

PALO VERDE NUCLEAR GENERATING STATION

Electrical Maintenance Training Program

Classroom Lesson



Electrical Maintenance Training Program	Date: 2/16/2011 9:39:03 AM
LP Number: NEA61L000108	Rev Author: BOB BALLARD
Title: Medium Voltage Circuit Breakers and Switchgear	Technical Review:
Duration : 36 HOURS	
	Teaching Approval:

INITIATING DOCUMENTS

None

REQUIRED TOPICS

None

CONTENT REFERENCES

29 CFR 1910 OSHA

PVNGS OSHP

VTM G080-0003 Vendor Technical Manual

13-E-MAA-001 MAIN Single Line Drawing

E-NAB-002 Elementary Diagram

E-NAB-014 Elementary Diagram

E009-224 Vendor Connection Diagram

E009-225 Vendor Connection Diagram

E009-21 Indoor Switchgear Drawing for 3000 AMP Breaker

E009-137 Indoor Switchgear Drawing

E-NAB-021 Elementary Diagram

32MT-9ZZ37: Overhaul Of Am-13.8-1000-4h G.E. Magna-Blast Circuit Breakers

32MT-9ZZ38: Overhaul Of Am-4.16-250-9h G.E. Magna-Blast Circuit Breakers

32MT-9ZZ39: Overhaul Of Am-4.16-350-2h G.E. Magna-Blast Circuit Breakers

01-E-MAA-002 Unit single line diagram

01-E-PBA-001 SINGLE LINE DIAGRAM 4.16 KV CLASS 1E POWER SYSTEM 01-E-PBA-S03

01-E-NAA-001 SINGLE LINE DIAGRAM 13.8 KV NON-CLASS 1E POWER SYSTEM 01-E-NAN-S05

01DP-0IS13 ELEC. SAFE WORK PRACTICES

CRDR 3018544 Inadvertant access to energized Calvert bus

CRDR 2885407 Close call during cleaning/inspection

01-E-NAF-0014 Control Wiring Diagram

CRDR - 3173901 - Fuse clip inspection identified wrong size fuse installed in switchgear.

CRDR - 3160784 - Cubicle PDAs not inspected or cleaned prior to returning equipment to Op's.

30TD-9ZZ01 - Circuit Breaker Racking Instructions

AO-E-NAA-0006 Single Line Diagram for AE-E-NAN-S07

VTM-G080-00452 GE instructions for Power/Vac breaker with ML-18 mechanism

VTD-G080-00451 GE MetalClad Switchgear components for Power/Vac

WSL 287219 Inspect/Clean Switchgear fro AE-E-NAN-S07

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

32MT-9ZZ88 Maintenance of General Electric Power/Vac Circuit Breakers

A0-E609-A125 Vendor control circuit for Power/Vac breaker

SER 4-02 Recurring Events: Electrical Workers Severely Injured While Performing Maintenance on Medium-Voltage Switchgear (4-kV to 13-kV)

01-E-NGB-0005 Elementary for Diagram for 480 Volt Non-Class 1E Power System LC 1E-NGN-L25

E009-00115 Metal Clad switchgear connection diagram E-NAN-S01G

E009-00116 Metal Clad switchgear connection diagram E-NAN-S01G

SOER 98-2 Circuit Breaker Reliability

32MT-9ZZ91 CLEAN/INSPECT 13.8KV & 4.16KV SWG.

LESSON PLAN REVISION DATA

Feb 16,
2011

Robert Ballard

TCS 3596352 initiated for revision change. Added SER 4-02

TCS 3565962 initiated for revision change. Updated lesson plan.

Tasks and Topics Covered

The following tasks are covered in Medium Voltage Circuit Breakers and Switchgear :

Task or Topic Number*	Task Statement
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Lesson: Medium Voltage Circuit Breakers and Switchgear

MVS03	Troubleshoot switchgear components
MVS04	Rework switchgear components
MVS05	Troubleshoot medium voltage circuit breakers
MVS06	Install/Rack in or rack out medium voltage circuit breakers

Total task or topics: 4

TERMINAL OBJECTIVE:

- 1 Using course references and training materials provided by the instructor, the plant electrician will be able to identify the basic components of the Medium Voltage circuit breaker and associated switchgear, explain their basic operation, and use this knowledge to troubleshoot if the breaker trips or fails to close. Final evaluation will be the successful completion of the associated LPE
 - 1.1 Identify where General Electric medium voltage switchgear and circuit breakers are utilized in the plant.
 - 1.2 Identify the GE Medium Voltage Switchgear's basic components and their function.
 - 1.3 Identify the GE Medium Voltage circuit breaker's basic components and their function
 - 1.4 Explain the basic theory of operation of the GE Medium Voltage circuit breaker
 - 1.5 Discuss the maintenance performed on Medium Voltage circuit breakers and Switchgear.
 - 1.6 Install and remove the GE Medium Voltage circuit breakers
 - 1.7 Perform basic inspection and troubleshooting of the GE Medium Voltage circuit breaker and switchgear, if the breaker trips or fails to close

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

TO: 1 Using course references and training materials provided by the instructor, the plant electrician will be able to identify the basic components of the Medium Voltage circuit breaker and associated switchgear, explain their basic operation, and use this knowledge to troubleshoot if the breaker trips or fails to close. Final evaluation will be the successful completion of the associated LPE

EO: 1.1 Identify where General Electric medium voltage switchgear and circuit breakers are utilized in the plant.

LESSON PLAN

Introduction

Pre-Job Brief

- Pre-job briefing on the day's activities modeling the use of the ***Palo Verde Standards & Expectations, Preventing Events:***
- Focus On Five:
Scope of Work – Classroom lecture per approved lesson plan with Power Point and written examination.
Task Sequence – Follow Enabling Objectives (EO) per approved lesson plan followed by written examination and student feedback.

1. Critical Steps: Using course references and training materials provided by the instructor, the plant electrician will be able to identify the basic components of the Medium Voltage circuit breaker and associated switchgear, explain their basic operation, and use this knowledge to troubleshoot if the breaker trips or fails to close. Final evaluation will be the successful completion of the associated LPE

METHODS AND ACTIVITIES

Ask the class if they have their S&E books.

Familiarize students with the scope of work, task sequence, and critical steps.

PVNGS Standards & Expectations Book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.

- 2. Identify error likely situations (error traps)
 - a. Discuss at least one specific error likely situation.
 - 1. Unexpected equipment conditions
 - 2. Lack of unclear standards
 - 3. Distractions/Interruptions

Review Error Precursors in S&E

- 3. Identify the “Worst” thing that can happen: Personal injury connected with the classroom.

