

Bearing Technical Calculation Tool Usage Method

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1-1. Overview of Bearing Technical Calculations

There are five technical calculations that can be performed within the NTN Bearing Technical Calculation Tool.

1.	Basic rating life	
	(calculation function)	 Can be input/output in SI units Input/output either grease lubrication or oil lubrication Bearing basic rating life based on JIS (<i>L</i>_{10h}) or modified rating life that takes into account <i>Q</i>_{1SO} (<i>L</i>_{10mh})
	(input item)	 Can be selected by entering the boundary dimensions (inner dia., outer dia., width) and searching for the bearing, or entering the bearing product name Selection of the calculated bearing life, lubrication (oil, grease) Up to 10 steps can be entered for the load placed on the bearing (radial load, axial load) and rot. speed Required life [For modified rating life] In addition to the above, the contamination level or contamination factor, lubricating oil kinematic viscosity (40°C, 100°C), and operating temperature
	(output item)	 Basic rating life (L_{10h}), basic dynamic load ratings, basic static load ratings, fatigue limit load, equivalent load, limiting speed (catalog, adjusted) [For modified rating life] In addition to the above, the modified rating life (L_{10mh}), contamination level or contamination factor, operating temperature, lubricating oil viscosity during operation, reference kinematic viscosity, viscosity ratio and life modification factor
2.	Gear load and bas	sic rating life
	(calculation function)	 Can be input/output in SI units Input/output either grease lubrication or oil lubrication Applies to 2 shafts Bearing supported at two points on the shaft Up to five gear meshing conditions Bearing basic rating life based on JIS (<i>L</i>_{10h}) or modified rating life that takes into account <i>α</i>_{ISO} (<i>L</i>_{10mh})
	(input item)	 Can be selected by entering the boundary dimensions (inner dia., outer dia., width) and searching for the bearing, or entering the bearing product name Distance bet. bearings Selection of the calculated bearing life, lubrication (oil, grease) Gear specifications Input shaft tor. Input shaft rot. [For modified rating life] In addition to the above, the contamination level or contamination factor, lubricating oil kinematic viscosity (40°C, 100°C), and operating temperature
	(output item)	 Gear torque of the input shaft and output shaft, rot. speed, and gear load (tangent dir. load, radial dir. load, axial dir. load) under each condition Total life (<i>L</i>_{10h}), brg. system life, basic dynamic load ratings, and fatigue limit load of each bearing Bearing load (radial dir. load, axial dir. load), limiting speed (adjusted), rot. speed, equivalent load, basic rating life (<i>L</i>_{10h}), and frequency of each bearing, under each condition [For modified rating life] In addition to the above, the modified rating life (<i>L</i>_{10mh}), contamination level or contamination factor, operating temperature, lubricating oil viscosity during operation, reference kinematic viscosity, viscosity ratio and life modification factor
3.	Bearing load and	basic rating life
	(calculation function)	 Can be input/output in SI units Input/output either grease lubrication or oil lubrication

Input/output entrier grease lubrication of on lubrication
 Selection of the calculated bearing life, lubrication (oil, grease)

	 Bearing basic rating life based on JIS (L_{10h}) or modified rating life that takes into account
(input item)	 Can be selected by entering the boundary dimensions (inner dia., outer dia., width) and searching for the bearing, or entering the bearing product name Distance bet. bearings Load conditions (radial load, axial load, moment load, load center position) Rot. speed [For modified rating life] In addition to the above, the contamination level or contamination factor, lubricating oil kinematic viscosity (40°C, 100°C), and operating temperature
(output item)	 Bearing basic rating life (L_{10h}), brg. system life Bearing load (radial load, axial load), equivalent load, basic dynamic load ratings, basic static load ratings Limiting speed (catalog, adjusted) [For modified rating life] In addition to the above, the modified rating life (L_{10mh}), contamination level or contamination factor, operating temperature, lubricating oil viscosity during operation, reference kinematic viscosity, viscosity ratio and life modification factor
4. Operating cleara	nce calculation
(calculation function)	 Can be input/output in SI units Radial internal clearance taking into account the fit with the shaft and bearing, bearing and housing, and shaft and housing material and temperature Fitting pressure and fitting stress calculation taking into account the fit with the shaft and bearing, bearing and housing, and shaft and housing material and temperature
(input item)	 Can be selected by entering the boundary dimensions (inner dia., outer dia., width) and searching for the bearing, or entering the bearing product name Bearing tolerances Radial internal clearance Shaft bore diameter, housing outer diameter Fit with shaft and housing Material of shaft and housing Shaft, housing temperature under operating condition
(output item)	 Minimum and maximum values of the residual clearance, fitting pressure and fitting stress after fitting (not taking into account the temperature of the shaft and housing) Minimum and maximum values of the operating clearance, fitting pressure and fitting stress under operating condition (taking into account the temperature of the shaft and housing)
5. Bearing vibration	n frequency
(calculation function)	 Calculate the bearing vibration frequency generated form within the bearing due to rotation of the bearing
(input item)	 Can be selected by entering the boundary dimensions (inner dia., outer dia., width) and searching for the bearing, or entering the bearing product name Rot. speed
(output item)	 Rotational speed of cage Rotational speed of cage relative to inner ring Number of load cycles of inner ring per second Number of load cycles of outer ring per second Rotational speed of rolling element

1-2. Screen flowchart

On-screen processing for each window is displayed in Fig. 1.



Fig. 1. Screen transition between each window

1-3. Bearing technical calculation screen operation

1-3-1. Description of on-screen buttons

Print	Prints the displayed screen on a printer or similar device.
ОК	If there is no error, proceed to the next screen. If there is an error, a warning screen is displayed.
Calculate	If there is no error, the calculation results screen is displayed. If there is an error, a warning screen is displayed.
Search	Search for bearings from the inner dia., outer dia. and width. (see <u>1-3-12. Bearing search window</u>)
Bearing A (B, C, D)	The basic rating life (L_{10h}) and the modified rating life (L_{10mh}) are displayed for each condition of the selected bearing.
Bearing life ······	If there is no problem with use under the operating conditions of the bearing, the total life of the bearing system and bearing is displayed. If there is a problem with use under the operating conditions of the bearing, an error message is displayed.
Detail of Brg. life	The basic rating life (L_{10h}) for each condition of each bearing and the modified rating life (L_{10mh}) depending on the selection are displayed.
Condition 1 (2, 3, 4, 5) ···	For <u>1-3-8. Gear load and basic rating life</u> , the screen switches to one where the gear specifications of meshing conditions for the selected gear are input.
Detailed display	The results of the detailed operating life for the selected bearing are displayed.
Main menu ·····	·Changes to the main menu.
Return ·····	Changes to the previous screen.

1-3-2. Description of selection items

Axial loadFor <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u>, when a bearing other than the following bearings is selected, click whether or not to apply an axial load with the mouse. (the load is applied by default)

Angular contact ball brgs., tapered roller brgs. (metric series), tapered roller brgs. (inch series)

Bearing typeFor <u>1-3-7. Basic rating life</u>, click the appropriate bearing from the following displayed bearing types with the mouse.

Deep groove ball brgs., expansion compensating brgs., miniature ball brgs., (metric series), angular contact ball brgs. (30°, 40°), four-point contact ball brgs., double row angular contact ball brgs., self-aligning ball brgs., cylindrical roller brgs., double row cylindrical roller brgs., tapered roller brgs. (metric series), tapered roller brgs. (inch series), double row tapered roller brgs. (outward facing), double row tapered roller brgs. (inward facing), spherical roller brgs., thrust ball brgs., thrust self-aligning roller brgs.

For <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u>, click the appropriate bearing from the following displayed bearing types with the mouse. Deep groove ball brgs., expansion compensating brgs., miniature ball brgs. (metric series), angular contact ball brgs. (30°, 40°), double row angular contact ball brgs., self-aligning ball brgs., cylindrical roller brgs., double row cylindrical roller brgs., tapered roller brgs. (metric series),

	tapered roller brgs. (inch series), double row tapered roller brgs. (outward facing), double row tapered roller brgs. (inward facing), spherical roller brgs.
	For <u>1-3-10. Operating clearance calculation</u> , click the appropriate bearing from the following displayed bearing types with the mouse.
	Deep groove ball brgs., cylindrical roller brgs. spherical roller brgs.
	For <u>1-3-11. Bearing vibration frequency</u> , click the appropriate bearing from the following displayed bearing types with the mouse.
	Deep groove ball brgs., angular contact ball brgs. (30°, 40°), self-aligning ball brgs. cylindrical roller brgs., tapered roller brgs. (metric series), tapered roller brgs. (inch series), spherical roller brgs.
Bearing tolerances	•For <u>1-3-10. Operating clearance calculation</u> , click the bearing precision to use from JIS Class 0, JIS Class 6, JIS Class 5, JIS Class 4 and JIS Class 2 with the mouse. (see <u>1-7. attached tables</u> 1 and 2)
Bearing selection ·····	For <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u> , select the bearing by entering the bearing type and NTN product name.
Shaft material	•For <u>1-3-10. Operating clearance calculation</u> , click the shaft material to use with the mouse. The materials that can be selected are as displayed below. (see <u>1-7. attached tables</u> 14) Bearing steels, carbon steels, gray iron castings, spheroidal graphite iron castings, aluminium, martensitic stainless steels, austenitic stainless steels, copper
Fit with shaft ·······	•For <u>1-3-10. Operating clearance calculation</u> , click the fit symbol of the bearing and shaft to use with the mouse.

The fit symbols that can be selected are as displayed below. (see 1-7. attached tables 6 to 9)

h7 j7 k7 r h8 h9 h10	d6	e6	f6	g5 g6	h5 h6 h7 h8 h9 h10	j5 j6 j7	js5 js6	k5 k6 k7	m5 m6	n6	p6	r6 r7
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 Housing material
 ·····For <u>1-3-10. Operating clearance calculation</u>, click the housing material to use with the mouse. The materials that can be selected are as displayed below. (see <u>1-7. attached tables</u> 14) Bearing steels, carbon steels, gray iron castings, spheroidal graphite iron castings, aluminium, martensitic stainless steels, austenitic stainless steels, copper

 Fit with housing
 ·····For 1-3-10. Operating clearance calculation, click the fit with bearing and housing symbol to use with the mouse.

 The fit symbols that can be selected are as displayed below. (see 1-7. attached tables 10 to 13)

						K5	M5	N5	
E6	F6	G6	H6	J6	JS6	K6	M6	N6	P6
	F7	G7	H7 H8	J7	JS7	K7	M7	N7	P7

.ubrication Click either oil or grease to use with the mouse. (grease is selected by default)			
Contact ang. ort	For <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u> , when a bearing other than the following bearings are selected, click the direction of the contact ang. wit the mouse.		
	Angular contact ball brgs., tapered roller brgs. (metric series), tapered roller brgs. (inch series)		
I/O Param. UnitI/O param. unit for load, etc., is SI only.			
Input shaft rotation di	rection For <u>1-3-8. Gear load and basic rating life</u> , click either clockwise or counterclockwise to use with the mouse. (clockwise is selected by default)		
Gear shape A (gear sl	 hape B)For <u>1-3-8. Gear load and basic rating life</u>, click the gear to use from spur, helical-right or helical-left with the mouse. (spur is selected by default) 		
Radial internal cleara	nce For <u>1-3-10. Operating clearance calculation</u> , click the bearing radial internal clearance to use from C2, CN, C3, C4 or C5 with the mouse. (see <u>1-7. attached tables</u> 3 to 5)		

1-3-3. Description of input items

Axial load	[.] For <u>1-3-7. B</u> For <u>1-3-9. B</u>	<u>asic rating life</u> , enter the axial load to be applied to the bearing. (kgf) <u>earing load and basic rating life</u> , enter the axial load to be applied to the bearing. (N)
Pres. angle ······	•For <u>1-3-8. G</u>	ear load and basic rating life, enter the pres. angle of the gear. (°)
Operating temperatur	e	For <u>1-3-7</u> . Basic rating life, <u>1-3-8</u> . Gear load and basic rating life, and <u>1-3-9</u> . Bearing load and basic rating life, enter the assumed operating temperature when the modified rating life L_{10mh} (taking into account α_{ISO}) was selected for the calculated operating life selection in each of these. If this is not entered, it will automatically be set to 20°C. (°C)
Shaft temperature une operating condition	der	For 1 <u>-3-10. Operating clearance calculation</u> , enter the temperature of the shaft under operating condition If this is not entered, it will automatically be set to 20° . (°C)
Housing temperature under operating condition		For <u>1-3-10. Operating clearance calculation</u> , enter the temperature of the housing under operating condition If this is not entered, it will automatically be set to 20° . (°C)
NTN product name	•Enter the N1 (for calculati name is unk	FN bearing number ons other than <u>1-3-7. Basic rating life</u> , click the "Search" button if the NTN product nown, and use the <u>1-3-12 Bearing search window</u>)
Contamination factor	<i>e</i> _c	For <u>1-3-7. Basic rating life</u> , <u>1-3-8. Gear load and basic rating life</u> , and <u>1-3-9. Bearing load and basic rating life</u> , select the contamination level or directly enter the value was selected for the calculated operating life selection in each of these.
Rot. speed ······	For <u>1-3-7. B</u> For <u>1-3-9. B</u> speed of the	<u>asic rating life</u> , enter the rot. speed of the bearing. <u>earing load and basic rating life</u> and <u>1-3-11. Bearing vibration frequency</u> , enter the rot. • shaft (inner ring). (min ⁻¹)

Calculated operating life	election …For <u>1-3-7. Basic rating</u> load and basic rating for each of these	ng life, <u>1-3-8. Gear load and basic rating life</u> , and <u>1-3-9. Bearing</u> <u>life</u> , select basic rating life (L_{10h}) or modified rating life (L_{10mh})
	(Basic rating life (L_{10}	h) is selected by default.)
Distance bet. effective	oad For <u>1-3-8. Gear load</u> if bearing A and bear below, enter the dista load of the other bea	and basic rating life and <u>1-3-9</u> . Bearing load and basic rating life, ring B (bearing C and bearing D) are the bearings displayed ance between the effective load of one bearing and the effective aring. (mm)
	Angular contact ball (inch series)	brgs., tapered roller brgs. (metric series), tapered roller brgs.
Distance between bea A and bearing B (distance between bea and bearing D)	ng ······For <u>1-3-8. Gear load</u> <u>distance rating life</u> , e ing C bearing B (bearing C	and basic rating life and <u>1-3-9. Bearing load and bearing basic</u> enter the distance between the bearing centers of bearing A and and bearing D). (mm)
Shaft bore diameter ···	or <u>1-3-10. Operating clearance</u> ne calculation will be made as a	calculation, enter the inner dia. of the shaft. If this is not entered, solid shaft. (mm)
Housing outer diameter…	or <u>1-3-10. Operating clearance</u> ntered, it will automatically be s	<u>calculation</u> , enter the outer dia. of the housing. If this is not et to a size 1.3 times the shaft outer dia. (mm)
Lubrication	or 1 <u>-3-7. Basic rating life</u> , <u>1-3-8.</u> asic rating life, select the contar	. Gear load and basic rating life, and <u>1-3-9. Bearing load and</u> mination level or enter the contamination factor directly.
Lubricating oil kinemation	viscosity For <u>1-3-7. Basic rating</u> load and basic rating for each of these. It i viscosity grade table (mm ² /s)	ng life, <u>1-3-8. Gear load and basic rating life</u> , and <u>1-3-9. Bearing</u> <u>life</u> , enter the lubricating oil kinematic viscosity at 40°C and 100°C s also possible to click and enter any item from the ISO dynamic or the grease characteristics table depending on the lubrication.
Use rate	or <u>1-3-7. Basic rating life</u> , enter ne step, there is no need to enter	the hours or the ratio for performing each step. If there is only er this. (hours or %)
Frequency	or <u>1-3-8. Gear load and basic ra</u>	ating life, enter the frequency of the gear meshing conditions. (%)
Steps	or <u>1-3-7. Basic rating life</u> , enter	the number of ways the load conditions and rot. speed change.
Inner dia., outer dia., v	dth For <u>1-3-7. Basic ratir</u> of at least the bearin the bearing. (mm) In the <u>1-3-12. Bearin</u> inner dia., bearing ou	ng life, if the NTN product name is unknown, enter the min or max g inner dia., bearing outer dia. or bearing width, and search for ng search window, enter the min or max of at least the bearing uter dia. or bearing width, and search for the bearing. (mm)
Input shaft rot.	or <u>1-3-8. Gear load and basic ra</u> nin ⁻¹)	ating life, enter the rot. speed to be applied to the input shaft.
Input tor.	or <u>1-3-8. Gear load and basic ra</u>	ating life, enter the torque to be applied to the input shaft. (N-mm)
Twisting angle	or <u>1-3-8. Gear load and basic ra</u> f the gear. (°)	ating life, when selecting the helical gear, enter the twisting angle
Gear pos.	or <u>1-3-8. Gear load and basic ra</u> ear. (mm)	ating life, enter the distance from the reference bearing to the

Teeth	For <u>1-3-8. Gear load and basic rating life</u> , enter the number of gear teeth.
Notes	Enter comments related to the calculations. The calculation is not affected even if this is left empty.
Module	For <u>1-3-8. Gear load and basic rating life</u> , enter the module of gear.
Moment load	For <u>1-3-9. Bearing load and basic rating life</u> , enter the moment load to be applied to the shaft. (N-mm)
Required life	For 1-3-7. Basic rating life, enter the minimum life required of the bearing. (hours)
Radial load	For <u>1-3-7. Basic rating life</u> , enter the radial load to be applied to the bearing. (N) For <u>1-3-9. Bearing load and basic rating life</u> , enter the radial load to be applied to the bearing. (N)

1-3-4. Description of output items

Axial load ······Axial load placed on the bearing (Fa) (N)						
Axial dir. load	For <u>1-3-8. Gear load and basic rating life</u> , the load generated in the gear axial direction is displayed. (N)					
Operating clearance …	For <u>1-3-10. Operating clearance calculation</u> , fit the bearing on to the shaft and housing, and the radial internal clearance under operating conditions is displayed. (mm) The min and max operating clearance is displayed as there are tolerances with the initial radial internal clearance, fit with shaft and fit with housing.					
NTN product name	·Bearing number					
Contamination factor	or For <u>1-3-7. Basic rating life</u> , <u>1-3-8. Gear load and basic rating life</u> , and <u>1-3-9. Bearing load</u> and basic rating life, the contamination level and contamination factor are displayed.					
Outer dia.	Bearing outer dia. (D) (mm)					
Rot. speed For <u>1-3-7. Basic rating life</u> and <u>1-3-11. Bearing vibration frequency</u> , the rot. speed of the bear displayed. (min ⁻¹) For <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u> , the rot speed of the bearing is displayed. (min ⁻¹)						
Number of load cycles outer ring per second	ofFor <u>1-3-11. Bearing vibration frequency</u> , the number of rolling elements that pass through a single point on the outer track surface per second. (Hz)					
Reference kinematic v	iscosity \cdots Depends on rotation speed n and size (D_{pw}) of the bearing. (mm ² /s)					
Basic static load rating	ys Static radial load (static central axial load) (C_{or} or C_{oa}) (N) corresponding to the calculated contact stress displayed below at the contact center with the rolling element and track being subjected to maximum load					
	Self-aligning ball brgs.: 4600 MPa Other ball brgs.: 4200 MPa Roller brgs.: 4000 MPa					
	The total permanent deformation of the rolling element and track under these contract stresses is approximately 0.0001 times the diameter of the rolling element.					

