

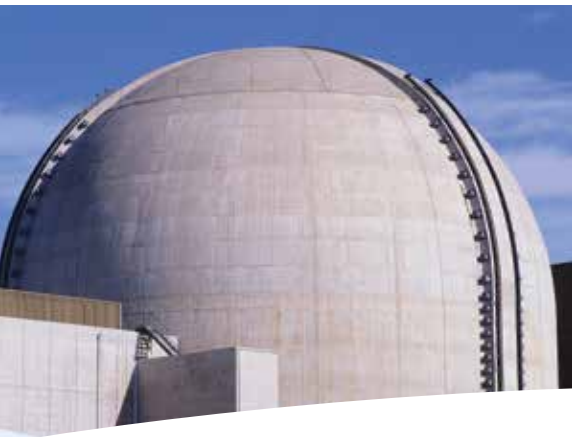


## ***Nuclear Power***

Pumps • Seals • Engineering and Technical Support  
Re-rates and Upgrades • Aftermarket Services



***Experience In Motion***



## **Supplier of Choice to the Nuclear Power Industry**

*Flowserve has been a pioneer of virtually every significant advancement in pumping technology to meet the nuclear steam supply system (NSSS) and balance of plant (BOP) or steam-side fluid movement and control application requirements. Flowserve equipment is installed in more than 200 nuclear power plants worldwide. Over 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®
- Durametallc®

### **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.

# The Recognized Nuclear Expert

Flowserve has played a prominent role in the development of the nuclear power industry from its birth in the late 1940s through global commercialization and now with the newest generation of advanced reactor designs. Engineering new pump models and modifying existing designs to fit the specific duty conditions of these new reactors, Flowserve has already achieved certified supplier status with several advanced reactor design firms.



Flowserve develops the first “canned” pump prototype for modern nuclear power pumps.

1948

Flowserve supplies liquid metal pumps to the first non-military nuclear power plant to make Moorpark, California, the first community entirely lighted by nuclear power.



1953



Flowserve supplies pumps for the first nuclear-powered submarine, the U.S.S. Nautilus.

1957

Flowserve provides the first shaft-sealed primary coolant pumps for commercial reactors, facilitating increases in plant power ratings from small prototypes to 1000 MW class commercial stations.

1961



Flowserve provides the first nuclear recirculation pumps with water-lubricated hydrostatic bearings.

1965



1988

Flowserve opens the industry’s only contaminated pump test loop for testing repaired and upgraded nuclear pumps.



2001



Flowserve introduces the N-Seal, the most thoroughly tested and proven primary pump seal in the nuclear industry.

2010

Flowserve successfully installs the N-Seal in a Westinghouse™ PWR.

Flowserve continues to build on an installed base of more than 5000 pumps in commercial nuclear plants.

Today

™ Westinghouse is a trademark of Westinghouse Electric Corporation.




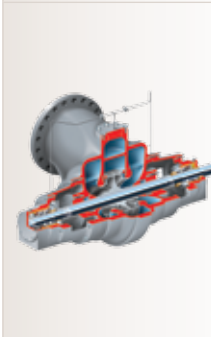
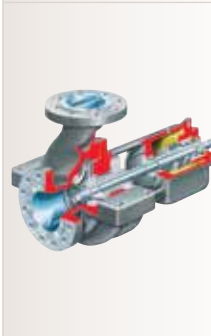
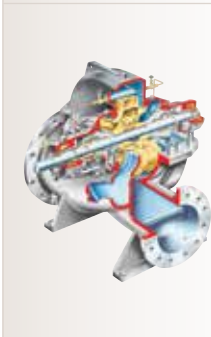

## ***Nuclear Island***

The next generation of nuclear power plants (NPPs) will be safer and less expensive to build and operate. Already, today's NPPs are being designed with a minimum operating life of 60 years. New reactor designs focus on squeezing more power out of uranium fuel to reduce the amount of radiated waste, and they will be cheaper and quicker to build through reactor design and systems standardization. Further out, Generation 4 reactors are being designed to absorb excess heat through greater coolant volume, better circulation and bigger containment structures. They are expected to be even more efficient and may virtually eliminate disposal problems associated with spent fuels.

Flowserve is continuously working with the industry's foremost reactor design firms to meet their safety and steam-side fluid movement and control needs. Flowserve engineers have modified and re-engineered proven and reliable pump models to consistently address ever-advancing application specifications and expectations. Evidence of this commitment is the company's selection as a preferred supplier by several of the world's leading reactor design and construction organizations.

