Browns Ferry ATRIUM-11 Fuel Transition

License Amendment Request: Pre-Application Meeting

June 8, 2020

Background

- TVA intends to transition to ATRIUM-11 fuel at Browns Ferry
  - First reload targeted for unit 2 reload 22 in February 2023
- TVA has experience with ATRIUM-11 fuel
  - Eight LUAs were inserted into unit 2 in 2015
  - Have completed nearly three two year cycles of irradiation
  - No adverse operating experience
- Framatome advanced methods are needed to support ATRIUM-11
- TVA will docket a Licensing Amendment Request (LAR) to request approval to add the methods to the Technical Specifications
  - Implementation addressed under 10 CFR 50.59

Licensing Approach

- TVA will follow the Brunswick and Susquehanna LAR approaches
- LAR will demonstrate application of new methods using an equilibrium Browns Ferry ATRIUM-11 core
- Select cycle specific reports will be provided for information post LAR for the implementation cycle
- LAR will also address RAIs received during Brunswick and Susquehanna LAR reviews, as applicable

LAR Content Overview

- Fuel cycle design report
  - Document BFN equilibrium ATRIUM-11 core design
- Nuclear fuel design report
  - Document bundle design details of equilibrium cycle assemblies
- Assembly mechanical design report
  - Compliance with SRP and Framatome mechanical design criteria
  - Compatibility of ATRIUM-11 with BFN co-resident fuel and reactor internals
- Fuel rod thermal mechanical design report
  - Demonstrate application of RODEX4 to ATRIUM-11 using equilibrium cycle design

LAR Content Overview (cont)

- Thermal hydraulic report
  - Demonstration of thermal hydraulic compatibility of ATRIUM-10 XM and ATRIUM-11 at BFN
- Methods applicability supplement
  - Address topics related to ATRIUM-11 and new methods
  - Similar in content to Brunswick report ANP-3705P
- LOCA report
  - Analysis of BFN break spectrum with NRC approved AURORA-B LOCA method
  - Derivation of exposure dependent MAPLHGR limits
- Stability report
  - BEO-III with CDA demonstration analysis

LAR Content Overview (cont)

- ATWS-I report
  - Demonstrate application of RAMONA5-FA method using equilibrium ATRIUM-11 core
- Control rod drop accident report
  - Demonstrate application of AURORA-B CRDA using BFN equilibrium ATRIUM-11 core
- Transient demonstration report
  - Demonstrate application of AURORA-B AOO using BFN equilibrium ATRIUM-11 core
- Limitations and Conditions (L&C) Report
  - Brunswick and Susquehanna LARs did not address L&Cs up front
  - Resulted in RAIs
  - Address L&Cs of the new Framatome methods SERs
    - Some L&Cs will need to be addressed as part of implementation cycle reports

ATWS-I

- LAR will request changing the licensing basis method from GEH TRACG04 to the Framatome RAMONA5-FA method
- Framatome method now NRC approved
  - ANP-10346P-A Revision 0, “ATWS-I Analysis Methodology for BWRs Using RAMONA5-FA”
- Key plant inputs will be unchanged from the analysis in the MELLLA+ LAR
  - Feedwater temperature reduction rate
  - Operator response times
- Does NRC plan on performing confirmatory TRACE analyses?
  - ATRIUM-11 core and thermal hydraulic information only
  - NRC need date?

BEO-III with CDA

- TVA intends to follow the Brunswick precedent for stability
  - Stability analysis will utilize the RAMONA5-FA methodology to analyze events and generate time dependent LPRM responses for each trial case
  - LPRM responses will be fed into a separate code for evaluation with the confirmation density algorithm (CDA)
  - Time of trip will be determined by this code
- Framatome will use time of trip values to determine CPR response for each trial and margin to SLMCPR

BEO-III with CDA (cont)

- Implementation will differ from Brunswick in one regard
- Brunswick used a screening process to reduce the number of cases analyzed with CDA
- TVA approach will integrate the CDA evaluation into the Framatome analysis process
  - CDA utilized for all aspects of the evaluation
  - Every stability trial case evaluated by RAMONA5-FA will have a CDA evaluation
  - No screening out of cases
  - No issues of PBDA tripping before CDA
    - Time of trip always based on CDA

