PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson

Mechanical Maintenance Training	**Date: 10/26/2010**
LP Number: NME30C000303	**Rev Author: CURT CLUFF**
Title: Thrust Bearing Maintenance	**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 14:08:41 -07'00'
Duration : 4 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 14:30:06 -07'00'

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

CRDR 2439146, Fall From RCP Thrust Bearing

31MT-9RC06: Reactor Coolant Pump Disassembly and Assembly

31MT-9RC24: Reactor Coolant Pump Thrust Bearing Disassembly, Examination, and Assembly

Unit 2 RCP Thrust Bearing Failure information letters (Reference NMC13-25)

DMWO 2852724: Work Order Instructions for Installation of Floating Seal Ring on RCP Thrust Bearings

LESSON PLAN REVISION DATA

Oct 26, 2010	Curt Cluff	Minor rewording and refining for clarification and added changes due to Thrust Bearing upper seal modification DMWO 2852724 [TCSAI 3277044]

Tasks and Topics Covered

The following tasks are covered in Thrust Bearing Maintenance :

Task or Topic Number*	Task Statement
Lesson:	Thrust Bearing Maintenance
RCP005	Maintain Reactor Coolant Pump thrust bearings

Total task or topics: 1

TERMINAL OBJECTIVE:

1 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%.

1.1 Identify components in thrust bearing assembly.

1.2 State the steps to disassemble thrust bearing.

1.3 State steps to assemble thrust bearings.

CONTENT	METHODS AND ACTIVITIES
I. Motivation RCP is an important piece of equipment. Incorrect thrust bearing operation has been a cause of shutting down a plant or entry into the Containment Building under power, so our maintenance activities are critical	Focus student attention on "What's In It For Me".
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) 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%.	PVNGS Standards & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.
2. Identify error likely situations (error traps) a. Discuss at least one specific error likely situation.	Look at Error Precursors in S&E book
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 components in thrust bearing assembly.	
EO02 State the steps to disassemble thrust bearing.	
EO03 State steps to assemble thrust bearings.	

TO: 1 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%.

EO: 1.1 Identify components in thrust bearing assembly.

CONTENT	METHODS & ACTIVITIES
I. Rotating Assembly	New slide, Item 6
A. Shaft	New slide, Item 3
1. Located axially in the center of the bearing assembly	
2. Aligns and connects all the rotating elements of the thrust bearing	
3. Transfers the energy of the motor to the pump	
B. Shaft sleeves (upper and lower)	Item 14 & Item 8
1. Surround the shaft at the upper and lower journal bearing and seal areas	
2. Prevent scoring of the shaft during normal or abnormal wear of the bearings and seals during operation	
3. Cheaper and easier to replace than the shaft	
C. Rotor	Item 1
1. A flange type of area keyed to the shaft near the midpoint (end-to-end)	
2. Part of the thrust bearing working surface. The pads ride against the rotor	

CONTENT	METHODS & ACTIVITIES
II. Stationary Thrust Bearing Assemblies	
A. Upper thrust bearing	Change Slide, Item no. 11
1. Assembly above the rotor	
2. Maintains axial alignment of the rotor whenever there is an upward thrust overall (system fully pressurized)	
B. Lower thrust bearing	Item no. 5
1. Assembly below the rotor	
2. Maintains axial alignment of the rotor whenever there is a downward thrust overall (system is at low pressure)	
III. Supporting Parts	
A. Reservoir	New Slide
1. Located on outside of the motor support, below thrust bearing assembly.	Click to show location. Click again to show photo
2. Storage for thrust bearing oil reserves	
B. Journal bearings	Slide change
1. Located along the shaft above and below the thrust bearing	Click to identify locations.
2. Maintain radial alignment of the shaft	
C. Bearing assembly covers	Click to identify locations
1. One each above and below the rotor, not attached to the shaft	
2. House the thrust bearing components	
3. Keep the internal parts aligned and impurities out	

CONTENT	METHODS & ACTIVITIES
D. Mechanical seal assembly	Click to identify locations
1. Below the lower journal bearing	
2. Keeps the journal bearing oil in the bearing housing and impurities out	
E. Floating Seal	
1. Above the upper journal bearing	
2. 3-piece floating seal assembly	
3. Diffuser & Feedscrew assembly	
a. Diffuser/Feedscrew [28] directs the flow out of the floating seal outwards	
b. Plate weldment [10] works with the diffuser/feedscrew to limit eddy currents [splashing]	Slide show assembled relationships
4. Felt Wiper to absorb vapors	

EO: 1.2 State the steps to disassemble thrust bearing.

