# Reactor Coolant Pump Bearings and Seals

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COURSE TERMINAL OBJECTIVE

Given work order and maintenance procedures, the Maintenance Mechanic will state the steps to disassembly, inspect, repair, and reassemble the Reactor Coolant Pump thrust bearing and seal assemblies in accordance with maintenance procedures as demonstrated by passing a written exam with a minimum grade of 80%.

LESSON 1 TERMINAL OBJECTIVE

Given technical manual and maintenance procedure, the maintenance mechanic will identify major components of the Reactor Coolant Pump and state the steps to disassemble, inspect, repair, and reassemble the Reactor Coolant Pump in accordance with maintenance procedure 31MT9RC06 as demonstrated by passing the final exam with a minimum grade of 80%.

LESSON 1 ENABLING OBJECTIVES

EO01 Identify the major components of the RCP.
EO02 Identify steps to remove the thrust bearing.
EO03 Identify steps to remove the seal housing.
EO04 Identify steps to remove suction pipe and diffuser.
EO05 State the steps to install the suction piping and diffuser.
EO06 State the steps to install the seal housing.
EO07 State the steps to couple the shafts.
**EO01 Identify the major components of the RCP.**

**Purpose of the Reactor Coolant Pump [RCP]**

The Purpose of the Reactor Coolant Pump [RCP] is to supply cooling water to the reactor core during normal operations. It will transfer the water from the reactor to the steam generator and back during normal operations. The RCP is not required for emergency decay heat removal due to the natural circulation designed into the system. It is therefore not considered critical to safety of the plant. It is, however, necessary for power operations. The RCP is also used to heat up the primary system during startup.

**System Tie-in**

The reactor coolant pumps (RCPs) are centrifugal pumps which maintain Reactor Coolant flow (approximately 114,625 gpm per pump). The flow exiting the reactor coolant pump enters the discharge leg and returns to the reactor vessel through four inlet nozzles (two per loop). The section of pipe between the outlet of the steam generator and reactor vessel is called the cold leg. Cold leg temperature is approximately 564.5°F at zero power and 555.5°F at full power.

The RCP motor employs a flywheel that is located below the upper bearing and serves to increase the rotating inertia of the RCP assembly. This increases the pump coastdown time and reduces the rate of decay of coolant flow when electrical power to the motor is lost. This coastdown flow helps ensure adequate heat removal from the core on a four pump loss of flow. The coastdown characteristics of the reactor coolant pumps ensure reactor core damage does not occur following a complete loss of power.
Motor

The motor is located on top of the RCP. Its purpose is to supply power to the pump rotor by converting electrical energy to mechanical energy.

Motor Support Stand

The motor support stand is between the pump and the motor, spanning the area from the upper flange [bottom of the motor] to the top of pump bowl.

The purpose of the motor support stand is to absorb the torque of the motor and maintain motor to pump end alignment. It also supports the vertical weight of the motor.

Thrust Bearing

The thrust bearing is located inside the motor support stand between the flex & rigid couplings.

The purpose of the thrust bearing is to support the weight of the rotor when shut down and depressurized as well as to prevent upward movement of the rotor with the system pressurized, running or not. This will maintain the proper clearances between running and stationary parts.
Flexible Coupling

The flexible coupling is located between the motor and the thrust bearing on the shaft. The purpose of the flex coupling is to allow for minor misalignments between the motor and pump ends of the shaft. This will allow for growth of the pump shaft as it heats up during operation. In conjunction with the rigid coupling, the flex coupling allows for the removal of the shaft seals without removing the motor and thrust bearing.

Rigid Coupling

The rigid coupling is located directly below the thrust bearing on the shaft. The purpose of the rigid coupling is to connect the shaft of the pump to the intermediate shaft through the thrust bearing. It is also designed to allow for removal of the shaft seals without removing the motor or thrust bearing.

Seal Housing

The seal housing is located on top of the pump casing, surrounding the shaft. The purpose of the seal housing is to provide the pressure boundary on top of the RCP. It holds together the seal components to keep potentially contaminated water from leaking out of the reactor coolant system at the shaft penetration.

The seal housing contains: Seals I, II, and III (I is on the bottom, III is on top); the Feed Screw (Located below seal I) and Feed Bushing (Surrounds the feed screw); and the Water Lubricated Journal Bearing (Below the feed screw).
Impeller

The impeller is located at the bottom of the shaft, inside the pump casing.

The purpose of the impeller is to convert the mechanical energy of the rotor to kinetic energy of the fluid. The impeller adds kinetic energy to the primary coolant.

The impeller is classified as a closed, single suction impeller.

Suction Pipe

The suction pipe is located below the impeller eye (suction) extending into the suction piping.

The purpose of the suction pipe is to direct the water flow in the suction line to the suction eye of the impeller. This pipe separates the pump bowl into the suction and discharge areas.

Diffuser

The diffuser is in the area surrounding the impeller.

The purpose of the diffuser is to transfer the kinetic energy of the fluid to potential energy (pressure) and direct the fluid to the discharge of the pump. The use of a diffuser for this purpose minimizes the radial pressure differential across the impeller.

Systems interrelations

The following systems are tied to the Reactor Coolant System:

- Electrical to the motor
- Component cooling water
- Seal water (Chemical & Volume Control system)
- Seal leakage (Reactor Drain Tank)
- Housing drain
- Instrumentation lines
- Instrumentation electricity
- Valve and auxiliary pump motor power supplies
- Thrust bearing hydraulic oil system lines & cooling system
Reactor Coolant Pump Bearings and Seals
EO02 Identify steps to remove the thrust bearing.

The Thrust Bearing will have to be removed periodically for inspection, for repair of the bearing, the pump rotor, or the pump seal and casing parts. The following describes the basic steps for removing the thrust bearing.

Preliminary

The electrical connections must be deenergized and disconnected by the electricians.

Component cooling lines for the pump motor must be drained and they are then disconnected. We have encountered problems in the past in finding the bolts for reinstallation later. One time we even found the wrong size (oversized) bolts installed on a flange.

Two oil valves are opened to drain the hydraulic fluid back to the reservoir. It requires approximately 11 hours to completely drain the oil from the thrust bearing.

Removal of oil and water lines

- Remove the flexible Kenett cover (item 2)

- Disconnect pipe straps (8 & 16) from the piping prior to removal of piping. Shims (9) removed from the pipe support brackets must be identified when bagged for replacement in the same location.

- Disconnect the oil piping and remove. Take steps to catch the drips. The top and bottom of pipe (1) have unions that can be removed so the cooler cover and flange do not have to be disassembled. Pipe (22) has a cover which must be removed and is part of the “Fire Protection Piping”. This includes removal of swagelock fittings (50) and the flange oil collector (46). Pipe (12) can physically be swung clear without removal but it interferes with the walkway and thrust bearing access.

- Disconnect and remove cooling water piping. Unbolt flanges for piping (23 & 24). Remove pipe support members (28, 31, & 32). The support in front of the access window (34) can be removed to allow access to the flex coupling, but that is not necessary.
Figure 6-2. Lube Oil and Cooling Water Piping Assemblies Removal.
Uncouple Flexible Coupling

- Hand tighten the 4 motor centering bolts (attached to the motor support flange). This will center the motor shaft for reassembly alignment. The bolts are located in the RCP C-van on a shelf.

- Remove the bolts from the upper half of the coupling adapter assembly (motor side). The coupling remains secured by the thrust bearing half it is still bolted to.
Motor removal

- Unbolt the motor from the motor support flange.
- Rig and remove the motor (weight approx. 60 tons).

**NOTE:** Safety concerns:

Fall hazard: a Mechanic fell from the top of the RCP Motor. He was wearing his harness as a fall arrest system and was therefore relatively unharmed.

Noise hazard: when the motor is running, it is a very high noise hazard. You must have hearing protection when in Containment while RCPs running, especially if working near them.
Primary piping removal

The Reactor Coolant system must be drained below the level of the center of the hot leg, vented, and purged of hydrogen. Rad protection will be notified and the seal housing drained by opening the seal housing drain valve (Nozzle #10). This will be done by operations.

- Disconnect the nozzle weldments from their piping and hangers to allow for pulling back out of the way.
- Unbolt all 10 nozzle weldments at the first flange outside the motor support stand.

Uncouple Rigid Coupling

NOTE: Verify the flange relationship is match-marked for reassembly prior to commencing the disassembly

The Reactor Coolant system must be depressurized prior to removing the rigid coupling stud bolts. The speed sensor instruments must be removed (I&C) and the sensor disc assembly (2) moved so the stud bolts can have adequate clearance for removal.

- Loosen the twelve nuts (3) and remove ten of the studs (4) and nuts. You can use “Baby Biach”, but many use a slugging wrench for disassembly. Leave 2 in place, 180° apart.

NOTE: If gases are noticed to escape as the pump shaft is lowered, raise the pump shaft up and contact RP before proceeding.

- Rapidly lower the pump shaft and seat the shaft stop seal (internal to the pump)
Removal of Thrust Bearing

- Loosen and remove the fourteen hex-head bolts securing the thrust bearing lower flange to the motor support. Use a large (1” drive) air impact wrench. The bolts in back may need tubing or hangers removed if not able to remove with extensions and swivels.

- Thrust bearing (1) rigged for removal and rigging tensioned. Install lifting eyes on the four equally spaced threaded holes on the thrust bearing lower flange (2). Attach rigging to the eyes. Ensure the lifting eyes and shackles are not protruding beyond the OD of the lower Thrust Bearing Flange or they will not clear the Motor Support Stand at the top. Thrust bearing assembly weighs about 8 tons.

- Center the crane over the assembly, and lift the thrust bearing carefully out of the motor stand.
EO03  **Identify steps to remove the seal housing.**

Verify the blank flange is removed from the seal housing drain and that the housing is drained, the remove the seal pressure instrument lines.

**Studbolt tensioning/detensioning**

- Remove the 2 rows of socket head cap screws in the clamping ring.

- Clean the ring and studs and install stud tensioner equipment. Note anything found on cleaning. There are numerous cases where studs have failed or sheared off due to Boric acid stress corrosion, so this step is very important to plant safety and longevity.

- Install 2 tensioners, 180° from each other. (This can be done with one if necessary.) The first one should be installed at the point farthest from the access.

- Compressed air is hooked up to the air filter inlet. The stud tensioner pumping unit is tested and primed. Hydraulic hoses are hooked to the tensioners (try to minimize air coming in). Air will be bled when cylinders are retracted.

- Lower the tensioner until the base rests on the clamping ring

- Turn the drive gear handle clockwise.