Basic rating life	When individual bearings within the same group are rotated under the same conditions, this is the actual total number of rotations that is possible when 90% (90% reliability) of those bearings rotate without any flaking caused by rolling fatigue is generated. When the bearing is rotated at a fixed rpm, the total number of hours is used. (hours)
Basic dynamic load rat	ings A certain static radial load (central axial load) (<i>C</i> r or <i>C</i> a) (N) that the bearing should theoretically be able to withstand a basic rating life of 1 million rotations.
Gear torque	For <u>1-3-8. Gear load and basic rating life</u> , the torque applied to the gear is displayed. (N-mm)
Limiting speed	As the rot. speed of the bearing increases, the temperature of the bearing increases due to friction heat generated within the bearing, which causes burning and other damage, preventing reliable operation of the bearing from continuing. This limiting rotational speed is called the limiting speed. (min ⁻¹) The "Catalog" is the limiting speed value listed in the "NTN BII and Roller Bearing Catalog" (CAT.NO.2203/E). The "Adjusted value" is the value acquired when the adjusted coefficient is applied by applying a load to the "Catalog" value.
Count of result	For <u>1-3-7. Basic rating life</u> , this is the number of bearings when (basic rating life) \geq (required life) is met.
Residual clearance ···	For <u>1-3-10. Operating clearance calculation</u> , the radial internal clearance is displayed with the bearing fit to the shaft and housing. (mm) The min and max residual clearance is displayed as there are tolerances with the initial radial internal clearance, fit with shaft and fit with housing.
Corrected rating life	The life corrected using the $a_{\rm ISO}$ factor that was calculated from the contamination factor, lubricating oil kinematic viscosity, operating temperature, etc., against the basic rating life L_{10h} . (hours)
Bearing life	For <u>1-3-8. Gear load and basic rating life</u> , the total life of each bearing takes into account the frequency of gear meshing conditions. (hours) For <u>1-3-9. Bearing load and basic rating life</u> , this is the basic rating life (L_{10h}) of each bearing calculated from the bearing load placed on each bearing. (hours)
Brg. system life ·······	For <u>1-3-8. Gear load and basic rating life</u> and <u>1-3-9. Bearing load and basic rating life</u> , this is the life for bearing systems that are supported by two bearings until either bearing becomes damaged due to rolling fatigue. (hours)
Modified rating life …	Obtained with the following formula from the basic rating life using the life modification factor $L_{nm} = a_1 \cdot a_{ISO} \cdot L_n$
Life	For <u>1-3-8. Gear load and basic rating life</u> , this is the basic rating life (L_{10h}) for each meshing condition of the gear in the Detail of Brg. life window. (hours) For <u>1-3-9. Bearing load and basic rating life</u> , this is the basic rating life (L_{10h}) for each bearing in the Detail of Brg. life window. The value is the same as "Bearing life." (hours)
Life modification factor ···	Obtained by integrating material characteristics and lubrication conditions. It is given as a function like the following formula in ISO 281:2007.
	$\alpha_{\rm ISO} = f\left(\frac{e_c C_{\rm u}}{p} k\right)$
Lubrication	The selected lubrication conditions are displayed. (oil lubrication or grease lubrication)

Use rate	For <u>1-3-7. Basic rating life</u> , the hours or the ratio for performing each step is displayed. If the number of steps is "1" and no use rate is entered, the use rate in the output is displayed as "1." (hours or %)
Frequency	For <u>1-3-8. Gear load and basic rating life</u> , the frequency of the gear meshing conditions is displayed. (%)
Tangent dir. load	 For <u>1-3-8. Gear load and basic rating life</u>, the load generated in the gear Tangent dir. is displayed. (N)
Total life	For <u>1-3-8. Gear load and basic rating life</u> , this is the total life of each bearing taking into account the frequency of the meshing condition of the gear in the Detail of Brg. life window. (hours) For <u>1-3-9. Bearing load and basic rating life</u> , this is the basic rating life (L_{10h}) for each bearing in the Detail of Brg. life window. The value is the same as "Bearing life" and "Life." (hours) • The selected units are displayed. (SI unit or Gravit. unit)
Rotational speed of rolling element	For <u>1-3-11. Bearing vibration frequency</u> , the rot. speed of the rolling element per second is displayed when viewed from the center of the bearing. (Hz)
Equivalent load	A certain static radial load (central axial load) placed on the bearing so that the same life as the life of bearings achieved under actual load conditions is attained. ($Pr \text{ or } Pa$) (N)
Inner dia.	Bearing inner dia. (d) (mm)
Number of load cycles of inner ring per second	For <u>1-3-11. Bearing vibration frequency</u> , the number of rolling elements that pass through a single point on the inner track surface per second. (Hz)
Rotational speed of cage ··· relative to inner ring	For <u>1-3-11. Bearing vibration frequency</u> , this is the rotational speed of the cage per second relative to the standard rotating inner ring. (Hz)
Width	Bearing width (B) (mm)
Fitting stress	For <u>1-3-10. Operating clearance calculation</u> , the stress generated when fitting the shaft and bearing is displayed. (MPa)
	The min and max fitting stress is displayed as there are tolerances in fitting with the shaft.
Fitting stress	For <u>1-3-10. Operating clearance calculation</u> , the stress generated when fitting the bearing and housing is displayed. (MPa)
	The min and max fitting stress is displayed as there are tolerances in fitting with the housing.
Fitting pressure (bearing and housing)	For <u>1-3-10. Operating clearance calculation</u> , the pressure generated when fitting the bearing and housing is displayed. (MPa)
	The min and max fitting pressure is displayed as there are tolerances in fitting with the housing.
Fitting pressure (shaft and bearing)	For <u>1-3-10. Operating clearance calculation</u> , the pressure generated when fitting the shaft and bearing is displayed. (MPa)
	The min and max fitting pressure is displayed as there are tolerances in fitting with the shaft.
Fatigue limit load ·····	Load applied on bearings that becomes the fatigue limit stress at the maximum load contact part of the raceway. This depends on the bearing internal specifications, quality, and material strength. The fatigue limit load values with respect to the NTN bearing numbers are specified in each specification table. (N)
Rotational speed	For <u>1-3-11. Bearing vibration frequency</u> , this is the rot. speed of the cage per second. (Hz)

NotesDetails entered into the notes are displayed as they are.

- Required lifeFor 1-3-7. Basic rating life, the required life that was entered is displayed. (hours)
- Radial loadRadial load placed on the bearing (Fr) (N)
- Radial dir. loadFor <u>1-3-8. Gear load and basic rating life</u>, the load generated in the gear radial direction is displayed. (N)

1-3-5. Description of quantity symbols

- *B*Bearing width (mm)
- CBasic dynamic load ratings (N)
- Ca ······Basic dynamic axial load ratings (N) If the bearing type is four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. C=Ca
- Cr ·······Basic dynamic radial load ratings (N) If the bearing type is a bearing other than four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. C=Cr
- CoBasic static load ratings (N)
- CoaBasic static axial load ratings (N) If the bearing type is four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. Co=Coa
- Cor.....Basic static radial load ratings (N) If the bearing type is a bearing other than four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. Co=Cor
- d······Bearing inner dia. (mm)
- DBearing outer dia. (mm)

$$dp$$
 ······As determined by $dp = \frac{d+D}{2}$ (mm)

- Fa ······Axial load (N)
- FrRadial load (N)
- n ······Rot. speed (min⁻¹)
- *P*Equivalent load (N)
- Pa ······Equivalent axial load (N) If the bearing type is four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. P=Pa
- Pr ······Equivalent radial load (N) If the bearing type is a bearing other than four-point contact ball brgs., thrust ball brgs., thrust spherical roller brgs. P=Pr

1-3-6. Technical calculation menu screen

NTN		Usage Method (1596K3) 2 Instructions for Use, Desclaimer, etc. S Inquiry 3
Bearing Technical Calculation Tool		
	Select a calculation from the following menu.	
	Basic rating life	
	Gear load and basic rating life	
	Bearing load and basic rating life	
	Operating clearance calculation	
	Bearing vibration frequency	
		Copyright in NTN Corporation. All Right Reserv

Screen No. 1 Technical calculation menu window

1-3-7. Basic rating life

1. Bearing selection

acic rating life						
basic rating life						
lotes (feel free to use ti Test data No.1	his field)					
			Al .			
alculation cond	itions					
The field marked with * i	s required.Enter numbers as ha	ilf-width.				
	· Danie cation Mo. 1.44					
	 Modified rating life - L 	lered)				
Selection of the	<note></note>					
calculated bearing	Fatigue limit load Cu used	for the calculation (of L10mh depends on ti	he bearing mate	rial. Therefore, b	earings
, me	Bearings that are not mad	de of bearing steel ti	hat underwent standard	i heat treatment	cannot be used	for the
	calculation.					
(Precautions and terms o	f use) Select grease lubrication	for double sealed be	arings or double shielded	bearings		
Lubrication	· Grease Oil					
	1. 					
Bearing type *	Deep Groove Ball Brgs.		•			
Bearing type *	Deep Groove Ball Brgs.	arch…	•			
Bearing type * Product number	Deep Groove Ball Brgs.	arch…	•			
Bearing type * Product number -*The following items wi	Deep Groove Ball Brgs.	earch…	•			_
Bearing type * Product number *The following items wi	Deep Groove Ball Brgs. Se	tarch…	•	nin	max	
Bearing type * Product numberThe following items wi	Deep Groove Ball Brgs. Se disabled if a product numb	earch	•	nin	max	
Bearing type * Product number = The following items w Inner dia. (mm)	Deep Groove Ball Brgs. Se disabled if a product numb	xarch…	• 25	nin to	max 40	
Bearing type * Product number *The following items w Inner dia. (mm) Outer dia. (mm)	Deep Groove Ball Brgs. Se disabled if a product numb	varch…	• 25 50	nin to	max 40 60	
Bearing type * Product number = *The following items w Inner dia. (mm) Outer dia. (mm)	Deep Groove Ball Brgs. Se If be disabled if a product numb	ver is entered.	• 25 50	nin to	max 40 60	
Bearing type * Product number =*The following items w Inner dia. (mm) Outer dia. (mm) Width (mm)	Deep Groove Ball Brgs. Se If be disabled if a product numb	er is entered.	• 25 50 10	nin to to to	max 40 60 20	
Bearing type * Product number *The following items w Inner dia. (mm) Outer dia. (mm) Width (mm)	Deep Groove Ball Brgs. Se disabled if a product numb	verch…	• 25 50 10	nin to	max 40 60 20	

Screen No. 2 Bearing selection window

(selection item) (see <u>1-3-2 Description of selection items</u>) Life selection, bearing type, lubrication

(input item) (see <u>1-3-3 Description of input items</u>)

Enter the calculation details into the notes if necessary.

If the NTN product name is known

Enter the NTN product name.

If the NTN product name is unknown

Enter at least one of inner dia. (min and max), outer dia. (min and max), and width (min and max).

NTN

2. Enter operating conditions

ione reacting	life			
tes (feel free t: st data No.1	o use this field)			
erating co	onditions			
e field marked	with * is require	d.Enter numbers as half-width.		
Steps * Contamination factor ec * See index		4	Required life (hours)	1000
		Standard cleanliness Manual input	Lubricating oil dynamic viscosity (mm ² /s)* See grease natures	40°C: 131 100°C: 12.2 «Note» Please consult NTN Engineering when using Jubricant
Unit for us	e rate *	• hours O Percentage (%)		
Unit for us	e rate * Rad	hours Percentage (%) ial load * Axial load *	Rot. speed (min'	1) * Use rate*
Unit for us Step No.	e rate * Rad	hours Percentage (%) Ial load * Axial load * 400	Rot. speed (min	1) * Use rate*
Unit for us Step No. 1 2	e rate * Rad 1000 1500	hours Percentage (%) ial load * Axial load * 400 600	Rot. speed (min 1000 1200	1 2
Unit for us Step No. 1 2 3	e rate * Rad 1000 1500 2000	hours Percentage (%) Hal load * Axial load * 400 600 800	Rot. speed (min 1000 1200 1400	1) * Use rate* 1 2 4
Unit for us Step No. 1 2 3 4	e rate * Rad 1000 1500 2000 2000	hours Percentage (%) Axial load * Axial load * 400 600 800 1000	Rot. speed (min 1000 1200 1400 1600	1) * Use rate* 1 2 4 4
Unit for us Step No. 1 2 3 4 5	e rate * Rad 1000 1500 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000	Rot. speed (min 1000 1200 1400 1600	1)* Use rate* 1 2 4 4
Unit for us Step No. 1 2 3 4 5 6	e rate * Rad 1000 1500 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000	Rot. speed (min 1000 1200 1400 1600	²) * Use rate ⁴ 1 2 4 4
Unit for us Step No. 1 2 3 4 5 6 7 7	e rate * Red 1000 1500 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000	Rot. speed (min 1000 1200 1400 1600	¹) * Use rate* 1 2 4 4 4
Unit for us Step No. 1 2 3 4 5 6 7 8 0	e rate * Rad 1000 1500 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000	Rot. speed (min* 1000 1200 1400 1600	1) * Use rate* 1 2 4 4 4
Unit for us Step No. 1 2 3 4 5 6 6 7 7 8 9 0	e rate * Rad 1000 1500 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000	Rot. speed (min 1000 1200 1400 1600	1) * Use rate* 1 2 4 4 4
Unit for us Step No. 1 2 3 4 5 6 7 8 9 9 10	e rate * Rad 1000 2000 2000	hours Percentage (%) Ial load * Axial load * 400 600 800 1000 1000 C	Rot. speed (min' 1000 1200 1400 1600	²) * Use rate ⁴ 1 2 4 4 4

Screen No. 3 Enter operating conditions (The section in the red box is only for the modified rating life)

(input item) (see 1-3-3 Description of input items)

Always enter the number of steps.

Enter the required life if necessary.

Always enter the rot. speed and use rate for each step. For a single step, the use rate does not need to be entered. Enter the required item for each step for the radial load and axial load.

(When modified rating life was selected) Select the contamination level or select "Direct input" and then directly enter the contamination factor value. Always enter the lubricating oil kinematic viscosity for 40°C and 100°C. Always enter the operating temperature. Click the "See index" button to open the "Contamination factor ec index" and confirm the content of each contamination level. Also, click the "See ISO grade table" button (for oil lubrication) and the "See grease characteristics table" button (for grease lubrication) to open a table with typical base oil viscosity for each lubricant. Click the row in the table to enter the corresponding base oil viscosity value in the column for 40°C and 100°C of the lubricating oil kinematic viscosity.

3. Life calculation results display

<List display of life>

asic rating	life								
date ruting	inc								
et data No.1									
on one work									
perating co	onditions								
I/O Para	n. Unit	SI Unit [mm, N, MPa]			Lu	brication		Greas	se
Steps		4			Require	d life (hours))	1,00	0
Unit for use rate			hours		Cour	nt of result		5	
Contamination factor e _C		s	tandard cleanlin	cleanliness Lut		Lubricating oil dynamic viscosity (mm ² /s)		40°C: 131 100°C: 12.2	
Operating tem	perature (°C)		20						
alculation r lect a product in Product number	esult the following lis Basic dynamic load ratings	t to display r Equivalent	nore detailed inf Basic rating life (hours)	ormation, Basic rating life (hours)	Limiting speed	Limiting	Inner dia.	Outer dia.	Width
	(N)	load (N)	L10mh	L10h	(Catalog)	(Adjusted)	(mm)	(mm)	(mm)
6205	15 500.00	2 270.00	39 500.0	3 800.0	13 000	10 600	25.0	52.0	15.0
60/28	13 800.00	2 240,00	33 000.0	2 790.0	14 000	10 900	28.0	52.0	12.0
62/28	19 800.00	2 340.00	125 000.0	7 200.0	12 000	10 700	28.0	58.0	16,0
6006	14 700.00	2 270.00	48 000.0	3 250.0	13 000	10 300	30.0	55,0	13.0
60/32	13 100.00	2 250.00	31 500.0	2 360.0	12 000	9 050	32,0	58.0	13.0
				Print					

Screen No. 4 List display of life (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, required life, count of result, units, lubrication, **NTN** product name, basic dynamic load ratings, equivalent load, basic rating life (L_{10h}), limiting speed (catalog, adjusted), inner dia., outer dia., width

Note 1) The basic rating life (L_{10h}) is displayed as "9999999.9" if it exceeds 10 million hours.

Note 2) If the count of results exceeds 24, a scroll bar is displayed on the right edge of the screen and the screen can be moved up and down.

Click " \triangle " with the mouse: move the screen up

Click " \bigtriangledown " with the mouse: move the screen down

(When modified rating life was selected) The contamination factor, lubricating oil kinematic viscosity (40°C, 100°C), operating temperature, and modified rating life (L_{10mh}).

-	-			
searing rechnical Calculation	1001			
Basic rating life				
Notes				
Test data No.1				
Calculation condition	s			
Product number		6205	I/O Param. Unit	SI Unit [mm, N, MPa]
Required life (hours)		1,000	Lubrication	Grease
Contamination factor e_C	Stand	ard cleanliness	Lubricating oil dynamic viscosity (mm²/s)	40°C: 131 100°C: 12.2
Operating temperature (°C)		20		
Step No. Radia	load	Axial load	Rot. speed (min*1)	Use rate (hours)
1	1 000	400	1 000	1
2	1 500	600	1 200	2
3	2 000	800	1 400	4
Calculation result	N)	15 500 00	Equivalent load P (N)	7 770 00
Basic static load ratings C. (0	7.850.00	Equivalent load P (N)	550.00
Limiting speed Catalog (min	->	13,000	Limiting speed Adjusted (min ⁻¹)	10 600
Basic rating life - L10h (hou	()	3 800.0	Modified rating life - L10mh (hours)	39 500.0
Contamination factor ec		0.5	Viscosity rate x <approx.></approx.>	4.0000
Viscosity during operation v (mm ² /s) <approx.></approx.>		504.5728	Reference kinematic viscosity vi (mm ² /s) <approx.></approx.>	19.2582
Life modification factor atso <approx.></approx.>		10.3924		
		0	🛃 Print	
		+ Main r	menu 🔸 Return	

<Details of life calculation results>

Screen No. 5 Detailed display of life calculation results (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, **NTN** product name, required life, count of result, units, lubrication, step No., radial load, axial load, rot. speed, use rate, basic dynamic load ratings, basic static load ratings, equivalent load, limiting speed (catalog, adjusted), basic rating life (L_{10h}).

