# Clay Lake WTW

## NI Water investment to elimate risk to future supply due to high turbidity, organic carbon levels and algal loads

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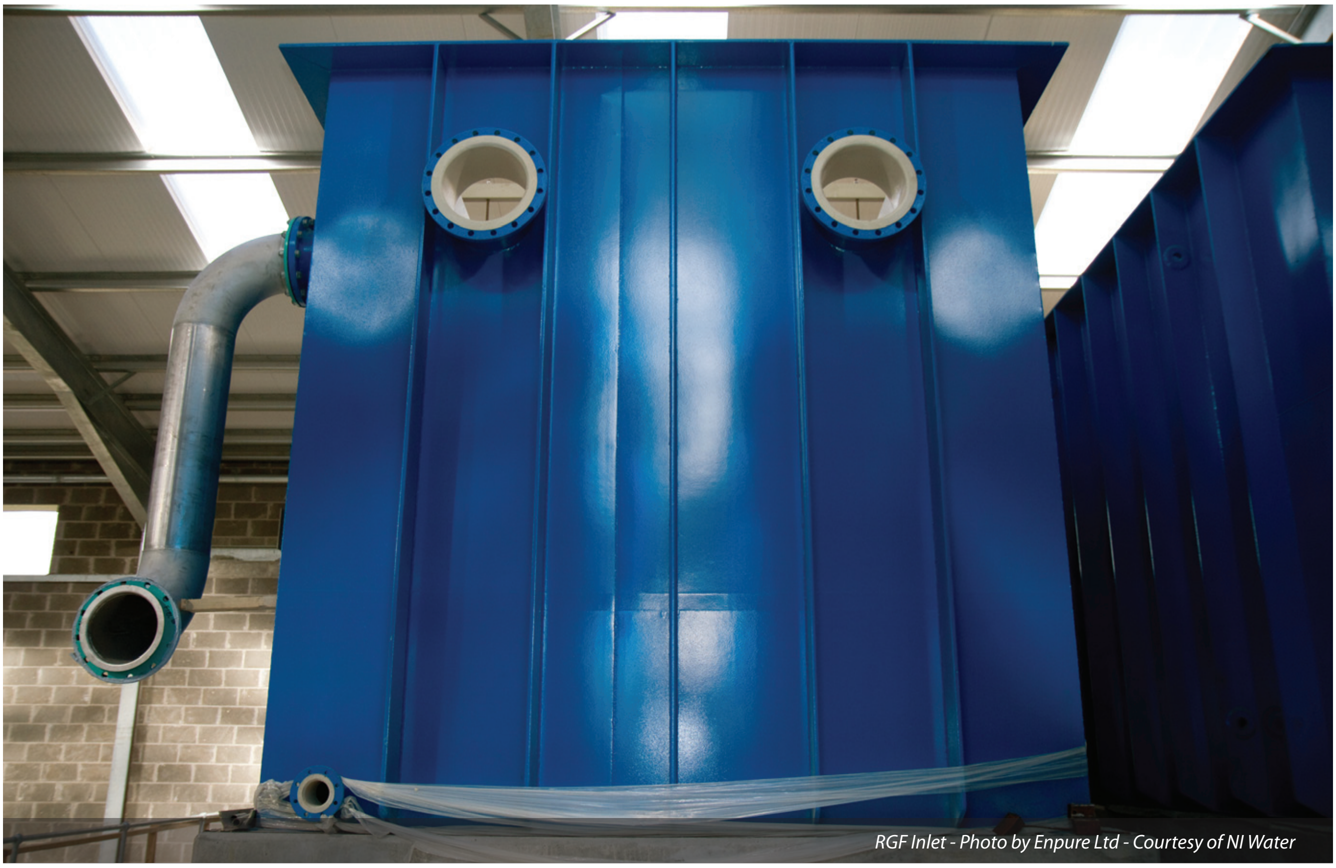
Clay Lake is located 3km south of the town of Keady in County Armagh, Northern Ireland, and is a 45 hectare impounded shallow fresh water lake that varies from 4–12m deep. It is in a natural clay hollow and is fed by a number of small burns. It is the sole abstraction for the current treatment works that feeds the town and local area service reservoir. Being an exposed, large surface area lake, the source water treatment objectives are affected by climate and algal blooms in the late spring and summer, whilst in the autumn and winter, the works can experience turbidity spikes. The drinking water safety plan for the works in the last five years has noted rising turbidity and organic carbon levels in the lake. Climate change indicates wetter and warmer weather that point to higher risk of treated water THM risks from organics and algal loads.