- Thread the puller bar system onto the stud exerting slight downward force on holding nut while turning holding nut handles clockwise. Thread it down until the holding nut bottoms on the spring plate and then back off 1/2 turn. **The number of turns is critical in this procedure to preclude damage to the tensioner or studs.**
• Repeat on the stud nearest to the pump opening, 180° from the first one.

• Gradually increase the hydraulic pressure until both stud nuts are loose. Record the tension (psi) on the chart.

• Turn both tensioner drive gear handles 6 turns counter-clockwise to back nut off.

• Repeat per the sequence required in the procedure, until all nuts are loose.

NOTE: It may be necessary to reinstall and retension adjacent nuts to loosen the last four nuts, then remove again.

• Remove tensioner base and puller bar assemblies.

• Remove all nuts

Clamping Ring Removal

• Remove all studs but 3, 120° apart. Install stud guards on those studs.

• Raise clamping ring with jacking bolts. Keep it level. It only needs to be raised a little to ensure freedom of movement and a level attitude.

• Rig and remove the clamping ring
Rig and remove the seal housing

- Push the nozzle weldments out of the way. Make sure not to bend the piping, as flange alignment would be affected. Retract the nozzle weldments approximately 1/2” to remove flex gaskets, preventing their falling into the bowl.

- Wipe down the housing and motor support stand to prevent dirt from falling into the primary coolant.

- Care must be taken to prevent swinging or other motion which could damage the impeller.

- Remove 4 cover bolts and attach the special lift rig

- Removal of the seal housing will be thoroughly coordinated with RP and security. The radiation readings are very significant. Movement is generally coordinated straight into the Fuel Building with security maintaining the doors open.

- Plug the casing for temporary closure. This could be a makeshift plug if only to remove housing then continue working inside. Use the regular temporary plug if not immediately working inside.

- Remove the bolts from the nozzle weldments. The weldments will have to be pushed into the motor support stand as far as possible to remove bolts and washers. Retract the weldment and secure out of the way when all bolts and washers are removed.
EO04  Identify steps to remove suction pipe and diffuser.

General and Preparatory

- The pump casing must be drained and the reactor defueled prior to commencing this part.
- Relative locations of the components must be marked prior to disassembly.
- Inspect for damage to diffuser, piping, locking sleeves, bolting, etc. during disassembly. It must be recorded.

Suction pipe removal

- Remove the suction pipe capscrews and washers (1), then remove the suction pipe ring and the 4 alignment taper pins (2).
- Install the suction pipe adapter on the pipe and lift it out of the suction pipe carefully (2,400 lbs).
- Install a blank at the inlet nozzle to the bowl for a platform to stand on or at a minimum, an FME cover.
Diffuser removal

- Ring segments are removed by removal of the socket-head capscrews. Uncrimp the locking sleeves (3) and remove the ring segments that bridge the gaps (2 ea) (4).

- Remove the locking pins from the hex nuts on each wedge assembly (drilling may be necessary) (5). Loosen and remove the wedge assembly from the pocket (record location for reassembly).

- Remove the attached segments, then rig and lower the diffuser half (5 vane) into the pump casing with lifting eyes, maintaining a level attitude (1500 lbs). Change rigging and remove the diffuser with a nylon strap through one of the diffuser vanes.

- Repeat for the other half (6 vane)
EO05  State the steps to install the suction piping and diffuser.

General instructions for reassembly

- Lubricate the O-rings with DI water unless specified otherwise in the procedure.
- Lubricate the casing studs and holes.
- Lubricate other threaded surfaces with approved lubricant.
- Clean bolts, threaded holes and washers before installing.

Diffuser replacement

- Install locking sleeves (1) into holes in ring segments and stake the sleeves into the holes.
- Do the same for the suction pipe bolting ring (2)
- Take and record measurements as required in appendix O to verified the diffuser gets fully seated.

"W" dimension on the diffuser (1" to 2" depth micrometer)

"PCT" dimension on the casing (8" to 9" outside micrometer)
• Calculate the assembled dimensions as per chart.

• Insert the keys in the slots of the diffuser halves (3) and secure them with the socket head cap screws and torque.

• Reinstall the two diffuser halves in the reverse order of the removal. Reinstall the 6-vane first. Lower it into the casing with nylon strap and put it in position with the lifting eyes. Position the ring segments where they belong and install the socket head capscrews. Repeat with the 5-vane diffuser half.

**Suction pipe replacement**

• Remove any temporary covers installed in the bowl.

• Lower the suction pipe into the casing using the adapter. Align it so that the jacking bolt holes will straddle the diffuser splits about equally and the four tapered pins are aligned with their holes. If the taper pins do not align, new holes will have to be drilled--contact the Planner.

• Install the 4 taper pins and drive them with a moderate hammer blow.

• Measure the gap in the diffuser splits (C & D) and between the shoulder and ledge (A & B)

• Lubricate and install suction pipe bolting ring and the 24 socket-head cap screws and washers into the suction pipe. Tighten hand tight only.

• Remove the lifting eyes and torque the capscrews. Take Step-block measurements to verify the seating of the assembly and compare with calculated values.
Wedge installation

- Insert the wedges into the diffuser pockets. Select the proper sized wedge for both the left and the right side.

- Begin to torque the wedge. Loosen the ring segment screws on the diffuser half with the largest peripheral gap and torque the wedges to 40 ft-lbs., then retorque the capscrews on ring segments.

- Loosen the other half’s capscrews and torque the wedges to 100 ft-lbs.

- Loosen all capscrews and torque the wedges to 125 ft-lbs, then retorque all the capscrews.

- Drill and pin the wedges. Ensure to prevent chips from falling into the system while drilling. Pin the wedge nut assemblies and stake the pin in 4 places. Install the last two ring segments.

EO06 \textit{State the steps to install the seal housing.}

Preparation

- Lubricate the pump casing studs and holes with Never Seez and install all but three casing studs – the three are to be 120° apart.

- Install the seal housing lifting fixture and seal housing alignment jig.

- Examine the seal housing for cleanliness and damage to ensure it is ready for installation.

- Reinstall the bolts and washers in the nozzle weldements, then ensure they are retracted about 1/2".
Replacement

- Remove the cover over the opening and install the spiral wound gasket and seal ring into the casing.

- Lower the seal housing and impeller into the casing. Maintain the seal housing level and prevent swinging during lowering. To protect the impeller, the alignment jig inside motor support helps, once the housing is down far enough.

- When set, lower the pump shaft onto the stop seal by backing off on the coupling stud nuts. Remove the lifting fixture, then install the studs, nuts and washers removed for the lift fixture and torque them.

Nozzle weldments

- Reinstall the gaskets and snug up the bolting hand-tight. When installed, torque the bolts to 195 ft-lbs.

Install the clamping ring

- Install the bullet-nosed studguards in preparation for clamping ring installation. This will protect the studs due to the high potential for damaging them during the clamping ring installation.

- Carefully lower the clamping ring into position, aligning it with the dowel pin on the seal housing and mounting flange.

- Install the clamping ring/seal housing socket head capscrews and torque to 358 ft-lbs. in two steps. Check for a gap of .039-.059" between the clamping ring relief groove and the seal housing with a feeler gauge. The tolerance is a variation of up to ±.002" between the readings.

- Lubricate, install and torque the clamping ring/motor support stand socket head cap screws. Torque to 95 ft-lbs.
Main closure stud bolting

- Reinstall the last three studs, then lubricate the studs and nuts. Install the nuts hand tight.

- Remove plugs from the end of the studs to measure the elongation with a depth micrometer or equivalent. There is a special rig set up for this including a rod through the stud and a rest to set the depth micrometer on.

- Ensure the gauging holes are thoroughly cleaned before taking measurements or the tensioning will be erroneous.

- Set up the Biach stud tensioners as before. Tension in 3 steps as per the chart and record the elongation. Replace plugs in the measurement holes in the studs. Remove the tensioner and store.

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<th>Casing Stud Tensioning Table</th>
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EO07  *State the steps to couple the shafts.*

Install The Thrust Bearing

- Installation is basically the reverse of removal. The covers protecting the gears on the rigid coupling must be removed first.

- Align the dowel pin on the motor support stand with the hole in the thrust bearing when lowering the thrust bearing onto the thrust bearing motor support stand flange. Tapered alignment pins are commonly used for this task.

- Install the studs and keyed washers and torque to 770 ft-lbs using the standard sequence. They are installed and torqued from below the thrust bearing. We commonly use a 19:1 or 14:1 multiplier with a torque wrench and extensions.
Couple the Rigid Coupling

- The match marks must be aligned to the coupling halves. To align them, turn the thrust bearing shaft rather than the pump shaft end which is resting on the stop seal. Damage to the seal could result from turning the pump end.

- The rigid coupling studs are easily galled or damaged, so lubricate two studs with Never-Seez and install them 180° apart in their numbered hole. Numbers are on the shaft under the flange and they match the numbers on the studs and nuts. Install the studs with longer threaded section up. The nuts with a "P" are installed on the bottom, "A" are on the top.

- Raise the pump shaft by tightening the two nuts together until the coupling halves mate. Lubricate and install the remaining 10 studs and torque to 285 ft-lbs., then 575 ft-lbs. This is commonly done with “Baby Biach” tensioners to prevent galling of the studs and nuts. For balance purposes, the height of the stud above the flange must be measured. Torque the nuts until the studs are elongated by .63mm or .0248".
Install Miscellaneous Components

- Install the lower speed sensor disc
- Install the pressure seal instrument piping
- Reinstall the blank flange on the seal housing drain line

Install the Motor

- This is basically the reverse of the removal. If it is necessary to rotate the motor shaft, the motor rotor lifting device must be installed.

Align the Flexible Coupling

- Note that this is a coupling alignment, so the shaft does not have to be rotated. The indicator is moved to eight locations around the flange with the maximum differential being the TIR.
- Measure the parallel offset and check the face for angular misalignment. Use the chart to identify if the combined misalignment is acceptable.
• If not acceptable, jacking screws on the motor support stand top flange may be used to move the motor. 50 tons being supported by the polar crane will allow the jacking bolts to move the motor on its stand. Release the weight from the crane.

• Torque the capscrews on the motor support stand. The alignment will have to be monitored during torquing to ensure the torquing does not misalign the coupling. Torque to 3050 ft-lbs.

Couple the Flexible Coupling

• Secure the diaphragm pack and adaptor assembly to the coupling half mounted on the motor shaft and torque to 325 ft-lbs.

Reinstall the Oil and Water Lines

• The O-ring on the horizontal thrust bearing cover flanges have the groove in the piping side (CRDR 2384324). They have been known to fall out of the groove. When Component Cooling water was introduced, many gallons of water entered the Kennet unit.

