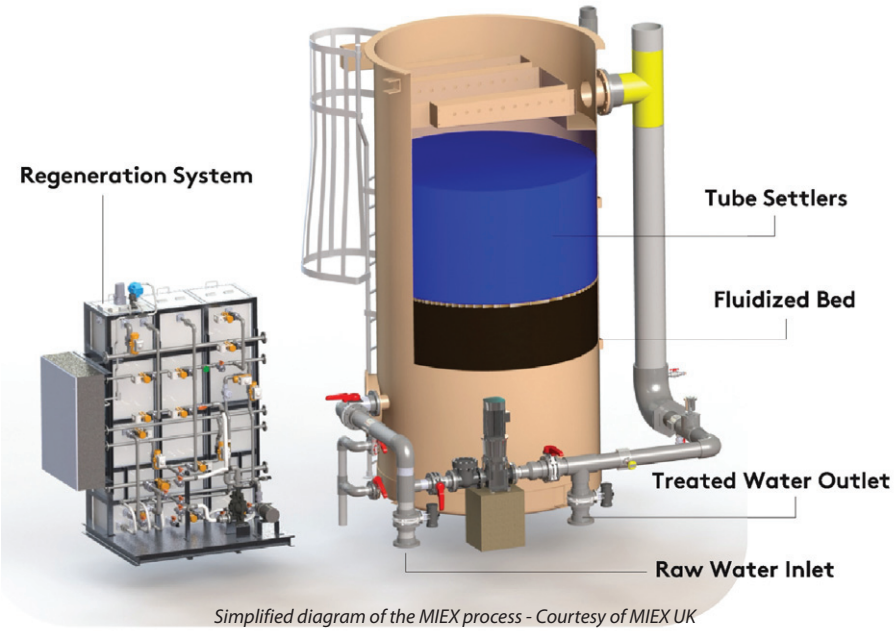
Tarbert WTW

new magnetic ion exchange (MIEX) pre-treatment plant to remove DOC and mitigate THM failure risk by reducing the organic load on the DAF/RGF plant

Tarbert WTW is located on the edge of Loch Fyne, an inland sea loch, west of the small village of Tarbert in Argyll & Bute. The water treatment works is supplied from the Loch a' Chaorainn located 5 miles north-west of the treatment works, serving a population of approximately 3,000. To remove the risk of trihalomethane (THM) failure, Scottish Water have started construction of a new £5.5m Magnetic Ion Exchange (MIEX) plant upstream of the exiting WTW; a first of its kind treatment technology for Scottish Water. Scottish Water's Non-Infrastructure Alliance Partner Efficient Service Delivery (ESD), a joint venture of MWH Treatment, Black & Veatch and Galliford Try, commenced construction in late July 2020.



Simplified diagram of the MIEX process - Courtesy of MIEX UK

Project background

The existing process comprises flocculation, followed by clarification/filtration via dissolved air flotation (DAF) units which are combined with the primary rapid gravity filters (RGF). Primary filtered water is then chlorinated and disinfected before being pumped from the chlorine contact tank through the manganese contactors (MCT). Secondary filtered water is then dosed for plumbosolvency control before reaching the clear water tank. The works has a maximum daily output of 1.3 ML/d.

In recent years, due to increasing raw water colour in the reservoir, Scottish Water had become concerned about a rise in dissolved organic carbon (DOC) in the treatment process at Tarbert, particularly in the late summer and autumn months. Organic carbon, when it comes into contact with chlorine, can form trihalomethanes (THM's). Scottish Water's SR15 business plan identified the need to undertake studies to determine the root cause of THM formation at Tarbert WTW and a number of other treatment works along the west coast of Scotland. Through these investigations, Scottish Water identified that the treatment process at Tarbert does not remove sufficient TOC, thereby leaving the works at a high risk of THM failure in distribution.

With the need established, Scottish Water selected ion exchange as the preferred process option to address the THM issue at Tarbert. The preferred technology was the MIEX process developed by MIEX UK, a subsidiary of Australian based Ixom Pty Ltd.

