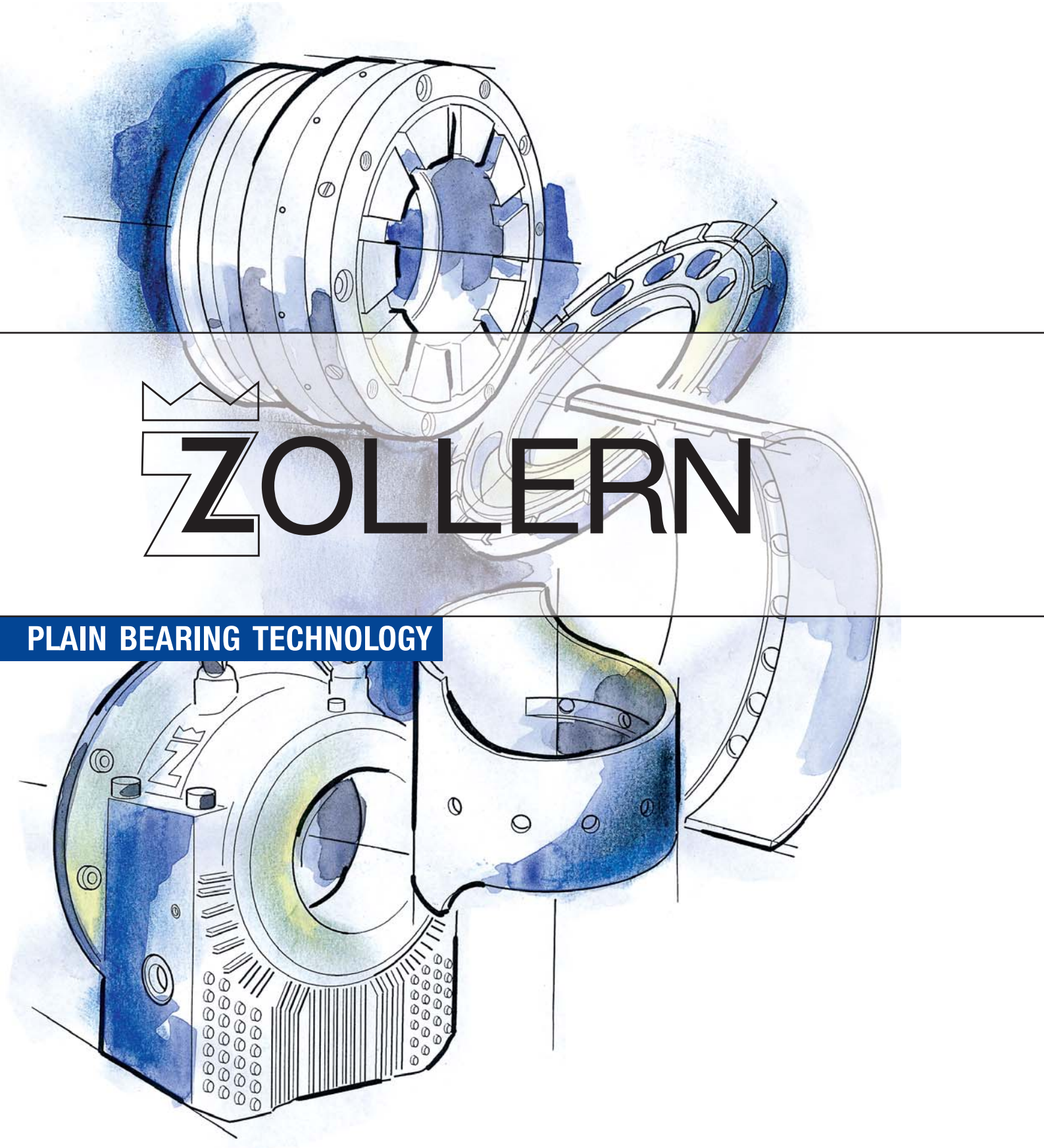
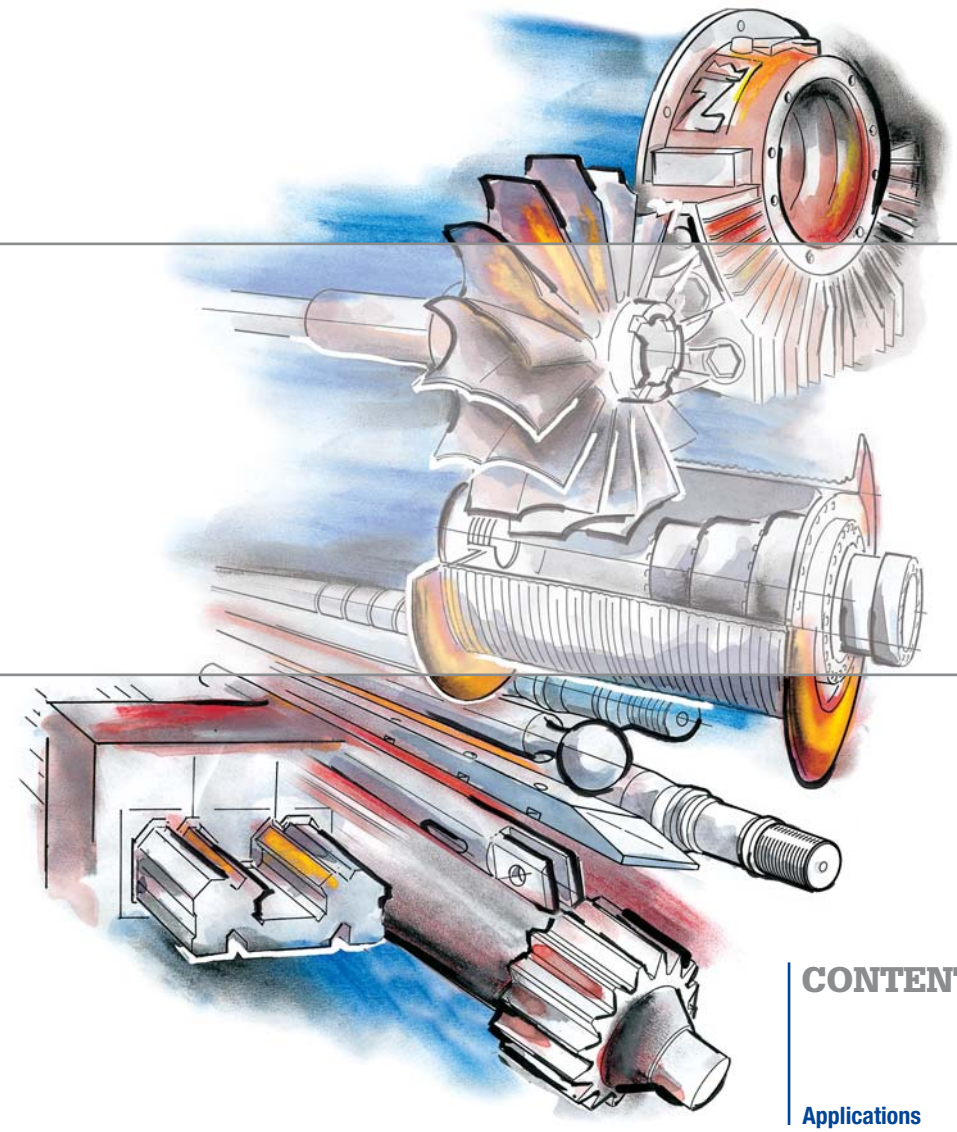


