

Brunswick Nuclear Plant

Emergency Diesel Generator No. 1
Trip and Failure of Engine Crankshaft Bearing



Introduction

- Scotty Hinnant Senior VP & CNO
- Jim Scarola Site Vice President
- Steve Howard Manager Operations
- Randy Ivey Manager Support Services
- Susan Rogers Manager Maintenance
- Tim Trask Manager Engineering
- Bob Rishel Supervisor – PSA

Agenda

- Opening Remarks
- Event Review
- Diesel Generator Reliability
- Mitigating Systems
- Key Lessons Learned
- Closing Comments

Opening Remarks

- *BNP agrees with the finding and preliminary significance determination.*

EDG 1 – Sequence of Events

Planned Maintenance October 23 – 30

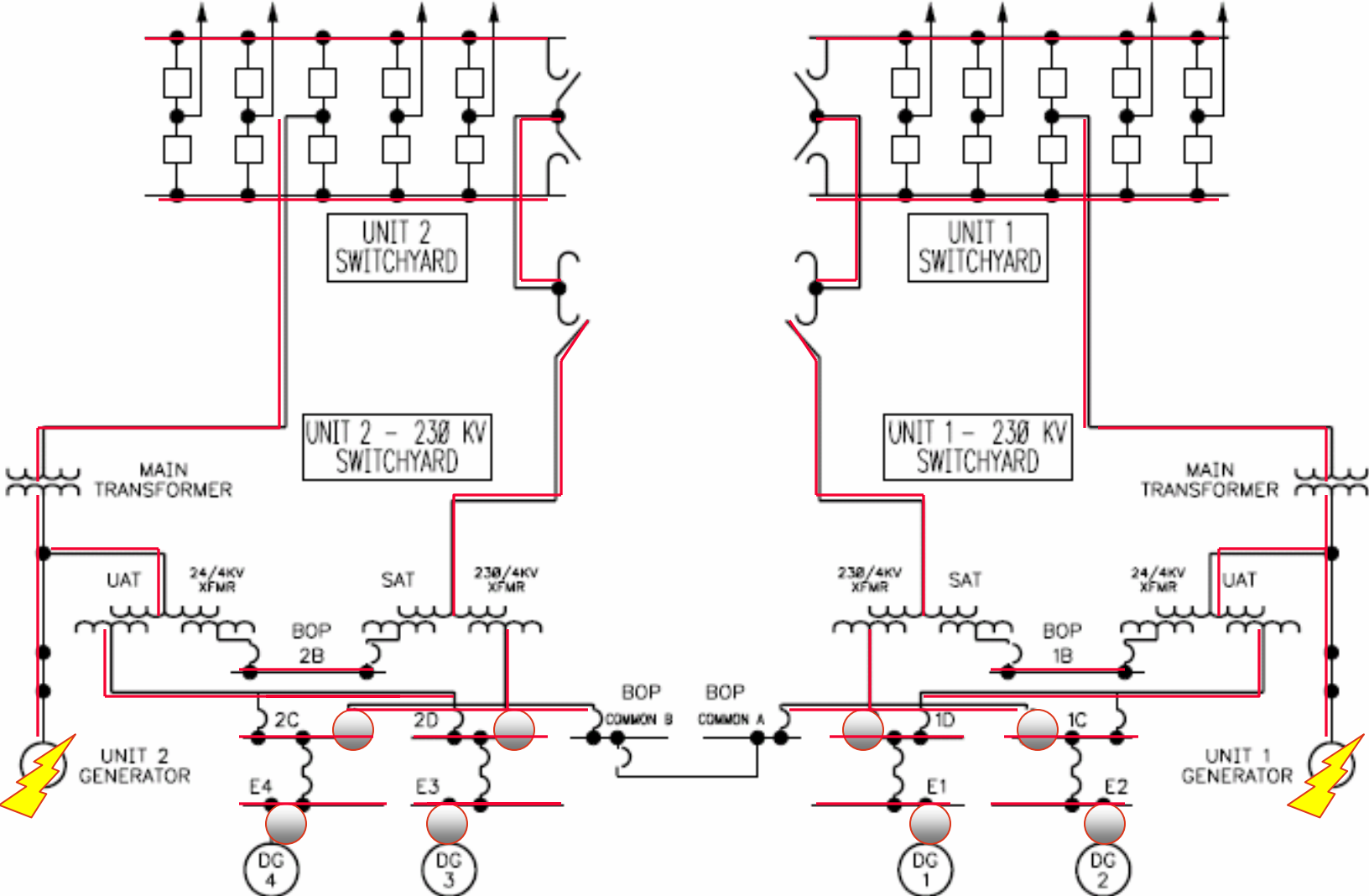
- Oct 23rd - EDG 1 Removed From Service For Planned Maintenance Activities.
 - ◆ Corrective Maintenance
 - ◆ Preventive Maintenance
 - ◆ 72 Month Inspection Activities
 - ◆ Margin Improvement
 - ◆ Power Potential Transformer Replaced

