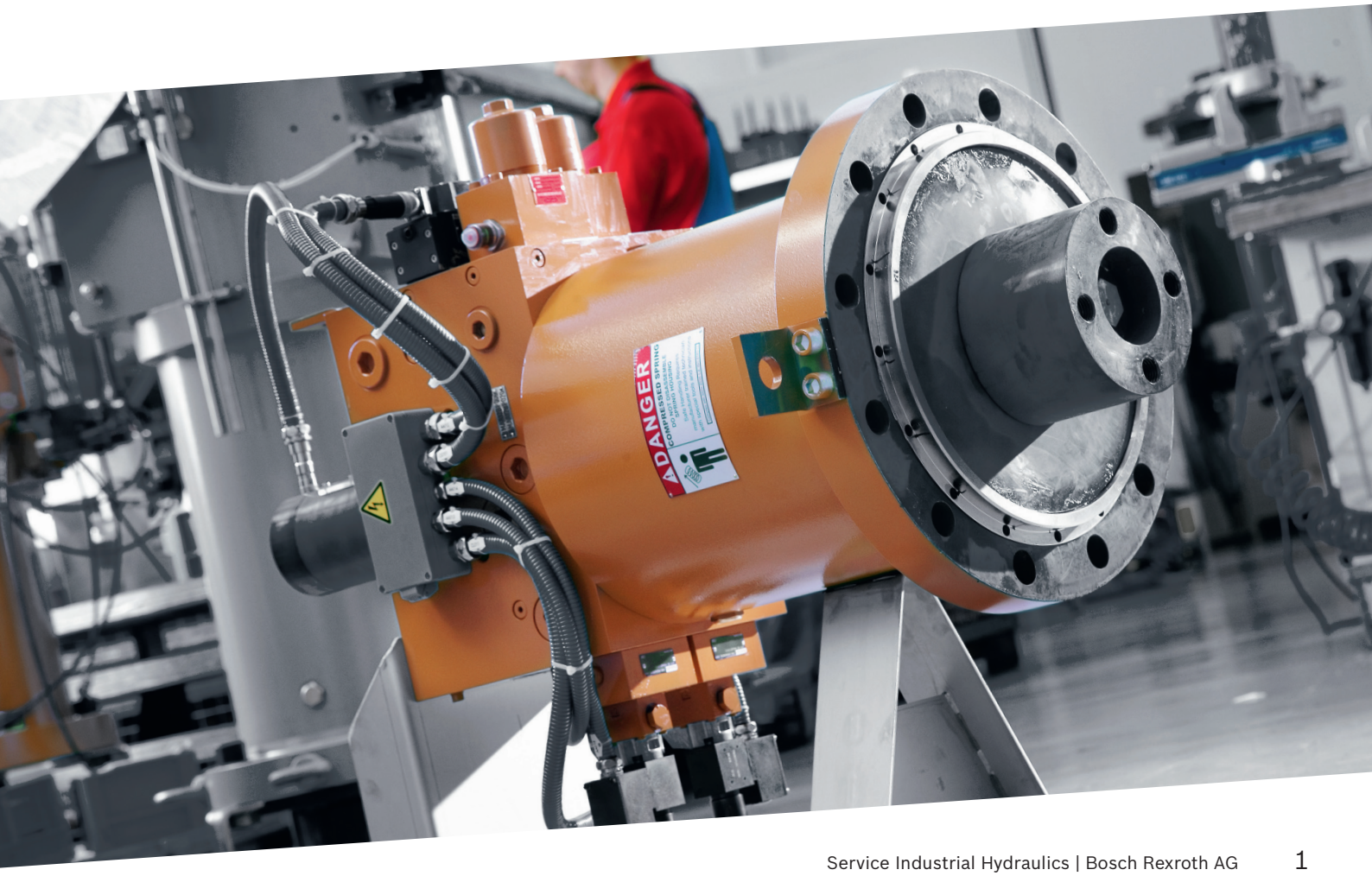
rexroth
A Bosch Company

Hydraulic actuators for gas and steam valves

FAILURES AND HIGH COSTS CAN BE PREVENTED WITH PLANNED MAINTENANCE

Eight out of ten power plant operators do not realize what they are risking if they allow seal wear in hydraulic actuators to simply take its course. In this practical guide you will find out how to cost-effectively prevent damage and production downtime with predictive planning.