CONTENT	METHODS & ACTIVITIES
NOTE: This procedure assumes that the thrust bearing has been removed per 31MT-9RC06 (Lesson 1) and installed on a turntable.	
I. Disassembly Steps	
A. Engineering must be notified	
1. For any unacceptable measurements or internal examinations	
2. When noticing any discrepancy which may require rework, repair, or replacement	

CONTENT	METHODS & ACTIVITIES
B. Shaft Lift Measurement	Change slide
1. Install a dial indicator on top of the driveshaft (point A) to measure shaft lift	
2. Install an eyebolt in end of driveshaft and lift shaft till thrust bearing is supported on the shaft rotor – alternative, use hydraulic jack under the rotor	Q--What if I keep lifting? A--The reading will remain the same—relative location of shaft to housing wouldn't change.
3. Record shaft lift	
a. Acceptable is .030” to .034”	
b. Notify planner and engineering if not acceptable so parts and plan can be developed	
C. Measure the “U” dimension	
1. For reference when reassembling	
2. Required depth is .000” to .020”	
D. Removal of coupling, reservoir, seal, and lower journal	
1. Invert thrust bearing (bottom up) using the turntable	Slide – show turntable, noting hazards
a. Fall hazard when setting the thrust bearing	
b. Ensure tied off away from the hole while setting	PPE, Harness, tied off away from the hole
c. Plug/plate covers the hole when thrust bearing is not there	
2. Unbolt rigid coupling half	Change Slide, show parts
a. Rigid coupling half removal tooling	Change slide show tool parts and identify how used
b. If using standard wrenches, must hold the shaft with the coupling spanner tool	

CONTENT	METHODS & ACTIVITIES
3. Install protective cover on coupling and shaft	Change slide, show example of protective cover
4. Remove lower speed sensor disc	Change slide
5. Remove oil catch basin reservoir assembly	Click to point out reservoir, click again for photo of last two
6. Unbolt and lift oil thrower off driveshaft	Change slide
7. Take and record Dimension X – distance from shaft protection sleeve to stationary seal, then remove screws and lift lower bearing cover off the thrust bearing housing assembly	Click to highlight
8. Remove the mechanical seal insert and O-ring from the bearing cover	Click to highlight, then Change slide, use photo to show cover and seal insert
9. Remove screws and lift deflector assembly off the driveshaft	Change slide
10. Remove setscrews and remove mechanical seal off the driveshaft	Click to highlight, then change slide for photo
a. Inspect O-rings and seals for condition and save for engineering inspection	
b. Remove spacer under the mechanical seal	Change slide
11. Disassemble the lower journal bearing as follows:	Change slide to show parts location
a. Loosen and remove the hex head bolts	Change slide and show hex bolts
b. Loosen the button-head capscrews and lower the bearing housing until the assembly rests on the shaft oil impeller assembly.	Point out button-head capscrews, change slide and show parts relationship
c. Remove bolts and lift pad retainer out of assembly	

CONTENT	METHODS & ACTIVITIES
d. Remove the journal pads from the journal housing using the tapped holes.	Change slide, pads in journal, marked. Change again, journal pad removed and parts relationship
1) Ensure each pad is marked to allow it to be reinstalled in the same position.	
2) One pad has a thermowell for monitoring temperature. Verify it has been removed prior to pulling the pads	
e. Lift the journal bearing housing out of the thrust bearing assembly	
12. Install dummy aluminum bushing in place of journal bearing	
a. Protects the bearing when inverting	
b. Holds rotor in position while on its side	
E. Removal of coupling , seal, and upper journal	
1. Invert the thrust bearing assembly into its normal position, crane rail down	Change slide to show the upper parts for disassembly
2. Remove screws and washers and remove the speed sensor bracket weldments	Slide to show weldments
3. Remove seal assembly parts	
a. Remove screws and remove felt retaining split ring	
b. Remove screws and remove the upper small split cover	
c. Remove and discard the felt ring	
d. Clean and remove Permatex No. 2 from under the flange and between the mating faces of the two halves	