ZOLLERN

PLAIN BEARING TECHNOLOGY



The ZOLLERN Group

The ZOLLERN Group is an international company with over 3000 employees. Our fields of activity include drive systems (automation, gears and winches), plain bearing technology, mechanical engineering components, foundry technology and steel profiles.

CONTENTS

ZOLLERN

PLAIN BEARING TECHNOLOGY

OSTERODE

BRAUNSCHWEIG

HERBERTINGEN

CATAGUASES, BR

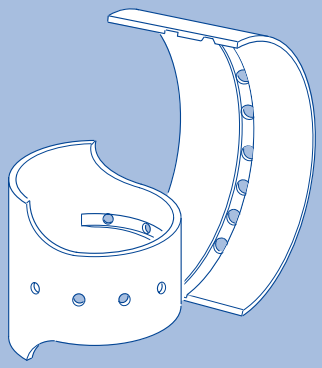
LES MUREAUX, F

ZOLLERN plain bearings – keeping everything in motion

Throughout the world ZOLLERN stands for high-quality plain bearings. The international competition demands innovation, delivery reliability, product quality and excellent customer service. Variegated designs of special plain bearings and multilayer compound castings adapt to the specific market demands. A glance at our product range reveals that ZOLLERN produces suitable plain bearings for every application whether for the purpose of generating, converting and conveying energy in diesel and gas engines, gearboxes, turbines and turbo-machines or in other industrial applications.