In order for gas and steam turbines to generate electricity with the right output and rotational speed, the supply of media must be precisely controlled. Hydraulic actuators ensure exact control of the valves. In the event of a malfunction, they also carry out an important safety function by mechanically moving the valves into an safety position via spring force in order to disrupting the flow of medium or redirecting it. In order to ensure this in the long term, it is essential that the hydraulic actuators for gas and steam turbines are inspected and maintained at regular intervals in accordance with the relevant legal regulations and manufacturer's recommendations. The reason: each hydraulic actuator – no matter how high-quality it is – exhibits wear due to operational reasons. The wear starts on the seals and, in the absence of maintenance, may extend to other components. Anyone who disregards this fact, and waits until an obvious failure occurs, risks high repair costs and long waiting periods until unrestricted production can be resumed.



IMMINENT LOSS OF THE SIL CAPABILITY

If the specifications from the operating instructions and the safety manual are not complied with – maintenance requirements and proof-test intervals, for example – or if the actuators are not properly used, under certain circumstances the drive loses its SIL conformity and thus its suitability for safety-related applications. Improper usage includes the use of dirty or contaminated hydraulic oil. This can lead to failure of the solenoid valves and cartridge valves, as well as to increased wear on the piston rod seal and the piston rod. In addition, unsuitable placement in the escaping steam can cause damage due to overheating (cf. 1.3), which can subsequently result in strong corrosion on safety-related components – such as magnetic and cartridge valves, piston rod, and spring assembly. Last but not least, a lack of regulation or control poses a risk to the SIL capability, because inadmissible oscillations could cause significant wear in short time.

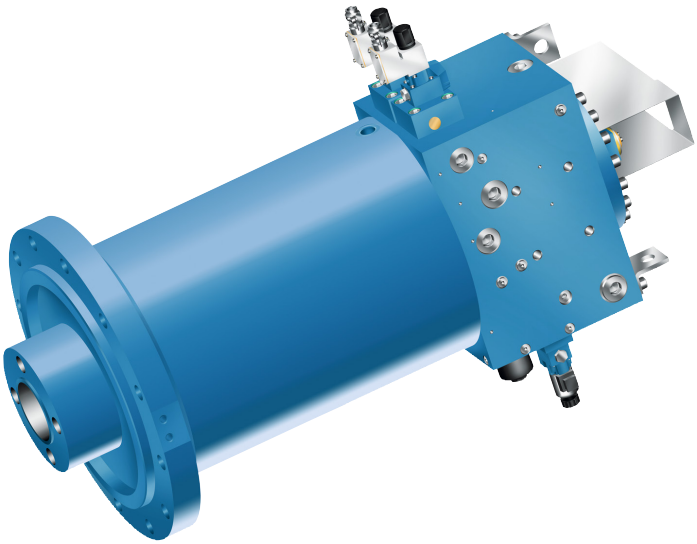
1. Damage causes:

1.1. Ongoing seal wear

In particular, if the piston and rod seals are not replaced according to the schedule for the actuator – at the latest after six years, the wear will lead to functional impairments. First, leakage occurs; later, there is damage to the piston and the piston housing. Depending on the circumstances, this leads directly to failure. On the one hand, the wear ensues regardless of the product quality due to the aging process of the sealing material, which gradually becomes brittle and porous, so that the sealing effect decreases. On the other hand, the frequency of the changes in movement, in combination with the stroke length, plays a role. The strokes are therefore to be determined by the control system so as to ensure that an adequate lubricating film and thus low-wear operation for the seals are ensured. Constant operation in the short-stroke range, on the other hand, leads to increased seal wear and damage to the mating surfaces. Especially in the case of short strokes at high-frequency, the replacement intervals for seals recommended in the maintenance schedule can be significantly reduced. Regular monitoring is essential.
In the case of actuators that only extend to short strokes or remain in one position over a longer period of time – depending on the application, this could be several weeks or months – separated seal particles mostly remain in the chamber, as there is hardly any exchange of the oil. Thus, contamination on the inside of the cylinder builds up and the sealing rings wear down more quickly.

