PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training

Classroom Lesson

Mechanical Maintenance Training	**Date: 7/23/2010 6:52:26 AM**
LP Number: NMC61C000603	**Rev Author: LEE BAKER**
Title: Control System	**Technical Review:** Martin J. Sullivan Digitally signed by Martin J. Sullivan DN: cn=Martin J. Sullivan, o=Mechanical Planning, ou=8561, email=Martin.Sullivan@apc.com, c=US Date: 2010.07.27 06:13:57 -07'00'
Duration : 2 HOURS	**Teaching Approval:** Steinmetz, Tim P(Z99348) Digitally signed by Steinmetz, Tim P(Z99348) DN: cn=Steinmetz, Tim P(Z99348) Reason: I am approving this document Date: 2010.07.27 09:25:59 -07'00'

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

SER 86-18: Diesel Generator Overspeed

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 Control System :

Task or Topic Number*	Task Statement
Lesson:	Control System
EDG009	Inspect governor on emergency diesel engine
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: 4

TERMINAL OBJECTIVE:

1 Given applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain the maintenance performed on the EDG Control System, demonstrated by passing a written exam with a score of 80% or better.

1.1 Describe the function of the EDG Control System

1.2 Describe the operation of the EDG Speed Automatic Speed Controls

1.3 Describe the operation of the EDG Automatic Fuel Controls

1.4 Describe the EDG Automatic and Manual Safety Shutdown Controls

1.5 Explain routine preventive maintenance performed on the EDG Control System.

CONTENT	METHODS AND ACTIVITIES
I. Motivation	Focus student attention on "What's In It For Me".
II. Pre-Job Brief	
A. Pre-job briefing on the day's activities modeling the use of the Palo Verde Standards & Expectations, Preventing Events	
B. 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 applicable maintenance instructions the Maintenance Mechanic will, state the function of and explain the maintenance performed on the EDG Control System, demonstrated by passing a written exam with a score of 80% or better	
2. Identify error likely situations (error traps)	Look at Error Precursors in S&E book
a. Discuss at least one specific error likely situation.	
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.
C. Break policy	
1. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow.

CONTENT	METHODS AND ACTIVITIES
III. Lesson Enabling Objectives	Read and/or discuss the lesson objectives
EO01 Describe the Function of the EDG Automatic Controls	
EO02 Describe the operation of the EDG Automatic Speed Controls	
EO03 Describe the operation of the EDG Automatic Fuel Controls	
EO04 Describe the EDG Automatic and Manual Safety Shutdown Controls	
EO05 Explain routine preventive maintenance performed on the EDG Automatic Controls	

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

EO: 1.1 Describe the function of the EDG Control System

CONTENT	METHODS AND ACTIVITIES

I. Functions

A. The automatic controls consist of speed, fuel, and safety shutdown controls

1. Speed Controls

a. An electric-hydraulic governor positions fuel injection pumps via linkages to operate the engine at its rated speed (600 rpm). Speed control components consist of

1) Main governor and fuel linkage

2) Overspeed governor

2. Fuel Controls

a. Series of solenoid and pneumatic valves that positions the fuel control cylinder (in the fuel control linkage) to the “on” or “off” position during EDG start up, normal shutdown and emergency shutdown consisits of

1) Fuel control linkage

2) Fuel control panel

3. Safety Shutdown Controls

a. Test Mode

1) There are 19 shutdown devices that will stop the engine in the "test mode"

2) We will not be discussing all 19 in this course

CONTENT	METHODS AND ACTIVITIES
b. Emergency Mode 1) There are only 3 shutdown devices that will stop the engine in the "emergency mode". 2) Those are 1) Overspeed 2) Generator differential and 3) Low lube Oil	*All other shutdowns are active but will not stop the unit in emergency mode of operation. They will only cause an alarm and light an annunciator on the control panel*

EO: 1.2 Describe the operation of the EDG Speed Automatic Speed Controls

CONTENT **METHODS AND ACTIVITIES**

I. Automatic Speed Controls

A. Main Governor and Fuel Linkage

1. Location

a. Mounted on left side of engine drive end

2. Function

a. Position fuel injection pumps, via linkage, to operate engine at its rated speed

3. Construction

a. Drive

1) Driven from end of left camshaft drive gear shaft.

