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Amiad's pre-treatment systems used in NEWater factories

By Dr Mike Coffey

In this article we focus on the NEWater project in Singapore, where high grade reclaimed water, to supplement water supply requirements, is produced from treated secondary effluent at NEWater factories. We describe how Amiad's ABF10000 (BRUSH) filters are used in NEWater factories for the effective pre-treatment of secondary treated effluent. After this screening, subsequent micro-/ultra-filtration (MF/UF) and reverse osmosis (RO) treatment technologies from various manufacturers are used to produce NEWater. The NEWater produced is used mainly for direct supply to industrial users with high standards required for their feed-water, and a small proportion of NEWater is blended with rainwater in reservoirs as a raw water feed to produce water for potable use.

We explain how the pre-filtration technology operates, and how this is integrated into a variety of MF-/UF-RO systems. Examples of successfully installed Amiad screen filtration units are featured in the Singapore NEWater factories at Bedok, Kranji, Seletar and Ulu Pandan.

The Singapore NEWater Project

In 1998, the PUB, Singapore's national water agency, and the Ministry of the Environment initiated a programme called the Singapore Water Reclamation Study (the NEWater Study). The aim of the project was to determine the suitability of using NEWater as a source of raw water to supplement Singapore's water supply.

The programme used combinations of water treatment technology from various suppliers in order to produce high grade reclaimed water from secondary treated effluent, and has subsequently commissioned full-scale treatment facilities at several locations.

NEWater is produced from a multiple barrier treatment process. After passing through the Amiad strainers, the feedwater goes through the first and second stages of NEWater treatment process utilising microfiltration (MF) and reverse osmosis (RO). The

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third treatment stage is UV disinfection which acts as an additional safeguard to the treatment process. The quality of NEWater produced using these advanced technologies consistently meets United States Environmental Protection Agency and World Health Organisation drinking water standards/guidelines. In all cases, effective pre-treatment by means of screen filtration is required to reliably produce the high grade reclaimed water at the high volume rate required. Amiad's ABF 10000 (BRUSH) screen filtration, featured in this article, is used at the NEWater factories commissioned to date.

Three NEWater factories have now been commissioned as part of the NEWater project, with a fourth due to go on-line by the end of 2006. NEWater is used primarily to meet industrial demand, including applications where a very high quality supply is necessary. A small proportion of the reclaimed water is also blended with rainwater in reservoirs, which is subsequently treated using conventional technology to produce a water for potable use.

The Singapore NEWater project has built upon the experience of projects elsewhere, for example by Orange County Water District in South Carolina, USA, where a similar Planned Indirect Potable Use (PIPU) procedure has been used to blend reclaimed water with groundwater supplies since 1976. Many examples exist globally of Unplanned Indirect Potable Use procedures (UIPU), whereby mixed fresh source water and effluent discharge, for example river abstraction which receives treated effluent discharge from upstream population centres, is reused after appropriate treatment.

In Singapore, after an initial period of pilot testing, the first two full-scale NEWater Factories were commissioned in late 2002 at Bedok (Figure 1) and Kranji. In January 2004 the third water reclamation plant was commissioned at Seletar, and a fourth is to be commissioned in 2006 at Ulu Pandan. The first three NEWater Factories can produce 96 MLD (96000 m³/day) of NEWater (32, 40 and 24 MLD from Bedok, Kranji and Seletar respectively). The new plant at Ulu Pandan will more than double this supply by initially adding 116 MLD treatment capacity.

Currently, a small quantity, which is about 1% of Singapore's total water consumption, of NEWater is introduced to reservoir supplies and the target for the future NEWater blending rate is 45.5 MLD or about 2.5% of the total water consumption by 2011. Non-potable use of NEWater includes supply to semiconductor wafer fabrication plants, demonstrating the exceptional quality of the reclaimed water produced at the NEWater factories.

NEWater meets relevant international water quality standards. Permeate water quality achieved (compared against WHO/USEPA standards in parentheses where appropriate) include: <200 µS/cm conductivity, total dissolved solids <100 mg/L (standards 500/1000 mg/L), pH 7.0-8.5 (standard 6.5-8.5), and alkalinity and total hardness better than 20 mg/L CaCO₃ equivalent.