The requirement profiles of the plain bearings in modern machine designs are as many as they are varied. It is not only the design principle of a machine but also its size and anticipated operating conditions which have a decisive effect on the design of the plain bearings used and their combinations of materials. A technically efficient, economically viable plain bearing system must therefore be specially adapted to the requirement profile of the machine. A consequence of the development of engines and machines to produce higher and higher outputs is that the plain bearings must accommodate increasingly high static and dynamic loadings while, at the same time, still achieving prolonged durability in service. That is why the world's leading manufacturers of engines and machines place their trust in our products and their quality.

COMBUSTION ENGINES AND PISTON-TYPE MACHINES

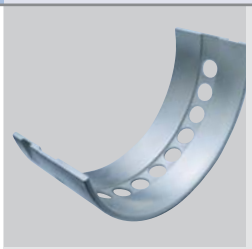


1 Plain bearing shell

2 Bushing

3 Turbocharger bearing

4 Thrust bearings



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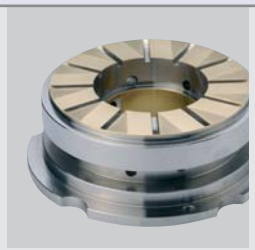

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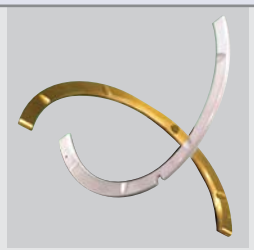

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Plain bearing shells

Thin-walled split radial plain bearings for two-stroke crosshead and four-stroke trunk piston internal combustion engines and for other piston-type machines. Generally used as main bearings, conrod bearings and crosshead bearings, and as bearings for camshafts and control shafts.

Thin- and thick-walled, split, combined radial/thrust bearings (flange bearings) as main bearings for all kinds of piston-type machines and as bearings for camshafts and control shafts.

Bushings

One-piece radial plain bearings for the piston pins of four-stroke trunk piston internal combustion engines and crossheads, camshafts and control shafts, intermediate bearings, rocker arms and items of ancillary equipment such as pumps – also as combined radial/thrust bearings.

Turbocharger bearings

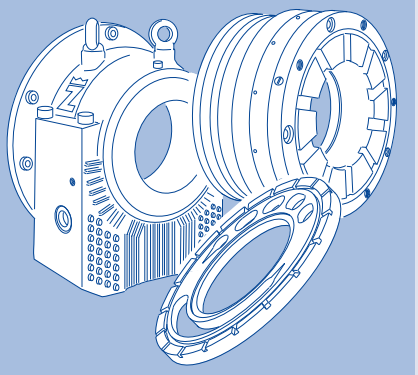
One-piece thick-walled radial plain bearings with particular bore profiles for very high circumferential speeds and one-piece thrust bearing rings with special profiling for extreme axial thrust – also as combined radial/thrust bearings.

Thrust bearings

Thin- and thick-walled thrust bearing rings in split and non split design, and combined axial-/radial bearings (flange bearings) for crankshafts, camshafts and control shafts.

ZOLLERN

INDUSTRIAL AND PLANT ENGINEERING



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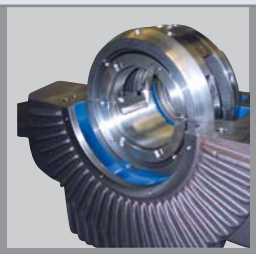

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Energy conversion machineries

Tilting pad and thick-walled bearings

Radial/thrust bearings as tilting pad bearings for applications with high circumferential speeds or thrust loadings, or as thick-walled plain bearings with high inherent stability and special bore profiles. Principal applications are turbines, gearboxes, turbo-compressors, fans, vertical generators, electrical machines, turbochargers.

