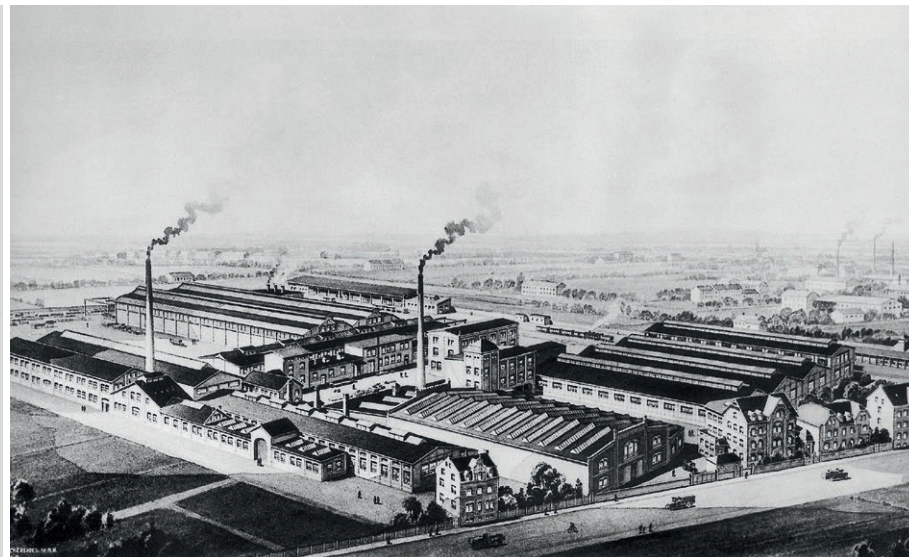


SMOOTH AND POWERFUL DRIVE

**ZF COUPLINGS AND CLUTCHES
FOR MARINE APPLICATIONS**





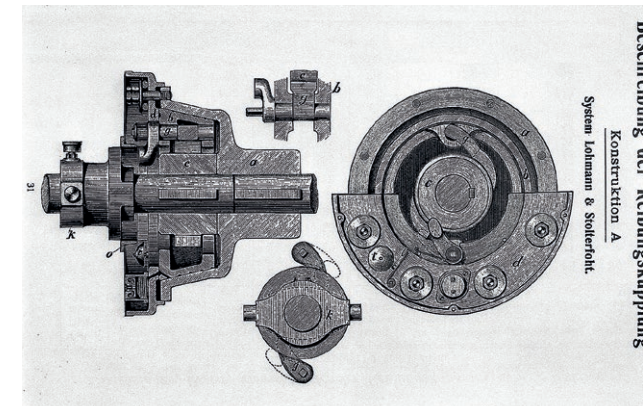
THE INVENTORS OF THE FRICTION CLUTCH

ZF Industriebetriebe Witten GmbH is the successor company of the former Lohmann + Stolterfoht GmbH and has thus inherited a long history in transmission and clutch technology.

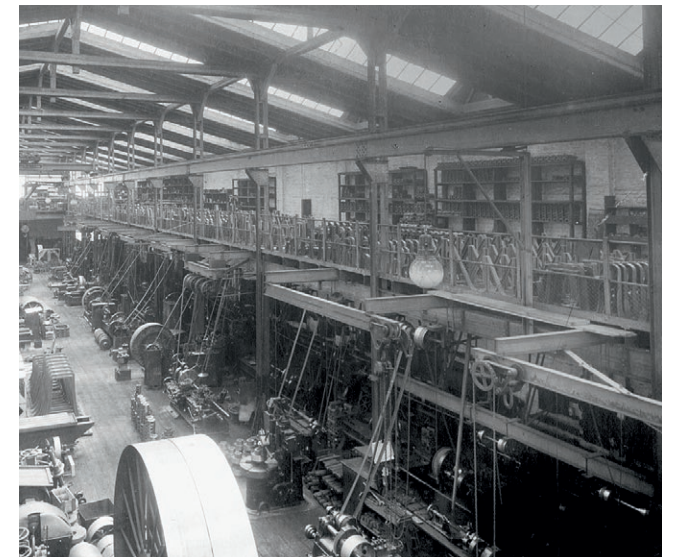
In 1884, Max Lohmann and Max Stolterfoht laid the foundation for their new company with a revolutionary invention. On September 08, they founded the Lohmann + Stolterfoht GmbH (L+S). Independent from each other, they both discovered the principle of the friction clutch. Whereas all known clutches until then were claw clutches which could only be shifted during stand-still, the new clutch could be actuated under load. Known as “A”-coupling, the patented novelty was the basis for an extensive product program, for which the fundamental mechanical principles are still valid today.

