MIPF Facility, Electrical Power Systems Design Criteria

Design Guidance

- Evaluate the following sections of 10 CFR Part 50 :
  - 50.49 Environmental qualification of electric equipment important to safety for NPP. As determined by site assessment
  - 50.63 Loss of all alternating current power. Apply

Design Guidance

- Evaluate 10 CFR Part 50 Appendix A, "General Design Criteria for Nuclear Power Plants":
  - General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena." As determined by site assessment/graded approach
  - General Design Criterion 3 "Fire Protection." Graded approach
  - General Design Criterion 4 "Environmental and Dynamic Effects Design Basis." As determined by site assessment/ graded approach
  - General Design Criterion 17 "Electric Power Systems." Apply
  - General Design Criterion 18 "Inspection and Testing of Electric Power Systems." Apply

Design Guidance

- Evaluate NRC Regulatory Guides:
  - Regulatory Guide 1.32, "Criteria for Power Systems for NPPs," endorses IEEE 308, with conditions. Graded approach
  - Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," endorses IEEE 308/603, with conditions. Graded approach
  - Regulatory Guide 1.204, "Guidelines for Lightning Protection of NPPs," endorses NFPA 780, with conditions apply. Apply
  - Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems," endorses IEEE 384 with conditions. Apply

Design Guidance

- Evaluate NRC Regulatory Guides:
  - Regulatory Guide 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for NPPs," endorses IEEE 344, with conditions. As determined by site assessment
  - Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for NPPs," endorses IEEE 323, with conditions. As determined by site assessment
  - Regulatory Guide 1.155, " Station Blackout." **Graded approach**
  - Regulatory Guide 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems." Graded approach

Design Guidance

- Evaluate NRC Regulatory Guides:
  - Regulatory Guide 1.9, "Application and Testing of Safety - Related Diesel Generators in NPPs," endorses IEEE 387, with conditions. Graded approach
  - Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems," endorses IEEE 379, with conditions. Apply
  - Regulatory Guide 1.40, "Qualification of Continuous Duty Safety-Related Motors for NPPs," endorses IEEE 334. Apply
  - Regulatory Guide 1.41, "Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments," endorses IEEE 308. Apply

Design Guidance

- Evaluate NRC Regulatory Guides:
  - Regulatory Guide 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for NPPs," endorses IEEE 484 and IEEE 450, with conditions. Apply
  - Regulatory Guide 1.129, "Maintenance, Testing , and Replacement of Vented Lead-Acid Storage Batteries for NPPs," endorses IEEE 484, IEEE 485, and IEEE 450, with conditions. Apply

Design Guidance

- Use the following standards:
  - ANSI/NFPA 70 National Electrical Code (NEC). Apply
  - C2 - National Electric Safety Code (NESC). Apply

Electrical Power System

- Definitions:
  - The electrical portion of the safety system that performs Safety Functions Category 1 is classified as IEEE Class 1E.
  - **Class 1E**: Electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal or are otherwise essential in preventing significant release of radioactive material to the environment
  - **Engineered Safety Features**: Features of a unit , other than reactor trip or features used only for normal operation, that are provided to prevent, limit, or mitigate the release of radioactive material

Class 1E Design Criteria

- Engineered Safety Feature

  The Emergency Electrical Power System (Class 1E) is an auxiliary supporting feature that will provide electric power to engineered safety features:

  - Single-failure tolerant (redundancy, independence, diversity)
  - Fail-safe
  - Reliability
  - Maintainability
  - In-service testability

Reactor Electrical Power Systems

- Satisfy starting and operating maximum demand for all operating modes of the reactors (startup, operation, shutdown and accident mitigation):
  - During normal plant operation all the non-Class 1E and Safety Class 1E Loads will receive power from **Normal Electrical Power System (NEPS)**
  - When the Normal Electrical Power System is not available, the Safety Class 1E Loads will receive power from the **Emergency Electrical Power System (EEPS)**.
  - During a Station Blackout (SBO), allocated Essential Loads will receive power from an **Alternate AC Source**