*RGF Inlet - Photo by Enpure Ltd - Courtesy of NI Water*

### Existing facility

The treatment process at NI Water's Clay Lake WTW consisted of slow sand filters fed at 4.5MLD from a small existing raw water balancing tank through micro-strainers. The filtrate was then pumped through 2 (No.) retrofitted GAC filters, pH corrected and chlorinated before storage in a contact tank and final pumping to the areas service reservoir.

4 (No.) slow sandfilters and micro-strainer were made redundant in 2007 by the addition of a pre-coagulated submerged membrane microfiltration process on the site as a Cryptosporidium barrier.

High turbidity spikes and the filamentous nature of the algae reduced the treatability of the water with this process and, taken in conjunction with existing site hydraulic limitations, meant the future supply zone demand was at risk of failing.

The limitations can be summarised as follows:

- Seasonally high solids loadings to the membrane units leading to deteriorating flux and production problems, more regular chemical cleaning regimes and increased maintenance demands.
- Algal loads and blinding of the membranes and poor cleaning. Organic breakthroughs leading to reduced GAC bed life and risk of breakthrough and elevated supply zone trihalomethane (THM) levels.
- The higher spikes of solids loadings in the plant led to sludge blanket rising in thickening plant and carryover into the supernatant returns.
- High manganese levels in raw water which the current treatment process plant was not designed to remove.
- Volume and quality limited consents for environmental discharges limiting emergency discharges to periodic GAC process washwater. Washwater recovery systems must be capable of direct recovery while in production as there are no emergency storage facilities on site.

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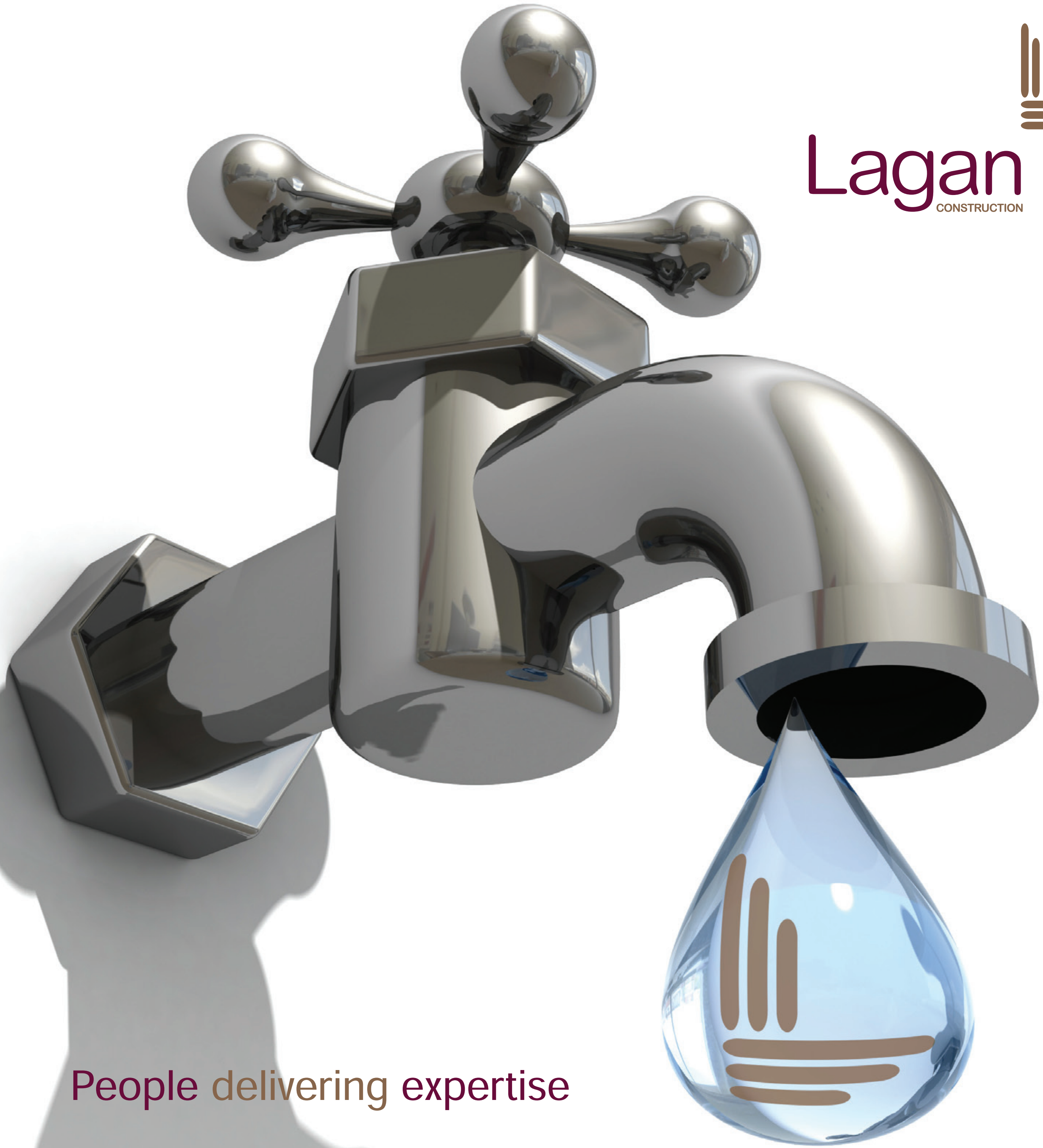

