95.0	114.0	1.1	0.6	98.6	1.80
	130	22	1.985	7017	117.0	98.0	122.5	1.1	0.6	102.8	3.50
	150	28	3.991	7217	131.0	104.0	140.0	2.0	1.0	110.3	3.10
90	125	18	1.279	71918	115.0	100.0	119.0	1.1	0.6	103.5	1.80
	140	24	2.558	7018	125.5	104.5	131.5	1.5	0.6	110.0	3.80
	160	30	4.939	7218	139.0	111.0	149.0	2.0	1.0	117.2	3.30
95	130	18	1.301	71919	120.0	105.0	124.0	1.1	0.6	108.3	2.00
	145	24	2.668	7019	130.5	109.5	136.5	1.5	0.6	114.8	3.80
100	140	20	1.808	71920	128.5	111.5	133.5	1.1	0.6	115.6	2.10
	150	24	2.800	7020	135.5	114.5	141.5	1.5	0.6	119.7	3.80
	180	34	7.122	7220	155.5	124.5	167.0	2.1	1.1	131.0	3.80
105	145	20	1.896	71921	133.5	116.5	138.5	1.1	0.6	120.5	2.10
	160	26	3.550	7021	144.5	120.5	150.0	2.0	1.0	127.0	4.00

		Basic load ratings in lbf		Max. speed in rpm	
Series C	a (mm)	C dynamic	Co static	Grease	Oil
71911CV	16	4,500	4,160	17,000	2,000
7011CV	19	6,860	5,850	16,000	2,000
7211CG1	21	11,930	9,000	14,500	2,500
71912CV	16	4,700	4,570	15,000	24,000
7012CV	19	7,310	6,640	15,000	23,000
7212CG1	22	14,630	11,030	12,500	19,500
71913CV	17	4,880	4,930	14,500	22,000
7013CV	20	7,430	6,980	14,000	21,000
7213CG1	24	15,080	12,150	11,500	17,500
71914CV	19	8,890	6,530	13,000	20,000
7014CV	22	9,680	9,000	13,000	20,000
7214CG1	25	17,330	13,500	11,000	16,500
71915CV	20	6,860	7,090	12,500	19,000
7015CV	23	9,900	9,450	12,000	19,000
7215CG1	26	18,000	14,630	10,000	16,000
71916CV	21	6,980	7,430	12,000	18,000
7016CV	25	13,280	12,380	11,000	17,000
7216CG1	28	21,150	17,550	9,400	15,000
71917CV	23	8,210	8,780	11,000	17,000
7017CV	25	13,730	13,280	10,500	16,000
7217CG1	30	24,300	20,480	8,700	14,000
71918CV	23	8,550	9,340	10,500	16,000
7018CV	27	16,430	15,530	10,000	15,000
7218CG1	32	27,900	23,630	8,100	12,500
71919CV	24	9,680	10,690	9,900	15,000
7019CV	28	16,650	16,430	9,700	14,500
71920CV	26	11,030	12,380	9,500	14,500
7020CV	29	17,100	17,330	9,300	14,000
7220CG1	36	33,750	28,580	7,200	11,000
71921CV	27	11,250	12,830	9,200	14,000
7021CV	31	18,900	19,350	8,800	13,500

		Basic load ratings in lbf		Max. speed in rpm	
Series H	a (mm)	C dynamic	Co static	Grease	Oil
71911HV	22	4,250	3,940	15,000	24,000
7011HV	26	6,530	5,600	14,000	22,000
7211HG1	29	11,480	8,550	12,500	19,500
71912HV	23	4,430	4,300	14,500	22,000
7012HV	27	6,860	6,300	14,000	21,000
7212HG1	31	13,950	10,580	11,000	17,500
71913HV	25	4,590	4,590	14,000	21,000
7013HV	28	7,090	6,640	13,000	19,000
7213HG1	33	14,400	11,700	10,000	16,500
71914HV	28	6,300	6,190	12,500	19,000
7014HV	31	9,110	8,440	12,500	19,000
7214HG1	35	16,430	12,830	9,700	15,000
71915HV	29	6,530	6,640	12,000	18,000
7015HV	32	9,340	9,000	11,000	17,000
7215HG1	36	17,100	13,950	9,100	14,500
71916HV	30	6,640	6,860	11,000	17,000
7016HV	35	12,600	11,930	10,500	16,000
7216HG1	39	20,030	16,650	8,500	13,000
71917HV	33	7,760	8,210	9,900	15,000
7017HV	36	13,050	12,600	9,000	15,000
7217HG1	41	23,180	19,350	7,800	12,000
71918HV	34	7,990	8,780	9,900	15,000
7018HV	39	15,530	14,850	9,200	14,000
7218HG1	44	26,550	22,500	7,300	11,000
71919HV	35	9,110	9,900	9,200	14,000
7019HV	40	15,980	15,530	8,900	13,500
71920HV	38	10,350	11,480	8,600	13,000
7020HV	41	16,200	16,430	8,600	13,000
7220HG1	50	32,180	27,230	6,400	9,800
71921HV	39	10,580	11,930	8,600	13,000
7021HV	44	17,780	18,230	7,900	12,000

Series 719 70 72



Dimensions (mm)			Weight	Series	Shoulder and fillets (mm)					Lubrication opening (mm)	
d	D	B	lbs		D1	d2	D4	r2 max	r3 max	D5	E
110	150	20	1.962	71922	138.5	121.5	143.5	1.1	0.6	125.5	2.10
	170	28	4.410	7022	153.0	127.0	160.0	2.0	1.0	134.0	4.50
	200	38	9.989	7222	172.5	137.5	185.5	2.1	1.1	145.0	4.30
120	165	22	2.624	71924	151.5	133.5	157.5	1.1	0.6	137.7	3.30
	180	28	4.741	7024	163.0	137.0	170.0	2.0	1.0	144.0	4.50
	215	40	12.348	7224	185.5	149.5	197.5	2.1	1.1	157.5	4.30
130	180	24	3.462	71926	165.0	145.0	172.0	1.5	0.6	149.8	3.70
	200	33	7.012	7026	179.5	150.5	189.0	2.0	1.0	158.0	5.30
140	190	24	3.704	71928	175.0	155.0	182.0	1.5	0.6	159.8	3.70
	210	33	7.541	7028	189.5	160.5	199.0	2.0	1.0	168.0	5.30
150	210	28	5.777	71930	192.5	167.5	199.0	2.0	1.0	174.0	4.10
	225	35	9.173	7030	203.0	172.0	213.0	2.1	1.0	180.0	5.70
160	220	28	6.086	71932	202.5	177.5	209.0	2.0	1.0	184.0	4.10
	240	38	11.312	7032	216.0	184.0	227.0	2.1	1.0	192.0	6.20
170	230	28	6.417	71934	212.5	187.5	219.0	2.0	1.0	194.0	4.10
	260	42	15.391	7034	232.5	197.5	246.0	2.1	1.1	206.4	6.60
180	250	33	9.393	71936	229.0	201.0	237.5	2.0	1.0	208.3	4.70
	280	46	19.845	7036	249.5	210.5	264.0	2.1	1.1	219.8	7.80
190	260	33	9.878	71938	239.0	211.0	247.5	2.0	1.0	218.3	4.70
	290	46	20.727	7038	259.5	220.5	274.0	2.1	1.1	229.8	7.80
200	280	38	13.583	71940	255.5	224.5	266.0	2.1	1.0	232.0	5.50
	310	51	26.791	7040	276.5	233.5	292.0	2.1	1.1	243.6	8.60
220	300	38	14.928	71944	275.5	244.5	286.0	2.1	1.0	252.0	5.50
	340	56	35.897	7044	304.0	256.0	321.0	3.0	1.1	268.6	8.60
240	320	38	16.030	71948	295.5	264.5	306.0	2.1	1.0	272.0	5.50

