Pump Supplier To The World

Flowserve is the driving force in the global industrial pump marketplace. No other pump company in the world has the depth or breadth of expertise in the successful application of pre-engineered, engineered and special purpose pumps and systems.

A Leader in the Nuclear Industry

Flowserve’s experience as nuclear specialists dates to the birth of the nuclear power generation industry. Today, Flowserve continues to provide products and services that remain on the leading edge of technological advances in nuclear power. Capabilities include ASME Code Class 1, 2 and 3 pumps, parts, and nuclear mechanical seals, plus full repair, upgrade and maintenance services, technical and engineering support.

Heritage Names of Distinction

ACEC™ Centrifugal Pumps
Aldrich® Pumps
Byron Jackson® Pumps
Cameron® Pumps
Durco® Pumps
Flowserve® Pumps
IDP® Pumps
Jeumont-Schneider™ Pumps
Pacific® Pumps
Pleuger® Pumps
Scienco® Pumps
Sier-Bath® Rotary Pumps
United® Centrifugal Pumps
Western Land Roller® Irrigation Pumps
Wilson-Snyder® Pumps
Worthington® Pumps
Worthington Simpson® Pumps
Nuclear Pumps
Flowserve has long maintained a leadership position in the nuclear industry. In 1948 the Company supplied prototype zero-leakage pumps for the U.S.S. Nautilus. In 1957 Flowserve also designed liquid metal coolant pumps that helped Moorpark, California, become the first community entirely lit by nuclear power. From such an outstanding beginning, Flowserve continues as the leader in today's generation of nuclear industry pump technology.

Flowserve provides pumps and parts for primary coolant, shutdown cooling, charging makeup, reactor and steam generator feed and auxiliary pumping services.

Nuclear Seals
Flowserve's N-Seals demonstrate superior sealing performance during simulated station blackout and transient testing, which includes changes in temperature, pressure and shaft movements. Test data confirm the Flowserve N-Seal to be expertly designed and highly reliable under emergency conditions.

Expert Nuclear Services
To keep nuclear equipment running at peak performance, Flowserve's technical service experts provide customized services ranging from advice and consultation, to inspection, repair or remanufacturing through full turnkey project management. Flowserve is one of only two OEMs providing hot shop services on nuclear pumps and seals.
From First to Foremost in Nuclear Pumping Technology

Flowserve’s experience as nuclear specialists dates to the birth of the nuclear power generation industry when it provided innovative pumping and sealing technologies under the Byron Jackson trade name. Today, with the addition of the IDP family of nuclear pump models, Flowserve continues the tradition with pumps and systems that remain on the leading edge of technological advances in nuclear power.

Innovation: A Continuing Hallmark of Flowserve in the Nuclear Power Industry

New generation designs and upgraded components for BWR, PWR and PHWR plants have contributed to more reliable performance and easier maintenance. One example is the Flowserve heat exchanger design for reactor recirculation pumps. With no moving or wearing parts and no maintenance requirements, this design provides:

- Shaft protection against thermal cracking
- Seal protection under hot standby conditions
- Greater operational flexibility
- Easy disassembly and inspection

Flowserve Pumps for Nuclear Services

- Primary Coolant/Circulating
- Residual Heat Removal
- Containment Spray
- Core Spray
- Low Pressure Safety Injection
- High Pressure Safety Injection
- Charging/Makeup
- Shutdown Cooling
- Essential Service Water
- Screen Wash
- Emergency Feedwater
- Coolant Injection
- Reactor Water Cleanup
- Component Cooling
- Reactor Feed (BWR)
- Steam Generator Feed (PWR)
- Circulating Water
- Condensate Extraction
- Heater Drain
- Feedwater Booster
- Additional Services
Fourth generation primary coolant pump design
In 1992 Flowserve introduced a new primary pump design specifically to eliminate the thermal cracking detected in some primary pumps engineered in the 1960s. This revolutionary design, consisting of replacement covers, heat exchangers and rotating elements, employs state-of-the-art technology to eliminate the thermal cracking issue. Fourth Generation pump upgrades have been installed around the world, significantly increasing the reliability and operability of nuclear power plants.

Flowserve’s primary coolant pump is supplied or upgraded to rigorous technological and NSSS design standards for:
- Boiling water reactors (BWR)
- Pressurized water reactors (PWR)
- Pressurized heavy water reactors (PHWR)

The major pump assembly consists of impeller, pump case, cover-driver mount, integral heat exchanger, mechanical seal cartridge, hydrostatic pressurized radial bearing, shaft and semi-rigid pump to motor shaft coupling.

Pump casing is a one-piece casting. The BWR and PHWR case is of double volute design; the PWR uses a diffuser with a torus-type casing.