Production set-up in Witten

In 1890, one year after Max Stolterfoht passed away, the business was transferred to Witten, where the family of Max Lohmann owned sufficient real estate and manufacturing facilities for the production of the new couplings. As well as extending the production, sales and marketing facilities were established. This gave way to a close cooperation with a large customer of friction clutches: The submarine business needed couplings which connected the diesel motor with the propeller shaft. Thus, close relations with the ship-



Based on the invention of the friction clutch Max Lohmann set up production with the newly founded company Lohmann + Stolterfoht in 1884 in Witten. Initially couplings and clutches were designed and manufactured, followed by the production of gearboxes. (r.)



building industry were also established. The delivery of the first marine reverse-reduction gears in 1926 not only extended the production program, but also enlarged the access to the marine industry.

Eventful history

Since 1955, Lohmann + Stolterfoht changed ownership several times, until in 2009 the traditional company was erased from the Trade Register and it was fully merged into the Bosch Rexroth Group. When ZF took over the large gear business from Bosch Rexroth in 2015, the heritage of Lohmann + Stolterfoht also went over to ZF. As successor company of the former L+S, ZF Industriebetriebe Witten GmbH relies on the long years of experience in gearbox design and production and combines it with the transmission technology know-how from ZF.

New perspectives

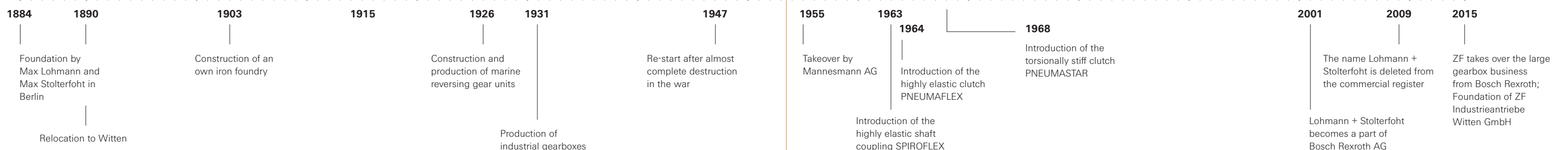
ZF is the world’s third largest automotive supplier and a global leader in driveline and chassis technology as well as active and passive safety technology. Indus-

trial Technology is the division where ZF bundles its activities for “Off-Road” applications. It comprises the development and production of transmissions and axles for agricultural- and construction machinery as well as driveline technology for material handling systems, rail- and special vehicles. The division is also responsible for the worldwide business of marine propulsion systems, aviation technology as well as the development and production of gearboxes for wind turbines. Large industrial gearboxes and test systems for various kinds of applications in driveline and chassis technology are also included in the division’s portfolio.

ZF Industriebetriebe Witten GmbH is responsible for the Industrial Drives Business Unit and offers gearboxes for mining applications and large construction machines, industrial machinery and equipment, ropeway systems as well as gearboxes, couplings and clutches for marine and offshore applications.



Foundation of ZF

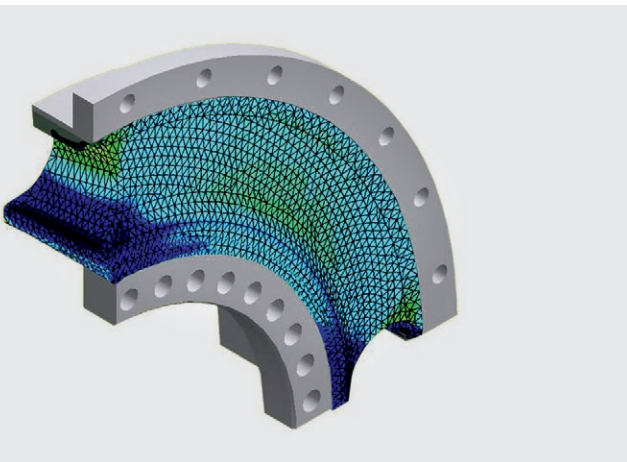


EXPERTS FOR COUPLINGS AND CLUTCHES IN MARINE APPLICATIONS

Over one hundred years of experience in development and production paired with the know-how of ZF in driveline technology is the basis on which ZF Industrieantriebe Witten GmbH is able to offer a technically mature range of reliable couplings and clutches for general and heavy engineering and marine applications.