EDG 1 – Sequence of Events

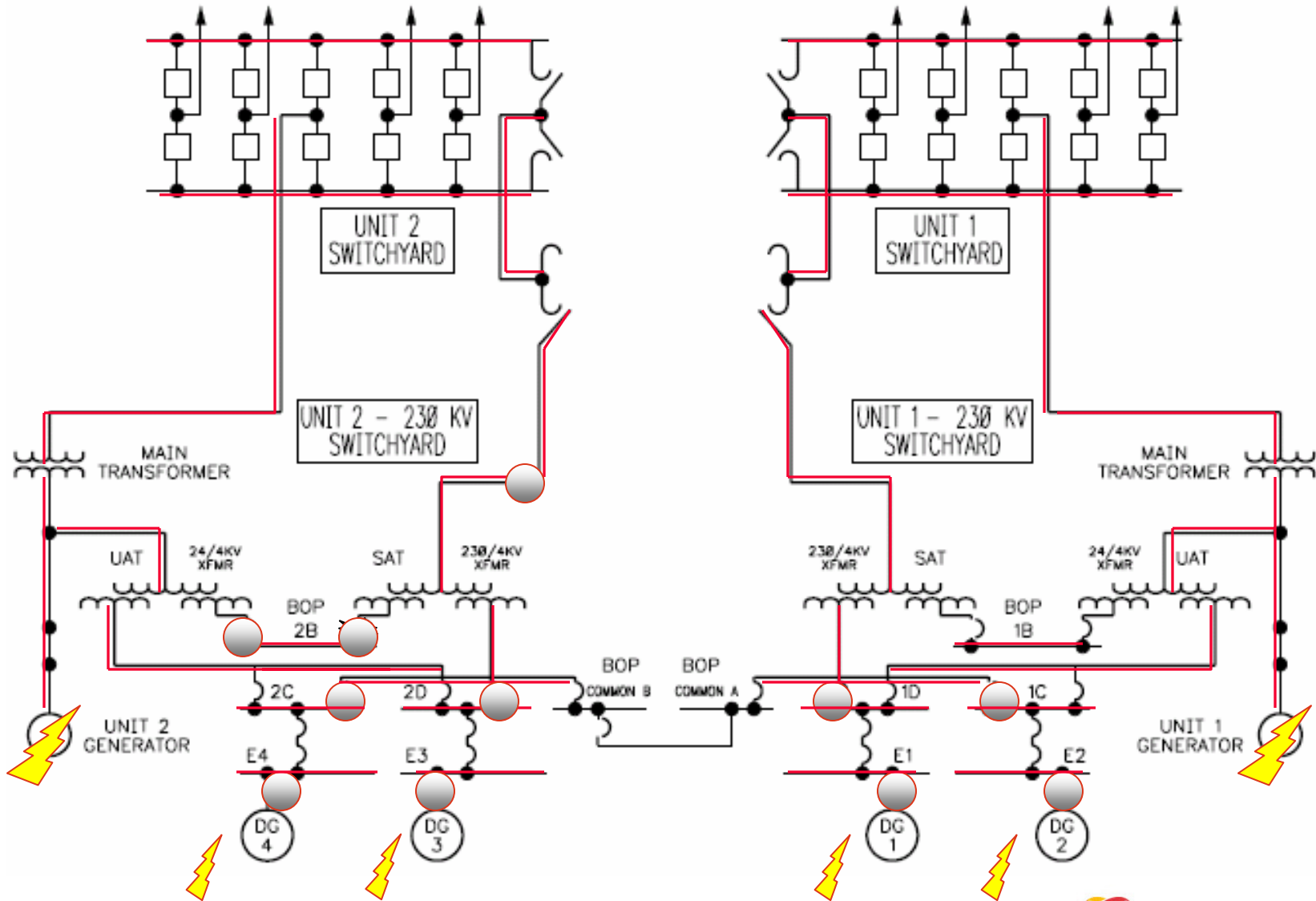
Planned Maintenance October 23 – 30

- Oct 29th EDG 1 Available
 - ◆ Post-maintenance testing run, lubricating oil strainer high differential pressure alarms were received
- Oct 28th & 29th
 - ◆ Post maintenance activities
 - ◆ EDG 1 started and was run 5 times
 - ◆ Cumulative run time ~15 ½ hours
- Oct 30th EDG 1 declared operable

