PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson

Mechanical Maintenance Training	**Date: 10/26/2010 4:07:39 AM**
LP Number: NME30C000402	**Rev Author: CURT CLUFF**
Title: Seal Replacement	**Technical Review:** Kleinman, Dean W(Z56639) Digitally signed by Kleinman, Dean W(Z56639) DN: cn=Kleinman, Dean W(Z56639) Reason: I have reviewed this document Date: 2011.03.04 15:04:39 -07'00'
Duration : 6 HOURS	**Teaching Approval:** Baker Sr, Lee E(Z07641) Digitally signed by Baker Sr, Lee E(Z07641) DN: cn=Baker Sr, Lee E(Z07641) Date: 2011.03.04 15:18:06 -07'00'

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

31MT-9RC26: Reactor Coolant Pump Sulzer Bingham Seal Disassembly and Assembly

31MT-9RC22: Reactor Coolant Pump Seal Housing Disassembly, Examination, and Assembly (Sulzer Bingham)

31MT-9RC23: Reactor Coolant Pump Sulzer Bingham Seal Replacement

LESSON PLAN REVISION DATA

Oct 26, 2010	Curt Cluff	Minor rewording and refining for clarification and modified introduction [TCSAI 3277044]

Tasks and Topics Covered

The following tasks are covered in Seal Replacement :

Task or Topic Number*	**Task Statement**
Lesson:	Seal Replacement
RCP001	Maintain mechanical seals (Reactor Cooling Pump)

Total task or topics: 1

TERMINAL OBJECTIVE:

1 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 Reactor Coolant Pump in accordance with maintenance procedure 31MT9RC23 as demonstrated on the final written exam with a minimum grade of 80%.

1.1 Identify major components of the Reactor Coolant Pump seal assemblies.

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

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

1.4 State the steps to disassemble and reassemble seal housing internals.

1.5 State the steps to install new seals.

1.6 State the steps to seat thrust bearing.

1.7 State the steps to couple the shafts.

CONTENT	METHODS AND ACTIVITIES
I. Motivation	Focus student attention on "What's In It For Me".
A. Look at replacement of the seal without removing the motor or thrust bearing	
B. Requires some steps unique to this task	
II. Pre-Job Brief	
A. Focus On Five (Task Preview)	
Familiarize worker with the scope of work, task sequence, and critical steps.	
1. Critical Steps (Terminal Objectives)	PVNGS Standards & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.
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%.	
2. Identify error likely situations (error traps)	Look at Error Precursors in S&E book
a. Discuss at least one specific error likely situation.	
3. Identify the Worst thing that can happen.	Apply to the setting you're in. (Lab versus Classroom)
4. Identify specific error prevention defenses to be used.	What defenses can we employ to prevent the "Worst thing that could happen"
5. Identify actions to assure proper configuration control.	This may not be applicable in every training setting.
B. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow.

CONTENT	METHODS AND ACTIVITIES
III. Lesson Introduction	
A. Lesson Enabling Objectives	Read and/or discuss the lesson 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.	

TO: 1 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 Reactor Coolant Pump in accordance with maintenance procedure 31MT9RC23 as demonstrated on the final written exam with a minimum grade of 80%.

EO: 1.1 Identify major components of the Reactor Coolant Pump seal assemblies.

CONTENT	METHODS & ACTIVITIES
I. Seal Assembly Parts	Change slide
A. Rigid Coupling	This is a review--they should already be familiar
1. Located between the thrust bearing and the seal housing assembly	
2. Connects the shaft of the thrust bearing with the shaft of the pump	
B. Seal Housing	Click to highlight
1. Surrounds the seal assemblies and the pump shaft	
2. Pressure boundary for the pump	
3. Holds the seals between the rotating and stationary components of the RCP	
C. Thrust Ring Retainer	Change slide
1. Located at the extreme upper portion of the seal housing	Aka “disaster bushing”
2. Directs any leakage through the seals to the leakoff lines to prevent potentially contaminated liquid from entering the environment	