Upgraded rotating element uses a one-piece welded shaft-impeller-journal assembly. The design eliminates internal bolts, cap screws and locking devices that could come loose and cause premature failure. The fully machined assembly is balanced as a single rotating unit.

Hydrostatic-pressurized radial bearing, mounted directly above the impeller, requires no source of cooling water as is the case with earlier design carbon bearings. The bearing operates submerged in radioactive system water at loop temperature of approximately 304°C (580°F).

BWR and PHWR Operating Parameters
- Flows to 11 900 m³/h (52 300 gpm)
- Heads to 250 m (815 ft)
- Temperatures to 304°C (580°F)
- Pressures to 129 bar (1870 psi)
- Speeds to 1800 rpm
- Power to 9400 kW (12 600 hp)

PWR Operating Parameters
- Flows to 24 500 m³/h (108 000 gpm)
- Heads to 107 m (350 ft)
- Temperatures to 304°C (580°F)
- Pressures to 172 bar (2500 psi)
- Speeds to 1200 rpm
- Power to 7500 kW (10 000 hp)
Shutdown Cooling, Residual Heat Removal and Low Pressure Safety Injection Pumps

Utilized in pressurized and boiling water reactors for N Stamp safety related applications, this vertical, forged casing, single stage design is available in various stainless steel materials.

The pump’s unique coupling design allows ease of maintenance for quick mechanical seal replacement in harsh environments.

ASME Section III
Class 2 and 3
N Stamp Pumps

Normal Charging Pump

This pump is designed specifically for normal charging service. It features patented modular impellers, which result in a unique, compact design providing low-flow stability and reliability over a wide range of flows without surging and pulsations.

Other features include: modularized assembly and disassembly; forged barrel with no attachment welds; cartridge mechanical seals with no external seal injection piping; ball-ball construction with no need for an external forced feed lube oiling system; dry disk spacer type coupling for ease of component servicing; and flanged axial thrust-balancing device for optimum thrust balance.

This multistage double case design offers many distinct cost-savings advantages over positive displacement type pumps, whether as original supply or as a replacement-system upgrade. The Flowserve design, as a replacement for a positive displacement pump, eliminates negative operational and readiness issues, including: high maintenance activity; short packing life; high packing leakage; breakage of key components; elaborate support systems (cooling water, piping dampeners and stabilizers); and high levels of radioactive water and noble gas leakage.

Operating Parameters
- Flows to 900 m³/h (4000 gpm)
- Heads to 245 m (800 ft)
- Temperatures to 120°C (250°F)
- Pressures to 200 bar (3000 psi)

Normal Charging Pump Operating Parameters
- Flows to 45 m³/h (200 gpm)
- Heads to 1920 m (6300 ft)
- Temperatures to 120°C (250°F)
- Pressures to 200 bar (3000 psi)
Reactor and steam generator feed pumps are available in diffuser and volute casing configurations, and with a choice of pressure breakdown bushing or conventional mechanical sealing. Both of these single stage, high speed pump models feature between bearings centerline supported mounting, radially split casings and double suction impellers.

**Feed Pumps Operating Parameters**
- Rated flows to 5065 m³/h (22 300 gpm)
- Heads to 910 m (3000 ft)
- Temperatures to 206°C (402°F)
- Pressures to 87 bar (1265 psi)
- Speeds to 6000 rpm
- Power to 15 000 kW (20 000 hp)

**Circulating Water Pump Operating Parameters**
- Flows to 115 000 m³/h (500 000 gpm)
- Heads to 75 m (250 ft)
- Temperatures to 65°C (150°F)
- Pressures to 5 bar (75 psi)

**Other Flowserve Pump Models Available for Class 3 and Steam Side Services**
- **Horizontal Multistage Designs**
  - Double case diffuser and volute
  - Axially split and radially split case diffuser
  - Axially split and radially split case volute
- **Horizontal Single Stage Designs**
  - Single suction, radially split case
  - Double suction, axially split and radially split case
- **Vertical Designs**
  - Single stage and multistage open pit
  - Single stage and multistage canned design

**Condensate Extraction Pump Operating Parameters**
- Flows to 4550 m³/h (20 000 gpm)
- Heads to 460 m (1500 ft)
- Temperatures to 132°C (270°F)
- Pressures to 55 bar (800 psi)
Flowserve’s commitment to continuous improvement of product reliability guided the development of the N-Seal, the world’s most advanced nuclear sealing technology. Nuclear plants throughout North America, Europe and Asia have achieved maximum benefits from this high quality, long life seal.

