



High Precision Bearings for Combined Loads

Axial/radial bearings · Axial angular contact ball bearings ·
Axial/radial bearings with angular measuring system

Foreword

Focus on complete system

Schaeffler With trend-setting bearing arrangement solutions for feed spindles, main spindles, rotary tables and linear guidance units, Schaeffler has been at the forefront of the world market for decades. However, bearing components alone are often no longer the decisive factor for these machine subsystems.

Our customers are continuing to benefit from significant performance improvements and unique selling points. In order to optimise the entire machine tool system, it is also becoming ever more important to integrate important functions such as measurement, sealing, lubrication, braking etc. in the components themselves. This intellectual approach focusses on the complete system, including the bearing and bearing position. This means that you can access a product range that gives optimum coverage for all your applications in the machine tool.

Direct drives and mechatronic solutions

The requirements for bearing arrangements and drives have increased continually over recent years. These key components have a considerable influence on each other.

There is increasingly frequent usage of direct drives and mechatronic solutions in machine tools. We therefore have Schaeffler Industrial Drives as a further strong specialist in our provider network, which enables us to supply you from a single source with not only bearing elements but also components precisely matched to the drive system.

This opens up completely new technical and economic design possibilities for your requirements as well as significant advantages in the time and process chain.

In terms of products, we can offer you a comprehensive, precisely balanced range, precision technology and top product quality. In order to support your development stages as effectively as possible, we also have a worldwide network of engineers and service and sales technicians working for you and ensuring that we maintain close contact with you in your own location.

We are therefore confident that we have the right product for you, from a robust individual component right through to the defining high end system solution.

Foreword

Technically and economically convincing

Constant cost pressure is forcing manufacturing companies to continuously increase productivity in production. This pressure has manifested itself as an impressive evolution in the field of machine tools, tools and processes over the last few decades.

Multifunctionality and the interlinking of machines aim to reduce downtimes, increase material flow, flexibility and cost-effectiveness, and facilitate unmanned shifts. In support of this, workpieces are increasingly being set up on pallets for processing. The pallets are fed to the machine tool by pallet changer and processed. This pallet task in the machine tool is increasingly requiring media to be transferred to the rotating table or the pallet to be clamped. A machine tool is increasingly being regarded as a system in which the main components such as the drive, bearing arrangement, measuring system and controller must be compatibly matched.

Rotary table bearings, drive systems and measuring systems from Schaeffler enable sustainable solutions for machine tools.

The new YRTCMA and YRTCMI bearings offer the design freedom of a maximum centre passage combined with easy assembly and commissioning, leading to considerable cost reductions for the rotary axis.

Review

In earlier times, classic, standalone turning and milling machines still dominated machining in production.

Rotary tables were primarily used in milling machines in the form of so-called indexing heads. In this instance, indexing heads or tables serve as workpiece carriers, which are required to support all machining forces and position the workpiece with a high degree of precision. Dynamics play no part here.

With the further development of machine tools towards numerically controlled, multi-axis and partially interlinked machining equipment and lines, the simple mechanical indexing heads have also developed into rotary tables with a high level of technical complexity.

The drive technology plays a decisive role in the rotary table system. In the past, the most commonly used technology was the worm drive. Worm gears are capable of transmitting high torques in milling operations, are usually self-locking and are therefore still used today.

Trend towards direct drives

In recent years, direct drive rotary tables have been added to the proven worm drive. The major advantage of direct drives is that they are virtually backlash- and maintenance-free, permit high accelerations and speeds and can operate without a reduction gear. The use of direct drives does, however, place significantly higher demands on the temperature management of the rotary table. The higher speeds generate more heat in both the drive and the bearing. The electrical power loss in the integrated rotary table drive must be dissipated from the system in addition to the waste heat from the bearing. Due to its significant influence on the bearing arrangement and locking system, and resulting effect on the accuracy of the workpiece, thermal stability is an important criterion in the rotary table. In addition to the bearing, Schaeffler also offers the appropriate measurement and drive technology.

In order to use the machine to its full performance potential in flexible production, the greatest attention must be paid, particularly during milling and turning, to the power losses (of the components) at different operating points.

However, the particular challenge here is the absence of an optimal design point for tailoring the system and the resulting need to cover a wide design range. The demands on the components shift according to the approach taken by the machine manufacturer in handling the turning and milling task, and result in a new system that has to play like an orchestra.

Simultaneous machining

In a classic milling machine, the rotary table serves as a workpiece carrier, which supports all machining forces and positions the workpieces with a high degree of accuracy.

More recently, simultaneous operation has been added as a further task. In this instance, the rotary table acts as a feed axis and is jointly responsible for the achievable surface qualities of the machined parts.

For the rotary table, this means higher requirements in terms of a constantly low frictional torque with maximum tilting rigidity. An excessively high frictional torque would generate more heat in the bearing, resulting in a loss of preload due to thermal expansion.

Foreword

- Milling operation** Most of the power loss that occurs during milling is in the stator of the direct drive. An internal rotor motor should be used in preference here, as the heat is readily dissipated by means of water cooling. External rotor motors are conceivable for maximum torques, although the system used to cool the stator is slightly more elaborate.
- Turning operation** In a classic turning machine, the rotary table bearing also supports the machining forces but must also reach significantly higher speeds. Bearings with a significantly lower tilting rigidity are used here in favour of the higher speed.
- In turning applications, an increase in rotor temperature occurs. This is linked to the table plate and the resulting heat must be dissipated via the bearing. As a result, the demands on the temperature management of the rotary table are increased.
- In order to increase flexibility in production, options which combine turning/milling applications with automated solutions are being used with increased regularity. With this method of machining, the workpiece is usually machined in milling operation first and can then be machined in turning operation without reclamping. This allows tighter tolerances to be achieved with shorter set-up times.

Effect of the bearing arrangement on the performance capability of the rotary table

Conflicting goals: high tilting rigidity versus high speed

Modern rotary axis bearings such as bearing YRTC-XL from Schaeffler are characterised by a high tilting rigidity and high limiting speed.

In general, the following applies: The tilting rigidity correlates with the preload available in the bearing as a result of the design. The higher the preload, the higher the tilting rigidity. High preload values, however, give rise to a higher friction or temperature in the bearing and thus reduce the achievable limiting speed. Bearing manufacturers must use their know-how to resolve these conflicting goals and achieve both a high tilting rigidity and a high limiting speed with low friction.

Why is this important? To answer this in simple terms:

■ Rigidity + Speed + Flexibility = Precision + Material removal rate = Productivity

A number of applications require both a rigid and a fast bearing, such as simultaneous turning and milling. Machine type also plays a role. Universal machining centres are used in a variety of applications. If speed is the decisive criterion for maximum productivity in one production order, it may be rigidity in the next. As a result, the bearing must be suitable for every possible production task and permit maximum productivity with the required quality. For this reason, the bearing must always be viewed in the context of its adjacent construction.

The rotary table is a complex system composed of thermal sources and temperature reductions. The temperature gradients lead to varying heat distribution and, as a result, to varying degrees of bearing component growth, which can lead to a loss of preload in the bearing. The reduction in preload has a direct impact on bearing tilting rigidity. Furthermore, heat-induced effects can also lead to deformations in the rotary table housing.

One of the core competences of the rotary table builder is to define a suitable cooling strategy. The bearing manufacturer assists the builder in this task by providing a bearing system that permits the maximum possible preload at the specified speed requirements.

Foreword

Interaction between bearing, measuring system and drive

The interaction between the three key components in a rotary table – namely the bearing, measuring system and drive – is crucial to the quality of a workpiece. All three components must be optimally matched and dimensioned.

As already described, the bearing should have a high level of rigidity while exhibiting a low frictional torque.

The direct drive must exhibit a high degree of efficiency, i.e. the electrical energy used should be converted into mechanical energy with the least possible degree of power loss. This may involve delivering consistently high torque up to the operating point or enabling high speeds.

In addition to system accuracy, installation position and installation accuracy play a particularly crucial role in angular measuring devices. It is important that the spread of measurement values is as low as possible as this cannot be compensated for. Installation at the height of the bearing arrangement is optimal, as this minimises the tilting between the bearing and the axis of the measuring system. Eccentricity also has a considerable influence on the positional accuracy of the rotary table.

Embedded measuring systems, such as those used in machine tools, are limited in terms of the central passage. For this reason and particularly in the case of swivel axes or automated solutions, the measuring system is placed outside of the optimal position, which leads to a significantly higher positional deviation. The new YRTCMA and YRTCMI bearings offer the design freedom of a maximum centre passage combined with easy assembly and cost reductions for the rotary axis.

Bearing YRTCMA provides an optimal combination of high-precision bearing and angular measuring device thanks to the integration of an inductive, absolute dimensional scale on the inner ring, which is ground to high accuracy. Typical applications include use in rotary tables and swivel type heads in machine tools and in the C axis of turning machines.

The orientation of the reading head relative to the dimensional scale has a considerable influence on angular measuring devices without a dedicated bearing arrangement. The fluctuation of the measurement gap in particular has a major influence. Attachment and adjustment therefore have a significant influence on the achievable overall accuracy. Bearing YRTCMA solves this problem with the patented, adjustment-free radial attachment of the reading head. The minimal eccentricity of the inner ring, on which the dimensional scale is mounted, rounds off the components to provide a highly accurate measuring device.

Bearing YRTCMA offers all established absolute measurement protocols such as EnDat2.2, DRIVECLiQ, Serial Interface Fanuc or SSI1VSS with functional reliability, enabling integration into standard machine tool controllers. As a result of the absolute value, the rotary axis does not require a reference run and thus offers maximum collision protection for the machine.

Bearing YRTCMI has an analogue 1VSS interface and should be used in preference in applications which call for signal transmission via a slip ring.

Bearing YRTCMA is also a highly attractive alternative in financial terms to the combination of measuring device and bearing arrangement. Expensive connection points for the measuring device and elaborate alignment between measuring device and bearing are thus avoided. In the event of a service, the reading head does not need to be matched and can be replaced with minimal outlay. As a result of carrying out the replacement via the side of the housing, neither the workpiece nor the device has to be dismantled in the event of a service.

High precision bearings for combined loads

Axial/radial bearings **10**

Axial/radial bearings are double direction axial bearings for screw mounting, with a radial guidance bearing. These ready-to-fit, greased units are very rigid, have high load carrying capacity and run with particularly high accuracy. They can support radial forces, axial forces from both directions and tilting moments free from clearance. The bearings are available in several series.

For applications in indexing tables and swivel type milling heads, the most suitable bearing is generally series YRTC.

For applications involving rapidly rotating, direct drive axes, there is series YRTS. Due to their high limiting speeds and very low, uniform frictional torque across the whole speed range, these bearings are particularly suitable for combination with torque motors.

For higher accuracy requirements, these bearings are also available with restricted axial and radial runout accuracy.

Axial angular contact ball bearings **10**

Axial angular contact ball bearings ZKLDf are low-friction, ready-to-fit, greased bearing units with high accuracy for very high speeds, high axial and radial loads and high demands on tilting rigidity.

Axial angular contact ball bearings are particularly suitable for precision applications involving combined loads. Their preferred areas of use are bearing arrangements in rotary tables with a main spindle function, for example in combined milling and turning, as well as in milling, grinding and honing heads and in measurement and testing equipment.

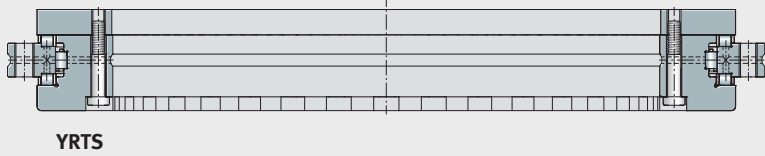
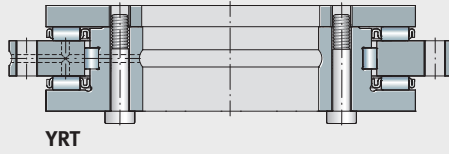
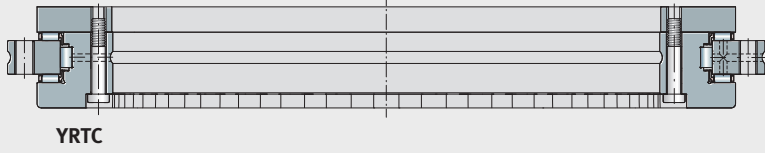
Axial/radial bearings with angular measuring system **82**

Axial/radial bearings YRTCM and YRTSM are equipped with a magneto-resistive, incremental angular measuring system. In conjunction with the two-head electronic measuring system MEKO or SRM, extremely high system accuracies and angular resolutions are achieved.

Axial/radial bearings YRTCMA and YRTSMA are inductive, absolute angular measuring system bearings, in which the angular measuring system from AMO GmbH is integrated. These are available with the absolute measuring heads MHA, which are screw mounted directly onto the bearing outer ring by the customer.

Axial/radial bearings YRTCMi are inductive, incremental angular measuring system bearings, in which the angular measuring system from AMO GmbH is also integrated. These are available with the incremental measuring heads MIH, which are also screw mounted directly onto the bearing outer ring by the customer.

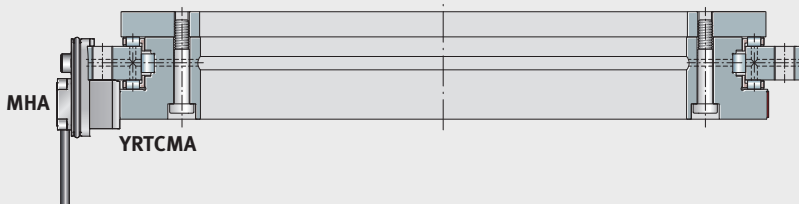
Further information on axial/radial bearings with absolute value angular measuring systems YRTMA and YRTSMA can be found in special publication SSD 30, see page 122.



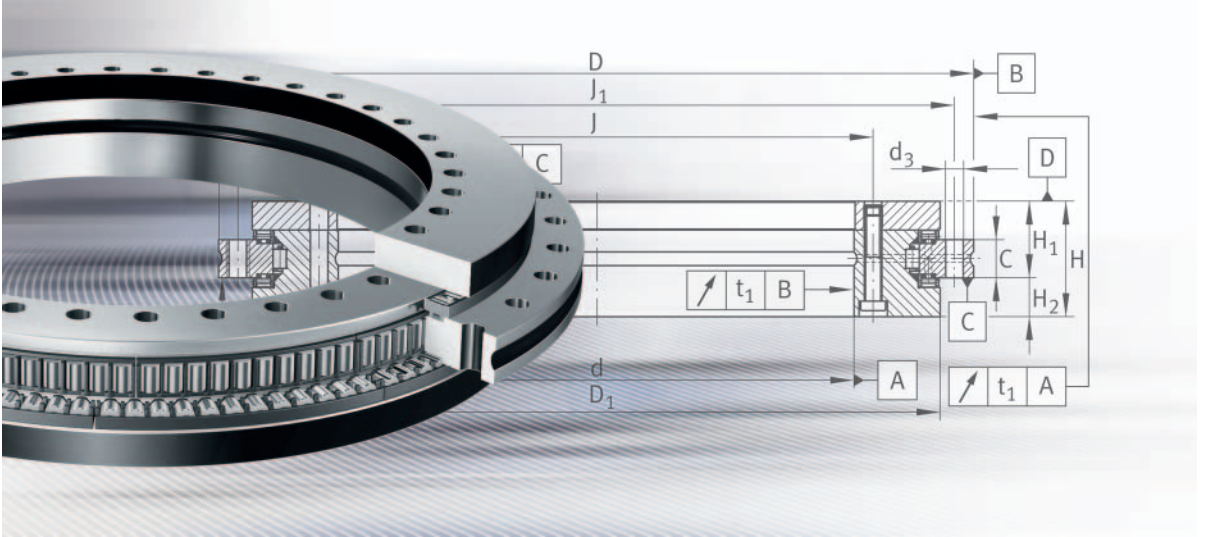
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Axial/radial bearings
Axial angular contact ball bearings

Axial/radial bearings

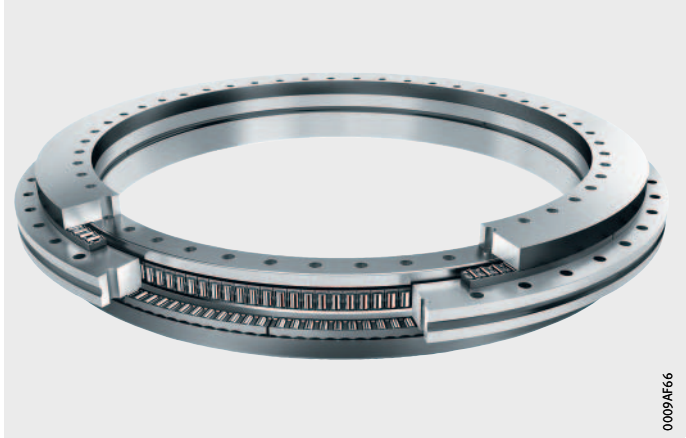
Axial angular contact ball bearings

	Page
Product overview	Axial/radial bearings, axial angular contact ball bearings 12
Features 13
	Axial/radial bearings 14
	Axial angular contact ball bearings..... 15
	Operating temperature..... 15
	Suffixes 15
Design and safety guidelines	General safety guidelines..... 16
	Basic rating life..... 16
	Static load safety factor 17
	Static limiting load diagrams..... 17
	Limiting speeds 21
	Temperature distribution in the rotary axis system..... 21
	Bearing preload 23
	Frictional torque 24
	Relubrication and initial operation 26
	Design of the adjacent construction 28
	Fits 29
	L-section ring without support ring or with support ring..... 33
	Improved ease of mounting..... 36
	Fitting..... 37
	Static rigidity 38
Accuracy 38
	Axial/radial bearings YRT and YRTC 39
	Axial/radial bearings YRTS 41
	Axial/radial bearings ZKLDF 42
Dimension tables	Axial/radial bearings, double direction, YRT 44
	Axial/radial bearings, double direction, YRTC 46
	Axial/radial bearings, double direction, YRTS 48
	Axial angular contact ball bearings, double direction, ZKLDF..... 50

Product overview **Axial/radial bearings** **Axial angular contact ball bearings**

Axial/radial bearings

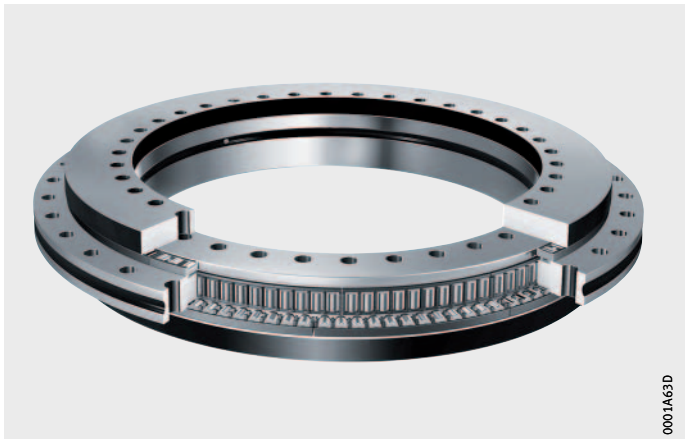
YRT, YRTC



0009AF66

For higher speeds

YRTS



0001A63D

Axial angular contact ball bearings

ZKLDf



0001A63E

Axial/radial bearings

Axial angular contact ball bearings

Features Axial/radial bearings YRTC and YRTS and axial angular contact ball bearings ZKLDF are ready-to-fit high precision bearings for high precision applications with combined loads. They can support radial loads, axial loads from both sides and tilting moments without clearance and are particularly suitable for bearing arrangements with high requirements for running accuracy.

Due to the fixing holes in the bearing rings, the units are very easy to fit.

The bearings are radially and axially preloaded after fitting.

With angular measuring system

Axial/radial bearings are also available with an absolute value angular measuring system or have systems with pitch-coded reference marks. The measuring systems can measure angles to an accuracy of a few angular seconds by non-contact means, see page 82 and page 122.

Areas of application

Schaeffler has an exceptionally large selection of rotary table bearings for a wide variety of machining processes, axis types, sizes, cutting forces and speed ranges. The two axial/radial cylindrical roller bearing series YRTC-XL, YRTS (S = Speed) and the double row axial angular contact ball bearings of series ZKLDF represent the largest product range for rotary tables and rotary axes on the market. These bearings are geometrically interchangeable. The integral measuring system can be selected as an option for series YRTC and YRTS.

- YRTC-XL
 - X-life quality
 - applications include positioning and swivel axes operating under high loads and gear hobbing machines
- YRTS
 - as bearing arrangements for high-speed rotary axes and rotary tables
 - applications include ultra-precision milling and grinding machines, gear cutting machines
- ZKLDF
 - for bearing arrangements with high operating durations such as rotary tables with a main spindle function
 - applications include combined milling and turning, as well as milling, grinding or honing

Axial/radial bearings

Axial angular contact ball bearings

n_G = limiting speed
 c_{kL} = tilting rigidity

- ① ZKLDF
- ② YRTS
- ③ YRTC
- ④ YRT

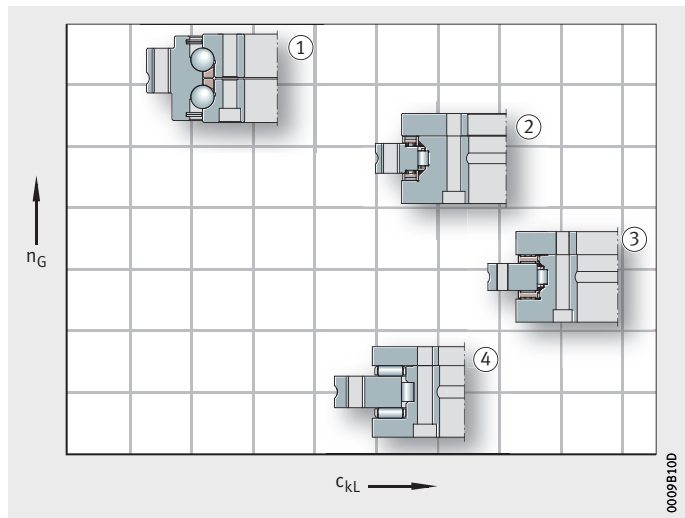


Figure 1
 Speed and tilting rigidity

New solutions from the modular system concept

Regardless of whether High-Speed, high-performance or high-precision solutions are required, – Schaeffler customers can select exactly the right components for their rotary axes and rotary tables from a highly specialised modular concept. The three standard torque motor series from Schaeffler Industrial Drives can be combined as required with the three rotary table or rotary axis bearing series, to permit the design of the most suitable solution for every machine used in machining processes. The components are optimally combined by Schaeffler engineers to meet customer requirements (perfectly matched to the machining task and to the required precision and dynamics).

Axial/radial bearings

Axial/radial bearings YRTC and YRTS have an axial and a radial component.

The axial component has a cage-guided roller set and is preloaded clearance-free after fitting. Bearings of series YRTS generally have a cage in the radial component. Bearings of series YRTC either have a radial cage or are designed with a full complement cylindrical roller set, depending on the size. The outer ring, L-section ring and shaft locating washer have fixing holes.

Lubrication

The initial greasing of YRTS corresponds to the grease Arcanol LOAD150 and, in the case of YRTC, to the grease Arcanol MULTITOP. The bearings can be lubricated via the outer ring and L-section ring.

Axial angular contact ball bearings

Axial angular contact ball bearings ZKLDF comprise a single-piece outer ring, a two-piece inner ring and two ball and cage assemblies with a contact angle of 60°. The outer ring and inner ring have fixing holes for screw mounting of the bearing on the adjacent construction.

Lubrication

The initial greasing of axial angular contact ball bearings ZKLDF corresponds to the grease Arcanol MULTITOP. The bearings can be lubricated via the outer ring.

Operating temperature

Axial/radial bearings and axial angular contact ball bearings are suitable for operating temperatures from -30 °C to +100 °C.

Suffixes

Available designs

Suffix	Description	Design
H ₁ ...	YRTC, YRTS: closer tolerance on mounting dimension H ₁ (postscript: H ₁ with tolerance ± ...) For restricted tolerance value, see page 39	Special design, available by agreement only
H ₂ ...	YRTC, YRTS: closer tolerance on mounting dimension H ₂ (postscript: H ₂ with tolerance ± ...) For restricted tolerance value, see page 39	
PRL50	YRTC, YRTS: axial and radial runout tolerances restricted by 50% (postscript: axial and radial runout 50%)	
	YRTS: axial and radial runout tolerances of the rotating inner ring restricted by 50% (postscript: axial and radial runout of the inner ring 50%)	
VSP	For mounting with an axially supported L-section ring in series YRTC, see page 34	

Axial/radial bearings

Axial angular contact ball bearings

Design and safety guidelines

General safety guidelines

The general safety guidelines must be observed. Further information relating to safety of control circuits: see Axial/radial bearings with angular measuring system, page 82.

Protection against accidental contact (DIN EN 60529)

The guidelines on protection against accidental contact in accordance with DIN EN 60529 must be observed.



After fitting, rotating components must be provided with adequate protection against accidental contact in operation.

Usage for the intended purpose

The products in this publication are suitable for use in chip-forming machine tools and in particular for the bearing arrangements of high precision rotary axes in milling and turning machines. Any usage outside the specified area or for purposes other than that intended is at the personal responsibility of the user.

Further information relating to bearings with angular measuring system: see page 105.

Modifications to the product

Modifications to the product are not permissible and will invalidate the warranty.

Machine safety under the terms of the Machinery Directive

The following rotary table bearings are, under the terms of the Machinery Directive 2006/42/EC, a component for integration in a complete system (finished or unfinished machine). The data and tests given in this publication relate purely to the components and are not a substitute for the detailed tests of the complete system.

Operating time

The mean operating time between two failures is described as the MTBF (Mean Time Between Failure). This can be calculated by agreement for rolling bearings and angular measuring devices. The operating time for rolling bearings is calculated on the basis of the load and speed duty cycle.

Basic rating life

The load carrying capacity and life must be checked for the radial and axial bearing component.

Please contact us in relation to checking of the basic rating life. The speed, load and operating duration must be given.

Static load safety factor

The static load safety factor S_0 indicates the security against impermissible permanent deformations in the bearing:

$$S_0 = \frac{C_{0r}}{F_{0r}} \text{ or } \frac{C_{0a}}{F_{0a}}$$

S_0 – Static load safety factor
 C_{0r}, C_{0a} – Basic static load rating according to dimension tables
 F_{0r}, F_{0a} – Maximum static load on the radial or axial bearing.



In machine tools and similar areas of application, S_0 should be > 4 .

Static limiting load diagrams

The static limiting load diagrams can be used:

- for rapid checking of the selected bearing size under predominantly static load
- for calculation of the tilting moment M_k that can be supported by the bearing in addition to the axial load.

The limiting load diagrams are based on a rolling element set with a static load safety factor $S_0 \geq 4$, as well as the screw and bearing ring strength.

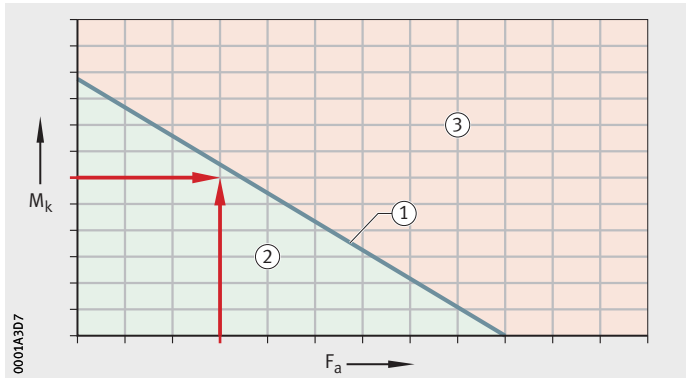


The static limiting load must not be exceeded when dimensioning the bearing, *Figure 2 to Figure 9*, page 20.

