Case Study
Dams & Reservoirs

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USK RESERVOIR: THE IMPORTANCE OF VALVE SELECTION

Usk Reservoir sits on the River Usk 30 miles north of the city of Swansea in South Wales. The source of the Usk, derived from a word meaning 'abounding in fish', is in Fan Brycheiniog. Fan Brycheiniog is the highest peak in the Black Mountain region of the Brecon Beacons National Park.

Built in 1955, Usk Reservoir lies 320m above sea level. The reservoir comprises an earth dam some 30m high and 480m wide. It is the first UK example of an earth dam with horizontal drainage blankets[1].

The challenge

Usk Reservoir is owned and managed by Dwr Cymru Welsh Water (DCWW). The works mentioned in this case study were initially conceptualised some time ago.

They form part of DCWW's response to the requirements of the Habitats Directive which focuses on the conservation of natural habitats and of wild fauna and flora[2].

In essence, the works are designed to give DCWW enhanced control of water releases to the Rivers Usk and Wye both from a habitat and draw down safety perspective.

Surge Pressure Impact and Valve Selection Importance

The engineering consultancy Arup was reviewing design options. Arup engineers were particularly concerned that works to enhance water releases could lead to surge pressure damaging legacy pipework within the reservoir. Understanding the operational characteristics of different valve specifications was, therefore, paramount.

Greg Morris (Business Development Manager – Dams, Reservoirs & Hydro) engaged in several in-depth discussions with Arup engineers relating to the optimal choice of control valve. Greg explained that the risk of surge pressure was mitigated through the design of the valve. In particular, both under electrical and manual operation, the valve was designed to ensure it closed slowly (operational speed between 50 – 100mm/min) and smoothly to ensure flow was regulated gradually, without any pulsing effects taking place.

Greg provided a 3D animation of the proposed control valve which demonstrated how the valve operated. He was able to reassure Arup that no surge pressures would be created in any upstream pipework provided the correct valve type and valve size was specified.

Designs are finalised, contracts awarded and valves specified

Mott MacDonald was later appointed as consulting engineer on the project by DCWW. Glenfield Invicta's involvement in earlier consultations ensured we were well placed to win the contract and became heavily involved in the design, specification and supply of the valves.

Greg remained Glenfield Invicta's principal point of contact throughout the project from design through to commissioning.

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The main technical challenges were the surge potential as discussed earlier, and the high flow velocities acting on the system.

Several valves were specified across the system. An Orbinox Model CH fixed cone discharge valve (DN450) was recommended by Glenfield Invicta as the principal control valve due to the relatively slow operating speed and the need for a smooth and regulated flow regulation performance.

An important objective of the Usk Reservoir project was to achieve accurate compensation flows. The required range and accuracy of compensation flows[3] led to the specification of a Series 872 needle control valve (DN300).

The image below shows the commissioning of the fixed cone discharge valve and needle valve working in parallel:

Isolation gate valves were required on the upstream tunnel (DN450) and embankment toe (DN800). In both cases Series 54[4] reservoir-specification gate valves were specified to meet the required 100-year design life and accommodate the high flow velocities.

As can be seen from the second image, above, centre, space within the upstream tunnel was restricted and Glenfield Invicta supplied 3D models of the gate valve to ensure it fitted within the space envelope.

Consideration was also given to the orientation of the electrical actuator and gearbox to avoid any fouling with the tunnel walls. Glenfield Invicta engineers also installed the actuators and extension spindle arrangements on site.

Greg Morris - Business Development Manager Dams, Reservoirs & Hydropower - emphasised the fundamental importance of technical support in the award of the supply contract to Glenfield Invicta:

'As with all dam and reservoir projects, technical support is paramount in securing the business. Lots of time, effort and resource was spent reviewing system drawings and specifications, selecting the correct valve type, calculating the optimal size and confirming the exact specification of valve for each application.

'The really rewarding aspect of this project for me was that we (Glenfield Invicta) worked with several of our sister companies from across the AVK Group, including Orbinox, ACMO and Anhui, to deliver a valve package that comprehensively met the quite onerous requirements of the Usk project.

'I am very fortunate as an engineer to have the luxury of access to the product ranges of so many AVK Group valve manufacturers which means I am able to offer the ideal product for virtually every application'.

AVK ORBINOX ACMO

[1]Horizontal drainage blankets

All earth dams have a degree of seepage. One solution to control seepage and drawn down water levels in the embankment is to incorporate a drainage blanket into the downstream toe of the dam. A drainage blanket consists of a 'seam' of (typically) coarse local aggregate with a permeability higher than that of the surrounding materials.

Horizontal drainage baskets are a misnomer as they are typically inclined at angles of 2° to 5°!

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[2]Reservoirs and the Habitat Directive

In a report* published in November 2018, Wood Environment & Infrastructure Solutions summarised the potential environmental changes associated with the construction and operation of impoundment dams. These include:

Construction of reservoir
- Land take and habitat loss
- Impact on water and air quality
- Changes to surface and groundwater

Hydrology
- Noise and vibration
- Biological changes e.g. the introduction of invasive non-native species

Operation
- Reduced sediment loads
- Physio-chemical changes caused by the water released from the reservoir having a different physio-chemical profile from the natural baseline
- Hydrological changes
- Groundwater changes
- Local micro-climates

[3]Compensation flows

Compensation water is defined as the flow that must be discharged below an impounding reservoir to maintain the water rights of riparian* owners and other abstractors downstream.

*Relating to or situated on the banks of a river

[4]Series 54 reservoir-specification gate valves

Glenfield Invicta has developed a specialist reservoir-specification for gate valves to accommodate the operating parameters required on reservoirs which can be onerous. For example, the seat and body rings in the gate valve have to be screwed and pinned to be able to accommodate considerable flow velocities that are well in excess of standard water systems.

To develop the reservoir-specification, Glenfield Invicta took the standard AVK Series 54 metal seated gate valve as its starting point and developed an enhanced design. Key features include:

Aluminium bronze shoes and channels result in a very tight and continuous tolerance between the body and wedge throughout the valve stroke. This reduces potential vibration and fatigue damage. It also reduces bearing stresses on the contact areas as well as improving the alignment and sealing performance of the valve. Operational torque requirements are lower due to the reduced friction coefficients.

The addition of a **jacking screw** (or two on certain sizes) at the base of the valve allows a direct axial thrust to be applied to the base of the wedge. If the valve has been closed for long periods of time, it can become increasingly difficult to operate. Rotating the jacking screw 'pushes' the base of the wedge up a small distance, sufficient to 'crack' the valve out of its seated position; normal operation of the valve from the valve stem can then be carried out with ease. The jacking screw also acts as a mechanical stop which prevents over-travel of the wedge which can cause considerable operational issues with metal seated gate valves.

Stainless steel fasteners and stem, and an increase in coating thickness, combine to prevent corrosion and increase the valve's operating life.

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