CONTENT	METHODS & ACTIVITIES
e. Inspect bottom of upper small split cover and top of oil thrower for signs of wear or damage due to rubbing against each other	
f. If SAT, no adjustment of the gap is required	
4. Remove the driveshaft lock nut	Click to highlight parts
a. Special wrench/adapter	Change slide and show wrench and coupling
b. Was torqued to 1,500 ft-lbs, so you will need to restrain rotation of the shaft	May be as high as 2,500 ft-lbs
c. If not using the Hy-torc adapter, we commonly restrained with a come-along attached to a small shackle on the coupling half	
5. Lift Zurn coupling half off driveshaft with upper speed sensor disc attached	Change slide to show parts on drawing
a. Does not always come up easily	
b. May require heating the coupling half	
6. Inspect the Zurn coupling hub near the diffuser and feedscrew to verify no contact has occurred	
7. Intermediate Upper Cooling Chamber Cover removal	
a. Remove socket head capscrews	
b. Remove hex head screws and discard keyed washers	
c. Remove the cover and gasket	
d. Clean breather on the cover	
8. Expanding plug assembly removal	
a. Remove socket head capscrew and remove modified standoff block	

CONTENT	METHODS & ACTIVITIES
b. Hold wrench flats and loosen full hex nut	Change slide to show plug assembly parts
c. Inspect Viton seal for damage, replace plug assembly as necessary	
9. Diffuser plate weldment and feedscrew removal	
a. Remove socket head capscrews then remove diffuser plate weldment	
b. Remove diffuser and feedscrew	
10. Motor coupling spacer removal	
a. Remove coupling spacer from drive shaft	
b. Matchmark and remove keys from the driveshaft keyways	Change slide to show keys and spacer
11. Floating Seal Assembly removal	Note requirement for careful handling of parts due to fine finishes that are easily damaged
a. Remove four (4) button head screws from floating seal cover	
b. Remove floating seal cover	
c. Carefully finesse the floating seal assembly and floating seal housing assembly up and over the upper shaft sleeve – suction may necessitate use of lifting rods to remove	
d. Parts will be receive a documented inspection	
12. Remove the oil sensor level probe from cooler chamber cover	Change slide to drawing and show sensor probe on cover
13. Remove cooler closure flanges (#42) and lube line flange and line (#46) projecting through the cooler cover, then unbolt and remove cooler chamber cover and O-ring	Click to highlight each

CONTENT	METHODS & ACTIVITIES
14. Remove coupling nuts, oil cooler tube assemblies and two seal rings	Click to highlight
15. Remove the oil cooler brackets and if necessary the oil cooler	
16. Ensure I&C has remove the RTD assemblies	Change slide
17. Upper journal bearing disassembly (This is identical to the lower journal bearing disassembly.)	
a. Uncrimp the tab washers and remove the bolts that secure pad retainer to the thrust bearing housing (outer bolts)	Click to show bolts
b. Loosen the button head socket capscrews and lower journal bearing until it rests on the thrust pad carrier ring.	Click to show capscrews
c. Remove screws and lift pad retainer out	
d. Using tapped holes, remove journal pads from housing. Mark each pad (on removal) as to its installation position.	Change slide, change again for photo
18. Lift the journal bearing housing out of thrust bearing	Change slide for photo with journal bearing removed
F. Removal of bearing cover with upper thrust shoes	
1. Remove nuts from thrust pad cover assembly stud bolts	Change slide, identify nuts and cover
2. Install lifting eyes and carefully lift the bearing cover assembly off the bearing housing	
3. Turn bearing cover over and position on temporary supports with the upper thrust pads facing up	
a. Take care not to damage thrust pads or lubrication lines	

CONTENT	METHODS & ACTIVITIES
b. Tricky rigging operation – will want to flip and must be controlled	**Prevent Events:** 2-minute drill and self-check/peer check to ensure rigging flip will be controlled
G. Removal of drive shaft	Change slide to show rotor without cover installed
1. Install eyebolt in upper end of driveshaft	
2. Lift the driveshaft out of the bearing housing (2,700 lbs)	Change slide and discuss removal and installation into table
a. Must ensure that the lower thrust pads do not adhere to the rotor when lifted	
b. Driveshaft must be as <u>perfectly</u> vertical as possible during lift to avoid damage	
c. Not a difficult rigging operation, because the rotor is symmetrical and balanced	
3. Place driveshaft assembly on bench with an opening for the shaft	
H. Removal of shaft sleeves and rotor	Change slide and identify parts
1. Thread eyebolts into the upper shaft sleeve and lift sleeve from shaft. Remove keys	Change slide to show eyebolts in shaft sleeve – change again to show rotor with shaft sleeve removed
2. Install eyebolts in both ends of the shaft and invert the shaft and lower rotor onto bench	Change slide and show parts that are being discussed
a. Rotor is being held in place by split ring assembly and impeller on one side	
b. Rotor is directly against the split ring on the other side	
c. 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 capscrews when upright	

