

DESIGNING WITH ROLLING BEARINGS. PART 3: SPECIAL TYPES

1. NOTATION AND UNITS

In this notation, units are given for the SI system. The notation used conforms, where appropriate, to British Standards.

C	dynamic load rating	N
d	bearing bore diameter	mm
D	bearing overall diameter	mm
F	load on bearing	N
P	equivalent dynamic load	N
X	factor for calculation of equivalent load	
Y	factor for calculation of equivalent load	
<i>Subscripts</i>		
a	axial	
o	static	
r	radial	

2. INTRODUCTION

This Item is the third of three ESDU Data Items (see References 1 & 2 for Parts 1 and 2) dealing with design considerations in rolling bearing selection. The Item is intended to make the designer aware of some of the bearing types not fully covered in Parts 1 & 2. These bearings may allow him to meet more exacting requirements or may offer him production and assembly advantages. However, in all applications it is recommended that the bearing manufacturers should be consulted before the bearings covered in this Item are used.

This Item considers double row angular contact ball bearings, cylindrical roller bearings with ribs on both rings, multi-row cylindrical roller bearings, split roller bearings, needle roller bearings, high precision bearings, plummer blocks, bearings with housings, take-up units, airframe control bearings and rod-end bearings. There are many specialised bearing types outside the scope of this Item.

The general characteristics of the bearings and their typical applications are described. Guidance is given, where appropriate, on the calculation of equivalent loads and an appendix is included on the axial load carrying ability of cylindrical roller bearings with ribs on both rings. Charts are provided for selecting suitable dimensions of double row angular contact ball, caged needle roller and double row cylindrical roller bearings.

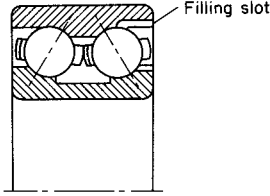
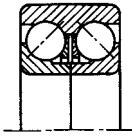
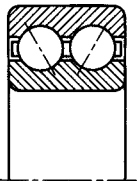
3. TABULATED BEARING INFORMATION

This Item is intended to be used after the designer has consulted Part 1 or Parts 1 and 2 together in order to obtain a solution. It is impractical to give firm rules for choosing which of the bearing types covered by this Item should be considered for a particular application. The designer is, therefore, advised to familiarize himself with all the bearing types, by studying the tabulated information given in this Section, paying particular attention to their shortcomings.

In some cases where it has not been possible to obtain a solution using the selection flow charts of Parts 1 & 2, alternative bearing types, not fully covered by Parts 1 or 2, will have been indicated. For example, where there are particularly high speed or precision requirements the information on high precision bearings should be studied.

In other cases a solution may have been indicated by use of the selection flow charts in Parts 1 and 2 but the designer may have decided, on the basis of consideration of factors outside the scope of Parts 1 & 2, that the indicated solution is not entirely acceptable. For example, it may be impractical for the designer to specify bearing housings as an integral part of the design in which case the information on plummer blocks and bearings with housings should be studied. Alternatively, the designer may wish to redesign using a single bearing which carries the moment loads by adopting an overhung shaft layout. In this case the information on double row angular contact ball and needle roller bearings should be studied.

