Crystal River Unit 3 Regulatory Conference Region II, Atlanta, GA

July 22, 2005

Progress Energy

- Introduction – Dale Young
- Description of Finding – Mike Annacone
- Electrical Distribution and Plant Layout – Steve Barkofski
- Response Timeline – Dave Porter
- Probabilistic Safety Assessment – Dave Miskiewicz
- Conclusions - Mike Annacone
- Closing Remarks – Dale Young

Background – NRC Triennial Inspection

- Findings related to today's presentation:
  - Single failure criteria violation for 4160V ES protective relaying.
  - B EDG lockout reset manual action not considered feasible in required time frame
- Introduced during implementation of Off-Site Power and Backup Emergency Safeguards Transformer installations (1990/1993)
- Vulnerability originally recognized in Fire Study as a Fire Protection issue (Appendix R Manual Action) but not as a Single Failure Criteria Violation

Background – Single Failure Issue

- Modifications implemented
  - Eliminating need for manual action to reset the B EDG lockout.
- Immediate extent of condition – 4160V and 480V Emergency Safeguards power distribution protective relaying and metering with no additional vulnerabilities identified
- Root Cause Analysis performed:
  - Failure to perform Failure Modes Effects Analysis during OPT/BEST modifications
  - Corrective Actions:
    - Implement FMEA process
    - Detailed Extent of Condition completed with no additional vulnerabilities identified

Highlights of NRC Findings:

- Reliance on manual actions vs. physical separation or protection
- Local Manual Action to reset B EDG Lockout not feasible:
  - Proximity to Fire location – Fire in A ES SWGR Room
    - Fire Team entry through B ES SWGR Room requires fire door between rooms to be open, No floor drains in rooms
  - Manual Action time critical – 30 minutes:
    - Restoration of ventilation and cooling to Emergency Feedwater Isolation and Control (EFIC)
  - Operator arrival at B SWGR room – 25 minutes, room not yet ventilated – smoke filled, water on floor, water mist
    - CR3 Time validated / NRC walk-down

CR-3 Insights

- 30 minute time requirement to re-establish EFIC room cooling is conservative.
  - **Fire Study 30 minute time limit conservatively chosen for simplicity**
  - **At least 120 minutes available**
  - **Steam driven EFP-2 remains available**
- Fire Study and NRC SDP do not credit use of Auxiliary Feedwater System.
  - **System free of fire damage**
  - **FWP-7 has it's own diesel generator**
  - **Emergency Operating Procedures direct system use when EFW unavailable**

CR-3 Insights

- As a result of the above items, secondary side heat removal is not lost
  - **Eliminates uncertainties in Phase II evaluation regarding:**
    - **Effectiveness of secondary side cooling following an overcooling event**
    - **Primary system response with a delay in secondary side heat removal**
- Only one scenario causes loss of power to Unit Auxiliary loads
  - **Reduces probability of normal secondary side heat removal loss**

CR-3 Insights

- At least one off-site power transformer remains available in all scenarios
- EDG availability without room cooling
  - Diesel has started and is running unloaded
  - Engine coolant and lube oil cooling remains unaffected
  - No power to EDG Room Supply Fans until ES Bus re-powered
  - Engine heat raises room ambient temperature

Electrical Distribution and Physical Layout

- CR3 Energy Complex Switchyard Layout
- Emergency Safeguards (ES) Electrical Buses
- Control Complex Physical Layout
- Photos of the ES Switchgear Rooms
- Photos of the ES Switchgear Control Cubicles
- Fire Scenarios
- Mechanical / Hydraulic Time Line
- ES Switchgear Room Fire Model
- Evaluation of Auxiliary Feed Water Pump Circuits

