PALO VERDE
NUCLEAR GENERATING STATION

Electrical Maintenance Training

Classroom Lesson

Electrical Maintenance Training Program		**Date:**
LP Number: NEA09	**Rev. : 1**	**Rev Author: Mark Owens**
Title: Electrical Print Reading		**Technical Review:**
Duration : 20 Hours		
		Teaching Approval:

COURSE/LESSON PLAN TERMINAL OBJECTIVE:

1.0 Given reference material the student will demonstrate the ability to read and troubleshoot electrical engineering and vendor prints, mastery will be demonstrated by obtaining a score of ≥ 80% on a written exam.

ENABELING OBJECTIVES

1.1 **Identify and discuss electrical components per applicable references**

1.2 **Describe the Electrical distribution from the Start Up Transformers to the switchgear in the powerblock**

1.3 **Identify the 13.8Kv power distribution with the Main Generator on line and off line**

1.4 **Explain the Electrical distribution for the 4.16Kv Non-Class Power system (NB)**

1.5 **Explain the Electrical distribution for the 4.16Kv Class Power system (PB)**

1.6 **Discuss the Calvert Bus configuration for the 13.8Kv and 4.16Kv distribution**

1.7 **Identify and discuss AC and DC distribution paths and equipment**

1.8 **Identify and discuss electrical components and symbols associated with switchgear circuit breaker ENANS02D**

1.9 **Identify and discuss electrical components and symbols associated with switchgear circuit breaker internal control circuit for ENANS02D**

1.10 **Identify and discuss electrical components and symbols associated with load center ENGNL08**

1.11 **Identify and discuss electrical components and symbols associated with Motor Control circuit breaker ENHNM22**

1.12 **Identify and discuss the Emergency Bearing Oil Pump (EBOP) motor control and power circuitry**

1.13 **Identify and discuss electrical components on the vendor ladder diagram for the Emergency Bearing Oil Pump (EBOP)**

1.14 **Identify and discuss electrical components on schematic 0_-E-OWB-0008**

1.15 **Identify and discuss electrical components in auxiliary (Aux.) relay cabinets**

1.16 **Discuss electrical theory as it pertains to troubleshooting (T/S)**

1.17 **Identify and discuss troubleshooting techniques and guidelines**

EO 1.1	Identify and discuss electrical components per applicable references

1.1 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.1 Identify and discuss electrical components per applicable references

Standard Numbering and Symbols: 13-E-ZZB-0001-0007

- Drawings 13-E-ZZB-001 through 003 list standard abbreviations used.

  Examples:

AFAS	AUX FEEDWATER ACTUATION SIGNAL
AS	AMMETER SWITCH
BAS	BELL ALARM SWITCH
CC	CLOSING COIL
CT	CURRENT TRANSFORMER
EBOP	EMERGENCY BEARING OIL PUMP
LOCA	LOSS OF COOLING ACCIDENT

- Drawing 13-E-ZZB-004 lists General Function Numbers used.

  Examples:

42	RUNNING CIRCUIT BREAKER
51	AC TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER
59	OVERVOLTAGE RELAY
72	DC CIRCUIT BREAKER
27	UNDER VOLTAGE RELAY
74	ALARM RELAY

- Drawing 13-E-ZZB-005 through 007 is the General Symbol List**.**
- Drawing 13-M-ZZP-003 is a drawing that shows Symbols and Legends Flow Diagrams and P & I Diagrams.

  Examples:

Pressure	PT – Transmitter	PS – Switch
Level	LT – Transmitter	LS – Switch
Temperature	TT – Transmitter	TS – Switch
Vibration	VT – Transmitter	YS – Switch

Procedure 80DP-0CC04 (Plant Numbering)

- Purpose:
  The purpose of this procedure is to describe and control plant numbering for PVNGS. This procedure implements the pertinent requirements of ANSI N45.2.11 - 1974, Quality Assurance Requirements for the Design of Nuclear Power plants.

  Scope:
  This procedure applies to numbering designation schemes as described in the Appendices to this procedure. This procedure controls the list of valid system, facility, and functional area designators (Appendices C and D). Use of these designators in any plant numbering designation shall be in accordance with the requirements of this procedure.

  List of Appendices used by Electrical:

  App. A Unit Designators
  App. B Discipline Codes
  App. C System/Facility/Functional Area Designators (Alphabetical by Designator)
  App. D System/Facility/Functional Area Designators (Alphabetical by Description)
  App. E Separation Groups
  App. F Electrical Equipment/Location Numbers
  App. G Electrical Cable Scheme Numbers
  App. H Electrical System Raceway Numbers
  App. I Equipment Numbers
  App. J Emergency Lighting System Fixture Num.
  App. K Instrument Numbers
  App. O Electrical Cable Tray Support Numbers
  App. P HVAC Support Numbers
  App. Q Plant Numbering Process Flowchart

Given a Single Line Electrical Drawing, locate, and describe the information found in the following.

- The Title Block: Important features include
  Drawing Number
  Description
  Revision
  Quality Class Indicator (highest class on Drawing)

  Will indicate the highest class of any component on the drawing.

  Q - Component necessary for nuclear safety of the public.

  QAG - component necessary for continued full power operation OR safety of plant personnel. It will be treated like Q system or component.

  NQR - components not quality related.

- The Legend:
  A table which gives a description of each device number used on the single line drawing. It gives information on the manufacturer, type and usually model number. This information can be used in gaining more information on individual devices from vendor manuals**.**

- The Function Table:
  This table outlines the function performed by a relay device. The Function Tables are normally found on Single Line Drawings.
  If it is not found on the Drawing, the 'NOTES' section will inform you as to which drawing it can be found on.

- The notes Section:
  This section gives information on non-standard conditions on the drawing, or amplifying remarks about certain devices.

  Information that may not be on the print may be found in the notes.

  The notes are a good tool for additional information not shown on the print.

EO 1.2	Describe the Electrical distribution from the Start Up Transformers to the switchgear in the powerblock

1.2 Main Idea

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.2 Describe the Electrical distribution from the Start Up Transformers to the switchgear in the powerblock	
Distribution:	
• 1. Three Start-up Transformers: AENANX01, AENANX02, AENANX03 525KV/13.8KV each having two secondary windings. A “Y” winding and a “Z” winding.	Review print 13-E-MAA-0001
• AENANX01: Y windings through disconnect switch AENANW01A, the normal feed is 3ENANS06C to power 3ENANS06. Alternate feed through the Y winding and disconnect switch AE-NAN-W01A to 1ENANS05D. Power to switchgear is underground lines. Z winding through disconnect switch AENAN-W01B, normal feed is to 2ENANS05D. Alternate feed is to 1ENANS06F. The overhead “Jack-Bus” is used to distribute power to the switchgear. The “Jack-Bus” is a tube shaped aluminum bus.	Cables enter the “D” cubicle to 3ENANS06C Cables enter the “E” cubicle to 1ENANS05D
• AENANX02: Y windings through disconnect switch AENANW02A, the normal feed is 1ENANS06H to power 1ENANS06. Alternate feed through the Y winding and disconnect switch AE-NAN-W02A to 2ENANS05B. Power to switchgear is underground lines. Z winding through disconnect switch AENAN-W02B, normal feed is to 3ENANS05D. Alternate feed is to 2ENANS06A. The overhead “Jack-Bus” is used to distribute power to the switchgear.	Cables enter in the “G” cubicle for 1ENANSO6H Cables enter in the “A” cubicle for 2ENANS05B

- AENANX03:

  Y windings through disconnect switch AENANW03A, the normal feed is 2ENANS06C to power 2ENANS06. Alternate feed through the Y winding and disconnect switch AE-NAN-W03A to 3ENANS05B. Power to switchgear is underground lines.

  Cables enter in the “D” cubicle for 3ENANS06C
  Cables enter the “A” cubicle for 3ENANS05B

  Z winding through disconnect switch AENAN-W03B, normal feed is to 1ENANS05B. Alternate feed is to 3ENANS06A. The overhead “Jack-Bus” is used to distribute power to the switchgear for 3ENANS06.

  Cables enter in the “C’ cubicle for 1ENANS05B

- Unit 1 NANS05 AND NANS06 has circuit breakers to NANS03 and NANS04.
  Unit 2 and 3 do not have breakers to NANS03 and NANS04 from NANS05 and NANS06. They are hard tied to the bus.

