EA 14-008

Jeremy Browning, Site Vice President
Arkansas Nuclear One
Entergy Operations, Inc.
1448 SR 333
Russellville, AR 72802-0967

SUBJECT: SUMMARY OF REGULATORY CONFERENCE TO DISCUSS SAFETY SIGNIFICANCE OF ARKANSAS NUCLEAR ONE UNIT 1 DROPPED STATOR

Dear Mr. Browning:

On May 1, 2014, members of the U.S. Nuclear Regulatory Commission (NRC) staff met with representatives of the Arkansas Nuclear One facility to discuss the apparent violation affecting both units related to the drop of the Unit 1 main generator stator as documented in NRC Inspection Report 05000313;368/2013012, issued on March 24, 2014 (ML14083A409). The focus of the regulatory conference was a discussion on the safety significance of the finding. The discussion included Unit 1 mitigating actions focusing on the use of temporary power to recover the electrical buses and Unit 2 procedural electrical power recovery actions.

For Unit 1, three non-proceduralized and non-engineered success paths associated with recovery of electrical power were discussed, with the variation of Success Path 1 being actually used, after the event, to restore power to the vital buses within 6 days. Your staff indicated that this power was available for use within 4.4 days and could have been used in an emergency. The delay on re-energizing the vital buses with offsite power was based on completing and approving the engineering, installation, and operating procedures documentation. The three success paths all had estimated times to being available to re-energize the electrical buses of 60 hours or less. This information was discussed during your presentation on Slides 15 – 35. Your staff also discussed other recovery actions. Based on credit for the recovery options, your staff estimated the conditional core damage probability of 5.5E-6.

For Unit 2, the focus was on procedurally directed electrical power recovery strategies. This information was discussed during your presentation on Slides 81 – 86. Based on these recovery options, your staff estimated the conditional core damage probability of 1.8E-6.

The NRC staff asked questions during the Regulatory Conference, with some questions requiring additional information that you indicated you would supply to us by Friday, May 9. The NRC will continue to review the information that you provided during the Regulatory Conference and the
subsequent information that was requested in order to reach a final significance determination. We are developing our final risk significance and will issue a final significance determination letter in June.

A copy of your presentation slides is included as Enclosure 1. Copies of the NRC slides (Enclosure 2) and meeting attendance (Enclosures 3 and 4) are included.

This regulatory conference was transcribed, and a copy of the transcription will be made available and placed into the NRC’s Agencywide Documents Access and Management System (ADAMS). This Category 1 public meeting was attended by 52 members of the public, both telephonically and in the Region IV office.

In accordance with 10 CFR 2.390 of the NRC’s “Rules of Practice,” a copy of this letter and its enclosures will be available electronically for public inspection in the NRC’s Public Document Room or from the Publicly Available Records (PARS) component of the NRC’s ADAMS. ADAMS is accessible from the NRC web site at http://www.nrc.gov/reading-rm/adams.html (The Public Electronic Reading Room).

Sincerely,

/RA/

Gregory E. Werner, Chief
Project Branch E
Division of Reactor Projects

Docket Nos.: 50-313, 50-368
License Nos.: DPR-51, NPF-6

Enclosures: 1. ANO Presentation Slides
2. NRC Slides
3. Meeting Attendance at Region IV
4. Meeting Attendance by Phone
Opening Comments

Jeremy Browning
ANO Site Vice-President
Opening Comments

- ANO and Entergy recognize the significance of the event
- Plant personnel took appropriate actions and plant mitigating systems performed as designed to protect the health and safety of the public
- Entergy concurs with the performance deficiency
- Independent root cause evaluations performed
- Effective corrective actions to prevent re-occurrence were taken addressing the root causes, contributing causes, extent of condition and extent of cause
- Entergy understands its responsibility for the oversight of vendor performance
- We appreciate the opportunity to share additional information that improves the accuracy of the estimated risk following the event
Agenda

- Unit 1
  - Response
  - Recovery Actions
  - Significance Determinations
- Break
- Unit 2
  - Response
  - Recovery Actions
  - Significance Determinations
- Site Actions and Common Cause
- Fleet Learnings
- Closing Comments
Unit 1 Overview

- Focus on NRC event tree
  - 4160VAC power recovery
  - Inventory control recovery
- Provide a basis that the probability of failure to recover is not 1.0 as assumed by the NRC analysis
- Discuss three success paths for the reestablishment of 4160VAC power
- Discuss a separate success path for inventory makeup to the reactor coolant system
- Apply risk modeling techniques to provide best estimate of actual plant risk
ANO Unit 1
Response and Recovery

Gary Sullins
Unit 1 Manager – Shift Operations
David McKenney
Engineering Supervisor
Initial Conditions

