

Powerful, efficient, reliable Key components for combined cycle power plants

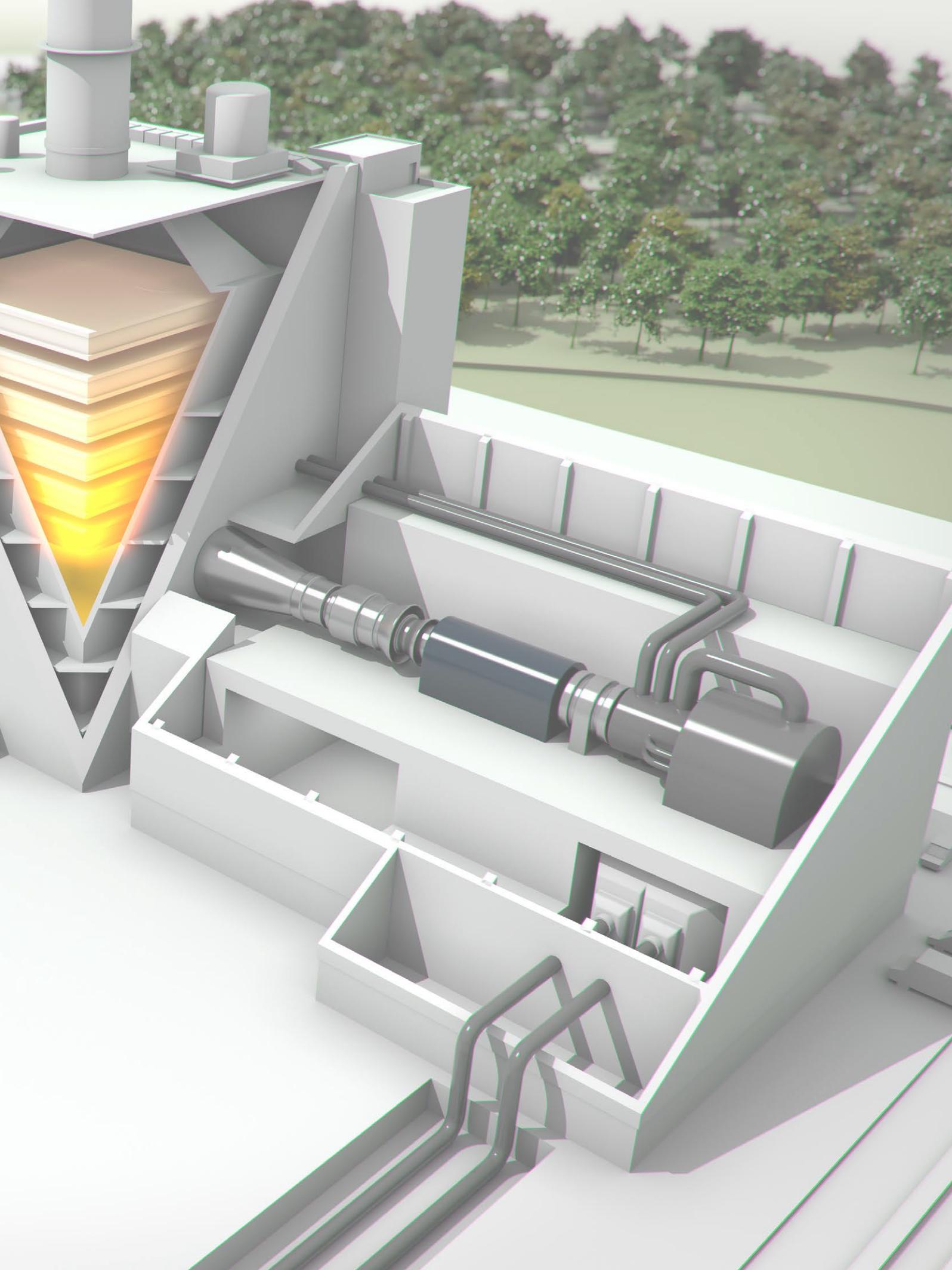




Voith has been a trusted partner for the combined cycle power plant market for 50 years. Our products are extremely reliable and make your operation more efficient.