Talk about the hazards in the lab setting.

- 4. Identify specific error prevention defenses to be used: Point out possible hazardous, classroom and lab conditions, identify location of working telephone, identify fire extinguisher, identify exit routes and emergency phone number 4444.

What defenses can we employ to prevent the “Worst” thing that could happen?

- 5. Identify actions to assure proper configuration control: N/A

This may not be applicable in every training setting.

- Schedule:
Class begins at 0730 and ends at approximately 1700 hrs.

- 1. Length of class = 36 Hr.
- 2. Break Policy = There will be a 10 minute break approximately every 50 minutes. Everyone returns from breaks and lunch on time.
 - a. Perform a 2-Minute drill: Page 51/52
 - 1. At instructor’s discretion, not to interrupt class flow.
 - 2. After lunch

- 3. Evaluation: 100% on a Lab Practical Evaluation

- 4. Post training critique: Students will fill out a feedback form prior to leaving the class.

- Qualification:

- 1. Identify what the students will be qualified to do upon completion of the course:

From the electrical Master Task List

- MVS03 Troubleshoot switchgear components
- MVS04 Rework switchgear components.
- MVS05 Troubleshoot medium voltage circuit breakers
- MVS06 Install/Rack in or out medium voltage circuit breakers

Lesson Presentation:

Line Department Leaders or Directors should Kick-off continuing training cycles, including emphasis on standards & expectations related to the cycle's topics.

Procedure Use and Adherence

- Electrical Safe Work Practices (01DP-01S13)
- Job Hazard Analysis (01DP-01S14)
- Heat Stress Prevention Program (01DP-01S17)
- Asbestos (01DP-01S16)
- Inspection/Cleaning of 13.8 KV and 4.16 KV Switchgear (32MT-9ZZ91) or WSL's
- FME (30DP-9MP03) and Housekeeping (30DP-0WM12)
- Technical Document (30TD-9ZZ01)

1.1 Main Idea

EO1.1 Identify where General Electric medium voltage switchgear and circuit breakers are utilized in the plant.

I. Palo Verde Utilization of General Electric Medium Voltage Switchgear & Circuit Breakers:

- NA - 13.8 KV Non Class 1E Power
- NB - 4.16 KV Non Class 1E Power
- PB - 4.16 KV Class 1E Power

A. 13.8KV MAGNE-Blast Circuit Breakers Locations:

13,800 volt Magne-blast breakers can be found in the startup switchyard and the non-class switchgear rooms. They are the largest of our switchgear breakers.

Magne-Blast circuit breakers are an Air Magnetic type breaker

Ref S/L drawing 13-E-MAA-0001 and 01-E-MAA-0002

1. NAN-S05 & NAN-S06 Switchyard Intermediate Bus

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

See Power point and discuss layout and distribution of the startup yard

2. NAN-S03 & NAN-S04 Located plant south of the Turbine Bldg.

- Provides 13.8 Kv power from off site to NAN-S01 and NAN-S02 with generator off line.
- Provides 13.8 Kv to the ESF Transformers that provide 4.16 Kv to the Class 1E Switchgear (PB).

NAN-S03A/B breakers are a not an Air Magnetic type. They are a Vacuum type breaker. ML-13 and control circuits very similar.

See NAB-0021

ESF - Emergency Safety Feature

Discuss fast bus transfer

3. NAN-S01- Turbine Bldg. Switchgear: Discuss the possibility of cross-tied power, point out the backfeeds and what could possibly be powered from other sources.

Ref. Print 13-E-MAA-0001

Discuss lineups to backfeed from NB
See Power Point

4. NAN-S02- Turbine Bldg. Switchgear: Ref S/L drawing 1-E-MAA-002 to discuss the possibility of cross-tied power, point out the backfeeds and what could possibly be powered from another source.

- With the Main Generator on line, the 13.8KV power is distributed to NANS01 and NANS02 via the Unit Aux Transformer (MANX02).
- The Unit Aux. Transformer takes the output of the Main Generator (24KV) and steps it down to 13.8KV for each secondary winding.

B. NAN-S03AB VACUUM BREAKERS

Located next to NAN-S03 switchgear

- One in each unit
- Receives 13.8 kV from the SBO
- Vacuum type Breakers
- ML-13 Operating mechanism

Discuss removal of breaker from switchgear

C. 13.8 Kv GE Power/Vac circuit breaker location

- a. AE-E-NAN-SO7
- b. Located at the Station Blackout Yard
- c. Provides 13.8 Kv backup power to each unit in emergency.

See Prints 13-E-MAA-0001 and A0-E-NAA-0006

Breakers rack in horizontal in switchgear

Discuss the distribution of class and non-class power

D. 4.16 KV MAGNE-Blast Circuit Breakers Locations:

1. NBN-S01 - Turbine Bldg. Switchgear
2. NBN-S02 - Turbine Bldg. Switchgear
3. PBA-S03 - Control Bldg. Class 1E
4. PBB-S04 - Control Bldg. Class 1E

E. Medium Voltage Rating Definition:

Medium-voltage per IEEE states that an electrical system having a maximum RMS AC Voltage above 1000V to 72,500V.

1. 13.8 kV Breakers:
Breaker information can be found on the nameplate. S/N, (current rating and so on)
a. 1200 AMP
b. 3000 AMP
System designator is NA

2. 4.16 kv Breakers:
a. 1200 amp (Class 1E) PB – Class 1E
b. 1200 and 3000 amp (Non-Class) NB – Non-Class

EO: 1.2 Identify the GE Medium Voltage Switchgear's basic components and their function.

LESSON PLAN

METHODS AND ACTIVITIES

EO 1.2

See Power Point

- 1. Devices installed in the switchgear and mounted on the door are identified on drawings by function numbers.

Drawing 13-E-ZZB-004 lists the General Function numbers

Examples:

- 33 POSITION SWITCH
- 51 AC TIME OVERCURRENT RELAY
- 52 AC CIRCUIT BREAKER
- 59 OVERVOLTAGE RELAY
- 72 DC CIRCUIT BREAKER
- 27 UNDER VOLTAGE RELAY
- 74 ALARM RELAY
- 86 LOCK OUT RELAY

□ Prefix numbers used with switchgear:

Examples:

- 227 UNDER VOLTAGE NAN-S01 & NAN-S02
- 652 AC CIRCUIT BREAKER NAN-S03, S04 & S07
- 486 LOCK OUT RELAY NBN-S01 & NBN-S02
- 733 POSITION SWITCH PBA-S03 & PBB-S04
- 351 AC TIME OVERCURRENT NAN-S05 & S06

Review drawings 01-E-NAB-014 and 13-E-ZZB-0004

Components of the Switchgear:

- Main Bus
- Switchgear Cubicle (for Magne-Blast)
 - ✓ Bus located in the front of switchgear
 - ✓ Line located in the back of switchgear
- DC control power circuit breaker

AE-E-NAN-S07 Bus horizontal thru the back of the switchgear.