CONTENT	METHODS & ACTIVITIES
D. Seal Assemblies I, II, and III	Change Slide
1. Between the housing and the shaft	
2. Seal I on bottom, III on top	Click to highlight each of them
3. Seals the clearances between the rotating parts (shaft) and the stationary parts (housing)	
E. Feed bushing	Click to highlight location
1. Below the seal I assembly, surrounding the feed screw	
2. In conjunction with the feed screw, it minimizes the possibility of potentially contaminated liquid entering the seal system	
F. Feed ring	Click to highlight
1. Below the seal I assembly, surrounding the shaft, inside the feed bushing	
2. Directs the flow of seal water towards the impeller to cool the water lubricated journal bearing	
G. Water lubricated journal bearing	Click to highlight
1. Located between the impeller and the feed ring	
2. Maintains the positional relationship (alignment) between the rotating and stationary parts of the pump	
H. Seal robot	Change slide
1. Attached over the RCP seal housing retainer ring bolts and nuts off to one side	
2. Lifts and lowers the parts of the seal assembly evenly and controllably	

EO: 1.2 State the steps to raise thrust bearing for seal replacement.

CONTENT	METHODS & ACTIVITIES
I. Prerequisites	**Prevent Events:** These items should be covered in pre-job brief and 2-minute drills to emphasize importance. Add peer checking also
A. Area must be cleaned and FME measures established (covers ready) to preclude the introduction of foreign material into the system	
B. Wear cotton gloves when handling bearings or seals on their mating surfaces	
C. Match mark parts for easy reassembly	
D. Take the necessary precautions for working around inhibited/borated systems	
E. All parts to be removed should be bagged and tagged	
II. Remove oil and water lines	Change slide, then change again: Only need to remind them – review material
A. This was previously described in lesson 1.	Change slides (next 3) to show photos of the connections
B. Since the thrust bearing will still have to be lifted considerably, the lines will still have to be removed	Change slide to illustrate the need to raise the Thrust Bearing
1. Hanger bracket shims must all be reinstalled in the same location	
2. Ensure bolting and shims are bagged and tagged for easy identification	
C. Remember the FME covers for all openings	**Prevent Event:** pre-job and 2-minute drill – procedure requirement

CONTENT	METHODS & ACTIVITIES
III. Uncouple/remove flexible coupling	
A. Locate or make match mark for diaphragm packs and coupling halves to aid in reassembly	Change slide to show match marks
B. Remove coupling bolts and nuts securing diaphragm and adapter assembly to coupling halves.	Change slide to show removing bolting
C. Remove diaphragm packs and adapters and set on top of thrust bearing	Change slide to show removed section on top of thrust bearing
IV. Raise the thrust bearing	Change slide to show the thrust bearing assembly for illustration only.
A. Disconnect rigid coupling (covered in lesson 1)	Click to highlight
1. Shift Supervisor permission/signature is required	
2. Note conditions may not allow lowering onto the stop seal yet	
3. Can still proceed by installing mechanical jacks to hold the shaft off the stop seal	Change slide to show mechanical jacks
B. Remove bolts and keyed washers holding thrust bearing to motor support stand.	Change slide, then change slide again for photo
C. Install four lifting eyes into thrust bearing support flange	Change slide
D. Attach four, 3-ton come-a-longs through lower motor frame holes with straps	Change slide
E. Install 3 alignment pins	Change slide
1. They install in the threaded holes for the hold-down bolts	NOTE: although not identified in the procedure, they should be used to more easily align the dowel pin upon reinstallation

CONTENT	METHODS & ACTIVITIES
2. Cannot be installed in the same holes as the eyebolts	
F. Raise the thrust bearing high enough to allow installation of seal crane robot (about 13 inches)	Change slide
G. Install four safety stops and relax come-a-longs until most of the weight is on the safety stops	Click to highlight, then change slide to show closeup
H. Examine mating surfaces of coupling halves for spline wear or misalignment	
I. Install cover on splines to product them from damage	

EO: 1.3 State the steps to remove seals (I, II, & III).