### Nuclear Island Pump Models

	<p><b>CA</b></p> <ul style="list-style-type: none"> <li>• Radially split, double case multistage pump</li> <li>• <b>Applications:</b> Safety injection, CVCS charge, emergency feedwater</li> </ul>
	<p><b>DFSS/DVSS</b></p> <ul style="list-style-type: none"> <li>• Radially split, single-stage pump</li> <li>• <b>Applications:</b> Reactor coolant, reactor recirculation, primary heat transport, shutdown cooling</li> </ul>
	<p><b>WD/WDF</b></p> <ul style="list-style-type: none"> <li>• Radially split, single-stage pump</li> <li>• <b>Applications:</b> Residual heat removal, containment spray</li> </ul>
	<p><b>MEV</b></p> <ul style="list-style-type: none"> <li>• Vertical single-stage pump</li> <li>• <b>Applications:</b> Essential service water, miscellaneous cooling</li> </ul>
	<p><b>APKD</b></p> <ul style="list-style-type: none"> <li>• Vertical double case, double-suction, multistage pump</li> <li>• <b>Applications:</b> High-pressure core flood, residual heat removal</li> </ul>

	<p><b>CAM/CAV</b></p> <ul style="list-style-type: none"> <li>• Radially split, double case, multistage pump</li> <li>• <b>Applications:</b> CVCS charge, control rod drive</li> </ul>
	<p><b>EG</b></p> <ul style="list-style-type: none"> <li>• Radially split, double-suction, single-stage pump</li> <li>• <b>Applications:</b> Component cooling</li> </ul>
	<p><b>HPX/Mark 3™</b></p> <ul style="list-style-type: none"> <li>• Overhung impeller, single-stage pump</li> <li>• <b>Applications:</b> Fuel pool, safety chilled water and waste treatment</li> </ul>
	<p><b>LPN/LNN</b></p> <ul style="list-style-type: none"> <li>• Axially split, double-suction, single-stage pump</li> <li>• <b>Applications:</b> Component cooling water, service water booster</li> </ul>
	<p><b>VTP</b></p> <ul style="list-style-type: none"> <li>• Vertical turbine, multistage wet-pit pump</li> <li>• <b>Applications:</b> Essential water service, screen wash, miscellaneous cooling</li> </ul>

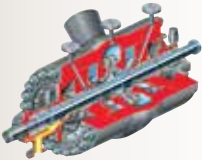


## ***Turbine Island***

Steam-side pumps in nuclear service require the highest degree of system reliability and efficiency over a wide range of plant operating requirements. High temperatures and fluctuating operating parameters can lead to marginal NPSH conditions, so pumps must exhibit excellent suction performance. In addition, high-efficiency operation is required to minimize parasitic energy usage within the plant. A broad range of pumps with optimized, high-efficiency hydraulics ensures plant operators produce power with the minimum amount of energy usage.

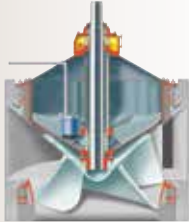
Flowserve steam-side pumps and mechanical seals for feed, condensate and circulating water are preferred globally for their proven reliability and lowest total cost of ownership in both conventional and nuclear power plants. Also, Flowserve engineers have the requisite hydraulic and mechanical application know-how, thermal cycle expertise and materials knowledge for the successful application of a highly efficient, reliable steam-side pumping system.

### Turbine Island Pump Models



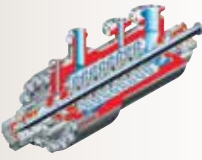
**CN/HDR**

- Radially split, double-suction, single-stage pump
- **Applications:** Reactor/steam generator feed




**BSV/BCV**

- Vertical, concrete volute, wet-pit pump
- **Applications:** Circulating water




**CSB**

- Radially split, double case, multistage pump
- **Applications:** Start-up reactor/steam generator feed, standby



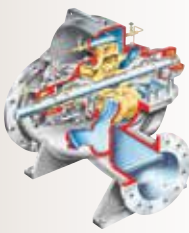
**HDX**

- Radially split, double-suction, single-stage pump
- **Applications:** Reactor/steam generator feed booster, condensate booster




**APKD**

- Vertical double case, double-suction, multistage pump
- **Applications:** Condensate extraction, heater drain




**LPN/LNN**

- Axially split, double-suction, single-stage pump
- **Applications:** Condensate booster, closed cooling water



**VCT**

- Vertical mixed flow pump
- **Applications:** Circulating water



**VTP**

- Vertical turbine, multistage wet-pit pump
- **Applications:** Service water



## *Plant Up-Rates and Life Extensions*

Plant license extensions and power up-rates present attractive alternatives to new plant construction in the nuclear industry. Operating licenses have been extended from 30 or 40 years to up to 60 years, while power up-rates of as much as 30% have been possible. This typically requires the upgrading, up-rating and/or replacement of existing equipment. Upgrading and/or up-rating is usually preferable to replacement, since costly modifications to civil works and piping can generally be avoided.

