National Graphene Institute

Scientific | Case Study

The Client

Graphene has been called "the most exciting material of the 21st century", its properties and full potential are still being discovered but its possibilities appear almost limitless. Already it is being developed for use in applications ranging from microelectronics to structural engineering and from DNA sequencing to water purification. It's an allotrope of carbon in the form of a two-dimensional, atomic-scale, hexagonal lattice. It is, effectively, a monatomic thick sheet of graphite so can be regarded as the basic structural element of other allotropes, including charcoal, carbon nanotubes and fullerenes.

This structure imbues graphene with many extraordinary properties: it is about 200 times stronger than steel by weight, conducts heat and electricity with greater efficiency than copper, it is also a zero-gap semiconductor, has a specific surface area comparable to that of activated carbon and is almost completely transparent, yet so dense that even helium cannot pass through it.

So exciting is the potential for graphene that the Government allocated £70m for graphene research, the result is a £61m National Graphene Institute built, appropriately, at The University of Manchester, where the material was first isolated by Sir Andre Geim and Sir Kostya Novoselov in 2004. £38m of the funding came from the Government and the balance from the European Regional Development Fund (ERDF). The NGI operates as a 'hub and spoke' model, working with other UK institutions involved in graphene research. The 7,800 square metre building houses state-of-the-art facilities, including two ISO Class 5 cleanrooms and two floors of support laboratories.

The building services contract for the project, which won the prestigious 'Project of the Year' in the H&V News Awards 2015, was awarded to Balfour Beatty Engineering Services. This included the design supply and installation of ultrapure water (UPW) systems for the cleanrooms and laboratories, which they entrusted to Veolia Water Technologies UK.

Key Figures

- 12 PURELAB® Option Q across 3 laboratory areas
- 7,825m^2 building area
- 1,500m^2 of Class 100 and 1000 cleanrooms
- Supply 3000 l/h ultrapure water
- Supply 200 l/h Type 1 laboratory water
- Delivered on time and on budget

The Client's Needs

The building is divided into three laboratory areas:

• The lower ground floor cleanrooms (32 POU)

• The first and second floor analytical laboratories (12 POU)

• The third floor chemistry laboratory and furnace room (20 POU)

All the laboratory areas require high quality water supplies. The cleanrooms need a total of 3000 l/h of Type 1+ ultrapure water distributed to 32 points of use (POU) – all of which need to meet a customised water quality specification. This specification is based on the ASTM D5127 Standard Guide for Ultra Pure Water used in the Electronics and Semiconductor Industry Type E1.2, but with some parameters at significantly lower concentrations.

The first and second floor laboratories have a total of 12 points of use, each with a peak demand of 120 l/h of Type 1 water; NGI wanted these laboratories to be as flexible as possible, with the possibility to move points of use around the laboratory area rather than having fixed work stations. The third floor chemistry laboratory has 20 points of use with a total demand of 200 l/h of Type 1 water.

Expertise

To meet these critical requirements, Balfour Beatty Engineering Services needed to work in close partnership with a water treatment company with a proven track record of expertise and service excellence. With this in mind, Balfour Beatty Engineering Services chose Veolia. Veolia appointed a dedicated Project Engineer to manage the entire project, from concept and front end engineering design (FEED) through installation, testing and commissioning to final validation. Veolia's Project Engineers use the latest project management techniques, have a broad depth and breadth of market knowledge and expertise. Quality is further assured by using 3D modelling to design the plant layout, conducting site surveys, and creating detailed design documents, which are prepared by expert design engineers.

The Solution

Veolia's engineers worked in partnership with Balfour Beatty Engineering Services' team to develop bespoke solutions for each of the laboratory and clean room areas.

In the third floor chemistry laboratory, softened water is fed to a Centra 200 standard packaged unit that delivers Type 3 water to a reservoir. This water is pumped through a mixed bed deionisation cylinder to polish it to Type 1 quality, and then on to a distribution loop, to the points of use, with the unused water returning to the reservoir.

Veolia's highly innovative solution provided the flexibility required in the first and second floor laboratories by supplying 12 PURELAB® Option Q water purifiers that can be moved around the area and connected to a convenient mains water supply anywhere in the laboratory, using a special flexible connection device.

To produce the exceptionally high quality ultrapure water for the cleanrooms, Veolia's engineers designed a bespoke plant using state-of-the-art technology as described below.

Process Description

Ultrapure Water Production

In the customised water purification system for the cleanrooms, mains water is filtered and softened to protect the downstream equipment from hard water scale and to increase the recovery of the membrane plant, minimising waste water. The softened water is pumped to the primary deionisation plant which uses twin pass reverse osmosis. The first pass removes 95-98% of dissolved ionic and organic contaminants from the water, 75% of this feed water is recovered in a permeate tank and the 25% waste water is discharged to the rain water harvesting system to minimise water waste, reduce costs and energy consumption. The permeate is pumped to the second pass reverse osmosis, where the recovery is 90%, and the 10% reject flow is returned to the raw water tank for reuse. The permeate from this second pass reverse osmosis unit is further treated by continuous electro-deionisation to better than 10MΩ.cm resistivity. This is followed by irradiation with ultraviolet light of 185nm photo-oxidising wavelength to oxidise any residual organic matter to carbon dioxide which, in turn, is removed, along with oxygen, by membrane degassing. The resulting purified water is passed to the storage tank. If the tank is full, the water is automatically recycled to the permeate tank.

Ultrapure Water Distribution

The nitrogen blanketed 7,000 litre UPW tank, which is part of the polishing system, provides a reservoir. The water is pumped from the tank through another 185nm UV photo-oxidation unit followed by two cylinders, arranged in series and containing mixed bed deionisation resin, which carry out the final polishing to 18.2MΩ.cm resistivity followed by a 0.1µm absolute cartridge filter, a UV lamp, operating at the germicidal wavelength of 254nm, and an ultrafilter, which combine to ensure that the water is free from particles and bacterially pure. The resulting UPW is continuously circulated to points of use by a PVDF distribution loop with unused water returning to the UPW tank. Continuous recirculation minimises the possibility of microbiological contamination in the storage and distribution system.

Veolia Water Technologies
Windsor Court, Kingsmead Business Park,
High Wycombe, HP11 1JU
Office. +44 (0)1628 897000
www.veoliawatertechnologies.co.uk