Clay Lane WTW

collaborative working makes cost and time savings by retrofitting an innovative enhanced coagulation and membrane solution within a small footprint

by Dan Claydon CEng MICE

United Utilities' Clay Lane WTW supplies customers in the Rochdale area with a maximum of 16Ml per day of treated drinking water. A long-term deterioration in raw water quality feeding the works (increasing colour) meant UU had an AMP5 Regulatory Undertaking to improve treatment and secure compliance with standards for colour and trihalomethanes. With very little space available at site for new structures the initial solution was to develop a new £22m WTW consisting of lamella clarification and two stages of filtration, on land available at the site of the existing Bamford Service Reservoir. The Process Alliance design team identified an opportunity to upgrade the existing WTW primary filtration stage by replacing it with membrane filtration. This had a much smaller footprint than the proposed three stage works, enabling it to be constructed within the limits of the existing site, thus reducing costs to £15m and making a significant saving in the order of £7m.

Access to the top of the membrane racks from the mezzanine floor - Courtesy of United Utilities

Challenges

The project team faced three significant issues:

- Enhanced coagulation upstream of membranes had never before been undertaken by UU
- Available footprint for the new processes was limited
- The WTW had to be operating at full production in time for the strategically important Haweswater Aqueduct (HA) outage. The HA transports 500ML/day from the Lake District to customers in and around Greater Manchester. UU planned to close the aqueduct in October 2013 to undertake cleaning and maintenance. To maintain supply to customers it was crucial that throughout the HA outage all WTWs fed from alternative sources, including Clay Lane, were operating at full capacity.

Set against this immovable deadline the challenge was to complete a 12 month trial before designing, constructing and commissioning the refurbished WTW.

The existing WTW

Hydraulically the WTW is part of a pressurised system being located part way between Greenbooth Impounding Reservoir upstream and Bamford SR downstream. It is able to operate under gravity or utilising a raw water booster pump depending on the required output and upstream reservoir level.

Originally a service reservoir site, water treatment at Clay Lane has been undertaken for over 60 years. Over time the treatment processes have been expanded to include enhanced coagulation, primary filtration (pressure filters, 7 (No.) located within a brick and

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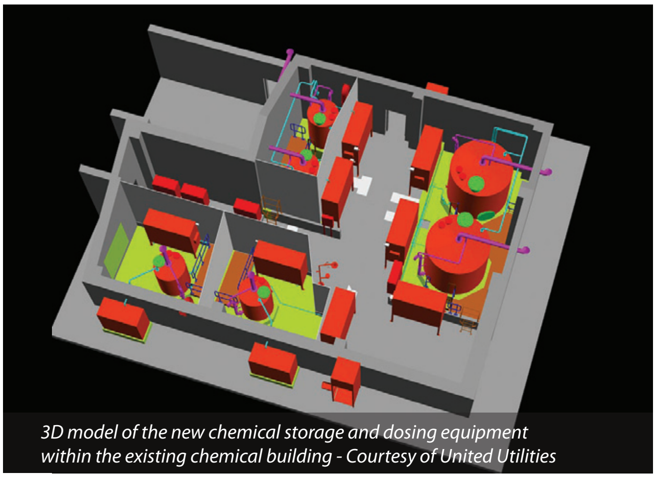
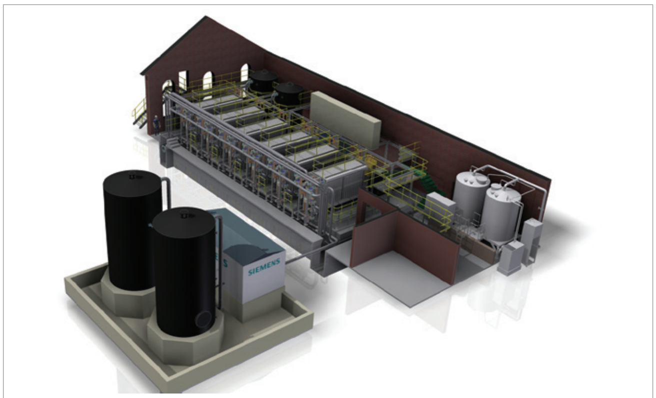
Existing primary filter hall at Clay Lane WTW - Courtesy of MWH

Existing primary filters prior to their removal and installation of the membrane system - Courtesy of MWH



3D model of the new chemical storage and dosing equipment within the existing chemical building - Courtesy of United Utilities



Use of 3D visualisation by specialist subcontractor (Evoqua WT) at an early design stage gave the client/design team confidence that the existing filter hall could be reused - Courtesy of Evoqua Water Technologies

stone primary filter house and 3 (No.) external), 3 (No.) secondary pressure filters for manganese removal and 2 (No.) duty/assist ultraviolet (UV) disinfection units.