EO 1.3	Identify the 13.8Kv power distribution with the Main Generator on line and off line

1.3 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.3 Identify the 13.8Kv power distribution with the Main Generator on line and off line

General:

- With the Main Generator off line such as during outages or a trip, the 13.8 KV power comes from off-site.

  NANS05 – NANS03, NANS03B – NANS01
  NANS06 – NANS04, NANS04B – NANS02

  With the Main Generator on line, the 13.8KV power is distributed to NANS01 and NANS02 via the Unit Aux Transformer (MANX02).

Review print 13-E-MAA-001

- The Unit Aux. Transformer takes the output of the Main Generator (24KV) and steps it down to 13.8KV for each secondary winding.

  The “X” winding supplies power to NANS01 via the NANS01A breaker.
  The “Y” winding supplies power to NANS02 via the NANS02A breaker.

- In the event that the unit receives a turbine trip during normal operation, a fast bus transfer will occur and NANS01A & NANS02A will open and NANS03B & NANS04B will close.

  Transfer should take place in 155 milliseconds or less. Power is then distributed from off site through NANS05 & NANS06.

- In the event of a station blackout (SBO), the gas turbine generators (GTGs) will supply 13.8KV AC power from NANS07 to the emergency loads of the blacked out unit for a duration of four hours ensuring that stable operating conditions can be maintained during the SBO.

- Switchgear NAN-S03AB ties in to the 13.8 kV non-class IE power system on the line side of breaker NAN-S03A which is the non-class IE feeder breaker that provides preferred off-site power to train A ESF transformer NBNX03, which normally feeds class IE bus PBA-S03.

- The GTGs can only be brought in on the PBA-S03 side but can supply PBB-S04 if needed through a bus tie to operate the proper equipment.

BUS AND LINE: PER 32MT-9ZZ81

- BUS: The primary distribution point that is connected directly to the bus

  For all load breaker cubicles, this is the point where the load breaker directly connects to the bus.

  For all supply breaker cubicles (main or alternate supply breakers) this is the point where the supply breaker directly connects to the bus

  LINE: The point that is not directly connected to the bus

  For all load breaker cubicles, this is the point where the load breaker directly connects to its load.

  For all supply breaker cubicles (main or alternate supply breakers) this is the point where the supply breaker directly connects to the supply breaker.

EO 1.4	Explain the Electrical distribution for the 4.16Kv Non-Class Power system (NB)

1.4 Main Idea

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.4 Explain the Electrical distribution for the 4.16Kv Non-Class Power system (NB)	
General:	
• Normal service transformers NBNX01and NBNX02 convert non-class IE, 13.8 kV power to 4.16 kV non-class IE power.	See prints 13-E-MAA-001 01-E-NAA-004 and 01-E-NAN-005
• Breakers NANS01N and NANS02N are the feeder breakers to the Normal Service Transformers.	
• During normal operation, transformer supply is from the main generator through the unit auxiliary transformer; however, during startup or upon loss of the unit generator, it is supplied by off-site power through buses NAN-S03 and S04.	
• 4.16 kV non-class IE switchgear system consists of two buses designated NBN-S01and NBN-S02. Buses NBN-S01and S02 supply in-plant loads.	Talk about abnormal line-ups during outages.
• The NBN-S01 and NBN-S02 buses are designed with the ability to allow a fast bus transfer from the normal service transformer source to the opposite NB source bus via the bus tie breaker NBN-S01C. The feature allows the 4.16 kV bus loads to remain energized in the event of a loss of the normal service transformer.	Point out to the students the hazards of back-feeds.
• At times during outages, or unavailability of off-site power, NBNS01 or NBNS02 can provide back-feed power through a Normal Service Transformer (NBNX01or NBNX02) to provide 13.8KV to NANS01 or NANS02. This would not be a normal line up.	13.8KV would be at the line side of NANS03B or NANS04B during a back-feed.

EO 1.5	Explain the Electrical distribution for the 4.16Kv Class Power system (PB)

1.5 Main Idea

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.5 Explain the Electrical distribution for the 4.16Kv Class Power system (PB)	
General:	
• The class IE 4.16 kV AC distributes the electrical power received from off-site or on-site sources to safety related loads.	See Prints 13-E-MAA-001, 01-E-PBA-001 and 01- EPBA-002
• The 4.16 kV AC system receives preferred (off-site) power through two Engineered Safety Features (ESF) service transformers or standby power from two Emergency Diesel Generators (EDG's), and distributes power to PBAS03 and PBBS04 Switchgear.	
• The two 4.16 kV AC buses are normally supplied by electrical power from the preferred off-site power source through the ESF service transformers. These two transformers convert non-class IE 13.8 kV preferred offsite power to 4.16 kV class IE power, with each transformer furnishing one class IE load group. Load group 1 (PBA-S03) supplies safety train 'A' and load group 2 (PBB-S04 bus) supplies safety train 'B'. A safety train is defined as that equipment considered essential for a safe shutdown of the reactor. These two trains are provided for redundant protection.	Discuss PT's in adjacent cubicles that could be energized

- Under normal circumstances, transformer NBN-X03 supplies bus PBA-S03 and transformer NBN-X04 supplies bus PBB-S04 with one exception.

  The exception is that, during plant modes 5 and 6, both trains can be employed but only one is required.

  If either transformer is not available, the bus normally supplied by that transformer can be fed by the other transformer.

  Feeding a bus from the cross train source is not normally done, however during abnormal/emergency conditions the cross train bus may be supplied from the unaffected transformer.

- Standby power can be supplied to the safety train 'A' bus (PBA-S03) by Emergency Diesel Generator PEA-G01 and to the safety train 'B' bus (PBB-S04) by Emergency Diesel Generator PEB-G02.

  The Gas Turbine Generators (GTG's) at the WRF can supply emergency power to the ESF service transformer NBN X03 via breaker NAN S03AB.

Ask students to determine breakers that feed NBNX03 and X04

Discuss cross tie breakers and system line up

EO 1.6	Discuss the Calvert Bus configuration for the 13.8Kv and 4.16Kv distribution

1.6 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.6 Discuss the Calvert Bus configuration for the 13.8Kv and 4.16Kv distribution

The Calvert Bus was manufactured by the Calvert Company.

- The Calvert Bus is a Non-segregated phase bus duct that is an electrical device engineered to economically transmit power safely from one piece of electrical equipment to another (|e. transformer to switchgear, switchgear to switchgear).

  The current is carried along rigid aluminum square tubes or rectangular aluminum bars. Conductors are insulated to prevent phase to phase or phase to ground faults.

- 13.8Kv (NA) Calvert Bus Runs.

  From the Unit Aux. Transformer (MANX02), the Calvert Bus (NAN-A01) runs from the “X” Winding to NANS01.

  The Calvert Bus (NAN-A02) runs from the “Y” Winding to NANS02.

  NANA03 runs from NANS03B to NANS01
  NANA04 runs from NANS04B to NANS02

  Review prints 01-E-MAA-002, 13-E-ZYP-015 and vendor print E015-28

- 4.16Kv (NB) Calvert Bus Runs

  NBNA01 runs from NBNX01 to NBNS01A
  NBNA02 runs from NBNX02 to NBNS02A
  NBNA03 runs from NBNX03 and splits into two other Calvert Bus runs, NBNA08 and NBNA09
  NBNA08 runs to PBAS03L
  NBNA09 runs to PBBS04L
  NBNA04 runs from NBNX04 and splits into two other Calvert Bus runs, NBNA05 and NBNA06.
  NBNA05 runs to PBAS03K
  NBNA06 runs to PBBS04K
  NBNA07 is a cross tie run between NBNS01C and NBNS02

  OE# 25032- Employee Inadvertently accessed Energized Section of 4.16Kv

  OE# 10028- Electricians performed work on wrong equipment while energized

EO 1.7	Identify and discuss AC and DC distribution paths and equipment

1.7 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.7 Identify and discuss AC and DC distribution paths and equipment

Non-class

- General:
  With the Main Generator on line, NANS01 & NANS02 are fed from the Main Generator (24KV) via the Unit Aux.Transformer (13.8KV).

  During outages or a trip, NAN-S01& NAN-S02 are fed from offsite power through NAN-S03 & NAN-S04.