500KV Switchyard One-Line Diagram

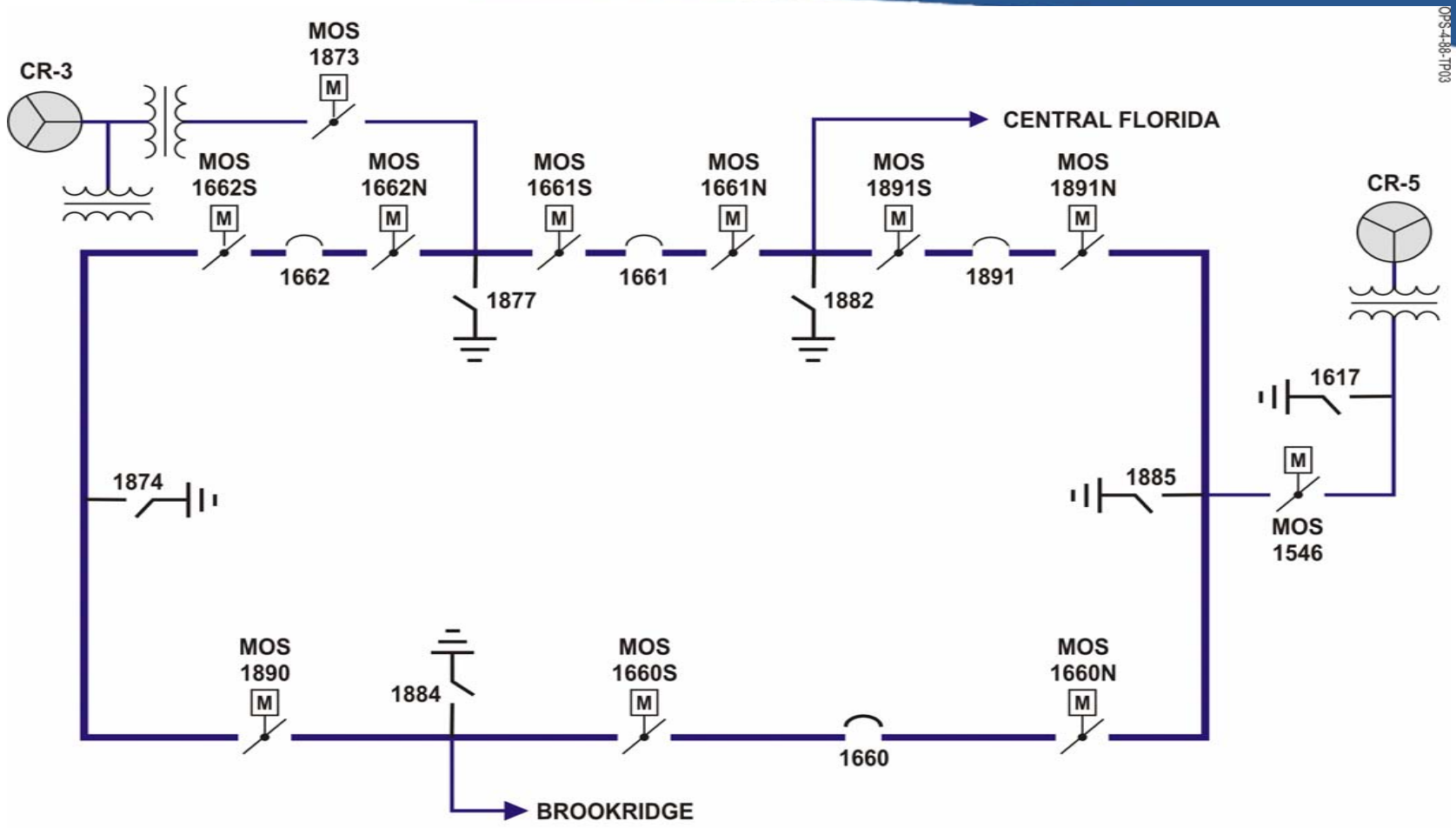

Figure 1 - Crystal River 500KV Switchyard

230KV Switchyard One-Line Diagram

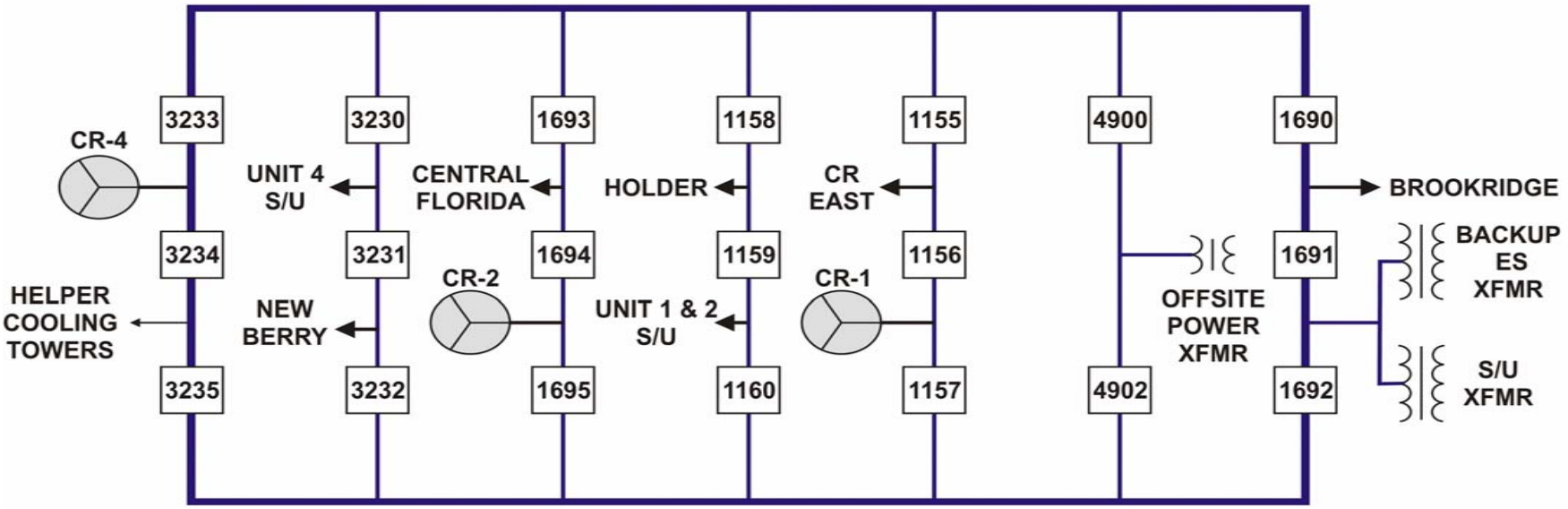

Figure 2 - 230KV Switchyard

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Emergency Safeguards (ES) Buses

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Control Complex 108’ Elevation

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Control Complex 108’ Elevation “B” 4160V Switchgear (SWGR) Room

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Control Complex 108’ Elevation “B” 4160V SWGR

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Control Complex 108’ Elevation “A” 4160V SWGR

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Control Complex 108’ Elevation “A” 4160V SWGR

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Control Complex 108’ Elevation “A” 4160V SWGR

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Control Complex 108’ Elevation

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Fire Scenarios

- Evaluated Fire Scenarios in the “A” 4160V Switchgear Room
  - **Fire had to impact the CT relay circuits associated with a single failure issue.**
  - **Result in a loss of both ES Buses.**
  - **Require the manual action to reset the B-EDG lockout.**
- Validated four cabinet fires
  - **Three cabinets, 3207, 3211 and EFP-1, that are located on the north section of the A ES Bus.**
  - **One Cabinet, 3205, located on the south section of the A ES Bus.**

Establishing Ventilation Cooling

- Appendix R Fire Study
  - Mechanical Hydraulic Timeline
  - Identifies time critical functions to ensure safe shutdown
  - Meeting the time line is one of the methods of establishing the feasibility of manual actions
- Engineering Evaluation 61671
  - Evaluated margin HVAC Calculation
  - Temperature Rise timeline modeled
  - Critical equipment design temperatures are not exceeded for 140 minutes

Establishing Ventilation

- Summary
  - For a fire in the “A” ES 4160V Switchgear Room, the loss of ventilation will cause the temperature to increase in the Control Complex
  - Modeling of the Control Complex shows that EFIC Room equipment will not be challenged for at least 140 minutes after loss of all ventilation.
  - 120 minutes to reset lockout relay provides additional 20 minutes to restore ventilation

