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Vulkan Verlag

2017/2018

# IndustrialValves

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# Plunger Valves as control valves in water supply systems

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**The protection of our environment asks for sophisticated plant technology and process control. In line with this, the requirements of planners and operators of water supply systems keep increasing with regard to the safe function and reliability of the valves used. In addition to this, taking economical aspects into consideration, plant builders increasingly decide for universally applicable products with assembly advantages and a high degree of safety of operation. The requirements for the quality and ease of operation of the valves were a real challenge. All components had to ensure the absolutely trouble-free and fully automatic operation of the complex process.**

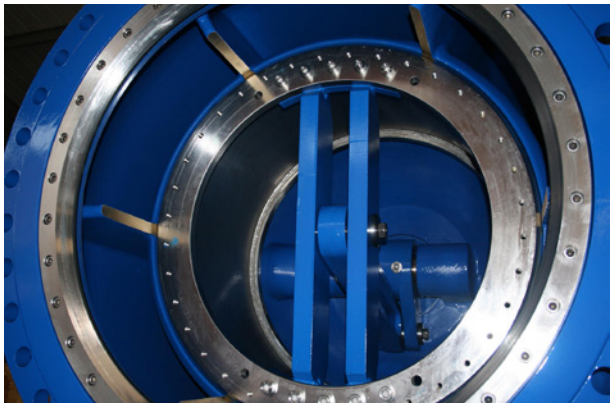
As early as in the 1930s, the performance of water supply systems and hydropower stations was increased in a way that the requirements in terms of pipeline diameters and pipeline lengths as well as operating pressures and flow velocities increased. The shut-off devices used at that time, mostly wedge gate valves, had to be optimized and adapted to the new demands. Wider sealing rings were used, wedge guides were reworked or also extended, but in the end, the conventional gate valve was not a suitable control valve.

At that time, the annular slide valve constituted a special type within the valve business. However, the round cross-section of the annular slide valve was transformed into an annular cross-section by an internal body, which turned into a round cross-section again at the outlet of the valve. This was how the annular slide valve got its name. In the course of the years, the annular slide valve evolved into the needle valve and afterwards to annular piston valve and plunger valve.

**Picture 1: VAG RIKO® Plunger Valve with electric actuator**

Plunger valves are special control valves, designed specifically for control tasks in all kind of water supply systems. Unlike gate valves and butterfly valves, which are mainly used as shut-off valves only in pipeline networks, plunger valves meet the special requirements of control functions. Plunger valves are mainly used where volumetric flow rates need to be precisely apportioned or where water pressures have to be accurately controlled or reduced.

The VAG RIKO® Plunger Valve is a straightway control valve, i.e. it has an annular flow cross-section in any position (**Picture 1**). Inside the body, the plunger (also referred to as piston) is moved axially in flow direction by a crank gear towards the sealing seat of the valve. VAG RIKO® Plunger Valves are control and regulating devices, which generate different pressure losses in pipeline systems by way of continuous narrowing towards the seat to change the flow rate in dependence of the regulating distance. Depending on the application, the nominal diameter of the



**Picture 2: Bronze-weld guides of a VAG RIKO® Plunger Valve DN 1600 (64")**

**Picture 3: Water jet from a VAG RIKO® Plunger Valve DN 800 (32") with pipe hood DN 1200 (48") as bottom outlet in a dam**

valve has to be large enough to ensure that at the lowest pressure difference the highest required flow rate is achieved and/or that maximum differences in pressure are reduced without causing any cavitation. Additionally, any damage to the downstream pipeline system or structure by vibration or cavitation must be prevented over the entire regulating distance.