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*DAF and Flocculation tanks prior to cladding*
*Photo by Enpure Ltd - Courtesy of NI Water*


*DAF to RGF gallery*
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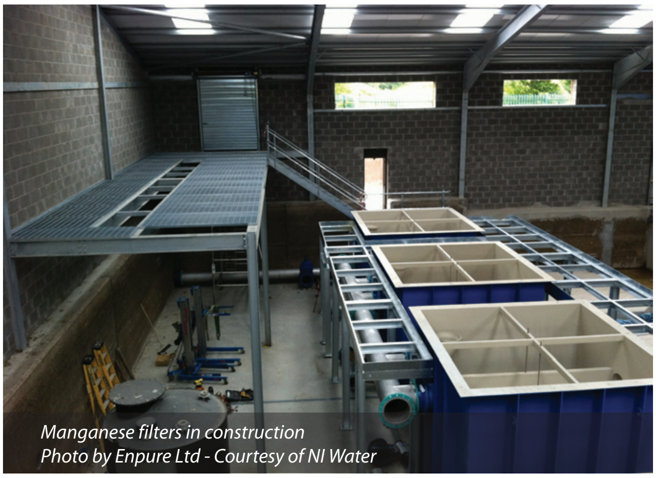
*Manganese filters in construction*
*Photo by Enpure Ltd - Courtesy of NI Water*


*GAC filter No. 1*
*Photo by Enpure Ltd - Courtesy of NI Water*

## Background to the new works

NI Water commissioned a project for additional conventional treatment as part of a Remedial Works Scheme. The Clay Lakes remedial process is located in a new building built over existing refurbished slow sand filters.

New process equipment to provide a parallel conventional DAF/Filtration treatment train is designed to allows higher throughputs to be achieved consistently at periods of high solids and algal loading in the raw water from the lake. The scheme also incorporates the 2 (No.) existing GAC adsorbers which are relocated and with a third identical unit provide 15 minutes empty bed contact time at current flows and the ability to increase the works flow to 6MLD and provide 12 minutes EBCT.

The existing chemical plant is upgraded with new equipment for the higher throughputs but also provides an independent chemical dosing and allows reuse of all existing chemical building storage and dosing facilities. A washwater and sludge handling facility is included in the new treatment train which doubles the sludge handling capacity of the site and eliminates the risk of solids supernatant carry over affecting the process.

The new works allows the existing membrane plant to be run in parallel or in series with the new process as demand and raw water quality determines. Final water from the new process stream is potable quality and can be chlorinated to gravitate to the existing clearwater tanks for contact time, storage and distribution to the potable Water Supply Zone. The design's layout was determined by the need for reuse of existing raw water pumps and the surrounding building heights and the economies of cost and carbon to minimise the need for excavations, structures and disruption to the existing process on site.