M_k = maximum tilting moment
 F_a = axial load

- ① Bearing, size
- ② Permissible range
- ③ Impermissible range

Figure 2
 Static limiting load diagram
 (example)



Axial/radial bearings

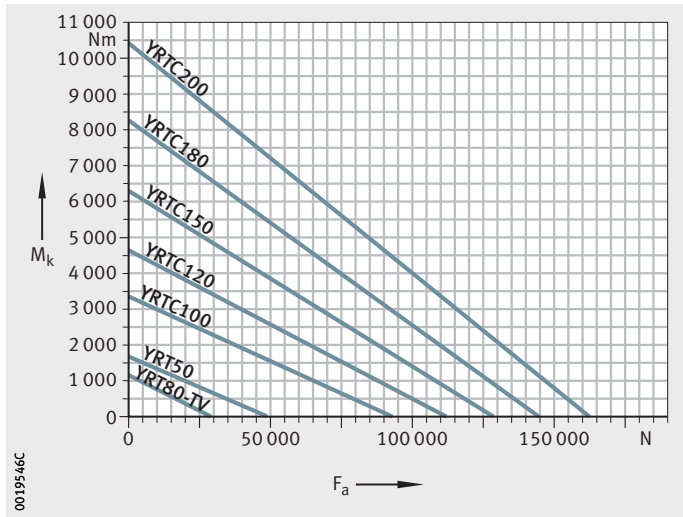
Axial angular contact ball bearings

Axial/radial bearings

The static limiting load diagrams for YRTC and YRTS are shown in *Figure 3* to *Figure 7*, page 19.

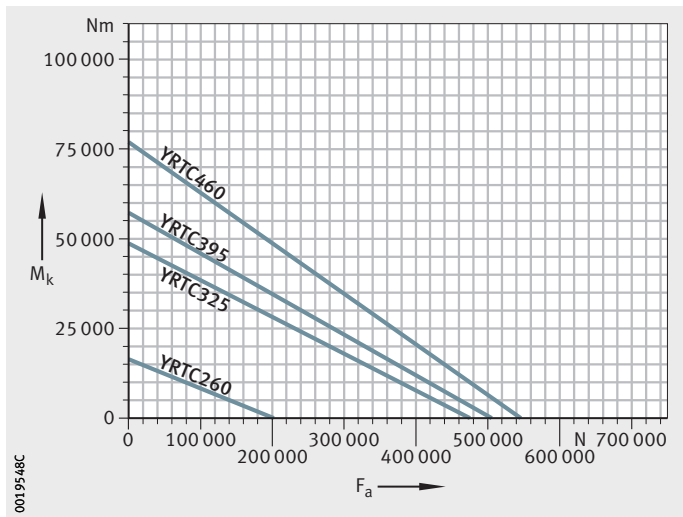
M_k = maximum tilting moment
 F_a = axial load

Figure 3
 Static limiting load diagram
 for YRTC50 to YRTC200



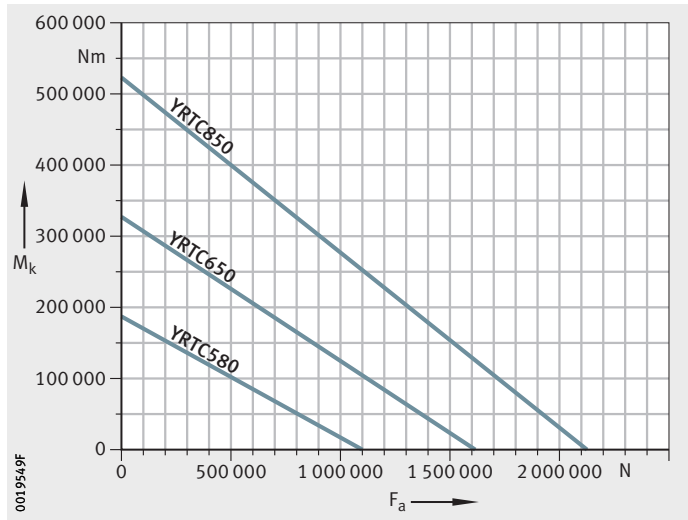
M_k = maximum tilting moment
 F_a = axial load

Figure 4
 Static limiting load diagram
 for YRTC260 to YRTC460



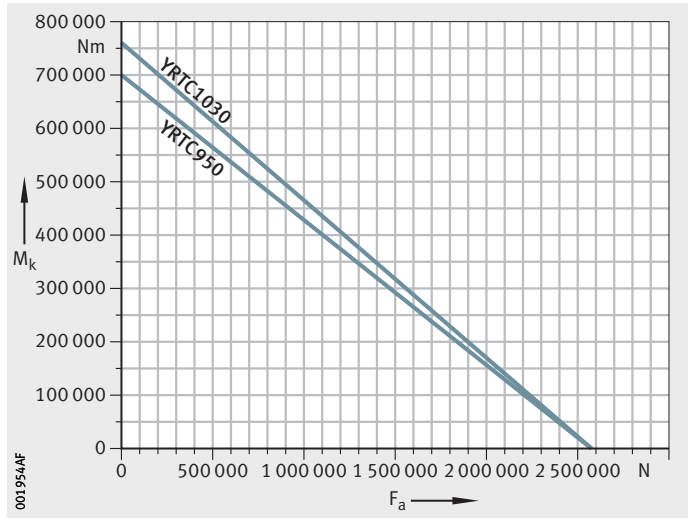
M_k = maximum tilting moment
 F_a = axial load

Figure 5
 Static limiting load diagram
 for YRTC580 to YRTC850



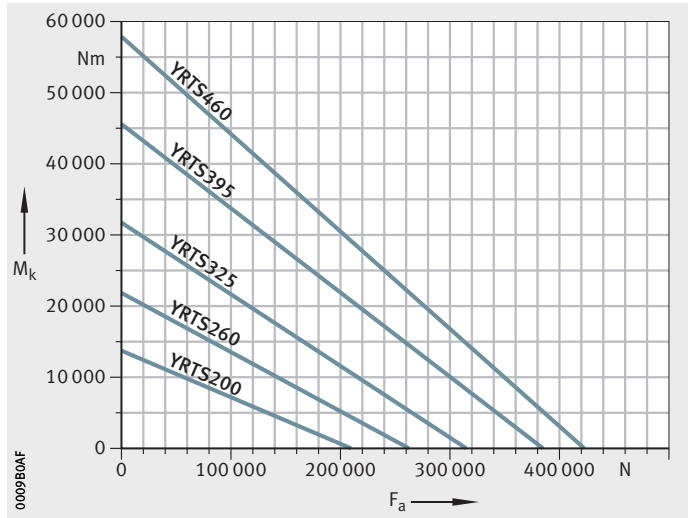
M_k = maximum tilting moment
 F_a = axial load

Figure 6
 Static limiting load diagram
 for YRTC950 to YRTC1030



M_k = maximum tilting moment
 F_a = axial load

Figure 7
 Static limiting load diagram
 for YRTS200 to YRTS460



Axial/radial bearings

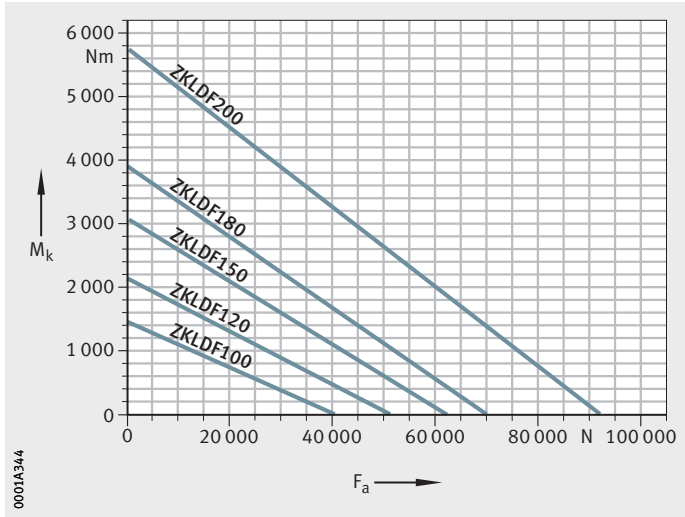
Axial angular contact ball bearings

Axial angular contact ball bearings

The static limiting load diagrams for the series ZKLDF are shown in Figure 8 and Figure 9.

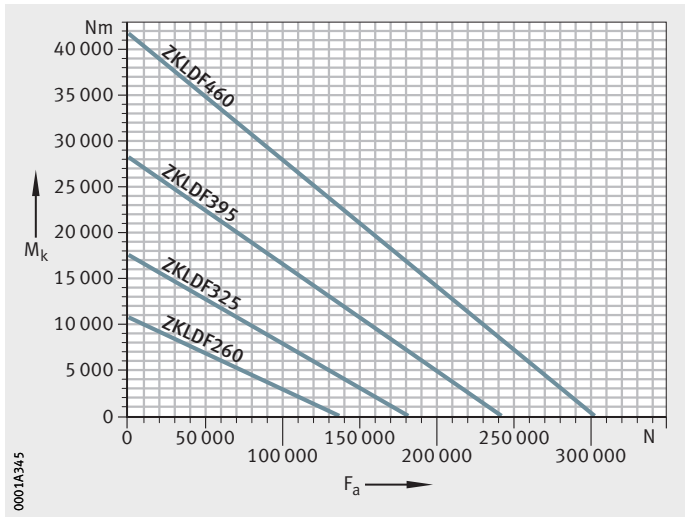
M_k = maximum tilting moment
 F_a = axial load

Figure 8
 Static limiting load diagram for ZKLDF100 to ZKLDF200



M_k = maximum tilting moment
 F_a = axial load

Figure 9
 Static limiting load diagram for ZKLDF260 to ZKLDF460



Limiting speeds



In bearing selection, the following guidelines and the limiting speeds must be observed, see dimension tables.

If the environmental conditions differ from the specifications in relation to adjacent construction tolerances, lubrication, ambient temperature, heat dissipation or from the normal operating conditions for machine tools, the stated limiting speeds must be checked. Please contact us.



In applications with a high operating duration ED or continuous operation at a speed of more than $n \times d = 35\,000 \text{ min}^{-1} \cdot \text{mm}$ at an ED > 10%, the series YRTS or ZKLDF should be selected in the bore range from 200 mm to 460 mm.

Axial radial bearings YRTC, YRTS and axial angular contact ball bearings ZKLDF

The limiting speeds n_G stated for these bearing series were determined on test rigs.

During the test, the following conditions apply:

- grease distribution cycle according to the defined data, *Figure 14, page 27*
- maximum increase in bearing temperature of 40 K in the area of the raceway
- operating duration ED = 100%, which means continuous operation at the limiting speed n_G
- bearing fully screw mounted on solid fixtures
- no external load, only preload and mass of the fixtures

Temperature distribution in the rotary axis system

Rotary axes with a main spindle function, such as those used for combined milling and turning and with direct drive by a torque motor, are systems with complex thermal characteristics.

The temperature distribution in the rotary axis system must be considered in greater detail during the design process:

- Asymmetrical rotary axis housings can undergo asymmetrical deformation due to heating.
- In turn, out-of-round bearing seats lead to additional bearing load, reduced life and a negative influence on running behaviour and running accuracy.
- Temperature management of the rotary axis in the form of targeted cooling and heating is generally necessary for high performance rotary axes. For simulation work, the Schaeffler Group has high performance simulation tools available.

Axial/radial bearings

Axial angular contact ball bearings



Where there is non-uniform temperature distribution between the inner and outer ring, rotary axis bearings with ball contact (ZKLDF) show more tolerant behaviour than rotary axis bearings with line contact (such as axial/radial cylindrical roller bearings or crossed roller bearings).

The stated bearing characteristics only apply if the bearing preload remains unchanged. The bearing preload can be altered by mechanical stresses, such as those which can be caused by temperature differences or adjacent machine elements (such as force-locking clamping connections for example).

Design regulations

Proven design regulations based on practical experiences, *Figure 10, page 23:*

- In preference, flange mount the rotor of the torque motor on the rotary table plate, to keep the flow of heat through the bearing to a minimum. Attention should be paid to the additional generation of heat in the rotor in high speed applications.
- The distance between the motor and the bearing should be as large as possible. A large distance reduces the transfer of heat from the rotor to the bearing. The stresses occurring between the components as a result of varying thermal expansion are reduced by the increased elasticity of the system. The heat gradient should be as low and constant as possible.
- The rotary table plate bearing must be centered with sufficient rigidity to allow the overall system to attain a high level of rigidity. The risk of deformation to the bearing seat due to the increase in the temperature of the rotor is also reduced.
- Use torque motors which are suitable for the requirements only, with low loss of power and a high motor constant. We recommend using torque motors from Schaeffler Industrial Drives.

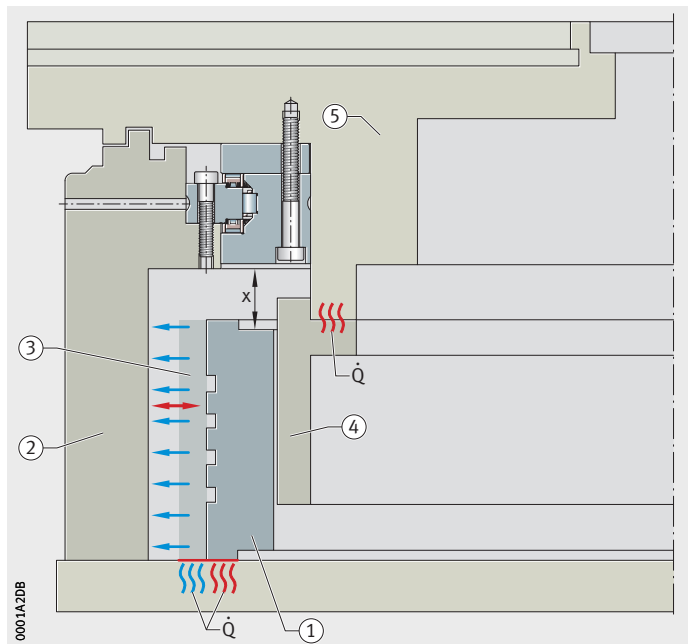


Regulated cooling of the stationary and rotating components may be required in order to limit the temperature variations between the bearing inner and outer ring.

\dot{Q} = heat flow
 x = distance from torque motor to bearing

- ① Stator of the torque motor
- ② Rotary table housing
- ③ Stator cooling
- ④ Rotor of the torque motor
- ⑤ Rotary table plate

Figure 10
 Ideal rotary table,
 taking account of the occurring heat



Bearing preload

Once the bearings have been fitted and fully screw mounted, they are radially and axially clearance-free and preloaded.

Temperature differences

Temperature differences between the shaft and housing influence the radial bearing preload and thus the operating behaviour and operating life of the bearing arrangement.

If the shaft temperature is higher than the housing temperature, the radial preload will increase proportionally, so there will be an increase in the rolling element load, bearing friction and bearing temperature, while the operating life will be reduced.

If the shaft temperature is lower than the housing temperature, the radial preload will decrease proportionally, so the rigidity will decrease to bearing clearance. There will be an increase in wear, the operating life will be reduced and noise due to slippage may occur.

Axial/radial bearings

Axial angular contact ball bearings

Frictional torque

The bearing frictional torque M_R is influenced primarily by the viscosity and quantity of the lubricant and the bearing preload:

- The lubricant viscosity is dependent on the lubricant grade and operating temperature.
- When relubrication is carried out, the lubricant quantity is increased for a short time until the grease is distributed and the excess quantity has left the bearing.
- During initial operation and after relubrication, bearing friction is increased until the lubricant has been distributed within the bearing.
- The bearing preload is dependent on the mounting fits, the geometrical accuracy of the adjacent parts, the temperature difference between the inner and outer ring, the screw tightening torque and mounting situation (bearing inner ring axially supported on one or both sides).

Guide values for frictional torque M_R

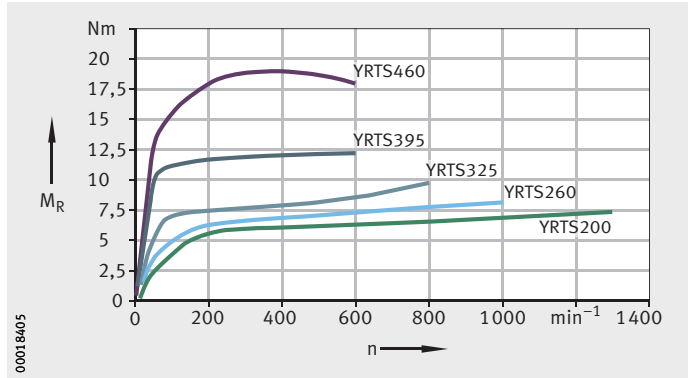
The stated frictional torques M_R are statistically determined guide values for bearings with grease lubrication after a grease distribution cycle and at an operating temperature of $\vartheta = 50\text{ °C}$, *Figure 11*, *Figure 12*, page 25, and *Figure 14*, page 27. For mounting with an unsupported L-section ring for bearing series YRTC and YRTS, the measured frictional torques, *Figure 11*, apply. In the mounting variant with an L-section ring supported over its whole surface, these values are increased as a function of the washer thickness and the geometrical accuracy of the supporting ring by an average of 10% to 20%. The guide values for the frictional torque for axial/radial bearings YRT were determined at a measurement speed $n = 5\text{ min}^{-1}$, see dimension tables.



Deviations from the tightening torque of the fixing screws will have a detrimental effect on the preload and the frictional torque. For YRT bearings, it must be taken into consideration that the frictional torque can increase by a factor 2 to 2,5 with increasing speed.

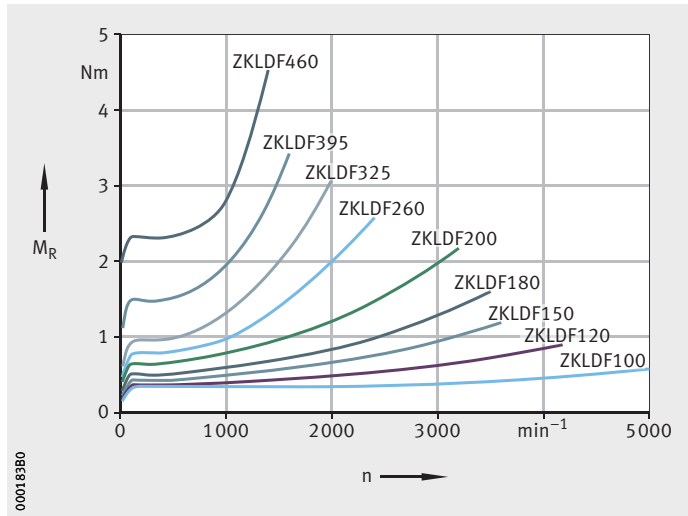
M_R = frictional torque
 n = speed

Figure 11
 Frictional torques as guide values
 for YRTS,
 statistically determined values
 from series of measurements



M_R = frictional torque
 n = speed

Figure 12
 Frictional torques as guide values
 for ZKLDF,
 statistically determined values
 from series of measurements



Axial/radial bearings

Axial angular contact ball bearings

Relubrication and initial operation

The speed capability, friction, rating life, functional capability and the durations of relubrication intervals are essentially influenced by the grease used, see table.

Axial/radial bearings YRTC and YRTS can be relubricated via a lubrication groove in the L-section ring and the outer ring.

Axial angular contact ball bearings ZKLDF can be relubricated via a lubrication groove in the outer ring.

Bearing series YRTC from bore diameter 580 mm and bearing series YRTS and ZKLDF have an additional lubrication connector in the bearing screw mounting face of the outer ring. This allows reliable feed of lubricant even where there is a large fit clearance in the bearing seat or the outer ring is free, *Figure 13*.

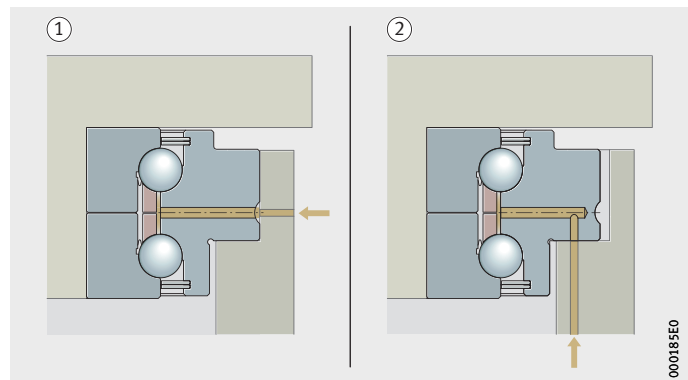
For calculation of the relubrication quantities and intervals based on a stated load spectrum (speed, load, operating duration) and the environmental conditions, please contact us.

Relubrication

Series	Relubrication using grease
YRTC, ZKLDF	Arcanol MULTITOP
YRTS	Arcanol LOAD150

- ① Relubrication via the lubrication groove in the outer ring
- ② Relubrication via the outer ring screw mounting face

Figure 13
Options for relubrication



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Initial operation

Rolling bearings may exhibit increased frictional torque during initial operation, which can lead to overheating where there is immediate operation at high speeds.



In order to prevent overheating of the bearing, the running-in cycle must always be carried out, *Figure 14*. The cycle may be shortened if there is appropriate monitoring of the bearing temperature.

The bearing ring temperature must not exceed +60 °C.

In the case of swivel type axes (low speed or small operating duration), the running-in cycle is not required.

Overlubrication

The bearings may be damaged by overheating as a result of increased frictional torque when operating at high speeds if they have been accidentally overlubricated.

In order to achieve the original frictional torque again, the running-in cycle in accordance with *Figure 14* should be carried out.

n_G = limiting speed
according to dimension tables
t = time

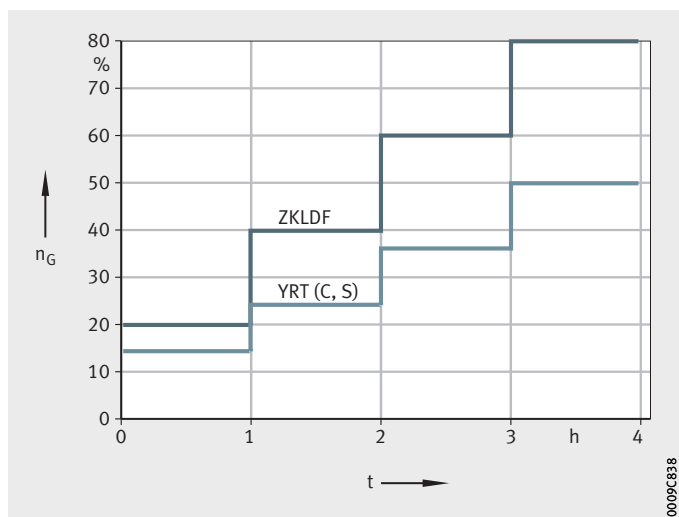


Figure 14
Running-in cycle for initial operation
and after overlubrication

Further information

- The further information on lubrication in Catalogue HR 1, chapter Lubrication must be observed.

Axial/radial bearings

Axial angular contact ball bearings

Design of adjacent construction



YRTC, YRTS and ZKLDF have almost the same mounting dimensions.

Geometrical defects in the screw mounting surfaces and fits will influence the running accuracy, preload and running characteristics of the bearing arrangement. The accuracy of the adjacent surfaces must therefore be matched to the overall accuracy requirement of the subassembly.

The adjacent construction should be produced in accordance with *Figure 15* and the tolerances must be in accordance with the tables starting on page 31. Any deviations will influence the bearing frictional torque, running accuracy and running characteristics.

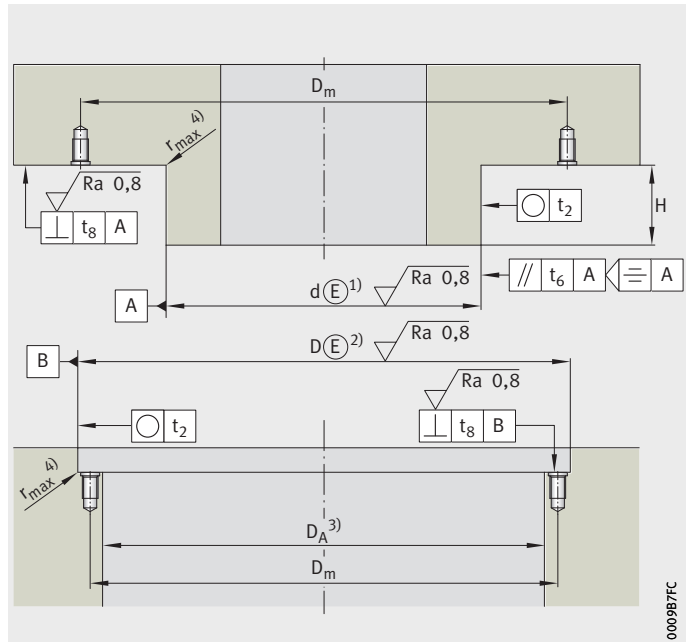


Figure 15
Requirements
for the adjacent construction

Legend

- 1) Tolerance class: see tables, page 31 to page 32. Support over whole bearing height. It must be ensured that the means of support has adequate rigidity.
- 2) Tolerance class: see tables, page 31 to page 32. A precise fit is only necessary if radial support due to the load or a precise bearing position is required.
- 3) Note the bearing diameter D_1 in the dimension tables. Ensure that there is sufficient distance between the rotating bearing rings and the adjacent construction.
- 4) Values, see table Maximum corner radii of the fit surfaces for YRTC, YRTS and ZKLDF, page 32.

Fits

The selection of fits leads to transition fits, i.e. depending on the actual dimensional position of the bearing diameter and mounting dimensions, clearance fits or interference fits can arise.



The fit influences, for example, the running accuracy of the bearing and its dynamic characteristics.

An excessively tight fit will increase the radial bearing preload. As a result:

- there is an increase in bearing friction and heat generation in the bearing as well as the load on the raceway system and wear
- there will be a decrease in the achievable speed and the bearing operating life.

For easier matching of the adjacent construction to the actual bearing dimensions, each bearing is supplied with a measurement record.

Axial and radial runout accuracy of the bearing arrangement

The axial and radial runout accuracy is influenced by:

- the running accuracy of the bearing
- the geometrical accuracy of the adjacent surfaces
- the fit between the rotating bearing ring and adjacent component



For very high running accuracy, the rotating bearing ring should ideally have a fit clearance 0 and it should be ensured that the bearing has preload in operation, see page 23.

Recommended fits for shafts

The shaft should be produced to tolerance class h5 © and for series YRTS in accordance with table, page 32.

If there are special requirements, the fit clearance must be further restricted within the stated tolerance classes:


- Requirements for running accuracy:
For maximum running accuracy and with a rotating bearing inner ring, the aim should be to achieve as close as possible to a fit clearance 0. The fit clearance may otherwise increase the bearing radial runout. With normal requirements for running accuracy or a stationary bearing inner ring, the shaft for series YRTC and ZKLDF should be produced to h5 ©. For axial/radial bearings YRTS, the recommended fits for shaft and housing bore must be observed, see table, page 32.
- Requirements for dynamic characteristics:
 - For swivel type operation ($n \times d < 35\,000 \text{ min}^{-1} \cdot \text{mm}$, operating duration $ED < 10\%$) the shaft should be produced to h5 ©. The tolerance class h5 © can be used under these operating conditions for series YRT, YRTC, YRTS and ZKLDF.
 - For higher speeds and longer operating duration, the fit interference must not exceed 0,01 mm.
For series YRTS, the fit interference must not exceed 0,005 mm.

