Grant County
PUBLIC UTILITY DISTRICT

Priest Rapids P08 GCB Incident Root Cause Analysis Results

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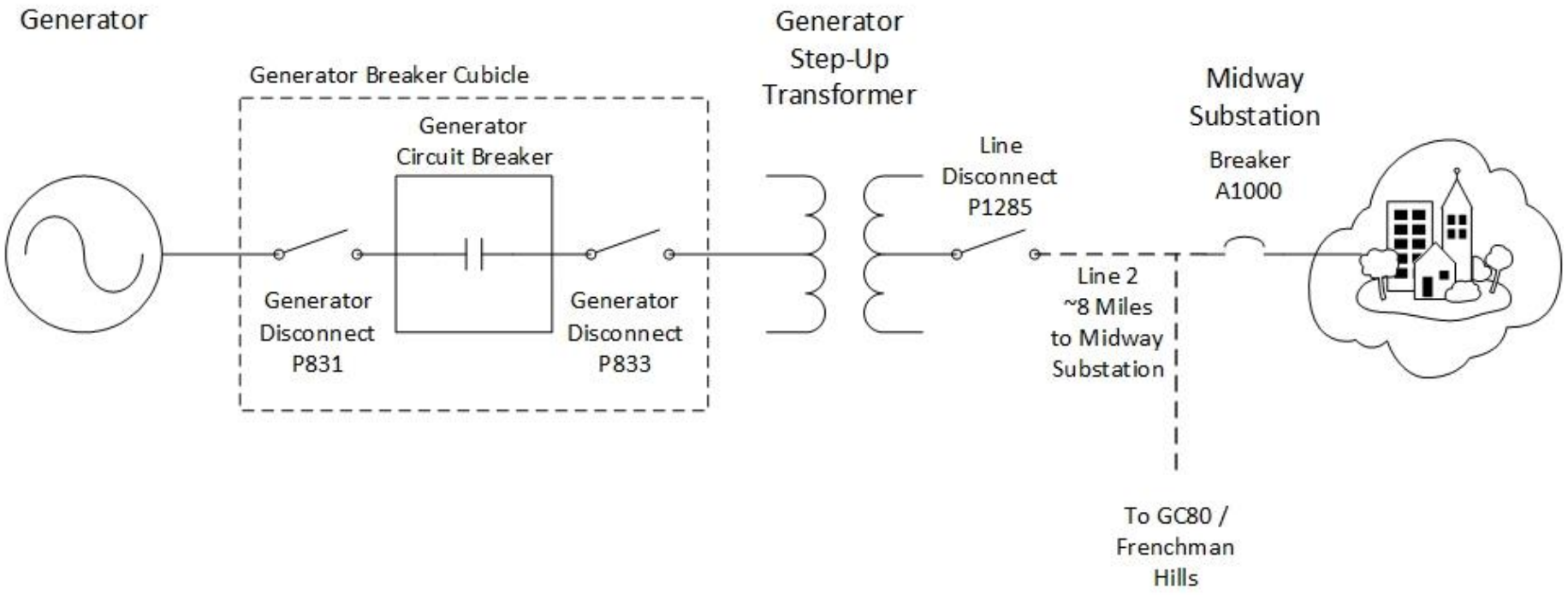
Topics to Review

- Generator circuit breaker functionality and layout
- Incident significant switches/disconnects
- Events leading up to the incident
- Incident timeline summary
- Incident root cause analysis (RCA) approach
- Purpose of performing a RCA
- RCA definitions
- Incident causes
- Generator circuit breaker forensic results
- Summary
- Questions?

GCB Functionality and Layout

- What is a Generator Circuit Breaker (GCB)?
  - An automatically or manually operated electrical switch designed to connect a generator to an electrical distribution or transmission grid
- What does a GCB do?
  - Connect or disconnect the generator to the grid under normal conditions
  - Functions (opens or trips) to protect the electrical circuit or equipment from damage caused by overload or short circuit by interrupting current flow under a fault condition
- What size of GCBs are at Priest Rapids?
  - Medium-voltage circuit breakers: 1-72 kV
  - All Priest Rapids units = 13.8 kV
- What type of breaker is at Priest Rapids?
  - Sulfur hexafluoride (SF6) breaker
  - These breakers interrupt the current by creating and extinguishing the arc in a container or bottle, with its contacts surrounded by SF6 to extinguish the arc