Plain bearings type Z

Z-bearings are high performance bearings complying with the applicable ISO standard and designed on the modular principle. The broad application spectrum for the different types of bearings (pedestal, flange-mounted and centre flange bearings) covers electrical machines, fans, turbines and test rigs

Hydraulic components

Sliding elements

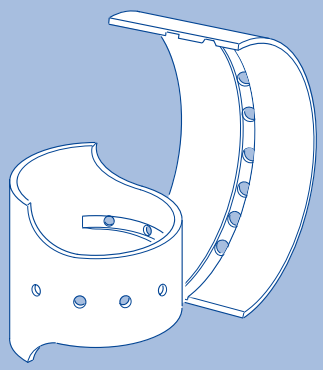
Valve plates and holding down devices for axial piston pumps and motors subject to high loadings, with high precision geometry and plane parallelism, as ready-to-install elements or semi-finished products.

Special industrial application

Hydrostatic bearing systems

Radial, thrust and combined hydrostatic bearings for spindle units, guides and thread gears as well as bearings for test rigs and special purposes, with a variety of regulating systems; compound bearing materials for applications in special purpose machines.

COMBUSTION ENGINES AND PISTON-TYPE MACHINES



Our production processes are aligned to the specific requirements of plain bearings for large diesel engines, e.g. crush height measuring, fineboring for large diameters or the electro-plating processes, which are worldwide leading.

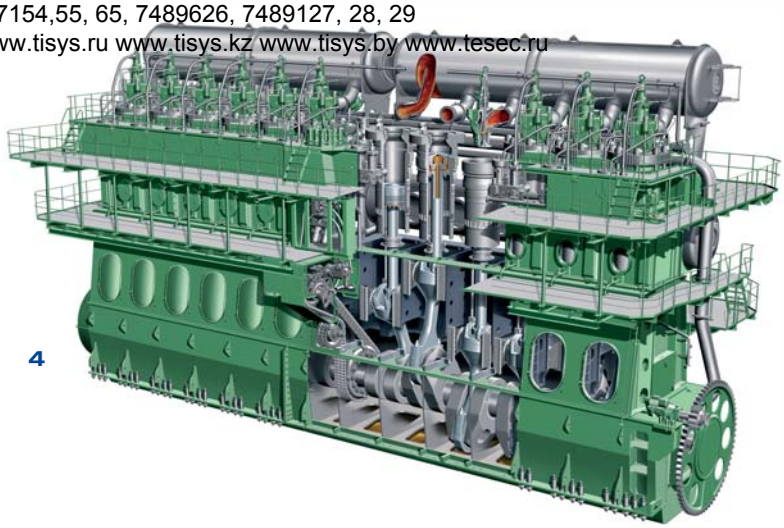
Our employees in R&D, production and quality draw their know-how and expertise from years of experience in the field of plain bearing technology for combustion engines and general industrial engineering.

ZOLLERN BHW customer service is available at all times. Whether to examine and evaluate a plain bearing or merely to provide expert information on plain bearing technology or tribology.

ZOLLERN BHW's test rig technology is unique. Thanks to the so-called two-pulse concept, combined with high stress loading frequencies, prolonged operating times can be represented in short-term tests ("screening").

Environmental awareness is taken into account by, among other things, a unique metal recycling facility with an adjoining quality control.

ZOLLERN



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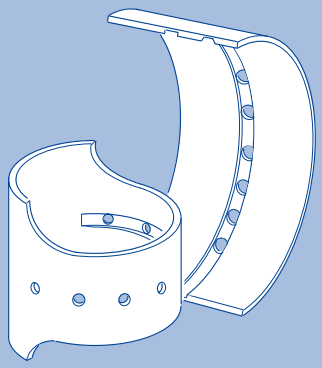
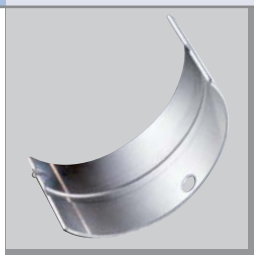


1 Bearing shell consisting of steel/lead-bronze/electroplated layer, diameter 250 mm

2 Bearing shell consisting of steel/aluminium alloy, diameter 280 mm

3 Deburring of a large size bearing, diameter 940 mm

4 MAN B&W 12K98ME-C
two-stroke diesel engine with main, conrod and crosshead bearings made by ZOLLERN BHW



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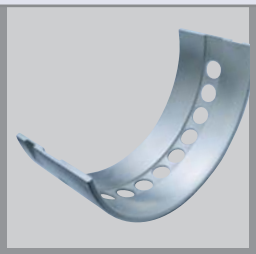

