Browns Ferry Nuclear Plant

Maximum Extended Load Line Limit Analysis Plus License Amendment Request

Gerry Doyle
Director EPU
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BFN MELLLA+
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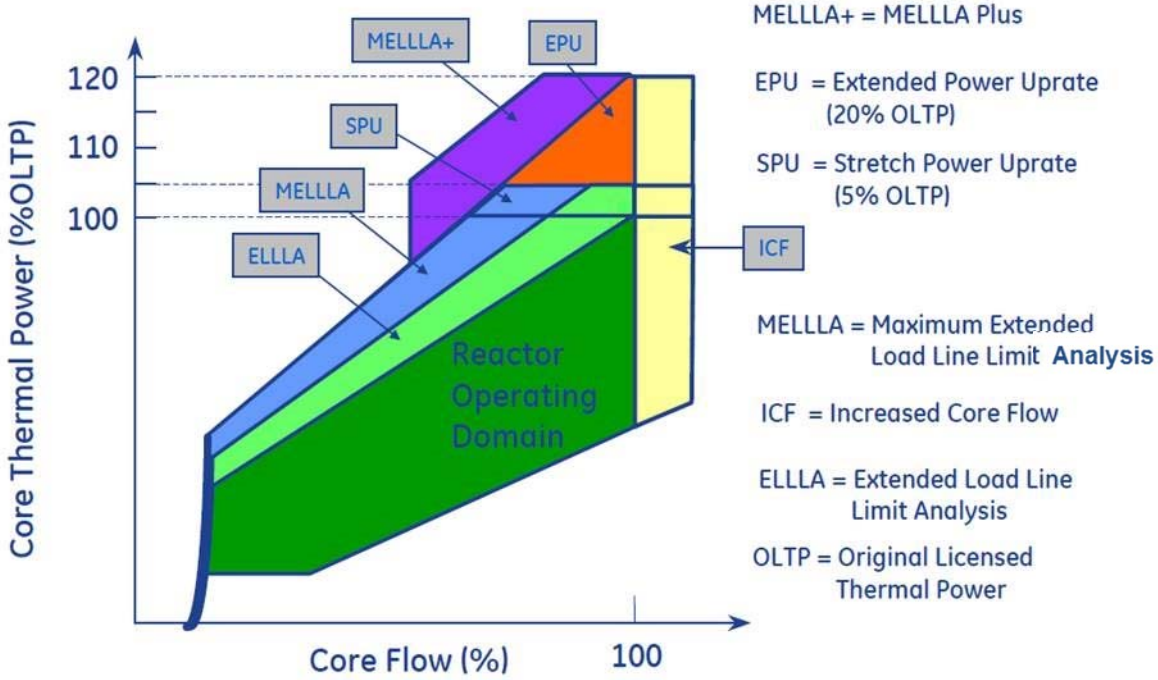
BFN MELLLA+ Overview

- Extended Power Uprate (EPU) power levels restrict flow window
  - Maximum Extended Load Line Limit Analysis (MELLLA) rod line extrapolated to EPU power
    - Licensed flow window reduced: 99% - 105% core flow at rated EPU power
    - Administrative margin would limit operating flow window: 100% - 104% range
- MELLLA Plus (MELLLA+) raises the maximum allowed rod line
  - Licensed flow window: 85% - 105% core flow at rated EPU power

MELLLA+ Boundary



BFN MELLLA+
Benefits for Browns Ferry Nuclear Plant

- MELLLA+ expands nominal core flow window at EPU conditions
  - Reduction in number of end of cycle down-powers
  - Fewer control rod manipulations required to manage reactivity
- Detect and Suppress Solution – Confirmation Density (DSS-CD) provides improved core instability detection algorithm
- Increases station capacity factor during the operating cycle