- Day 7 of Refueling Outage
- Fuel transfer canal flooded
  - 12 hour time to boil
  - 115 hour (4.8 day) time to core uncovery
- Power distribution supplying vital switchgear is unavailable
  - Distribution from Startup Transformers (SU1 and SU2)
  - Supply from Alternate AC Diesel Generator (AACDG)
- Vital switchgear unaffected
- 480VAC Offsite Power remained available in Power Block throughout the event from local distribution (London Line)
Emergency Response

- Emergency Response Organization activated immediately following event
  - Outage Control Center organization transitions into Technical Support Center
  - Emergency Operations Facility (EOF) manned and focused on obtaining offsite support
    - Equipment
    - Resources
Human Resources

Approximate number of key departmental personnel (including contract personnel supporting a department) available on site on the day of the event:

- CRAFT 295 (including 45 electrical craft)
- ENGINEERING 40 (not including contractors)
- OPERATIONS 60

Per Shift Numbers
NRC Event Tree – Unit 1

Loop Event Tree Diagram with nodes and branches indicating the sequence of events and outcomes.

4160 VAC power recovery

Inventory control recovery

End State (Phase - CD)

Enclosure 1
Basis for Unit 1 Recovery Actions

- Provide basis for core cooling success paths if emergency diesel generator (EDG) failed (dominant cut set)
  - Three success paths to recover 4160VAC Power Source(s) were developed as part of event response
    - Cable from Startup 1 Transformer (SU1)
    - Cable from Alternate AC Diesel Generator Breaker
    - Cable from Unit 2 Non-Vital Switchgear
  - One Success Path for 480VAC power cables for Reactor Coolant System (RCS) Makeup
- All actions consistent with and less complex than demonstrated recovery actions
Unit 1 Response

- Priorities Dictated by Actual Plant Conditions
  - Actual Plant Conditions
    - Unit 1 in a stable condition
    - Redundant trains available for decay heat removal
  - Priorities
    - Avoid challenges to available power sources
    - Protect Decay Heat Removal (DHR) and support systems
    - Protect Spent Fuel Pool (SFP) Cooling
    - Minimize potential for personnel injury
    - Optimize temporary configurations for future electrical recovery actions
Unit 1 Post Event Response

- Restored DHR within 5 minutes
- Restored SFP cooling with less than 3 degree temperature rise
- Reliably operated both EDGs and both trains of DHR
- Recovery path chosen for 4160VAC offsite power recovery based on both vital trains in service and > 300,000 gallons of water in refueling canal
  - Provided offsite power capability to 4160VAC vital busses in 4.4 days
    - Design featured flexibility for operation and accommodations for turbine building repairs
  - Demonstrated source of offsite power placed in service in 6 days
- Additional simple contingency actions were being developed had power further degraded
Unit 1 Pre-Event Response

Switchyard Auto Transformer (22KV Off-Site Power)

PRE-EVENT ANO-1 AC ELECTRICAL ALIGNMENT

Switchyard 161 KV Overhead (Off-Site Power)

NON VITAL VITAL

NU1 A1 A111
A113 4160VAC

A3 A308 A309 A310
K-4A EDG

VITAL 4160VAC

X5 A301

B5 B512 B513
VITAL 480VAC

Unit 2

2A1 2A4
2A9
2A902 2A904 2A1001

2K-9 AAC

Alternating AC 4160VAC

A213 A211
A213 4160VAC

A4 A408 A409 A410
K-4B EDG

VITAL 4160VAC

B6 B612 B613

B6 VITAL 480VAC

Enclosure 1
Unit 1 Post Event Response
Demonstrated Success – Provided 4160VAC From Offsite Unit 1 Transformer to Unit 1 Vital Switchgear

**SU1 TRANSFORMER TO A3/A4 SWGR OFFSITE 4160VAC POWER**

**ACTUAL AVAILABLE FOR USE – 4.4 DAYS**

- **Switchyard Auto Transformer (22KV Off-Site Power)**
- **SU1**
- **Temporary 4160VAC Breaker**
- **TEMPORARY CABLE**
- **2A9**
- **2A1001**
- **2K-9 AAC**
- **Damaged Portion of Cable**
- **K-4A EDG**
- **A308**
- **A310**
- **K-4B EDG**
- **A408**
- **A410**

**SPLICE TEMPORARY CABLE TO UNDAMAGED PORTION OF 2A901 CABLE IN A3 SWGR ROOM**

**VITAL 4160VAC**

**VITAL 4160VAC**

*Enclosure 1*
Demonstrated Success – Provided 4160VAC From Offsite Unit 1 Transformer to Unit 1 Vital Switchgear.
Demonstrated Success – Provided 4160VAC From Offsite Unit 1 Transformer to Unit 1 Vital Switchgear

