PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson

Mechanical Maintenance Training	**Date: 10/26/2010**
LP Number: NME30C000202	**Rev Author: CURT CLUFF**
Title: Mechanical Seal Assemblies	**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 13:32:43 -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 14:33:41 -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

N001-0602-00644 - Sultzer-Bingham Seals

DMWO 2774550, Addition of backup ring [also DMDI 2911439]

LESSON PLAN REVISION DATA

Oct 26, 2010	Curt Cluff	Minor rewording and refining for clarification and incorporation of DMWO 2774550 [TCSAI 3277044]

Tasks and Topics Covered

The following tasks are covered in Mechanical Seal Assemblies :

Task or Topic Number*	Task Statement
Lesson:	Mechanical Seal Assemblies
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 components in the Reactor Coolant Pump seal and state steps to disassemble, inspect, repair, and reassemble Reactor Coolant Pump seal assemblies in accordance with maintenance procedures 31MT9RC26 AND 31MT9RC22. as demonstrated by passing the final written exam with a minimum grade of 80%.

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

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

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

1.4 State the steps needed to assemble seal assemblies I, II, and III.

CONTENT	METHODS AND ACTIVITIES
I. Motivation A. Seal maintenance is the most common mechanical task on the RCPs B. A seal failure at PVNGS caused leakage into the pump bowl 1. Resulted in damage to several RCP nuts and studs. 2. Some had to be replaced prior to pressurizing the reactor C. High frequency of RCP seal failures has prompted utilities and vendor reps to review the subject in detail. Some of the major causes were identified as follows: 1. Improper maintenance—errors in installation and refurbishing of seals, such as placing them in the wrong orientation, failure to vent them properly, or omitting the placement of O-rings, have resulted in failures. 2. Foreign material present 3. Human errors 4. Excessive Vibrations D. Recommendation: Plant personnel should be trained and qualified for RCP seal maintenance to ensure quality work and minimize radiation exposure per ALARA program requirements. Consider using seal mockups, vendor training or job performance aids to improve expertise.	Focus student attention on "What's In It For Me".

CONTENT	METHODS AND ACTIVITIES
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 the Reactor Coolant Pump seal and state steps to disassemble, inspect, repair, and reassemble Reactor Coolant Pump seal assemblies in accordance with maintenance procedures 31MT9RC26 and 31MT9RC22 as demonstrated by passing the final written exam with a minimum grade of 80%.	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 Explain the Principles of Operation of the Mechanical Seal Assembly.	
EO02 Identify components in Seal I, II, and III and their functions.	
EO03 State the steps necessary to disassemble seals I, II, and III.	
EO04 Define acceptable/unacceptable flaws on seal assembly components.	
EO05 State the steps needed to assemble seal assemblies I, II, and III.	

TO: 1 Given tech manual and maintenance procedures, the maintenance mechanic will , identify components in the Reactor Coolant Pump seal and state steps to disassemble, inspect, repair, and reassemble Reactor Coolant Pump seal assemblies in accordance with maintenance procedures 31MT9RC26 AND 31MT9RC22. as demonstrated by passing the final written exam with a minimum grade of 80%.

EO: 1.1 Explain the Principles of Operation of the Mechanical Seal Assembly.

CONTENTS	METHODS & ACTIVITIES
I. Basic Seal Description	**Slide –** Picture of a Seal to guide through this discussion
A. Three sets of rotating and stationary surfaces in close contact	
B. Fluid between them is enough for lubrication and cooling	
C. The spring is for proper face loading to determine proper leakoff amount	
D. Static seals to prevent bypassing the dynamic seal, rendering them virtually ineffective.	
II. Operation of RCP Seals	**Slide –** Picture of an individual seal--point out the relative parts described in the basic seal
A. Three single seals in series	
B. Entire seal arrangement has clean fluid entering under the first stage	**Slide –** Picture of entire seal arrangement
1. Some of the water goes down through the bearing, keeping out the fluid directly from the reactor coolant system	
2. Remaining water goes either through the seal or bypasses the seal to be cooled and minimize the heat to the second stage seal	

CONTENTS	METHODS & ACTIVITIES
3. The second also has a bypass for cooling prior to contacting the 3rd stage seal	
4. The third stage has a leakoff and the excess goes to the Reactor Drain Tank	
III. Associated Systems	**Slide –** Plant drawing showing system interrelations labeled
A. Chemical and Volume Control	
B. Reactor Drains	
C. Nuclear cooling	

EO: 1.2 Identify components in Seal I, II, and III and their functions.