BFN MELLLA+
Project Goals

- High quality License Amendment Request (LAR)
- Effective integration into plant systems
- Effective training for plant operators and plant maintenance staff
- Smooth transition to plant operations
- Implement MELLLA+ for all three units prior to Browns Ferry Nuclear Plant (BFN) Unit 3 End of Cycle conditions

BFN MELLLA+
Approach to Fuel and Plant Licensing Analyses

All topical areas of the MELLLA+ Licensing Topical Report (NEDC-33006P-A) will be addressed in the BFN MELLLA+ LAR

- GE Hitachi (GEH) MELLLA+ Licensing Topical Report process with GEH methodologies and analyses will address:
  - Non-fuel impacts
  - Long term Anticipated Transient Without Scram (ATWS) and ATWS Instability (ATWS-I) explicitly modeling ATRIUM 10XM fuel
- AREVA methodologies and analyses will address:
  - Fuel, core design, Core Operating Limits Report fuel limits, Loss of Coolant Accident (LOCA) and transient analyses
  - ATWS and American Society of Mechanical Engineers overpressure
  - Methods applicability to MELLLA+
- TVA will address:
  - Modifications to implement MELLLA+
    - License Conditions and Technical Specifications Changes
    - Average Power Range Monitor and Oscillating Power Range Monitor setpoints and implementation
  - Probabilistic Risk Assessment, procedure updates, operator training
  - Application of existing plant-specific EPU analysis

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Approach to Fuel and Plant Licensing Analyses

- BFN MELLLA+ LAR to be based on current AREVA ATRIUM 10XM fuel type
- BFN MELLLA+ LAR to include
  - GEH MELLLA+ Safety Analysis Report (M+SAR)
  - AREVA MELLLA+ SAR (AMSAR)
    - Similar to Power Uprate Safety Analysis Report/Fuel Uprate Safety Analysis Report approach of BFN EPU LAR
  - AREVA fuel related reports similar to recent BFN fuel transition LARs and BFN EPU LAR
    - Transition cycle design report
      - Basis of representative Reload Report analyses
      - BFN 3 cycle 19 EPU core re-depleted at MELLLA+ conditions
    - Equilibrium cycle ATRIUM 10XM design report
      - Basis of AMSAR fuel related analyses
      - EPU equilibrium core re-depleted at MELLLA+ conditions
    - Reload Analysis Report (transition cycle based)
      - Full representative reload evaluation

BFN MELLLA+
Approach to Fuel and Plant Licensing Analyses

- AREVA fuel related reports similar to recent BFN fuel transition LARs and BFN EPU LAR (continued)
  - Fuel rod thermal mechanical report
    - Demonstrates application of RODEX4 to BFN at MELLLA+ conditions
  - Fuel thermal hydraulic report
    - Demonstrate continued acceptability of thermal hydraulic performance of ATRIUM 10XM and legacy ATRIUM 10 fuel at MELLLA+ conditions
  - Safety Limit Minimum Critical Power Ratio Report
    - Performed for representative transition core using SAFLIM3D
  - Methods applicability report
    - Plant specific demonstration of AREVA methods applicability at MELLLA+ conditions
    - Update to prior supplements of ANP-2860, Browns Ferry Unit 1 – Summary of Responses to Request for Additional Information, Extension to use ATRIUM 10XM Fuel for Extended Power Uprate
    - Address prior Browns Ferry fuel related Requests for Additional Information (RAIs), including MELLLA+, as well as applicable RAIs from other utilities' recent LARs

BFN MELLLA+
Approach to Fuel and Plant Licensing Analyses

- AREVA fuel related reports similar to recent BFN fuel transition LARs and BFN EPU LAR (continued)
  - LOCA
    - New break spectrum analysis at MELLLA+ conditions
      - ATRIUM 10XM fuel based
      - Consistent with ATRIUM 10XM EPU analysis in ANP-3377, Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU)
    - Break spectrum and ATRIUM 10XM fuel Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) reports included in LAR
    - Legacy ATRIUM 10 LOCA approach
      - LOCA system response from the MELLLA+ based ATRIUM 10XM analysis will be used to drive ATRIUM 10 hot channel heatup
      - ATRIUM 10XM break spectrum is applicable because the two types are closely matched thermal hydraulically
      - MAPLHGR report for ATRIUM 10 provided
      - Limiting Peak Clad temperature is at Beginning of Life
        - Legacy ATRIUM-10 fuel will be at twice burned exposure