For series ZKLDF, the fit dimension should be based on the inner ring with the smallest bore dimension in accordance with the measurement record supplied.



Axial/radial bearings

Axial angular contact ball bearings

Recommended fits for housings

The housing should be produced to tolerance class J6  and for series YRTS in accordance with table Recommended fits for shaft and housing bore for YRTS, page 32.

If there are special requirements, the fit clearance must be further restricted within the stated tolerance classes:

- Requirements for running accuracy:
For maximum running accuracy and with a rotating bearing outer ring, the aim should be to achieve as close as possible to a fit clearance of 0. With a static bearing outer ring, a clearance fit or a design without radial centring should be selected.
- Requirements for dynamic characteristics:
 - For predominantly swivel type operation ($n \times d < 35\,000 \text{ min}^{-1} \cdot \text{mm}$, operating duration ED < 10%) and a rotating bearing outer ring, the housing fit should be produced to tolerance class J6 . The tolerance class J6  can be used under these operating conditions for series YRT, YRTC, YRTS and ZKLDF.
 - For axial/radial bearing YRTS with a higher speed and operating duration, a thermal FE calculation of the subassembly must be carried out.



If the calculations show a higher temperature at the shaft and bearing inner ring than at the bearing outer ring, it may be advantageous not to centre the bearing outer ring radially or to produce the housing fit as a clearance fit with at least 0,02 mm clearance. This will reduce the increase in preload that occurs where there is a temperature differential between the inner ring and outer ring of the bearing. However, if the temperature differential is too great, this may lead to overloading of the screw connections of the outer ring and the screw connection will start to slip. The result of this is radial clearance in the bearing arrangement of a cold machine.

If the calculations at the bearing outer ring show an identical or higher temperature in relation to the inner ring, then the housing should be produced in accordance with the recommended fits for shaft and housing bore for YRTS, see table, page 32.

Fit selection depending on the screw connection of the bearing rings

If the bearing outer ring is screw mounted on the static component, a fit seating is not required or a fit seating can be produced as stated, see tables, page 31 to page 32. If the values in the table are used, this will give a transition fit with a tendency towards clearance fit. This generally allows easy fitting.

If the bearing inner ring is screw mounted on the static component, it should nevertheless for functional reasons be supported over the whole bearing height. The mounting dimensions should then be selected accordingly, see tables, page 31 to page 32. If these values in the table are used, this will give a transition fit with a tendency towards clearance fit.

Geometrical and positional accuracy of the adjacent construction



The values given in the following tables for geometrical and positional accuracy of the adjacent construction have proved effective in practice and are adequate for the majority of applications.

The geometrical tolerances influence the axial and radial runout accuracy of the subassembly as well as the bearing frictional torque and the running characteristics.

Diameter and geometrical tolerances for shafts for YRTC and ZKLDF

Nominal shaft dimension		Deviation ¹⁾ Tolerance class h5 ©	Roundness tolerance	Parallelism tolerance	Perpendicularity tolerance
d mm			t ₂	t ₆	t ₈
over	incl.	µm	µm	µm	µm
50	80	⁰ ₋₁₃	3	1,5	3
80	120	⁰ ₋₁₅	4	2	4
120	180	⁰ ₋₁₈	5	2,5	5
180	250	⁰ ₋₂₀	7	3,5	7
250	315	⁰ ₋₂₃	8	4	8
315	400	⁰ ₋₂₅	9	4,5	9
400	500	⁰ ₋₂₇	10	5	10
500	630	⁰ ₋₃₂	11	5,5	11
630	800	⁰ ₋₃₆	13	6,5	13
800	1 000	⁰ ₋₄₀	15	7,5	15
1 000	1 250	⁰ ₋₄₇	18	9	18

¹⁾ The envelope condition © applies here.

Diameter and geometrical tolerances for housings for YRTC and ZKLDF

Nominal housing bore dimension		Deviation ¹⁾ Tolerance class J6 ©	Roundness tolerance	Perpendicularity tolerance
D mm			t ₂	t ₈
over	incl.	µm	µm	µm
120	180	⁺¹⁸ ₋₇	5	5
180	250	⁺²² ₋₇	7	7
250	315	⁺²⁵ ₋₇	8	8
315	400	⁺²⁹ ₋₇	9	9
400	500	⁺³³ ₋₇	10	10
500	630	⁺³⁴ ₋₁₀	11	11
630	800	⁺³⁸ ₋₁₂	13	13
800	1 000	⁺⁴⁴ ₋₁₂	15	15
1 000	1 250	⁺⁵² ₋₁₄	18	18

¹⁾ The envelope condition © applies here.

Axial/radial bearings

Axial angular contact ball bearings

Recommended fits
for shaft and housing bore
for YRTS

Axial/radial bearing	Shaft diameter ¹⁾ d mm	Housing bore ¹⁾ D mm
YRTS200	200 $\begin{matrix} -0,01 \\ -0,024 \end{matrix}$	300 $\begin{matrix} +0,011 \\ -0,005 \end{matrix}$
YRTS260	260 $\begin{matrix} -0,013 \\ -0,029 \end{matrix}$	385 $\begin{matrix} +0,013 \\ -0,005 \end{matrix}$
YRTS325	325 $\begin{matrix} -0,018 \\ -0,036 \end{matrix}$	450 $\begin{matrix} +0,015 \\ -0,005 \end{matrix}$
YRTS395	395 $\begin{matrix} -0,018 \\ -0,036 \end{matrix}$	525 $\begin{matrix} +0,017 \\ -0,005 \end{matrix}$
YRTS460	460 $\begin{matrix} -0,018 \\ -0,038 \end{matrix}$	600 $\begin{matrix} +0,017 \\ -0,005 \end{matrix}$

¹⁾ Envelope condition © applies to the tolerances.

Geometrical and
positional accuracy
for shafts
for YRTS

Axial/radial bearing	Roundness tolerance t_2 μm	Parallelism tolerance t_6 μm	Perpendicularity tolerance t_8 μm
YRTS200	6	2,5	5
YRTS260 to YRTS460	8	2,5	7

Geometrical and
positional accuracy
for housings
for YRTS

Axial/radial bearing	Roundness tolerance t_2 μm	Perpendicularity tolerance t_8 μm
YRTS200 to YRTS460	6	8

Maximum corner radii
of the fit surfaces
for YRTC, YRTS and ZKLDf

Bore diameter d mm		Maximum corner radius r_{max} mm
over	incl.	
50	200	0,1
200	580	0,3
460	1 030	1

Mounting dimensions H_1 , H_2



If the height variation must be as small as possible, the H_1 dimensional tolerance must conform to the tables, from page 38, and *Figure 16*.

The mounting dimension H_2 defines the position of any worm wheel used, *Figure 16* and *Figure 17*, page 34, L-section ring with support ring.

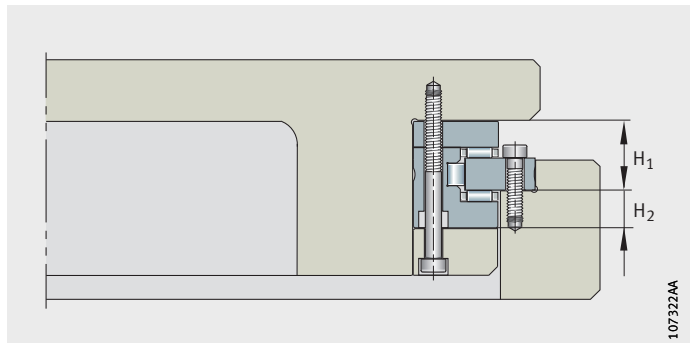


Figure 16
Mounting dimension H_1 , H_2

L-section ring without support ring or with support ring

The outward-facing axial surfaces of the shaft-mounted bearing rings of YRTC, YRTS and ZKLDF can be mounted supported over their whole surface on one or both sides, *Figure 17*, page 34. The support ring (for example a worm wheel) must be ordered separately.

In bearings of series ZKLDF, the rigidity and frictional torque are not influenced by the support ring.

In fitting of the series YRTC and YRTS with an L-section ring supported axially over its whole surface, there is an increase in the axial rigidity in the direction of the support ring as a function of the support ring rigidity and in the tilting rigidity of the bearing position. In this case, delivery with a different preload match is necessary for YRTC, suffix VSP.



If the normal design of series YRTC (without suffix VSP) is mounted with a supported L-section ring, there will be an increase in the bearing frictional torque.

The shaft locating washer must be supported axially over its whole surface by the adjacent construction. In the case of YRTC-VSP, the L-section ring must also be axially supported over its whole surface in order to achieve the stated rigidity values.

For series YRTS and ZKLDF, there is only one preload match. In YRTS bearings, the increase in rigidity and frictional torque is slight and can normally be ignored, see page 24.

Axial/radial bearings

Axial angular contact ball bearings

L-section ring without support ring

In the case of “L-section ring without support ring”, the bearing designation is:

■ YRTC <bore diameter>

L-section ring with support ring

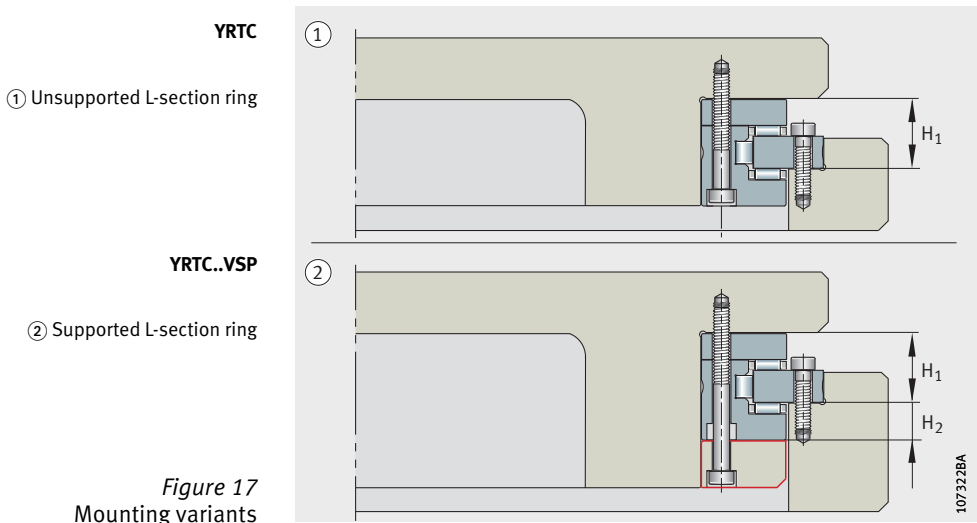
For the case “L-section ring with support ring”, the bearing designation is:

■ YRTC <bore diameter> **VSP**



In the case of series YRTC, the height of the support ring should be at least as large as the dimension H_2 of the bearing.

Any mounting conditions that deviate from our suggestions, *Figure 17*, may impair the function and the performance data of the bearings. For different designs, please contact us.

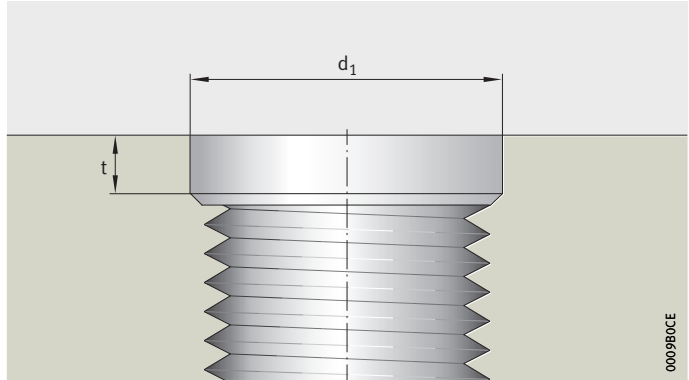


Design of fixing threads in the adjacent construction

Produce the thread in the adjacent construction with a cylindrical countersink to ensure bearing running accuracy, *Figure 18* and table. If the cylindrical countersink is not applied, the surface may become deformed when the fixing screws are tightened.

d_1 = countersink diameter
 t = countersink depth

Figure 18
 Design of fixing threads in the adjacent construction



Design of countersink

Thread	Countersink diameter d_1 mm	Countersink depth t mm
M4	4,4	1
M5	5,5	1
M6	6,6	1
M8	8,8	1
M10	11	1
M12	13,2	1
M16	17,6	1

Axial/radial bearings

Axial angular contact ball bearings

Improved ease of mounting

In order to ensure that the lubrication hole in the bearing is correctly positioned relative to the lubrication hole in the machine housing, bearings YRTC with bores from 580 mm, and bearings YRTS and ZKLDF have a so-called pilot pin hole, see table and *Figure 19*.

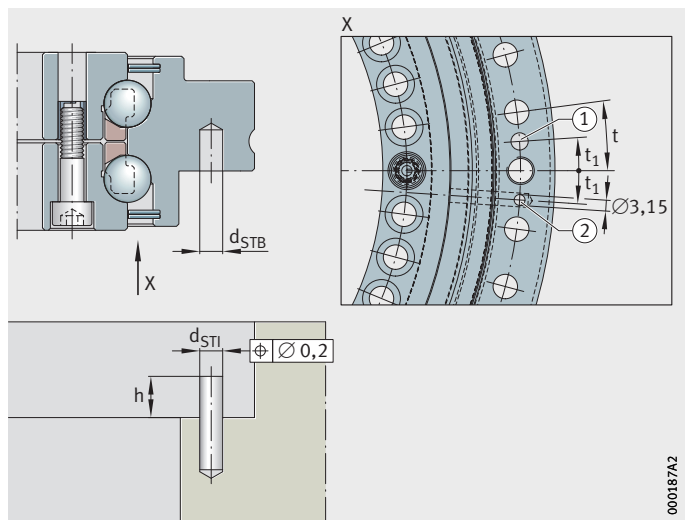
Pilot pin hole

Shaft diameter d mm		Pin height h mm	Pin diameter d_{STI} mm	Pin hole d_{STB} mm
over	incl.	max.		min.
–	460	4	4	5
460	580	6	6	8
580	–	8	8	10

YRTC
YRTS
ZKLDF

- ① Pilot pin hole for positioning of lubrication hole
- ② Lubrication hole
 $t_1 = 0,5 \cdot t$

Figure 19
Improved ease of mounting with axial lubrication hole



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Fitting Retaining screws secure the bearing components during transport. For easier centring of the bearing, the screws should be loosened before fitting and either secured again or removed after fitting.

Tighten the fixing screws in a crosswise sequence using a torque wrench in three stages to the specified tightening torque M_A , while rotating the bearing ZKLDf, *Figure 20*:

- Stage 1 40% of M_A
- Stage 2 70% of M_A
- Stage 3 100% of M_A

Observe the correct grade of the fixing screws.



Mounting forces must only be applied to the bearing ring to be fitted, never through the rolling elements.

Bearing components must not be separated or interchanged during fitting and dismantling.

If the bearing is unusually difficult to move, loosen the fixing screws and tighten them again in steps in a crosswise sequence. This will eliminate any distortion.

Bearings should only be fitted in accordance with TPI 103, Fitting and Maintenance Manual.

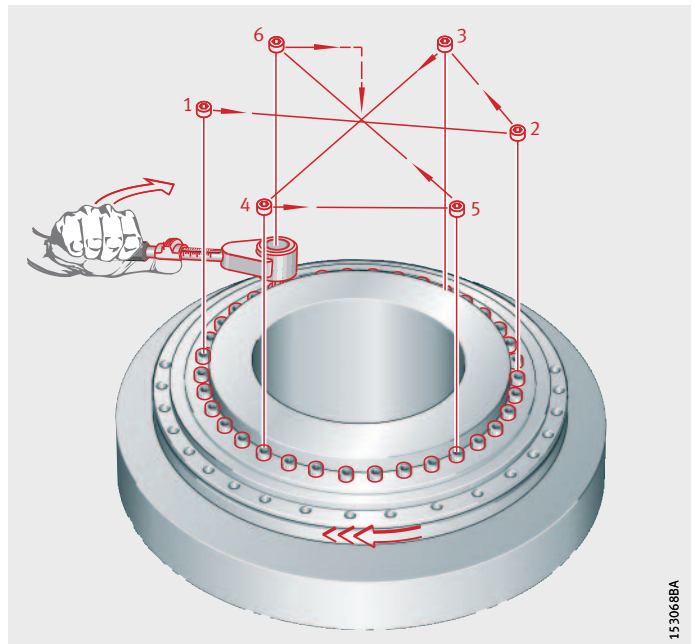


Figure 20
Tightening of fixing screws

Axial/radial bearings

Axial angular contact ball bearings

Static rigidity The rigidity of a bearing position is a description of the magnitude of the displacement from the ideal position under load. The static rigidity thus has a direct influence on the accuracy of the machining results.

The dimension tables give the rigidity values for the complete bearing position, see page 44 to page 50. These take account of the deflection of the rolling element set as well as the deformation of the bearing rings and the screw connections.

The values for the rolling element sets are calculated rigidity values and are for information purposes only. They facilitate comparison with other bearing types, since rolling bearing catalogues generally only give the higher rolling element set rigidity values.

Accuracy The dimensional tolerances are derived from tolerance class 5. The diameter tolerances stated are mean values in accordance with ISO 1132.

The bearing bore in series YRTC and YRTS may be slightly conical in the delivered condition. This is typical of the bearing design and is a result of the radial bearing preload forces. The bearing will regain its ideal geometry when fitted.

Explanation of features

Short designation	Description
d	Nominal bore diameter
$t_{\Delta dmp}$	Bore deviation
D	Nominal size of outside diameter
$t_{\Delta Dmp}$	Deviation of outside diameter
U	Upper limit deviation
L	Lower limit deviation
H_1	Contact surface height of outer ring
$t_{\Delta H1s}$	Height deviation
H_2	Contact surface height of outer ring
$t_{\Delta H2s}$	Height deviation
t_1	Axial and radial runout

Axial/radial bearings YRT and YRTC

The geometrical tolerances correspond to tolerance class 4 in accordance with ISO 492 (DIN 620-2).

Dimensional tolerances

mm	d ¹⁾		mm	D ¹⁾	
	t _{Δdmp}			t _{ΔDmp}	
	U mm	L mm		U mm	L mm
50	0	-0,008	126	0	-0,011
80	0	-0,009	146	0	-0,011
100	0	-0,01	185	0	-0,02
120	0	-0,01	210	0	-0,015
150	0	-0,013	240	0	-0,015
180	0	-0,013	280	0	-0,018
200	0	-0,015	300	0	-0,018
260	0	-0,018	385	0	-0,02
325	0	-0,023	450	0	-0,023
395	0	-0,023	525	0	-0,028
460	0	-0,023	600	0	-0,028
580	0	-0,025	750	0	-0,035
650	0	-0,038	870	0	-0,05
850	0	-0,05	1 095	0	-0,063
950	0	-0,05	1 200	0	-0,063
1 030	0	-0,063	1 300	0	-0,08

¹⁾ The diameter tolerances stated are mean values (DIN 620).

Mounting dimensions, normal design

mm	H ₁			H ₂		
	mm	t _{ΔH1s}		mm	t _{ΔH2s}	
		U mm	L mm		U mm	L mm
50	20	+0,025	-0,025	10	+0,02	-0,02
80	23,35	+0,025	-0,025	11,65	+0,2	-0,2
100	25	+0,025	-0,025	13	+0,02	-0,02
120	26	+0,025	-0,025	14	+0,2	-0,2
150	26	+0,03	-0,03	14	+0,02	-0,02
180	29	+0,03	-0,03	14	+0,025	-0,025
200	30	+0,03	-0,03	15	+0,025	-0,025
260	36,5	+0,04	-0,04	18,5	+0,025	-0,025
325	40	+0,05	-0,05	20	+0,025	-0,025
395	42,5	+0,05	-0,05	22,5	+0,025	-0,025
460	46	+0,06	-0,06	24	+0,03	-0,03
580	60	+0,25	-0,25	30	+0,25	-0,25
650	78	+0,25	-0,25	44	+0,25	-0,25
850	80,5	+0,3	-0,3	43,5	+0,3	-0,3
950	86	+0,3	-0,3	46	+0,3	-0,3
1 030	92,5	+0,3	-0,3	52,5	+0,3	-0,3

Axial/radial bearings

Axial angular contact ball bearings

Mounting dimensions,
restricted design

d	H ₁			H ₂		
		t _{ΔH1s} ¹⁾			t _{ΔH2s} ¹⁾	
		U	L		U	L
mm	mm	mm	mm	mm	mm	mm
50	20	–	–	10	–	–
80	23,35	–	–	11,65	–	–
100	25	–	–	13	–	–
120	26	–	–	14	–	–
150	26	–	–	14	–	–
180	29	–	–	14	–	–
200	30	–	–	15	–	–
260	36,5	–	–	18,5	–	–
325	40	–	–	20	–	–
395	42,5	–	–	22,5	–	–
460	46	–	–	24	–	–
580	60	+0,075	-0,075	30	+0,03	-0,03
650	78	+0,1	-0,1	44	+0,03	-0,03
850	80,5	+0,12	-0,12	43,5	+0,03	-0,03
950	86	+0,3	-0,3	46	+0,03	-0,03
1 030	92,5	+0,15	-0,15	52,5	+0,03	-0,03

¹⁾ Special design with suffix H1 or H2, see table, page 15.

Axial and radial runout

d	t ₁ ¹⁾	
	Normal ²⁾	Restricted ³⁾
mm	μm	μm
50	2	1
80	3	1,5
100	3	1,5
120	3	1,5
150	3	1,5
180	4	2
200	4	2
260	6	3
325	6	3
395	6	3
460	6	3
580	10	5 ⁴⁾
650	10	5 ⁴⁾
850	12	6 ⁴⁾
950	12	6 ⁴⁾
1 030	12	6 ⁴⁾

¹⁾ Measured on fitted bearing with ideal adjacent construction.

²⁾ For rotating inner and outer ring.

³⁾ For rotating inner and outer ring, suffix PRL50.

⁴⁾ Available by agreement.

Axial/radial bearings YRTS

The geometrical tolerances correspond to tolerance class 4 in accordance with ISO 492 (DIN 620-2).

Dimensional tolerances

mm	d ¹⁾		D ¹⁾		
	t _{Δdmp}		mm	t _{ΔDmp}	
	U mm	L mm		U mm	L mm
200	0	-0,015	300	0	-0,018
260	0	-0,018	385	0	-0,02
325	0	-0,023	450	0	-0,023
395	0	-0,023	525	0	-0,028
460	0	-0,023	600	0	-0,028

¹⁾ The diameter tolerances stated are mean values (DIN 620).

Mounting dimensions

mm	d	H ₁		H ₂ mm
		t _{ΔH1s}		
		U mm	L mm	
200	30	+0,04	-0,06	15
260	36,5	+0,05	-0,07	18,5
325	40	+0,06	-0,07	20
395	42,5	+0,06	-0,07	22,5
460	46	+0,07	-0,08	24

Axial and radial runout

mm	d	t ₁ ¹⁾	
		Normal ²⁾	Restricted ³⁾
		μm	μm
200		4	2
260		6	3
325		6	3
395		6	3
460		6	3

¹⁾ Measured on fitted bearing with ideal adjacent construction.

²⁾ For rotating inner and outer ring.

³⁾ For rotating inner ring only, suffix PRL50/IR.

Axial/radial bearings

Axial angular contact ball bearings

Axial/radial bearings ZKLDF

The geometrical tolerances correspond to tolerance class 4 in accordance with ISO 492 (DIN 620-2).

Dimensional tolerances

mm	d ¹⁾		mm	D ¹⁾	
	t _{Δdmp}			t _{ΔDmp}	
	U mm	L mm		U mm	L mm
100	0	-0,01	185	0	-0,015
120	0	-0,01	210	0	-0,015
150	0	-0,013	240	0	-0,015
180	0	-0,013	280	0	-0,018
200	0	-0,015	300	0	-0,018
260	0	-0,018	385	0	-0,02
325	0	-0,023	450	0	-0,023
395	0	-0,023	525	0	-0,028
460	0	-0,023	600	0	-0,028

¹⁾ The diameter tolerances stated are mean values (DIN 620).

Mounting dimensions

mm	d	H ₁	
		t _{ΔH1s}	
		U mm	L mm
100	25	+0,175	-0,175
120	26	+0,175	-0,175
150	26	+0,175	-0,175
180	29	+0,175	-0,175
200	30	+0,175	-0,175
260	36,5	+0,2	-0,2
325	40	+0,2	-0,2
395	42,5	+0,2	-0,2
460	46	+0,225	-0,225

Axial and radial runout

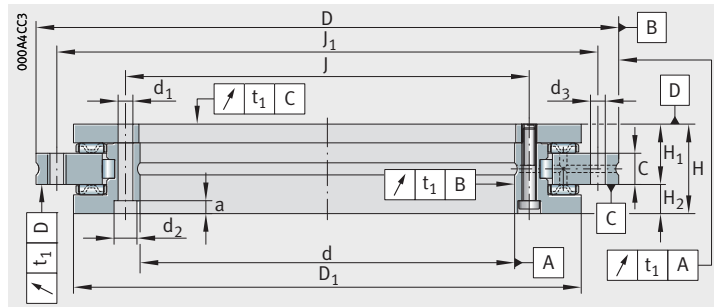
mm	d	t ₁ ¹⁾ Normal ²⁾ μm
100		3
120		3
150		3
180		4
200		4
260		6
325		6
395		6
460		6

¹⁾ Measured on fitted bearing with ideal adjacent construction.

²⁾ For rotating inner and outer ring.

Axial/radial bearings

Double direction



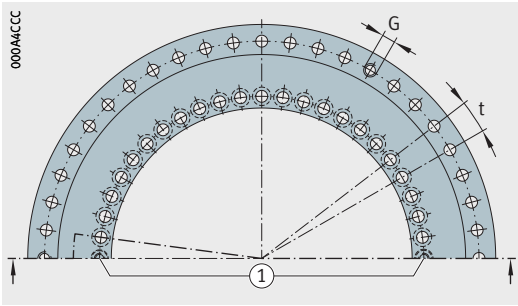
YRT

Dimension table · Dimensions in mm

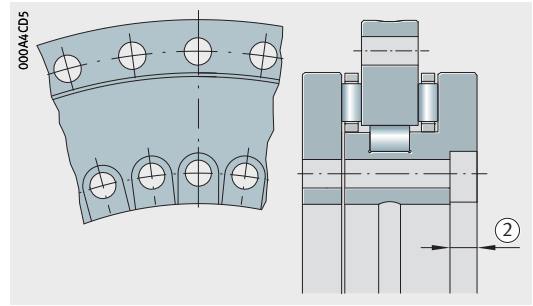
Main dimensions							Basic load ratings				Limiting speed ¹⁾ n_G min^{-1}	Mass $\approx m$ kg	Designation
							axial		radial				
d			D		H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN				
50	0	-0,008	126	0	-0,011	30	56	280	28,5	49,5	440	1,6	YRT50
80	0	-0,009	146	0	-0,011	35	38	158	44	98	350	2,4	YRT80-TV⁶⁾

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area

- 1) For high operating durations or continuous operation, please contact us.
- 2) Including retaining screws or threaded extraction holes.
- 3) Diameter of inner ring for design of adjacent construction.
- 4) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 5) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 6) Cages made from glass fibre reinforced polyamide 66.
- 7) Screws M5 (on inner ring) to 8,5 Nm and screws M4 (on outer ring) to 4,5 Nm.
- 8) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 45.



