Balanced Stator™ Seal for Reactor Coolant Pump Retrofits
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In the nuclear power generation industry, safe operation, plant reliability and the technology to ensure productive operation are of paramount importance. At Sulzer, our focus is on providing the service, expertise and proven, tested product to meet the needs of this critical industry.

**Unparalled Seal Performance**

The Balanced Stator™ seal is an ultra-high-performance cartridge unit that provides lifespan and leakage control unmatched by conventional seals. Employing patented flexible stator geometry, the Balanced Stator™ seal automatically compensates for pump shaft deflections. Leakage is predictably controlled to less than 0.03 gpm (0.11 liter/min) Maintenance-free periods extend from four to eight years.

The hydrodynamic Balanced Stator™ seal has three stage redundancy and a proven track record that the competition's hydrostatic or hydrodynamic seal simply cannot match.

**Versatile for Any Retrofit**

The Balanced Stator™ seal is available for any reactor coolant or recirculation pump. Sulzer provides replacement mechanical seals for other manufacturer's reactor coolant pumps (RCP) and installs the Sulzer Balanced Stator™ seal in RCPs from all the major original equipment manufacturers (OEMs).

**Installation Efficiency**

Main coolant pump (MCP) seal performance often hampers plant availability by causing forced outages and requiring frequent change-outs. Because we recognize the cost in downtime and hot-shop work to modify existing pump components, Sulzer approaches retrofits by implementing an absolute minimum of modifications to existing hardware. Two, three, or four stage seal cartridges with internal staging coils can be retrofitted into existing pumps with virtually no plant impact. Existing cooling water and injection systems can remain unchanged.
Stator™ Seal Features and Benefits

**Rotating Seal Ring and Support Ring**
One of the unique features of the patented Balanced Stator™ seal is the support mechanism for the rotating seal ring. During temperature and pressure transients the seal sleeve deflects at a different rate than the rotating seal ring. The carbide rotating support ring isolates this effect so it is not transmitted to the sealing face. This is accomplished through the similar rates of expansion of the two rings and the narrow support nose on the seal sleeve and rotating seal ring. The location and shape of the support nose – determined by the finite element analysis – eliminates moments and deflections which would cause leakage during transients in other designs.

**Transient Sensitivity Eliminated**
The patented Balanced Stator™ seal, unlike other seals, has been designed to perform under all known transient conditions. The basic Balanced Stator™ seal arrangement was developed as a refinement of the balanced end-face seal in which all the balance diameters are on the non-rotating seal parts. This configuration is utilized for its ability to tolerate pump shaft tilt without subjecting the floating member and secondary seal to axial cycling.

**Cost Effective Results**
Retrofit of your reactor coolant or recirculation pump seals is not a project entered into lightly. Conversely, it is costly for maintenance and repair of poorly performing seal packages in a 'hot' environment (as well as dealing with the cost of lost generating capacity). We think you will find a Balanced Stator™ retrofit package has an amazingly short payback period. Sulzer is ready to bring a team of seal professionals to explain the benefit of the Balanced Stator™ seal for your facility. Find out what the possibilities are for your application by contacting one of our representatives.
Comprehensive Service and Support

Purchase of a Balanced Stator™ seal retrofit buys much more than a shipment of parts. It also entitles your utility to become a valued recipient of the Sulzer support system. Support options and features include:

Field Change Support
Sulzer provides support including instructions, procedures, tooling, training and factory assistance necessary to make a seal conversion within one normal maintenance outage. Our experienced seal engineering team also facilitates any necessary change to plant licensing documentation resulting from the RCP seal change.

Optional Training Programs
This can be instrumental to fully prepare your operations and maintenance personnel in the important basics of servicing and operation of the Balanced Stator™ seal.

Field Service Capability
Our experienced field engineers can ensure immediate attention to your operating needs, backed by reliability/maintainability programs to monitor seal performance on a continual basis.

Containers for Shipping and Storage
Specialized containers are available for complete spare seals or separate parts. These provide a sealed, controlled environment for delicate O-rings and seal faces and ensure indefinite shelf life.

Optional Fitness Fixture
This allows an assembled seal cartridge to be fully pressure checked, including staging pressure, before installation. This proven procedure assures proper seal assembly before installation in your pump.