Note 1) The basic rating life is displayed as "9999999.9" if it exceeds 10 million hours.

(When modified rating life was selected) The modified rating life (L_{10mh}), contamination factor, viscosity ratio, kinematic viscosity, reference kinematic viscosity, life correction factor.

1-3-8. Gear load and basic rating life

1. Bearing setting

aring Technical C	Celoviation Tool
ear load an	d basic rating life
tes (feel free to s ist data No.2	use this field)
lculation co	onditions
e field marked wit	th * is required. Enter numbers as half-width.
earing selection-	
A 0 8 0 0	c. ∞ p
election of the alculated earing life *	Besc rating He - Lton Moded rating He - Lton (#30 III considered) Adother strang He - Lton (#30 III considered) Albace Tradius limit load Cu used for the calculation of L1Dinh depends on the bearing material. Therefore, bearings made of bearing materials that underwent standard heat treatment (through hardening) can be acpled. Bearings that an not made of bearing steel that underwent standard heat treatment cannot be used for the calculation.
ubrication	Grease Get
ontamination actor e _C *	Standard deanliness
ubricating oil ynamic iscosity *	40°C 100°C See grease natures <htc> <ht>See grease natures diotes: Please consult NTN Engineering when using lubricars with extreme pressure additive.</ht></htc>
ubricating oil ynamic iscosity * operating emperature C) *	40°C 100°C See greate natures choose Please could NTN Engineering when using bancant with excerne pressure addove.
ubricating oil ynemic scosity * perating mperature C) * earing type *	40°C 100°C See grease natures
ubricating oil ynamic iscosity * perating emperature C) * earing type * roduct number	40°C 100°C See grease natures https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com https://www.execution.com www.execution.com <a href="https://www.execution.c</td></tr><tr><td>ubricating oil
ynamic
scosity *
perating
imperature
C) *
earing type *
roduct number
of Param. Unit</td><td>40°C 100°C See grease natures
https://www.extensionality.org/light-care https://www.extensionality.org/light-care https://www.extensionality.org/light-care https://www.extensionality.org/light-care https://www.extensionality.org/light-care https://www.extensionality.org/light-care https://www.extensionality.org/light-care <a a="" href="https://www.extensionality.org/light-care
<a href=" https:="" light-care<="" www.extensionality.org=""> <a a="" href="https://www.extensionality.org/light-care
<a href=" https:="" light-care<="" www.extensionality.org=""> <a href="https://www.extensionality.org/light-care
<a href=" https:="" light-c<="" td="" www.extensionality.org="">
ubricating of memic accosity * persting persting c) * reduct number reduct number () Param. Unit istance bit. A nd B (mm) *	40°C 100°C See grease natures <toolsey a="" additive.<br="" be="" constraint="" extreme="" of="" pressure="" set="" the="" with=""><toolsey a="" additive.<br="" be="" constraint="" extreme="" of="" pressure="" set="" the="" with=""><toolsey 100c.<="" a="" be="" constraint="" exceed="" going="" is="" of="" set="" td="" temperature="" the="" to=""> Choose a figure of [Bearring A] Choose a figure of [Bearring A] Please select - Search Still Unit (mm, N, 10%)</toolsey></toolsey></toolsey>
ubricating of ynamic accesity * perating imperating projections (C) * earing type * roduct number of Param. Unit istance bit. A nd B (mm) *	40°C 100°C See grease natures 100°C See grease natures

Screen No. 6 Bearing setting window (The section in the red box is only for the modified rating life)

(selection item) (see <u>1-3-2 Description of selection items</u>)

When the bearing type is angular contact ball brgs. (30°, 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series)

Bearing selection, bearing type, lubrication, contact ang. ort. and for other bearing types Bearing selection, bearing type, lubrication, axial load

(input item) (see 1-3-3 Description of input items)

Enter the calculation details into the notes if necessary.

If the NTN product name is known

Enter the NTN product name.

If the NTN product name is unknown

Click the "Search" button and search for the relevant bearing. (see <u>1-3-12. Bearing search window</u>) When the bearing type is angular contact ball brgs. (30°, 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series), enter the distance bet. effective load (bearing A and bearing B, bearing C and bearing D). For other bearing types,

enter the distance between bearing A and bearing B, and the distance between bearing C and bearing D. (When modified rating life was selected) Select the contamination level or select "Direct input" and then directly enter the contamination factor value. Always enter the lubricating oil kinematic viscosity for 40°C and 100°C. Always enter the operating temperature. Click the "See index" button to open the "Contamination factor ec index" and confirm the content of each contamination level. Also, click the "See ISO grade table" button (for oil lubrication) and the "See grease characteristics table" button (for grease lubrication) to open a table with typical base oil viscosity for each lubricant. Click the row in the table to enter the corresponding base oil viscosity value in the column for 40°C and 100°C of the lubricating oil kinematic viscosity.

2. Enter gear specifications

ear load and basic rating li	fe	
car load and basic ruling i		
tes (feel free to use this field) st data No.2		
	A	
lculation conditions		
e field marked with * is required.Enter nu	mbers as half-width.	
-Conditions		Input shaft rotation direction
Condition 1 Condition 2 Condition 2	condition 3 Condition 4 Condition 5	5 Clockwise
		C-clockwise
Constrant	Constant D	
- Gear type A	Gear type b	
Heisal-right	C Helical-right	
Helical-left	C Helical-left	
nput tor.	90000	
nput shaft rot.	1000	
1) Teeth	Teeth A: 30	Teeth B: 20
2) Module	2	
3) Pres. angle (deg)	10	
4) Gear pos. (mm)	c: 120	d: 140
5) Twisting angle (deg)		
6) Frequency (%)	100	
	OK	

Screen No. 7 Gear specification input window

- (button items) (see <u>1-3-1 Description of on-screen buttons</u>) Condition 1 (condition 2, condition 3, condition 4, condition 5)
- (selection item) (see <u>1-3-2 Description of selection items</u>) Input shaft rotation direction, gear type A, gear type B

(input item) (see <u>1-3-3 Description of input items</u>) Input tor., input shaft rot. speed, number of teeth, module, pressure angle gear position: gear A is the distance from bearing A, gear B is the distance from bearing C (If gear A (B) is to the right of bearing A (C): enter pos. If gear A (B) is to the left of bearing A (C): enter neg.) Twisting angle (helical gear only) The frequency is up to five conditions, and the total of all conditions must be 100%.

3. Calculation results display

<Gear load>

Gear load and basic rating life									
lotes									
est dat	a No.2								
alcul	ation condi	itions , N, MPa]							
alcul	ation resul	t Gear torque	Rot. speed	Tangent dir. load	Radial dir. load	Axial dir. load			
		(N·mm)	(min ⁻¹)	(N)	(N)	(N)			
Jear A	Condition 1	90 000	1 000	3 000	-530	0			
	Condition 2								
	Condition 3								
	Condition 4								
_	Condition 2								
ear B	Condition 1	60.000	1 500	-3.000	530	0			
	Condition 2								
	Condition 3								
	Condition 4								
	Condition 5								
			Be	Print					

Screen No. 8 Gear load display

(output item) (see 1-3-4 Description of output items)

Notes, units, lubrication, gear torque, rot. speed, tangent dir. load, radial dir. load, axial dir. load

		1100			
Gear load	l and basic	rating life			
Notes					
Test data No.:	2				
alculatio	n condition	าร			
I/O Param.	Unit: SI Unit [m	im, N, MPa]			
Lubrication:	Grease				
alculatio	n result				
	Product	Basic dynamic load ratinos	Bearing life (hours)	Bearing life (hours)	1
	number	(N)	L10h	L10mh	Brg. system life (hours
Bras, A	7205	18 000	20 000	1 160	8 050
an Brit Le	72058	16 400	12 000	260	10.0070
Brgs. B	72030			5778507003	
Brgs. B Brgs. C	6302	12 700	11 100	17 400	200 Calcolate 100
Brgs. B Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050	405	3 150
Brgs. B Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050	17 400 405	3 150
Brgs. B Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050 *The displayed oper	17 400 405 rating life calculation is the	3 150
Brgs. B Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050 *The displayed oper	17 400 405 rating life calculation is the	3 150 basic rated operating life
Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050 *The displayed oper Detail of Brg. life	17 400 405 rating life calculation is the	3 150
Brgs, B Brgs, C Brgs, D	6302 6302	12 700 12 700	11 100 4 050 *The displayed oper Detail of Brg. life	17 400 405 rating life calculation is the	3 150
Brgs. B Brgs. C Brgs. D	6302 6302	12 700 12 700	11 100 4 050 *The displayed ope Detail of Brg. life	17 400 405 rating life calculation is the	3 150
Brgs, B Brgs, C Brgs, D	6302 6302	12 700 12 700	11 100 4 050 *The displayed oper Detail of Brg. life	17 400 405 rating life calculation is the	3 150

<Total life of bearing system and bearings>

Screen No. 9 Display of total life of bearing system and bearings (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, units, lubrication, NTN product name, basic dynamic load ratings, bearing life (L_{10h}): Total life of each bearing (hours)

Brg. system life: total life of combination of bearing A and bearing B, and bearing C and bearing D (hours)

Note 1) The life is displayed as "9999999.9" if it exceeds 10 million hours.

(When modified rating life was selected) Modified rating life (L_{10mh}): Total life of each bearing (hours)

<Detail of Brg. life>

ocal loau	and basic	rating li	fe						
Notes									
Test data No.2									
Calculation	conditior	ıs							
Brgs. A Prod Total life (ho	luct number: 7 urs): 20 000	205 I/C Lu	D Param. Unit: (n brication: Grease	ım, N, MPa]					
Calculation	result								
Basic dynamic l atings (N)	oad	1	000 Basic static load ratings (N)				10 300		
Imiting speed Catalog(min ⁻¹)		1	4 000						
	Radial load	Axial load	Limiting speed Adjusted (min* 1)	Rot. speed (min ⁻¹)	Equivalent load	Life (hours) L10h	Life (hours) L10mh	Frequency (%)	
	1 220	1 600	1 000	2 030	1 690	20 000	2 000	100	
Condition 1									
Condition 1 Condition 2									
Condition 1 Condition 2 Condition 3									
Condition 1 Condition 2 Condition 3 Condition 4							13 13		
Condition 1 Condition 2 Condition 3 Condition 4 Condition 5									
Condition 1 Condition 2 Condition 3 Condition 4 Condition 5			Bros, A	Bras. B B	ras. C Bras. D	T.			
Condition 1 Condition 2 Condition 3 Condition 4 Condition 5			Brgs, A	Brgs. B Br	rgs, C Brgs, D	I			
Condition 1 Condition 2 Condition 3 Condition 4 Condition 5			Brgs, A	Brgs. B B	rgs. C Brgs. D	I			

Screen No. 10 Display of details of bearing life (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, NTN product name, units, lubrication, basic dynamic load ratings, basic static load ratings, limiting speed catalog value

Total life: total life taking into account the frequency of each bearing (hours)

The output items below are displayed for each condition.

Radial load, axial load, limiting speed adjusted value, rot. speed, equivalent load, life (L_{10h}), frequency.

Note 1) The life is displayed as "9999999.9" if it exceeds 10 million hours. (When modified rating life was selected) Life (L_{10mh})

1. Bearing setting

saring Technical C	alculation Tool	
Bearing load	and basic rating life	
iotes (feel free to s fest data No.3	se this field)	
alculation co	nditions	
The field marked wit	h * is required.Enter numbers as half-width.	
Bearing selection-		
Selection of the celculated bearing life *	Beaic rating life - Lise: Modified rating life - Lise: (asso is considered) choice- Fatigue limit load Cu used for the calculation of LiDmh depends on the medic of bearing materials that undervert standard heat treatment (th Bearings that are not made of bearing steel that undervent standard he calculation.	bearing material. Therefore, bearings ough hardering) can be aboled at treatment cannot be used for the
Lubrication	Grease Top (Precautions and terms of use) Select presse lubrication for double sealed by	sarings or double shielded bearings
Contamination factor e _C *	Standard cleanliness	
Lubricating oil dynamic viscopity *	40°C 22 100°C 4.3 See grease natures chotes Please consult NTN Engineering when using lubroant with extreme	pressure additive.
Operating temperature (°C) *	20 - Rotes- Please consult NTN Engineering when the operating temperature is	going to exceed 100C.
Bearing type *	Choose a type of [Bearing A] Angular Contact Ball Brgs.	A . B
Product number	7210 Search	⊞ ⊞ ⊞ ⊞
I/O Param. Unit	SI Unit (mm, N, HPa)	
Distance bet. effective load a (mm) *	100	<u>, ,</u> ,
-Contect and or		
Avial load		

Screen No. 11 Bearing setting window (The section in the red box is only for the modified rating life)

(selection item) (see <u>1-3-2 Description of selection items</u>)

When the bearing type is angular contact ball brgs. (30°, 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series), bearing selection, bearing type, lubrication, I/O param. unit, contact ang. ort.

Bearing selection, bearing type, lubrication, contact ang. ort. and for other bearing types Bearing selection, bearing type, lubrication, axial load

(input item) (see 1-3-3 Description of input items)

Enter the calculation details into the notes if necessary.

If the NTN product name is known

Enter the NTN product name.

If the NTN product name is unknown

Click the "Search" button and search for the relevant bearing. (see 1-3-12. Bearing search window)

When the bearing type is angular contact ball brgs. (30°, 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series),

Enter the distance bet. effective load a.

For other bearing types,

Enter the distance between bearing A and bearing B.

2. Enter operating conditions

Parming load and basic rating life Dotes (feel free to use this field) fest data No.3 perating conditions The field marked with * is required.Enter numbers as half-width. Rot. speed (min ⁻¹): * 1500 Load center 1 100 200 5000 Load center 2 800 200 100 150 150									
Bearing load and basic rating life totes (feel free to use this field) Test data No.3 Pperating conditions The field marked with * is required.Enter numbers as half-width. Rot. speed (min ⁻¹): * 1500 Load center 1 100 200 5000 40 Load center 3 200 100 150	earing Technical	Calculation To	0						
Notes (feel free to use this field) Test data No.3 Operating conditions The field marked with * is required.Enter numbers as half-width. Rot. speed (min ⁻¹): * 1500 Load center 1 100 200 5000 Load center 2 800 200 100 150 150 addial load: Arrel 1. Pos., Upward: Neg., theg. there for brg. A: Neg., the left of brg. A: Neg., the right: Pos. Load center for brg. A: The left of brg. A: Neg., The right: Pos. Load center for brg. A: The left of brg. A: Neg., the right: Pos. Load center for brg. A: The left of brg. A: Neg., the right: Pos. Load center form brg. A: The left of brg. A: Neg., The right: Pos. Load center 6 OK	Bearing loa	d and basi	c rating li	ife					
Apperating conditions The field marked with * is required.Enter numbers as half-width. Rot. speed (min ⁻¹): * 1500 Load center 1 100 Load center 1 100 Load center 2 800 200 5000 Load center 3 200 100 150	Notes (feel free to Test data No.3	o use this field)				đ			
Rot. speed (min ⁻¹): * 1500 Distance from brg. A (mm Job (min ⁻¹): * Load center 1 100 30 -30 Load center 3 200 200 5000 40 Load center 3 200 100 150	Operating co	onditions with * is required	l.Enter number	s as half-w	dth.				
Radiel load Axial load Moment load Distance from brg. A (mm Load center 1 100 30 -30 -30 Load center 2 800 200 5000 40 Load center 3 200 100 150	Rot. speed (min	⁻¹): *	1500						
Load center 1 100 30 -30 Load center 2 800 200 5000 40 Load center 3 200 100 150 40 Kadel load: A → B : Pos., Upward: Neg. Kadel load: A → B : Pos., B → A : Neg. Atoment load: Clockwise: Pos., C-clockwise: Neg. Neg. Jostance from brg. A: The left of brg. A: Neg., The right: Pos. Vertice Wain menu + Return Keturn		Radia	al load		Axial load	м	loment load	Distanc	e from bra. A (mm)
Load center 2 800 200 5000 40 Load center 3 200 100 150 40 Kadel load: Downward: Pos., Upward: Neg. Kadel load: A → B : Pos., B → A : Neg. Atoment load: Clockwise: Pos., C-clockwise: Neg. Jostance from brg. A: The left of brg. A: Neg., The right: Pos.	Load center 1	100		30				-30	
Load center 3 200 100 150 adial load: Downward: Pos., Upward: Neg. viail load: A → B : Pos., B → A : Neg. Itoment load: Clockwise: Pos., C-clockwise: Neg. Istance from brg. A: The left of brg. A: Neg., The right: Pos. OK	Load center 2	800		200		5000		40	
adial foad: Downward: Pos., Upward: Neg. xial [bad: A → B : Pos., B → A : Neg. forment load: Clockwise: Pos., C-clockwise: Neg. istance from brg. A: The left of brg. A: Neg., The right: Pos. OK + Main menu + Return	Load center 3	200		100		150			
Main menu Return	ladial load: wial load: 4oment load: Distance from brg.	Downward: A → B ; Clockwise: A: The left of brg	Pos., Up Pos., B Pos., C- p. A: Neg., Th	ward: 1 → A : 1 clockwise: 1 e right: 1	Veg. Veg. Veg. Pos. OK				
					• Main menu •	Return			

Screen No. 12 Operating conditions input window

(input item) (see 1-3-3 Description of input items)

Always enter the rot. speed.

Enter the radial load (downward: pos., upward: neg.), the axial load ($A \rightarrow B$: pos., $B \rightarrow A$: neg.), moment load (clockwise: pos., counterclockwise: neg.) placed on each load center into the required items.

Distance from bearing A: distance from bearing A of each load center (mm)

(if bearing A is on the left of the load center: neg., if bearing A is on the right of the load center: pos.)

Enter the distance from bearing A only for load centers where a load is placed.