Series 719 CV 70 CV 72 CG1

Contact angle

15°

Series C	a (mm)	Basic load ratings in lbf		Max. speed in rpm	
		C dynamic	Co static	Grease	Oil
71922CV	27	11,480	13,280	8,900	13,500
7022CV	33	21,830	22,050	8,300	12,500
7222CG1	40	39,830	36,000	6,300	9,700
71924CV	30	15,750	18,230	8,200	12,500
7024CV	34	22,950	24,530	7,700	11,500
7224CG1	42	43,430	42,080	5,700	8,700
71926CV	33	18,900	22,050	7,500	11,500
7026CV	39	29,480	30,830	7,000	10,500
71928CV	34	19,580	23,630	7,200	11,000
7028CV	40	31,050	34,200	6,600	10,000
71930CV	38	23,630	28,800	6,500	9,000
7030CV	43	35,550	39,600	6,200	9,300
71932CV	39	23,850	29,700	6,200	9,400
7032CV	46	40,280	45,450	5,800	8,800
71934CV	41	24,080	31,500	5,800	8,900
7034CV	50	45,000	51,750	5,400	8,100
71936CV	45	30,380	38,930	5,400	8,300
7036CV	54	54,900	65,250	5,000	7,600
71938CV	47	31,280	41,180	5,200	7,900
7038CV	55	56,250	68,630	4,800	7,300
71940CV	51	43,200	54,680	4,800	7,400
7040CV	60	63,000	79,880	4,500	6,900
71944CV	54	40,500	54,450	4,400	6,800
7044CV	66	66,380	88,880	4,100	6,200
71948CV	57	41,630	57,380	4,200	6,400

Series 719 HV 70 HV 72 HG1

Contact angle

25°

Series H	a (mm)	Basic load ratings in lbf		Max. speed in rpm	
		C dynamic	Co static	Grease	Oil
71922HV	40	10,690	12,380	8,200	12,500
7022HV	47	20,700	20,930	7,600	11,500
7222HG1	55	38,030	34,430	5,600	8,700
71924HV	44	14,850	17,100	7,500	11,500
7024HV	49	21,600	23,180	6,900	10,500
7224HG1	59	41,400	40,050	5,100	7,800
71926HV	48	17,780	20,700	6,900	10,500
7026HV	55	27,900	29,250	6,500	9,800
71928HV	50	18,450	22,050	6,400	9,800
7028HV	57	29,250	32,400	6,100	9,200
71930HV	56	22,280	27,000	5,900	9,000
7030HV	61	33,530	37,580	5,700	8,600
71932HV	58	22,500	27,680	5,600	8,500
7032HV	66	38,030	42,980	5,300	8,100
71934HV	61	23,180	29,480	5,300	8,100
7034HV	71	42,530	49,050	5,000	7,500
71936HV	67	28,580	36,230	4,900	7,500
7036HV	77	51,980	61,880	4,600	7,000
71938HV	69	29 ,080	38,480	4,700	7,200
7038HV	79	53,330	65,250	4,400	6,700
71940HV	75	40,730	51,530	4,400	6,800
7040HV	85	59,630	75,380	4,200	6,300
71944HV	77	38,250	50,850	4,000	6,200
7044HV	93	63,000	84,380	3,700	5,700
71948HV	84	39 ,050	53,550	3,800	5,800

Preload - Axial and radial rigidities of bearing arrangements DU DB DF

Reference	Deflection constant	Preload (lbf)			Axial rigidity (lbf/µm)			Radial rigidity (lbf/µm)		
	K (1)	7	8	9	7	8	9	7	8	9
71900CV	1.50	3	9	17	3	5	7	16	23	28
7000CV	1.36	6	18	36	4	7	10	22	32	38
7200CG1	1.24	9	27	52	5	9	12	29	40	48
71900HV	0.73	5	16	32	7	11	15	15	21	26
7000HV	0.66	10	29	59	9	15	20	20	28	34
7200HG1	0.60	14	41	81	12	18	25	25	35	44
71901CV	1.35	3	10	19	3	5	8	20	27	33
7001CV	1.28	7	20	41	5	7	11	25	36	43
7201CG1	1.23	9	29	56	5	9	12	30	42	51
71901HV	0.65	6	17	34	8	13	17	18	25	30
7001HV	0.62	11	32	63	11	16	21	23	31	38
7201HG1	0.60	16	45	90	13	19	25	27	38	47
71902CV	1.27	5	16	32	4	7	9	24	34	41
7002CV	1.20	7	23	45	5	9	12	28	39	48
7202CG1	1.15	10	29	61	6	9	13	33	46	56
71902HV	0.61	8	25	50	10	15	20	21	30	37
7002HV	1.58	12	36	72	12	18	25	25	35	43
7202HG1	1.57	17	50	99	14	21	28	30	41	51
71903CV	1.21	6	17	34	5	7	10	26	36	45
7003CV	1.09	8	24	47	5	9	13	32	44	54
7203CG1	1.05	14	38	79	7	11	16	37	50	62
71903HV	0.58	9	27	54	11	16	22	23	32	40
7003HV	0.53	14	38	77	13	20	26	29	39	49
7203HG1	0.54	20	63	126	16	24	32	32	45	55
71904CV	1.04	8	25	50	6	10	14	33	47	58
7004CV	0.96	14	41	81	7	13	19	42	58	70
7204CG1	0.92	19	59	113	9	15	21	46	64	76
71904HV	0.51	12	38	77	14	21	28	29	42	51
7004HV	0.47	23	68	135	18	27	37	37	52	64
7204HG1	0.47	32	92	185	20	31	43	41	56	69
71905CV	0.96	9	27	54	7	11	15	38	53	65
7005CV	0.87	16	45	90	9	15	21	48	66	80
7205CG1	0.84	23	68	135	10	17	25	55	76	93
71905HV	0.47	14	41	81	16	24	31	33	47	58
7005HV	0.43	25	72	144	20	30	41	42	59	73
7205HG1	0.42	34	101	203	23	36	49	47	66	80
71906CV	0.93	9	27	54	7	11	16	40	55	68
7006CV	0.83	19	56	113	10	16	24	55	77	94
7206CG1	0.77	29	86	171	11	18	26	64	87	106
71906HV	0.45	14	43	86	16	25	33	34	49	61
7006HV	0.41	29	90	180	22	34	46	48	67	83
7206HG1	0.40	45	135	270	26	40	54	56	78	95

