

PALO VERDE NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson



Mechanical Maintenance Training	Date: 7/23/2010 6:38:37 AM
LP Number: NMC61C000703	Rev Author: LEE BAKER
Title: Heads, Liners, Pistons, & Connecting Rods	Technical Review:
Duration : 5 HOURS	Teaching Approval:

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

EER 92-DG-030: Service Bulletin 752; Piston Pin End Caps and Lower Oil Scraper Ring Removal

EER 93-DG-013: Service Bulletin 770; Piston and Liner tolerances Piston style/ date identification

EER 93-DG-022: Alternate method of aligning the cylinder liners to frame on installation

LER 3-89-004: EDG Rocker Arm Failure

VTM-C628-001: Diesel Generator Tech Manual

VTM-C628-002: Diesel Generator Auxiliaries

OE 16510 Time pressure causes inadequate emergency diesel maintenance.

TCSAI 2704928 Diesel defficiency trend.

M018-0619 Drawing Note #2 Specifying Loctite Gasket Maker being applied to head.

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]

**Title: Heads, Liners, Pistons, & Connecting
Rods**

Lesson Plan #: NMC61C000703

Tasks and Topics Covered

The following tasks are covered in Heads, Liners, Pistons, & Connecting Rods :

Task or Topic Number*	Task Statement
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Lesson: Heads, Liners, Pistons, & Connecting Rods

EDG001	Dismantle EDG engine (remove cylinder head and pull piston and liner)
EDG002	Reassemble EDG engine (install liner, piston, and cylinder)
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 maintenance performed on the EDG Heads, Liners, Pistons, and Connecting Rods demonstrated by passing a written exam with a score of 80% or better.
 - 1.1 Describe the EDG Cylinder heads and give the function
 - 1.2 Describe the EDG Cylinder head components giving location, function, basic construction and operation
 - 1.3 Explain the basic process to dismantle the EDG Cylinder Heads
 - 1.4 Describe the EDG Pistons and Connecting Rods and their components giving location, function, basic operation and construction.
 - 1.5 Explain the basic process to dismantle the EDG Pistons and Connecting Rods.
 - 1.6 Describe the EDG Liners and give the function
 - 1.7 Explain the basic process to disassemble the EDG Liners
 - 1.8 Explain the basic process to reassemble the EDG Liners
 - 1.9 Explain the basic process to reassemble the EDG Pistons and Connecting Rods
 - 1.10 Explain the basic process to reassemble the EDG Cylinder Heads

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 & 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 maintenance performed on the EDG Heads, Liners, Pistons, and Connecting Rods 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 & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.</p> <p>Look at Error Precursors in S&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 Cylinder heads and give the function

EO02 Describe the EDG Cylinder head components giving location, function, basic construction and operation

EO03 Explain the basic process to dismantle the EDG Cylinder Heads

EO04 Describe the EDG Pistons and Connecting Rods and their components giving location, function, basic operation and construction

EO05 Explain the basic process to dismantle the EDG Pistons and Connecting Rods

EO06 Describe the function of the EDG Liners

EO07 Explain the basic process to disassemble the EDG Liners

EO08 Explain the basic process to reassemble the EDG Liners

EO09 Explain the basic process to reassemble the EDG Pistons and Connecting Rods

EO10 Explain the basic process to reassemble the EDG Cylinder Heads

**Title: Heads, Liners, Pistons, & Connecting
Rods**

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TO: 1 Given applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain maintenance performed on the EDG Heads, Liners, Pistons, and Connecting Rods demonstrated by passing a written exam with a score of 80% or better.

EO: 1.1 Describe the EDG Cylinder heads and give the function

CONTENT

METHODS AND ACTIVITIES

I. Cylinder Heads

A. Function

1. Complete the cylinder enclosure
2. Contain the intake and exhaust valves and the push rods and rocker arms for operating them
3. House the fuel injector
4. House the air start valves
5. Provide ports for exhaust, air intake and jacket water cooling

B. Description

1. Cylinder head made of individual cast mechanite iron
2. Houses eight water connections carrying cooling water from the cylinder liner to the head
3. Secured to cylinder block with studs and nuts
4. A Fire gasket seals the head to the cylinder liner

EO: 1.2 Describe the EDG Cylinder head components giving location, function, basic construction and operation