2) Consists of a set of bevel gears in a housing

3) Horizontal drive shaft is splined to camshaft drive gear shaft and the vertical shaft is splined to governor shaft

4) Drive is lubricated from engine lubrication system

4. Operation

a. Electro-hydraulic

1) Electric signal generated from generator output current and frequency provides input to control governor

CONTENT	METHODS AND ACTIVITIES

2) Control governor utilizes electric signal to control internal hydraulic system to adjust for proper terminal shaft position

3) Terminal shaft is coupled to fuel linkage which controls injection pump position and thus engine speed is controlled

b. Hydraulic

1) In the event of an electric speed control failure the hydraulic feature provides speed control of the engine

2) Hydraulic portion of governor is isochronous with manual speed, percent load and droop adjustments

3) Speed will be regulated slightly higher during hydraulic governor operation

B. Overspeed Governor

1. Location

a. Mounted on right side of engine drive end

2. Function

a. Shutdown the EDG in the event of an overspeed condition

3. Construction

a. Drive

1) Drive is same as main governor except that it is driven from end of right camshaft. Drive is lubricated from engine oil system

b. Governor

CONTENT	METHODS AND ACTIVITIES
1) An overspeed fuel shutdown valve is mounted on right side of the governor with the roller on the plunger riding against a lever on the terminal shaft	
2) A cable is attached to lever on left side terminal shaft with the other end attached to trip lever which holds the lever attached to shutdown butterfly valve in turbo charger air inlet	*Optional OE Operating Experience- During 1R11 post maintenance testing of EDG 1A, the diesel tripped, but not as expected. The fuel racks went to the closed position, but the butterfly valve was still in the latched condition. The butterfly control cable was too tight. The failure of the air intake shutdown butterfly valve was directly caused by an out-of -adjustment cable* See CRDR 2703923 (Failure #704)

4. Operation

   a. When EDG speed reaches 660 rpm the terminal shaft

   b. Actuates the overspeed valve

      1) This positions fuel control cylinder to "off" thus positioning fuel injectors to "no fuel”

      2) Trips shut spring loaded butterfly valve in turbocharger air inlet

         a) This removes air required to support combustion to stop diesel

EO: 1.3 Describe the operation of the EDG Automatic Fuel Controls

CONTENT	METHODS AND ACTIVITIES

I. Fuel Control System

A. Fuel Control Panel

1. Location

a. Mounted between control and overspeed governors at rear end of EDG

2. Function

a. Controls the operation of the fuel control cylinder

3. Construction

a. Consists of two solenoid valves, two pneumatic valves, a shuttle valve and one pneumatic switch

4. Operation

a. System valves supply and vent air as necessary to control the fuel control cylinder during starting, normal shutdown and safety shutdowns of the EDG

EO: 1.4 Describe the EDG Automatic and Manual Safety Shutdown Controls

CONTENT	METHODS AND ACTIVITIES
I. Automatic Safety Shutdowns	
A. Low Lube Oil Pressure (EMERGENCY & TEST MODE SHUTDOWN	
1. Location	
a. The low lube pressure valves are mounted on the engine beside the gauge panel	
2. Function	
a. Protects engine from damage in the event of a loss of lube oil pressure	
3. Operation	*Recovery involves investigating and correcting cause*
a. Lube oil pressure from main turbocharger and engine lube headers is monitored.	
b. If engine oil pressure falls to 30 psi, valve vents control air from the safety trip valve through the trip lockout	
B. Overspeed Shutdown (EMERGENCY & TEST MODE SHUTDOWN)	
1. Location	
a. Mounted on right hand side of the engine	
2. Function	
a. Protects engine from damage in the event of an overspeed	
3. Operation	*This governor has a self contained hydraulic power source. Check oil at sight glass regularly when the engine is running.*
a. Engine driven centrifugal hydraulic overspeed governor is driven off the end of the camshaft drive gear shaft	
b. Governor senses engine speed and is set to trip at 660 RPM	