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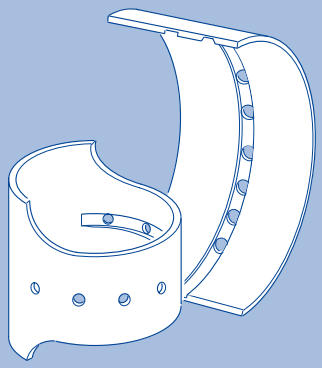
Plain bearing shells

- designed for internal combustion engines and other piston-type machines, but also proven in other areas of general industrial machines, e.g. gearboxes and roll stands
- with a ratio of wall thickness to diameter less than 0.06
- bimetal plain bearings in materials consisting of steel/white metal or steel/aluminium, trimetal plain bearings made of steel/bronze or steel/aluminium with an additional lining
- with steel supporting shells and bearing metal coatings of between 0.5 and 3 mm and linings of between 0.01 and 0.04 mm
- type of material selected to meet the requirements of the stress loading profile
- made in exchangeable halves. When arbitrarily assembled, the pair of bearing shells always fits in such a way that, when installed, the seat complies with the specified prestress level
- if required, compensation for housing distortion by adapted wall thickness progression to support the optimum bearing function, so that the inner diameter complies with a geometric shape which favours the formation of a uniform lubricating film
- tested with special crush height measuring machines, which we produce also for our customers. The crush height is the characteristic required to achieve the necessary prestress in installed condition

4



1 Piston pin bushing made of steel/lead-bronze, diameter 190 mm

2 Camshaft bushing made of steel/lead-bronze, diameter 210 mm

3 Guide bushing for a piston rod made of bronze/white metal, diameter 80 mm

4 Crankshaft of a piston-type compressor

1

2

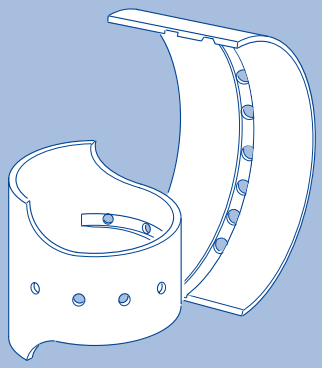
3

Bushings

- for universal applications in engine and machine manufacturing, in thin- or thick-walled designs
- available in various combinations of materials and dimensions from 50 to 800 mm
- made of steel/lead-bronze or steel/white metal by the compound centrifugal casting method
- made of steel/lead-bronze or steel/aluminium bimetal strip with welded joint, with electroplated lining as an option
- with precisely turned or ground outer diameter (between centres or centreless)
- with special external shape for piston pin bushings
- with specially shaped grooves for oscillating movement
- with precise concentricity of outer and inner diameters
- with defined eccentricity of outer and inner diameters
- with cylindrical bore or multi-lobe sliding profile
- with special supporting cradle for crosshead bushings without lift

ZOLLERN

4



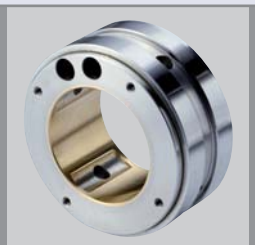
1 Turbocharger radial/thrust bearing with multi-lobe profile

2 Radial turbocharger bearing

3 Crankshaft thrust washer

4 Wärtsilä W6L46
four-stroke diesel engine with ZOLLERN BHW main- and conrod bearings, piston pin and camshaft bushings

1



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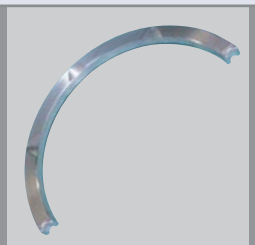


3

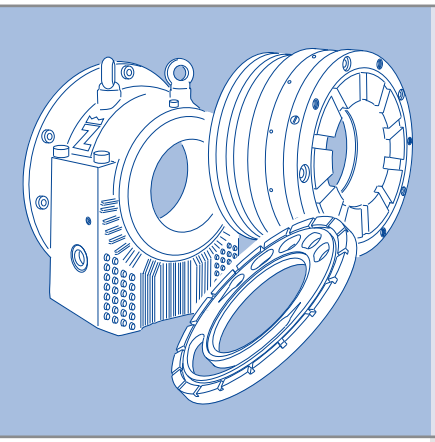
Turbocharger bearings

- radial bearings for high circumferential speeds with 2-, 3- or 4-lobe profile
- thrust bearings with customized taper land profile for highest specific load
- also as combined radial/thrust bearings
- in fixed or floating execution
- predominantly made of bearing metals on a bronze base
- on request with additional sliding layer

