



N-Seal Nuclear Primary Pump Seal Upgrade



Experience In Motion



Supplier of Choice to the Nuclear Power Industry

Since the late 1940's, Flowserve has been a pioneer of pump and seal technology for the nuclear power industry. With many "firsts" to its credit over the decades, Flowserve has advanced pump and seal performance, safety and reliability for Nuclear Steam Supply System applications. Flowserve equipment is installed in more than 200 nuclear power plants worldwide. More than 300 Flowserve reactor primary pumps are providing utmost service reliability. Flowserve has more than 5000 pumps installed in nuclear power plants around the world and offers technical expertise and aftermarket support worldwide.

The Most Trusted Product Brands in Nuclear Power Generation

Pumps

- Byron Jackson®
- IDP®
- Pacific®
- Worthington

Seals

- Flowserve®
- BW Seals®
- Durametallic®

Qualifications

Flowserve has maintained the necessary domestic and international qualifications for the design and manufacture of its pumps and seals. These include ASME Section III, RCC-M, and JSME accreditation and certification for its equipment in primary coolant, safety-related and conventional services.

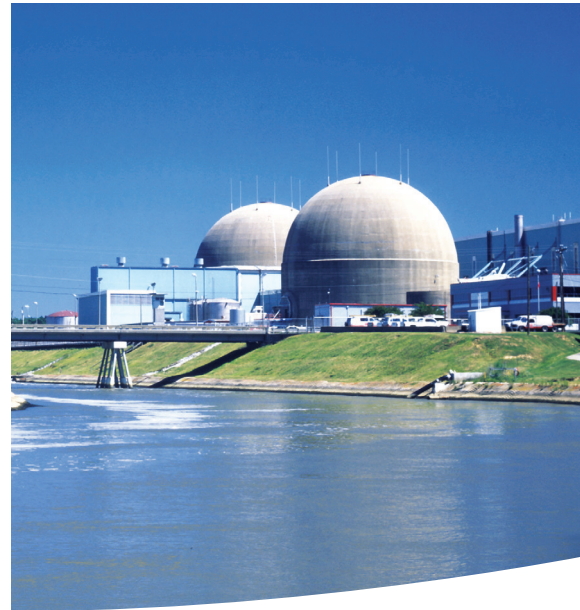
Flowserve is fully qualified to provide Class 1, 2 and 3 safety-related equipment, parts, repairs and service. It is in complete compliance with U.S. Regulation 10CFR50 Appendix B and equivalent international standards like IAEA GS-R-3. For ASME Section III Code repairs and replacements, Flowserve maintains a Nuclear Repair (NR) stamp.

Facilities

Flowserve operates several customer-approved nuclear manufacturing and service facilities in North America, Europe and Asia. Flowserve Hot Shops offer repair and upgrade of contaminated pumps, seals and associated equipment, regardless of OEM. A global network of Quick Response Centers (QRC) provides local parts and service support for balance of plant equipment.

N-Seal

Nuclear Primary Pump Seal Upgrade



Proven Performance

Nuclear plant operators must have confidence that their primary pump seals are able to safely and reliably endure the full range of plant operating transients, including extreme pressures and temperatures. With the Flowserve N-Seal, there is no doubt.

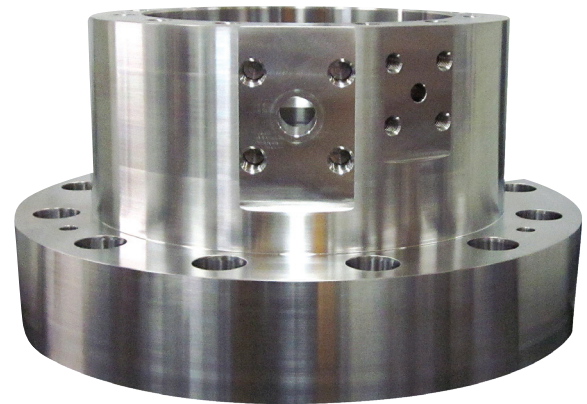
The result of years of research, thousands of hours of rigorous testing and decades of primary pump application experience, the Flowserve N-Seal represents the nuclear industry's most advanced mechanical seal technology. Since 1988, it has provided proven service and fail-safe redundancy in nuclear power plants throughout North America, Europe and Asia. Designed for stable operation over a design life of 50 000 hours, existing N-Seal installations have exceeded 150 000 hours of operation, with no evidence of component wear or structural degradation of elastomers.