CONTENT

METHODS AND ACTIVITIES

- I. Component Description
 - A. Main Valves
 - 1. Location
 - a. Two intake and two exhaust valves located in each cylinder head
 - 2. Function
 - a. Intake Valves
 - 1) Open to allow fresh air to enter the cylinder to support combustion
 - b. Exhaust Valves
 - 1) Open to allow gases from combustion to leave the cylinder
 - 3. Operation
 - a. Camshaft works in conjunction with rocker arm assembly to open the main valves against spring pressure in timed relation with engine firing order. Camshafts rotate at half the engine speed and opposite direction of the crankshaft

CONTENT**METHODS AND ACTIVITIES**

4. Construction
 - a. Valve stems are chrome plated
 - 1) This provides a resistance to wear
 - b. Valves are reverse seated to provide positive seating during compression and firing strokes
 - c. Valves ride inside a removable (press fit) guide (bushing)
 - d. Valve seats are removable inserts. Valves and seats are matched sets and are not interchangeable. They are ground at 30 degree angle and lapped for metal to metal seal

- B. Rocker Arm Assembly
 1. Location
 - a. In top of cylinder head
 2. Function
 - a. In conjunction with cams mounted on the camshaft it operates the main valves in timed relation to engine firing order
 - b.
 3. Operation
 - a. As camshaft turns cams (Intake and Exhaust) operate roller
 - b. Roller moves up forcing Crosshead up which in turn forces Push Rod up via Push Rod Bearing
 - c. Push Rod actuates a Rocker Arm (either intake or exhaust) which forces open the appropriate valve
 - d. As the camshaft continues to turn the ball follows the cam down. This reverses the above process and the valve is forced shut by spring pressure

CONTENT

METHODS AND ACTIVITIES

- 4. Construction
 - a. Rocker arms are made of steel and have bushings pressed into place
 - b. An adjustable tappet and hydraulic valve lifter are installed in the valve operating end of each rocker arm. Lifters are manufactured as a set and parts are not interchangeable

EO: 1.3 Explain the basic process to dismantle the EDG Cylinder Heads**CONTENT****METHODS AND ACTIVITIES**

I. Dismantle Cylinder Heads

*Identify the Critical Steps**Identify Error likely situations*

A. Remove Cylinder Head

What is the worse thing that can happen

1. Drain engine coolant
2. Remove fuel line from injection pump to fuel injector
3. Remove breather and head cover from head
4. Disconnect the following
 - a. Fuel drain line and lube oil lines between head and fuel pump
 - b. Lubricating oil line from the head
 - c. Water outlet piping
 - d. Air starting pilot air line and main starting air header
5. Remove test cock valve
6. Move piston to TDC on compression stroke
 - a. This relieves valve spring tension on rocker arms
7. Remove oil line between rocker arm stands
8. Remove rocker assemblies and push rods
9. Install two retaining tools where pushrods were removed
 - a. This tool retains the crossheads in power head while it is being removed
10. Using tool (Nozzle puller) pull fuel nozzle out of head. Using tool, remove copper gasket from bottom of fuel nozzle mounting port
11. Remove cylinder head stud nuts and washers
12. Install bullet noses on studs

CONTENT

METHODS AND ACTIVITIES

13. Install head lifting tool.

Self Check/ Peer Check to ensure that bolts for head lift tool are torqued prior to lifting head

14. Using crane and suitable rigging, slowly raise head off cylinder block and studs and move it to a previously prepared position

NOTE: Head must be lifted off straight so not to damage water connections

a. Use a chain fall between hoist and cylinder head to facilitate handling

B. Remove Main Valves from Cylinder Head

What is the worse thing that can Happen

1. Use spring compressor tool on spring to remove seal, keeper, retainer and spring

CAUTION: MAKE SURE TOOL IS PROPERLY SECURED. SAFETY GLASSES ARE TO BE WORN. VALVE SPRING IS CAPABLE OF EXERTING GREAT FORCE IF THE COMPRESSOR TOOL SHOULD SLIP. FINGERS SHOULD NOT BE USED TO INSTALL OR REPLACE SPRING RETAINER OR KEEPER

