St. Lucie Unit 1
Regulatory Conference
Plant Centered Loss Of Offsite Power

March 21, 2017

Nuclear Excellence Model

Vision

We are a team that delivers consistent excellent performance

Mission

We will produce energy in a safe, reliable, cost effective way, while caring for our employees, communities and the environment

Values

- Conduct all activities to demonstrate a deep respect for Nuclear Safety
- Live the Safety Guiding Principles
- Be a Self-Improving Culture & Learning Organization
- Maximize the time spent on Prevention and Detection to minimize / eliminate Correction activities
- Foster a work environment where we are the employer of choice

Core Principles

Operationally Focused	Passion for Excellence	Engaged Leaders	Standardized Processes	Responsive to Stakeholders	Effective Workforce Planning
Engaged Employees	Effective Long-Range Planning	Strong Teamwork	Strong Ownership & Accountability	Effective Supervisors	Worklife Balance

Strategic Focus Areas

Operational Excellence

Organizational Effectiveness

Generation Reliability

Effective Business & Financial Performance

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NEXTera® ENERGY


PDC
Prevention
Detection
Correction
"Do the job right the first time"
Value
Maximize the time spent on
Prevention and Detection
to minimize / eliminate Correction activities
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SIC/LO
Work hard, do the right thing (take action)
Effectively evaluate consequences of events
Implement corrective actions in a timely manner
Attributes of a self-improving culture and learning organization
Sustain performance, knowledge and skills
Effective structures and processes for change management
Objectively identify problems
Look outward and forward
Prevent recurrence of industry events
Value
Be a Self-Improving Culture
& Learning Organization
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Attendees

- **Tom Summers, Regional Vice President**
- **Mark Jones, Site Engineering Director**
- **Steve Merrill, Operations Shift Manager**
- **Anil Julka, Fleet Risk and Reliability Manager**
- **Mike Snyder, Site Licensing Manager**
- **Larry Nicholson, Fleet Licensing Director**

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Agenda

- Opening Remarks – Tom Summers
- Event & Operational Response – Steve Merrill
- Cause & Corrective Action – Mark Jones
- Risk Significance – Anil Julka
- Closing Remarks – Tom Summers

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Opening Remarks

Tom Summers
Regional Vice President

Event Investigation

Mark Jones

Site Engineering Director

Unit 1 experienced an automatic trip from 38% power

Event Summary

- During power ascension following an outage, Unit 1 tripped at 38% power.
- Safety related electrical busses did not transfer to the Startup Transformers as expected.
- Safety related electrical busses were automatically powered from the Emergency Diesel Generators without complication.
- Operators manually restored power to the first safety related electrical bus from the Startup Transformers at 55 minutes following trip.

No equipment damage occurred. Power from switchyard remained available during event. All remaining systems responded as designed.

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Unit 1 trip was caused by actuation of the Inadvertent Energization (INAD) generator protection circuit

Immediate Cause Determination

- **INAD actuation was not blocked as designed due to missing wire on Main Generator synchronization selector switch.**
  - Missing wire resulted from 2013 human error during modification to Unit 1 automatic synchronizer circuit and prevented block of INAD circuit.
  - INAD actuation prevented automatic bus transfer to Startup Transformer. Manual bus transfer to Startup Transformer remained.
- **Condition could cause INAD actuation only after manual synch. and only when power exceeded 38%.**
  - Manual synchronization is atypical in startup. August 2016 was first manual synchronization since modification implementation.
  - Operation following previous automatic synchronizations uneventful.

Missing wire would only cause event at 38% power during power ascension after manual synchronization of the Main Generator.

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Event Summary and Operational Response

Steve Merrill

Operations Shift Manager

Event Summary – Initial Conditions

- **Unit 1 at 38% power following an outage.**
  - Standard practice is to have additional staffing in the control room for oversight and control board peer checks during the plant startup.
    - -- Minimum is one Unit Supervisor and two Reactor Operators.
    - -- The following additional operators were in the Control Room:
      - Shift Manager
      - Extra Reactor Operator
      - Assistant Operations Manager (SRO licensed)
  - Both trains of Emergency Diesels (EDG) and Auxiliary Feedwater (AFW) were operable.
    - -- Technical Specifications require all AFW pumps and both EDG trains available prior to Mode 1 change.

Risk mitigation factors included additional licensed operators and key safety system availability.

Event Summary – Immediate Response

- **Actuation of the Main Generator Lockout relay caused an automatic turbine and reactor trip.**
  - The lockout sequence inhibited automatic transfer from auxiliary to the startup transformers powering safety related buses; resulting in a plant centered loss of power connection to the switchyard.
  - Both Unit 1 Emergency Diesel generators started and automatically and powered their respective safety related bus loads.
  - Operators recognized offsite power remained available to the station switchyard with normal voltage and Unit 2 remained unaffected.