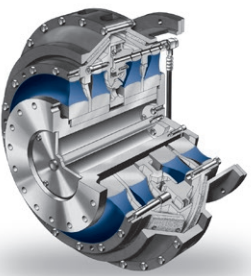
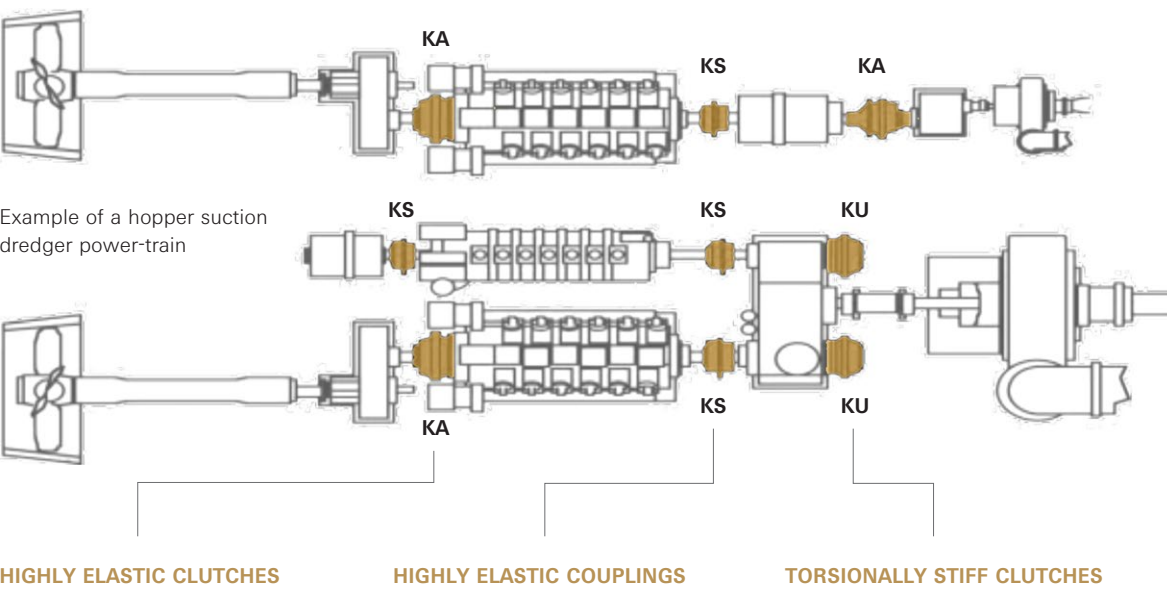
Numerous theoretical factors as well as extensive practical experience form the basis for the design of the coupling. The selection of the correct coupling size is based on the nominal torque of the transmission element. The calculation of the suitable rubber-hardness of the elements derives from the results of the torsional vibration calculations. ZF's engineering and simulation competence supports the process right from the start. Extensive calculations like the finite-element-method as well as dynamic simulations ensure that the coupling design is tailor-made for the customer-specific application. Prior to delivery, all couplings are tested on ZF test benches under the highest quality criteria to guarantee a trouble-free and reliable operation.

This results in couplings which are particularly suitable for the installation in diesel-engine transmission units and wherever torsional vibrations must be taken into consideration. Due to the high torsional flexibility of the rubber elements, the couplings relocate the resonances between the system frequencies and the excitation frequency of the input and working machines outside the operation torque range. The high dampening qualities dampen any remaining oscillation amplitudes and thus protect the valuable system. Furthermore, the couplings compensate within given tolerances for any center mismatches, axial as well as angular offsets of the connected components (motor, gearbox, generator, etc.). Additionally, the rubber elements insulate structure-borne vibrations efficiently. ZF couplings have been approved without reservation by all renowned classification companies for the installation in marine main and auxiliary drives.



Customer-specific design
Extensive calculations like the finite-element-method as well as dynamic situations ensure a tailor-made design of the ZF couplings.

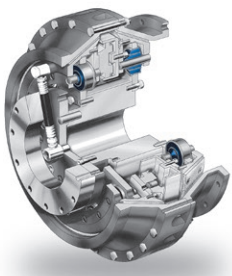
COMPLETE RANGE ZF offers a wide range of couplings and clutches for the complete power-train of all kinds of vessels, boats and yachts.



PNEUMAFLEX RANGE
The particular features of a highly elastic torsionally and vibration-damping coupling are perfectly combined with those of a pneumatically operated double cone friction clutch in the form of our PNEUMAFLEX clutch. This reliably separates or connects the power flow between a diesel engine and the drive unit.



SPIROFLEX RANGE
The highly elastic torsionally SPIROFLEX shaft couplings with their rubber elements compensate for off-center misalignment and deviations from the angular and axial position. Their high vibration-damping capabilities make them indispensable for drive units susceptible to torsional vibrations.