2. Mark each valve so it can be installed in same location from which it was removed

3. Remove valves and remove carbon or other deposits. **Do not scrape or nick valves**

C. Inspect and Resurface Main Valves

CONTENT**METHODS AND ACTIVITIES**

1. Area of valve, which contacts the valve seat, should be a smooth band without excessive nicks or inconsistencies. Any indication of leakage requires valve grinding
 2. Check valve stems for straightness and chrome chipping which could lead to guide and cylinder damage. Indication of any of these requires replacement of valve
 3. Check valve for cracks with dye penetrant. If a crack is found replace the valve
 4. Valves may be refaced
 - a. Use tool inserted in holes in valve head to drive valve
 - b. Valve seat angle is 30 degrees. Interference angles are not recommended and both valve and seat should be ground to a true 30 degrees
 - c. Use a suitable valve grinder
 - d. Some small pits are permissible providing they do not exceed 1/16" diameter; however, pronounced steps in valve or seat due to "beat in" must be removed
- D. Remove Main Valve Inserts
- CAUTION: LAYING A BEAD WITH AN ARC WELDER TO SHRINK THE INSERT IS NOT RECOMMENDED BECAUSE OF THE POSSIBILITY OF CRACKING THE HEAD.**
1. Use insert puller to remove all valve inserts
 - a. There is a recess machined under each insert for the use of this tool
- E. Dismantle Rocker Arm Assembly

"Beat in" is effect seen due to valves beating on their seats while opening and closing

CONTENT

METHODS AND ACTIVITIES

1. Remove stands from shaft
2. Remove rocker arms from shafts
3. Remove adjusting screw by loosening nut and screwing adjusting screw out of the arm
4. Remove retaining ring and tappet and lifter, from rocker arm

EO: 1.4 Describe the EDG Pistons and Connecting Rods and their components giving location, function, basic operation and construction.

CONTENT

METHODS AND ACTIVITIES

I. Piston & Connecting Rods

A. Piston

1. Description

- a. One-piece, oil cooled cast iron pistons with seven ring grooves are used. Only six rings are installed as the lower oil control ring has been removed per a modification that has been implemented
- b. Works to compress and ignite (compression ignition) fuel and air mixture in the cylinder and then transfers the resulting force to the connecting rod

CONTENT

METHODS AND ACTIVITIES

2. Construction

a. Piston Bushing

- 1) One-piece, bronze, fitted in each piston. Originally had two metal caps which sealed ends of the bushing, but those were removed when the piston ring mod was incorporated

b. Piston Crown

- 1) Cooled by a continuous spray of lubricating oil, that is directed to underside of piston crown through passages drilled in connecting rods and piston pin

c. Piston Rings

1) Oil Rings

- a) Two rings are used
- b) equipped with expanders and have double scrapers

2) Compression Rings

- a) Cast iron type, installed without expanders

B. Connecting Rods

1. Function

- a. Transfers force of piston to the crankshaft

CONTENT

METHODS AND ACTIVITIES

- 2. Description
 - a. Steel forgings "H" shape sectional design
 - b. Master Connecting Rod
 - 1) All master connecting rods are located on the right side of the engine
 - 2) Two piece construction
 - 3) Cap is secured to rod by studs and nuts
 - 4) Rod is drilled to provide an oil passage to piston pin and to bottom of piston crown
 - c. Articulated Connecting Rod
 - 1) Linked to master rod by a pin in a bronze bushing
 - 2) Pin is doweled and bolted to articulated rod at master rod
 - 3) Rod is drilled to provide two oil passages to piston pin and bottom of piston crown
 - d. Piston pins of both connecting rods are doweled and bolted to a saddle at the upper end of each rod
 - 1) This design provides nearly a full length bearing surface for the pin in the piston

EO: 1.5 Explain the basic process to dismantle the EDG Pistons and Connecting Rods.

CONTENT

METHODS AND ACTIVITIES

I. Dismantle Pistons and Connecting Rod

A. Remove Piston from Master Connecting Rod

NOTE: Piston must be removed from master connecting rod since it is impossible to remove the master connecting rod through the bore of the cylinder