• A precaution on the union fitting under the protective cover. Turning this fitting can loosen the entire vertical tubing. This can create a leak that is a fire hazard (HP tubing). There is a special wrench to hold that tube to keep it from turning while tightening the union.
RCP Events of note

Situation 1 (PVNGS, U-1, 10/23/96, CRDR 97-0031)

During testing of RCP 2B, it was found that the phase rotation was backwards. They desired to continue testing other pumps and to perform “sweeps” on the other RCPs. Decided to hold RCP 2B still while continuing to perform sweeps on the other RCPs by using a spanner wrench in RCP 2B to prevent reverse rotation. An EER that was used to evaluate a previous case using the spanner did not account for the same situation they were in and the spanner wrench was not strong enough, so it wrapped itself around the shaft.

Lesson learned – the spanner wrench is for holding during torquing or turning the shaft only. Use of a tool for other than its designated purpose requires engineering evaluation.

Situation 2 (PVNGS U-1, 10/25/96, CRDR 97-0029)

During performance of 31FT-9RC01, RCP Lube Oil Collection System Inspection, one step states “Verify Kennet Unit Flexible Cover is in good condition and installed.” The condition of the cover was marked as “Accepted” on October 21-24 (2B on Oct. 24). While walking down the Containment Building, the NRC inspector questioned the condition of the 2B cover on October 25. The condition obviously had not changed.

Acceptance criteria was not specific, but it must meet its purpose. The purpose of cover (Per UFSAR):

“The lift pump discharge connection flange is considered subject to failure and is shrouded with a silicon-treated, glass cloth shield. The shroud is Seismic Category I and provides an envelope for the oil spray, and serves to collect and direct the oil to the collection system...”

The ability to meet this purpose is subjective according to the individual doing the inspection.

There were contributing factors to the condition of the cover. While working in the area, people used the Kennet unit for a walkway. Walking on the fabric damages it severely.

CORRECTION: New Kennet covers were manufactured and installed in each of the units at their next outage. The specific criteria for acceptability of Kennet covers have been established.
LESSON 2 TERMINAL OBJECTIVE

Given tech manual and maintenance procedures, the maintenance mechanic will identify components in the Reactor Coolant Pump seal and state steps to disassemble, inspect, repair, and reassemble Reactor Coolant Pump seal assemblies in accordance with maintenance procedures 31MT9RC26 and 31MT9RC22 as demonstrated by passing the final written exam with a minimum grade of 80%.

LESSON 2 ENABLING OBJECTIVES

EO01 Explain the Principles of Operation of the Mechanical Seal Assembly.

EO02 Identify components in Seal I, II, and III and their functions.

EO03 State the steps necessary to disassemble seals I, II, and III.

EO04 Define acceptable/unacceptable flaws on seal assembly components.

EO05 State the steps needed to assemble seal assemblies I, II, and III.
EO01  Explain the Principles of Operation of the Mechanical Seal Assembly.

Basic Seal Description

The seal consists of three sets of rotating and stationary surfaces in close contact to each other. The fluid between them is enough for both lubrication and cooling of the surfaces.

The springs in the seals are for proper face loading to establish the proper leakoff amount.

The static seals keep the fluid from bypassing the dynamic seal, which would render them virtually ineffective.

Operation of RCP Seals

The RCP Seal is three single seals in series. The entire seal arrangement has clean fluid entering under the first seals. Some of the water goes down through the bearing, keeping out the fluid directly from the reactor coolant system. The remaining water goes either through the seal or bypasses the seal to be cooled and minimize the heat to the second stage seal.

The second also has a bypass for cooling prior to contacting the 3rd stage seal. The third stage has a leakoff and the excess goes to the Reactor Drain Tank.

Associated Systems

Chemical and Volume Control
Reactor Drains
Nuclear cooling
EO02  Identify components in Seal I, II, and III and their functions.

Seal Retainer

The seal retainer is the exterior boundary of the seal assembly. It is the housing for the stationary parts of the seal assembly.

Shaft Protection Sleeve

The shaft protection sleeve is the interior boundary of the seal assembly. It holds the rotating elements of the seal assembly.

Carrier Ring

The carrier ring holds the stationary seal face which is the stationary half of the sealing surface. Springs between the carrier and the seal retainer push the sealing faces against each other to establish the desired leakoff rate.

Rotating Seal Ring

The rotating seal ring is attached to the flange of the shaft protection sleeve. The rotating face of the seal assembly—contains the rotating half of the actual sealing surface.

Drive Pins

The drive pins hold the seal assemblies to each other. The inner pins hold the shaft protection sleeves together. The outer pins hold the seal retainers together. These pins must be pulled to allow us to separate the seal assemblies from each other.

Seal Cover

The cover is on the bottom of the Seal I assembly, surrounding the seal retainer. It keeps the shaft protection sleeve assembly captured inside the seal retainer assembly.
Items which can be used to distinguish the different seals

The top of Seal III assembly is relatively flat. It does not need to be pinned to an assembly above it. Seal III also has a leakoff port for water that leaks past the seals.

The bottom of Seal I includes a Seal Cover. It has a pin that needs to align with the feed screw.

The diameters are slightly different to facilitate installation.

- Seal III is the largest outside diameter, the smallest inside diameter
- Seal II is about .080” smaller on the OD and .080” larger on the ID
- Seal I is about .080” smaller than II on the OD and .080” larger on the ID

EO03 **State the steps necessary to disassemble seals I, II, and III.**

Seal Cartridge Disassembly

- Install the sleeve jacking tool on the Seal III if not installed. Ensure the “halo” is locked in place. Tighten the jacking screw until the drive pins between Seal III and Seal II seal retainers are loose.
- Back off the jacking screws and remove the 2 inner drive pins. Remove Seal III and put it in its storage container.
- Repeat with the Seal II assembly and place the Seal I in a storage container also.
Seal I disassembly

- Record the pump ID number and seal serial number and set the Seal I assembly on blocks to protect the dowel pin in the shaft protection sleeve.

- Separate the rotating subassembly from the stationary subassembly as follows:

1. Tighten the jacking screws enough to insert carrier retainers. The spring gap should be about 1/8” when you are able to install carrier retainers.

2. Back off the jacking screws until the carrier is held by the retainers.

3. Remove the drive pins, then lift the seal retainer and shaft protection sleeve assemblies off the seal cover.

4. Remove seal cover and lower the Seal I assembly back onto the 3/4” blocks.

5. Remove the sleeve jacking tool.
6. Hold shaft protection sleeve subassembly in place and lift the seal retainer/carrier subassembly off.

- Disassemble shaft protection sleeve subassembly as follows:

  1. Remove O-ring from ID. Lift rotating seal ring straight up and off the shaft protection sleeve. Set face up on a soft, clean surface. Remove the centering O-rings.

  2. Remove the rotating seal support ring and the “face” O-ring.

  3. Remove the anti-rotation pin from the shaft protection sleeve.
Seal Retainer/Carrier Disassembly

- Remove the 2 O-rings from the OD.
- Set the retainer assembly in a Spring Compression tool. Place the spring compression tool on the work table. Attach the seal retainer holder to the retainer with the proper alignment. The anti-rotation lug must be lined up with the punch marks on the seal retainer holder.
- Place the seal retainer/carrier assembly in the carrier holder. Punch marks on carrier holder show the location of the anti-rotation lug. This allows the pins in the carrier holder to align with the holes in the carrier face. Install the handwheel on each of the 3 threaded rods.
- Separate carrier assembly from retainer assembly as follows:
  1. Turn down handwheels until the carrier retainers can be removed
  2. Back off the handwheels evenly until spring support the seal retainer
  3. Remove the handwheels and lift the seal retainer subassembly off the carrier
  4. Remove springs, O-rings and backup ring from the carrier and remove the carrier/stationary seal ring subassembly form the carrier holder
- Seal Retainer disassembly
  1. Remove Spirolox retaining ring
  2. Turn over on 2” blocks and install installation tool. Using a soft hammer, tap the secondary seal sleeve out. Remove the O-ring.

- Carrier/Stationary Seal Ring disassembly
  1. Remove Spirolox retaining ring and the retainer ring
  2. Remove O-ring and backup ring by poking with sharp awl or equivalent
  3. Lift stationary seal ring out of carrier

Seal II and III assemblies
- Do not have the covers on the bottom
- Essentially the same process for the remaining steps
EO04  *State the steps needed to assemble seal assemblies I, II, and III.*

**Inspection**

- Comprehensive inspection criteria is contained in the procedure.
- O-rings and springs are also inspected, though they are not reused. The inspection is for a potential failure analysis.
- Several dimensions are taken that are critical to seal operation.

**Assemble Seal Retainer Subassembly**

- Seal Sleeve Installation. Use Dow Corning 55 O-ring lubricant and install the O-ring.
  
  ![Seal Sleeve Installation Diagram](image)

  - Carefully guide the seal sleeve into the seal retainer. Using the installation tool and a soft mallet, tap the sleeve into the retainer until it bottoms.
  - Install the Spirolox retaining ring.

**Reassemble Carrier subassembly**

- Determine which carrier and stationary seal go together based on critical dimensions.
- To install the O-ring on the Stationary Seal Ring, set the Seal Ring on a soft cloth face down (chamfer side up). Lightly lubricate the O-ring, then slide it down until it is about 1/8” from the front edge. Repeat with the backup ring with the concave side facing the O-ring until it touches the O-ring. Clean the backside surface with lint-free cloth to remove any excess lubricant from the OD.

![Stationary Seal Ring Diagram](image)
• Install the Stationary Seal Ring into the carrier. Orient the Stationary seal ring face-up over the carrier. Set the ring down into the carrier – the O-ring will hold the seal ring up.

• Carefully place the O-ring installation tool over the stationary seal ring and press the O-ring into the carrier O-ring groove. The stationary seal ring should be seated against the carrier at this time.

• Place the retainer ring over the O-ring and secure with the Spirolox retaining ring. Wipe the seal ring with a clean, lint-free cloth.

• Turn the carrier over and install the O-ring and backup ring.

Assemble Shaft Protection Sleeve Subassembly

• Place shaft protection sleeve on the Sleeve Compression tool baseplate. If this is a Seal I assembly, a minimum ¼” keystock will be required to protect the pin. Ensure the anti-rotation pin is installed in the shaft protection sleeve.

• Determine which protection sleeve and associated parts go together based on critical dimensions. The thickest stationary seal ring [Dimension T] is assigned to Seal I, the thinnest to Seal III. The thickest carrier is assigned to Seal I and the thinnest to Seal III.