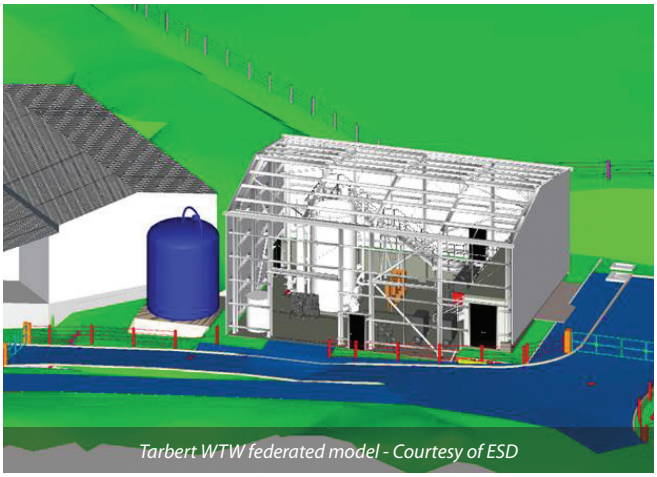
The MIEX process will be used as a pre-treatment stage to remove DOC from water prior to any existing treatment, mitigating THM failure risk by reducing the organic load on the DAF/RGF, and in turn reducing the risk of the DAF/RGF failing to remove organic load effectively. This will result in lower THM formation once the filtered water is chlorinated. The introduction of MIEX is also likely to lead to a reduction in chemical usage for coagulation and significantly reduce solids loading.

The MIEX process

The MIEX process proposed at Tarbert is based around using MIEX Resin developed by MIEX UK. The key process units include a gravity fed, high rate contactor vessel containing the MIEX Resin and the Resin Regeneration skid. Raw water from the inlet main enters at the bottom of the contractor and comes into contact with the MIEX Resin. The magnetised ionic MIEX Resin (positive charge) attract negatively charged DOC with the ion exchange then taking place. MIEX treated water subsequently overflows into the collection launders located at the top of the vessel and MIEX effluent proceeds to the next stage of treatment.

The regeneration skid consists of tanks and process equipment used to regenerate the resin with a brine (salt) solution. Resin is periodically drawn off from the contactor for regeneration by exchanging the positively charged DOC with chloride ions from a brine solution, creating a waste stream of concentrated DOC and brine.


Tarbert WTW - existing works - Courtesy of ESD


Tarbert WTW federated model - Courtesy of ESD


MIEX contactor unit - Courtesy of ESD

Put simply, the resin removes the DOC material from the raw water and the resin is then washed (regenerated) to create the waste brine. The waste brine is a concentrated saline solution which can be safely discharged at a low flow to the sea loch. This process solution does not require any additional chemicals.

While the MIEX technology has previously been used in North America (50+ installations) and Australia, within the UK, only a small number of significantly larger plants (of a different configuration) have been constructed, therefore limited reference sites existed.

Given this, the ESD project team looked to engage early with MIEX UK through a professional services contract to develop the outline design of the high rate contactor (HRC) option, complete HAZOPs and design reviews with Scottish Water stakeholders and ensure that a specification compliant offering was developed (or appropriate waivers obtained) and develop a delivery strategy.

Outline and detailed design

Initial scoping activities and engagement with MIEX UK commenced in late 2017, with the outline design commencing in 2018. The existing works is situated on a hillside beside a watercourse adjacent to a Site of Special Scientific Interest and has poor access for construction. The site is further constrained by variable ground levels, the need to maintain landowner access alongside the site and anticipated rock at low levels below ground.

Given the location of existing infrastructure and the site constraints, there were limited locations for siting the plant and it was quickly determined that an area of open ground to the rear of the existing works (and upstream of the existing raw water inlet) would present the best solution for construction and maintenance.

The hydraulics of the MIEX plant are relatively straightforward. The contactor unit itself is a gravity up flow contactor with limited losses (5m) over the unit, with all other flows between the resin regeneration skid being small and pumped. The process design provided by Ixom identified the following key components:

- MIEX contactor (5.8m high x 2.6m diameter).
- Resin regeneration skid (comprising salt saturator tank, brine tank and regeneration tank).
- Virgin resin skid.
- Resin loss skid.
- Air compressors.

The following additional components were identified by the design team to complete the design:

- New building structure to house MIEX plant and equipment and MCC room.
- MIEX plant MCC.
- Salt saturator.
- Service water booster set.
- Pre and post-MIEX sample instrumentation.
- Buried brine waste tank and pipeline.
- Extension to the existing site access road.

The salt saturator was included to remove potential manual handling issues that would have been required had the salt compartment in the regeneration skid been the sole point of application.

The design was originally prepared in a traditional 2D format however, following investment approval, and having reviewed the complexity of the existing ground topography, it was considered beneficial to build a 3D ground model.