Thrust bearings

- for the axial guidance of crankshafts and camshafts
- ready-to-install thrust rings and combined radial/thrust bearings (flange bearings)
- split and non split thrust rings
- solid bronze or aluminium or multi-layer materials with special linings
- thin- or thick-walled flange bearings
- materials and structure as for engine radial bearings

INDUSTRIAL AND PLANT ENGINEERING



Industrial bearings such as cylindrical radial plain bearings or multi-lobe or tilting pad bearings have long been traditional products of ZOLLERN BHW. The former factory in Herzberg founded in 1950 under the name of GMH started designing and producing so-called multi-lobe bearings at an early stage.

The first tilting pad bearings were developed in the 1970s (when the firm was trading under the name of Glyco). ZOLLERN is also recognized as a leading manufacturer of hydrostatic plain bearings. The development of the bearing clearance compensating system and its pressurising characteristics dates back to the early 1980s.

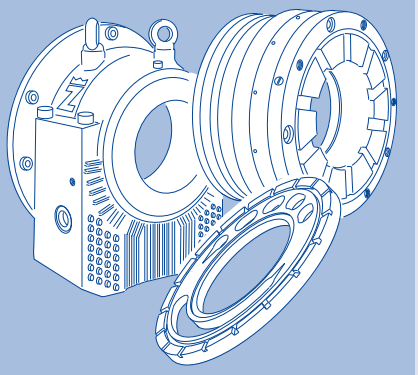
The staff in the design and research and development departments are continuing the company's successful tradition in the field of plain bearing innovations and providing the customer with support appropriate to the latest state of the art.

The special designs of the respective hydrodynamic and hydrostatic plain bearings also underlie the fact that we have our own dedicated range of machines.

Our environmental awareness is reflected by, among other things, a unique metal recycling facility with adjoining quality control.

ZOLLERN

ENERGY CONVERSION MACHINERIES



1 Thick-walled radial/thrust bearings

2 Combined tilting pad bearing

3 Radial and axial tilting pad plain bearings

4 Steam turbine with radial tilting pad plain bearings with hydrostatic lift

1

2

3

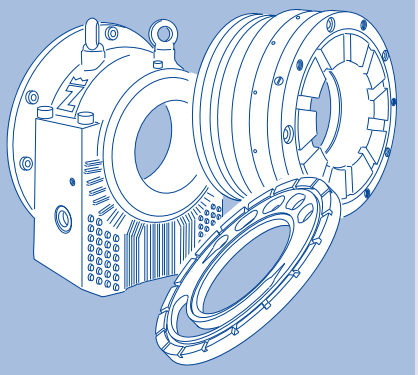
Thick-walled radial and radial/ thrust plain bearings

- split plain bearings for general industrial applications, e.g. gearboxes, turbines and electrical machines
- thick-walled configuration ensures high thermal stability
- available in standard and non-standard sizes
- standard configuration in a combination of steel/white metal and diameters up to 1600 mm; non-standard versions in steel/bronze in diameters up to 800 mm, with or without additional lining
- processed to ready-to-install condition: scraping-in is generally not necessary
- with bore profiles matched to the requirement profile; cylindrical bore, 2-, 3- or 4-lobe profile, offset halves
- with hydrostatic starting aid if required
- with temperature or vibration measuring sensors if required

Radial and thrust tilting pad plain bearings

- for use at very high circumferential speeds or axial loadings and general use in machines such as turbines, turbo gearboxes, turbo compressors, fans and vertical generators
- dimensions and designs to ZOLLERN BHW standard or customers' specifications
- configured for one or both directions of rotation
- with hydrostatic starting aid if required
- with temperature or vibration measuring sensors if required

ENERGY CONVERSION MACHINERIES



1 Pedestal plain bearing

2 Vertical bearing

3 Centre flange bearing ZM on a generator

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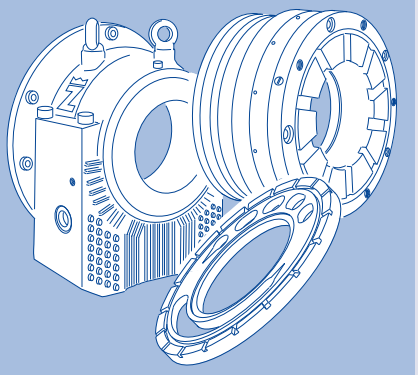
Plain bearings type Z

ZOLLERN Z-bearings comprise a series of high performance plain bearings complying with DIN standards 31690, 31693 and 31694 for a wide range of applications (electrical machines, fans, turbines and test rigs). The modular principle was consistently applied to the different types (pedestal, flange and centre flange bearings), permitting different modules from the system to be combined at any time.

