Decades of Sealing Expertise:

From Seal Qualification Lab to Trusted Global Nuclear Industry Advisor

The following article, the second in a series of four, describes the development and continuous improvement of qualified sealing products, flange assemblies and sealing systems installed in the base of pressurized water reactor nuclear power plants (PWR NPP), as well as important organizational changes and production improvements.

Sealing Research Lab Key to Engineered and Qualified PWR NPP Sealing Solutions

In the early 1970s, France began building its fleet of nuclear power plants and initiated the construction and operation of the European Gaseous Diffusion Uranium Enrichment Consortium (EURODIF) plant for civil uranium production as part of its growing nuclear power industry. From the very beginning, it was recognized that a high level of performance and safety was required for the generation of nuclear power. To ensure these criteria were met, nuclear sealing technologies were implemented through an integrated process of scientific-technical cooperation. This qualification process tested sealing solutions to ensure their precise sealing abilities and technical feasibility.

Thus, French Alternative Energies and Atomic Energy Commission (CEA) partnered with Technetics Group to create a joint sealing laboratory in Pierrelatte and begin the testing and qualification process.

Maestral Sealing Laboratory, operated by the CEA, the French Alternative Energies and Atomic Energy Commission (Commissariat à l'énergie atomique et aux énergies alternatives), and Technetics Group in Southern France.

Fig.1: Pierrelatte sealing laboratory

This laboratory combines the comprehensive nuclear expertise and competencies of the CEA with the sealing-specific expertise of a highly specialized, technologically innovative corporation. Work performed at the sealing performance in order to maintain the qualification of that specific product portfolio and ensure its qualification into the future.

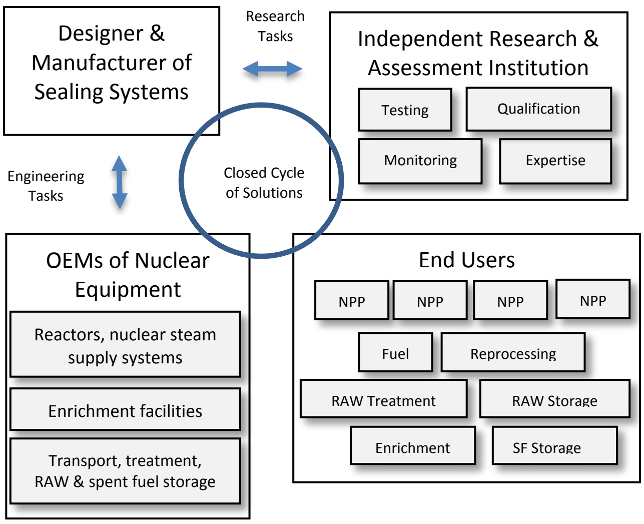


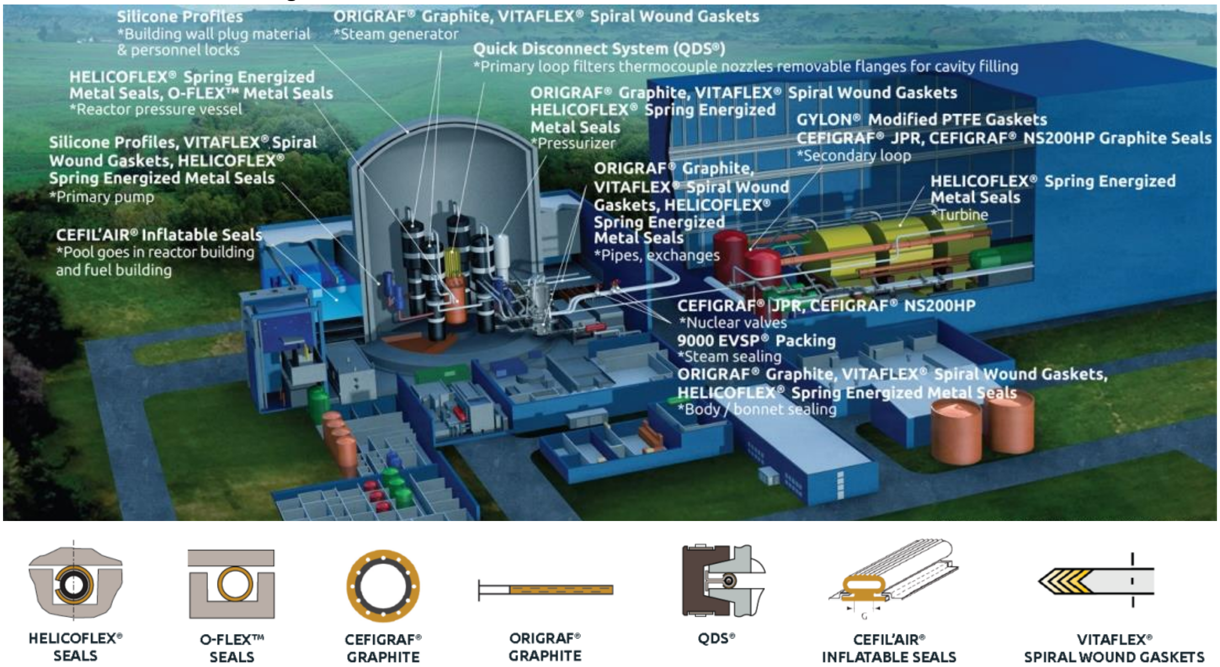
Fig.2: Solution cycle for defined sealing performance

Through integration into the overall system of the French nuclear sector, as well as within the internationally cooperative nature of leading nuclear and power technology vendors, NPP operating utilities and main Gen-IV research programs (ITER, ASTRID, ALLEGRO, etc.), the laboratory represents a scientific-technical center of long-term experience and continued feedback from the operation and maintenance of nuclear power plants and facilities worldwide.