  NAN-S01 & NAN-S02 feed various loads, CW, RC, NB Transformers and Load Centers.

  480 Volt Load Centers feed various plant loads and 480 Volt MCC's (Motor Control Centers).

- Review single line drawing 01-E-NAA-0005 for 01-E-NAN-S02.

  NAN-S02D feeds Load Centers NGN-L14, NGN-L08 and NGN-L18

  NGN-LO8E2 Breaker feeds MCC NHN-M22

  NHN-M2214 is the normal feed to Battery Charger NKN-H18, ("F" Battery Charger).

NKN-H17	(E) Battery Charger	Norm. Feed	NKN-M45
NKN-H18	(F) Battery Charger	Norm. Feed	NKN-M46
NKN-H19	(G) Battery Charger	Supply to	NKN-D19
NKN-H20	(E1) Battery Charger	Alt. Feed	NKN-M45
NKN-H21	(EF) Battery Charger	Alternate to	M45/M46

  NKN-M4606 is the supply breaker to MLONP05 (EBOP) Emergency Bearing Oil Pump

NA = non-class 13.8KV

NG = non-class 480V Load Centers

NH = non-class 480V MCC's

NK = non-class 125 VDC

See Drawing 01-E-NKA-001

NKN-H19 (G) located at Cooling Twr. #1 in each respective unit.

H = Battery Charger

F = Battery

Class

- General:

  PBA-S03 and PBB-S04 provides 4.16KV power to Safety Related Equipment.

  4.16KV is supplied to the Load Centers and stepped down to 480 Volts (PG).

  PB = Class 4.16KV

- Review a distribution path from AC to DC starting from PBB-S04.

  Breakers in PBB-S04 supply power to feed Load Centers PGB-L32, PGB-L34, and PGB-L36

  PGB-L32 feeds: PHB-M32and PHB-M38

  PGB-L34 feeds: PHB-M34 (class) and NHN-M72 (non-class)

  PGB-L36 feeds: PHB-M36 (class) and NHN-M20 (non-class)

  PHB-M32 associated breakers feed:
  PKD-H14 Battery Charger
  PND-V28 Voltage Regulator

  PHB-M34 associated breaker feeds:
  PKB-H14 “BD” Battery Charger

  Battery Charger PKB-H12 is the normal feed to DC MCC PKB-M42.

  Battery Charger PKB-H14 “BD” can supply power to feed MCC’s PKB-M42 or PKD-M44 if needed.

  The normal battery charger provides a float (trickle) charge to battery PKB-F12 to keep the battery fully charged. The battery is available as a standby DC source to carry the control center load automatically in case of a power loss to the charger.

  Loads off of PKB-M42:
  Control power for the Reactor Trip Switchgear SBB-C03
  PKB-D22 DC Distribution Panel
  Input power to PNB-N12 Inverter

  PG = Class 480 Volt Load Center

  PH = Class 480 Volt MCC’s

  NHN-M72 and NHN-M20 Non-Class MCC’s will trip on a SIAS signal for load shed
  See Drawing 01-E-PKA-001

  PK = Class 1E 125 VDC Power

  H = Battery Charger

  PN = Class 1E Instrument AC power

  V = Voltage Regulators

  SB = Reactor Protection

PNB-N12 Inverter provides 120 VAC to the Vital Instrument Distribution.

Voltage Regulator PNB-V26 provides a bypass of 120 VAC to feed the Vital Instrument Panel PNB-D26 during the loss of the Inverter.

See 01-E-PNA-002 for plant loads for PNB-D26

For units 2 and 3, the transfer to the regulator is through the static switch (automatic) from the normal source to backup source in the event of loss of normal source (inverter).

For unit 1, the transfer is manual from the normal source to backup source in the event of loss of normal source (inverter). Unit I does not have a static switch

EO 1.8	Identify and discuss electrical components and symbols associated with switchgear circuit breaker ENANS02D

1.8 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.8 Identify and discuss electrical components and symbols associated with switchgear circuit breaker ENANS02D

See drawing 01-E-NGB-002

Single line drawing 01-E-NAA-005:

- Switchgear NAN-S02 is fed from the Unit Aux. Transformer (MAN-X02) when the unit is on line, and NAN-S04B when off line.

  NAN-SO2D feeds three load centers by 3 parallel feeds of single 3/C #4/0 cable: NGN-L14, NGN-L08, and NGN-L18

  Power is delivered through a 1200 Amp Magne-Blast Breaker.

  Current is monitored through 3 CT's with 150/5 ratios.
  The CT's feed into 3 protective relays 250/251F (Feeder).
  Current flows through the protective relays 250/251F and to the AS (Ammeter switch) and 1 local ammeter.
  Aux. CT is connected to 'B' phase from the AS and to a remote Ammeter (control room).

  The 250G receives its signal from a single window type CT. The CT has all three phases passing through it and monitors ground current.

  The 286 Lockout relay is actuated by 250/251F, 250G, and 51N – 62 (See dotted line "D" to print (01-E-NGA-008).

250 = Inst. Overcurrent relay

251 = AC Time Overcurrent relay

F = Feeder

M = Motor

B = Bus

BN = Bus Neutral

G = Ground

Control Circuit for NAN-S02D:

See "F" drawing 01-E-NGF-002

See vendor print E009-0094

- DC Control power for switchgear is supplied from NKN-D4202. See note 3a, 3b, and 3c.

  3a NKN-D42
  3b NKN-D4202
  3c Drawing NKA-004

  Positive wire P02 comes in to point 3 on the control power breaker. Negative wire N02 comes in to point 1 on the control power breaker in the switchgear cubicle.

Fuses on elementary drawings do not reflect vendor designators:

See Handswitch development table for CS-1 and CS-2

- FU-1 "UC" 15 Amp:

  FU-1/UC supplies power to charge the closing springs through stab #1 in the internal breaker rectangular box. The chevron symbol represents a secondary disconnect (See print 01-ENAB-021).

  See DWG 01-E-NGF-002 sh 3

  Supplies power to the local handswitch (CS-1) to close the breaker and local green and clear light indication.

  See DWG E009-0094

  The negative from FU-1/UC enters the internal breaker box through stab #8.

- FU-2 "UT" 35 Amp:

  FU-2/UT fuse supplies power through the local and remote handswitches CS-1 and CS-2 to the trip circuit.

  Provides power for the local white and red light indication.

  The positive from the trip circuit enters the internal breaker through pin #9.

  The negative enters through pin #10.

- FU-3 "UA" 10 Amp:

  FU-3/UA has two fuses, each of which is positive.

  FU-3/UA term points 3 and 4 provide power to remote handswitch CS-2 to energize the "CR" relay to close the breaker. Also provides power for the remote green light indication.

  FU-3/UA term points 1 and 2 provide power to remote handswitch CS-2 to energize the "TR" relay to trip the breaker. Also provides power for the remote red light indication.

- FU-4 "UL" 10 Amp:

  FU-4/UL provides power to the elevating mechanism control circuit.

- Control Circuit:

  Local handswitch CS-1 contacts 8/8T close to provide power to close the breaker through the 233 position switch with the breaker in the test position and will bypass the 286 contacts.

  233 = position switch

  CS-1 contacts 4/4T close the breaker in test or in the racked up position with the 286 contacts in the circuit

  CS-2 remote handswitch contacts 5/6 will close to energize the "CR" relay to close contacts 1/7 to close the breaker.

  CR = close relay

  CS-1 local handswitch contacts 1/1T will close to trip the breaker.

  CRDR #2797037 2ENAN-S06 Normal Supply Breaker unexpectedly closed while replacing the dust cover on the CR relay.

  Remote handswitch CS-2 contacts 1/2 will close to energize the "TR" relay to close contacts 1/7 to trip the breaker.

- Trips:

  186R-1X2 protective relay contact 3/4.

  227-SX-2 protective relay contact 3/4.

  Each Loadcenter fed from NAN-S02D has a 62 Agastat that will trip the breaker. The 62 Agastat is actuated by the 51N relay. If the neutral overcurrent condition does not clear within .5 sec's the Agastat will time out and trip the 13.8kv feeder breaker NAN-S02D.

  250/251F protective relay will trip the breaker during a instantaneous ground fault or a time AC overcurrent condition.