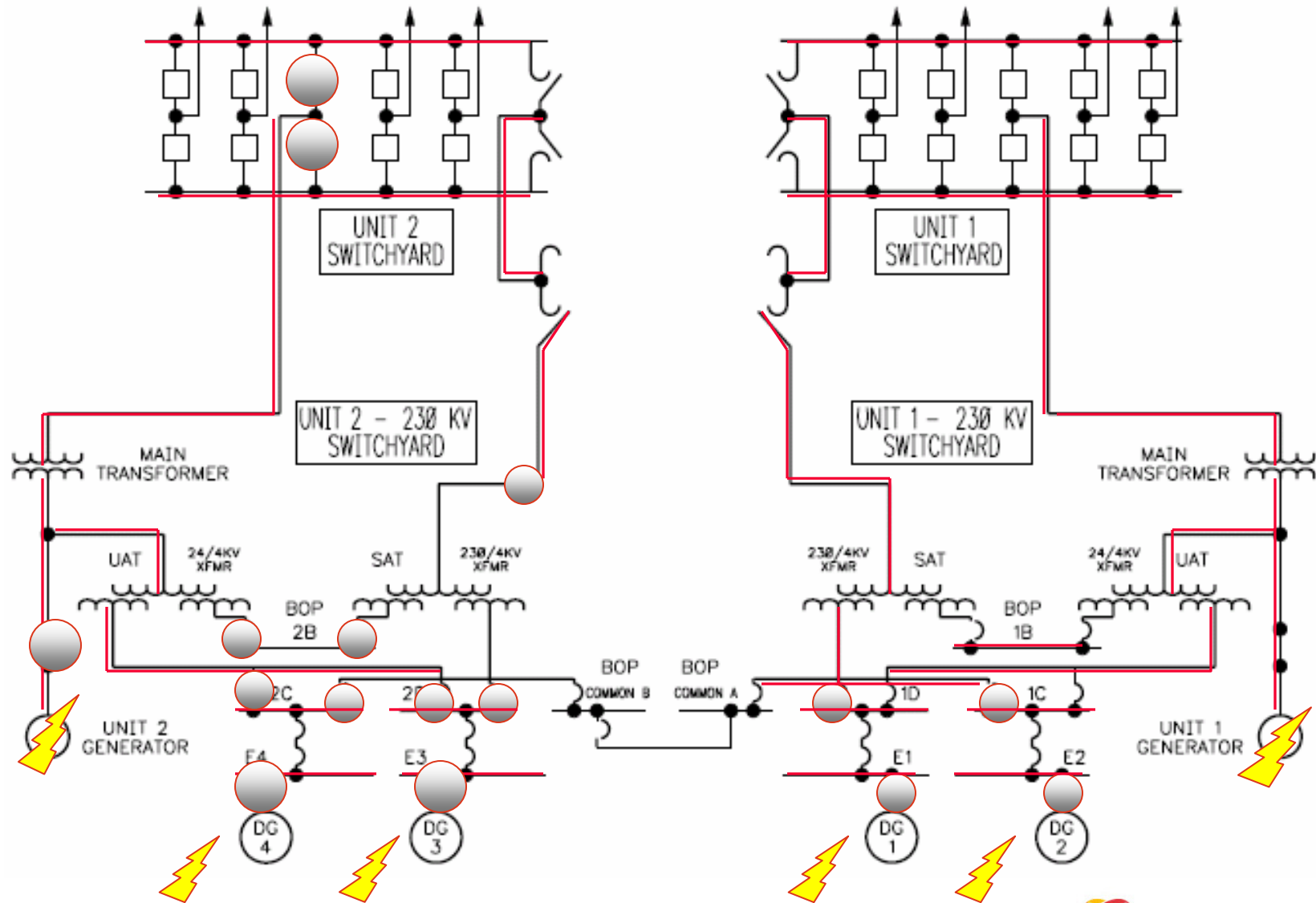
At Power Electrical System Lineup



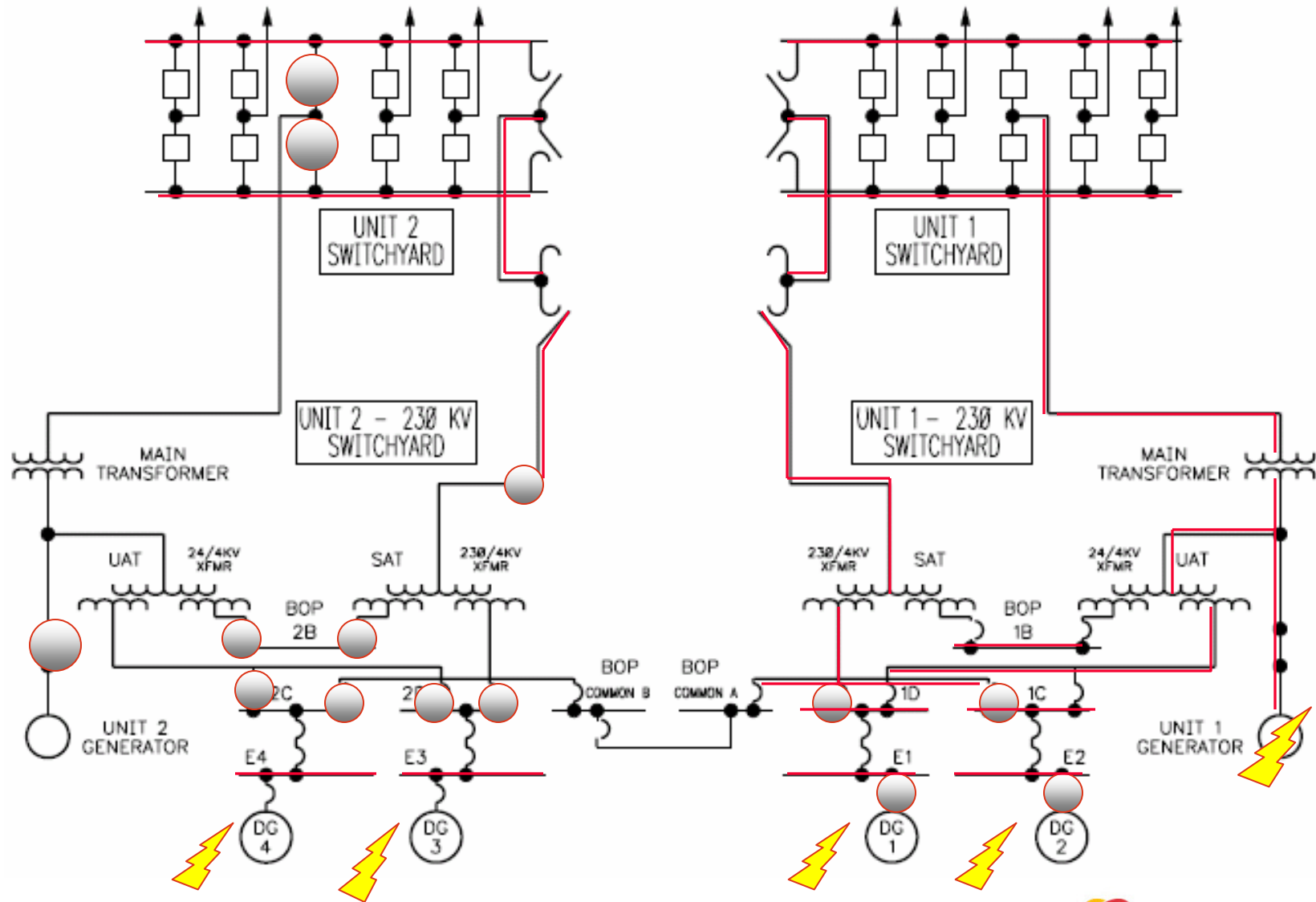
U2 SAT Flex Link on Phase A Fails