CONTENT

METHODS AND ACTIVITIES

1. Remove Cylinder Head Assembly. Take care to remove carbon ring at the top of the cylinder bore
 2. Engage Turning Gear and remove crankcase cover doors involved
 3. Rotate crankshaft to a position in which piston pin bolts are accessible
 4. Remove piston pin bolts and washers with tools (Wrench to tighten/loosen piston pin bolt) and (Master rod piston pin bolt wrench guide)
 5. Attach tool (piston lifting tool) to piston. Rig lifting tool and piston to overhead crane
 6. Insert a 1" board through the crankcase door and hold it up beside the rod so that the top end of the rod will not fall against the inside of the piston
 7. Raise the piston a few inches while holding the board in place safely
 8. Carefully remove the piston while continuing to hold the top end of the rod with the board so that the rod will not strike the inside of the liner
 9. Tie a leather boot or similar protection over the upper end of the rod, then carefully remove the board
 - a. This protector will prevent damage to the liner wall as the rod slides up or down with crank rotation
 - b. Re-install piston pin bolts to keep piston pin from falling out
- B. Remove Piston from Articulated Connecting Rod

CONTENT

METHODS AND ACTIVITIES

1. If desired the articulated rod may be removed with the piston through the bore of the cylinder. In this case disconnect articulated rod from master rod and do not remove piston from articulated rod. In this way when the piston is removed the articulated rod will still be attached
 2. Same as removing the piston from the main connecting rod
 - a. Rod "H" size is different, and the wrench guide must be designed to fit on the different sized rod (not normally used)
- C. Remove Master Connecting Rod

NOTE: Master Connecting Rods can only be removed via the crank case!

CONTENT

METHODS AND ACTIVITIES

1. Engage Turning Gear, ensure the test cock valves are opened and remove crankcase doors involved
 2. Remove cylinder heads on master and articulated rods associated with the master connecting rod that is to be removed
 3. Remove articulated rod and piston associated with master connecting rod that is to be removed
 4. Remove piston associated with master connecting rod
 5. Using a 1-1/4" eyebolt connected through one of the master rod piston pin bolt holes rig the master rod to the crane via the cylinder bore
 6. Using 1-7/16" eyebolts in articulated rod pin rig the bottom of the master rod to a crane via the articulated cylinder bore
 7. Remove connecting rod cap, studs and washers from the master rod
 8. Rig the master rod out of the engine via the crankcase access doors
 - a. Protect the crankshaft journal with a thick rubber sheet or equivalent
- D. Inspect Master and Articulated Connecting Rods
1. Examine rod for cracks and examine piston pin and articulate rod pin saddles for evidence of galling

CONTENT	METHODS AND ACTIVITIES
<p>2. Two methods to check rods suspected of being bent:</p> <p>a. Swab out oil passage, hold a small light at one end of hole and sight through from other end</p> <p>b. Attempt to pass a straight rod of uniform diameter several thousandths smaller than the actual oil passage diameter (i.e., Drill rod)</p> <p><i>NOTE: If there is any doubt as to whether a rod is bent it should be replaced since once bending begins it may continue at an accelerated rate</i></p> <p>1) measure articulated rod pin to bushing clearance</p> <p>2) Inspect crankshaft journal</p> <p>3) Inspect connecting rod bearing bore and if it is distorted or worn, install a new rod</p> <p>E. Inspect piston</p> <p>1. Remove piston guides and slide pin out bushing</p> <p>2. Thoroughly clean the piston using a carbon removing solvent (Oven cleaner)</p> <p>a. Use a stiff <u>non</u>-wire bristle brush</p> <p>3. Check piston for wear, scoring and scuffing</p> <p>4. Determine piston to cylinder liner clearance</p> <p>a. Two types of pistons, either manufactured before or after 5/1/93</p>	<p><i>Any bending will be noted by light rays being reflected and shadowy</i></p> <p><i>Max. allowable clearance is 0.009"</i></p> <p><i>Actions if reading are out of specification</i></p> <p><i>EER 93-DG-013: Piston/Liner clearances and ring end gap</i></p> <p><i>See work order or tech manual for proper clearances</i></p>