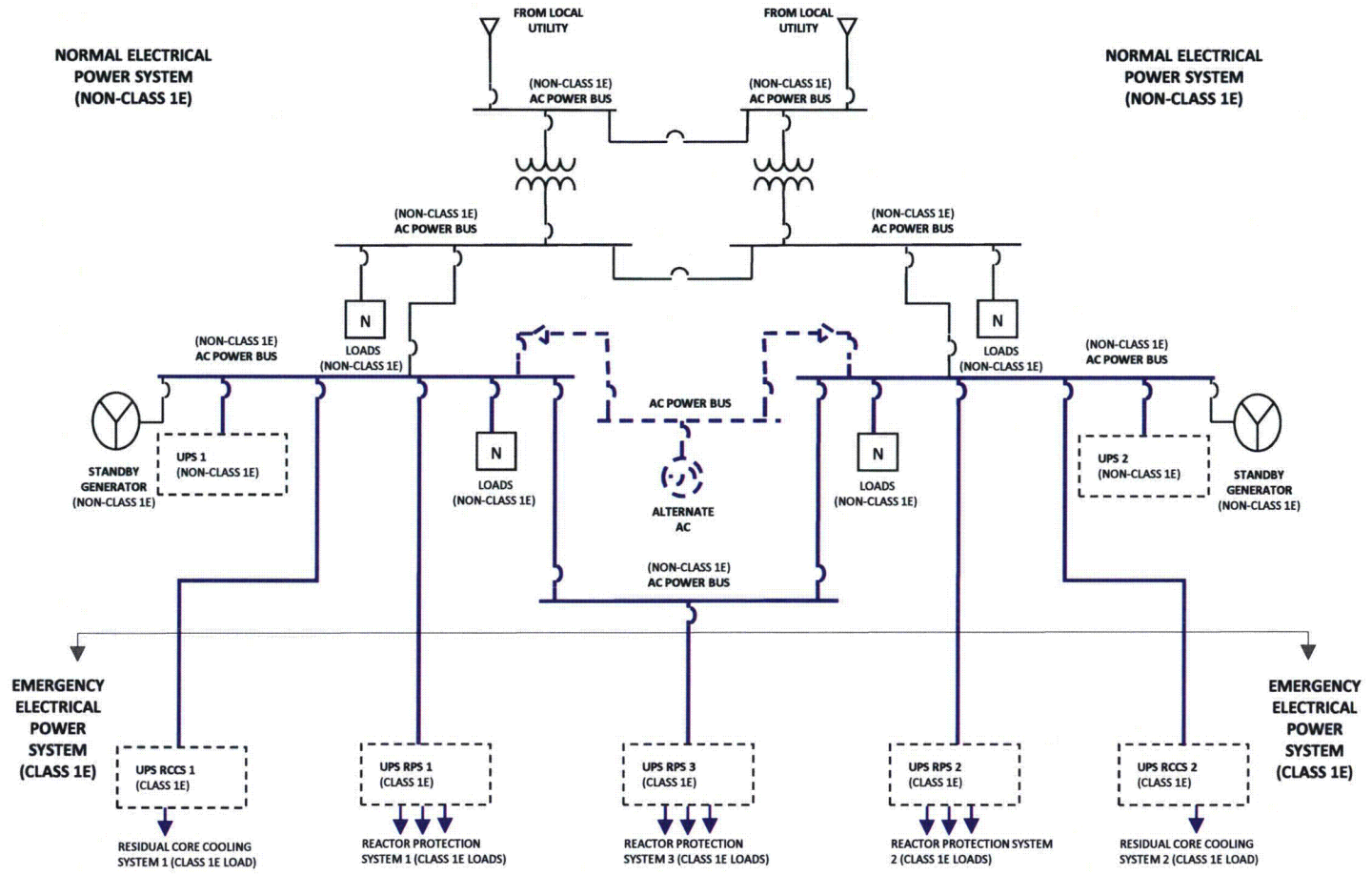
General Electrical Features

- Grounding System
  - Facility grounding grid
  - Transformer substation grounding mesh
  - Instrumentation grounding
  - Equipment grounding
- Lightning Protection System
  - Lightning rods
  - Equipotential grounding rings directly interconnected with the facility grounding grid
  - Surge arresters for equipment protection