CONTENT	METHODS & ACTIVITIES
I. Install crane	
A. Remove seal sensing lines as necessary	Change slide to identify brackets
1. Seal sensing line brackets may need to be removed for operation of the seal crane	
a. Procedure identifies removal of all 3 sensing lines	
b. If not required, only have to remove those needed for seal crane operation	
2. Must matchmark all locations and the brackets	
3. Ensure brackets and any shims are installed exactly as removed	
B. Crane is disassembled prior to bringing in and loading into the pump bay	Change slide to show procedure picture

CONTENT	METHODS & ACTIVITIES
C. Install base assembly	Change slide
1. Install over 2 RCP studs just to the side of the window	Crane has been installed on both sides. Fittings may need to be modified to fit on the opposite side from where last used.
2. Lock down with base nuts snug tight	
D. Install post assembly, hub assembly, and boom assembly onto the base	Change slide
1. Ensure pins are tight	
2. Lock boom up with cylinder assembly and pin	Change slide
E. Install trunnion tool	Show on drawing then click to show assembled crane
F. Hook up hoses to the pump	Change slide
G. Verify operation	**Prevent Events**: Self-checking and peer verification
1. Check which knobs control which functions	
2. Practice moving for control and direction before picking the parts	
3. Ensure PSV pressure is set below 800 lbs.	
II. Remove lower half-coupling	Change slide shows coupling removal parts
A. Locate match marks between coupling half and pump shaft – marks must be visible	**Prevent Events:** Ensures there are matchmarks for reassembly
B. If not done prior to raising the Thrust Bearing, smoothly but quickly lower pump shaft onto static stop seal (built into the pump)	
1. Radioactive gases may escape while lowering	

CONTENT	METHODS & ACTIVITIES
2. If leakage is excessive, block shaft back up and notify rad protection before proceeding	
C. Remove socket head cap screws	
1. Ensure the pump shaft does not turn during coupling removal	**Prevent Events:** 2-minute drill – not damage the stop seal. Remember, there is a **special tool** for the capscrew removal
2. 45º 1st pass, then last 45º 2nd pass then remove on 3rd pass	
3. Each pass is done in marked numerical order	
D. Remove the coupling half	
1. Install two coupling studs through trunnion assembly inner plate, 180° apart	
2. Assemble inner and outer plates of trunnion assembly and install on trunnion tool of seal robot	Change slide
a. Engage two nuts on the bolts, ensuring they are evenly spaced to lift the coupling half evenly	
b. Lift lower coupling until it clears the pump shaft, and then remove the coupling half	
3. Install cover plates, top and bottom, to protect the teeth	Change slide to note protective cover on the shaft, similar to the two on the coupling half
CAUTION: Contact radiation protection group before proceeding. Exposure rates and contamination levels may vary considerably.	
E. ISI inspection (If required)	
1. If ISI is going to perform NDE on the pump shaft, the hole inside the shaft must be unplugged	

CONTENT	METHODS & ACTIVITIES
2. Remove the Stopfen (17 mm socket) and Bolzen (special slide hammer allthread) plugs	Change slide
3. Note if there is any water inside the hole and remove	Preserving Evidence – if water is found it must be noted to engineering
III. Remove seals	
A. Thrust Ring Retainer removal	Change slide
1. Loosen and remove 12 capscrews (126) from the thrust ring retainer (125)	
2. The locking rings (127) will release when capscrews are turned or a punch may be used to release them	
3. Attach the trunnion ring to the thrust retainer with ½" –13 UNC studs/nuts	Change slide
4. Using care not to damage the Carbon throttle bushing, remove the thrust retainer	Change slide
B. Remove segmented thrust ring	Change slide to show ring
1. Install a sleeve jacking tool "Halo" on the Seal III shaft protection sleeve with retaining pins	**Prevent Events**: Self and peer checking to ensure tool pins are fully engaged
2. Jack sleeve down until segmented thrust ring is loose	
3. Pry the segmented thrust pieces out	
a. Segment with parallel ends comes out first	
b. Other two segments can then be removed	
C. Seal III removal	
1. Fasten trunnion plate to the top of the seal with two ½"-13 UNC studs & 4 nuts	Change slide