(1) Axial deflection constant in µm (lbf)$^{-2/3}$ 7 = light preload 8 = medium preload 9 = heavy preload

Reference	Deflection constant	Preload (lbf)			Axial rigidity (lbf/µm)			Radial rigidity (lbf/µm)		
	K (1)	7	8	9	7	8	9	7	8	9
71907CV	0.84	12	37	74	8	14	19	47	66	81
7007CV	0.76	23	68	135	11	19	27	64	89	109
7207CG1	0.77	41	119	225	14	23	32	75	103	124
71907HV	0.41	20	59	117	20	30	40	43	59	73
7007HV	0.37	38	113	225	27	41	55	58	81	100
7207HG1	0.38	63	189	383	32	49	67	66	93	115
71908CV	0.75	17	52	104	10	17	25	58	82	100
7008CV	0.73	25	74	149	12	20	29	69	96	117
7208CG1	0.80	42	126	248	13	22	31	75	105	127
71908HV	0.37	27	81	162	25	38	51	52	73	90
7008HV	0.36	41	119	248	28	43	60	61	86	107
7208HG1	0.39	68	203	405	32	48	65	67	95	116
71909CV	0.70	18	52	104	11	18	25	67	90	112
7009CV	0.72	31	81	180	13	21	31	74	99	124
7209CG1	0.77	52	158	315	16	27	38	83	110	134
71909HV	0.34	27	81	162	26	39	52	59	79	99
7009HV	0.36	47	146	293	32	50	68	64	87	108
7209HG1	0.37	83	248	495	38	58	78	71	95	117
71910CV	0.66	18	52	104	11	18	26	73	98	123
7010CV	0.67	32	95	189	14	25	36	82	111	138
7210CG1	0.75	54	162	324	17	28	40	88	116	142
71910HV	0.32	27	83	167	27	41	54	65	87	109
7010HV	0.33	50	151	299	33	52	70	73	97	121
7210HG1	0.36	86	257	513	40	61	82	77	103	126
71911CV	0.63	29	76	160	15	23	34	83	111	138
7011CV	0.65	40	110	230	16	25	37	90	121	151
7211CG1	0.70	72	180	360	18	27	39	101	133	163
71911HV	0.31	45	120	240	35	50	67	73	98	122
7011HV	0.32	63	160	340	38	54	73	79	106	132
7211HG1	0.33	110	280	560	42	60	80	89	118	145
71912CV	0.60	31	81	170	16	25	37	90	120	150
7012CV	0.61	45	120	260	18	28	41	100	134	167
7212CG1	0.67	90	220	450	20	31	43	113	148	181
71912HV	0.29	49	130	260	38	54	74	80	107	133
7012HV	0.30	72	180	380	42	60	82	88	118	148
7212HG1	0.33	130	340	670	47	66	88	98	130	160
71913CV	0.57	34	90	190	17	27	40	97	131	163
7013CV	0.59	49	130	270	19	29	43	106	141	176
7213CG1	0.64	94	240	470	21	33	46	120	158	193
71913HV	0.28	54	130	280	41	58	80	86	115	144
7013HV	0.29	76	190	390	44	63	85	93	124	154
7213HG1	0.30	140	350	700	49	70	93	103	138	170
71914CV	0.57	45	120	250	19	29	44	106	140	176
7014CV	0.58	63	160	350	21	32	48	117	156	194
7214CG1	0.65	100	260	520	22	33	47	122	161	197
71914HV	0.28	70	180	370	44	64	86	93	125	156
7014HV	0.29	94	240	500	48	70	94	102	138	171
7214HG1	0.31	160	400	810	51	72	96	107	143	176