General Electrical Features

- Cable Specifications
  - Non-Safety Class 1E
    - Copper conductors
    - Polymeric insulated
    - No flame propagation
    - Low smoke/halogen free characteristics
  - Safety Class 1E
    - All of above and fire resistance also required

Electrical Power System Diagram



Reactor Electrical Power Systems

- Normal Electrical Power System (NEPS)
  - Power for normal operation and normal shutdown of the facility.
- Emergency Electrical Power System (EEPS)
  - Power when NEPS is not available, for safety-related equipment required to support Engineered Safety Features
- Station Blackout Power Source (SBPS)
  - Power to allocated essential loads during station blackout (SBO), when off-site power is unavailable coincident with standby diesel generators unavailable

Reactor NEPS Power Supplies

- Off-site power from local utility 12 kV AC-3 phase
- Two on-site redundant commercial standby diesel generators 480Y/277 VAC, 3-phase (sharing between reactors and with RPF and WCF will be derived from safety assessment)
  - Seven day fuel oil storage for full loading
- Two on-site redundant commercial UPSs 208Y/120 VAC (independent and not shared among facilities)
  - Autonomy time will be derived from safety assessment
- In-service testability for standby diesel generators and commercial UPSs

Reactor NEPS Power Distribution

- Single or double redundant 12 kV feeders from local utility (will be derived from safety and availability assessments)
- Facility distribution center (12 kV AC 3-phase)
- Reactor transformer substation (two redundant transformers 12 kV-480Y/277 VAC, 3-phase)
- Reactor distribution voltages
  - 480Y/277 VAC, 3-phase for motors
  - 208Y/120 VAC, 3-phase for lighting and control
  - < 120 VAC instrumentation
  - 250 VDC battery for UPSs

Reactor NEPS Distribution Equipment

- Medium voltage switchgear
- Low voltage switchgear
- Motor control centers
- Power distribution panels
- Lighting panels

Reactor NEPS Operation

- During normal plant operation all the non-safety and safety loads will receive power from off-site power service
- When off-site power not available or voltage/frequency degraded, the standby diesel generators will start automatically and will be directly connected to the NEPS
- When off-site power service is available to be restored, the standby diesel generators are disconnected from the NEPS before off-site power is reconnected by manual means

Reactor NEPS Non-1E Loads

- NEPS provides power to Non-Class 1E (Safety Categories 2 and 3) Loads:
  - Primary and Secondary Cooling Systems
  - Water treatment systems
  - HVAC system
  - Reactor Control and Monitoring System
  - Post Accident Monitoring
  - Radiation Monitoring System
  - Services (lighting, compressed air, water)
  - Lifting devices
  - Fire protection
  - Communication
  - Security

Emergency Electrical Power System

- Power supplies and distribution system provide power to Class 1E Loads and controls
- Class 1E electric loads separated into:
  - Two redundant load groups for RCCS
  - Three redundant groups for RPS
- Each redundant load group will have access to NEPS (off-site and on-site)
- Electrical equipment will be qualified IEEE Class 1E to ensure performance as required in the design basis during their installed life according to site and service conditions and Safety Function

EEPS Sources

- NEPS non-safety related but supplies safety-related systems during normal operation
- In event of loss of NEPS, the on-site Class 1E UPSs automatically will provide power to Class 1E Loads:
  - On-site two redundant Class 1E UPSs 408Y/277 VAC (independent and not shared among facilities)
  - On-site three redundant Class 1E UPSs 208Y/120 VAC (independent and not shared among facilities)
  - Autonomy time will be derived from safety assessment
  - In-service testability will be provided for Class 1E UPSs

