PALO VERDE
NUCLEAR GENERATING STATION

Electrical Maintenance Training Program

Classroom Lesson

Electrical Maintenance Training Program	**Date: 5/12/2011 9:00:02 AM**
LP Number: NEA40C000505	**Rev Author: MARK OWENS**
Title: Emergency Diesel Gen Lesson Plan #5	**Technical Review:** Frasquillo, Peter (Z35948) Digitally signed by Frasquillo, Peter (Z35948) DN: cn=Frasquillo, Peter (Z35948) Reason: I have reviewed this document Date: 2011.05.13 16:23:13 -07'00'
Duration : 6 HOURS	
	Teaching Approval: Meredith, Robin T(Z00799) Digitally signed by Meredith, Robin T(Z00799) DN: cn=Meredith, Robin T(Z00799) Reason: I am approving this document Date: 2011.05.13 16:40:08 -07'00'

INITIATING DOCUMENTS

None

REQUIRED TOPICS

None

CONTENT REFERENCES

VTM-C628-00001 EDG

CRDR 3325283

32MT-9PE01 18 DIESEL GEN. INSPECTION
13-M018-000157
13-M018-000080
13-M018-000082
13-M018-000159

CONTENT REFERENCES

None

REVISION COMMENTS

May 12, 2011	Mark Owens	Removed all references to the old K1 contactor

Tasks and Topics Covered

The following tasks are covered in Emergency Diesel Gen Lesson Plan #5 :

Task or Topic Number*	Task Statement
Lesson:	Emergency Diesel Gen Lesson Plan #5
EDG01	Maintain Emergency Diesel Generators (EDG)
EDG02	Maintain Non-Power Block Generators

Total task or topics: 2

TERMINAL OBJECTIVE:

5.0 Given reference materials, the student will identify the components of and describe the purpose of the Diesel Generator Voltage Control System. Mastery will be demonstrated by achieving a score of 80% or greater on a written evaluation.

5.1 State the purpose of the Exciter and identify its components and their locations.

5.2 State the purpose and identify the locations of the Exciter Components located in High Voltage Cabinet B03.

5.3 State the purpose and identify the locations of the 90VRB Exciter Components.

5.4 State the purpose and identify the locations of the 90VR Exciter Components.

5.5 State the purpose and identify the locations of the components that support the operation of the Exciter Unit.

TO: 5.0	**Given reference materials, the student will identify the components of and describe the purpose of the Diesel Generator Voltage Control System. Mastery will be demonstrated by achieving a score of 80% or greater on a written evaluation.**

EO: 5.1 State the purpose of the Exciter and identify its components and their locations.

LESSON PLAN **METHODS AND ACTIVITIES**

- Purpose:

  Supply a direct current (DC) to the generator field and to maintain constant output voltage under varying conditions.

  Static type: No moving parts.

- Components: The exciter is comprised of three sections and support components.

  A. Section 1: High voltage components
  Location: JDGA/BB03 (High Voltage Cubicle)
  1. Potential Transformers
  2. Current Transformers
  3. Magnetic Reactors (MR)

  B. Section 2: 90VRB (Bridge Section)
  Location: JDGA/BB02
  1. Bridge Units
  2. Bridge Transfer Switch (S1/43B) & Relay K2
  3. SAM (Semiconducting Annunciator Monitor)
  4. RGFM (Remote Gate Firing Module)
  5. K9 Bridge Failure Relay

C. Section 3: 90VR (Voltage Regulator Section)
Location: JDGA/BB02
1. AVR (Auto Voltage Regulator)
2. MVR (Manual Voltage Regulator)
3. IPS (Instantaneous Pre-Positioning System)
4. PDPs (Power Driven Potentiometers)
5. Startup/Shutdown relays K1, 62K1, FF, LR,
6. K3/K4 relays (switching Module)

D. Section 4: Support components
Location: JDGA/BB02
1. 27VP1/2 Relays
2. 4GEX1/2 Relays
3. 3AM Relay
4. 3L & 3R Relays

Location: Generator
1. Slip rings
2. Brushes

EO: 5.2 State the purpose and identify the locations of the Exciter Components located in High Voltage Cabinet B03.