The Bus is on the bottom in the upper compartment and on the top in the lower compartment. See power point.

See vendor tech. manuals VTD-G080-00451 and VTD-G080-00452 for details on switchgear components.

Magne-Blast Circuit Breaker

Fuses & Fuse blocks:

- Inside the Switchgear, fuses are not labeled like the Elementary print
- The vendor drawing or Control Wiring ('F') drawing will show designator.
 - UC (FU-1)
 - UT (FU-2)
 - UA (FU-3)
 - UL (FU-4)

Some cubicles have additional fuses

Review drawings 01-E-NAB-0014, 01-E-NAF-0014, E009-0225

For NAN-S03AB breaker cubicles, the control power breaker and fuses are behind the internal relay door.

See Power Point

May need a ladder to reach some of the fuse blocks

CRDR – 3173901

- Performing section 5.0 of 32MT-9ZZ33, Fuse and fuse clip inspection. Found a 15 amp fuses installed in the UL circuit, (Breaker racking circuit) print 02E-NBF-002, SH 3, shows a 10 amp should be in this circuit. The non-conforming condition was corrected under WM 2953354. 10 amps fuses installed, APN # 44400102

Potential Transformers:

- Potential transformer drawers
- Many Buses have normal and alternate feeds.
- Review Plant drawings
- Understand line up configuration
- Install Barriers on energized equipment
- Power may enter one cubicle and then go to another

Review prints 01-E-NAA-0001 and 01-E-PBA-0001

See Power Point

Discuss hazards with PT's during switchgear maintenance.

CRDR 3018150 Inadvertent Load Shed of 1ENANS02

On 5/22/07, an Electrical Technician inadvertently caused a Loss of Power (LOP) for bus 1ENANS02 (S02). The technician was walking down a permit and was checking tags when he started to open an incorrect PT Drawer. This action resulted in a Load Shed of the S02 Bus. Due to the installation of temporary power to support scheduled bus outages, both lighting load centers were being supplied by S02 at the time of the LOP. This resulted in a loss of all normal lighting in the Power Block. All work in the effected areas was halted until the S02 Bus and subsequently the lighting load centers could be re-energized.

Ask what would have prevented this event.

HU tools – Two Minute drill, Self-Checking, Peer Checking,

Manual shutters:

- a. The safety barrier required to isolate energized Rosettes
- Cluster fingers and bushings
 - Space Heaters
 - Current Transformers
 - Various control relays

- Roof top Bushings on outdoor Switchgear
 - Pad
 - Collar
 - Bushing

- Switchgear Door Mounted

Components:

Indication lights:

- **White light: (86 lockout)** also indicates continuity through the coil and contacts of the relay.
- **Green light** (open)
- **Red light** (closed) also indicates continuity through the trip coil.
- **Clear light** (springs charged)

See Power Point

Review drawings 01-E-NAB-0014, 01-E-NAF-0014, E009-0225

Green light will also get brighter when the “86” is tripped or the breaker in the test position

1. 86 Lockout

Explain the purpose of the 86 lockout

2. Protective Relays:

Examples:

- a. Over current;
- b. Ground fault;
- c. Under voltage

3. Hand switch

Switchgear elevating mechanism

1. Racking motor See Power Point
2. Manual racking handle
3. Anti-Creep Device
4. Roll Pins
5. Stop Studs
6. Miter Gears
7. Spur Gear
8. Pinion Gear
9. Chain & Sprockets
10. Jack Screw

11. **52M/Up & 52H/Down** (interrupts Pos. polarity to motor) Switches contain Mercury
 - a. 52M/Up: Open only in extreme raised position of the breaker. See print NAB-0021
 - b. 52H/Down Lower Limit: Open only in extreme lower position of the breaker.

12. **Position (33) switches:** Monitors the position of the breaker:
 - a. 233L on the 13.8 kv breaker
 - b. 733L on the Class 1E 4.16 kv breaker

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

13. **75/Clutch Switch** :(interrupts Neg. polarity to motor)

- a. 75/Clutch Switch: Opens and closes by the racking handle to start and stop the racking motor.

14. Stationary auxiliary switch (operated by the plunger interlock)

252 for NANS01
652 for NANS03
See vendor prints

EO: 1.3 Identify the GE Medium Voltage circuit breaker's basic components and their function

LESSON PLAN

1.3 Main Idea

I. INTERNAL COMPONENTS:

A. ML-13 Operating Mechanism:

- Magne-Blast breakers are air magnetic with the ML-13 operating mechanism.
- GE Vac breakers (NAN-S03AB) are vacuum breakers with the ML-13 operating mechanism

B. Charge-discharge indicator:

1. Shows condition of closing springs.
2. Failure of this spring will cause the breaker to trip free.

C. Manual close button:

1. Closing latch is rotated from under the closing roller on the switch cam.
2. This releases the closing springs.

METHODS AND ACTIVITIES

Use extreme caution when using a ratchet to charge the closing springs with the cover on. It is best to charge the springs pushing on the ratchet.

AE-E-NAN-S07 is a Power/Vac type breaker with the ML-18 operation mechanism.

Show the prop-reset spring.

(SME) CAUTION: Depressing the button with your finger may cause injury, use a tool handle to avoid injury when the breaker closes.

D. Manual trip lever:

1. Rotates the Trip Latch off of the Trip Roller.
2. This releases the opening springs.

CAUTION: Depressing the button with your finger may cause injury, use a tool handle to avoid injury when the breaker closes.

E. Trip latch, and trip coil:

1. Mounted on the trip shaft and latches on the trip roller.
2. Trip coil is energized to lift latch off the roller and trip the breaker.

(SME) Watch for pinch points and sharp cotter keys when the covers are removed.

F. Auxiliary Switch:

1. Operates breaker "A" and "B" contacts.
2. Top 4 contacts are "B" contacts, odd numbered & are normally closed, Bottom 4 contacts are "A" even numbered & are normally open.
3. There are eight of these contacts on the print & they are shown as draw out contacts.

Review elementary and vendor drawings and look at contact operation.

G. Positive interlock shaft and roller:

1. Operates 52/IS, which prevents operation unless the circuit breaker is fully raised or fully lowered.
2. The positive interlock-switch is on the top left side of the circuit breaker.