EEPS Distribution

- Reactor Electric Power Distribution System
  - Distribution circuits to redundant equipment will be physically and electrically independent of each other
  - Reactor distribution voltages
    - 480Y/277 VAC, 3-phase for motors
    - 208Y/120 VAC, 3-phase for instrumentation and control
    - < 120 VAC for sense and command
    - 250 VDC battery for UPSs
- Reactor Electric Power Distribution Equipment
  - Class 1E power distribution panels
  - Class 1E motor control centers

EEPS Loads

- Emergency Electrical Power System will provide power to Class 1E loads (Safety Category 1) via Class 1E portions of NEPS:
  - Residual Core Cooling System (RCCS Division A-B)
  - Reactor Protection System (RPS Division A-B-C)

EEPS Cable Routing

- Five separation Class 1E Groups:
  - Safety related circuits for Div A – Class 1E (RPS A-RCCS-A)
  - Safety related circuits for Div B – Class 1E(RPS B-RCCS-B)
  - Safety related circuits for Div C – Class 1E (RPS C)
- Separation criterion according to IEEE 384
- Raceway separation of redundant Class 1E systems and non-Class 1E systems
- Also, two separation non Class 1E Groups:
  - Non-safety related circuits for Group 1 – non-Class 1E
  - Non-safety related circuits for Group 2 – non-Class 1E

Station Blackout Power Source

- Alternate AC source(s) provide electrical supply to allocated essential loads
  - Alternate diesel generator(s) 480Y/277 VAC, 3-phase will be manually connected at allocated permanent switchboards during a SBO event (sharing derived from safety assessment)
    - Fuel storage provisions will be derived from safety assessment
  - Electrical equipment will ensure performance specified in the design basis according to site and service conditions and Safety Function

Station Blackout Loads

- Alternate AC source(s) will provide power to allocated essential loads:
  - DC power continuity
  - HVAC
  - Emergency illumination
  - Communication
  - Security
- Final list will be derived from safety assessment