- Temporary breaker supplying power to vital switchgear from SU1 transformer
### Demonstrated Success – Provided 4160VAC From Offsite Unit 1 Transformer to Unit 1 Vital Switchgear

<table>
<thead>
<tr>
<th>SU1 Source (Actual Installation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7*50 = 350 feet of cable routing</td>
</tr>
<tr>
<td>7*500 = 3500 feet of cable routing</td>
</tr>
<tr>
<td>28 splices/terminations – 4160VAC</td>
</tr>
<tr>
<td>Modify SWGR Room Door</td>
</tr>
<tr>
<td>Seismic Cable Support</td>
</tr>
<tr>
<td>Temporary 4160VAC Breaker</td>
</tr>
<tr>
<td>DC control for Temp Breaker</td>
</tr>
<tr>
<td>Temporary Breaker Setup &amp; Testing</td>
</tr>
</tbody>
</table>

**106 Hours (4.4 Days)**
Implementation Process

- Temporary Electrical Power
  - Recovery team was continuously investigating additional options
  - Additional on-site 4160VAC sources were considered and scope of work determined
  - Technical Support /Outage Control Center considered options
  - Additional technical support onsite
  - Implementation would have been controlled by
    - EN–DC–136 “Temporary Modifications”
Implementation Process

TSC/OCC/OPS
IDENTIFY NEED(S)

Engineering Defines Concept and Scope

Engineering Provides Details to Planning for WO Preparation

Plant Personnel Install and Test Using Normal Work Order Process

AVAILABLE FOR USE

IMMEDIATE NEED?

YES

Authorize Emergency Temporary Modification

PLACE IN SERVICE

NO

Engineering Refines Scope and Design Requirements

Develop Temporary Modification Documentation

TEMPORARY MODIFICATION REVIEW & APPROVAL COMPLETE
Demonstrated Success – SU1 Source

- Restored Off Site Power to Vital Switchgear
  - Craft personnel were qualified and scheduled to perform the same type activities in outage when replacing circulating water pump 4160VAC cables
  - Cable routed away from recovery zone
  - Provided option to tie either or both trains of vital power to SU1
  - Allowed the EDGs to remain available to feed their respective train
  - Available in 4.4 days
Contingent Success Paths

- Three Alternate 4160VAC Power Source(s) Success Paths
  1. Cable from Startup 1 Transformer (SU1)
  2. Cable from Alternate AC Diesel Generator breaker
  3. Cable from Unit 2 Non-Vital Switchgear (Condensate Pump Supply)

- Estimated installation completion times for these success paths based on the actual installation of demonstrated 4160VAC power source
  - Adjustments made to reflect reduced work scope
Success Path 1 – Cable From Offsite SU1 Transformer

Switchyard
Auto Transformer
(22KV Off-Site Power)

SU1

SU1 TRANSFORMER TO A3/A4 SWGR
OFFSITE 4160VAC POWER
EXPEDITED INSTALLATION (60 HRS)

TEMPORARY CABLE CONNECTED DIRECTLY TO
SU1 4160VAC WINDINGS

K-4A EDG
A308

A3
VITAL 4160VAC

K-4B EDG
A408

A4
VITAL 4160VAC

A310
SPLICED TEMPORARY CABLE TO UNDAMAGED
PORTION OF 2A901 CABLE IN A3 SWGR ROOM

A10
Success Path 1 – Cable From Offsite SU1 Transformer
Success Path 1 – Cable From Offsite SU1 Transformer

SU1 Supply to Vital 4160 VAC – Expedited *vs.* Demonstrated Source

<table>
<thead>
<tr>
<th>SU1 Expedited Installation</th>
<th>SU1 Source (as installed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7*250=1750 feet of cable routing</td>
<td>7*500=3500 feet of cable routing</td>
</tr>
<tr>
<td>7*50=350 feet of cable routing</td>
<td></td>
</tr>
<tr>
<td>14 splices/terminations – 4160V</td>
<td>28 splices/terminations – 4160V</td>
</tr>
<tr>
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</tr>
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</table>

| 60 Hours                                    | 106 Hours                                |
Success Path 2 – Alternate AC Diesel Generator

[Diagram showing electrical systems and paths]
Success Path 2 – Alternate AC Diesel Generator

ALTERNATE AC DIESEL 2K-9
ON-SITE POWER TO ANO-1 VITAL AC CONTINGENCY
EXPEDITED INSTALLATION (36 HRS)

Switchyard Auto Transformer (22KV Off-Site Power)

TEMPORARY CABLE

ALTERNATE AC 4160VAC

DISCONNECT A409 CABLE AND SPLICE TO TEMPORARY CABLE

A2

VITAL 4160VAC

A3

K-4A EDG

A308

A310

K-4B EDG

A408

A409

A410

4160VAC

ENTERGY

Enclosure 1
Success Path 2 – Alternate AC Diesel Generator
## Success Path 2 – Alternate AC Diesel Generator