Stationary Seal Ring
Part # 1802623

Cross Section (449)
"IP" .050 +.010
-.010
"T" .800 +.000
-.015

Applicable Notes:
1,3,7
• Calculate the clearance between the end of the anti-rotation pin and the bottom of the hole in the rotating seal ring (.005” min).

• Assemble the rotating seal to the shaft protection sleeve as follows:

  1. Install one “centering” O-ring in the groove. Install a dry (no lube) “face” O-ring. Press the support ring by hand over the “centering” O-ring. Lightly lubricate other “centering” O-ring and install it in the upper “centering” O-ring groove. Install dry “face” O-ring to the backside O-ring groove of the rotating seal ring.

  2. Install the rotating seal ring. Press down by hand. Visually check that all O-rings are still in their grooves and have not slipped off.
Assemble Carrier Subassembly to the Seal Retainer Subassembly

- Prepare the Spring Compression tool by removing the handwheels and setting the adjusting nuts to the approximately height “H” for installing the springs. Then set the carrier subassembly onto the carrier holder. Align the pins and ensure the anti-rotation lug is aligned with the punchmark.

- Set seal retainer subassembly into the spring compression tool and attach the seal retainer holder to the seal retainer, aligning the anti-rotation slot with the punchmarks.

- Position the seal retainer over the carrier holder and align the slot with the lug on the carrier, then lower the retainer over the threaded rods until the seal retainer holder rests on the nuts.
• Connect the two assemblies as follows:

1. Install the 30 springs between the seal retainer and carrier. Install into the seal retainer first, then compress slightly and guide into the corresponding hole in the carrier. Use a mirror and visually verify that all springs are installed correctly.

2. Lower the retainer assembly until the weight is supported by the springs. Using the handwheels, lower the seal retainer until the anti-rotation lug and slot are ready to engage. Verify they are aligned, rotating as necessary to align.

3. Use the handwheels and lower the Seal Retainer subassembly over the carrier subassembly. The handwheels should turn easily. They should not have to be forced.

4. Verify the O-rings are not being pinched/damaged. Use a mirror to ensure proper engagement while aligning.

• Install the carrier retainers. Remove the handwheels. Lift the seal retainer/carrier subassembly and set it on the assembly bench. Remove the eyebolts and seal retainer holder.

Complete Seal Assembly – Seal I

• Set the seal retainer cover on the baseplate with ¼” keystock. Set the Seal I shaft protection sleeve subassembly on the baseplate. Install the Seal Retainer assembly.

• Wipe the rotating and stationary seal faces with a lint-free cloth. Align the four drive-pin holes and lower the Seal I retainer/carrier onto the seal cover. Install the four drive-pins.

• Lubricate and install O-ring on the inside of the shaft protection sleeve. Lubricate and install O-rings on the outside of the seal retainer.
Seal II final assembly/installation

- Set the Seal II shaft protection sleeve subassembly on the Seal I assembly. Install the two drive pins.
- Install the seal retainer and O-rings the same as with Seal I.

Seal III final assembly/installation

- Set the Seal III shaft protection sleeve subassembly on the Seal II assembly. Install the two drive pins.
- Install seal retainer and O-rings the same as with Seal I.
- Install the shaft jacking tool and tighten the jacking screws.
- Remove the nine carrier retainers.
Seal Setting Measurement

- Install the sleeve compression tool. Install the tool plate, washer, and nut on the threaded rod. Tighten to clamp the shaft protection sleeves together.

- Back off the jacking screws. The seal setting gap should read 0.250” ± 0.005”. All three should read 0.240” to 0.300”. Measure the “K” dimension so we can determine the seal setting gap when installed.

Seals can now be fitness tested and installed

- Installation must be within 120 days of fitness test.

- Fitness test verifies all three seals are installed correctly.
LESSON 3 TERMINAL OBJECTIVE

Given tech manual and maintenance procedures, the maintenance mechanic will identify components in thrust bearing assembly and state the steps to disassemble, inspect, repair, and reassemble Reactor Coolant Pump thrust bearing in accordance with maintenance procedure 31MT9RC24 as demonstrated on the final written exam with a minimum grade of 80%.

LESSON 3 ENABLING OBJECTIVES

EO01 Identify components in thrust bearing assembly.

EO02 State the steps to disassemble thrust bearing.

EO03 State steps to assemble thrust bearings.
EO01  *Identify components in thrust bearing assembly.*

Rotating Assembly

The **Shaft** is located axially in the center of the bearing assembly. It aligns and connects all the rotating elements of the thrust bearing. The shaft transfers the energy of the motor to the pump.

The **Shaft Sleeves** (upper and lower) surround the shaft at the upper and lower journal bearing and seal areas. Their purpose is to prevent scoring of the shaft during normal or abnormal wear of the bearings and seals during operation. Sleeves are much cheaper and easier to replace than the complete shaft.

The **Rotor** is a flange type of area keyed to the shaft near the midpoint (end-to-end) of the shaft. It is a major part of the thrust bearing working surface. The thrust bearing pads ride against the rotor.

Stationary Thrust Bearing Assemblies

The **Upper thrust bearing** is the part of the thrust bearing assembly that is directly above the rotor. This part maintains the axial alignment of the rotor whenever there is an upward thrust overall (i.e., the system is fully pressurized).

The **Lower thrust bearing** is the part of the thrust bearing assembly that is directly below the rotor. Its purpose is to maintain axial alignment of the rotor whenever there is a downward thrust overall (i.e., the system is at low pressure).

Supporting Parts

The **Reservoir** is located on the outside of the motor support, below the thrust bearing assembly. It serves as the location for thrust bearing oil reserves.
The **Journal bearings** are located along the shaft, one above and one below the thrust bearing itself. It serves to maintain the radial alignment of the shaft.

The **Bearing assembly covers**, one each above and below the rotor, are not attached to the shaft. They are the upper and lower housing for the thrust bearing components. They serve to keep the internal parts aligned and the impurities out. To seal the gap between the cover and the rotating assembly, the lower cover has a **mechanical seal**. The upper cover uses a floating seal (35 & 36), diffuser/feedscrew, flinger ring (33) and felt wipers (3) to prevent leakage.
EO02  *State the steps to disassemble thrust bearing.*

**NOTE:** This procedure assumes that the thrust bearing has been removed per 31MT-9RC06 (Lesson 1) and installed on a turntable.

**Prior to Disassembly**

- Engineering must be notified prior to any measurements or internal examinations and when noticing any discrepancy which may require rework, repair, or replacement.

- Take the **Shaft Lift** Measurement. Install a dial indicator on top of the driveshaft (point A) to measure shaft lift. Install an eyebolt in the end of the driveshaft or a jack below and lift the shaft until the thrust bearing is supported on the shaft rotor and record the shaft lift. The acceptable value is .030” to .034”. Notify engineering if this value is not acceptable so parts and a plan can be developed.

- Measure the “U” dimension for reference to compare to after reassembly to verify all parts are fully seated against each other. The required dimension is .000” to .020”.
Remove the coupling, reservoir, seal, and lower journal.

- Invert the thrust bearing (bottom up) using the turntable. There is a significant fall hazard when setting the thrust bearing, so ensure you are tied off away from the hole while setting [handrail is acceptable for fall restraint]. A plug/plate covers the hole when the thrust bearing is not there.

- Unbolt the rigid coupling half using the rigid coupling half removal tooling. If you are using standard wrenches, you must hold the shaft with the coupling spanner tool to keep it from turning. After removal, install a protective cover on the coupling and shaft ends.

- Remove the lower speed sensor disc, oil catch basin reservoir assembly, and unbolt and lift the oil thrower off driveshaft.
After taking measurement ‘X’, the distance from the shaft protection sleeve to the stationary seal, remove the screws and lift the lower bearing cover off the thrust bearing housing assembly. Remove the mechanical seal insert and O-ring from the bearing cover.

Remove the screws and lift the deflector assembly off the driveshaft, then remove the setscrews and remove the mechanical seal off the driveshaft. Inspect the O-rings and seals for condition and save them for engineering inspection. Remove the spacer under the mechanical seal.

Disassemble the lower journal bearing

1. Loosen and remove the hex head bolts.

2. Loosen the button-head capscrews and lower the bearing housing until the assembly rests on the shaft oil impeller assembly. Remove the bolts and lift the pad retainer out of the assembly.
3. Remove the journal pads from the journal housing using the tapped holes. Ensure each pad is marked to allow it to be reinstalled in the same position. One pad has a thermowell for monitoring temperature. Verify the thermowell has been removed prior to pulling the pads.

4. Lift the journal bearing housing out of the thrust bearing assembly.

5. Install a dummy aluminum bushing in place of journal bearing. This protects the bearing when inverting the assembly in the turntable by holding the rotor in position while on its side.
Remove the coupling, seal, and upper journal

- Invert the thrust bearing assembly into its normal position, crane rail down

- Remove the upper speed sensor weldment brackets and store. Remove felt retaining ring split cover. Remove the upper small split cover and remove and discard the felt seal. Inspect cover for indications of rubbing between the cover and the oil thrower. If sat, no adjustment of the gap is required.
• Remove the driveshaft lock nut. This requires using a special wrench/adapter. This nut was torqued to 1,500 ft-lbs, so you will need to restrain the shaft to prevent rotation. If not using the hy-torc tool, the shaft will have to be restrained with a come-along attached to a small shackle on the coupling half to prevent it from turning.

• Lift the Zurn coupling half off of the driveshaft with the upper speed sensor disc attached. It does not always come up easily and may require heating the coupling half to facilitate removal.

• Remove bolting and remove the intermediate upper cooling chamber cover and gaskets. Inspect and clean the breather.
- Remove and store the modified standoff block, then loosen and remove the Expanding Plug assembly by holding the wrench flats and loosening the hex nuts.

- Disassemble the diffuser assembly.
  1. Remove capscrews and remove the diffuser plate weldment.
  2. Remove the diffuser and feed screw.
- Remove the motor coupling spacer and matchmark and remove the shaft keys.
• Floating seal removal

1. Unbolt and remove the floating seal cover and inspect for signs of wear and damage.

2. Carefully finesse the floating seal assembly and housing assembly up and over the shaft sleeve. This may require using threaded rods in the housing assembly due to suction of the oil. Inspect for wear or damage. Inspect shaft sleeve for wear or damage.

• Remove the oil sensor level probe from cooler chamber cover

• Remove cooler closure flanges and lube line projecting through the cooler cover, then unbolt and remove cooler chamber cover and O-ring.