  Positive voltage flows through the normally closed contacts of the 286 and energizes the 286 relay coil and closes contacts 2/2C to trip the breaker.

  The contacts in series with the 286 open to protect the coil from being continuously energized. Contacts 7/7C also open to prevent the breaker from being closed. The 286 will lockout any other actuations until it is manually reset after a 286 trip.

  Remote and local green light indication is actuated through the 252b contact on the breaker indicated by the chevron symbol, stabs 11 and 12.

  All other indication contact functions come from the breaker internal control circuit which will be covered later in the course.

TR = trip relay

186R-1X2 monitors NAN-S04 UV, CEDMCS

227-SX-2 monitors NAN-S02 UV
Ref. print 01-E-NAB-015

Ref. Drawing NGB-016

286 = lockout

See vendor print E009-0022 Aux. switch contacts 5 and 5C go to pins 11 and 12

EO 1.9	Identify and discuss electrical components and symbols associated with switchgear circuit breaker internal control circuit for ENANS02D

1.9 Main Idea

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.9 Identify and discuss electrical components and symbols associated with switchgear circuit breaker internal control circuit for ENANS02D	
Internal Control Circuit:	
• Pin Connections to breaker control circuit:	See 01-E-NAB-021
Pin 1 = positive side of 125V to the charging motor/anti-pump relay (52Y)	See Vendor E009-022
The clear light will let you know if the springs are charged (If the light is on the springs are charged).	CRDR # 3014909 02-E-NAN-S01K clear light did not illuminate when springs charge
Pin 8 = negative side of 125 VDC for the charging motor/ anti-pump relay and closing coil.	
The control room will receive an alarm if the breaker closes and the springs do not recharge (for class 1E breakers only).	
Pin 3 = negative side of clear light from pin 8 through the 52 SM/LS contacts 5/6.	52X Spring release coil (closing coil) operates close latch to release the charged closing springs
Pin 4 = positive side with control switch to the closing coil and anti-pump relay.	52SM/LS Limit switch for spring charging motor. Contacts 1/2, 3/4, open and contact 5/6 closes when the springs are fully charged

- Breaker Closing:

  With control power applied, the closing springs charge.

  Control switch taken to close, this applies a positive 125 Vdc to pin 4.

  Goes through 52IS contact if breaker is fully elevated or fully lowered in the cubicle.

  52IS Interlock switch, closed when the breaker is fully racked up or fully racked down in the test position.

  52Y coil is not energized. 52Y contacts at terminals 7 to 3 and 4 to 8 are "b" contacts, thus they are closed.

  The 52LC contacts are closed if the closing springs are compressed and the closing spring ratchet is latched.

  52/LC Latch checking switch is only on the VCB (Vacuum Circuit Breakers) NANS03AB

  Contacts 1/1C on the (52) auxiliary switch are closed when the breaker is in the open position (b Contact).

  Contacts 6/5 will be closed on 52/sm/ls when the closing springs are fully charged.

  52X coil will energize when current flows through the 52/sm/ls contact to pin 8 (the negative side).

  When the 52X coil picks up it releases the closing springs and the breaker closes.

- After breaker closure:

  The breaker operating mechanism is latched into place keeping the breaker closed.

  The closing springs have discharged to close the breaker and the motor starts to compress the closing springs.

  The positive side of 125V can come in through pin 1.

  52IS (positive interlock) contacts 1/2 close when breaker is fully raised or fully lowered in the test position.

  52/SM/LS contacts 1/2 close when the springs are discharged.

  52/CL/MS contacts 1/2 will reclose after the closing springs have fully discharged and the latch monitor switch then resets.

  52 CL/MS Close latch monitoring switch. Monitors the position of the close latch to ensure it is capable of blocking the closing springs.

  The spring charging motor then energizes and recharges the closing springs through a ratchet and pawl assembly.

- Anti-pump feature:

  Function: To prevent an immediate closure of the breaker after a trip until the close signal is removed, and re-initiated. This ultimately means that the breaker cannot be electrically closed more than once with the same close signal.

  Prevents breaker from re-closing on a potentially faulted load.

  A 52Y coil will energize when 52/sm/ls contact 3/4 closes. The 52/sm/ls contacts are open only when the closing springs are fully charged.

  When the 52Y coil energizes, seal-in contact 7/1 closes. The 52Y coil remains sealed in and energized with a positive voltage at pin #4.

  Two series 52Y contacts 7/3 & 4/8 open to prevent the 52X-spring release coil from closing the breaker until the unwanted close signal is removed.

  The anti-pump coil 52Y is energized during the charging of the closing springs and will drop out once the springs are charged if a close signal is not on pin # 4.

- Breaker Tripping:

  When the breaker is closed, contacts on aux. switch 2/2C and 4/4C are closed (a contacts).

  When a positive voltage is applied at pin # 9 the trip coil 52/TC is energized tripping the breaker.

EO 1.10	Identify and discuss electrical components and symbols associated with load center ENGNL08

1.10 Main Idea

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.10 Identify and discuss electrical components and symbols associated with load center ENGNL08	
• Single line drawing 0_-E-NGA-0008:	
Loadcenter ENGNL08 is fed from NANS02D by a single 3/C (conductor) #4/0 cable.	
Power passes through a 13.8KV, 600A, 3-pole Load Interrupter switch to the loadcenter transformer.	In cubicle L08T see note 9 for Kirk key information
Three Lightning Arrestors (LA) are connected to the Interrupter switch and ground.	
The transformer has the following characteristics: 1. Dry type 2. Primary = 13.8KV Delta 3. Secondary = 480/277V Wye (grounded neutral) 4. 1000KVA	In cubicle L08X
The transformer provides power through L08B2 supply brkr. to L08 bus.	
The ground off the secondary is monitored by a single CT with a primary to secondary ratio of 600/5.	CT = Current Transformer
The CT feeds a 51N relay, which feeds a 62 relay.	51N = AC Time Overcurrent Relay (Neutral)
The 62 relay provides a trip signal (F-D) to the 13.8KV supply brkr. S02D (see function table).	62 = Time Delay Stopping or Opening Relay
The 51N relay also provides a signal to the L08B2 86 relay (see function table for the B2 86 relay).	86 = Locking Out Relay
The L08 bus is monitored by a PT that looks at Phases “A” and “B” through two 7A fuses. The PT has a 480V primary and 120V secondary.	PT = Potential Transformer In cubicle L08B1
The PT feeds a 27 relay which provides a signal to the annunciator (F-A) and the computer (F-Q).	27 = Undervoltage Relay
The PT also feeds local and remote (JRMNB01) voltmeters (0-600V), through a 3A fuse.	JRMNB01 = Control Board in Control Rm.

- ENGNL08E2 General Information:

  A drawout breaker is symbolized by the breaker symbol and the chevrons.

  A K-don type breaker is denoted by fuses (1000A).

  The breaker utilizes an SS4 (Solid State) type trip device which will trip the 86 relay. — See function table

  The 86 relay will perform the following functions:
  1. Input to the annunciator
  2. Trip feeder brkr. (L08B2)
  3. Input to the computer

  The cables off the line side of the brkr are 3 single 500 KCMil conductors. — KCMil = 1000 Circular Mils (K = Latin pre-fix for 1000) MCM = 1000 Circular Mils (M = Roman numeral for 1000)

  A single CT (window type), with all three cables passing through it, is monitoring the ground current. The CT has a primary to secondary ratio of 600/5.

  The CT feeds a 51G relay that also trips the 86 relay. — 51G = AC time overcurrent Relay

  Loadcenter brkr. ENGNL08E2 feeds Motor Control Center (MCC) ENHNM22. — See drawing 0_-E-NHA-00022

- ENGNL08E2: Control circuit:

  Control power is supplied by NKND41 brkr. 09 at P.O.F.B. "EE" (30A) in the rear of cubicle L08E2.

  P.O.F.B. = Pull Out Fuse Block

  Power is supplied on wires P05 (positive) and N05 (negative).

  Numbers by each fuse indicate the specific termination point for that fuse

  Positive power is carried through fuse "EF" (10A) to remote indication at JRMNB01C1.

  JRMNB01C1 = Control board in the control rm.

  Rectangular boxes in the control circuit connected by chevrons indicate that the circuitry inside the box is internal to the brkr (ACB closing circuit/ACB trip circuit).

