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# *Overview of 08/23/11 Earthquake Response and Restart Readiness Demonstration Plan*

## *North Anna Power Station Units 1 and 2*

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# *Introduction and Agenda*

*Gene Grecheck*
*Vice President, Nuclear Development*

# Agenda

- Overview of Event
  - Station
  - ISFSI
- Seismic Results
- Restart Readiness Demonstration Plan
- Results to Date
- Restart Schedule
- Summary
- Questions

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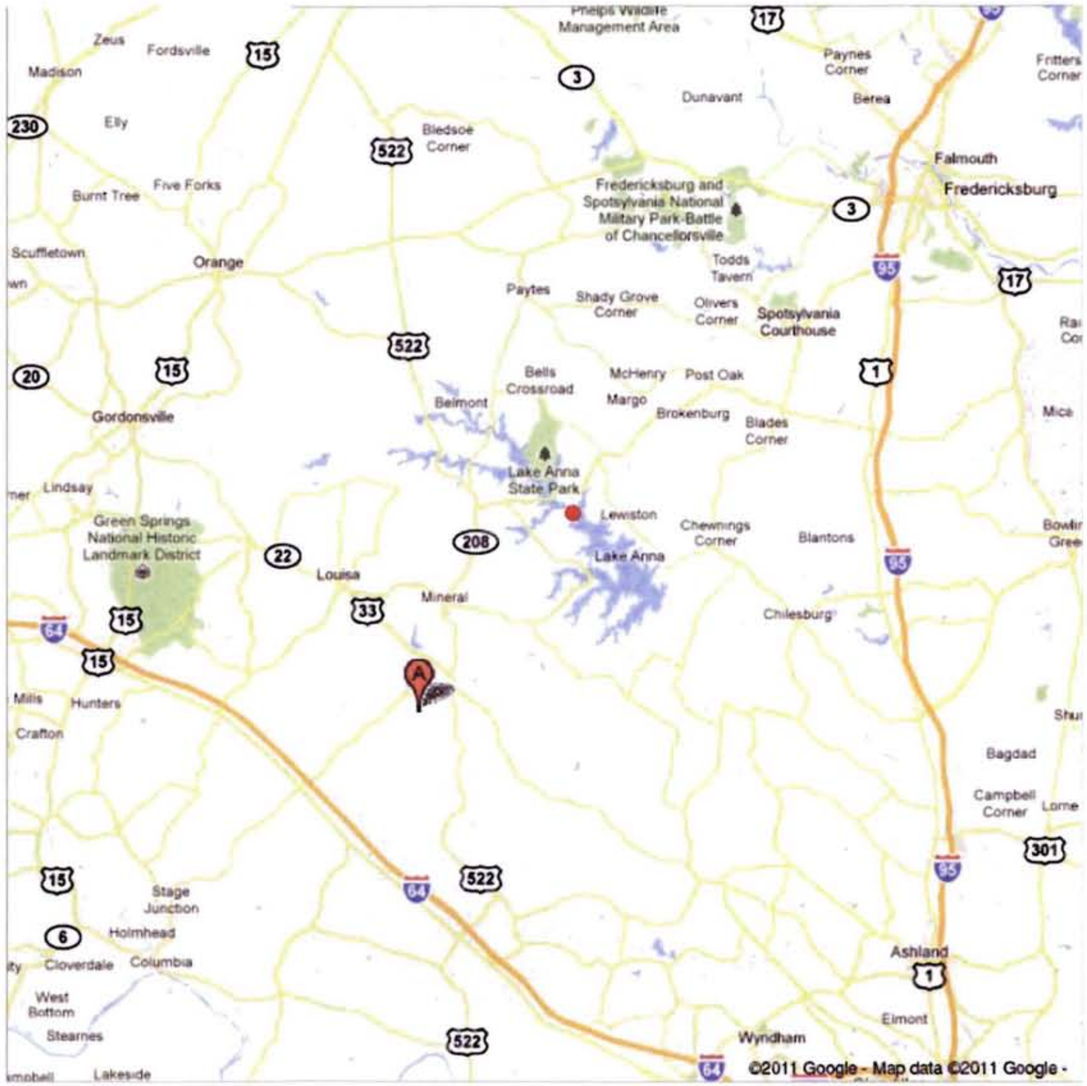
# *Overview of Event*

*Fred Mladen*
*Director, Station Nuclear Safety and Licensing*

# Overview of Event

*Quake Epicenter*

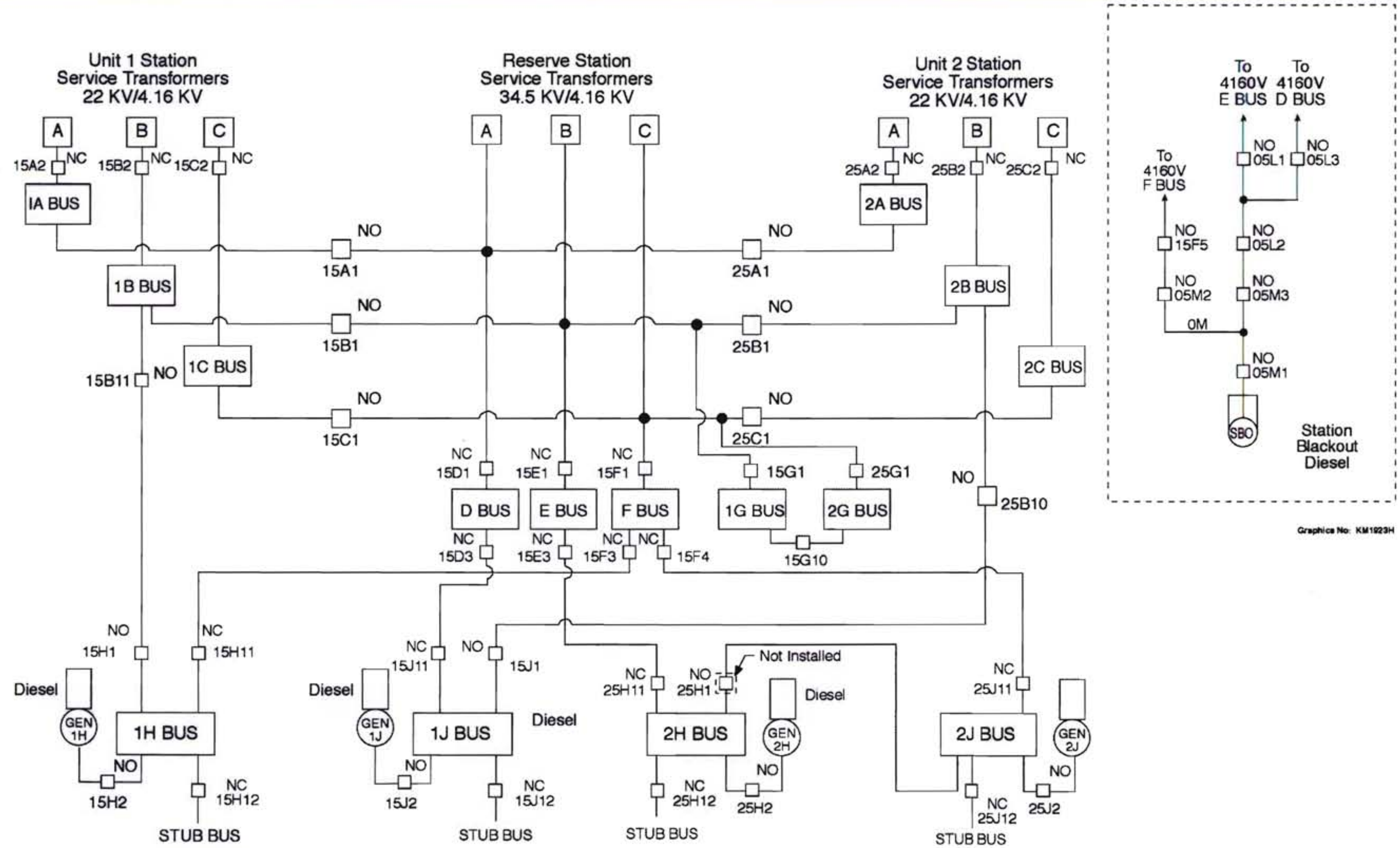
*(~Eleven miles southwest of North Anna Power Station)*