To ensure that the right modifications are implemented, it is important to take a systems approach where existing

equipment and system performance is fully evaluated (baselined) prior to any changes. For example, the main circulating water pumps cannot be upgraded before essential steps are taken, such as verifying the water system's curve and evaluating the performance of intake structures.

With its evaluation and engineering capabilities as well as its analytical and empirical tools, Flowserve provides a fully integrated systems approach to pump up-rates and upgrades whether the pumps were originally supplied by Flowserve or another manufacturer.





### A Systems Approach

Flowserve is committed to maximizing plant profitability by reducing the total life cycle costs of pumping systems. While it's easy to focus on a specific piece of equipment, it is imperative to recognize no pump operates in isolation. That's why Flowserve uses a holistic approach that helps plant operators optimize unit performance by identifying deficiencies and improvement opportunities at the system level.

#### Nuclear Steam Supply System Assessments

To achieve increased plant output, nuclear utilities are increasingly turning to stretch and extended power up-rate (EPU) projects. Flowserve assessments of a system's actual capabilities under increased demand and extended transient conditions establish a more realistic baseline for unit up-rates than relying on the original design criteria. Flowserve engineers can ensure proper actions are taken to address:

- Unit up-rates
- Unit derate due to high condenser backpressure
- Heater fouling and inefficiency
- Energy optimization
- Hydraulic optimization
- Pump performance or efficiency degradation
- Seismic evaluations

#### Safety System Assessments

Nuclear power plants must continuously assess and maintain operability of their engineered safety systems to ensure they perform as designed. These systems are low- and high-pressure pumped fluid systems including, but not limited to:

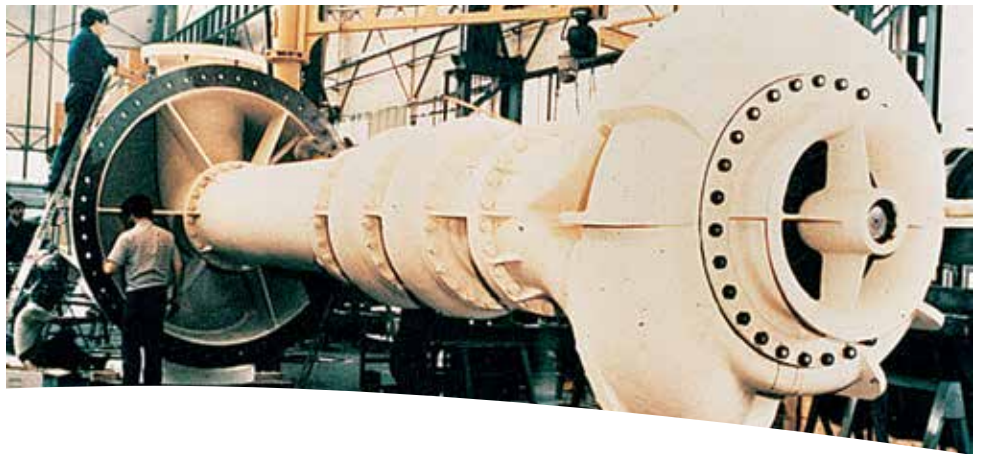
- Residual heat removal
- Low-pressure injection
- High-pressure injection
- Core spray
- Essential service water

Flowserve engineers can make verifying safety system operability easy, safe and accurate. By installing and utilizing precise wireless sensors on critical components, they can collect real-time data on parameters such as flow, temperature, pressure and vibration levels. The sensors' long life and "always on" capability ensures all planned and unplanned actuations result in a high-resolution bank of data. Using this data and hydraulic modeling software, engineers can determine maintenance and modifications required to restore system performance.

#### Hydraulic Upgrades — An Integrated Process

The use of sophisticated techniques and software is essential to any hydraulic upgrade, including computational fluid dynamics (CFD), balanced with careful field measurements to ensure the integrity of computer simulations. A typical hydraulic upgrade involves:

- Data collection — Flowserve engineers collect field measurements for use in the CFD study.
- CFD analysis — Accurate computer models of systems and pump hydraulics form the basis for component upgrade recommendations.
- Model testing — Small-scale models are tested to verify performance under actual operating scenarios.
- Production — Actual components are produced after performance verification.
- Field testing — Field testing confirms the upgrade performs as predicted in the plant environment.