AAC DG to Vital 4160VAC vs. SU1 to Vital 4160VAC Demonstrated Source

<table>
<thead>
<tr>
<th>AAC DG to ANO–1 Vital 4160 VAC</th>
<th>SU1 Source (as installed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7*100=700 feet of cable routing</td>
<td>7*500=3500 feet of cable routing</td>
</tr>
<tr>
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<tr>
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<td></td>
</tr>
<tr>
<td>Minor 2A901 Term Point Repairs</td>
<td></td>
</tr>
</tbody>
</table>

| 36 Hours | 106 Hours |
Success Path 3 - Cable From Unit 2 Non-Vital Switchgear

ANO-2 CONDENSATE PUMP FEEDER
ON-SITE & OFF SITE POWER TO
ANO-1 VITAL AC CONTINGENCY
EXPEDITED INSTALLATION (36 HRS)

Switchyard
Auto Transformer
(22KV Off-Site Power)

SU1

Switchyard
161 KV Overhead
(Off-Site Power)

SU2

2A1
4160VAC

2A1001
2A904

2K-9
AAC

ALTERNATE AC 4160VAC

TEMPORARY CABLE

DISCONNECT A409 CABLE AND SPLICE TO TEMPORARY CABLE

K-4A EDG

A3
VITAL 4160VAC

A308

A310

K-4B EDG

A410
A409
A408

VITAL 4160VAC

A4

2P-2C
ANO-2 Condensate Pump

4160VAC

A2

2A106
NOTE 2
Success Path 3 – Cable From Unit 2 Non-Vital Switchgear

UNIT-2
UNIT-1

Secondary Sample Room

Train Bay

2A2 - 4160VAC SWGR
2H2 - 6900VAC SWGR

2A1
4160VAC SWGR

2A9 Alternate AC 4160VAC SWGR

2H1 - 6900VAC SWGR

A2 - 4160VAC SWGR
H2 6900VAC SWGR

A1 - 4160VAC SWGR
H1 6900VAC SWGR

X3 B3 460V B4 480V X4

Normal Off-Site Feeder Cable to Vital 4160VAC Switchgear A4

Temporary Cable
**Success Path 3 – Cable From Unit 2 Non-Vital Switchgear**

2A106 to Vital ANO–1 4160VAC *vs.* SU1 to Vital 4160VAC Demonstrated Source

<table>
<thead>
<tr>
<th>2A106 to ANO–1 Vital 4160 VAC</th>
<th>SU1 Source (as installed)</th>
</tr>
</thead>
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<tr>
<td>7*100=700 feet of cable routing</td>
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<td></td>
</tr>
<tr>
<td>Minor 2A106 Interlock Defeats</td>
<td></td>
</tr>
<tr>
<td>36 Hours</td>
<td>106 Hours</td>
</tr>
</tbody>
</table>
Other 4160 VAC Success Paths

- Additional success paths for 4160VAC Power to vital busses were considered and scoped
  - Portable Diesel Generator (4160VAC)
  - Unit Aux Transformer backfeed from offsite 500KV line (Variation of SU1 temporary modification)
  - Restoration of A1 Non-Vital Switchgear fed from SU2 offsite transformer
Summary – 4160 VAC Success Paths

- Simple design concepts (typical of normal outage activities)
- Simple to implement (typical of normal outage activities)
- Craft personnel were qualified and scheduled to perform the same type activities in outage when replacing circulating water pump 4160VAC cables
- Cables would have been routed away from damaged turbine building areas
- Success paths spatially and electrically independent
- Success paths could be implemented in parallel
  - Sufficient time to implement other success paths sequentially if one of the success paths failed
- Alternate 4160VAC Success Paths are less complex than the demonstrated source of offsite power which was actually installed and available in 4.4 days
NRC Event Tree – Unit 1

4160 VAC power recovery

Inventory control recovery

End State (Pre-CD):
1. OK
2. OK
3. OK
4. CD
5. OK
6. CD
7. OK
8. CD
9. OK
10. OK
11. CD
12. OK
13. CD
14. OK
15. CD
16. OK
17. OK
18. OK
19. CD
Success Path 4 – Forced Flow Makeup

- Forced flow makeup to RCS via Borated Water Recirculation Pump
- One of six methods directed by Loss of Decay Heat Removal procedure
- Support actions
  - Provide temporary 480VAC power to Borated Water Recirculation Pump
    - 480VAC local distribution unaffected and available in Unit 1 power block
  - Establish makeup to Borated Water Storage Tank (BWST) per procedure
- 20 hours to implement
- Provides 180 GPM at 100 PSI RCS Pressure
  - Approximately 50 GPM required
Success Path 4 – Forced Flow Makeup