LESSON PLAN

METHODS AND ACTIVITIES

- Location: B03 Components

A. Power Boost Current Transformer (PBCT)
Power Potential Transformer (PPT)
1. Transforms the generators output voltage (4160) and current (954.2 amps) to usable inputs for the voltage regulator and bridge units.
2. 300VAC, 245 Amps is delivered to the bridge & voltage regulator

B. Magnetic Reactors (MR):
Prevent equipment damage by limiting the current through the bridge diodes and SCR's.

C. Metering Potential Transformer (MPT):
Provides feedback to the EDG metering loops for control room and local panel output Volts, HZ, KW and KVAR metering.

D. Paralleling Current Transformer (PCT):
Connected in the droop mode it adds a voltage to the AVR that allows the AVR to regulate VARs instead of generator terminal voltage when paralleled to the grid.

E. Relaying Potential Transformer (RPT):
Provides feedback to the engine speed regulating governor 2301A, voltage regulator, and generator protection relays.

What would you expect on a Permit to safety work on this equipment?
1. Air start system
2. DG output Brkr. (grounded)
3. Diesel Mode selector switch
4. DG output cabinet grounded

Def: Current limiting Reactor
A reactor connected in series with the phase conductors for limiting the current that can flow in a circuit under short circuit conditions, or under other operating conditions such as starting, synchronizing, ETC.

EO: 5.3 State the purpose and identify the locations of the 90VRB Exciter Components.

LESSON PLAN

METHODS AND ACTIVITIES

- Purpose: Converts the Gen. Output (AC) to DC and controls how much current reaches the Gen. field:

  A. Bridge Units:
  1. Two bridge units associated with the excitation system.
  2. Either one can be used to produce the required DC field excitation.
  3. Both bridges are located inside B02 cabinet on the wall across from the door.
  4. Each bridge unit uses 6 diodes to change AC to DC and three SCR's to control the amount of current that reaches the exciter field.
  5. When the SCR gate receives a signal from the AVR via the RGFM, the SCR’s turn on and shorts (shunts) around the generator field.
  6. The sooner in the cycle the SCR's gate on, the less current is applied to the generator field and the output voltage decreases.

B. Bridge Transfer Switch (S1/43B):

1. The bridge transfer switch (S1/43B) is a very large mechanical switch located on the front of the B02 cabinet

2. It determines which bridge unit supplies the generator field and the voltage regulator. Reference drawing M018-82.

3. To transfer from one bridge unit to the other, the diesel generator must be shut down. **NOT FOR LIVE TRANSFER.**

C. Bridge Transfer Relay (K2):

1. The bridge transfer relay (K2) is a latching relay that determines which bridge is supplying Neg. power to both the AVR and the MVR. Reference M018-80.

2. The K2 relay changes states when the Bridge Transfer switch is manually switched. Batt. Positive is applied through the bridge transfer switch contacts to either the latch or reset coil of K2.

D. Remote Gate Firing Module (RGFM) Unit:

1. The RGFM circuit is used to isolate AVR circuitry from the higher power bridge output system. Ref M018-445.

2. The gate cathode leads of an SCR are extremely sensitive to noise and interference, therefore, it is not a good practice to switch these leads when transferring control from one bridge to another.

3. Wired in parallel. Only the unit connected to the energized bridge is functional because the other RGFM has no power applied.

E. Semiconducting Annunciator Monitoring (SAM) Unit:

1. The function of the SAM unit is to monitor the bridge SCR's and diodes.

2. If a diode or SCR fails, the respective LED illuminates and a Bridge Failure alarm is received via the K9 (74BF) relay.

3. SAM Unit is only monitoring once generator output is ≥ 60% (VR1/2 contacts) rated voltage and after field flash has been initiated (FF). Reference M018-81.

F. Bridge Failure Relay (74BF) (K9):

1. Interface between the Parsons Peebles Bridge and the Cooper Bessemer control system.

2. The SAM unit triggers this relay. When the SAM goes into an alarm condition (any on-line bridge SCR or diode fails), the K9 relay (74BF) relay is energized.

3. When 74BF (K9) energizes, contact 20-22 (contact F4C3 on M018-160) closes, causing 74BF LED (L-A14) (M018-141) to energize. Terminal 930 & 950 goes to the engine panel 1A & 47 (Wire List).