CONTENT	METHODS & ACTIVITIES
2. Lift seal until split blocking ring can be installed on the seal II retainer	**Prevent Events:** STAR and 2-minute drill – What you expect and what to do if you don't see it
a. This will require additional force to initially break the assembly loose	Identify ways that have assisted such as 2 – ¾ ton come–a–longs attached to the thrust bearing
1) O-rings bond with the housing and shaft	
2) Come-a-longs attached between the thrust bearing and the seal are used to initially break the seals loose	
b. If the entire shaft lifts, set back down and may have to jack the seal up against the shaft before removing	Note where and how it has been jacked in the past
3. Set seal on split blocking ring	Click to highlight
4. Remove pins	Click to highlight
a. Outer pins can be removed with the jacking screws pushed down, relieving the spring tension from the seal retainer	
b. Inner pins may require that the jacking screws on the halo be backed off slightly	Click to highlight
c. Pin removal tool or screw should be used to minimize potential for dropping pins	Click to highlight
5. Lift and remove the Seal III cartridge – DO NOT remove jacking ring	Change slide (4 times) to show photos of removal
D. Seal II removal	Change slide
1. Attach a 2nd sleeve jacking tool to the Seal II shaft protection sleeve	**Prevent Events:** Ensure engaged in the sleeve, 700 lbf, Self-peer check, 2-minute drill
2. Fasten trunnion to seal II retainer	

CONTENT	METHODS & ACTIVITIES
3. Lift seal until split blocking ring can be removed from the Seal II assembly	
4. Continue lifting until the split blocking ring can be installed on the Seal I retainer	
5. Set Seal assembly onto split blocking ring	
6. Remove pins	
a. Outer and inner as before	
b. Jacking tool will likely need to be tightened for removal of the outer pins and loosened for removal of the inner pins	
7. Lift and remove the Seal II cartridge – DO NOT remove jacking ring	
E. Seal I assembly removal	Change slide
1. Attach trunnion to the seal assembly	
2. Lift and remove split blocking ring	
3. Continue lifting and remove Seal I cartridge	
4. Do <u>NOT</u> remove drive pins in the seal I assembly	
IV. Seal Housing Adapter (Top Hat) Removal	This step is not necessary for normal seal work
A. Remove ½" blind flange and O-ring on the seal housing adapter	Change slide
B. Have engineering take gap measurement	Engineering will direct this and any other measurements they want taken
1. Between housing and adapter	
2. For assisting in root cause analysis of leakage	
3. Install transfer punch bushings and mark the hole locations sufficient to align the tophat when lowering back down	

CONTENT	METHODS & ACTIVITIES
4. Loosen the studs in standard sequence but do not remove yet (engineering measurement is required)	
5. Remove the nuts	
6. Remove transfer punch bushings and install lifting hooks in jackscrew holes	Change slide to show hooks
7. Turn hooks until top hat is clear of rabbit fit	
8. Attach robot to hooks with lifting bar on outer trunnion	
9. Lift and remove top hat	Change slide to show 2nd view

EO: 1.4 State the steps to disassemble and reassemble seal housing internals.

CONTENT	METHODS & ACTIVITIES
	Note that these steps are not commonly done (reference 31MT-9RC22)
I. Lower feed screw (feed ring) removal	Change slide
A. Lower trunnion down and to align with holes in the feed screw (view A)	
1. Install 575mm (25 in) long bolts into feed screw and raise until U-strap can be placed into position	View B
2. Replace 575mm bolts with 130mm (5 in) bolts and remove feed screw (view C)	Change slide
II. Feed bushing removal	Point out view D
A. Same operation as with the feed screw	
1. Use different bolt holes in the trunnion inner plate	

CONTENT	METHODS & ACTIVITIES
2. Bolt diameter is smaller	
a. 12mm dia. Compared to 16mm	
b. Long bolt is 560mm (24 1/4 in) long	
c. Short bolt is 40mm (1 5/8 in) long	
III. Journal bearing removal	Change slide
A. Use same bolts as the feed screw removal	
1. Same operation as the feed screw except different holes in the trunnion inner plate	
2. U-strap cannot be used, and stop pins will have to be used into holes provided in the side of the journal bearing (View B, item 8)	
B. Care must be taken to prevent damage to the carbon liner	
C. Same bolts and process for the shaft protection sleeve	Change slide to shaft protection sleeve removal
IV. Internals Reassembly	
A. Prerequisites	
1. Care must be taken to not rotate the shaft during reassembly or it could cause damage to the pump stop seal	Change slide, show stop seal on shaft
2. Shaft and housing interior must be checked for cleanliness	
B. **NOTE:** Reinstallation is basically the reverse of removal.	
V. Journal bearing installation	Change slide
A. If the shaft protection sleeve has been removed, it will be installed first	
1. Determine if the interference fit is in tolerance	
a. Shaft OD measured	

