PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson

Mechanical Maintenance Training	**Date: 10/26/2010**
LP Number: NME30C000103	**Rev Author: CURT CLUFF**
Title: Pump Disassembly and Reassembly	**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 16:32:59 -07'00'
Duration : 5 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 16:35:00 -07'00'

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

SOER 84-05, Bolt Degradation or Failure in Nuclear Power Plants

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

CRDR 9-6-0269: Spanner Wrench Restraint Inadequate (TCS 97-0031)

CRDR 9-6-1247: Kennet Unit flex cover inadequate (TCS 97-0029)

CRDR 2384324: Nuc Cooling Water Leak upon startup

Systems Training Manual

LESSON PLAN REVISION DATA

Oct 26, 2010 Curt Cluff Minor editorial changes for clarification [TCSAI 3277044]

Tasks and Topics Covered

The following tasks are covered in Pump Disassembly and Reassembly :

Task or Topic Number*	**Task Statement**
Lesson:	Pump Disassembly and Reassembly
RCP004	Maintain Reactor Coolant Pump
RCP005	Maintain Reactor Coolant Pump thrust bearings

Total task or topics: 2

TERMINAL OBJECTIVE:

1 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%.

1.1 Identify the major components of the RCP.

1.2 Identify steps to remove the thrust bearing.

1.3 Identify steps to remove the seal housing.

1.4 Identify steps to remove suction pipe and diffuser.

1.5 State the steps to install the suction piping and diffuser.

1.6 State the steps to install the seal housing.

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. There are many frequent maintenance items which must be performed on a Reactor Coolant Pump. Without the RCP, we cannot operate the plant, so the maintenance must be performed well to preclude excessive unexpected shutdowns.	
B. Examples of unexpected shutdowns due to the RCP	
1. Journal failed on Thrust Bearing after rebuilding the bearing	
2. Seal replacement required during plant startup on a seal that was not reworked, only removed and replaced for tophat work	
3. Shaft and shaft sleeve cracking requiring replacement between refueling outages	
C. Each of these cost considerable time and financial losses	
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 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%.	

CONTENT	METHODS AND ACTIVITIES
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.
A. Schedule	Lay out the schedule and expectations for schedule adherence
1. Length of class	
2. Break policy	
a. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow.
3. Evaluation – multiple choice exam	
4. Post training critique	Feedback (i.e. Class Climate)

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

TO: 1 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%.

EO: 1.1 Identify the major components of the RCP.

CONTENT	METHODS & ACTIVITIES
I. Purpose of the RCP. A. Supply cooling water to the reactor core during normal operations. B. Transfer the water from the reactor to the steam generator and back during normal operations. C. The RCP is not required for emergency decay heat removal due to the natural circulation designed into the system. 1. Not considered critical to safety of the plant. 2. Is necessary for power operations. D. Used to heat up the primary system during startup	Change slide: show cutaway view of the RCP for assisting the discussion of the location of the various component parts

CONTENT	METHODS & ACTIVITIES
II. Reactor Coolant and Safety System Tie-In	
A. The reactor coolant pumps (RCPs) are centrifugal pumps which maintain Reactor Coolant flow (approximately 114,625 gpm per pump)	
B. Flow exiting the reactor coolant pump enters the "discharge leg" and returns to the reactor vessel through four inlet nozzles (two per loop).	
C. The section of pipe between the outlet of the steam generator and reactor vessel is called the "cold leg".	
D. Cold leg temperature is approximately 564.5°F at zero power and 555.5°F at full power.	
E. The RCP motor employs a flywheel that is located below the upper bearing and serves to increase the rotating inertia of the RCP assembly.	
1. This increases the pump coastdown time and reduces the rate of decay of coolant flow when electrical power to the motor is lost.	
2. This coastdown flow helps ensure adequate heat removal from the core on a four pump loss of flow.	
3. The coastdown characteristics of the reactor coolant pumps ensure reactor core damage does not occur following a complete loss of power	
III. Motor	
A. Located on top of the RCP	Click to highlight
B. Purpose	
1. Supply power to the pump rotor	
2. Done by converting electrical energy to mechanical energy	

