



Browns Ferry Nuclear Plant

Extended Power Uprate License Amendment Request Flow Induced Vibration Monitoring Program

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BFN EPU – Agenda

Introductions

G. Doyle

Overview and Schedule

G. Doyle

Browns Ferry Nuclear Plant Flow Induced Vibration (FIV)
Monitoring Program

P. Donahue

Questions/Comments

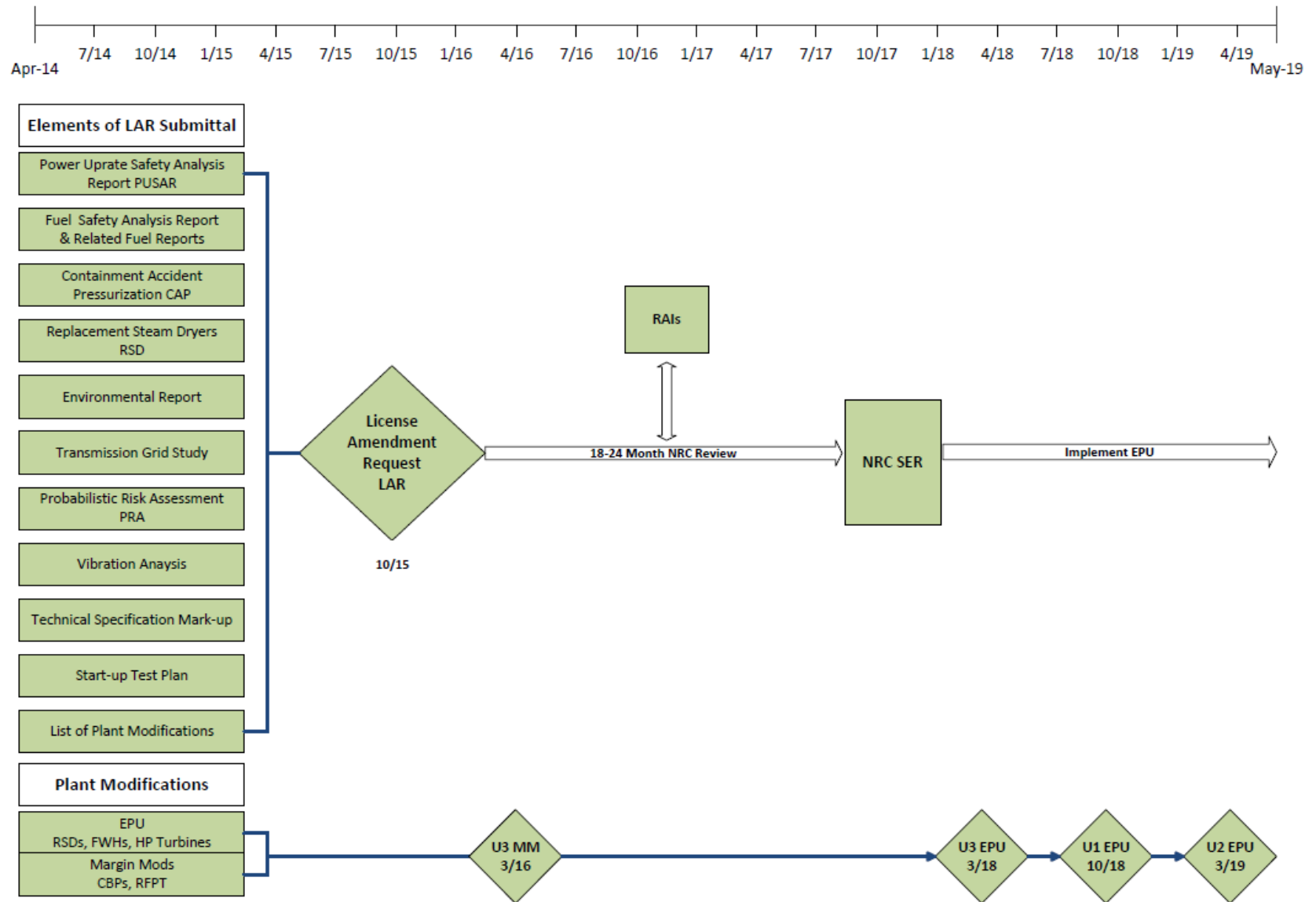
G. Doyle

BFN EPU – Overview and Schedule

New consolidated Browns Ferry Nuclear Plant (BFN) Extended Power Uprate (EPU) License Amendment Request (LAR) submittal