The N-Series primary pump seal has been developed for use in all manufacturers’ pumps for the following plant types:
- Boiling Water Reactor (BWR)
- Pressurized Water Reactor (PWR)
- Pressurized Heavy Water Reactor (PHWR)

This unique series of seals is designed for all anticipated steady-state and emergency transient operating conditions. Benefits include:
- Improved reliability
- Reduced maintenance
- Extended plant operation cycles
Years of research and tens of thousands of hours of full-scale verification and qualification testing have gone into perfecting the advanced nuclear mechanical seal cartridge for primary pumps. The following test scenario bears witness to Flowserve’s commitment to leading edge nuclear sealing technology.

**Test Parameters and Results Are Impressive.**
The N-9000 Seal cartridge was performance-aged for over 6000 hours under normal and emergency transient situations, which included rapid changes in pressure and temperature as well as dynamic axial, radial, orbital and angular shaft displacements. During the station blackout scenario, reliable performance was sustained despite the loss of cooling water and seal injection for over eight hours.

**One of the most advanced test stands in the world** can be computer controlled to dynamically simulate operating and emergency situations.

**Portable seal test stands** allow for on-site simulation of plant conditions before installation. This dramatically reduces seal leakage risks after installation.
- Designed for maximum maneuverability and ease of transport
- Stainless steel construction for elimination of test contamination
- Easy access to pullout gauges

**Hands-on, on-site seal training** provides plant personnel with real life, practical exposure to primary pump seal technology including:
- Theory
- Operation
- Maintenance
Flowserve offers a full range of repair services including hot shop contaminated component reconditioning services and performance testing. The nuclear service team provides quick, professional solutions based on OEM engineering and manufacturing expertise.

*Flowserve is a Full Service Specialist to the Nuclear Industry, Offering:*
- Primary pump repairs
- Auxiliary and steam side repairs
- Safety related repairs
- Contaminated repairs
- Compliance with U.S. Regulation 10CFR50 Appendix B
Flowserve’s Experienced Engineers, Repair Technicians, Qualified Inspectors and Technical Service Representatives support ASME Section III Class 1, 2 & 3 Safety Related and Commercial Grade Repairs.

- Twenty-four hour service
- Detailed inspection and reverse engineering
- Troubleshooting and failure analysis
- Non-destructive examination
- Section IX welding
- Precision rotor stacking and balancing
- Performance, NPSH and hydrostatic testing
- Section XI program

Repair and Upgrade of Contaminated and Non-contaminated Nuclear Components

- Pumps and pump components for all nuclear services
- Valves and valve components
- Primary coolant pump seals
- Most other contaminated equipment and components

Flowserve Hot Shop Capabilities

Flowserve is the leading supplier of Hot Shop services to the nuclear industry. The radioactive materials license held by Flowserve’s alliance partners enables Flowserve to provide valuable, full service repair and upgrades of contaminated pumps and equipment.

Flowserve Hot Shop Benefits Include:

- Valuable site manrem 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
- DOT licensed shipping and transportation
- Responsible disposal of radioactive waste and by-products

National Board Approved Repair Organization Center

This level of recognition and achievement underscores the excellence achieved by Flowserve’s Nuclear Repair Center Quality Program. The Nuclear Repair (NR) Stamp allows customers to place orders for ASME Section III Code product repairs and replacements without invoking their internal ASME Section XI Inservice Inspection Program.
Flowserve’s philosophy of continuous improvement has led to the development of hundreds of mechanical, metallurgical and hydraulic upgrades for existing pumps. Flowserve can improve the Mean Time Between Repair (MTBR) and optimize the hydraulic performance of older pumps through proven upgrades.

**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**
- Laser-hardening 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.
Flowserve’s dedication to technological leadership has resulted in product enhancements and redesigns for multiple nuclear applications. Common upgrades are described below.

**Cooling Water Pump Upgrades Include:**
- Latest impeller design
- Heavy-duty shaft & bearings
- A-gap or B-gap modifications
- Cartridge mechanical seals
- Bearing protectors

**Residual Heat Removal (RHR) Pump Redesign Provides for:**
- Easy access cartridge seal
- Removable spacer coupling
- Separate heavy-duty pump shaft
- Anti-galling wear rings

**RLIJ Charging Pump Upgrades Include:**
- New high-strength shafting
- A-gap and B-gap modifications
- Latest mechanical seal design
- 360-degree bearing housings
- Laser-hardened impeller hubs

**Various End Suction Pumps Can Be Upgraded to Include:**
- Direct replacement pullouts
- Stiffer shafts
- Longer-life bearings
- Cartridge mechanical seals
Flowserve provides a broad range of on-site services for outage planning, dose reduction, schedule execution and cost efficiency. These services are available for:

- Primary pumps
- Safety related and steam side pumps
- Non-safety related pumps
- Contaminated and non-contaminated equipment
- Equipment from all manufacturers

**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 aggressive cost and 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:

- Replacement of welded-in primary reactor pumps
- Foundation baseplate and piping changes
- *In situ* modifications for equipment upgrades
- Primary pump motor removal
- Primary pump upgrades to best available technology
Flowserve’s broad experience in on-site services for the nuclear industry 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 percent for reduced exposure and cost impact
- Redesigned to yield a 75 percent 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 from containment.

