The Lee Tunnel - Tideway Pumping Station

an 87m deep/38m diameter pumping shaft to transfer the volume of the Lee Tunnel to BecktonSTW

by Phil Muir CEng MIMechE

The Lee Tunnel is part of Thames Water's London Tideway Improvements Scheme, which will return the River Thames to an acceptable state of cleanliness by 2023. The improvements scheme comprises three projects, the upgrade of five major sewage treatment works on the River Thames, the Lee Tunnel and the Thames Tideway Tunnel which will connect to Lee Tunnel. At the heart of the Lee Tunnel is the Tideway Pumping Station, an 87m deep by 38m diameter pumping shaft, situated at Beckton STW. Its sole purpose is to transfer the tunnel's volume into Beckton for treatment. The pumping station has been engineered to operate under the both the Lee Tunnel flows and the future Thames Tideway Tunnel loads. This paper details the operational equipment within this shaft.

Pumping shaft central wall slipform - Courtesy of Thames Water

Lee Tunnel overview

The Lee Tunnel generates the required improvement to the London's sewer system by removing combined discharges of stormwater and sewage to the River Thames and lower River Lee. The tunnel, which will have an internal diameter of 7.2m, is being constructed at an average of 75m below the ground, running 6.9km from the Abbey Mills Pumping Station complex in Stratford, East London, to the Beckton STW in East London.

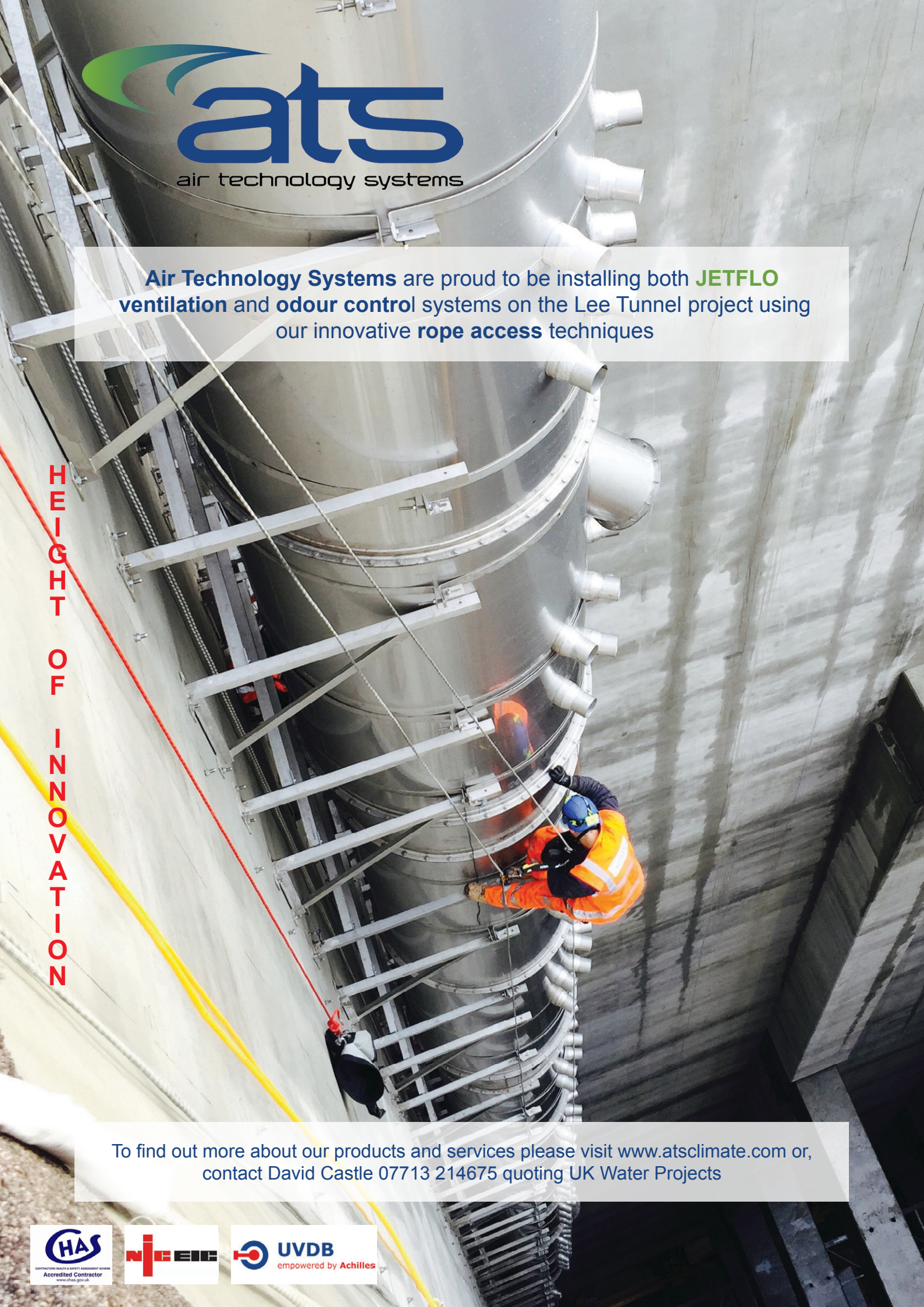
The tunnel is required to store 350,000m^3 of stormwater and sewage, which is pumped out to Beckton STW following each tunnel filling event, subject to STW capacity availability once the storm event has abated. The project requires the construction of 87m deep dry well pumping shaft known as the Tideway Pumping Station, the focus of this article.