• Remove the oil cooler tube assemblies, seal rings, and brackets. If necessary, remove the oil cooler.
• Ensure that I&C has remove the RTD assemblies

• Disassemble the upper journal bearing. (This is identical to the lower journal bearing disassembly.)

1. Uncrimp the tab washers and remove the bolts that secure pad retainer to the thrust bearing housing (outer bolts)

2. Loosen the button head socket capscrews and lower journal bearing until it rests on the thrust pad carrier ring.

3. Remove screws and lift pad retainer out

4. Using tapped holes, remove journal pads from housing. Mark each pad (on removal) as to its installation position.

5. Lift the journal bearing housing out of thrust bearing
Removal of bearing cover with upper thrust shoes

- Remove the nuts from the thrust pad cover assembly stud bolts

- Install lifting eyes and carefully lift the bearing cover assembly off the bearing housing. Turn the bearing cover over and position it on temporary supports with the upper thrust pads facing up. Take care not to damage thrust pads or lubrication lines. This is a tricky rigging operation because the cover will want to flip in most rigging configurations, but this must be controlled to prevent damaging the pads or oil lines.

Removal of drive shaft

- Install an eyebolt in the upper end of the driveshaft

- Lift the driveshaft out of the bearing housing (2,700 lbs). The driveshaft must be as perfectly vertical as possible during the lift to avoid damage. This is not a difficult rigging operation, because the rotor is symmetrical and balanced. Ensure none of the lower thrust bearing pads adheres to the rotor when lifting.

- Place the driveshaft assembly in a bench with an opening for the shaft, resting on the rotor.
Removal of shaft sleeves and rotor

- Thread eyebolts into the upper shaft sleeve and lift sleeve from the shaft. Remove the keys.

- Install eyebolts in both ends of the shaft, invert the shaft, and lower the rotor into the bench.

  NOTE: Prior to this time, the rotor is being held in place by the split ring assembly and the impeller on the opposite side of the split ring. The rotor is resting directly against the split ring. Allen capscrews capture the split ring and shaft sleeve between the impeller and the rotor. The weight of the rotor was on the impeller and the capscrews when upright. Now that it is inverted, the weight of the shaft is on the rotor through the split ring.

- Thread eyebolts into the oil impeller (11), remove the capscrews and lift the impeller off the shaft.

- Thread eyebolts into the lower shaft sleeve (8) and lift the sleeve from the shaft.

- Remove the O-ring, key (9), and split ring (6) from the shaft. NOTE: the rotor will be lifted prior to removing the split ring. Install an eye bolt in the lower end of the driveshaft and lift the shaft out of the thrust bearing rotor (1).

- Remove the key (5) and spacer ring (4).
Removal of lower thrust bearing

- Lift the lower thrust pad assembly out of the bearing housing and position it on temporary support with the pads facing up.

Complete disassembly

- Remove temporary aluminum lower journal bearing installed earlier

- Rig and lift the bearing housing to gain access to the five plugs on the outside of the housing (#14) and remove plugs while hanging.

- Cover all parts for cleanliness until inspected

What to inspect for

- Perform and visual inspection for damage, wear, and deep scratches. Any questions, contact engineering. This inspection will include all bearing surfaces, both the pads and the sleeves and rotor surfaces.

- Measurements to be performed prior to complete reassembly include the shaft lift and rotor thickness. Additional measurements are required if specific parts are to be replaced.

Items to be examined

- Upper thrust pads. If upper pad replacement is necessary, the following must be performed.
  1. Remove pad lube assemblies and seal rings from the cover. Remove the socket head capscrews (#10) and pad stops (#9) to release the pad assemblies. Replacement requires 7 new pad assemblies (one of which has the RTD hole (#8)).
  2. Measure the new pad thickness and compare to the old pads (in an unworn area). Contact engineering to verify the measurements match the original measurements. Based on the measurement, Engineering will determine if the assembled measurements must be taken and recorded.
• Lower thrust pads. If lower thrust pad replacement is necessary, the following must be performed.

1. Remove lower pads (items 1) from carrier ring (2) by removing the pad stops (3)

2. Obtain 11 new pads and install on the carrier ring with pad stops. Measure the new pad thickness and compare to the old pads (in an unworn area). Contact engineering to verify the measurements match the original measurements. Based on the measurement, Engineering will determine if overall measurement "F" must be taken and recorded.

• Both faces of the thrust bearing rotor

• Shaft sleeves and journal bearing pads
EO03  *State the Steps to Assemble Thrust Bearings*

GENERAL ASSEMBLY NOTES:

Cleanliness must be verified – past thrust bearing failure was attributed to possible foreign material intrusion. The mounting surface of the thrust bearings must also be clean and smooth. Measurements are taken to ensure all parts are assembled correctly. Contaminants could skew the measurements.

Use approved thrust bearing lubricant or equivalent when lubricating O-rings.

Use Never Seez pure nickel special nuclear grade lubricant or equivalent on threaded parts unless specified otherwise.

If parts affecting measurements (shaft lift) have been replaced, take measurements and record on data sheets (Appendix G).

Event Description

During U2R7, the Thrust bearing on RCP 2B had been disassembled and inspected. About 1 week after the outage ended, the 2B RCP thrust bearing’s lower journal bearing showed large step increases in temperature to where the temperature limitations for the bearing were approached. The limitations were then exceeded and the plant was shut down to investigate and repair the problem.

Affected component

The thrust bearing’s lower journal bearing was destroyed. Upon disassembly it was noted that the thrust bearing was contaminated with babbit throughout.

The bearing was monitored during disassembly to find root cause. No obvious abnormalities were discovered. All parts were assembled correctly. All component parts were intact. The babbit that was distributed throughout the thrust bearing was from the lower journal bearing pads. They, along with the shaft protection sleeve were destroyed.
Observations

A chunk of material was found embedded in one pad. An analysis of this material found that it was babbit and stainless steel from the shaft protection sleeve mixed with oil. No unusual or foreign material was found.

Hypothetical cause

The vendor called it Stainless Steel Wooling. A piece of stainless steel is scraped off (for whatever reason) possibly by foreign material prior to embedment into the babbit. This stainless sliver cuts more metal off before the sliver becomes embedded into the babbit. It becomes self-perpetuating.

The cause is unknown, but is possibly caused by foreign material under the right conditions.

Added additional inspection points for foreign material during the reassembly

Disassembled and inspected additional internal channels where foreign material could have gained entrance through flow passage holes in the bottom of the cooler chamber. As a result, we now pull off the inspection cover on the end to verify they are clean. This is required to be done after lifting the thrust bearing off the flip stand and setting it on legs.

This failure accentuates the need for strict FME measures.

LOWER THRUST BEARING INSTALLATION

Place the lower thrust pad assembly inside the bearing housing. Ensure the assembly is correctly seated and its stop pin is seated in the hole in the bearing housing.
Position the thrust bearing rotor (pump end up) on the assembly stand with a hole in it to accommodate the driveshaft.

Check that the dowel pin (2) is installed in thrust bearing rotor (1).

Slide the spacer ring (#4) upward onto shaft above the keyway (for #5) and install the key (#5), temporarily supporting spacer ring.

Lower the driveshaft through the thrust bearing rotor and install the split ring (#6) in the groove on shaft. Continue lowering the shaft until the split ring and spacer ring are seated against the thrust bearing rotor.

**SLEEVE AND ROTOR INSTALLATION**

Lubricate and insert the O-ring (#7) into the lower shaft sleeve (#8). Install key (#9) on the driveshaft and lower the shaft sleeve over the driveshaft.

Lock the split ring halves onto the shaft. Install new locking sleeves (#10) into the oil impeller and stake. Place the impeller on the thrust bearing rotor and align with the dowel pin. Install the capscrews (#12) securing the impeller and the lower shaft sleeve to the rotor.

Lift the driveshaft assembly and turn the motor end up.

Lubricate and install the O-ring (#13) into upper shaft sleeve (#14) and install the sleeve onto the driveshaft.

**DRIVE SHAFT INSTALLATION**

Lift the driveshaft assembly and lower it into the bearing housing with the rotor resting on THE lower thrust pad assembly (#5).
BEARING COVER WITH UPPER THRUST BEARING INSTALLATION

Lubricate and install the housing to cover O-rings (1 large (#9) and 3 small (#10)) into the thrust bearing housing-to-cover seat.

Lift the upper thrust pad and bearing cover assembly (#11) and lower it over the stud bolts onto the bearing housing, aligning the dowel pin (#7) and the drilled hole in the cover.

Install the nuts and lockwashers (#12-#13) and torque the nuts to 200 ft-lbs – DO NOT bend lock washers (1) yet.

Perform shaft lift measurements. This is the same measurement as was done before. It verifies the assembly is correct and the parts are all pushed together. The best way here is with a depth micrometer.

If a dial indicator is used, you must perform the following to obtain the shaft lift measurements.

Temporarily install the Zurn coupling half, lockwasher, and nut – torque to 600 ft-lbs. Take shaft lift measurement. When acceptable, remove the Zurn coupling half and continue with re-assembly.

If not acceptable, you may be able to increase the cover torque and make it acceptable if not fully metal-to-metal (experience has shown the 200 ft-lb on the cover bolts does not always achieve metal-to-metal fit).

Finish torquing the upper bearing cover nuts to 960 ft-lbs and crimp keyed washers. Check the dowel pin (#7 high) in bearing cover assembly (for aligning upper journal bearing assembly) for damage,
UPPER JOURNAL

Check that the pad stops (4) are installed in the upper journal bearing. Check the locating pin (5) in the journal bearing housing to ensure it is free from damage. Lower the journal bearing housing over the driveshaft into the thrust bearing upper cover assembly until it is temporarily seated on carrier ring.

Vertically align the holes for the RTD sleeve in the journal bearing housing and thrust bearing. Lubricate the bearing surfaces with thrust bearing lubricant and set the journal pads into the annulus between the housing and upper shaft sleeve.

Lower the pad retainer (#8) over the driveshaft and align the dowel pin hole with the dowel pin (#5) in thrust bearing cover. Install capscrews (#3, shorter ones) in alternate holes. Tighten to raise the journal bearing housing against the pad retainer. Install tab washers (#30) and hex head bolts (#31) securing the upper journal bearing assembly to the thrust bearing assembly.

Install and seat RTD sleeves with O-rings. Care must be taken to not damage the O-rings and fully seat the V-rings. Details for installation are spelled out in the procedure.

NOT SEATED [BELOW]

Install the cooler chamber cover on the housing – make sure the cover does not bear on the filter adapters.

FULLY SEATED [ BELOW]

Install the oil lines and flanges.
FLOATING SEAL ASSEMBLY

Clean and oil mating surfaces before installing, then install the floating seal housing [36] with the counterbored holes on bottom. These holes must align with the button head capscrews [43] installed in the Journal Bearing pad retainer.