P08 GCB Functionality and Layout



Incident Significant Switches/Disconnects

Midway A1000 circuit breaker

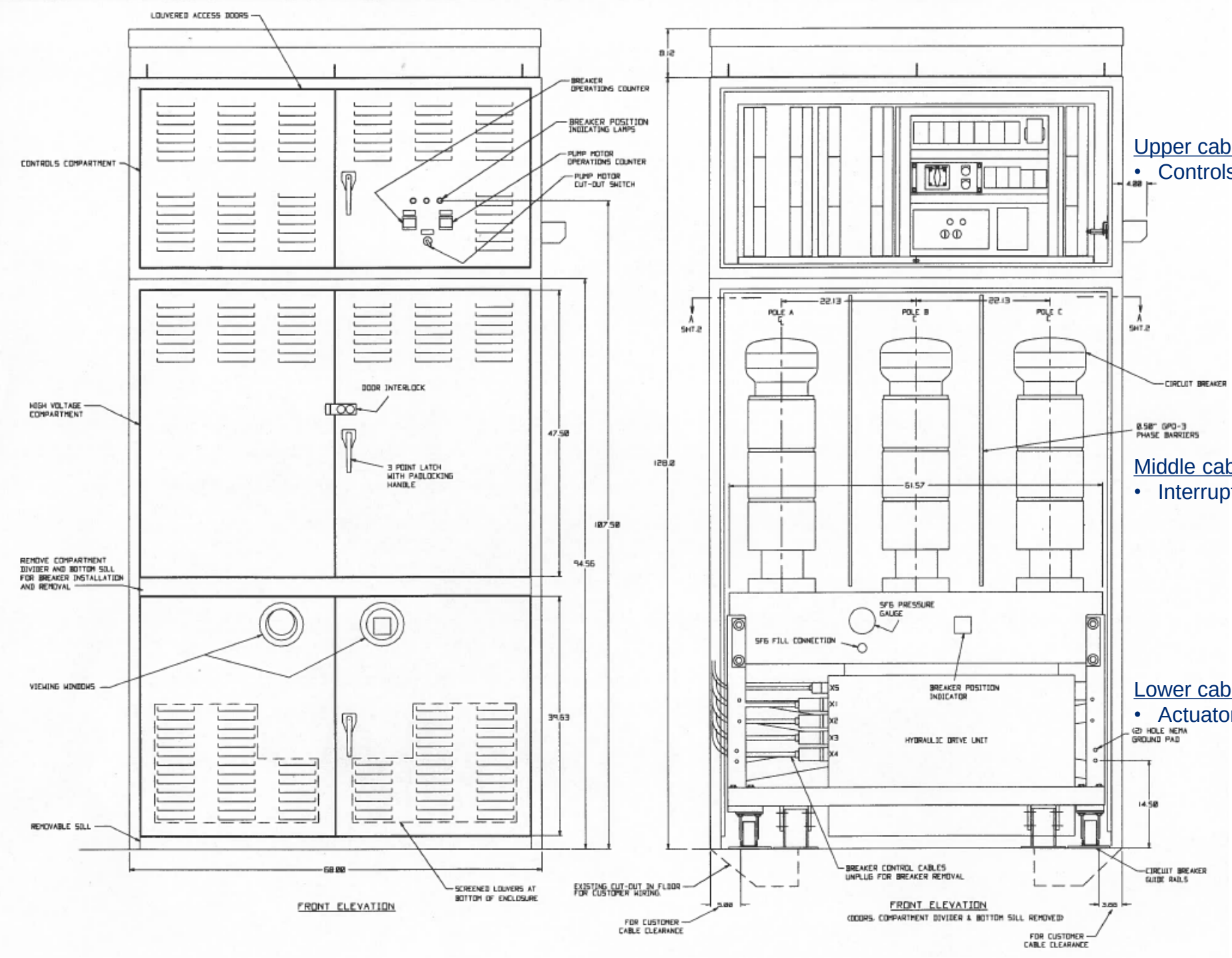
- The breaker controls Line 2 from Midway substation to Priest Rapids
  - This line services transformers C and D – four units (P05 thru P08)
- Continued on clearance at the beginning of the day (10/8) - Line 2 de-energized
- Clearance through Power Management's Dispatch

Transformer D disconnect 1285

- Prohibits energy coming into or leaving the "stepped up side (230 kV)" of transformer D for unit 8
- Operated – and left open – by Electricians and I&C Technicians as a part of scheduled maintenance

P08 Generator Disconnects 831/833

- Prohibits energy coming into or leaving P08 (13.2 kV)
- Continued on clearance at the beginning of the day (10/8) – prohibits energy coming into or leaving P08 generator and Generator Circuit Breaker (GCB)
- Clearance through Power Management's Dispatch