CONTENT	METHODS & ACTIVITIES
b. Protection sleeve ID measured	
c. .0012” - .0027” interference	
2. Wipe clean and heat sleeve to 310 ºF	
3. Wipe down shaft	
4. Remove sleeve from oven and quickly install onto shaft – hold in position until cool	
5. Measurements must be taken to ensure the shaft sleeve is seated before installing the journal bearing – if questionable, contact engineering	
B. Install 40mm (1 5/8 in) bolt into the top of the journal bearing through the trunnion plate holes	
C. Center the journal bearing over the shaft and carefully lower it down to install the stop pins and set onto the seal housing	
D. Replace 40mm bolts with 575mm (23 in) bolts	
E. Raise the trunnion, equalize the load, and remove the stop pins	
F. Carefully lower the journal bearing over the shaft so as not to damage the carbon face	
1. Align the key (1) with the keyway by rotating the trunnion plate	
2. When the journal bearing is seated properly, remove the bolts	
VI. Feed bushing installation	
A. Record measurement "A1" in the seal housing and "W" on the feed bushing for feed bushing seating checks	Change slide to show measurement location – click to show W location
B. Reinstall key if removed and verify dowel pin is installed	Change slide to show feed bushing installation

CONTENT	METHODS & ACTIVITIES
C. 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.	
D. Reinstall feed bushing similar to the journal bearing with the following exceptions	
1. Use the proper size bolts	
2. Rest the feed bushing on the U-strap while changing the bolt length to the longer bolts	
3. If force is required <u>to overcome resistance from new O-ring</u> use hardwood blocks and levers 180° apart (place eyebolts in place of removed bolts in the seal cover for the fulcrum)	
4. **NOTE:** DO NOT USE FORCE IF IT IS COCKED OR HUNG UP ON KEYWAY	Emphasize that this would possibly damage the machined surfaces on bushing and shaft
5. Take and record feed bushing measurement "A" to within 0.10mm (.004").	Change slide
a. Compare calculated dimension with actual (Calculated = A1 - W)	
VII. Feed screw installation	Change slide
A. Lubricate and install O-ring in feed screw bore	
B. Install 130mm (5 in) bolts with washers and lift feed screw	
C. Place on U-strap and change to the 575mm bolts	
D. Install the same as with feed bushing	
E. Take and record measurement “G”	
1. Ensure feed screw is properly seated	

CONTENT	METHODS & ACTIVITIES
2. Engineering contacted if not within .015" of historical measurement	

EO: 1.5 State the steps to install new seals.

CONTENT	METHODS & ACTIVITIES
I. General instructions	
A. Check bolt and dowel pin holes for cleanliness	
B. Use Neolube 2 or equivalent for threads unless otherwise specified	
II. Bolzen and Stopfen Plug reinstallation	Change slide
A. Using new O-ring lubricated with Molykote 41, insert Bolzen plug	
1. Can use the threaded rod from the special slide hammer	
2. Distance (4.7") is measured to make sure it is fully seated	
B. Lubricate Stopfen plug threads with Molykote 41 and install plug, torquing to 10 ft-lbs	
III. Seal Housing Adapter (Top Hat) Installation	
A. Remove plugs (38 – 42) one at a time and replace the O-rings.	Change slide
1. Lubricate O-rings with Molykote 55	
2. Reinstall plugs in the same hole they were removed from	**Prevent Events –**follow procedure, and do one at a time
a. The five plugs are each a different length	
b. They must be installed in the proper location	