Our product portfolio:

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Speed control for boiler feed pump

Variable speed couplings

In a combined cycle power plant, many design safety margins are considered for the feed water pump. This means that even in a base load plant, the pump already operates far within the throttle mode and thus a lot of energy is wasted.

- Safety margins in flow (10 to 25 %)
- Safety margins in pump speed (5 %)
- Safety margins in pressure (5 to 20 %)
- Safety margins in steam production (5 %)

The operating point of a pump results from the intersection of pump characteristic curve with the system's resistance curve. Other operating points may be obtained by increasing the sys-

tem's head loss by throttling. In addition to the head loss, the pump efficiency decreases significantly when operating at lower flow rates.

A more economical way to control the pump flow is to change its speed, resulting in different pump characteristic curves.

The use of a variable speed coupling allows reducing the speed of the boiler feed pump for partial load conditions. This results in significant energy savings compared to fixed speed operation with throttle valve. In addition, the pump can be operated close to its optimum efficiency over the whole speed range.

Benefits

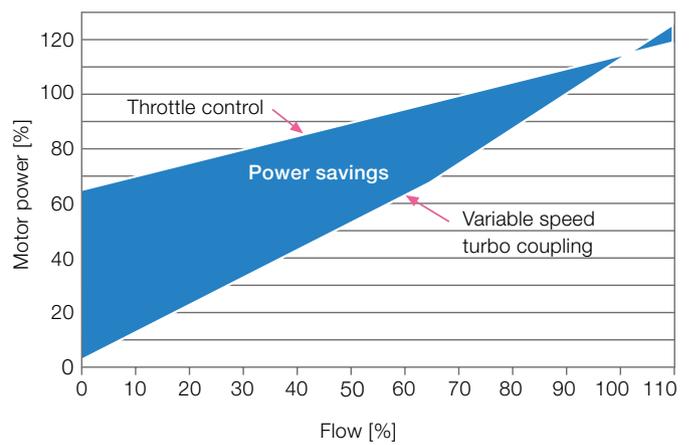
- + Outstanding reliability
- + Increases the reliability of the whole drive train
- + Energy saving against throttle control
- + Simplicity → low grade of complexity
- + Robustness → suitability for outdoor operation also under extreme climatic conditions
- + Spare parts availability throughout the whole lifecycle (30 years and more)
- + Low maintenance expenditures (maintainability / serviceability) are very high
- + Integral lube oil system

Product description

Variable speed turbo couplings are fluid couplings, connecting the motor with the boiler feed pump. They enable stepless speed control of the pump. Hydrodynamic couplings provide wear free power transmission and vibration dampening between input and output. In addition they can also serve as the lube oil system in the drive train; i.e., they can supply lube oil to the motor and to the boiler feed pump. With the scoop tube (moved by an actuator), the content of oil inside the runner parts is being changed and therefore the output speed of the machine.

When using speed regulation, additional cost savings can be achieved by selection of a less expensive recirculation control flow valve and a 100% control valve (small differential pressure). With service life of a power plant averaging about 30 years, no one can predict fuel and gas prices as well as load patterns over this period of time. Flexibility is a key issue for today's advanced power station technology. The operation of boiler feed pumps should be flexible, too. This can only be achieved by variable speed operation of pumps.

Comparison of motor power consumption between the use of throttle control and variable speed turbo coupling



S-Type variable speed turbo coupling



**200 kW to
6000 kW**
power and
3000 / 3600
rpm speed

Cost comparison of throttle control versus variable speed turbo coupling

3x50 % Boiler feed pumps	Throttle control		Turbo couplings	
	425 MW	Test block	425 MW	Test block
Operating points				
Operating hours	[h/yr]	7990	10	7990
Flow	[kg/s]	62.70	78.38	62.70
Head	[bar]	131.99	115.21	93.50
Feed water density	[kg/m ³]	925.87	925.87	925.87
Pump efficiency	[%]	78.96	80.00	80.00
Pump speed	[rpm]	2980	2980	2487
Absorbed power	[kW]	1 132	1 219	791
Slip losses	[kW]	–	–	157
Mechanical losses	[kW]	–	–	12
Total power	[kW]	2 x 1 132	2 x 1 219	2 x 960
Energy per year	[kWh]	18 089 360	24 380	15 340 800
Total energy per year	[kWh]		18 113 740	15 366 340
Energy cost 1 kWh: 0.05 €	[€]	905 687		768 317

Savings: 137 370 € per year

Example: Cost return studies have shown that amortization time by speed variation is usually between 6 and 20 months.