## ***Equipment Re-Rates and Upgrades***

Flowserve can improve the mean time between repair (MTBR) and optimize the hydraulic performance of older pumps through proven upgrades. Existing system evaluations or post-accident studies can be performed to analyze internal wear and rotordynamic interactions to confirm equipment integrity. Hundreds of mechanical, metallurgical, and hydraulic upgrades for existing pumps have been developed that can be applied across the spectrum of safety-related and steam-side pumps.

### ***Mechanical Design***

- Stiffer rotor designs improve bearing and seal life and reduce overall pump vibration.
- Bearing capability is increased with tri-land and tilt-pad bearings.
- Conversion from packed stuffing boxes to mechanical seals eliminates pump leakage.
- Improved coupling designs allow easier maintenance and reduce vibration levels.
- Heavy-duty bearing housings reduce vibration and extend bearing life.

### ***Materials Science***

- Direct laser deposition (DLD) extends the life of wear parts.
- Cavitation-resistant impellers provide longer impeller life and reduce pump vibration.
- Superstraight™ pump shafts reduce shaft deflection and vibration.
- Non-metallic bearings provide longer bearing life.
- Corrosion-resistant alloys extend component life.

### ***Hydraulic Engineering***

- A-gap and B-gap modifications allow for smoother pump operation over a larger hydraulic range.
- The latest biased wedge impeller designs and other modifications reduce vibration levels at low flow conditions.
- Improved efficiency designs reduce system operation costs.
- Vertical pump re-bowling allows a pump's operating range to be changed.
- NPSH improvements increase the life of first-stage impellers.





The dedication of Flowserve to technological leadership has resulted in product enhancements and redesigns specific to multiple nuclear applications. Common upgrades are described below.

**Cooling Water and Condensate Pump Upgrades**

Cooling water and condensate pump upgrades include:

- Latest impeller design
- Heavy-duty shaft and bearings
- Improved NPSH characteristics
- Cartridge mechanical seals
- Bearing protectors

**Residual Heat Removal (RHR) Pump Redesign**

An RHR pump redesign provides:

- Easy-access cartridge seal
- Removable spacer coupling
- Separate heavy-duty pump shaft
- Anti-galling wear rings

**Feed Pump Upgrades**

- Increased flow impeller
- Improved NPSH characteristics
- A-gap and B-gap modifications
- Cartridge mechanical seals
- Direct laser deposition hardening of impeller hubs

**Charging Pump Upgrades**

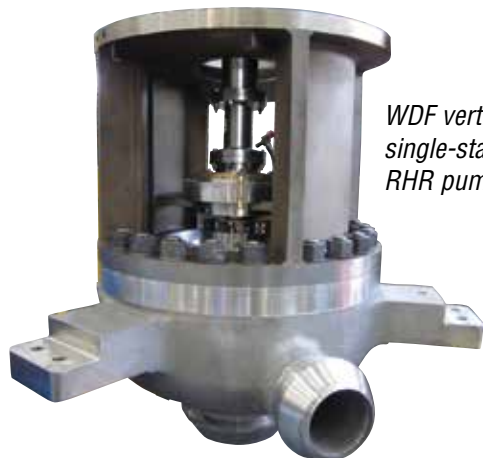
Charging pump upgrades include:

- New high-strength shafting
- A-gap and B-gap modifications
- Latest mechanical seal design
- 360° bearing housings
- Laser-hardened impeller hubs

**End Suction Pump Upgrades**

Various end suction pumps can be upgraded to include:

- Direct replacement pullouts
- Stiffer shafts
- Longer-life bearings
- Cartridge mechanical seals



WDF vertical, single-stage RHR pump



## Services

Each day a nuclear power plant (NPP) is offline during a scheduled maintenance and refueling outage can cost the utility up to US\$2 million in power replacement costs. Rapid, qualified servicing is essential to station profitability.

### On-Site Services

Flowserve provides a broad range of on-site services for outage planning, dose reduction, schedule execution and cost efficiency. These services are available for:

- ASME Section III Class 1 primary pumps and seals (recirculation pumps, reactor coolant pumps and heat transport pumps)
- ASME Section III and RCC-M Class 2 and 3 safety-related pumps
- Conventional steam-side pumps
- Commercial pumps (i.e., non-safety)
- Contaminated and non-contaminated equipment
- Equipment from all manufacturers (OEMs)

**Consulting Services** provide on-site direction for nuclear utility work. Factory trained and experienced field specialists offer expertise for:

- Pump overhauls
- Problem diagnostics and resolution
- Technical supervision



**Project Services** include both project planning and project management. Flowserve has extensive experience in developing plans that integrate technical requirements with customer outage planning activities.