This integration also allows for experience, feedback and understanding of almost all types of NPP technology. Clearly defined and measured operating conditions are simulated by respective test stands in the laboratory to monitor seal behavior and characteristics. These tests are key to providing and maintaining the largest portfolio of engineered qualified sealing solutions in the nuclear industry.

An initial milestone of such research and development includes the qualification and respective benchmarking of metal-to-metal sealing technologies with spring-energized metal seals. This technology, well known to the industry as HELICOFLEX®, was first applied to the equipment in the EURODIF enrichment plant. Consequently, this system and other types of engineered sealing solutions were created and designed on the basis of the metal-to-metal concept in order to fulfill specifically defined sealing performance requirements for a wide range of sealing tasks. These spring-energized metal seals are employed in various components and systems throughout nuclear power plants (Fig. 3) and other forms of nuclear power-based equipment.

Fig.3: ENGINEERED SOLUTIONS FOR DEMANDING ENVIRONMENTS®



Operating Periods of Nuclear Power Plants Set Performance Challenges

Today, a total of 437 commercial nuclear power reactors are operating in 31 countries (ENS, January 2013). More than half of these plants have been in operation for over 20 years, the majority of which rely on pressurized water reactor systems. This constitutes a tremendous amount of operating hours (in the range of several tens of millions), and provides a great deal of respective operating experience and feedback to design and technology providers.

Uranium enrichment and nuclear fuel producers, as well as facilities and container technologies for the transport, treatment and interim storage of radioactive waste and spent fuel, provide large accumulated times of nuclear technology equipment use information. This creates a tremendous amount of data for nuclear power plants and nuclear component providers with background and experience in the creation of sealing solutions, while providing deep insight into the long-term characteristics of seals and the corresponding NPP component over long operating periods.

As sealing performance is a function of load to the sealing system and the functional area of the seal, Westinghouse Electric Company, the source where many pressurized water reactor systems stem from, set an initial 5% standard measure for the two main properties. They stated that a seal must maintain "maximal load" (Fig. 4), which challenges the elasticity of a seal, and "minimal contact seal area in order to maximize sealing stress", which exploits the plasticity and sealing ability of a resilient seal.

$$\frac{[\text{seal free height}] - [\text{groove depth}]}{[\text{seal free height}]} \cdot 100\%$$

Amount seal compression (%)

(per individual resilient seal design & material)

Fig.4: General formula for seal compression applicable since late 1950s

Operational and maintenance experiences prove that the lifespan and characteristics of sealed mechanical assemblies change as they age. Characteristics, such as surface waviness, increase over time and influence the pressing behavior of the mechanical assembly, consequently working against the elasticity tolerance of the seal.

Further, the operational cycles of the unit's component flanges and their mating surfaces are often affected by corrosion driven by aggressive substances like sulfur, halogens and chlorides. Over time, this works against the original design of the flange, reducing the seal connection and specified leak tight performance. As a result, surface conditions of the mechanical assembly evolve and the seal is faced with the additional burden of compensating for these altered conditions.

During the operation of an NPP, high temperatures and pressures cause conditions known as "flange rotation" or "flange movement" within assembly geometries. These deformations negatively influence sealing solutions, thus requiring NPP operators to demand more elastic, resilient seals in order to prepare for lifespan extension. Furthermore, Generation III+ nuclear power plants are designed for a 60-year lifespan with much higher power output capacities, requiring larger geometries for components, flanges and seals.

The scalability and elasticity of applicable sealing materials are limited by metal properties and by design and production technologies. Thus, the required solution demands significantly higher elasticity and plasticity characteristics than the historic 5% seal compression standard (Fig. 4).

Embedding engineered sealing solutions into a cycle (Fig. 2) appears here as a pioneering notion and is a promising method for present and future sealing tasks in demanding environments. Specialized laboratories contribute to long-term experience in upgrade processes for existing NPPs, allowing for improved safety, performance and technological support. The results are more sophisticated seal designs and higher seal compressions, ensuring elasticity and plasticity remain the most important aspects of sealing performance.

Specific results of such achievements will be introduced and discussed in the third part of this sealing series.

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Note: *The text is the second in a series of four texts about engineered sealing solutions in nuclear energy, which arise in the context of cooperation between the portal energia.sk, Technetics Group and EEE JacobyKo. The next text will focus on the detailed references and on fundamental conclusions for the installation of metal-to-metal sealing in new nuclear power plants.*

Link to first text: link .

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***Poznámka**: Text je druhým zo série štyroch textov o problematike inžinieringových riešení tesnení v jadrovej energetike, ktorá vzniká v rámci spolupráce medzi portálom energia.sk, Technetics Group a EEE JacobyKo. Nasledujúci text sa zameria na detailnejšie referencie a príkladne výsledky konceptu kov na kov pre inštalácie v nových jadrových elektrárňach.*

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