Oil the mating parts on the floating seal assembly [35], then “finesse” the floating seal assembly down over the shaft sleeve. Align the pin with the slot in the housing.

Oil the mating parts on the floating seal cover [38] and install it on top of the floating seal housing assembly. Align the hole with the dowel pin in the floating seal housing. Install the button-head capscrews [37]. Ensure the floating seal housing does not rotate and torque the capscrews.

EXPANDED PLUG ASSEMBLY

Verify the expanded plug assembly [17] is fully assembled, that lower the two jam nuts against washer and Loctite 242 is applied. The coupling and nipple on top are tightened.

Insert the plug in a clean hole. The upper extra thick washer will be 1-2 mm [about \(\frac{1}{16}\)"] below the surface of the upper bearing cover.

Expand the seal by backing off the “full hex nut” and then apply Loctite 242 to the exposed threads below. Tighten the “full hex nut” until the Viton begins to extrude past the upper extra thick flat washer. Back off the nut until there is no more extrusion past the upper extra thick flat washer.

MODIFIED STANDOFF BLOCK

Lubricate the O-ring [15] and install it into the modified standoff block [7], then install the block [check the O-ring]. Secure it with the M10 x 170 socket head capscrew [13] on the inboard hole. Use Loctite 242 on the threads.
DIFFUSER & FEEDSCREW AND COUPLING SPACER

Lower the diffuser and feedscrew [28] onto the floating seal cover. Align the counterbored holes on the bottom with the buttonhead capscrews. Install the diffuser plate weldment [10] onto the diffuser and feedscrew. Center the diffuser & feedscrew using feeler gauges as needed to ensure an even distance from the shaft sleeve [16]. Install the socket head capscrews [1] and torque.

MOTOR COUPLING SPACER

Install the shaft keys [42], aligning the matchmarks. Install the motor coupling spacer showing the printed INSTALL THIS SIDE UP on the top.

INTERMEDIATE COOLING CHAMBER COVER

Install standoff blocks [6] if removed. They are secured with 160mm bolts on the outboard side and 170mm bolts on inboard side with Loctite 242 on the threads and torqued.

Install the intermediate gasket [20] on the intermediate cover [2]. Scarf the ends of the gasket [cut at 45°] and apply contact cement [27] on the ends together.
Install Permatex to the three (3) standoff blocks and place the cover on the standoff blocks, ensuring the drain hole aligns to the modified standoff block. If gasket is not thick enough to compress, apply a second gasket on top of the first.


Install the breather [30] on the cover with thread sealant.

ZURN COUPLING HUB

Install the Zurn Coupling hub [41] onto the shaft and install the lock washer [40]. Neverseez the shaft nut [39] and install – torque to 2000 ft-lbs. You can use a jack from below to help ensure the sleeves pull up tight. Do not bend the lockwasher yet, some adjustment may be necessary.
Measure the U dimension. It should measure between .000” and .020”, matching the number when disassembled. If replacement parts have modified the number and it is not in this range, fabricate a new spacer cut for a .010” calculated U dimension. If the dimension is not at least .000”, we can increase the torque up to 2,500 fl-lbs to obtain the U-dimension.

This measurement verifies the shaft is fully pulled up into the rotor and sleeves. Other dimensions are only required if parts were replaced that could affect the overall dimensions. If acceptable and the shaft lift was OK, bend the lock washer tabs against the lock nut flat after verifying clearance between the thrower and the bottom of the small split cover.

SMALL SPLIT COVER AND FELT SEAL

Verify the position of the oil thrower. Install one half of the small split cover [9] and measure the position of the oil thrower [33]. The acceptance criteria is between .080” and .120” to the bottom of the small split cover.

Remove the half of the small split cover installed for the measurement.

Apply Permatex No. 2 under flange and between mating surfaces of halves then install the small split cover [9] halves onto the intermediate cover. Loctite and install 8 capscrews [5], then torque the capscrews. Bend over the lockwasher [40] tab.
Coat the inside diameter of the Felt Seal [3] with Chevron GST 68 and install the felt seal into the cup of the small split cover. Ensure it is installed in the proper direction, wrapped around shaft the ensure the inside surface is lubed.


Invert the thrust bearing assembly on the turntable and remove the temporary aluminum journal bearing. Assemble the lower journal bearing (#28) onto the thrust bearing assembly as per the upper journal bearing assembly.
LOWER MECHANICAL SEAL (#29) INSTALLATION

Verify cleanliness and assemble the rotating unit of the upper mechanical seal. Install the shaft packing (O-ring, #2), then push the seal ring (carbon insert, #3) into the compression unit (#1) and hold in place with the wire hold ring (#4).

Install O-ring onto the mechanical seal insert stationary element and insert it into seal cover. This requires some force on the seal face to seat the O-ring. Protect the seal face from damage.

Measure dimension “A” in four places and record the average.

Calculate dimension “B” for upper seal and record.

\[ B = \text{Distance from seal face to bearing housing face} \]

\[ B = A + 0.125'' \]

Install the spacer ring, chamfer side down, flush onto the shaft protection sleeve. Lubricate the rotating seal assembly with the approved thrust bearing oil and install on the driveshaft.

Measure the “B” dimension and compare it with the calculated value. If not the same, remove the mechanical seal and spacer and re-machine the spacer.
Reinstall the spacer and seal assembly and apply Loctite #242 to the setscrews and tighten to 12-36 in-lbs. Measure in four places and verify the height is parallel within .005” to .010”.

Install the deflector assembly using four button head screws.

LOWER BEARING COVER INSTALLATION

Lubricate and install three O-rings (#24 & #25 (2)) in the lower bearing cover, inside face up. Check for dowel pin installation in the thrust bearing housing for positioning the lower bearing cover. Invert and install the lower bearing cover with the mechanical seal insert and O-rings over the driveshaft onto the thrust bearing housing and align it with the dowel pin. Ensure the mechanical seal insert and O-rings do not fall out or change position.

Install locking sleeves (#21) into the lower bearing cover bolt holes and stake. Secure the lower bearing cover with capscrews (#22) and torque. Crimp the locking sleeves to the capscrews.
OIL THROWER INSTALLATION (#19)

Install locking sleeves (#17) into the oil thrower and stake. Check the dowel pin in the oil thrower for damage and install nine O-rings (#83 & #84 (8)).

Position the oil thrower on the shaft, align the dowel pin with the hole in the lower shaft sleeve of the rotor assembly and secure it with capscrews (#18).

DRAIN OIL RESERVOIR INSTALLATION

Lubricate and insert the O-ring (#16) into the groove on the mounting face of the drain oil reservoir (#14). Lift the assembly consisting of drain oil reservoir (#14), O-ring (#16), catch basin (#76), and gasket (#80), and install it onto the lower bearing cover.

Lubricate the bolts and initially tighten them with keyed washers down. Check the gap between the thrower (#19) and the splash guard (#75) of the drain oil reservoir. Adjust if necessary by loosening the bolts on the splash guard and enlarging the holes. Torque with flat washers.

Torque the bolts with keyed washers on the catch basin assembly and bend up the keys.

Install the lower speed sensor disc assembly onto the driveshaft. Do not crimp the washers until the speed sensor detector is installed and calibrated in case the location must be adjusted.

RIGID COUPLING INSTALLATION

Clean and inspect the mating teeth, then install the coupling half onto the driveshaft with the match marks aligned. Lubricate and install the capscrews in the numbered holes from where they were removed. (Both the bolts and the holes are numbered.)

Apply preload torque (167 ft-lbs) using the correct tightening sequence (numbered order). Finish tightening by turning an extra 89° of bolt turn after the initial preload torque. This is done in two steps, in the same order. You visually identify the turning amount by using the marks on the coupling.
FINISHING ASSEMBLY AND PREPARATION

Install the thermowell assembly.

Verify the torque of the stud tensioner crane rail assembly bolts.

Invert the thrust bearing housing assembly back to the upright position and removal from turntable. NOTE that there is a safety concern at this time. When removing the thrust bearing, you are creating a fall hazard with a 5’ diameter opening. To minimize the impact of this hazard, verify all the equipment is off of the platform before removing thrust bearing and ensure a safety plug is available for the hole.

Once the thrust bearing is removed, legs are normally attached to it and it is set down. If done in the containment building, it can be set directly into the RCP.

Prior to setting, there are four openings on the outside that must be inspected. There is also one opening (a fifth) that is not open to the bearing.
LESSON 4 TERMINAL OBJECTIVE

Given tech manual and maintenance procedures, the maintenance mechanic will identify major components of the Reactor Coolant Pump Seal assembly and state the steps to replace seals in the Reactor Coolant Pump in accordance with maintenance procedure 31MT9RC23 as demonstrated on the final written exam with a minimum grade of 80%.

LESSON 4 ENABLING OBJECTIVES

EO01 Identify major components of the Reactor Coolant Pump seal assemblies.
EO02 State the steps to raise thrust bearing for seal replacement.
EO03 State the steps to remove seals (I, II, & III).
EO04 State the steps to disassemble and reassemble seal housing internals.
EO05 State the steps to install new seals.
EO06 State the steps to seat thrust bearing.
EO07 State the steps to couple the shafts.
EO01 Identify major components of the Reactor Coolant Pump seal assemblies.

RIGID COUPLING

The Rigid Coupling is located between the thrust bearing and the seal housing assembly and connects the shaft of the thrust bearing with the shaft of the pump.

SEAL HOUSING

The Seal Housing surrounds the seal assemblies and the pump shaft. It is the pressure boundary for the pump. It holds the seals between the rotating and stationary components of the RCP.

THRUST RING RETAINER

The Thrust Ring Retainer is located at the extreme upper portion of the seal housing. It directs any leakage through the seals to the leakoff lines to prevent potentially contaminated liquid from entering the environment.

SEAL ASSEMBLIES I, II, AND III

The seal assemblies seal the clearances between the rotating parts (shaft) and the stationary parts (housing). Seal assembly I is on the bottom, and seal assembly III is on the top.

FEED BUSHING

The feed bushing is located below the seal I assembly, surrounding the feed screw. Working in conjunction with the feed screw, it minimizes the possibility of potentially contaminated liquid entering the seal system.

FEED RING

The feed ring is located below the seal I assembly, surrounding the shaft, inside the feed bushing. It directs the flow of seal water towards the impeller to cool the water lubricated journal bearing.