CONTENTS	METHODS & ACTIVITIES
I. Seal Retainer	**Slide –** Seal picture for configuration of parts
A. The exterior boundary of the seal assembly	
B. Housing for the stationary parts of the seal assembly.	
II. Shaft Protection Sleeve	**Click**
A. Interior boundary of the seal assembly	
B. Holds the rotating elements of the seal assembly	
III. Carrier Ring	**Click**
A. Holds the stationary seal face-the stationary half of the sealing surface	
B. Springs between the carrier and the seal retainer push the sealing faces against each other to establish the desired leakoff rate	

CONTENTS	METHODS & ACTIVITIES
IV. Rotating Seal Ring	**Click**
A. Attached to the flange of the shaft protection sleeve	
B. Rotating face of the seal assembly—contains the rotating half of the actual sealing surface	
V. Drive Pins	**Click**
A. Hold seal assemblies to each other	
1. Inner ones hold shaft protection sleeves together	
2. Outer ones hold seal retainers together	
B. Must be pulled to separate seal assemblies	
VI. Seal Cover	**Slide**
A. On the bottom of the Seal I assembly, surrounding the seal retainer	
B. Keeps the shaft protection sleeve assembly captured inside the seal retainer assembly	
VII. Items which can be used to distinguish the different seals	**Slide**
A. Top of Seal III assembly is relatively flat	**Click**
1. Does not need to be pinned to an assembly above it	
2. Has a leakoff port for water that leaks past the seals	
B. Bottom of Seal I	**Click**
1. Includes a Seal Cover	
2. Has a pin that needs to align with the feed screw	

CONTENTS	METHODS & ACTIVITIES
C. Diameters	
1. Seal III is the largest outside diameter, the smallest inside diameter	
2. Seal II is about .080” smaller on the OD and .080” larger on the ID	
3. Seal I is about .080” smaller than II on the OD and .080” larger on the ID	

EO: 1.3 State the steps necessary to disassemble seals I, II, and III.

CONTENTS	METHODS & ACTIVITIES
I. Seal Cartridge Disassembly	This assumes the seal assemblies went to the rebuild area as a single cartridge
A. Install the sleeve jacking tool on the Seal III if not installed	Use procedure pictures to illustrate the steps
1. Ensure the “halo” is locked in place	**Slide**
2. Tighten the jacking screw until the drive pins between Seal III and Seal II seal retainers are loose	
B. Remove Seal III	
1. Back off the jacking screws and remove the 2 inner drive pins	**Slide**
2. Remove Seal III and put in storage container	**Slide**
C. Repeat with Seal II assembly	
D. Place Seal I in a storage container also	**Slide**

CONTENTS	METHODS & ACTIVITIES
II. Seal I disassembly	**Slide**
A. Preparation	
1. Record pump ID number and seal serial number	
2. Set Seal I assembly on blocks to protect the dowel pin in the shaft protection sleeve	Show on slide
B. Separate rotating and stationary subassemblies	
1. Tighten jacking screws enough to insert carrier retainers	**Click**
2. Spring gap should be about 1/8” when able to install carrier retainers	Point out gap on slide
3. Back off jacking screws until carrier is held by retainers	**Prevent Events:** Self-check/STAR. Ensure the retainers are holding before removing the jacking tool
4. Remove the drive pins, then lift the seal retainer and shaft protection sleeve assemblies off the seal cover	**Slide**
5. Remove seal cover and lower the Seal I assembly back onto the ¾” blocks	**Slide** show resting on blocks to protect pin
6. Remove the sleeve jacking tool	
7. Hold shaft protection sleeve subassembly in place and lift the seal retainer/carrier subassembly off	
C. Disassemble shaft protection sleeve subassembly	
1. Remove O-ring from ID	**Click**
2. Lift rotating seal ring straight up and off the shaft protection sleeve	Mention, then New **Slide**, show parts
a. Set face up on a soft, clean surface	**Click**

CONTENTS	METHODS & ACTIVITIES
b. Remove the centering O-rings	**Click**
c. Remove the rotating seal support ring and the “face” O-ring	**Click**
d. Remove the anti-rotation pin from the shaft protection sleeve	**Click**
D. Seal Retainer/Carrier Disassembly	
1. Remove the 2 O-rings from the OD	
2. Set in Spring Compression tool	**Slide**
a. Place the spring compression tool on the work table and disassemble	
b. Attach seal retainer holder to the retainer	Note holder, seal retainer, then change **slide**
1) with the proper alignment	Again note holder and position of markings **Click**
2) Anti-rotation lug lined up with punch marks on seal retainer holder	**Click**
c. Place seal retainer/carrier assembly in carrier holder	New **slide**
1) Punch marks on carrier holder show location of anti-rotation lug	
2) Allows pins in carrier holder to align with holes in carrier face	**Slide** Note pin position
d. Install handwheel on each of the 3 threaded rods	
3. Separate carrier assembly from retainer assembly	Show parts being operated
a. Turn down handwheels until the carrier retainers can be removed	**Click**
b. Back off the handwheels evenly until spring support the seal retainer	