CONTENT	METHODS & ACTIVITIES
B. Prepare for installation	
1. Lube and install a minimum of 4 studs on top of seal housing	
2. Install 3 small O-rings on the top face of the seal housing	Click to highlight
3. Install large O-ring on top face of seal housing – lubricate with Molykote 55	Click to highlight
4. Install locator jackscrews in Top Hat, protruding about ½"	
C. Install Seal Housing Adapter (Top Hat)	Change slide
1. Do NOT allow stud lube to contact O-rings	
2. Ensure dowel pin in the housing is aligned with the hole in the adapter (Top Hat)	Click to highlight
3. Jackscrews are seated in their center-punched holes	Click to highlight, again to remove
4. Install 4 nuts on the studs hand tight	
D. Seat the Seal Housing Adapter	
1. Incrementally lower the adapter using the jackscrews	**Prevent Events:** peer checking to ensure remains level so there is no binding and fully seated
2. Keep the four nuts lightly tensioned	
3. Ensure it comes down level and all 4 jackscrews remain seated in their punch marks until fully seated	
4. Ensure nuts tight enough to prevent lateral movement and remove the lifting/locator jackscrews	
5. Install the remaining studs, washers, and nuts into the seal housing	

CONTENT	METHODS & ACTIVITIES
E. Torque the nuts on the Housing Adapter	
1. Initial torque is 50 ft-lbs	
a. Ensure the housing is centered first, as defined by engineering	**Prevent Events:** Peer check to ensure the housing is centered and does not move. 2-minute drill on how to prevent it – these joints have leaked due to not being fully seated (machining interference problem)
b. Take it to 50 ft-lbs in as many increments as possible to prevent moving off-center	
c. If the housing moves, re-center using jacking screws again and beginning again	
d. Torque to 100 ft-lbs and reverify centering	
2. Fully torque to 1196 ft-lbs in:	**Prevent Events:** Peer check to ensure the housing is centered and does not move. 2-minute drill on how to prevent it
a. Normal sequencing	
b. Five stages, 200, 300, 500, 800, & 1196	
c. Reverify centered after each step	
F. Reinstall blind flange on seal housing adapter with locking sleeves and new o-ring	Change slide
IV. Preparing Seals for Installation	
A. Separated into transport containers for movement in and out of the Containment Building	Change slide
1. Each has a lifting bar on the inside for transporting	
2. Designated for lifting a single cartridge, not the entire set	

CONTENT	METHODS & ACTIVITIES
B. Verify seal cavity is clean	
C. Verify half key and flathead screw installed on shaft	
D. Install new locking rings on the thrust retainer and stake to the retainer	Change slide
V. Seal I assembly installation	
A. Note that there may be measurements to be taken prior to seal installation	Change slide
1. Depends on the work that was performed	
2. G = ±.015" from the historic values is always taken, even if the feed screw was not removed	
B. Prep the seal	Change slide
1. Lubricate all O-rings with DC55 grease	
2. Fasten to the trunnion plate	
3. Remove Seal I cartridge from the container	
4. Install one inner and two outer O-rings in their grooves	**Prevent Events:** self and peer check to ensure the O-ring is in the groove
C. Install the seal assembly	
1. Position over the pump shaft	
2. Rotate seal assembly to align the dowel pin in the shaft protection sleeve with the slot in the lower feed screw	
3. Lower the seal assembly into the pump cavity and install the 2-piece blocking ring in the Seal I retainer	Change slide
4. Remove the capscrews and trunnion assembly	

CONTENT	METHODS & ACTIVITIES
VI. Seal II assembly installation	Change slide
A. Prepare Seal II assembly the same as the Seal I assembly	
B. Position Seal II assembly over the pump shaft and lower over the Seal I assembly	Change slide
C. Connect the two seal assemblies together	
1. Rotate the Seal II assembly until the indexing pin on the Shaft Protection sleeve is aligned and lower	
2. Install two drive pins on the inside of the shaft protection sleeve	
3. Install 4 drive pins on the outside of the Seal II retainer	
4. Adjustment may be required on the sleeve jacking tool for the outside pins	
D. Lower Seal assemblies	Change slide
1. Lift the Seal assemblies to remove the 2-piece blocking ring from Seal I	
2. Lower the Seal Assemblies down until the 2-piece blocking ring can be installed on Seal II	
NOTE: Pay attention to the drive pins as the assemblies are installed. We have had them fall out in the past during seal installation.	
E. Remove capscrews, trunnion, and sleeve jacking tool	
VII. Install Seal III assembly	
A. Record the 3rd stage retainer serial number for inclusion on ASME Section XI repair/replacement form	