Hole pattern



YRT80-TV

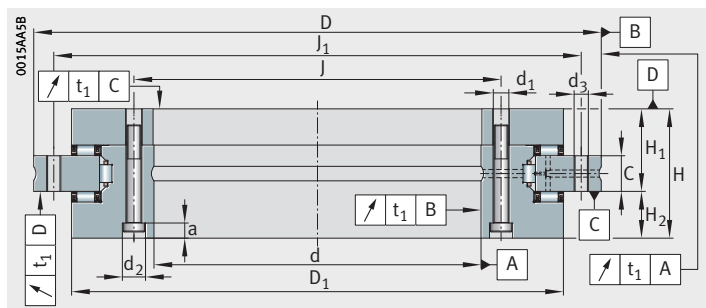
Dimensions							Fixing screws						Pitch ²⁾		Threaded extraction hole		Screw tightening torque ⁵⁾
							Inner ring			Outer ring							
d	H ₁	H ₂	C	D ₁ ³⁾ max.	J	J ₁	d ₁	d ₂	a	Quantity ⁴⁾	d ₃	Quantity ⁴⁾	n	t	G	Quantity	M _A Nm
50	20	10	10	105	63	116	5,6	-	-	10	5,6	12	12	30	-	-	8,5
80	23,35	11,65	12	130	92	138	5,6	10	4	10	4,6	12	12	30	-	-	8,5 ⁷⁾

Dimension table (continued) · Dimensions in mm

Main dimension	Designation	Rigidity ⁸⁾					
		of bearing position			of rolling element set		
		axial	radial	Tilting rigidity	axial	radial	Tilting rigidity
d		c _{aL} kN/μm	c _{rL} kN/μm	c _{kL} kNm/mrad	c _{aL} kN/μm	c _{rL} kN/μm	c _{kL} kNm/mrad
50	YRT50	1,3	1,1	1,25	6,2	1,5	5,9
80	YRT80-TV ⁶⁾	1,6	1,8	2,5	4	2,6	6,3

Axial/radial bearings

Double direction



YRTC

Dimension table · Dimensions in mm

Main dimensions						Basic load ratings				Limiting speeds ¹⁾		Mass ≈ m kg	Designation	
						axial		radial		Continu- ous oper- ation	Swivel type oper- ation ²⁾			
d			D			H	dyn. C _a kN	stat. C _{0a} kN	dyn. C _r kN	stat. C _{0r} kN	n _G min ⁻¹	n _G min ⁻¹		
100	0	-0,01	185	0	-0,02	38	105	455	49,5	88	1 200	–	3,65	YRTC100-XL
120	0	-0,01	210	0	-0,015	40	112	520	69	124	900	–	4,61	YRTC120-XL
150	0	-0,013	240	0	-0,015	40	128	650	74	146	800	–	5,4	YRTC150-XL
180	0	-0,013	280	0	-0,018	43	134	730	100	200	600	–	7,2	YRTC180-XL
200	0	-0,015	300	0	-0,018	45	147	850	123	275	450	–	9,2	YRTC200-XL
260	0	-0,018	385	0	-0,02	55	168	1 090	140	355	300	–	17,8	YRTC260-XL
325	0	-0,023	450	0	-0,023	60	247	1 900	183	530	200	–	24,7	YRTC325-XL
395	0	-0,023	525	0	-0,028	65	265	2 190	200	640	200	–	32,5	YRTC395-XL
460	0	-0,023	600	0	-0,028	70	290	2 550	265	880	150	–	45,2	YRTC460-XL
580	0	-0,025	750	0	-0,035	90	580	4 450	235	730	80	200	89	YRTC580-XL
650	0	-0,038	870	0	-0,05	122	910	6 800	455	1 300	70	170	170	YRTC650-XL
850	0	-0,05	1 095	0	-0,063	124	1 020	8 500	520	1 690	50	125	253	YRTC850-XL
950	0	-0,05	1 200	0	-0,063	132	1 080	9 500	550	1 890	45	110	312	YRTC950-XL
1 030	0	-0,063	1 300	0	-0,08	145	1 140	10 300	580	2 050	40	100	375	YRTC1030-XL

① Two retaining screws

1) Including retaining screws or threaded extraction holes.

2) Short operating duration.

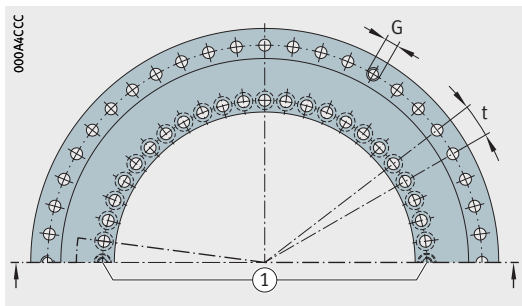
3) Diameter of inner ring for design of adjacent construction.

4) Attention!

For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.

5) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.

6) Rigidity values taking account of the rolling element set,
the deformation of the bearing rings and the screw connection.
For explanations, see page 47.



Hole pattern

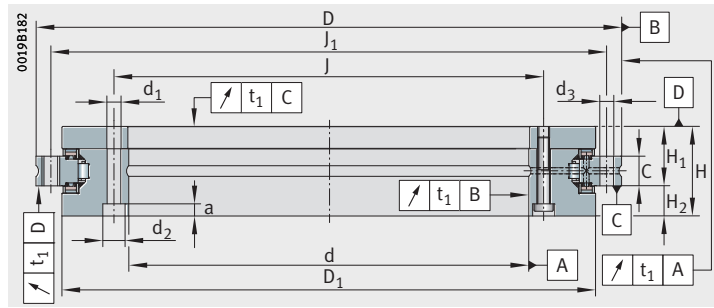
Dimensions							Fixing screws						Pitch ¹⁾		Threaded extraction hole		Screw tightening torque
							Inner ring			Outer ring							
d	H ₁	H ₂	C	D ₁ ³⁾ max.	J	J ₁	d ₁	d ₂	a	Quan- tity ⁴⁾	d ₃	Quan- tity ⁴⁾	n	t	G	Quan- tity	M _A ⁵⁾ Nm
100	25	13	12	161	112	170	5,6	10	5,4	16	5,6	15	18	20	M5	3	8,5
120	26	14	12	185	135	195	7	11	6,2	22	7	21	24	15	M8	3	14
150	26	14	12	214,5	165	225	7	11	6,2	34	7	33	36	10	M8	3	14
180	29	14	15	245,1	194	260	7	11	6,2	46	7	45	48	7,5	M8	3	14
200	30	15	15	274,4	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	18,5	18	347	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	20	20	415,1	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	22,5	20	487,7	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	24	22	560,9	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
580	60	30	30	700	610	720	11,4	18	11	46	11,4	42	48	7,5	M12	6	68
650	78	44	34	800	680	830	14	20	13	46	14	42	48	7,5	M12	6	116
850	80,5	43,5	37	1018	890	1055	18	26	17	58	18	54	60	6	M12	6	284
950	86	46	40	1130	990	1160	18	26	17	58	18	54	60	6	M12	6	284
1030	92,5	52,5	40	1215	1075	1255	18	26	17	70	18	66	72	5	M16	6	284

Dimension table (continued) · Dimensions in mm

Main dimension	Designation	Rigidity ⁶⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
d							
100	YRTC100-XL	2,65	2,25	7,5	8,7	3,7	23,5
120	YRTC120-XL	2,9	2,6	11,2	9,8	4	35,5
150	YRTC150-XL	3,8	3,2	18,6	12	4,8	61
180	YRTC180-XL	4,7	3,6	29	13,5	5,3	88,5
200	YRTC200-XL	4,9	4,1	40	15,5	6,2	128
260	YRTC260-XL	6,9	5,3	104	19	8,1	265
325	YRTC325-XL	7,1	6,3	159	33	9,9	633
395	YRTC395-XL	9,9	5,8	280	37	13	1002
460	YRTC460-XL	12	6,5	429	43	17	1543
580	YRTC580-XL	11,9	2,9	735	41,8	11,2	1960
650	YRTC650-XL	20,6	7,3	1193	51,4	8,2	3554
850	YRTC850-XL	26,5	11,9	2351	61,9	12	6772
950	YRTC950-XL	31,3	13,8	3313	72,7	17,9	11494
1030	YRTC1030-XL	36,4	11,2	5400	74,9	14,2	11165

Axial/radial bearings

Double direction



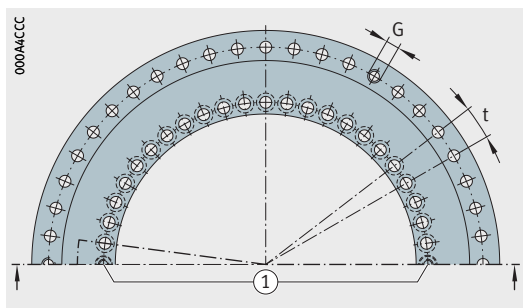
YRTS

Dimension table · Dimensions in mm

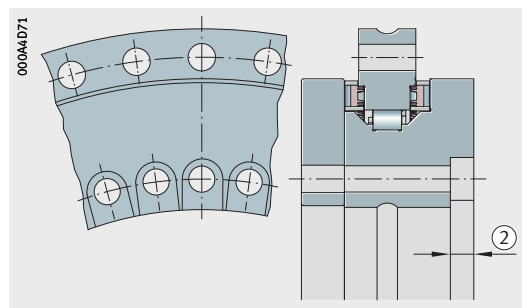
Main dimensions						Basic load ratings				Limiting speed n_G min ⁻¹	Mass ≈ m kg	Designation	
						axial		radial					
d			D			H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN			
200	0	-0,015	300	0	-0,018	45	155	840	94	226	1 160	9,7	YRTS200
260	0	-0,018	385	0	-0,02	55	173	1 050	110	305	910	18,3	YRTS260
325	0	-0,023	450	0	-0,023	60	191	1 260	109	320	760	25	YRTS325
395	0	-0,023	525	0	-0,028	65	214	1 540	121	390	650	33	YRTS395
460	0	-0,023	600	0	-0,028	70	221	1 690	168	570	560	45	YRTS460

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area

- 1) Including retaining screws or threaded extraction holes.
- 2) Diameter of inner ring for design of adjacent construction.
- 3) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 4) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 5) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 49.



Hole pattern



YRTS325

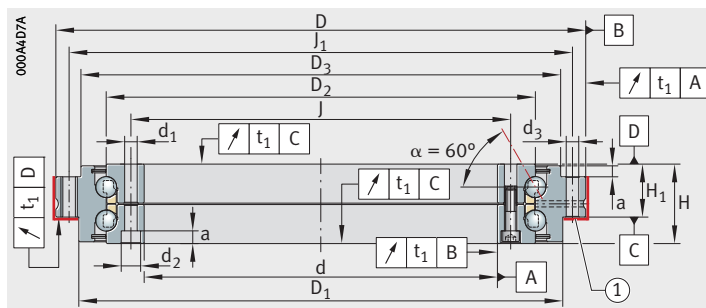
Dimensions					Fixing screws							Pitch ¹⁾		Threaded extraction hole		Screw tightening torque	
					Inner ring				Outer ring								
d	H ₁	H ₂	C	D ₁ ²⁾ max.	J	J ₁	d ₁	d ₂	a	Quantity ³⁾	d ₃	Quantity ³⁾	n	t °	G	Quantity	M _A ⁴⁾ Nm
200	30	15	15	274,4	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	18,5	18	347	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	20	20	415,1	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	22,5	20	487,7	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	24	22	560,9	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) · Dimensions in mm

Main dimension	Designation	Rigidity ⁵⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
d							
200	YRTS200	4	1,2	29	13,6	3,9	101
260	YRTS260	5,4	1,6	67	16,8	5,8	201
325	YRTS325	6,6	1,8	115	19,9	7,1	350
395	YRTS395	7,8	2	195	23,4	8,7	582
460	YRTS460	8,9	1,8	280	25,4	9,5	843

Axial angular contact ball bearings

Double direction



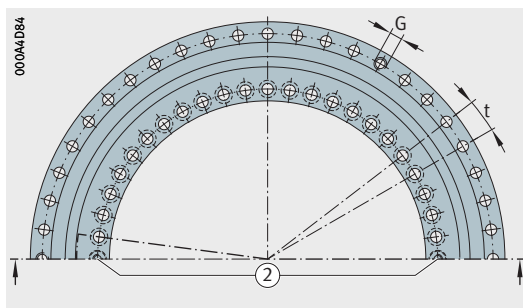
ZKLDF

Dimension table · Dimensions in mm

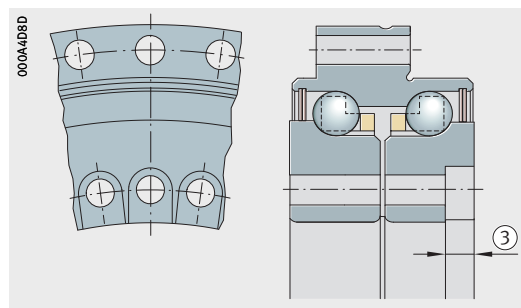
Main dimensions ¹⁾							Basic load ratings		Limiting speed ²⁾ n_G min ⁻¹	Mass $\approx m$ kg	Designation
d	D			H	dyn. C_a kN	stat. C_{0a} kN					
100	0	-0,01	185	0	-0,015	38	71	265	5 000	3,8	ZKLDF100
120	0	-0,01	210	0	-0,015	40	76	315	4 300	4,8	ZKLDF120
150	0	-0,013	240	0	-0,015	40	81	380	3 600	5,6	ZKLDF150
180	0	-0,013	280	0	-0,018	43	85	440	3 500	7,7	ZKLDF180
200	0	-0,015	300	0	-0,018	45	121	610	3 200	10	ZKLDF200
260	0	-0,018	385	0	-0,02	55	162	920	2 400	19	ZKLDF260
325	0	-0,023	450	0	-0,023	60	172	1 110	2 000	25	ZKLDF325
395	0	-0,023	525	0	-0,028	65	241	1 580	1 600	33	ZKLDF395
460	0	-0,023	600	0	-0,028	70	255	1 860	1 400	47	ZKLDF460

① Contact surface, centring diameter ② Two retaining screws ③ Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area

- 1) Sizes $d > 460$ mm available by agreement.
- 2) The limiting speeds increased by a factor of two are valid for bearings of the current generation with internal suffix -B.
- 3) Including retaining screws or threaded extraction holes.
- 4) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 5) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 6) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 51.



Hole pattern



ZKLDF100, ZKLDF325

Dimensions ¹⁾							Fixing screws					Pitch ³⁾		Threaded extraction hole		Screw tightening torque	
							Inner ring			Outer ring							
d	H ₁	D ₁	D ₂	D ₃	J	J ₁	d ₁	d ₂	a	Quantity ⁴⁾	d ₃	Quantity ⁴⁾	n	t	G	Quantity	M _A ⁵⁾ Nm
100	25	161	136	158	112	170	5,6	10	5,4	16	5,6	15	18	20	M5	3	8,5
120	26	185	159	181	135	195	7	11	6,2	22	7	21	24	15	M8	3	14
150	26	214	188	211	165	225	7	11	6,2	34	7	33	36	10	M8	3	14
180	29	244	219	246	194	260	7	11	6,2	46	7	45	48	7,5	M8	3	14
200	30	274	243	271	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	345	313	348	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	415	380	413	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	486	450	488	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	560	520	563	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) · Dimensions in mm

Main dimension d	Designation	Rigidity ⁶⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
100	ZKLDF100	1,2	0,35	3,6	2,2	0,35	5
120	ZKLDF120	1,5	0,4	5,5	2,5	0,4	8
150	ZKLDF150	1,7	0,4	7,8	2,9	0,4	12
180	ZKLDF180	1,9	0,5	10,7	2,8	0,5	16
200	ZKLDF200	2,5	0,6	17,5	3,7	0,6	26
260	ZKLDF260	3,2	0,7	40	4,7	0,7	54
325	ZKLDF325	4	0,8	60	5,4	0,8	90
395	ZKLDF395	4,5	0,9	100	6,3	0,9	148
460	ZKLDF460	5,3	1,1	175	7,1	1,1	223



**Rotary table bearings with
integrated angular measuring system**

Rotary table bearings with integrated angular measuring system

	Page
Product overview	
Rotary table bearings with integrated angular measuring system.....	54
Features	
.....	55
Operating principle	58
Design and safety guidelines	
Electronic interfaces	61
Functional safety	63
Technical data	65
Adjacent construction	75
Ordering examples	
Ordering numbers.....	76

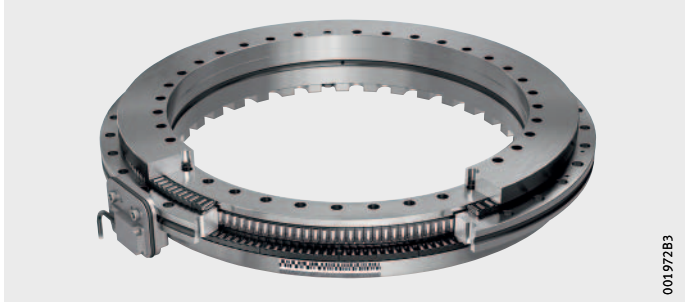
Product overview

Rotary table bearings with integrated angular measuring system

Axial/radial bearings

With absolute or incremental dimensional scale

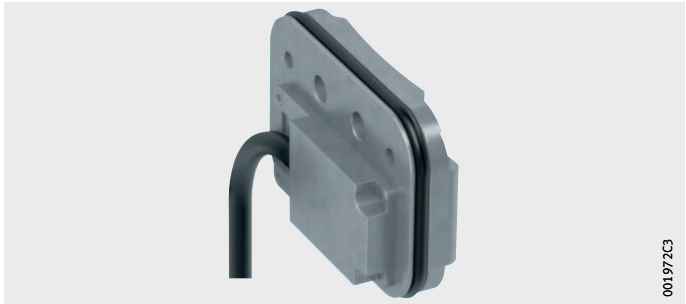
YRTCMA, YRTCMI



Electronic measuring system

Measuring head, suitable for radial screw mounting

MHA, MHI



Measuring head, suitable for axial screw mounting

MHA, MHI



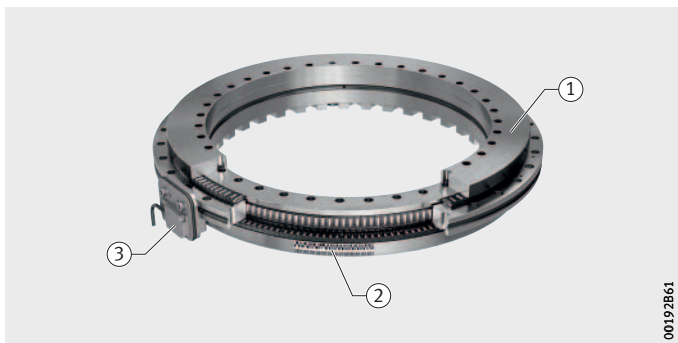
Rotary table bearings with integrated angular measuring system

Features

The bearing-integrated angular measuring system is intended for appropriate use in electrically driven, position-controlled machine tool axes for the purpose of recording actual angular values. It consists of two assemblies: the measuring system bearing and the measuring head, *Figure 1*.

- ① Rotary table bearing YRTCMA
- ② Measurement ring
- ③ Measuring head MHA-0

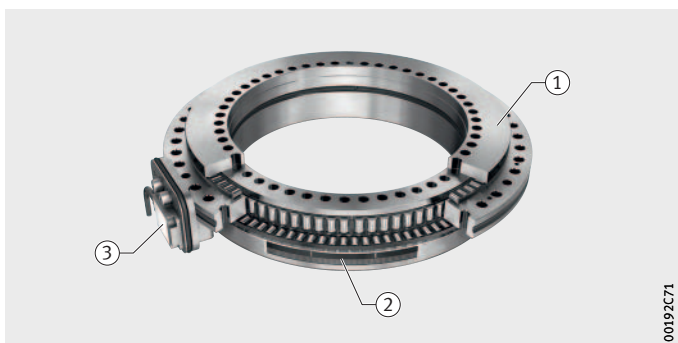
Figure 1
Bearing-integrated inductive measuring system (absolute)



The measuring system bearing is identical in design to the rotary table bearings YRTC and YRTS, except for the additional inclusion of a measurement ring of type AMO on the inner ring of the measuring system bearing, which features a regular grating structure as angular pitch with a pitch period of 1 000 μm . A stainless steel strip is used as the carrier material for the measurement ring, into which the periodic angular pitch is introduced by means of a high-precision photolithographic method with subsequent etching process. The measuring system bearings are alternatively available with absolute coded measurement rings, *Figure 1*, or with incrementally coded measurement rings, *Figure 2*. The product designation YRTCMA or YRTSMA refers to the first design and YRTCMI to the second.

- ① Rotary table bearing YRTCMI
- ② Measurement ring
- ③ Measuring head MHI-0

Figure 2
Bearing-integrated inductive measuring system (incremental)



Rotary table bearings with integrated angular measuring system

The measuring head works according to the inductive AMOSIN® measuring principle. The measuring head contains the primary and secondary coils for the inductive scanning of the measurement ring, the electronic measuring head system, interfaces, line driver and a cable with plug connector. The measuring heads with absolute measuring system interfaces in the MHA design are matched to the absolute variant of the measuring system bearing. The measuring heads with an incremental measuring system interface in the MHI design are matched to the incremental variant of the measuring system bearing. AMOSIN® is a trademark of AMO GmbH.

The measuring heads can be screwed directly onto the respective outer ring of the measuring system bearing. There are two mechanical variants of the measuring heads. With the variant that is suitable for radial screw mounting to the outer ring, *Figure 3*, there is no adjustment of the measurement gap and accessibility is very good. As a result, the time associated with mounting work is reduced. In contrast, the version for axial screw mounting to the bearing outer ring, *Figure 4*, requires an adjustment of the measurement gap, but is smaller than the version referred to above.

Figure 3
Radial measuring head
MHA-0

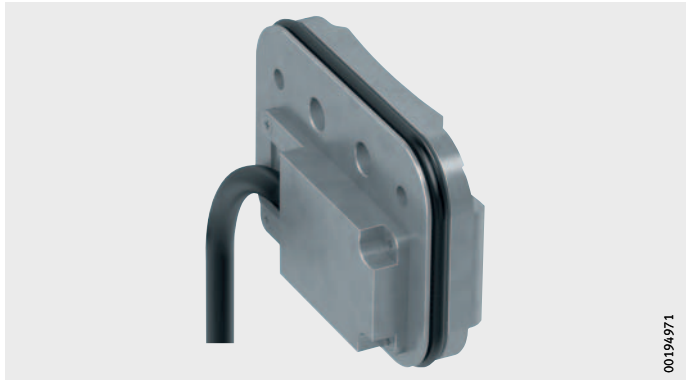


Figure 4
Axial measuring head
MHA-2



Advantages
of the measuring system

- very good control characteristics (high control stability and high dynamics) due to the rigid mechanical connection to the adjacent construction
- extremely high system accuracies achieved with a single measuring head due to the use of precision components
- hollow shaft design; the centre of the axis is freely available for additional components
- non-contact and wear-free
- measurement carried out irrespective of tilting and position
- unaffected by oils, greases, cooling lubricants and magnets
- easy to mount as adjustment of the measurement gap is not required
- no need for alignment of the bearing and a separate measuring system
- no additional parts; the resulting space saved can be used for the machining area of the machine.
- gives savings on components, overall design envelope and costs due to the compact, integrated design requiring fewer components
- available with all common measuring system interfaces
- reference search movement is not required with absolute measuring systems
- incremental measuring systems are electronically compatible with all common machine tool controllers

Characteristics
of measuring system bearings

The measuring system bearing:

- has very high tilting rigidity
- has a very low frictional torque
- permits high mechanical limiting speeds
- undergoes minimal heating in continuous operation
- permits maximum positional accuracy

Rotary table bearings with integrated angular measuring system

Operating principle

The AMOSIN® operating principle for scanning the angular pitch works on an inductive and non-contact basis. The planar coil structure, which is built into the measuring head (sensor), is unique and consists of multiple coil units arranged in a line in the direction of measurement, which in turn are composed of primary and secondary coils arranged on top of each other, *Figure 5*, page 59.

As a result of manufacturing the sensor unit on a flexible substrate using multi-layer technology, the curvature of the coil structure is matched to the curvature of the measurement rings.

The primary coils are excited with a high-frequency alternating voltage for inductive scanning of the measurement ring. This leads to the generation of electromagnetic alternating fields around the primary windings, which are damped by the crosspieces in the measurement ring and not damped by gaps.

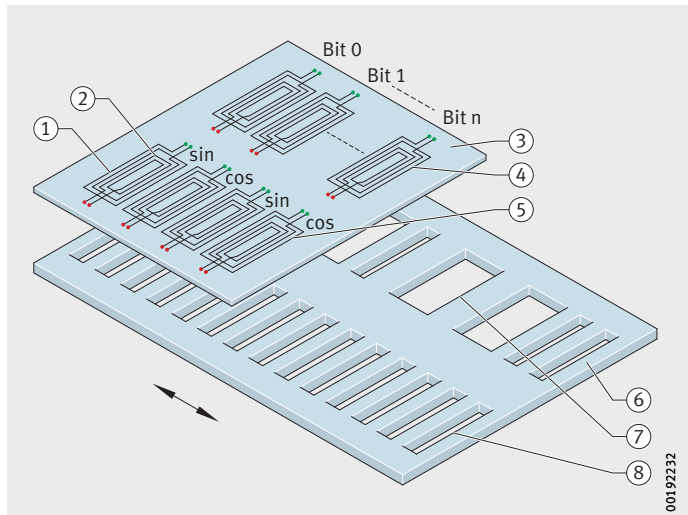
For the measurement ring that is attached to the inner ring featuring a rotation facility, the following applies: The inductive coupling factor between the primary and secondary coils is influenced and modulated when the measurement ring moves relative to the measuring head (sensor). Depending on whether crosspieces or gaps are opposite the secondary coils, a lower or higher alternating current is induced in the secondary windings. The positional value in the measuring head is determined as follows from these differently modulated voltages.

Determination of position with absolute angular measuring systems

In absolute measuring systems, an angular pitch with absolute coding and an angular pitch with incremental coding are arranged on the measurement rings in a circumferential direction, *Figure 5*. Both angular pitches are scanned using primary and secondary coils designed specifically for this purpose. Immediately after switching on the operating voltage, all primary coils are excited by alternating voltage. This leads to the generation of a unique bit pattern in the absolute secondary coils, from which the absolute angular position is determined by the measuring head for each pitch period. SIN-COS-modulated voltages are also generated in the incremental secondary coils, on the basis of which exact positions are determined and more finely resolved within a pitch period. The absolute actual angular position is calculated from these two sets of angle data - the angular position per absolute pitch period and the high-resolution angular position within the incremental pitch period - and transmitted to the controller via the serial data interface.

