Alstom Grid can draw on more than 70 years’ experience in the development, manufacture and operation of mechanical spring operating mechanisms for high-voltage circuit breakers. Since the very first spring operating mechanism (the FK 2) was introduced in 1934, marking the start of a trend away from the solenoid, motor and pneumatic operating mechanisms that had prevailed until then, seven decades have spawned three generations of spring operating mechanisms with 20 different types.

Today, over 80,000 spring drive systems for HV circuit breakers are in use around the world with satisfied Alstom Grid customers. “Though the pure spring operating mechanism is not the sole mechanical drive architecture for circuit breakers, it is by far the most reliable one,” says Martin Walt, Manager of Operating Mechanism Development. Two other alternatives are actually available: the hydraulic drive, where the force is generated by pressurised gas (or a spring), and the pneumatic drive, ...

**Spring operating mechanisms: designed for reliability, durability and performance**

Thanks to 70 years of experience in spring operating mechanisms for circuit breakers, Alstom Grid’s competence centre in Oberentfelden, Switzerland, achieves the highest design and quality standards.
The pure spring operating mechanism is by far the most reliable mechanical drive architecture for circuit breakers.

powered with compressed gas. However, the CIGRE Brochure 83 inquiry on HV circuit breaker failures revealed that the availability of the circuit breaker depends mainly on the reliability of its operating mechanism. Compared to pure spring drives, the minor failure rates of pneumatic drives is double and for hydraulic drives seven times higher.

"Unlike pure spring drives, pneumatic and hydraulic architectures can be subject to leakages over time due to the required fully loaded condition," Walt adds. So Alstom Grid relies largely on spring operated mechanical drives for its whole range of circuit breakers, from Air- and Gas-Insulated Switchgear (AIS and GIS) to generator circuit breakers, with spring energy ratings up to 12,500 joules for the 550 kV, 63 kA GIS application.

Two springs, three movements...

"A circuit breaker spring drive includes two sets of springs, one to open the contacts, the other to close them," Walt explains. "The system should possess the energy to perform a complete open-close-open cycle, the opening spring being loaded by the energy released during the action of the closing spring." Reaction times are extremely short: 30-40 milliseconds for the opening movement, and 100 ms for closing. In the case of a circuit failure due, for example, to a lightning strike, the circuit
breaker protects the system by opening the contacts; then, to restore the electrical supply as soon as possible, it instantly tries to close them again (second movement). However, if the fault is still present – a fallen tree has downed a power line, for example – the opening spring has to be ready to react once more (third movement).

The circuit breaker is indeed the safety element in an electrical network. When commanded to do so by the control system, its operating mechanism accelerates the contacts – weighing from a few kilograms up to 80 kg – to a speed of 3 up to 14 m/s within a few milliseconds, then brakes them to a stop at the end of the stroke. Along with their basic function, operating mechanisms must meet stringent requirements as to quality, precision, reliability and service life. Designed for a service life of 40 years and 10,000 cycles, a circuit breaker in high voltage service is active, however, only once or twice a year (overhead lines) or for three or four times a day (e.g., power plant). Even though the cumulative activity duration is merely a question of minutes in its whole lifetime, the operating mechanism, once energy is loaded into the spring, has to store it without loss for many years, ready to release it in response to a switching command.

Reliability starts from the design stage

Alstom Grid has a very experienced development team of engineers and designers of operating mechanisms. The competence centre in Oberentfelden, Switzerland, is responsible for achieving the highest quality standards for the operating mechanisms produced worldwide, and uses state-of-the-art development tools and test equipment to ensure the quality of design and fabrication: 3D CAD software, static FEM and dynamic simulation tools for stress analysis, and a test laboratory for endurance testing, equipped with a digital high-speed camera and a climatic chamber for real operational conditions testing with temperatures ranging from -55°C to +58°C. The incorporation of many decades of experience with spring operating mechanisms has led to a dynamic optimisation of their performance. “Crucial advantages gained as a result include low-impact dynamic operation, minimum internal energy transfers (low ‘reactive’ power dissipation), the elimination of dashpots in closing systems, simplified function and a 30 percent reduction in the number of parts compared to prior generations.” As a result, Alstom Grid customers profit from products with lower wear, reduced maintenance cost (no required maintenance for up to 10,000 switching operations), very high availability combined with even longer service life, low noise emission, and more. Future trends include the reduction of the energy needed in the drives thanks to low energy chambers in the GIS and AIS circuit breakers.

THE FK 3.X SERIES

Driven by the evolution of international standards and customer needs, as well as by cost optimisation and respect for the environment, the advancement of spring operating mechanisms development and fabrication is at the heart of Alstom Grid’s competence centre strategy. The trend has been to develop a drive family that can be used for all GIS, AIS, Dead-Tank and generator breaker applications, with as little adaptation as possible and a preference for standardised products to achieve attractive costs. The third generation of Alstom Grid’s spring mechanisms, the FK 3.X family, has been recently upgraded and expanded to cover a wide range of closing energies by optimising the energy ratings of the individual types. The FK3-4/132 drive, for instance, has undergone a redesign with a change of manufacturing technology. Other innovative versions of the FK 3.X family that will appear on the market by 2012–2013 show significant advances such as higher rates for specific applications, energy range, cost optimisation and design standardisation.