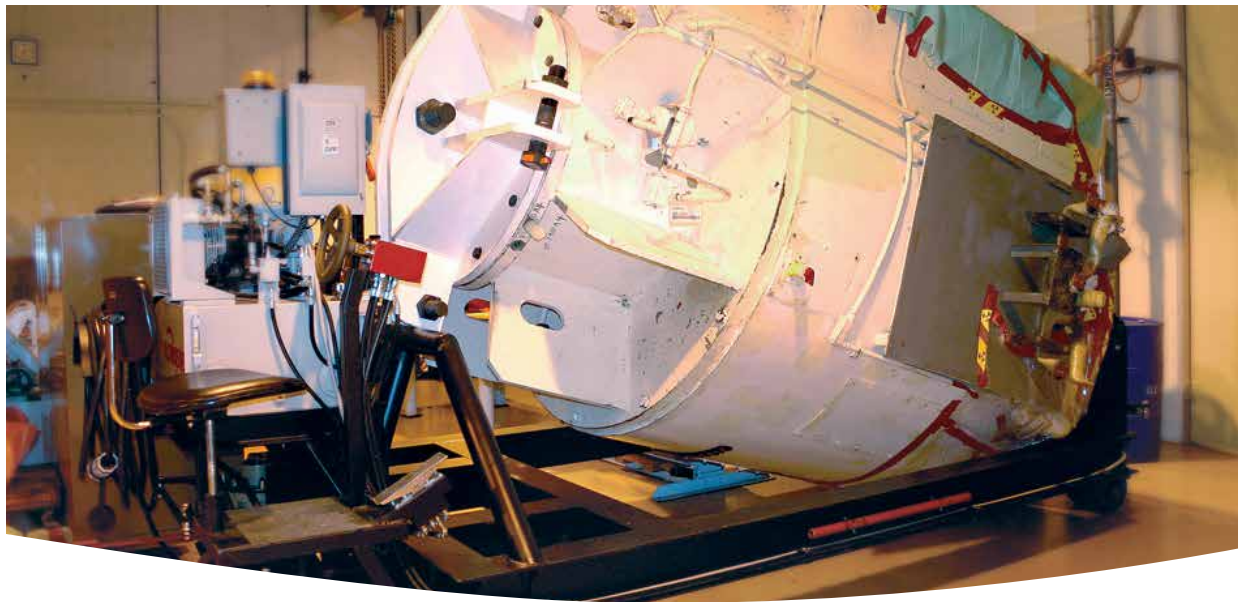


Seasoned professionals execute project plans by providing technical direction and task management skills to meet customer schedule objectives.

**Turnkey Services** provide end-to-end solutions for the most difficult pump-, seal- and motor-related tasks. Flowserve takes full responsibility for all major activities. These include: outage work scope development; integrated planning and scheduling; inventory inspections; procedure development; field machining, welding and craft labor. Specialized work such as hot alignment, in-service testing and dynamic balancing may also be provided.

Flowserve has successfully directed complex activities such as:

- Foundation baseplate and piping changes
- In-site modifications for equipment upgrades
- Reactor recirculation pump motor removal
- Primary pump upgrades to best available technology
- Primary seal upgrade



### **Special Tooling**

Flowserve has broad experience in on-site services for the nuclear industry, which has resulted in continuous development and improvement of tooling designed to install and maintain critical pump- and motor-related components.

#### **Seal Removal Tooling**

- Time savings of up to 90% for reduced exposure and cost impact
- Redesigned to yield a 75% weight reduction
- Increased load capacity
- Quick-disconnect features for easy installation and removal

**Self-Powered Motor Transports** address the problems associated with transporting heavy, primary pump motors in and out of the drywell.

- Self-contained hydraulic motor power
- Spin-on-center wheel design for maneuverability through congested passageways and tight clearances
- Removal of 20 400 kg (45 000 lbs) motors in a few hours, rather than several shifts
- Significant reductions in exposure and associated costs

**Hydraulic Coupling Installation Tools** are designed to simplify the installation of tapered shaft couplings.

- No heating required for installation
- Repeatable, controlled installations to improve equipment operation
- Reduced maintenance time

**Special Tooling Kits** provide for safe and easy handling, assembly, alignment and shielding of contaminated and critical pump components.



*Hydraulic coupling tool*



## **Aftermarket Services, Parts and Components**

Experienced Flowserve engineers, repair technicians, qualified inspectors and technical service representatives support important repairs to safety-related and steam-side equipment.

Flowserve operates several nuclear service facilities that maintain the required regional certifications to support the nuclear industry globally. This includes the manufacture of spare parts as well as the complete repair and upgrade of safety-related equipment.