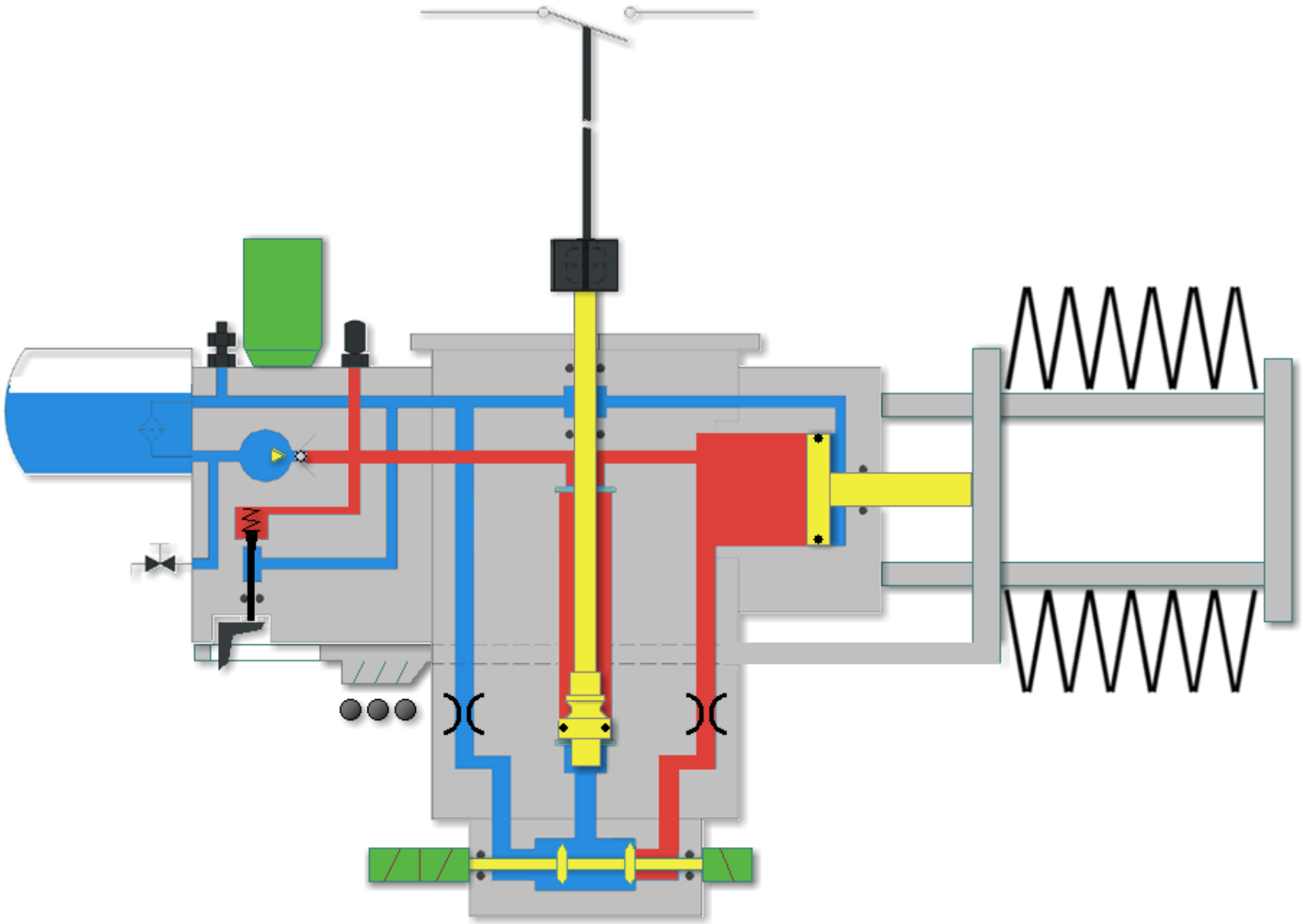


Upper cabinet
- Controls

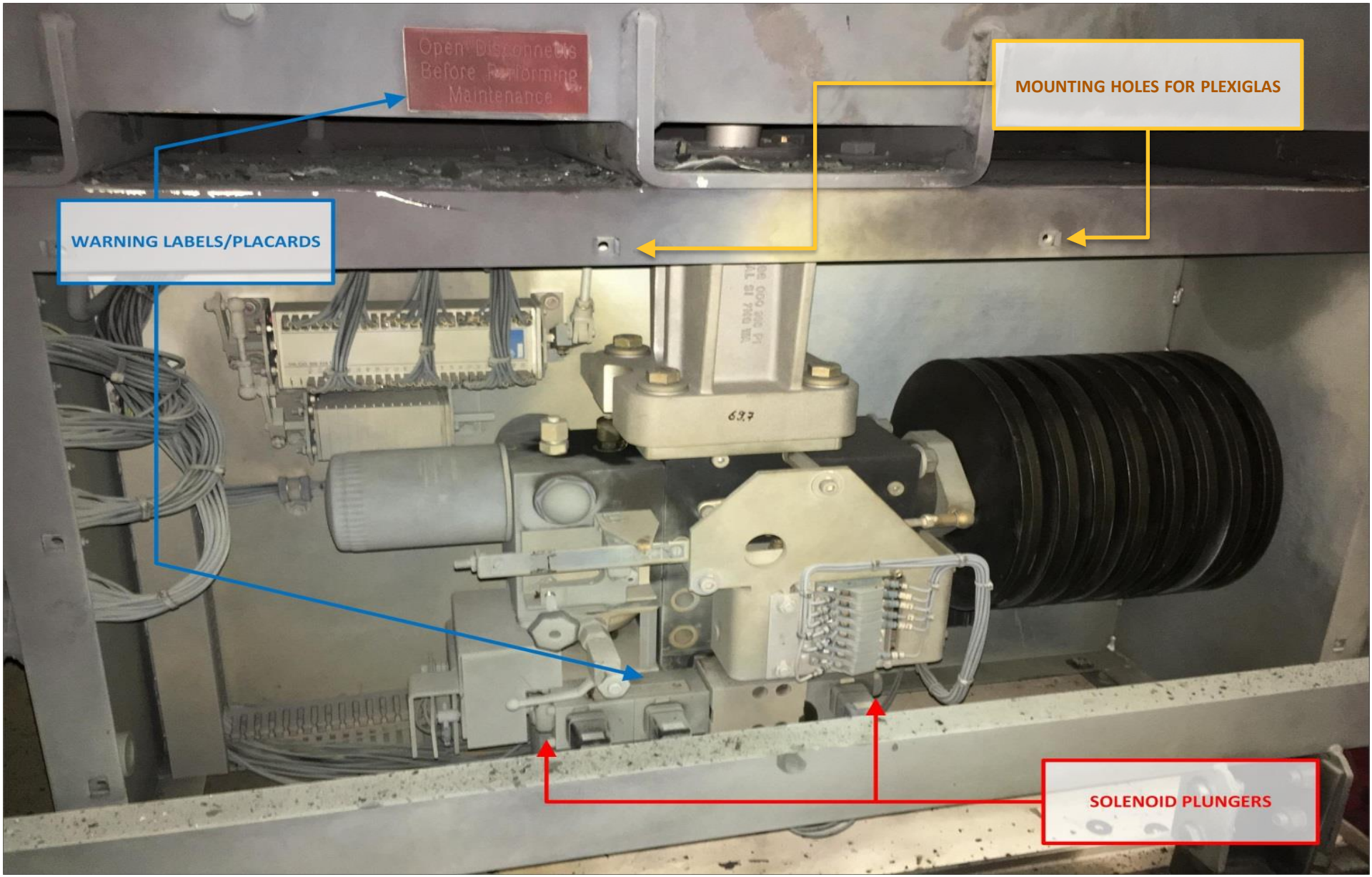
Middle cabinet
- Interrupters

Lower cabinet
- Actuator

Operating mechanism charched in open position



Hydraulic Drive Spring – Center Panel (plexiglas removed)