CONTENT	METHODS AND ACTIVITIES
C. Generator Differential (EMERGENCY & TEST MODE SHUTDOWN)	
1. Location	
a. Relays located in the local panel	
2. Function	*A generator differential exists when current into a generator winding is not equal to the current leaving that winding.*
a. Protects generator from damage in the event of an electrical fault resulting from a generator differential	
3. Operation	*When a generator differential exists, a lockout on the local generator control panel trips and de-activates the emergency mode fuel control solenoid valves and test mode remote trip solenoid valve which shuts off fuel supply. The lockout must be manually reset before the engine can be restarted*
a. Beyond Scope	
D. High Jacket Water Temperature Shutdown (TEST MODE SHUTDOWN ONLY)	
1. Location	
a. Senses temperature in the cooling water header	
2. Function	
a. Shuts down engine on a loss of cooling water	

CONTENT	METHODS AND ACTIVITIES
3. Operation a. The high water temperature valve will shutdown the engine if water temperature exceeds 205°F b. Shutdown is accomplished by air pressure being vented off the safety trip valve c. The high water temperature valve will reset itself when the jacket water cools d. The trip is bypassed on startup and shutdown < 280 RPM	*Operators or OPS Engineering will most likely be involved in investigating cause*
E. Low Turbocharger Lube Oil Pressure Shutdown (TEST MODE SHUTDOWN ONLY) 1. Location a. The low turbocharger lube oil pressure valve is located near the engine gauge panel on the left base of the engine 2. Function a. Prevents damage to turbocharger in the event of a loss of lube oil 3. Operation a. Monitors turbocharger b. If oil pressure falls to 30 psi, the valve vents control air from the safety trip pilot valve through the trip lockout valve c. Causing engine to shut down d. Valve resets itself	
F. Turbocharger Thrust Bearing Failure Detector (TEST MODE SHUTDOWN ONLY) 1. Location a. Installed in the turbocharger air inlet casing cap	

CONTENT	METHODS AND ACTIVITIES
2. Function a. Detects failure of the Turbocharger thrust bearing	
3. Operation a. If clearance is excessive, the bearing sleeve lock nut will rub the end of the detector heating the fusible alloy and melting it. When the metal alloy melts, control air is dumped off the safety trip pilot valve and stops the engine b. The detector must be replaced before the unit can be restarted	*The trip is bypassed on startup and shutdown < 280 RPM* *Recovery involves making repairs to turbocharger possible bearing replacement and/or detector replacement*
G. Excessive Engine Vibration Shutdown	**Tech Manual says this is deleted?**
1. Location	
2. Function a. Protect engine from an un-monitored malfunction that causes the engine to vibrate beyond the normal amount	
3. Operation a. A magnet holds a spring loaded lever assembly in place b. Lever assembly controls a ball valve c. When inertia of lever assembly plus force of loading springs exceeds holding force of magnet upon increasing engine vibration, the lever assembly snaps to tripped position and remains there until reset d. This lifts valve off of its seat venting air from safety trip valve and stopping engine in test mode	*Recovery involves resetting detector. Resetting is also accomplished when applying starting air to the lockout during startup*
H. Main and Outboard Bearing High Temperature Shutdown (<u>TEST MODE SHUTDOWN ONLY</u>)	

CONTENT	METHODS AND ACTIVITIES
1. Location a. Two temperature detectors are installed in each main bearing cap 2. Function a. Protects the bearings and crankshaft against excessive heat buildup 3. Operation a. All detectors are set to trip at 228 degrees F b. Detector consists of a body, ball valve, locknut fuse rod assembly and loading spring c. Spring-loaded fuse rod is secured to tip by an easily melted metal alloy d. If temperature of a bearing shell becomes hot enough to melt the alloy, the fuse rod is instantly released e. Spring action moves the rod forward 5/16" to unseat the ball and allows control air to be dumped off the safety trip valve and stop the engine in the test mode	.