Operators diagnosed the event with multiple and diverse indications.

Event Summary – Restoration Steps

- **The unit was stable in hot standby using natural circulation cooling for decay heat removal with AFW and Atmospheric Steam Dump Valves.**
  - Auxiliary Feed Water was manually initiated per procedure and ahead of automatic actuation.
    - -- The low power history and shutdown of the reactor coolant pumps resulted in a smaller RCS heat load to control.
      - Lower RCS heat input extends the inventory demands for the Condensate Storage Tanks.
  - Operators used plant specific Combustion Engineering Emergency Operating Procedures to diagnose and control the plant.
  - An Unusual Event was declared for plant power separation from the switchyard.
  - In-plant verifications were performed to ensure no equipment damage prior to electrical bus restoration.
    - -- Offsite power was restored to both of Unit 1’s safety related busses within 70 minutes.
    - -- All breakers were closed from the control room.

Operators and systems performed as expected during the recovery.

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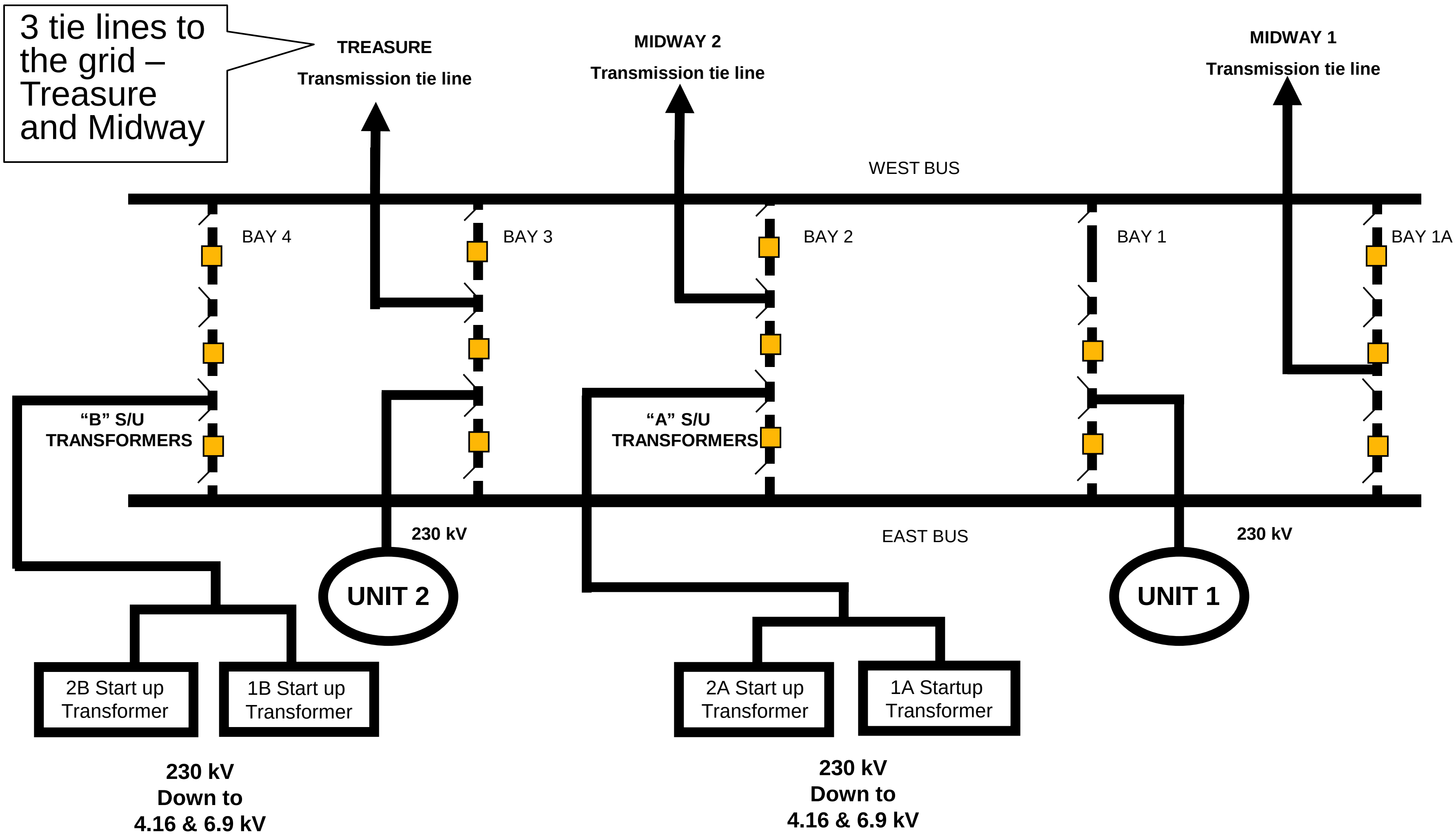
Switchyard Distribution



Power to the switchyard was never lost and no equipment was damaged.