CONTENT	METHODS & ACTIVITIES
d. Now that it is inverted, the weight of the shaft is on the rotor through the split ring	
3. Thread eyebolts into oil impeller (11), remove cap screws and lift impeller off the shaft	
4. Thread eyebolts into lower shaft sleeve (8) and lift sleeve from shaft	
5. Remove the O-ring, key (9), and split ring (6) from the shaft	NOTE: rotor is lifted prior to removing the split ring
6. Install an eye bolt in the lower end of the driveshaft and lift the shaft out of the thrust bearing rotor (1)	
7. Remove the key (5) and spacer ring (4)	
I. Removal of lower thrust bearing	Change slide for lower bearing removal parts
1. Lift the lower thrust pad assembly out of the bearing housing	
2. Position on temporary support with pads facing up	
J. Complete disassembly	
1. Remove temporary aluminum lower journal bearing installed earlier	
2. 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	
3. Cover all parts for cleanliness until inspected	
II. What to inspect for	
A. Damage	
B. Wear	
1. Visual	

CONTENT	METHODS & ACTIVITIES
2. Measurements	
a. Shaft lift	
b. Rotor thickness	
C. Deep Scratches	
1. Visual	
D. Potential Foreign Material	
1. Housing will need to be raised out of the flip stand to gain access to the five plugs on the outside	
2. Remove the capscrews from the plugs and clean	
3. Ensure all openings are covered	
III. Items to be examined	
A. Upper and lower thrust pads	
1. Upper pad replacement (if necessary)	Change slide to show parts for pad replacement
a. Remove pad lube assemblies and seal rings from the cover	Click to highlight
b. Remove socket head capscrews (#10) and pad stops (# 9) to release the pad assemblies	Click to highlight
c. Requires 7 new pad assemblies (one of which has the RTD hole (#8)	
d. Measure the new pad thickness and compare to the old pads (in an unworn area)	
1) Contact engineering to verify the measurements match the original measurements	

CONTENT	METHODS & ACTIVITIES
2) Based on measurement, Engineering to determined if assembled measurements must be taken and recorded	Will show measurements later
2. Lower pad replacement (if necessary)	Change slide for parts/pad replacement
a. Remove lower pads (items 1) from carrier ring (2) by removing the pad stops (3)	
b. Obtain 11 new pads and install on the carrier ring with pad stops	
c. Measure the new pad thickness and compare to the old pads (in an unworn area)	
1) Contact engineering to verify the measurements match the original measurements	
2) Based on measurement, Engineering to determined if overall measurement "F" must be taken and recorded	Click to show Top of pad to bottom of carrier ring “F” dimension
B. Both faces of the thrust bearing rotor	
C. Shaft sleeves and journal bearing pads	

EO: 1.3 State steps to assemble thrust bearings.

CONTENT	METHODS & ACTIVITIES
I. NOTES:	
A. Cleanliness must be verified	
B. Mounting surface of thrust bearings must also be clean and smooth	Change slide to illustrate parts for reassembly and need for cleanliness and precision
1. Measurements ensure all parts are assembled correctly	
2. Contaminants could skew the measurements	
C. Use approved thrust bearing lubricant or equivalent when lubricating O-rings	
D. Use Never Seez pure nickel special nuclear grade lubricant or equivalent on threaded parts unless specified otherwise	
E. If parts affecting measurements (shaft lift) have been replaced, take measurements and record on data sheets (Appendix G)	
II. Event Description	
A. Condition	
1. During U2R7, the Thrust bearing on RCP 2B had been disassembled and inspected	
2. About 1 week after the outage, the 2B RCP thrust bearing's lower journal bearing showed large step increases in temperature	
a. Temperature limitations for the bearing were approached	
b. Limitations were then exceeded	
3. Plant was shut down to investigate/repair	