Temporary Power to Vital Loads & P-66 Borated Water Pump
EXPEDITED INSTALLATION (20 HRS)

NOTES:
1. Connect temporary cable to B51 MCC bus.
2. B6 could be back fed if necessary to power Green Train Battery Charger.
3. Portable Diesel Generator could be used if London Line unavailable.
4. MCC B5185 and B2145 are located within 20 feet of each other.
Success Path 4 – Forced Flow Makeup
Success Path 4 – Forced Flow Makeup
Success Path 4 – Forced Flow Makeup
Success Path 4 – Forced Flow Makeup

- Summary
  - Simple design concepts (standard electrical connections)
  - Simple to implement (typical outage temporary modification)
  - 480VAC temporary power typical of normal outage activities
  - 480VAC local distribution unaffected by event and available in power block at a disconnect switch
  - Success path spatially and electrically independent from 4160VAC Success Paths
  - Multiple variations of temporary power connection points are available
  - If one of the success paths or connection points failed, there was sufficient time to implement another path sequentially
Additional Benefits of Success Path 4

- Powering B51 provides additional makeup options
  - SFP Cooling Pump
  - Gravity Feed
    - Requires BWST makeup and Reactor Building (RB) vent
    - Vent path available via RB Purge exhaust
- Also energizes battery chargers and inverters for instrumentation
Timeline for Success Paths

Station Blackout
T=0

Expedited SU 1 Source
T= 60 hours
T= 72 hrs
T= 115 hrs

AACDG
T=36 hours
T= 48 hrs
T= 72 hrs
T= 115 hrs

Unit 2 Non-Vital Switchgear
T=36 hours
T= 48 hrs
T= 72 hrs
T= 116 hrs

Forced Flow Makeup
T=20 hours
T= 48 hrs
T= 72 hrs
T= 115 hrs

Demonstrated Offsite
4160VAC Available
T=4.4 Days

Available Inventory
T=4.8 days
Confidence in Success

- Substantial margin in response time (4.8 days available inventory)
- Refueling outage resources immediately available
  - Stator lift would only occur during major outages
  - Fleet resources available
- Simple and straightforward installations
  - Installed utilizing existing processes
  - Consistent with typical outage activities
  - Required materials onsite
  - Response time available to inspect and test success paths prior to energization
- Defense in Depth – multiple success paths
- Successfully demonstrated response by actually installing and making 4160VAC power available in 4.4 days
Significance Determination
Unit 1

Richard Harris
Manager, Emergency Planning
Key Objectives

- Realistic estimate of risk utilizing best available information
  - Review key assumptions in the NRC risk assessment
  - Identify applicable ANO success paths
  - Assess impact of ANO success paths on the NRC analysis
- Present ANO Risk significant results
Significance Determination – Unit 1

- Desired result is a safe and stable end state
- NRC Event Tree model was reviewed to understand method and results
- Event tree dominant sequences were reviewed
- No credit in the NRC event tree for potential recovery actions associated with 4160VAC and inventory control
- Assumption is not realistic based on the actual recovery of offsite power and the potential for other success paths
NRC Event Tree – Unit 1

4160 VAC power recovery

Inventory control recovery

1.95E-3

Enclosure 1
Methodology

- Consulted available resources for determining an acceptable method of calculating recovery factors
- No definitive standard was identified for calculating recovery factors for shutdown conditions
- A realistic risk assessment must include recovery potential that was present
- Ultimate goal is to determine best estimate recovery factor
Methodology Development

- Assembled expert team
  - Risk analyst
  - Operations
  - Outside consultants
- Different methods and options considered
- Modeling methods ultimately selected
  - HRA Calculator
  - EPRI’s “Human Action Reliability Procedure”, TR-101711
Recovery Elements Considered

- Cognitive/Decision Making
- Design Development
- Execution
Cognitive/Decision Making Factors

- Cognitive elements that are important to success were developed
  - Examples
    - Cues
    - Assessment against safety functions
    - Contingency plan development
    - Outage resources immediately available
    - Simplicity of temporary modifications
- HRA Calculator was reviewed for applicability
- It was determined that the Cognitive portion of the HRA Calculator is applicable for this element
Design Development Factor

- Examples of design development issues that were considered
  - Resource limitations and dynamics
  - Affect on existing systems
  - Operating Crew/Staff interaction
  - Temporary Modification development

- Concluded that the HRA Calculator does not adequately address Design Development Factor

- Alternative approaches were considered
  - Determined that the recovery event tree from EPRI’s Human Action Reliability Procedure was applicable
Recovery Event Tree from EPRI