PNEUMASTAR RANGE
Where fast and reliable declutching is indispensable and torsional vibrations in the power transmission can be neglected, the torsionally stiff, pneumatically operated PNEUMASTAR clutch is the right drive element to choose. The only wear to which these clutches are subject is that of their environmentally acceptable friction pads.



HIGHLY ELASTIC COUPLINGS SPIROFLEX

Experience from more than 20,000 drive installations has led to the high torsional elasticity and excellent dampening capability of the SPIROFLEX shaft coupling that renders this coupling indispensable for propulsion systems prone to torsional vibration. The most significant feature of the coupling is its rubber elements' high torsional flexibility. Various rubber hardness grades effectively influence the natural frequencies arising in the respective drive system. As a result of major development efforts considerable improvements were attained in the area of attaching rubber material to steel parts. The shaping of the vulcanization surfaces of ring elements and segments as well as the shaping of the rubber contours, which has been proven by comprehensive testing and documentation, led to an uniform, low stress/strain distribution over cross sectional area as well as to a low deformation energy density at the segmental faces. The extreme reductions of stresses in the marginal zone of rubber-to-metal bonding interfaces and a high dynamic safety are further advantages.

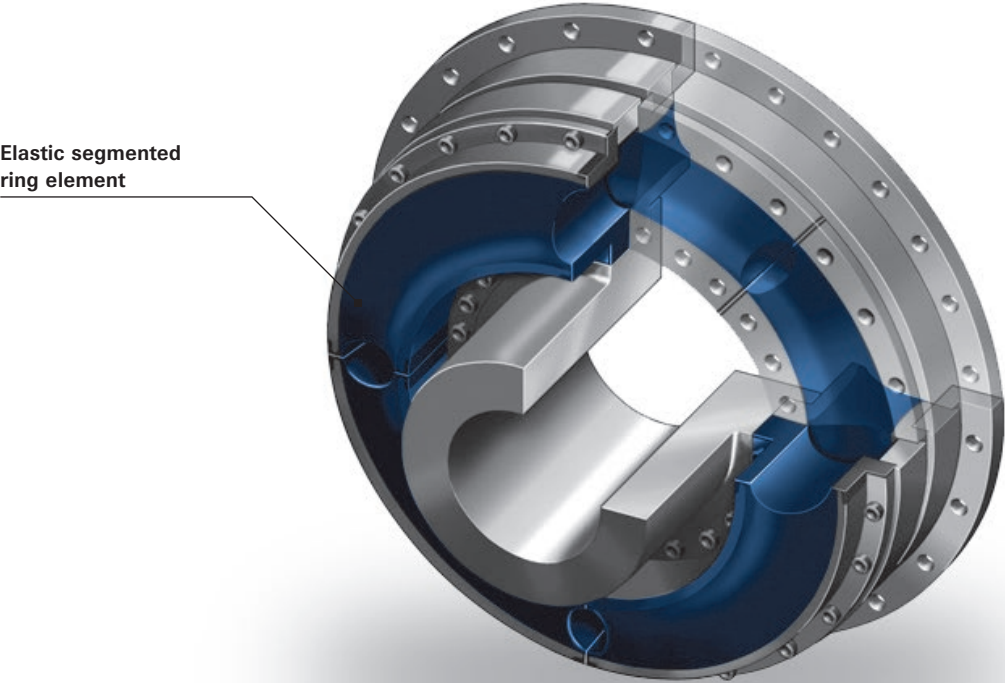
MAIN ADVANTAGES OF SPIROFLEX COUPLINGS

- High torsional flexibility
- Different rubber hardness grades available
- Especially torsionally soft couplings can be built by arranging rubber elements in series
- Elements can be removed radially
- Exclusively features frictionally locked connections
- Backlash-free torque transmission
- Flywheel connecting dimensions acc. to DIN 6288
- Up to four parallel arranged segment rings

→ Accessories see page 9

TECHNICAL DATA		from	up to
Nominal torque T_{kN}	kNm	3.41	928
Permiss. damping power P_{kW}	kW	0.18	6.08
Dyn. torsional stiffness $C_{T\ dyn}$	kNm/rad	2.18	5,584
Max. speed n_{max}	min ⁻¹	520	3,200
Diameter D	mm	390	2,100
Weight m_{total}	kg	79.4	6,204

Figures for standard product range. Special types on request.



HIGHLY ELASTIC CLUTCHES PNEUMAFLEX

The special qualities of a highly torsionally elastic and vibration dampening coupling and those of a pneumatically operated double cone friction clutch are purposefully combined in this PNEUMAFLEX clutch. It reliably interrupts or establishes the flow of power between the diesel engine and the other driving components. Experience from some 5,000 installations that have been operating the PNEUMAFLEX clutch since 1964 has led to the development of the technologically advanced highly elastic clutch as it is offered today. The clutching components comprise two inner friction cones which are pressed against two outer friction conical faces via the pneumatically actuated clutch cylinder. The elastic part comprises rubber elements arranged in parallel which were completely optimized enhancing the coupling's reliability and performance significantly.