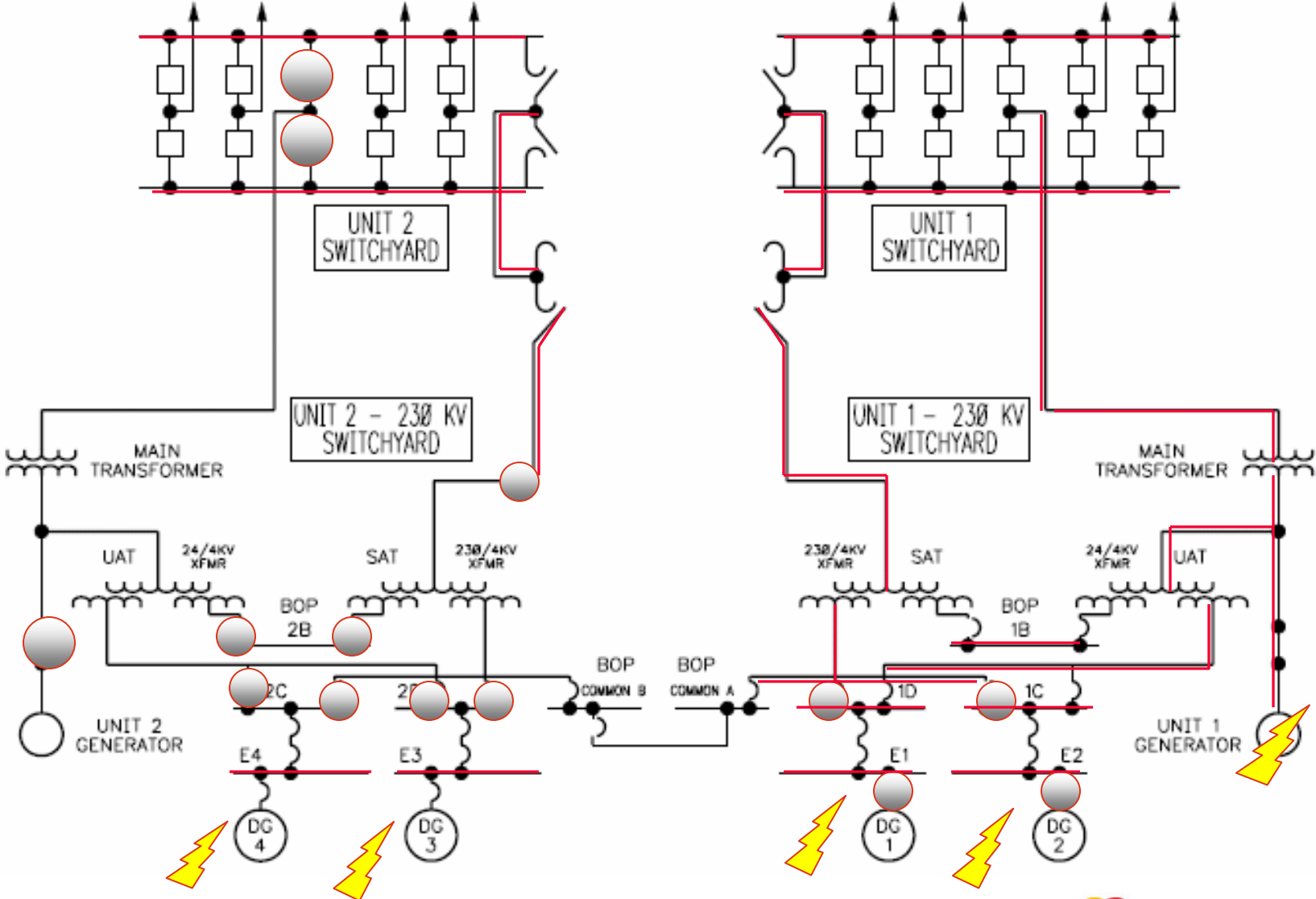
Operators Insert Manual Trip on U2



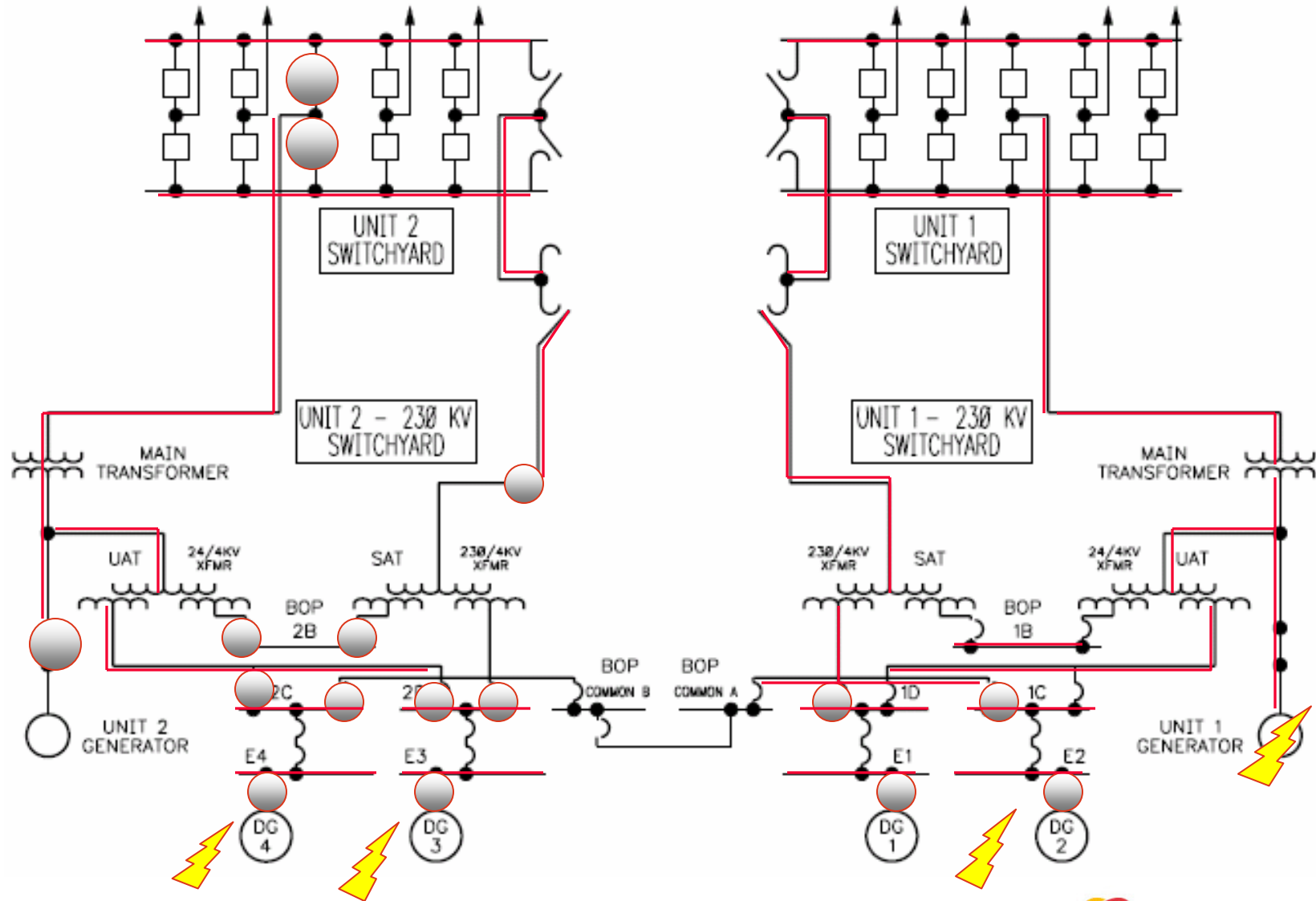