The chemical water quality of the permeate is similarly impressive, containing sulphate < 5 mg/L (standard 250 mg/L), nitrate <15 mg/L, ammonia-nitrogen <1.0 mg/L (standard 1.5 mg/L) and residual chlorine <2 mg/L (standard < 5 mg/L). Metals in the permeate, including aluminium, barium, boron, copper, iron and zinc are all <0.1 mg/L, <0.05 mg/L for some, and similarly are well below the WHO/USEPA quality standards (in the range 0.2 – 5 mg/L).

As required by these same standards, faecal coliform and enterovirus are undetectable in NEWater and bacteriological water quality is excellent. (A full appraisal of the NEWater quality can be found in the Expert Panel Review Report, available from www.pub.gov.sg/NEWater_files).

ABF 10000(BRUSH) for effective pre-filtration

Amiad ABF filters are heavy-duty strainers with a self-cleaning capability, manufactured in a range of treatment capacity sizes (see Figure 2). Effective screening in the range 3500-200 µm is achieved. Amiad ABF filtration systems are fitted in parallel (see Figure 3), with 3 active units and a fourth in reserve, allowing for an uninterrupted treatment capacity in excess of 2000 m³/hour at Bedok (500 µm screening) and 1500 m³/hour at Seletar (200 µm screening).

The filters work by straining effluent through a cylindrical filter head from inside-to-out, the unit benefiting from a large screen area (6000-10000 cm²). A filter cake forms on the inside of the head, and produces a pressure differential between the unit inlet and outlet. When this pressure differential reaches 0.5 bar the self-cleaning mechanism is triggered. Two stainless steel revolving brushes, powered by an electric motor, sweep the cylinder free of trapped cake and flush this via an exhaust from the cylinder head. The self-cleaning operation takes approximately 15 seconds allowing uninterrupted operation of the filtration unit. Although the pressure-initiated self-cleaning trigger is reliably monitored by a pressure differential switch, the unit self-cleaning facility can alternatively be time-event triggered.

Amiad ABF filters are very robust. An epoxy-coated carbon steel 37-2 or 316L housing contains a stainless steel 316L screen and PVC/acetyl coated stainless steel brushes, with rubber and Teflon seals. A range of inlet/outlet valve sizes allows for easy incorporation of Amiad filtration units to various plant treatment systems. The units can be fitted in-line with UF/MF and other treatment systems from various manufacturers. Working pressures in the range 0.8-10 bar are normal, although this working range can be extended to 25 bar if necessary by using appropriately manufactured Amiad filtration units.

The flexibility of Amiad filter installations, combined with their robust construction and automated self cleaning proved attractive to the NEWater project plant designers, and their proven effectiveness has seen their introduction to all four of the NEWater factories in Singapore.

Amiad pre-filtration is installed at NEWater factories

The effectiveness of treatment of raw source water using combined technologies was extensively tested in pilot studies prior to commissioning of full-scale NEWater factories in Singapore. Recognising the successes achieved with PIPU and UIPU elsewhere globally, an Expert Panel comprising individuals from within and outside Singapore, reported its findings to the Singapore PUB in June 2002.

NEWater produced at a pilot scale was extensively tested for physical, chemical and microbiological parameters and compared against the benchmark standards set by the WHO and the USEPA National Primary and Secondary Drinking Water Quality Guidelines. Additional toxicological studies were conducted on the produced NEWater assessing, amongst other things, potential endocrine disrupting activity.

The pilot plant, located at the Bedok water reclamation plant, produced 10 MLD NEWater. Secondary effluent source water (BOD₅ ca. 10 mg/L, TSS 10 mg/L, 6 mg/L ammoniacal-N, 400-1600 g/L total dissolved solids) was micro-screened, then underwent MF to 0.2 µm, with chlorine dosing either side of this MF process to control biofouling, and was demineralised by RO.