The works features a complimentarily designed process stream that maximised production while minimising footprint and operational costs.

## The main features of the works are described below.

***Inlet works:*** New inlet works from the existing raw water lift pumps incorporates a blended treated supernatant reuse stream from a returns blending tank. A flow measurement and new sampling station includes instrumentation for pH, turbidity and raw water dissolved organic carbon (DOC). The chemical dosing for coagulation is carried out in a new static mixer and the wide range of raw water conditions meant that pH correction was allowed for, with either sulphuric acid or lime that are hardwired interlocked to prevent accidental mixing of acids and alkali.

A separate static mixer is used for coagulation and aluminium sulphate was shown from flotation jar tests to be the most cost effective coagulant. The pH correction dose for flocculation is controlled by new duty/stand-by pH instruments, and additional treatment with polyelectrolyte is provided for at the inlet of the flocculators should it be necessary.

The coagulation process is controlled by an operator adjustable PLC programmable algorithm that minimises the coagulant dosed to optimise organics removal in the downstream processes. Research has shown that algal load varies qualitatively as well, and this, along with the need to switch to a more solids/turbidity removal based control system at different times of the year, means there are times when a purely charge based system is surpassed by empirical control. The software allows the operator to manage coagulant demand heuristically.

***Flocculator streams:*** These are designed to capture and partially settle any high solids loads from turbidity spikes and are duty/stand-by, each having two stages that can be independently set up to vary and optimise the mixer speed and energy input so as to minimise power consumption. Each flocculator stream is designed to be periodically flushed by the operator while in service, eliminating the need for plant shut downs or reduced production. The flushing waste stream is diverted to the washwater recovery system.

***Clarification:*** Is provided by 2 (No.) Enflo-vite® Dissolved Air Flotation streams from Enpure/Lagan (Shearwater Consortium). These incorporate patented nozzle technology that optimises turndown and maximises the throughput and flotation rate of the DAF unit. Each unit has a nominal design to NI Water's specifications of 10m/h which is safely below the unit's proven performance of 15 to 20m/h while producing clarified water below 1 NTU.

Clarified water from each unit has sampling and on line instrumentation for turbidity. On compact high rate DAFs the clarified water quality can be compromised by floated solids removal, and on small works such as Clay Lake, where hydraulic removal is not possible, mechanical removal is the only option.

Shearwater Consortium have developed a rotating paddle and beach type scraper design across their DAF design range and this has proven to be a simple, robust and reliable solution. As a result of the improved solids removal efficiencies, the amount of water circulating in the waste treatment system is reduced allowing safer designs for water reuse.

***Rapid gravity filters:*** The clarified water is processed by duty/stand-by rapid gravity filters each with PLC outlet flow control for Cryptosporidium robustness and hydraulic flow control. Each unit is sampled for coagulant metal residual and turbidity, while common RGF filtered water has DOC measurement which links with the pre-flocculation dosing coagulation control algorithm. They are closely flow controlled to prevent against solids breakthrough and have plug valves with electro-pneumatic positioners that are fail safe without the use of battery back-up or UPS systems.

The plant hydraulics of the filters were designed to allow safe start up and shut down of the plant and preventing water passing through the filter of poor quality. Space restrictions meant that rinse to waste facilities could not be provided so slow start control was designed to be as robust as practically possible.

The facility for a slug of polyelectrolyte added to the backwash water at the end of the wash stage has been incorporated, should the operator demand shorter ripening times to increase plant production over the course of the production cycle.

Designed by Enpure/Lagan, the RGF filters are welded and coated steel tanks with raised plenum type floors and nozzles designed to give both separate and combined air scour backwashing. As there is only one set of backwash pumps (duty/standby) for all three stages of filters, the pumps needed to be designed for maximum GAC expansion to incorporate higher washrates for backwashing and rinsing and refill.

The filter is commissioned with a single deep coarse sand media and incorporates dual washout launders to allow the addition of additional media that can extend run times and/or higher rates of operation. The production design run time is twenty-four hours.