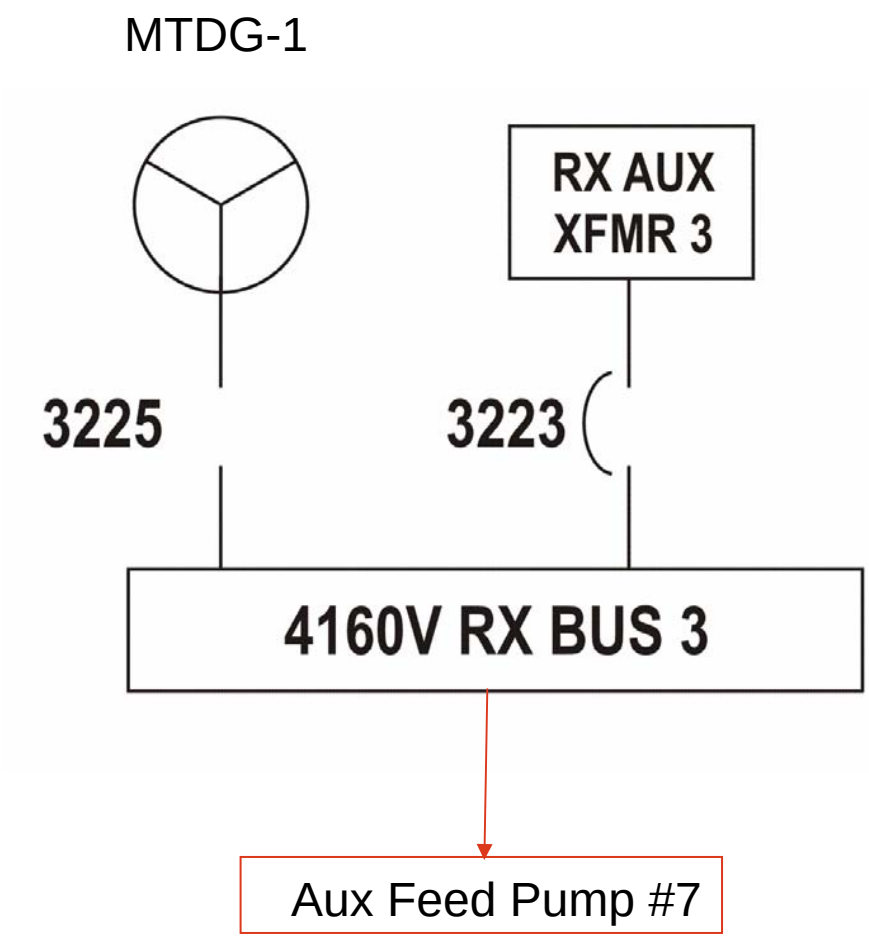
Fire Model

- Conditions of Habitability in the Switchgear Rooms
- A Fire Model was prepared by an independent consultant
  - Modeled the conditions in the “A” 4160V Switchgear Room for credible fire scenarios
  - Evaluated the habitability of the “B” 4160V Switchgear Room

Fire Model

- Results of the Fire Model:
  - No Hot Gas Layer formed
  - Visibility restored within 60 minutes except for smoldering fire
  - Toxic gas and oxygen levels remain acceptable in the “B” Switchgear Room

Auxiliary Feed Water Pump – FWP-7



Auxiliary Feed Water Pump Circuits

- **Engineering Disposition 60385 evaluated:**
  - **Power and control circuits for FWP-7**
  - **Power and control circuits for MTDG-1**
- **Conclusions:**
  - **FWP-7 and MTDG-1 power and control circuits remain free from fire damage**
  - **Can be started from the control room**

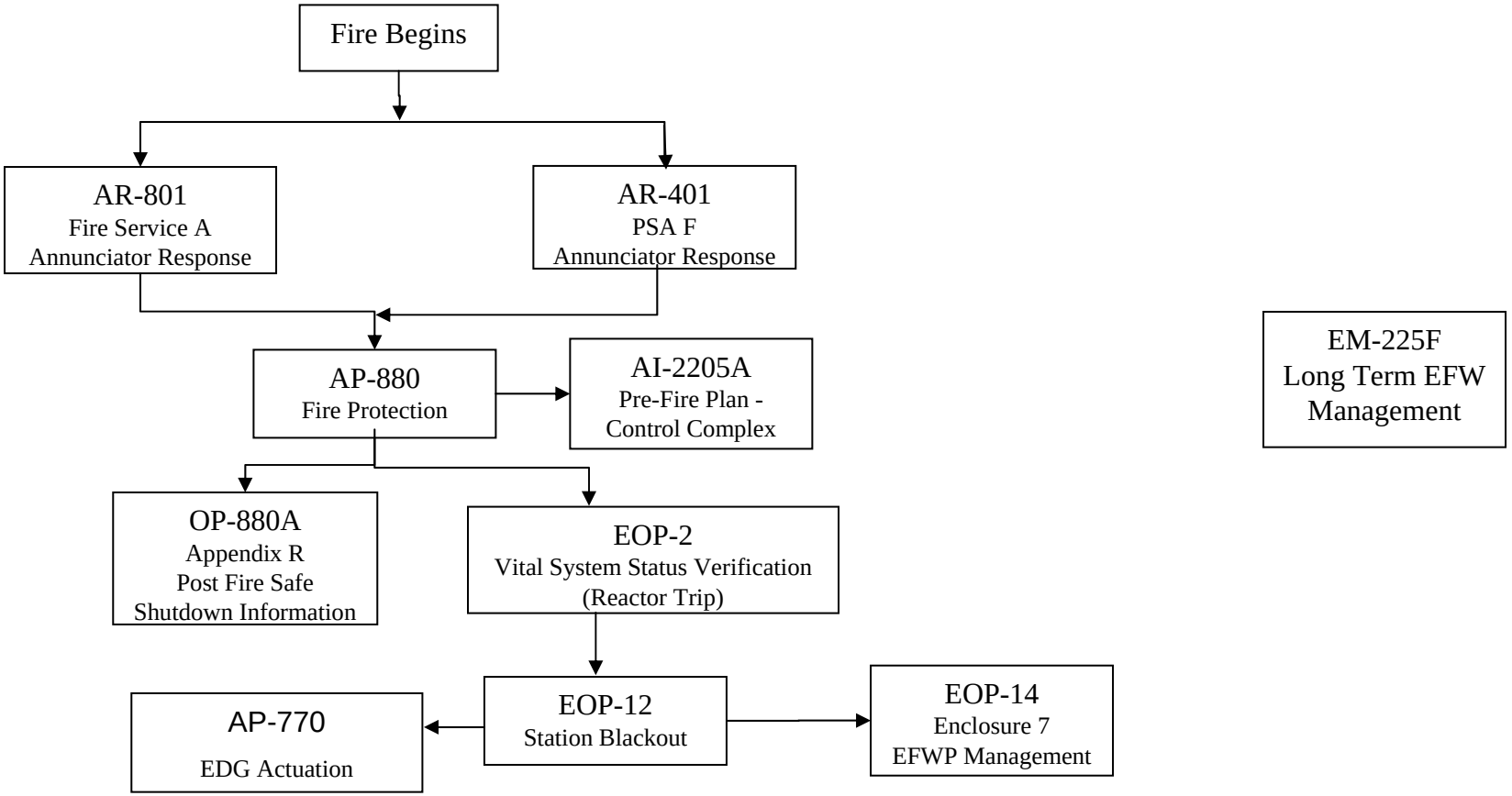
Electrical Distribution and Physical Layout Summary