CONTENT	METHODS & ACTIVITIES
B. Prepare Seal III assembly	Change slide
1. Lubricate all O-rings with DC55 grease	
2. Fasten to the trunnion plate	
3. Remove Seal III cartridge from the container	
4. Install one inner	**Prevent Events:** self and peer check to ensure the O-ring is in the groove
5. Install two outer O-rings in their grooves with a backing ring on the upper groove	
a. Backup ring on top of the O-ring	
b. Concave surface facing down	
C. Position Seal III assembly over the pump shaft and lower over the Seal II assembly	Change slide
D. Connect the two seal assemblies together	
1. Rotate the Seal III assembly until the indexing pin on the Shaft Protection sleeve is aligned and lower	
2. Install two drive pins on the inside of the shaft protection sleeve	
3. Install 4 drive pins on the outside of the Seal III retainer	
4. Adjustment may be required on the sleeve jacking tool for the outside pins	
E. Lower Seal assemblies	Change slide
1. Lift the Seal assemblies to remove the 2-piece blocking ring from Seal II	
2. Lower the seal cartridge into the pump cavity	
a. Dowel pin in Seal I shaft protection sleeve must engage with slot in the feed screw	

CONTENT	METHODS & ACTIVITIES
b. Mark on the Seal III shaft protection sleeve identifies location of dowel pin if shaft was marked	Note that a level or plumb bob could have been used to mark the top of the shaft for easier alignment
c. Fully lowered when top of Seal III retainer is even with or slightly below the bottom of the groove for the thrust ring	
VIII. Complete reassembly	
A. Install segmented thrust ring	Change slide
1. Remove trunnion and move seal crane out of the way	
2. Install 3 segment pieces – segment with parallel ends is installed last	
3. Back off the sleeve jacking screws and remove the tool from the Seal III shaft protection sleeve	Change slide to show photo of segmented thrust ring installed
B. Install thrust ring retainer	Change slide
1. Use trunnion on seal robot	
2. Lower carefully over Seal III shaft protection sleeve and onto the thrust ring	Click to highlight
3. Remove trunnion and move crane assembly	
4. Align holes and install capscrews	
5. Torque to 20 ft-lbs, 3 passes, max of 30% on first pass	
6. Stake the locking rings to the capscrews	Click to highlight
7. CRITICAL STEP: Take measurement Kf	
a. Compared to Ks to verify running seal clearances	
b. Ks is taken from 31MT-9RC26 when the seal was rebuilt	

EO: 1.6 State the steps to seat thrust bearing.

CONTENT	METHODS & ACTIVITIES
I. Install rigid half-coupling	Change slide
A. Position rigid coupling half under crane	
B. Attach coupling half to crane by installing coupling stud bolts through trunnion inner plate and coupling half and securing with two stud hex nuts	
C. Orient coupling match marks with marks on pump shaft	
D. Lower coupling half onto pump shaft	
1. Align match marks (XXX) prior to meshing teeth	
2. Install coupling bolts to secure in place	
a. Holes are numbered to correspond with bolt numbers	
b. Lubricate threads and both sides of hardened washer with Never-Seez	
c. Install lower coupling with socket head cap screws prefixed with a "P" for "pump shaft" <u>hand tight</u>	
E. Remove seal crane assembly to provide clearance	
F. Torque Lower coupling bolting	Click to add bolt
1. Initial torquing	
a. Center capscrew to 649 ft-lbs	
b. Outer capscrews to 167 ft-lbs	
2. Final tightening	
a. Use special coupling bolt wrench to prevent rotation of pump shaft	