- Code Class 1 primary reactor coolant/recirculation pumps and mechanical seals
- Code Class 2 and 3 safety-related pumps and mechanical seals
- Contaminated and non-contaminated equipment and components

In addition, Flowserve is a leading supplier of hot shop services to the nuclear industry. The radioactive material licenses held by its alliance partners enable Flowserve to provide valuable full-service repair and upgrades of contaminated pumps and equipment.

For BOP and auxiliary pump service, Flowserve maintains a global network of Quick Response Centers (QRCs) specifically geared to providing parts, repairs and services for existing installations.

### **Aftermarket Services**

Flowserve aftermarket services include:

- Service routinely provided within 24 hours with immediate shipment of inventoried components and quick-turnaround manufacturing for non-stock components
- Detailed inspection and reverse engineering of parts and components, regardless of OEM
- Troubleshooting and root cause failure analysis
- Non-destructive examination
- Section IX welding
- Precision rotor stacking and balancing
- Performance, NPSH and hydrostatic testing
- Installation, troubleshooting, repair and replacement activities in accordance with site's Section XI program

### **Hot Shop Benefits**

Flowserve hot shop benefits include:

- Valuable site man-rem cost reduction assistance
- State-of-the-art decontamination of reactor coolant pump rotors and covers
- OEM engineering and manufacturing expertise
- Full machine shop capabilities, including Section IX welding and precision balancing
- Control watch and other radiation control coverage
- Licensed shipping and transportation
- Responsible disposal of radioactive waste and by-products



### ***New Impeller for Higher Duty Point Saves Money***

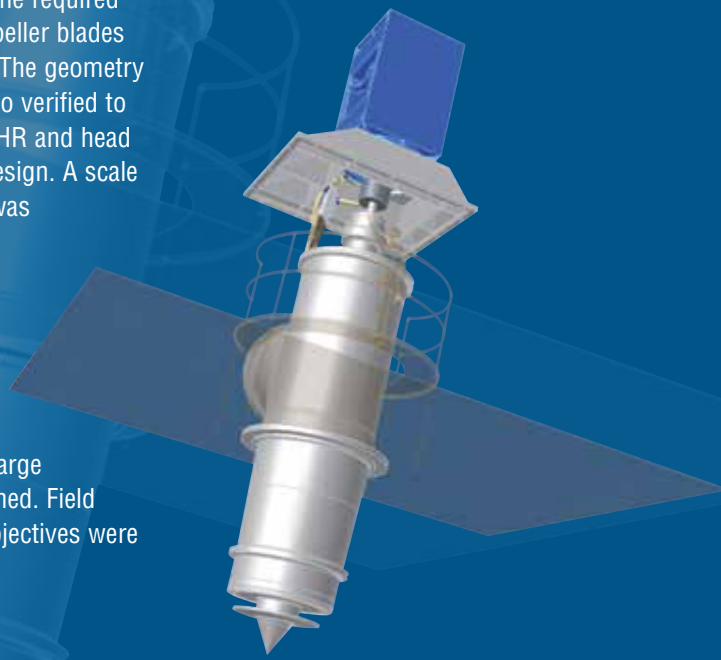
**The Challenge:** A nuclear power station needed to re-rate its 16 axial flow vertical circulating pumps to attain a 125% duty point. The changeover had to be accomplished over two and one-half years at minimum cost, without modifications to the civil structures and changes to the pit dimensions.

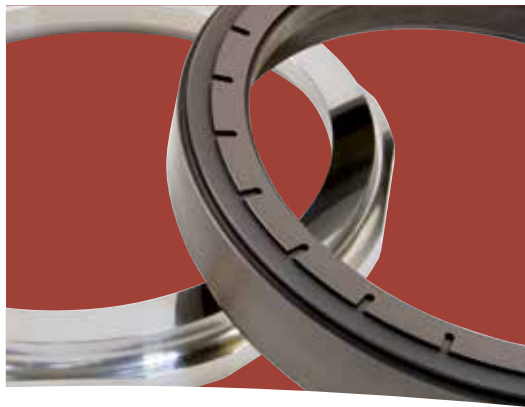
**The Solution:** The hydraulic performance of the pumps was analyzed by computational fluid dynamics (CFD). Using these calculations, the propeller was designed to produce the required head. The inlet geometry of the propeller blades was optimized for minimal NPSHR. The geometry of the water intake channels was also verified to avoid potential deterioration of NPSHR and head performance of the new propeller design. A scale model of the final propeller design was constructed for testing.

Pump model testing proved that the new design would meet the requirements for the new duty point without changes to the civil works or pit dimensions. The pumps' inner-column, complete with elbow/discharge section and motor stand, were retained. Field testing confirmed that the design objectives were met and exceeded.