Reference	Deflection constant	Preload (lbf)			Axial rigidity (lbf/µm)			Radial rigidity (lbf/µm)		
	K (1)	7	8	9	7	8	9	7	8	9
71915CV	0.54	49	130	270	21	32	47	115	154	191
7015CV	0.56	67	170	370	22	34	51	124	164	205
7215CG1	0.62	110	270	540	23	35	49	129	171	209
71915HV	0.27	76	190	400	48	69	94	101	135	169
7015HV	0.27	100	260	540	52	74	99	108	145	180
7215HG1	0.30	170	420	830	54	76	101	114	151	187
71916CV	0.53	49	130	290	21	33	49	118	160	199
7016CV	0.57	85	220	480	24	37	55	134	180	224
7216CG1	0.60	130	330	650	25	38	54	142	187	229
71916HV	0.26	81	200	420	50	72	97	106	141	175
7016HV	0.27	130	340	710	56	80	109	119	158	198
7216HG1	0.29	200	490	990	59	83	110	124	165	203
71917CV	0.51	63	160	350	24	37	54	132	175	218
7017CV	0.54	90	240	510	25	39	58	141	189	235
7217CG1	0.59	150	370	740	27	41	58	152	201	246
71917HV	0.25	94	240	510	54	78	106	115	154	192
7017HV	0.27	140	360	740	59	85	114	124	167	207
7217HG1	0.29	220	560	1,100	63	89	118	133	177	218
71918CV	0.49	67	170	370	25	39	58	141	187	234
7018CV	0.54	110	280	610	27	42	62	151	201	251
7218CG1	0.58	170	430	850	29	44	62	164	216	265
71918HV	0.24	103	260	540	59	84	114	124	165	206
7018HV	0.26	170	430	890	62	90	122	132	177	221
7218HG1	0.27	260	650	1,300	68	96	127	143	190	235
71919CV	0.49	72	190	420	26	41	60	145	196	244
7019CV	0.52	110	300	630	28	44	64	158	211	262
71919HV	0.24	120	290	610	62	88	119	129	173	215
7019HV	0.26	180	450	930	66	95	128	139	186	232
71920CV	0.48	85	220	480	28	44	65	157	211	262
7020CV	0.51	120	310	660	29	46	67	165	222	275
7220CG1	0.58	200	520	1,050	31	47	66	174	230	281
71920HV	0.23	130	340	710	66	94	128	139	185	232
7020HV	0.25	180	470	980	69	99	134	145	195	244
7220HG1	0.28	310	790	1,550	72	102	135	152	203	250
71921CV	0.47	90	230	490	29	46	67	164	219	271
7021CV	0.50	130	350	740	31	49	71	174	234	290
71921HV	0.23	140	360	730	68	99	133	144	194	240
7021HV	0.24	210	530	1,100	73	105	141	154	206	257
71922CV	0.45	94	240	520	31	47	70	170	226	281
7022CV	0.50	150	400	850	33	51	75	183	246	305
7222CG1	0.56	240	610	1,200	34	51	71	192	253	310
71922HV	0.22	140	370	760	71	102	138	149	201	250
7022HV	0.24	240	610	1,250	77	110	148	161	216	270
7222HG1	0.27	380	930	1,850	79	112	148	167	223	276
71924CV	0.45	130	330	700	34	53	78	191	255	317
7024CV	0.47	170	440	940	36	56	83	200	268	335
7224CG1	0.52	260	640	1,300	37	56	78	213	283	346
71924HV	0.22	200	490	1,050	80	114	155	169	225	281
7024HV	0.23	260	670	1,400	84	121	163	177	238	296
7224HG1	0.24	390	970	1,950	87	123	162	185	248	306

(1) Axial deflection constant in µm (lbf)$^{-2/3}$ 7 = light preload 8 = medium preload 9 = heavy preload

Reference	Deflection constant	Preload (lbf)			Axial rigidity (lbf/µm)			Radial rigidity (lbf/µm)		
	K (1)	7	8	9	7	8	9	7	8	9
71926CV	0.44	150	390	840	37	57	85	204	274	342
7026CV	0.47	210	550	1,200	38	60	88	216	288	359
7226CG1	0.50	270	660	1,350	39	59	83	226	299	367
71926HV	0.22	230	600	1,250	86	123	167	181	242	302
7026HV	0.23	330	840	1,750	90	129	175	190	255	318
7226HG1	0.24	400	1,000	2,000	92	130	172	196	262	324
71928CV	0.42	160	430	900	40	62	90	221	296	366
7028CV	0.44	230	610	1,300	42	66	97	237	317	394
7228CG1	0.50	310	760	1,550	41	62	87	236	312	383
71928HV	0.20	260	650	1,350	93	133	179	195	262	326
7028HV	0.22	370	930	1,900	100	142	192	210	280	349
7228HG1	0.24	470	1,150	2,350	97	137	181	206	275	340
71930CV	0.41	200	520	1,100	44	68	100	244	326	404
7030CV	0.43	270	710	1,500	45	71	104	255	341	424
7230CG1	0.49	340	840	1,700	43	65	91	252	334	410
71930HV	0.20	310	790	1,650	102	147	198	215	288	359
7030HV	0.21	430	1,100	2,250	107	153	207	225	302	376
7230HG1	0.23	510	1,300	2,550	103	145	191	219	293	363
71932CV	0.40	210	540	1,150	45	71	104	253	338	420
7032CV	0.43	310	810	1,700	49	76	111	273	365	454
7232CG1	0.48	380	960	1,900	46	69	97	271	359	441
71932HV	0.19	320	820	1,700	106	152	206	223	299	373
7032HV	0.21	480	1,250	2,550	114	164	221	241	323	402
7232HG1	0.23	560	1,400	2,800	109	153	201	233	312	386
71934CV	0.38	220	570	1,200	48	75	110	270	360	447
7034CV	0.41	350	920	1,950	52	81	118	290	390	484
71934HV	0.19	350	880	1,800	114	162	220	239	319	398
7034HV	0.20	550	1,400	2,900	122	175	236	257	344	429
71936CV	0.38	270	710	1,500	52	81	118	289	387	480
7036CV	0.41	450	1,150	2,450	56	87	127	315	419	521
71936HV	0.19	420	1,100	2,200	120	174	235	254	343	426
7036HV	0.20	700	1,750	3,700	131	189	254	277	372	462
71938CV	0.36	300	750	1,600	55	86	126	308	413	511
7038CV	0.40	480	1,250	2,600	59	91	133	330	441	546
71938HV	0.18	450	1,150	2,350	129	186	251	272	365	455
7038HV	0.20	740	1,900	3,850	138	198	267	291	390	485
71940CV	0.38	370	980	2,050	58	90	132	323	433	535
7040CV	0.40	540	1,400	3,000	62	96	140	346	464	576
71940HV	0.19	580	1,500	3,050	136	194	264	285	383	476
7040HV	0.20	850	2,150	4,450	145	208	280	306	410	511
71944CV	0.36	380	990	2,100	63	97	143	349	466	578
7044CV	0.38	610	1,600	3,450	68	107	158	382	514	640
71944HV	0.17	600	1,500	3,100	146	210	283	308	413	513
7044HV	0.19	960	2,450	5,050	160	231	311	338	454	564
71948CV	0.34	400	1,050	2,250	67	104	152	371	496	617
71948HV	0.16	640	1,650	3,350	156	224	303	329	441	549

Bearing tolerances and precision classes

The precision of rotation of the spindle is a very important characteristic which has a direct influence on the precision of machining.
To satisfy this requirement, SNR ROULEMENTS produces its bearings in the following precision classes:
- very high precision ISO 4
- super precision ISO 2