Loss of Offsite Power



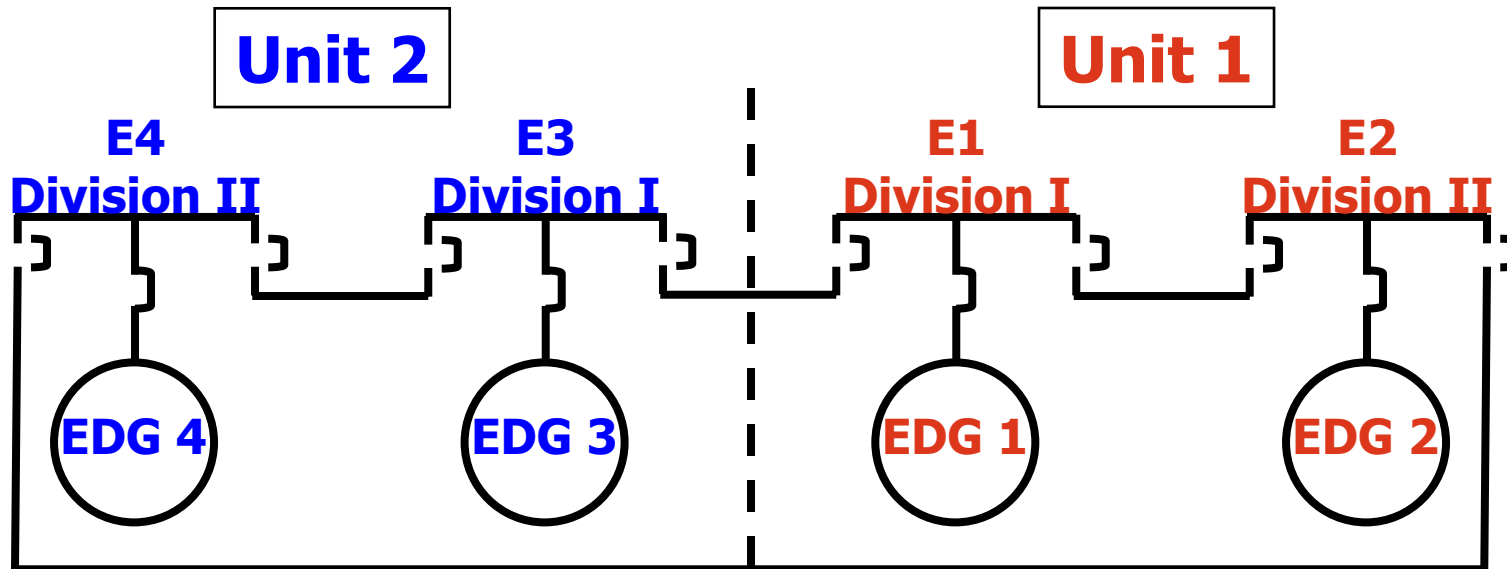
Unloaded DG 1 Trip



Backfeed Established



Emergency Power Loads



