Rotork Engineering Manager Ivan Burnell (left) and Sales & Marketing Director Carlos Elvira with an example of a Rotork NA1 nuclear qualified valve actuator

Pedigree and specialisation –

Rotork's strengths in the nuclear power generation industry

In common with other power generation technologies, nuclear energy relies heavily on electric valve actuators for safe and efficient plant operation. In particular, electric valve actuators are used for crucial safety-related duties, both inside and outside the nuclear containment area or nuclear island. In both cases these duties demand actuators that are built to strict material specifications and approved to the most stringent testing and qualification standards. Leading actuator manufacturer Rotork Controls has been active in the nuclear energy industry throughout its fifty-year history. Valve World met with Ivan Burnell, Rotork's Engineering Manager, and with Sales and Marketing Director Carlos Elvira to find out more about the company's extensive experience in the field, current activities and thoughts for the future.

At the time of Rotork's birth in the 1950's the UK's Magnox nuclear generation programme was under way, and by the beginning of the 1960's Rotork electric actuators were being supplied to Magnox projects. Ivan Burnell, Rotork's Engineering Manager, who is responsible for the company's nuclear actuator product activity, takes up the story: "By that time the USA and Canada were already the centre of attention for nuclear energy in terms of engineering specialists and end users. Rotork therefore sought qualification to the prevailing IEEE 382 - "IEEE Standard for Qualification of Actuators for Power-Operated Valve Assemblies With Safety Related Functions for Nuclear Power Plants," recognised internationally as the highest standard for actuator qualification."

By 1972 Rotork achieved its first IEEE 382 qualification. Since then Rotork has been a member of the SC2 Committee overseeing nuclear standards within IEEE and an active member of the SC2.3 sub-committee IEEE382 working group that is responsible for the development of the standard to ensure that the prescribed qualification levels meet the evolving design and safety requirements. Nuclear power governing bodies such as the US Nuclear Regulatory Commission have consistently driven enhancements to the specifications and their implementation in use, to which in general the worldwide utilities conform and which Rotork is committed to comply with and support.

Rotork's commitment is further illustrated by its decision to independently test its nuclear product to the IEEE 382 - 1980 standard at the end of the 1970's. In a programme costing over USD 1 million, Rotork obtained full third party accreditation from Wyle Laboratories in Huntsville, Alabama. Subsequently Rotork has continually updated its qualification and developed its 3-phase and DC actuator product specification to achieve or exceed upgraded IEEE 382 standards as they have emerged.

Going back to the 1970's, Rotork was also involved in nuclear qualification in Europe and in 1976 successfully participated in one of the first independent LOCA (Loss of Coolant Accident) tests, performed at Marviken in Sweden. By the late 1970's Rotork had been awarded the contract to supply safety related actuators to ESCOM's Koeberg Nuclear Power Station in South Africa through French architect engineers Framatome. As part of this supply Rotork successfully completed testing under full pressure, temperature and flow conditions on critical safety primary containment valves at EDF's test facility at Tricastin, Lyon, France.

Rotork NA actuators fitted to high-pressure steam valves

Testing for the "cumulative effect"

In addition to being one of the first manufacturers to submit to independently accredited qualification, Rotork is also virtually alone in subjecting the same test actuator to all the different elements of the test programme, thus proving that it will survive the cumulative effect of the elements, rather than individual or selected elements, as Mr. Burnell explains: "Taking IEEE 382 as the most severe test regime, our actuator has to undergo an ageing process involving heat, mechanical wear, pressurisation, vibration and radiation that equates to 40 years inside the containment of a PWR followed by design basis events (DBE) in the form of seismic and LOCA simulation in accordance with the IEEE 382, Case 4. This puts it in the equivalent of a loss of coolant accident situation after an installed lifespan of 40 years, at which point it must operate at full load - without fail - in order to pass the test.

We believe that the most representative type of testing is where a completely assembled actuator is taken from our production facility through the qualification process ensuring that it is exposed to the cumulative effect of the operating conditions within the power plant. In our opinion, the adoption of piecemeal qualification where individual components or sub-assemblies are tested is not representative of real operating conditions."

The Three Mile Island accident in 1979 and the subsequent accident at Chernobyl have led to the development of new philosophies and strategies for constructing and maintaining nuclear power plants by utilities around the world.