***Granular activated carbon:*** The 2 (No.) existing stainless steel welded plate granular activated carbon (GAC) filters on site were added with relift pumps between the membrane plant and the contact tank. This was a process bottleneck and an OPEX pumping expense.

In operation, they were challenged by the high levels of organics in the water and provided only 10 minutes of contact time meaning breakthrough was reached in eighteen months. The site's location also gave higher logistics costs as there are no GAC regeneration facilities in Ireland.

The project set out to incorporate these units in the hydraulic profile plus provide a third identical unit. The building and the process pipework and control system was designed to allow one new unit to be commissioned independently. This arrangement had to be capable of also allowing one new unit to be operated at maximum hydraulic loadings, allowing the old GAC units to be decommissioned and re-erected in the new building while not compromising the water quality.

A flow controlled bypass arrangement was designed to ensure that production demand from the supply zone could always be met. The programme of works was carefully designed around this key activity to encompass supply chain and site logistical considerations and any interruption to Northern Ireland Water's production on site was minimised.

The existing GAC unit controls including ancillaries such as a new air blower and on line instrumentation were incorporated into the new plant's Profibus control system. The outlet valve gear on each GAC was also changed as the headloss restrictions and overall cascade control system through the plant meant that the existing outlet valves on the GAC unit's had to be replaced.

NI Water require that GAC transfer operations be efficient and the design is sympathetic to ensuring issues such as water use, ease of access and disposal of rinse water to return to service safely were addressed. Commonality of equipment use between the sets of filters has been achieved while ensuring that process quality and production quantity are maintained.

***Manganese removal:*** One of the drivers for the new plant was the addition of a manganese removal process. The manganese levels in the raw water periodically challenged the existing process which could not remove manganese in the soluble form. Bench studies indicated that oxidation and precipitation of the post GAC water could sufficiently reduce the manganese levels to the recommended supply zone quality levels in DWI Regulation 27.

Post GAC water was combined and a chemical dosing and mixing system, using chlorination and lime pH correction on the common distribution header to three manganese removal filters, was used.

As available floor space was a problem the filters were designed to fit into the hydraulic profile but maximise the above media volume of water. In this way a separate contact tank was unnecessary.

The flow from each filter was again flow controlled electro-pneumatically and allowed for emergency shutdown and an overflow to waste: features added to enable the plant to be easily started and shut down. The flow to the manganese filters is at a controlled pH and chlorine setpoint and the instrumentation for these critical instruments is on line and duty/standby. Other critical instruments are on independent profibus control channels - ensuring process resilience.

## Treated water

The manganese treated water is final water, and instrumentation for aluminium residual, free chlorine, pH turbidity and manganese residual measurement, as well as full manual sample facilities are provided on the metered water leaving the plant.

Final treated water flows out to join the pipe to the common clearwater tanks, or flows can be diverted to the returns blending tank where it can be returned or pumped to the raw water balance tank and possibly treated the membrane plant. This facility allows a future two stage treatment process as a possibility: using of all or part of the treatment capability of the new plant as raw water and treatment objectives dictate.

Such innovations in process flexibility combining conventional and advanced process stages with the possibility of expansion and modification is seen as the way forwards by the designers.

All of the above are housed in the new treatment building over the two old slow sand filters. The space where the third sand filter used to be has been modified to house the clean and dirty washwater tanks, the returns blending tank, and the associated pumps.

Other components the building houses includes; 2 (No.) stainless steel (duty/stand-by) WRC design thickeners, a (50m$^3$) GRP sludge storage tank) with an integral mixer, electrical supplies, MCC, PLC with UPS as necessary, and the telemetry alarm and control systems integration.

## Conclusion

The £2.3 million Clay Lake WTW project started on 6 April 2011. The principal contractors are the Shearwater Consortium JV, comprising Lagan Construction and Enpure. The civil designers for the project are WDR and RT Taggart.

The main sub-contractors and equipment suppliers are JK Fabrications (tanks, pipework and mechanical installation), TES (NI) Ltd (MCCs), Allied Tanks (tanks and saturators), Aerzen Machines (air blowers), Industrial Valves Ltd, Plenty Mixers, Seepex Pumps and Xylem Water Solutions.

At the time of writing (July 2012), pipework and electrical installation is ongoing. Phase 1 is due to be completed in September 2012, with Phase 2 completing in December 2012.