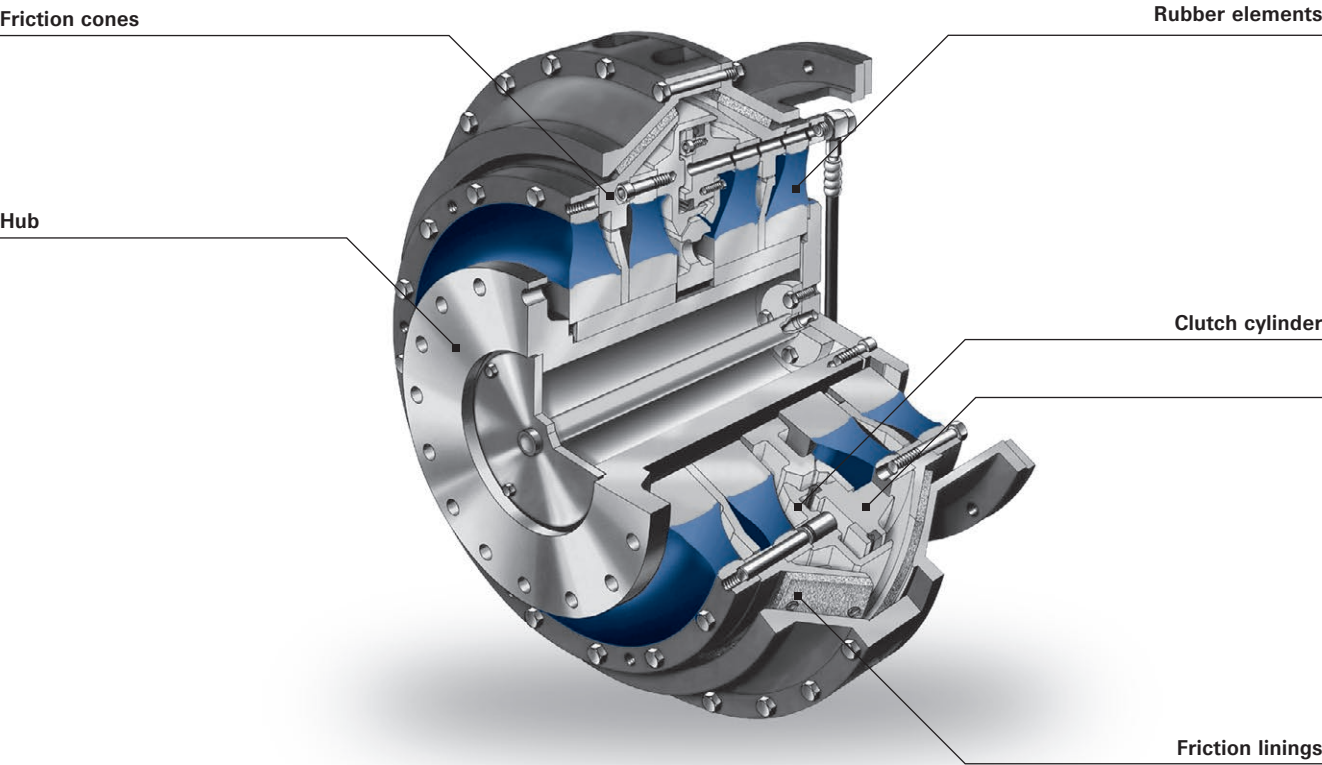
MAIN ADVANTAGES OF PNEUMAFLEX CLUTCHES

- Combination of a dry friction clutch and highly elastic coupling without short-lived idle bearing system
- Complete separation of primary and secondary sides
- Backlash-free, no wear of components subject to backlash
- Smooth and easily controllable engaging operation
- Protects the propulsion system against overloads if a slip monitoring unit is used (see page 9)
- Clutches of type KAP can be vertically removed

→ Accessories see page 9

TECHNICAL DATA		from	up to
Nominal torque T_{kN}	kNm	3.41	304
Permiss. damping power P_{kW}	kW	0.37	3.70
Dyn. torsional stiffness $C_{T\ dyn}$	kNm/rad	13.1	1,748
Max. speed n_{max}	min ⁻¹	660	2,400
Diameter D	mm	525	1,740
Weight m_{total}	kg	208	8,463

Figures for standard product range. Special types on request.