The finned Z-bearing housings, which are made of nodular cast iron GGG 40, provide the optimum dissipation of heat. The spherical bearing shell support was chosen so that the forces generated are evenly directed into the lower part of the housing. The housings are therefore capable of accommodating extreme stresses. They are also supplied in insulated versions in order to prevent creeping currents.

If required, additional equipment can be ordered with the bearing, such as oil supply systems and monitoring instruments. If desired, all parts can also be supplied with inspection certificates (DNV, LRS, GL etc.).

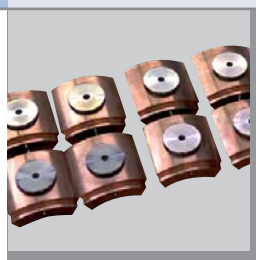
ZOLLERN



1 Radial tilting pad made of copper-chrome

2 Radial tilting pad bearing

3 Thrust bearing pad



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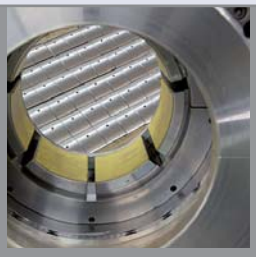

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Special configurations

- pads made of the compound material steel/ white metal (St/Z-BHW 36); in special cases, steel/lead-bronze
- tilting pad thrust bearings with or without levelling pieces
- thrust and radial tilting pads can also be supplied as complete sets or as spare parts
- we will also calculate the dimensions, number of pads and oil flow requirements for your plain bearing design

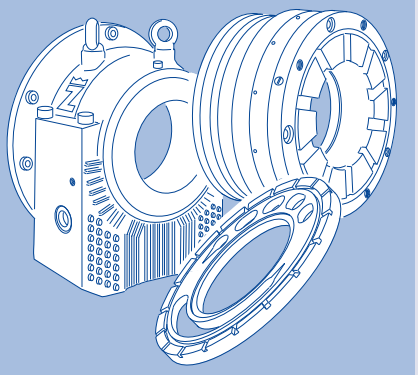
Bearing metal linings and repairs

- as sliding elements for hydraulic machines, power transmission and other applications; made of compound casting as steel/white metal, steel/bronze or steel/bronze/white metal
- as ready-to-install compound casting sliding elements or prefabricated steel blanks with bearing metal coating
- coated by custom designed casting and application procedures
- ultrasonic bonding check and dye-penetration test for non porosity
- supply of high quality white metals for repair purposes or linings

Typical applications: Planetary gear bolts, hydraulic cylinders for axial piston pumps and spherical plain bearings such as spherical shells for diesel engines

4

HYDRAULIC COMPONENTS



1 Valve plate

2 Holding-down device

3 Control disc

4 Cross section of a Parker axial piston pump

1

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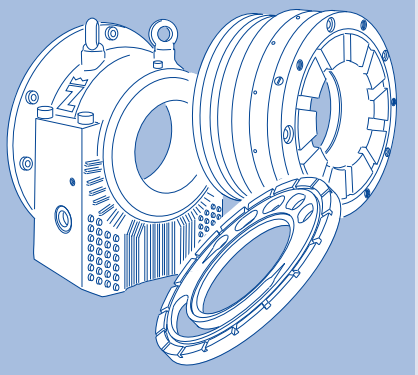
Sliding elements

- valve plates and holding-down devices for axial piston pumps and motors
- made of the compound material steel/Z-BHW 46 for high loadings, pulsating and vibrating stresses
- outstanding wear resistance, even under exceptional operating conditions, such as cavitation, oil corrosion and lack of lubrication
- as ready-to-install parts and semi-finished products
- with dimensionally accurate geometry and plane parallelism due to double-sided grinding and lapping and by monitoring the dimensional accuracy with high precision, computer aided measuring instruments