- ① Primary windings
- ② Secondary windings
- ③ Sensor substrate/microcoils
- ④ Absolute scanning
- ⑤ Incremental scanning
- ⑥ Measurement ring
- ⑦ Angular pitch with absolute coding
- ⑧ Angular pitch with incremental coding

Figure 5
Operating principle of inductive, absolute AMOSIN® angular measuring systems



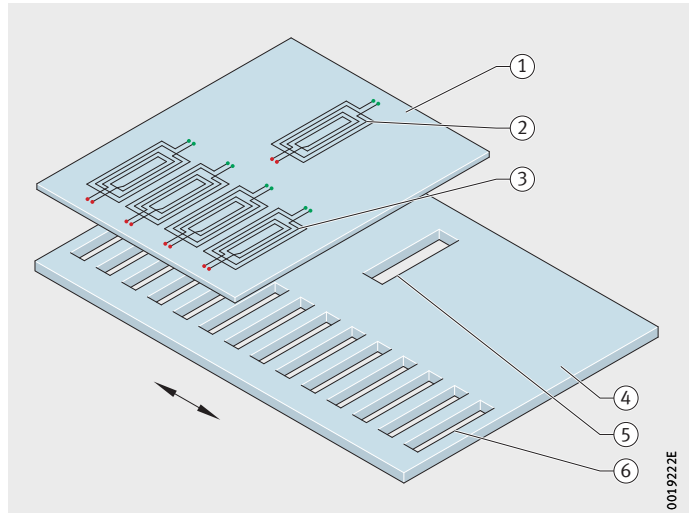
Rotary table bearings with integrated angular measuring system

Determination of position with incremental angular measuring systems

In incremental measuring systems, an angular pitch with incremental coding and several pitch-coded reference marks are arranged on the measurement rings in a circumferential direction, *Figure 6*. These two structures are scanned using primary and secondary coils designed specifically for this purpose. Immediately after switching on the operating voltage, all primary coils are excited by alternating voltage. As a result, SIN-COS-modulated voltages are generated in the incremental secondary coils, which are transmitted to the controller as analogue SIN-COS voltage signals. In the controller, the analogue voltage signals undergo A/D conversion and higher interpolation to generate the current incremental actual angular position. The pitch-coded reference marks are also scanned as a result of scanning the reference marks. This requires a search movement, in which the absolute actual angular position can be determined by the controller by passing over a minimum of two reference marks.

- ① Sensor substrate/microcoils
- ② Reference mark scanning
- ③ Incremental scanning
- ④ Measurement ring
- ⑤ Reference mark
- ⑥ Incremental angular pitch

Figure 6
Operating principle of inductive, incremental AMOSIN® angular measuring systems



Design and safety guidelines

Electronic interfaces

Absolute interface EnDat 2.2

The measuring system interface EnDat 2.2 is a digital, bi-directional interface for measuring devices. It is able to output positional values as well as read out and update information stored in the measuring device, or store new information. Due to the serial transmission of data, four signal lines are sufficient.

The data DATA are transmitted synchronously with the clock signal CLOCK predetermined by the electronic post-processor.

In addition to the EnDat-2.2 command set, no analogue 1 V_{ss} signals are output.

The achievable clock frequency is determined by the length of the cable (maximum 100 m). With running time compensation in the electronic post-processor, clock frequencies of up to 16 MHz or cable lengths up to a maximum of 100 m are possible.

Transmission frequencies of up to 16 MHz in combination with long cable lengths place high technical demands on the cable. Longer cable lengths are achieved with the 1 m long measuring head cable and an extension cable. As a general rule, the entire transmission path must be designed for the respective clock frequency. For this reason, the sole use of extension cables specified and approved for EnDat 2.2 is recommended. Any interruptions in the signal line, due to slip rings for example, should also be avoided.

The digital electronic interface EnDat 2.2 is compatible with the Heidenhain TNC 640 controller and additionally compatible with the Siemens Sinumerik 840D sl controller via the Siemens sensor module SMC40, from firmware version 4.5 and 4.6.

The measuring systems EnDat 2.2 are self-configuring, therefore no parameters specific to the measuring system have to be entered into the controller.

Rotary table bearings with integrated angular measuring system

Absolute interface DRIVE-CLiQ®

The measuring system interface DRIVE-CLiQ® is a digital, bi-directional interface for measuring devices. It is able to output positional values as well as read out and update information stored in the measuring device, or store new information. Due to the serial transmission of data, four signal lines are sufficient.

The data DATA are transmitted synchronously with the clock signal CLOCK predetermined by the electronic post-processor.

Longer cable lengths are achieved with the 1 m long measuring head cable and an extension cable. As a general rule, the entire transmission path must be designed for the respective clock frequency. For this reason, the sole use of extension cables specified and approved for DRIVE-CLiQ® is recommended. Any interruptions in the signal line, due to slip rings for example, should also be avoided.

The digital electronic interface DRIVE-CLiQ® is compatible with the Siemens Sinumerik 840D sl controller.

The measuring systems DRIVE-CLiQ® are self-configuring, therefore no parameters specific to the measuring system have to be entered into the controller.

Absolute interface SSI+1Vss (mixture of digital and analogue)

The SSI interface is a serial, digital interface via which absolute positional values are output. The data DATA (28 data bits) are transmitted synchronously with the clock signal CLOCK predetermined by the electronic post-processor. In addition, three places are available for special bits (error, warning and parity), whereby the warning bit is active and constantly at "0". If an internal error was detected in the measuring head, the error bit is set at "1".

Two analogue voltage signals, SIN and COS, which can be highly interpolated in the electronic post-processor, are also output via the incremental 1 Vss interface. The sinusoidal incremental signals SIN and COS have an electrical phase-offset of 90° and an amplitude of nominally 1 Vss.

The interface SIN COS SSI+1Vss is compatible with the Siemens Sinumerik 840D sl controller and with the Siemens Sinamics S120 via the sensor modules SMC20, SMC30, SME25 and SME125, from firmware version 2.4.

The measuring systems SS1+VSS are not self-configuring, therefore the parameters which are specific to the measuring system have to be entered into the controller and are made available to the user on request.

Absolute interface Fanuc05 (FANUC αi)	<p>The Fanuc05 interface (interface version High Resolution Type B) is a serial, digital interface via which absolute positional values are output.</p> <p>The data DATA are transmitted synchronously with the clock signal CLOCK predetermined by the electronic post-processor.</p> <p>The measuring systems Fanuc05 are not self-configuring, therefore parameters specific to the measuring system have to be entered into the controller.</p>
Incremental interface SIN COS 1Vss + REF (analogue)	<p>The measuring system outputs two analogue voltage signals, SIN and COS, which can be highly interpolated in the electronic post-processor, and a pitch-coded reference signal REF, via the incremental 1 Vss interface.</p> <p>The sinusoidal incremental signals SIN and COS have an electrical phase-offset of 90° and an amplitude of nominally 1 Vss.</p> <p>The interface SIN COS is compatible with the Siemens Sinumerik 840D sl controller and with the Siemens Sinamics S120 via the sensor modules SMC20, SME20 and SME120.</p> <p>The incremental measuring systems SIN COS 1Vss are not self-configuring, therefore the parameters which are specific to the measuring system have to be entered into the controller and are made available to the user on request.</p>
Functional safety	<p>The angular measuring systems with the digital, electronic measuring system interfaces EnDat 2.2, DRIVE-CLiQ® and analogue measuring system interface SIN COS 1Vss are intended for positional determination on rotary axes in applications with a safety focus. These angular measuring systems can be used under normal conditions and in authorised operation for safety-related positioning control loops in applications with a safety focus to IEC 61508 and EN ISO 13849-1.</p> <p>The mechanical connection of the measuring device to the drive also has safety implications, in addition to the electronic interface.</p> <p>As the controller cannot necessarily detect such errors, an error exclusion is often required in order to loosen the mechanical connections.</p> <p>In the standard Adjustable speed electrical power drive systems, DIN EN 61800-5-2:2017-11, Table D.8, the loosening of the mechanical connection between the measuring system and drive is listed as an error case for consideration.</p>

Rotary table bearings with integrated angular measuring system

In order to be able to use the angular measuring system in a safety-focussed application, the user must use a suitable controller. The fundamental task of the controller is to communicate with the measuring system and reliably evaluate the measuring system data.

For this reason, the safety parameters for the angular measuring systems and the error assumption/error exclusion analysis in Table D.8 for motion and position feedback sensors in accordance with standard DIN EN 61800-5-2:2017-11 are available on request for safety-related analyses of the entire system.

The user of the angular measuring system is solely responsible for:

- the correct implementation, on the machine side, of the signal monitoring of digital interfaces and of analogue interface SIN COS 1Vss in accordance with safety integrity (for example, specification and implementation of the evaluation circuit and logic)
- evaluating the safety integrity of the measuring system in its application environment on the basis of technical data (for example, MTTFd)
- the correct design, on the application side, of the adjacent construction of the measuring system bearing in accordance with the design specifications
- the correct fitting or mounting of the measuring system bearing in accordance with the mounting manual
- the correct fitting or mounting of the measuring head in accordance with the mounting manual

The data in the following documents must be observed in relation to the intended use of the angular measuring system:

- product information
- design specifications
- mounting instructions
- error assumption/error exclusion analysis and safety parameters of the angular measuring system
- CE declaration of conformity (by agreement)
- specification of a reliable controller from the respective controller manufacturer
- datasheet for encoder system connection to sensor module

Technical data

Angular resolution and system accuracy

The achievable angular resolution, i.e. the number of analogue output signal periods (pitch periods) with incremental measuring systems or the smallest possible resolvable angular step for absolute measuring systems with digital interfaces, depends on the diameter of the measuring system bearing. The system accuracy also depends on the diameter of the measuring system bearing, see table, page 66, and is additionally influenced by the:

- pitch accuracy of the measurement ring
- positional deviations during a signal period
- scanning quality of the measuring head
- quality of the electronic signal processing system of the measuring head
- eccentricity of the bearing outer ring and measuring ring relative to the theoretical axis of rotation
- roundness of the bearing outer ring

The listed values for system accuracy without compensation are maximum approved values that will not be exceeded. Some of the influencing variables lead to reproducible (repeatable) error quotas and some to non-reproducible (random) error quotas. The reproducible error quotas can be determined metrologically with the aid of the reference angular measuring system, stored in the controller as a correction table and compensated for mathematically. The values listed with compensation in the System accuracy column can be achieved with the aid of this compensation method.

The following influences are excluded from the values for system accuracy:

- mechanical deviations due to mounting
- external electronic influences
- resolution of the positional regulator or controller

Rotary table bearings with integrated angular measuring system

Angular resolution and system accuracy of absolute measuring system bearings YRTCMA, YRTSMA

Designation	Pitch periods [number per revolution]	Angular resolution		System accuracy	
		SSI+1Vss [per revolution]	EnDat 2.2, FANUC α i, DRIVE-CLiQ® [per revolution]	Without compensation [± angular seconds]	With compensation [± angular seconds]
YRTCMA150	672	672×1 024	23 bit	9,7	3
YRTCMA180	768	768×1 024	23 bit	9,3	2,6
YRTCMA200, YRTSMA200	860	860×1 024	23 bit	8,3	2,3
YRTCMA260, YRTSMA260	1 088	1 088×1 024	24 bit	6,6	1,8
YRTCMA325, YRTSMA325	1 302	1 302×1 024	24 bit	6	1,5
YRTCMA395, YRTSMA395	1 530	1 530×1 024	24 bit	5,1	1,3
YRTCMA460, YRTSMA460	1 760	1 760×1 024	24 bit	4,4	1,1
YRTCMA580	2 196	2 196×1 024	25 bit	6,2	1,3
YRTCMA650	2 508	2 508×1 024	25 bit	5,4	1,1
YRTCMA850	3 200	3 200×1 024	25 bit	4,3	0,9
YRTCMA950	3 540	3 540×1 024	25 bit	3,9	0,8
YRTCMA1030	3 808	3 808×1 024	25 bit	3,6	0,7

The description provided above for the absolute measuring system bearings YRTCMA and YRTSMA also applies analogously to the incremental measuring system bearings YRTCMI, see table. The basic differential pitch of the pitch-coded reference marks is also listed for the measuring system bearings.

Angular resolution and system accuracy of incremental measuring system bearings YRTCMI

Designation	Pitch periods [number per revolution]	Basic pitch of the reference marks [pitch periods]	System accuracy	
			Without compensation [± angular seconds]	With compensation [± angular seconds]
YRTCMI180	768	48	11,9	5,1
YRTCMI200	860	86	10,6	4,6
YRTCMI260	1 088	64	8,4	3,6
YRTCMI325	1 302	62	7,5	3
YRTCMI395	1 530	90	6,4	2,6
YRTCMI460	1 760	80	5,5	2,2

Measuring heads MHA The absolute measuring head MHA is available with the fully digital interfaces EnDat 2.2, FANUC α i and DRIVE-CLiQ[®], as well as with the mixed digital and analogue interface SSI+1Vss.

Characteristics	Unit	Measuring head MHA			
Interface	–	EnDat 2.2	FANUC α i	DRIVE-CLiQ [®]	SSI+1Vss
Designation	–	EnDat 2.2	Fanuc05	DQ	SSI+1Vss
Grating period	μ m	1 000			
Maximum input frequency	kHz	20			
Clock frequency	–	\leq 16 MHz	–	100 MBit/sec	\leq 1 MHz
Safety parameters	–	Available by agreement	Not applicable	Available by agreement	
Supply voltage range	DC V	3,6 to 14		10 to 36	3,6 to 14
Power consumption	W	1,5		2,1	1,5
Current consumption	mA	300 (at DC 5 V)		85 (at DC 24 V)	300 (at DC 5 V)
Cable Sheath material	–	PUR UL Style 20963 80°C 30V			
Ends	–	4×0,09 mm ² 4×0,14 mm ²			6×2×0,09 mm ²
Length at measuring head	m	1 ^{+0,03}			
Diameter	mm	4,5 ^{±0,1}			
Bending radius with single bend	mm	\geq 10			
Bending radius with deflection	mm	\geq 50			
Plug connection	–	8-pin coupling M12, pins			17-pin coupling M23, pins
Working temperature range	°C	–10 to +85			
Storage temperature range	°C	–20 to +85			
Electrical protection type	–	IP67 (type MHA-2) IP68 (type MHA-0)			
Rotary table bearing series	–	YRTCMA150 to YRTCMA1030 YRTSMA200 to YRTSMA460			

DRIVE-CLiQ[®] is a protected trademark of Siemens AG.

Rotary table bearings with integrated angular measuring system

Measuring heads MHI

The incremental measuring head MHI is available with the analogue interface SIN COS 1Vss + REF.

Characteristics	Unit	Measuring head MHI
Interface	–	Analogue output signals SIN COS 1Vss
Designation	–	SIN COS 1Vss
Grating period	μm	1 000
Maximum input frequency	kHz	100
Safety parameters	–	Available by agreement
Supply voltage range	DC V	4 to 7
Power consumption	W	approx. 1,3
Current consumption	mA	approx. 260 (at DC 5 V)
Cable Cable sheath material	–	PUR UL Style 20963 80°C 30V
Ends	–	6×2×0,09 mm ²
Cable length of measuring head	m	1 ^{+0,03}
Cable diameter	mm	4,5 ^{±0,1}
Bending radius with single bend	mm	≧ 10
Bending radius with deflection	mm	≧ 50
Plug connection	–	12-pin coupling M23, pins
Working temperature range	°C	–10 to +85
Storage temperature range	°C	–20 to +85
Electrical protection type	–	IP67 (type MHI-2) IP68 (type MHI-0)
Rotary table bearing series	–	YRTCMI180 to YRTCMI460

Rotary table bearings with integrated angular measuring system

Technical data
on measuring system bearings

Technical data

Designation	Basic load ratings, rigidity of rolling elements		
	axial		
	C_a	C_{0a}	C_{aL}
	kN	kN	kN/ μm
YRTC150, YRTCMA150	128	650	12
YRTC180, YRTCMA180, YTCMI180	135	730	13,5
YRTC200, YRTCMA200, YTCMI200	147	850	15,5
YRTC260, YRTCMA260, YTCMI260	168	1 090	19
YRTC325, YRTCMA325, YTCMI325	247	1 900	33
YRTC395, YRTCMA395, YTCMI395	265	2 190	37
YRTC460, YRTCMA460, YTCMI460	290	2 550	43
YRTC580, YRTCMA580	577	4 450	41,8
YRTC650, YRTCMA650	916	6 800	51,4
YRTC850, YRTCMA850	1 017	8 500	61,9
YRTC950, YRTCMA950	1 080	9 500	72,7
YRTC1030, YRTCMA1030	1 130	10 300	74,9

1) Short operating duration.

2) Consultation with Schaeffler.

			Rigidity of bearing		Tilting rigidity		Limiting speed		Bearing frictional torque
radial			axial	radial	Rolling elements	Bearing			Mr at 5 min ⁻¹ Nm
C _r	C _{0r}	C _{rL}	C _{aL}	C _{rL}	C _{kL}	C _{kL}	n _G	Swivelling operation ¹⁾	
kN	kN	kN/μm	kN/μm	kN/μm	kNm/mrad	kNm/mrad	min ⁻¹	min ⁻¹	
75	146	4,8	3,8	3,2	61	18,6	800	2)	4
100	200	5,3	4,7	3,6	88,5	29	600	2)	5
123	275	6,2	4,9	4,1	128	40	450	2)	6
140	355	8,1	6,9	5,3	265	104	300	2)	9
183	530	9,9	7,1	6,3	633	159	200	2)	13
200	640	13	9,9	5,8	1 002	280	200	2)	19
265	880	17	12	6,5	1 543	429	150	2)	25
235	730	11,2	11,9	2,9	1 960	735	80	200	60
458	1 300	8,2	20,6	7,3	3 554	1 193	70	170	70
520	1 690	12	26,5	11,9	6 772	2 351	50	125	130
550	1 890	17,9	30,7	13,6	11 494	3 058	45	110	170
577	2 050	19	36,4	15,2	14 285	5 400	40	100	250

Rotary table bearings with integrated angular measuring system

Dimensions

- ① Shaft locating washer
- ② Outer ring
- ③ Measurement ring

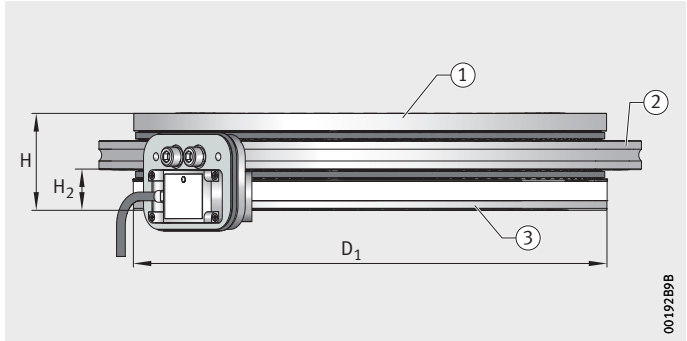


Figure 7
Dimensions

Dimensions of YRTCMA, YRTSMA, YRTCM I

Designation	Dimensions in mm		
	H	H ₂	D ₁ ∅
YRTCMA150	47	21	214,5
YRTCMA180, YRTCM I180	50	21	245,1
YRTCMA200, YRTSMA200, YRTCM I200	51	21	274,4
YRTCMA260, YRTSMA260, YRTCM I260	57,5	21	346,9
YRTCMA325, YRTSMA325, YRTCM I325	61	21	415,1
YRTCMA395, YRTSMA395, YRTCM I395	65	22,5	487,7
YRTCMA460, YRTSMA460, YRTCM I460	70	24	560,9
YRTCMA580	90	30	699,7
YRTCMA650	122	44	799
YRTCMA850	124	43,5	1 019,3
YRTCMA950	132	46	1 127,5
YRTCMA1030	145	52,5	1 212,8

Dimensions of YRTC, YRTS

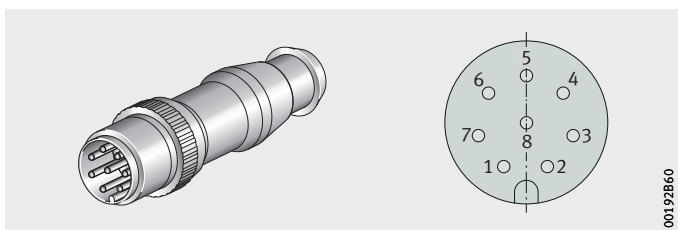
Designation	Dimensions in mm		
	H	H ₂	D ₁ ∅
YRTC150	40	14	214
YRTC180	43	14	244
YRTC200, YRTS200	45	15	274
YRTC260, YRTS260	55	18,5	345
YRTC325, YRTS325	60	20	415
YRTC395, YRTS395	65	22,5	486
YRTC460, YRTS460	70	24	560
YRTC580	90	30	700
YRTC650	122	44	800
YRTC850	124	43,5	1 018
YRTC950	132	46	1 130
YRTC1030	145	52,5	1 215

For additional bearing-specific performance data, dimensions and tolerances, as well as design and mounting recommendations, please also refer to the Technical Product Information for rotary table bearing series YRTC and YRTS.

3D CAD data files are available on the entire bearing and measuring head series, which can be sent on request or downloaded from the Schaeffler website.

Connector assignment of interfaces

Figure 8
Plug connection interfaces
EnDat 2.2, FANUC α i and
DRIVE-CLiQ[®]



Connector assignment for interfaces
EnDat 2.2, FANUC α i and
DRIVE-CLiQ[®]

Parameters	Signal designation	PIN	Cable colour
Power supply	Up	8	Green/brown
	Sensor Up	2	Blue
	0V	5	Green/white
	Sensor 0V	1	White
Signals for absolute positional value	DATA+	3	Grey
	DATA-	4	Pink
	CLOCK+	7	Purple
	CLOCK-	6	Yellow

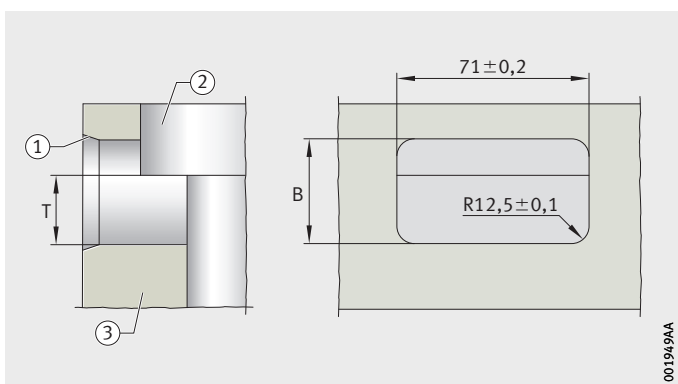
Adjacent construction

Measuring head MHA-0, which is suitable for radial screw mounting, has a flange into which a circumferential groove, containing an O ring, is incorporated, *Figure 11*. The purpose of this O ring is to protect the interior of the rolling bearing against external environmental influences and to retain the rolling bearing grease.



Figure 11
Measuring head MHA-0
suitable for radial screw mounting

A suitable opening, with dimensions matched to this seal, can be milled into the axis housing, *Figure 12*.



- ① Joining bevel for O ring
- ② Observe mounting position of bearing and measuring head in the housing
- ③ Housing (customer side)

Figure 12
Dimensions

Dimensions

Designation	Depth T mm	Width B mm
YRTCMA180, YRTCMI180	30,5±0,1	50±0,1
YRTCMA200, YRTSMA200, YRTCMI200	30,5±0,1	50±0,1
YRTCMA260, YRTSMA260, YRTCMI260	30,5±0,1	53±0,1
YRTCMA325, YRTSMA325, YRTCMI325	30,5±0,1	55±0,1
YRTCMA395, YRTSMA395, YRTCMI395	30,5±0,1	55±0,1
YRTCMA460, YRTSMA460, YRTCMI460	30,5±0,1	57±0,1
YRTCMA580	34,5±0,1	69±0,1
YRTCMA650	39,5±0,1	78±0,1

Rotary table bearings with integrated angular measuring system

Ordering examples Ordering numbers

The structure of the designations and the ordering numbers for rotary table bearings and measuring heads can be found below.

Structure of designations of rotary table bearings YRTCMA

Components of designation	Possible data	Description
① Bore diameter	150	–
	180	
	200	
	260	
	325	
	395	
	460	
	580	
	650	
	850	
	950	
	1030	
② Pitch accuracy	03 ± 3 μm	with YRTCMA150 to YRTCMA460
	05 ± 5 μm	with YRTCMA580 to YRTCMA1030
③ Pitch periods, 360°	0672	with YRTCMA150
	0768	with YRTCMA180
	0860	with YRTCMA200
	1088	with YRTCMA260
	1302	with YRTCMA325
	1530	with YRTCMA395
	1760	with YRTCMA460
	2196	with YRTCMA580
	2508	with YRTCMA650
	3200	with YRTCMA850
	3540	with YRTCMA950
	3808	with YRTCMA1030

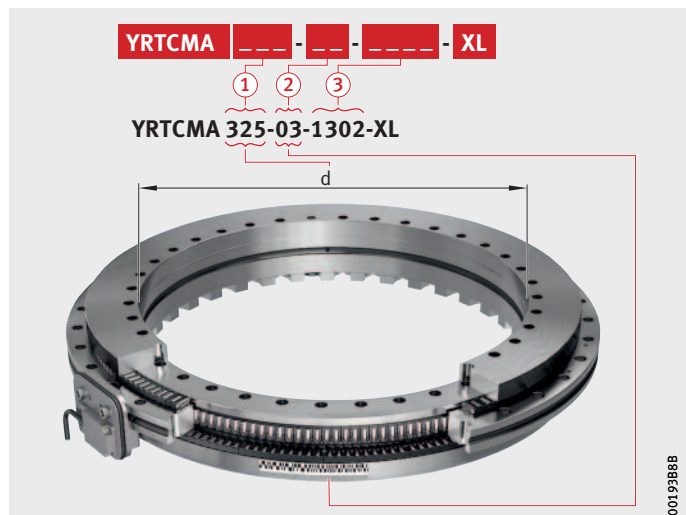


Figure 13
Ordering number code for
absolute measuring system
bearings YRTCMA

**Structure of designations
of rotary table
bearings YRTSMA**

Components of designation	Possible data	Description
① Bore diameter	200	–
	260	
	325	
	395	
	460	
② Pitch accuracy	03 ± 3 μm	–
③ Pitch periods, 360°	0860	with YRTSMA200
	1088	with YRTSMA260
	1302	with YRTSMA325
	1530	with YRTSMA395
	1760	with YRTSMA460



Figure 14
Ordering number code for
absolute measuring system
bearings YRTSMA

Rotary table bearings with integrated angular measuring system

Structure of designations of absolute measuring head MHA

Components of designation		Possible data	Description
①	Type	150	Matched to bearing type (bore diameter)
		180	
		200	
		260	
		325	
		395	
		460	
		580	
		650	
		850	
		950	
		1030	
②	Mechanical design	0	Suitable for radial screw mounting
		2	Suitable for axial screw mounting
③	Electronic interface	0	SSI+1Vss
		2	DRIVE-CLiQ® (DQ)
		7	Fanuc05 (FANUC αi)
		6	EnDat 2.2
④	Absolute resolution per pitch period	1	10 bit (SSI+1Vss)
		3	14 bit (EnDat 2.2, FANUC αi, DQ)
⑤	Maximum input frequency	4	20 kHz (standard)
⑥	Analogue pitch factor	0	Factor 1 (not subdivided) for SSI
		N	EnDat 2.2, FANUC αi, DQ
⑦	Pitch periods, 360°	0672	with MHA150
		0768	with MHA180
		0860	with MHA200
		1088	with MHA260
		1302	with MHA325
		1530	with MHA395
		1760	with MHA460
		2196	with MHA580
		2508	with MHA650
		3200	with MHA850
		3540	with MHA950
3808	with MHA1030		
⑧	Cable length in m	1	Standard
⑨	Electrical connections	7	17-pin coupling M23, pin for SSI +1Vss
		8	8-pin coupling M12, pin for EnDat 2.2, 7 Fanuc05 (FANUC αi), DQ
⑩	Direction of cable connection	1	Left (standard)
⑪	Circuit version	A	–