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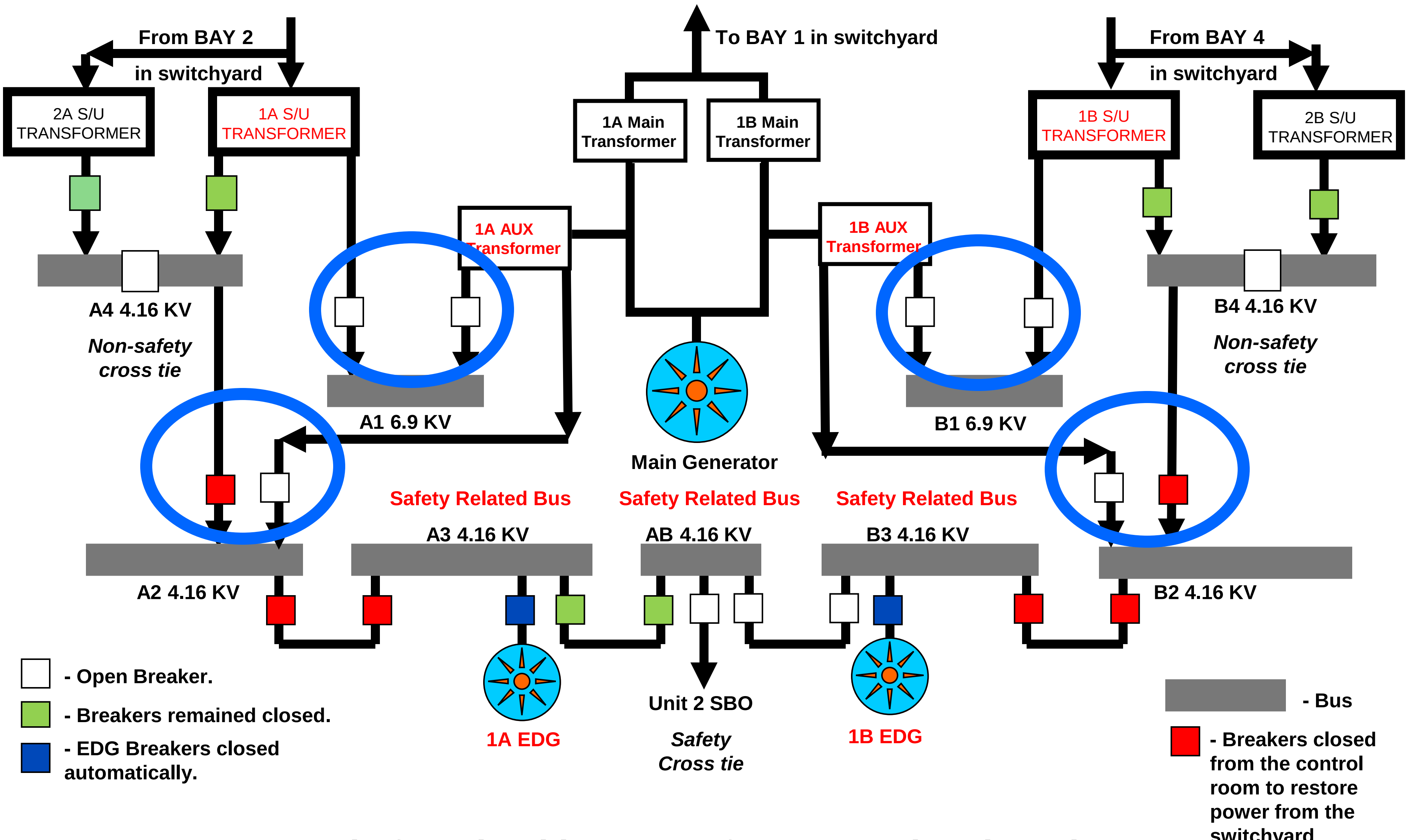
Unit 1 – Main Power Distribution System



An automatic fast dead bus transfer swaps the circled breakers from Auxiliary to Start-up transformers after a unit trip within 10 cycles.