CONTENT	METHODS & ACTIVITIES
B. Affected component	
1. The thrust bearing's lower journal bearing was destroyed	Change slide to show photos of destroyed journal bearing parts
2. Thrust bearing was contaminated with babbit throughout	Change slide, show babbit contamination
C. Monitored disassembly to find root cause	
1. Found no obvious abnormalities	
a. All parts were assembled correctly	
b. All component parts were intact	
2. Found babbit distributed throughout the thrust bearing	
3. Lower journal bearing pads and shaft protection sleeve were destroyed	
D. Observations	Change slide to see damaged parts again
1. Chunk of material found embedded in one pad	
2. Analysis found it was babbit and stainless steel from the shaft protection sleeve mixed with oil	
3. No unusual or foreign material found	
E. Hypothetical cause	
1. Vendor called it Stainless Steel Wooling	
2. Piece of stainless steel is scraped off (for whatever reason) possibly by foreign material prior to embedment into the babbit	
3. This stainless sliver machines more metal off before the sliver is embedded into the babbit	
4. Self-perpetuating	

CONTENT	METHODS & ACTIVITIES
F. Cause is unknown – possibly foreign material under the right conditions	
G. Added additional inspection points for foreign material during the reassembly	
1. Disassembled and inspected additional internal channels	Change slide to identify additional inspection points
a. Entrance into flow passage through holes in the bottom of the cooler chamber	Click to show holes
b. Now pull off inspection cover on end to verify clean	Click to identify inspection cover
c. Required after lifting off the flip stand and setting up on legs	
2. Points out the need for strict FME measures	**Prevent Events:** Self and Peer checking and 2 minute drill of hazard assessment for Foreign Material regularly
III. Lower thrust bearing installation	
A. Place lower thrust pad assembly in bearing housing	
1. Ensure assembly is correctly seated and its stop pin is seated in the hole of bearing housing	Click to identify stop-pin
B. Position the thrust bearing rotor (pump end up) on assembly stand with hole to accommodate driveshaft	Change slide for shaft parts discussion
C. Check dowel pin (2) is installed in thrust bearing rotor (1)	Click to identify dowel pin on the rotor

CONTENT	METHODS & ACTIVITIES
D. Slide the spacer ring (#4) upward onto shaft above the keyway (for #5)	Click to identify spacer ring and key
1. Install key (#5), temporarily supporting spacer ring	
2. Lower the driveshaft through the thrust bearing rotor and install split ring (#6) in groove on shaft.	Click to identify split ring
3. Continue lowering shaft until split ring and spacer ring are seated against the thrust bearing rotor	
IV. Sleeve and rotor installation	Click to identify shaft sleeve
A. Lubricate and insert the O-ring (#7) into lower shaft sleeve (#8)	
B. Install key (#9) on driveshaft and lower shaft sleeve over the driveshaft	
C. Lock the split ring halves	
1. Install new locking sleeves (#10) into oil impeller and stake	
2. Place the impeller on thrust bearing rotor and align with dowel pin	
3. Install the capscrews (#12) securing the impeller and the lower shaft sleeve to the rotor	
D. Lift the driveshaft assembly and turn the motor end up	
E. Lubricate and install the O-ring (#13) into upper shaft sleeve (#14) and install sleeve onto driveshaft	Click to highlight upper shaft sleeve
V. Drive shaft installation	Change slide
A. Lift the driveshaft assembly	
B. Lower into bearing housing with rotor resting on lower thrust pad assembly (#5)	

CONTENT	METHODS & ACTIVITIES
VI. Bearing cover with upper thrust installation	
A. Lubricate and install housing to cover O-rings (1 large (#9) and 3 small (#10)) into thrust bearing housing-to-cover seat	Click to highlight
B. Lift the upper thrust pad and bearing cover assembly (#11)	Click to highlight
C. Lower over stud bolts onto the bearing housing, aligning dowel pin (#7) and drilled hole in cover	
D. Install nuts and lockwashers (#12-#13) and torque to 200 ft-lbs – DO NOT bend lock washers (1)	Click to highlight
E. Perform shaft lift measurements	Change slide
1. This is the same measurement as was done before	
2. Verifies the assembly is correct and parts are pushed together	
3. Best way here is with depth micrometer	Click to show where to take this measurement
4. If dial indicator is used, must perform the following to obtain shaft lift measurements	
a. Temporarily install Zurn coupling half, lock-washer, and nut – torque to 600 ft-lbs	
b. Take shaft lift measurement	
c. If acceptable, remove Zurn coupling half and continue with re-assembly	
5. 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 does not always achieve metal-to-metal fit)	Note that if this does not fix it, the procedure requires that you contact engineering for disposition
F. Finish torquing the upper bearing cover nuts to 960 ft-lbs and crimp keyed washers	