At the Abbey Mills Pumping Station a single combined sewer overflow discharging into the River Lee is responsible for about 40% of all stormwater that ultimately flows into the River Thames, which equates to 16 million tonnes per year. The Lee Tunnel will carry these stormwater flows from Abbey Mills to Beckton STW, which has been upgraded and expanded to ensure that the facility can handle these additional loads.

Undertakings

MVB, a joint venture of Morgan Sindall, Vinci Construction Grands Projets and Bachy Soletanche, was awarded a design and construct contract for the Lee Tunnel in early 2010, with UnPS, Bachy Soletanche and Mott MacDonald acting as the detailed designers.

The £711m project is being delivered under a NEC 3 Option C form of contract. Thames Water's project management team, led by CH2M Hill and including AECOM, work at site in a collaborative 'one team' manner with MVB. Prior to contract award AECOM had undertaken the concept, planning, and reference design for the Lee Tunnel on behalf of Thames Water.


ats
air technology systems
Air Technology Systems are proud to be installing both JETFLO ventilation and odour control systems on the Lee Tunnel project using our innovative rope access techniques
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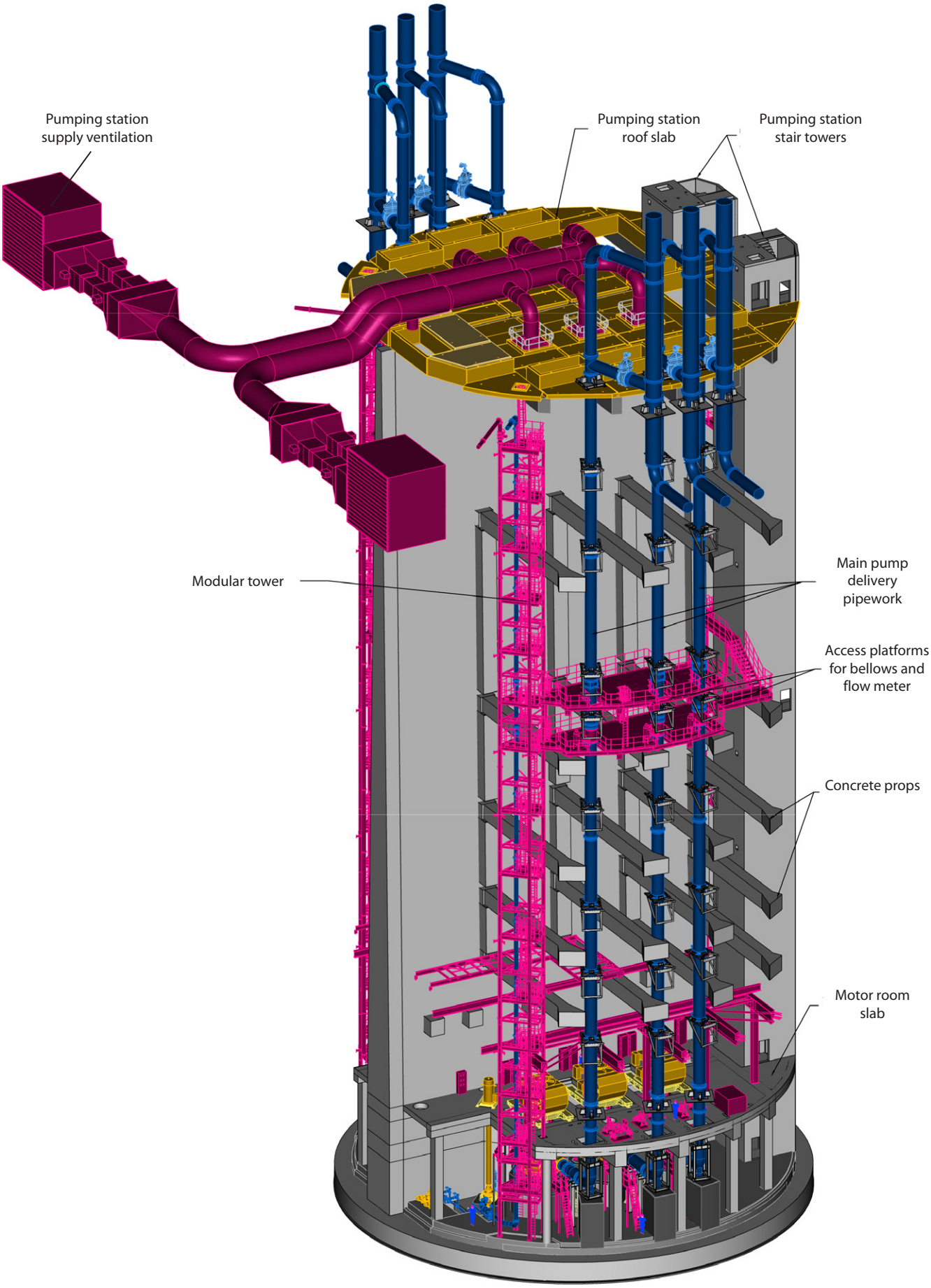

Tideway Pumping Station, section from 3D Model - Courtesy of Thames Water

The heart of Lee Tunnel system

At the heart of the Lee Tunnel is the Tideway Pumping Station. This 87m deep and 38m in diameter pumping shaft is situated at Beckton STW and its sole purpose is to transfer the tunnel's volume into Beckton for treatment. As the flows enter the tunnel and volume is filled, the level in the three wet shafts will rise; Shaft F at Abbey Millls (the feed to the tunnel and its highest point), the Connection Shaft and the Overflow Shaft (both located at Beckton.