PWR Balanced Stator™ Seal Retrofit Installation List

<table>
<thead>
<tr>
<th>RCP manufacturer</th>
<th>NSSS</th>
<th>RPM</th>
<th>Original install</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulzer Pumps</td>
<td>B&amp;W</td>
<td>1190</td>
<td>1980</td>
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<tr>
<td>Byron Jackson</td>
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<td>900</td>
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<tr>
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<td>1190</td>
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<tr>
<td>Westinghouse</td>
<td>B&amp;W</td>
<td>1190</td>
<td>2000</td>
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</table>

Note: Total retrofit run time experience to date: over 3 million hours.
Testing and Field Operation Record

Seal Fully Tested
The Balanced Stator™ seal has been qualified for reactor coolant pump service by tests both in seal testers and in the reactor coolant pump test facility at Sulzer. Seal testers have repeatedly been used to perform continuous tests from 100 hours to 9,000 hours duration.

Each seal stage utilizes common replacement components which duplicate original seal parts precisely, drastically reducing inventory requirements.

Pump Operation In-House Testing

<table>
<thead>
<tr>
<th>In-house procedure</th>
<th>Model</th>
<th>Total hours</th>
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<tbody>
<tr>
<td>Eight separate pump tests</td>
<td>RDV 950 B-3</td>
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<tr>
<td>Four separate pump tests</td>
<td>RQV 875 B-2</td>
<td>207</td>
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<tr>
<td>Pump development test</td>
<td>BV 450 B-3</td>
<td>303</td>
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Seal Testers

<table>
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<th>Test type</th>
<th>Model</th>
<th>Hours tested</th>
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</tr>
<tr>
<td>Two-stage seal</td>
<td>Endurance</td>
<td></td>
<td>1052</td>
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<tr>
<td>Three-stage seal</td>
<td>Endurance/qualification</td>
<td></td>
<td>3021</td>
</tr>
<tr>
<td>BWR two-stage seal</td>
<td>Qualification</td>
<td></td>
<td>1107</td>
</tr>
<tr>
<td>PWR (913 MW) three-stage seal</td>
<td>Qualification</td>
<td>RQV 875 B-3</td>
<td>3034</td>
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<tr>
<td>Three-stage seal</td>
<td>Special tests</td>
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<td>Total hours 52459</td>
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Balanced Stator™ Seal Design Features

**Seal Springs**
- Special tests conducted to determine secondary seal friction and the required spring load.
- Springs designed to provide necessary force for the seal to function even with large shaft displacements and low RCS pressure.

**Secondary Seal**
- Ethylene propylene O-ring and backup ring located on the carrier – assures the pressure loading around the carrier will be constant as shaft position changes.
- Backup ring prevents O-ring extrusion in event single seal stage becomes subjected to full system pressure.
- The surface on which the O-ring rides is coated with a wear-resistant chrome oxide ceramic overlay.

**Controlled Full-fluid Film**
- Seal is designed to develop controlled full-fluid film lubrication between rotating and stationary seal faces – allowing a minimum amount of leakage.
- Tests show actual leakage rates with the seal to be substantially less than 0.03 gpm (0.11 liter/min), compared to leakage rates many times higher for other mechanical seal designs.

**Stationary Seal Ring**
- Configuration determined by FEA analysis and verified by development testing.
- Various balance ratios, face widths, and cooling notch configurations were evaluated in the process of optimizing the design.
- Carbon material receives non-destructive examination to assure it’s internal integrity. Front and back faces are lapped flat.

**Stationary Seal Ring Carrier**
- Provides necessary support and isolation for the stationary seal ring.
- This critically important part was designed using FEA analysis.
- A single anti-rotation lug located over the secondary seal prevents carrier rotation and allows the carrier to track shaft deflection without restriction.
- Location of the anti-rotation lug near the secondary seal minimizes relative motion and wear that would otherwise occur on the mating surface.
- Backseat surface which supports the stationary ring is lapped flat within two helium light bands (.000023 in) (0.00058 mm).
**Typical Retrofit Installation**

- Seal cartridge
- 3-stage seal assembly
- Pump cover

**Seal Staging Flow**

Schematic showing direction of flow through seal stages. Staging coils are illustrated away from the seal holder for clarity.

- Pump shaft
- Seal leakage
- Upper seal
- Staging flow
- Pump cover
- Staging coil
- Middle seal
- Lower seal
- Injection water
- Pump bearing
- Restriction bushing
- Heat exchanger