The first VAG Plunger Valve was developed in 1932 in Mannheim/ Germany. Meanwhile VAG has evolved the VAG RIKO® Plunger Valve, proven for decades, to make it suitable for control tasks in water supply systems. Today's VAG RIKO® Plunger Valve is available in almost all nominal diameters between DN 150 and 2200 (6" up to 88") and in pressure ratings ranging from PN 10 to 40 (145 to 580 Psi). Meanwhile a great number of plunger valves are in use worldwide – even valves of sizes DN 600 (24") and DN 800 (32") with a nominal pressure of PN 100 (1.500 Psi). In all sizes and pressure ratings, the compact body is made of premium-quality ductile iron EN-GJS 400-15 (ASTM A536 60-40-18). Up to DN 600, the inner parts are made entirely of grade A2 stainless steel as a standard. For all nominal diameters up to and including DN 2200, the piston is guided by bronze-welded longitudinal guides (**Picture 2**). This ensures optimal longitudinal guiding and thus the backlash-free sliding of the plunger with very low operation torques at the same time.

Each diameter is always a single piece body and the inner body is connected to the outer body by cast ribs. On the inlet side, the inner body is a spherical shape. The design of the annular space results in a continuous narrowing towards the seat. The piston or plunger is moved by an internal crank drive. New sealing systems for the body seat, the

**Picture 4: VAG RIKO® Plunger Valves DN 1000 (40") with hydraulic actuators in a hydropower plant**

**Picture 5: VAG RIKO® Plunger Valve DN 1200 (48") in a water supply network**

plunger and the shaft bearings guarantee absolute corrosion protection, excellent performance and a long service life. Due to the fully enclosed bearing, no fluid (water) can penetrate into the bearing, and

the dry-bearing design ensures high durability and long lifetime as well. The sealing of the shaft is adopted from the proven sealing principle of the VAG EKN® Butterfly Valve, i.e. the shaft is sealed by a double O-ring seal. Inside the valve, between the body and the plunger, a double-acting four lip Quad-Ring seal assures more seal tightness and stability in dynamic applications. It is resistant to twisting and ensures permanent tightness even under high stress cycles. The valve seal at the sealing seat is arranged in the no-flow zone in a way that prevents stones and pebbles from causing damage to the valve seal and minimizes wear of the seal. All seals are approved according to the German DVGW W 270 regulations worksheet, which allows their unrestricted use with drinking water. All casted parts are protected against corrosion by an epoxy coating according to the German GSK guidelines (Heavy corrosion protection) with a minimum thickness of 250 microns (approx. 10 mils). For seawater applications a special version with internal rubber lining and internal parts made of duplex stainless steel is available.

## FIELDS OF APPLICATION

VAG RIKO® Plunger Valves are suitable for use with raw water, drinking water and cooling water with temperatures of usually up to 60 °C (140 °F). The main fields of application of plunger valves include:

- Conveyance of water in catchment basins and dams
- Bypass lines of hydropower stations
- Long-distance pipelines
- Water treatment in waterworks
- Water supply in pump stations
- Supply control of elevated tanks
- Drinking water networks
- Cooling water circuits of industrial and power plants

Here, the VAG plunger valves have stood the test of time for decades in many projects all over the world. Plunger Valves can be installed in water pipelines and in dams as bottom outlet valves at the end of pipelines (**Picture 3, 4, 5**).

Furthermore, VAG RIKO® Plunger Valves can also be used in air inlet control systems of activating basins in wastewater treatment plants as notably better control characteristics than with knife gate valves or wafer-type butterfly valves can be achieved.

## PLANNING AND DESIGN

Plunger valves are modulating valves, which, according to the throttling principle, generate pressure losses in pipelines to change the flow rate according to a desired characteristic in dependence of the regulating distance. The nominal diameter of the plunger valve and its regulating behavior are always dependent on each other. However, they can only be determined one after another and then have to be adjusted to each other. Their regulating behavior is always influenced by the resistances present in the entire plant. This means:

- the longer the pipeline, the higher the resistance,
- the larger the total of the resistances present in the plant is in relation to the resistance of the open plunger valve, the lower the throttling effect will be.