CONTENT	METHODS & ACTIVITIES
IV. Motor Support Stand	
A. Located between the pump and the motor from upper flange to top of bowl	Click to highlight
B. Purpose	
1. Absorb torque of motor	
2. Maintain motor to pump end alignment	
3. Support vertical weight of motor	
V. Thrust Bearing	
A. Located inside the motor support stand between the flex & rigid couplings	Click to highlight
B. Purpose	
1. Support the weight of the rotor when shut down and depressurized	
2. Prevent upward movement of the rotor with system pressurized, running or not.	
3. Maintain proper clearances between running and stationary parts	
VI. Flexible Coupling	
A. Located between the motor and the thrust bearing on the shaft.	
B. Purpose	
1. To allow for minor misalignments between the motor and pump ends of the shaft	
2. To allow for growth of the pump shaft as it heats up during operation	
3. To allow (in conjunction with the rigid coupling) for the removal of the shaft seals without removing the motor and thrust bearing	

CONTENT	METHODS & ACTIVITIES
VII. Rigid Coupling	
A. Located directly below the thrust bearing on the shaft	Change slide
B. Purpose	
1. Connect the shaft of the pump to the intermediate shaft through the thrust bearing	Change slide
2. To allow for removal of the shaft seals without removing the motor or thrust bearing	
VIII. Seal Housing	
A. Located on top of the pump casing, surrounding the shaft.	Change slide
B. Purpose	
1. The pressure boundary on top of the RCP	
2. Hold together the seal components to keep potentially contaminated water from leaking out of the reactor coolant system at the shaft penetration.	Change slide for different view. The discussion of "how" will occur in lesson 2.
C. Housing contains:	Change slide to show where these parts are, but explain that the details will be in lessons 2 and 4.
1. Seals I, II, and III (I is on the bottom, III is on top)	Click three times to highlight each
2. Feed Screw (Located below seal I)	Click to highlight
3. Feed Bushing (Surrounds the feed screw)	Click to highlight
4. Water Lubricated Journal Bearing (Below the feed screw)	Click to highlight
IX. Impeller	Change slide
A. Located at the bottom of the shaft, inside the pump casing.	

CONTENT	METHODS & ACTIVITIES
B. Purpose	
1. Convert the mechanical energy of the rotor to kinetic energy of the fluid	
2. Adds kinetic energy to the primary coolant	
C. Classification	
1. Closed	
2. Single suction	
X. Suction Pipe	Click to highlight
A. Located below the impeller eye (suction) extending into the suction piping	Show location on **Slide**
B. Purpose	
1. Direct the water flow in the suction line to the suction eye of the impeller	
2. Separates the bowl into suction and discharge areas	
XI. Diffuser	
A. Located in the area surrounding the impeller	Click to highlight
B. Purpose	
1. Transfer the kinetic energy of the fluid to potential energy (pressure)	
2. Directs the fluid to the discharge of the pump	
3. Minimizes pressure differential across the impeller	
XII. Systems interrelations	**Slide** shows the basic connections to the RCP
A. Electrical to the motor	
B. Component cooling water	

CONTENT	METHODS & ACTIVITIES
C. Seal water (Chemical & Volume Control system)	
D. Seal leakage (Reactor Drain Tank)	
E. Housing drain	
F. Instrument lines	
G. Instrument electricity	
H. Valve and auxiliary pump motor power supplies	
I. Thrust bearing hydraulic oil system lines & cooling system	

EO: 1.2 Identify steps to remove the thrust bearing.