<table>
<thead>
<tr>
<th>Non-recovery Event</th>
<th>Time available for action</th>
<th>Relative Complexity of action</th>
<th>Availability of training or practice for action</th>
<th>Nature of environment for work area</th>
<th>Qualitative Probability of Failure</th>
<th>Quantitative Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>long (&gt;4 hrs)</td>
<td></td>
<td>simple</td>
<td>trng/practice</td>
<td>good</td>
<td>low</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>no trng/practice</td>
<td>poor</td>
<td>mod. Low</td>
<td>0.03</td>
</tr>
<tr>
<td>Intermediate (1-4 hrs) (similar development)</td>
<td></td>
<td></td>
<td>trng/practice</td>
<td>good</td>
<td>mod. Low</td>
<td>0.03</td>
</tr>
<tr>
<td>short (&lt;1 hr) (Similar development)</td>
<td></td>
<td></td>
<td>no trng/practice</td>
<td>poor</td>
<td>mod. High</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>no trng/practice</td>
<td>good</td>
<td>mod. High</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Execution Factor

- Evaluated the list of execution steps for successful implementation
- HRA Calculator was reviewed for applicability
- It was concluded that this element can be properly modeled by the HRA Calculator
- Individual steps from the implementing instructions for the Temporary Modification that was actually implemented were evaluated for this portion of the analysis
Quantification of Recovery Factor

- Using processes discussed above
  - HRA Calculator was used to determine the Cognitive and Execution results
  - A screening factor assigned to the recovery event tree from EPRI was used to estimate the Design Implementation results
    - Screening factor dominates results and provides some conservatism
  - Results were included in a fault tree logic for determining the failure probability
4160VAC Recovery Fault Tree

Operator Fails to Reenergize Emergency Busses from a Temporary Modification

- **ELEC_REC**

Operator Fails to Reenergize Emergency Busses from a Temporary Modification

- **ELEC_REC_1**
  - **G078**
  - Operator Fails to Reenergize Emergency Busses from SU1 Temporary Modification
    - **ELEC_REC_SU1**
      - **1.00E-02**
  - **ELEC_REC_2A9**
    - **G037**
    - Operator Fails to Reenergize Emergency Busses from 2A9 Temporary Modification
      - **ELEC_REC_2A9**
        - **1.30E-02**

Reenergize Emergency Busses at A310 from SU1 T-Mod

- **G079**

Development Recovery: 4160VAC Power Recovery

- **DEVELOP_REC_POWER**
  - **3.00E-02**

Reenergize Emergency Busses at A409

- **G076**

2A9 Recovery

- **G082**

ANO-2 Condensate Pump Feeder to ANO-1 AC - Power Recovery

- **G077**

Operator Fails to Reenergize Emergency Busses from ANO-2 Condensate Pump Temporary Modification

- **ELEC_REC_ANO2_COND**
  - **1.00E-02**

Modeling Method Results

The resulting point estimate for 4160VAC recovery fault tree is 3.1E–02
4160VAC Recovery Evaluation – Alternate 1

- Using a normal distribution, performed a statistical assessment for Mean Time To Repair (MTTR) vs. available time
- Assumed best estimate completion times as the mean (60 hours)
- Used a standard deviation of 20 hours
- Results in a probability of failure = 2.6E-3
4160VAC Recovery Evaluation – Alternate 2

- Actual offsite power was restored before the calculated time to core uncovery
  - Calculated a recovery factor using HRA Calculator for the time between recovery of power and core uncovery
  - Night orders were in place
  - Operator actions were not complicated
- Results in a probability of failure = 2.0E-03
NRC Assumptions for Inventory Recovery

- NRC model did not give credit for this recovery action
- Success Path 4 – Forced Flow Makeup
Recovery Dependencies

- Reviewed dependencies between the 4160VAC recoveries and inventory recoveries
- Each of the recovery options would be worked independently
  - Sufficient persons available to work multiple success paths
  - No spatial conflicts between the two main recoveries
- Conclusion: No dependency between 4160VAC and inventory control recoveries
Inventory Control Recovery Factor

- Same approach applied to inventory recovery as was applied in determining the 4160VAC recovery factor
- These results were included in a fault tree logic for determining the failure probability
Recovery Fault Tree for Inventory Control
Modeling Method Results

The resulting point estimate for inventory recovery fault tree is $4.0 \times 10^{-2}$
Results

- When these recoveries are applied to the NRC’s event tree model, the results are estimated to be 5.5E-06 CCDP
## Results to Include Sensitivities

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<th>Estimated NRC CCDP Results with Recoveries</th>
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*Inventory Control*
ANO Shutdown PRA Risk
Significant Results

- ANO developed event tree for Unit 1
- Utilized industry experts
- Quantifying this event tree has resulted in a core damage probability to be $4.8 \times 10^{-6}$
Conclusion

- ANO’s demonstrated response to the loss of offsite power provides overwhelming evidence that the probability of failure is not 1.0 as assumed by the NRC analysis.