- CR3 has a robust switchyard
- CR3 has modified the protective relaying circuits by removing the watt-hour meter, thus removing the single failure mechanism
- The modeling of the control complex temperatures shows that there is time available to accomplish the manual action.
- Fire modeling supports the ability of the operator to reset the lockout in the “B” Switchgear Room
- FWP-7 and its emergency power source MTDG-1 are unaffected by fires in the “A” Switchgear Room

Fire Response

- Five Man On-Site Brigade
  - Team Leader is a Licensed Operator
  - Cart Driver is a Non licensed Operator
- Site Emergency Response Coordinator
  - Responds to provide assistance and act as Emergency Medical Technician
- Security provides scene control
- Local Fire Departments
  - Provides backup support

Response Procedures



Control Complex - 108’ Elevation

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T3 – T5 Plant Response

- CR Enters Abnormal Procedure (AP) -880, Fire Protection and performs the following:
  - Sound fire alarm/muster Fire Brigade
  - Secure ventilation
  - Isolate PORV

T5 – T10 Plant Response

- **AP-880 –** Secondary Plant Operator (SPO) Charges fire header for Control Complex
- **AP-880 -** CR Closes Borated Water Storage Tank (BWST) valves
- **AP-880 -** CR Transfers both ES 4160V Buses to Offsite Power Transformer
  - **FTL will request "A" ES 4160V de-energization**
- Fire Brigade is dressed with Primary hose charged
  - **Secondary hose being charged**

Control CompleDELETED DUE TO PRO

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T10-T15 Fire Brigade Response

- Primary team enters “A” ES 4160V SWGR room with fog nozzle.
  - Second nozzle man trained to carry extinguisher
- Secondary team is in ready status at muster area with charged backup line
- Limiting extinguishing time is smoldering fire
  - Takes ~ 20 minutes to extinguish
  - Requires opening upper cabinets to locate fire

T10 -T15 Plant Response

- Trip reactor if fire is impacting safe operation
- Perform EOP-2, Reactor Trip, Immediate Actions
  - **Ensure Reactor is shut down**
  - **Ensure Turbine valves are closed**
- Transition to EOP-12, Station Blackout
- **AP-880 Enclosure 1** CR Initiates both Trains of EFW
- **AP-880 Enclosure 1** CR Isolates Main feedwater and Main steam to both steam generators

T15-T20 Plant Response

- **EOP-12** CR Isolates Main Steam to both steam generators
- **EOP-12** Isolate losses to reactor coolant system
- **EOP-12** CR Ensures EFW is operating (EFP-3, EFP-2 or FWP-7)
  - **FWP-7 and its diesel (MTDG-1) can be started and controlled from Control Room**
- **EOP-12** SPO Aligns Backup air to atmospheric dump valves
- **EOP-12** CR Manages battery loads