CONTENT	METHODS & ACTIVITIES
I. Why removed	
A. For inspection	
B. For repair of bearing, pump rotor, or pump seal and casing parts	
II. Preliminary	
A. Permits	Note here that one permit is not used for the entire process – done in stages
1. Permits hung to allow disassembly only to a certain point before the next permit is hung	
2. Must know what you are allowed to do during each stage	
3. Common stages	
a. Motor breaker and instrumentation	

CONTENT	METHODS & ACTIVITIES
b. Nuclear Cooling (NC) to allow Thrust Bearing and Motor Removal	
c. RC system work added for seal replacement	
B. Electrical connections de-energized and disconnected by electricians	
C. Component cooling lines for the pump motor must be drained and they are then disconnected	
1. Have encountered problems finding the bolts for reinstallation	
2. One time found the wrong size (oversized) bolts installed on a flange	
D. Two oil valves opened to drain the hydraulic fluid back to the reservoir.	Slide shows the valve locations – Slides with pictures follow
NOTE: Approximately 11 hours is required to drain oil from the thrust bearing.	
1. Some oil will need to be drained from the Kenett Unit prior to draining the Thrust Bearing	
2. Between the Kenett Unit and the Thrust Bearing, there is more than the capacity of the Kenett Unit to hold	
E. Removal of oil and water lines	Numbers refer to part numbers on slide.
1. Remove flexible Kenett cover (2)	Slide – Flex cover removal allows access to the hydraulic unit.
2. Disconnect pipe straps (8 & 16) from the piping prior to removal of piping.	
NOTE: Shims (9) removed from pipe support brackets must be identified when bagged, for replacement in the same location.	

CONTENT	METHODS & ACTIVITIES
3. Disconnect oil piping and remove	
a. Catch drips	Why? Mess, fire and slip hazard, & potentially contaminated
b. Top and bottom of pipe (1) have unions that can be removed so the cooler cover and flange do not have to be disassembled	Show location of the union on the slide
c. Pipe (22) has a cover which must be removed,	Locate on slide
1) Part of the “Fire Protection Piping”	
2) Includes removal of swagelock fittings (50) and flange oil collector (46)	
d. Pipe (12) <u>can</u> be swung clear without removal <u>but</u> interferes with walkway and thrust bearing access	
4. Disconnect and remove cooling water piping	Refer to slide for parts locations
a. Unbolt flanges for piping (23 & 24)	
b. Remove pipe support members (28, 31, & 32)	
c. Support in front of access window (34) can be removed to allow access to the flex coupling, but rarely is	
III. Uncouple Flexible Coupling	
A. Conditions set	
1. All four RCPs will be tagged out	
2. Anti-rotation device is in the motor only	

CONTENT	METHODS & ACTIVITIES
B. Hand tighten the 4 motor centering bolts (attached to the motor support flange)	Slide to show motor support flange
1. This will center the motor shaft for reassembly alignment.	
2. Bolts are located in the RCP C-van on a shelf	
C. Remove bolts from the upper half of the coupling adapter assembly (motor side)	Slide--show bolts to be removed
D. Coupling remains secured by the thrust bearing half it is still bolted to	Identify remaining bolts below
IV. Motor removal	
A. Unbolt motor from motor support flange.	
B. Rig and remove motor (weight approx. 60 tons)	
C. Safety concerns	**Prevent Events:** 2-minute drill to evaluate safety hazards in environment
1. Fall hazard	**Slide**
a. Mechanic fell from the top of the RCP Motor	
b. Was wearing fall arrest system	
c. Relatively unharmed	
2. Noise hazard	Could note that this is not a concern when they are all tagged out
a. When running, very high noise hazard	
b. Must have hearing protection when in Containment while RCPs running, especially if working near them	Remaining slides can be used to show parts of the motor removal process

CONTENT	METHODS & ACTIVITIES
V. Primary piping removal	
A. Reactor coolant system must be drained below the level of the center of the hot leg, vented, and purged of hydrogen	
B. Rad protection notified and seal housing drained	
1. Open seal housing drain valve (Nozzle #10)	**Slide** shows this connection
2. This will be done by operations	
C. Disconnect nozzle weldements from their piping and hangers to allow for pulling back out of the way	**Slide** shows how nozzle weldements are attached.
D. Unbolt all 10 nozzle weldements at the first flange outside the motor support stand	
VI. Uncouple Rigid Coupling	
NOTE: The flange relationships should be match marked for reassembly prior to commencing the disassembly	**Slide** – shows a typical match mark
A. Reactor coolant system must be depressurized prior to removing the rigid coupling stud bolts.	
B. Speed sensor instruments must be removed (I&C) and the sensor disc assembly (2) moved so the stud bolts to clear for removal.	**Slide** shows the speed sensor
C. Loosen twelve nuts (3) and remove ten of the studs (4) and nuts.	
1. Can use “Baby Biachs”, but many commonly use slugging wrench.	**Slide**
2. 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.	