CONTENT	METHODS AND ACTIVITIES
<ul style="list-style-type: none"> b. Measure piston skirt approximately 1" from bottom edge directly below piston pin and at point 90 degrees from pin. <ul style="list-style-type: none"> 1) <i>Pistons manufactured skirt diameters</i> <ul style="list-style-type: none"> a) <u>before</u> 5/1/93 is 13.487" b) <u>after</u> 5/1/93 is 13.485" c. Measure I.D. of cylinder liner d. Subtract piston from liner diameter to get the clearance <ul style="list-style-type: none"> 1) <i>Clearance is 0.012 - 0.018" for pistons manufactured <u>before</u> 5/1/93</i> 2) <i>Clearance is 0.014 - 0.019" for pistons manufactured <u>after</u> 5/1/93</i> 	<p>Use Self Check/ Peer Check when obtaining measurements</p> <p><i><u>New liner bore is 13.499" to 13.500". Worn liner <u>maximum</u> bore is 13.510"</u></i></p> <p>If clearance is outside of these tolerances then inform your supervisor</p>
<ul style="list-style-type: none"> 5. Check ring side clearance <ul style="list-style-type: none"> a. Measure the ring groove width with feeler gages b. Measure the new ring width with micrometer c. Difference between ring groove and new ring width is the ring side clearance d. If ring groove wear is excessive, it can lead to lube oil consumption and/or ring breakage 	
<ul style="list-style-type: none"> 6. Check piston ring end gap <ul style="list-style-type: none"> a. The proper method is to "insert each ring into the liner (the liner that the ring is going to be used in) and then measure the end gap" using feeler gauges 	<p><i>EER 93-DG-013: Piston/Liner clearances and ring end gap</i></p>
<ul style="list-style-type: none"> 7. Check piston pin bore for wear and scoring 8. Using an inside micrometer, measure piston pin bushing I.D. at two points on each end of bushing 	<p><i>Show where measurements taken on piston or draw on board</i></p>

CONTENT**METHODS AND ACTIVITIES**

9. Measure piston pin at two positions on each end of pin
NOTE: Pins subjected to heat distress (usually identified by a rainbow blue effect) must be replaced. Pin finish and diameter are critical. Do not attempt reconditioning
10. Check connecting rod studs, piston pin bolts, and articulated-pin bolts for damaged threads and cracks
 - a. Replace questionable items
- F. Remove piston oil wiper and compression rings
NOTE: When rings are removed new rings have to be installed
 1. Using tool (Ring expander)remove piston rings one at a time
- G. Remove piston pin bushing
CAUTION: DURING REMOVAL OF PISTON PIN BUSHING BE EXTREMELY CAREFUL NOT TO CUT INTO THE PISTON
 1. Cut through bushing at bails to relieve press fit
 2. Remove bushing dowels and remove bushing

EO: 1.6 Describe the EDG Liners and give the function

CONTENT

METHODS AND ACTIVITIES

I. Liners

A. Function

1. Bore is machined and honed to precise dimensions to provide for a close tolerance fit with the piston and its rings which ride up and down inside the liner

B. Description

1. Rests in a counterbore in bore of the cylinder block about six inches below the top
2. A gasket composed of a synthetic rubber binder and asbestos filler is used between the liner and its seat in the counterbore
3. Liner is cooled by jacket water circulating between the liner and the cylinder block

EO: 1.7 Explain the basic process to disassemble the EDG Liners

CONTENT

METHODS AND ACTIVITIES

I. Dissassembly

A. Remove Cylinder Liner

1. Remove four studs that are located in the threaded puller screw locations
2. Remove drain plug and drain coolant from liner seal
3. Remove hold-down capscrews that secure cylinder liner to cylinder block
4. Remove "O-Rings from water connections and discard
5. Match-mark expansion seal to facilitate reassembly
6. Carefully remove flange, gasket, split flange, gaskets and expansion seal by removing capscrews

Troubleshooting Note: If water is found in the oil, check expansion joints for damage as they are thin walled and susceptible to injury during maintenance activities

7. Thread four capscrews (jacking bolts) into stud holds with cylinder liner lifter under two of them 180 degrees apart

CAUTION: IF A JACK IS USED FROM BELOW THE LINER TO LOOSEN LINER, THE EXPANSION SEAL MUST BE REMOVED FIRST

8. Tighten screws evenly until liner is pulled loose and capscrews are tightened on the lift rig
9. Using crane and suitable rigging slowly lift liner out of block
10. Remove the remaining four (4) head studs

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EO: 1.8 Explain the basic process to reassemble the EDG Liners**CONTENT****METHODS AND ACTIVITIES**

I. Reassemble the Liners

A. Installing the Cylinder Liner - Old Method

1. Apply "Loctite Plastic Gasket" to gasket surface on cylinder block
2. Lower cylinder liner over studs and into cylinder block with lifter and align using liner positioning tool