Emergency Feedwater (EFW) and Auxiliary Feedwater (AFW) Systems

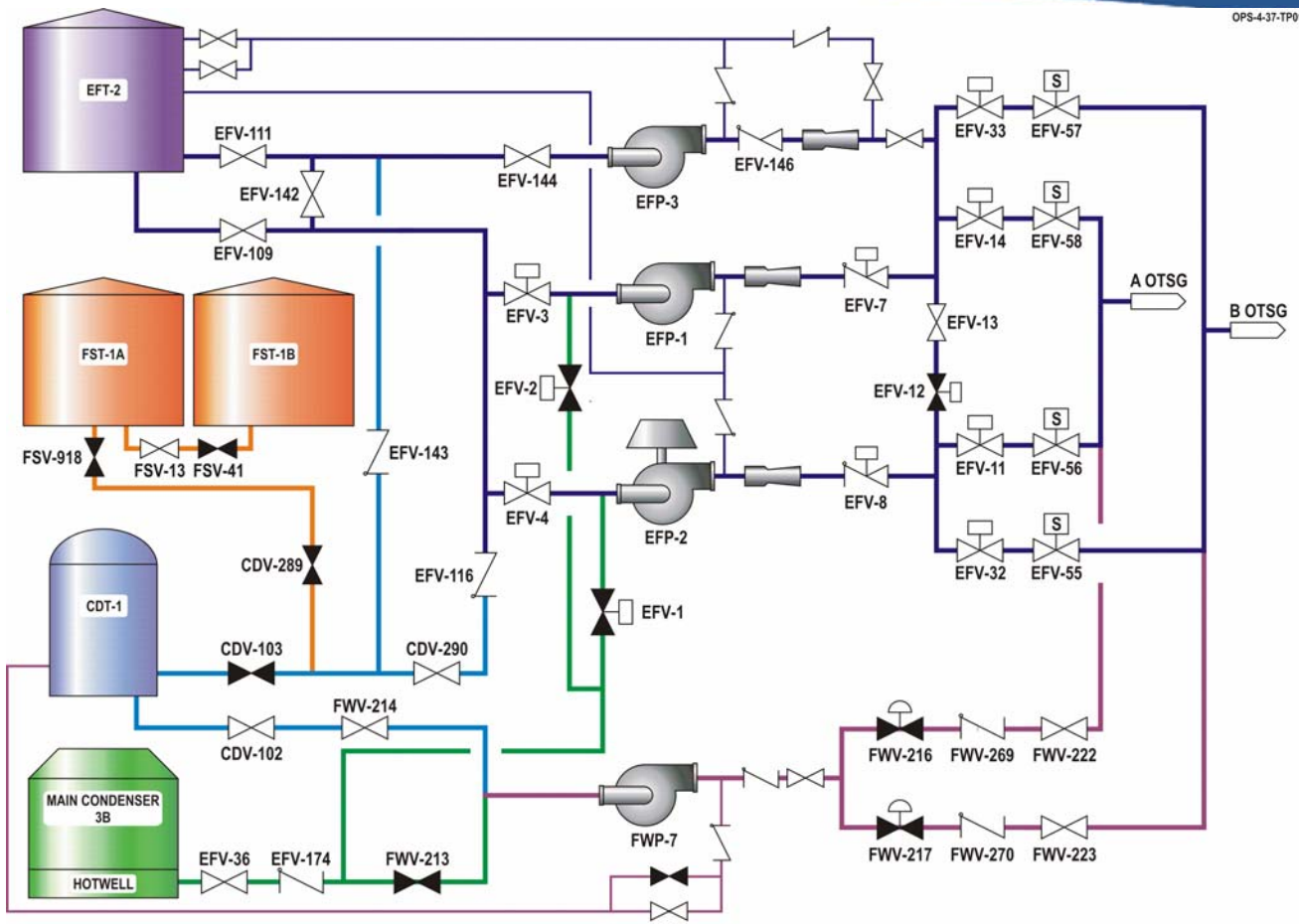

FIGURE 1 - EMERGENCY AND AUXILIARY FEEDWATER

T20 –T35 Plant Response

- **OP-880A** PPO aligns EFP-2 flow path to prevent spurious valve closure (T20)
- **OP-880A** PPO aligns EFP-3 flow path to prevent overfill (T32)
- **OP-880A** PPO Opens Breakers for BWST valves (T35)
- Fire is out (T35)

T35-T60 Plant Response

- **OP-880A** PPO is available to reset “B” EDG Lockout (T-37)
  - Smoke should clear to 4 ft visibility in 20 minutes after SWGR room door is closed
  - If habitability of room is impaired, the PPO has SCBA in local area and full bunker gear available in Fire Brigade dress out area
  - IF “B” ES 4160V SWGR room is inaccessible for PPO, CR would notify FTL to have Cart Driver (Operator) perform action

Control Complex 108’ Elevation “B” 4160V SWGR – South Bus

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Operator Manual Action

- Only two of this type lockouts in “B” ES 4160V SWGR room
  - Second is for HPI pump ES select
- Proper lockout operation provides immediate feedback (EDG output breaker closure)
  - IF lock out reset is unsuccessful, task can be re-performed
- Fire brigade members are in electrically rated boots.
- High voltage gloves are staged just outside SWGR rooms