# Sequence of Events

| | |
|---|---|
| ***08/23/11*** | Both units at 100% power; U1 Turbine Driven AFW pump removed from service for scheduled surveillance test |
| 13:51:00 | Magnitude 5.8 earthquake with epicenter near Mineral, Va. |
| 13:51:11 | Reactor Trip Breakers open on negative flux rate trip (Both Units Mode 3) |
| 13:51:12 | Transformers 1-EP-MT-1A, 2-EP-MT-1A,1B, 1C, all RSSTs, 1-EP-SST-1C and Switchyard Transformer #2 tripped due to sudden pressure relay actuations (Loss of offsite power) |
| 13:51:20 | All four EDGs auto start and energize their respective emergency buses |

# North Anna Electrical Distribution System




□ NO - Normally Open

□ NC - Normally Closed

# Sequence of Events

| | |
|---|---|
| 14:03 | ALERT declared Tab HA6.1, Shift Manager judgment |
| 14:19 | 1-FW-P-2 available (flowing to “A” S/G) |
| 14:40 | 2H EDG manually tripped on coolant leak 2H Emergency Bus de-energized |
| 14:55 | ALERT declared Tab SA1.1 U2 AC capability reduced to a single source (2J EDG) |
| 15:18 | 2H Emergency Bus re-energized by the Station Blackout (SBO) Diesel |

# Sequence of Events

| | |
|---|---|
| 17:23 | Energized C RSST and F transfer bus |
| 17:40 | 2J emergency bus transferred to C RSST |
| 17:48 | 1H energized from F transfer bus, securing 1H EDG |
| 20:03 | B RSST energized |
| 20:17 | A RSST energized |
| 22:58 | Offsite power supplying Emergency Busses, 3 EDGs and SBO diesel in 'Auto' and available |

# Sequence of Events

***8/24/11***

08:51 Commenced Unit 1 cooldown

11:16 Downgrade to NOUE under Tab HU1.1

13:15 NOUE terminated

13:34 Unit 1 in Mode 4, Hot Shutdown

21:26 Unit 1 in Mode 5, Cold Shutdown

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# Sequence of Events

***8/25/11***

01:08 NOUE declared under Tab HU1.1(aftershock)

11:37 Commenced Unit 2 cooldown

16:22 Unit 2 in Mode 4, Hot Shutdown

***8/26/11***

14:05 NRC notification EP criteria seismic activity >OBE met but not declared (EAL HA6.1 versus HA1.1)

16:23 NRC notification of potential unanalyzed condition (DBE above 5 Hz)

20:38 Unit 2 in Mode 5, Cold Shutdown

# Sequence of Events

***8/28/11***

15:36 NOUE terminated

***9/1/11***

05:18 NOUE Declared, tab HU1.1 (aftershock)

12:23 NOUE terminated

# U2 Turbine Building

*Powdex Demineralizer Tanks*

*(Non-safety Related)*

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# U2 Turbine Building

*Powdex Demineralizer Tanks Base Pedestal*

*(Non-safety Related)*

# Unit 1 Containment Seal Table Room
## (Interior Wall)

# Unit 1 Containment Seal Table Room – Excavated Section

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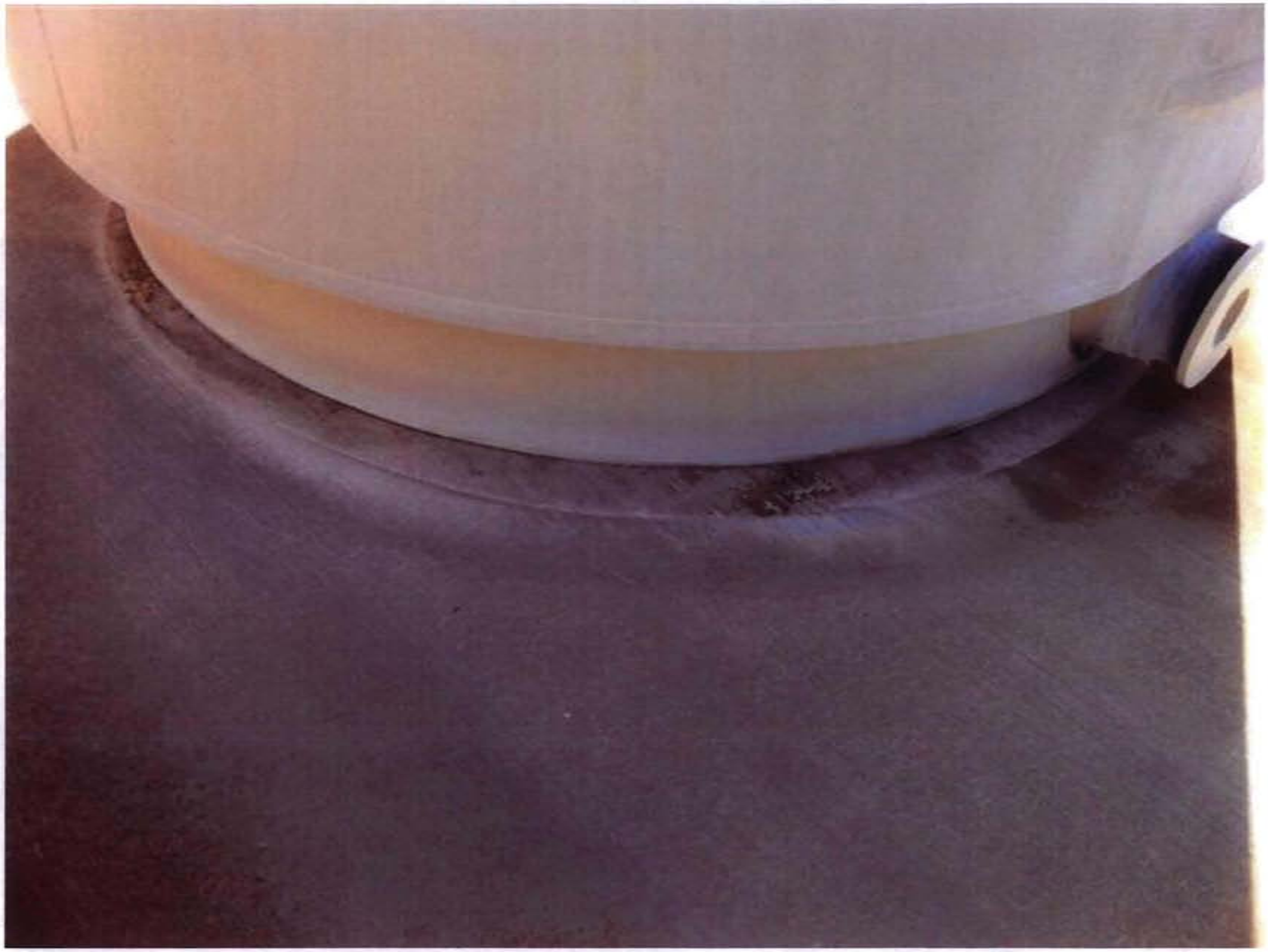
# Dry Cask Storage Pad No.1