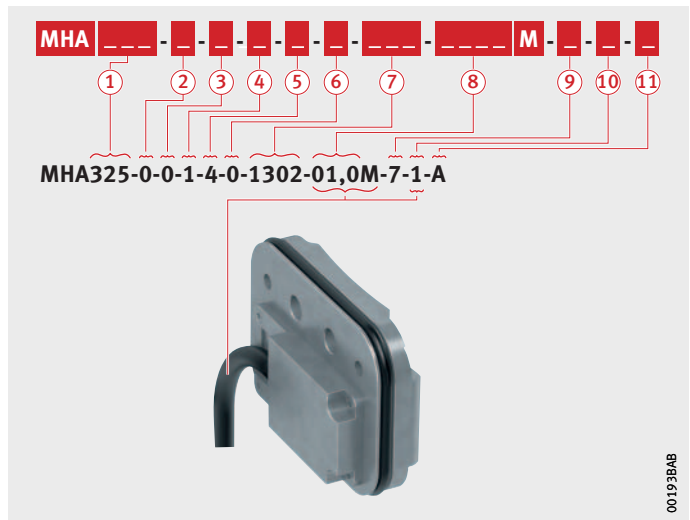


Figure 15
Ordering number code for
absolute measuring heads MHA

Rotary table bearings with integrated angular measuring system

Structure of designations of rotary table bearings YRTCMI

Components of designation	Possible data	Description
① Bore diameter	180	-
	200	
	260	
	325	
	395	
	460	
② Pitch accuracy	03 ± 3 μm	-
③ Pitch periods, 360°	0768	with YRTCMI180
	0860	with YRTCMI200
	1088	with YRTCMI260
	1302	with YRTCMI325
	1530	with YRTCMI395
	1760	with YRTCMI460

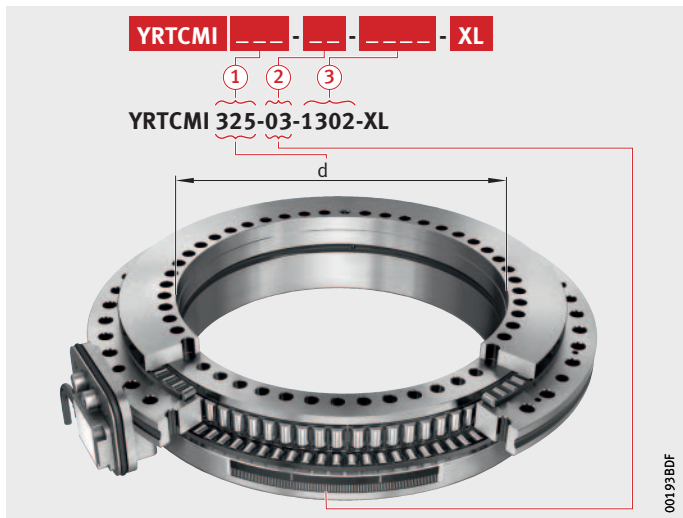


Figure 16
Ordering number code for
incremental measuring system
bearings YRTCMI

00193BDF

Structure of designations of incremental measuring head MHI

Components of designation		Possible data	Description
①	Type	180	Matched to bearing type (bore diameter)
		200	
		260	
		325	
		395	
		460	
②	Mechanical design	0	Suitable for radial screw mounting
		2	Suitable for axial screw mounting
③	Electronic interface	1	SIN COS 1Vss
④	Maximum input frequency	1	100 kHz
⑤	Analogue pitch factor	1	Factor 1 (not subdivided)
⑥	Pitch periods, 360°	0768	with MHI180
		0860	with MHI200
		1088	with MHI260
		1302	with MHI325
		1530	with MHI395
		1760	with MHI460
⑦	Cable length in m	1	Standard
⑧	Electrical connections	1	12-pin coupling M23, pins
⑨	Direction of cable connection	1	Left (standard)
⑩	Circuit version	A	–

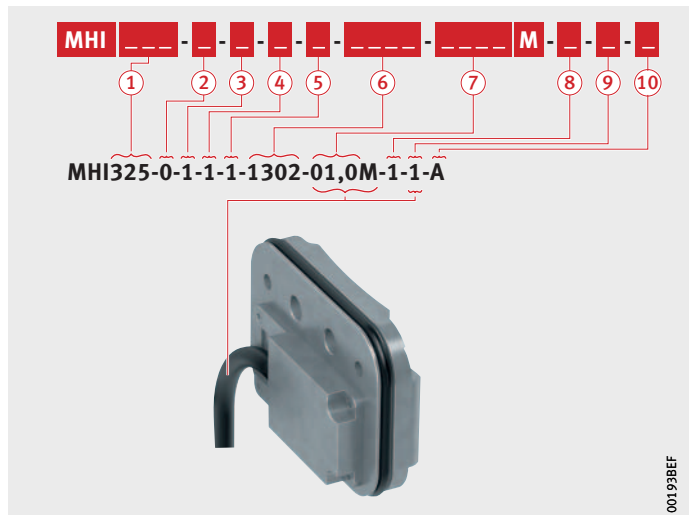
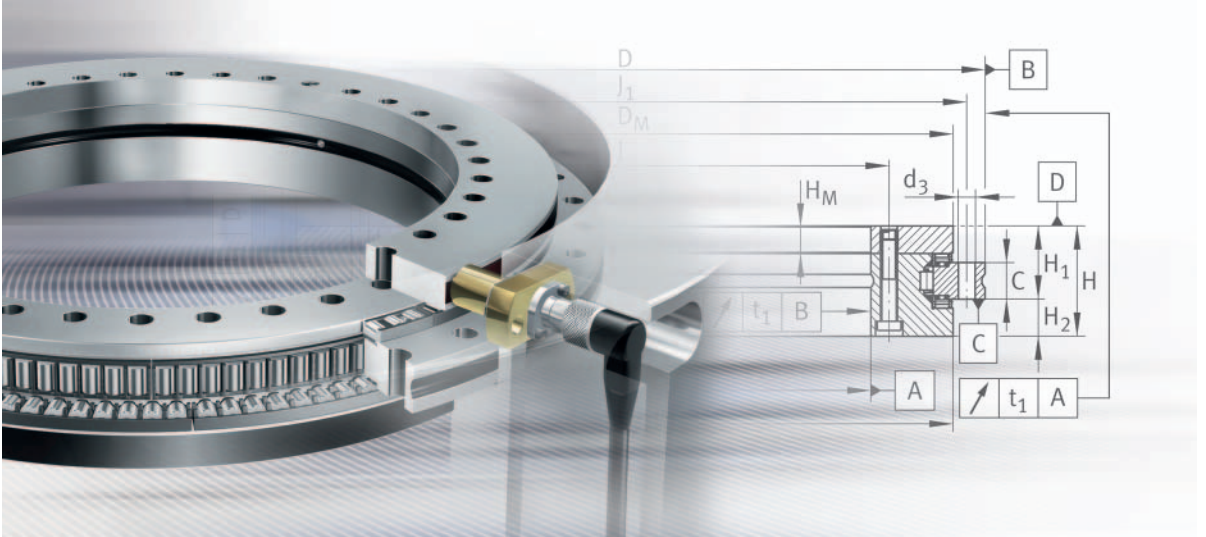


Figure 17
Ordering number code for incremental measuring heads MHI



**Axial/radial bearings
with angular measuring system**

Axial/radial bearings with angular measuring system

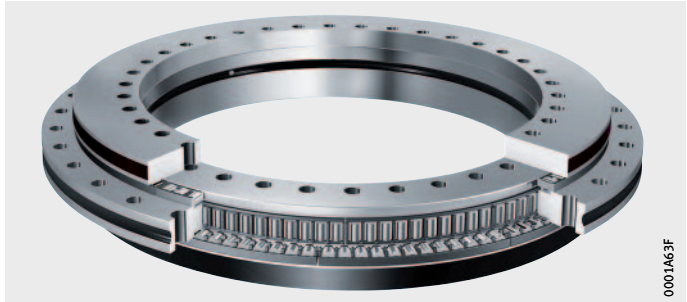
	Page
Product overview	Axial/radial bearings with angular measuring system 84
Features	Advantages of the angular measuring system 85
	Dimensional scale 86
	Measuring heads with magneto-resistive sensors 87
	Electronic evaluation system 87
	Cables for signal transmission 88
	Setting and diagnosis program 90
	Measurement accuracy 91
	Error-free signal transmission 93
	Measures to protect against interference 94
	Laying of signal cables 96
	Compatibility 97
	Test according to standard 98
	Technical data 100
	Detection of zero position, functional principle 102
	Special design 102
Design and safety guidelines	Design of adjacent construction 103
	Safety-related information about the measuring device under the terms of the Machinery Directive 105
	Fitting 106
Ordering example, ordering designation	Unit 108
	Also required... 109
	Replacement parts 109
Dimension tables	Axial/radial bearings, double direction, with absolute value angular measuring system, YRTCMA 110
	Axial/radial bearings, double direction, with absolute value angular measuring system, YRTCMI 112
	Axial/radial bearings, double direction, with absolute value angular measuring system, YRTSMA 114
	Axial/radial bearings, double direction, with incremental angular measuring system, YRTCM 116
	Axial/radial bearings, double direction, with incremental angular measuring system, YRTSM 118
	SRM electronic measuring system 120

Product overview

Axial/radial bearings with angular measuring system

Axial/radial bearings
With magnetic dimensional scale

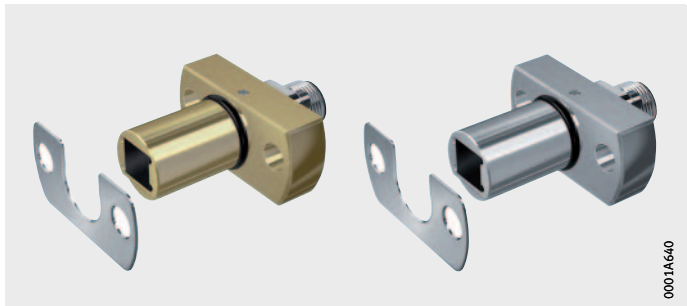
YRTCM, YRTSM



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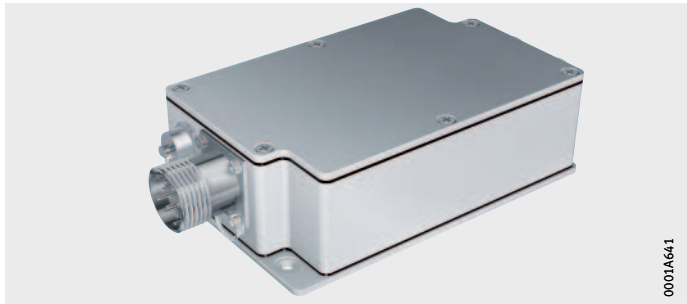
Electronic measuring system
Measuring heads with shims

SRM



0001A640

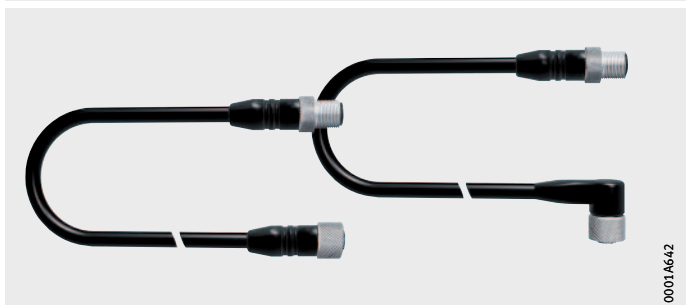
Electronic evaluation system



0001A641

Connection cable
For measuring heads and electronic
measuring system

SRMC



0001A642

Axial/radial bearings with angular measuring system

Features

Axial radial bearings with angular measuring system comprise an axial/radial bearing YRTCM or YRTSM each with a dimensional scale, an SRM electronic measuring system and signal leads SRMC. The electronic measuring system SRM comprises two measuring heads, two stacks of shims and an electronic measuring system. The signal leads for connecting the measuring heads to the electronic evaluation system can be ordered individually in various designs.

The electronic measuring system MEKO/U will continue to be available but should no longer be used for new designs.

Bearings of series YRTCM or YRTSM correspond in mechanical terms to axial/radial bearings YRTC or YRTS but are additionally fitted with a magnetic dimensional scale. The measuring system can measure angles to an accuracy of a few angular seconds by non-contact, magneto-resistive means.

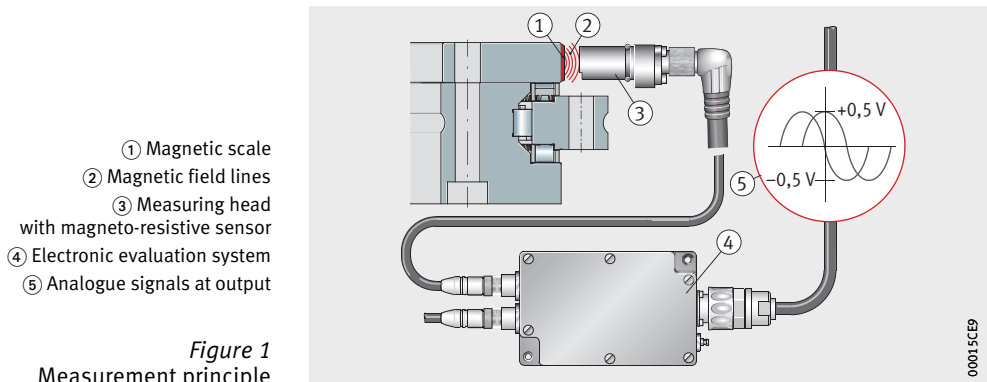
For the mechanical part of axial/radial bearings YRTCM or YRTSM, the information provided on page 13 to page 42 applies.

Advantages of the angular measuring system

The measuring system, *Figure 1*, page 86:

- allows, due to the rigid connection to the adjacent construction, very good control characteristics (control stability and dynamics) and is therefore particularly suitable for axes with torque motor drive
- offers a high maximum measuring speed of up to 16,5 m/s
- operates by non-contact means and is therefore not subject to wear
- carries out measurement irrespective of tilting and position
- has automatically self-adjusting electronics
- has a self-centring function
- is unaffected by lubricants
- is easy to fit, the measuring heads are easily adjustable, there is no need for alignment of the bearing and a separate measuring system
- requires no additional parts
 - the dimensional scale and measuring heads are integrated in the bearing and adjacent construction respectively
 - the resulting space saved can be used for the machining area of the machine
- does not give any problems relating to supply lines, since these can be laid within the adjacent construction directly through the large bearing bore
- gives savings on components, overall design envelope and costs due to the compact, integrated design requiring fewer components

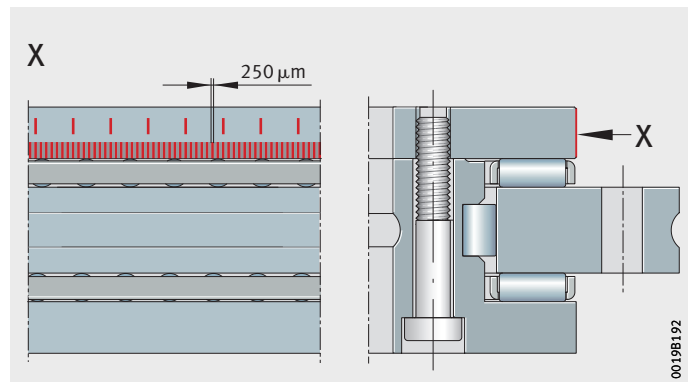
Axial/radial bearings with angular measuring system



Dimensional scale

The dimensional scale is applied without seams or joins to the outside diameter of the shaft locating washer. The magnetically hard coating has magnetic poles at a pitch of $250\ \mu\text{m}$ that serve as angle references, *Figure 2*.

The angular position is measured incrementally, i.e. by counting the individual increments. For a fixed datum point for the angular position after the machine is switched on, an additional reference mark is therefore also required.



Reference marks

The system has pitch-coded reference marks in order to quickly create the absolute datum point. Every 15° , reference marks are applied with defined different pitches, so that the absolute datum point is achieved by passing over two adjacent reference marks (maximum 30°).

Measuring heads with magneto-resistive sensors

The measuring heads are colour coded:

- the silver measuring head (white) scans the incremental track
- the gold measuring head (yellow) scans the incremental track and the reference marks.

The two measuring heads are designed for optimum use of space. They are fixed in a slot in the adjacent construction by means of two fixing screws.

MR effect

The small magnetic fields are detected as a result of the magneto-resistive effect (MR effect). Compared with magnetic heads, the MR sensors allow static measurement of magnetic fields, i. e. electrical signals are derived without movement, in contrast to magnetic heads.

The resistance layer of the MR sensors is designed such that the resistance changes when a magnetic field is perpendicular to the current flow.

When the magnetic pitch moves past the MR sensor, two sine wave signals with a phase offset of 90° are generated with a period length of $500 \mu\text{m}$.

O-rings for sealing

The measuring heads have O rings to seal against the egress of oil and the ingress of fluids such as cooling lubricants.

Electronic evaluation system

The electronic evaluation system operates with the aid of a digital signal processor (DSP).

The input signals are digitised by an analogue/digital converter.

The high performance processor (DSP) automatically compares the sensor signals and calculates the effective angular value from the sensor signals by means of vector addition. Correction is carried out, for example, on the offset of the analogue signals.

A digital/analogue converter generates synthetic analogue signals as a $1 V_{SS}$ value.

The electronic evaluation system can be positioned at any location or within the adjacent construction. It is connected to the controller by means of a conventional 12-pin extension cable.

The lead for transmitting the voltage signals from the electronic evaluation system to the electronic post-processor can be up to 100 m long.

Axial/radial bearings with angular measuring system

Cables for signal transmission

The signal cables for connecting the measuring heads to the electronic evaluation system are available in the lengths 1 m, 2 m and 3 m, see table, page 89.

The connection side for the electronic evaluation system has a straight plug. The connection side to the measuring head is suitable for straight plugs or 90° elbow plugs.

In the case of the elbow plug, the cable outlet direction is defined in relation to the mounting position of the measuring heads.

Advantages

The cables are suitable for use in machinery and plant for chip-forming machining:

- the cables and plugs are shielded
- the cable sheathing is made from polyurethane (PUR), halogen-free and flame-resistant
- the signal cables are free from halogens, silicones and PVC as well as resistant to microbes and hydrolysis
- the cables are resistant to oils, greases and cooling lubricants
- the cables are suitable for dynamic use in flexible trunking (it must be ensured that they are laid correctly).

Bending cycles

When laid in flexible trunking, the cables can achieve ≥ 2 million bending cycles under the following test conditions:

- bending radius 65 mm ($10 \times D$)
- acceleration 5 m/s^2
- travel speed 200 m/min
- travel distance 5 m, horizontally

Plug connectors

INA plug connectors are robust and designed for use in industrial environments. When connected, they conform to protection grade IP 65 (DIN EN 60529).

The large sheathed areas of the plugs ensure effective shielding.

Connection cables

Measuring heads are connected using cables with 90° elbow plugs or cables with straight plugs, *Figure 3*.

- ① 90° elbow plug (SRMC...-A)
- ② Straight plug (SRMC...-S)

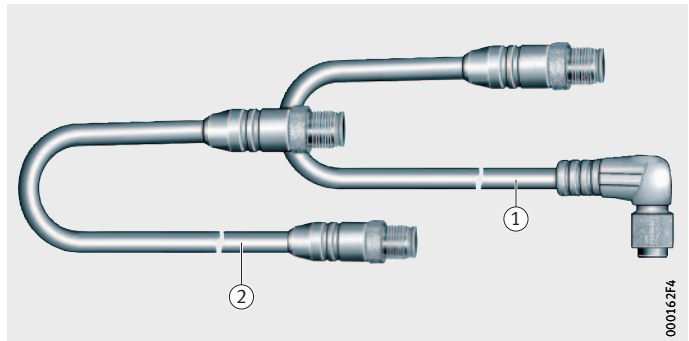


Figure 3
Connection cable

Design and length of connection cable, see table.

Designs

Plug design	Cable length m	Ordering designation
Straight plugs on both ends	1	SRMC1-S
	2	SRMC2-S
	3	SRMC3-S
Straight plug and 90° elbow plug	1	SRMC1-A
	2	SRMC2-A
	3	SRMC3-A

Other designs available by agreement.

Dimensions of plugs and measuring heads, see page 121.



Use cables of the same length for connecting the two measuring heads in a measuring system.

Axial/radial bearings with angular measuring system

Setting and diagnosis program

The distance between the measuring heads and the outside diameter of the shaft locating washer is set using the setting and diagnosis software MEKOEDS, *Figure 12*, page 107 and see MON 18, Axial/radial bearings with integral angular measuring system.

The software is also used to check the function of the fitted measuring system and detect defects in the measuring system.

MEKOEDS is supplied on a USB memory stick, *Figure 4*.

The USB memory stick also contains the appropriate manuals, see page 109. The current version of MEKOEDS and the manuals are available at <https://www.schaeffler.de>.

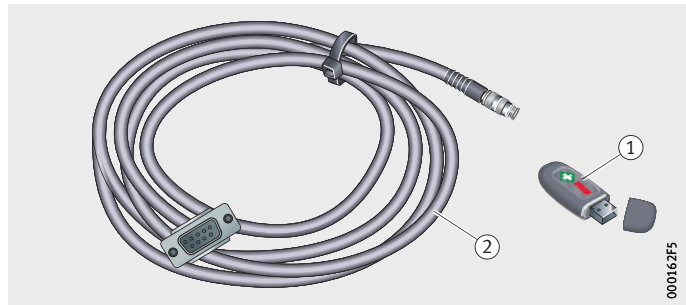
Interface cable

The measuring system is connected to a PC (serial interface) using the interface cable, *Figure 4*.

The interface cable is included in the delivery of MEKOEDS, the length is 5 m. If the PC does not have a serial interface, we recommend the use of a conventional serial/USB converter, which is not included in the delivery.

- ① USB memory stick
- ② Interface cable

Figure 4
MEKOEDS



The measuring system data can be recorded, displayed in diagram form, printed out and sent by e-mail to the Schaeffler Group for evaluation.

Measurement accuracy

The more accurate the angular measurement, the more accurately a rotary axis can be positioned. The accuracy of angular measurement is essentially determined by:

- ① the quality of the dimensional scale
- ② the quality of scanning
- ③ the quality of the electronic evaluation system
- ④ the eccentricity of the dimensional scale to the bearing raceway system
- ⑤ the runout deviation of the bearing arrangement
- ⑥ the elasticity of the measurement system shaft and its linkage to the shaft to be measured
- ⑦ the elasticity of the stator shaft and shaft coupling

For the measuring system integrated in the bearing, only points ① to ③ are relevant.

The eccentricity in point ④ is completely eliminated by the diametrically opposed arrangement of the MR sensors.

Points ⑤ to ⑦ play only a very minor role in the INA measuring system.

Positional deviations

Positional deviations within a revolution are the absolute measurement errors over one revolution of the system (measured at +20 °C ambient temperature):

- YRTCM150 $\cong \pm 6''$
- YRTCM180 $\cong \pm 5''$
- YRTC(S)M200, YRTC(S)M260, YRTC(S)M325, YRTC(S)M395, YRTC(S)M460 $\cong \pm 3''$

Since the dimensional scale is directly connected, i.e. without any compensation elements, with the rolling bearing, deflections in the bearing raceway system due to machining forces could affect the measurement result. This effect is eliminated by the diametrically opposed arrangement of the measuring heads in the electronic evaluation system.

Axial/radial bearings with angular measuring system

Measurement record

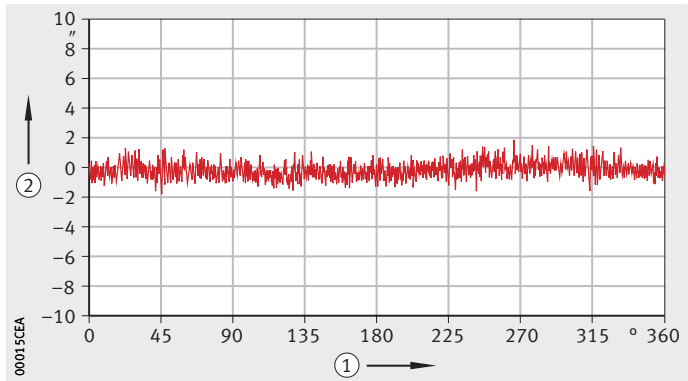
Each measuring system bearing is supplied with an accuracy measurement record, *Figure 5*.

The accuracy is measured on the coded washer of bearing YRTCM or YRTSM when the coding is applied and is documented.

The measurement trace shows the pitch error of the coding.

- ① Measurement travel in degrees
- ② Deviation in angular seconds

Figure 5
Excerpt from a measurement trace,
example:
YRTM395 – serial no. 03/09/004



Error-free signal transmission

If the INA measuring system is fitted and operated as specified, it fulfils the requirements of Directives 89/336/EEC and 92/031/EEC for electromagnetic compatibility (EMC).

Adherence to the EMC directive in accordance with the following standards is demonstrated:

- EN 61000-6-2 Immunity
 - ESD:
EN 61000-4-2
 - radiated electromagnetic fields:
EN 61000-4-3
 - burst:
EN 61000-4-4
 - surge:
EN 61000-4-5
 - conducted immunity:
EN 61000-4-6
 - magnetic field:
EN 61000-4-8
- EN 55 011-B Emission
 - interference voltage:
EN 55 011-B
 - perturbing radiation
EN 55 011-B

Possible sources of electrical interference in the transmission of measurement signals

Disruptive voltage is mainly generated and transmitted by capacitive or inductive interference. Interference can occur through lines and equipment inputs and outputs.

Sources of interference include:

- strong magnetic fields due to transformers and electric motors
- relays, contactors and solenoid valves
- high frequency equipment, pulse devices and magnetic stray fields due to switched-mode power supply units
- supply mains and leads to the equipment mentioned above



Interference in initial operation can generally be attributed to absent or inadequate shielding of the measurement leads or insufficient spacing between the signal and power cables.

The overall design should be such that the function of the measuring system is not influenced by sources of electrical or mechanical interference.

Axial/radial bearings with angular measuring system

Measures to protect against interference



The precision bearing and measuring system must be handled with care.

The dimensional scale and sensor surface of the measuring heads are unprotected once the protective covers have been removed.

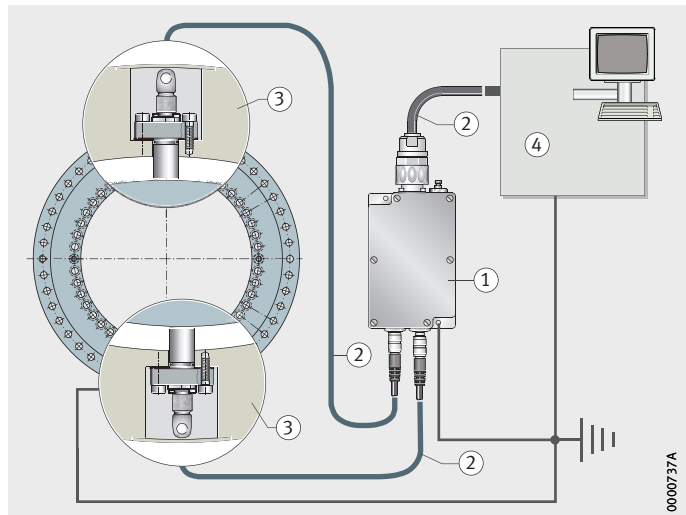
Screw the electronic evaluation system firmly to the earthed machine frame, *Figure 6*. If screw mounting surfaces are non-conductive, one of the fixing screws should be connected by electrically conductive means over the largest possible cross-section and a short route with the machine frame; all measuring system components must have the same potential.