1.2. Incorrect maintenance or assembly

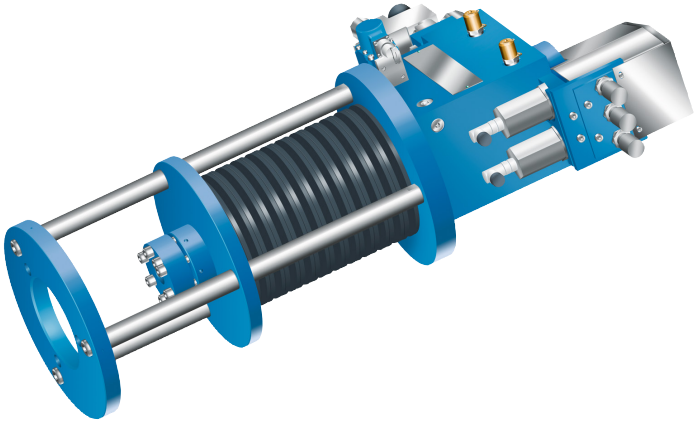
Apart from the wear, maintenance or assembly errors could also be the cause of permanent damage to the actuators. A common source of error is the alignment to the steam or gas valve. If a valve and piston rod are not properly aligned, lateral forces acting on the coupling place stress on the guide belts. Consequently, the guide belts and the seals wear excessively. A further cause of damage resulting from faulty handling is the filling of the hydraulic system with an incorrect fluid. This can trigger a chemical reaction between the seal and the fluid, which in turn accelerates the process of wear and tear.



◂ **Not recognizable from the outside: The natural aging process makes the seals inside become brittle and porous. Permanent operation in short-stroke range additionally limits the sealing effect.**

1.3. Special risks associated with steam valves

Power plant operators who generate electricity by means of steam should also observe the leak-tightness of the steam valves in the direction of the cylinder. If the more than 500 C hot medium flows long enough over the outer coating of the actuator, the coating can “burn off” there so that the surface becomes corroded. Apart from this obvious damage, the spring assembly inside the cylinder can also be damaged, which, in the event of a malfunction, subjects the valve purely mechanically to up to 400 KN force in the locked position.
At the interface to the armature – the coupling – the ambient temperature must not exceed 200 °C. As a result of the effects of excessive heat, the existing anticorrosive coating – consisting of a layer of wax on the Belleville washer system – can be damaged. If a rusty spring cup breaks, the actuator loses its safety function. In this case, the component requires an immediate overhaul in a manufacturer’s certified service center.



▲ **Safety-relevant component: The spring assembly inside the cylinder brings the valve into the safety position purely mechanically in the event of a malfunction. If it breaks due to corrosion, the actuator loses its safety function.**

In addition, uncontrolled steam discharge can damage the actuator due to overheating of the hydraulic fluid, because the fluid temperature must not exceed 70 C in circulation. If the system can not compensate for the influx of heat, the hydraulic oil will be “burnt”. This means that it becomes viscous and sticky. The seal wear increases, valves and other components lose their freedom of movement and function.

2. Consequences of inadequate maintenance

2.1. Reduced control quality

Even before the seals lose their originally intended function through continued wear, increasing internal or external leakage leads to energy losses. The accompanying temperature rise in turn promotes wear and tear in other areas of the hydraulic system. Another consequence of the increased leakage is diminished control quality. Therefore, under certain circumstances, the system would no longer be able to adjust the required performance of the turbine with sufficient accuracy.