- 25 of 27 TN-32 casks shifted during earthquake
- Largest shift was 4.5″ on TN-32.21
- No alarms were received, alarm panel test sat
- Radiological conditions were normal
- 6 pairs of casks <16′ center to center
- Confirmed all cask heat loads <27.1 KW, therefore, minimum 16′ spacing requirement not applicable
- Evaluating possible cask movement following aftershocks

# Dry Cask Storage Pad No. 1

# TN-32.21 Cask Movement



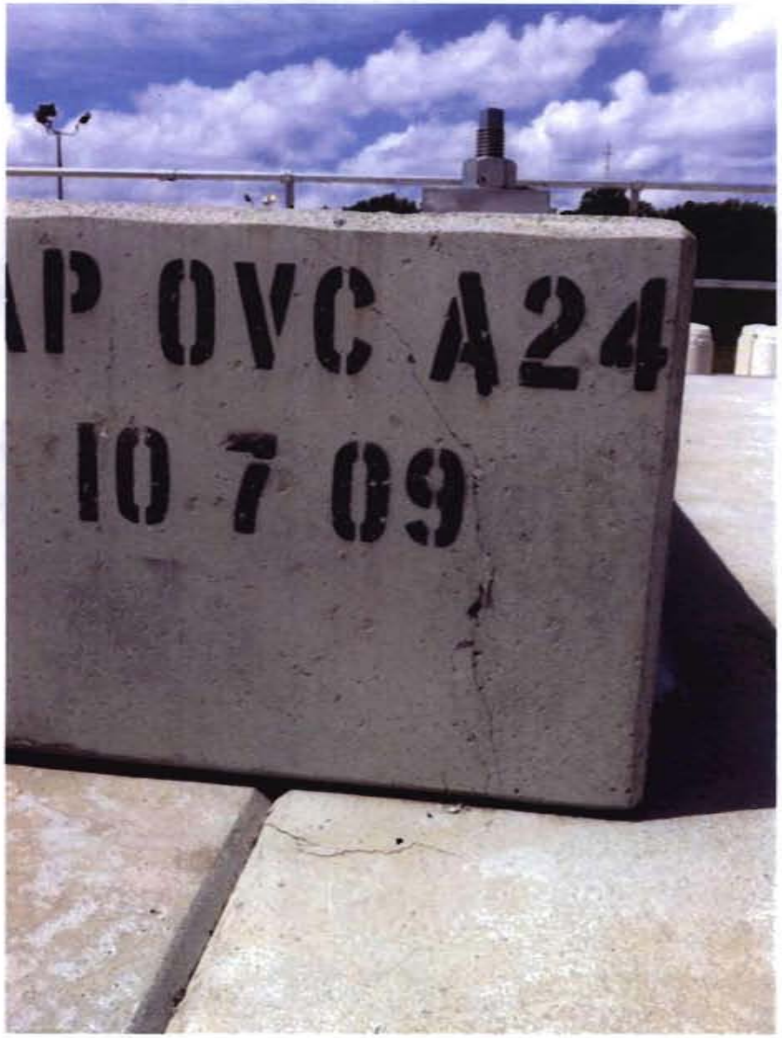
# Dry Cask Storage Pad No. 2

- NUHOMS Horizontal Storage Module
  - Gaps noted
  - Limited concrete damage (non-structural)
- HSMs were intact and capable of performing their intended function
- Radiological conditions were normal

# Dry Cask Storage Pad No. 2

# NUHOMS HSM

# NUHOMS HSM




*Roof Vents*

# NUHOMS HSM Roof Vent Screen

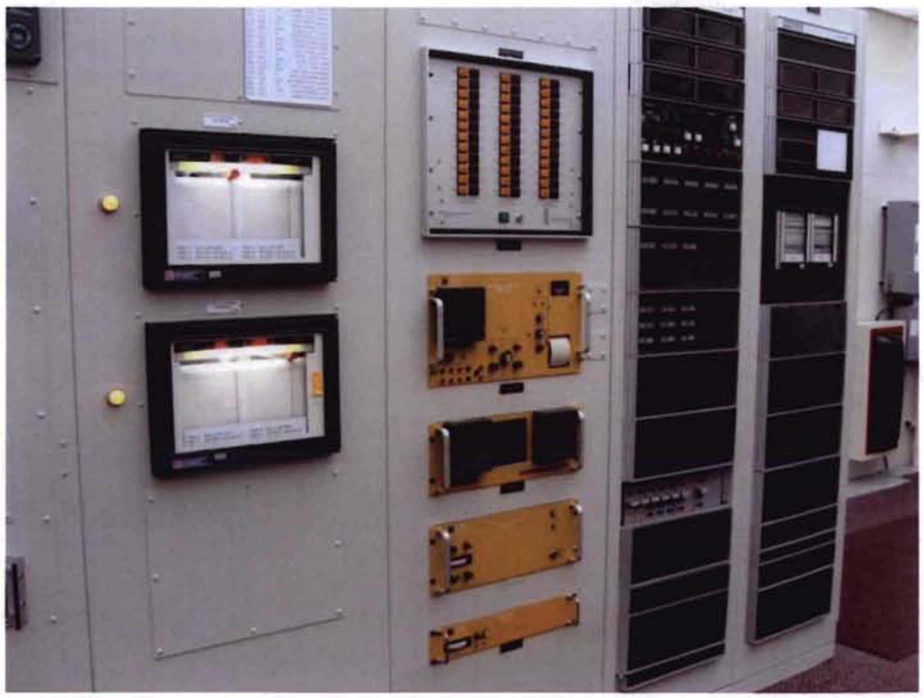
# *Seismic Results*

*Eric Hendrixson*
*Director, Nuclear Engineering*

# Plant Seismic Instrumentation

- The station has two separate recording systems, an active system (provided by Kinemetrics Inc.) and a primarily passive system (provided by Engdahl)
- Both systems provide input to the Main Control Room (MCR) via a common instrumentation panel

*MCR Seismic Instrumentation Panel*



# Plant Seismic Instrumentation

- Kinemetrics
  - Triaxial Seismic Trigger
  - Triaxial Seismic Switch
  - Triaxial Time History Accelerograph
- Engdahl
  - Triaxial Response Spectrum Recorder
  - Triaxial Peak Accelerograph

# Plant Seismic Instrumentation (Kinemetrics - Active)

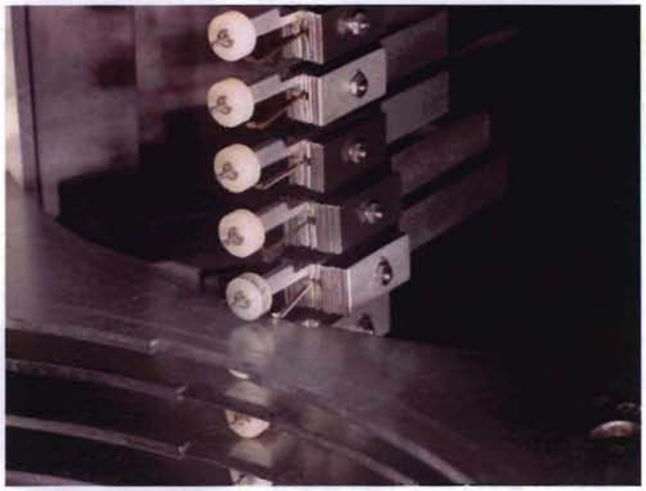
| Sensor Type | Location/Elevation | Equipment Mounting |
|---|---|---|
| Triaxial Time History Accelerograph | Unit 1 Containment 216' | U1 Containment Mat |
| Triaxial Seismic Trigger | Unit 1 Containment 216' | U1 Containment Mat |
| Triaxial Seismic Switch | Unit 1 Containment 216' | U1 Containment Mat |
| Triaxial Time History Accelerograph | Unit 1 Containment 291' | U1 Containment Operating Deck |