CONTENT	METHODS & ACTIVITIES
D. Rapidly lower the pump shaft and seat the shaft stop seal (internal to the pump)	
VII. Removal of Thrust Bearing	
A. Loosen and remove the fourteen hex-head bolts securing the thrust bearing lower flange to the motor support.	**Slide**
1. Use a large (1” drive) air impact wrench	
2. Ones in back may need tubing or hangers removed if not able to remove with extensions and swivels	
B. Thrust bearing (1) rigged for removal and rigging tensioned	**Slide**
1. Install lifting eyes on the four equally spaced threaded holes on the thrust bearing lower flange (2).	
2. Attach rigging to the eyes.	
a. Ensure lifting eyes and shackles are not protruding beyond the OD of the lower Thrust Bearing Flange.	
b. Will not clear the Motor Support Stand at the top if they do	
3. Thrust bearing assembly weighs about 8 tons.	
C. Center the crane over the assembly, and lift the thrust bearing carefully out of the motor stand.	

EO: 1.3 Identify steps to remove the seal housing.

CONTENT	METHODS & ACTIVITIES
I. Preliminaries	
A. Verify blank flange removed from seal housing drain, and housing is drained	**Slide** – nozzle #10 – drained if no fluid is coming out of the drain line
B. Remove seal pressure instrument lines.	**Slide**
II. Clamping ring removal	
A. Remove the 2 rows of socket head cap screws in clamping ring.	**Slide** shows two rows of screws and clamping ring
B. Clean ring and studs and install stud tensioner equipment. Note anything found on cleaning.	Notify Team Leader of any boron buildup found.
1. 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.	Discuss some of the cases to emphasize the severity of Boric Acid corrosion (SOER 84-05 & Recent RCP leaks)
2. On March 10, 1982, and Maine Yankee, 6 of 20 studs broke while removing the manway covers on a steam generator because of Boric Acid stress corrosion.	**Slide** shows our boron buildup from a past outage
C. Install 2 tensioners, 180° from each other. (This can be done with one if necessary.) The first one should be installed at the point furthest from the access.	
III. Studbolt tensioning/detensioning	**Slide** for installation onto pump & for detail of parts of tensioner
A. Compressed air is hooked up to the air filter inlet.	
B. Stud tensioner pumping unit is tested and primed.	
C. Hydraulic hoses are hooked to the tensioners	
1. Try to minimize air coming in	

CONTENT	METHODS & ACTIVITIES
2. Air will be bled when cylinders are retracted	
D. Operation of the tensioner	
1. Lower tensioner until base rests on clamping ring	
2. Turn drive gear handle clockwise.	
3. Thread puller bar system onto 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.	
NOTE The number of turns is critical in this procedure to preclude damage to the tensioner or studs.	Emphasize overextending of Biach Tensioners if not fully retracted is a significant recurring problem
4. Repeat on the stud nearest to the pump opening, 180° from the first one.	
5. Gradually increase hydraulic pressure until both stud nuts are loose. Record tension (psi) on chart.	
6. Turn both tensioner drive gear handles 6 turns counter-clockwise to back nut off.	
7. 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.	
E. Remove tensioner base and puller bar assemblies.	
F. Remove all nuts	
G. Remove all studs but 3, 120° apart	
H. Install stud guards on those studs.	**Slide**