Inner ring
Tolerances in µm

Tolerances	Symbol (1)	Bore (d) in mm: Over / Including	6 / 10	10 / 18	18 / 30	30 / 50	50 / 80	80 / 120	120 / 150	150 / 180	180 / 250
Tolerance on mean diameter	Δ dmp	ISO 4	0 / -4	0 / -4	0 / -5	0 / -6	0 / -7	0 / -8	0 / -10	0 / -10	0 / -12
		ISO 2	0 / -2.5	0 / -2.5	0 / -2.5	0 / -2.5	0 / -4	0 / -5	0 / -7	0 / -7	0 / -8
Roundness	Series 719 Δ dp max	ISO 4	4	4	5	6	7	8	10	10	12
		ISO 2	2.5	2.5	2.5	2.5	4	5	7	7	8
	Series 70-72	ISO 4	3	3	4	5	5	6	8	8	9
		ISO 2	2.5	2.5	2.5	2.5	4	5	7	7	8
Taper	Δ dmp max	ISO 4	2	2	2.5	3	3.5	4	5	5	6
		ISO 2	1.5	1.5	1.5	1.5	2	2.5	3.5	3.5	4
Radial run-out	K_{ia} max	ISO 4	2.5	2.5	3	4	4	5	6	6	8
		ISO 2	1.5	1.5	2.5	2.5	2.5	2.5	2.5	5	5
Face run-out with respect to bore	S_d max	ISO 4	3	3	4	4	5	5	6	6	7
		ISO 2	1.5	1.5	1.5	1.5	1.5	2.5	2.5	4	5
Raceway run-out with respect to face	S_{ia} max	ISO 4	3	3	4	4	5	5	7	7	8
		ISO 2	1.5	1.5	2.5	2.5	2.5	2.5	2.5	5	5
Width tolerance (single bearing)	Δ B_s	ISO 4	0	0	0	0	0	0	0	0	0
		ISO 2	-40	-80	-120	-120	-150	-200	-250	-250	-300
Face parallelism	V B_s max	ISO 4	2.5	2.5	2.5	3	4	4	5	5	6
		ISO 2	1.5	1.5	1.5	1.5	1.5	2.5	2.5	4	5

(1) The tolerance symbols comply with standard ISO 492

Precision standards equivalence

Quality	ISO	ABEC	DIN
Very high precision	4	7	P4
Super precision	2	9	P2

Outer ring
Tolerances in µm

Tolerances	Symbol (1)	Outside diameter (D) in mm: Over / Including	2.5 / 18	18 / 30	30 / 50	50 / 80	80 / 120	120 / 150	150 / 180	180 / 250	250 / 315	315 / 400
Tolerance on mean diameter	Δ Dmp	ISO 4	0 / -4	0 / -5	0 / -6	0 / -7	0 / -8	0 / -9	0 / -10	0 / -11	0 / -13	0 / -15
		ISO 2	0 / -2.5	0 / -4	0 / -4	0 / -4	0 / -5	0 / -5	0 / -7	0 / -8	0 / -8	0 / -10
Roundness	Series 719 Δ Dp max	ISO 4	4	5	6	7	8	9	10	11	13	15
		ISO 2	2.5	4	4	4	5	5	7	8	8	10
	Series 70-72	ISO 4	3	4	5	5	6	7	8	8	10	11
		ISO 2	2.5	4	4	4	5	5	7	8	8	10
Taper	Δ Dmp max	ISO 4	2	2.5	3	3.5	4	5	5	6	7	8
		ISO 2	1.5	2	2	2	2.5	2.5	3.5	4	4	5
Radial run-out	K_{ea} max	ISO 4	3	4	5	5	6	7	8	10	11	13
		ISO 2	1.5	2.5	2.5	4	5	5	5	7	7	8
Outside diameter run-out with respect to face	S_{ea} max	ISO 4	4	4	4	4	5	5	5	7	8	10
		ISO 2	1.5	1.5	1.5	1.5	2.5	2.5	2.5	4	5	7
Raceway run-out with respect to face	S_{ea} max	ISO 4	5	5	5	5	6	7	8	10	10	13
		ISO 2	1.5	2.5	2.5	4	5	5	5	7	7	8
Width tolerance (single bearing)	Δ C_s	ISO 4 / ISO 2	Values identical to those of the bearing inner ring									
Face parallelism	V C_s max	ISO 4	2.5	2.5	2.5	3	4	5	5	7	7	8
		ISO 2	1.5	1.5	1.5	1.5	2.5	2.5	2.5	4	5	7

(1) The tolerance symbols comply with standard ISO 492.

Bearing contact surface and seating tolerances

Bearing seat tolerances

The bearing seats (shaft OD and housing bore) must be very close to the bearing dimensions to avoid having too loose or too tight a fit. This practice will allow the proper preload to be achieved without the reduction of rotational precision. Generally we recommend the fits specified below. When installing the bearings, we advise matching them with their seats to avoid assembling parts at opposite extremes of their tolerance limits, which would lead to an excessively loose or tight fit.