- Supersedes previous BFN EPU submittals
 - Addresses current BFN conditions and licensing basis (e.g., AREVA ATRIUM 10XM fuel type)
- Uses the format of RS-001, Review Standard for Extended Power Upgrades
- Addresses previous applicable NRC Requests for Additional Information (RAIs)
- Applies improved submittal verification process to ensure completeness and accuracy
- We are here to present and discuss our Flow Induced Vibration Monitoring Program
 - Vibration Monitoring Program is consistent with existing guidance
 - Includes discussions on monitoring scope and acceptance criteria

BFN EPU – Overview and Schedule



BFN EPU – FIV Monitoring Program

Background

- Vibration levels of the Main Steam (MS) and Feedwater (FW) piping are expected to increase by approximately 35% based on flow increases of up to 16%
- Other possible sources of increased vibration, such as flow instabilities or acoustic resonance as a result of increased flow velocities, may contribute to EPU vibration levels
- Acoustic vibration suppressors have been installed on the MS system at the BFN units to reduce vibration susceptibility of piping and components
- Flow rates in portions of the Condensate (CD), Extraction Steam (ES) and Heater Drains (HD) systems increase similarly to MS and FW, and are susceptible to increased vibration at EPU conditions
- Confirmatory test program will be implemented to monitor piping and attached component vibration levels during initial power ascension to EPU conditions
- Vibration studies associated with Steam Dryer replacement, including effects of Reactor Recirculation Pump vane passing frequencies will be addressed as part of Steam Dryer vibration monitoring

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Previous Vibration Monitoring

- Vibration levels at Current Licensed Thermal Power (CLTP) (3458 MWt) were obtained as part of the BFN Unit 1 restart in 2007
- Additional CLTP vibration data was collected in 2008, for BFN Unit 1 MS and FW piping and components
- These tests provided vibration information that led to the installation of Acoustic Vibration Suppressors (AVS) on BFN Units 1, 2, and 3
- BFN Unit 1 CLTP vibration monitoring results are part of the basis for the vibration monitoring that will be performed during EPU power ascension for BFN Units 1, 2, and 3

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Previous Vibration Monitoring (continued)

- MS and FW Piping Location Selection
 - Hydraulic and structural models of the MS and FW piping were created for determination of the vibration monitoring locations and development of the vibration acceptance criteria
 - The vibration monitoring locations were selected based on the structural time history analysis results, where significant displacements occurred relative to other locations
 - The measurement locations were also selected such that the general overall piping response would be reflected in the data and it would not be likely that significant vibrations would be missed

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Previous Vibration Monitoring (continued)

- Acceptance Criteria Development
 - Allowable displacement and acceleration limits at the selected measurement locations were calculated based on the analysis results and American Society of Mechanical Engineers (ASME) code fatigue stress limits for steady state vibration consistent with ASME OM-S/G, Part 3 (OM-3)
 - The primary acceptance criteria are in terms of displacement, which is directly proportional to pipe stress
 - Secondary acceptance criteria in terms of acceleration were determined for locations where accelerometers are used for monitoring

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Previous Vibration Monitoring (continued)

- Acceptance Criteria Development
 - The displacement limits for MS and FW are applicable for vibration frequencies up to 50 Hz, which corresponds to the frequency range in which the most significant structural displacement responses are expected
 - Piping displacements due to excitation frequencies above 50 Hz are typically insignificant relative to the lower frequency displacements
 - Secondary acceleration limits established for the FW piping inside containment are also applicable for frequencies up to 50 Hz, since significant forcing frequencies and structural responses above 50 Hz are not expected in the FW system
- Acceptance Criteria used during previous vibration monitoring to be applied to EPU vibration monitoring

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Operating Experience

- NEDO-33159, Extended Power Uprate Lessons Learned and Recommendations
- Significant Event Report (SER) 2-06, Operating Experience (OE) 22641 at Quad Cities and recent NRC finding (Dresden) – Main Steam Relief Valve (MSRV) failures related to vibration
- Institute of Nuclear Power Operations (INPO) Report 13-22 Feed Regulator Valve Failure – Air supply line failure due to high vibration at Waterford
- INPO Report 12-81 Steam Bypass Control Valve Failures – Vibration related Steam Bypass Control System failures at St Lucie
- BFN component specific evaluations based on OE – Fatigue and Wear
 - MSRVs – Target Rock Solenoid Valves and Pilot Assemblies, Temperature Elements
 - MSIVs – Limit Switches
 - MS, HPCI, RCIC Valve Operators and Limit Switches