CONTENTS	METHODS & ACTIVITIES
c. Remove the handwheels and lift the seal retainer subassembly off the carrier	
d. Remove springs, O-rings and backup ring from the carrier and remove the carrier/stationary seal ring subassembly form the carrier holder	
4. Seal Retainer disassembly	New **slide** – point out parts
a. Remove Spirolox retaining ring	
b. Turn over on 2” blocks and install installation tool	New **slide**
c. Using a soft hammer, tap the secondary seal sleeve out	
d. Remove O-ring	
5. Carrier/Stationary Seal Ring disassembly	New **slide**
a. Remove Spirolox retaining ring and the retainer ring	
b. Remove O-ring and backup ring by poking with sharp awl or equivalent	**Prevent Events:** 2-minute drill care not to scratch seating surfaces
c. Lift stationary seal ring out of carrier	
E. Seal II and III assemblies	New **slide**
1. Do not have the covers on the bottom	Point out lack of cover
2. Essentially the same process for the remaining steps	

EO: 1.4 State the steps needed to assemble seal assemblies I, II, and III.

CONTENTS	METHODS & ACTIVITIES
I. Inspection	**Slide** of partially disassembled seal assembly, can point to parts as desired
A. Comprehensive inspection criteria is contained in the procedure	
B. O-rings and springs are also inspected	
1. Not reused	
2. Inspection is for potential failure analysis	
C. Several dimensions taken that are critical to seal operation	
II. Assemble Seal Retainer Subassembly	Use procedure pictures to illustrate
A. Seal Sleeve Installation	New **slide**, show sleeve installation
1. Dow Corning 55 O-ring lubricant	
2. Install O-ring	
3. Carefully guide seal sleeve into seal retainer	
4. Using installation tool and soft mallet, tap the sleeve into the retainer until it bottoms	
5. Install the Spirolox retaining ring	

CONTENTS	METHODS & ACTIVITIES
B. Reassemble Carrier subassembly	
1. Determine which carrier and stationary seal go together based on critical dimensions	**Prevent Events:** self-checking to ensure the proper parts are assembled
2. Install O-ring on Stationary Seal Ring	New **slide**, show parts during assembly
a. Set Seal Ring on a soft cloth face down (chamfer side up)	
b. Lightly lubricate O-ring	
c. Slide down until about 1/8” from the front edge	Show location on next **slide**
d. Repeat with the backup ring with the concave side facing the O-ring until it touches the O-ring	
e. Clean backside surface with lint-free cloth to remove any excess lubricant from the OD	
3. Install Stationary Seal Ring into carrier	Show this installation on the next **slide**
a. Orient the Stationary seal ring face up over the carrier	
b. Set the ring down into the carrier – the O-ring will hold the seal ring up	
c. Carefully place the O-ring installation tool over the stationary seal ring and press the O-ring into the carrier O-ring groove	**Prevent Events:** The tolerance is close, so 2 minute drill to evaluate how to not chip the seal
d. The stationary seal ring should be seated against the carrier at this time	
4. Place the retainer ring over the O-ring and secure with the Spirolox retaining ring	Next **slide**
5. Wipe the seal ring with a clean, lint-free cloth	

CONTENTS	METHODS & ACTIVITIES
6. Turn the carrier over and install O-ring and backup ring	
III. Assemble Shaft Protection Sleeve Subassembly	
A. Place shaft protection sleeve on the Sleeve Compression tool baseplate	Next **slide**
1. If Seal I assembly, a minimum ¼" keystock will be required to protect the pin	
2. Insure the anti-rotation pin is installed in the shaft protection sleeve	Next **slide**
3. Determine which protection sleeve and associated parts go together based on critical dimensions	**Prevent Events:** self-checking to ensure the proper parts are assembled
a. The thickest stationary seal ring [Dimension T] is assigned to Seal I, the thinnest to Seal III	Next **slide**, **click** again to show which dimension
b. The thickest carrier is assigned to Seal I and the thinnest to Seal III	Next **slide**, **click** again to show which dimension
4. Calculate the clearance between the end of the anti-rotation pin and the bottom of the hole in the rotating seal ring (.005" min)	Next **slide** and follow the identified measurements
B. Assemble rotating seal to the shaft protection sleeve	
1. Install O-rings and support ring	
a. Install one "centering" O-ring in grove	Next **slide**
b. Install a dry (no lube) "face" O-ring	
c. Press the support ring by hand over the "centering" O-ring	Next **slide**
d. Lightly lubricate other "centering" O-ring and install it in the upper "centering" O-ring groove	Next **slide**