"The approach adopted by Rotork to nuclear actuator qualification has enabled us to meet and exceed the new requirements being imposed by legislators and the designers of the new breed of power plants that are emerging," Mr. Burnell continues. In addition to increased test levels Rotork also developed design and change control

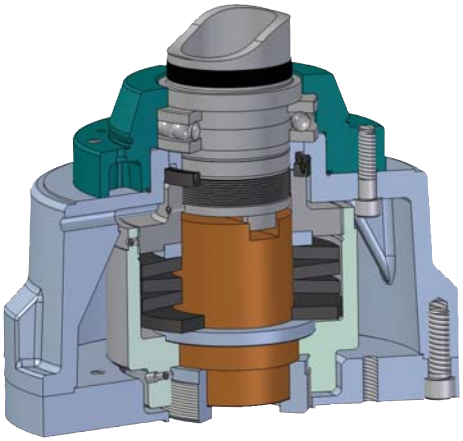
Summary of Qualification of Rotork Nuclear Class Actuators

TEST PARAMETER	QUALIFICATION	METHOD	MARGIN
Mechanical wear aging	2000 cycles	Test	N/A
Thermal aging/qualified life (yrs)	13 years at 66°C >40 years at 54°C >200 years at 40°C	Test	N/A
Pressurisation aging	15 cycles 0-65psig	Test	N/A
Vibration aging	0.75g, 5-100-5Hz, 90 minutes in each orthogonal axis SRV aging -9000 cycles Chugging - 8400 cycles	Test	
Seismic Dynamic Loads	RMF, 8g ZPA RIM, 5g input SSE, 4g input OBE	Test	0
Atmosphere/Spray	Saturated air and steam mixture with chemical spray (0.475lps/m^2) consisting of (typically) 0.28 molar H_3BO_3 (6,200 ppm boron), 0.064 molar $N_2S_2O_3$, and NaOH to make a pH OF 10.5 at room temperature	Test	N/A
Radiation (Gy) Normal + DBE	2.5E+06 Gamma	Test	10%
DBE environment LOCA	256°C Profile IEEE382 Case IV inside containment PWR + MSLB.	Test	5%

procedures and material traceability recording supported by a full 10CFR50 Appendix B quality programme that ensures the products are manufactured to the highest levels.

The current situation

Whereas nuclear power plant business in the USA declined from 1980 onwards, Rotork continued to win substantial contracts in other parts of the world including Canada, Europe, Scandinavia, Russia, India, South Africa, Korea and the Far East, where the company is now fulfilling contracts for new power stations in China. This activity, which is greatly assisted by the local support provided by Rotork's international network of sales offices, has also been facilitated by a dedicated part of Mr. Burnell's engineering team serving full-time nuclear activity.



Cutaway drawing of the Thrust Compensator

The current basis of qualification for Rotork nuclear actuators is IEEE 382 - 1996 but the company has not stopped improving safety levels and updating. Rotork's current revalidation programme - nearing completion at an independent test facility in Canada - will confirm compliance with the latest design standards that apply to the Westinghouse Advanced Passive reactor, AP1000, General Electric's Advanced Boiling Water (ABWR) and Economic Simplified Boiling Water Reactor (ESBWR) and AREVA's Evolutionary Power Reactor (EPR) which are under consideration for new nuclear programmes in the USA, China and elsewhere.

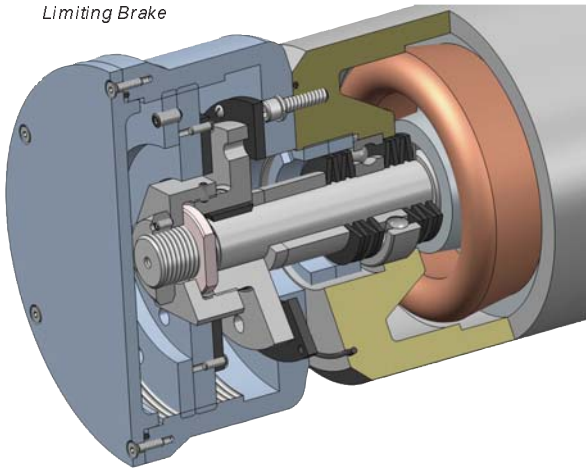
"In fact," Mr. Burnell adds proudly, "some of the projects which we recently supplied demanded standards that exceeded the generic qualification levels and we have been able to achieve them with our standard nuclear product. We have a team of engineers dedicated to developing, maintaining and supporting our nuclear products, driven by our commitment to meet qualification and quality requirements as laid down in Rotork's QA programmes. Rotork quality systems and procedures are audited triennially by NUPIC."