The Connection Shaft is essentially the wet well for the Tideway Pumping Station and is the lowest point on the whole Tideway system. It also contains coarse screens which are cleared by a surface mounted rake and grab system. The two shafts are connected via a 30m long sprayed concrete lined tunnel finished with a stainless steel liner.

From the suction tunnel the effluent flows into the suction culvert, located in the centre of the base of the Tideway Pumping Station. The culvert is where the flows are presented to the Lee Tunnel's 6 (No.) main pumps and 2 (No.) drain down pumps. At the culvert the flow is divided by a stainless steel baffle wall, where it is presented to the 6 (No.) pump suction bends. The station remains split throughout the dry well of the pumping station via the central wall. The reason behind this division is to create a hardened pumping station, which in catastrophic failure in one half of the station, the other half of the station will remain fully operational.

The main pumps and risers

The main pumps are 3.4MW single stage end-suction Super Pumps supplied by KSB (cast and manufactured by GIW Industries) and have been uniquely designed to meet the challenging duty of the Lee Tunnel and ultimately the Tideway scheme. Each main pump is capable of delivery 3,000l/s with a maximum station design flow of 12,000l/s and lifts the flow by over 88m from the pumping station's basement to the surface. The pumps individually sit on 4.3m high reinforced concrete plinths and within each plinth there is a 1.4m diameter stainless suction bend which connects to the base of the pump. The 2.2m diameter stainless steel impeller has a 400mm pass through to enable the pumping of relatively large solids.