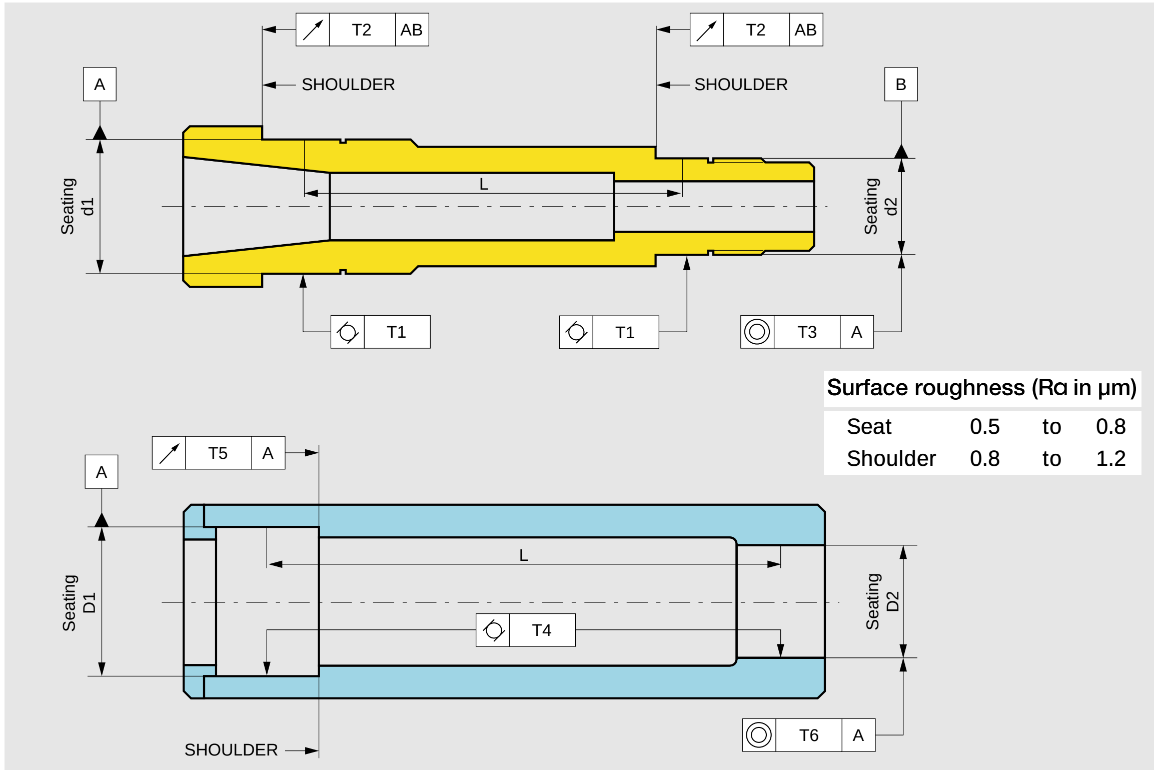
Tolerances in microns

Nominal diameter (mm)	Shaft			Housing					
	ISO4		ISO2	ISO4				ISO2	
				Fixed assembly		Floating assembly		Fixed assembly	Floating assembly
	h4 (1)	js4(2)	/	JS5(1)	K5(2)	H5(3)	Loose fit (4)	JS4	/
10 to 18	0 -5	±3	0 -4	/	/	/	/	/	
> 18 to 30	0 -6	±3	0 -4	±4	+1 -8	+9 0	2 to 10	±3	+8 +2
> 30 to 50	0 -7	±4	0 -5	±5	+2 -9	+11 0	3 to 11	±4	+10 +2
> 50 to 80	0 -8	±4	0 -5	±6	+3 -10	+13 0	3 to 12	+4	+11 +3
> 80 to 120	0 -10	±5	0 -6	±7	+2 -13	+15 0	5 to 15	±5	+13 +3
> 120 to 180	0 -12	±6	0 -8	±9	+3 -15	+18 0	5 to 17	±6	+16 +4
> 180 to 250	0 -14	±7	0 -10	±10	+2 -18	+20 0	7 to 22	±7	+18 +4
> 250 to 315	/	/	/	±11	+3 -20	+23 0	7 to 27	±4	+21 +5
> 315 to 400	/	/	/	±12	+3 -22	+25 0	7 to 30	±9	+23 +5

(1) Light load C/P > 16, medium load 10 ≤ C/P ≤ 16
(2) Heavy load C/P < 10
(3) We recommend a tolerance, but the optimum fitting is obtained by matching the housing and bearings within the loose fit limits specified in the column (4).

Shape and position tolerances for shoulders and seats

The performance of the spindle (precision of rotation, heat level) depends, to a large extent on the quality of machining of the shoulders and seats. To obtain the desired performance, it is vital for these characteristics to be within the tolerances recommended by SNR.
Remark: the required shoulder diameter and fillet radii tolerances are specified on page 28.



Surface roughness (Ra in µm)			
Seat	0.5	to	0.8
Shoulder	0.8	to	1.2

Maximum tolerances in microns

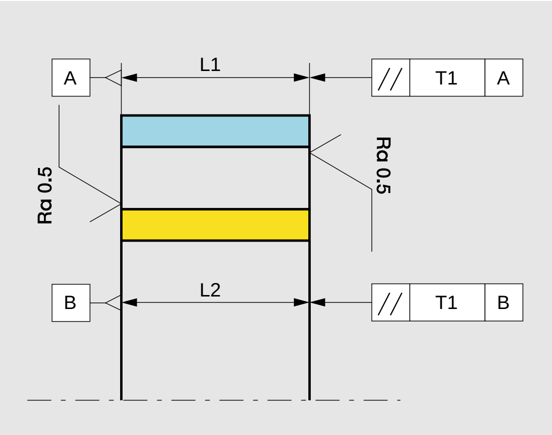
Nominal diameter of seat (mm)	Shaft						Housing					
	T1		T2		T3		T4		T5		T6	
	ISO4	ISO2	ISO4	ISO2	ISO4	ISO2	ISO4	ISO2	ISO4	ISO2	ISO4	ISO2
10 to 18	1.5	1	2	1.2			/	/	/	/	/	/
> 18 to 30	2	1	2.5	1.5	0.013L (1)	0.008L (1)	2	1.5	2.5	1.5		
> 30 to 50	2	1.5	2.5	1.5			2.5	1.5	2.5	1.5	0.015L (1)	0.010L (1)
> 50 to 80	2.5	1.5	3	2			3	2	3	2		
> 80 to 120	3	2	4	2.5			3.5	2.5	4	2.5		
> 120 to 180	3.5	2	5	3.5	0.025L (1)	0.013L (1)	4.5	3	5	3.5		
> 180 to 250	4	2.5	7	4.5			5	3.5	7	4.5	0.030L (1)	0.015L (1)
> 250 to 315	/	/	/	/	/	/	6	4	8	6		
> 315 to 400	/	/	/	/	/	/	6	4.5	9	7		

(1) L = span between assembly centerlines in mm

Tolerances for spacers and clamping nuts

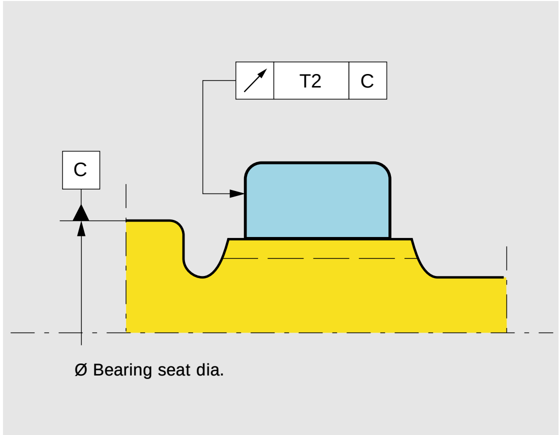
The rotational precision of the spindle also depends on the manufacturing precision of the spacers and nuts.

Spacers



They must be sufficiently rigid to avoid any bending during tightening. Their length should not exceed 200 mm. Their face parallelism tolerance and permissible length variances are specified below.

Clamping nuts



Whether the nut is threaded or pressed on, its clamping face must be perpendicular to the bearing seat. The axial run-out tolerance of the face is specified below.