4

SPECIAL INDUSTRIAL ENGINEERING



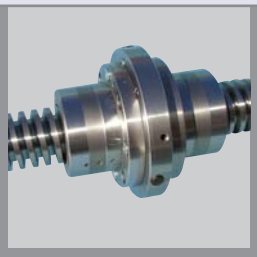
1 Hydrostatic radial/thrust bearing (rotary table bearing)

2 Hydrostatic screw-type drive

3 Grinding spindle unit

4 Gearwheel profiling machine with hydrostatic plain bearing system

1



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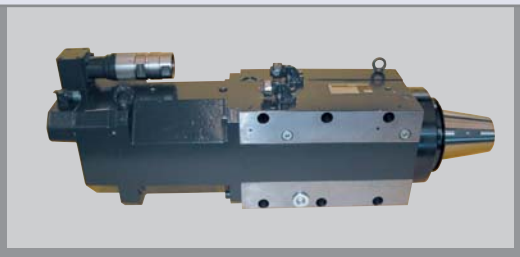

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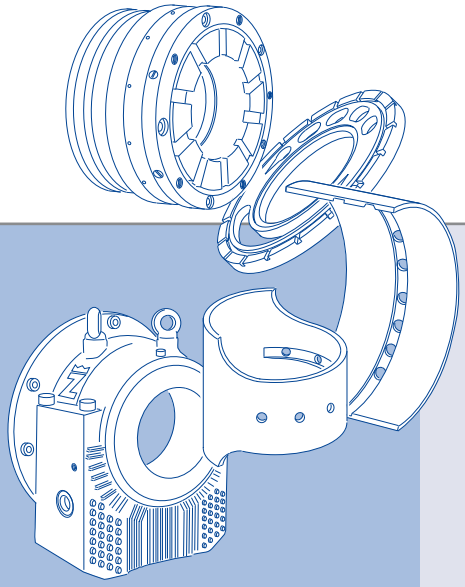
Hydrostatic bearing systems and components

- **for machine tools**
- **for industrial engineering**
- **for testing and measuring systems**

- hydrostatic systems and components ensure the utmost manufacturing precision and the highly efficient damping of vibrations from production processes
- wear resistance ensures consistent processing precision
- no stick-slip effects and outstanding protection against crashes
- compact design, thanks to the ZOLLERN bearing clearance compensating system
- circumferential speeds in the bearing up to 65 m/s
- thermal stability resulting from heat dissipation by way of cooled lubricating oil
- available as complete systems and individual components
- made of compound materials steel/lead/bronze, steel/white metal, steel/aluminium and special materials optimized for the intended purpose

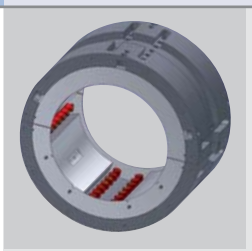


RESEARCH AND DEVELOPMENT APPLICATION ENGINEERING

1 Radial tilting pad bearing with controlled lubrication and hydrostatic system

2 Exploded view of Fig.1

3 Test rig for engine bearings



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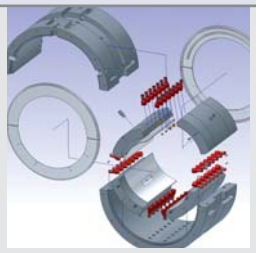

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The plain bearing – nothing new since Leonardo da Vinci?

While the principle remains unchanged, tools and materials, by contrast, are new and ultra-modern. High precision computing methods, such as FEM and EHD, deliver data for design work based on the 3D-CAD method and, in conjunction with competent application know-how, give rise to the optimum solutions to problems – whether in respect of prototypes, individual components or mass produced parts. Whether it be the design of a bearing for a new machine or engine associated, needless to say, with the appropriate choice of material, or an increase in the output of an existing machine, a tailor-made configuration always takes pride of place. Hydrostatic, hydrodynamic or elasto-hydrodynamic, the specific application decides on the appropriate technology.

Test rig trials serve to verify the proposed solution. ZOLLERN BHW possesses one of the largest and most modern plain bearing test rigs in the world, which permits all types of stress loadings to be simulated. Even specific preliminary development is possible involving the actual bearing housing.

Increasing demands on the efficiency of the bearings in modern engines and machines are our incitation to develop new plain bearing materials and designs. High stress loading capacities, prolonged durability and the protection of the shaft in the event of damage are just as essential development objectives as economical and reliable production methods.

ZOLLERN