3.1 Main Features of Double Row Angular Contact Ball Bearings

Types of Double Row Angular Contact Ball Bearings	
(i) Back-to-back double row angular contact ball bearing with filling slot.  3 XXX Equivalent dynamic load: Equivalent static load: Estimation of required size:	Typical contact angle 32° Axial load should be restricted in the direction that loads filling slot row. $P = XF_r + YF_a$ (See Part 1, Section 5.3.1) where $X = 1$, $Y = 0.73$ when $F_a/F_r \leq 0.86$ $X = 0.62$, $Y = 1.17$ when $F_a/F_r > 0.86$ $P_0 = F_r + 0.63F_a$ (See Part 1, Section 5.8.1) See Figure 1 (See also Part 1, Section 5.4)
(ii) Back-to-back double row angular contact ball bearing with two piece inner ring.  3 XXX DA Equivalent dynamic load: Equivalent static load: Estimation of required size:	Typical contact angle 45° Inner ring should be axially clamped on shaft. $P = XF_r + YF_a$ (See Part 1, Section 5.3.1) where $X = 1$, $Y = 0.47$ when $F_a/F_r \leq 1.33$ $X = 0.54$, $Y = 0.81$ when $F_a/F_r > 1.33$ $P_0 = F_r + 0.46F_a$ (See Part 1, Section 5.8.1) See Figure 2 (See also Part 1, Section 5.4)
(iii) Face-to-face double row angular contact ball bearing.  LDJK XX or MDJK XX Equivalent dynamic load: Equivalent static load: Estimation of required size:	Typical contact angle 30° Load rating is lower than with other types of double row angular contact ball bearings. $P = XF_r + YF_a$ (See Part 1, Section 5.3.1) where $X = 1$, $Y = 0.78$ when $F_a/F_r \leq 0.8$ $X = 0.63$, $Y = 1.24$ when $F_a/F_r > 0.8$ $P_0 = F_r + 0.66F_a$ (See Part 1, Section 5.8.1) See Figure 3 (See also Part 1, Section 5.4)

(continued)

General Comments on Double Row Angular Contact Ball Bearings

Provide axial location in both directions (versions with a filling slot have limited axial load capacity in one direction).

Can carry radial loads, axial loads or combined loading (versions with a filling slot have limited axial load capacity in one direction).

Back-to-back double row angular contact ball bearings can carry moderate loads in, for example, cam followers or wheel hubs.

Available with in-built axial clearance, zero clearance or pre-load.

No adjustment of internal clearance required.

Face-to-face double row angular contact ball bearings can accommodate small misalignment.

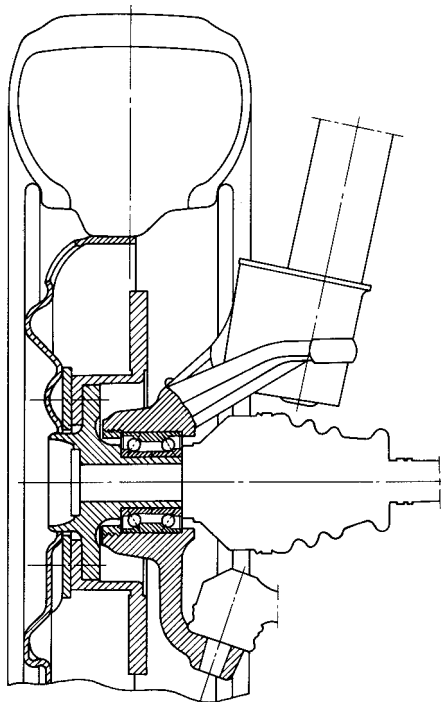
Back-to-back double row angular contact ball bearings require precise alignment.

Lower limiting speed than single row angular contact ball bearings by about 20 to 30 per cent.

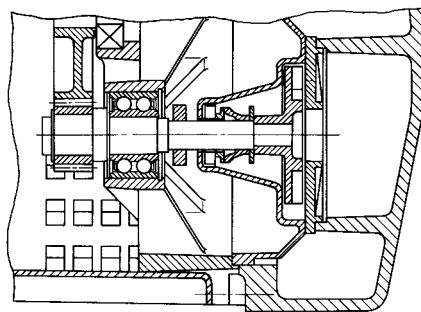
Available with internal seals, shields or circlip grooves.

More compact than adjacent pair of single row bearings and when oil lubricated usually require lubrication to be applied from both sides.

Typical Applications of Double Row Angular Contact Ball Bearings



The Sketch shows a back-to-back double row angular contact ball bearing on an automobile front wheel hub. A double row angular contact ball bearing was chosen to eliminate the need for adjustment and ease assembly.