Operator Manual Action

- Post Fire Room Conditions
  - **Smoke diminishing**
    - **Natural or forced ventilation**
  - **Water in SWGR room is less than 1”**
    - **Trained to use Primary hose to divert water to hallway**
    - **Water drains to Control Complex stairwell**
    - **Water absorbing devices are on fire cart for water management**
  - **Could be steam in atmosphere**
    - **Trained to minimize time “B” to “A” SWGR door is opened**

Operator Manual Action

- Establishing EFIC Room Cooling
  - Following Power restoration
    - **CR starts EFIC room fan (1 minute)**
    - **SPO starts Appendix R Chiller (5 minutes)**
    - **Total time for EFIC ventilation restoration is less that 66 minutes from fire initiation**

Technical Support Center

- Staffed at maximum of 75 minutes
- Provides support and guidance outside of EOPs and APs
- EM-225F provides guidance for diverse EFW/AFW lineups (EFP-3)
- Provide guidance for electrical distribution alignment

Summary

- Reset of “B” EDG lockout is feasible
- Restoration of EFIC room ventilation can be accomplished well before equipment temperature limits are exceeded
- Primary heat removal is maintained with EFP-2
- FWP-7 provides a readily available source of backup to emergency feedwater
- EFP-3 and Offsite Power available via Technical Support Center guidance

PSA Model Inputs and Methodology

PSA Analysis

- Fire Modeling
- Initial Conditions
- Initiator Selection
- Appendix R Procedure Impacts
- Human Reliability Analysis (HRA)
- Core Damage Frequency
- Conservatisms
- Sensitivities

PSA Model Inputs and Methodology

Fire/Smoke Model

- Considered Thermal and High Energy Fires
- Suppression times assumed out to 35 minutes from alarm
- Habitability ("Cleared") conditions based on:
  - visibility (4ft)
  - carbon monoxide (500 ppm)
  - oxygen (16%)
  - temperature (116F)
  - radiant heat flux (2.5kW/m2)

PSA Model Inputs and Methodology

Fire/Smoke Model

- **Thermal Fires**
  - **200kw and 65kw**
  - **Initial Damage limited to cubicle (can propagate)**
  - **No hot gas layer (HGL)**
  - **Smoke "cleared" within 60 minutes for all cases except smoldering fires**
- **High Energy Arcing Faults (HEAF)**
  - **All targets within 3ft (H) and 5ft (V) are failed at T=0**
  - **No HGL**
  - **Smoke "cleared" within 60 minutes**

PSA Model Inputs and Methodology

Initial Conditions

- On-line 100% power
- “A” 4160V ES Bus aligned to OPT (BKR 3211)
- “B” 4160V ES Bus aligned to BEST (BKR 3206)
- Operating equipment
  - MUP-1B
  - RWP-1, SWP-1C (non-safety related)
  - “A” train HVAC

PSA Model Inputs and Methodology

Initiator Selection

- **FMEA of single failure scenarios was performed**
- **Abnormal bus alignments can be screened out based on time spent in these configurations (<1%)**
- **With normal bus alignment the fire must create:**
  - **ES “A” bus fault**
  - **CT path open with ground present on ESA side of OPT circuits**
- **Initiators limited to cubicles containing or close to the CT circuits connecting the OPT feeds to breakers 3211 & 3212**

PSA Model Inputs and Methodology

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PSA Model Inputs and Methodology

Two fire initiators modeled

- **Fire 1 – North Bus Breaker cubicles 3207,3211,EFP-1**
  - **HEAF and Thermal fires (1.86E-04/yr)**
    - **Conservatism, HEAF in 3207 is less likely based on data**
    - **Conservatism, Thermal fire in EFP-1 cubicle needs to propagate**
  - **Fails both ES buses at T=0**
    - **Control Complex HVAC stops**
    - **No Makeup (incl. RCP seal injection)**
    - **Emergency Diesels can not load due to fault**
    - **Plant trip assumed (manual or 3207 protective circuitry)**
    - **Startup transformer continues supplying offsite power to unit loads (RWP-1, SWP-1C ,RCPs, Battery Chargers, IA, MFW)**
    - **BEST available**

PSA Model Inputs and Methodology

Two fire initiators modeled (cont.)