- 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 lb) 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.
Flowserve’s Engineering Services provide customers with capabilities that augment customers’ staffs with additional manpower and functional expertise. Services include: nuclear class engineering analysis; diagnostics; root cause analysis; product and metallurgy upgrade recommendations; problem solving; testing and design reviews.

**Engineering Analyses**
Expert engineers use the latest, proven engineering tools and analyses to support projects for all types and brands of pumps and related equipment. Capabilities include:
- Advanced stress analysis
- Dynamic analysis
- Thermal analysis
- Hydraulic evaluations
- Computerized fluid dynamic analysis (CFD)
- Finite element analysis (FEA)
- Structural analysis
- Failure analysis
- Vibration analysis/pressure pulsation analysis
- Code analysis

**Vibration Diagnostics and Analysis**
Analyses range from simple point vibration readings to complete vibration spectrum analyses, singling out rotating speed peak-to-peak signatures. Services include:
- Data collection
- Data reduction
- Recommendations
- Problem solving
- Factory acceptance testing
- Field acceptance testing
- Predictive maintenance programs
In addition to industry-leading analysis capabilities, Flowserve takes a hands-on approach to help customers implement recommended solutions.

**On-Site Services Integration**
When analysis leads to recommendations requiring equipment or system modifications, Flowserve can leverage its extensive On-Site Services capabilities to coordinate resources and implement the desired changes and upgrades.

**Flowserve’s Factory and Portable CMM Technology Provide Highly Accurate Reverse Engineering Capabilities**
- Product upgrades
- Engineered solutions
- Automated design

**Pump Testing Services**
Customers can take advantage of Flowserve’s world class testing facilities to help diagnose pump problems and prove out upgrades and modifications.

**Pump Testing Capabilities**
- Up to 39 750 m³/h (175 000 gpm)
- Up to 10 000 rpm
- Up to 18 650 kW (25 000 hp)
- NPSH testing
Availability of high quality parts and components for nuclear equipment is a critical consideration. Flowserve augments its repair capabilities with comprehensive manufacturing and quality assurance capabilities for spare parts.

**Flowserve N Stamp facilities** use best available manufacturing equipment, quality tools, and testing equipment to manufacture parts for all nuclear equipment requirements including:

- ASME Code Class 1, 2, 3 components
- Safety related components
- Commercial, non-safety related components

Flowserve maintains a global network of warehouses and manufacturing facilities, assuring its customers the highest available level of service. This far-reaching network provides:

- Immediate shipment of inventoried components anywhere in the world
- Quick-turnaround manufacturing for non-stock components
- Capabilities for all manufacturers’ parts
The Recognized Nuclear Experts

Flowserve has long been the recognized leader in pump technology for the nuclear industry. The following examples highlight some of Flowserve’s ground-breaking achievements in nuclear industry pump technology.

1948 – Flowserve develops the first “canned” pump prototype for modern nuclear power pumps.

1953 – Flowserve supplies pumps for the first nuclear-powered submarine, the U.S.S. Nautilus.

1957 – 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.

1961 – 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.

1965 – Flowserve provides the first nuclear recirculation pumps with water lubricated hydrostatic bearings.

1983 – Flowserve successfully tests the largest U.S. liquid sodium pump for Clinch River Breeder Reactor.

1988 – Flowserve introduces the N-Series seal, the most thoroughly tested and proven primary pump seal in the nuclear industry.

2001 – Flowserve opens the industry’s only contaminated pump test loop for testing repaired and upgraded nuclear pumps.

Present – Flowserve continues to build on an installed base of more than 3500 pumps in commercial nuclear plants.

1948 - 1988: Flowserve has been a leader in developing nuclear pumps. In the early years, Flowserve developed the first “canned” pump prototype for modern nuclear power pumps. In 1953, Flowserve supplied pumps for the first nuclear-powered submarine, the U.S.S. Nautilus. In 1957, Flowserve supplied liquid metal pumps to the first non-military nuclear power plant in Moorpark, California.


1983 - 2001: In 1983, Flowserve successfully tested the largest U.S. liquid sodium pump for Clinch River Breeder Reactor. In 1988, Flowserve introduced the N-Series seal, the most thoroughly tested and proven primary pump seal in the nuclear industry.

Present - Flowserve continues to lead in nuclear pump technology, with a focus on repairing and upgrading nuclear pumps.

Flowserve has been a leader in developing nuclear pumps since the early years, with achievements highlighted in the following examples:

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With The World's Leading Pump Brands

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