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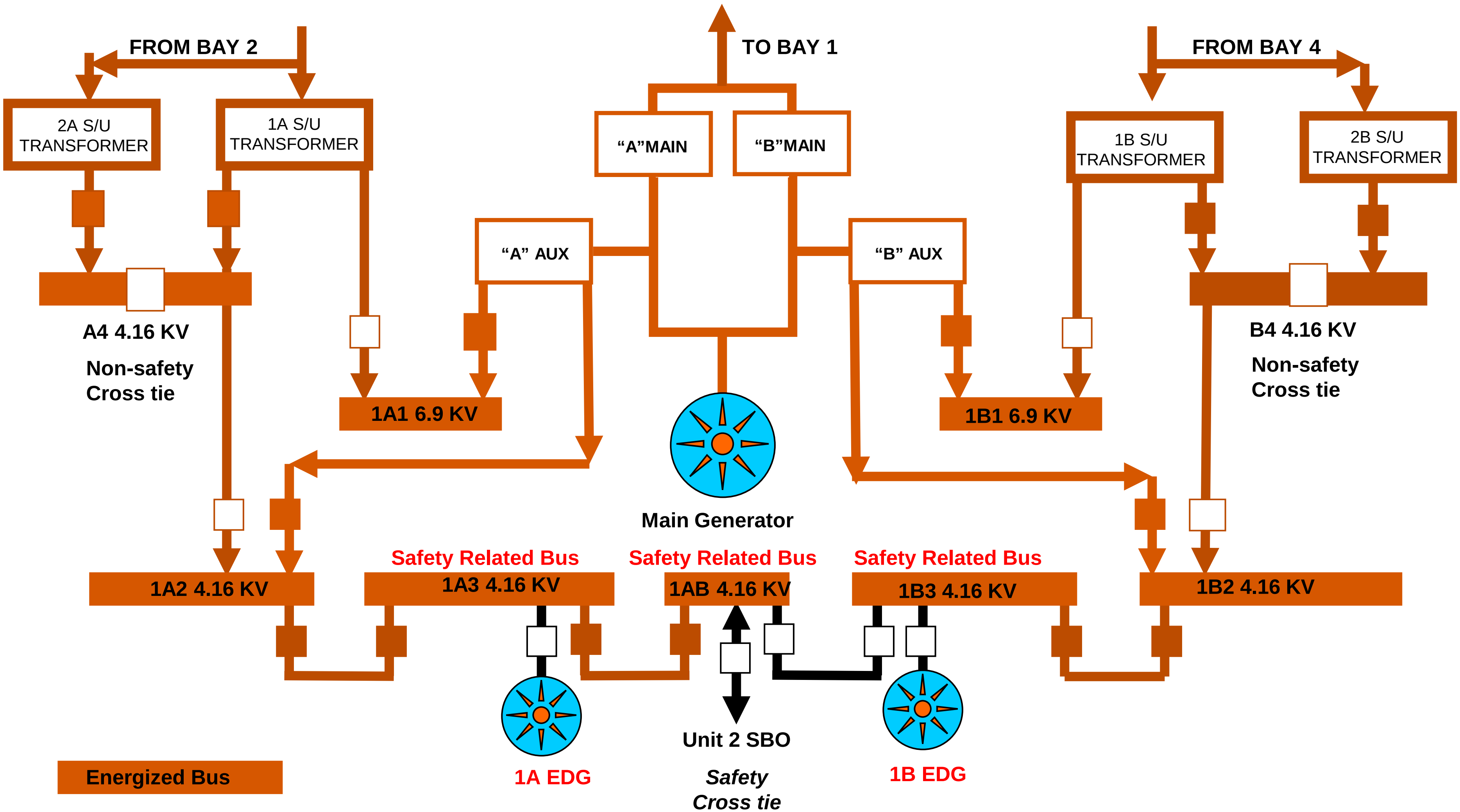
Unit 1 – Main Power Distribution System