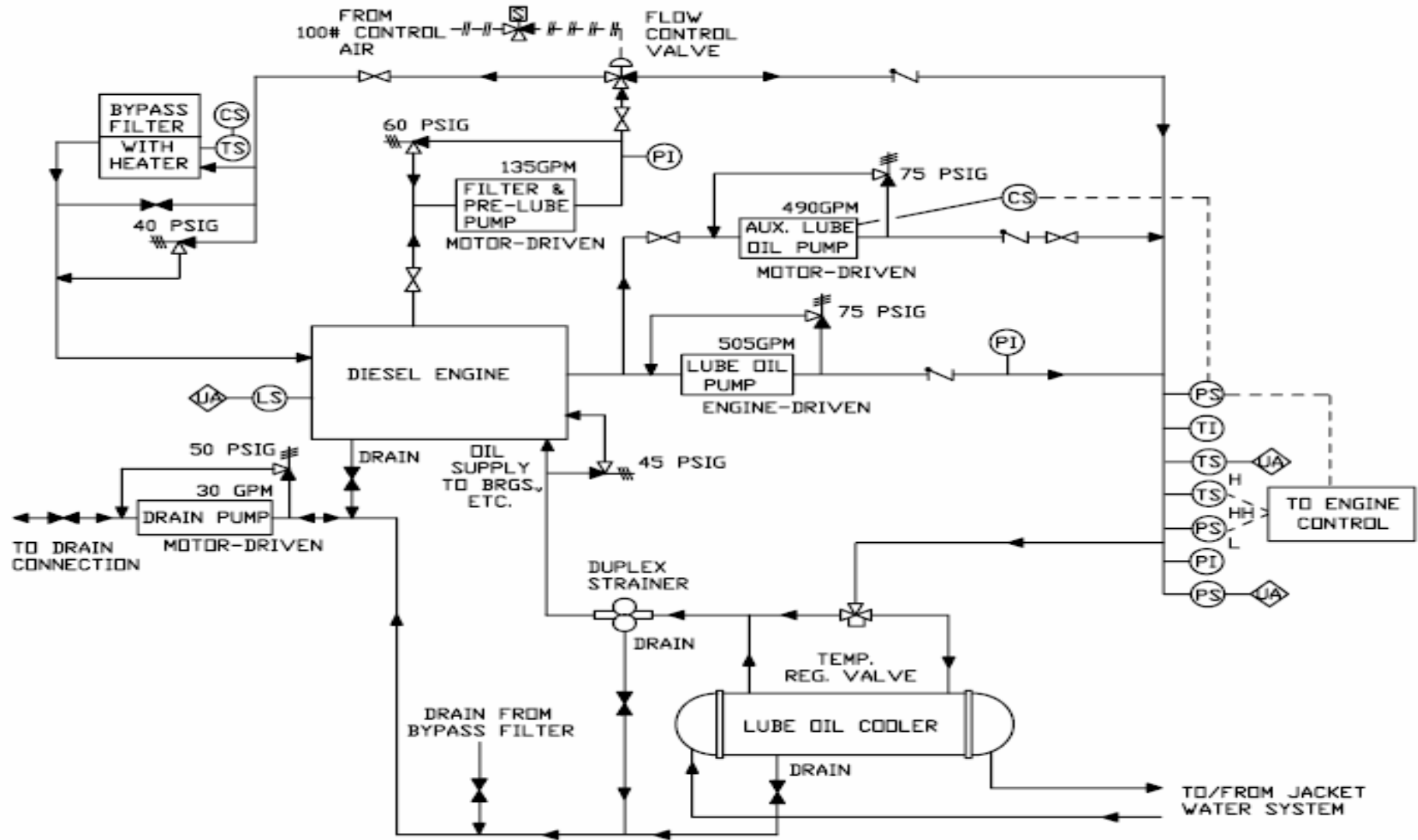
E4 Loads
NSW Pump 2B
RHR Pump 2B
CS Pump 2B
Fire Pump
RHR Pump 1B
CSW Pump 2B
RHR SW Pump 2B
RHR SW Pump 1B
CSW Pump 1A