NOTE: The springs will not charge unless this contact is closed.

H. Driving eccentric:

1. Positions driving pawl.

I. Driving pawl:

1. Engages ratchet wheel to rotate to charge the closing springs.

J. Latching pawls (TWO):

1. Latches the ratchet wheel when it is moved by the drive pawl.
2. Ratchet wheel rotates to charge the springs

K. Positive interlock switches (52/IS):

1. Closed when Circuit Breaker fully lowered or fully raised.

L. Positive interlock Roller in the V-Notch:

2. Clutch handle in switchgear must be released and positive interlock roller must be in the "V"notch.
3. When lowered the breaker must be in the test position.

Show location and demonstrate manually charging the springs.

The positive interlock roller must be perpendicular to the breaker to allow the contacts to close.

M. Spring charging motor:

1. Drives the eccentric to charge the springs.

N. Closing spring (s):

(SME) keep fingers away from the springs when they are charged

1. Discharges to close the breaker

O. Closing latch:

1. Holds the springs charged when the roller on the switch cam is resting against it.

P. Closing coil:

1. Energizes to move the close latch to release the springs to close the breaker.

Q. Close latch monitoring switch 52/CL/MS:

Monitors the position of the close latch. It will not allow the springs to charge unless the latch is capable of blocking the springs. (Close latch is in position to latch to the close latch roller).

1. Located on the bottom of the circuit breaker at the end of the manual push button rod. This contact needs to be closed to charge the springs.
2. The close paddle latch operates the close latch-monitoring switch.

R. Switch cam:

(SME) Keep fingers away from the closing springs when they are charged

Operates 52/SM/LS & holds the closing springs charged.

S. Power switches 52/SM/LS are the charging motor switches:

See Power point

1. Location left side of breaker next to the switch cam.
 - Contacts 1-2 are closed with the springs discharged to allow the springs to charge, and will open to stop the charging motor.
 - Contacts 3-4 pickup and drop out the Anti-Pump relay.
 - 5-6 needs to be closed for the breaker to close and provides a negative path for the clear light indication.

Why are they called power switches?
All of the current going to the charging motor also goes thru contacts 1-2.

CRDR – 3017056 - 3ENANS03B
Inability close or auto close on a “fast bus transfer” – due to closing springs not charged. Found that the charging spring motor brushes were worn such that the charging spring motor was not functional.

CRDR - 3014909 – 2-E-NAN-S01K
for the "B" CW pump breaker "clear" light does not illuminate when the breaker is racked in but the closing springs do charge. FIN Elec found breaker has bad contact block.

T. Anti-Pump relay (52Y): (Description will come later in course.)

1. Located on bottom of the ML-13 at the front of the breaker.

U. Plunger inter-lock:

1. Operates with breaker main contacts.
2. Operates the stationary (52) contacts in the switchgear cubicle.

V. Secondary disconnect:

1. Provides connection between the circuit breaker and the switchgear cubicle for control power.

For GE Power/Vac breakers see vendor prints VTD-G080-00451 and VTD-G080-00452

W. Opening spring (s)

Review breaker components and their locations

1. Charged when the breaker is closed.
2. Provides quick opening when brk. Is tripped.

EO: 1.4 Explain the basic theory of operation of the GE Medium Voltage circuit breaker

LESSON PLAN

EO 1.4

- I. Theory of Operation: (Magne-Blast)
 - A. Current Ratings:
 - B. Continuous:
 - 1. Amount of current a breaker can carry without exceeding the standard temperature rise.
 - 2. 1200 and 3000 Amp
 - C. Maximum Interrupting:
 - 1. 37 kA for 13.8 circuit breakers
 - 2. 29 kA for 4.16 class 1E circuit breakers
 - D. Interrupting Time:
 - 1. This is the time it takes breaker to trip (the time it takes when the breaker receives the trip signal till the time the breaker opens).
 - 2. Time between sensing of overcurrent and Circuit Breaker opening.
 - a. The circuit breaker trip time acceptance criteria is \leq 55 milli-seconds.
- Breaker Interlocks:
- 1. Spring Release Interlock:
 - a. Function: Discharges closing and opening springs when the breaker is being inserted or removed from its cubicle.
 - 2. This interlock prevents a breaker from inadvertently operating during removal or insertion from cubicle.

METHODS AND ACTIVITIES

For details on the GE Power/Vac for AE-ENAN-S07 see Tech. Manuals.
VTD-G080-00451 and VTD-G080-00452

All over current protection is provided by the relaying.

Note: Some Breakers at Unit #3 have a double "v" notch (spring discharge cam) & springs may not discharge when lowering breaker.
See Power Point

3. A spring discharge cam is mounted on the left side of each cubicle and will come in contact with the spring discharge linkage on the breaker when it is installed or removed.
 - a. Switchgear: Note, when you remove the breaker the springs will discharge.
 - b. Note: the closing springs always need to be **discharged** before the breaker is racked up.

4. Breaker/Switchgear Interlock (positive interlock)
 - a. Function:
 - 1) Prevents the breaker from being elevated or lowered while in the closed position. The interlock also prevents the breaker from being closed unless the breaker is fully raised (inserted in bus) or fully lowered (removed from bus).

 - 2) The positive interlock will jam the closing springs if a manual close is attempted while the breaker is between the fully raised and fully lowered positions.

 - 3) A limit switch (52 IS) is located on the left side behind the auxiliary switches. This limit switch will prevent the 52X-closing coil from energizing unless the breaker is fully elevated or lowered.

Talk about the possibilities of bending the spring discharge pin on the

b. Plunger Interlock:

- 1) The plunger is operated via a clip on the operating crank and operates the Aux-switch mounted in the cubicle.
- 2) The Aux-switch operates control circuit contacts.
 - a) These contacts are seen on an elementary drawing, control wiring diagram, and vendor drawings. show the students typical drawings. These contacts are mounted in the cubicle. (See Power Point)

- 3) During some functional testing (such as ISG testing) a test link may be installed to operate the aux.-switch.
- 4) If the test link is not installed properly the motive force from Circuit Breaker operation can cause the clip to bend.

Show the class the test link (Flag)

- a) You do not need the test link installed to cycle the breaker, all that is required is the connection of the umbilical cable.
- b) The test link may be required when performing circuit functional checks (like ISG).
- c) Make sure there is about an 1/8-inch play in the flag during installation.
- d) If the link is not installed properly it can break or bend the operating rod for the Aux switches.