WATER LUBRICATED JOURNAL BEARING

The Water Lubricated Journal Bearing is located between the impeller and the feed ring. It maintains the positional relationship (alignment) between the rotating and stationary parts of the pump.
SEAL ROBOT

The seal robot is attached over the RCP seal housing retainer ring bolts and nuts off to one side of the opening. It is a tool designed to lift and lower the parts of the seal assembly evenly and controllably.

EO02 State the steps to raise thrust bearing for seal replacement.

PREREQUISITES

The area must be cleaned and FME measures established (covers ready) to preclude the introduction of foreign material into the system.

Wear cotton gloves when handling bearings or seals on their mating surfaces.

Match mark parts for easy reassembly.

Take the necessary precautions for working around inhibited/borated systems.

All parts to be removed should be bagged and tagged.

REMOVE OIL AND WATER LINES

This was previously described in lesson 1. Since the thrust bearing will still have to be lifted considerably, the lines will still have to be removed, just as they would if removing the bearing. Remember to keep track of part locations - hanger bracket shims must all be reinstalled in the same location. Ensure bolting and shims are bagged and tagged for easy identification.

Remember to use the FME covers for all openings.
UNCOUPLE/REMOVE FLEXIBLE COUPLING

Locate or make a match mark for the diaphragm packs and coupling halves to aid in reassembly. Remove coupling bolts and nuts, securing the diaphragm and adapter assembly to the coupling halves. Remove the diaphragm pack and adapter spool piece and set it on top of the thrust bearing.

RAISE THE THRUST BEARING

Disconnect the rigid coupling (covered in lesson 1). The Shift Supervisor permission/signature is required before doing this. Conditions may not allow lowering onto the stop seal yet, but the Shift Supervisor can still allow you to proceed by installing mechanical jacks to hold the shaft off the stop seal.

Remove the bolts and keyed washers holding the thrust bearing to the motor support stand. Install four lifting eyes into the thrust bearing support flange. Attach four, 3-ton come-a-longs through the lower motor frame holes with wire straps.
Install three alignment pins. They install in threaded holes for the hold-down bolts, but they cannot be installed in the same holes as the eyebolts. Raise the thrust bearing high enough to allow installation of the safety stops (about 13 inches). Install the four safety stops and relax the come-a-longs until most of the weight is on the safety stops.

Examine the mating surfaces of the coupling halves for spline wear or misalignment. Install a cover on the splines to protect them from potential damage.

**EO03 State the steps to remove seals (I, II, & III).**

**INSTALL SEAL CRANE/ROBOT**

Remove the seal sensing lines and brackets as necessary for installation and operation of the seal crane. The procedure identifies removal of all 3 sensing lines, but if not required, only remove those needed for seal crane operation. You must matchmark all locations and the brackets to ensure the brackets and any shims are installed exactly as they were removed.
The crane is disassembled prior to bringing it in and loading it into the pump bay. Install the base assembly over 2 RCP studs just to the side of the access window. Lock the base down with base nuts snug tight. Install the post assembly, hub assembly, and boom assembly onto the base. Ensure the pins are tight. Lock the boom up with the cylinder assembly and pin it. Install the trunnion tool.

Hook up hoses to the pump and verify operation. Check which knobs control which functions. Practice moving the robot so that you can easily control it movements before picking any of the parts.
REMOVE THE LOWER HALF-COUPLING

Locate the match-marks between the coupling half and the pump shaft. The marks must be visible.

If not done prior to raising the Thrust Bearing, smoothly but quickly lower pump shaft onto static stop seal (built into the pump). Radioactive gases may escape while lowering, so RP must be notified. If leakage is excessive, block the shaft back up and notify rad protection before proceeding.

Ensure the pump shaft does not turn during coupling capscrew removal. Remove the socket head capscrews by turning 45° on the 1st pass, then a second 45° on the 2nd pass then completely remove on the 3rd pass. Each pass is done in marked numerical order.

Install the two coupling studs through the trunnion assembly inner plate, 180° apart. Assemble inner and outer plates of trunnion assembly and install on trunnion tool of seal robot. Engage the two nuts on the bolts, ensuring they are evenly spaced to lift the coupling half evenly. Lift the lower coupling until it clears the pump shaft, and then remove the coupling half. Install protective cover plates, top and bottom, to protect the teeth.

CAUTION: Contact radiation protection group before proceeding. Exposure rates and contamination levels may vary considerably.

If ISI is going to perform NDE on the pump shaft, the hole inside the shaft must be unplugged. Remove the Stopfen (17 mm socket) and Bolzen (special slide hammer allthread) plugs. Note if there is any water inside the hole and then remove it.
REMOVE SEALS

Thrust Ring Retainer removal

Loosen and remove the twelve capscrews (126) from the thrust ring retainer (125). The locking rings (127) will release when the capscrews are turned or a punch may be used to release them.

Attach the trunnion ring to the thrust retainer with ½”–13 UNC studs/nuts. Using care not to damage the Carbon throttle bushing, remove the thrust retainer.

Remove segmented thrust ring

Install a sleeve jacking tool (Halo) on the Seal III shaft protection sleeve with retaining pins. Jack the sleeve down until the segmented thrust ring is loose. Pry the segmented thrust pieces out – the segment with the parallel ends comes out first. The remaining two segments can then be removed.
Seal III removal

Fasten the trunnion plate to the top of the seal with two ½”-13 UNC studs & four nuts. Lift the seal until the split blocking ring can be installed on the seal II retainer. This may require additional force to initially break the assembly loose – the O-rings may have attached to the housing and the shaft. If the entire shaft lifts, set it back down. You may have bread the seal loose by jacking the seal up against the shaft before removing it.

Lift the seal assemblies and install the split blocking ring. Lower the assemblies on the split blocking ring.

Remove the drive pins. The outer pins can be removed with the jacking screws pushed down, relieving the spring tension from the seal retainer. The inner pins may require that the jacking screws on the halo be backed off slightly. The pin removal tool or a screw should be used to minimize the potential for dropping the pins.

Lift and remove the Seal III cartridge – DO NOT remove jacking ring.
Seal II removal

Attach a 2nd sleeve jacking tool to the Seal II shaft protection sleeve. Fasten the trunnion to the seal II retainer. Lift the seal until the split blocking ring can be removed from the Seal II assembly. Continue lifting until the split blocking ring can be installed on the Seal I retainer. Set Seal assembly onto split blocking ring.

Remove the drive pins. Outer and inner are removed as with the third stage. The jacking tool will likely need to be tightened for removal of the outer pins and loosened for removal of the inner pins.

Lift and remove the Seal II cartridge – DO NOT remove jacking ring.
Seal I assembly removal

Attach the trunnion to the seal assembly. Lift and remove the split blocking ring. Continue lifting and remove the seal I cartridge.

Do NOT remove drive pins in the seal I assembly.
SEAL HOUSING ADAPTER (TOP HAT) REMOVAL

Remove the ½” blind flange and O-ring on the seal housing adapter.

Have engineering take the gap measurement between the housing and adapter for assisting in root cause analysis of leakage.

Install transfer punch bushings and mark the hole locations sufficient to align the tophat when lowering it back down. Loosen the studs in standard sequence but do not remove yet (engineering measurement is required). Remove the nuts.

Remove the transfer punch bushings and install lifting hooks in the jackscrew holes. Turn the hooks until the top hat is clear of the rabbit fit.

Attach the robot to the hooks with the lifting bar on the outer trunnion. Lift and remove the top hat.
State the steps to disassemble and reassemble seal housing internals.

LOWER FEED SCREW (FEED RING) REMOVAL

Lower the trunnion down and align with holes in the feed screw (view A). Install 575mm (25 in) long bolts into feed screw and raise until U-strap can be placed into position. Replace the 575mm bolts with 130mm (5 in) bolts and remove the feed screw (view C).

FEED BUSHING REMOVAL

The Feed Bushing is removed with virtually the same steps as the feed screw (view D). You will use different bolt holes in the trunnion inner plate and the bolt diameter is smaller (12mm dia. compared to 16mm). The long bolt is 560mm (24 1/4 in) long and the short bolt is 40mm (1 5/8 in) long.
JOURNAL BEARING REMOVAL

Use same bolts as the feed screw removal. Perform the same steps as the feed screw except for the use of different holes in the trunnion inner plate. However, in this case the U-strap cannot be used. Stop pins are installed into the holes provided in the side of the journal bearing (View B, item 8). Care must be taken to prevent damage to the carbon liner.

The same bolts and process is used for the shaft protection sleeve removal.

INTERNALS REASSEMBLY

CAUTIONS:

Care must be taken to not rotate the shaft during reassembly or it could cause damage to the pump stop seal.

Shaft and housing interior must be checked for cleanliness

NOTE: Reinstallation is basically the reverse of removal.

JOURNAL BEARING INSTALLATION

If the shaft protection sleeve has been removed, it will be installed first. Determine if the interference fit is in tolerance. Take a shaft OD measurement and a protection sleeve ID measurement. The interference should be .0012” - .0027”.

Wipe clean and heat sleeve to 310 ºF. Wipe down the shaft. Remove the sleeve from the oven and quickly install onto the shaft – hold in position until cool.

Install 40mm (1 5/8 in) bolt into the top of the journal bearing through the trunnion plate holes. Center the journal bearing over the shaft and carefully lower it down to install the stop pins and set onto the seal housing. Replace the 40mm bolts with 575mm (23 in) bolts. Raise the trunnion,
equalize the load, and remove the stop pins. Carefully lower the journal bearing over the shaft so as not to damage the carbon face. Align the key (1) with the keyway by rotating the trunnion plate.

When the journal bearing is seated properly, remove the bolts

FEED BUSHING INSTALLATION

Record measurement "A1" in the seal housing and "W" on the feed bushing for feed bushing seating checks.

Reinstall the key if removed and verify dowel pin is installed. Lubricate O-ring with Molykote 41.

**NOTE:** The use of Molykote 41 for lubricating the O-rings prior to installation applies to all the O-rings installed in this procedure.

Reinstall feed bushing similar to the journal bearing with the following exceptions: use the proper size bolts; rest the feed bushing on the U-strap while changing the bolt length to the longer bolts. If force is required to overcome resistance from new O-ring use hardwood blocks and levers 180° apart (place eyebolts in place of removed bolts in the seal cover for the fulcrum).

**NOTE:** DO NOT USE FORCE IF IT IS COCKED OR HUNG UP ON KEYWAY

Take and record feed bushing measurement "A" to within 0.10mm (.004"). Compare calculated dimension with actual (Calculated = A1 - W).

FEED SCREW INSTALLATION

Lubricate and install O-ring in feed screw bore. Install 130mm (5 in) bolts with washers and lift feed screw. Place on U-strap and change to the 575mm bolts. Install the same as with feed bushing.
EO05 State the steps to install new seals.