Chemical systems on site included for pH correction (lime, sulphuric acid), coagulation (aluminium sulphate, polymer and polydadmac) and for oxidation/network chlorine residual (sodium hypochlorite).

Feasibility of membranes

The extremely limited footprint within the existing WTW restricted the potential process solutions. It was also vital to maintain a gravity fed pressurised system for as wide an operational flow range as possible, thereby avoiding the high operating costs associated with booster pumping.

Replacing the existing first stage pressure filters with pressurised membrane filters was identified as a potential solution which would satisfy these constraints and meet the deteriorating raw water driver.

The feasibility of this option was investigated by reviewing information available on similar installations and undertaking a 12 month pilot trial. Under the UU framework agreement for membrane filters Evoqua Water Technologies (formerly Siemens) was employed to undertake a raw water membrane trial at Clay Lane WTW.

Pilot trials were required to identify key design parameters and to ensure issues regarding pre-treatment, water quality, membrane operation and performance were understood. The trial specifically investigated the use of pre-coagulation under optimised pH conditions to determine the optimal performance of a microfiltration membrane by investigating the relative impact of flux, backwash interval and coagulant dose upon the rate of transmembrane pressure (TMP) development.

Initially there were issues with membrane performance; a rapidly increasing TMP resulting in unacceptably short trial run-times. Further investigation of this issue identified two causes; underdosing of coagulant and poor pH control with lime water dosing. Subsequent trial runs used an increased coagulant dose and sodium hydroxide for pH control. Results improved significantly,with all parameters meeting or exceeding the required performance levels and confirmed coagulation upstream of the membrane as a viable option.

Design partnership

Following the successful conclusion of the trial a full scale outline solution for the whole WTW needed to be produced. Evoqua Water Technologies was employed on a design consultancy basis to work with the United Utilities Process Alliance design team which included engineers from UU and MWH with constructability advice from KMI+ as UU's Process Partner.

Together this multi-disciplinary design team successfully produced the necessary design deliverables and undertook various reviews with the WTW Operators, including a HAZOP study and Access, Lifting, Maintenance and Fire review. Ultimately the changes to the WTW were significant and included:

- Demolition and removal of existing plant.
- Chemical storage and dosing systems for sodium hydroxide, aluminium sulphate, sulphuric acid (50%), sodium hypochlorite, sodium bisulphite - all located within the existing chemical room.
- A booster pumping station including kiosk, pumps and pre-screens.
- 6 (No.) membrane filters including foundations, access steelwork, clean in place system and MCC - all located within the existing primary filter house.

- Membrane neutralisation system - located on the existing external primary filter slab.
- Interstage flow measurement and three new chemical point of applications for dosing.
- Relocation of sample board/water quality instruments.
- New powdered activated carbon (PAC) dose rig and kiosk.
- New control systems for the whole WTW.

Innovative design tools were utilised to good effect; in particular the use of 3D AutoCAD drawings to lay out equipment within the confines of the existing primary filter house and chemical buildings. Ensuring that all equipment was accessible to maintain and operate within these relatively small existing buildings was absolutely fundamental to the viability and success of the project.

Without compromising on the safety of operatives the team successfully challenged several standard methods of access. For example designing out the need for permanent access ways to the top of chemical tanks and accessing the top of the membrane racks directly from a mezzanine floor, as opposed to using temporary floor mounted access equipment as at other membrane sites.

Construction phase

A clear benefit of the Process Alliance partnership between UU and KMI+ was realised with the early release of an enabling works contract ahead of the main contract being awarded. This allowed KMI+ to protect the construction schedule by decommissioning and removing the existing primary treatment plant and associated chemical dosing from January 2012. Full approval and the main contract followed in March 2012.