- Fire 2 – South Bus Breaker cubicle 3205
  - HEAF fire only (1.42E-05/yr)
    - **Conservative, HEAF is less likely based on data**
  - Fails both ES buses at T=0
    - **Control Complex HVAC stops**
    - **No Makeup (incl. RCP seal injection)**
    - **Emergency Diesels can not load due to fault**
    - **Loss of Startup transformer**
    - **OPT available**

PSA Model Inputs and Methodology

Other modeled impacts due to Appendix R Fire Procedures

- EFP-3 injection lines closed and de-energized
- PORV-block closed and de-energized
- MSIVs closed, MFW tripped

PSA Model Inputs and Methodology

HRA Impacts

- **No credit for local actions outside control room**
  - **EFP-3 recovery due to HVAC**
  - **Local start/control of FWP-7**
- **Reduced Credit for time critical control room actions**
  - **Early start of FWP-7 to limit RCS re-pressurization**
  - **Trip RCPs following loss of SW cooling**
- **Appendix R actions**
  - **Restore “B” ES power by resetting EGDG-1B lockout**
- **TSC actions**
  - **EFP-3 (if EFP-2 and FWP-7 unavailable)**
  - **Offsite Power (if Diesel generator unavailable)**

PSA Model Inputs and Methodology

Timeline for HRA

- **T=0 min., fire initiation/alarm, AP-880**
- **T=12 min., diagnosis compete, enter EOPs, trip RX**
- **T=18 min., operator dispatched to perform Appendix R manual actions**
- **T=35 min., fire extinguished**
- **T=37 min., operator available to reset lockout**
  - **Typically simple action (< 1 min to perform), complicated by environmental conditions**
  - **Fire brigade members available to assist, Qualified operators**
  - **Smoke "cleared" @ T=60 for most cases**
- **T=60 min., lockout reset ("B" 4160V power restored)**
  - **EGDG-1B operation may be impacted**
- **T=66 min., EFIC room cooling restored**
- **T=75 min., TSC operational**
  - **Begin efforts to align offsite power if EDG unavailable**
- **T=120 min., last opportunity to restore EFIC cooling**
- **T=140 min., EFIC failure (ends credit for EFP-2)**
  - **Start FWP-7 (EOP action)**
  - **Attempt other recovery (TSC support)**
- **T=200 min., Core damage 1 hr after loss of all core cooling**

PSA Model Inputs and Methodology

Appendix R Manual Action

- Timeline
  - Tsw = 120 minutes
  - $T_{1/2}$ = 12 minutes
  - Tm = 48 minutes
- Probabilities
  - 1.0E-01 (typical screening value)
  - 6.7E-02 (traditional HRA methodology, with unfavorable PSFs to account for fire condition)
  - 4.4E-02 (credit applied for fire brigade assistance*)
  - 2.1E-02 (unfavorable PSFs, no fire complications)

PSA Model Inputs and Methodology

TSC Recovery Actions

- EFP-3, (EM-225F)
  - Open EFV-12,13 to feed through “B” train injection path
  - Open EFV-14,33 to feed through “A” train injection path
- BEST, (AP-770, OP-880A)
  - Available for fire scenarios involving North “A” bus
  - Availability obvious due to continued operation of Startup Transformer
  - Simple control room action
- OPT, (AP-770, OP-880A)
  - Available for fire scenarios involving South “A” bus
  - Availability would need to be deliberately determined
  - Simple control room action
- Completion any of these actions within 1 hour from loss of core cooling (0.3)

PSA Model Inputs and Methodology

Conservatisms

- Fire frequencies
  - not all modeled fires will create the subject faults
    - Smoldering fires (high smoke production) are less likely to cause the fault before suppressed
    - propagation of low energy fires between cabinets is less likely before suppression
  - HEAFs in normally open breakers less likely
- 4 hour battery life
  - CR3 2004 LOOP event demonstrated > 8hrs (non-1E)

PSA Model Inputs and Methodology

CDF = 1.47E-07/yr

- Emergency Diesel available
- Initiating Event Frequency (2.0E-04)
- Appendix R manual action (4.4E-02)
  - Fire brigade assistance credited
- FWP-7 (EOP directed, HEP = 5.6E-03)
  - Full credit for control room action
- Other recoveries (TSC support, HEP = 0.3)
  - EFP-3
  - Offsite power

PSA Model Inputs and Methodology

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Conclusions

- Unit Auxiliary Loads lost in only one fire scenario
- At least 120 minutes available before EFIC is inoperable
  - Room conditions able to be improved, or more time for dress-out
  - Time for repeated attempts to reset the EDG lockout
- Auxiliary Feedwater and EFP-2 remain available – secondary side heat removal not lost
- EFP-3 can be restored with TSC Guidance
- Operator action is simple, trained on, proceduralized, and provides immediate feedback
- Fire brigade members may be used for manual action after fire out
- Offsite power can be restored if EDG unavailable

Closing Remarks