TORSIONALLY STIFF CLUTCHES

PNEUMASTAR

The PNEUMASTAR clutch is a torsionally stiff double-cone friction clutch. The clutching components consist of two inner and two outer friction cones of which the inner ones are pneumatically pressed against the outer tapered friction faces via a clutching cylinder. Rubber sleeve springs form the torsionally stiff portion of the clutch. As the clutching components are moved over the rubber sleeve springs during the actuation of the clutch, a wear-causing axial sliding movement between the various contacting parts is avoided. Pneumatic operation of the clutch enables speedy and precise manoeuvring, which is a prerequisite to qualify the clutch for use in the marine application. For example, a twin-engine installation can be manoeuvred with a counter-rotating propeller, without the need to reverse the engines continually. This is achieved by having engines running in opposite rotation to each other and connected via the manoeuvring clutch onto a twin-input/single-output reduction gearbox. Selective engagement/disengagement of the clutches will provide the manoeuvring facility.

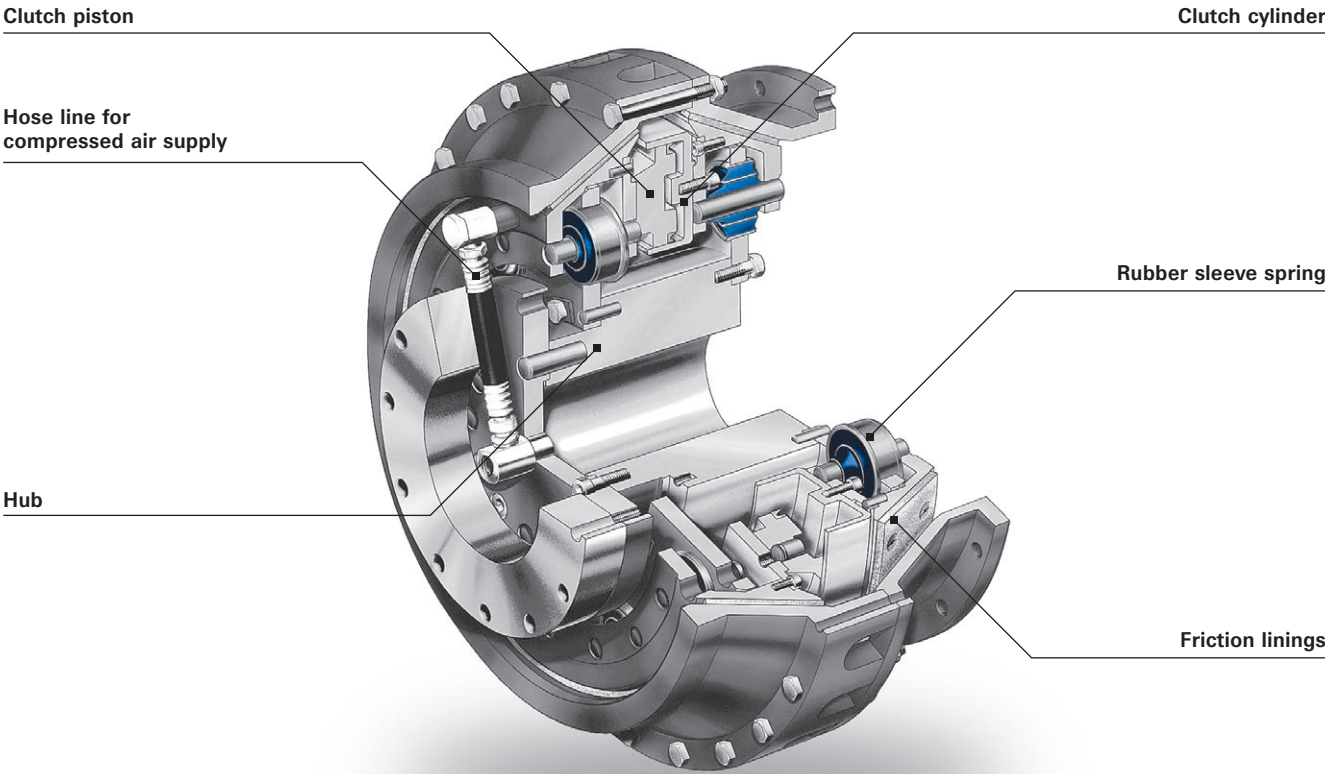
MAIN ADVANTAGES OF PNEUMASTAR CLUTCHES

- Combination of a dry friction clutch and torsionally stiff coupling without short-lived idle bearing system
- Complete separation of primary and secondary sides
- Backlash-free, no wear of components subject to backlash
- Smooth and easily controllable engaging operation
- Protects the propulsion system against overloads if a slip monitoring unit is used (see page 9)
- Pneumatically switchable

→ Accessories see page 9

TECHNICAL DATA		from	up to
Nominal torque T_{kN}	kNm	5.56	1,390
Dyn. torsional stiffness $C_{T\ dyn}$	kNm/rad	906	263,656
Max. speed n_{max}	min ⁻¹	520	2,900
Diameter D	mm	525	2,540
Weight m_{total}	kg	155	18,955

Figures for standard product range. Special types on request.