- ANO has instituted a reasonable method for assessing the risk of recovery.

- ANO calculated the risk associated with the stator drop to be in the mid E-6 range.
Break
ANO Unit 2
Opening Comments

Jeremy Browning
ANO Site Vice–President
Opening Comments

- Plant personnel took appropriate actions
- Plant mitigating systems performed as designed
- Priorities for system alignment and restoration of plant systems were based on actual plant conditions
- Procedurally directed and available success paths not credited in NRC risk model
- Available Success Paths would have been driven and implemented by existing procedures and processes
- Available Success Paths are trained on and are not complex and can be implemented in a timely manner
- Success Paths are modeled in existing PRA models
- Additional modeling improves the accuracy of the estimated risk
ANO Unit 2
Response & Recovery

John Hathcote
Unit 2 Manager – Shift Operations
Objectives

- Provide detail of procedurally directed electrical power recovery strategies using immediately available power sources
  - Offsite SU2 transformer available to power non-vital 4160VAC switchgear (2A2)
  - Alternate AC Diesel Generator
  - Cross tie vital 4160VAC busses 2A3/2A4
Unit 2 Response

- Unit 2 100% power
- ‘B’ Reactor Coolant Pump (RCP) tripped due to breaker vibration
- Reactor tripped as a result of RCP trip
- Uncomplicated post trip response
- Off-site source auto-transferred from UAT to SU3
- Diagnosed Reactor Trip Recovery
Unit 2 Response

- SU3 lock out occurred ~90 minutes post trip
  - Water migration into the bottom of the RED train non-vital 4160VAC switchgear cubical 2A113
- SU2 automatically aligned to RED train
  - 2A1 and 2A3 energized from SU2
- GREEN train initially de-energized
  - GREEN train 2A2 and 2A4 de-energized based on selected configuration (2A2 feed from SU2 in PTL)
    - 2A2 remained de-energized
    - GREEN Train 4160VAC Vital Bus (2A4) energized by #2EDG on Bus undervoltage condition
Unit 2 Response

- SU2 Offsite Transformer Design
  - Capable of supplying both Units
  - Operating procedures limit the number of busses on both units that can be auto-transferred to SU2
    - 2A2 breaker hand switch in Control Room in pull to lock to control auto loading in SU2
  - Capable of manual loading both busses to SU2

- SU2 Offsite Transformer remained available for use on the GREEN (2A2/2A4) Train
  - Procedural guidance to manually energize 2A2 from SU2
  - Power was stable and SU2 to 2A2 was not needed
  - Later transferred power from SU2 to 2A2
Unit 2 Response

- Unit 2 in a stable condition with power to all safety equipment
- Redundant systems available for decay heat removal
- Alternate AC Diesel Generator and 2A9 to Unit 2 busses were not damaged and were available
  - Initially declared unavailable
  - Not needed to support Unit 2
    - SU2 to both RED and GREEN Trains
    - #1 and #2 EDGs operable
Unit 2 Recovery

- Priorities dictated by circumstances
  - If additional power challenges were to occur
    - Unit 2 Control Room would re-diagnose
    - LOOP, SBO, Functional Recovery
    - Pursue procedurally directed action for recovery of available power
      - Feed to 2A2 from SU2
      - Alternate AC Diesel Generator
      - Cross tie 4160VAC busses 2A3 and 2A4
Unit 2 Recovery

- Feed for 2A2 from SU2
  - Proceduralized
  - Control Room staff trained on this action
  - In Control Room activity
  - Available resources
Unit 2 Recovery

- Alternate AC Diesel Generator (AACDG) available to Unit 2
  - AACDG and 2A9 feeds to Unit 2 not affected
  - Only visible damage was associated with 2A9 feed to Unit 1 load side connections to A1 and A3
    - Fully capable of supplying Unit 2 loads if required
    - Confirmed later by Electrical Maintenance and Engineering through inspection and testing
  - 2A9 status verification was not given a high priority based on the stable condition of the units
Unit 2 Recovery

- AACDG available for Unit 2
  - Emergency Use
    - In a black out condition, EOPs instruct operations to utilize the AACDG
    - AACDG would have been used by the Control Room to power a vital 4160VAC bus and satisfy a safety function
      - Available in ~15 minutes
      - Adequate time available to establish feed in SBO
        - 6 hours until transition to manual operations on Unit 2 EFW pump
Unit 2 Recovery

- Ability to cross-tie 4160VAC Busses was available to the Operators
  - Proceduralized
  - Operations staff is trained on this action
  - Resources available
Conclusion

- Available success paths not credited in NRC risk model
  - 2A2 availability from SU2
  - AACDG
  - Cross tie 4160VAC busses 2A3/2A4
- Four of five possible power sources available
- Resources
- Training
- Procedures
Significance Determination
Unit 2