RKM-Type geared variable speed turbo coupling



RKM-Type
geared variable speed turbo
coupling for a BFP with
5000 to
6000 rpm



“For almost 40 years Voith has supplied variable speed fluid couplings as boiler feed pump drives for combined cycle power plants, successfully supporting the CCPP boom since the beginning of this millennium. A fleet of more than 1,300 units is currently (2018) in operation. The main success factor is the unmatched reliability based on a robust design.”

Ralph Höfert, Product Manager Variable Speed Couplings at Voith, Germany

Starting and turning devices for gas and steam turbine

Hydrodynamic torque converters

Reliable starting of gas turbines is essential for safe operation of combined cycle power plants. Providing a high torque for breakaway and acceleration into the self-sustaining speed range of the gas turbine are the key functionalities of the Voith torque converter family for starting gas turbines.

Based on the indirect principle of hydrodynamic power transmission invented more than 100 years ago by Hermann Föttinger, torque converters are used to optimally adapt the characteristics of a driver to the needs of the driven machine.

Mechanical energy, from a typically constant speed driver, is transformed into kinetic energy in a fluid flow by a pump wheel and reconverted back into mechanical energy via a turbine wheel.

The momentum support, which is essential for torque and speed conversion, is achieved by changing the flow by means of guide vanes. This principle is the basis for high availabilities and a long life-time. In numbers: Mean time between failures of >100 years are achieved based on our experience with thousands of torque converters in operation all over the world. Challenging environmental conditions like desert, offshore or extreme cold conditions are also typical areas of operation. Optional available integrated turn devices are used for maintaining the gas turbine as well as safe cooling of the turbine rotor.

Various models and add-ons are available to match the torque converter to your specific starting needs.

Hydrodynamic torque converter



Benefits

- + Fixed or variable guide vanes for smooth and controlled startup
- + Drainable housing to eliminate disconnecting coupling
- + Integrated turn device for safe cooling and maintenance
- + Single torque converters for space saving integration into gas turbine frame
- + Complete starter packages ready commissioned

Rotor turning gears

Rotor turning gear units primarily provide safe cooling for hot rotors in a steam or gas turbine or compressor by slow turning. This helps the rotor remain dimensionally stable. Rotor turning gear units also provide for breakaway, startup, or precise positioning of shaft trains.

Overrunning clutch operating principles

The rotor turning gear unit can be mounted on the free pinion shaft end of a gear unit, for example. After checking the start-up conditions (electrical voltage, lubricating oil pressure, hydraulic fluid boost, turbine rotor stopped), the rotor turning gear unit establishes the connection with the rotor on startup. The rotor turning gear unit then brings the shaft train to a pre-defined speed.

As the line continues to accelerate, the rotor turning gear unit decouples by having the slip gearing release the connection from the rotor turning gear unit and the swivel pinion in the axial direction and allowing the centrifugal forces to push the locking latches radially outwards. The rotor turning gear unit now spins down until it shuts off. If the shaft train shuts down for maintenance work, for example, the rotor turning gear unit is simultaneously brought back up to its rated speed. The

latches lock in, and the rotor turning gear unit and the shaft connect upon speed synchronization. The shaft train is brought to a low speed in a controlled manner. The rotor turning gear unit is switched off in order to stop the rotor.