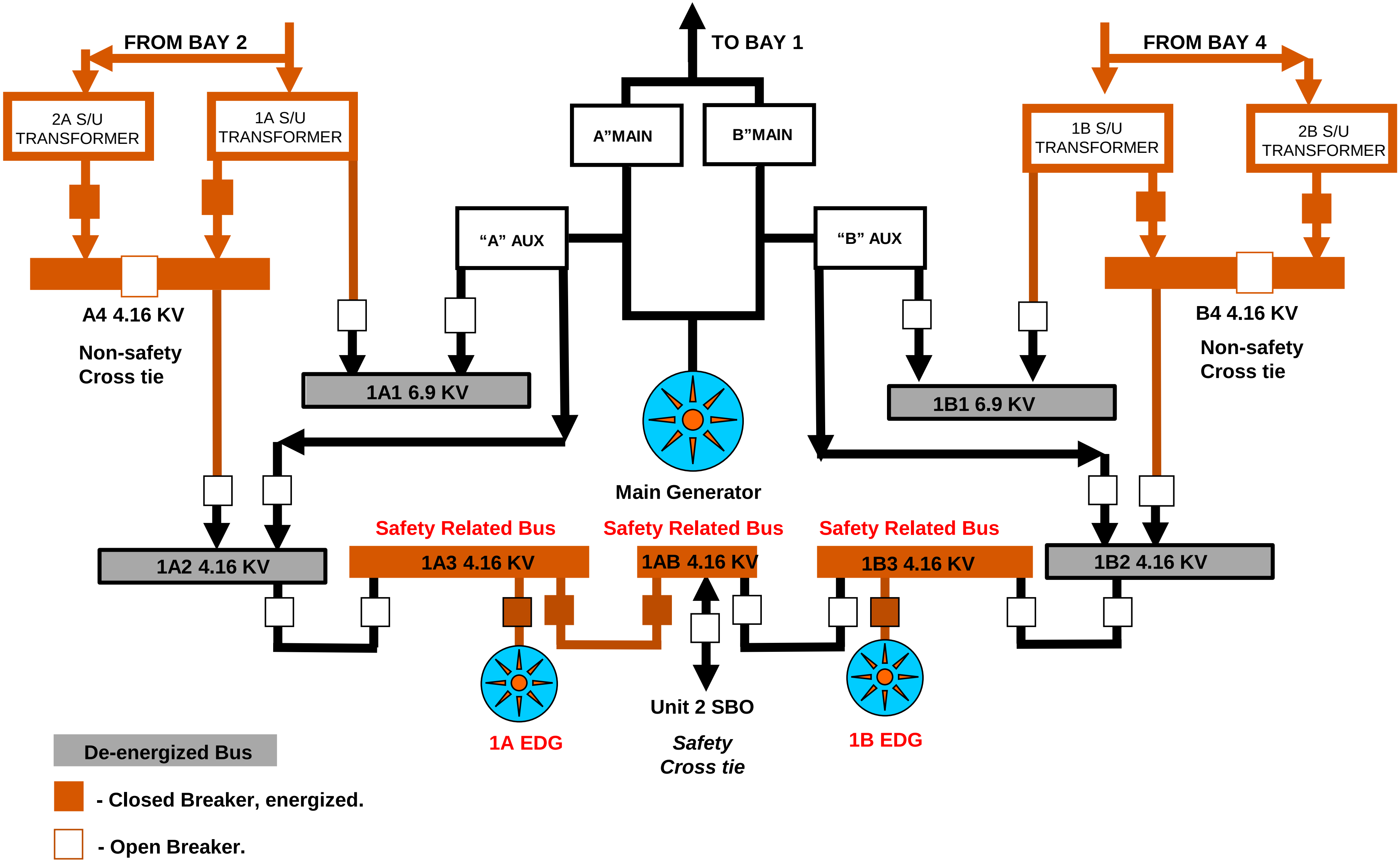
Energized Bus

- Closed Breaker, energized.

- Open Breaker.

