

# PALO VERDE NUCLEAR GENERATING STATION

## Mechanical Maintenance Training

### Classroom Lesson



<b>Mechanical Maintenance Training</b>	<b>Date: 7/23/2010 6:58:21 AM</b>
<b>LP Number: NMC61C000802</b>	<b>Rev Author: LEE BAKER</b>
<b>Title: Bearings</b>	<b>Technical Review:</b>
<b>Duration : 3 HOURS</b>	<b>Teaching Approval:</b>

**Title: Bearings**

**Lesson Plan #: NMC61C000802**

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**INITIATING DOCUMENTS**

Task Analysis of Tasks

**REQUIRED TOPICS**

None

**CONTENT REFERENCES**

Cognizant Engineer (P. Curry)

PM Task # 007516

VTM-C628-001: Diesel Generator Tech Manual

VTM-C628-002: Diesel Generator Auxiliaries

**LESSON PLAN REVISION DATA**

Jul 23, 2010 Lee Baker

Revised Lesson Plan to:

Incorporate Human Performance and Prevent Events strategies [TCSAI 3478459]

Add systems training tie-in of the Class Electrical systems [TCSAI 3260637]

Include OE from IN 07-27 [TCSAI 3319710]

Tasks and Topics Covered

The following tasks are covered in Bearings :

Task or Topic Number*	Task Statement
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Lesson: Bearings

EDG003	Locate a tripped main or connecting rod bearing temperature shutdown detector
EDG004	Perform routine maintenance on emergency diesel engine
EDG010	Troubleshoot emergency diesel engine

Total task or topics: 3

**TERMINAL OBJECTIVE:**

- 1 Given applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain preventive maintenance associated with the EDG Bearings, demonstrated by passing a written exam with a score of 80% or better.
  - 1.1 Describe the EDG Bearings giving location, function, basic operation and construction
  - 1.2 Explain the routine preventive maintenance performed on the EDG Bearings

**CONTENT****METHODS AND ACTIVITIES**

<p>I. Motivation</p>	<p>Focus student attention on “What’s In It For Me”.</p>
<p>II. Pre-Job Brief</p> <p>A. Pre-job briefing on the day’s activities modeling the use of the Palo Verde Standards &amp; Expectations, Preventing Events</p> <p>B. Focus On Five (Task Preview)</p> <p>Familiarize worker with the scope of work, task sequence, and critical steps.</p> <p>1. Critical Steps (Terminal Objectives)</p> <p>Given applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain preventive maintenance associated with the EDG Bearings, demonstrated by passing a written exam with a score of 80% or better</p> <p>2. Identify error likely situations (error traps)</p> <p>a. Discuss at least one specific error likely situation.</p> <p>3. Identify the Worst thing that can happen.</p> <p>4. Identify specific error prevention defenses to be used.</p> <p>5. Identify actions to assure proper configuration control.</p> <p>C. Break policy</p> <p>1. Two Minute Drill – After lunch at a minimum</p>	<p>PVNGS Standards &amp; Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.</p> <p>Look at Error Precursors in S&amp;E book</p> <p>Apply to the setting you’re in. (Lab versus Classroom)</p> <p>What defenses can we employ to prevent the “Worst thing that could happen”</p> <p>This may not be applicable in every training setting.</p> <p>At Instructor’s discretion, not to interrupt class flow.</p>

**CONTENT**

**METHODS AND ACTIVITIES**

III. Lesson Enabling Objectives

Read and/or discuss the lesson objectives

EO01 Describe the EDG Bearings giving location, function, basic operation, and construction

EO02 Explain the routine preventative maintenance performed on the EDG Bearings

**TO: 1** Given applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain preventive maintenance associated with the EDG Bearings, demonstrated by passing a written exam with a score of 80% or better.