Richard Harris
Manager, Emergency Planning
Key Objectives

- Best estimate of risk utilizing available information
  - Review key assumptions in the NRC risk assessment
  - Identify applicable ANO success paths
  - Discuss ANO risk significant results
NRC Assumptions Affecting Dominant Sequences

- Review of the NRC results for the Unit 2 SDP
  - Dominant cutsets are driven by a loss of vital power
    1. 2A2 unavailable
    2. AACDG unavailable
    3. No credit to cross tie 4160VAC busses 2A3/2A4
4160 VAC Power Recovery

- 2A2 was available from SU2
- Operations guidance and procedures available for offsite power feed to 2A2
- ANO PRA existing recovery for aligning SU2 to 2A2 is 8.0E−4
4160 VAC Power Recovery

- Operations guidance and procedures available for AACDG alignment if needed for loss of vital power
- AACDG was available and would have successfully provided power to the vital loads
- ANO has increased PRA unavailability by a factor of 0.1 for AACDG (unavailability assumed to be 0.17)
4160 VAC Power Recovery

- 2A3 / 2A4 cross tie capability was available
- Per Operations guidance and procedures, 4160VAC busses 2A3/2A4 would have been cross tied if needed for loss of vital power
- ANO PRA existing recovery of the 2A3/2A4 cross tie is 2.0E-4
Results

- These new results present a risk that is categorized as 1.8E-6 CCDP

- A sensitivity analysis reflects the following
  - 3.9E-7 CCDP – lower bound
  - 5.3E-6 CCDP – upper bound
Site Actions & Common Cause

Dale James
ANO Regulatory & Performance Improvement Director
Corrective Actions

- Lift plan for refurbished stator incorporated Root Cause findings
  - Developed Detail Engineering Change Package
  - Computer modeling
  - Load test
  - Third Party Independent Review

- Revised Entergy Fleet procedure EN-MA-119, Material Handling Program, to require a documented engineering response to evaluate specially designed temporary lifting devices
  - Owner review in accordance with EN-DC-149, Acceptance of Vendor Documents
  - Verification of a third party independent review of vendor calculations
  - Verification of load test
Corrective Actions

- Revised Entergy Fleet procedure EN-DC-114, Project Management
  - Guidance for contract language to ensure necessary design documentation provided
  - Guidance for Project Management team expertise for high consequence evolutions
- Reinforced standards for vendor oversight plans
- Established structured tool for project management oversight
- Subsequent directive issued requiring manager level validation of mitigating actions
- Industry wide web cast hosted by ANO Site VP discussing the event and lessons learned
Common Cause Review

- Review of 2013 conditions including stator drop for common causal factors
  - Seven plant conditions included in the review
    - Interviews conducted to provide additional insights
  - Trend Code and Keyword review of Category A and B Condition Reports from 2012–Present for further refinement
  - External agency and assessment report reviewed
  - Review performed by team consisting of independent analysis, fleet and ANO personnel
- Specifically charged with assessing oversight as a common causal factor
Fleet Learnings

Joe Kowalewski
Senior Vice President and COO – Southern Regional Operations
Fleet Learnings

- Entergy depends on contractors to perform work to improve the reliability and improve the safety of the plant
- Entergy must have robust processes and oversight in place to detect and correct errors before they cause significant consequences
Actions Completed

- EN-MA-119 Material Handling and EN-DC-114 have been revised to incorporate lessons learned from the ANO Stator Event
- Communication of lessons learned to the Fleet and assessment of ongoing projects with heavy lifts
- Organizational changes to provide additional oversight of engineering activities for major project and additional oversight of site project management
- Improvements in the skill assessment of supplemental personnel supervision, including Entergy presence at oral boards and evaluated practical exercises
Actions In–Progress

- Common cause evaluation of contractor performance issues
- Participation in industry committee supporting assessment and lessons learned of industry wide high consequence vendor/contractor performance issues
- Evaluation of Fleet process and oversight improvements based on industry wide lessons learned
- Implementation of improvements in the validation of completed actions for the mitigation of identified high project risks
Closing Comments

Jeremy Browning
ANO Site Vice-President
Arkansas Nuclear One Regulatory Conference

Nuclear Regulatory Commission - Region IV
Arlington, TX
May 1, 2014
Agenda

• Introduction of Participants
• NRC Opening Remarks
• Licensee Presentation
• NRC Caucus
• Final Questions
• Closing Remarks
• Conference Adjournment
• Questions and Comments from Members of the Public
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# NWX-US NUCLEAR REGULATORY COM Conference Call

**Mr. James Melfi - Conference Leader**  
**May 1 2014 @ 12:00 PM CT**  
**Confirmation # 4934859**

## Speakers:

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## Attendees:

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