## OUTLET TYPE / SEAT

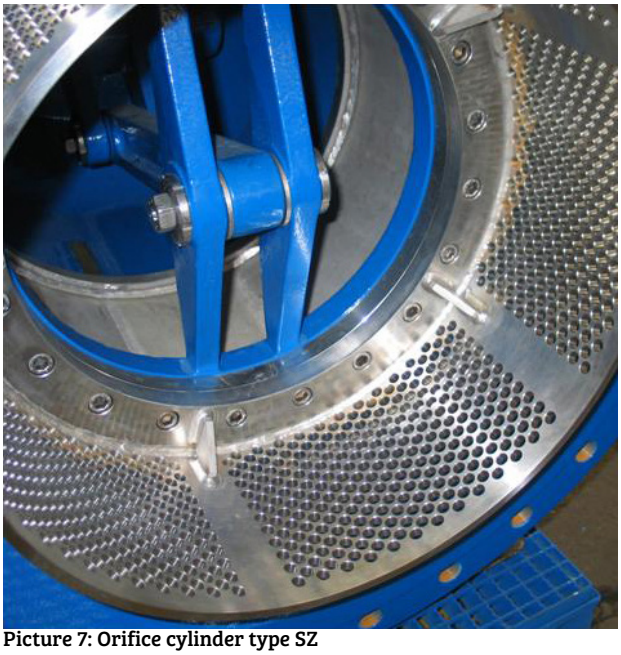
Due to its linear control characteristic, the VAG RIKO® Plunger Valve ensures excellent cavitation behavior and minimum pressure loss in fully opened position at the same time. Its outlet type is variable and, in the form of a kit, allows the change of the valve characteristic. This is an essential advantage as the valve can be adapted to different operation conditions even after its delivery. The cylinders divide the flow into separate water jets, which meet again on the discharge side downstream of the plunger in the centerline of the pipe and dissipate the energy of the water without the risk of cavitation.

Depending on the application and the operation specifications, different types of outlets such as standard seat ring (**Picture 6**), orifice cylinder (**Picture 7**) or slotted cylinder (**Picture 8**) as well as various customized cylinders are available to prevent cavitation **Picture 9**).

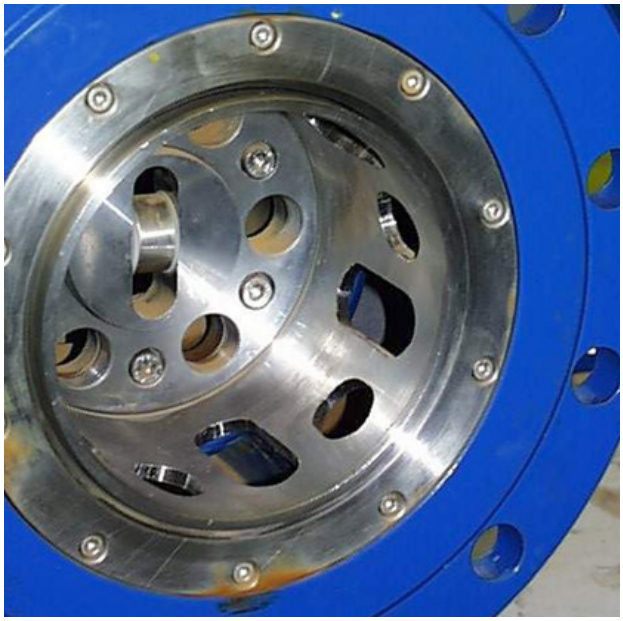
## PLANNING AND DESIGN OF PLUNGER VALVES WITH THE VAG USECAD® DESIGN SOFTWARE

The individual design of the control valve and its various outlet types can be realized by using the VAG's proprietary UseCAD® software tool. The specifications needed for reliable design include the dynamic pressure upstream and downstream of the control valve as well as the desired flow rates Qmin and Qmax. This allows the accurate determination of the control behavior. Cavitation-free control behavior should always be aimed at.