**EO: 1.1 Describe the EDG Bearings giving location, function, basic operation and construction****CONTENT****METHODS AND ACTIVITIES**

- I. Bearing Descriptions
  - A. Main Bearings
    - 1. Location
      - a. Intermediate Bearings (11 ea)
        - 1) Located at ends of crank-shaft, on either side of crankshaft sprocket and between all cranks except 5 and 6
        - 2) Center Bearing (1 ea)
          - a) Located between cranks 5 and 6
    - 2. Function
      - a. Support the crankshaft within the engine and provide a surface for the shaft to rotate on
    - 3. Operation
      - a. Oil is carried from main oil header to main bearing caps by flexible hose lines
        - 1) These hoses "age harden" and must be replaced periodically
      - b. A groove in center of bearing shell matches oil inlet passage in bearing cap
      - c. From the main bearing oil flows through drilled crankshaft to two adjacent crankpin bearings
      - d. Each bearing is equipped with two high temperature shutdown detectors



CONTENT	METHODS AND ACTIVITIES
<p>4. Construction</p> <p>a. Tri-metal, split shell, precision-plated bearings</p> <p>b. Bearing caps are dowelled to centerframe to insure accurate alignment</p> <p>c. Each Bearing consists of 2 identical shells</p> <p>    1) Each shell has a tang on one end which engages a milled groove in arch of bearing cap to assure accurate alignment</p> <p>d. Height of each shell is larger than one-half the outside diameter to provide a crush or squeeze when assembled</p> <p>e. <b><u>CAUTIONS</u></b></p> <p>    1) <b><i>Shims are not to be used to adjust bearing clearance.</i></b></p> <p>    2) <b><i>Do not file bearing caps to reduce bearing clearance</i></b></p> <p>    3) <b><i>Replace both shells when bearing clearance becomes excessive</i></b></p>	<p><b>ARE THESE BEARINGS BABBIT LINED?</b></p>
<p>5. Unit 3 EDG connecting rod failure</p> <p>a. diesel was on a test run when a loud noise was heard and it began to overspeed</p> <p>b. It was tripped, but continued to run</p> <p>c. A piston had gone through the side of the diesel generator, and air was being sucked into the crankcase and feeding the cylinders with air and fuel (the lube oil)</p> <p>d. Firefighters filled the crankcase with foam to shut down the diesel</p>	<p>PVNGS OE 1934</p> <p>What Happend</p>

**CONTENT****METHODS AND ACTIVITIES**

- e. Cause was determined to be a fabrication error. Original bore was improperly drilled for the master connecting rod bearing
- f. Weld buildup was used to repair, and rebore the hole
- g. The weld buildup was of a material not capable of handling the abuse it received in this application, and it therefore began to crack
- h. The crack propagated through the base metal and sheered the connecting rod

Why Did It Happen

**B. Thrust Bearings****1. Location**

- a. 2 thrust shoes are located on first and second main bearing caps from the flywheel end. Bearings are half circles and are located on the upper half of the crankshaft

b.

**2. Function**

- a. Limit crankshaft end play

**3. Operation**

- a. A machined surface on the crankshaft web contacts the thrust shoes to limit the end play

**4. Construction**

- a. Thrust bearing shoes are half round and have no clearance adjustment

**C. Connecting Rod Bearings****1. Location**

- a. At the end of each master connecting rod

**CONTENT**

**METHODS AND ACTIVITIES**

- 2. Function
  - a. Support the connecting rods on the crankshaft and provide a surface for the connecting rods to drive the crankshaft
  
- 3. Operation
  - a. Annular groove in middle of shell allows lubricating oil to enter the drilled passages in the connecting rod to supply oil to the piston and pin bushings
  
- 4. Construction
  - a. Precision tri-metal, split shell bearing
  - b. Each cap is equipped with two high temperature shutdown detectors
  
- D. Outboard Bearing
  - 1. Location
    - a. Mounted on engine-generator base outboard of the generator
  
  - 2. Function
    - a. Support the crankshaft outboard of the generator and provide a surface for the shaft to rotate on
  
  - 3. Operation
    - a. Self aligning with its own lubrication system

**ARE THESE BEARINGS  
BABBIT LINED?**

**CONTENT**

**METHODS AND ACTIVITIES**

- 4. Construction
  - a. Pedestal-mounted housing containing a babbitt-lined split bearing
  - b. Bearing alignment is achieved by raising or lowering the bearing housing by means of shims between the pillow block and the soleplate
  - c. Insulating material is installed between the pillow block and soleplate
  - d. Prevents bearing damage from electrical sources