Rotork's specialised nuclear product range

So what is it about Rotork's nuclear actuator product range that enables it to successfully achieve and exceed the standards laid down by the nuclear industry? Rotork's Sales and Marketing Director Carlos Elvira continues the story: "Key features inherent in all Rotork actuator designs become even more significant in the nuclear scenario. Firstly, the robust construction of a mechanically simple design will help to ensure long-term reliability. Secondly, Rotork's 'double sealed' enclosure will keep the environment out to ensure that the rugged mechanical elements are not let down by corroded electrical components."

Rotork offers two levels of nuclear qualified product, both developed from the 'A' Range design, which has been proven in hundreds of thousands of installations and many different industries. The NA1E actuator is designed for active or passive duty within the nuclear containment or island, where active refers to valves that have to operate during and after a reactor emergency. The NA5E is

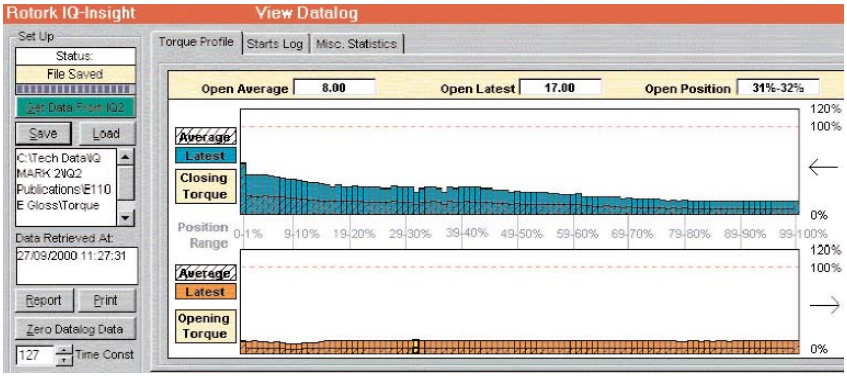
Cutaway drawing of the Torque Limiting Brake



Rotork IQ actuators installed at a power station in the USA.

designed for active duty outside of the nuclear containment. The difference between the two basically relates to the level of radiation exposure to which they will be subject and both are constructed only from approved materials throughout. Mr. Elvira: "Sizing an electric actuator for nuclear safety duties presents challenges which are uncommon in other industries. Safety factors can result in the torque and thrust provided by the actuator to achieve the speed of operation essential during an emergency being on the limit of what the valve can withstand when accident conditions are not present. Rotork has therefore developed innovative solutions for these potential 'over-sizing' issues which ensure the long-term protection and reliability of the installed valve. The Torque Limiting Brake can be fitted to the motor rotor shaft in order to restrict excessively high torque loadings being applied to the valve. Similarly, the Thrust Compensator is a modified, spring-loaded output base that will 'cushion' the effect of extreme thrust loadings at the end of the valve stroke. Both have proved to be very successful in the field and are included in the nuclear qualification programme. Secondary gearboxes from Rotork Gears are also available with nuclear qualification to achieve greater multi-turn torque outputs from the actuator or provide quarter-turn valve operation, completing what we believe to be the most comprehensive and best qualified nuclear actuator product range from any manufacturer. And in addition to electric actuators Rotork has also qualified its quarter turn fluid power actuators for active safety related duty inside the containment of nuclear power plants."

Rotork IQ Pro intelligent electric actuator with hand-held, 'non-intrusive' setting and data transfer tool



Sample of IQ-Insight downloaded data logger diagnostic information as displayed on a PC, showing the last recorded valve operating torque graph.

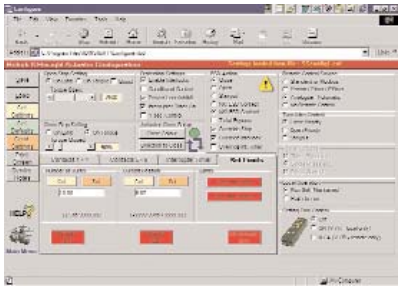
The intelligent option

In 1993, Rotork introduced the world's first intelligent actuator with 'non-intrusive' technology, with the launch of the IQ Mark 1. Now in its third generation - designated IQ Pro - the technology is recognised as industry standard in many fields including nuclear power generation. The use of solid state electronics as an alternative to switch mechanisms and counter limiting devices is inappropriate for qualification to nuclear safety standards inside containment, but these features, combined with others involving data-logging and diagnostics, bring many benefits that can be used in the numerous non critical, non safety duties that are outside the containment area of nuclear power plant. These benefits include 'non-intrusive' configuration and data transfer by means of hand held instruments via a secure infrared link. For example, the technology enables a 'footprint' of valve operating torque to be established during commissioning. The data logger installed as standard in the IQ actuator then creates an historical record of valve operations which can be downloaded and analysed on a PC running Rotork IQ-Insight software. Analysis reveals the trend in valve operating torque which can be used to prepare preventative maintenance schedules, thus optimising plant utilisation and preventing unexpected interruptions.