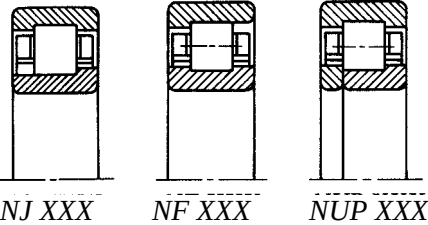
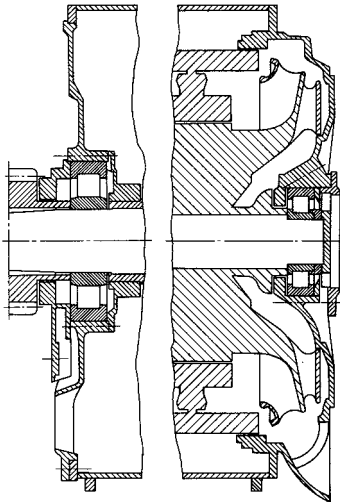
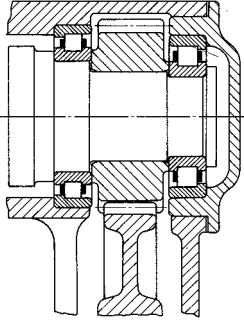


The Sketch shows a back-to-back double row angular contact ball bearing used on an overhung pump impeller spindle.

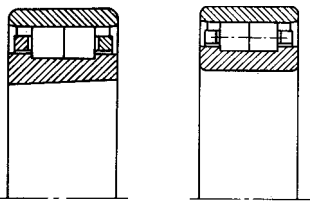
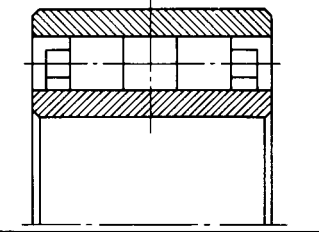
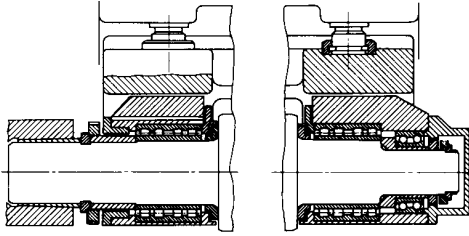
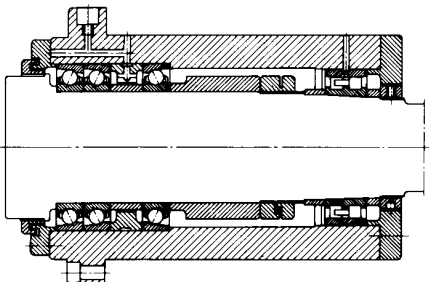
The bearing has a contact angle of 32° , is fitted with seals at both sides and is "lubricated for life". A double row angular contact ball bearing was chosen in order to achieve a compact neat design.

Other applications include track rollers and cam followers.

3.2 Main Features of Cylindrical Roller Bearings with Ribs on Both Rings

Types of Cylindrical Roller Bearings with Ribs on Both Rings	
 NJ XXX NF XXX NUP XXX	Single row cylindrical roller bearings with one or two additional ribs. Some versions have a separate rib or thrust collar.
Equivalent dynamic load: Equivalent static load: Estimation of required size:	$P = F_r$ (See also Appendix A) $P_o = F_r$ (See Part 1, Section 5.8.1) See Part 1, Figures 5 and 6
General Comments on Cylindrical Roller Bearings with Ribs on Both Rings	
Can provide axial location in one or both directions depending on design. Light or intermittent axial load may be accommodated (see Appendix A). Requires good lubrication of load bearing ribs. Versions with two integral additional ribs have lower radial load rating than other types of cylindrical roller bearings.	
Typical Applications of Cylindrical Roller Bearings with Ribs on Both Rings	
	The Sketch shows two cylindrical roller bearings used to support the shaft of a traction motor for an electric locomotive. Axial location is provided by a cylindrical roller bearing with ribs on both rings. The particular bearing shown incorporates a separate inner ring flange (or angle ring).
	The Sketch shows a typical input pinion of a spur gear drive mechanism. Each bearing provides axial location in one direction only.