  Numbers by the chevrons correspond to the number of the secondary stab for the brkr.

  125VDC is supplied to the brkr. closing circuit at brkr. secondary stabs 1 and 7.

  Negative power is supplied to the brkr. closing circuit at secondary stab 5.

  Positive power is only applied to the "Test PB Close" pushbutton on the brkr. from secondary stab 8 when the brkr. is in the test position as denoted by the "TP" next to the chevron.

  An "OP" next to a chevron indicates that power passes through that secondary stab only when the brkr is in the operate position.

  Positive power is applied to secondary stab 3 from local "PB Close" pushbutton when closed and two normally closed contacts in series from relay 86. In the operate position this applies a close signal to the brkr. control circuitry to close the brkr.

  Negative power is supplied to the brkr. tripping circuit at secondary stab 2.

  Positive power is applied to secondary stab 4 from the local "PB Trip" pushbutton when closed. This will trip the brkr. open.

  Positive power is applied to secondary stab 4 from two contacts in series from the 86 relay when the relay is energized. This will trip the brkr. open.

  Positive power is only applied to the "Test PB Trip" pushbutton on the brkr. from secondary stab 9 when the brkr. is in the test position as denoted by the "TP" next to the chevron.

- Negative power is always applied to the coil of the 86 relay (Pt. F) through two normally closed 86 contacts in series. Positive power is applied to the coil of the 86 relay (Pt. C) through two normally closed 86 contacts when the “52 BAS OVLD SW HAND RESET” contact is closed. This contact is located on the brkr. and is closed by an overcurrent condition.

  Positive power is applied to the coil of the 86 relay (Pt. C) through two normally closed 86 contacts in series when the contacts on the 51G relay close. This is a PR&C protective relay.

  When the coil of the 86 relay is energized it opens the contacts between (“B” and “C”) and (“F” and “G”), this protects the relay from being continuously energized. It also closes the contacts between 12 and 18 which apply positive power to the brkr. trip circuit through secondary stab 4.

  Red and Green local and remote indication is provided to indicate when the brkr is open and closed. Positive power is always applied to both the red and green light indication.

  Local and remote red lights are energized when the brkr is closed and negative power is applied to secondary stab 4 from the trip coil and an “a” contact in the brkr trip circuitry. Indication is lost when the brkr opens and the “a” contact opens.

  Local and remote green lights are energized through a “b” contact on the brkr (secondary stabs 2/6) and variable resistors. If the brkr. trips and the 86 relay is energized two normally open 86 contacts in both the local and remote circuits close and shunts out part of the resistors causing the green lights to shine more brightly. If the brkr is racked down with an umbilical cord both local and remote green lights are energized brightly through a position switch (33-1).

  Annunciation to the control room is received through two normally closed 86 contacts in series (11/13) when the 86 relay is energized.

BAS = Bell Alarm Switch
OVLD = Overload
SW = Switch

LC tripping sequence:
1. CT’s inside the brkr sense current
2. A proportional signal is sent to the SST
3. The SST sends a signal to the Magnetic Latch
4. The magnetic latch actuates the trip bar
5. The trip bar actuates the BAS

The energized red light gives indication of trip coil continuity when the brkr is closed.

- ENGNL08E2 Internal circuitry:

L/a = Auxiliary sw. contact, open when the brkr is open and closed when the brkr is closed.	"a" type contacts mirror the condition of the brkr
L/b = Auxiliary sw. contact, closed when the brkr is open and open when the brkr is closed.	"b" type contacts are opposite of the condition of the brkr
LS/1 (LS/3) = Limit sw. contact, closed when the springs are discharged and open when the springs are charged.	
LS/2 = Limit sw. contact, open when the springs are discharged and closed when the springs are charged.	
Y = Anti-pump relay	The purpose of the anti-pump relay is to prevent the brkr from closing into a fault when there is a hard (constant) close signal. The hard close signal must be removed to de-energize the anti-pump relay to enable the brkr to close.
Y/1 = Normally open Anti-pump relay contact, seals in the Anti-pump relay.	
Y/2 = Normally closed Anti-pump relay contact, disables the close latch release coil (X).	
X = Closing latch release coil: When this coil is energized it mechanically closes the brkr.	
TC = Shunt trip coil: When this coil is energized it mechanically trips the brkr.	

- With control power applied:

  A Pos signal is applied to stab 1 (if the brkr is in the test position a Pos signal is applied to stabs 8 and 9).

  A Neg signal is applied to stabs 2, 5, and 7.

  The Neg signal at stab 2 is applied to stab 6 through contact L/b (7/8) and illuminates the local and remote green lights.

  If there is a hard Pos signal at stab 3, the Anti-pump relay (Y) will energize through LS/3 and seal in through Y/1. Contact Y/2 will open preventing the brkr from closing.

  When the “Motor Disc Sw” is closed, the spring charging motor is energized through LS/1 and L/b (1/2), charging the springs.

  The motor disconnect switch is a double pole/single throw switch

  The following contacts change state:
  LS/1 opens de-energizing the spring charging motor
  LS/2 closes enabling the close latch release coil (X)
  LS/3 opens disabling the anti-pump relay (Y)

  Applying a pos to stab 3 (remote close) or, with the brkr in test, pressing the “TEST PB CLOSE” pushbutton on the brkr, will energize the close latch release coil (X) through contacts LS/2, L/b (3/4) and Y/2 and the brkr will close.

  The following contacts change state:
  L/b (1/2) opens disabling the spring charging motor
  L/b (3/4) opens disabling the close latch release coil (X)
  L/a (5/6) closes enabling the trip coil (TC) and energizing the red lights
  L/b (7/8) opens de-energizing the green lights

  When the brkr closes the springs discharge returning LS/1/2/3 to their original configuration.

  Applying a Pos to stab 4 (remote trip) or, with the brkr in test, pressing the “TEST PB TRIP” pushbutton on the brkr, will energize the trip coil (TC) through contact L/a (5/6) and open the brkr.

  The following contacts change state:
  L/b (1/2) closes charging the springs
  L/b (3/4) closes enabling the close latch release coil (X)
  L/a (5/6) opens disabling the trip coil (TC) and de-energizing the red lights
  L/b (7/8) closes energizing the green lights

When the springs charge the following contacts change state:
LS/1 opens de-energizing the spring charging motor
LS/2 closes enabling the close latch release coil (X)
LS/3 opens disabling the anti-pump relay (Y)

The brkr is set up for another close.

EO 1.11	Identify and discuss electrical components and symbols associated with Motor Control circuit breaker ENHNM22

1.11 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.11 Identify and discuss electrical components and symbols associated with Motor Control circuit breaker ENHNM22

- Single line drawing 0_-E-NHA-0022:

  Motor Control Center (MCC) NHNM22 is fed by 3 single 500 KCMil conductors coming from NGNL08E2.

  M = Motor Control Center
  Incoming feed lines bolt directly to the MCC bus in cubicle NHNM2201
  Only one set of chevrons is shown. This is to illustrate that the line side of the bus is usually bolted

  NHNM2214 is a drawout style brkr as denoted by the chevrons.

  The brkr has the following characteristics:
  1. 225AF (Amp Frame)
  2. 100AT (Amp Trip)
  3. TM (Thermal Magnetic)

  M = Magnetic only (usually has overloads)

  A ground fault sensor is monitoring the input to the brkr with all three conductors passing through the CT as denoted by the CT symbol.

  The CT feeds a 50G relay.

  50G = Instantaneous ground fault

  The 50G relay provides a signal to trip the brkr upon a ground condition.

  Q. Why do MCC's have control power transformers?
  A. To power ground fault relays and/or starters, lights, etc.

  The MCC bucket contains a control transformer as denoted by the transformer symbol.

  Q. Why doesn't M2219 have a control transformer? It has a starter
  A. Control power comes from M2218 (see "B" and "F" prints)

  The cables off of the line side of the brkr are 3 single 2/0 conductors.

  NHNM2214 feeds battery charger NKNH18 which is a 50KVA load.

  H = Battery Charger Subsystem F

EO 1.12	Identify and discuss the Emergency Bearing Oil Pump (EBOP) motor control and power circuitry

1.12 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.12 Identify and discuss the Emergency Bearing Oil Pump (EBOP) motor control and power circuitry

- General:

  The Main Turbine Emergency Bearing Oil Pump (EBOP) motor is a “Compound” vertical type CD 40HP 1750 RPM 125VDC motor rated for 110 gpm at 15 psig.