3. Calculation results display

<Brg. system life>

Rearin	a load and bacic r	ating life			
Dearm	ig load and basic i	ating me			
Notes					
Test data	No.3				
Calcula	tion conditions				
I/O Par	am. Unit: [mm, N, MPa]				
Lubrica	tion: Oil				
Calcula	tion result				
		Basic dynamic load ratings	Bearing life (hours)	Bearing life (hours) L10mh	Brg. system life (hours)
	Product number	(N)	L10h		
Brgs. A	Product number 7210	(N) 45 500	L10h 2 400 000	240 000	2 260 000
Brgs. A Brgs. B	Product number 7210 7210	(N) 45 500 45 500	L10h 2 400 000 9 999 999.9	240 000 2 627 964.9	2 260 000
Brgs. A Brgs. B	Product number 7210 7210	(N) 45 500 45 500 Deta	L10h 2 400 000 9 999 999.9 *The displayed operating i il of Brg. life	240 000 2 627 964.9 Ife calculation is the basic rates	2 260 000 d operating life.

Screen No. 13 Display of brg. system life (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, units, lubrication, **NTN** product name, basic dynamic load rating bearing life: Basic rating life (L_{10h}) of each bearing (hours)

Brg. system life: life of combination of bearing A and bearing B (hours)

Note 1) The life is displayed as "9999999.9" if it exceeds 10 million hours.

(When modified rating life was selected) Modified rating life (L_{10mh}) of each bearing (hours).

<Detail of Brg. life>

NUMBER					Us Instructions fo	x Use, Disclaimer, etc. Inquiry a
Searing Technical (Calculation Too	x				
Bearing load	l and basi	c rating life				
Notes						
Test data No.3						
Calculation co	onditions					
(L10mh)	esult	Lubric	ation: Oil			
Basic dynamic load	ratings (N)	45 500	Basic	static load ratings (N) 31 500	
imiting speed Cata	alog (min ^{*1})	10 000				
Radial load	Axial load	Limiting speed (min ⁻¹)	Rot. speed (min ⁻¹)	Equivalent load	Life (hours) L10h	Life (hours) L10mh
760	555	10 000	1500	760	2 400 000	240 000
			Brgs. A Brgs.	в		

Screen No. 14 Display of details of bearing life (The section in the red box is only for the modified rating life)

(output item) (see 1-3-4 Description of output items)

Notes, units, lubrication, NTN product name, basic dynamic load ratings, basic static load ratings, limiting speed (catalog value, adjusted value), radial load, axial load, rot. speed, equivalent load

Total life: basic rating life of the bearing (hours)

Life: Basic rating life of the bearing (hours) L_{10h} (= total life)

(When modified rating life was selected) Life: Modified rating life of the bearing (hours) L_{10mh}

Note 1) The life is displayed as "9999999.9" if it exceeds 10 million hours.

1-3-10. Operating clearance calculation

1. Enter calculation conditions

ATH		Usage Method (159640) In Instructions for Use, Disclaimer, etc. So Ingury So
earing Technical Calcula	tion Tool	
Operating cleara	nce calculation	
Notes (feel free to use thi Test data No.4	rfeid)	
Operating condition	ons	
The field marked with * is	required.Enter numbers as half-width.	
I/O Param, Unit	SI Unit (mm, N, MPa)	
Bearing type *	• Please select •	
Product number *	Search…	
Bearing tolerances *	+ Please select + •	
Radial internal clearance •	Please select	
Shaft bore diameter	(mm) Solid shaft w/o input	
Fit with shaft *	- Please select - •	
Shaft material *	Please select	
Housing outer diameter	(mm) Bearing outer diameter x 1.3 w/o input	
Fit with housing *	Please select •	
Housing material *	- Please select -	
Temperature of inner ring	(°C) 20°C w/o input	
Temperature of outer ring	(°C) 20°C w/o input	
	Calculate	
	+ Main menu + Return	

Screen No. 15 Bearing setting window

(selection item) (see <u>1-3-2 Description of selection items</u>)

Bearing type, bearing tolerances, radial internal clearance, fit with shaft, shaft material, fit with housing, housing material.

(input item) (see 1-3-3 Description of input items)

Enter the calculation details into the notes if necessary.

If the NTN product name is known

Enter the NTN product name.

If the NTN product name is unknown

Click the "Search" button and search for the relevant bearing. (see <u>1-3-12</u>. Bearing search window) Enter the required items for shaft bore diameter, housing outer diameter, shaft temperature and housing temperature under operating condition.

2. Calculation results display	2.	Calculat	ion res	ults d	isplay
--------------------------------	----	----------	---------	--------	--------

aring Technical Calculation	n Tool			
perating clearance	e calculation			
otes				
est data No.4				
alculation condition	าร			
) Param. Unit: SI Unit (mm.	, N, MPa)			
Product numbe	er: 6210 🔽 🗛	D data (external link)		
earing tolerances	JIS Class 0	Radial internal clearanc	e CN	
haft bore diameter		Fit with shaft	k5	
haft material	Bearing steels	Housing outer diameter	6	
it with housing	M7	Housing material	Bearing stee	łs
emperature of inner ring	20	Temperature of outer n	ng 20	
alculation result				
Warning				
Clearance is negative	quantity. Review the condition	ons.		
(1) After Etting			min	11 mar
(1) After fitting			- min	mdx
Residual clearance			0.017543500365015	0.013151602509153
Fitting pressure (shaft and t	bearing)		1.2791189240225	15.988986550281
Fitting pressure (bearing an	d houing)		0:	7.1997098692172
Fitting stress (inner ring)			6.5699376797511	82.124220996889
Fitting stress (outer ring)			0	57.410845633873
	22077.)		17.17.17.17.	248700
(2) Under operating cond	ition		min	max
Operating clearance			0.017543500365015	0.013151602509153
Fitting pressure (shaft and t	bearing)		1.2791189240225	15.988986550281
Fitting pressure (bearing an	d houing)		0.	7.1997098692172
Fitting stress (inner ring)			6.5699376797511	82.124220996889
Fitting stress (outer ring)			0	57.410845633873
		Print		
		Main manu . Datum		
		• main menu • Keturn		

Screen No. 16 Display of calculation result

(output item) (see 1-3-4 Description of output items)

Notes, units, NTN product name

The min and max of each of the following items is displayed.

After fitting: residual clearance, fitting pressure (shaft and bearing), fitting pressure (bearing and housing), fitting stress (inner ring), fitting stress (outer ring)

Under operating condition: operating clearance, fitting pressure (shaft and bearing), fitting pressure (bearing and housing), fitting stress (inner ring), fitting stress (outer ring)

1-3-11. Bearing vibration frequency

1. Enter calculation conditions

			Instructions for OSE, Concerner, His and Inquiry St
Bearing Technical Calculat	ion Tool		
Bearing vibration	frequency		
Notes (feel free to use this	field)		
Test data No.5		4	
Calculation condition	ons		
The field marked with * is re	equired.Enter num	bers as half-width.	
Bearing type *	Deep Groov	e Ball Brgs. (Open type) •	
Product number *	6210	Search	
Rotational speed of inner ring (min ⁻¹) *	3600		
		Calculate	
		+ Main menu + Return	
	_		

Screen No. 17 Calculation conditions input window

- (selection item) (see <u>1-3-2 Description of selection items</u>) Bearing type
- (input item) (see 1-3-3 Description of input items)
 - Enter the calculation details into the notes if necessary.
 - If the NTN product name is known
 - Enter the NTN product name.
 - If the NTN product name is unknown
 - Click the "Search" button and search for the relevant bearing. (see <u>1-3-12</u>. Bearing search window) Always enter the rot. speed.

earing Technical Calcul	ation Tool	
Bearing vibratio	n frequency	
Notes		
Test data No.5		
Calculation condi	tions	
Bearing type	Deep Groove Ball Brgs.	
Product number	6210	
Rotational speed of inner ring (min ⁻¹)	3600	
Calculation result		
Rotational speed of cage	24.557142857143 (Hz)	
Rotational speed of cage relative to inner ring	35.442857142857 (Hz)	
Number of load cycles of inner ring per second	354.42857142857 (Hz)	
Number of load cycles of outer ring per second	245.57142857143 (Hz)	
Rotational speed of rolling element	159.9114735658 (Hz)	
	🙆 Print)
	🔸 Main menu 🔸 Retu	m

Screen No. 18 Display of calculation result

(output item) (see <u>1-3-4 Description of output items</u>)

Notes, bearing type, **NTN** product name, rot. speed, rotational speed of cage, rotational speed of cage relative to inner ring, number of load cycles of inner ring per second, number of load cycles of outer ring per second, rotational speed of rolling element

1-3-12. Bearing search window

For bearing setting screens other than calculations for "Basic rating life," if the NTN product name is unknown, clicking the "Search" button displays the following window.

1. Bearing search window 1

Deep Groove Ball Brgs.		
nter numbers as half-width.		
	min	max
Inner dia. (mm)		to
Outer dia. (mm)		to
Width (mm)		to

Screen No. 19 Bearing search window 1

(input item)

Enter at least one of inner dia., outer dia. or width.

Inner dia. :

Inner dimensions of bearing (min and max) (mm)

(Input example) If the i	nner dia	ı. o	f the rea	quired bearing is	25mm o	or more and	30mm o	r less
Inner dia. (mm): enter	25	to	30					

Outer dia. :

Outer dimensions of bearing (min and max) (mm)

(Input example) If the outer dia. of the required bearing is 50mm or more and 60mm or less Outer dia. (mm): enter $\begin{bmatrix} 50 \\ 0 \end{bmatrix}$ to $\begin{bmatrix} 60 \\ 0 \end{bmatrix}$.

Width :

Width dimensions of bearing (min and max) (mm) (Input example) If the width of the required bearing is 10mm or more and 20mm or less

Width (mm): enter 10 to 20

NTN

2. Bearing search window 2

Product number	Inner dia. (mm)	Outer dia. (mm)	Width (mm)	Basic dynamic load ratings (N)	Basic static load ratings (N)
6700	10.000	15.000	3.000	950.0	435.0
6800	10.000	19.000	5.000	2 030.0	925.0
5900	10.000	22.000	6.000	2 990.0	1 270.0
5000	10.000	26.000	8.000	5 050.0	1 960.0
5200	10.000	30.000	9.000	5 650.0	2 390.0
5300	10.000	35.000	11.000	9 100.0	3 500.0
5701	12.000	18.000	4.000	1 030.0	530.0

Return Close

Screen No. 20 Bearing search window 2

(Bearing search method)

- (1) For "Bearing search window 2," click the NTN product name to be used with the mouse. (the clicked bearing is displayed as white text on a black background to distinguish it from the others)
- (2) Click the "OK" button.
- (3) For the bearing setting screen for each calculation, enter the searched NTN product name into the NTN product name field.
- Note 1) If the count of results exceeds 14, a scroll bar is displayed on the right edge of the screen and the screen can be moved up and down.

Click " \triangle " with the mouse: move the screen up

Click " \bigtriangledown " with the mouse: move the screen down

1-4. Warning screens

1-4-1. Basic rating life

(1) "The entered load is too large. Contact NTN for more information."

The equivalent load calculated from the entered load conditions is a larger value than either "Basic dynamic load ratings ÷2" or "Basic static load ratings" for all bearings corresponding to the bearing selection conditions. For expansion compensating brgs., this is also displayed when the equivalent load exceeds the limiting load.

- (2) "The entered rotational speed exceeds the limiting speed. Contact NTN for more information." The entered rot. speed is a value larger than the adjusted limiting speed of all bearings that correspond to the bearing selection conditions.
- (3) "The entered load is too large and the limiting speed cannot be adjusted. Contact NTN for more information." If *C*/*P* < 5, the above warning is displayed.
- (4) The axial load is too large for the radial load to adjust the limiting speed. Contact NTN for more information." For deep groove ball brgs., expansion compensating brgs., miniature ball brgs. (metric series), angular contact ball brgs. (30°, 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series), when Fa/Fr > 2.0, the above warning is displayed. For spherical roller brgs., when either Fa/Fr > 2.0 or $Fa/Fr > 2 \cdot e$, the above warning is displayed.
- (5) " $dp \cdot n < 10000$. (see manual for quantity symbols) Contact NTN for more information." If $dp \cdot n < 10000$ from the entered rot. speed and bearing inner dia. and outer dia., the above warning is displayed.
- (6) "Axial loads cannot be taken into account for life calculations with cylindrical roller brgs. For cylindrical roller brgs. (NJ, NUP, NF type) with an axial load placed on them, a separate limiting axial load must be considered."

If an axial load is entered to calculate the life of cylindrical roller brgs. and double row cylindrical roller brgs., the above warning is displayed.

1-4-2. Gear load and basic rating life, bearing load and basic rating life

(1) "The load placed on bearing A is too large. Contact NTN for more information."

If there is even one bearing with the equivalent load calculated from the load placed on each bearing that exceeds "basic dynamic load ratings) \div 2" or "(basic static load ratings)" of each bearing, the above warning is displayed. An example of the above example is when the load placed on bearing A exceeds either "basic dynamic load ratings) \div 2" or "(basic static load ratings)."

For expansion compensating brgs., this is also displayed when the equivalent load exceeds the limiting load.

(2) "The input rotational speed of bearing A exceeds the limiting speed. Contact NTN for more information."

If there is even one bearing with the rot. speed acting on each bearing that exceeds the adjusted limiting speed of each bearing, the above warning is displayed.

An example of the above example is when the rot. speed acting on bearing A exceeds the adjusted limiting speed.

(3) "The load placed on bearing A is too large and the limiting speed cannot be adjusted. Contact NTN for more information."

If either bearing is C/P < 5, the above warning is displayed. An example of the above is when the load placed on bearing A is C/P < 5.

(4) "For bearing A, the axial load is too large for the radial load. Contact NTN for more information."

For deep groove ball brgs., expansion compensating brgs., miniature ball brgs. (metric series), angular contact ball brgs. (30° , 40°), tapered roller brgs. (metric series), tapered roller brgs. (inch series), when Fa/Fr > 2.0, the above warning is displayed. An example of the above is when the load placed on bearing A is Fa/Fr > 2.0.

(5) "For bearing A, the axial load is too large for the radial load to adjust the limiting speed. Contact NTN for more information."

For spherical roller brgs., when either Fa/Fr > 2.0 or $Fa/Fr > 2 \cdot e$, the above warning is displayed.

- (6) "For bearing A, dp·n < 10000. (see manual for quantity symbols) Contact NTN for more information." For either bearing, if dp·n < 10000 from the entered rot. speed and bearing inner dia. and outer dia., the above warning is displayed.</p>
- (7) "Axial loads cannot be taken into account for life calculations with cylindrical roller brgs. For cylindrical roller brgs. (NJ, NUP, NF type) with an axial load placed on them, a separate limiting axial load must be considered."

For either bearing, if an axial load is entered to calculate the life of cylindrical roller brgs. and double row cylindrical roller brgs., the above warning is displayed.

(8) "Is it OK to place an axial load on two bearings?"

For "Bearing load and basic rating life," if an axial load is placed on two bearings other than angular contact ball brgs. or tapered roller brgs., the above warning is displayed. If YES, proceed to the next step. If NO, return to the bearing selection screen and reselect the axial load.

1-4-3. Operating clearance calculation

(1) "The clearance is negative. Check the values again."

If the min residual clearance or the min operating clearance is negative, the above warning is displayed. A calculation result is output.

- (2) "Interference is out of the standard of safety. Review the fit."
 - Max fitting stress after fitting (inner ring)
 - Max fitting stress under operating condition (inner ring)

If either of these exceeds 127 MPa, the above warning is displayed. A calculation result is output.

(3) "The conditions to use the bearing are not suitable because of high temperature."

If a temperature that exceeds 150°C has been entered for the shaft temperature under operating condition or the housing temperature under operating condition, the above warning is displayed. A calculation result is output.

1-5. Error messages

1-5-1. Basic rating life

(1) "Select a bearing type"

In the <u>1-3-7-1. Bearing selection window</u>, clicking the "OK" button without selecting a bearing type displays the above error message.

(2) "The NTN product name is incorrect"

In the <u>1-3-7-1. Bearing selection window</u>, clicking the "OK" button after entering an incorrect **NTN** product name displays the above error message.

(3) "The inner dia. (MIN > MAX) is incorrect"

In the <u>1-3-7-1. Bearing selection window</u>, clicking the "OK" button with the (min) > (max) for the entered dimensions (inner dia., outer dia., width) displays the above error message.

(4) "Fa/Co > 0.5. Life calculation is not possible (see manual for quantity symbols) Contact NTN for more information."

If an NTN product name has been entered, if the entered axial load (*F*a) is not within the $0 \le Fa/Co \le 0.5$ range for deep groove ball brgs., the above error message is displayed.

(5) "Fa/Co > 0.3. Life calculation is not possible (see manual for quantity symbols) Contact NTN for more information."

If an NTN product name has been entered, if the entered axial load (*F*a) is not within the $0 \le Fa/Co \le 0.3$ range for miniature ball brgs., the above error message is displayed.

(6) "The calculation is not possible because the equivalent load (P) = 0."

If an **NTN** product name has been entered, when both the radial load and axial load have not been entered in the <u>1-3-</u> <u>7-2. Operating conditions input window</u>, the above error message is displayed.

(7) "Equivalent load 0 division"

If an **NTN** product name has been entered, when the rot. speed has not been entered in the <u>1-3-7-2</u>. Operating <u>conditions input window</u>, the above error message is displayed.

(8) Enter a number of 10 or less for the number of steps"

If nothing has been entered, or a value of 11 or more has been entered as the number of steps in the <u>1-3-7-2</u>. <u>Operating conditions input window</u> and the "Calculate" button is clicked, the above error message is displayed.

(9) "No applicable data could be found"

When selecting "deep groove ball brgs." or "expansion compensating brgs." as the bearing type in the <u>1-3-7-1</u>. <u>bearing selection window</u> and entering the dimensions to search for bearings, if it is not within the $0 \le Fa/Co \le 0.5$ range from the entered operating conditions, the above error message is displayed. Also, when selecting "miniature ball brgs." as the bearing type and entering the dimensions to search for bearings, if it is not within the $0 \le Fa/Co \le 0.5$ range from the entered operating conditions, the above error message is displayed. Also, when selecting "miniature ball brgs." as the bearing type and entering the dimensions to search for bearings, if it is not within the $0 \le Fa/Co \le 0.3$ range from the entered operating conditions, the above error message is displayed.

When entering dimensions and searching for bearings in the <u>1-3-7-1</u>. Bearing selection window, if both the radial load and axial load have not been entered in the <u>1-3-7-2</u>. Operating conditions input window, the above error message is displayed.

When entering dimensions and searching for bearings in the <u>1-3-7-1</u>. Bearing selection window, if the rot. speed has not been entered in the <u>1-3-7-2</u>. Operating conditions input window, the above error message is displayed.

(10) "No bearings meet the required life with these operating conditions"

If there are no bearings that meet the required life when entering the operating conditions and clicking the "Calculate" button, the above error message is displayed.