5. Closing Sequence:

Umbilical for testing is marked with spiral colored tape. Called a candy stripe.

a. Electric Operation:

- 1) For testing purposes we have an umbilical cord with some of the pins removed to by-pass interlocks that would normally be in the circuit while the breaker is being tested.
- 2) Control power through hand switch, interlocks, and protection contacts (pins 4 & 8).
- 3) 125VDC picks up 52X coil
- 4) 52X coil pushes closing latch
- 5) Closing latch moves away from closing latch roller on the switch cam.
- 6) Closing latch roller can now move and this allows the compressed power of two closing springs to be released.
- 7) The closing springs rotate a cam and move the linkage attached to the movable contacts.
- 8) The linkage is held in the closed position by a prop and prop pin.
- 9) Opening springs are compressed and latched.
- 10) The charging motor is energized and compresses the closing springs (pins 1 & 8) and the breaker is ready for another close when needed.

6. Manual Operation: **Discuss how to manually charge the closing springs.**

(SME) Use extreme caution when using a ratchet to charge the closing springs with the cover on. It is best to charge the springs pushing on the ratchet.

- a. The manual close button on the Circuit Breaker moves the closing latch (same as 52X coil).

1) TOOLS NEEDED:

- a) A one half inch drive ratchet
- b) A 5/8th inch socket.
- c) This will be placed on the motor driving eccentric and rotated to charge the closing springs.

- b. Operation is the same as electric except that closing springs will not recharge if control power is not available.
- c. Manual operation bypasses all protection relays, electric interlocks, and power source synchronizing equipment, exercise extreme caution if using this method.
 - 1) **NOTE:** This function is a last resort for emergency operation.

7. Opening Sequence:

- a. Electric operation:
 - 1) Hand switch to open or trip.
 - 2) Control power through the, interlocks, and protection contacts (pins 9&10).
 - 3) 125 VDC picks up trip coil (TC).

- 4) The TC pulls the trip latch off of the trip roller.
- 5) Trip roller is now permitted to collapse the linkage to the contacts (moves the prop pin off of the prop).
- 6) The unlatched roller also permits the compressed opening springs to expand and open the main and arching contacts.

8. Manual Operation:

- a. Trip lever on Circuit Breaker. Moves the same trip latch off the trip roller as previously discussed.
 - 1) **NOTE: This function is a last resort for emergency operation.**
- b. Sequence of events is the same as for electric operation.

9. Internal Control Circuit:

- a. Pin Connections to Control circuit.
- b. Pin 1 - positive side of 125V to the charging motor anti-pump relay (52Y).
 - 1) The clear light will let you know if the springs are charged. (If the light is on the spring are charged).

Ref Dwgs: E-NAB-0014, E-NAB-021 and vendor prints E009-00225 and E009-00021

- c. Pin 8 - negative side of 125 VDC for the charging motor, anti-pump relay and closing coil.
 - 1) The control room will receive an alarm if the breaker closes and the springs do not recharge. (For class 1E breakers only).
- d. Pin 3 - negative side of clear light from pin 8 through the 52 SM/LS contacts 5-6.
- e. Pin 4 - positive side with control switch to the closing coil and anti-pump relay.

On "PB" breakers an alarm is received if closing springs do not charge.

10. To close breaker:

- a. Breaker closing springs are charged.
- b. Control switch taken to close, this applies the positive side of the 125 Vdc to pin 4.
- c. Goes through 52IS contact if breaker is fully elevated or fully lowered in the cubicle.
- d. 52y coil is not energized. The 52y contacts at terminals 7 to 3 and 4 to 8 are "b" contacts, thus they are closed.
- e. The 52LC contacts are used only on the VCB type breakers. Contacts are closed when the trip shaft is in the proper position after springs are charged.
- f. Contacts 1&1C on the (52) auxiliary switch are closed when the breaker is in the open position (B Contact).

See print 01-E-NAB-0021

- g. Contacts 6 to 5 will be closed on 52/sm/lS when the closing springs are fully charged.
 - h. 52X coil will energize if current will flow through the 52/sm/lS contact to pin 8 (the negative side).
 - i. When the 52X coil picks up it releases the closing springs thusly closing the breaker.
11. When the breaker has closed the following actions result:
- a. The breaker operating mechanism is latched into place keeping the breaker closed.
 - b. The closing springs have discharged to close the breaker and the motor starts to compress the closing springs.
 - c. The positive side of 125V can come in through pin 1.
 - d. 52IS (positive interlock) contacts 1-2 close when breaker is fully raised or fully lowered.
 - e. 52/sm/lS contacts 1-2 close when the springs are discharged.
 - f. 52/cl/ms contacts 1-2 will reclose after the closing springs have fully discharged and the latch monitor switch then resets.
 - g. The spring charging motor then energizes and recharges the closing springs through a ratchet and pawl assembly.

12. Anti-pump feature:

a. **Ask: What is Anti Pump?**

b. Function:

- 1) 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.

- 2) Prevents breaker from re-closing on a potentially faulted load.
- 3) A 52Y coil will energize when 52/sm/l/s contact 3 to 4 closes. The 52/sm/l/s contacts are open only when the closing springs are fully charged.
- 4) When the 52Y coil energizes, a seal-in contact (7 to 1) closes.
- 5) Two series 52Y contacts (7 to 3 & 4 to 8) open to prevent the 52X-spring release coil from closing the breaker

Note: On 1200 amp and 3000 amp "NA" (13.8KV) breakers, a new style Anti-Pump relay (Allen-Bradley) is being installed. Electrically wired the same with different terminal numbers. See print E009-00021

EO: 1.5 Discuss the maintenance performed on Medium Voltage circuit breakers and Switchgear.

LESSON PLAN

METHODS AND ACTIVITIES

EO 1.5

Preventive Maintenance performed on Switchgear:

- **Discuss WSL's and 32MT-9ZZ91 used for switchgear PM's.**
 - Ensure the permits are adequate for work to be performed.
 - **Review your electrical boundaries**
 - Review the drawings with all personnel involved with the work.
 - Thoroughly check the temporary power lineup. Ensure that the effects of installed temporary power are understood. Normal configuration listed on plant drawings is not always applicable during unit outages.
 - Thoroughly check drawings for alternate feeds. Ensure that the plant lineups are understood.

Inspect/Clean for AE-E-NAN-S07 is performed under WSL – 287219 every 4 years. Instructions are very similar. Some equipment not used with Power/Vac switchgear e.g, Roof top bushings, Lightning arrestors etc.

Show example on power point of Temporary power from 1-E-NAN-S05 to 1-E-NAN-S06.
Ref. procedure 32MT-1NA05

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

☐ SER 4-02

- Recurring Events: Electrical Workers Severely Injured While Performing Maintenance on Medium-Voltage Switchgear (4-kV to 13-kV).
- Electrical workers at U.S. and international nuclear power plants continue to experience injuries while performing maintenance on medium-voltage switchgear components. Since mid-1998, nine workers at five power plants have been shocked, burned, or severely injured. Near misses have also occurred. One of the more severe events resulted in a fatality at an international power plant.