Maximum tolerances in microns

Nominal bore of spacer or nominal diameter of bearing seat (mm)	Spacer				Nut	
	T1		Difference in length between L1 and L2		T2	
	ISO4	ISO2	ISO4	ISO2	ISO4	ISO2
10 to 18	2	1	2	1	5	3
> 18 to 30	2	1	2	1	6	4
> 30 to 50	2	1	2	1	7	4
> 50 to 80	2	1	3	2	8	5
> 80 to 120	3	2	3	2	10	6
> 120 to 180	3	2	4	3	12	8
> 180 to 250	4	3	5	4	14	10

Sealing

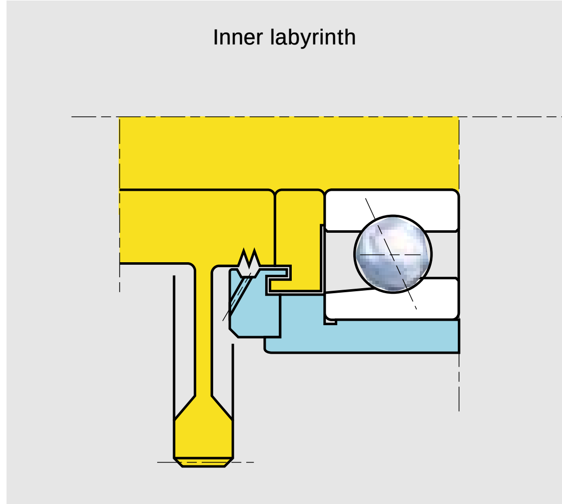
Effective sealing of the spindle is vital to prevent contamination from particles or cutting fluid. This would damage the lubricant and the bearing races. Such infiltration will cause abnormal heating, loss of machining precision, and possibly even locking of the spindle through spalling of balls and rings.

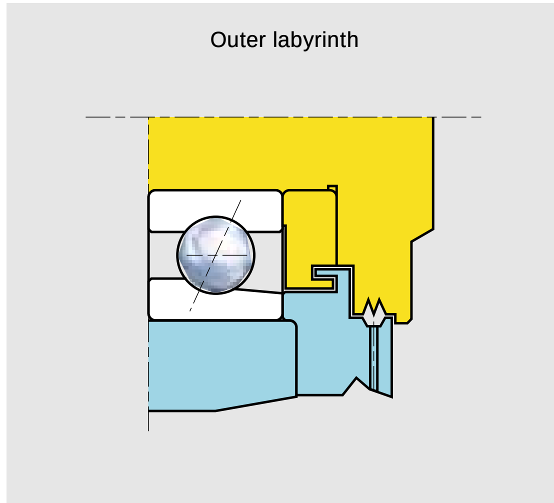
Proper sealing must be ensured not only during machine operation but also during the shutdown phases, and in particular during the washing and cleaning phases.

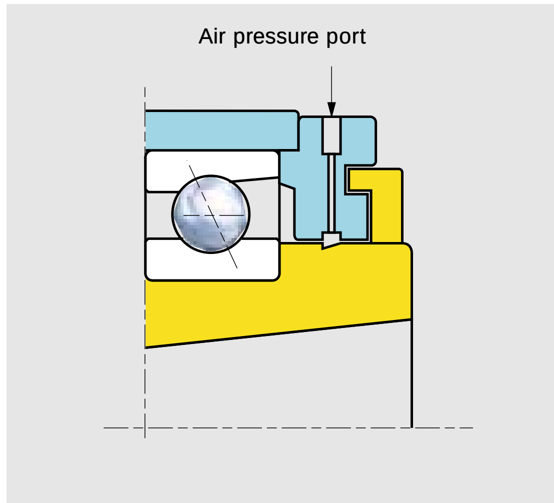
Sealing devices

The choice depends on several factors:
- the spindle external and internal environment
- the maximum speed of rotation
- the method of lubrication

Principle devices
- seals
- labyrinth seals
- air pressure port
- internal pressurization







Lubrication

Lubrication fulfills several main functions:

- Inserting a film of oil between bearing components to reduce friction
- Ensuring cooling by evacuating the heat generated in the case of oil lubrication
- Protecting the bearing against corrosion.

The choice of lubrication type depends essentially on the maximum speed of rotation, the loads, and therefore the quantity of heat to be evacuated. It also depends on the design of the machine.
Grease lubrication is recommended when the desired maximum speed allows, and if the heat generated can be dissipated by conduction without causing abnormal heating (ΔT: permissible temperature increase of 35 to 45°F). Otherwise, we recommend oil-mist or air-oil lubrication.

Oil lubrication

When the speed of rotation exceeds the maximum limit for grease lubrication, oil lubrication must be selected. In general, SNR recommends choosing an oil with low viscosity, approximately 20 centistokes at 40° C (98 SUS at 100° F), to minimize heating except when applied loads are very high.

Most commonly used methods of oil lubrication:

- oil-mist lubrication
- air-oil lubrication

Oil-mist lubrication

Lubrication is ensured by spraying oil into a flow of air. The air circulation ensures cooling.
The oil flow rate must be very low, and the air must be filtered and dry.
For example, in a 7016 bearing, the oil flow rate should be 50 mm^3 (0.0017 ozfl) per hour per bearing, and the air pressure 10 to 30 psi. Note that the positive pressure generated inside the spindle will improve its sealing efficiency.

Air-oil lubrication

This system displays some advantages over oil-mist lubrication:
- less oil escaping to the atmosphere
- better control of the quantity of lubricant introduced into the bearing.

Oil droplets are projected periodically into an air flow.
Example of settings for a 7016 bearing:
- Oil flow rate: 60 mm^3 (0.002 ozfl)/hour and per bearing
- Injection interval: 8 min.
- Air pressure: 15 to 35 psi.

Remark:
The above settings are given for information only. They must be optimized to obtain the lowest heat level.

Circulation channels
The lubricant must be inserted as close as possible to the bearing and be introduced between the inner ring and the cage. The oil inlet pitch diameter (D5) and the space between the inner ring and the cage (E) are specified on page 28.

Grease lubrication

Modern greases offer the possibility of lubrication for life with good resistance to high speeds and loads without excessive operating torque.

SNR recommends its LUB GV grease:

• Base: synthetic oil, lithium soap
• Additives:
- oxidation inhibitor,
- wear inhibitor,
- corrosion inhibitor,
- extreme pressure.
• Low viscosity: 15 cSt at 40°C (77 SUS at 100° F)
Service temperature: -60°C to +120°C (-75°F to 250°F)

The volume of grease recommended by SNR is specified in the table opposite.
This volume has to be adjusted according to the operating NDm value based on the correction factors below.