ACCESSORIES FOR

COUPLINGS AND CLUTCHES



ZF also supplies various accessories for couplings and clutches to protect the entire installation against overloading due to torque shocks or torsional vibrations.

Electro-Pneumatic Remote Control Device

For PNEUMAFLEX and PNEUMASTAR clutches, the Electro-Pneumatic Remote Control Device PFA 8600 serves to adjust the engaging time and trigger alarm in the event of compressed air failure. If the standard solenoid valves have been actuated by external interlocking devices, the remote control device automatically disengages the clutch or blocks its engagement. Furthermore, the device serves to control the automatic changeover from engaging air pressure to operating air pressure as well as the automatic disengagement of the clutch if the clutching air pressure falls below the level required for slipfree torque transmission.

Electronic Slippage Monitoring Device

The Electronic Slippage Monitoring Device CA indicates on PNEUMAFLEX and PNEUMASTAR clutches inadmissible clutch-slippage. The monitoring function of the unit is based on measuring the speed difference arising between the primary and secondary part of the clutch. Thus the maintenance-free and contact-free monitoring unit offers additional safety to prevent damage due to overloading.

Electronic Alternating Angle Measuring Device

The Electronic Alternating Angle Measuring Device FA serves to monitor excessive torques resulting from torsional vibrations. The device measures and monitors alternating angles superimposed on the nominal angle of twist in highly torsionally elastic SPIROFLEX and PNEUMAFLEX couplings respectively clutches. Measurement parameter is the changing angle of twist between the primary and secondary part of highly elastic rubber elements of the coupling. The measuring device is maintenance-free, operates contact-free and does not suffer mechanical wear. To ensure a high degree of functional reliability this monitoring system is equipped with integrated circuits.

Electronic Engaging Blockade Device

The Electronic Engaging Blockade Device EEB is an independent monitoring unit for clutches. It prevents PNEUMAFLEX and PNEUMASTAR clutches from being destroyed in the event the secondary side of a propulsion system is blocked by external influence. During engagement the primary and secondary speed rates are compared within a selectable time span. Measurement is taken in a contactless manner via pulse encoder. Initiating the engagement of the clutch is governed by monitoring the secondary side speed rate. The electronic components are maintenance-free and do not suffer mechanical wear.