The existing primary pressure filters were enclosed steel tanks with an in situ concrete plenum floor and a layer of sand/gravel media. In total there were 10 (No.) filters to be cleared, 7 (No.) of which were within the primary filter hall. With no internal lifting facility, limited headroom and restricted access there was no practical means of removing the filters whole.

This meant the filters would have to be broken down in situ and removed in sections, to suit the largest crane that the building could accommodate. This was done by first draining the filters and then extracting the media and composite steel external skin. The internal concrete plenum floor was then diamond wire sawn into sections that could be lifted out of the building using a pick and carry type crane.

The filter plinths and associated pipework were then broken out and removed from the building clearing the way for the installation of the membrane plant.

Construction and installation

The new primary treatment membrane plant including backwash tanks and MCC were located within the existing cleared primary treatment building; the new chemical dosing rigs, bulk storage tanks and dosing rigs were located within an adjacent redundant workshop; the blowers were to be installed within a new blower building and the membrane cleaning plant was to be located outside, adjacent to the existing primary treatment building.

The booster pumps, PAC dosing plant and the membrane cleaning plant were located within new kiosks on the existing works site.

The limited footprint available for the installation of the new membrane plant within the existing primary filter building required the introduction of a mezzanine level to increase the available floor area to position equipment.

This eliminated the need for a separate MCC kiosk adjacent to the primary treatment building and enabled the MCC to be located adjacent to the membrane plant that it was controlling.

New booster pumping station kiosk had to fit between the existing pipe loop and primary filter house structures - Courtesy of United Utilities

Diamond wire cutting the existing filters into small enough sections to remove with a pick and arry crane - Courtesy of KMI+

New sodium hypochlorite storage and dosing retrofitted within the existing chemical building - Courtesy of KMI+

Ground floor access to the membrane racks and compressors Courtesy of KMI+

Space within the primary filter house was at a premium Courtesy of United Utilities

Similarly the chemical storage tanks were constructed with support skirts to reduce the footprint of the retaining bund, thus increasing the available floor space to install chemical dosing rigs and providing increased access to maintain the equipment.

The most significant challenge of the construction and installation phase of the project was to coordinate the installation and working of a number of specialist subcontractors, taking account of the constraints of retro-fitting a new plant into an existing works and the reuse of the existing buildings.

Any delay to the installation programme would have been a critical delay to the completion of the programme and had the potential to impact on the Haweswater Aqueduct outage. The limited space around the works for storage of equipment prior to installation required the procurement and delivery of equipment to be based on a just in time basis to ensure the installation programme was maintained.

The limitations on headroom to lift equipment and access into the existing building that was to be used to house the new primary treatment plant and associated equipment required meticulous planning to maintain an efficient installation programme. To overcome the limitations on lifting and access within the existing buildings for lifting equipment required the use of a number of different lifting techniques to install the plant.

The 6 (No.) membrane modular units were installed using machine skates while the bulk storage tank for the membrane backwash and the chemical storage were installed with spider cranes. The installation of the chemical storage tanks with support skirts needed to be coordinated with the construction of the bunds.

To enable the installation of the tanks the bunds around the tanks were constructed in two stages. The rear and side walls were constructed prior to placing the tanks and the front wall constructed after placing the tank, thus avoiding the need to lift the tanks over the bund wall.

The membrane cleaning plant utilised the piled foundation from the redundant external primary filters removed as part of the enabling works package.

A notable construction challenge for KMI+ included the coordination of 10 significant subcontractor packages including demolition and site clearance, building and MEICA works all within the physically constrained site working areas. This was done successfully with the construction team working over 150,000 hours without a single lost time accident or environmental incident.

KMI+ delivered to the schedule achieving water into supply before the end of June 2013 and, most importantly, in time for Clay Lane WTW to be available at full production during the HA Outage.

Conclusion

Close collaborative working between UU, KMI+ and Evoqua Water Technologies was key to the successful delivery of this complicated retrofit within the very small footprint of the existing WTW. The project was delivered safely with Water Into Supply achieved in June 2013 ahead of schedule and the imminent HA Outage. The innovative solution also made considerable savings compared to the new build alternative.

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