Events Leading Up To The Incident

September 3

- P08 taken out of service to repair a turbine oil leak

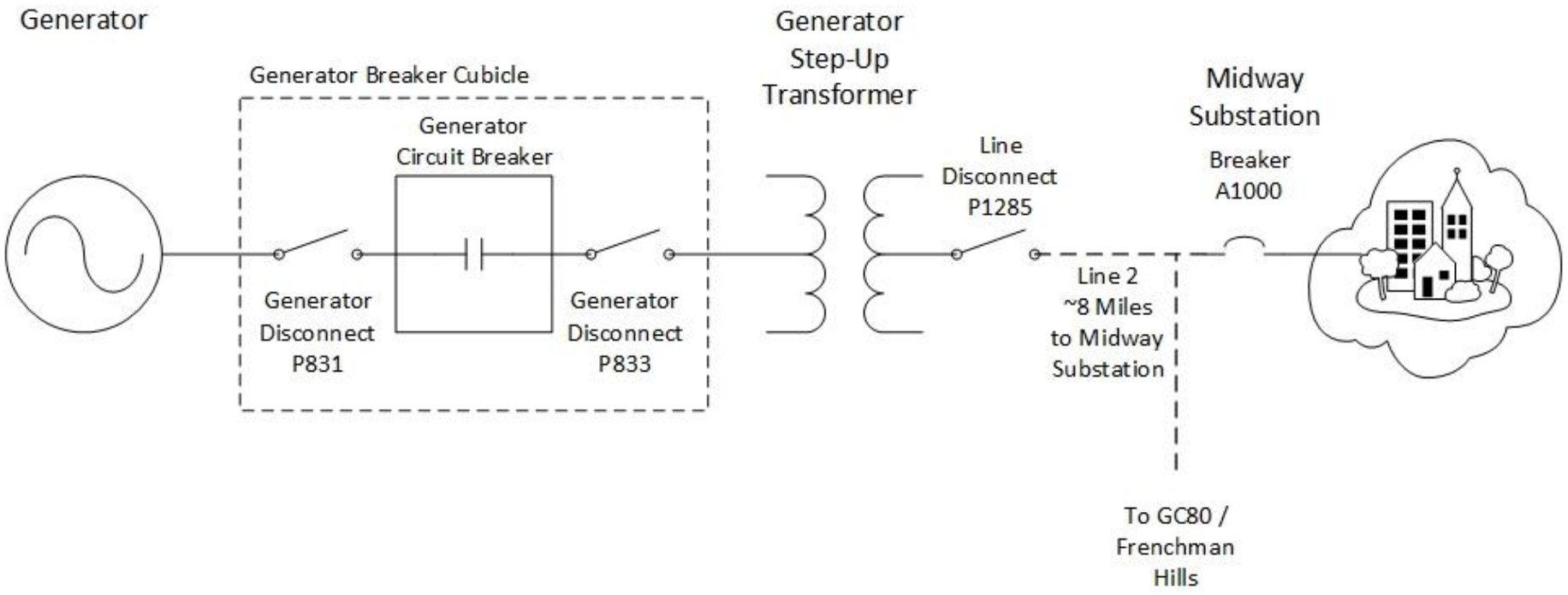
October 5 - 8

- Transformer D and relay maintenance outage
  - Serves P07 and P08
- Line 2 out of service
  - Serves transformers C and D: four units P05 – P08

October 8 (Thursday – end of Hydro work week)

- Line 2 scheduled to return to service
- Units P05, P06, P08 scheduled to return to standby

P08 GCB Functionality and Layout



Incident Timeline Summary

The following timeline is a summary of the incident events on October 8, 2015

13:16 > Midway A1000 Clearance released
- Notification and switching starts to energize Line 2

15:27 > Midway A 1000 breaker closed
- Line 2 energized to disconnect 1285

16:01 > P08 Generator Disconnects 831/833 closed
- Breaker not energized since Transformer D disconnect 1285 still open

> P08 GCB open

Incident Timeline Summary

16:02

> Operator observes problem with P08 pump and reports to Control Room
  - The pump provides pressure for breaker to open/close

> Senior Operator calls Electrical Foreman
  - Reported P08 breaker will not close

> Electrical Foreman dispatches 2 Electricians (E1 & E2)

> E1 proceeds to GCB

> E2 gets FR clothing on and tells other Electricians (E3 & E4) about breaker problem

16:16

> Chief starts pump and stopwatch (typical troubleshooting check), goes to Control Room

16:17

> E1 arrives at GCB, followed by E3

> Electricians turn off pump in GCB

> Electricians begin troubleshooting

> Chief Operator returns to GCB

Incident Timeline Summary

16:17 (cont.)
> Chief Operator opens the GCB lower cabinet doors
> E4, Foreman & E2 arrive at GCB
> Chief Operator starts pump
> Electricians verify pump gear condition/operation
> Plexiglas protective cover removal started
> E4 attempts to assist with cover removal, but Foreman keeps E4 out due to lack of FR clothing

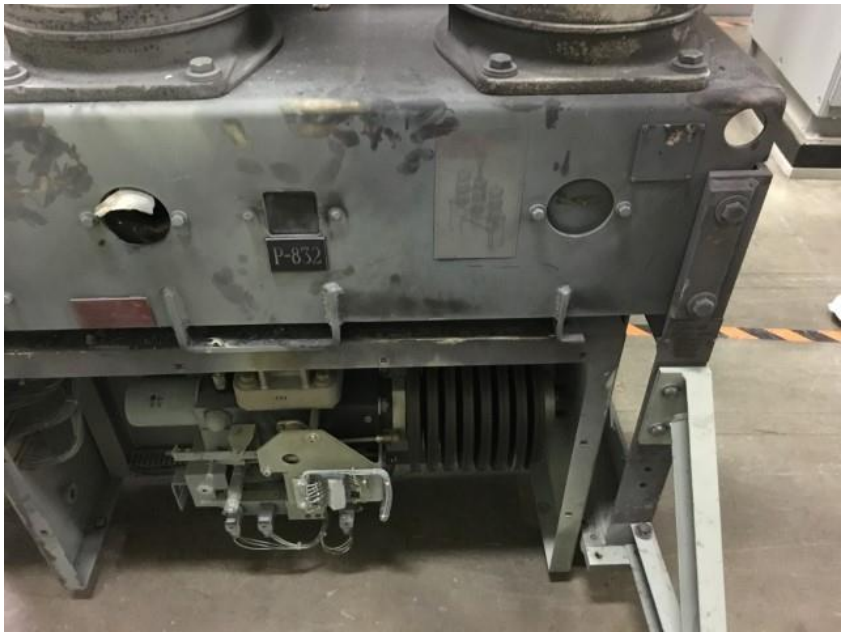
16:19
> Operator closes Transformer D Disconnect 1285 - continuation of tasks to bring units back to standby
> GCB now energized from the transformer side