# Plant Seismic Instrumentation (Engdahl - Passive)

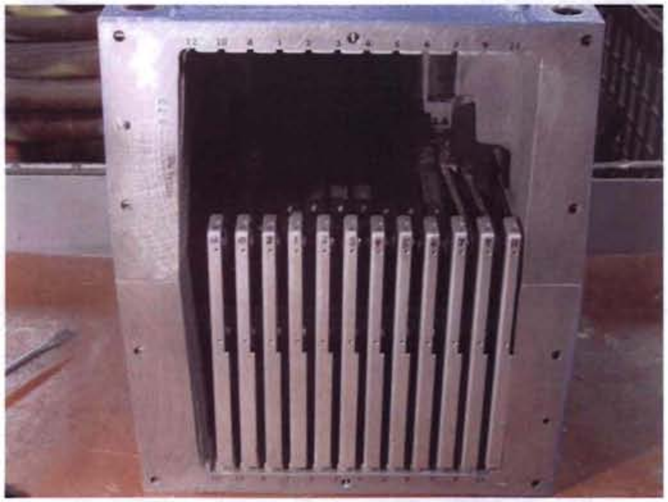
| Sensor Type | Location/Elevation | Equipment Mounting |
|---|---|---|
| Triaxial Response Spectrum Recorder | Unit 1 Containment 216' | Unit 1 Containment Mat |
| Triaxial Response Spectrum Recorder | Unit 1 Containment 231' | Unit 1 Residual Heat Removal (RHR) pump and heat exchanger area |
| Triaxial Response Spectrum Recorder | Aux Building 244' | In between Unit 1 and Unit 2 Component Cooling (CC) pumps |
| Triaxial Response Spectrum Recorder | Aux Building 274' | Near Unit 1 "A" CC heat exchanger |
| Triaxial Peak Accelerograph | Unit 1 Containment 218' | On Unit 1 "C" Safety Injection Accumulator discharge piping |
| Triaxial Peak Accelerograph | Unit 1 Containment 241' | On Unit 1 "B" RHR heat exchanger |
| Triaxial Peak Accelerograph | Aux Building 279' | On Unit 1 "A" CC heat exchanger, |