Major components replaced included:

- Propeller; however, the existing propeller nose cone was re-used
- Pump casing to the same dimensions as replaced components
- Shaft, due to dimensional deviations of the new propeller, with improved torsional strength
- Driver to accommodate higher required power
- Motor support frame





## ***N-Seal Primary Pump Seal***

The N-Seal primary pump seal represents the nuclear industry's most advanced mechanical seal technology. Developed for use in all OEM reactor coolant, heat transport and recirculation pumps, the N-Seal is found in NPPs throughout North America, Europe and Asia.

### ***Features and Benefits***

- **Cartridge Construction** simplifies installation, 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.
- **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 Capabilities** maximizes operating life. Tests confirm sealing integrity is maintained throughout all plant transient scenarios.
- **Abeyance Back-up Shutdown Seal** (patent pending) automatically actuates when leakage from the primary seal exceeds a threshold velocity.

### ***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:

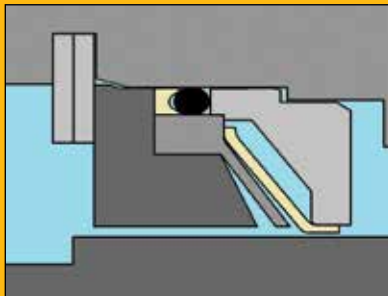
- **Low Conversion and Installation Costs** — Modifications to existing piping and instrumentation are usually not required. As a consequence, existing operating procedures may be maintained, and costs associated with Design Change Packages (DCP) are minimized.
- **Reduced Man-rem Exposure** — The cartridge 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.

### ***Reliable, Predictive Maintenance***

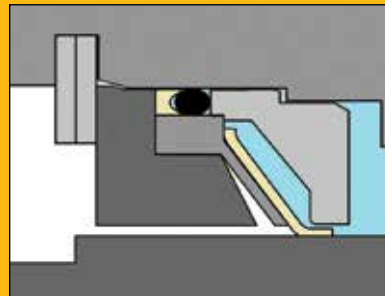
With advanced monitoring systems installed on the N-Seal, station operators are able to predict when maintenance is required. Costly preventive maintenance can be eliminated. The long-term result is predictable seal operation with improved safety, reliability and economy.



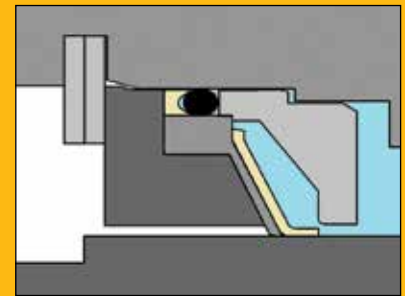
## Abeyance Seal Actuation Sequence



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.



## ***Other Mechanical Seals***

As nuclear power generation plant designs evolve, pump sealing devices with expanding capabilities and performance characteristics are required. Flowserve provides an extensive line of mechanical seals for both safety-related and steam-side nuclear plant applications.

### ***Safety-Related Seals***

Safety-related seals are built to 10CFR50 Appendix B requirements. Bills of material are subjected to full inspection and traceability per code requirements. Pressure boundary components are hydrostatically tested and documented in accordance with code rules. Pump and seal systems are tested to demonstrate reliable performance under emergency conditions and periodically tested in-service to ASME and RCC-M code rules. High temperature and solids-resistant face upgrades minimize the need for external seal support systems.



### ***Commercial Steam-Side Seals***

While not subject to nuclear code requirements, commercial steam-side seals are subjected to full inspection and traceability. Advanced engineering techniques and materials technologies ensure reliable performance at high temperatures with difficult lubrication conditions.

At Flowserve, ongoing development has optimized performance and seal life for these critical conditions:

- High face speeds on large shaft diameters
- High pressures and temperatures on water
- Minimum reaction to temperature transients
- “Hot standby” capability
- Ability to maintain seal integrity under low or lost suction conditions
- Ability to withstand electro-corrosion



## ***Nuclear Valves and Actuators***

Flowserve offers a full complement of valves, actuators and services for the nuclear industry with: ASME Section III N, NPT Stamp and RCC-M design and production capability; and NR Stamp repair accreditation. Flowserve supports its nuclear valve program with a dedicated team of engineering, field service, quality assurance and production experts.

Flowserve nuclear valve qualifications include:

- ASME Section III N, NA, NPT and NR stamp
- ASME Section III Class 1, 2, and 3 Design and Manufacturing
- Customer and industry accepted ASME Section III, ASME NQA-1, 10 CFR Appendix B and ISO 9001 quality assurance systems
- Industry-first ASME QME-1 functional qualification
- Actuators environmentally qualified per IEEE 323, 344 and 382
- Full NDE capability including radiography, ultrasonic, magnetic particle and liquid penetrant examinations
- Full welding and heat treat capabilities
- 3-D solid modeling for stress, natural frequency, flow and thermal gradients

***For more information, please contact the Flowserve Flow Control Division.***

## ***A Full Range of Valves, Actuators and Components***

Flowserve valves will be found throughout the NPP—from the most critical reactor safety-related applications to high demanding BOP steam-side services and to the more routine auxiliaries.