16:20
> E1 & E3 start to leave (time to catch carpool)
> E4 asks if they tried the (manual actuation) solenoids, then reaches in and presses left (open) solenoid and then presses right (close) solenoid
> Breaker slowly closes and incident occurs

Generator Breaker Cubicle

Generator Circuit Breaker

Cubicle Module



Forensic Analysis Underway

Incident Root Cause Analysis (RCA) Approach

- District and IBEW 77 agreed to complete a joint RCA
- Severe incident - external assistance and processes warranted.
- Contracted with Energy Northwest (ENW)
  - Procedures more robust – used at Columbia Generating Station Nuclear Plant
  - ENW provided an individual that regularly performs RCA as part of their normal duties.
- The RCA Team consisted of ENW, District union and management employees. Representatives from Safety Department, Hydro Engineering, Hydro Operations, and Transmission and Distribution.

Purpose Of Performing A RCA

There are two primary purposes of performing a RCA

1) Determine all of the causes (direct, root, and contributing) that were responsible for the incident occurring.

2) Establish corrective actions that address all of the causes to prevent the incident from occurring again.

RCA Definitions

Direct Cause

- The event that is the immediate initiating agent which leads to or allows the incident to happen.
- This is the action that physically resulted in the incident (the what).

Root Cause(s)

- Agent, failure, or fault, from which a chain of effects or failures originates (the why).
- The cause that, if corrected, would prevent recurrence.

Contributing Cause(s)

- Agent, failure or fault which is partly responsible for development of the incident.
- These are the causes that if eliminated would not necessarily have prevented the incident, but could decrease either the severity of the incident or the possibility of the incident occurring.

RCA Definitions

Corrective Action(s)

- These are the actions assigned to address all of the causes of the incident to prevent it from occurring in the future.

Management

- For the purpose of the RCA report, management is defined as non-union employees at the supervisor level and above.
  - Includes management as a whole at the District.
  - As a group, management is responsible for
    - Establishing a healthy safety culture
    - Setting expectations
    - Providing adequate policies and procedures
    - Reinforcing expectations, policies and procedures.

Incident Causes

Direct Cause

- The breaker was manually slow closed while energized with unit P08 in a stopped position.

When the breaker was manually closed – 30 to 40 times longer than designed - the unit was at a dead stop.

Manually closing the breaker bypasses all interlocks designed to prevent it from closing under unsafe conditions.

The breaker is designed to close into a moving, synced unit; NOT slow closed into a stopped unit.

This caused severe arcing and overpressure within the GCB which resulted in the explosion.

Incident Causes

Root Cause 1

- Management is not adequately setting and enforcing safety expectations which has resulted in a poor safety culture.
  - During the event, shortcuts taken which all stem from an inadequate enforcement of expectations
    - No job brief
    - Minimal communications among the team members
    - Assumptions on energy isolation and standby clearance
    - Lack of onsite control of work activities

Management Responsibilities - Overview

- Provide effective training
- Reinforce use of error prevention tools and standards
- Define clear roles and responsibilities associated with safety
- Enforce expectation of appropriate PPE usage
- Consistently observe, coach and correct as appropriate employees regarding safety policies, procedures, behaviors and expectations

Incident Causes

Root Cause 2

- On-site leaders (Chief and Foreman) did not control the work activities. Additionally they did not ensure the energy sources were isolated prior to allowing the Electricians to troubleshoot the GCB.

Chief Operator Responsibilities – Overview

- Safe, efficient, and correct operation of the generating facility
- Ensure all safety regulations and safe clearance procedures are performed and a safe work environment for all employees
- Actively promote adherence to and enforcement of procedures, policies and safety rules
- Since the GCB was not on clearance, the Chief Operator was responsible for the GCB itself according to District policy, procedure and position description

Electrical Foreman Responsibilities - Overview

- Have thorough knowledge and understanding of the District's Safe Clearance Procedure Manual and District's safety policies
- Ensure a safe work environment for all employees
- Actively promote adherence to and enforcement of procedures, policies and safety rules

Incident Causes

Contributing Cause 1

- The policy requiring job briefs has not been adequately enforced and does not explicitly say that it applies to emergent as well as planned work.

Had a job brief been conducted it would have forced the individuals to slow down, eliminating the “end of the day/hurry up and go home” mentality.

It would have required problem clarification/re-evaluation and communication when the plan changed.