4. 74BF (DS1) energized phototransistor at A4B3 (M018-144), causing 74BFX to pickup, closing its contacts at G1G4 (M018-156) causing an Excitation Bridge Failure Annunciator alarm (window C-8).

EO: 5.4 State the purpose and identify the locations of the 90VR Exciter Components.

LESSON PLAN

METHODS AND ACTIVITIES

- Purpose:

  Maintain a constant voltage output with a varying load. Controls output from the field.

  Components:

  A. Automatic Voltage Regulator board (90VRA/AVR)
  B. Manual Voltage Regulator board (90VRM/MVR)
  C. Instantaneous Pre-positioning System (IPS/IPP)
  D. Power Driven Potentiometers (PDP)
  E. Startup & Shutdown Contactors
  F. Switching Module K3/K4
  G. 27VP1, 27VP2
  H. Control Relays

- AVR Function:

  A. Sensing Circuit:
  The purpose of the sensing circuit is to convert an AC voltage that reflects the generator output voltage to an equivalent DC voltage.

  B. External Reference Circuit:
  Takes an input from the operator (PDP) in test mode and changes the voltage drop across R2 to either raise or lower the voltage reference point. In emergency mode the IPS unit replaces the PDP

  C. Stabilizing Circuit:
  Generates a voltage signal for the error amp and provides feedback which prevents the regulator from overreacting (hunting).

  D. Error Circuit:
  The error amplifier compares the DC voltage obtained from the sensing circuit with that of the reference voltage. An output voltage that reflects the difference of the two voltages is generated and applied to each of the firing circuits.

  E. Synchronizing Circuit:
  This circuit develops the timing signal for firing the field SCR's which is applied to the firing comparator circuit.

  F. Firing Comparator Amp. (U3, U5 And U7):
  The comparator circuit compares the varying error signal to the sawtooth synchronizing signals to determine when to gate (turn on) its associated field SCR.

- AVR operation:

  Generator output voltage increases.

  Sensing circuit voltage increases.

  Summing point voltage increases.

  Output of error amp increases.

  Firing comparator amp turns on (fires) sooner in cycle.

  SCR's turn on sooner in cycle.

  Field shorted sooner, generator output voltage decreases.

- MVR:
  A. The Manual voltage regulator board is essentially an automatic regulator board with the speed sensing circuit, droop (paralleling transformer) circuit, and stabilizing network removed.

  B. It applies and maintains a fixed DC voltage to the generator field. Responds only to changes to the summing point from the external voltage rheostat (R2) that is controlled by the operator.

  C. Manual Voltage Regulation is not currently used at Palo Verde.

Operations would have to constantly be adjusting voltage for varying loads.

- K3/K4 Switching Module:
  Relays K3 and K4 makeup the switching module.

  The function of this module is to allow the manual or automatic voltage regulator to supply the bridge units.

  Whenever the operator takes the handswitch to Automatic or Manual, the associated 3AM contact closes energizing K3/4 or K3AK4A thereby connecting the AVR or MVR to the field SCR's via the RGFM. Reference M018-159 & 699.

  When an emergency start occurs, the 4GEX contacts change state, taking the MVR out of the circuit and placing the AVR in control.

  Significant CRDR 3325283:
  On May 7th, 2009 during the slow start governor modification Design Validation Testing (DVT) the generator experienced a sudden loss of field excitation. An intermittent high resistance condition (> 4.5 ohms) was found to be created when the switching module was bumped or otherwise jarred in a manner that caused the K4 relay to shift within its base. This condition caused the Remote Gate Firing Module to send a continuous gating signal to the rectifier bridge SCRs causing them to continuously shunt excitation away from the field.

  The Root Cause of this event was a loose connection between the K4 relay at pin 5 and its associated socket in the relay base at the K4 relay pin 5 pin-to-socket interfaces. This loose connection allowed resistance to vary across the negative power lead connection between the Remote Gate Firing Module and the Automatic Voltage Regulator. This condition has existed since at least 2001.

OE: 2001 CRDR 2432009
"poor contact between the K4 plug-in relay pins and its socket, and a loose terminal block connecting the switching module relays to existing external generator control cabinet wiring, would have caused the problems that occurred in this event".

2004 CMWO 2728901
Documented that the resistance across the K4 4-5 contact could be varied by pressing down on the switching module hold-down plate.