2.2. Mechanical damage (worst case)

If the damage of the seal system has deteriorated to such an extent that it leads to mechanical contact between the piston rod and cylinder housing, the main components suffer permanent damage. Due to the leakage that occurs, the actuator can no longer properly perform its regulatory function. Although this is not safety-relevant with the Belleville spring washer system intact, the damage is however much greater. Because in comparison to preventive seal replacement, an extraordinary repair is now due which, in comparison with a normal overhaul, is significantly more complicated and more expensive. The reason: the main components of the actuator, such as the cylinder housing and piston, are generally not stockable items for the manufacturer due to the large variance. Some parts must even be cast and then machined. In the worst case, this could take weeks or months. If the waiting period occurs during the high season, operators must possibly accept painful constraints to production.

3. Recommendations for practical use

3.1. Preventing the worst-case scenario

Anyone who wishes to avoid the worst-case scenario in a cost-efficient manner, should not only comply with the maintenance rules and instructions, but also schedule major inspections in a timely manner. This way the manufacturer has enough time to provide the necessary parts and carry out the repairs, as well as performing the final functional test.

If the actuator must be repaired, it is essential that the power plant operator ensures that the final examination also includes the safety functionality and that everything is documented in detail. This is the only way to ensure that, in the event of a malfunction, the actuator operates perfectly and the SIL capability is maintained. Only the original manufacturer can guarantee this, however, as he has the original specification, e.g. for the spring tension. Alternative providers cannot guarantee this, because they don't have the same materials, nor do they have specific information regarding rigidity, etc. Only with the right combination of hydraulic fluid, piston rod, spring assembly, corrosion protection, etc. can the manufacturer achieve the same longevity and the same safety level as with the initial delivery.

3.2. Have proof tests performed

In order to ensure the SIL conformity in the long term, after five years – at least every six years or after 50,000 hours of operation – a proof test must be performed. During this test, the manufacturer inspects all safety-related components in accordance with the maintenance requirements. If components with restricted functionality are thereby discovered, or during preventive maintenance, they will be replaced. Furthermore, a functional test is always performed in accordance with the instructions for commissioning of the system and its safety-related functions, as well as according to the manufacturer's operating instructions and documentation. The actuator is thereby tested just the same as during the initial commissioning of the system. The reason being that, before every re-commissioning, the user is required to validate the safety function, including the safety period of the safety system, and to traceably document it.

3.3. Predictive planning

In terms of risk minimization, the standard overhaul with seal replacement should be a matter of course – every two to six years, depending on the maintenance schedule and load stress. Power plant operators should plan approximately ten working days for the duration of this measure, including functional testing, plus transport as well as import and export from the country, as the case may be. If the accompanying inspection reveals damage to the actuator, the manufacturer will inform the customer with corresponding photographic proof and submit a subsequent offer. The further procedure will be jointly discussed. If there is still time for the repair, you can already have replacement parts ordered or manufactured at an early stage for a later maintenance step. In addition to the regular seal replacement, the condi-

▸ **If you want to avoid unplanned costs and shutdowns, it is a good idea to follow the maintenance plan. In order to maintain the SIL conformity permanently, a proof test with the manufacturer is essential.**

tion of the spring assembly should be a major focal point. This can be done in advance of a maintenance operation by a specialist, just checking the spring force and apparent condition (e.g. rust formation).
A good point in time for major overhauls or repairs is during a low-output phase of the power plant – in spring, summer or winter, depending on the geographical location. After the overhaul, OEM manufacturers typically offer a 12-month guarantee on the entire drive.

3.4. Maintenance backlog: What should be done if there is time pressure?

If the maintenance has been neglected in the past, the operator should lose no time and immediately contact the manufacturer. Discussing matters with the experts makes it possible to better assess the condition of the actuators in order to minimize the time and financial risks. Typically, the manufacturer first informs about the technical interrelationships and then explains the various options for action. Based on age and maintenance history, it can now be decided as to whether the device needs to be returned for a standard overhaul or whether it is sufficient to inspect the device within the scope of an on-site visit to the power plant. There, Field Service assesses the current condition of the system and, if necessary, carries out additional measurements. If there are several actuators of the same type in the same power plant, under certain circumstances it is worthwhile to stock a spare device in order to bridge a gap in maintenance times.