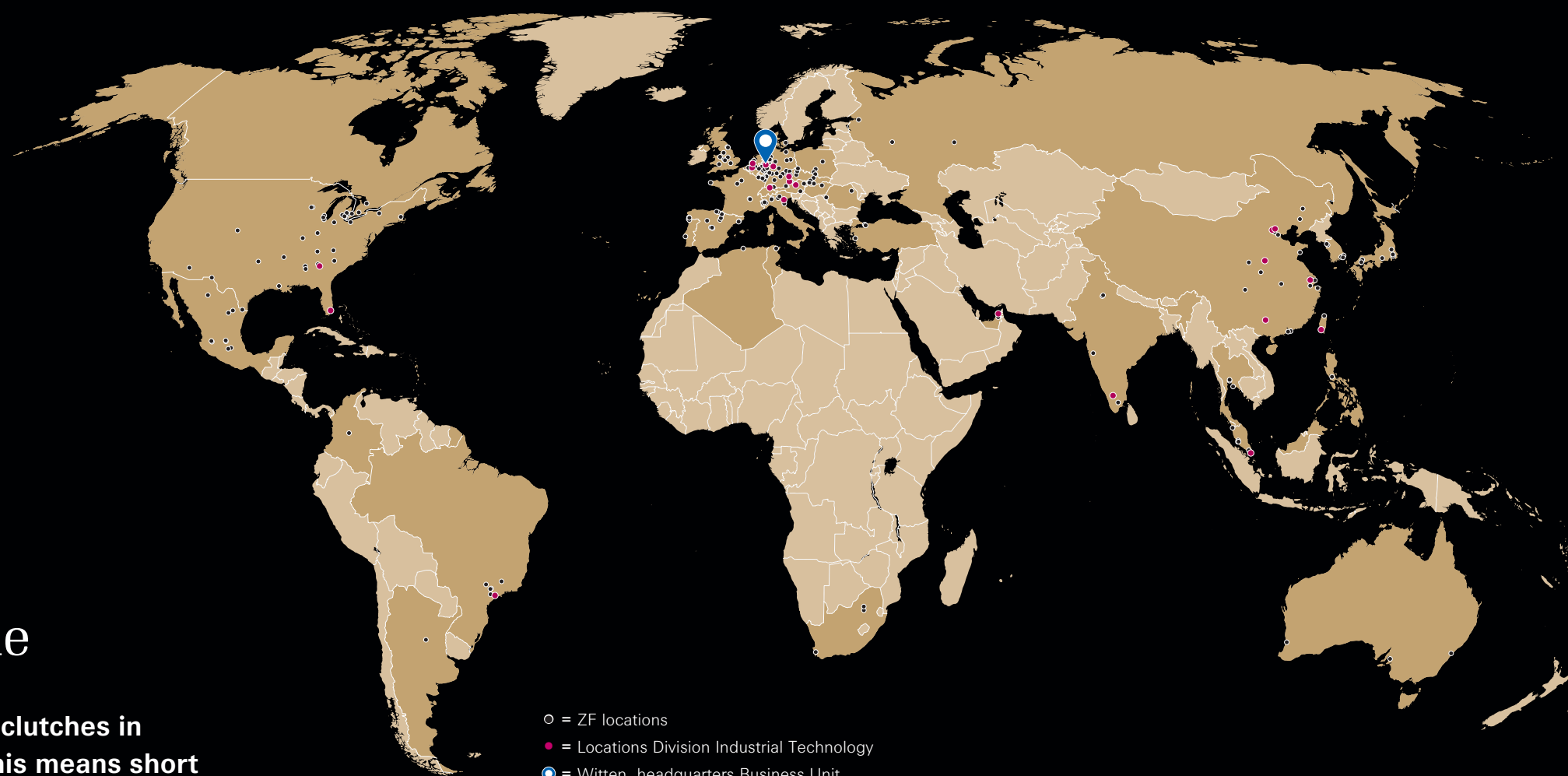
33

OWN SERVICE COMPANIES



650

SERVICE PARTNERS WORLDWIDE



- = ZF locations
- = Locations Division Industrial Technology
- = Witten, headquarters Business Unit Industrial Drives

Excellent service worldwide

ZF offers a professional service for its couplings and clutches in almost every region of the world. For the customer this means short distances, fast reaction times, the right experts on short notice, and thus, a trouble-free drive train operation.

Complete customer satisfaction is one of the top objectives which ZF wants to achieve with its products and services. This demand determines the quality of all the services linked to our products, starting with development and consultancy through after-sales service.

ZF supports you as a reliable partner over the whole life cycle of your couplings and clutches. The core activities in the service are coordinated by the Witten location and carried out on-site – including the whole spectrum of after-sales services from consultancy to train-

ing sessions, from product selection to commissioning, from quality optimisation to documentation.

Furthermore, with the ZF Services Business Unit the group has a global service organisation which ensures that ZF products operate reliably over the whole life cycle. 33 ZF service companies and over 650 service partners in all the important markets ensure customer proximity and global deployment, combined with regional approaches which take into account the specific requirements of individual markets and applications.

ZF INDUSTRIEANTRIEBE WITTEN GMBH OFFERS EXTENSIVE SERVICES FOR CLUTCHES AND COUPLINGS



EXCHANGE COUPLINGS AND CLUTCHES

ZF has produced and delivered more than 30,000 couplings/clutches. Whenever exchange is needed, ZF Industrieantriebe Witten GmbH acts fast and reliably.



REPAIR

Our thorough knowledge of coupling/clutch designs ensures a flawless and cost-optimised repair. Overhaul and new production of single parts are carried out by us according to the original drawings. Prior to shipment, repaired couplings and clutches are tested according to strictest quality standards on our test benches and all results are recorded in a test protocol.



SPARE PARTS

This service is characterized by speed, competence and worldwide efficient logistics. You receive original manufacturers' spare parts – even after the end of series production – as well as spare part kits and conversion kits for existing equipment.



INSPECTION AND EARLY DAMAGE DETECTION

Predictive maintenance of the couplings and clutches increases the availability of your machine or plant and improves the efficiency in operation. Our qualified service technicians possess extensive experience in detecting damage at an early stage with the assistance of proven inspection programmes and modern measuring and testing equipment.



FIELD SERVICE

Our qualified and experienced service technicians provide fast support on the spot worldwide, ranging from the visual inspection through endoscopy to structure-borne sound measurement, repair and oil analysis.

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MOTION AND MOBILITY