The pump and motor are coupled via a carbon shaft, which will rotate at 333 rpm. The Siemens A-modyn vertical motors are located on the Motor Room Floor in the shaft and are expected to generate approximately 100KW of heat during operation. The innovative cooling method is via inline heat exchangers which form 24m of each main riser. The heat exchanger cools the pumps by using the pumped fluid so the excess heat is transferred and taken away by the pumped flow.

Each motor weighs 30 tons and measures 2.85m long x 2.75m high and 3.83m wide. The motors feature Rockwell Automation variable frequency drives that are housed in the power supply complex (PSC), approximately 100m (laterally) from the pumping shaft.

As the flow leaves the pumps it is driven into 1m diameter PN16 316-L stainless steel riser pipes. The pipework contains a set of expansion bellows 41m up from the shaft base, these bellows allow the pipework to expand or contract up to 80mm. This movement is to compensate for the temperature difference the pipework will experience when in and out of operation.

Uniquely the pipework is not supported by the shaft walls, although there are galvanised mild steel guide brackets, but these are for vibration containment only and do not carry load.

The load of pipework below the bellows is transferred to the shaft's base via huge reinforced concrete plinths. Above the bellows the pipework is support by the shaft's roof slab, with the load evenly distributed through a bespoke ring stiffener designed by the pipework system designer Piping Engineering Solutions (PES).

PUMPS: Key Facts						
Pumps	**Number of Pumps**	**Arrangement**	**Duty Head (m)**	**Flow Rate per fan (l/s)**	**Power**	**Weight (Tonnes)**
Main Pumps	6 (3 per each half of station)	Duty/Assist/Standby	87.1	3,050	3.52MW	90
Drain Down Pumps	2	Duty/Standby	83.8	260	500KW	8.1
VENTILATION SYSTEM: Key Facts						
Shaft	**Number of Fans**	**Fan Type**	**Arrangement**	**Flow Rate per fan (m^3/s)**	**Power (KW)**	**Weight (kg)**
Main Shaft Extraction	2	Axial	Duty/Assist	21.45	45	622
Main Shaft Supply	2	Axial	Duty/Assist	21.45	90	976
Access Shaft	2	Centrifugal	Duty/Standby	17.7	75	1742

The drain down pump system/operation

KSB have also supplied the duty/standby drain down pumps. There is one pump in each half of the pumping station but they share a sump at the end of the suction culvert. The drain down pumps are designed to empty the final 500m^3 of effluent at the base of the Connection Shaft and suction culvert. The operation of these pumps follows a final effluent flushing of the culvert, which is carried out by the pumping station's sparging system.

This system agitates any sediment that has collected within the culvert by directing final effluent at 8 bar pressure into the drain down pump sump. This debris clearance has been demonstrated through hydraulic modelling completed by BHR Group.

This hydraulic modelling showed that the automatic addition of final effluent to the drain down pump cycle fluidises sediment and ensure the drain down pump operates satisfactorily.

Pump protection

Both the main and drain down pumps benefit from condition based monitoring (CBM) systems that protect the pumps from damage by highlighting changes in their operational performance. The CBM has two hardwired loops, one looking at the pump and motor bearing vibration the other loop monitors the following;

a) Temperature (on pump thrust bearings and motor windings).
b) Pressure (lubricating oil system and cooling water system).
c) Level (motor leak detection, lubricating oil system and cooling water system).
d) Flow (seal flushing system).
e) Moisture.

If any of these parameters waiver from their pre-set range then the pump will automatically commence its shutdown sequence in order to protect the pump from damage.

One of the 3.4MW single stage end-suction Super Pumps
Courtesy of Thames Water

Shaft ventilation system
Courtesy of Thames Water

Large Weholite Modular tank built as part of Cambridge sewage treatment upgrades

Newport based Asset International Ltd has delivered the largest Weholite Modular tank ever built to Anglian Water's Cambridge Water Recycling Centre, to form part of the inter-process pumping for the plant's ongoing £21 million upgrade.

Ahead of the initiation of the AMP6 period in April 2015, Anglian Water is investing £21 million to increase the treatment capacity of the sewage treatment works in Cambridge.