Now, the benefits of the N-Seal are available to users of other OEM primary pumps.

Adaptable Design

Available in several sizes and configurations, the Flowserve N-Seal is easily adapted to existing primary pumps in pressurized water reactors (PWR), pressurized heavy water reactors (PHWR) and boiling water reactors (BWR):

- Reactor coolant pumps (RCP)
- Heat transport pumps (HTP)
- Reactor recirculation pumps (RRP)



First-stage seal housing with integral flanges.

State-of-the-Art Testing and Manufacturing

Flowserve is the only RCP manufacturer backed by its own mechanical seal division. The result is dedicated N-Seal R&D and manufacturing that supports customer needs.

Features and Benefits

Cartridge Construction simplifies installation and keeps associated costs low. It also enables more accurate seal setting and facilitates testing of the complete seal prior to installation.

Redundant Seal Design consists of two, three or four stages, depending on the reactor type. Each stage is capable of handling 100% of the system pressure. During normal operation, system pressure is distributed equally among the stages. In the event of stage failure, pressure is automatically redistributed among the remaining stages, allowing the plant to safely complete the fuel cycle.

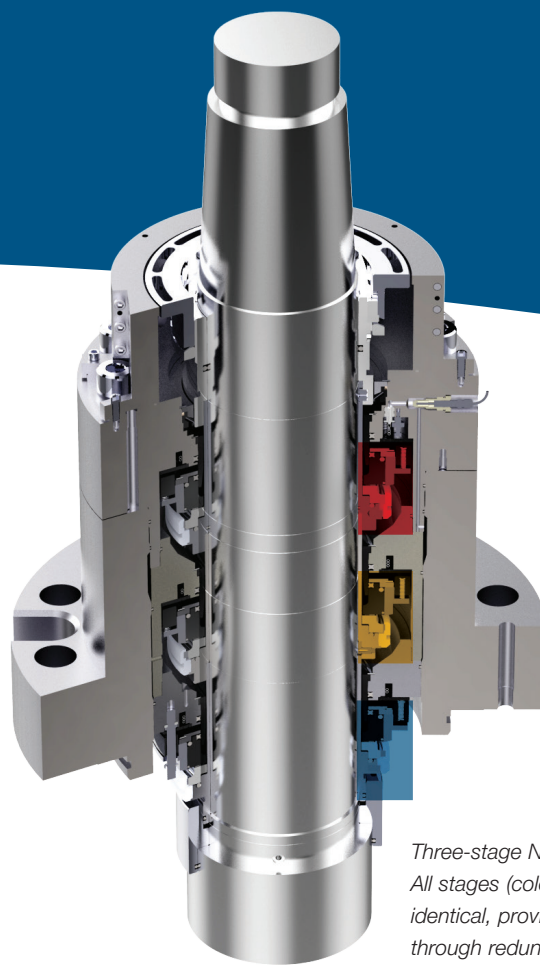
Hydrodynamic Seal Face Technology outperforms hydrostatic designs with dramatically improved reliability and running periods. Three different seal face lift designs are available to ensure faces are non-contacting over a broad operating range: Mayer groove, slotted carbon and precision face topography. Selection depends on site-specific factors, including reactor design and reactor water cleanliness.

Interchangeable Stage Components enable spare parts inventories and carrying costs to be reduced. Maintenance, training and assembly procedures are also simplified.

Large Axial and Radial Travel Capability maximizes operating life. Tests confirm sealing integrity is maintained throughout all plant transient scenarios.

Abeyance Seal is a back-up shutdown seal that automatically actuates when leakage from the primary seal exceeds a threshold velocity.

Seal Face Surfaces for BWR are laser machined to withstand electro-corrosion in ultrapure water, while maintaining proper lubrication and seal face separation.