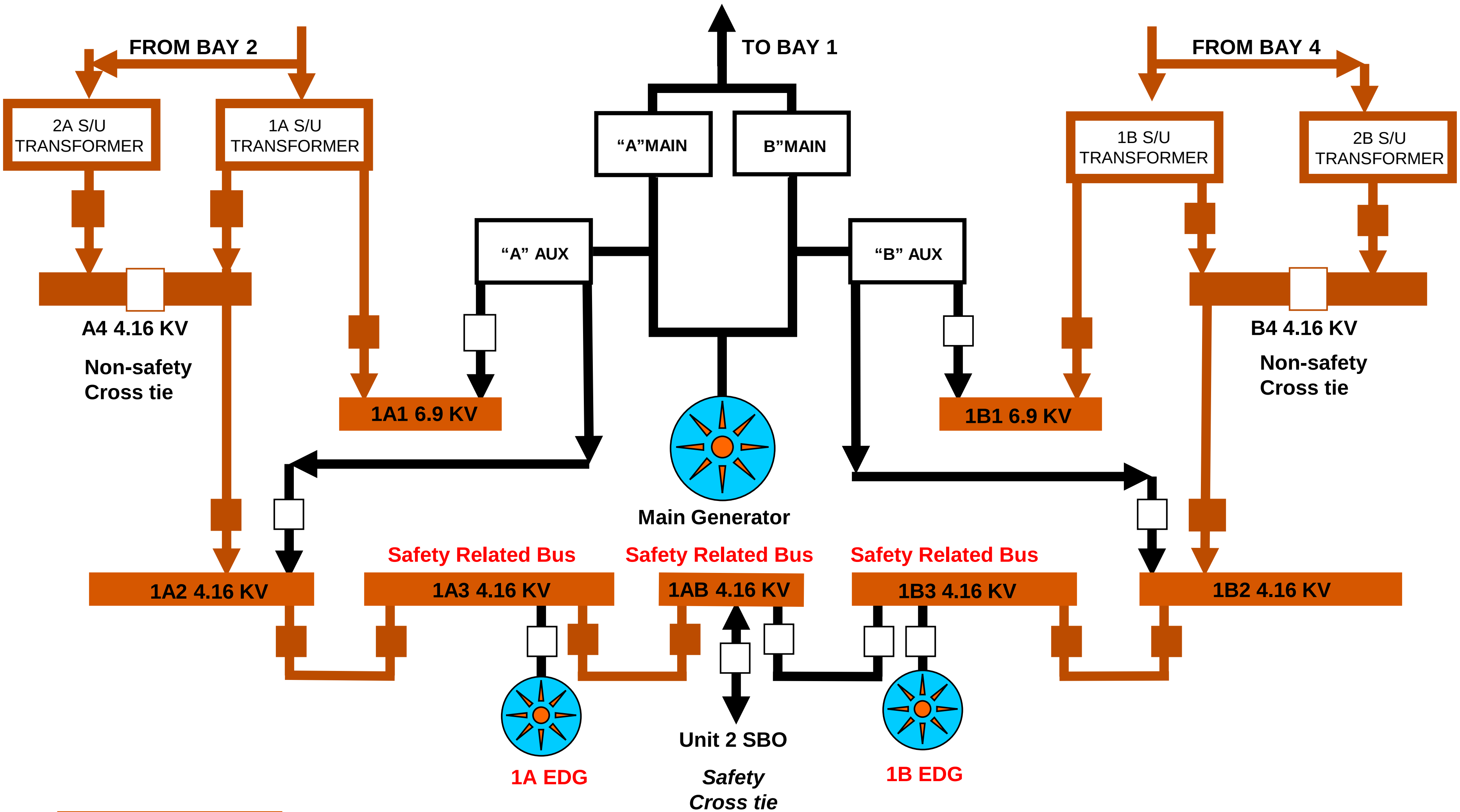
Normal Power Alignment

Unit 1 – Main Power Distribution System



Loss Of Power Alignment

Unit 1 – Main Power Distribution System



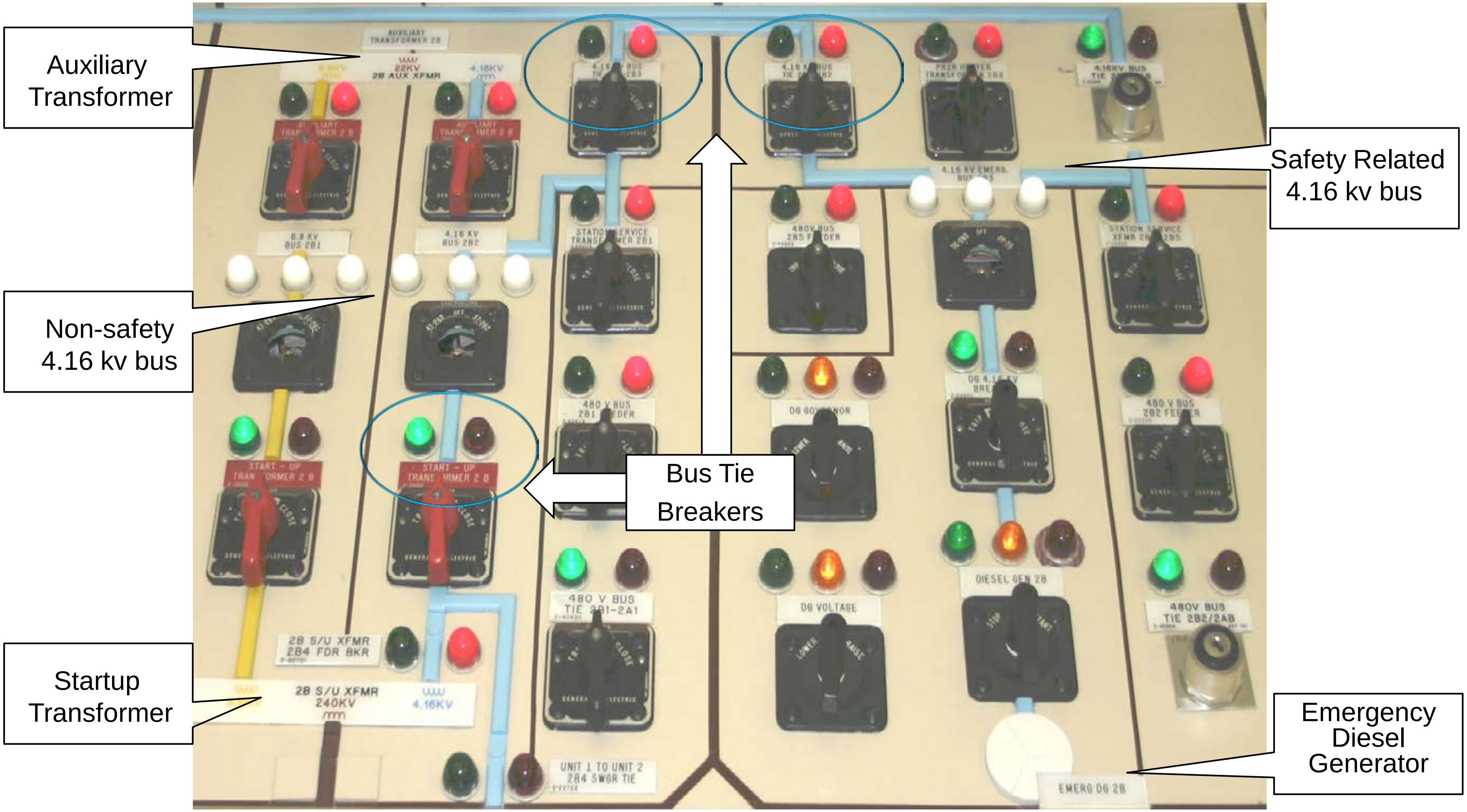
Energized Bus

- Closed Breaker, energized.

- Open Breaker.

Normal Mode 3 Alignment

Control Room Electrical Panel
Distribution Panel ‘B’ Side



Power Restoration Scenarios

- **Loss Of Offsite Power and Station Black Out scenarios for electrical power recovery paths include procedure steps for the following:**
  - Automatic or local start of an emergency diesel generator.
  - Restoring either electrical train through the Startup Transformers.
  - Using Safety Related Station Blackout cross tie connections.
  - Using non-safety cross tie connections between Startup Transformers.

Implementation of any recovery path mitigates the event.

Operations Training

- **Loss Of Offsite Power (LOOP) and Station Black Out (SBO) scenarios are components of Initial and Continuing Operator training programs.**
  - A two year frequency for continuing licensed operator training is required for LOOP and SBO, with a week of classroom and simulator training focused on electrical system recovery.
  - Nine separate Job Performance Measures in licensed operator training cover the different proceduralized methods to power a safety related bus.
    - JPMs provide systematic training evaluations for Operator performance during field walk through and simulator sessions.

Training and procedures ensure repeatable operator performance.

Operations Training

- **Simulator crew evaluation results:**
  - All crews (43 of 43) in the biennial simulator training from 2010 to 2016 successfully restored power to a safety related bus in Station Blackout scenarios in under 24 minutes.
    - -- No crew failures noted in training.
  - Four loss of power connection to switchyard simulator scenarios were performed in 2017.
    - -- Half of the site licensed operators participated, with each scenario varied for power level, AFW availability, and EDG availability.
    - -- All crews restored power from the switchyard to the first safety related bus in less than 1 hour.

- **Video for Simulator LOOP and SBO.**

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PRA and Risk Significance

Anil Julka
Fleet Nuclear Risk and Reliability Manager