1-5-2. Gear load and basic rating life, bearing load and basic rating life

(1) "Select a bearing type"

In the <u>1-3-8-1. Bearing setting</u> and <u>1-3-9-1. Bearing setting window</u>, clicking the "OK" button without selecting at least one bearing type displays the above error message.

(2) "Enter the NTN product name"

In the <u>1-3-8-1. Bearing setting</u> and <u>1-3-9-1. Bearing setting window</u>, clicking the "OK" button without selecting entering the **NTN** product name displays the above error message.

(3) "The NTN product name is incorrect"

In the <u>1-3-8-1. Bearing setting</u> and <u>1-3-9-1. Bearing setting window</u>, clicking the "OK" button after entering an incorrect **NTN** product name displays the above error message.

(4) "The inner dia. (MIN > MAX) is incorrect"

In the <u>1-3-8-1</u>. Bearing setting and <u>1-3-9-1</u>. Bearing setting window, when clicking the "Search" button and searching for bearings, clicking the "Search" button with the (min) > (max) for the entered dimensions (inner dia., outer dia., width) displays the above error message.

(5) "Enter the correct value for distance bet. bearings"

In the <u>1-3-8-1</u>. Bearing setting and <u>1-3-9-1</u>. Bearing setting window, clicking the "OK" button without entering the distance between bearing A and bearing B, or the distance between bearing C and bearing D (or the distance between bearing contact ball brgs. and tapered roller brgs.) displays the above error message.

(6) "Wrong combination of the contact ang. ort."

In the <u>1-3-8-1. Bearing setting</u> and <u>1-3-9-1. Bearing setting window</u>, when angular contact ball brgs., tapered roller brgs. (metric series) or tapered roller brgs. (inch series) are selected, if the contact ang. ort. has been selected but the same angle has been selected for both contact angles, the above error message is displayed.

(7) "Bearing type not applicable."

In the <u>1-3-8-1</u>. Bearing setting and <u>1-3-9-1</u>. Bearing setting window, if bearing A and bearing B, or bearing C and bearing D is set as angular contact ball brgs. or tapered roller brgs., and the other is set as bearings other than angular contact ball brgs. or tapered roller brgs., the above error message is displayed.

(8) "The total frequency is not 100%"

In the <u>1-3-8-2. Gear specification input window</u>, if the total frequency is not 100%, completely entering the gear specifications and clicking the "Calculate" button displays the above error message.

(9) "Calculation error"

In the <u>1-3-8-2. Gear specification input window</u>, clicking the "Calculate" button without entering any frequency at all displays the above error message.

(10) "The calculation not possible because the equivalent load (P) = 0 [Bearing A (condition 1)]"

In the <u>1-3-8-2. Gear specification input window</u>, if only the input tor. of the gear specifications are not entered but other items are entered, clicking the "Calculate" button clears all gear loads (tangent dir., radial dir., axial dir.) in <Gear loads> in the <u>1-3-8-3 Calculation results display window</u>. Clicking the "Bearing life" button here displays the above error message.

(11) "The calculation not possible because the rot. speed (*n*) = 0 [Bearing A (condition 1)]"

In the 1-3-8-2. Gear specification input window, if only the rot. speed of the gear specifications are not entered but other items are entered, clicking the "Calculate" button clears all rot. speeds for gear A and gear B in <Gear loads> in the 1-3-8-3 Calculation results display window. Clicking the "Bearing life" button here displays the above error message.

(12) "Enter the correct value for gear specifications"

In the <u>1-3-8-2. Gear specification input window</u>, if at least one of the number of teeth and module of gear A and gear B have not been entered, clicking the "Calculate" button displays the above error message.

(13) "Enter the correct value for rot. speed"

In the <u>1-3-9-2. Load conditions input window</u>, clicking the "OK" button without entering the rot. speed displays the above error message.

(14) "The calculation not possible because the equivalent load (P) = 0 [Bearing A]"

In the <u>1-3-9-2. Load conditions input window</u>, clicking the "OK" button without entering any loads at all displays the above error message.

(15) "*Fa/Co* > 0.5 for bearing A. Life calculation is not possible (see manual for quantity symbols) Contact NTN for more information."

If any of the bearings include deep groove ball brgs., and the axial load placed on those bearings is not within the $0 \le Fa/Co \le 0.5$ range, the above error message is displayed.

(16) "Fa/Co> 0.3 for bearing A. Life calculation is not possible (see manual for quantity symbols) Contact NTN for more information."

If any of the bearings include miniature ball brgs., and the axial load placed on those bearings is not within the $0 \le Fa/Co \le 0.3$ range, the above error message is displayed.

1-5-3. Operating clearance calculation

(1) "Required items have not been entered"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with no selection items selected at all, or not entering the **NTN** product name, the above error message is displayed.

(2) "Select a bearing type"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Search" button of the **NTN** product name without selecting a bearing type displays the above error message.

(3) "The NTN product name is incorrect"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with an incorrect **NTN** product name entered, or if the bearing type and the **NTN** product name do not match, the above error message is displayed.

(4) "Bearing inner diameter ≤ Shaft bore diameter. Impossible to calculate."

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with the entered shaft bore diameter exceeding the bearing inner dia. displays the above error message.

(5) "The value of inner dia. (housing outer diameter) is inappropriate"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with the entered shaft bore diameter (housing outer diameter) value negative or a character other than a number displays the above error message.

(6) "Housing outer diameter \leq Bearing outer diameter. Impossible to calculate."

In the <u>1-3-10-1</u>. Operating conditions input window, clicking the "Calculate" button with the entered housing outer diameter less than the bearing outer dia. value displays the above error message.

(7) "The value of the shaft (housing) temperature under operating condition is inappropriate."

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with the entered shaft (housing) temperature under operating conditions other than a number displays the above error message.

(8) "MIN inner dia. is incorrect"

In the <u>1-3-10-1 Operating conditions input window</u>, when clicking the **NTN** product name "Search" button and searching for bearings, clicking the "Search" button with the entered dimensions (inner dia., outer dia., width) other than a number, the above error message is displayed.

(9) "The inner dia. (MIN > MAX) is incorrect"

In the <u>1-3-10-1 Operating conditions input window</u>, when clicking the **NTN** product name "Search" button and searching for bearings, and

(1) The "Search" button is clicked with (min) entered for dimensions (inner dia., outer dia., width) > (max),

(2) The "Search" button is clicked without entering a min value for dimensions (inner dia., outer dia., width) and a negative value entered of max, the above error message is displayed.

(10) "No applicable data could be found"

In the <u>1-3-10-1 Operating conditions input window</u>, clicking the **NTN** product name "Search" button and searching for bearings, and there are bearings that meet the conditions for dimensions (inner dia., outer dia., width), the above error message is displayed.

(11) "Precision symbols are not defined for large diameter bearings"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with both an **NTN** product name with a large inner dia. and outer dia., and precision symbols that have not been defined with JIS have been entered for those inner dia. and outer dia., the above error message is displayed.

(12) "Fit symbols are not defined for large diameter bearings"

In the <u>1-3-10-1. Operating conditions input window</u>, clicking the "Calculate" button with both an **NTN** product name with a large inner dia. and outer dia., and fitting symbols that have not been defined with JIS have been entered for those inner dia. and outer dia., the above error message is displayed.

1-5-4. Bearing vibration frequency

(1) "Required items have not been entered"

In the <u>1-3-11-1. Calculation conditions input window</u>, clicking the "Calculate" button without either the bearing type, **NTN** product name or rot. speed entered, the above error message is displayed.

(2) "The corresponding bearing type does not exist"

In the <u>1-3-11-1. Calculation conditions input window</u>, clicking the "Search" button of the **NTN** product name without selecting a bearing type displays the above error message.

(3) "The NTN product name is incorrect"

In the <u>1-3-11-1. Calculation conditions input window</u>, clicking the "Calculate" button with an incorrect **NTN** product name entered, or if the bearing type and the **NTN** product name do not match, the above error message is displayed.

(4) "The value of rot. speed is inappropriate"

In the <u>1-3-11-1. Calculation conditions input window</u>, clicking the "Calculate" button with the entered rot. speed value negative or a character other than a number displays the above error message.

(5) "MIN inner dia. is incorrect"

In the <u>1-3-11-1 Calculation conditions input window</u>, when clicking the **NTN** product name "Search" button and searching for bearings, clicking the "Search" button with the entered dimensions (inner dia., outer dia., width) other than a number, the above error message is displayed.

(6) "The inner dia. (MIN > MAX) is incorrect"

In the <u>1-3-11-1 Calculation conditions input window</u>, when clicking the **NTN** product name "Search" button and searching for bearings, and

(1) The "Search" button is clicked with (min) entered for dimensions (inner dia., outer dia., width) > (max),

(2) The "Search" button is clicked without entering a min value for dimensions (inner dia., outer dia., width) and a negative value entered of max, the above error message is displayed.

(7) "No applicable data could be found"

In the <u>1-3-11-1 Calculation conditions input window</u>, clicking the **NTN** product name "Search" button and searching for bearings, and there are bearings that meet the conditions for dimensions (inner dia., outer dia., width), the above error message is displayed.

1-6. Calculation formula

1-6-1. Description of quantity symbols

<i>K</i> t	Tangent dir. load of gear	(N)
<i>K</i> s	Radial dir. load of gear	(N)
<i>K</i> a	Axial dir. load of gear	(N)
<i>M</i> ······	Torque applied to gear	(N · mm)
<i>z</i> ······ :	Teeth of gear	
<i>m</i> ·····:	Module of gear	
$D_{\rm p}$: Pitch diameter	of gear $(=\frac{z \cdot m}{\cos\beta})$	(mm)
α:	Pres. angle of gear	
β	Twisting angle of gear (helical gear only)	
$SB_1 \cdots :$	Distance between bearing A and bearing B	(mm)
SG_1 ······ :	Distance between bearing A and gear A	(mm)
$SB_2 \cdots $	Distance between bearing C and bearing D	(mm)
$SG_2 \cdots $	Distance between bearing C and gear B	(mm)
D_{pA}	Pitch diameter of gear A	(mm)
$D_{\rm pB}$	Pitch diameter of gear B	(mm)
$F_{\rm r}$	Radial load placed on bearing	(N)
<i>F</i> a:	Axial load placed on bearing	(N)
$F_{\rm rA}$	Radial load placed on bearing A	(N)
FrB ·····	Radial load placed on bearing B	(N)
$F_{\rm rC}$	Radial load placed on bearing C	(N)
$F_{\rm rD}$	Radial load placed on bearing D	(N)
F_{aA}	Axial load placed on bearing A	(N)
<i>FaB</i>	Axial load placed on bearing B	(N)
<i>P</i> ······ :	Equivalent load	(N)
<i>P</i> _r :	Equivalent radial load	(N)
<i>P</i> a	Equivalent axial load	(N)
<i>P</i> m:	Average value of equivalent load	(N)
<i>P</i> _i :	Equivalent load placed on each step	(N)
P_{\min} · · · · · · · · · · · · :	Min value of equivalent load	(N)
<i>P</i> _{max} :	Max value of equivalent load	(N)
<i>p</i> ······ :	Life calculation formula index	
	Ball bearings $P = 3$	
	Roller bearings $P = 10/3$	
<i>n</i> ······ :	Rot. speed	(min ⁻¹)
<i>n</i> i	Rot. speed of each step	(min ⁻¹)
<i>n</i> m:	Average value of rot. speed	(min ⁻¹)
$n_{1,n_{2},\cdots,n_{n}}\cdots\cdots$	Rot. speed of each step	(min ⁻¹)
<i>t</i> i ······	Use rate of each step	(hours or %)
$t_{1,t_{2},\cdots t_{n}}\cdots$	Use rate of each step	(hours or %)
<i>X</i> ······ :	Radial load coefficient	
<i>Y</i> ······ :	Axial load coefficient	
<i>Y</i> _A :	Axial load coefficient of bearing A	
<i>Y</i> _B :	Axial load coefficient of bearing B	

Fri ·····	Radial load placed on shaft load center	(N)
Fmi ······	Moment load placed on shaft load center	(N · mm)
L_1	Distance from bearing A to load center	(mm)
<i>L</i> в	Distance from bearing A to bearing B	(mm)
<i>L</i> 10h ······	Basic rating life	(hours)
<i>L</i> _T	Total life of bearing system	(hours)
<i>L</i> t	Total life of bearing unit	(hours)
<i>L</i> _A	Basic rating life of bearing A	(hours)
<i>L</i> в	Basic rating life of bearing B	(hours)
L10hi	Basic rating life under each meshing condition	(hours)
<i>C</i> ······	Basic dynamic load ratings	(N)
<i>e</i>	When both are ball bearings $e=10/9$	
	When both are tapered roller bearings $e=9/8$	
	When one is a ball bearing, and the other is a tapered roller bearing $e=(10/9+9/8)$	/2
<i>q</i> i · · · · · · · · · · · · · · · · · · ·	Frequency of gear meshing conditions	(%)
<i>S</i>	Shaft bore diameter	(mm)
H · · · · · · · · · · · · · · · · · · ·	Housing outer diameter	(mm)
<i>T</i> s	Shaft temperature under operating condition	(°C)
Тн	Housing temperature under operating condition	(°C)
$d \cdots $	Bearing inner dia.: (nominal dimensions)	(mm)
<i>D</i> ······	Bearing outer dia.: (nominal dimensions)	(mm)
dd min \cdots	Min value of bearing inner dia. tolerance	(mm)
dd_{\max}	Max value of bearing inner dia. tolerance	(mm)
DDmin	Min value of bearing outer dia. tolerance	(mm)
<i>DD</i> _{max}	Max value of bearing outer dia. tolerance	(mm)
SSmin	Min value of shaft outer dia. tolerance	(mm)
SSmax	Max value of shaft outer dia. tolerance	(mm)
HHmin ·····	Min value of housing outer dia. tolerance	(mm)
HH_{\max} · · · · · · · · · · · · · · · · · · ·	Max value of housing outer dia. tolerance	(mm)
$C_{\rm rmin}$	Min value of radial internal clearance	(mm)
$C_{r \max}$	Max value of radial internal clearance	(mm)
<i>E</i> s	Young's modulus of shaft	(MPa)
<i>V</i> s	Poisson's ratio of shaft	
αs	Coefficient of linear thermal expansion of shaft	(1/°C)
Ен	[:] Young's modulus of housing	(MPa)
<i>V</i> H	Poisson's ratio of housing	
αH	Coefficient of linear thermal expansion of housing	(1/°C)
Ев	Young's modulus of bearing inner ring, outer ring (= 2080	00 MPa)
d_{m}	Average inner ring groove diameter	(mm)
<i>D</i> m	Average outer ring groove diameter	(mm)
<i>D</i> r	Cuter ring groove diameter	(mm)
S_{\circ}	Expansion of shaft outer dia. nominal dimensions taking into account temperature	(mm)
d_{\circ}	Expansion of bearing inner dia. nominal dimensions taking into account temperature	(mm)
<i>D</i> ₀	Expansion of bearing outer dia. nominal dimensions taking into account temperature	(mm)
Но	Expansion of housing inner dia. nominal dimensions taking into account temperature	e (mm)
<i>m</i> i	Average value of interference of shaft and inner ring	(mm)
<i>O</i> ⁱ	Standard deviation of interference of shaft and inner ring	(mm)
<i>m</i> o	Average value of interference of outer ring and housing	(mm)
σ_{\circ}	Standard deviation of interference of outer ring and housing	(mm)

λ_{i} :	Average inner ring groove diameter coefficient of expansion	
λ o ······:	Average outer ring groove diameter coefficient of expansion	
<i>M</i> _i :	Average value of clearance reduction due to fitting with inner ring and shaft	(mm)
\sum_i :	Standard deviation of clearance reduction due to fitting with inner ring and shaft	(mm)
<i>M</i> _o :	Average value of clearance reduction due to fitting with outer ring and housing	(mm)
\sum_{0}	Standard deviation of clearance reduction due to fitting with outer ring and housing	(mm)
$\Delta_{\rm t}$:	Clearance reduction due to temperature difference of shaft and housing	(mm)
$U_{\rm m}$:	Average value of operating clearance	(mm)
$U\sigma$:	Standard deviation of operating clearance	(mm)
Qs, Qi, Qo, QH, mf	$\sigma_{\rm f}$, $\sigma_{\rm f}$, to, $\mu_{\rm t}$, $\sigma_{\rm t}$ ···································	
U_{\min} :	Min value of operating clearance	(mm)
U_{\max} :	Max value of operating clearance	(mm)
Pimin:	Min value of fitting pressure (shaft and bearing)	(MPa)
Pimax ······:	Max value of fitting pressure (shaft and bearing)	(MPa)
σ imin:	Min value of fitting stress (inner ring)	(MPa)
σ_{imax}	Max value of fitting stress (inner ring)	(MPa)
Pomin:	Min value of fitting pressure (bearing and housing)	(MPa)
Pomax ······:	Max value of fitting pressure (bearing and housing)	(MPa)
σ omin ······	Min value of fitting stress (outer ring)	(MPa)
<i>σ</i> o max ······	Max value of fitting stress (outer ring)	(MPa)
<i>n</i> i:	Rot. speed of inner ring	(min ⁻¹)
α_0	Contact ang.	(°)
<i>Z</i> ······ :	Number of rolling elements	(No.)
D_{w} :	Rolling element diameter	(mm)
d_{pw}	Rolling element pitch diameter	(mm)
<i>n</i> c:	Rotational speed of cage	(Hz)
<i>n</i> ci:	Rotational speed of cage relative to inner ring	(Hz)
<i>f</i> c ····· :	Number of load cycles of inner ring per second	(Hz)
<i>f</i> ce:	Number of load cycles of outer ring per second	(Hz)
<i>N</i> a:	Rotational speed of rolling element	(Hz)
L10mh:	Modified rating life	(hours)
$a_{ m ISO}$:	Modified rating life factor	
<i>ec</i> :	Contamination factor	
C_{u} ······ :	Fatigue limit load	(N)
<i>v</i> ······ :	Viscosity during operation (mm²/s)
v_1 ······ :	Reference kinematic viscosity (mm²/s)
κ ······	Viscosity ratio	

1-6-2. Gear load

$$K_{t} = \frac{2 \cdot M}{D_{p}}$$

 $K_{s} = K_{t} \cdot \tan \alpha \quad \text{(spur)}$ $= K_{t} \cdot \frac{\tan \alpha}{\cos \beta} \quad \text{(helical gear)}$

 $K_a = K_t \cdot \tan \beta$ (helical gear only)

Each positive and negative gear load in this catalog has been set from the rotation direction of the input shaft when viewing bearing A from bearing B, and the twisting direction of each gear as in **Table 1**.