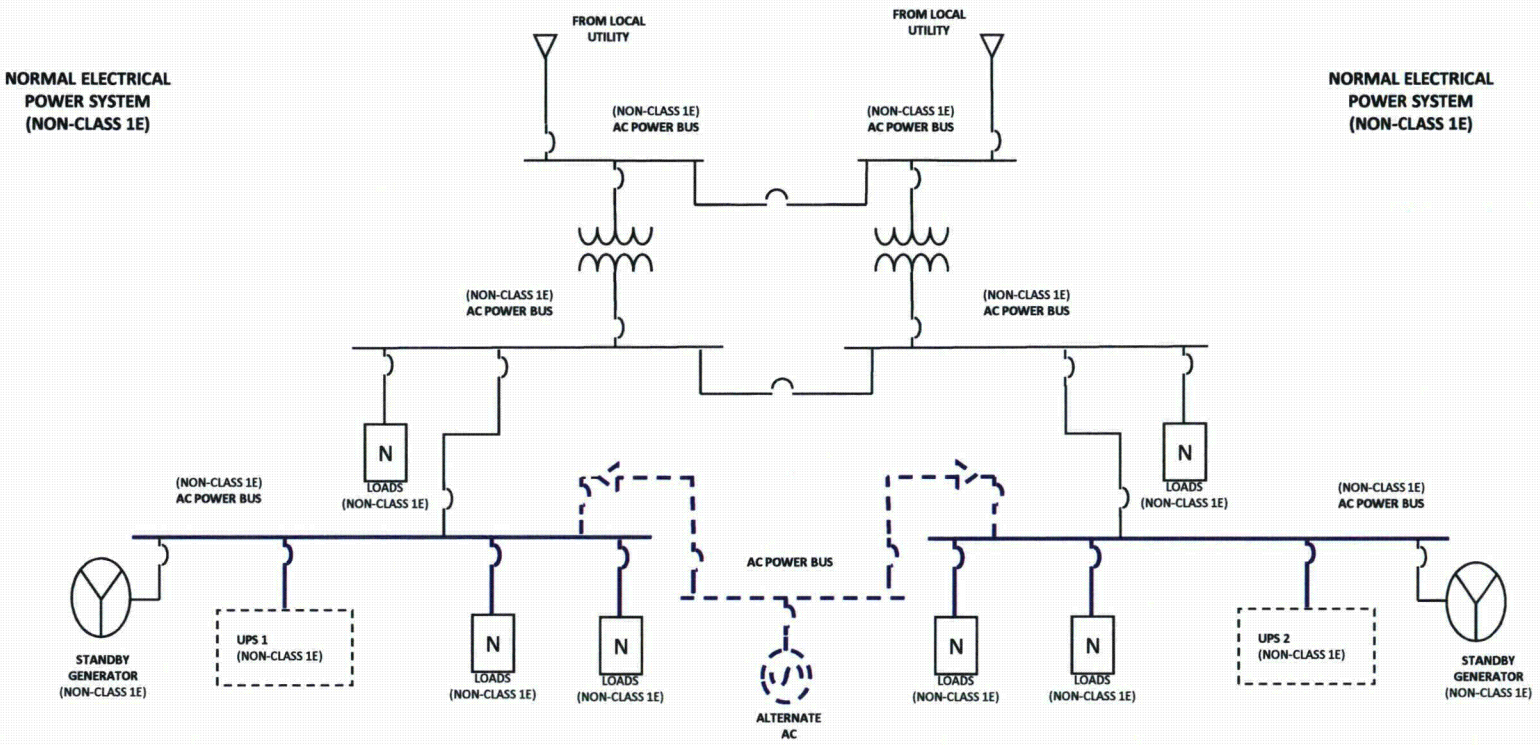
RPF/WCF Electrical Power System

- Electrical Power System will be capable of satisfying starting and operating maximum demand for all operating modes (startup, operation, shutdown, and accident mitigation):
  - During operation, all loads (non-Class 1E) will receive power from NEPS
  - No Emergency Electrical Power System because no safety-related loads (i.e., no Class 1E loads) as determined by the conceptual safety assessment
  - During station blackout, allocated essential loads will receive power from an alternate AC source

RPF/WCF Electrical Power Systems

- NEPS provides power for operation
- SBO power source provides power to allocated essential loads, when off-site power is lost coincident with unavailability of the standby diesel generators

Electrical Power System Diagram



RPF/WCF Cable Routing

- Two separation Groups:
  - Non-safety related circuits for Group 1 – Non-Class 1E
  - Non-safety related circuits for Group 2 – Non-Class 1E
- Separation criterion will be arranged
- Raceways identified to distinguish between non-Class 1E system Groups

RPF/WCF NEPS Power Supplies

- Off-site power from local utility 12 kV AC-3 phase
- On-site two redundant commercial standby diesel generators 480Y/277 VAC, 3-phase (sharing among RPF, WCF, and reactors determined from safety assessment)
  - 7 days' fuel oil storage for full loading
- Two on-site redundant commercial UPSs 208Y/120 VAC (independent and not shared among facilities)
  - Autonomy time will be derived from safety assessment
- In-service testability for the commercial standby diesel generators and UPSs

RPF/WCF NEPS

- Distribution System:
  - Same criteria as Reactor NEPS distribution
- Distribution Equipment:
  - Same types as Reactor NEPS distribution
- Non-Class 1E Loads:
  - Same types as Reactor NEPS loads

RPF/WCF SBO

- Power source:
  - Same characteristics as Reactor SBO
- Essential loads:
  - Same types as Reactor SBO

Questions?

Closing

Coquí looks forward to continue working with the NRC on this important project.

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