Picture 6: Standard type E



Picture 7: Orifice cylinder type SZ



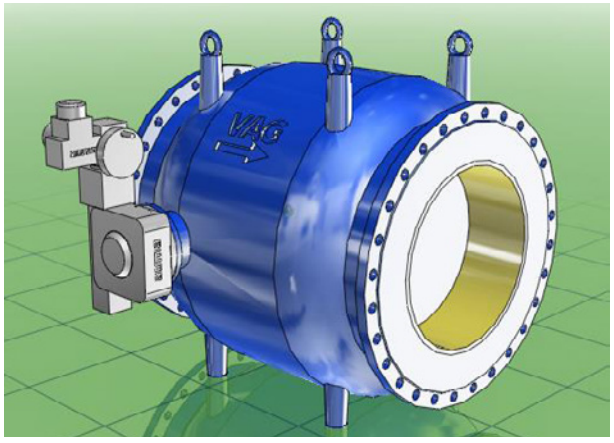
Picture 8: Slotted cylinder type LH

Picture 9: Control device short type

The wide range of applications it provides makes the versatile VAG UseCAD® software interesting to the most diverse groups of users. It helps users to find the right valve for the intended application purpose, to determine suitable nominal diameters for specific flow rates and to design plants so that they are free from cavitation.

## DEPARTURE TO THE THIRD DIMENSION

In the past few years, VAG has continuously extended and updated the software and has adapted it to the requirements of practice. The highlight of the most recent version VAG UseCAD® 7.0 is the automatic generation of 3D images of various types of valves. Where some years ago, 2D drawings were the most commonly used planning format, design work is now moving increasingly to the third dimension. Monitoring of collisions, planning of plants and many other tasks ask for three-dimensional valve models today. The 3D solid models generated with VAG UseCAD® 7.0 can be exported into all common 3D formats such as DWG 3D, IGES 3D, SAT 3D or STEP 3D. Thanks to this, they can be read into diverse user planning systems and be aligned there. Special attention has been paid to the so-called critical valve components as their movability can have a decisive influence on the alignment of the plant (**Picture 10**).



**Picture 10: 3D projection of a VAG RIKO® Plunger Valve DN 1000 (40") with gearbox and electric actuator**

Besides the 3D generation novelty, the VAG UseCAD® 7.0 supports all areas of conventional valve planning and supplies valve knowledge in a condensed form. The electronic valve catalogue provides extensive technical information. Besides technical data sheets, sales texts and valve symbols, the VAG UseCAD® naturally also supplies 2D projections of the entire range of valves for conventional 2D planning. Here, too, the user first selects the valve type, makes further selections via the nominal diameter and type of actuator and then receives the matching 2D image or 3D images. Depending on the type of valve, the software generates up to four projections in the dwg or dxf formats. The integrated viewer allows the user to view the drawing also without CAD software. Through the export function, all required 2D or 3D views can be saved and retrieved in the planner's individual software program.

The function of pressure loss calculation rounds off the valve catalogue. This additional program allows the calculation of the pressure losses developing during the flow – over the entire range of various pipeline elements. With its user-friendly addition of the valves and pipeline components used, such as elbows or dividers, the program calculates the resulting pressure loss. The results can be exported and can thus be adopted into the user documentation fast and easily.

## INSPECTION AND OPERATION INTERVALS

After assembling on each valve a tightness and body test will be performed in the factory before the valve will be delivered to the customer. According to the German DVGW W 392 regulations worksheet, after commissioning plunger valves should be checked for tightness, operability and condition of the corrosion protection at least once per year. In case of extreme operation conditions, these inspections should be performed more frequently.

## SUMMARY

The VAG RIKO® Plunger Valve is a straightway regulating and control valve, which has an annular flow cross-section in any position. Inside the body, the plunger is moving axially in flow direction by a crank gear towards the sealing seat of the valve. Plunger valves are regulating and control devices, which, by continuous narrowing towards the seat, generate pressure losses in pipeline systems to change the flow rate in dependence of the regulating distance. The nominal diameter of the valve has to be large enough to ensure that at the lowest pressure difference the highest required flow rate is achieved. Additionally, any damage to the downstream pipeline system or structure by vibration or cavitation must be prevented over the entire regulating distance.

VAG supplies the entire range over all nominal diameters and pressure ratings and offers the right solution – however complicated the application may be.

## LITERATURE

R. Heiler, Valves in water supply systems
VAG brochures

**IFAT 2018**
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