NOTE: EER 93-DG-022 offers an alternate method of installing the cylinder liners by temporarily rigging/bolting the head to the liner and using the head as the guide. When this method is used, care must be taken to ensure that the head to liner index (head to liner position) is correct

- a. Install pin (6), in the head inlet valve push rod opening (9). This opening is on the centerline of the cylinder bore. Tighten pin locking nut (10)
- b. Remove O-rings from the two water connection holes and assemble the two guides (7)
- c. Attach a lifting device to the eyebolt (5), and carefully insert the pin (6), into the support (2), while lowering the positioner
- d. Support the positioner tool with blocks, then attach the lifting device to the lifter, and with the liner supported by the lifter, turn the liner until guides, (7), align with the two water connections in the liner
- e. Remove the blocking and lower positioner on pin (6), until guides (7), are engaged with the liner water connections
- f. Now the liner and water connections are in correct position to engage the head

CONTENT

METHODS AND ACTIVITIES

3. Place a heavy hairpin type clamp across top of liner and over two head studs 180 degrees apart
 - a. Tighten nuts down evenly on both studs to seat liner
 4. Remove nuts and hairpin clamp
 5. Secure cylinder liner to cylinder block with capscrews and washers
 6. Apply gasket cement to split flange gasket and position it on bottom of cylinder block
 7. Position expansion seal against gasket and secure with split flange and capscrews
 - a. Tighten capscrews finger tight
 8. Apply gasket cement to lower flange gasket, position it between expansion seal liner
 - a. Align holes and install flange to liner and seal securing with capscrews
 9. Tighten capscrews on split flange
 10. Install new "O-Rings on liner water connections
- B. Installing the Cylinder Liner - New Method
- EER 93-DG-022: 9/8/93 Alternate method to align liner to frame when replacing cylinder liners***
1. The alternate method of installing the cylinder liners is to temporarily rig/bolt the head to the liner and use the head as the guide
- NOTE: When this method is used, care must be taken to ensure that the head to liner index (head to liner position) is correct***

Discuss use of "round end" allen wrench for cap screws to prevent damage to the "wrinkle belly"

EO: 1.9 Explain the basic process to reassemble the EDG Pistons and Connecting Rods**CONTENT****METHODS AND ACTIVITIES**

- I. Reassemble Pistons and Connecting Rods
 - A. Install Master Connecting Rod

CAUTION: Proper torque of fasteners during reassembly cannot be stressed enough. Consequences of improper torque can be severe and may even be life threatening!

 1. Reverse the steps followed to remove it
 2. Torque master rod pin bolts with tools (Wrench to tighten/loosen piston pin bolt) and (Master rod piston pin bolt wrench guide)
 - B. Install Articulated Connecting Rod
 1. Reverse steps followed in removing the rod
 2. Use locating pin to align the rod with both the rod pin and the piston pin
 3. Torque articulated rod articulated pin bolts with tools KSV-44-Q (Wrench to tighten/loosen piston pin bolt) and (Articulated rod piston pin bolt wrench guide)

CONTENT

METHODS AND ACTIVITIES

C. Install Piston Pin Bushing

1. Cool new bushing to less than -95 degrees F

CAUTION: DO NOT HANDLE EXTREMELY COLD ITEMS WITH UNPROTECTED HANDS!

NOTE: Each new bushing has a rib or bail across bottom to aid in assembly. Do not remove the rib before it is installed!

- a. Immerse in alcohol and dry ice for 2 hours, or in liquid nitrogen for 20 minutes
2. Carefully align bushing with piston to insure proper positioning; press bushing into piston
- NOTE: Install bushing immediately after taking it from coolant as it will heat rapidly**
3. Cut rib from bushing with a hacksaw and smooth sawed edges
 4. Lock bushing to piston:
 - a. On both sides of bushing drill a hole between bushing and piston, tap the holes, install set screws and stake them
 5. Blue check piston pin to bushing:
 - a. If bearing contact area is less than 80%
 - 1) Scrape high spots with a bearing scraper to obtain proper fit
 6. Lubricate piston pin and install it
 7. Check pin-to-bushing clearance as discussed

DO NOT reinstall the pin caps per *EER 92-DG-030*

D. Install Piston Rings

EER 92-DG-030: Piston Pin End Caps are not installed and Lower Oil Scraper Ring is removed or not installed