CONTENT	METHODS & ACTIVITIES
IV. Raise clamping ring with jacking bolts	**Slide (2)** just to show the clamping ring while discussing it.
A. Keep it level	
B. Only needs to be raised a little to ensure freedom of movement and level attitude.	
C. Rig and remove clamping ring	
V. Push nozzle weldements out of the way	**Slide** shows weldements and how they will have to be pushed outward to clear for seal housing removal
A. Make sure not to bend the piping, as flange alignment would be affected.	
B. Retract nozzle weldements approximately 1/2” to remove flex gaskets, preventing their falling into the bowl.	**Prevent Events**: Foreign Material – 2-minute drill and self and peer checking
VI. Rig and remove seal housing	**Slide** shows how the housing is to be rigged
A. Wipe down housing and motor support stand to prevent dirt from falling into the primary coolant.	
B. Care must be taken to prevent swinging or other motion which could damage the impeller.	
C. Remove 4 cover bolts. Attach special lift rig	
D. Remove seal housing	
1. This will be thoroughly coordinated with RP and security	
2. Radiation readings are extremely high	
3. Movement is generally coordinated straight into the Fuel Building with security maintaining doors open	

CONTENT	METHODS & ACTIVITIES
VII. Plug the casing for temporary closure	
A. Could be makeshift plug if only to remove housing then continue working inside	
B. The regular temporary plug if not immediately working inside	**Slide** shows temporary plug--note the stud positions also.
VIII. Remove the bolts from the nozzle weldements	
A. The weldements will have to be pushed into the motor support stand as far as possible to remove bolts and washers	**Prevent Events:** FME concern 5-questions
B. Retract the weldements and secure out of the way when all bolts and washers are removed.	This is a potential FME concern as well as protecting the bolts

EO: 1.4 Identify steps to remove suction pipe and diffuser.

CONTENT	METHODS & ACTIVITIES
I. General and Preparatory	Note that this inspection is done by cameras by a vendor, so this section is for information on construction only, not the details of disassembly/reassembly Use **Slide** to show relationship of parts
A. Pump casing must be drained and the reactor defueled prior to commencing this part	
B. Relative locations must be marked prior to disassembly	
C. Inspect for damage to diffuser, piping, locking sleeves, bolting, etc. during disassembly. It must be recorded.	This was the 10-yr. Inspection

CONTENT	METHODS & ACTIVITIES
II. Suction pipe removal	**Slide** show all parts and relationships
A. Remove suction pipe capscrews and washers (1)	
B. Remove suction pipe ring and 4 alignment taper pins (2)	
C. Install suction pipe adapter on pipe and lift out the suction pipe carefully (2,400 lbs)	
D. Install a blank at the inlet nozzle for a platform to stand on, or at a minimum an FME cover	
III. Diffuser removal	
A. Ring segments are removed by removal of the socket-head capscrews at the time of removal	
B. Uncrimp locking sleeves (3)	
C. Remove ring segments that bridge the gaps (2 ea) (4)	
D. Remove locking pins from the hex nuts on each wedge assembly (drilling may be necessary).(5)	
E. Loosen and remove the wedge assembly from the pocket (record location for reassembly)	
F. Remove attached segments, rig, and lower diffuser half (5 vane) into the pump casing with lifting eyes, maintaining level attitude (1500 lbs).	**Slide**
G. Remove diffuser with nylon strap through one of the diffuser vanes.	**Slide**
H. Repeat for the other half (6 vane)	

EO: 1.5 State the steps to install the suction piping and diffuser.

CONTENT	METHODS & ACTIVITIES
I. Suction Pipe and Diffuser Installation	Note: this section will likely not be done, so remembering details is not important – simply an overview of how the parts are assembled together and what holds them in place
A. General instructions for reassembly	
1. Lubricate O-rings with DI water unless specified otherwise in the procedure	
2. Lubricate casing studs and holes.	
3. Lubricate other threaded surfaces with approved lubricant.	
4. Clean bolts, threaded holes and washers before installing.	
II. Diffuser replacement	
A. Install locking sleeves (1) into holes in ring segments	**Slide**
1. Stake sleeves into holes.	Staking sleeves is covered in lesson 2
2. Do the same for the suction pipe bolting ring (2)	
3. Take and record measurements as required in appendix O to verified the diffuser gets fully seated.	**Slides (2)** show where to take readings and what to calculate
a. "W" dimension on the diffuser (1" to 2" depth micrometer)	
b. "PCT" dimension on the casing (8" to 9" outside micrometer)	
c. Calculate assembled dimensions as per chart.	