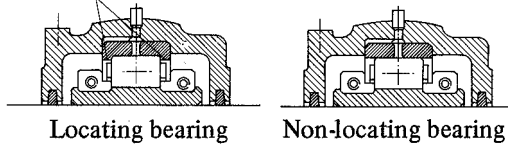
3.3 Main Features of Multi-row Cylindrical Roller Bearings

Types of multi-row Cylindrical Roller Bearings	
(i) <i>Double row cylindrical roller bearings.</i>  NN XXXXK NN XXXX <i>Equivalent dynamic load:</i> $P = F_r$ (See Part 1, Section 5.3.1) <i>Equivalent static load:</i> $P_o = F_r$ (See Part 1, Section 5.8.1) <i>Estimation of required size:</i> See Figure 7 (See also Part 1, Section 5.4)	Two rows of cylindrical rollers incorporated in one bearing. Parallel bore and taper bore versions are available.
(ii) <i>Multi-row cylindrical roller bearings.</i>  <i>Equivalent dynamic load:</i> $P = F_r$ (See Part 1, Section 5.3.1) <i>Equivalent static load:</i> $P_o = F_r$ (See Part 1, Section 5.8.1) <i>Estimation of required size:</i> Consult manufacturers	More than two rows of cylindrical rollers incorporated in one bearing.
General Comments on Multi-row Cylindrical Roller Bearings	
Combines large radial load capacity with good speed capability and compact overall diameter. Limiting speed lower than single row bearings (consult manufacturers). More difficult to lubricate than single row bearings. Taper bore facilities mounting and replacement or allows adjustment of radial internal clearance on for example precision spindles (See Part 1, Appendix B).	
Typical Applications of Multi-row Cylindrical Roller Bearings	
	The Sketch shows a steel mill roller supported by multi-row cylindrical roller bearings. This bearing type was chosen because of the very large predominantly radial loads.
	The Sketch shows a double row cylindrical roller bearing with taper bore mounted on a matching taper on the drive end of a machine tool spindle. Internal clearance adjustment is achieved by axial adjustment of this bearing.

3.4 Main Features of Split Roller Bearings

Types of Split Roller Bearings

Locating flanges (lips)



Locating bearing

Non-locating bearing

A split roller bearing is a cylindrical roller bearing constructed in such a way that the two halves of the bearing may be assembled round and clamped to the shaft.

Both locating and non-locating bearings are available. Split seals for use with these bearings are available. Spherical roller (double row) versions are available.

Equivalent dynamic load:

$$P = F_r \text{ (See Part 1, Section 5.3.1)}$$

Equivalent static load:

$$P_o = F_r \text{ (See Part 1, Section 5.8.1)}$$

Estimation of required size:

Consult manufacturers

General Comments on Split Roller Bearings

Used where shaft layout prevents bearings from being drawn off the shaft axially on, for example, friction winders.

Freedom of shaft design allowing, for example, integral end couplings.

On large installations individual parts of split bearing are easier to handle than complete assembly.

“Top” half of bearing may be removed for inspection purposes.

In hostile environments bearings can be changed quickly on, for example, forced draft fans for marine boilers.

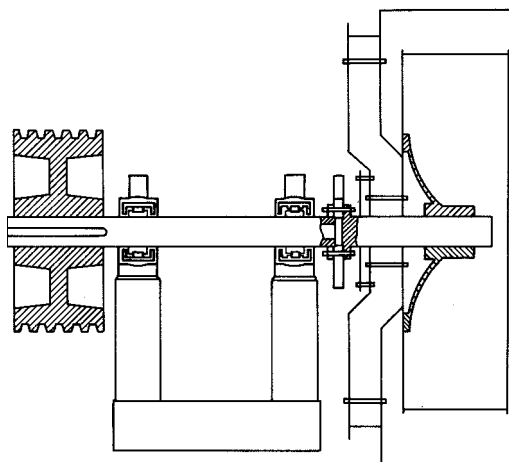
Used on long shaft installations with many support bearings, for example steel industry cooling bed reciprocating mechanism shafts or marine propeller shafts.