Discussion would have had to occur about the equipment being energized and the need to open the 831/833 generator disconnects prior to starting work.

Incident Causes

Contributing Cause 2

- Knowledge gap related to the GCB equipment among the Electricians, the Chief Operator and Senior Operator.

The Chief lacked the knowledge that the breaker could be operated simply by pressing the hydraulic solenoid plunger in the lower cabinet.

Not all of the Electricians knew about the solenoid plungers and the equipment response that would follow.

Additionally, there is a lack of knowledge about the potential risks associated with the GCB lower cabinet.

Incident Causes

Contributing Cause 3

- None of the employees involved had a questioning attitude about safe work practices or situational awareness in the events leading up to the incident.

Highly qualified employees.

All employees involved receive regular clearance training, but none of them questioned the status of the equipment or the need for isolating it.

Every employee has the responsibility to ensure their own personal safety.

- Washington Administrative Code
- Employee position descriptions

Some employees did have questions about the situation, but none spoke up with their questions.

Incident Causes

Contributing Cause 4

- The GCB external failure protection scheme did not account for the failure mode experienced during this event.

The GCB failure protection scheme was designed to protect equipment and personnel for failures experienced during normal operating conditions.

Did not account for a manual operation in which the lockout circuits are bypassed while under inadequate spring pressure or SF6 gas pressure conditions.

If the failure protection scheme had accounted for this failure mode, the equipment damage and injuries would have reduced in severity but not definitely eliminated.

Breaker Forensic Results

- Powertech Labs of Surrey, British Columbia, Canada completed forensic investigation on the GCB

- The forensic results:
  - The GCB functioned as designed
  - No issues of performance due to age or maintenance

- GCB closure 15 minutes after the incident
  - No conclusive evidence for the closure has been identified at this time
  - Theorized that due to the heat and stress of the explosion that after 15 minutes, the metals within the GCB cooled causing the closure (release).

In short – breaker performance did not cause this incident.

Corrective Actions

- Corrective actions for each root and contributing case identified.

- Corrective actions includes:
  - Identified action
  - Deliverable
  - Responsible Party
  - Due Date

The responsible party for each action will be held accountable for completing it by the due date.

The following are the identified corrective actions – summarized in some cases – for the P08 Incident.

Corrective Actions

RC 1: Management has not adequately established and enforced safety expectations

1. Evaluate current safety culture, including safety expectation for all employees, determine desired state, develop and implement plan to achieved desired state.

2. Evaluate the effectiveness of the internal inspection program (currently safety job audits at Hydro)

3. Complete a plan for Job Hazard Assessment (JHA) implementation.

4. Identify all moderate to high safety risk hydro plant equipment. Prioritize and schedule completion of JHA for identified equipment.

5. Assess the effectiveness of the operator evaluation program against operator job duties, equipment knowledge, hazard assessment and clearance procedure adherence. Develop action plan to address deficiencies.

Corrective Actions

RC 2: On-site Leaders (Chief Operator and Electrical Foreman) did not adequately control emergent work

1. Investigate, if possible, additional reasons that on-site leaders did not adequately control emergent work and identify any resulting corrective actions.

Corrective Actions

CC 1: The job brief policy has not been adequately enforced and does not explicitly state that it applies to emergent work.

1. Revise the job brief policy to include emergent work.

2. Clarify job brief expectation via District wide communication and conduct reviews of emergent work job briefs for a period of three months.

Corrective Actions

CC 2: There is a knowledge gap related to the generator circuit breaker among Electricians and Operators.

1. Provide comprehensive training on the generator circuit breakers to all Hydro Operators and Electricians.

2. Implement an initial and recurring training program for the above training.

3. Implement a recurring equipment training program for Electricians and Mechanics similar to Operator Annual Training (OAT).

Corrective Actions

CC 3: The employees did not have situation awareness or a questioning attitude related to safe work practices.

1. Implement an Error Prevention Tool Policy (error prevention tools are human error prevention techniques focused on anticipating, preventing and catching active errors before they become events).
   a) Examples include three-way communication and STAR [Stop, Think, Act, Review]

Corrective Actions

CC 4: The generator circuit breaker external failure protection scheme did not account for the failure mode experienced during this event.

1. Evaluate revising generator circuit breaker protection scheme logic.

Corrective Actions

Other Corrective Actions

1. Revise the clearance policy to include emergent work. Evaluate the continued use of “Operator Standby” clearance practices for modification or elimination.

2. Add new placard to plexiglas cover of all GCB cabinets with wording that requires opening the disconnects anytime that the cover is removed.