GENERAL INSTRUCTIONS

Check bolt and dowel pin holes for cleanliness.

Use Neolube 2 or equivalent for threads unless otherwise specified.

BOLZEN AND STOPFEN PLUG REINSTALLATION

Using new O-ring lubricated with Molykote 41, insert Bolzen plug. The threaded rod from the special slide hammer can be used to insert it. Measure the distance (4.7") to make sure it is fully seated.

Lubricate Stopfen plug threads with Molykote 41 and install plug, torquing to 10 ft-lbs.

SEAL HOUSING ADAPTER (TOP HAT) INSTALLATION

Remove plugs (38 – 42) one at a time and replace the O-rings. Lubricate the O-rings with Molykote 55. Reinstall the plugs in the same holes they were removed from.
Prepare the seal housing and top hat for top hat installation. Lube and install a minimum of four studs on top of seal housing. Install three small O-rings on the top face of the seal housing. Install the large O-ring on the top face of the seal housing – lubricate with Molykote 55. Install the locator jackscrews in the Top Hat, protruding about ½”.

Install the Seal Housing Adapter (Top Hat). Do NOT allow the stud lube to contact the O-rings. Ensure the dowel pin in the housing is aligned with the hole in the adapter (Top Hat). The Jackscrews must be seated in their center-punched holes to ensure alignment. Install four nuts on the studs hand tight.

Seat the Seal Housing Adapter by incrementally lowering the adapter using the jackscrews. Keep the four nuts lightly tensioned. Ensure it comes down level and all four jackscrews remain seated in their punch marks until fully seated. Ensure the nuts tight are enough to prevent lateral movement and remove the lifting/locator jackscrews.

Install the remaining studs, washers, and nuts into the seal housing. Torque the nuts on the Housing Adapter. The initial torque is 50 ft-lbs. Ensure the housing is centered first, as defined by engineering. Take it to 50 ft-lbs in as many increments as possible to prevent moving off-center. If the housing moves, re-center using jacking screws again and beginning again.

Torque to 100 ft-lbs and reverify centering. Fully torque to 1196 ft-lbs using normal sequencing in five stages, 200, 300, 500, 800, & 1196. Reverify centered after each step.

Reinstall blind flange on seal housing adapter with locking sleeves and new o-ring.

PREPARING SEALS FOR INSTALLATION

Seals are separated into transport containers for movement in and out of the Containment Building. Each has a lifting bar on the inside for transporting. These lifting bars are designed for lifting a single cartridge, not the entire set.

Verify the seal cavity is clean before installing seal cartridges.

Verify the half key and flathead screw are installed on the shaft.
Install new locking rings on the thrust retainer and stake to the retainer.

SEAL I ASSEMBLY INSTALLATION

Note that there may be measurements to be taken prior to seal installation, depending on the work that was performed – e.g., \( G = \pm 0.015" \) from the historic values.

Prep the seal assembly for installation. Lubricate all O-rings with DC55 grease. Fasten the seal to the trunnion plate. Remove the Seal I cartridge from the container. Install one inner and two outer O-rings in their grooves.

Install the seal assembly. Position the assembly over the pump shaft. Rotate the seal assembly to align the dowel pin in the shaft protection sleeve with the slot in the lower feed screw. Lower the seal assembly into the pump cavity and install the 2-piece blocking ring in the Seal I retainer. Remove the capscrews and trunnion assembly.
SEAL II ASSEMBLY INSTALLATION

Prepare Seal II assembly the same as the Seal I assembly.

Position Seal II assembly over the pump shaft and lower it over the Seal I assembly.

To connect the two seal assemblies together, rotate the Seal II assembly until the indexing pin on the Shaft Protection sleeve is aligned and then lower it. Install the two drive pins on the inside of the shaft protection sleeve. Install 4 drive pins on the outside of the Seal II retainer. Adjustment may be required on the sleeve jacking tool for the outside pins.

To lower the seal assemblies, lift the combined Seal assemblies enough to remove the 2-piece blocking ring from Seal I. Now lower the Seal Assemblies down until the 2-piece blocking ring can be installed on Seal II. Remove capscrews, trunnion, and sleeve jacking tool.

INSTALL SEAL III ASSEMBLY

Record the 3rd stage retainer serial number for inclusion on the ASME Section XI repair/replacement form.

Prepare Seal III assembly by lubricating all O-rings with DC55 grease. Fasten the seal to the trunnion plate. Remove the Seal III cartridge from the container. Install one inner and two outer O-rings in their grooves with a backing ring on the upper groove. The backup ring will be on top of the O-ring with the concave surface facing down.

Position Seal III assembly over the pump shaft and lower over the Seal II assembly.

To connect the two seal assemblies together, rotate the Seal III assembly until the indexing pin on the Shaft Protection sleeve is aligned and lower. Install the two drive pins on the inside of the shaft protection sleeve. Install the four drive pins on the outside of the Seal III retainer. Adjustment may be required on the sleeve jacking tool for the outside pin installations.
To lower the seal assemblies, lift the seal assemblies enough to remove the 2-piece blocking ring from Seal II, then lower the seal cartridge into the pump cavity. The dowel pin in Seal I shaft protection sleeve must engage with slot in the feed screw. Mark on the Seal III shaft protection sleeve to identify the location of the dowel pin to align it with the corresponding mark on the shaft. The seal assembly is fully lowered when the top of the Seal III retainer is even with or slightly below the bottom of the groove for the thrust ring.

COMPLETE REASSEMBLY

Install the segmented thrust ring. Remove the trunnion and move the seal crane out of the way. Install 3 segment pieces – the segment with the parallel ends is installed last. Back off the sleeve jacking screws and remove the tool from the Seal III shaft protection sleeve.

Install the thrust ring retainer. Use the trunnion on the seal robot and carefully lower it over the Seal III shaft protection sleeve and onto the thrust ring. Remove the trunnion and move the crane assembly. Align the holes and install the capscrews. Torque to 20 ft-lbs in three passes, with a maximum of 30% on the first pass.

Stake the locking rings to the capscrews.
EO06 State the steps to seat thrust bearing.

INSTALL THE RIGID HALF-COUPLING

Position the rigid coupling half under the crane. Attach the coupling half to the crane by installing the coupling stud bolts through the trunnion inner plate and coupling half and securing with two stud hex nuts.

Orient the coupling match marks with the marks on the pump shaft and lower the coupling half onto pump shaft. Align the match marks (XXX) prior to meshing the teeth.

Install the coupling bolts to secure the coupling in place. Holes are numbered to correspond with bolt numbers. Lubricate the threads and both sides of the hardened washers with Never-Seez. Install the lower coupling with the socket-head cap screws prefixed with a "P" for "pump shaft" hand tight. Remove the seal-crane assembly to provide adequate clearance.

Torque the lower coupling bolting. The initial torquing is: center capscrew to 649 ft-lbs; outer capscrews to 167 ft-lbs. The final tightening is done using the special coupling bolt wrench to prevent rotation of pump shaft. The 1st pass is to 1st mark (22.5º & 45º). The 2nd pass is to 2nd mark (45º & 90º).

Measure dimension E. This gap defines the running clearance. Engineering will take whatever extra measurements are needed to ensure the running clearances are correct. This dimension has been shown to be a precursor to having a bearing shaft sleeve cracking. If the E dimension has too high a number, it can indicate this is the problem. In Unit 3, the 1B RCP had a cracked shaft sleeve and the only evidence prior to the high vibration was the high ‘E’ dimension.
Lower the pump shaft back onto the static seal (stop seal). Remember that each time the shaft is raised or lowered, there is the potential for gas and water to escape. This potential, however, is minimized with the current seals – they never fully separate.

**LOWER AND RESEAT THRUST BEARING**

Locate the match marks between the rigid coupling halves and remove the upper and lower coupling protective plates. Raise the thrust bearing and remove the safety stops. Lower thrust bearing. Align the dowel pin on the thrust bearing flange (alignment pins should do this). Align the rigid coupling match marks. If necessary, rotate the thrust bearing shaft rather than the pump shaft to do the alignment.

Remove the lifting equipment. Insert keyed washers and bolts into the thrust bearing and torque.

**EO07 State the steps to couple the shafts.**

**COUPLE THE RIGID COUPLING**

Lubricate two studs and nuts 180° apart. The holes are numbered under the flange for the corresponding numbered nuts and studs. The nuts stamped with the letter "P" are on the bottom (Pump) side of the studs. The nuts stamped with the letter "A" are on the top of the studs. Install them hand tight.

Quickly raise the pump shaft by tightening two stud nuts together until the coupling halves mate. Ops must be contacted 1st. If seal injection is on, reverse flow could occur, pushing the internal O-rings out of their grooves.

Install the remaining studs. The top of the stud must be adjusted to between 2 7/16” and 2 ½” above the flange. Ensure they are in the right holes and the nuts are on the right end. Measure and record the no-load stud length to the nearest ten-thousandths of an inch.

**TENSION STUDBOLTS**

The coupling is tensioned in 3 steps. We generally use the Baby Biachs but you can use standard torque wrenches with multipliers, but this increases the potential for galling of the stud, nut, and washers. The final elongation value is .248±.0008”
RESET SPEED SENSOR

Loosen the speed sensor capscrews and slide the disc into approximate position. Final alignment is by I & C.

ALIGN THE FLEXIBLE COUPLING

The alignment should not have changed, but may have, so this is more an alignment verification.

Center the shaft with the motor centering bolts as measured with inside micrometers.

Measure the parallel offset of the thrust bearing and motor shafts. Measure the face parallelism to check for angular misalignment of thrust bearing and motor shafts. Plot both values on the graph.

If not satisfactory, you will need to move the motor to attain alignment, which would require loosening all the motor bolting and lifting 50 tons of motor weight with the crane.

Reverify readings and adjust until correct.

INSTALL FLEXIBLE COUPLING

Align the matchmarks on the flange of the diaphragm pack with those on the coupling half mounted on thrust bearing drive shaft. If not aligned, rotate the motor. Rotation of the motor requires use of Motor Rotor Lifting device. Note that there are occasions when aligning the matchmarks on both the motor and the thrust bearing portion may not be possible (motor removed and replaced, e.g.).

Secure the diaphragm pack and adaptor assembly (Zurn spoolpiece) to the coupling halves mounted on the thrust bearing and motor shafts with bolts and nuts torqued to 325 ft-lbs in three steps. Punch the bolt heads to identify the number of times torqued (maximum of 5 times allowed).

RECONNECT THE OIL AND WATER LINES

As per lesson 1.