CONTENTS	METHODS & ACTIVITIES
e. Install dry “face” O-ring to the backside O-ring groove of the rotating seal ring	**Slide**
2. Install the rotating seal ring	
a. Press down by hand	
b. Visually check that all O-rings are still in their grooves, not slipped off	
IV. Assemble Carrier Subassembly to the Seal Retainer Subassembly	
A. Prepare Spring Compression tool	Next **Slide**
1. Remove handwheels	
2. Set adjusting nuts to approximately height “H” for installing springs	
B. Set carrier subassembly on the carrier holder	Next **slide**
1. Aligning the pins	
2. The anti-rotation lug aligned with the punchmark	
C. Set seal retainer subassembly into the spring compression tool	Next **slide**
1. Attach seal retainer holder to the seal retainer, aligning the anti-rotation slot with the punch marks	
2. Position the seal retainer over the carrier holder and align the slot with the lug on the carrier	
3. Lower the retainer over the threaded rods until the seal retainer holder rests on the nuts	Next **slide**

CONTENTS	METHODS & ACTIVITIES
D. Connect the two assemblies	
1. Install the 30 springs between the seal retainer and carrier	Point out spring installation
a. Into seal retainer first	
b. Compress slightly and guide into the corresponding hole in the carrier	
c. Use a mirror and verify all springs are installed correctly	Next **slide**
2. Lower the retainer assembly until the weight is supported by the springs	
3. Using handwheels, lower the seal retainer until the anti-rotation lug and slot are ready to engage	
a. Verify they are aligned	
b. Rotate as necessary to align	
4. Use handwheels and lower the Seal Retainer subassembly over the carrier subassembly	**Prevent Events:** Self-checking – no turning back after assembly
a. Handwheels should turn easily – they should not have to be forced	
b. Verify O-rings are not being pinched/damaged	Next **slide**
c. Use a mirror to ensure proper engagement while aligning	
5. Install carrier retainers	
6. Remove handwheels	Next **Slide**
7. Lift seal retainer/carrier subassembly and set it on the assembly bench	
8. Remove the eyebolts and seal retainer holder	

CONTENTS	METHODS & ACTIVITIES
V. Complete assembly	
A. Seal I	Same slide
1. Set seal retainer cover on the baseplate with ¼" keystock	
2. Set the Seal I shaft protection sleeve subassembly on the baseplate	
3. Install Seal Retainer assembly	
a. Wipe rotating and stationary seal faces with lint-free cloth	
b. Align the 4 drive-pin holes and lower the Seal I retainer/carrier onto the seal cover	
c. Install 4 drive-pins	
4. Lubricate and install O-ring on inside of shaft protection sleeve	
5. Lubricate and install O-rings on the outside of the seal retainer	
B. Seal II final assembly/installation	
1. Set the Seal II shaft protection sleeve subassembly on the Seal I assembly	New **Slide**
2. Install 2 drive pins	
3. Install seal retainer and O-rings the same as with Seal I	
C. Seal III final assembly/installation	
1. Set the Seal III shaft protection sleeve subassembly on the Seal II assembly	New **slide**
2. Install 2 drive pins	
3. Install seal retainer and O-rings the same as with Seal I	

CONTENTS	METHODS & ACTIVITIES
D. Install shaft jacking tool	New **slide**
1. Tighten the jacking screws	
2. Remove the nine carrier retainers	
VI. Seal Setting Measurement	New **Slide**
A. Install sleeve compression tool	
1. Install tool plate, washer, and nut on threaded rod	
2. Tighten to clamp the shaft protection sleeves together	
B. Back off the jacking screws	
1. Read 0.250” ± 0.005” seal setting gap	
2. All three should read 0.240” to 0.300”.	
3. Measure the “K” dimension to determine the seal setting gap when installed	
C. Seals can now be fitness tested and installed	New **slide** (info only)
1. Installation must be within 120 days of fitness test	
2. Fitness test verifies all three seals are installed correctly	

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.