*The editor & publishers would like to thank Matthew Simpson, Project Manager with Enpure Ltd for the Shearwater Consortium, and Nicandro Porcelli, Senior Process Engineer with Enpure Ltd, for providing the above article for publication.*

*RGFs in the foreground, DAFs, GAC and Manganese filters in construction - Photo by Enpure Ltd - Courtesy of NI Water*

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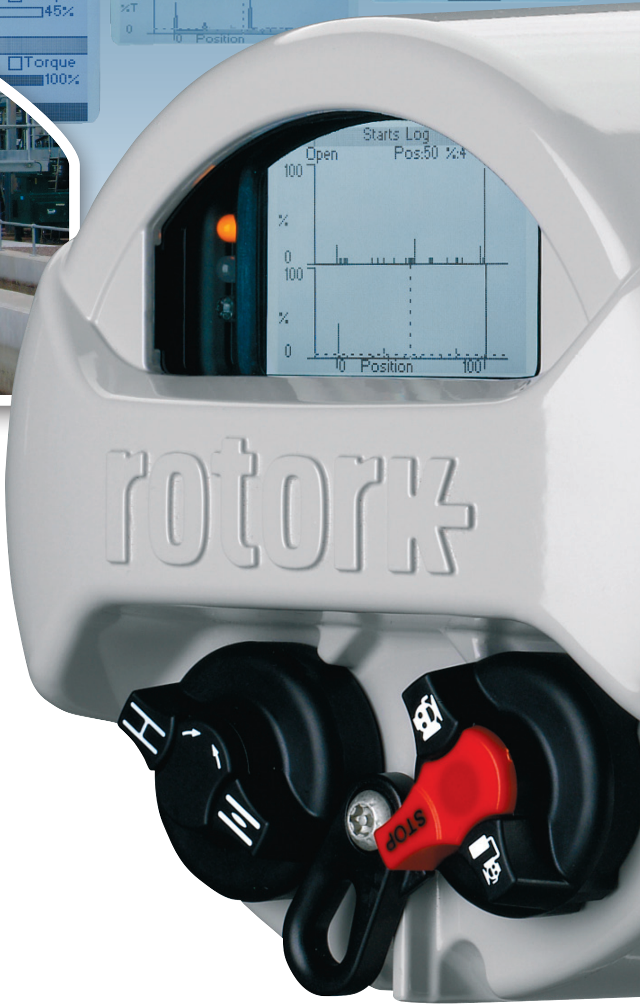


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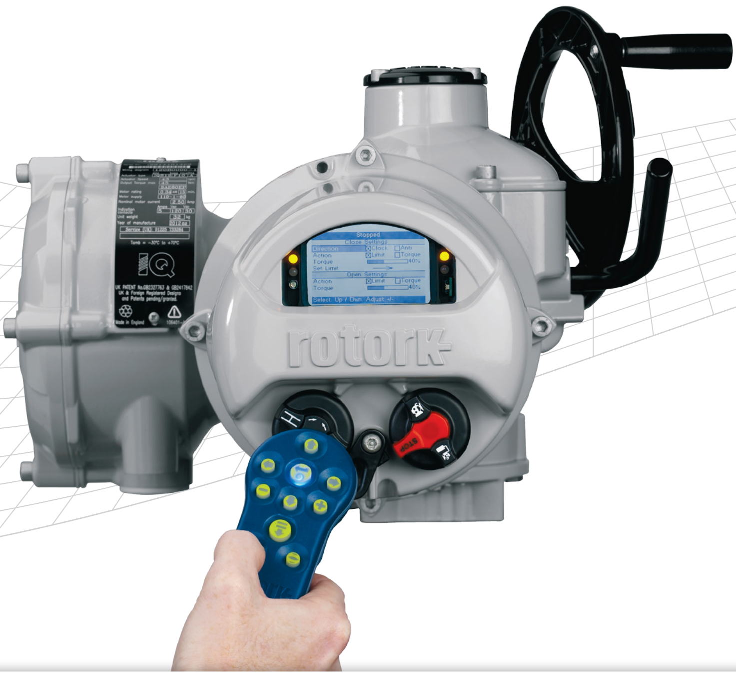


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