Risk Significance in Choice Letter

- **SPAR results**
  - Initial SPAR analysis was significantly conservative.
  - Based on NEE-supplied information, NRC added credit for:
    - -- Electrical room cooling.
    - -- Feedwater recovery following offsite power availability.
    - -- Realistic CST unavailability.
    - -- Realistic failure probability for feed and bleed.
  - The risk dropped to slightly greater than 1E-06.
  - NEE and NRC agree that these credits were appropriate.
- **NEE reviewed the results of the SPAR analysis after these changes were made – observations:**
  - 7 of the top sequences are station blackout (SBO) sequences with failure of offsite power recovery in 6 hours.
  - SPAR model offsite power recovery timeframe is based on industry-average data.

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Offsite Power Recovery – Case 1

- **Plant centered loss of power to the switchyard**
  - As indicated by Operations, this was a simple LOOP recovery.
  - Time to restore power was well below the industry average.
  - The actual recovery time during the event was 70 minutes (both trains) with both EDGs running; validated by observed simulator runs.
  - Past training records of simulator runs validated the short recovery time.

- **NEE changes to SPAR analysis**
  - The 6-hour industry average of offsite power recovery failure was replaced with a human reliability analysis.
  - SPAR-H analysis of this operator action gives a failure probability of 4.4E-03.

Offsite power recovery credit specific to the Performance Deficiency should be used in lieu of industry-average historical data.

New information on industry comparisons

Plant centered power loss industry comparisons

- Although the NEE PRA model includes a range of equipment failure possibilities, the Unit 1 event initiator did not have any irreversible conditions as noted in industry plant centered many LOOP event initiators.

Industry Plant Centered LOOP complications	Unit 1 Event	Industry LOOPs
Failure in isophase bus duct	No	YES
Non-segregated bus explosion	No	YES
Switchgear fire in non-safety bus	No	YES
Startup Transformer damage	No	YES
Failure of both 230kV breakers	No	YES
Design vulnerabilities	No	YES
Emergency Diesel Generator OOS	No	YES
Switchyard component failures	No	YES

None of these equipment failure initiators were part of the Unit 1 Performance Deficiency.