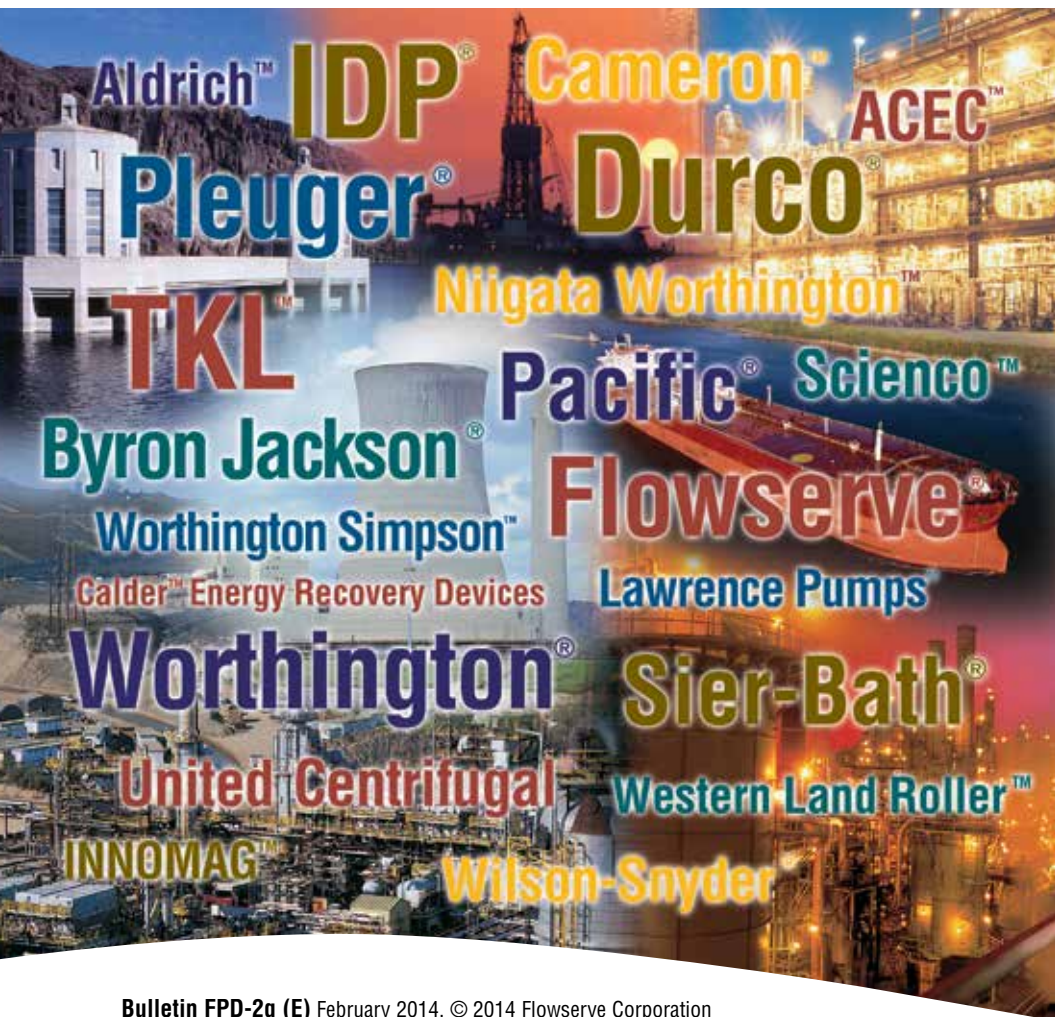
Flowserve Anchor/Darling® and Edward® critical application valves include mainsteam isolation valves (MSIVs) and main feedwater isolation valves (MFIVs) supplied with stored energy actuators. A variety of check valves provide pump protection against recirculation and reverse flow.

Flowserve nuclear valve styles include: globe valves in angle, Y- and T-Pattern configurations; gate valves in wedge, split wedge and parallel slide configurations; quarter-turn valves in butterfly, plug and ball configurations; check valves in lift, swing and tilting disc designs; and control valves in linear and rotary configurations.



*MSIV Valve*

In addition to nuclear valves, Flowserve also offers the Limitorque® motor operators. These actuators are environmentally qualified to the latest requirements and have been vastly utilized for critical nuclear power generation applications.



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