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EPU Vibration Monitoring

- MS and FW Monitoring Scope
 - Inside Containment MS and FW
 - MS Piping: 7 monitoring locations, 12 measurements (1 or 2 directions per location)
 - FW Piping: 9 monitoring locations, 14 measurements (1 or 2 directions per location)
 - MS Components: 8 monitoring locations, 24 measurements (3 directions per location)
 - Outside Containment MS and FW
 - MS piping: 11 monitoring locations, 20 measurements (1 to 3 directions per location)
 - FW piping: 13 monitoring locations, 23 measurements (1 or 2 directions per location)

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EPU Vibration Monitoring (continued)

- Component Monitoring Scope
 - BFN operating history indicates that excessive component vibrations should be not expected at EPU conditions
 - In order to provide confirmation that component vibrations will be within acceptable limits at EPU conditions, selected components will be instrumented with accelerometers
 - The selected components include:
 - Four safety-relief valves (SRV)
 - One main steam isolation valve (MSIV)
 - Inboard isolation valve for the MS drain piping
 - Inboard isolation valve for the reactor core isolation cooling (RCIC) turbine steam supply line
 - Inboard isolation valve for the high pressure coolant injection (HPCI) turbine steam supply line

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EPU Vibration Monitoring (continued)

- Balance of Plant (BOP) Systems Monitoring Scope
 - Condensate System
 - The CD piping between the 3rd stage feedwater heaters and the reactor feedwater pumps (RFPs) as well as the CD piping between the 4th stage feedwater heaters and the 3rd stage feedwater heaters were selected for EPU vibration monitoring
 - Extraction Steam System
 - The ES piping from the high pressure (HP) turbine to the 1st stage feedwater heaters and the ES piping from the low pressure (LP) turbine to the 2nd stage feedwater heaters was selected for EPU vibration monitoring
 - Heater Drains System
 - The HD system between the 1st and 2nd stage feedwater heaters and between the 2nd and 3rd stage feedwater was selected for EPU vibration monitoring

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EPU Vibration Monitoring (continued)

- Small Bore Piping Susceptibility Evaluation
 - Considerations
 - The presence or absence of a tie-back support
 - The routing and support configurations of the small bore lines
 - Lines with unsupported concentrated masses or long, unsupported runs
 - The expected amplitudes of the header vibrations
 - Small bore lines included in the large bore piping models
 - The time history analysis results are used to determine the susceptibility of the small bore lines to the header-induced vibrations
 - Potentially susceptible configurations will be identified and addressed
 - Any necessary modifications identified in the analysis will be made prior to EPU power ascension
 - Previous studies identified 10 locations for EPU monitoring studies
 - Additional locations for EPU monitoring may be identified as a result of the susceptibility evaluation

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Conclusions

- Review of previous vibration data collected during BFN Unit 1 restart power ascension testing indicates CLTP vibration levels well within acceptable limits
- Extrapolation of the CLTP data to EPU power levels indicates that vibration of piping and components will not be adversely affected by EPU operation
- Piping and attached components on systems experiencing significant flow increases as a result of EPU will be included in the vibration monitoring program
- Piping vibration acceptance criteria is based on ASME OM-3
- Component vibration acceptance criteria is based on component-specific dynamic characteristics and industry experience
- Small bore piping assessments will be performed to identify potentially susceptible configurations, and any modifications required to reduce vibration susceptibility will be made prior to EPU power ascension

BFN EPU – Acronym List

- ASME – American Society of Mechanical Engineers
- AVS – Acoustic Vibration Suppressors
- BFN – Browns Ferry Nuclear Plant
- BOP – Balance of Plant
- CD – Condensate
- CLTP – Current Licensed Thermal Power
- EPU – Extended Power Uprate
- ES – Extraction Steam
- FW – Feedwater
- HD – Heater Drains
- HP – High Pressure
- HPCI – High Pressure Coolant Injection
- Hz – Hertz
- INPO – Institute of Nuclear Power Operations
- LAR – License Amendment Request
- LP – Low Pressure
- MS – Main Steam
- MSIV – Main Steam Isolation Valve
- MSRV – Main Steam Relief Valve
- MWt – Megawatt Thermal
- NRC – Nuclear Regulatory Commission
- OE – Operating Experience
- OLTP – Original Licensed Thermal Power
- RAI – Request for Additional Information
- RCIC – Reactor Core Isolation Cooling
- RFP – Reactor Feedwater Pump
- SER – Significant Event Report
- SRV – Safety Relief Valve

BFN EPU – Questions/Comments