CONTENT	METHODS & ACTIVITIES
4. Insert keys in slots of diffuser halves (3) and secure with socket head cap screw and torque.	**Slide** shows location
5. Reinstall reverse of the removal.	
a. 6 vane first	
b. Lower into casing with nylon strap, put in position with lifting eyes.	**Slide** if necessary--shows carrying by strap
c. Position ring segments in where they belong and install socket head capscrews.	**Slide** will show proper orientation if desired
d. Repeat with 5 vane	
III. Suction pipe replacement	
A. Remove temporary covers	
B. Lower suction pipe into the casing using adapter	**Slide** shows adapter
C. Align so that the jacking bolt holes will straddle the diffuser splits about equally and the four tapered pins align with their holes.	**Slide** shows what this means and where
1. If taper pin holes do not align, new holes will have to be drilled--contact Planner.	
2. Install the 4 taper pins and drive them with a moderate hammer blow.	
D. Measure gap in diffuser splits (C & D) and between shoulder and ledge (A & B)	Show where to measure
E. Lubricate and install suction pipe bolting ring and 24 socket-head cap screws and washers into the suction pipe. Tighten hand tight only.	
F. Remove lifting eyes	
G. Torque capscrews	
H. Take Step block measurements	Show where
1. Verifies seating of the assembly	**Slide** show what we're referring to

CONTENT	METHODS & ACTIVITIES
2. Compare with calculated values	
IV. Wedge installation	**Slide** for reference to wedges
A. Insert wedges into the diffuser pockets	
B. Select proper sized wedge-left/right	
C. Wedge torquing	
1. Loosen ring segment screws on diffuser half with largest peripheral gap	a or b on **Slide**
2. Torque wedges to 40 ft-lbs	
3. Retorque capscrews on ring segments	
4. Loosen other half capscrews	
5. Torque wedges to 100 ft-lbs	
6. Loosen all capscrews	
7. Torque wedges to 125 ft-lbs	
8. Retorque capscrews	
D. Drill and pin wedges	
1. Prevent chips from falling into system	
2. Drill and pin wedge nut assemblies	
3. Stake pin in 4 places	
E. Install last two ring segments	**Slide –** show 0° and 180° slotted ring segments

EO: 1.6 State the steps to install the seal housing.

CONTENT	METHODS & ACTIVITIES
I. Seal Housing Installation	
A. Preparation	
1. Lubricate pump casing studs and holes with Never Seez	
2. Install all but three casing studs, the three are to be 120° apart.	
3. Install seal housing lifting fixture and seal housing alignment jig.	**Slide**
4. Examine seal housing for cleanliness and damage	
5. Reinstall bolts and washers in nozzle weldements, then ensure they are retracted about 1/2".	
B. Replacement	
1. Remove cover, install spiral wound gasket and seal ring into casing.	**Slide** shows approximate location
2. Lower seal housing and impeller into casing.	
3. Maintain seal housing level and prevent swinging during lowering.	
a. Protection of the impeller	
b. Alignment jig inside motor support helps once housing is down far enough	**Slide**
4. Lower pump shaft onto stop seal by backing off coupling stud nuts.	Show coupling stud nut location
5. Remove lifting fixture	
6. Install studs nuts and washers removed for lift fixture and torque	