Standard overhaul at the manufacturer's facility, with original spare parts:

- Visual inspection of the condition in the delivered state, with photographic documentation
- Disassembly: Cylinder housing, piston rod, piston, spring unit, add-on components, and measuring unit
- Verification:
  - Cylinder housing, piston rod and piston, as well as the measurement of the running surfaces and adherence to permissible wear limits, in accordance with the design requirements, and also the chrome layer in terms of minimum thickness
  - Spring unit: visual inspection of the Belleville spring washers and protective pipe
  - Add-on components (e.g. control block, valves, filters, etc.)
  - Measurement units: Position transducer and limit switch
- Drafting of findings report with photo documentation

4. Conclusion: good planning is half the battle

It is advisable for power plant operators with steam or gas valves to protect hydraulic actuators against unplanned downtime and avoid the ensuing costs. The easiest way to do this is to adhere to the manufacturer's maintenance schedules right from the first day of operation. In addition, regular condition analyses by Field Service can help to discover unusual damage and the error sources, and to initiate immediate countermeasures or plan them in a timely manner. In case of a maintenance backlog, on the other hand, as an immediate measure it is urgently recommended to immediately contact the manufacturer in order to jointly assess the situation and to discuss the next steps. This ensures that power plant operation can continue unrestricted or with planned maintenance.

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Repair by the manufacturer with original-spare parts:

- Cleaning of all components
- Resealing of the sealing elements of the cylinder and all components with certified OEM spare parts, which ensure the operational safety
- Finishing of the running surfaces by polishing with precision processing machinery
- Maintenance of the filters by replacing the seals, the filter elements and the clogging indicator
- Replacement of all wear parts, such as air filters, measuring ports, plug screws, bolts, locking rings, guide rings etc.
- Assembly with manipulators and state-of-the-art lifting devices
- Functional testing of all assembly components according to specified criteria and with settings as per the initial delivery, in order to ensure operational safety
- Full functional test of all specified values according to the initial delivery state
- Creating a test protocol

EXAMPLE OF MAINTENANCE SCHEDULE

In the table below, the individual work is arranged by maintenance interval and by assemblies / parts.

Table 1: Maintenance schedule

When?	Where?	What?	Comments
Every 3 months	Hydraulic components of the energy cylinder Hydraulic lines and fittings	Visual inspection Clean possible contamination and leakage.	This allows for the better identification, observation and removal, if necessary, of leakage. Remove any parts lying around. Immediately remove leaked fluid. Slip hazard!
	Electric connections, cables, connectors and cable sockets, electric cables	Visual inspection	In case of damage or visible signs of aging, have them replaced without delay. Ensure correct fastening.
	Visual clogging indicator at the filters	Visual inspection Check the function	If the visual clogging indicator at one filter responds, the filter element is contaminated and must be replaced.
Every 6 months Moreover the same extent as for "Every 3 months"	All components	Clean contaminated parts (remove possible dust deposits). Immediately wipe off leaked oil using a cloth.	This allows for the better identification, observation and removal, if necessary, of leakage.
Every 24 months (every 36 months at the latest) Moreover the same extent as for "Every 6 months"	Filters	Exchange the filter element	Observe chapter 12.2 "Exchanging components"
	Seat, directional and/or servo valves (if available)	Check the switching times and the function	
	Position measurement system	Check the function	
	Proximity switch	Check the function	
	Hydraulic lines	Check all lines and fittings for leakage and externally visible damage! Immediately remedy any damage!	Immediately renew the hydraulic lines in case of: ▶ Damage ▶ Leaks
	Spring assembly, spring forces and guides (if available)	Check the condition and ensure perfect functioning	The spring assembly may only be exchanged by a certified Bosch Rexroth Service Center (see chapter 17.1 "List of addresses")! Observe chapter 10.4 "Maintenance and repair".
Every 5 years (every 6 years at the latest) Moreover the same extent as for "Every 24 months"	All seals	Exchange of the seals	The seals may only be exchanged by a certified Bosch Rexroth Service Center (see chapter 17.1 "List of addresses")!