3. Evaluate installing kirk keys on GCB lower cabinet doors.

Corrective Actions

Effectiveness Review

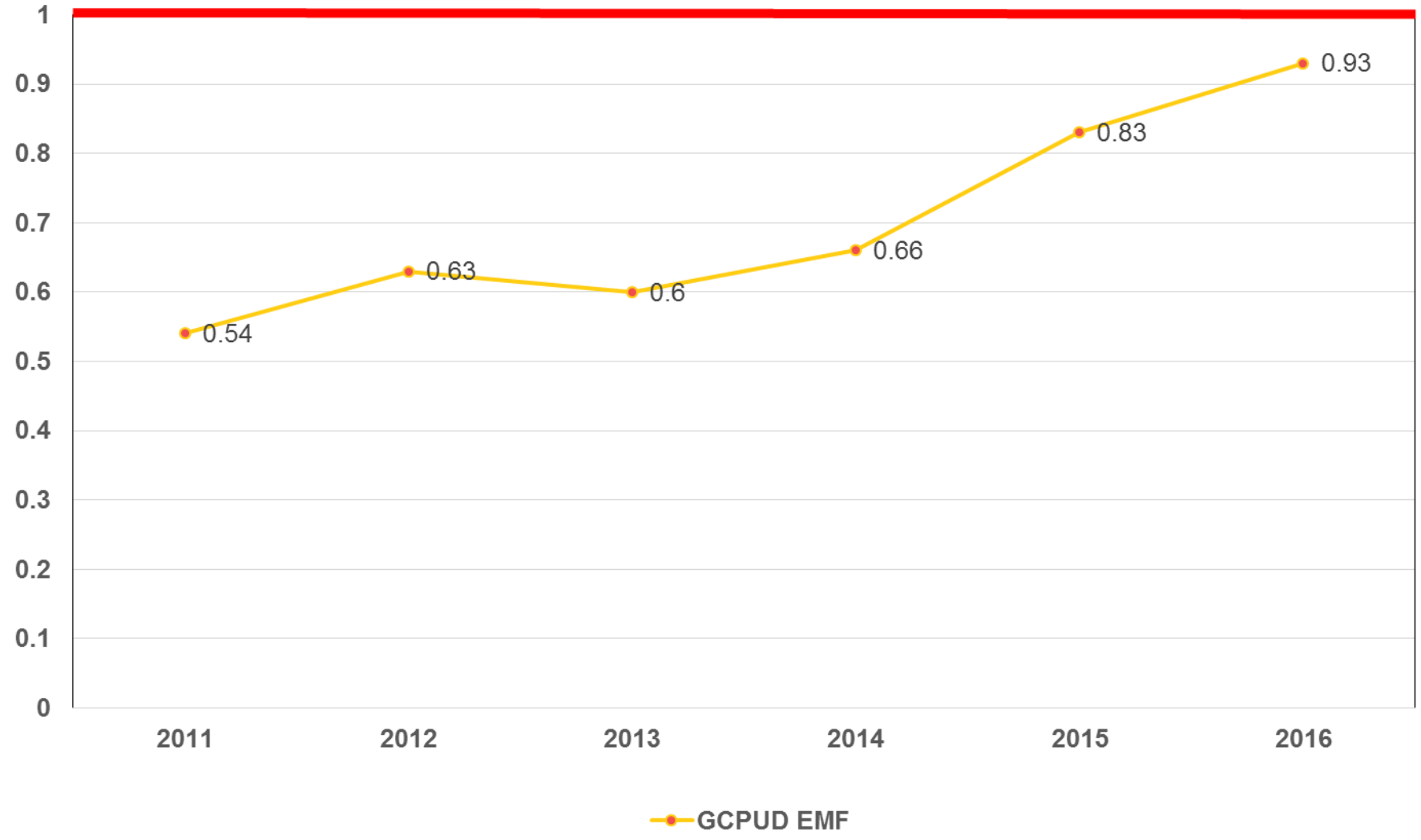
1. Perform a corrective action effectiveness review on the corrective actions.

At a minimum, assess performance in the following areas:

- Conduct a follow-up independent safety culture survey. Success is an improved safety culture.
- Conduct a follow-up test of the Electricians and Operators to assess their knowledge and proficiency of the GCBs. Define a passing score and pass rate that represent the minimum required proficiency level.
- Verify completion rate of required safety audits.

GCPUD EMF

(Industry average is 1.0)



Summary

- District Management and IBEW 77 agree that all incident causes have been identified and appropriate corrective actions established.
- The District is committed to completing all the necessary corrective actions as well as maintaining an ongoing review of effectiveness.
- Biggest challenge: Moving the District's safety culture to a safer state.
  - Safety culture is not created by one action but rather a history of actions and inaction.
  - From this point forward we are working to clearly define expectations of all employees and ensuring appropriate accountability occurs.
  - It should be everyone's goal to have Grant PUD be known as the safest place to work in the industry.

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Questions?

Thank you.