BEO-III with CDA (cont)

- Current backup capabilities will be retained
  - Manual BSP regions retained
  - ABSP retained and functional
  - Validity of BSP regions and ABSP setpoints confirmed each reload
- No changes to the Tech Spec actions for an inoperable OPRM required

Preferred Stability Approach for LAR

- Generic BEO-III topical still under NRC review
  - TVA desires to reference the generic in the Browns Ferry LAR
- Use of CDA will require a plant specific report
- Plant specific report
  - Would reference the generic report for the overall BEO-III methodology
  - Describe the incorporation of CDA within the calculation framework
  - Describe how the CDA code used by Framatome complies with the approved CDA and Browns Ferry implementation
  - Describe how the CDA is validated on the Framatome computational platforms

Backup Stability Approach for LAR

- Two options if generic BEO-III topical not approved prior to LAR
  - Options differ in terms of how the generic topical ultimately gets referenced
  - CDA aspects still included as discussed on the prior slide
- Option 1 - generic report approval imminent at LAR submittal
  - Plant specific report duplicates the methodology description in the generic report
  - Plant specific report will address draft Limitations and Conditions from generic report
  - Once generic approved the LAR would be amended to reference the approved report
  - Avoids having identical generic and plant specific topical reports
- Option 2 - generic report review extends well beyond LAR submittal
  - Plant specific report duplicates the methodology description in the generic report
  - Use RAI process to address any Limitations and Conditions if not available at the time of LAR submittal
  - Plant specific methodology topical would remain as Browns Ferry licensing basis

Control Rod Drop Accident

- Application of NRC approved AURORA-B CRDA method
  - ANP-10333P-A Revision 0, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident Scenarios”
  - Methodology applied on a cycle specific basis
    - Demonstration analysis based upon ATRIUM-11 equilibrium core.
- Will address RIA criteria in Reg Guide 1.236
  - By end of October 2020 TVA will use available RG-1.236 (draft or final)
- Show current dose analysis for event remains bounding
  - Dose aspects will consider steady state and transient release criteria
    - Transient release fraction from DG-1327 Rev 1 (July 2019)
      - A part of this material did not remain in RG 1.236
    - Steady state release fractions based on Reg Guide 1.183, July 2000

Transient Demonstration Analysis

- A demonstration analysis using the ATRIUM-11 equilibrium core will be performed using NRC approved AURORA-B AOO method
  - ANP-10300P-A Revision 1, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios"
- Case matrix similar to Brunswick
  - Base case analyses for turbine trip, load rejection, and feedwater controller failure
  - Rated power and select off rated powers including below P_{bypass}
  - Event disposition for UFSAR Chapter 14 events
  - Brunswick RAI on equipment out of service will be addressed
    - Table of rated power case results for each currently licensed equipment out of service domain (alone and in combination) will be presented
  - Report will discuss specifics on scram times, cycle exposure points, and full range of power flow points that will be analyzed for the full reload report