NDm (10^6)	Correction factor
0.4	1
0.4 to 0.8	0.75
> 0.8	0.60

Example:
Bearing 7016 designed to be used with an NDm of 0.7×10^6,
Volume of grease per bearing:
10 cm^3 x 0.75 = 7.5 cm^3 (0.25 ozfl)

Reminder:
NDm = product of multiplying the mean bearing diameter (mm) by the speed of rotation (rpm).

Introduction of grease: see page 46.

Mean volume of grease per bearing in cm^3 tolerance ± 10%			
Bore Code	Series 70	Series 72	Series 719
00	0.3	0.4	0.2
01	0.4	0.5	0.2
02	0.5	0.6	0.3
03	0.6	0.8	0.3
04	1.0	1.3	0.5
05	1.2	1.7	0.6
06	1.6	2.3	0.7
07	2.0	3.3	1.0
08	2.5	3.5	1.5
09	3.2	5.3	1.6
10	3.4	6.2	1.7
11	4.7	7.5	2.2
12	5.0	9.2	2.3
13	5.3	11	2.5
14	7.5	13	4.2
15	7.8	14	4.3
16	10	16	4.5
17	11	21	6.3
18	14	26	6.5
19	15	/	7.3
20	16	38	9.7
21	19	/	10
22	24	52	10
24	25	63	14
26	40	/	19
28	42	/	20
30	51	/	30
32	64	/	31
34	83	/	32
36	107	/	50
38	110	/	52
40	140	/	74
44	190	/	80
48	/	/	86

Recommended fitting practices

The precautions taken when fitting bearings have a considerable influence on the results obtained once the spindle is in service.

General precautions

Cleanliness is critical. The spindles must be assembled in a clean, well-lit room, away from the manufacturing areas to avoid any risk of contamination.

Pre-assembly checks

The dimensions and tolerances of the spindle component parts must be verified before installation. Refer to the characteristics defined in the chapters "bearing shoulder and seat manufacturing tolerances" and "spacer and clamping nut tolerances".
All parts, except the bearings, must be carefully cleaned and dried before assembly.

Precautions concerning the bearings

Keep bearings in their original box until just before they are to be fitted. The oil film used to protect them against corrosion is compatible with all lubricants we recommend.
Do not clean the bearings.

Installation of bearings

The bearing seats must be coated with an oil having corrosion-inhibitor additives.

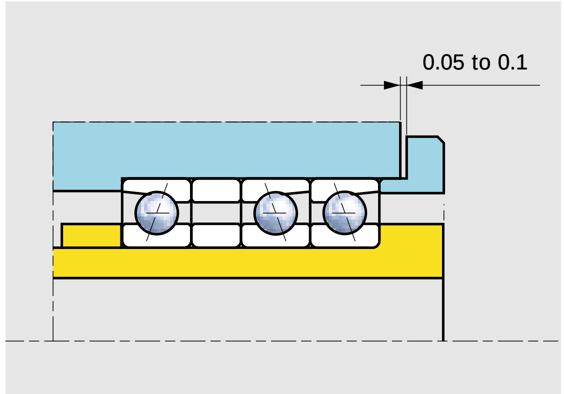
Choice of outside diameter and bore dimensions
To obtain the desired preload and to ensure uniform distribution of the external load between the bearings in an arrangement, it is recommended to have virtually identical interference or loose fits between these bearings and their seats (shaft and housing).
The outside diameter and bore dimensions are imprinted on the box: the choice of dimensions can therefore be made without removing the bearing from its package.

Lubrication:
• Choice: see lubrication chapter, page 44.
• Precautions:
- When grease lubrication is used, put the proper volume as indicated on page 45.
- The grease must be introduced with a graduated syringe.
- SNR can provide bearings pre-greased: suffix D.
- In the case of oil lubrication, introduce in the bearing some oil of the same type as that specified for the application. Taking this precaution will avoid the risk of a dry start which could seriously damage the bearings.

Position of bearings:

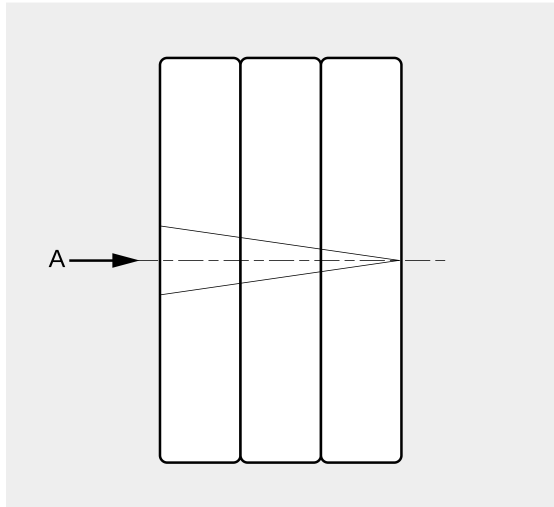
• Universal bearings and universal pairs: be extremely careful to position the bearings according to the correct contact angles.

• Matched bearing arrangements:
- An arrangement is inseparable and must not be mixed up.
- Re-match the V marked on the outside diameter of the bearings in order to correctly position the bearings in the arrangement.
- Position the apex of the V in the direction of the external axial load A.



Fitting:

• Heat-assisted fitting (expansion) is preferable to any other method.
If this is impossible, apply the pressure to the entire perimeter of the ring to be fitted. Do not exert any pressure on the other ring because the balls must never transmit a force-fitting load.
• Fitting by impact (e.g. with a hammer) is strictly prohibited.
• The end-cap bolts should be progressively tightened in a criss-cross manner to prevent skewing of the outer ring(s) in the housing.
• Check that the shaft does not become distorted when the nut is tightened, measure the out-of-roundness and rotational run-out of the spindle before and after tightening: the values should be identical.



Run-in Procedure

The run-in procedure has a considerable influence on the precision of spindle rotation and its service life. It is therefore important to take great care with this operation.
The procedure must be carried out in steps, which depend on the type of spindle and the temperature rise.
The speed of rotation of the first step must be low enough (NDm of the order of 10^5) to be certain the lubrication film is established.
The duration of each step depends on the time required for the bearing temperatures to stabilize; as soon as the temperature is stabilized, proceed to the next step.

Technical assistance – failure analysis

SNR services

SNR ROULEMENTS can help you with prototype installations or post-operation analysis of bearings.
To enable the SNR technical services to perform an optimum analysis, it is essential to:
• remove the bearings with the utmost care: difficult to differentiate defects resulting from the service conditions and those due to careless removal.
• send the bearings as is (do not clean them)
• mark the position of the bearings in the spindle
• provide information on the fitting and operating conditions: speed, load, lubrication, etc.
• supply an assembly drawing of the spindle.