- Purpose:
  The EBOP is designed to supply lube oil to the main turbine and generator bearings while the turbine is on the turning gear and while the turbine is coming up to speed, or in an emergency condition. It takes suction from the oil reservoir and discharges into the bearing header prior to the oil coolers.

  The EBOP is physically located in the Turbine Bldg. 140’ elevation, on top of the Lube Oil reservoir tank in the Lube Oil room (05NT500WTC0140).

  The DC motor starter control box LONK01 is physically located in the Turbine Bldg. 140’ elevation, just out side of the Lube Oil room.

05NT500WTC0140 = 05 Ft. North of column T5 and 00Ft. West of column TC on the 140’ elevation.
T = Turbine Bldg

- Standby:

1. 125VDC is applied across the motor/control circuit supplied by _ENKNM4606.
2. Main contactor “M” is de-energized (dropped out).
3. Normally open contact “M” (in the motor start circuit) is open.
4. Normally closed contacts “1A” and “2A” (in parallel with resistor “RS”) are open.
5. Relay “2A” is energized (picked up) through contact “1A” and resistor “2RS”.

TDO = Time Delay Opening

6. Relay “AX” is de-energized (dropped out) due to the open “2A” contact.

TDD = Time Delay De-energizing

7. Relay “1A” is energized (picked up) through contacts “CS-1” (11/11C), “M”, and resistor “1RS”.
8. Relay “MX” is energized (picked up) through contacts “CS-1” (11/11C), and “M”.
9. Undervoltage contact “27-1X” is open (closes on load center L14 undervoltage).

27 = Undervoltage relay
L14 feeds the Main Turbine Turning Gear oil pump _E-LON-P04

10. Contact “CS-1” (1/1C) is open (closed only when the handswitch is taken to the start position).
11. Contacts “CS-1” (11/11C) and “2A” are closed.
12. The Turning Gear and Main Shaft oil pump pressure switches (PSL7A/B/C/D) are open.

PSL = Pressure Switch Low

13. The “Green” light on RMNB06F is energized (illuminated) through contacts “CS-1” (11/11C), “2A”, and “MX”.

The green light indicates that relays “1A” and “2A” are energized (picked up) and indicates integrity of coil relay “M

14. The “Red” light on RMNB06F is de-energized (extinguished) due to the open “MX” contact.
15. Relay “62” (time delay on drop out) is energized through contacts “49” and “CS-1” (11/11C).

62 = Time delay stopping or opening relay

The “62” relay is always energized unless contacts “49” or “CS-1” (11/11C) open and gives an overload or pre-trip alarm to the control room. There is a 5 sec. time delay.

49 = Machine or transformer thermal relay

16. The “Amber” light on RMNB06F is de-energized (extinguished) due to the open “MX” contact.

The Amber light tells operations whether the EBOP was started in “Auto” or “Manual”

- Manual Starting:

1. Handswitch “CS-1” is taken to the start position and contact “CS-1” (1/1C) closes.
2. Main contactor “M” energizes (picks up) and its seal in contact closes.
3. Contact “M” (in the motor circuit) closes and the motor starts through resistor “RS” (starting current is limited).
4. Normally closed contact “M” opens.
5. Relay “1A” de-energizes and 1 sec. later drops out.
6. Contact “1A” (in parallel with resistor “RS” R1/R2) closes, shunting out part of resistor “RS” R1/R2.
7. Contact “1A” opens and de-energizes relay “2A” and .75 seconds later it drops out.
8. Contact “2A” (in parallel with resistor “RS” R2/R3) closes, completely shunting out resistor “RS” R2/R3.
9. Contact “2A” opens in the start circuit.
10. Contact “2A” closes and relay “AX” energizes (picks up) and closes it’s two contacts (this sets up relays “1A” and “2A” to energize at full voltage).
11. Relay “MX” is de-energized (drops out).
12. The “Green” light on RMNB06F is de-energized (extinguished) due to the open “2A” and “MX” contacts.
13. The “Red” light on RMNB06F is energized (illuminated) through contacts “CS-1” (11/11C) and “MX”.
14. The “Amber” light is de-energized (extinguished) due to the open “CS-1” (9C/9) contact (opens in the after start position).

A typical rotor winding has small impedance and cannot limit the flow of current at standstill (starting). When running, the motor develops a voltage (counter emf) that opposes the line voltage and limits current flow. This voltage is proportional to the motor speed. To protect the rotor winding, resistance is inserted when voltage is first applied during starting. The resistance is cut out in steps as the motor accelerates, until on the last step the motor runs directly across the line voltage.

- Auto start:

  1. The Turning gear and Main Shaft oil pump pressure switches (PSL7A/B/C//D) close.
  2. Main contactor “M” energizes (picks up) and its seal in contact closes.
  3. Contact “M” (in the motor circuit) closes and the motor starts through resistor “RS” (starting current is limited).
  4. Normally closed contact “M” opens.
  5. Relay “1A” de-energizes and 1 sec. later drops out.
  6. Contact “1A” (in parallel with resistor “RS” R1/R2) closes, shunting out part of resistor “RS” R1/R2.
  7. Contact “1A” opens and de-energizes relay “2A” and .75 seconds later it drops out.
  8. Contact “2A” (in parallel with resistor “RS” R2/R3) closes, completely shunting out resistor “RS” R2/R3.
  9. Contact “2A” opens in the start circuit.
  10. Contact “2A” closes and relay “AX” energizes (picks up) and closes its two contacts (this sets up relays “1A” and “2A” to energize at full voltage).
  11. Relay “MX” is de-energized (drops out).
  12. The “Green” light on RMNB06F is de-energized (extinguished) due to the open “2A” and “MX” contacts.
  13. The “Red” light on RMNB06F is energized (illuminated) through contacts “CS-1” (11/11C) and “MX”.
  14. The “Amber” light is energized through contacts “CS-1” (11/11C) (9/9 C) and “MX”.

- EBOP running:

  1. Contacts “M”, “1A”, and “2A” (in the motor start circuit) are closed.
  2. Contact “1A” is open and relay “2A” is de-energized (dropped out).
  3. Contact “2A” is closed and relay “AX” is energized (picked up) and its two contacts are closed.
  4. Relays “1A” and “MX” are de-energized (dropped out) because contact “M” is open.
  5. Contact “2A” (in the start circuit) is open.
  6. Main contactor “M” is energized and sealed in through its normally open contact.
  7. The “Green” light on RMNB06F is de-energized (extinguished) due to the open “MX” contact.
  8. The “Red” light on RMNB06F is energized (illuminated) through contacts “CS-1” (11/11C) and “MX”.
  9. The “Amber” light is energized (illuminated) if the EBOP started in auto (through contacts “CS-1” (11/11C) (9/9 C) and “MX”) and de-energized if started in manual (contact “CS-1” (9C/9) is open).

- Stopping: The EBOP needs to be stopped manually by operations whether it was started manually or automatically.

  1. Handswitch “CS-1” is taken to the stop position and contact “CS-1” (11/11C) opens.
  2. Main contactor “M” is de-energized (dropped out) and its seal in contact opens.
  3. Contact “M” (in the motor start circuit) opens de-energizing the EBOP motor.
  4. Normally closed contact “M” closes.
  5. Relay “MX” energizes (picks up) through contacts “M” and “CS-1” (11/11C).
  6. Relay “1A” energizes (picks up) through contacts “AX”, “M”, and “CS-1” (11/11C).
  7. Relay “2A” energizes (picks up) through contacts “AX” and “1A”.
  8. Normally closed contacts “1A” and “2A” in the motor start circuit (paralleling resistor “RS”) open placing resistor “RS” back in the motor circuit.
  9. Contact “2A” (in the start circuit) closes (enabling the start circuit).
  10. Relay “AX” de-energizes and drops out after 1 second when contact “2A” opens.
  11. The two normally open “AX” contacts open when the “AX” relay de-energizes (drops out).
  12. Relays “2A” and “1A” stay energized through resistors “2RS” and “1RS”.
  13. The “Green” light on RMNB06F is energized (illuminated) through contacts “CS-1” (11/11C), “2A”, and “MX”.
  14. The “Red” light on RMNB06F is de-energized (extinguished) due to the open “MX” contact.
  15. The “Amber” light is de-energized (extinguished) due to the open “MX” contact.