CONTENT	METHODS & ACTIVITIES
G. Check the dowel pin (#7 high) in bearing cover assembly (for aligning upper journal bearing assembly) for damage	Change slide
VII. Upper Journal, Seal and Coupling	
A. Upper journal bearing installation	Change slide
1. Check that the pad stops (#4) are installed in the upper journal bearing	Click to highlight
2. Check the locating pin (#5) in the journal bearing housing free from damage	Click to highlight
3. Lower the journal bearing housing over the driveshaft into thrust bearing upper cover assembly until temporarily seated on carrier ring.	Could point out that the carrier ring is the structure which holds the thrust bearing pads in place.
4. Vertically align the holes for the RTD sleeve in journal bearing housing and thrust bearing	Change slide
5. Lubricate bearing surfaces with thrust bearing lubricant	
6. Set journal pads into annulus between housing and upper shaft sleeve	Change slide
7. Lower the pad retainer (#8) over the driveshaft and align dowel pin hole with the dowel pin (#5) in thrust bearing cover	Change slide
8. Install capscrews (#3, shorter ones) in alternate holes, tighten to raise the journal bearing housing against the pad retainer	
9. Install tab washers (#30) and hex head bolts (#31) securing the upper journal bearing assembly to the thrust bearing assembly	Change slide

CONTENT	METHODS & ACTIVITIES
B. Install and seat RTD sleeves with O-rings	Click to highlight
1. Care must be taken to not damage the O-rings and fully seat the V-rings	Click to show photo of the correct installation
2. Details for installation are spelled out in the procedure	**Prevent Events** – procedure compliance
C. Install cooler chamber cover on housing--make sure the cover does not bear on the filter adapters	Change Slide
D. Install oil lines and flanges	Click to highlight, but no training need be done on this point
VIII. Floating Seal Assembly	**Slide**
A. Clean and oil mating surfaces before installing	
B. Floating seal housing [36]	**Slide**
1. Counterbored holes on bottom	
2. These holes must align with the button head capscrews [43] installed in the Journal Bearing pad retainer	
C. Floating seal assembly [35]	
1. Oil mating parts	
2. "Finesse" the floating seal assembly down over the shaft sleeve	**Emphasize this means not to force the seal over – it can get cocked if not careful**
3. Align pin with slot in housing	
D. Floating seal cover [38]	**Slide**
1. Oil mating parts	
2. Install on top of floating seal housing assembly	
3. Align hole with dowel pin in floating seal housing	

CONTENT	METHODS & ACTIVITIES
E. Button head capscrews [37]	**Slide show parts, what has been done, and what's next**
1. Install	
2. Ensure floating seal housing does not rotate and torque capscrews	
IX. Expanded Plug Assembly	**Slide**
A. Verify assembly [17] is fully assembled	**Slide [use back and forth with previous slide as desired]**
1. Lower two jam nuts against washer and Loctite 242 applied	
2. Coupling and nipple on top are tightened	
B. Insert plug	
1. Clean hole	**Slide**
2. Upper extra thick washer will be 1-2 mm [about 1/16"] below surface of upper bearing cover	**Slide**
C. Expand seal	
1. Back off "full hex nut" and apply Loctite 242 to threads below	
2. Tighten "full hex nut" until Viton begins to extrude past upper extra thick flat washer	
3. Back off until no more extrusion past the upper extra thick flat washer	
D. Modified standoff block	**Slide**
1. Lubricate O-ring [15] and install it into the modified standoff block [7]	
2. Install block [check O-ring]	
3. Secure with M10 x 170 socket head capscrew [13]	**Slide**
a. On inboard hole	

CONTENT	METHODS & ACTIVITIES
b. Use Loctite 242 on the threads	**Slide – show parts locations**
X. Diffuser & Feedscrew and Coupling Spacer	**Slide**
A. Lower diffuser and feedscrew [28] onto floating seal cover	**Slide**
1. Align counterbored holes on bottom with buttonhead capscrews	**Slide**
B. Install diffuser plate weldment [10] onto diffuser and feedscrew	**Slide**
C. Center diffuser & feedscrew	**Slide**
1. Use feeler gauges	
2. Even distance from shaft sleeve [16]	
D. Install socket head capscrews [1] and torque	**Slide – show parts locations**
E. Motor Coupling Spacer	
1. Install shaft keys [42], aligning matchmarks	
2. Install motor coupling spacer showing INSTALL THIS SIDE UP	**Slide**
XI. Intermediate Cooling Chamber Cover	
A. Install standoff blocks [6] (if removed)	**Slide**
1. 160mm bolts on outboard side	
2. 170mm bolts on inboard side	
3. Loctite 242 on threads and torque	
B. Install intermediate cover	**Slide**
1. Install gasket [20] on intermediate cover [2]	
a. Scarf ends of the gasket [cut at 45º]	**Slide**
b. Contact cement [27] ends together	
2. Permatex the three (3) standoff blocks	**Slide**