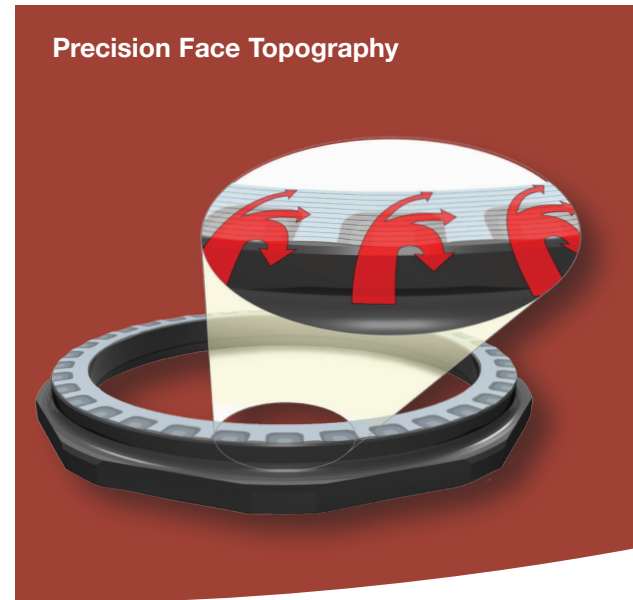


*Three-stage N-Seal.
All stages (colored) are
identical, providing safety
through redundancy.*

Safety Through Redundancy

Each of the stages of the N-Seal is designed to handle 100% of the system pressure. Having multiple stages creates a safety margin through redundancy. During normal operation, system pressure is equally distributed among the stages, reducing wear on each individual stage.

More importantly, though, the N-Seal's multiple stage design means it can continue to operate safely, even if a stage fails. System pressure is automatically redistributed across the remaining stages. The same is not true of seal designs with uneven stage loading, which must be shut down immediately if the first stage fails.



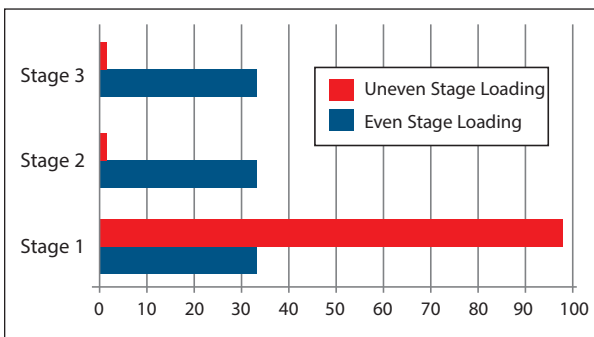
Reliable, Predictive Maintenance

With advanced monitoring systems installed on the N-Seal, station operators are able to predict when maintenance is required. Costly preventive maintenance can be eliminated. The long-term result is predictable seal operation with improved safety, reliability and economy.

Hydrodynamic Sealing Technology

All stages of the N-Seal employ hydrodynamic

Load Sharing Reduces Wear and Provides Safety Margin



sealing technology (see images above), which offers major advantages over hydrostatic designs:

- Hydrodynamic seal face designs produce a more stable and predictable separation over wider pressure variations while reducing leakage and face wear.

- Hydrodynamic seals eliminate electrophoresis effects as a result of their thin fluid film, seal face materials and self-cleaning design.

Ease of Installation

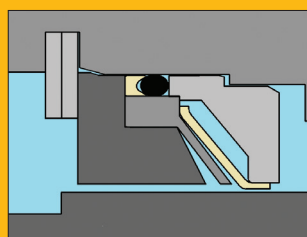
The N-Seal features a dimensionally interchangeable cartridge that enables it to be installed in all OEM primary pumps. Installation is considerably easier than traditional OEM seals, providing the following benefits:

Low Conversion and Installation Costs — The N-Seal is a direct replacement for existing primary seal systems. One- and two-piece cartridge designs are available to accommodate space constraints. Modifications to existing piping and instrumentation are usually not required. As a consequence, existing operating procedures may be maintained, and costs associated with Design Change Packages (DCP) are minimized.

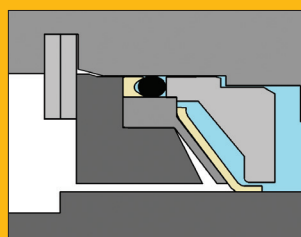
Reduced Man-rem Exposure — The cartridge design of the N-Seal means no component assembly is required in containment. Furthermore, the N-Seal can be leak tested prior to going into containment. Man-rem exposure is reduced, resulting in increased personnel safety and cost savings during installation.