CONTENT**METHODS AND ACTIVITIES**

1. Insure all piston ring grooves are thoroughly cleaned
2. Using tool 2-01T-108-001 (Ring Expander) install piston rings, one at a time
DO NOT reinstall the lower oil scraper ring per ***EER 92-DG-030***.
 - a. Install each oil control ring with scraper edge down
 - b. Install each compression ring with inscription "top" toward head of piston
 - c. All joints should be staggered 180 degrees before piston is inserted in cylinder

E. Installing Piston

NOTE: When installing new piston rings deglaze the cylinder liner

1. Install tools (Piston Ring Compressor) and (Piston Lifting Tool) on piston
2. Install locating pin in piston pin
3. Set (Piston Entering Funnel) on top of cylinder liner
4. Lubricate cylinder liner, and slowly lower piston into liner (be careful not to permit piston rings to break or chip)

CAUTION: WHEN INSTALLED, THE PISTON MUST BE TURNED SO THAT THE COOLING OIL OUTLET ORIFICE IS TOWARD THE CENTER OF THE ENGINE

CONTENT**METHODS AND ACTIVITIES**

5. Attach piston pin to connecting rod with piston-pin bolts and washers (removing locating pin)
6. Torque pin bolts with tools (Wrench to tighten/loosen piston pin bolt) and K (Articulated rod pin bolt wrench guide) or Master rod pin bolt wrench guide
7. After twenty four hours of engine operation following reassembly, check piston pin bolts, articulated rod pin bolts, and connecting-rod cap bolts for correct torque

NOTE: After installing new piston rings, start engine and operate at about one quarter load: Gradually increase load to full load over a two hour period. This allows new rings to "wear in" and properly seal to liner

EO: 1.10 Explain the basic process to reassemble the EDG Cylinder Heads

CONTENT

METHODS AND ACTIVITIES

I. Reassemble the Cylinder Heads

A. Install Main Valve Inserts

1. Check valve seat insert counterbore in head for out of roundness
 - a. If out of roundness exceeds 0.001", bore should be remachined
 - 1) Remove only enough material to clean up
2. Based on measurements of valve seat insert counterbore in head, select an insert that will give a 0.003" to 0.005" interference fit
3. Chill new insert in alcohol and dry ice or liquid nitrogen

CAUTION: AFTER INSERTS ARE COOLED, THEY SHOULD BE HANDLED WITH TONGS OR GLOVES BECAUSE DIRECT CONTACT WITH SKIN MAY RESULT IN FROSTBITE

4. Make sure that counterbore in head is clean
5. Place chilled insert squarely over counterbore
 - a. Use a soft faced hammer and drive insert into its seat
 - b. After insert equalizes temperature with cylinder head check clearance between insert and cylinder head
 - 1) Clearance must be less than 0.0015"
 - a) Excessive clearance between the insert and cylinder head results in poor heat transfer and shortens valve life

B. The valve guides are installed in a similar manner *Briefly go over*

CONTENT

METHODS AND ACTIVITIES

C. Install Main Valves

1. Install valve from same location it was removed
2. Use tool to compress valve spring

CAUTION: OBSERVE THE CAUTION FOR REMOVAL OF VALVE SPRINGS PREVIOUSLY IN THIS LESSON

3. Install retainer, keeper and seal

D. Assemble Rocker Arm Assembly

1. Install retaining ring and tappet and lifter, into rocker arm

Note: The rocker arm is not installed on the head until the head install and torqued

2. Install adjusting screw and tighten locknut
3. Install rocker arms into shafts
4. Install stands onto shaft

E. Install Cylinder Head

1. Seal around stud holes in the head with Loctite Gasket Maker
2. Install new "O" -Rings on water and oil drain connections and crosshead guides
3. Install a new fire gasket in recess in the top of the liner
4. Lift head using special lift tool (KSV-44-D), and carefully place it on the cylinder block and studs
 - a. Check alignment of cylinder head to cylinder liner and cylinder block

This is done per M018-0619 Drawing, Note #2

- 1) Open associated cylinder head cam trough opening and using a feeler gauge

Point out that alignment should not change unless cylinder liner was removed. Explain to students that this alignment check came from C-B Bulletin #698

