Replacement of valves at Rur Schwammenauel, Germany

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The Rur dam with the Schwammenauel hydropower station is located in the Nordeifel mountains near the city of Heimbach, Germany. With its storage volume of 203 × 10⁶ m³, it is one of the country's largest dams. After more than 65 years of service, the valves at the bottom outlet had to be replaced. The old plunger valves were replaced by hollow jet valves with a much higher capacity.

The Rur dam and hydro station, on the river Rur, began operation in 1938 following the completion of its first stage. In the second stage, the dam's crest height was raised to el. 284.43, resulting in a maximum storage level of about 71 m. By volume, the Rur dam has the largest storage lake in the district water supply and dam system of Nordeifel and North Rhine Westphalia, and the second largest dam in Germany. The lower lake of the dam ensures flood protection and compensation for water shortages. The main tasks of the upper storage lake include raw water supply and power generation. The raw water taken from the storage lake is used for the drinking water supply of the Greater Aachen area. The Francis turbine in the nearby hydropower station of Schwammenauel with a capacity of 9.5 MW, generates power for peak demand.

1. Feasibility study, invitation to tender and preparation

The dam, pipelines and valves date back to the time when the first stage was built. Despite regular maintenance of the valves, they showed increasing signs of wear as a result of ageing, see photo (a) below. During function tests, the valves were found to be sluggish and thus difficult to operate. This situation resulted in limited operability of the bottom outlet from the year 2002 on, and encouraged the operator of the dam, the Wasserverband Eifel-Rur (WVER) in Düren to commission a feasibility study with a market analysis for the repair of the valves, in 2003.

The results of this study showed that replacement of the valves and actuators would be less expensive than repairing the old equipment.

Following a public invitation to tender, Heinrich Scheven Anlagen- und Leitungsbau GmbH in Erkrath was commissioned to build the hydraulic steelworks and to supply the new valves including actuators. Heinrich Scheven in turn commissioned VAG Armaturen GmbH in October 2004 to manufacture and supply the valves and pipe adapters.

VAG Armaturen GmbH has more than 100 years of experience in the manufacturing of heavy duty water supply valves and has been producing butterfly valves and hollow jet valves for more than 50 years. Based on this long-term experience, VAG's technicians and engineers were closely involved in the project as early as the planning stage.

After the contract had been awarded for the reconstruction and renewal of the hydraulic steelworks in the valve house of the Rur dam, the inlet of the bottom outlet pipe was closed with a penstock on the water side of the dam, the bottom outlets were emptied and the old parts of the equipment were removed in mid-June 2005. Then the actual reconstruction work could begin.

2. Requirements

For the selection of the new valves, two criteria were essential:

• The DIN 19700 standard, applicable since June 2004, had to be complied with. This standard requires bottom outlets to have an increased flow capacity of 50 m³/s for each outlet.
• The structural conditions, which could only be changed to a limited extent, made it difficult to install the hollow jet valves, which weigh up to 23 t.

3. New equipment installed

The calculations made during the planning stage resulted in the selection of the following valves and pipe adaptors.

(a) View of the originally installed valves, which were leaking.

(b) Far right: A RIKO DN 250 plunger valve with venting set in the bypass, above the EKN DN 2300 butterfly valve with a brake and lift cylinder.

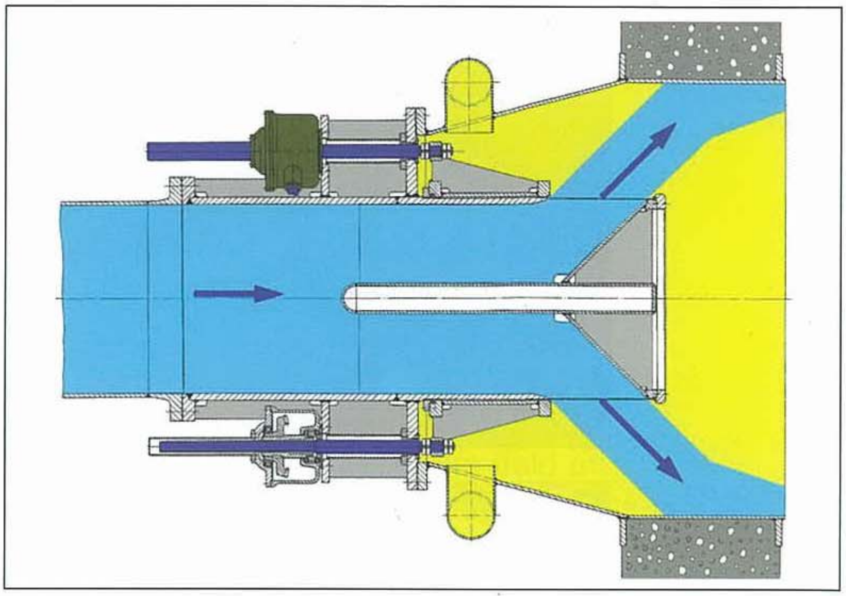
The new hydraulic steelworks consist of:

- two DN 2000 bottom outlets with a DN 2000 pipe adaptor, serving as a transition pipe adaptor from the concrete encased bottom outlet pipes, with non-standardized flanges, to standardized DIN flanges;
- two VAG EKN DN 2000 butterfly valves with a brake and lift cylinder, to prevent pipe bursts;
- two DN 2000/1800 pipe adaptors as a reducer to the nominal width of the hollow jet valves;
- two DN 1800 dismantling joints to compensate for the difference between the face-to-face dimensions;
- two DN 1800 elbow segments and two VAG DN 1800 hollow jet valve with a downstream venting set, with a diameter of 3200 mm and a guide pipe with a diameter of 3600 mm.