Safe Shut-Down Features

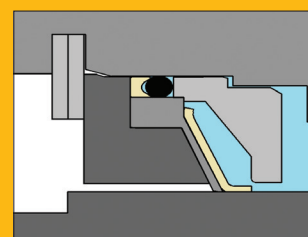
Abeyance Seal Actuation Sequence



Normal operation



Initialization



Full deployment

Fail-Safe Operation

Since 1986, Flowserve has extensively tested the N-Seal to validate all operating parameters and ensure complete safety. The multi-stage design of the N-Seal provides the redundancy required for safe operation under all plant transient conditions, including station blackout, 10CFR50 Appendix R and National Fire Protection Association (NFPA) 805 loss of seal cooling scenarios.

- **Performance Testing** — Flowserve has repeatedly tested the N-Seal under normal and emergency transient conditions to ensure it meets the most exacting performance requirements. Tests have included rapid pressure and temperature changes as well as dynamic axial, radial and orbital shaft displacements. The N-Seal's successful completion of these tests, including several endurance tests up to 5600 hours, indicates reliable and stable operation for more than five years or 50 000 hours under normal and abnormal plant operating conditions. Actual operation has demonstrated maintenance-free operation up to 150 000 hours.
- **Station Blackout (SBO) Testing** — Flowserve conducted full-scale SBO tests to evaluate the N-Seal's performance. Results demonstrated the N-Seal (without abeyance seal) experienced very low leakage (about 0.0025 L/s [0.04 gpm]) over an eight-hour coping period.
- **Loss of Seal Cooling (LOSC) Testing** — In the event of dynamic operation during an LOSC fire scenario, the N-Seal will be exposed to full reactor operating conditions while the pump is running. Tests

demonstrated the N-seal is able to withstand operation under these conditions for more than one hour. This provides station operators ample time to respond by tripping the manual breakers.

Abeyance Seal Actuation

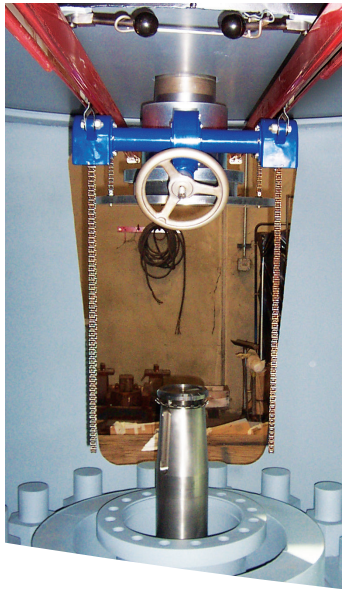
To further enhance the ability of the seal to cope with a loss of seal cooling (LOSC), all new N-Seal cartridges are equipped with an abeyance seal.

The abeyance seal is a passive device which does not rely on complex sub-assemblies with small springs, pistons or other devices. It remains inactive until significant leakage from the seal stages occurs. At that time, the abeyance seal automatically actuates under the pressure generated by the leakage across it, forming a near-zero leakage backup seal.

The actuation mechanism does not damage any permanent components of the seal or pump. A simple seal rebuild brings the equipment back to operational conditions when ready.

Tests demonstrated the abeyance seal alone extends LOSC coping time an additional 96 hours under the most rigorous operating conditions.

Product Support



Continuous Improvement

Flowserve continues to develop and improve products and services for installing and maintaining critical nuclear components.

Seal Removal Tooling

- Designed to enhance safety during seal and coupling removal and replacement (see photo at top, left)
- Time savings up to 90% for reduced exposure and cost
- Redesigned to reduce overall weight
- Quick disconnect for easy installation and removal

Test Cart

Portable seal test carts allow on-site flow and pressure testing before installation. This dramatically reduces seal leakage risks after installation.

- Designed for maximum maneuverability and transportation



- Stainless steel construction to eliminate contamination
- Optional water source included

Advanced Testing Facility

The Flowserve primary pump seal test stand (see photo at top, middle) is one of the most advanced in the world. State-of-the-art equipment allows engineers to dynamically test seal components and complete cartridges under a range of operating conditions and emergency situations. This includes endurance testing to simulate 50 000 hours of operation.

On-Site Seal Training

Hands-on, on-site seal training using full-size seal models provides plant personnel with real-life, practical exposure to primary pump seal technology, including:

- Theory
- Operation
- Maintenance

Project Services

Flowserve has extensive experience in both project planning and project management services. Flowserve engineers develop plans that integrate technical requirements with customer outage planning activities. These seasoned professionals execute project plans by providing technical direction and task management skills to meet customer schedule objectives.



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