# Triaxial Response Spectrum Recorder

Triaxial Response Spectrum Recorder



Recorder Scratch Plates Styluses

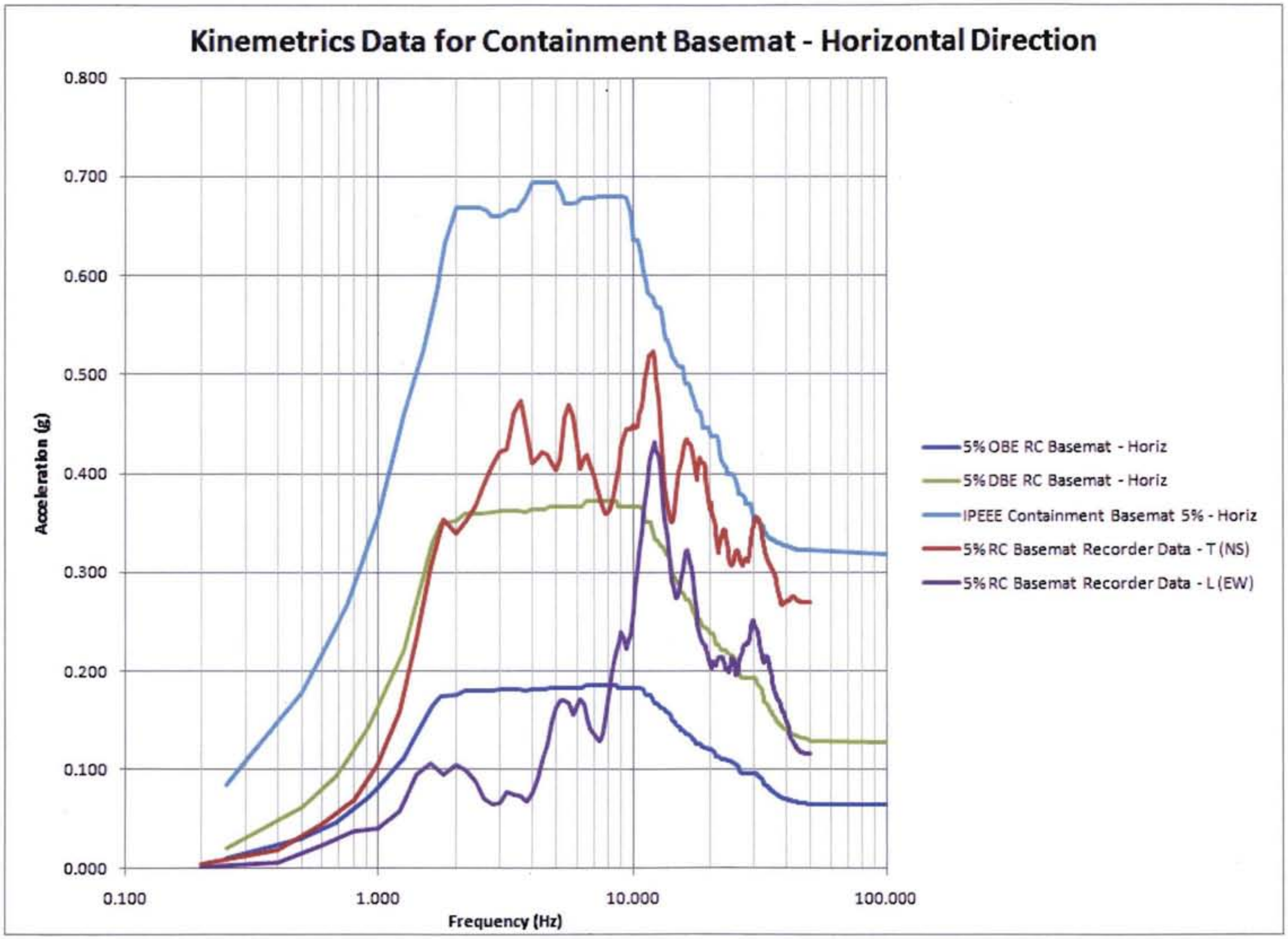


Recorder Scratch Plates

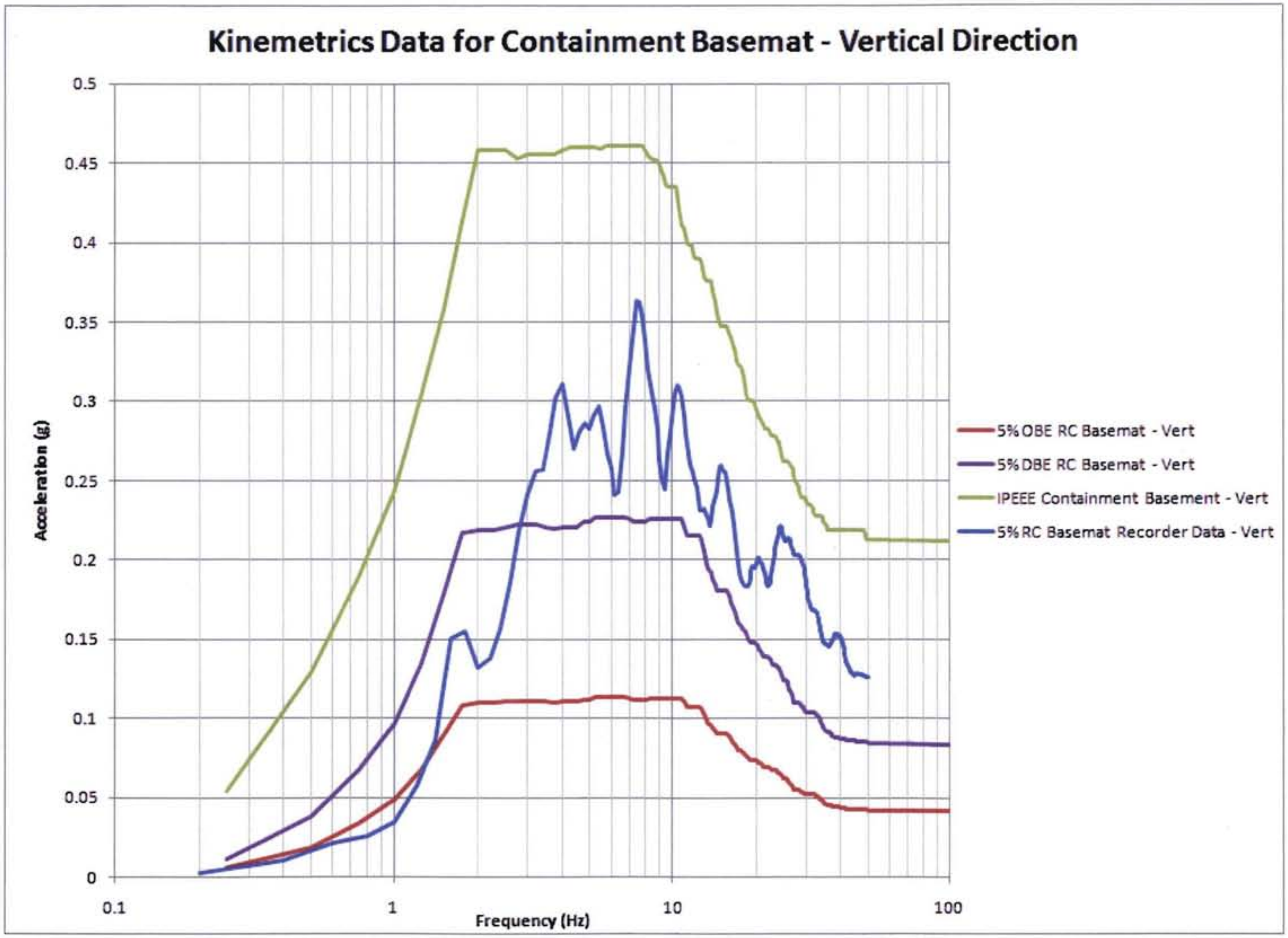
# North Anna Design Basis Seismic Criteria (Station and ISFSI)

| | Horizontal Peak Ground Acceleration (g) Rock | Vertical Peak Ground Acceleration (g) Rock | Horizontal Peak Ground Acceleration (g) Soil | Vertical Peak Ground Acceleration (g) Soil |
|---|---|---|---|---|
| OBE | 0.06 | 0.04 | 0.09 | 0.06 |
| DBE | 0.12 | 0.08 | 0.18 | 0.12 |

# Comparison of Kinemetrics Data – Horizontal Direction



# Comparison of Kinemetrics Data – Vertical Direction



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# Cumulative Absolute Velocity (CAV)

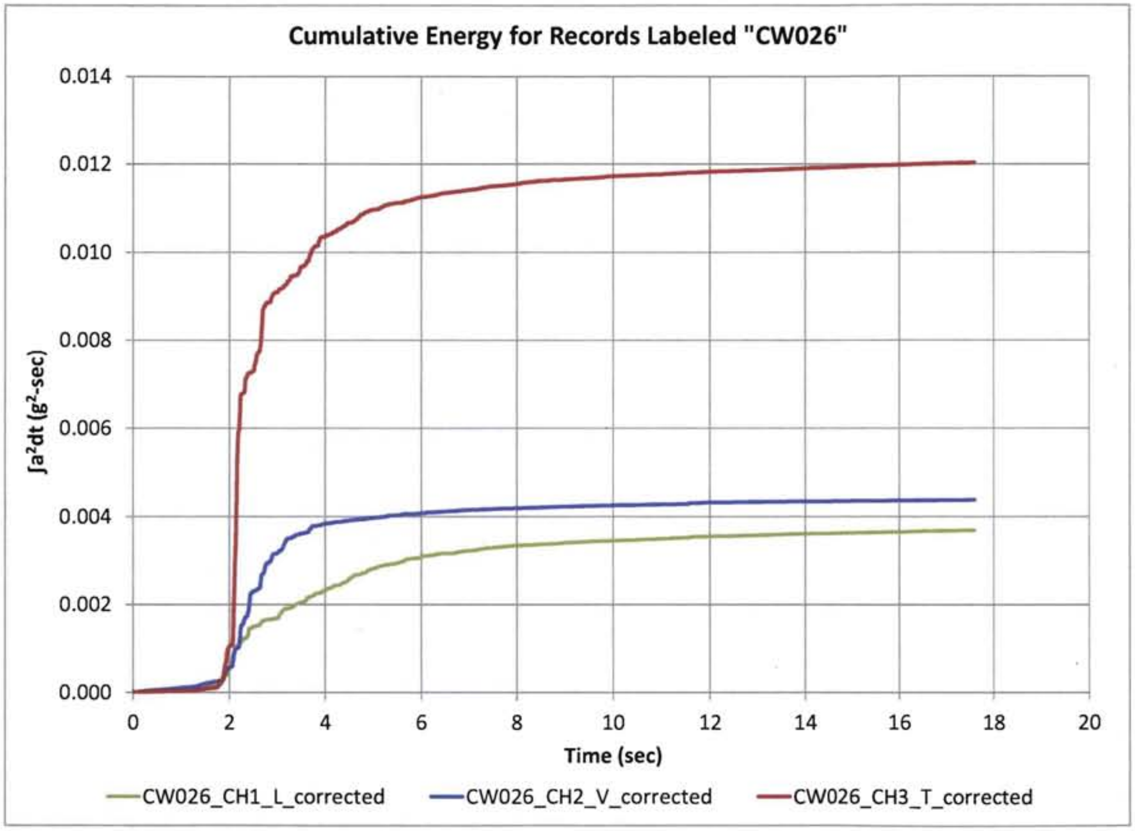
- Concept used by EPRI to address OBE Exceedance in 1988 (EPRI NP-5930)
- Indicator of damage based on analysis of 263 time-histories from 42 earthquakes
- OBE Exceedance criterion is CAV <0.16 g-sec (EPRI TR-100082 and RG 1.166)
- Criterion is conservative and has a minimum factor of three

# Plant Seismic Response Results

| | East-West (g-sec) | North-South (g-sec) | Vertical (g-sec) |
|---|---|---|---|
| Kinemetrics | 0.137 | 0.175 | 0.118 |
| SGH | 0.118 | 0.169 | 0.105 |
| Bechtel | 0.134 | 0.181 | 0.113 |
| **Average** | **0.130** | **0.175** | **0.112** |

(CAV limit = 0.16 g-sec, per NRC RG 1.166)

# Husid Function Plot – Representation of Cumulative Energy




**Cumulative Energy (HUSID Plot) for the Containment Basemat Records**

**Effective Strong Motion Duration for Records Labeled "CW026"**

| Time History | Effective Strong Motion Duration (sec) |
|---|---|
| CW026_CH1_L_corrected | 3.1 |
| CW026_CH2_V_corrected | 1.5 |
| CW026_CH3_T_corrected | 1.0 |

# Seismic Margin

As part of response to GL 88-20 (IPEEE) and GL 87-02 (USI-A46 ), the following actions were completed:

- Extensive inspections of 1800 safe shutdown components assuming an earthquake peak acceleration of 0.3g for IPEEE
- With few exceptions, components evaluated could withstand 0.3g or higher
- Worst case capacity of 0.16g, which exceeds 0.12g DBE
- Modifications provided additional seismic ruggedness
- Comprehensive peer review walkdown of 20% sample