The permeate was disinfected using UV. Design performance of the pilot plant was equalled or bettered over a period of two years, removing >97% TDS, >94% ammonia-N, >99% total organic carbon, and achieving a permeate turbidity of <0.1 NTU. The plant proved to be both robust and reliable throughout the trials, with energy

requirements 0.7-0.9 kW/m³ (design criterion 1.2 kW/m³). NEWater successfully met water quality benchmarks and exhibited no toxicological effects. The Panel concluded that NEWater is safe for potable use, and on this basis Singapore PUB commenced full-scale NEWater generation.

The NEWater factories use MF/UF and RO/UV technology from various manufacturers to achieve a high quality product. At all four NEWater factories, their optimal performance benefits from effective pre-treatment of the secondary treated effluent. Amiad single stage 500 µm stainless steel wedgewire screen ABF (BRUSH) systems are installed at all four of the NEWater factories, providing excellent protection for later stage treatment by the provision of a reliably screened feed-stream. Combined, the screening and UF/MF processes remove suspended solids and most colloidal particles, reducing influent turbidity of up to 6 NTU to < 0.1 NTU RO feed-water turbidity. This ensures provision of a consistently good quality feed water for subsequent RO treatment, and facilitates long-term sustainable NEWater production from the NEWater plants.

At Bedok and Kranji, Amiad ABF-10000 (BRUSH) pre-treatment is installed as a precursor to submerged MF membranes. The effluent is then processed through low fouling composite (LFC) membranes, the hydrophilic surface of which is manufactured to be of similar pH to secondary effluent; the RO membrane is thus less prone to sorption of organic fouling entities. This combination of appropriately chosen MF/UF membrane technology with low fouling potential, protected by Amiad pre-treatment screening, has contributed to the success of the NEWater project, since NEWater is reliably produced in an affordable way with relatively low operating costs.

Excellent long term performance has been demonstrated at the Singapore NEWater factories, where cleaning requirements are only infrequent and permeate quality is stable. The success of the first three plants has been followed by the construction of the largest NEWater factory yet at Ulu Pandan, which uses the same tried-and-tested approaches used at the other three plants, including Amiad ABF (BRUSH) screen filtration.

Conclusions

The Singapore NEWater project successfully uses UF/MF-RO treatment of source raw water, combined with UV disinfection, to supplement existing water supplies for industrial use and for potable supply, when blended with rainwater in reservoirs and normally treated. Following extensive pilot testing of the technology, three full-scale water reclamation plants at Bedok, Kranji and Seletar produce 96 MLD NEWater, whilst a fourth plant at Ulu Pandan, due to be commissioned this year, will more than double this generation capacity.

NEWater is produced using technology from various manufacturers. All four NEWater factories are served by Amiad pre-filtration screening, using their robust and reliable automated self-cleaning steel mesh ABF (BRUSH) filtration units. These Amiad units effectively treat the influent feed-water and are an integral part of the plant that reliably provides a high quality permeate on a large scale.

NEWater now forms an important alternative source water supply in Singapore. The proven success of the technology has given rise to an ambitious expansion of the project, in which Amiad is the technology of choice for pre-filtration screening.

Contact Details

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For further details on Amiad's products please visit www.amiad.com.

Images

Figure 1: The Bedok NEWater Visitor Centre



Figure 2: The Amiad ABF (BRUSH) filtration unit.



Figure 3: Four Amiad ABF-10000 (BRUSH) 14" units fitted in parallel at Bedok. Treatment in excess of 2000 m³/hour influent is achieved, screening influent to 500 µm.



Notes to Editor



Founded in 1962, Amiad's Headquarters in Israel now occupies over 40,000 m² including an Injection Moulding Plant, Production and Assembly Halls, Warehouses and Office Space. Amiad also have an international filtration training centre and research laboratories. Amiad is one of the world's most significant producers of water filtration products and filtration solutions. Through strategic acquisitions, international expansions and substantial research and development investments, Amiad continues to strengthen its technology and market base.. Further details on Amiad Filtration Systems Limited can be viewed at www.amiad.com



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