			-	•	
Rotation direction of input shaft	Twisti	ng direction of gear	Tangent dir. Ioad	Radial dir. Ioad	Axial dir. Ioad
	CoorA	Right screw	Pos.	Neg.	Neg.
Clockwice	GearA	Left screw	Pos.	Neg.	Pos.
CIUCKWISE	Goar B	Right screw	Neg.	Pos.	Neg.
	Geal D	Left screw	Neg.	Pos.	Pos.
	GoorA	Right screw	Neg.	Neg.	Pos.
Countorolookwico	GearA	Left screw	Neg.	Neg.	Neg.
Counterclockwise	CoorD	Right screw	Pos.	Pos.	Pos.
	Gear B	Left screw	Pos.	Pos.	Nea.

Table 1 Positive and negative of each gear load

Note 1) Axial dir. load not taken into account for spurs.

Note 2) Gear twisting direction not taken into account for spurs.

1-6-3. Load distribution on bearings

1. Gear load

Radial load (applies to both spurs and helical gears)



 When the twisting direction of gear A is right and the direction of rotation is clockwise, or the twisting direction of gear A is left and the direction of rotation is counterclockwise,

$$F_{\rm rA} = \sqrt{\left(\frac{SB_1 - SG_1}{SB_1}K_{\rm t}\right)^2 + \left(\frac{SB_1 - SG_1}{SB_1}K_{\rm s} + \frac{D_{\rm pA}}{2 \cdot SB_1}K_{\rm a}\right)^2}$$

$$F_{\rm rB} = \sqrt{\left(\frac{SG_1}{SB_1}K_{\rm t}\right)^2 + \left(\frac{SG_1}{SB_1}K_{\rm s} - \frac{D_{\rm pA}}{2 \cdot SB_1}K_{\rm a}\right)^2}$$

$$F_{\rm rC} = \sqrt{\left(\frac{SB_2 - SG_2}{SB_2}K_{\rm t}\right)^2 + \left(\frac{SB_2 - SG_2}{SB_2}K_{\rm s} - \frac{D_{\rm pB}}{2 \cdot SB_2}K_{\rm a}\right)^2}$$

$$F_{\rm rD} = \sqrt{\left(\frac{SG_2}{SB_2}K_{\rm t}\right)^2 + \left(\frac{SG_2}{SB_2}K_{\rm s} + \frac{D_{\rm pB}}{2 \cdot SB_2}K_{\rm a}\right)^2}$$

2) When the twisting direction of gear A is left and the direction of rotation is clockwise, or the twisting direction of gear A is right and the direction of rotation is counterclockwise,

$$\begin{split} F_{\rm rA} &= \sqrt{\left(\frac{SB_1 - SG_1}{SB_1}K_{\rm t}\right)^2 + \left(\frac{SB_1 - SG_1}{SB_1}K_{\rm s} - \frac{D_{\rm pA}}{2 \cdot SB_1}K_{\rm a}\right)^2} \\ F_{\rm rB} &= \sqrt{\left(\frac{SG_1}{SB_1}K_{\rm t}\right)^2 + \left(\frac{SG_1}{SB_1}K_{\rm s} + \frac{D_{\rm pA}}{2 \cdot SB_1}K_{\rm a}\right)^2} \\ F_{\rm rC} &= \sqrt{\left(\frac{SB_2 - SG_2}{SB_2}K_{\rm t}\right)^2 + \left(\frac{SB_2 - SG_2}{SB_2}K_{\rm s} + \frac{D_{\rm pB}}{2 \cdot SB_2}K_{\rm a}\right)^2} \\ F_{\rm rD} &= \sqrt{\left(\frac{SG_2}{SB_2}K_{\rm t}\right)^2 + \left(\frac{SG_2}{SB_2}K_{\rm s} - \frac{D_{\rm pB}}{2 \cdot SB_2}K_{\rm a}\right)^2} \end{split}$$

Note 1) For spurs, $K_a = 0$

Axial load (helical gear only)

1) Angular contact ball brgs. and tapered roller brgs.

If a radial load (F_r) is placed on angular contact ball brgs. and tapered roller brgs., a component force is generated in the axial direction. This is called the induced thrust load (F_a). The size of the induced thrust load is determined with the following formula.

$$F_a' = \frac{0.5 \cdot F_r}{Y}$$
 (N or kgf)

The calculation of the axial load and equivalent load of each bearing when angular contact ball brgs. and tapered roller brgs. are positioned opposite each other.

(a) Back-to-back arrangement



(1) For
$$\frac{0.5 \cdot F_{\text{rA}}}{Y_{\text{A}}} \leq \frac{0.5 \cdot F_{\text{rB}}}{Y_{\text{B}}} + K_{\text{a}}$$

$$F_{aA=} \frac{\mathbf{0.5} \cdot F_{rB}}{Y_{B}} + K_{a}$$
$$F_{aB=} \frac{\mathbf{0.5} \cdot F_{rB}}{Y_{B}}$$

(2) For $\frac{\mathbf{0.5} \cdot F_{\mathrm{rA}}}{Y_{\mathrm{A}}} > \frac{\mathbf{0.5} \cdot F_{\mathrm{rB}}}{Y_{\mathrm{B}}} + K_{\mathrm{a}}$

$$F_{aA=} \frac{\mathbf{0.5} \cdot F_{rA}}{Y_A}$$
$$F_{aB=} \frac{\mathbf{0.5} \cdot F_{rA}}{Y_A} - K_a$$

(a) Face-to-face arrangement



(1) For
$$\frac{0.5 \cdot F_{rB}}{Y_{B}} \leq \frac{0.5 \cdot F_{rA}}{Y_{A}} + K_{a}$$

$$F_{aA} = \frac{0.5 \cdot F_{rA}}{Y_{A}}$$

$$F_{aB} = \frac{0.5 \cdot F_{rA}}{Y_{A}} + K_{a}$$
(2) For
$$\frac{0.5 \cdot F_{rB}}{Y_{B}} > \frac{0.5 \cdot F_{rA}}{Y_{A}} + K_{a}$$

$$F_{aA} = \frac{0.5 \cdot F_{rB}}{Y_{B}} - K_{a}$$

$$F_{aA} = \frac{1}{Y_{B}} - K$$
$$F_{aB} = \frac{0.5 \cdot F_{rB}}{Y_{B}}$$

1) Other bearings

- If there is an instruction to place an axial load on the bearing setting screen, place an axial load on the bearing.
- (1) If the load is placed on a single row, the entire axial load is placed on those bearings.
- (2) If the load is placed on two rows, half the axial load is placed on those bearings.

2. Load placed on shafts

Radial load

Bearing radial load calculated from the radial load and moment load placed on the shaft load center



Axial load

1) Angular contact ball brgs. and tapered roller brgs.

Replacing the axial dir. load (K_a) of the gear with the axial load (F_a) placed on the shaft means the calculation method is the same as <u>1-6-3-1.2 Axial load of the gear load</u>.

2) Other bearings

If there is an instruction to place an axial load on other bearing setting screens, place an axial load on the bearing.

- (1) If the load is placed on a single row, the entire axial load is placed on those bearings.
- (2) If the load is placed on two rows, half the axial load is placed on those bearings.

1-6-4. Calculation of equivalent load

1. Radial bearings excluding cylindrical roller brgs.

- 1) Application bearings : Deep Groove Ball Brgs.
 - Expansion Compensating Brgs. Miniature Ball Brgs. Angular Contact Ball Brgs. Double Row Angular Contact Ball Brgs. Self-Aligning Ball Brgs. Tapered Roller Brgs. (Metric series) Tapered Roller Brgs. (Inch series) Double Row Tapered Roller Brgs. (Outward facing type) Double Row Tapered Roller Brgs. (Inward facing type) Spherical Roller Brgs.
- 2) Equivalent load formula

 $P_{\rm r} = X \cdot F_{\rm r} + Y \cdot F_{\rm a}$

2. Cylindrical Roller Brgs.

1) Application bearings Cylindrical Roller Brgs Double Row Cylindrical Roller Brgs.

2) Equivalent load formula

 $P_{\rm r} = F_{\rm r}$

3. Thrust Spherical Roller Brgs.

1) Application bearings : Thrust Spherical Roller Brgs.

2) Equivalent load formula

 $P_{a} = F_{a} + 1.2 \cdot F_{r}$ (however, $F_{r}/F_{a} \le 0.55$)

4. Thrust Spherical Roller Brgs.

- 1) Application bearings \therefore Four-Point Contact Ball Brgs.
 - Thrust Ball Brgs. Double Row Thrust Ball Brgs. Thrust Cylindrical Roller Brgs.
- 2) Equivalent load formula

 $P_{a}=F_{a}$

1-6-5. Calculation of average equivalent load when calculating bearing unit life

$$P_{\mathrm{m}} = \left\{ \frac{\Sigma \left(P_{\mathrm{i}}^{p} \cdot n_{\mathrm{i}} \cdot t_{\mathrm{i}} \right)}{\Sigma \left(n_{\mathrm{i}} \cdot t_{\mathrm{i}} \right)} \right\}^{1/p}$$

1-6-6. Calculation of basic rating life

$$L_{10h} = \frac{10^6}{60 \cdot n} \left(\frac{C}{P}\right)^p$$

Note 1) For bearing unit life calculations, if there are 2 or more steps, enter the average value of the rot. speed determined with the following formula into the rot. speed of the above formula

$$n_{\rm m} = \frac{n_1 \cdot t_1 + n_2 \cdot t_2 \cdots n_{\rm m} \cdot t_{\rm m}}{t_1 + t_2 \cdots t_{\rm m}}$$

1-6-7. Calculation of total life of bearing system

Determine the total life of the shaft supported by bearing A and bearing B as follows.

$$L_{\rm T} = \frac{1}{\left\{ (1/L_{\rm A})^e + (1/L_{\rm B})^e \right\}^{\frac{1}{2}}}$$

1-6-8. Total life of the bearing unit calculated from the frequency of meshing conditions of the gear in 1-3-8. Gear load and basic rating life

$$L_{t=} \frac{100}{\Sigma\left(\frac{q_{i}}{L_{10hi}}\right)}$$

1-6-9. Calculation of average inner ring groove diameter, average outer ring groove diameter

The average inner ring groove diameter d_m , average outer ring groove diameter D_m and outer ring groove diameter D_r is calculated with the following formula.

Bearing type	$d_{ m m}$	$D_{ m m}$	Dr
Deep Groove Ball Brgs.	$1.05 \cdot \frac{4d+D}{5}$	$0.95 \cdot \frac{d+4D}{5}$	<u>d+4D</u> 5
Cylindrical Roller Brgs.	$1.05 \cdot \frac{3d+D}{4}$	$0.98 \cdot \frac{d+3D}{4}$	<u>d+3D</u> 4
Spherical Roller Brgs.	<u>2d+D</u> <u>3</u>	$0.97 \cdot \frac{d+4D}{5}$	<u>d+4D</u> 5

Table 1 Average inner and outer ring groove diameter, outer ring groove diameter

1-6-10. Expansion of each component dimension taking into account shaft and housing temperature

Calculate expansion of each component dimension taking into account shaft and housing temperature with the following formula.

 $S_{0}=d \cdot \alpha_{S} \cdot (T_{S}-20)$ $d_{0}=d \cdot 12.5 \cdot 10^{-6} \cdot (T_{S}-20)$ $D_{0}=D \cdot 12.5 \cdot 10^{-6} \cdot (T_{H}-20)$ $H_{0}=D \cdot \alpha_{H} \cdot (T_{H}-20)$

1-6-11. Calculation of inner ring and shaft

1-6-11-1. Calculation of average value of interference of inner ring and shaft, and standard deviation of interference of inner ring and shaft

Calculate the average value of interference m_i and standard deviation of interference σ_i of the inner ring and shaft with the following.

(1) Calculate $(S_0+SS_1) - (d_0+dd_2)$

If $(S_0+SS_1) - (d_0+dd_2) \ge 0$, proceed to \bigcirc ,

If $(S_0+SS_1) - (d_0+dd_2) < 0$, proceed to ③.

② Interference calculation for interference fit

$$m_{i} = \left(\frac{2 \cdot S_{0} + SS_{1} + SS_{2}}{2} - \frac{2 \cdot d_{0} + dd_{1} + dd_{2}}{2}\right) \cdot \frac{d}{d+3}$$
$$\sigma_{i} = \sqrt{\left(\frac{SS_{2} - SS_{1}}{2 \cdot 3}\right)^{2} + \left(\frac{dd_{2} - dd_{1}}{2 \cdot 3}\right)^{2}} \cdot \frac{d}{d+3}$$

③ Calculate $(S_0+SS_2) - (d_0+dd_1)$ If $(S_0+SS_2) - (d_0+dd_1) > 0$, proceed to ④, If $(S_0+SS_2) - (d_0+dd_1) \leq 0$, proceed to ⑤.

④ Interference calculation for transition fit

$$m_{\rm f} = \left(\frac{2 \cdot S_0 + SS_1 + SS_2}{2} - \frac{2 \cdot d_0 + dd_1 + dd_2}{2}\right) \cdot \frac{d}{d+3}$$
$$\sigma_{\rm f} = \sqrt{\left(\frac{SS_2 - SS_1}{2 \cdot 3}\right)^2 + \left(\frac{dd_2 - dd_1}{2 \cdot 3}\right)^2} \cdot \frac{d}{d+3}$$

If $t_0 = -m_f / \sigma_f$, determine μ_t , σ_t from **Table 2**.

Table 2 $\mu_t \cdot \sigma_t$ calculation chart

to	μt	σt	to	μt	σt
-3.0	0.0004	0.999	0.1	0.451	0.549
-2.8	0.0008	0.998	0.2	0.509	0.515
-2.6	0.0015	0.996	0.3	0.567	0.480
-2.4	0.0027	0.993	0.4	0.630	0.446
-2.2	0.005	0.988	0.5	0.698	0.412
-2.0	0.008	0.980	0.6	0.769	0.380
_1.8	0.014	0.969	0.7	0.843	0.349
1.6	0.023	0.953	0.8	0.920	0.318
-1.0	0.037	0.931	0.9	1.000	0.289
-1.4	0.056	0.902	1.0	1.083	0.262
-1.2	0.083	0.867	1.2	1.256	0.211
-1.0	0.100	0.846	1.4	1.437	0.168
-0.9	0.120	0.823	1.6	1.623	0.131
-0.8	0.143	0.799	1.8	1.814	0.100
-0.6	0.169	0.772	2.0	2.008	0.075
-0.5	0.198	0.744	2.2	2.205	0.056
-0.4	0.230	0.714	2.4	2.4027	0.041
-0.3	0.267	0.683	2.6	2.6015	0.029
-0.2	0.307	0.651	2.8	2.8008	0.020
_0.1	0.351	0.618	3.0	3.0004	0.014
-0.1	0.399	0.577			
U					

*Areas between each value are calculated with linear interpolation. If to < -3.0 and $3.0 < t_0$, conduct the calculation using the $-3.0 \le t_0 \le -2.8$ and $2.8 \le t_0 \le 3.0$ interpolation curve.

Using μ_t and σ_t from Table 2,

 $m_{\rm i} = m_{\rm f} + \mu_{\rm t} \cdot \sigma_{\rm t}$

 $\sigma_{i} = \sigma_{t} \cdot \sigma_{f}$

(5) Interference calculation for clearance fit

 $m_i=0, \sigma_i=0$

(end of 1-6-11-1)

(end of 1-6-11-1)

(end of 1-6-11-1)

1-6-11-2. Calculation of average inner ring groove diameter coefficient of expansion

Calculate the average inner ring groove diameter coefficient of expansion λ_i with the following.

$$Q_{i} = \frac{d_{m}^{2} + d^{2}}{d_{m}^{2} - d^{2}}$$

$$Q_{s} = \frac{d^{2} + S^{2}}{d^{2} - S^{2}}$$

$$\lambda_{i} = \frac{E_{s} \cdot (Q_{i} + 1)}{E_{s} \cdot (Q_{i} + 0.3) + E_{B} \cdot (Q_{s} - v_{s})} \cdot \frac{d}{d_{m}}$$

1-6-11-3. Calculation of clearance reduction due to fitting with inner ring and shaft

Calculate the average value M_i and standard deviation Σ_i of clearance reduction due to fitting of the inner ring and shaft.

 $\Sigma_{i} = \sigma_{i} \cdot \lambda_{i}$ $M_{i} = m_{i} \cdot \lambda_{i}$

1-6-12. Outer ring and housing calculation

1-6-12-1. Calculation of average value of interference of outer ring and housing, and standard deviation of interference of outer ring and housing

Calculate the average value of interference m_0 and standard deviation of interference σ_0 of the outer ring and housing with the following.

① Calculate $(D_0+DD_1) - (H_0+HH_2)$ If $(D_0+DD_1) - (H_0+HH_2) \ge 0$, proceed to ②, If $(D_0+DD_1) - (H_0+HH_2) < 0$, proceed to ③.

② Interference calculation for interference fit

$$m_{0} = \left(\frac{2 \cdot D_{0} + DD_{1} + DD_{2}}{2} - \frac{2 \cdot H_{0} + HH_{1} + HH_{2}}{2}\right) \cdot \frac{D}{D+3}$$
$$\sigma_{0} = \sqrt{\left(\frac{DD_{2} - DD_{1}}{2 \cdot 3}\right)^{2} + \left(\frac{HH_{2} - HH_{1}}{2 \cdot 3}\right)^{2}} \cdot \frac{D}{D+3}$$

③ Calculate
$$(D_0+DD_2) - (H_0+HH_1)$$

If $(D_0+DD_2) - (H_0+HH_1) > 0$, proceed to ④,
If $(D_0+DD_2) - (H_0+HH_1) \leq 0$, proceed to ⑤.

④ Interference calculation for transition fit

$$m_{t} = \left(\frac{2 \cdot D_{0} + DD_{1} + DD_{2}}{2} - \frac{2 \cdot H_{0} + HH_{1} + HH_{2}}{2}\right) \cdot \frac{D}{D+3}$$
$$\sigma_{t} = \sqrt{\left(\frac{DD_{2} - DD_{1}}{2 \cdot 3}\right)^{2} + \left(\frac{HH_{2} - HH_{1}}{2 \cdot 3}\right)^{2}} \cdot \frac{D}{D+3}$$

If $t_0 = -m_t / \sigma_t$, determine μ_t, σ_t from **Table 2**. Using μ_t and σ_t from **Table 2**,

$$m_0 = m_f + \mu_t \cdot \sigma_t$$

$$\sigma_0 = \sigma_t \cdot \sigma_r$$

(5) Interference calculation for clearance fit

$$m_0 = 0, \sigma_0 = 0$$

(end of 1-6-12-1)

(end of 1-6-12-1)

(end of 1-6-12-1)

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1-6-12-2. Calculation of average outer ring groove diameter coefficient of contraction

Calculate the average outer ring groove diameter coefficient of contraction λ_0 with the following.

$$Q_{0} = \frac{D^{2} + D_{m}^{2}}{D^{2} - D_{m}^{2}}$$

$$Q_{H} = \frac{H^{2} + D^{2}}{H^{2} - D^{2}}$$

$$\lambda_{0} = \frac{E_{H} \cdot (Q_{0} + 1)}{E_{B} \cdot (Q_{H} + \nu_{H}) + E_{H} \cdot (Q_{0} - 0.3)} \cdot \frac{D_{m}}{D}$$

1-6-12-3. Calculation of clearance reduction due to fitting with outer ring and housing

Calculate the average value M_0 and standard deviation Σ_0 of clearance reduction due to fitting of the outer ring and housing.