Consequently, safe shutdown components are capable of surviving seismic accelerations in excess of the DBE design criteria

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# *Restart Readiness Demonstration Plan*

# Dominion Restart Readiness Demonstration Plan

## North Anna UFSAR – Section 3.7.4.6

*Use of Data from Seismic Instrumentation* - In accordance with paragraph V(a) of Appendix A to 10 CFR 100, an orderly and sequential shutdown of the North Anna units will be carried out according to detailed written station procedures if a seismic event with vibratory ground motion equal to or exceeding that of the operational-basis earthquake occurs. **Prior to resuming operations, it will be demonstrated to the NRC that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public, or that the necessary repairs to those features have been completed.** *[emphasis added]*

# Restart Readiness Demonstration Plan

Based on exceeding the station OBE and DBE seismic criteria and the CAV limit, the station restart readiness assessment actions were based on the guidance contained in the following documents:

- RG 1.166, *Pre-earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions,* dated March 1997
- RG 1.167, *Restart of a Nuclear Power Plant Shut Down by a Seismic Event,* dated March 1997
- EPRI NP-6695, *Guidelines for Nuclear Plant response to an Earthquake,* dated December 1989

# EPRI NP-6695 Figure 3-1

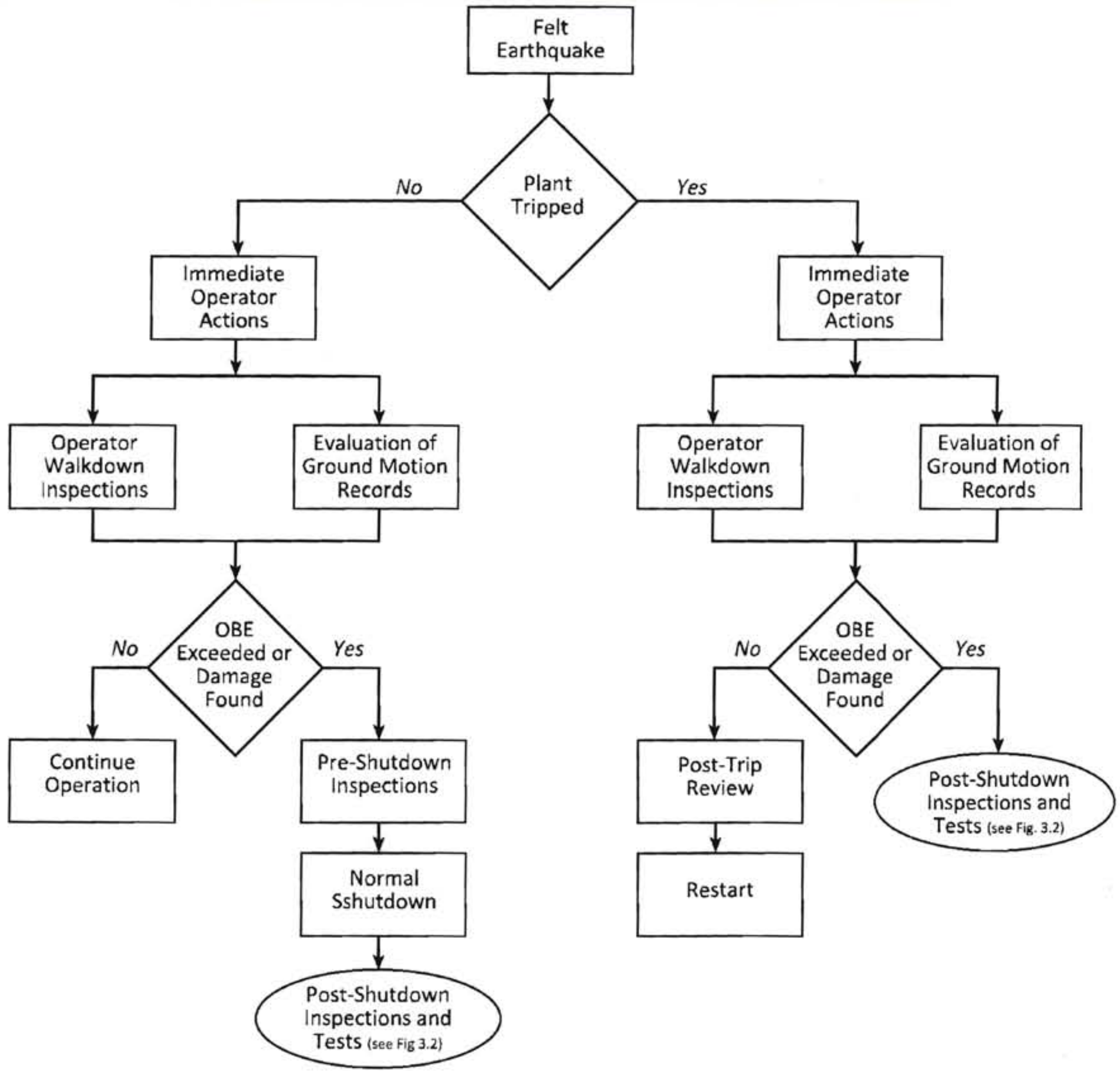


Figure 3-1. Flow Diagram of Short-Term Actions

# EPRI NP-6695 Figure 3-2

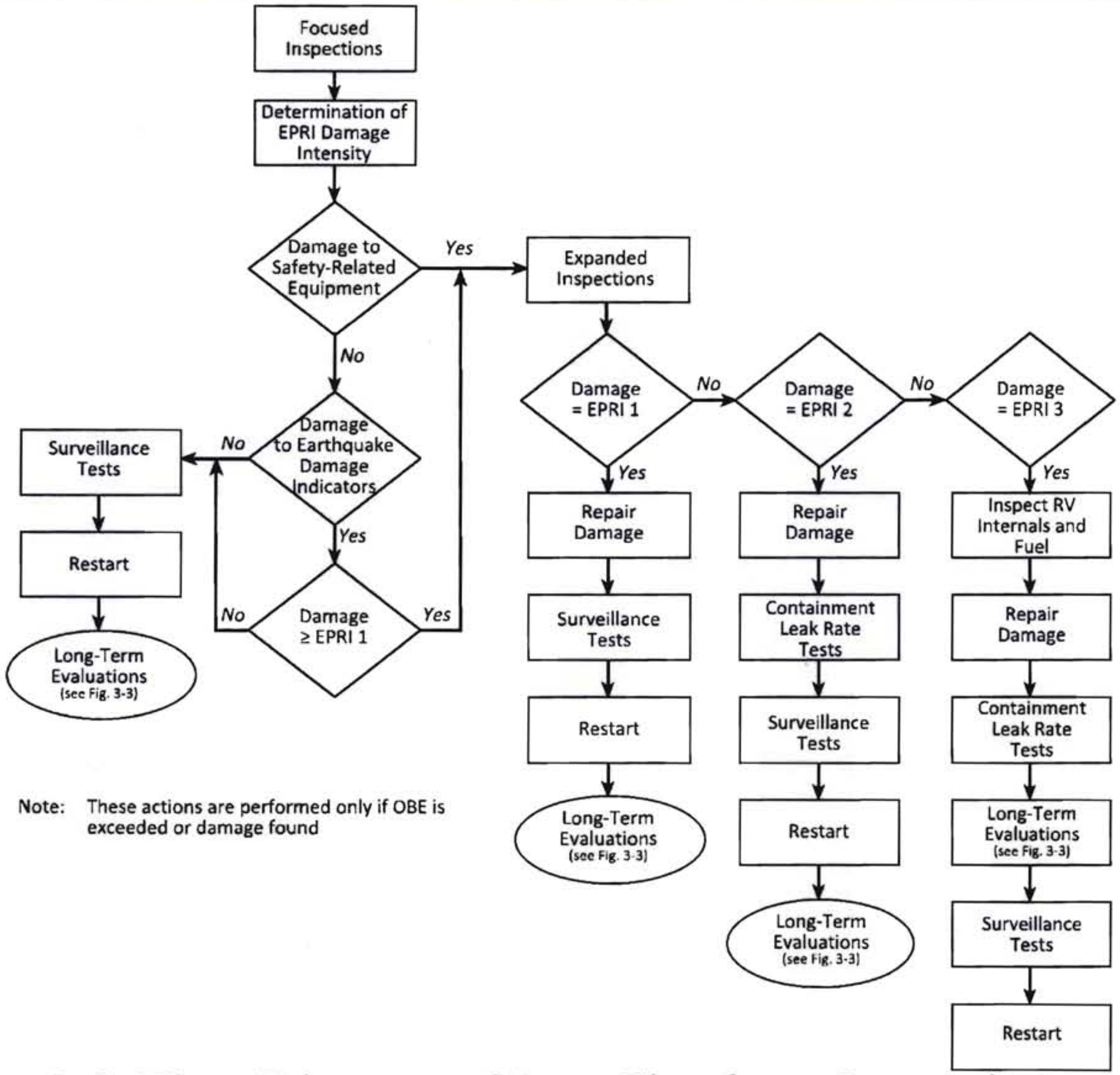


Figure 3-2. Flow Diagram of Post-Shutdown Inspections and Tests

# EPRI NP-6695 Figure 3-2

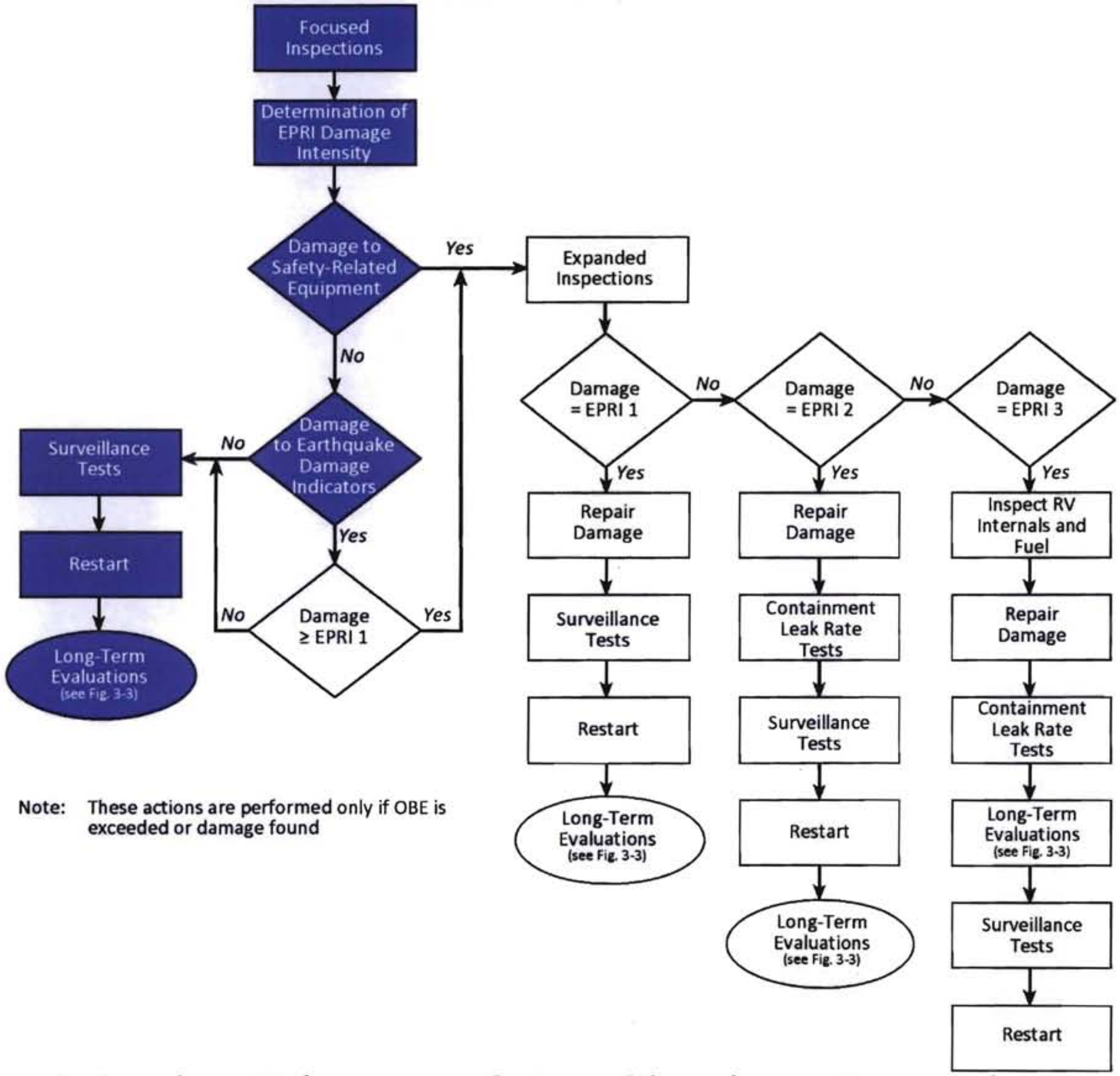


Figure 3-2. Flow Diagram of Post-Shutdown Inspections and Tests

# EPRI NP-6695 Figure 3-2

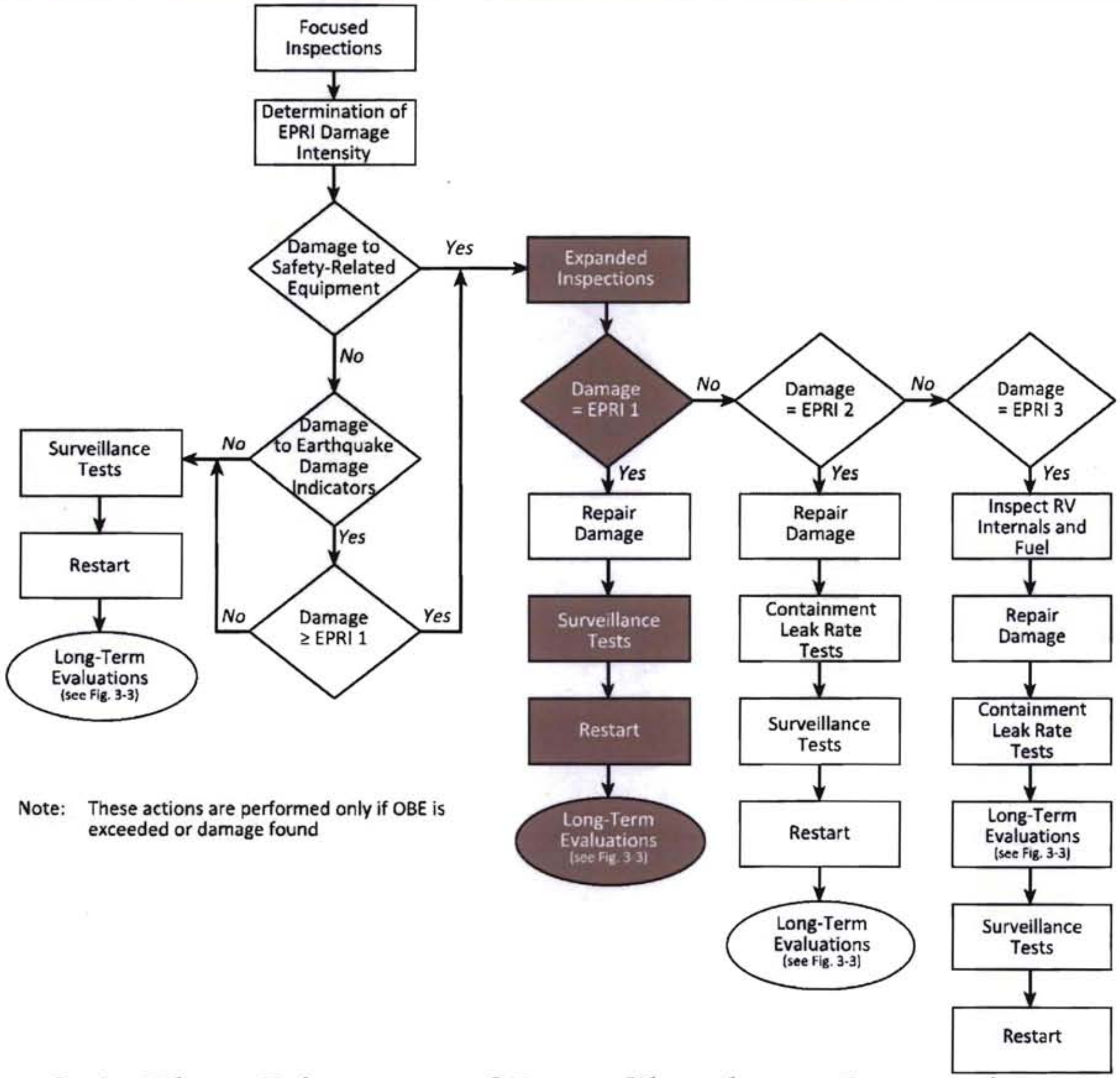


Figure 3-2. Flow Diagram of Post-Shutdown Inspections and Tests

## Dominion Restart Readiness Demonstration Plan

- Seismic Data Collection and Analysis
- Damage Assessment and Evaluation
- Restart Assessment
- Long-Term Actions

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# Restart Readiness Demonstration Plan

## Seismic Data Collection and Analysis

- Perform data collection/analysis of earthquake seismic data to quantitatively define earthquake magnitude - **Complete**
- Compare results with the station design basis OBE and DBE criteria to determine if they were exceeded - **Complete**
- Obtain 3rd party peer reviews of analysis by industry experts

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# Restart Readiness Demonstration Plan

## Damage Assessment and Evaluation

- Perform post-earthquake walkdowns/inspections of plant structures, systems and components (SSCs) consistent with regulatory and industry guidance (includes North Anna Spillway dam and SG tube inspections)