CONTENT	METHODS & ACTIVITIES
C. Nozzle weldements	**Slide**
1. Reinstall gaskets--snug up hand tight	
2. Torque to 195 ft-lbs.	
II. Install clamping ring	
A. Install bullet nosed studguards for clamping ring installation	
1. Protection of the studs due to high damage risk during clamping ring installation	
B. Lower carefully into position, aligning with dowel pin on seal housing and mounting flange	**Slide** shows dowel pin location
C. Install clamping ring/seal housing socket head capscrews and torque to 358 ft-lbs. in two steps.	
D. Check for gap of .039-.059" between clamping ring relief groove and seal housing with feeler gauge.	**Slide (2)** show where to measure
1. Tolerance of ±.002" between readings	
E. Lubricate, install and torque clamping ring/motor support stand socket head cap screws. Torque to 95 ft-lbs.	Those are the outer capscrews
III. Main closure stud bolting	**Slide**
A. Reinstall the last three studs	
B. Lubricate studs and nuts	
C. Install nuts hand tight	
D. Remove plugs from end of studs to measure elongation with a depth micrometer or equivalent	**Slides** to show holes, where, and how to measure
1. Special rigging setup, including rod through stud and a rest to set depth micrometer on	
2. Ensure the gauging holes are thoroughly cleaned before taking measurements or the tensioning will be erroneous	

CONTENT	METHODS & ACTIVITIES
E. Set up Biach stud tensioners as before	
F. Tension in 3 steps as per chart	**Slide** shows chart of tensioning values and order
G. Record elongation	Note that elongation is tensioned length minus original length
H. Replug measurement holes in studs	
I. Remove tensioner and store	

EO: 1.7 State the steps to couple the shafts.

CONTENT	METHODS & ACTIVITIES
I. Coupling the Flexible (Zurn) Coupling	
A. Install Thrust Bearing	
1. Reverse of removal	
2. Rigid coupling cover must be removed	
B. Align dowel pin on motor support stand when lowering the thrust bearing onto the thrust bearing motor support stand flange.	**Slide** shows bearing flange (part 3) and dowel pin (part 1)
C. Install studs and keyed washers	Parts 4 & 5.
1. Torque to 770 ft-lbs using standard sequence.	
2. Commonly use 19:1 or 14:1 multiplier with torque wrench with extensions	
D. Couple the Rigid Coupling	
1. Match marks must be aligned for coupling halves.	**Slides** – match marks again
a. Turn the thrust bearing shaft rather than the pump shaft end.	

CONTENT	METHODS & ACTIVITIES
b. Damage to the pump could result from turning the pump end.	
2. Rigid coupling studs are easily galled or damaged.	Ask--What is galling?
3. Lubricate 2 studs with Never-Seez and install 180° apart <u>in their numbered hole</u>	**Slides** – show where numbering is
a. Numbers are on the shaft under the flange and match numbers on studs and nuts	
b. Install studs with longer threaded section up	**Slides** show stud with more threads on top
c. Nuts with a "P" are install on bottom, "A" are on top.	
4. Raise pump shaft by tightening the 2 studs together until coupling halves mate.	
5. Lubricate and install the remaining 10 studs	
6. Torque to 285 ft-lbs., then 575 ft-lbs.	
a. Commonly done with “Baby Biach” tensioners	
b. Height above the flange must be measured	**Slide** [back one from baby Biach
7. Torque until elongated by .63mm or .0248".	**Slide** [Biach pump]
8. Install lower speed sensor disc	**Slide** Ask why not earlier? ANS: Couldn't install coupling bolts with sensor in position.
9. Install pressure seal instrument piping	
10. Reinstall blank flange on seal housing drain line.	

CONTENT	METHODS & ACTIVITIES
II. Install the Motor	
A. Reverse of removal	
B. If it is necessary to rotate the motor shaft, the motor rotor lifting device must be installed.	
III. Align the Flexible Coupling	
A. Taking Measurements	
1. Shaft does not have to be rotated	
2. Indicator is moved to eight locations around the flange	
B. Measure parallel offset	**Slide** shows setup for offset (make sure they know what "offset" is)
C. Check for angular misalignment	**Slide** shows setup for angular (make sure they know what "angular" is)
D. Use chart to see if the combined misalignment is acceptable	**Slide** is chart for acceptability
1. If not acceptable, jacking screws on the motor support stand top flange may be used to move the motor.	
2. 50 tons being supported by the polar crane will allow the jacking bolts to move the motor on its stand.	Remind them that the motor weighs 60 tons.
E. Release crane weight	
F. Torque capscrews on the motor support stand	**Slides** shows the capscrews and interferences for torquing
1. Alignment will have to be monitored during torquing to ensure the torquing does not misalign the coupling.	
2. Torque to 3050 ft-lbs.	