Following this, the project manager and design team made the decision to follow a digital delivery strategy with MIEX UK providing their 3D model for integration into Navisworks. The

building structure was then developed in AutoCAD Revit and the detailed steelwork design has subsequently been integrated into a federated model and is being shared further with the supply chain and back into Scottish Water.

This model has been used to avoid clashes which were identified during the detailed design and communicated to relevant subcontractors. Furthermore, the model was used for sequencing works to facilitate safer and efficient planning of construction works. Scottish Water Operations' Team have been able to visualise the future operational requirements and communicate any concerns about the access in and around the equipment, pipework and instrumentation.

As well as the challenges at the site, the project team (including ESD, MIEX UK, and Scottish Water) worked together in the early stages of the project to address key challenges including confirmation of the scope with respect to interfaces with the existing WTW, a review of raw water data and agreement on the design envelope, and determination of the optimal delivery strategy including breakdown of subcontract packages.

The site is also one of several in Argyll where the existing WTW control system (SCADA and PLC) are being replaced, requiring additional coordination across the project teams to integrate the designs and delivery execution plans.

Project delivery

The outline design, detailed design and construction of the upgrade to Tarbert WTW was allocated by Scottish Water to ESD, who work in close collaboration with Scottish Water and their framework suppliers to deliver the Non-Infrastructure programme. A summary of the key contractors engaged in the delivery of the Tarbert project is detailed below:

- ***Client***: Scottish Water
- ***Principal designer & contractor***: Efficient Service Delivery (ESD) - a joint venture between MWH Treatment, Black & Veatch and Galliford Try
- ***MIEX plant design, procurement & supply***: MIEX UK Ltd
- ***Civil & earthworks contractor***: McFadyen Contractors Ltd (Campbeltown)
- ***Steelwork, cladding & access metalwork***: Metalwork UK
- ***MCC/systems Integration***: Saftronics
- ***SCADA & PLC replacement***: Boultings
- ***Mechanical installation contractor***: Homer Burgess

The project experienced some delay in commencing site works due to COVID-19 restrictions, however work on site commenced in July 2020 and is due for completion in early 2022. Bulk earthworks are underway to establish the formation levels for the new MIEX plant building.

The site team is implementing further digital delivery measures, including developing a 4D Synchro output to inform on constructability and sequencing; and the use of iPads on site to reduce paper. Planning is in place to increase the use of digital technology on site, including making use of BIM Field, potentially online inductions, and time-lapse cameras.

The SCADA and PLC replacement project is also being delivered by ESD, with the CFAT planned for September 2020. This project will be delivered on site alongside the MIEX project civils works and will be completed in the Spring of 2021, in advance of the main M&E elements commencing on the MIEX project.

Further MIEX projects and benefits

Following on from the initial Tarbert WTW project, the ESD project team has subsequently carried out the design of two further Magnetic Ion Exchange plants at Ardrishaig WTW and Dhu Loch WTW. These plants have an output of 3.6 ML/d and 2.4 ML/d respectively and have a similar twin contactor design, which has allowed ESD to adopt an earlier approach to digital delivery and reuse the design to significant effect, resulting in cost and programme savings.

The detailed design for the works at Ardrishaig is complete and the project commenced on site in September 2020. Due to the proximity of the Ardrishaig site to Tarbert (10 miles) it is planned that excess crushed rock from Tarbert will be reused at Ardrishaig to minimise waste disposal.

Further carbon benefits will be delivered at the Ardrishaig site through the incorporation of a pump as turbine (PaT) solution, which was considered to be a more sustainable solution when compared to the construction of a new brake pressure tank. It is anticipated the turbine will offset around a third of the combined power requirements of the existing WTW and new MIEX plant. The design for Dhu Loch is approaching completion, with works commencement planned for late 2020.

All three Argyll projects were designed using 3D modelling, with each building on the previously developed model library. The Ardrishaig building and mechanical design model was almost completely reused at Dhu Loch, allowing the design team to focused mainly on fitting the previously designed building to new ground profile and clash detection.

The three MIEX plant projects and the five SCADA/PLC replacement projects are being delivered as part of a portfolio of works by ESD in Argyll, all with the objective of ensuring a safe and enhanced supply to Scottish Water's customers.

The editor and publishers would like to thank ESD and Scottish Water for preparing the above article for publication.

Excavation and rock break out - Courtesy of ESD


Clean stone storage - Courtesy of ESD