Discuss the Significant Event Report 4-02.

See power point for details

What Happened?

Why did it happen?

Can it happen here at Palo Verde? If it happens at Palo Verde, how can it be mitigated?

☐ CRDR - 3018544

- During the performance of work order 2947541--clean /inspect Calvert bus A07, employee assigned to the job inadvertently accessed an 4160V energized section of adjacent Calvert bus (A01) that was not part of the job scope. **Did all personnel understand the Bus and Switchgear configuration?**
- If any cubicles are found to be energized (such as temporary power, etc.), ensure that the particular cubicle is flagged and barricaded, to prevent inadvertent entry. (INPO SER 4-02)

❑ **CRDR - 2885407**

- Close Call” event occurred, on April 22, 2006, during the cleaning and inspection of 3ENANS05. For safety reasons cubicles which are energized are to be barriered off to warn workers not to enter. One of the two cubicles which were energized, was not barriered off as required by procedure 32MT-9ZZ91, Inspection/Cleaning of 13.8 kV and 4.16 kV Switchgear. Per 32MT-9ZZ01, step 3.3.2, If any cubicles are found to be energized (such as temporary power, etc.), ensure that the particular cubicle is barricaded, to prevent inadvertent entry.

❑ **Main Bus Inspection and Cleaning (WSL's and 32MT-9ZZ91)**

- Deviations from inspection/cleaning of ALL buswork, insulation, and/or primary disconnect assemblies (PDA's) shall be justified and documented in work order continuation sheets with concurrence by Engineering. (Re. CRAI 2802416)
- Inspect the primary disconnect assemblies (PDA) for cracking, chipping, or other signs of degradation. (Re. CRAI 2802416)
- Some areas are difficult to access. Some Bus work may have to be disassembled for access.

Use demineralized water for cleaning or wiping down Noryl insulation

Note: Do not allow Alcohol to contact any “Noryl” insulation.

Compartment Inspection and Cleaning

See power point

- Inspection and Cleaning shall be repeated for each switchgear compartment, completion of each compartment shall be recorded using the specific equipment locations furnished on the Multi-Equipment list.
- The Electric shop developed a Tracking Tool (form) for work performed in each cubicle to ensure all work is complete prior to close out. Review and understand instructions.
- Inspect all high voltage cable connections for cracks, loose connections, signs of arcing or tracking.

 CRDR - 3160784

- During the performance of the clean and inspect PM 3012119 on 2ENANS05. The Rear PDAs of switchgear cubicle 2ENANS05D were neither inspected nor cleaned. The discovery was made on 4_10_2008 after the permit had been swapped de-energizing S05A, S05B and energizing S05C, and SO5D. To perform the inspection and clean of 2ENANS05D Rear PDAs it was necessary to manipulate the permit back to a condition where S05C and SO5D would be de-energized. S05A and B would be energized. The resultant re-tag out caused a 24hr delay in work completion on 2ENANS05.

 CRDR – 3167454

- The REAR PDA boots on 2ENANS06A were not reinstalled after clean and inspect task. Electrical Maintenance was performing the clean and inspect PM on 2ENANS06 per work mech. 3012120. The activity must be performed in two separate acts. The first act requires a permit to de-energize S06A and S06B. After these two cubicles are cleaned/inspected, the permit swaps over and S06C and S06D become de-energized so that they can be cleaned and inspected.

Breaker Elevating Mechanism

- Clean/remove the old lubricant from the jack screws and other gearing.
- Apply new lubricate

Anti-Creep Plunger Inspection

- Inspect the anti-creep plunger for a bent shaft or damaged spring. Replace or repair defective anti-creep plunger parts.
- Pull the clutch handle and check smooth movement of the shaft. When the clutch is released and turned, verify that the disc will engage with one of the detentes. Adjust as necessary.

Meggering Instructions

- Chart explains which section to use for meggering unit specific busses
- Verify all potential transformer drawer(s) associated with bus to be meggered, are pulled out, regardless of whether or not they are on the permit. (Re. CRAI 2390499)
- Review and understand instructions for meggering each switchgear

Switchgear Hi-Pot (13.8 Kv)

- Ensure all breakers are racked down
- Ensure PT drawers are pulled out
- Barricade the area as per 01DP-0IS13
- Follow work instructions for rate of increase, time, and voltage
- Discharge Hi-Pot and Bus using a ground stick

Not performed on AE-E-NAN-S07 Switchgear.

Lighting Arrestors

- If working 13.8 kV switchgear E-NAN-S03, S04, S05, or S06, perform Doble testing of the 13.8 kV overhead lightning arrestors.
- If working E-NAN-S03 or E-NAN-S04, perform Doble testing on the internal lightning arrestor

DLRO Bushings Check (Roof Mounted Bushings)

- Ensure that the disconnect switch from the start-up transformer to the bus being worked is OPEN and tagged as appropriate and the feeder lines are grounded.
- Check the plant lineup between the units and ensure the proper permits are in place which includes cross-tie breakers from busses in all units. Also consider any grounding that is necessary.

- Reconnect the external lightning arrestor cables to the arrestors. Torque bolts to 42 ft-lbs for 1/2-inch, and 65 ft-lbs for 5/8-inch stainless steel bolts lubricated with Mobil 28.
- Reconnect the internal lightning arrestor cables to the arrestors. Torque bolts to 25 ft-lbs for 3/8-inch, 50 ft-lbs for 1/2-inch, and 65 ft-lbs for 5/8-inch stainless steel bolts lubricated with Mobil 28 grease.
- Tape connection of internal lightning arrestor per drawings E009-547 & E009-548.

- Perform Space Heater check
- Perform restoration

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

Preventive Maintenance performed on Breakers:

- Circuit Breakers are removed from service and inspected and tested per the associated procedures for that breaker type. These procedures consist of cleaning, inspecting, and adjustment of various components to ensure that the breaker performs as designed. This procedure also incorporates corrective actions learned through equipment history at Palo Verde.