- Perform comprehensive surveillance testing to validate SSC operability/performance
- Perform comprehensive inspections and evaluations of ISFSI pads and casks
- Perform evaluations of reactor vessel internals and fuel in the core, Spent Fuel Pool and New Fuel Storage Area
- Complete Root Cause Evaluation of reactor trip
- Document assessments/evaluations in appropriate engineering technical evaluations

# Restart Readiness Demonstration Plan

## Restart Assessment

- Complete inspections, evaluations, testing and repair, if necessary, of SSCs to ensure they are capable of performing their intended design functions
- Finalize and obtain FSRC review and approval of Engineering technical documents demonstrating SSC restart readiness
- Review and disposition open Condition Reports, as necessary, to ensure that no outstanding issues exist that would preclude restart

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# Long-Term Actions

- Installation of free-field seismic instrumentation
- Permanently re-power Seismic Monitoring Panel in MCR from an Uninterruptible Power Supply
- Coordinate update of the station seismic design and licensing bases with ongoing GI-199 resolution effort

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# *Results to Date*

*Mark Walker*

*Manager, Nuclear Site Engineering*

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# Results to Date

Although evaluations are continuing, to date, SSCs inspections have only identified superficial damage and Surveillance Tests have not identified any safety-related SSC operability issues related to the seismic event

- Inspector Training and Inspection Process
- Inspection results indicate North Anna in the "0" category of the EPRI Damage Intensity Scale
- As of 9/7/11
  - 82% of 134 system inspections completed
  - 97% of 141 structure inspections completed
  - 28% of 448 Surveillance Tests completed (Unit 1)
  - 20% of 50 High Confidence Low Probability of Failure (HCLPF) component SQUG inspections completed

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# *Restart Schedule*

*N. Larry Lane*
*Site Vice President – North Anna Power Station*

# NAPS U1 Restart Timeline

| | |
|---|---|
| 09/07 | Facility Safety Review Committee (FSRC) approval of Safe Shutdown System Operability Determination |
| 09/16 | Engineering Final Technical Evaluation review by FSRC |
| 09/18-20 | Comprehensive ESF functional testing complete |
| | Comprehensive post-event testing and inspections complete |
| | Start-up Assessment by FSRC |
| 09/22 | Containment close-out complete and unit ready to enter Mode 4 |

# NAPS U2 Planned Refueling Restart Timeline

| | |
|---|---|