The bearing components must be connected by electrically conductive means with equipotential bonding.

For signal connections, only shielded plug connectors and cables should be used.

- ① Electronic evaluation system
- ② Shielded plug connectors and cable
- ③ Adjacent construction
- ④ CNC (electronic post-processor)

Figure 6
Shielding and electronic post-processor



0000737A

Protection against magnetic fields



Magnetic fields will damage or erase the magnetic dimensional scale. This will lead to partial mismeasurement by the system.

Magnetic sources must be kept away from the magnetic scale on the outside diameter of the shaft locating washer. A field strength of approx. 70 mT or higher immediately on the magnetic dimensional scale carries the risk of damage due to the magnetic poles.

Magnetic dial gauge stands must not be placed directly on the coded washer; the guide value is at least 100 mm distance in air or 10 mm unalloyed steel, *Figure 7* and *Figure 8*.

Never touch the coding with magnetisable objects. Typical examples are knives, screwdrivers and dial gauge feelers.

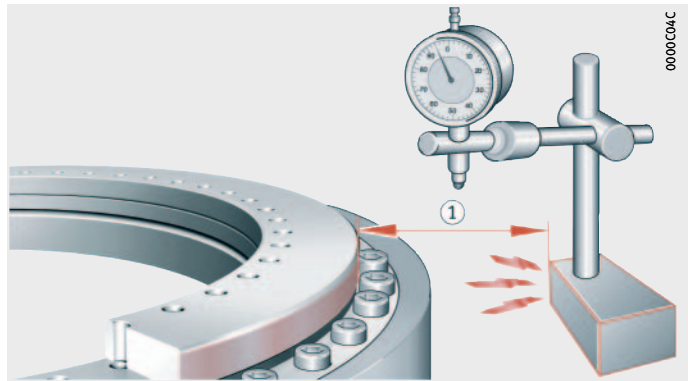
Prevent contact with magnetisable contaminants. These could otherwise be deposited on the magnetic coding and lead to impaired measurement accuracy.

This could be due to:

- contamination of the lubricant, for example due to the oil bath
- contamination washed off by condensation, e.g. in conjunction with cooling devices
- magnetisable wear debris from gears

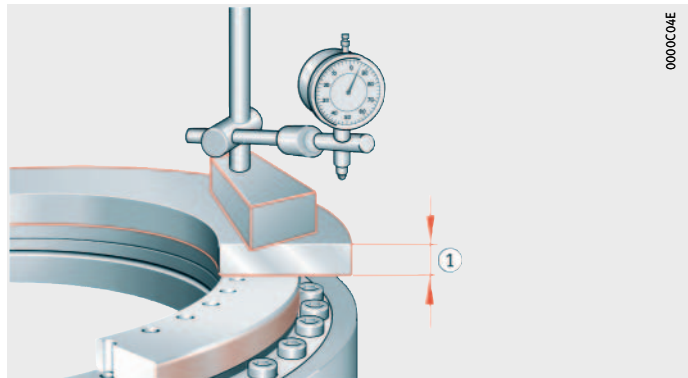
① Minimum distance > 100 mm

Figure 7
Minimum distance between magnetic dial gauge stand and shaft locating washer



① Shielding > 10 mm

Figure 8
Shielding by unalloyed steel



Axial/radial bearings with angular measuring system

Pressing down
the measuring head by hand



In order to protect the sensor chip against damage, the measuring head can only be pressed against the dimensional scale by hand. Forces > 50 N can lead to sensor damage.

Laying of signal cables

Laying of disruptive and suppressed or non-disruptive cables in parallel and in spatial vicinity should be avoided. Separation in air of > 100 mm is recommended. If adequate spacing cannot be achieved, additional shielding or earthed metallic partition walls between the cables should be provided.

The requirement for spatial separation of cables also applies to typical sources of interference such as servo drives, frequency converters, contactors, solenoid valves and choking coils.

Crossings

If cables must be crossed, this should be carried out at a 90° angle if possible.

Overlong cables

Overlong cables that are located rolled up in the switch cabinet will act as antennae and cause unnecessary interference. These cables should be cut to the required length.

Shielding

If shield separations are necessary, these should be reconnected over as large an area as possible. The free lead ends to the connector terminal should be as short as possible. Shield separations are a functional risk and should therefore be avoided.

Ends not required

Non-assigned ends should be connected on both sides with reference potential (chassis ground).

Motor connectors

No other cables for data cabling should be fed within shielded motor cables or terminal boxes for motor connectors. Spatial separation is also recommended here, for example by sheet metal partitions.



Interference suppression filter

Connections between interference suppression filters and the emission source should be kept as short as possible and should be shielded.

Compatibility	<p>The analogue output signals $1 V_{SS}$ of the incremental track can be processed by most conventional CNC controllers.</p> <p>For new applications, it should be checked whether the CNC controller can be parametrised in accordance with the technical data of the YRTCM or YRTSM</p> <p>For most controllers, the input parameters can be requested from us.</p>
Input of pulse rate	<p>On many controllers, the pulse rate can be directly inputted. Pulse rate, see table, page 100. In isolated cases, however, this is carried out via a whole number multiplication and division value. In these cases, the pulse rate cannot be entered exactly for sizes YRTCM200 or YRTSM200 and YRTCM395 or YRTSM395 and must be corrected using other parameters.</p>
Pitch-coded reference marks	<p>Some controllers cannot record signals from pitch-coded measuring systems. For these cases, the electronic measuring system can be supplied as a single reference mark measuring system. Please state this in the order text.</p> <p>The differential pitch between two adjacent reference marks is two signal periods. In the zero transition area, the system design of the encoder leads to a large difference. The controller must be capable of processing this aspect.</p> <p>In swivel type axes, the measuring system zero point (marked on the bearing using a drill bit) can be placed outside the scanning range of the yellow measuring head.</p> <p>With continuous monitoring of the pitch-coded reference marks, the limiting speed n_G for the reference run must not be exceeded, see page 110.</p>

Axial/radial bearings with angular measuring system

Test according to standard	The functional capability has been tested under changing climatic conditions, under mechanical load and in contact with water, oil and cooling lubricants.	
Climatic tests	The measuring system design has been tested in accordance with the following standards.	
Cold	According to standard Storage temperature Dwell time	IEC 68-2-1 -10 °C, ±3 °C 72 hours
Dry heat	According to standard Storage temperature Dwell time	IEC 68-2-2 +70 °C, ±2 °C 72 hours
Thermal cycling	According to standard Lower storage temperature Upper storage temperature Change gradient Dwell time Number of cycles	IEC 68-2-14 -20 °C, ±3 °C +60 °C, ±3 °C 1 °C/min 3 hours at each limit temperature 5
Thermal shock	According to standard Lower storage temperature Upper storage temperature Change duration Dwell time Number of cycles	IEC 68-2-14 -5 °C, ±3 °C +55 °C, ±3 °C ≤ 8 sec 20 min at each limit temperature 10
Humid heat, cyclic	According to standard Lower storage temperature Upper storage temperature Change duration Cycle duration Number of cycles	IEC 68-2-30 +25 °C, ±3 °C +55 °C, ±3 °C 3 hours to 6 hours 24 hours 6

Mechanical tests	The measuring system design has been tested in accordance with the following standards.	
	DIN EN 60086-2-6 MIL-STD-202, 204 C	Condition B
Vibration, sine wave (measuring heads)	According to standard Frequency range Vibration amplitude	IEC 68-2-6 10 Hz to 2 kHz ±0,76 mm (10 Hz to 60 Hz) 100 m/s ² (60 Hz to 2 kHz)
	Rate Load duration Number of frequency cycles Load directions	1 octave/min 240 min per axis 16 per axis All three main axes
Shocks (measuring heads)	According to standard Acceleration Shock duration Shock type Number of shock cycles Load directions	IEC 68-2-27 30 g 18 m/s Semisine wave 6 per axis All three main axes (i. e. a total of 18 cycles)
IP protection type, protection against ingress of water	The measuring system design has been tested in accordance with the following standards.	
	According to standard Protection type	DIN 40050-9 IP67 (SRM) IP65 (MEKO/U)
	Ingress protection testing is carried out with water as a medium and over a limited time period. All push-fit connections are fitted. The measuring system should therefore be fitted with protection against cooling lubricants.	
Chemical resistance (measuring heads)	The measuring system design has been tested in accordance with the following standards.	
Resistance to oils	Test media Storage temperature Storage duration	Mineral oil Aral Degol BG150 PAO Mobilgear SHC XMP150 Ester Shell Omala EPB150 PG Klüber Klübersynth GH6-150 +60 °C 168 hours
Resistance to cooling lubricants (KSS)	Test media Storage temperature Storage duration Concentration	Unitech Hosmac SL145 ZG Zubora 92F MR Oemeta Hycut ET46 Unitech Hosmac S558 +35 °C 168 hours 5% in water
	For different operating conditions, please contact us.	

Axial/radial bearings with angular measuring system

Technical data Technical data on the SRM electronic measuring system, see table.

SRM electronic measuring system

Data	Specification	Comments
Power supply	DC +5 V \pm 10%	–
Current consumption	280 mA	Box with measuring heads YE, WH
Scale	Magnetically hard coating with periodic North-South pitch	–
Incremental signals Pulse rate/accuracy (at +20 °C)	1 V _{SS} YRTCM150: 2 688/ \pm 6" YRTCM180: 3 072/ \pm 5" YRTCM200, YRTSM200: 3 408/ \pm 3" YRTCM260, YRTSM260: 4 320/ \pm 3" YRTCM325, YRTSM325: 5 184/ \pm 3" YRTCM395, YRTSM395: 6 096/ \pm 3" YRTCM460, YRTSM460: 7 008/ \pm 3"	–
Reference marks	24 piece, pitch approx. 15°, pitch-coded	–
Fixed reference mark pitch	30°	–
Differential pitch between two reference marks	2 signal periods	–
Data interface	RS232C	–
Recommended measurement step	0,0001°	–
Operating temperature	from 0 °C to +70 °C	–
Protection type (DIN EN 60 529)	IP67 (all plugs fitted)	–
Masses: ■ measuring heads ■ electronic evaluation system	each approx. 38 g 450 g	–
Electrical connections: ■ measuring heads ■ electronic post-processing system (not included in scope of delivery)	with PUR cable \varnothing 6,5 mm with plug \varnothing 15 mm or 12 pin flanged plug \varnothing 28 mm	–
Permissible cable length for electronic post-processor	max. 100 m	–
Humidity	max. 70% relative humidity, non-condensing	–
Output signal load	100 Ω up to 120 Ω	Recommended CNC input resistance

SRM electronic measuring system
continued

Data	Specification	Comments
Output signal ①, ②	0,9 V _{SS} typically, 0,8 V to 1 V max.	120 Ω load resistance, f = 100 Hz
Signal difference ①, ②	< 1% typically	Difference in output signal amplitude between signal ①, ②, f = 100 Hz
Output constant voltage	2,4 V ± 10%	Output signals ① +, ① -, ② +, ② -
Output offset voltage ①, ②	± 10 mV typically, ± 50 mV max.	Constant current offset between ① + and ① -, ② + and ② -
Reference signal Z ③	Width: 230° typically, 180° to 270° max. Centre position, <i>Figure 9</i> , page 102	From output signal period ①, ② at recommended reference movement speed
Reference signal mean voltage	2,4 V ± 10%	–
Reference signal level	0,8 V _{SS} typically, 0,6 V to 1 V max. inactive: –0,4 V active: +0,4 V	120 Ω load resistance
Output frequency ①, ②	DC up to 8 kHz max.	–
System resolution	max. 2 500 steps per sine wave	–

Axial/radial bearings with angular measuring system

Detection of zero position, functional principle

The CNC checks whether the signals ① to ③ are positive, see red quadrants, *Figure 9*. The zero position is then calculated, where ① = MAX (90°), ② = ZERO (0°).

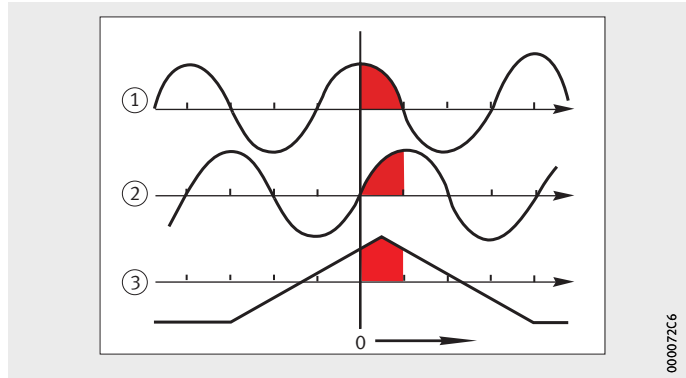
The reference signal form has no influence. It is important to highlight more than this one quadrant, but not more than one signal period.

- ① Output signal A
- ② Output signal B, 90° phase-offset from A
- ③ Reference signal Z

Figure 9
Reference signal position

Special designs

The SRM electronic measuring system is also available as a single reference mark measuring system. Please state this in the order text.



00007266

Design and safety guidelines

Design of adjacent construction



The locating bore for the measuring head should have a chamfer $1 \times 30^\circ$; the lead chamfer for the O ring of the measuring head.

The measuring head should be centred in all planes on the shaft locating washer and secured against rotation by means of a locating surface.

For centring of the coded shaft locating washer, the bearing must be supported over its entire height by the adjacent construction of the shaft.

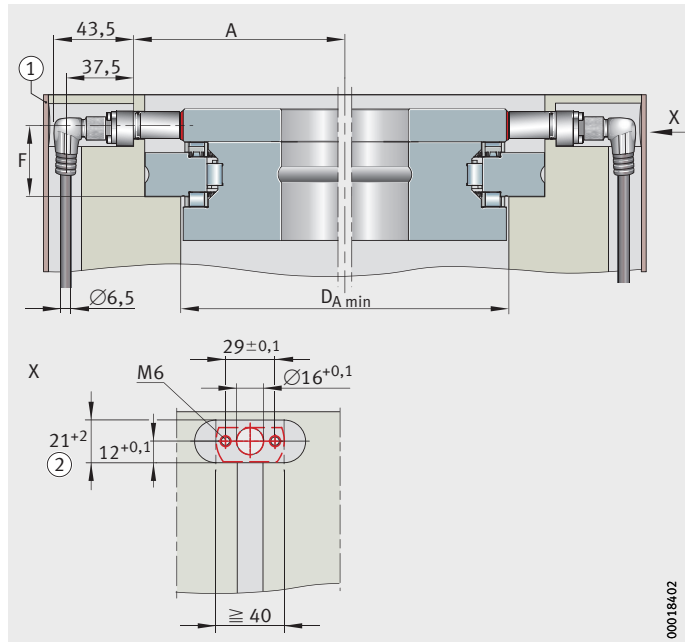
It is absolutely essential that the following are checked:

- the depth of the slot for the measuring heads conforms to dimension A, see table and *Figure 10*, page 104
- the screw mounting faces of the measuring heads are free from burrs and flat
- the arrangement of the measuring heads is $180^\circ \pm 1^\circ$, *Figure 10*, page 104 and *Figure 11*, page 106
- the recess diameter $D_{A \min}$ is machined in the adjacent construction for mounting of the bearing and the reliable function of the measuring system, see table
- the distance F is maintained after the measuring heads are fitted, see table and *Figure 10*, page 104
- the cable exit direction corresponds to the illustration, *Figure 10*, page 104 when using cables with 90° elbow plugs
- cables at the height of the measuring heads are relieved of tension; especially where 90° elbow plugs are used, cable tension forces can lead to overloading of the plugs

Recess diameter and distance

Axial/radial bearing Designation	Distance between sensor screw mounting surfaces and centre of bearing A -0,4 mm	Recess diameter $D_{A \min}$ mm	Distance F $\pm 0,1$ mm
YRTCM150	132	215	22
YRTCM180	147,2	245,5	25
YRTCM200, YRTSM200	160,6	274,5	25
YRTCM260, YRTSM260	196,9	345,5	29,75
YRTCM325, YRTSM325	231,3	415,5	32,5
YRTCM395, YRTSM395	267,5	486,5	33,75
YRTCM460, YRTSM460	303,8	560,5	36,5

Axial/radial bearings with angular measuring system



- ① Cover
 ② Fitting of a measuring head rotated by 180° (= no function) is not possible.

Figure 10
 Design of adjacent construction and diametrically opposed arrangement of measuring heads



If the measuring heads are located deep in the housing, they must be sufficiently accessible to allow setting of the measurement gap. The measuring heads and cable must be protected by a suitable cover against mechanical damage and long term contact with fluids. The positional orientation of the measuring heads is determined by the locating face. It is not sufficient to determine the positioning exclusively by means of the fixing screws. Observe the minimum bending radii for signal cables. Fluids must not be allowed to build up in the measuring head pockets (IP67).

**Safety-related information
about the measuring device
under the terms
of the Machinery Directive**

The angular measuring system meets the described product characteristics when used correctly. The measuring system is not suitable for use in safety-related control circuits and should not be used for this purpose. For systems with a safety focus, the positional value of the measuring device must be checked after the higher level system has been switched on. The measuring device is not developed in accordance with IEC 61508 and no SIL classification exists.

Characteristics of the measuring device relevant to hazard analysis:

- The system does not have redundant functional elements.
- Software is involved in generating the output signals.
- If the following events occur, a zero voltage signal is outputted by the electronic evaluation system once the initial operation procedure is complete, that can be detected by a suitable electronic post-processing system as an error:
 - defect in the power supply
 - error in plausibility testing of the two measuring head signals by means of 4 quadrant operation (detection of measuring head failure or loose connections, for example cable breakage)
 - undershoot in the permissible minimum amplitudes of the measuring head signals (detection of measuring head failure, detection of an impermissibly large increase in the measurement gap, for example after a machine crash)

Axial/radial bearings with angular measuring system

Fitting Due to the integrated dimensional scale and the small measuring heads designed for optimum use of available space, the measuring system is very easy to install.

Fitting guidelines for the axial/radial bearing

During fitting, the coded shaft locating washer is centred precisely by means of the shaft journal manufactured precisely over the whole bearing height.

Before fitting, the retaining screws on the inner ring should be loosened so that the bearing inner ring and shaft locating washer with the dimensional scale can align and centre themselves to each other without any force.



Do not use magnetised tools.

The magnetic dimensional scale has a protective strip for transport and fitting.

Do not remove the protective strip until after the bearing is fitted.

Note the additional information on fitting of axial/radial bearings YRTCM or YRTSM, see MON 100, High precision bearings for combined loads.

Fitting guidelines for measuring heads

The mounting position of the measuring heads is specified by the design of the locating pockets.

Diametrically opposed arrangement of measuring heads

The arrangement of the measuring heads must not be smaller or greater than a diametrically opposed arrangement of $180^\circ \pm 1^\circ$, otherwise any eccentricities in the shaft locating washer will affect the measurement accuracy, *Figure 10*, page 104 and *Figure 11*.

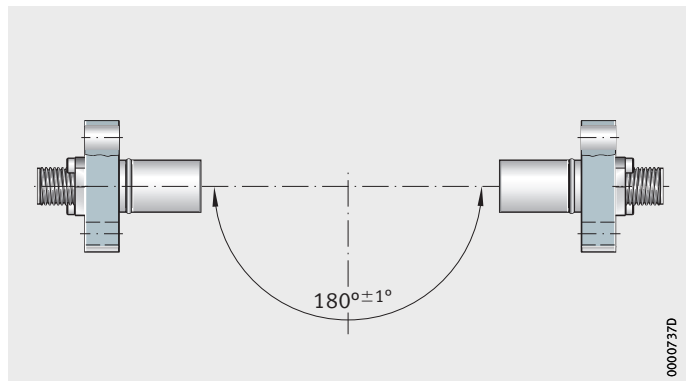


Figure 11
Diametrically opposed
arrangement of measuring heads

Fitting of measuring heads

First set the measuring heads using the MEKOEDS software and the shims supplied to the correct distance from the outside diameter of the shaft locating washer, *Figure 12* and page 90.

Setting: see MON 18, Axial/Radial bearings with integrated angular measuring system.

The software is then used to carry out a Teach-In process that matches the measuring heads to the electronic evaluation system.



Tighten the fixing screws carefully. Do not exceed an amplitude display of 80% in the MEKOEDS software during setting. The sensor surface of the measuring head must only be subjected to load by hand pressure. Forces > 50 N may damage the sensor surface.

- ▶ Visually check the screw mounting surface for the angular measuring head in the housing and remove any foreign bodies, contamination, grease and oil. Degrease the screw mounting surface by suitable means and leaving no residue, ensuring that no degreasing agent or foreign bodies penetrate the measuring system bearing.
- ▶ Fit the angular measuring head with the shims in the correct position, *Figure 12*.

- ① Shim
- ② Sealing ring
- ③ Fixing screws

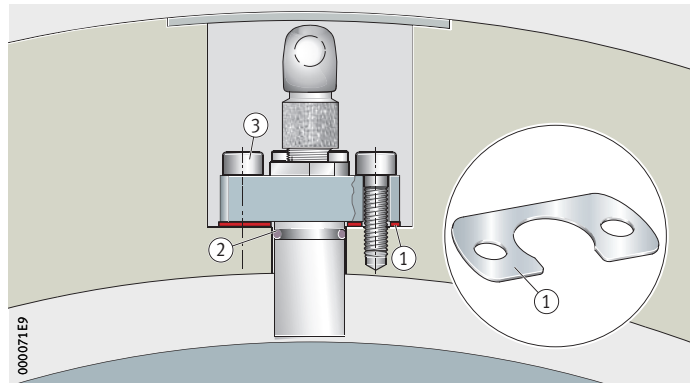


Figure 12
Fitting of measuring head

- ▶ Fasten the angular measuring head in the housing, ensuring that the measuring head is correctly positioned.
- ▶ Insert two new ISO 4762-compliant socket head cap screws M6-8.8 into the mounting holes and screw until finger tight into the prepared threaded holes.
- ▶ Set the measurement gap distance using the teach-in and diagnosis software.
- ▶ While monitoring the torque, tighten each of the two socket head cap screws with a tightening torque of 10 Nm – 1 Nm.
- ▶ Use a suitable paint to secure the screw heads against inadvertent loosening.
- ▶ Fasten the measuring head cable using suitable cable clamps to relieve the strain.

Axial/radial bearings with angular measuring system

Cables and plugs for signal transmission

The plugs for the input signals to the electronic evaluation system are of an 8 pin type.

At first Teach-In, the system automatically detects which measuring head (white or yellow) is connected to which input.



The measuring heads, plugs and cables must be protected from mechanical damage.

Ordering example, ordering designation

An axial/radial bearing of size 395 is required with measuring system, *Figure 13*.

Unit

The unit comprises:

- axial/radial bearing YRTSM395
- electronic measuring system SRM01
- two connection cables SRMC2-A with 90° elbow plugs on the measuring side for connecting to the electronic evaluation system, each cable 2 m long

Ordering designation

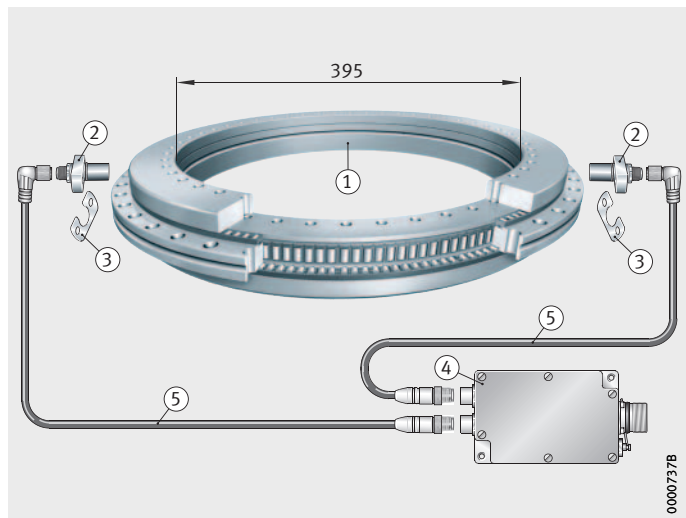
YRTSM395/SRM01/(2 pieces) SRMC2-A



Two cables must be ordered for each measuring system unit.

- ① YRTSM395
- ② Measuring heads
- ③ Shims
- ④ Electronic evaluation system
- ⑤ Connection cables

Figure 13
Ordering example,
ordering designation:
Unit



Also required...

The following are also required:

- setting and diagnosis software MEKOEDS (USB memory stick with interface cable, 5 m, can be used as often as required)
- fitting and maintenance manual for the bearing, MON 100
- teach-in and diagnosis manual for the measuring system, MON 18

Ordering designation

MEKOEDS

Manuals MON 100, High precision bearings for combined loads, and MON 18, Axial/radial bearings with integral angular measuring system, are also available as PDF files on the USB memory stick.

Both manuals can, however, also be obtained in printed form from Schaeffler.

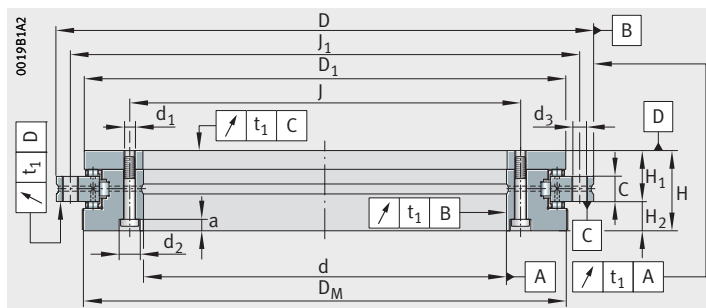
Replacement parts

The following replacement parts are available, *Figure 13*, page 108:

- only bearing shaft locating washer with coding
WSM YRT >bearing bore diameter<
- measuring head with reference sensor (yellow)
SRMH ye
- measuring head without reference sensor (white)
SRMH wh
- shims (packet)
SS-SRM
- electronic evaluation system
SRMB

Axial/radial bearings

Double direction
With absolute value angular
measuring system



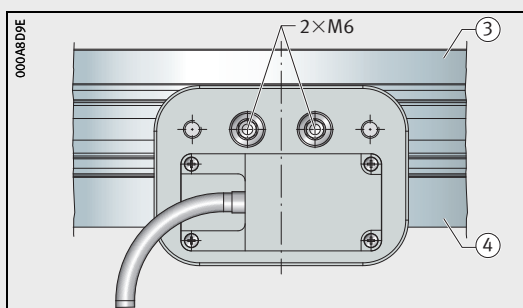
YRTCMA

Dimension table · Dimensions in mm

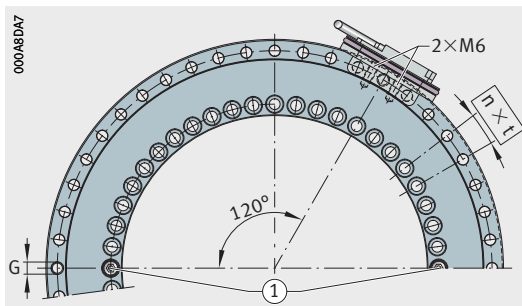
Main dimensions						Basic load ratings				Limiting speed ¹⁾ n_G min ⁻¹	Mass $\approx m$ kg	Designation	
						axial		radial					
d	D		H		dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN					
150	0	-0,013	240	0	-0,015	47	128	650	74	146	800	6,7	YRTCMA150-XL
180	0	-0,013	280	0	-0,018	50	134	730	100	200	600	8,5	YRTCMA180-XL
200	0	-0,015	300	0	-0,018	51 ⁷⁾	147	850	123	275	450	10,7	YRTCMA200-XL
260	0	-0,018	385	0	-0,02	57,5 ⁷⁾	168	1 090	140	355	300	18,7	YRTCMA260-XL
325	0	-0,023	450	0	-0,023	61	247	1 900	183	530	200	25	YRTCMA325-XL
395	0	-0,023	525	0	-0,028	65	265	2 190	200	640	200	33	YRTCMA395-XL
460	0	-0,023	600	0	-0,028	70	290	2 550	265	880	150	45	YRTCMA460-XL

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area ③ Shaft locating washer ④ Inner ring

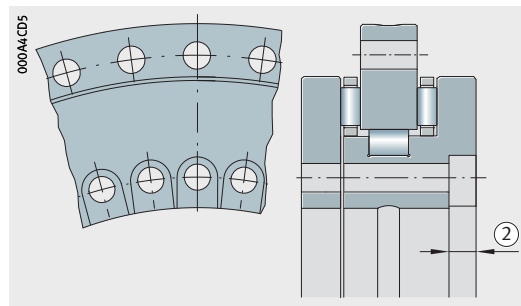
- 1) For high operating durations or continuous operation, please contact us.
- 2) Including retaining screws or threaded extraction holes.
- 3) Diameter of shaft locating washer for design of adjacent construction.
- 4) Diameter of dimensional scale on inner ring.
- 5) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 6) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 7) Dimension differs from the axial/radial bearing YRT.
- 8) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 111.