CONTENT	METHODS & ACTIVITIES
3. Place cover on the blocks ensuring drain hole aligns to modified standoff block	
4. If gasket does not compress, apply a second gasket on top of the first	
5. Secure cover	**Slide**
a. 3 hex head screw [11] with keyed washers [19] on standoff blocks	**Slide**
b. 190mm socket head capscrew [32] on modified standoff block with locktite on threads	
c. Torque all four	
6. Install breather [30] on cover with thread sealant	**Slide – show parts**
XII. Motor Coupling and Oil Thrower	**Slide**
A. Upper Speed disc [22] with collar [21]	
1. Slide up as far as possible	
2. Neverseez hex head screws [23]	
3. Loosely tighten screws to secure in place	**Slide**
a. If overly tightened, will be difficult to loosen speed sensor to readjust	
b. Requires loosening the capscrews and possible tapping up on the head of the screw to loosen the collar from the wedge	**Slide**
B. Zurn Coupling hub [41]	**Slide**
1. Install hub onto shaft	**Slide**
2. Install lock washer [40]	**Slide**
3. Neverseez shaft nut [39] and install – torque to 600 ft-lbs	**Slide**
4. Do not bend lockwasher yet – may need adjustment	

CONTENT	METHODS & ACTIVITIES
5. Measure U dimension	**Slide**
a. Between .000" and .020"	
b. If a new spacer, cut it to length for .010" calculated U dimension	
c. If not .000", allowable to increase torque up to 2,500 fl-lbs to obtain the minimum U-dimension	
6. When U-dimension is acceptable and the shaft lift is acceptable, bend up the tab washer	**NOTE: should wait until after verifying oil thrower position – step 4.114 repeats this step**
C. Measure shaft lift	**Slide**
1. Lower shaft	
2. Dial indicator on drive shaft – preload and zero the indicator	
3. Raise shaft and measure lift [.030" to .034" acceptable]	
XIII. Small Split Cover and Felt Seal	**Slide**
A. Verify position of oil thrower	
1. Install one half of small split cover [9]	
2. Measure position of oil thrower [33]	
3. Acceptance criteria is .080" to .120" to bottom of small split cover	
4. Remove the half of the small split cover installed for the measurement	
B. Install small split cover [9]	
1. Permatex No. 2 under flange and between mating surfaces of halves	
2. Install onto intermediate cover	

CONTENT	METHODS & ACTIVITIES
3. Loctite and install 8 capscrews [5]	
4. Torque capscrews	
C. Bend over lockwasher [40] tab	**This time, do it –STEP 4.114**
D. Felt Seal [3] installation	**Slide**
1. Coat ID of felt seal with Chevron GST 68	
2. Install felt seal into cup of small split cover	
a. Ensure proper direction	**Slide**
b. Must be wrapped around shaft in proper direction – ensure inside surface lubed	
3. Install retaining split ring [4] with hex head screws [5] and torque	**Slide [+ 2 more]**
XIV. Coupling, seal, reservoir, and lower journal	Change slide for bottom side reassembly
A. Invert thrust bearing assembly on turntable and remove the temporary aluminum journal bearing	
B. Assemble lower journal bearing (#28) onto thrust bearing assembly as per upper journal bearing assembly	Click to highlight
C. Lower mechanical seal (#29)	Click to highlight
1. Verify cleanliness and assemble the rotating unit of the upper mechanical seal	
a. Install the shaft packing (O-ring, #2)	
b. Push the seal ring (carbon insert, #3) into the compression unit (#1) and hold in place with the wire hold ring (#4)	
2. Install O-ring onto the mechanical seal insert stationary element and insert it into seal cover	
a. This requires some force on the seal face to seat the O-ring	