CONTENT

METHODS AND ACTIVITIES

- 2) Check underside of cam roller assembly for clearance completely around the cylinder block clearance hole and outside diameter of the crosshead guide
- 3) If clearance does not exist, notify the Diesel Engineer, and the cylinder liner will have to be re-aligned

F. Adjust tappets

- 1. Rotate crankshaft and position the piston for which the valve train components are to be measured on Top Dead Center (TDC) of the power stroke, the main valves will be closed
- 2. Install a dial indicator so that indicator tip rests on one of the intake valve spring retainers, then zero the indicator
- 3. Loosen tappet adjustment lock nut and slowly turn adjusting screw clockwise until indicator shows that valve has started to open
 - a. Allow the valve to remain in position (off its seat) for several minutes
 - 1) If the valve remains off its seat, the lifter is collapsed, and final adjustment can be made
 - 2) If valve seats itself during the waiting period, it must again be unseated with the adjusting screw and the waiting period repeated until the valve remains off of its seat

CONTENT

METHODS AND ACTIVITIES

- 4. After lifter is fully collapsed, back off adjusting screw until the dial indicator again reads "0" and then an additional 1-1/2 turns, and torque the lock nut
 - 5. Repeat these steps for all valves (inlet and exhaust)
 - 6. Install fuel injector in the head
 - 7. Install and or connect all piping and lines removed from the head
 - 8. Using a new gasket, install cover
 - 9. Connect fuel line from fuel pump to nozzle
 - 10. Connect fuel drain and fuel pump oil lines
- G. OE16510 - Time-Pressure Causes Inadequate Emergency Diesel Maintenance
- 1. Inadequate EDG Maintenance Performed What Happend

 - 2. Description: What Caused this to happen
 On April 17, 2002, Mechanical Maintenance completed 'B' Emergency Diesel (ED) maintenance during Refueling Outage 12 (RF12). Post maintenance testing immediately following diesel maintenance indicated there was double impact of the valves on #5 cylinder and the valves were opening 20 degrees early. The post maintenance run lasted for ten minutes before shutting down the engine

 - 3. A Work Order was immediately established to investigate and reset the valve lash. Upon opening the valve cover for #5 cylinder the rocker arm tappet setting nuts were found loose and dislodged. The intake nuts were dislodged and the exhaust nuts were loose at the top of the adjustment screws. The #5 cylinder tappet settings had been set after the vendor had examined the cylinder liner for glazing during RF12

CONTENT

METHODS AND ACTIVITIES

4. The valve tappet adjusting screws that were found loose had been torqued by day-shift mechanics. The remaining twenty-seven cylinder tappets were adjusted during RF12 by two mechanics on the night shift. The night-shift mechanics completed very comprehensive pre job research, pre job walk down, and pre job briefs prior to making the tappet adjustments. This work was originally slated to be accomplished on the night shift, not day shift

5. During the upper cylinder inspection, the night-shift mechanics noticed that #5 cylinder showed more wear than any of the other cylinders, so they wanted engineering to examine the wear. The night-shift engineer wanted the day-shift engineer and the vendor to also examine the wear prior to closing up the cylinder. The fuel injector was then left out until the vendor and day-shift engineer could examine the wear. After the vendor had completed his inspection, concluding that the wear was acceptable, Maintenance Supervision chose the day-shift mechanics to place the fuel injector and the rocker arm assembly back into cylinder #5.

CONTENT

6. Both day-shift mechanics were qualified diesel engine mechanics and a pre job brief took place. Because of their years of experience they were potentially working from an over-confident mental condition. They were performing the work without the benefit of the research that the night-shift mechanics had done. The day-shift mechanics were performing the work based on their raw mechanical ability, which was considerable, without any peer checks, QC verifications, or monitoring. The day-shift mechanics did not have the opportunity to perform a recent rocker arm inspection, so their skills were not as sharp. There was not a driving need to close the # 5 cylinder up during the day shift; however, due to perceived time-pressure Mechanical Maintenance Supervision chose the day-shift mechanics to close #5 cylinder
7. Can This Happen at PVNGS
8. How could this event have been mitigated

METHODS AND ACTIVITIES

Root Cause

The apparent cause was perceived time pressure due to the nearly completed ED engine work taking longer than originally scheduled and overconfidence of the mechanics performing the work

Schedule pressure

Discuss use of HU Tools (STOP), Questioning Attitude, What error precursors were evident

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.