CONTENT	METHODS & ACTIVITIES
IV. Couple the Flexible Coupling	**Slide**
A. Secure diaphragm pack and adaptor assembly to coupling half mounted on motor shaft	
B. Torque to 325 ft-lbs	
V. Reinstall the Oil and Water Lines	**Slide**
A. O-ring on horizontal thrust bearing cover flanges have the groove in the piping side (CRDR 2384324)	
1. Have been known to fall out of the groove	
2. When Component Cooling water was introduced, many gallons of water entered the Kennet unit.	
B. Precaution on union fitting under the protective cover	**Slide**
1. Can loosen entire vertical tubing	
2. Can create a leak that is a fire hazard (HP tubing)	
3. Special wrench to hold that tube while tightening the union	Simply an open end wrench narrowed down to fit into side flange opening
VI. RCP Events of note	
A. Situation 1 (PVNGS, U-1, 10/23/96, CRDR 97-0031)	**Slides (3)** to assist in identifying what happened. Use as desired.
1. During testing of RCP 2B, it was found that the phase rotation was backwards	
2. Desired to continue testing other pumps	

CONTENT	METHODS & ACTIVITIES
3. Desired to perform “sweeps” on the other RCPs a. Worked out how to hold RCP 2B still while continuing to perform sweeps on the other RCPs b. Spanner wrench installed in RCP 2B to prevent reverse rotation c. EER that was used to evaluate a previous case did not account for the same situation 4. Lesson learned a. Spanner wrench is for holding during torquing or turning the shaft only b. Use of a tool for other than its designated purpose requires engineering evaluation	
B. Situation 2 (PVNGS U-1, 10/25/96, CRDR 97-0029) 1. Performance of 31FT-9RC01, RCP Lube Oil Collection System Inspection a. One step states “Verify Kennet Unit Flexible Cover is in good condition and installed.” b. Accepted October 21-24 (2B on Oct. 24) c. NRC inspector questioned the condition of the 2B cover on October 25.	**Slides** show the Kennet Unit and its cover if desired for illustration

CONTENT	METHODS & ACTIVITIES
2. Acceptance criteria	Point out the problems with acceptance criteria and **ask** what they should do under these circumstances
a. 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...*"	
b. Ability to meet this is subjective according to the individual doing the inspection	
3. Contributing factors	
a. Working in the area, people used the Kennet unit for a walkway	
b. Walking on the fabric damages it severely	
4. Corrections	
a. New Kennet covers manufactured and installed in each of the units at their next outage	
b. Specific criteria for acceptability of Kennet covers has been established	

CONTENT	METHODS & ACTIVITIES
VIII. OE 17820 [Braidwood – inadequate procedures]	Use this OE to emphasize their responsibility to ensure lessons learned are properly documented
A. Event Description	
1. RCP motor was being reassembled	
a. Part of this was to center the 9-foot long shaft in the bearings to ensure .007" clearance from Q-class backup radial bushing	
b. Shaft was supported from the bottom, allowing the rotor to lean during the centering process	
2. After completion, the motor was started for an uncoupled run	
1) After a few minutes, the upper bearing heated to 60ºF above the melting point of the bearing surface material	
2) Stopped and inspected – only minor damage occurred	
3. Cause	
a. Special centering fixture that bolts to the motor was not used and not specified in the work document	
b. The need to have the shaft hanging from the thrust bearing and the motor level to within .07º was not in the work document or tech manual – only in Westinghouse training materials	Could note that a carpenter's level was used, but that was not precise enough
c. The step for shaft centering says to "center the thrust runner within the upper thrust bearing support" – that's all the instruction	

CONTENT	METHODS & ACTIVITIES
d. Basically, inadequate instruction and inadequate corrective action based on this same problem in other equipment	
4. Expectation	Discuss actions to prevent here
a. Ensure your work documents have adequate information to perform the work	
b. If information is found or discovered during the task, ensure it gets captured – these pumps do not get worked on a lot	

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. 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.