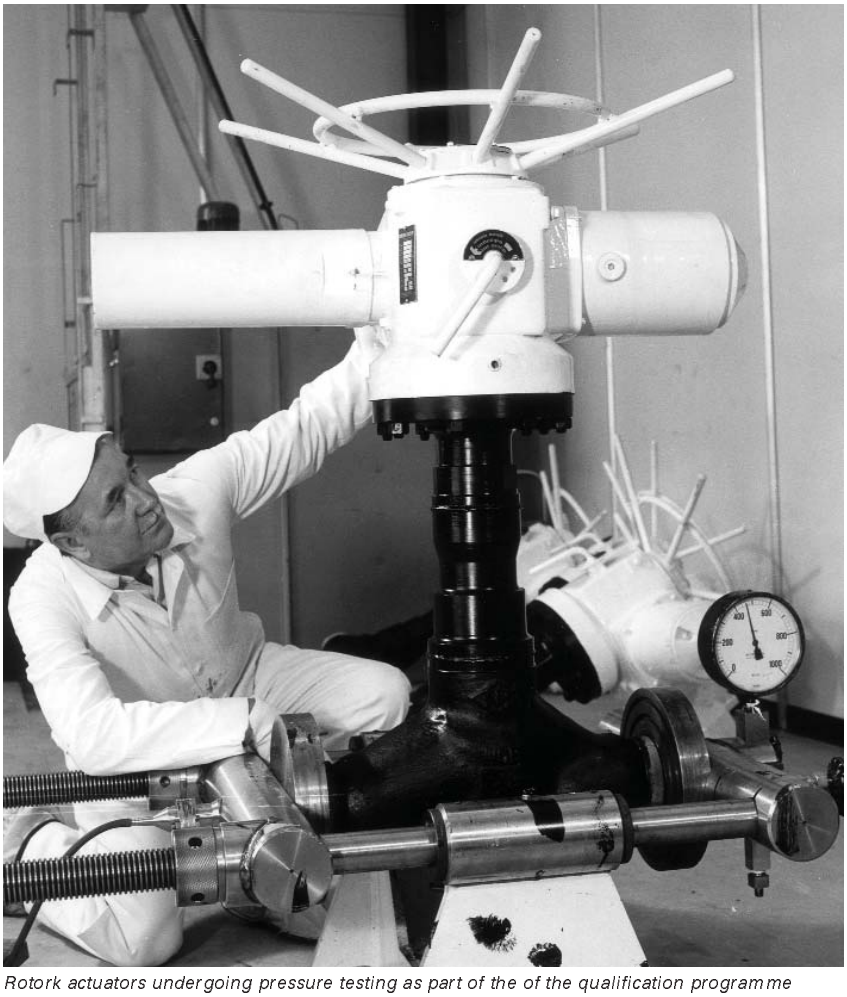
"Rotork can therefore confidently offer a superior technical solution for valve actuation in every area of the nuclear power plant, combining the benefits of single-source procurement with the lowest long-term cost of ownership, supported by a network of local after sales service on a worldwide basis," Mr. Elvira emphasizes.

What's next?

With global warming and other environmental issues to the fore, nuclear power generation is now back on the agenda as a viable and environmentally friendly major source of energy in the future. Advancements in technology and safety standards are continuing, with manufacturers such as Rotork making important contributions. In summing-up Rotork's future activity in the industry Mr. Elvira explains: "What's driving Rotork is the ability to achieve our customers' demands by exceeding the qualification standards. We provide the most reliable actuator design with independent, third party qualification and a proven track record stretching back for forty years. We have been in the industry for most of our history and are fully committed to it in the future."



Sample of IQ-Insight downloaded data logger diagnostic information as displayed on a PC, showing the actuator configuration settings



Rotork actuators undergoing pressure testing as part of the of the qualification programme