 $M_0 = m_0 \cdot \lambda_0$ $\Sigma_0 = \sigma_0 \cdot \lambda_0$

1-6-13. Calculation of clearance reduction due to temperature difference of shaft and housing

Calculate the clearance reduction Δ_t due to temperature difference of shaft and housing with the following formula

 $\Delta_{\mathrm{t}} = D_{\mathrm{r}} \cdot \mathbf{12.5} \cdot \mathbf{10^{-6}} \cdot (T_{\mathrm{S}} - T_{\mathrm{H}})$

(${\it \Delta}{\rm t}$ can be a negative value)

1-6-14. Operating clearance calculation

Calculate the average value U_m and standard deviation U_σ of the operating clearance with the following formula.

$$U_{\rm m} = \frac{C_{\rm r\,max} + C_{\rm r\,min}}{2} - (M_{\rm i} + M_0 + \Delta_{\rm t})$$
$$U_{\sigma} = \sqrt{\left(\frac{C_{\rm r\,max} - C_{\rm r\,min}}{2 \cdot 3}\right)^2 + \Sigma_{\rm i}^2 + \Sigma_{\rm 0}^2}$$

The min value of operating clearance U_{\min} and max value of operating clearance U_{\max} are the following.

 $U_{\min} = U_{m} - \mathbf{3} \cdot U_{\sigma}$ $U_{\max} = U_{m} + \mathbf{3} \cdot U_{\sigma}$

1-6-15. Calculation of fitting pressure (shaft and bearing), fitting stress (shaft and bearing)

Calculate the fitting pressure (shaft and bearing) min value P_{imin} , max value P_{imax} , fitting stress (inner ring) min value σ_{imin} , max value σ_{imax} with the following formulas.

$$P_{i\min} = \frac{\frac{\{(S_0 + SS_1) - (d_0 + dd_2)\} \cdot \frac{d}{d+3}}{2 \cdot d/2}}{\left(\frac{1 - \nu_s}{E_s} - \frac{1 - 0.3}{E_B}\right) + 2 \cdot \left[\frac{(S/2)^2}{E_s \cdot \{(d/2)^2 - (S/2)^2\}} + \frac{(dm/2)^2}{E_B \cdot \{(dm/2)^2 - (d/2)^2\}}\right]}$$

$$P_{i\max} = \frac{\frac{\{(S_0 + SS_2) - (d_0 + dd_1)\} \cdot \frac{d}{d+3}}{2 \cdot d/2}}{\left(\frac{1 - \nu_s}{E_s} - \frac{1 - 0.3}{E_B}\right) + 2 \cdot \left[\frac{(S/2)^2}{E_s \cdot \{(d/2)^2 - (S/2)^2\}} + \frac{(dm/2)^2}{E_B \cdot \{(dm/2)^2 - (d/2)^2\}}\right]}$$

$$\sigma \text{ imin} = \frac{1 + (d/d_m)^2}{1 - (d/d_m)^2} \cdot P \text{ imin}$$
$$\sigma \text{ imax} = \frac{1 + (d/d_m)^2}{1 - (d/d_m)^2} \cdot P \text{ imax}$$

1-6-16. Calculation of fitting pressure (bearing and housing), fitting stress (outer ring)

Calculate the fitting pressure (bearing and housing) min value $P_{0\min}$, max value $P_{0\max}$, fitting stress (outer ring) min value $\sigma_{0\min}$, max value $\sigma_{0\max}$ with the following formulas.

$$P_{0 \text{ min}} = \frac{\frac{\{(D_0 + DD_1) - (H_0 + HH_2)\} \cdot \frac{D}{D+3}}{2 \cdot D/2}}{\left(\frac{1-0.3}{E_B} - \frac{1-\nu_H}{E_H}\right) + 2 \cdot \left[\frac{(D_0/2)^2}{E_B \cdot \{(D/2)^2 - (D_0/2)^2\}} + \frac{(H/2)^2}{E_H \cdot \{(H/2)^2 - (D/2)^2\}}\right]}{\frac{\{(D_0 + DD_2) - (H_0 + HH_1)\} \cdot \frac{D}{D+3}}{2 \cdot D/2}}{\left(\frac{1-0.3}{E_B} - \frac{1-\nu_H}{E_H}\right) + 2 \cdot \left[\frac{(D_0/2)^2}{E_B \cdot \{(D/2)^2 - (D_0/2)^2\}} + \frac{(H/2)^2}{E_H \cdot \{(H/2)^2 - (D/2)^2\}}\right]}$$

$$\sigma_{0 \text{ max}} = \frac{1+(d/d_m)^2}{1-(d/d_m)^2} \cdot P_{0 \text{ max}}$$

$$\sigma_{0 \text{ min}} = \frac{1+(d/d_m)^2}{1-(d/d_m)^2} \cdot P_{0 \text{ min}}$$

1-6-17. Calculation of bearing vibration frequency

Calculate n_c , n_{ci} , f_{ci} , f_{ce} and n_a with the following formula.

$$n_{\rm c} = \frac{n_{\rm i} \cdot (d_{\rm pw} - D_{\rm w} \cdot \cos \alpha \, 0)}{2 \cdot d_{\rm pw} \cdot 60}$$
$$n_{\rm ci} = \frac{n_{\rm i} \cdot (d_{\rm pw} + D_{\rm w} \cdot \cos \alpha \, 0)}{2 \cdot d_{\rm pw} \cdot 60}$$

 $f_{\text{ci}}=n_{\text{ci}}\cdot Z$

 $f ce = n_c \cdot Z$

$$n_{a} = \frac{n_{i} \cdot (d_{pw}^{2} - D_{w}^{2} \cdot \cos^{2} \alpha_{0})}{2 \cdot d_{pw} \cdot D_{w} \cdot 60}$$

1-6-18. Calculation of modified rating life

Modified rating life can be obtained with the following formula using the reliability factor, life modification factor, and basic rating life.

 $L_{nm} = a_1 \cdot a_{ISO} \cdot L_n$

1-6-18-1 Calculation of reliability factor a_1

The value of reliability factor a_1 is provided in Appendix table 18 for reliability of 90% or greater.

* The Bearing Technical Calculation Tool uses a reliability of 90% L_{10} , that is $a_1 = 1$.

1-6-18-2 Calculation of modification factor $lpha_{\rm ISO}$

Life modification factor $\alpha_{\rm ISO}$ is a value obtained by integrating material characteristics and lubrication conditions, and given as a function like the following formula in ISO 281:2007. Specifically, it is obtained with the drawing or formula for each bearing type indicated in <u>1-16-18-7</u>.

$$a_{\rm ISO} = f\left(\frac{e_c C_{\rm u}}{p} k\right)$$

*The Bearing Technical Calculation Tool does not support the use of a lubricant with extreme pressure additive. Please consult **NTN** Engineering when using a lubricant with extreme pressure additive.

1-6-18-3 Calculation of viscosity ratio κ

Viscosity ratio for the lubricating material κ is represented by the following formula by the ratio of kinematic viscosity v in use with respect to reference kinematic viscosity v_1 of the lubricant.

$$\kappa = \frac{v}{v_1}$$

Reference kinematic viscosity v_1 depends on bearing rotation speed *n* and size (D_{pw}), and can be obtained with the following formula or from **Figure A.1**.

For $n < 1000 \text{ min}^{-1}$, $V_1 = 45\ 000\ n^{-0.83}\ D_{\text{pw}}^{-0.5}$ For $n \ge 1000\ \text{min}^{-1}$, $V_1 = 45\ 000\ n^{-0.5}\ D_{\text{pw}}^{-0.5}$



1-6-18-4 Calculation of reliability factor e_c

As shown in Appendix **table 16**, approximate values are determined by the bearing size (may be substituted by rolling element pitch diameter D_{pw} , average bearing diameter (d+D) /2), filtration and seal structures (including presence of pre-washing).

1-6-18-5 Calculation of fatigue limit load C_u

The fatigue limit load C_u is the load applied on bearings that becomes the fatigue limit stress at the maximum load contact part of the raceway. This depends on the bearing type, internal specifications, quality, and material strength, and in ISO 281:2007, 1.5 GPa is recommended as the contact stress corresponding to C_u for the bearings made of high purity bearing steel. The fatigue limit load values with respect to the **NTN** bearing numbers are specified in each specification table.

1-6-18-6 Calculation of equivalent load *P*

1-6-4. See calculation of equivalent load.

1-6-18-7 Calculation of life modification factor $a_{\rm ISO}$ for each bearing type

The value of life modification factor $\alpha_{\rm ISO}$ is determined based on **Figure A.2** to **Figure A.5** or the following formula (A.5) to formula (A.16) calculation for each bearing type.

However, care should be taken concerning the following points.

If $\ensuremath{\mathcal{A}_{\mathrm{ISO}}}$ > 50, $\ensuremath{\mathcal{A}_{\mathrm{ISO}}}$ = 50.

- (2) If κ > 4, α _{ISO} is calculated with κ = 4.
- 3 If κ < 0.1, $\mathcal{A}_{\rm ISO}$ cannot be calculated (the formula and figure do not apply)
- (4) If $\kappa < 1$ and $e_c \ge 0.2$, and a lubricant containing extreme pressure additive is used, the value $\kappa = 1$ can be used to calculate contamination factor e_c and life modification factor a_{ISO} . However, when the value for life modification factor a_{ISO} exceeds 3 as a result of this calculation, $a_{ISO} = 3$.



Figure A.2 Life modification factor $\alpha_{\rm ISO}$ (radial ball bearing)



Figure A.3 Life modification factor $\alpha_{\rm ISO}$ (radial roller bearing)

The curved lines shown in Figure A.2 are based on formula (A.5) to formula (A.7).

If
$$0.1 \le \kappa < 0.4$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{2.2649}{\kappa^{0.054381}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{P} \right)^{1/3} \right]^{-9.3} \dots \dots (A.5)$

If $0.4 \le \mathcal{K} < 1$,

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{1.9987}{\kappa^{0.19087}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{P} \right)^{1/3} \right]^{-9.3} \dots \dots (A.6)$$

If $1 \leq \mathcal{K} \leq 4$,

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{1.9987}{\kappa^{0.071739}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{P} \right)^{1/3} \right]^{-9.3} \dots \dots (A.7)$$

The curved lines shown in **Figure A.3** are based on formula (A.8) to formula (A.10).

If
$$0.1 \le \kappa < 0.4$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.3993}{\kappa^{0.054381}} \right) \left(\frac{e_c C_u}{P} \right)^{0.4} \right]^{-9.185} \dots \dots (A.8)$

If
$$0.4 \le \kappa < 1$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.2348}{\kappa^{0.19087}} \right) \left(\frac{e_{\rm c} C_{\rm u}}{P} \right)^{0.4} \right]^{-9.185} \dots (A.9)$

 $\text{ If } 1 \leq \mathcal{K} \leq 4,$

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.2348}{\kappa^{0.071739}} \right) \left(\frac{e_{\rm c} C_{\rm u}}{P} \right)^{0.4} \right]^{-9.185} \dots \dots (A.10)$$



Figure A.4 Life modification factor $\mathcal{\alpha}_{\rm ISO}$ (thrust ball bearing)



Figure A.5 Life modification factor $\mathcal{A}_{\rm ISO}$ (thrust roller bearing)

The curved lines shown in Figure A.4 are based on formula (A.11) to formula (A.13).

If
$$0.1 \le \kappa < 0.4$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{2.2649}{\kappa^{0.054381}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{3P} \right)^{1/3} \right]^{-9.3} \dots (A.11)$

If $0.4 \le \kappa < 1$,

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{1.9987}{\kappa^{0.19087}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{3P} \right)^{1/3} \right]^{-9.3} \dots (A.12)$$

If $1 \leq \mathcal{K} \leq 4$,

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(2.5671 - \frac{1.9987}{\kappa^{0.071739}} \right)^{0.83} \left(\frac{e_{\rm c} C_{\rm u}}{3P} \right)^{1/3} \right]^{-9.3} \dots (A.13)$$

The curved lines shown in Figure A.5 are based on formula (A.14) to formula (A.16).

If
$$0.1 \le \kappa < 0.4$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.3993}{\kappa^{0.054381}} \right) \left(\frac{e_{\rm c} C_{\rm u}}{2.5P} \right)^{0.4} \right]^{-9.185} \dots (A.14)$

If
$$0.4 \le \kappa < 1$$
,
 $\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.2348}{\kappa^{0.19087}} \right) \left(\frac{e_{\rm c} C_{\rm u}}{2.5P} \right)^{0.4} \right]^{-9.185} \dots (A.15)$

 $\text{ If } 1 \leq \mathcal{K} \leq 4,$

$$\alpha_{\rm ISO} = 0.1 \left[1 - \left(1.5859 - \frac{1.2348}{\kappa^{0.071739}} \right) \left(\frac{e_{\rm c} C_{\rm u}}{2.5P} \right)^{0.4} \right]^{-9.185} \dots (A.16)$$

1-7. Appendix tables

Bearing inr	ner dia. (d)	JIS C	lass 0	JIS C	lass 6	JIS C	lass 5	JIS C	lass 4	JIS C	lass 2
m	m	μ	m	μ	m	μ	m	μ	ım	μ	m
More than	or less	Upper	Lower								
0.6	18	0	-8	0	-7	0	-5	0	-4	0	-2.5
18	30	0	-10	0	-8	0	-6	0	-5	0	-2.5
30	50	0	-12	0	-10	0	-8	0	-6	0	-2.5
50	80	0	-15	0	-12	0	-9	0	-7	0	-4
80	120	0	-20	0	-15	0	-10	0	-8	0	-5
120	150	0	-25	0	-18	0	-13	0	-10	0	-7
150	180	0	-25	0	-18	0	-13	0	-10	0	-7
180	250	0	-30	0	-22	0	-15	0	-12	0	-8
250	315	0	-35	0	-25	0	-18	_	_	_	-
315	400	0	-40	0	-30	0	-23	_	_	_	_
400	500	0	-45	0	-35	_	_	_	_	_	_
500	630	0	-50	0	-40	_	_	_	_	_	_
630	800	0	-75	_	_	_	_	_	_	_	_
800	1000	0	-100	_	_	_	_	_	_	_	_
1000	1250	0	-125	_	_	_	_	_	_	_	_
1250	1600	0	-160	_	_	_	_	_	_	_	_
1600	2000	0	-200	_	_	_	_	_	_	_	_

Appendix table 1. Limiting dimensional tolerance of bearing inner dia.

Appendix table 2. Limiting dimensional tolerance of bearing outer dia.

Bearing ou m	ter dia. (<i>D</i>) m	JIS CI μ	lass 0 m	JIS C μ	lass 6 m	JIS C μ	lass 5 m	JIS CI μ	ass 4 m	JIS CI μ	ass 2 m
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
2.5	18	0	-8	0	-7	0	-5	0	-4	0	-2.5
18	30	0	-9	0	-8	0	-6	0	-5	0	-4
30	50	0	-11	0	-9	0	-7	0	-6	0	-4
50	80	0	-13	0	-11	0	-9	0	-7	0	-4
80	120	0	-15	0	-13	0	-10	0	-8	0	-5
120	150	0	-18	0	-15	0	-11	0	-9	0	-5
150	180	0	-25	0	-18	0	-13	0	-10	0	-7
180	250	0	-30	0	-20	0	-15	0	-11	0	-8
250	315	0	-35	0	-25	0	-18	0	-13	0	-8
315	400	0	-40	0	-28	0	-20	0	-15	0	-10
400	500	0	-45	0	-33	0	-23	—	—	—	—
500	630	0	-50	0	-38	0	-28	—	—	—	—
630	800	0	-75	0	-45	0	-35	—	—	—	—
800	1000	0	-100	0	-60	-	—	—	—	—	—
1000	1250	0	-125	—	—	—	—	—	—	—	—
1250	1600	0	-160	_	_	_	_	_	_	_	_
1600	2000	0	-200	_	_	_	_	_	_	_	_
2000	2500	0	-250	_	_	_	_	_	_	_	_

Bearing inr	ner dia. (d)	C	2	С	N	C	3	C	4	C	5
m	m	μ	m	μ	ım	μ	ım	μ	ım	μ	m
More than	or less	min	max								
6	10	0	7	2	13	8	23	14	29	20	37
10	18	0	9	3	18	11	25	18	33	25	45
18	24	0	10	5	20	13	28	20	36	28	48
24	30	1	11	5	20	13	28	23	41	30	53
30	40	1	11	6	20	15	33	28	46	40	64
40	50	1	11	6	23	18	36	30	51	45	73
50	65	1	15	8	28	23	43	38	61	55	90
65	80	1	15	10	30	25	51	46	71	65	105
80	100	1	18	12	36	30	58	53	84	75	120
100	120	2	20	15	41	36	66	61	97	90	140
120	140	2	23	18	48	41	81	71	114	105	160
140	160	2	23	18	53	46	91	81	130	120	180
160	180	2	25	20	61	53	102	91	147	135	200
180	200	2	30	25	71	63	117	107	163	150	230
200	225	2	35	25	85	75	140	125	195	175	265
225	250	2	40	30	95	85	160	145	225	205	300
250	280	2	45	35	105	90	170	155	245	225	340
280	315	2	55	40	115	100	190	175	270	245	370
315	355	3	60	45	125	110	210	195	300	275	410
355	400	3	70	55	145	130	240	225	340	315	460
400	450	3	80	60	170	150	270	250	380	350	510
450	500	3	90	70	190	170	300	280	420	390	570
500	560	10	100	80	210	190	330	310	470	440	630
560	630	10	110	90	230	210	360	340	520	490	690

Appendix table 3. Radial internal clearance of deep groove ball brgs.

Appendix table 4. Radial internal clearance of cylindrical roller brgs.