Measuring head suitable for radial screw mounting



Hole pattern, measuring head suitable for radial screw mounting



YRTCMA325

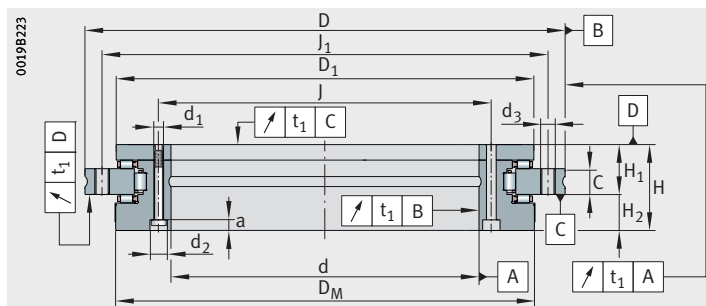
Dimensions							Fixing screws						Pitch ²⁾		Threaded extraction hole		Screw tightening torque
							Inner ring			Outer ring							
d	H ₁	C	D ₁ ³⁾	D _M ⁴⁾ max.	J	J ₁	d ₁	d ₂	a	Quantity ⁵⁾	d ₃	Quantity ⁵⁾	n	t	G	Quantity	M _A ⁶⁾ Nm
150	26	12	214,5	214	165	225	7	11	6,2	34	7	33	36	10	M8	3	14
180	29	15	245,1	244	194	260	7	11	6,2	46	7	45	48	7,5	M8	3	14
200	30	15	274,4	274	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	18	347	345	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	20	415,1	415	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	20	487,7	486	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	22	560,9	560	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) · Dimensions in mm

Main dimension d	Designation	Rigidity ⁸⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
150	YRTCMA150-XL	3,8	3,2	18,6	12	4,8	61
180	YRTCMA180-XL	4,7	3,6	29	13,5	5,3	88,5
200	YRTCMA200-XL	4,9	4,1	40	15,5	6,2	128
260	YRTCMA260-XL	6,9	5,3	104	19	8,1	265
325	YRTCMA325-XL	7,1	6,3	159	33	9,9	633
395	YRTCMA395-XL	9,9	5,8	280	37	13	1 002
460	YRTCMA460-XL	12	6,5	429	43	17	1 543

Axial/radial bearings

Double direction
With absolute value angular
measuring system



YRTCMI

Dimension table · Dimensions in mm

Main dimensions							Basic load ratings				Limiting speed ¹⁾ n_G min ⁻¹	Mass $\approx m$ kg	Designation
							axial		radial				
d	D		H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN						
180	0	-0,013	280	0	-0,018	50 ⁷⁾	134	730	100	200	600	8,5	YRTCMI180-03-0768-XL
200	0	-0,015	300	0	-0,018	51 ⁷⁾	147	850	123	275	450	10,7	YRTCMI200-03-0860-XL
260	0	-0,018	385	0	-0,02	57,5 ⁷⁾	168	1 090	140	355	300	18,7	YRTCMI260-03-1088-XL
325	0	-0,023	450	0	-0,023	61	247	1 900	183	530	200	25	YRTCMI325-03-1302-XL
395	0	-0,023	525	0	-0,028	65	265	2 190	200	640	200	33	YRTCMI395-03-1530-XL
460	0	-0,023	600	0	-0,028	70	290	2 550	265	880	150	45	YRTCMI460-03-1760-XL

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area ③ Shaft locating washer ④ Inner ring

1) For high operating durations or continuous operation, please contact us.

2) Including retaining screws or threaded extraction holes.

3) Diameter of shaft locating washer for design of adjacent construction.

4) Diameter of dimensional scale on inner ring.

5) Attention!

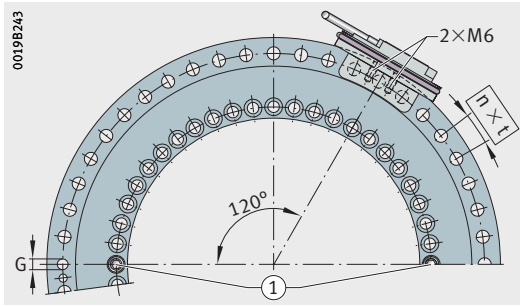
For fixing holes in the adjacent construction.

Note the pitch of the bearing holes.

6) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.

7) Dimension differs from the axial/radial bearing YRT.

8) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection. For explanations, see page 113.



Hole pattern

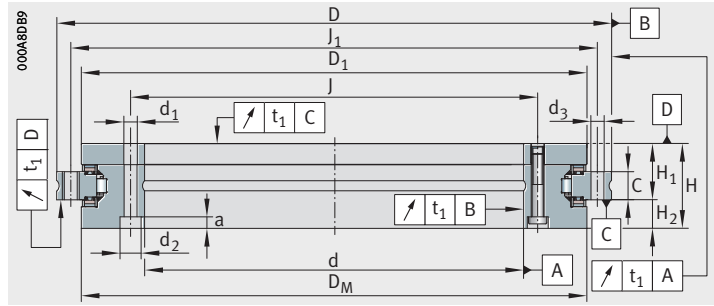
Dimensions							Fixing screws						Pitch ²⁾		Threaded extraction hole		Screw tightening torque
							Inner ring			Outer ring							
d	H ₁	C	D ₁ ³⁾	D _M ⁴⁾ max.	J	J ₁	d ₁	d ₂	a	Quantity ⁵⁾	d ₃	Quantity ⁵⁾	n	t	G	Quantity	M _A ⁶⁾ Nm
180	29	15	245,1	244	194	260	7	11	6,2	46	7	45	48	7,5	M8	3	14
200	30	15	274,4	274	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	18	347	345	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	20	415,1	415	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	20	487,7	486	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	22	560,9	560	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) · Dimensions in mm

Main dimension	Designation	Rigidity ⁸⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
d							
180	YRTCMI180-03-0768-XL	4,7	3,6	29	13,5	5,3	88,5
200	YRTCMI200-03-0860-XL	4,9	4,1	40	15,5	6,2	128
260	YRTCMI260-03-1088-XL	6,9	5,3	104	19	8,1	265
325	YRTCMI325-03-1302-XL	7,1	6,3	159	33	9,9	633
395	YRTCMI395-03-1530-XL	9,9	5,8	280	37	13	1 002
460	YRTCMI460-03-1760-XL	12	6,5	429	43	17	1 543

Axial/radial bearings

Double direction
With absolute value angular
measuring system



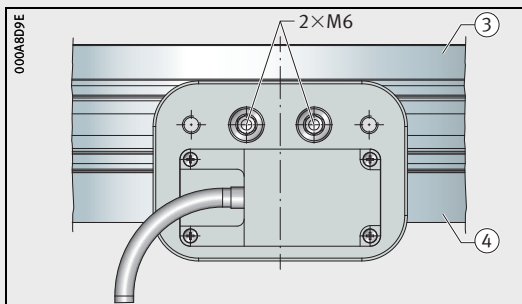
YRTSMA

Dimension table · Dimensions in mm

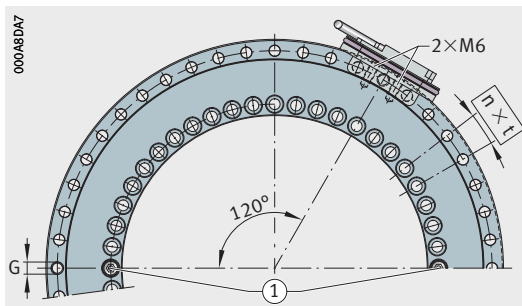
Main dimensions							Basic load ratings				Limiting speed ¹⁾ n_G min ⁻¹	Mass $\approx m$ kg	Designation
							axial		radial				
d		D		H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN					
200	0	-0,015	300	0	-0,018	51 ⁷⁾	155	840	94	226	1 160	10,7	YRTSMA200
260	0	-0,018	385	0	-0,02	57,5 ⁷⁾	173	1 050	110	305	910	18,7	YRTSMA260
325	0	-0,023	450	0	-0,023	61 ⁷⁾	191	1 260	109	320	760	25	YRTSMA325
395	0	-0,023	525	0	-0,028	65	214	1 540	121	390	650	33	YRTSMA395
460	0	-0,023	600	0	-0,028	70	221	1 690	168	570	560	45	YRTSMA460

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area ③ Shaft locating washer ④ Inner ring

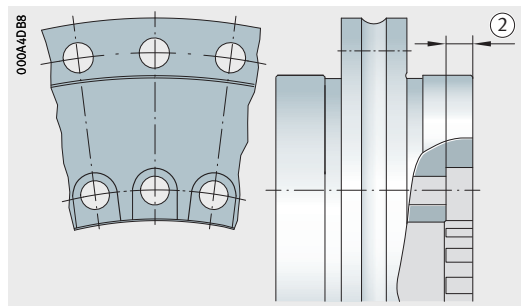
- 1) For high operating durations or continuous operation, please contact us.
- 2) Including retaining screws or threaded extraction holes.
- 3) Diameter of shaft locating washer for design of adjacent construction.
- 4) Diameter of dimensional scale on inner ring.
- 5) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 6) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 7) Dimension differs from the axial/radial bearing YRT.
- 8) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 115.



Measuring head suitable for radial screw mounting



Hole pattern, measuring head suitable for radial screw mounting



YRTSMA325

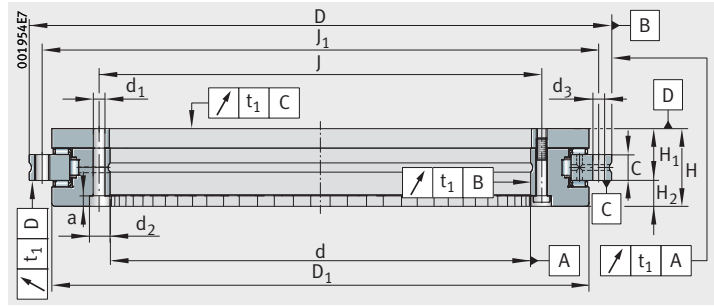
Dimensions							Fixing screws					Pitch ²⁾		Threaded extraction hole		Screw tightening torque	
							Inner ring				Outer ring						
d	H ₁	C	D ₁ ³⁾	D _M ⁴⁾ max.	J	J ₁	d ₁	d ₂	a	Quantity ⁵⁾	d ₃	Quantity ⁵⁾	n	t	G	Quantity	M _A ⁶⁾ Nm
200	30	15	274,4	274	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	18	347	345	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	20	415,1	415	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	20	487,7	486	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	22	560,9	560	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) - Dimensions in mm

Main dimension	Designation	Rigidity ⁸⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
d							
200	YRTSMA200	4	1,2	29	13,6	3,9	101
260	YRTSMA260	5,4	1,6	67	16,8	5,8	201
325	YRTSMA325	6,6	1,8	115	19,9	7,1	350
395	YRTSMA395	7,8	2	195	23,4	8,7	582
460	YRTSMA460	8,9	1,8	280	25,4	9,5	843

Axial/radial bearings

Double direction
with incremental angular
measuring system



YRTCM

Dimension table · Dimensions in mm

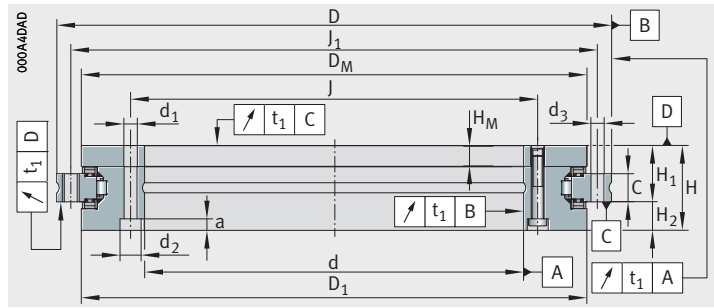
Main dimensions							Basic load ratings				Limiting speeds		Mass ≈ m kg	Designation
							axial		radial		Electronic evaluation system n_G min ⁻¹	Reference run n_{Ref} min ⁻¹		
d	D		H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN							
150	0	-0,013	240	0	-0,015	41 ⁶⁾	128			650	74	146	800	-
180	0	-0,013	280	0	-0,018	44 ⁶⁾	134	730	100	200	600	-	7,7	YRTCM180-XL ⁷⁾
200	0	-0,015	300	0	-0,018	45	147	850	123	275	450	-	9,7	YRTCM200-XL ⁷⁾
260	0	-0,018	385	0	-0,02	55	168	1 090	140	355	300	-	18,3	YRTCM260-XL
325	0	-0,023	450	0	-0,023	60	247	1 900	183	530	200	-	25	YRTCM325-XL
395	0	-0,023	525	0	-0,028	65	265	2 190	200	640	200	-	33	YRTCM395-XL
460	0	-0,023	600	0	-0,028	70	290	2 550	265	880	150	-	45	YRTCM460-XL

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area

- 1) Including retaining screws or threaded extraction holes.
- 2) Diameter of inner ring for design of adjacent construction.
- 3) Diameter of dimensional scale on shaft locating washer.
- 4) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 5) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 6) Attention!
H and H1 are 1 mm higher than standard bearing YRT!
- 7) The measuring head cannot be mounted between the fixing holes or the heads of the fixing screws. Two holes for fixing screws therefore remain unused in the bearing outer ring.
- 8) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 117.

Axial/radial bearings

Double direction
with incremental angular
measuring system



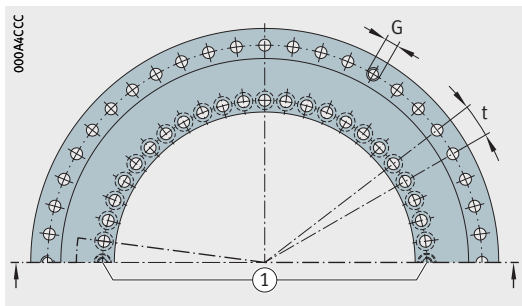
YRTSM

Dimension table · Dimensions in mm

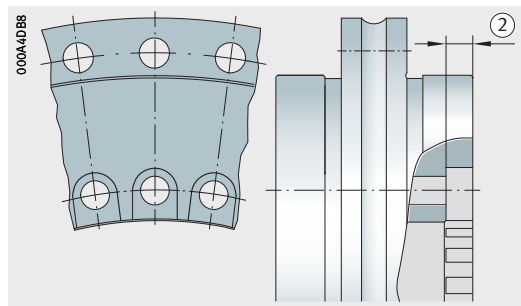
Main dimensions						Basic load ratings						Limiting speeds		Mass ≈ m kg	Designation
						axial			radial			Electroni evaluation system n_G min ⁻¹	Reference run n_{Ref} min ⁻¹		
d			D		H	dyn. C_a kN	stat. C_{0a} kN	dyn. C_r kN	stat. C_{0r} kN						
200	0	-0,015	300	0	-0,018	45	155	840	94	226	1 160	30	9,7	YRTSM200 ⁶⁾	
260	0	-0,018	385	0	-0,02	55	173	1 050	110	305	910	25	18,3	YRTSM260	
325	0	-0,023	450	0	-0,023	60	191	1 260	109	320	760	25	25	YRTSM325	
395	0	-0,023	525	0	-0,028	65	214	1 540	121	390	650	15	33	YRTSM395	
460	0	-0,023	600	0	-0,028	70	221	1 690	168	570	560	15	45	YRTSM460	

① Two retaining screws ② Screw counterbores open (in the L-section ring to the bearing bore), bearing inside diameter is unsupported in this area

- 1) Including retaining screws or threaded extraction holes.
- 2) Diameter of inner ring for design of adjacent construction.
- 3) Diameter of dimensional scale on shaft locating washer.
- 4) Attention!
For fixing holes in the adjacent construction.
Note the pitch of the bearing holes.
- 5) Tightening torque for screws to DIN EN ISO 4762, grade 10.9.
- 6) The measuring head cannot be mounted between the fixing holes or the heads of the fixing screws. Two holes for fixing screws therefore remain unused in the bearing outer ring.
- 7) Rigidity values taking account of the rolling element set, the deformation of the bearing rings and the screw connection.
For explanations, see page 119.



Hole pattern



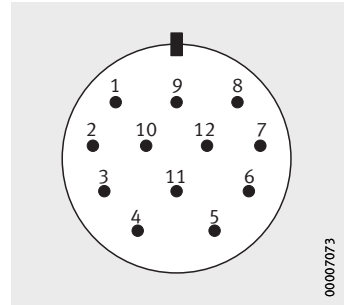
YRTSM325

Dimensions								Fixing screws						Pitch ²⁾		Threaded extraction hole		Screw tightening torque M _A ⁵⁾ Nm
								Inner ring				Outer ring						
d	H ₁	H _M	C	D ₁ ²⁾ max.	D _M ³⁾	J	J ₁	d ₁	d ₂	a	Quantity ⁴⁾	d ₃	Quantity ⁴⁾	n	t °	G	Quantity	
200	30	10	15	274,4	271,12	215	285	7	11	6,2	46	7	45	48	7,5	M8	3	14
260	36,5	13,5	18	347	343,69	280	365	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
325	40	15	20	415,1	412,45	342	430	9,3	15	8,2	34	9,3	33	36	10	M12	3	34
395	42,5	17,5	20	487,7	485,02	415	505	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34
460	46	19	22	560,9	557,6	482	580	9,3	15	8,2	46	9,3	45	48	7,5	M12	3	34

Dimension table (continued) - Dimensions in mm

Main dimension d	Designation	Rigidity ⁷⁾					
		of bearing position			of rolling element set		
		axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad	axial c _{aL} kN/μm	radial c _{rL} kN/μm	Tilting rigidity c _{kL} kNm/mrad
200	YRTSM200 ⁶⁾	5,4	1,6	67	16,8	5,8	201
260	YRTSM260	6,6	1,8	115	19,9	7,1	350
325	YRTSM325	7,8	2	195	23,4	8,7	582
395	YRTSM395	8,9	1,8	280	25,4	9,5	843
460	YRTSM460	4	1,2	29	13,6	3,9	101

SRM electronic measuring system



Plug configuration of 12 pin flanged plug

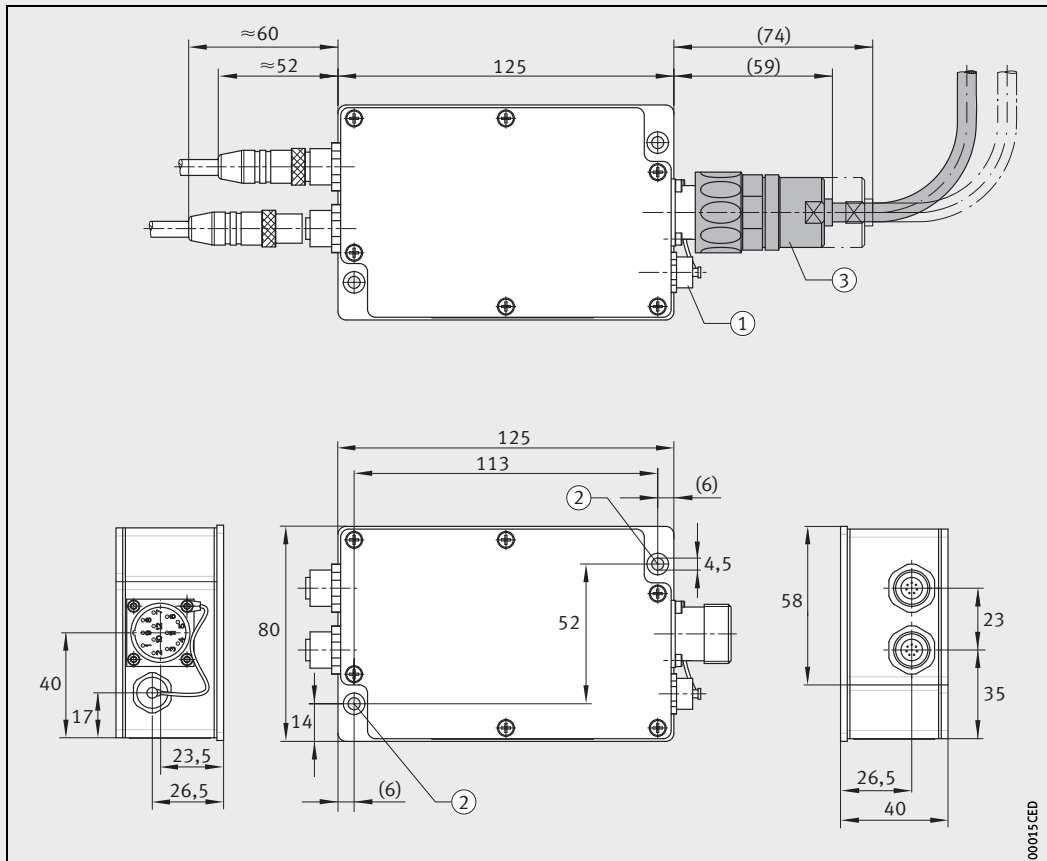
Plug configuration of 12 pin flanged plug

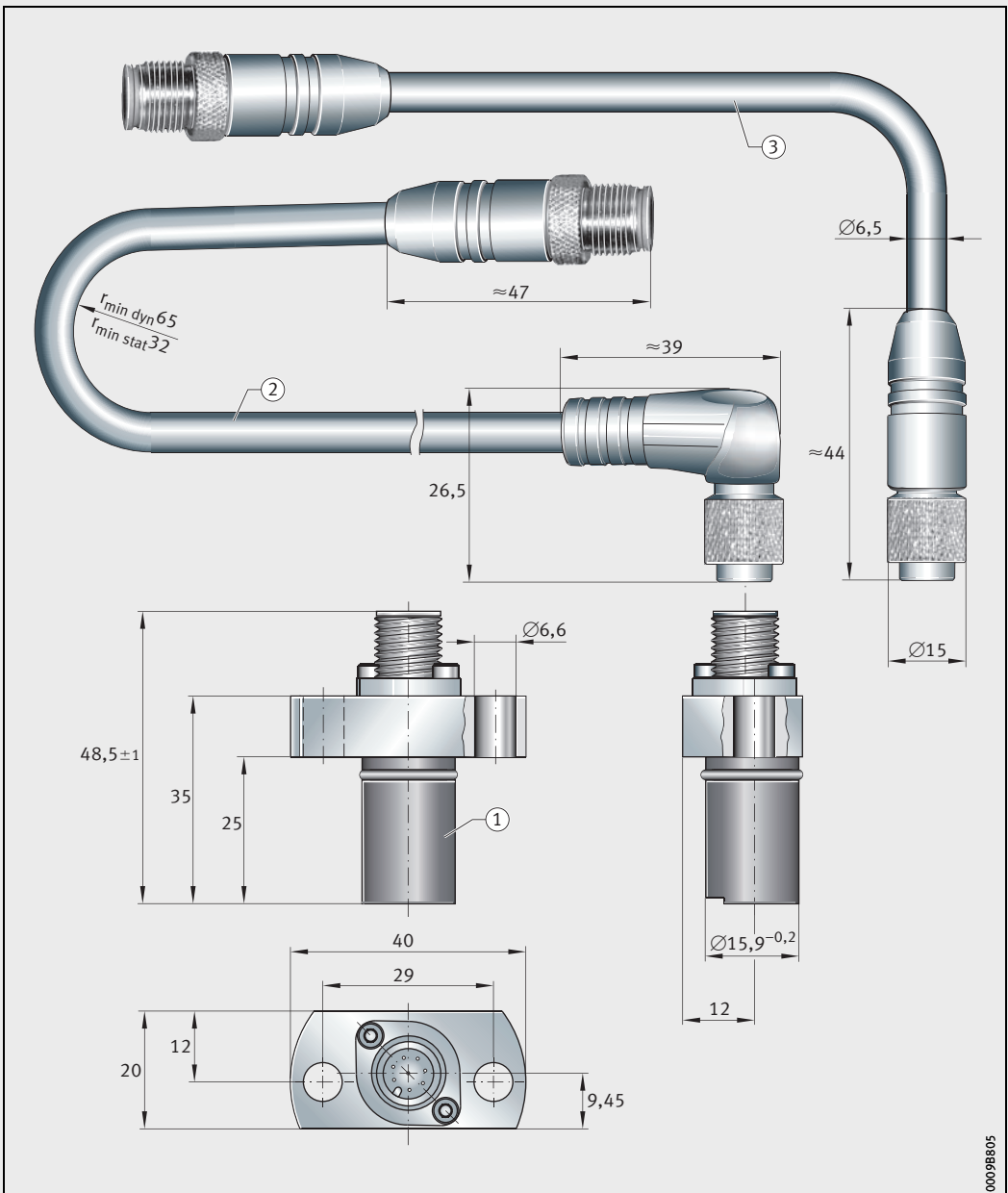
5	6	8	1	3	4	12	10	2	11	9	7	/
A		B		R		5 V (U_P)	0 V (U_N)	5 V (feeler)	0 V (feeler)	free	/	free
+	-	+	-	+	-	-	-	-	-	-	-	-
-	-	-	-	-	-	IEC 747 EN 50 178		-	-	-	-	-

The feeler cables are connected internally to the supply cable (2 with 12 and 11 with 10). They are used by the motor controller as a measurement cable in order to compensate the voltage drop on the supply cable (four-wire principle). If this function is not supported by the controller used, the two 5-V cables and both 0-V cables can be wired in parallel in order to reduce the voltage drop on the supply lead. The housing is shielded.

Electronic evaluation system (protection class IP67):

- ① Connection for RS232
- ② 2 holes for fixing screws DIN 912-M4×10
- ③ Shielded plug with cable to electronic post-processing system (not included in delivery)



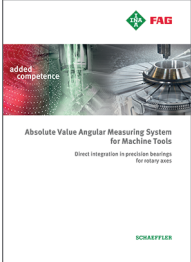


Measuring head ①, connection cable SRMC..-A ② and SRMC..-S ③.
 (Design of connection cable see page 89)



Double row axial/radial bearings YRTMA

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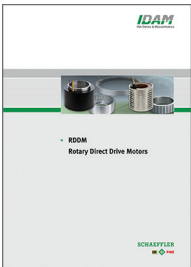
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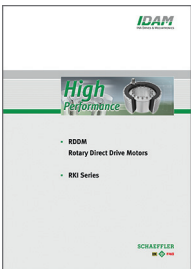
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