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New information on PRA sensitivity to EDG availability

Test and Maintenance - Case 2

- **Maintenance unavailability**
  - A typical SDP assumes average T&M unavailability unless the T&M activity is associated with the Performance Deficiency.
  - A realistic estimate of the risk of this Performance Deficiency assumes zero T&M unavailability. Basis for this conclusion:
    - -- This plant-specific Performance Deficiency could have only occur at 38% power ascension following manual synchronization of the main generator.
    - -- Important pieces of equipment are not removed from service for maintenance during this short time (approximately 16 hours) between Mode 1 and power ascension.
    - -- Records for last 3 years show EDG, AFW, and CCW were available below 40% during power ascension.
  - Risk falls below 1E-06 if only the EDGs' test and maintenance unavailability is set to zero; and other T&Ms left at average values.
  - Risk falls below 1E-06 if the EDGs' test and maintenance is simply halved.

It is our normal practice to not remove key equipment from service during power ascension.

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Local Operation of Turbine-Driven AFW Pump Case 3

- **Local operation of the steam driven AFW pump is credited in NEE PRA.**
- **There is clear procedural guidance for this action specified by procedures and tested in training.**
  - Local Operation of the steam driven 1C Auxiliary Feedwater Pump is specified in plant procedures .
  - Job Performance Measure used to ensure Operator proficiency.
    - JPM - *Locally Operate 1C Auxiliary Feedwater Pump*.

Local operation of the steam driven AFW pump is credited in NEE PRA.

Local Operation of Turbine-Driven AFW Pump Case 3

- **SPAR model does not credit manual AFW feeding.**
  - NEE PRA model does credit manual feeding of the Steam Generators via local operation of the steam driven Auxiliary Feedwater pump.

- **By itself, credit for this local operator action in the SPAR model lowers the CCDP to 4.7E-07.**
  - In combination with the adjustments for offsite power recovery and maintenance unavailability, credit for this action in the SPAR model lowers the CCDP to 2.4E-07.

Local operation of the steam driven AFW pump should be credited in the SPAR model.

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Combination of Changes - Case 4

- **SPAR model**
  - In combination with the adjustments for offsite power recovery, maintenance unavailability and AFW local operator action, credit for this action in the SPAR model lowers the CCDP to 2.4E-07.

- **NEE PSL1 PRA model**
  - PSL1 Regulatory Guide 1.200 compliant PRA model for CCDP is 3.2E-07.

Incorporation of these changes results in SPAR model and NEE PSL1 PRA model correlation.

Summary of each Case and FPL PRA model

Results and Comparisons

Model	LOOP CCDP	Comments
SPAR NRC Input	1.2E-06	FPL/NRC agreed-upon adjustments
SPAR FPL Changes – Case 1	4.7E-07	Offsite power recovery failure replaced with operator action to recover offsite power
SPAR FPL Changes – Case 2	6.4E-07	EDG T&M set to 0
SPAR FPL Changes – Case 3	4.7E-07	Credit for local operation of TDAFWP C
SPAR FPL Changes – Case 4 (combination of Cases 1, 2 and 3)	2.4E-07	Offsite power recovery failure replaced with operator action, EDG T&M set to 0, and credit for TDAFWP local operation
FPL PRA Model	3.2E-07	FPL's PSL1 RG-1.200-compliant PRA model

NRC results are from choice letter dated February 2, 2017
FPL results are from SPAR and in-house model – *includes FPL inputs and assumptions noted in previous slide*

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Conclusions

- **NEE made 3 Case study changes to the SPAR results for the SDP analysis:**
  1) Application of appropriate credit for offsite power recovery by operators within 6 hours, considering the new SPAR-H analysis.
  2) Adjustment to only EDG maintenance unavailabilities to properly reflect the actual and historical availability conditions associated with this Performance Deficiency.
  3) Application of credit for local operation of the turbine-driven AFW pump that was not previously considered.
- **Any one of these changes, by itself, would reduce the CCDP to significantly less than 1E-06.**
- **Combining all of them reduces the CCDP to the low E-7 range, consistent with the results using the NEE PSL1 PRA model.**

Closing Remarks

Tom Summers

Regional Vice President

Improvements to Offsite Power Reliability

- **Importance of Offsite Power**
  - Any failure is unacceptable and must be mitigated.

- **We are committed to improving reliability of offsite power through plant to grid modifications.**
  - Addition of another Bay in the switchyard for reliability in 2014.
  - Treasure substation modification for independent sources to the switchyard in 2015.
  - Turnpike underground transmission line from the switchyard added for power line protection in 2016.
  - Midway station barriers added for transformer protection in 2017.

Closing Remarks

Questions and Clarifications