CONTENT	METHODS & ACTIVITIES
b. Be sure to protect the seal face from damage	
3. Measure dimension “A” in four places and record the average	
4. Calculate dimension B , distance from seal face to bearing cover face: B = A + 0.125”	Change slide, click to review measuring point
5. Install the rotating seal assembly	
a. Install the spacer ring, chamfer side down, flush onto the shaft protection sleeve	
b. Lubricate the rotating seal assembly with the approved thrust bearing oil and install on the driveshaft	
6. Measure the “B” dimension and compare it with the calculated value – if not the same, remove the mechanical seal and spacer and re-machine to the proper dimension	
7. Reinstall the spacer and seal assembly and apply Loctite #242 to the setscrews and tighten to 12-36 in-lbs	
8. Measure in four places and verify the height is parallel within .005” to .010”	
D. Install deflector assembly using four button head screws	Change slide – photo – change again for part ID number
E. Lower bearing cover installation	
1. Lubricate and install three O-rings (#24 & #25 (2)) in the lower bearing cover, inside face up	Click to highlight
2. Check for dowel pin installation in thrust bearing housing for positioning the lower bearing cover	

CONTENT	METHODS & ACTIVITIES
3. Invert and install the lower bearing cover with mechanical seal insert and O-rings over the driveshaft onto thrust bearing housing and align with dowel pin	Click to highlight
4. **NOTE:** Ensure mechanical seal insert and O-rings do not fall out or change position	
5. Install locking sleeves (#21)in lower bearing cover bolt holes and stake	
6. Secure lower bearing cover with capscrews (#22) and torque. Crimp locking sleeves to capscrews	
F. Oil thrower installation (#19)	Click to highlight
1. Install locking sleeves (#17) into oil thrower and stake	
2. Check dowel pin in oil thrower for damage and install nine O-rings (#83 & #84 (8))	
3. Position oil thrower on shaft, align dowel pin with hole in lower shaft sleeve of rotor assembly and secure with capscrews (#18)	
G. Drain oil reservoir installation	Change slide
1. Lubricate and insert O-ring (#16) in groove on the mounting face of the drain oil reservoir (#14)	Click to highlight
2. Lift the assembly consisting of drain oil reservoir (#14), O-ring (#16), catch basin (#76), and gasket (#80).	Click to highlight
3. Install on lower bearing cover	
4. Lubricate bolts and initially tighten bolts with keyed washers down.	
5. Check gap between the thrower (#19) and splash guard (#75) of the drain oil reservoir.	

CONTENT	METHODS & ACTIVITIES
6. Adjust if necessary by loosening bolts on splash guard and enlarging the holes. Torque with flat washers	Change slide to show photo of splash guard partially bolted to the drain oil reservoir
7. Torque bolts with keyed washers on catch basin assembly and bend up keys	Change slide to show photo of assembled catch basin/splash guard on the Thrust Bearing
H. Install lower speed sensor disc assembly on the driveshaft. Do not crimp washers until speed sensor detector is installed and calibrated.	Click to highlight speed sensor disc
XV. Rigid coupling installation	Change slide to show location
A. Clean and inspect the mating teeth	Change slide again
B. Install the coupling half on driveshaft with match marks aligned	
C. Lubricate and install capscrews **in the same holes where removed** (bolts and holes are numbered)	Point out that the couplings have bolt numbers and bolts are numbered
D. Apply preload torque (167 ft-lbs) with correct tightening sequence (numbered order)	
E. Finish with an extra 89° of bolt turn after torque preload	Change slide to show tools made for this step
1. In 2 steps, same order	
2. Visually identify the turning amount using marks on the coupling	
F. Install thermowell assembly	Change slide
G. Verify torque of stud tensioner crane rail assembly bolts	Change slide, show photo of crane rail
H. Invert the thrust bearing housing assembly back to the upright position.	

CONTENT	METHODS & ACTIVITIES
XVI. Removal from turntable	**Prevent Events:** pre-job and 2-minute drill – creating fall hazard
A. Safety concern	
1. Creating a fall hazard with the 5’ diameter opening	CRDR 2439146
2. Verify all equipment is off the platform before removing thrust bearing	
3. Ensure plug is available for the hole	
B. Thrust bearing is removed	
1. Normally legs are attached and it is set down	
2. Can be set directly in the RCP	
3. 4 openings on the outside must be inspected	
a. One opening (a fifth) is not open to the bearing	
b. Drain hole from the top of the thrust bearing	

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

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students' needs. end with a statement leading to the next lesson. Use as a transitional function to tie the relationship of this lesson to the next lesson.