- 32MT-9ZZ33 MAINTENANCE OF MEDIUM VOLTAGE CIRCUIT BREAKERS TYPE AM-13.8-1000 (NA)
- 32MT-9ZZ34 MAINTENANCE OF MEDIUM VOLTAGE CIRCUIT BREAKERS TYPE AM-4.16-250 (PB)
- 32MT-9ZZ35 MAINTENANCE OF MEDIUM VOLTAGE CIRCUIT BREAKERS TYPE AM-4.16-350 (NB)

Maintenance on AE-E-NAN-S07 Power/Vac breakers are performed under 32MT-9ZZ88

Some of the things performed during the Maintenance procedure for breakers:

- As found Megger and DLRO test
- Trip and Release coil test
- As found Main contact and early "B" contact timing test
- Arc Chute removal and inspection
- Contact inspection
- Breaker and Mechanism inspection
- Aux Contact switch check
- Replace contacts 1-2 on 52/SMLS AND 1-2 on 52/CLMS
- Lubrication
- Arcing Contact Wipe

Title: **Medium Voltage Circuit Breakers and Switchgear**

Lesson Plan #:

NEA61L000108

- Primary Contact Wipe and Adjustments
 - Trip and closing latch wipes
 - Trip Armature travel
 - Motor and Relay Switch clearances
 - Driving and Latching Pawl Adjustments
 - As left data for DLRO, Meggering, and timing of contacts
 - As-Left Trip Coil and Closing Coil Pickup Voltage
 - Breaker and cubicle alignment
- Breakers are also overhauled on a periodic basis. The procedure consists of disassembly, cleaning, inspecting, lubricating, replacement of worn/damaged bushings/parts and reassembly to ensure that the breaker performs as designed.
- 32MT-9ZZ37 OVERHAUL OF AM-13.8-1000-4H G.E. MAGNE-BLAST CIRCUIT BREAKERS (NA)
 - 32MT-9ZZ38 OVERHAUL OF AM-4.16-250-9H G.E. MAGNE-BLAST CIRCUIT BREAKERS (PB)
 - 32MT-9ZZ39 OVERHAUL OF AM-4.16-350-2H G.E. MAGNE-BLAST CIRCUIT BREAKERS (NB)
- Corrective Maintenance for Circuit Breakers:**
- Some of the things reworked/replaced after troubleshooting include:**
 - Driving Pawl
 - Latching pawls
 - Ratchet Wheel
 - Switches/Contacts
 - Racking motor/brushes
 - Switch adjustments
 - Adjustments on interlocks for proper operation
 - Anti-Pump relay's
 - Trip Coils
 - Close Coils
 - Close Latch/Close Latch Roller Bearing

Corrective Maintenance on Switchgear:

- Replacement of damaged shutters
- Position switches
- Mercury Switches
- Racking Mechanism rework
- Fuse Blocks
- Rework connections on the Main Bus
- Replace Noryl insulation
- Rework damaged wiring in switchgear
- Replace/Rework PDA's

EO: 1.6 Install and remove the GE Medium Voltage circuit breakers

LESSON PLAN

METHODS AND ACTIVITIES

EO 1.6

I. Breaker Installation And Removal:

30TD-9ZZ01 - Instructions for racking circuit breakers in to and out of the breaker compartment.

30TD- 9ZZ01 will be used in the lab

A. **Electrical Safe Work Practices:** *The requirements for racking in or out 4.16KV or greater bus breakers, for purposes of flash protection, personnel shall use personal protective apparel to prevent personal injury in the event of an electrical flash.*

1. *Review 01DP-0IS13 for racking a "PB" 4.16KV breaker.*
2. *Review 01DP-0IS13 for racking a "NB" 4.16KV breaker.*
3. *Review 01DP-0IS13 for racking a "NA" 13.8KV breaker.*

- **During demonstrations and practice in the lab, students are not required to wear Flash Suits with hood. This will aid in their ability to hear, see, and feel during practice. Hard hat, safety glasses, gloves and work shoes are required beyond the PPE boundary.**

Take the students to the Lab and practice racking up and down the circuit breaker.

B. Removing the circuit breaker:

1. Verify breaker is open.
 - a. Open control power breaker.
 - b. Pull control power fuses (UC fuses).
 - c. Install elevator motor into cradle.
 - d. Plug in elevator motor

 - e. Elevator direction switch down.
 - f. Close the control power breaker.
 - g. Stand to side of open cubicle.
 - h. Pull on elevator operator handle to lower the breaker till the beaker is fully on the floor.

2. If It is a "class" bus and is operable, and the breaker is not being removed, then ensure all of the following seismic conditions exist.
 - a. The breaker is secured using one of the following methods.
 - 1) The breaker has been partially racked up.

 - a) The Class 1E Switchgear cabinet is seismically qualified when the breaker is racked anywhere between the fully racked up position and 1 inch off the cabinet floor. The breaker should be racked no higher than 2 inches off the floor to maintain electrical protection. Racking a breaker 1-2 inches off the floor maintains it in a disconnected position for tagging purposes.
 - b) Ensure that class 1E 4.16 KV cubical doors latches (upper & lower Allen key and door handle latches) on Class 1E 4.16 KV cubical doors are secured per 02DP-0ZZ01.

Discuss how to use the manual-racking crank at this point. This can be performed if the racking motor is bad or if the DC power is not available.

3. If the breaker is to be removed for maintenance:
 - a. Unlatch all three latches (upper & lower Allen key and door handle latches) on Class 1E 4.16 KV cubical doors. Remove breaker from cubicle.
 - b. Close cubicle door and ensure that all three door latches (upper & lower Allen key and door handle latches) are secured.
CRDR# 2791361 - Cubicle door latches were found in the unlatched position on "PB" Class 4.16 kv switchgear. Make sure all three latches are dogged "Latched".
 - c. Tag breaker with proper information and install a FME cover over the breaker to transport.

(SME) Be careful when removing the breaker from the cubicle. The breaker could bump the switchgear causing another breaker to trip. Be careful not to hit relays on door when removing the breaker.

C. Installation of the circuit breaker:

1. HU Tools:
 - When installing the breaker, verify that it is properly aligned with cubicle and slowly install breaker to prevent an unnecessary trip of equipment.
 - Always make sure that the springs are discharged before racking the breaker up.
2. Lubrication:
 - a. Apply Mobil 28 on the bushings and the ground stab.

30TD-9ZZ01 - Instructions for racking circuit breakers in to and out of the breaker compartment.

Unit 3

If racking out a breaker in 3E-NAN-S01, S02, S03 or S04 (except NAN-S03AB), closing springs may have to be manually discharged due to the double spring discharge cam in the switchgear.

4. To Install the Circuit Breaker: (30TD-9ZZ01)
 - a. Open control power breaker:
 - b. Pull the (UC) control power fuses, and verify the springs are discharged.
 - c. Place the breaker into the cubicle.
 - d. Verify that the ground stabs are aligned and connected.