Swivel pinion operating principle

The rotor turning gear unit can be mounted on the bearing housing of a gas turbine, for example. After checking the start up conditions – such as compressed air feed, electrical voltage, lubricating oil pressure, hydraulic fluid boost and stopped turbine rotor – the swivel pinion engages with the gearing on the turbine shaft. In this way, the rotor turning gear unit brings the shaft train up to the rated speed for the rotor turning gear unit. This enables the gas turbine to continue accelerating on its own. The rotor turning gear unit disengages and spins down until it shuts off. If the shaft train is shut down for maintenance work, the rotor turning gear unit returns to its rated speed once a specific turbine coastdown speed is reached. When the speeds are synchronized, the rotor turning gear unit swivel pinion re-engages and brings the shaft train to a low speed in a controlled manner. The rotor turning gear unit is switched off in order to stop the rotor.

Rotor turning gear units



Benefits

- + High reliability and low failure rates
- + High degree of flexibility in line configuration
- + Repair-related costs will be lower
- + An additional increase in system availability
- + Fully automatic operation

Connecting and safety couplings

Diaphragm couplings

The diaphragm coupling converts torque reliably, safely and without wear or the need for maintenance. Equipped with single or double diaphragms, these connection couplings cover a performance range between 100 and 70 000 kW.

Diaphragm couplings from Voith are the ideal connection of a turbo gearbox with the driving or driven machine. The EconTors single diaphragm coupling runs at speeds up to 8 000 rpm in medium-speed applications, whereas the TwinTors double-diaphragm coupling is used in high-performance compressors or test rigs at speeds up to 80 000 rpm.

Designs are available for all possible connection applications. The rotor dynamics, noise and airflow characteristics of the couplings can be optimized as needed.

High-performance diaphragm couplings are extremely robust, and their ability to compensate for an angular displacement of up to 0.5 degrees increases drive train operational reliability.

TwinTors diaphragm coupling



Benefits

- + Adapted to the operator's technical requirements
 - + Favorable total cost volume (CAPEX + OPEX)
 - + Designed to provide the best rotor dynamic characteristics
 - + High level of safety
 - + Minimizes maintenance expenses
 - + Low turbulence
 - + Special noise-protection measures
 - + Cooling and monitoring equipment
-

SafeSet torque limiting couplings for driveline protection

The SafeSet principle is simple: friction and adaptability. No material fatigue or wear ensures constant torque protection during operation.

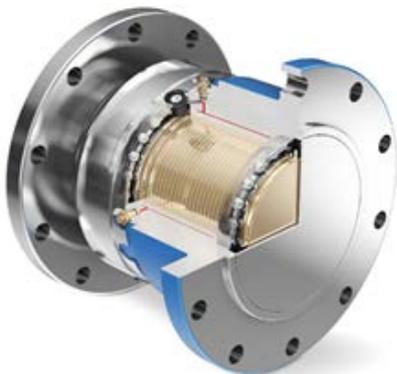
The SafeSet coupling includes a twin-walled hollow sleeve. Friction is generated upon expansion by pressurized hydraulic oil. The integrated shear tube holds pressure to ensure a constant but easy adaptable torque transmission. In an overload situation, the SafeSet slips and the shear tube shears off. Oil pressure drops and the frictional surfaces separate. Then the SafeSet rotates on the bearings without transmitting any torque.

Torque capacity available between 1 kNm and 20 000 kNm.

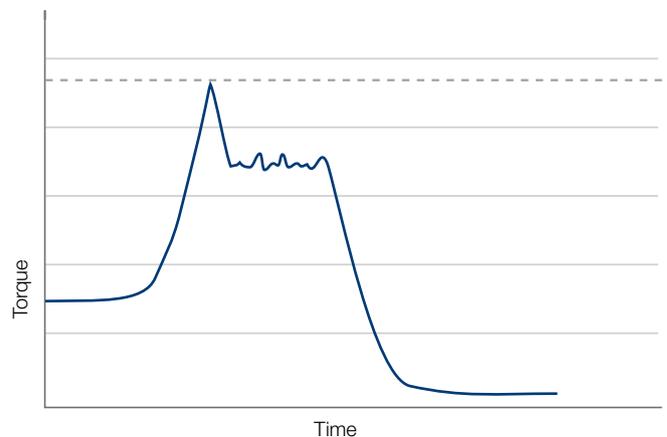
Benefits

- + Maximum driveline protection
 - + Accurate and constant release
 - + Adjustable release torque
 - + Quick resetting for maximum uptime
 - + Custom made to suit individual requirements
-