**EO: 1.2 Explain the routine preventive maintenance performed on the EDG Bearings**

**CONTENT**

**METHODS AND ACTIVITIES**

I. Surveillance

A. Foundation Fastener Torque Check

1. Purpose

- a. This ensures engine frame is secure and that engine alignment will not change. Care must be taken to **monitor body position** as achieving the following torque values takes significant effort

*Explain Why body position is important*

2. Basic Procedure

- a. Check torque of 1 1/2" foundation fasteners
  - 1) Minimum torque of 1455 ft-lbs not to exceed 10%, 1600.5 ft-lbs
  - 2) If fasteners are not at this torque tighten to proper torque
- b. Check torque of 1 1/4" foundation fasteners
  - 1) Minimum torque of 835 ft-lbs not to exceed 10%, 918.5 ft-lbs

*Are there any safety, PPE, concerns*

*Good place for a peer check*

B. Measure Crankshaft Web Deflection

1. Purpose:

- a. Insures crankshaft and main bearings are in alignment

**CONTENT**

**METHODS AND ACTIVITIES**

2. Hot Web Deflection Measurement Basic Procedure:

***NOTE: Engine should not be run less than 4 hours, at load, in order to ensure engine is hot and running properly, prior to performing hot web deflection checks. Procedure should be completed while engine is at or near operating temperature to obtain valid results***

***CAUTION: WAIT AT LEAST 15 MINUTES BEFORE OPENING CRANKCASE DOORS TO INSURE A CRANKCASE EXPLOSION DOES NOT OCCUR***

***TAKE APPROPRIATE PRECAUTIONS WHILE WORKING IN VICINITY OF HIGH TEMPERATURE FLUIDS.***

***THE CRANKCASE IS A CONFINED SPACE. A CONFINED SPACE ENTRY PERMIT IS REQUIRED***

**CONTENT****METHODS AND ACTIVITIES**

- a. Engage Turning gear and insure Test Cocks are open
- b. Insure foundation torque check has been completed
- c. Remove crankcase doors as necessary
  - 1) Remove only one crankcase door at a time, to minimize engine cooldown
- d. Take bearing temperature readings using surface pyrometer at specified locations
- e. Verify crankshaft is bottomed in main bearings
  - 1) Attempt to insert a .005" feeler gauge between the top of the bearing and the shaft
- f. Use a web deflection gage between the counterweights
  - 1) The crank webs have been center punched at the factory
- g. Web deflection readings shall be taken at the 3, 6, and 9 o'clock positions, with the web deflection gage zeroed as high on the cycle as possible
- h. While taking web deflection readings, allow approximately 5 minutes for web deflection gage to equalize temperatures with the crank web
  - 1) When setting gage for temperature equalization, pre-load the gage 1/2 the rod actuation movement, to prevent damage to the indicator and bending of the rods while equalizing
- i. Maximum allowable deflection is 0.003". Any reading greater than 0.003" shall be reported to the WGS and Diesel Engineer
- j. Perform steps c through i for the remaining crankshaft webs

**CONTENT****METHODS AND ACTIVITIES**

3. Cold Web Deflection Measurement Basic Procedure

***NOTE: Allow at least 24 hrs. cooldown prior to performing cold web deflection checks***

- a. Repeat steps c through j for cold web deflection readings

4. Engine Alignment Basic Procedure

- a. Where base is required to be lowered
  - 1) Loosen foundation bolt nuts
  - 2) With jacking bolts raise engine just enough to remove the chock
  - 3) Grind chock and replace
  - 4) Take weight off jacks and retighten foundation bolt nuts
- b. Where base is required to be raised
  - 1) Loosen foundation bolts nuts
  - 2) With jacking bolts raise engine just enough to remove the chock
  - 3) Replace with a new chock. Do not add shims
  - 4) Take weight off jacks and retighten foundation bolt nuts
- c. Perform steps a and b as necessary to remove deflection from crankshaft

- C. Measure Main Bearing Clearance

**NOTE: This procedure may be repeated to ensure validity of results**

1. Drain oil from base of engine and engage turning gear
2. Remove crankcase doors from each side at location to be checked. Maintain FME while doors are removed