  The two “AX” contacts are designed to allow relays “1A” and “2A” to pick up with full current.

  Relay “AX” has a 1 sec. time delay on drop out to allow relays “1A” and “2A” to pick up before it opens its contacts.

  Resistors “1RS” and “2RS” reduce current through relays “1A” and “2A” when they are normally energized prolonging the life of the relays.

EO 1.13	Identify and discuss electrical components on the vendor ladder diagram for the Emergency Bearing Oil Pump (EBOP)

1.13 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.13 Identify and discuss electrical components on the vendor ladder diagram for the Emergency Bearing Oil Pump (EBOP)

Definition: Ladder diagrams are specialized schematics commonly used to document industrial control logic systems. They are called "ladder" diagrams because they resemble a ladder, with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent.

See vendor print M400-0310-00035

Compare components from M400-0310-00035 to 01-E-LOB-0003

- General:
  The "L1" and "L2" designations refer to the two poles of a 120 VAC supply, unless otherwise noted. L1 is the "hot" conductor, and L2 is the grounded ("neutral") conductor.

  In ladder diagrams, the load device (lamp, relay coil, solenoid coil, etc.) is almost always drawn at the right-hand side of the rung.

  Switch contacts designed to prevent a control system from taking two incompatible actions at once (such as powering an electric motor forward and backward simultaneously) are called interlocks.

  Motor contactor (or "starter") coils are typically designated by the letter "M" in ladder logic diagrams.

  Continuous motor operation with a momentary "start" switch is possible if a normally-open "seal-in" contact from the contactor is connected in parallel with the start switch, so that once the contactor is energized it maintains power to itself and keeps itself "latched" on.

  Vendors usually have notes or a legend to determine what a device does, or is.

  A vendor may use an accepted industry standard symbol to denote a device or may use a generic symbol and label it to show what it is or does (ex. press. sw, temp. sw, flow sw, etc.).

  Vendors usually have their own device designators which corresponds to a Palo Verde designator (ex. Vendor =

PS3/4, PV = PSL-7A/B

EO 1.14	Identify and discuss electrical components on schematic 0_-E-OWB-0008

1.14 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.14 Identify and discuss electrical components on schematic 0_-E-OWB-0008

Schematic 0_-E-OWB-0008

- For the oil/water separator sump pumps _MOWNP08A and _MOWNP08B.

  The sump pumps are located in the yard area north of the Turbine BLDG. and the Nuclear Cooling Heat Exchangers and east of the Condensate Storage Tank.

  _MOWNP08A is powered from _ENHNM1113.
  _MOWNP08B is powered from _ENHNM0812.

  _ENHNM1113 is located on the 100’ of the Turbine Bldg. (04WTB09NT02100).
  _ENHNM0812 is located on the 100’ of the Turbine Bldg. (03WTB05ST04100).

  CAUTION: When working in NHNM1113, power to the “27” contacts and relays “AX”, “AY”, “AZ” and “83” can still be available from NHNM0812

OW = Oily Waste and Non-Radioactive Waste System

NH = 480V AC power

MCC = Motor Control Center

- General Information:
  The sump is provided with a float-type level control switch LC-10, which starts and stops the lead pump of the two sump pumps on high or low level.

  The sump is also provided with a second float with level switches LSLL-14 and LSHH-14. LSHH-14 inputs to the plant computer and actuate alarms in the control room on high-high level when relay “AX” is energized. The switches also supply start and stop signals to the second pump, and backup start and stop signals to the lead pump, on high-high (“AX” relay is energized) and low-low levels (“AY” relay is energized) (see print 13-J-03K-0093).

  An alternator (83) is provided which changes the lead pump for each cycle to equalize running time and wear on the two pumps. Its contacts are alternately closed when the coil is energized by receiving a Sump LVL Hi signal from LC-10. Both contacts are open when the coil is de-energized. See the chart for the “83” alternator on the schematic.

  The level switches and automatic transfer circuit is normally energized from NHNM1113 through two NO contacts on relay “27”. If NHNM1113 loses power, relay “27” de-energizes, its contacts change state and the circuit receives power from NHNM0812.

  Both sump pump motors can be manually started locally from “CS-1” (1-2) and “CS-2 (1-2)”. Both switches are 3-position maintained.

  If one MCC (sump motor) loses power the “83” relay will continue to alternate its contacts. The other sump motor will continue to cycle on and off through the “AZ” relay even though the alternator contact for that sump is open.

  The control transformers for the control circuits are 480v (primary) to 120v (secondary).

  The control transformer fuses are rated at 2.5 amps. One side of the secondary is grounded.

  If there is a long time over current condition for either MCC the “49” and “74” contacts will open and the “Green” indicating light will become brighter providing visual indication of the over current condition.

  Both sump motor space heaters are energized when the motors are de-energized and de-energized when the motors are energized.

LVL = Level

LC = Level Controller

LSLL = Level Switch Lo Lo

LSHH = Level Switch Hi Hi

42 = Running Circuit Breaker (AC Contactor)

49 = Machine or Transformer Thermal Relay

52 = AC Circuit Breaker

74 = Alarm Relay

83 = Automatic Selective Control or Transfer Relay

27 = Undervoltage Relay

- MCC M1113.

Hi condition:
1. When the sump tank sees a Hi level, switch LC-10 closes and energizes relays “83” and “AZ”.
2. Contacts “83” (2-3) and “AZ” in the start/stop circuit close.
3. Contactor “42-1” energizes through contacts “83” (2-3), “CS-1” (3-4), ”AY” and “49-1”.
4. The sump pump motor starts through breaker “52” (M1113), contacts “42-1” and the “49” overloads.
5. The sump level drops until switch LSLL-14 closes and energizes relay “AY”.
6. Contact “AY” in the start/stop circuit opens de-energizing contactor “42-1” stopping the sump pump motor.
7. Switch contact LSLL-14 opens as the sump tank fills up de-energizing relay “AY”.
8. Contact “AY” in the start stop circuit closes enabling the motor to start again.

The “AZ” contact only starts the motor if the alternate MCC has lost power and its 74 relay de-energizes.

The sump level drops until a “reset” of LC-10 occurs, at which time the motor stops due to the LC-10 contact opening.

LSLL-14 limit switch functions as a “safety” contact to stop the pump motor when the level is too low and thereby prevents pump cavitations or floating foreign material intrusion into the pump.

The pump normally cycles between HI and Low.

HI-Hi condition:
1. When the sump tank sees a Hi Hi level, switch LSHH -14 closes and energizes relay “AX”.
2. Contactor “42-1” energizes through contacts “AX”, “CS-1” (3-4), ”AY” and “49”.
3. The sump pump motor starts through breaker “52” (M1113), contacts “42-1” and the “49” overloads.
4. The sump level drops until switch LSLL-14 closes and energizes relay “AY”.
5. Contact “AY” in the start/stop circuit opens de-energizing contactor “42-1” stopping the sump pump motor.
6. Switch contact LSLL-14 opens as the sump tank fills up de-energizing relay “AY”.
7. Contact “AY” in the start stop circuit closes enabling the motor to start again.

- MCC M0812.

  Hi condition:
  1. When the sump tank sees a Hi level, switch LC-10 closes and energizes relays “83” and “AZ”.
  2. Contacts “83” (10-11) and “AZ” in the start/stop circuit close.
  3. Contactor “42-2” energizes through contacts “83” (10-11), “CS-2” (3-4), ”AY” and “49”.
  4. The sump pump motor starts through breaker “52” (M0812), contacts “42-2” and the “49” overloads.
  5. The sump level drops until switch LSLL-14 closes and energizes relay “AY”.
  6. Contact “AY” in the start/stop circuit opens de-energizing contactor “42-2” stopping the sump pump motor.
  7. Switch contact LSLL-14 opens as the sump tank fills up de-energizing relay “AY”.
  8. Contact “AY” in the start stop circuit closes enabling the motor to start again.