In the adjacent outdoor pipeline, with a diameter of DN 2300, leading to the Schwammenauel hydro station, a VAG EKN DN 2300 butterfly valve with a brake and lift cylinder was installed to prevent pipe bursts. This was combined with a DN 2300 dismantling joint to compensate for differences in face-to-face lengths. As a bypass valve for filling the DN 2300 power station pipeline, a VAG RIKO DN 250 plunger valve with downstream venting set was installed, see photo (b). The existing spring loaded DN 900 air valve, dating back to the origins of the dam and made by Bopp & Reuther (now VAG Armaturen) still functioned perfectly, so that its replacement was not necessary; this helped to reduce costs, see photo (c).

4. Implementation

To meet the DIN 19700 requirements, the old needle valves were replaced by VAG DN 1800 hollow jet valves with a higher capacity. To ensure that they would function reliably, even at high differential pressures, the two DN 1800 hollow jet valves were manufactured with an additional connecting flange with a nominal width of DN 3200, and wall pipes of the same dimensions. The wall pipes serve as venting devices for the hollow jet valves, and are equipped with DN 400 venting pieces leading to the top at a 45° angle on either side. These pieces are connected to DN 400 nominal width pipes which are taken through the concrete abutment of the outer wall to the top, so they take in air from outside. Because of the vacuum which builds up at the seat of the hollow jet valve, air is taken in from outside through the ventilation pipes, which prevents cavitation, see Figure above.



Schematic representation of a hollow jet valve with the venting set and wall pipe.

The hollow jet valves were supplied with pre-assembled wall pipes. During transportation, these valves were protected against distortion by strips of timber in the wall pipes, see photo (d) below. After assembly and alignment of the new operating equipment, the wall pipes, including the ventilation pipes, were encased in concrete in the new outer wall (1.3 m strength) of the valve house.

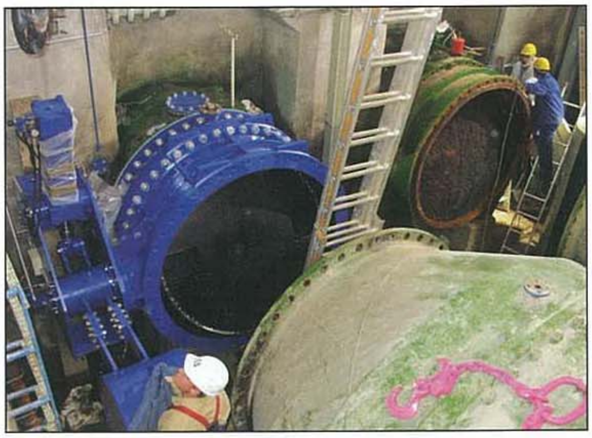
For maintenance, the hollow jet valves can be dismantled at any time from the concrete-encased wall pipes through the DN 3200 wall flange. After about four weeks, during which time the concrete was allowed to harden, the guide pipes with a diameter of 3600 mm were flange-mounted to the wall pipes located in the stilling basin. The guide pipes had to be used to transform the water jet coming out of the valves into an even and straight jet as no constructional modifications were allowed in the stilling basin.

The increase in capacity and performance to a total of 100 m^3/s also increased the risk of vibration in the

(c) Existing DN 900 air valve for venting the DN 2300 outdoor pipeline to the Schwammenauel hydropower station.

(d) Delivery of the first DN 1800 hollow jet valve, pre-assembled in the wall pipe, together with the associated guide pipe during entry into the gate valve house.

(e) Assembly of the right EKN DN 2000 butterfly valve with the brake and lift cylinder.



(f) The EKN DN 2000 butterfly valve for the right bottom outlet is opened slowly at a water pressure of 7 bar, during the factory leakage test.

bottom outlet system, when the system was running at full load. After extensive calculations, the engineers dimensioned the wall strengths for both the valves and the pipe adapters for pressure ratings of PN 25 and the flanges for a rated pressure of PN 16.

The decision to install the three VAG EKN butterfly valves was mainly influenced by the lack of space in the valve house. The safety valves for pipe burst prevention had to be supplied as a welded construction of manufactured steel with a short face-to-face length. Before the disks were manufactured, special models were made to ensure an optimum hydraulic flow pattern.

To ensure safe emergency closure in the case of a pipe burst, special cylinders are required. For this purpose, VAG's special brake and lift cylinder system called Hubbremse is used which, in this case, was adapted for the restricted space conditions. In the case of a pipe burst inside the valve house, the float-controlled devices will transmit a signal for emergency closure of the butterfly valves. The hydraulic cylinders of the brake and lift system installed in the two bottom outlets are installed perpendicular to the top. The 2 m-long levers for the drop weights of 3000 kg can all be dismantled, see photo (e). This construction made the transport to the construction site, the installation in the dam and, of course, also the assembly by Scheven a lot easier.

The DN 1800 hollow jet valve for the left bottom outlet during the first set-up.

5. Conclusion

At the beginning of September 2005, after a construction period of just three months, the hydraulic steel works were completed in time and without any delays. The new valves, which had been factory tested for pressure resistance and functioning at VAG's production facilities in Mannheim, Germany, then had to prove their operating reliability and tightness again during a trial run. After the flooding of the two bottom outlets and the removal of the penstock, the valves were tested in another trial run to check closure against water pressure from the storage lake. This proved both the performance capability of the valves and, at the same time, showed an increase of the output quantities of the new VAG hollow jet valves compared with the performance calculations.

As a result of excellent co-operation between the WVER, Heinrich Scheven and VAG-Armaturen GmbH, the dam and hydro plant resumed full operation according to plan in late 2005.

WVER, as the owner, is satisfied to have made the right decision in installing this new equipment to ensure the safe operation of its dam for a long time to come. ◊

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