E3 Loads
NSW Pump 2A
RHR Pump 2A
CS Pump 2A
RHR Pump 1A
CSW Pump 2A
RHR SW Pump 2A
RHR SW Pump 1A

E1 Loads
NSW Pump 1A
RHR Pump 1C
CS Pump 1A
RHR Pump 2C
CSW Pump 1A
RHR SW Pump 1C
RHR SW Pump 2C
CSW Pump 2C

E2 Loads
NSW Pump 1B
RHR Pump 1D
CS Pump 1B
Fire Pump
RHR Pump 2D
CSW Pump 1C
RHR SW Pump 1D
RHR SW Pump 2D

EDG 1 Trip On Low Lube Oil Pressure



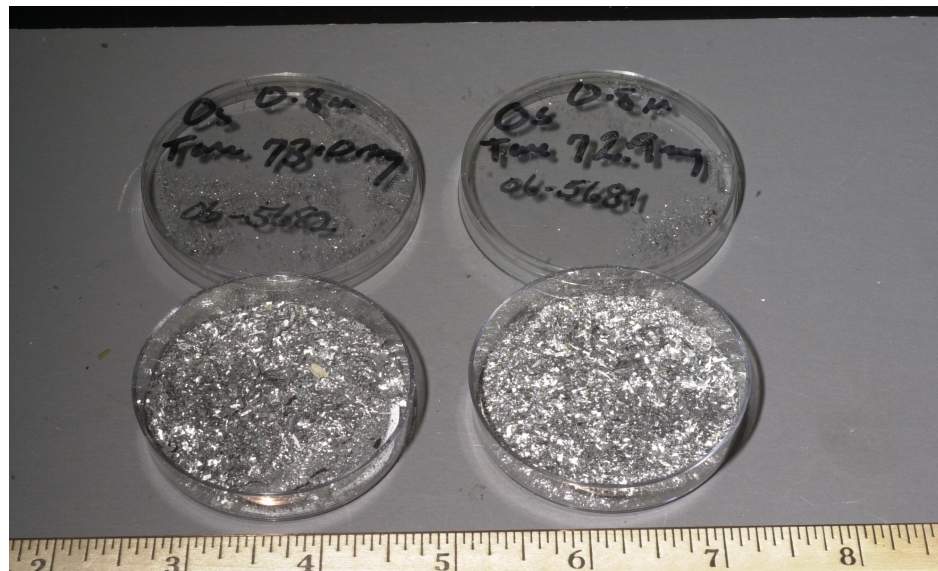
EDG 1 Trip On Low Lube Oil Pressure

- High Differential Pressure Caused By:
 - ◆ Aluminum shavings from failed bearing
 - ◆ Fibrous material from towel left in system during maintenance activities



EDG 1 Trip On Low Lube Oil Pressure

- Root Cause of Trip: Inadequate FME controls resulting in a cleaning cloth left in lube oil system
- Contributing Causes:
 - Method of refilling LO duplex strainer basket while DG running
 - Rationalized cleaning duplex strainer multiple times following maintenance as normal
 - Shavings from failed bearing contributed to high dp