SafeSet torque limiting coupling



SafeSet with instant release



Voith – Proven technology in combined cycle power plants





Actuators and control systems for turbomachinery

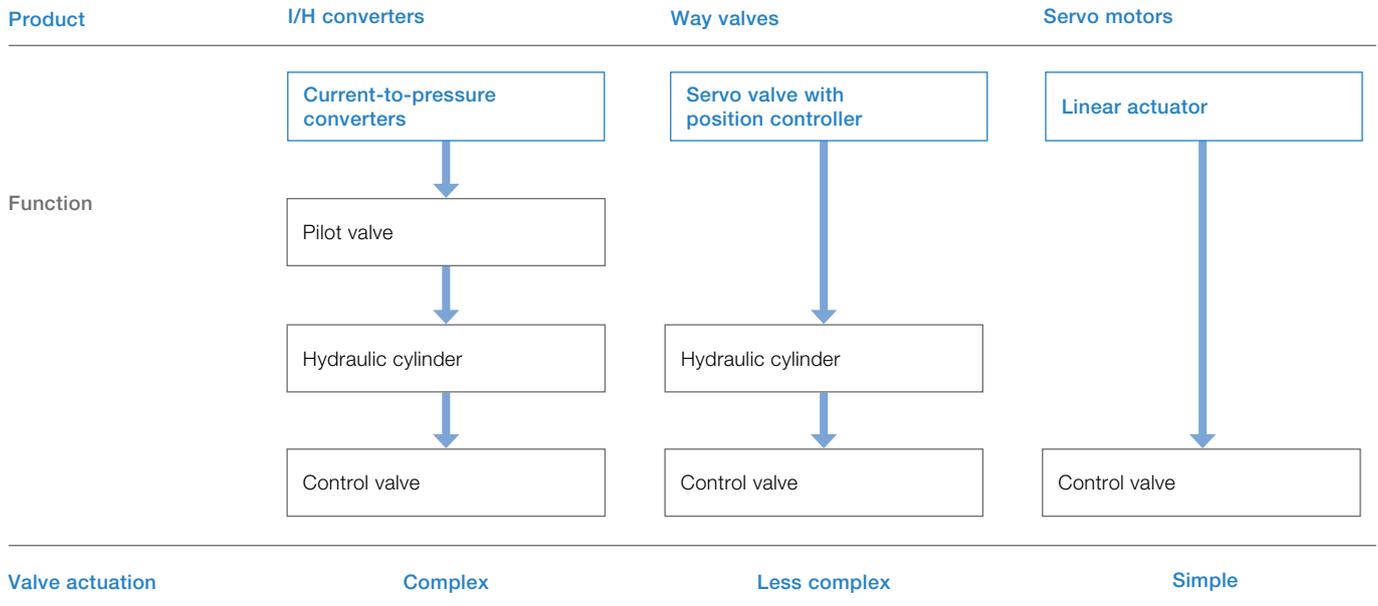
Control actuators

We design the actuator solutions in line with your requirements for safety and availability. For example, we offer redundant products for high-availability process units or certified products for potentially explosive atmospheres. In addition, most of our actuators are SIL certified and thus comply with the international standard for operational safety.

Benefits

- + Our actuators reduce the complexity of your overall control system.
- + The results are increased reliability and availability of your plant.
- + This helps you to run a trouble-free and profitable operation.
- + The outstanding control speed and precision of the actuators provide stable processes that ensure high quality for your products.

Three different product groups for actuating control valves



Voith product
 Provided by the customer

Safety actuators

The design of the products is compact and modular. This allows nearly all standard safety concepts for turbine control systems to be implemented in a cost-effective way. As an option, the products are available in explosion-proof design.

Controllers

Voith control systems are suitable for all steam turbines used to drive generators, compressors, pumps and other mechanically driven machines.

The control systems are available in two designs:

1. Standard controllers that are “pre-engineered” with standard software.
2. Customized controllers offering different functionality and redundancy options with adapted software and optional redundancy.