CONTENT	METHODS & ACTIVITIES
b. 1st pass is to 1st mark (22.5º & 45º)	Click to move
c. 2nd pass is to 2nd mark (45º & 90º)	Click to move
G. Dimension E	Change slide
1. This gap defines the running clearance	
2. Engineer will take whatever extra measurements needed to ensure running clearances are correct	
3. This dimension (along with the "G" dimension) has been shown to be a precursor to bearing shaft sleeve cracking	
a. Too high a number can indicate this problem	
b. Unit 3, 1B RCP had a cracked shaft sleeve and the only evidence prior to the high vibration was the high 'E' dimension	Change slide to show cracked shaft sleeve
H. Lower pump shaft back onto the static seal (stop seal)	Point out static seal on the shaft
1. Remember that each time the shaft is raised or lowered, there is the potential for gas and water to escape	
2. This potential, however, is minimized with the current seals – they never fully separate	
II. Lower and reseat thrust bearing	Generally a repeat of lesson 1
A. Locate match marks between rigid coupling halves and remove upper and lower coupling protective plates	Change slide
B. Raise thrust bearing and remove safety stops	Change slide
C. Lower thrust bearing	
1. Align dowel pin on thrust bearing flange	Change slide for alignment

CONTENT	METHODS & ACTIVITIES
2. Align rigid coupling match marks – rotate thrust bearing shaft rather than pump shaft to do the alignment	Change slide for alignment
D. Remove lifting equipment	
E. Insert keyed washers and bolts, torque	Change slide for bolting

EO: 1.7 State the steps to couple the shafts.

CONTENT	METHODS & ACTIVITIES
I. Couple rigid coupling	Change slide
A. Lubricate two studs and nuts 180° apart	
1. Holes are numbered under the flange for the corresponding numbered nuts and studs	**Prevent Events:** Peer check to ensure all parts are assembled correctly [Click to highlight]
2. Nuts stamped with the letter "P" are on the bottom (Pump) side of the studs	
3. Nuts stamped with the letter "A" are on the top of the studs	Change slide
B. Install them hand tight	
C. Quickly raise pump shaft by tightening two stud nuts together until coupling halves mate	**Prevent Events:** Procedure compliance. Can prevent damage to the seals
1. Ops must be contacted 1st	
2. If seal injection is on, reverse flow could occur, pushing internal O-rings out of their grooves	This has happened in the past, requiring seal disassembly again

CONTENT	METHODS & ACTIVITIES
D. Install remaining studs	
1. Top of the stud must be adjusted to between 2 $^{7}/_{16}$" and 2 ½" above the flange	Change slide
2. Ensure they are in the right holes and the nuts are on the right end	**Prevent Events:** Peer check to ensure all parts are assembled correctly
3. Measure and record the no-load stud length to ten-thousandths of an inch	
E. Tension studbolts	Change slide
1. Tension in 3 steps	
2. Use Baby Biachs but can use standard torque wrenches with multipliers	Note why Biach tensioners are preferred – minimize chances for galling
3. Final elongation is .248±.0008"	Change slide again to show pump
F. Reset speed sensor	Change slide – repeat of lesson 1, so only review if needed
1. Loosen bolts and slide into approximate position.	
2. Final alignment is by I & C	
II. Align flexible coupling	Review of lesson 1— Change slide - use slides for illustration
A. Alignment measurements	
1. Center the shaft with motor centering bolts	
2. Measure parallel offset of thrust bearing and motor shafts	Change slide
3. Check for angular misalignment of thrust bearing and motor shafts	Change slide
B. Plot both values on graph.	Change slide
1. If not satisfactory, move <u>motor</u> to attain alignment	

CONTENT	METHODS & ACTIVITIES
2. Reverify readings and adjust until correct	
III. Install flexible coupling	Review of lesson 1—use slides for illustration
A. Align matchmarks on flange of diaphragm pack with those on the coupling half mounted on thrust bearing drive shaft	
1. Rotation of motor requires use of Motor Rotor Lifting device	
2. Aligning matchmarks on both the motor and thrust bearing portion may not be possible (motor removed and replaced, e.g.)	
B. Secure diaphragm pack and adaptor assembly to coupling half mounted on motor shaft with bolts and nuts torqued to 325 ft-lbs in three steps	
C. Punch the bolt heads to identify the number of times torqued	
IV. Reconnect oil and water lines	Change slide – remind them that there were several lines discussed in lesson 1
A. As per lesson 1	

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory.

Objectives Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Ask questions that implement the objectives. Discuss students' answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students' needs. Use this opportunity to address the impending exam.