  When the “83” alternator relay is energized the contacts in the M0812 circuit close and the contacts in the M1113 circuit open.
  See VTD-S440-00003

  HI-Hi condition:
  1. When the sump tank sees a Hi Hi level, switch LSHH -14 closes and energizes relay “AX”.
  2. Contactor “42-2” energizes through contacts “AX”, “CS-2” (3-4), ”AY” and “49”.
  3. The sump pump motor starts through breaker “52” (M0812), contacts “42-2” and the “49” overloads.
  4. The sump level drops until switch LSLL-14 closes and energizes relay “AY”.
  5. Contact “AY” in the start/stop circuit opens de-energizing contactor “42-2” stopping the sump pump motor.
  6. Switch contact LSLL-14 opens as the sump tank fills up de-energizing relay “AY”.
  7. Contact “AY” in the start stop circuit closes enabling the motor to start again.

EO 1.15	Identify and discuss electrical components in auxiliary (Aux.) relay cabinets

1.15 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.15 Identify and discuss electrical components in auxiliary (Aux.) relay cabinets

Auxiliary Relay Cabinets: Cabinets that house control circuit components belonging to different circuits/systems.

Isolation Cabinet: A cabinet (_EZA_C02) that contains both "Class" and "Non-Class" circuits that are separated by a barrier. The coil of a relay is "Class" and the contacts of the relay are "Non-Class".

- Components: Terminal blocks, relays, disconnect switches, fuses, and resistors.

- Locations:
  15 cabinets in the Auxiliary Building
  6 cabinets in the Control Building
  2 cabinets in the Turbine Building

- Features:
  Terminal blocks show:
  Individual Terminal Block numbers
  Individual Terminal point numbers of TB
  Vendor wire numbers (locations)
  Cable scheme numbers (System Designators)
  Wire designators of each cable

- Maintenance:
  Hang SOD tags
  Replace/inspect ARD type relays
  Agastat type time delay relays
  Adjust Resistors
  Replace fuses
  Clean/Inspect cabinet and components

- Precautions:
  Review 13-EN-0306 Section 8.1.1 on ARD relays

  Use “Standards and Expectations” when working in relays
  Self Check/Peer Check/Flagging/2-min. drill/ETC.

  Review 01DP-0IS13 for requirements when working in cabinets.

  Review 30DP-9MP03 for FME requirements when working in cabinets.

- Review prints E022-00123/4/6/7 and
  01-E-HAB-0016

  Show “Key”, “Legend”, and “Notes”

  Define Symbols and nomenclature

  Show ARD and Agastat type relays, TB’s, Fuses, Resistors, Disconnect Switches

  Show how to find an “Elementary Print” for a scheme number

- Review prints E022-00101, 01-E-CHB-0017,
  01-E-CHF-0017, and 01-E CHF-0038

  Review isolation cabinet details

  Show differences between coil and contacts on prints (“Q” versus “Non-Q”).

EO 1.16	Discuss electrical theory as it pertains to troubleshooting (T/S)

1.16 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.16 Discuss electrical theory as it pertains to troubleshooting (T/S)

- Electrical theory:

  1. Electron flow theory: Current flows from the most negative point in the circuit to the most positive.
  2. A complete path must exist before current can flow.
  3. Voltage = the potential difference between two points in a circuit.
  4. Ohm = Resistance to current flow. Without resistance you would have a short circuit.
  5. In a DC circuit each resistor has a Pos. and a Neg. polarity to it.

- Ohms Law:

  $E = IR$

  $I = \frac{E}{R}$

  $R = \frac{E}{I}$

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EO 1.17	Identify and discuss troubleshooting techniques and guidelines

1.17 Main Idea

LESSON PLAN **METHODS AND ACTIVITIES**

EO 1.17 Identify and discuss troubleshooting techniques and guidelines

The process of detecting a problem, determining its cause, and taking corrective actions.

From the "Williams Learning" series

5 major steps of troubleshooting

- Identify the problem: Recognizing that a problem exists and observing its symptoms.
  - Visual/audio warnings (control room alarms)
  - Automatic shutdowns
  - A signal value not within its normal range
  - A piece of EQ does not perform its function

- Take preventive action: A short term action that is meant to put a circuit in a safe condition while work is performed to correct the problem.
  - Initiate an emergency shutdown
  - Switch the circuit from automatic to manual control
  - Bypass a piece of equipment
  - Use a piece of backup equipment

Operations typically does this

- Determine the cause of the problem: A process of elimination. Separating those factors that are not causing the problem from those that might be causing the problem.
  - Was the change in the circuits operation abrupt or gradual?
  - Is the problem intermittent or constant?
  - Have there been similar problems in the past?
  - Did the problem occur while the circuit was in a steady-state condition, or was the circuit in startup or shutdown?

  Sources of information:
  - Prints/diagrams
  - Experience (electricians and operators)
  - Supervision

  Two commonly used methods of elimination:
  - Serial method: Checking components in sequence one at a time.
  - Half-splitting method: Splitting the circuit in half again and again following the readings to where the problem is.

- Correct the problem: Making adjustments and repairing or replacing equipment. rework

- Return the circuit to normal operation: Reverse any preventative actions and ensuring the circuit operates properly (retest).

- Troubleshooting Guidelines:

  Never presume or assume anything.
  Try to recreate the problem unless there is a personnel safety concern or an equipment damage concern.
  You have to know how something works before you can fix it (what is it supposed to do, and not supposed to do).
  Never rule out having more than one problem.
  Consider what others (those who have worked on it previously or who operate it) have to say.
  Look at what the EQ/System is telling you. Indicating lights/programs/equipment position/ETC.
  Perform a thorough visual inspection Look/smell/hear/touch.
  Identify the weakest link in the EQ/System. The things that are supposed to fail first (breakers open/fuses blown/ETC.).
  Identify the easiest things to check/troubleshoot.
  Break the EQ/System into manageable or natural breaks/pieces.
  Write all testing steps/data/conditions down as you T/S or perform the step.
  Identify any parts/components recently replaced/repaired or adjusted. Could be wrong part, installed wrong, maladjusted, infant mortality, ETC.
  Verify all test devices (resistors, switches, ETC.), M&TE and leads are good.
  Verify that all new parts are the right ones and good/tested before installing them.
  Keep a log/history of all repairs/problems/anomalies, record all nameplate data from EQ.
  Identify whether you are T/S a symptom or the problem.
  Don’t listen to armchair troubleshooters. Be careful when others describe a problem (check it out for yourself).
  Verify that you have the correct information/references (prints, VTM’s, VTD’s, ETC.) material for the system/component and the specific model or part number for your EQ. prior to T/S

When T/S follow a logical sequence, don't skip around.
Recognize patterns or common occurrences that the EQ/System/Component develops before the problem happens.
Consolidate T/S steps if possible to save time.
Do not take resistance readings unless the following conditions are met:

A. The circuit is verified to be dead
B. You know the ohmic value of what you are testing.
C. The component is isolated in the circuit.
D. You are using the readings as a "go" "no-go"

When taking readings verify that you are not reading back or being affected by other EQ/Systems/Components.
When developing your T/S gameplan take physical location into consideration (can I physically get to the component that I want to T/S or test).
If more than one problem exists, look for common components (links) to each problem.
Notify Operations of all T/S activities and the effects it will have on equipment and systems.
Make appropriate notifications to protect other people working in the area.
Adhere to all procedures, guidelines and expectations while T/S.
Gather as much information (voltage readings, resistance readings, visual inspections, ETC.) before you change or manipulate anything (preserve "Root Cause of Failure" info).

- Troubleshooting (TS) AC circuits:

  Review “Resistance”, “Voltage Drop”, and Current in various AC circuits

  Provide T/S scenario for practice using print 01-E-OWB-0008.

  Review “System Training Manuals” for information on specific systems (EX. OW). Answer the questions “What is it”? and “Where is it at”?

  Review appropriate prints for EQ location. Review print 13-P-OOB-0001 for outside EQ locations

  Typical Problem: The oily waste separator sump is overflowing.

  Scenario #1 MCC M1113 has a red indication, and M0812 has a bright green indication.

  Scenario #2 MCC M1113 has a red indication, and M0812 has a green indication.

- Troubleshooting (TS) DC circuits:

  Review “Resistance”, “Voltage Drop”, and Current in various DC circuits

  Provide T/S scenario for practice using print 01-E-SGB-0001.

  Typical problem: Operations can not close valve SGAUV0134 in “Override” (the “Override” lights are lit)