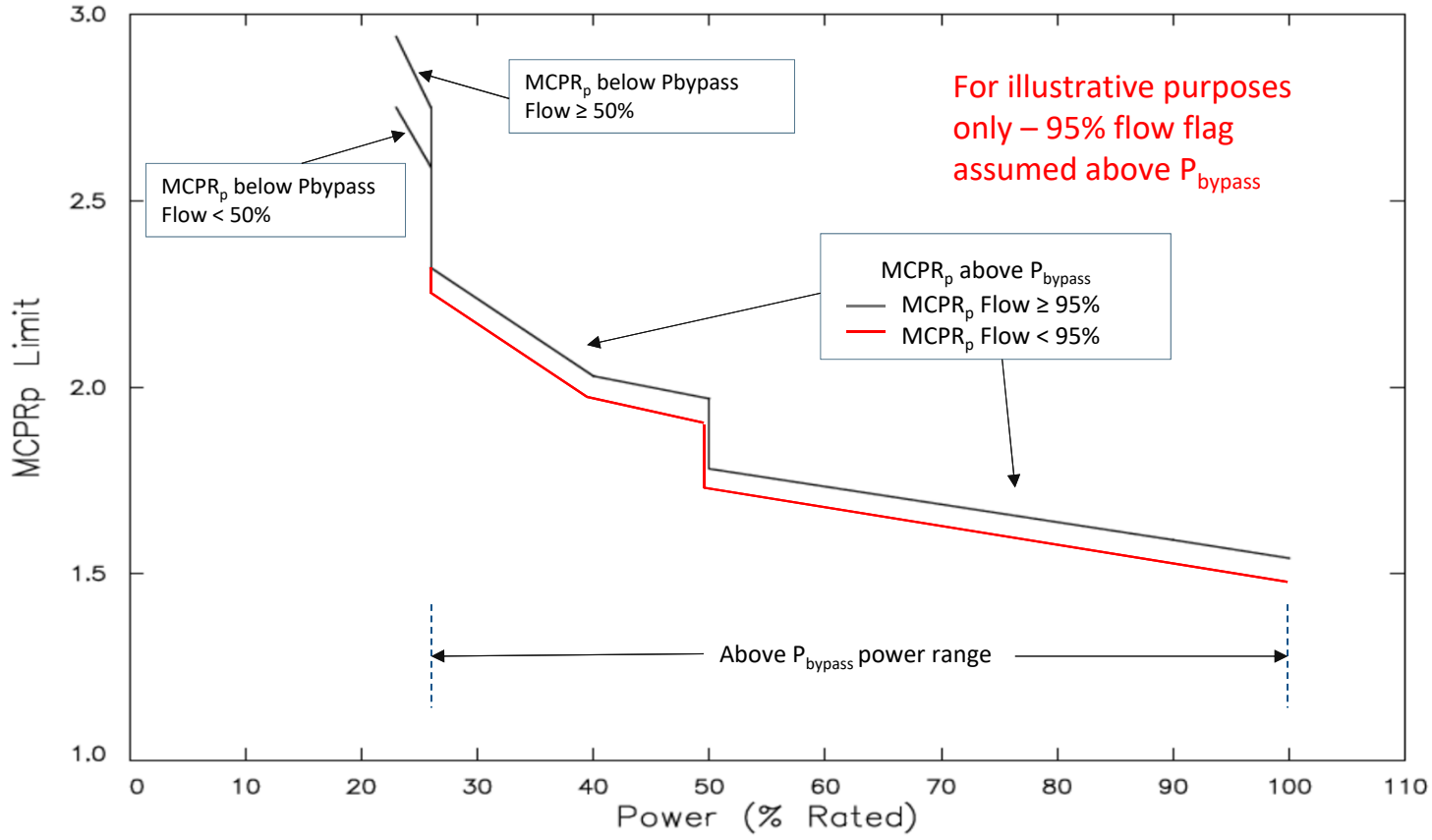
Transient Demonstration Analysis (cont)

- Additional cases
  - TVA is considering extending the ARTS thermal limits administration used below P_{bypass} to the power range above P_{bypass}
  - Below P_{bypass} $MCPR_p$ limits depend on both power and core flow
  - $MCPR_p$ limits at a specified power below P_{bypass} depend on whether core flow is above or below a specified value (50% flow for BFN)
    - This is referred to as a "flow flag"
  - Above P_{bypass} a single $MCPR_p$ limit at a given power is set by the transient results at the limiting core flow
    - Typically ICF sets the limit
  - If a similar flow flag concept is applied above P_{bypass}, you would have two $MCPR_p$ limits for a given power
    - One limit for flows above the flag value, and another limit for flows below the flag value

Transient Demonstration Analysis (cont)

- Additional cases (cont)
  - The purpose of applying the flow flag concept above P_{bypass} is for operating thermal margin gain
    - Very beneficial during startup and maneuvering when xenon transients can erode margins
  - Using increased core flow based $MCPR_p$ limits in the MELLLA+ region is restrictive
  - Using a $MCPR_p$ limit set by analysis at the intermediate flow flag value provides a less restrictive MCPR limit than the increased core flow based limit
    - Improves operating margin while at reduced flow in the MELLLA+ region especially for non steady state conditions
  - Core monitoring system will be modified to enforce the flow dependence of the $MCPR_p$ limits above P_{bypass} just as it does today below P_{bypass}
  - Concept illustrated on the next slide