**CONTENT****METHODS AND ACTIVITIES**

3. Rotate crankshaft until crankweb, adjacent to the bearing to be checked, is parallel with horizontal center line of crankshaft
4. Place a magnetic base dial indicator on the main bearing cap or on the engine where the stem can be placed against crankshaft

***CAUTION: DO NOT APPLY PRESSURE ON JACK AFTER DIAL INDICATOR READING STOPS OR DAMAGE TO CRANKSHAFT MAY RESULT***

5. Ensure crankshaft is bottomed in bearing to be checked
  - a. Place a hydraulic jack and blocks on the crank web and butt end of jack against center frame rib
  - b. Set indicator on zero and apply sufficient pressure on crankshaft to assure crank is bottomed
    - 1) If no indicator reading is observed, then shaft is seated
    - 2) If indicator shows a down-ward movement of shaft:
      - a) Remove bearing and check for possible wear. If bearing is removed, it shall be replaced
      - b) If bearing is worn, replace it
      - c) If bearing is not worn, engine alignment must be checked
6. Remove hydraulic jack and dial indicator
7. Span bottom of engine base with 6" H-beam across webs in the bottom of the crankcase
8. Place a hydraulic jack on the beam under the crank web
9. Install a dial indicator so it will contact the crankshaft and indicate upward movement

**CONTENT****METHODS AND ACTIVITIES**

10. Ensure dial indicator is zeroed and carefully jack shaft up until dial indicator stops
  - a. Crankshaft is now seated against upper bearing shell
  - b. Reading observed on dial indicator is running clearance
  - c. Bearings that exceed permissible maximum clearance (0.012") must be replaced

*Remind them the bearings must be replaced as a set*

**Troubleshooting note:** Depending upon which bearings are being checked, readings outside what is considered normal may be obtained (i.e. bearings near the aft end of the engine may yield different readings due to the weight of the flywheel on the crankshaft). Contact Diesel Engineer for interpretation of these readings.

**D. Measure Connecting Rod Bearing Clearance**

**NOTE: This procedure may be repeated to ensure validity of results**

1. Drain oil from base of engine and engage turning gear
2. Rotate the crankshaft in the clockwise direction and position the "master" rod of the cylinder to be checked at a convenient position at the discretion of the WGS. The clearance can be taken in any order
3. Lay a beam across webs in base or across door openings and place a hydraulic jack on it directly under connecting rod bearing cap
4. Place a dial indicator (with magnetic base) on a crank web with its stem on the master rod bail so that it will indicate up motion, and zero the dial indicator. (Dial Indicator A)

**CONTENT****METHODS AND ACTIVITIES**

5. Locate a second indicator with its stem on the crank web and its base on a main bearing cap so that it will indicate upward motion. (Dial Indicator B)
  6. Raise rod with jack until rod stops moving
    - a. Reading on dial indicator 'A', with its stem on the master rod bail, is bearing clearance
    - b. If dial indicator with its stem on crank web moves (Dial Indicator B), stop jacking immediately since the crankshaft is moving, and damage can result
      - 1) This also indicates that all the clearance has been taken up at the other dial indicator
  7. Bearing clearance is (0.008" - 0.014"). If it is excessive, or if it has increased 0.001" or more from its recorded "new bearing" clearance, remove the bearing, examine it and measure its thickness
    - a. If it shows signs of distress, or if it has decreased 0.001" or more in thickness, replace with a new bearing
- E. Measure Main Thrust Bearing Clearance
- NOTE: This procedure may be repeated to ensure validity of results
1. Insert appropriate size of feeler gages between the forward thrust shoe and crankshaft
    - a. Check 180 degrees around the shoe and record the smallest clearance
  2. Insert appropriate size of feeler gages between the aft thrust shoe and crankshaft
    - a. Check 180 degrees around the shoe and record the smallest clearance

**CONTENT**

**METHODS AND ACTIVITIES**

3. Add the two measurements together to obtain the total thrust clearance
  - a. If total thrust exceeds minimum/maximum clearance allowed (0.010" to 0.024"), initiate corrective action as necessary

## **SUMMARY OF MAIN PRINCIPLES**

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

### **Objectives Review**

Review the Lesson Objectives

Topic 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**

Oral questioning

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

### **Problem Areas**

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

### **Concluding Statement**

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.