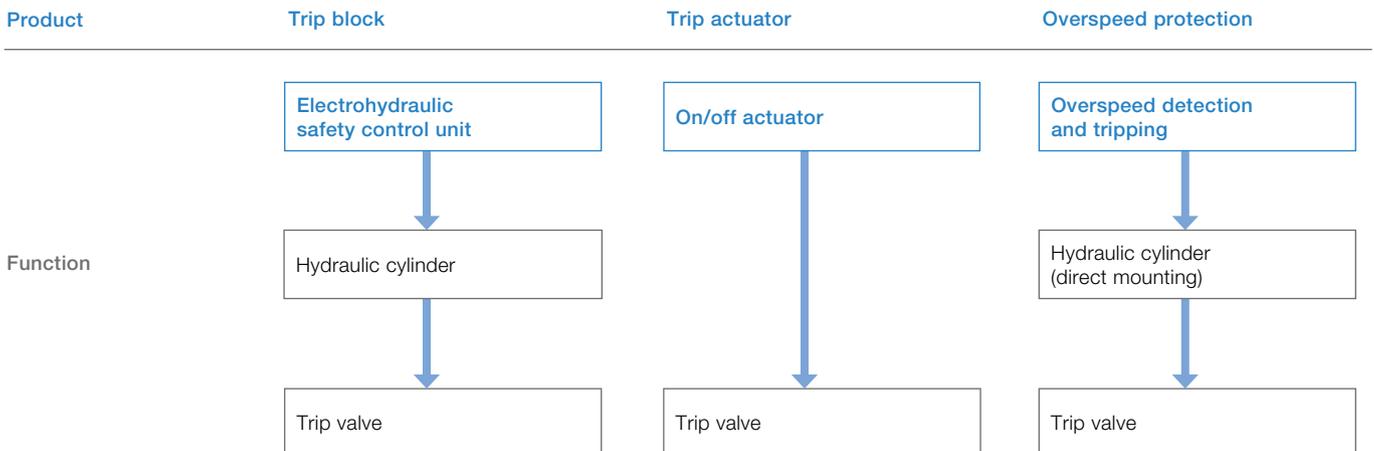
Benefits

- + In the event of a trip, your turbine safely shuts down via our actuators in the shortest possible time.
- + You avoid immediate and consequential damage resulting from turbine overspeed.

Benefits

- + Your turbine or compressor operates safely, reliably and efficiently with our controllers.
- + You ensure the productivity of your plant and the quality of the produced products.
- + Your turbine or compressor operates very efficiently with proven and multiple tested software algorithms. Our engineers are continually refining these algorithms and adapting them to the current state of the art.

Three product groups for actuating trip valves



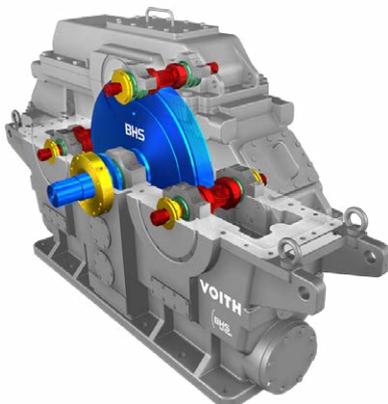
Integral gear units for fuel gas booster compressors

Integral gears

With more than 45 years of experience, Voith has supplied the core unit for over 2000 integrally geared compressors. These types of compressors have now established themselves in the process industry. Originally this field was clearly reserved for freestanding axial, radial and also reciprocating piston compressors. Among the main reasons for this development is the lower space requirement and the higher total efficiency of the compressor package.

Our standardized and customized gearbox solutions for fuel gas boosting applications provide the customer the ideal solution for their integrally geared compressor and help the operator to keep their power generation facility reliable and efficient.

Integral gear



Benefits

Integral gear technology provides a very efficient and reliable solution combined with space savings:

- + Customized to the operator's needs
- + Optimized for the compressor application
- + Long periods without unscheduled downtimes
- + Higher efficiency than comparable single-shaft designs
- + Each stage can be optimized to run at its ideal speed
- + Smaller footprint and low weight

Turbo gear units for gas and steam turbine

Parallel shaft gears and planetary gears

Voith gear units are used between gas or steam turbines and generators of combined cycle plants to convert torque with high efficiency.