Bearing inr	ner dia. (d)	С	2	С	N	C	3	C	4	C	5
m	m	μ	m	μ	m	μ	m	μ	m	μ	m
More than	or less	min	max								
10	24	0	25	20	45	35	60	50	75	65	90
24	30	0	25	20	45	35	60	50	75	70	95
30	40	5	30	25	50	45	70	60	85	80	105
40	50	5	35	30	60	50	80	70	100	95	125
50	65	10	40	40	70	60	90	80	110	110	140
65	80	10	45	40	75	65	100	90	125	130	165
80	100	15	50	50	85	75	110	105	140	155	190
100	120	15	55	50	90	85	125	125	165	180	220
120	140	15	60	60	105	100	145	145	190	200	245
140	160	20	70	70	120	115	165	165	215	225	275
160	180	25	75	75	125	120	170	170	220	250	300
180	200	35	90	90	145	140	195	195	250	275	330
200	225	45	105	105	165	160	220	220	280	305	365
225	250	45	110	110	175	170	235	235	300	330	395
250	280	55	125	125	195	190	260	260	330	370	440
280	315	55	130	130	205	200	275	275	350	410	485
315	355	65	145	145	225	225	305	305	385	455	535
355	400	100	190	190	280	280	370	370	460	510	600
400	450	110	210	210	310	310	410	410	510	565	665
450	500	110	220	220	330	330	440	440	550	625	735

Bearing in	ner dia. (d)	C	2	C	N	С	3	C4		C	5
m	m	μ	m	μ	lm	μ	m	μm		μ	m
More than	or less	min	max	min	max	max	max	min	max	min	max
14	24	10	20	20	35	35	45	45	60	60	75
24	30	15	25	25	40	40	55	55	75	75	95
30	40	15	30	30	45	45	60	60	80	80	100
40	50	20	35	35	55	55	75	75	100	100	125
50	65	20	40	40	65	65	90	90	120	120	150
65	80	30	50	50	80	80	110	110	145	145	180
80	100	35	60	60	100	100	135	135	180	180	225
100	120	40	75	75	120	120	160	160	210	210	260
120	140	50	95	95	145	145	190	190	240	240	300
140	160	60	110	110	170	170	220	220	280	280	350
160	180	65	120	120	180	180	240	240	310	310	390
180	200	70	130	130	200	200	260	260	340	340	430
200	225	80	140	140	220	220	290	290	380	380	470
225	250	90	150	150	240	240	320	320	420	420	520
250	280	100	170	170	260	260	350	350	460	460	570
280	315	110	190	190	280	280	370	370	500	500	630
315	355	120	200	200	310	310	410	410	550	550	690
355	400	130	220	220	340	340	450	450	600	600	750
400	450	140	240	240	370	370	500	500	660	660	820
450	500	140	260	260	410	410	550	550	720	720	900
500	560	150	280	280	440	440	600	600	780	780	1000
560	630	170	310	310	480	480	650	650	850	850	1100
630	710	190	350	350	530	530	700	700	920	920	1190
710	800	210	390	390	580	580	770	770	1010	1010	1300
800	900	230	430	430	650	650	860	860	1120	1120	1440
900	1000	260	480	480	710	710	930	930	1220	1220	1570
1000	1120	290	530	530	780	780	1020	1020	1330	1330	1720
1120	1250	320	580	580	860	860	1120	1120	1460	1460	1870
1250	1400	350	640	640	950	950	1240	1240	1620	1620	2080

Appendix table 5. Radial internal clearance of spherical roller brgs.

Appendix table 6. Limiting dimensional tolerance of shaft (1)

Dian classif m	neter ication m	d m	6 1	e n	:6 1	f(m	5 1	g m	5 า	gi m	6 I	h m	5 า	h6 m	6
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
6	10	-40	-49	-25	-34	-13	-22	-5	-11	-5	-14	0	-6	0	-9
10	18	-50	-61	-32	-43	-16	-27	-6	-14	-6	-17	0	-8	0	-11
18	30	-65	-78	-40	-53	-20	-33	-7	-16	-7	-20	0	-9	0	-13
30	50	-80	-96	-50	-66	-25	-41	-9	-20	-9	-25	0	-11	0	-16
50	80	-100	-119	-60	-79	-30	-49	-10	-23	-10	-29	0	-13	0	-19
80	120	-120	-142	-72	-94	-36	-58	-12	-27	-12	-34	0	-15	0	-22
120	180	-145	-170	-85	-110	-43	-68	-14	-32	-14	-39	0	-18	0	-25
180	250	-170	-199	-100	-129	-50	-79	-15	-35	-15	-44	0	-20	0	-29
250	315	-190	-222	-110	-142	-56	-88	-17	-40	-17	-49	0	-23	0	-32
315	400	-210	-246	-125	-161	-62	-98	-18	-43	-18	-54	0	-25	0	-36
400	500	-230	-270	-135	-175	-68	-108	-20	-47	-20	-60	0	-27	0	-40
500	630	-260	-304	-145	-189	-76	-120	—	_	-22	-66	—	_	0	-44
630	800	-290	-340	-160	-210	-80	-130	—	_	-24	-74	—	—	0	-50
800	1000	-320	-376	-170	-226	-86	-142	—	_	-26	-82	—	—	0	-56
1000	1250	-350	-416	-195	-261	-98	-164	—	—	-28	-94	_		0	-66
1250	1600	-390	-468	-220	-298	-110	-188	—	_	-30	-108	_	_	0	-78

Dian classif m	neter ication m	h μ	7 m	h P	8 .m	h μ	9 m	h1 μ	10 m	jt µ	; m	js μ	5 m	j6 μι	; m
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
6	10	0	-15	0	-22	0	-36	0	-58	4	-2	3	-3	7	-2
10	18	0	-18	0	-27	0	-43	0	-70	5	-3	4	-4	8	-3
18	30	0	-21	0	-33	0	-52	0	-84	5	-4	4.5	-4.5	9	-4
30	50	0	-25	0	-39	0	-62	0	-100	6	-5	5.5	-5.5	11	-5
50	80	0	-30	0	-46	0	-74	0	-120	6	-7	6.5	-6.5	12	-7
80	120	0	-35	0	-54	0	-87	0	-140	6	-9	7.5	-7.5	13	-9
120	180	0	-40	0	-63	0	-100	0	-160	7	-11	9	-9	14	-11
180	250	0	-46	0	-72	0	-115	0	-185	7	-13	10	-10	16	-13
250	315	0	-52	0	-81	0	-130	0	-210	7	-16	11.5	-11.5	16	-16
315	400	0	-57	0	-89	0	-140	0	-230	7	-18	12.5	-12.5	18	–18
400	500	0	-63	0	-97	0	-155	0	-250	7	-20	13.5	-13.5	20	-20
500	630	0	-70	0	-110	0	-175	0	-280	—	-	—	—	—	-
630	800	0	-80	0	-125	0	-200	0	-320	—	-	—	—	—	_
800	1000	0	-90	0	-140	0	-230	0	-360	_	_	_	_	_	—
1000	1250	0	-105	0	-165	0	-260	0	-420	_	_	_	_	_	—
1250	1600	0	-125	0	-195	0	-310	0	-500	_	_	_	_	_	—

Appendix table 7. Limiting dimensional tolerance of shaft (2)

Appendix table 8. Limiting dimensional tolerance of shaft (3)

Dian classif m	neter lication	js u	6 .m	j	7 เm	k u	5 m	k u	6 m	k u	7 m	m u	15 m	m µ	6 m
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
6	10	4.5	-4.5	10	-5	7	1	10	1	16	1	12	6	15	6
10	18	5.5	-5.5	12	-6	9	1	12	1	19	1	15	7	18	7
18	30	6.5	-6.5	13	-8	11	2	15	2	23	2	17	8	21	8
30	50	8	-8	15	-10	13	2	18	2	27	2	20	9	25	9
50	80	9.5	-9.5	18	-12	15	2	21	2	32	2	24	11	30	11
80	120	11	-11	20	-15	18	3	25	3	38	3	28	13	35	13
120	180	12.5	-12.5	22	-18	21	3	28	3	43	3	33	15	40	15
180	250	14.5	-14.5	25	-21	24	4	33	4	50	4	37	17	46	17
250	315	16	–16	26	-26	27	4	36	4	56	4	43	20	52	20
315	400	18	–18	29	-28	29	4	40	4	61	4	46	21	57	21
400	500	20	-20	31	-32	32	5	45	5	68	5	50	23	63	23
500	630	22	-22	—	—	—	—	44	0	70	0	—	—	70	26
630	800	25	-25	_	—	—	—	50	0	80	0	_	-	80	30
800	1000	28	-28	_	—	—	—	56	0	90	0	_	-	90	34
1000	1250	33	-33	_	_	—	_	66	0	105	0	_	_	106	40
1250	1600	39	-39	-	-	_	_	78	0	125	0	_	-	126	48

Diameter classification mm		n µ	6 .m	þ	i6 im	r μ	6 m	r7 μm		
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	
6	10	19	10	24	15	28	19	34	19	
10	18	23	12	29	18	34	23	41	23	
18	30	28	15	35	22	41	28	49	28	
30	50	33	17	42	26	50	34	59	34	
50	65	20	00	F1		60	41	71	41	
65	80	39	20	51	32	62	43	73	43	
80	100	45	00	50	07	73	51	86	51	
100	120	45	23	59	37	76	54	89	54	
120	140					88	63	103	63	
140	160	52	27	68	43	90	65	105	65	
160	180					93	68	108	68	
180	200					106	77	123	77	
200	225	60	31	79	50	109	80	126	80	
225	250	-				113	84	130	84	
250	280	66	24	00	FG	126	94	146	94	
280	315	00	34	00	50	130	98	150	98	
315	355	72	27	09	62	144	108	165	108	
355	400	75	57	90	02	150	114	171	114	
400	450	90	40	100	60	166	126	189	126	
450	500	80	40	100	00	172	132	195	132	
500	560	00	4.4	100	70	194	150	220	150	
560	630	00	44	122	70	199	155	225	155	
630	710	100	50	120	00	225	175	255	175	
710	800	100	50	130	00	235	185	265	185	
800	900	110	56	156	100	266	210	300	210	
900	1000	112	50	150	100	276	220	310	220	
1000	1120	132	66	186	120	316	250	355	250	
1120	1250	102	00	100	120	326	260	365	260	
1250	1400	156	78	218	140	378	300	425	300	
1400	1600	150	70	210	140	408	330	455	330	

-					-	-			
Δr	opendix	table 9	l imitina	dimensional	tolerance	of	shaft	(Δ)	۱
~	spenarz		Enning	annenorena	tororanoc	. .	onun	1-1	,

Appendix table 10. Limiting dimensional tolerance of housing hole (1)

Diameter classification mm		E6 μm		F6 μm		F μ	7 m	G μ	6 m	G7 μm		H6 μm	
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
10	18	43	32	27	16	34	16	17	6	24	6	11	0
18	30	53	40	33	20	41	20	20	7	28	7	13	0
30	50	66	50	41	25	50	25	25	9	34	9	16	0
50	80	79	60	49	30	60	30	29	10	40	10	19	0
80	120	94	72	58	36	71	36	34	12	47	12	22	0
120	180	110	85	68	43	83	43	39	14	54	14	25	0
180	250	129	100	79	50	96	50	44	15	61	15	29	0
250	315	142	110	88	56	108	56	49	17	69	17	32	0
315	400	161	125	98	62	119	62	54	18	75	18	36	0
400	500	175	135	108	68	131	68	60	20	83	20	40	0
500	630	189	145	120	76	146	76	66	22	92	22	44	0
630	800	210	160	130	80	160	80	74	24	104	24	50	0
800	1000	226	170	142	86	176	86	82	26	116	26	56	0
1000	1250	261	195	164	98	203	98	94	28	133	28	66	0
1250	1600	298	220	188	110	235	110	108	30	155	30	78	0
1600	2000	332	240	212	120	270	120	124	32	182	32	92	0

Diameter classification mm		H7 µm		H8 µm		J µ	6 m	J μ	7 m	JS6 μm		JS7 μm	
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
10	18	18	0	27	0	6	-5	10	-8	5.5	-5.5	9	-9
18	30	21	0	33	0	8	-5	12	-9	6.5	-6.5	10.5	-10.5
30	50	25	0	39	0	10	-6	14	-11	8	-8	12.5	-12.5
50	80	30	0	46	0	13	-6	18	-12	9.5	-9.5	15	-15
80	120	35	0	54	0	16	-6	22	–13	11	-11	17.5	-17.5
120	180	40	0	63	0	18	-7	26	-14	12.5	-12.5	20	-20
180	250	46	0	72	0	22	-7	30	-16	14.5	-14.5	23	-23
250	315	52	0	81	0	25	-7	36	-16	16	-16	26	-26
315	400	57	0	89	0	29	-7	39	–18	18	–18	28.5	-28.5
400	500	63	0	97	0	33	-7	43	-20	20	-20	31.5	-31.5
500	630	70	0	110	0	_	_	_	_	22	-22	35	-35
630	800	80	0	125	0	—		_	—	25	-25	40	-40
800	1000	90	0	140	0	_		_	_	28	-28	45	-45
1000	1250	105	0	165	0	_		_	_	33	-33	52.5	-52.5
1250	1600	125	0	195	0	_	_	_	_	39	-39	62.5	-62.5
1600	2000	150	0	230	0	_	_	_	_	46	-46	75	-75

Appendix table 11. Limiting dimensional tolerance of housing hole (2)

Appendix table 12. Limiting dimensional tolerance of housing hole (3)

Diameter classification mm		K5 µm		K6 μm		κ μ	7 m	Μ μ	l5 m	M6 µm		M7 μm	
More than	or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
10	18	2	-6	2	-9	6	-12	-4	-12	-4	-15	0	-18
18	30	1	-8	2	-11	6	-15	-5	-14	-4	-17	0	-21
30	50	2	-9	3	-13	7	-18	-5	-16	-4	-20	0	-25
50	80	3	-10	4	-15	9	-21	-6	-19	-5	-24	0	-30
80	120	2	-13	4	-18	10	-25	-8	-23	-6	-28	0	-35
120	180	3	-15	4	-21	12	-28	-9	-27	-8	-33	0	-40
180	250	2	-18	5	-24	13	-33	-11	-31	-8	-37	0	-46
250	315	3	-20	5	-27	16	-36	-13	-36	-9	-41	0	-52
315	400	3	-22	7	-29	17	-40	-14	-39	-10	-46	0	-57
400	500	2	-25	8	-32	18	-45	-16	-43	-10	-50	0	-63
500	630	—	_	0	-44	0	-70	—	_	-26	-70	-26	-96
630	800	—	—	0	-50	0	-80	—	—	-30	-80	-30	-100
800	1000	_	—	0	-56	0	-90	—	_	-34	-90	-34	-124
1000	1250	_	_	0	-66	0	-105	—	—	-40	-106	-40	-145
1250	1600	_	_	0	-78	0	-125	_	_	-48	-126	-48	-173
1600	2000	_	_	0	-92	0	-150	_	_	-58	-150	-58	-208

Dian	Diameter classification		5	N	16	N	7	Р	6	P	7
m	m	μm		μm		μ	m	μ	m	μ	n
More than	or less	Upper	Lower								
10	18	-9	-17	-9	-20	-5	-23	-15	-26	-11	-29
18	30	-12	-21	-11	-24	-7	-28	–18	-31	-14	-35
30	50	-13	-24	-12	-28	-8	-33	-21	-37	-17	-42
50	80	-15	-28	-14	-33	-9	-39	-26	-45	-21	-51
80	120	-18	-33	-16	-38	-10	-45	-30	-52	-24	-59
120	180	-21	-39	-20	-45	-12	-52	-36	-61	-28	-68
180	250	-25	-45	-22	-51	-14	-60	-41	-70	-33	-79
250	315	-27	-50	-25	-57	-14	-66	-47	-79	-36	-88
315	400	-30	-55	-26	-62	-16	-73	-51	-87	-41	-98
400	500	-33	-60	-27	-67	-17	-80	-55	-95	-45	-108
500	630	_	_	-44	-88	-44	-114	-78	-122	-78	-148
630	800	_	_	-50	-100	-50	-130	-88	-138	-88	-168
800	1000	—	—	-56	-112	-56	-146	-100	-156	-100	-190
1000	1250	_	_	-66	-132	-66	-171	-120	-186	-120	-225
1250	1600	_	_	-78	-156	-78	-203	-140	-213	-140	-265
1600	2000	_	_	-92	-184	-92	-242	-170	-262	-170	-320

Appendix table 13. Limiting dimensional tolerance of housing hole (4)

Appendix table 14. Material physical property value

Material	Young's modulus MPa {kgf/mm ² }	Poisson's ratio	Coefficient of linear thermal expansion $\times 10^{-6}$ (1/°C)
Bearing steels	208000 {21200}	0.3	12.5
Carbon steels	198900 {20300}	0.3	10.23
Cast iron	100500 {10250}	0.3	10.5
Spheroidal graphite iron castings	150900 {15400}	0.3	10.0
Aluminium	68940 {7030}	0.34	21.5
Martensitic stainless steels	199900 {20400}	0.3	17.1
Austenitic stainless steels	196500 {20050}	0.3	17.1
Copper	131000 {13370}	0.35	16.5

Note) Poisson's ratio and the coefficient of linear thermal expansion are not affected by the input param. unit.

Appendix table 15. Reliability factor a_1

Reliability %	Ln	Reliability factor a_1
90	L10	1
95	L_5	0.64
96	L_4	0.55
97	L_3	0.47
98	L_2	0.37
99	L_1	0.25
99.2	L _{0.8}	0.22
99.4	L0.6	0.19
99.6	$L_{0.4}$	0.16
99.8	$L_{0.2}$	0.12
99.9	$L_{0.1}$	0.093
99.92	L0.08	0.087
99.94	L0.06	0.080
99.95	$L_{0.05}$	0.077

Appendix table 16. Value of contamination factor e_c

	ec			
Contamination level	$D_{\rm pw}$ <100mm	<i>D</i> _{pw} ≥100mm		
Extremely high cleanliness Particle size about the same as the oil film thickness of lubricant, and laboratory level environment	1	1		
High cleanliness Oil filtered by an extremely fine filter, standard grease sealed bearings and seal bearings	0.8~0.6	0.9~0.8		
Standard cleanliness Oil filtered by a fine filter, standard grease sealed bearings and shielded bearings	0.6~0.5	0.8~0.6		
Light contamination The lubricant is slightly contaminated	0.5~0.3	0.6~0.4		
Normal contamination No sealing, rough filter is used, abrasion powder, environment in which particles enter from the periphery	0.3~0.1	0.4~0.2		
Heavy contamination Significantly contaminated surrounding environment, and a state in which sealing performance of bearings is insufficient	0.1~0	0.1~0		
Extreme contamination	0	0		