The significance of the increased resistance on the performance of the excitations system was not known or identified in either of these occurrences.

- IPS: Instantaneous Pre-Positioning System

  The IPS unit causes the voltage regulator to lock in at 4160 VAC (whatever voltage is preset by pot R2) upon an emergency start.

  It removes the power driven potentiometer from the circuit. This prevents an improperly positioned voltage potentiometer from effecting the operation of the diesel during an emergency start.

  IPS is required because it can take up to 20 seconds for the PDP to establish the proper voltage. The IPS unit establishes the proper reference signal to the AVR in less than one cycle.

The IPS unit is energized via terminal point 5 when voltage is greater than 60% (VR1 & VR2 contacts open) but does not affect the voltage regulator/exciter unless an emergency start occurs.

When an emergency start occurs, power is removed from terminal point 1 causing U1 output to be applied to terminal points 3 & 4. Terminal point 4 is common. Terminal point 3 goes to the AVR external voltage adjust (reference) point.

- PDP (65AMOP): Power Driven Potentiometer

  The purpose of the power driven potentiometers is to allow the raising or lowering of the diesel voltage during TEST MODE operation of the diesel.

  This allows the operator to raise or lower voltage to parallel to the grid and once on the grid allows the diesel to maintain proper excitation as load is applied or removed. Voltage is changed during Test Isochronous mode. VARS are changed during Test Droop Mode (Parallel Operations).

  There are two power driven potentiometers associated with the exciter system. One PDP (65AMOP) is for the automatic voltage regulator and the other PDP (65MMOP) is for the manual voltage regulator.

  Raise / Lower Circuit:
  A. When the operator takes the local or remote handswitch to raise, coil 3R is energized.

  B. When the operator takes the local or remote handswitch to lower, coil 3L is energized.

- PDP Operation:

  When the operator goes to raise, power goes through the 3AM contact to pin 1-125, out through pin 4, to closed contact 3R M1-T1 back to the PDP via pin 5.

  The PDP (65AMOP) will turn clockwise.

  Power comes out pin 7 and travels to the common via the closed 3L M1-T1 contact.

  Contact 3AM is open as long as the voltage regulator is in automatic.

  S1 contacts change state when the PDP reaches it maximum clockwise (CW) travel.

  S2 contacts change state when the PDP reaches it maximum counter clockwise (CCW) position.

  S3 and S4 contacts are not used at Palo Verde. The PDP will remain in the as-left position.

- Startup/Shutdown Circuit Function:

  This circuit contains the latching relay (LR), the field shorting Contactor (K1); the field shorting timing relay (62K1); the field flash Contactor (FF) and voltage permissive relays (VR1 & VR2).

These devices help to provide:
A. Flashing of the field via FF Contactor during start up.

B. Removal of the field flash via the voltage permissive relays VR1 & VR2 at 60% of EDG output. VR1/2 relays are energized by the RPTs and bridge rectifiers BR1/2.

C. VR1 & VR2 also turns on both the automatic and manual regulators, the IPS unit and energizes the SAM time delay relay (IS1 pins 6 & 7) at 60% of EDG output.

D. Shorting of the field via the K1 Contactor and the 62K1 and LR relays. These devices collapse the field excitation during the shutdown of the generator.

- Startup Operation:

  K1 Contactor: Telemecanique D-line

  A 3 - pole 110A, 125VDC contactor P/N LC1D115GD
  A mechanical latch with electric reset P/N LA6DK20F (removed at PVNGS)
  1 NO + 1NC Aux. contacts P/NLAD8N11.

  Replaces the old K1 contactor

  Shorts the field when energized and disables the FF relay.

Is energized for approximately 15 minutes when the stop button is pressed.

De-energized in stand-by

Change: The field is not continuously shorted

- 62K1 Relay: Agastat

  Model E7012PF
  E = Safety Related
  70 = 7000 Series relay
  1 = On Delay (TDE)
  2 = Double Pole/Double Throw
  P = 125VDC
  F = 1-10 Min. range

  Set at 9 minutes

  De-energizes K1 contactor 9 minutes after it is energized.
  Enables and disables the “Field Flash Ready” indication.

  Energized in stand-by

- L17 Field Flash ready light: Provides visual indication (on B02) that the Field Flash circuit is intact.