Planetary gear units cover powers up to 45 MW, speeds of up to 80 000 rpm and torques of over 550 000 Nm. With single-stage designs, ratios up to 12:1 are achieved; with two-stage, even ratios up to 80:1.

Parallel shaft gear units transmit power levels up to 85 MW with gear ratios available from 1:1 to 10:1.

All gear units can be customized to fit the application and meet the operator's needs. This means the driving and driven rotational direction, the toothing design, and the shape and material of the housing are all optimized to your equipment. The international standard for ISO, AGMA or API are fulfilled. The "Stoeckicht principle" ensures an ideal load balance between the sun pinion, planet gears and ring gears on planetary gears. Planetary gears achieve highest efficiencies at higher gear ratios $i > 6$, enable coaxial drive trains and are very compact.

Parallel shaft gears can be equipped with internal quill-shafts for direct connection of the generator, shaft-driven lube oil pumps, turning gears or with the AeroMaXX technology for high efficiency gears.

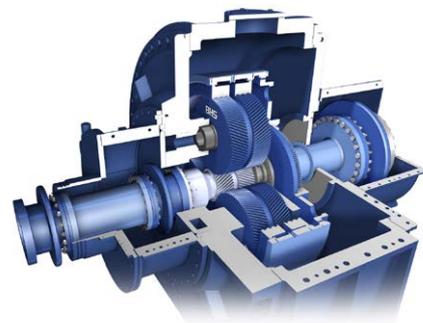
Connection couplings to the high-speed machine are already integrated into the planetary gear unit or can be ordered as a package with the parallel shaft gears.

These features enable a highly reliable solution with a service life over 250 000 operational hours. Unit efficiency can reach levels of up to 99.3 %, especially with AeroMaXX technology. This means that a very high level of overall productivity is achieved, particularly in applications where high powers are transmitted.

Benefits

- + **Efficiency:** saving energy with high efficiency gear solutions
- + **Availability:** increased lifetime and operational safety
- + **Reliability:** very long periods without unscheduled downtime
- + **Predefined standards customized to the operator's needs**
- + **Low noise levels due to the use of double helical gears**
- + **Lightweight and space-saving drive trains**

Parallel shaft gear and planetary gear





Our Service –
Part of Your
Business.

A competent service partner at your side

Backed by 500 service technicians, 43 workshops, and more than 150 years of industry experience, Voith Service is a reliable partner for operators of gas and steam turbine power plants. This team helps customers conquer daily challenges. Its guiding principle is to make operating power plant components from Voith's own production or third parties even more safe, reliable, durable and efficient.

In this process, Voith sees itself as a partner to power plant operators and, in accordance with its service philosophy, focuses its actions and efforts on the needs of each individual customer.

In addition to conventional services, Voith has options of special interest to the power plant industry: service agreements, rapid production and delivery of spare parts, individual warehousing concepts for machine fleets, prompt and economical equipment condition assessments, expert technical support for operational problems, as well as upgrades and retrofits for performance-increasing measures and modifications to operating methods.

Consult our experts on further optimizing the operation of your plant!

Explore service cases for drive trains with turbines, pumps and compressors at our website: www.voith.com/turbo-industry-service



Technical service & agreements

- 24/7 emergency number
- Engineering support
- Fault and root cause analysis
- Troubleshooting
- Remote service
- Status monitoring
- Condition assessment
- Measurements and analyses
- Customer training classes
- Service agreements
- Warranty extensions



Spare parts & replacement machines

- Spare parts packages
- Replacement machines
- Parts manufacture
- Express delivery
- Warehousing
- Tools and accessories



Maintenance, repair & overhaul

- Installation and commissioning
- Outdoor installations
- Repair shop-based servicing
- On-site repairs
- Emergency repairs
- Test runs



Retrofit & modernization

- Modernization
- Upgrades
- Exchange
- Retrofit
- Turnkey solutions

Offices and workshops worldwide



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Inspiring Technology
for Generations