Particularly on large bearings, split roller bearings are more economic to fit (and replace) than conventional roller bearings.

Unit cost is greater than non-split bearing.

Less suitable than non-split bearings for high speeds.

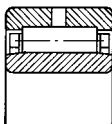
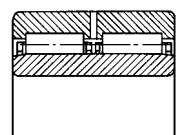
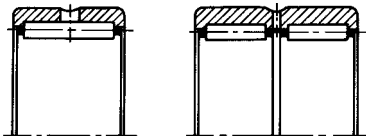
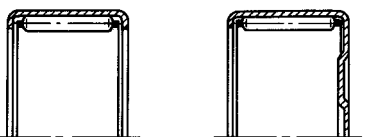
Typical Applications of Split Roller Bearings



The Sketch shows a fan used to introduce inert gas into the oil tanks of a tanker as they are being discharged. The fan shaft is supported by a locating and a non-locating split roller bearing.

Other applications include large machinery in coal mines and steel works and mechanical handling equipment and drives.

3.5 Main Features of Needle Roller Bearings

Types of Needle Roller Bearing	
(i) <i>Single row caged needle roller bearing.</i>  NA XXXXXX Equivalent dynamic load: Equivalent static load: Estimation of required size:	A single row of needle rollers run on inner and outer ring raceway surfaces. Bearings with one or two integral seals are available. $P = F_r$ (See Part 1, Section 5.3.1) $P_o = F_r$ (See Part 1, Section 5.8.1) See Figures 4, 5 & 6 (See also Part 1, Section 5.4)
(ii) <i>Double row caged needle roller bearing.</i>  NNA XXXX Equivalent dynamic load: Equivalent static load: Estimation of required size:	Two rows of needle rollers run on inner and outer ring raceway surfaces. Bearings with one or two integral seals are available. $P = F_r$ (See Part 1, Section 5.3.1) $P_o = F_r$ (See Part 1, Section 5.8.1) Consult manufacturers
(iii) <i>Needle roller bearing without inner ring.</i>  RNA XXXXXX RNNA XXXX Equivalent dynamic load: Equivalent static load: Estimation of required size:	Bearings run directly on suitably hardened and ground shaft.[†] Elimination of inner race reduces overall diameter of bearing and improves precision of running. $P = F_r$ (See Part 1, Section 5.3.1) $P_o = F_r$ (See Part 1, Section 5.8.1) Consult manufacturers
(iv) <i>Drawn cup needle roller bearing.</i>  RHNA XXXXXX RBNA XXXXXX Equivalent dynamic load: Equivalent static load: Estimation of required size:	The outer ring is drawn from thin sheet material. Closed end versions are available. Drawn cups rely on housing bore to retain roundness.[‡] Bearing runs directly on suitable hardened and ground shaft.[†] Elimination of inner ring and thin outer ring provides a low overall diameter bearing. Matching races are available. $P = F_r$ (See Part 1, Section 5.3.1) $P_o = F_r$ (See Part 1, Section 5.8.1) Consult manufacturers

(continued)

[†] The bearing manufacturers should be consulted regarding the required shaft specification. However, typical requirements are a surface finish better than $0.4\mu\text{m } R_a$ with no blemishes, oil holes to have blended edges, taper less than 0.008 mm over the bearing length or one half of shaft diameter tolerance (whichever is the smaller) and a shaft out-of-roundness less than 0.005 mm TIR or one half diameter tolerance (whichever is the smaller). A typical hardness would be 60 HRC.

[‡] Drawn cup bearings may be used in steel, cast iron or aluminium alloy housings but the minimum section of the housing should be $1\frac{1}{2}$ to 2 times the bearing section with steel housings and considerably more with aluminium alloy housings.