Flow Flag Above P_{bypass} Concept



Transient Demonstration Analysis (cont)

- Overpressure analysis
  - The report will include both ASME and ATWS overpressure cases
  - ASME analysis based on MSIV closure with flux scram
    - 102% EPU power at increased core flow and MELLLA+ min flow
  - ATWS analysis will evaluate MSIV closure and pressure regulator failure open transients
    - 100% EPU power at increased core flow and MELLLA+ min flow

Technical Specification Changes

- The following approved methods topicals will be added to TS 5.6.5.b
  - BAW-10247P-A, Supplement 1P-A, Revision 0, “Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 1: Qualification of RODEX4 for Recrystallized Zircaloy-2 Cladding” – Approved April 2017
  - BAW-10247P-A, Supplement 2P-A, Revision 0, “Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods” – Approved August 2018
  - ANP-10340P-A Revision 0, “Incorporation of Chromium-Doped Fuel in AREVA Approved Methods” – Approved May 2018
  - ANP-10335P-A Revision 0, “ACE/ATRIUM 11 Critical Power Correlation” – Approved May 2018
  - ANP-10300P-A Revision 1, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios” – Approved January 2018
  - ANP-10332P-A Revision 0, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios” – Approved March 2019
  - ANP-10333P-A Revision 0, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident Scenarios” – Approved March 2018
- The plant specific stability topical report will also be added
  - Description of the overall stability methodology will depend on timing of NRC review and approval of ANP-10344P Revision 0, “Framatome Best-Estimate Enhanced Option III Methodology,”

Technical Specification Changes (cont)

- TVA desires to include TSTF-564 related changes to the Tech Specs
- Framatome has established $MCPR_{95/95}$ values for the ATRIUM-10XM and the ATRIUM-11 fuel types
- A report documenting the derivation of the $MCPR_{95/95}$ values will be included in the LAR
  - Method used to derive the values is in accordance with the NRC approved process in the TSTF
- Two associated Tech Spec changes will be made:
  - TS 2.1.1.2 will be modified to reflect the $MCPR_{95/95}$ value, applicable to both two loop and single loop operation
  - TS 5.6.3 will be modified to require that the $MCPR_{99.9\%}$ values for two loop and single loop operation be included in the COLR
    - Modified language of TS 5.6.3 will be consistent with that shown in the TSTF

Implementation Cycle Reports

- TVA will provide cycle specific reports for information for the implementation cycle
- Reports will be provided on a schedule specified in the LAR
- Reports include:
  - Fuel Cycle Design Report
  - Nuclear Fuel Bundle Design Report
  - Safety Limit MCPR Report
    - May include cycle exposure dependent values
  - Fuel Rod Design Report
  - Reload Safety Analysis Report
    - Include disposition of events summary
    - Address remaining Framatome methodology Limitations and Conditions

Criticality Report LAR

- NRC reviewed the BFN rack criticality report as part of the EPU LAR
- EPU safety evaluation noted the criticality analysis reviewed for fuel types up to and including ATRIUM-10 XM
- TVA believes adding ATRIUM-11 to the spent fuel pool requires additional NRC review
- TVA will docket this report as a separate LAR
  - Approval needed earlier than the transition LAR to support receipt of first ATRIUM-11 reload batch in early fall of 2022
- Approval of this LAR only grants the ability to receive and store ATRIUM-11 fuel in the fuel pool racks
  - LAR will not change the existing Technical Specification k-infinity limit
- TVA does not view this LAR as having linkage with the transition LAR

Schedule

- Proposed date for criticality report LAR submittal – 5/28/2021
- Proposed date for transition LAR submittal - 6/9/2021
- Safety evaluation need date for criticality report LAR – 5/30/2022
  - 12 month review
- Safety evaluation need date for transition LAR – 12/9/2022
  - 18 month review
  - Outage start date 2/25/2023
- All but one of the new methods is NRC approved
  - LAR review can focus on application of the approved methods to BFN
- Critical NRC action is approval of BEO-III topical report by March 2021
  - Allows avoidance of supplementing the LAR or having a permanent plant specific methodology topical report


TVA