Asset International were commissioned by Anglian Water's @one Alliance to deliver a Weholite Modular tank for the project, which would be utilised as a pumping chamber, in order to transfer sewage to the new treatment units.

The dimensions required on site meant that the size of the Weholite Modular tank was larger than anything that had been built before at the South Wales factory. At 15 metres long, 4.5 metres wide and 5 metres high, the tank has a capacity of approximately 340m3, which translates to 340,000 litres of sewage.

Once the Weholite Modular tank left South Wales it was installed on site in Cambridge by the following morning, an impressive feat of engineering that would have seen a similar project undertaken in concrete taking up to 13 weeks to install.

Speaking about the project, Shaun Kalies, Sales Director at Asset, commented;

"Due to its sheer size a lot of complex design work went into the development of this Weholite Modular tank. We're really proud of the finished result, which is a testament to the innovative practices we employ in every project that we undertake."

Weholite Modular is a new product from Asset International which is more commonly associated with its large diameter plastic pipes. Weholite Modular can be used to construct CSO control chambers, pumping stations, flow control chambers, ventilation chambers, detention tanks and other strategic water management products.

Asset can customise the individual chambers according to customer specifications to include hatches, pipe supports, ladders and more, all the while taking into account traffic loads, groundwater pressure and soil loads.

For more information about Weholite call Asset International 01633 273081 or visit www.weholite.co.uk

WEHOLITE

ASSET International Ltd.

www.weholite.co.uk

Shaft ventilation system - Courtesy of Thames Water

Shaft ventilation system

The ventilation system has been designed, supplied and installed by Air Technology Systems (ATS). The two halves of the shaft are independently ventilated to provide a balanced fresh air and extract system.

Each half having two main areas for ventilation, main shaft and access shaft. For both areas the supply and extract system shall be configured to supply either 2 air change per hour (ac.h-1) or 4 ac.h-1 when operating in either unoccupied or occupied/pumping periods. The occupied mode within the main shaft is operated under the following conditions at 4 ac.h-1;

1. Gas monitoring: Indication of harmful gas build-up or oxygen depletion.
2. Upon personnel entering the shaft.
3. Main pumps in operation.

The access shaft houses the staircore and lift, and as such is the safe area in case of emergency. In emergency mode the fans ventilation systems shall operate as to provide Class B pressurisation of the staircore, lift shaft, lift motor room and lobby branches. The ventilation system is in pressurisation mode if one of the following sequences has occurred:

1. The fire detection system in the main pumping shaft detects a fire.
2. Gas monitoring – Indication of harmful gas build-up or oxygen depletion within the main pumping shaft.

The pumping station's entry system will also inhibit entry to the station if a harmful gas were detected. The system will automatically increase the air change rate to 4 ac.h-1 and the interlock would be held for a minimum of an hour before entry could be made. If the gas was the still present after an hour the air change rate would remain at 4 and entry would still be inhibited. To override this interlock would require a permit to enter.

The shaft maintenance facilities

The pumping station houses a 50 tonne safe working load gantry crane on the motor room floor, supplied by Pelloby Ltd. This crane is capable of removing all items from the station's basement and locating them on the load bay on the motor room floor. From this loading bay the equipment can be removed via a direct lift from a mobile crane through a hatch in station's cover slab.

The station also benefits from two electric traction lifts fitted within the service cores, supplied by Liftec. These lifts have 2,000Kg or 16 person capacity and have been designed to transfer maintenance materials and small plant as well as personnel. The lifts will provide access at 4 levels, namely the basement, motor room floor, flowmeter & bellows level and the top of pumping station. The flowmeters and bellows within the main riser pipework are accessible for maintenance and inspection via galvanised mild steel platforms.

Progress update

The Lee Tunnel Project will commence wet commissioning in November 2015 and scheduled to be fully operational by the end of December 2015.

On completion the Lee Tunnel will become the heartbeat of the London Tideway Improvement Scheme, providing robust capacity for its 120 year design life, successfully building on and complimenting the 150 year old Victorian sewage system designed by Sir Joseph Bazalgette.

The editor and publishers would like to thank Phil Muir, Senior Construction and Installation Manager, with CH2M Hill, for providing the above article for publication.