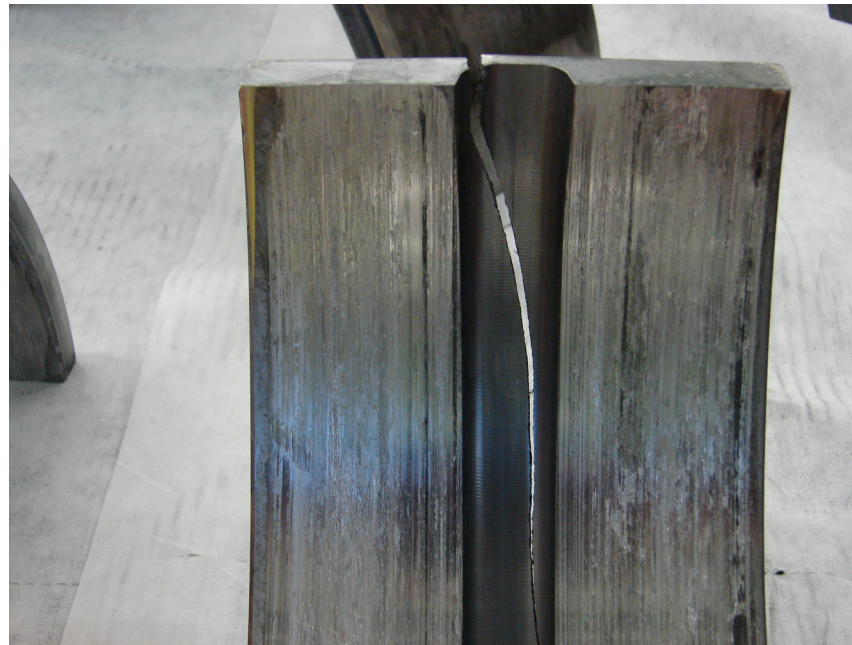


EDG 1 Trip On Low Lube Oil Pressure

- Inadequate Worker Practice
- Action to Prevent Recurrence: Establish High FME Job Classification for the DG Crankcases
- Immediate Actions:
 - ◆ Improved High FME Control
 - ◆ Accountability for Cleanliness Closeout

Failure Of Main Journal Bearing #9

- Bearing Failure Occurred Prior to Diesel Trip
- Bearing Damage/Cracking Probably Occurred Prior to Final Run
- Damage Similar to 1992 Failure of Same Bearing
- Bearing # 9 in Service 14 years
- Prior Bearing in Service 16 years



Failure Of Main Journal Bearing #9

- Cause: Increased Crankshaft Bearing Clearances
 - ◆ Resulted In Lower Initial Bearing Crush
 - ◆ Greater Operational Stresses on Bearings

Failure Of Main Journal Bearing #9

- Action to Prevent Recurrence
 - ◆ Replace DG1 Main Journal Bearings With Oversized Bearings



Failure Of Main Journal Bearing #9

- Other Corrective Actions
 - ◆ Determine Methodology for Performing Lift Checks
 - ◆ Install New Bearings
 - ◆ Establish Accurate Bearing Clearance Measurement
 - ◆ Perform plastigauge or similar measuring technique
 - ◆ Replace Main Journal Bearings on DG #2, #3 and #4
 - ◆ Evaluate Bearing Wear
 - ◆ Establish Preventative Maintenance Activities
 - ◆ Replace Connecting Rod Bearings on All DG's
 - ◆ Determine Acceptable Babbitt Thickness

Diesel Generator Reliability Review

- Completed in January 2007
- Performed Pareto Analyses using key inputs:
 - ◆ MSPI
 - ◆ Maintenance Rule
 - ◆ Planned and Unplanned Unavailability
 - ◆ Corrective Action Program
 - ◆ Work Orders
 - ◆ Self Assessments, Benchmarks, Audits, NRC Inspections
 - ◆ Vendor Input / Industry OE

Diesel Generator Reliability Review

Key Reliability Improvements Items

- **Allen Bradley Control Relays**

- ◆ All Normally Energized Critical Relays replaced
- ◆ EDG #3 and #4 Normally De-energized Critical Relays replaced in Refueling Outage
- ◆ EDG #1 and #2 Normally De-energized Critical Relays to be replaced before June 2007

- **Starting Air Reconfiguration and Improvements**

- ◆ 6 of 8 Pressure Reducing Valves replaced. EDG #2 to complete before June 2007.
- ◆ 6 of 8 Shuttle Valve replaced. EDG #1 to complete before June 2007.
- ◆ Design work commencing to change from air-to-run to air-to-stop

- **Aging of Capacitors in Control System**

- ◆ 30 of 56 Capacitors replaced
- ◆ Special Manufacturing Run in progress
- ◆ No current evidence of degradation.

- Power Potential Transformer replaced on all EDGs
- EDG #3 and #4 logic upgrade (27 PK Relays) complete.
- EDG #1 and #2 in Unit 1 2008 Outage.
- EDG #1 Bearings

Diesel Generator Reliability

Preventive Maintenance Evaluation

- In Progress, To Complete in May 2007
- Objectives
 - ◆ Validation of component criticalities
 - ◆ Upgrade of existing functional equipment groups
 - ◆ Identification of single-point vulnerabilities
 - ◆ Strengthening of PM basis
 - ◆ Identification & prioritization of health issues
 - ◆ System monitoring improvements

Diesel Generator Reliability

Interim Actions

- Increased Monitoring During EDG runs:
 - ◆ Thermography of electrical cabinets / components
 - ◆ Monitoring of critical engine parameters
 - ◆ Monitoring of operation and health of support systems

Diesel Generator Reliability

- Technology Transfer
 - ◆ Engine Solution Inc. to acquire NAK Technology (current vendor for Nordberg EDGs)
 - ◆ Joint Progress Energy / Duke agreement
 - ◆ Ensures continued and improved vendor support for EDGs

Other Mitigating Systems

- Mitigating System Reliability
 - ◆ Reviewing mitigating systems for similar vulnerabilities
 - ◆ Service Water
 - ◆ High Pressure Coolant Injection
 - ◆ Residual Heat Removal
 - ◆ Reactor Core Isolation Cooling
 - ◆ Detailed review of NCRs generated over the past 5 years

Lessons Learned

- Technical Rigor
- FME Culture and Practices
- Improved Contingency Plans
- Corrective Action Program Improvements

Closing Comments

Mr. Scotty Hinnant

Senior Vice President and Chief Nuclear Officer

Questions & Comments