| 09/07 | FSRC approval of the Safe Shutdown System OD |
| 09/12 | FSRC approval of the Mode 6 System OD |
| 09/12-15 | Reactor Disassembly- Inspections |
| 09/15-17 | Reactor Core Off-load to the SFP |
| 09/16 | Secondary activities complete |
| | Engineering Final Technical Evaluation review by FSRC |
| 09/17-30 | Defueled Primary Maintenance |
| 10/01-02 | Reactor Core Reload |
| 10/02-06 | Reactor Reassembly |
| 10/06-13 | Comprehensive ESF functional testing complete |
| | Comprehensive post-event testing and inspections complete |
| | Containment close-out complete |
| | Start-up Assessment by FSRC |
| 10/13 | Ready for Mode 4 |

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# *Summary*

*Gene Grecheck*
*Vice President, Nuclear Development*

# Summary

- OBE and DBE criteria were exceeded; however, CAV calculations indicate that significant damage would not be expected
- Extensive actions are underway to inspect, evaluate, test and repair, if necessary, SSCs to ensure they are capable of performing their required design basis functions - Results are confirming the CAV expectations
- To date, no safety related SSCs have been identified that require repair
- IPEEE and USI-A46 results demonstrate that safe shutdown SSCs are capable of withstanding peak accelerations in excess of DBE
- Unit will be ready for restart when we establish confidence that SSCs will perform as designed
- Long-term actions are planned to improve plant seismic monitoring capability and to re-evaluate plant OBE and DBE criteria in conjunction with resolution of GI-199

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# *Questions?*

# List of Acronyms

| | |
|---|---|
| AC | Alternating Current |
| AFW | Auxiliary Feedwater |
| DBE | Design Basis Earthquake |
| EAL | Emergency Action Level |
| EDG | Emergency Diesel Generator |
| EP | Electric Power or Emergency Plan |
| EPRI | Electric Power Research Institute |
| ESF | Engineered Safety Features |
| FSRC | Facility Safety Review Committee |
| FW | Feedwater |
| GI | Generic Issue |
| HSM | Horizontal Storage Module |
| IPEEE | Individual Plant Examination External Events |
| KW | Kilowatts |
| MT | Main Transformer |
| NRC | Nuclear Regulatory Commission |
| NOUE | Notification of Unusual Event |
| NUHOMS | Nuclear Horizontal Modular Storage System |
| OBE | Operating Basis Earthquake |
| OD | Operability Determination |
| P | Pump |
| RSST | Reserve Station Service Transformer |
| SBO | Station Blackout |
| SGH | Simpson Gumpertz & Heger |
| SFP | Spent Fuel Pool |
| SSC | Systems, Structures and Components |
| SST | Station Service Transformer |
| TN | Transnuclear |
| U1 | Unit 1 |
| U2 | Unit 2 |
| USI | Unresolved Safety Issue |

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