- e. Ensure mechanical interference block on breaker has clearance.
 - f. Install elevator motor into cradle - This may take some small adjustments.
 - g. Plug in elevator motor.
 - h. Elevator direction switch up.
 - i. Close the control power breaker.
 - j. Stand to side of open cubicle – safety precaution.

 - k. Pull on elevator operator handle to raise the breaker into the Switchgear.
 - l. Verify that there is no abnormal movement or binding of the breaker.
 - m. Verify that the bushings are lining up with the receivers, and that the shutters are open.
 - n. Verify that the secondary disconnect is making-up properly.
- D. After the breaker is fully racked up.
- 1. Verify that the positive interlock roller is approximately centered in the upper "V" notch.
 - a. ***Allow the students time to rack the breaker up and down.***
 - b. **Review procedure 30TD-9ZZ01 for racking breaker.**

Title: Medium Voltage Circuit Breakers and Switchgear

Lesson Plan #:

NEA61L000108

2. Verify that the positive interlock switch is made-up.
3. Verify that there is a gap between the stationary auxiliary switch operating rod and the plunger interlock bolt (about 1/8 of an inch).
 - a. NOTE: There is a requirement for a gap to keep the stationary switch from being damaged or the cam clip bent. May need to add or remove washers to obtain proper gap. Breaker gap measurements can be found from performance of inspect/test PM for breaker for plunger travel.
4. Ensure that all three latches (upper & lower Allen key and door handle latches) on Class 1E 4.16 KV cubical doors are secured per 02DP-0ZZ01.

E. GE Power/Vac – AE-E-NAN-S07

1. Removal and installation of circuit breaker is performed with a lift truck.
2. When installed in the switchgear, the breaker is supported by two horizontal steel tracks.
3. Breaker can be racked in and out with a manual racking tool.

Vendor tech. manuals have detailed instructions.

VTD-G080-00451

VTD-G080-00452

EO: 1.7 Perform basic inspection and troubleshooting of the GE Medium Voltage circuit breaker and switchgear, if the breaker trips or fails to close

LESSON PLAN

EO 1.7

I. The Breaker Trips or Fails To Close:

A. *Reference E-NAB-021*

- B. The breaker has received a close signal from the control room and failed to close.
 - 1. Examine associated relays for fault indication.
 - 2. If a fault is indicated the fault must be cleared to close the breaker.
 - a. Do not reset without Op’s permission.
 - 3. If no fault was found troubleshoot the breaker and Switchgear.

C. Troubleshooting the circuit breaker and Switchgear:

If the breaker is racked up, flash gear must be worn when the door is open during troubleshooting per 01DP-0IS13 Electrical Safe Work Practices

- 1. NOTE: If the breaker is suspected to be at fault, the test stand or an umbilical could be used to aid in troubleshooting. Obtain permission from operations prior to testing. Do not perform any work without the proper authorization or instructions.

METHODS AND ACTIVITIES

Ref. prints E-NAB-021, 01-E-NAB-0014, E009-0225,009-0021

Go over troubleshooting scenarios with students

Show Video: Nus High Voltage Circuit Breakers And Switches.

SOER 98-2: Circuit Breaker Reliability: (LaSalle U1, November 1997, breaker failed to close because lack of lubricant). Inspect breaker for lack of lubrication and old residual grease within the breaker operating mechanism.

If the troubleshooting is emergent.

Ref. Conduct of Maintenance

Parallel Path maintenance activities are initiated and controlled in accordance with 40DP-9WP01 - “Operations Processing of Work Orders”.

2. Switchgear:

- a. Check for incoming control power at the fuses and circuit breakers.
- b. If there is no control voltage at this point, troubleshoot back to the origin of the control voltage.
- c. Check the fuses.
 - 1) If the fuses are bad replace the fuses.
- d. Determines if there is voltage to the circuit breaker.
- e. If there is no control voltage at the breaker check back through the cubical interlocks

The Parallel Path Authorization form (PV-E0735) must be filled out, authorized and maintained in the field with the personnel performing the maintenance while the encompassed work is being performed and the Work Order is unavailable. (Found on E-Forms)

- 1) ***What do we know now at this time?***

3. Troubleshoot the circuit breaker:

- a. ***When there is control power to the circuit breaker, check the following on the circuit breaker (for the classroom uses the typical Magne-Blast elementary in the manufacturer's literature. Advise the student that plant drawings for various breakers will vary as control needs vary.***

Determine if the breaker can be racked down for further troubleshooting.
It is easier to troubleshoot without the flash gear on.

4. Perform initial observation of the breaker.

- a) Verify that the positive interlock lever is correctly positioned in the "V" notch.
- b) Check to see that the closing springs are charged.
- c) If springs are not charged check control circuit for motor.
- d) Check latching pawls and driving pawls

- e) With the hand switch attempt to close the circuit breaker.
- f) If the breaker does not close, check to see if there is control voltage at the 52X-closing coil (closing spring release device) when a close signal is applied to the breaker.
 - 1) Verify that the close signal is going to the breaker.
 - 2) Check control voltage to the 52x. This can be done by placing a meter from point 1c (positive) on the breaker's 52 Aux switch to point 6 (negative) of the 52 SM/LS (this is a normally closed set of contacts).
 - 3) If the breaker still does not close confirm that the 52 SM/LS contacts 5-6, 52/IS contacts 3-4, 52Y contacts, and 52 1-1c are closed to complete the circuit when the 52X receives a close signal.
 - 4) If you have control power to the breaker but not to the 52x the problem is internal to the breaker.
 - a) If the anti-pump relay is picked up the breaker will not close.
 - 5) If replacement breaker is required, contact planning and your Leader verify someone is qualified to perform replacement and breaker alignment.

When using an umbilical, ensure, per the elementary, that any interlocks associated with another breaker are disabled prior to cycling the breaker

Ask the class where would be a good place on the breaker to take readings.

5. If all efforts fail, and it is determined that the breaker will be manually closed it is imperative that a check is made to determine that control voltage is available to electrically trip the breaker. There needs to be power to the 52 auxiliary contacts that will allow the 52 TC to be energized to trip the breaker.
 - a. Take the breaker to the test stand and check.
 - b. If rework is required to perform, notify responsible planner.

6. Go over troubleshooting scenarios in lab.

E. Breaker trips

- a. Review your drawings, what would energize the trip coil?
 - b. See what relay flags are tripped
 - c. What would energize the 86 relay
 - d. Is the 86 relay locked out
 - e. May have to isolate circuit to find where the trip signal is coming from
 - f. If the breaker is tripping free, inspect the trip linkages, latches and internal breaker mechanism.
- F. Go over the troubleshooting scenarios in the lab.

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.