CONTENT **METHODS AND ACTIVITIES**

4. Recovery Steps
    a. Locate overheated bearing
        1) After engine cools (at least 15 minutes) remove two or three crankcase doors from left side of engine
        2) Disconnect control air line
        3) Apply a 15 - 20 psi air pressure to line and listen for air escaping from tripped detector
            a) This is overheated bearing
    b. Investigate and correct cause
    c. Install new fuse rod
        1) Make sure new fuse rod trip temperature (stamped on the fuse rod tip) is correct
    d. Reconnect control air line

I. Connecting Rod Bearing High Temperature Shutdown (<u>TEST MODE SHUTDOWN ONLY)</u>

1. Location
    a. Detectors are located in the bearing cap
2. Function
    a. Protects the connecting rod bearings and the crankshaft from excessive heat buildup

CONTENT **METHODS AND ACTIVITIES**

3. Operation
    a. All detectors are set to trip at 197 degrees F
    b. Operate the same as Main Bearing detectors except that when fuse rod is released, spring action moves it outward so that it trips a vent valve located inside the centerframe
    c. Tripped vent valve dumps control air off the safety trip valve and stops the engine in the test mode
        1) Vent valve is protected by an oil shield to prevent accidental tripping
4. Recovery Steps
    a. Locate overheated bearing
        1) After engine cools (at least 15 minutes) remove two or three crankcase doors from left side of engine
    b. Investigate and correct cause
    c. Install new fuse rod in the detector
        1) Make sure new fuse rod trip temperature (stamped on the fuse rod tip) is correct
    d. Manually reset the vent valve in the centerframe

J. Crankcase High Pressure Shutdown (<u>TEST MODE SHUTDOWN ONLY)</u>

1. Location
    a. The crankcase pressure shutdown valve is mounted on the left side of the engine between cylinders four and five
2. Function
    a. Prevent engine damage due to a possible crankcase explosion

CONTENT	METHODS AND ACTIVITIES
3. Operation	*Trip has to be manually reset*
a. Differential pressure detector trips vent valve at 0.5 psi	
b. Vent valve dumps control air off safety trip valve and stops engine when in the test mode	
II. Manual Shutdown (To be operated by operations personnel.)	
A. Location	
1. It is located on the left bank starting air piping	
B. Function	*Fuel cylinder is designed to maintain a full "on" position in case of a complete loss of control air pressure, thus the necessity for the manual override*
1. A manually operated fuel rack control handle provides a backup for engine shutdown on loss of control air	
C. Operation	*To recover shut manual shutdown quadrant lever*
1. Attached to fuel control linkage	
2. Depress lever and pull down	
3. Shuts off fuel	

EO: 1.5 Explain routine preventive maintenance performed on the EDG Control System.

CONTENT	METHODS AND ACTIVITIES
I. Preventive Maintenance	
A. Lubricate Overspeed Shutdown Butterfly Valve Linkage	
1. Basic Procedure	
a. Lubricate control rod end	
b. Lubricate pawl and fitted bolt	
B. Change Oil in Control and Overspeed Governors	
1. Basic Procedure	
a. Open drain valve. Drain old oil into appropriate container and inspect for debris, metal shavings, etc	
b. Flush governor out with Shell Rotella T40 oil and repeat as necessary.	Use **Self Check/ Peer Check** to verify proper oil type is used
c. Close drain valve and fill until oil is at the top of the sight glass but not visible at the oil filler	
d. Return equipment to operations	

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.