  The LR relay is a latching device. It retains its last state until a signal is applied to change its state. A loss of DC control power will not cause it to change state.

If the ERPB (excitation reset pushbutton) or an Emergency start occurs (4GEX1 contacts shut), Pos DC is applied to pin 20.

The positive voltage goes to the “reset” coil of the LR relay causing it to change state and changing its contact status (opens the contact).

This sets up the K1 contactor to be energized through contacts from the 62K1, 4X1 and 4X2 relays.

When the Excitation shutdown pushbutton (ESDPB) is pressed and the diesel is not in emergency start, then a positive voltage is applied to pin 21. This positive voltage is sent to the “latch” coil of the LR relay causing it to change state and changing its contact status (closes the contact). This energizes the K1 contactor and disables or shuts down the field flash circuit by de-energizing the “field flash” contactor.

When the manual field flash pushbutton (MFFPB) is pressed or the control system activates either of the field flash relays (14FFX1/2) pin 34 is placed to common and the “field flash” contactor (FF) is energized through K1’s auxiliary contact and contacts from VR1/2 flashing the field.

When control power is applied to the field flash circuitry, 62K1 is energized through 4X1/2 and 14FFX1/2 contacts. 62K1 starts timing out.

The K1 contactor is energized through 4X1/2 and 62K1 contact (has not timed out yet). This shorts the field.

When the 62K1 relay times out, K1 contactor is de-energized closing its Aux contact and allows lamp L17 to energize through the field flash relay and contacts 62K1 and VR1/2. This gives visual indication that the field flash circuitry is intact.

When a diesel start occurs contacts 4X1/2 open de-energizing 62K1 relay and light L17.

At 178 RPM contacts 14FFX1/2 change state and energize the field flash contactor through contacts from K1 (aux contact) and VR1/2.

When the field flash relay is energized the field is flashed.

At 60% of generator output VR1/2 open and the field flash contactor is de-energized.

When the diesel is stopped contacts 4X1/2 close energizing the K1 contactor and shorting the field.

Generator output voltage drops below 60% and VR1/2 close.

The generator cools down for 5 minutes (in test) and then begins to coast down.

At 178 RPM contacts 14FFX1/2 change state and relay 62K1 is energized and starts to time out.

Nine minutes later 62K1 relay times out, contactor K1 is de-energized closing its aux contact and indicating light L17 is energized.

- CR7: Blocking Diode
- CR8: Surge Suppressor – acts like a Zener diode in the control circuit, keeping the field voltage at a relatively constant voltage
- FFR: Field Flash Resistor limits current In the field
- C1/R1: Filter circuit

EO: 5.5 State the purpose and identify the locations of the components that support the operation of the Exciter Unit.

LESSON PLAN

METHODS AND ACTIVITIES

Ancillary Items:

- 27VP1, 27VP2:

  Generator voltage permissive relays 27VP1 & 27VP2 (energized from RPTs). Detect the generator output voltage and at >85% (102 VAC) the diesel output breaker is allowed to close. The field ground detector circuit is also energized. See M018-00160 coordinates B8 for 27VP1/2 setpoints.

- 3GUP1, 3GUP2 Unit Parallel control relays:
  These relays are energized if the unit is in test or placed in “Droop” which places the EDG in parallel operation. Energized by 3UP2.

- 3L/17 Lower Voltage control relay:
  Allows the operator to lower the generator voltage when the diesel is in "test mode" via the power driven potentiometer.

- 3R/16 Raise Voltage control relay:
  Allows the operator to raise the generator voltage when the diesel is in "test mode" via the power driven potentiometer.

- 3AM/18 Auto-Manual control relay:
  Selects between the local or remote station for the control circuits.

- 4GEX1/14, 4GEX2/15 Generator Emergency Run Relays:

  A. These relays are energized when the diesel receives an emergency start signal

  B. They take the diesel out of parallel/droop mode (de-energize 3UP).

  C. They ensure that the voltage regulator is in automatic regulation.

  D. They lock the IPS unit in operation (4160VAC).

  E. They remove the operator voltage control (PDP), and removes all generator trips except the generator differential trip.

- Generator Brushes/Slip Rings:

  Purpose: Provides the electrical interface between the generator rotor and the generator excitation system.