BFN MELLLA+
Approach to Fuel and Plant Licensing Analyses

- Treatment of 10 CFR 50.46c Issues
  - Same approach as included in BFN EPU LAR
    - Update ANP-3409, Fuel-Related Emergent Regulatory Issues, for MELLLA+ conditions
- Treatment of Reactivity Initiated Accidents (RIAs)
  - RIA will be evaluated with NRC-approved methodology
    - 230 Calorie limit will be imposed for fuel fragmentation
  - For BFN EPU LAR, an additional conservative RIA evaluation was presented in ANP-3409, Fuel-Related Emergent Regulatory Issues
    - MELLLA+ has no effect on fuel failure thresholds
    - ANP-3409 remains valid for MELLLA+
  - Revised regulation could be issued prior to LAR submittal
    - AREVA's AURORA-B Control Rod Drop Accident (CRDA) method is anticipated to be approved by NRC prior to issuance of new regulation
    - AURORA-B CRDA evaluation could be submitted

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GEH Methods Applicability to AREVA Fuel

- GEH previously presented information on methods applicability
  (during Brunswick Pre-application Meeting on August 20, 2013 (ML13277A038))
  - ATRIUM 10 Fuel Experience
  - ATRIUM 10XM Fuel for ATWS Methods
  - Uncertainty Identification/Management Process
  - ATRIUM 10XM Modeling Approach
  - Methods Application
    - Core Modeling
    - ATWS Analysis
    - Applicable Interim Methods Licensing Topical Report and MELLLA+ Licensing Topical Report Limitations and Conditions
- Concluded GEH Methods are applicable to ATRIUM 10XM fuel in the MELLLA+ condition
  - ATRIUM 10XM explicitly modeled
  - Uncertainties in modeling ATRIUM 10XM fuel with GEH methods addressed in a conservative fashion

BFN MELLLA+
AREVA Methods Applicability to MELLLA+

- AREVA previously presented information on methods applicability
  (during Brunswick Pre-application Meeting on April 17, 2014 (ML14135A511))
  - Applicability of AREVA methods to MELLLA+ conditions is described in Methods Applicability Report
    - Methods Applicability Report to be submitted in BFN MELLLA+ LAR
  - Restrictions for fuel dependent analyses presented in NEDO-33006-A were reviewed for applicability to AREVA methods
    - Required analysis reports will be submitted in BFN MELLLA+ LAR
- Concluded AREVA methods are applicable to MELLLA+ conditions
  - Steady state and transient neutronic and thermal-hydraulic analytical methods and codes systems supporting MELLLA+ will be applied within NRC approved applicability ranges
  - Calculation and measurement uncertainties applied in MELLLA+ applications are valid
  - Assessment database and uncertainty of model used to simulate the plant response to MELLLA+ conditions are equivalent to core and assembly conditions for which AREVA methodology was benchmarked
  - AREVA analyses will comply with the fuel-specific limitations and conditions from the generic MELLLA+ Safety Evaluation for NEDO-33006-A
    - Methods-specific limitations will be addressed consistent with NRC approved AREVA methodologies

BFN MELLLA+
Approach to Thermal Hydraulic Solution

- BFN will use GEH Detect and Suppress Solution - Confirmation Density (DSS-CD)
  - Referenced in MELLLA+ Licensing Topical Report
  - BFN Unit 1 already has hardware – configured as Option III
    - Some modification required to update to present day hardware configuration
    - Make common with new BFN Unit 2 and 3 DSS-CD configuration
    - BFN Operations and Maintenance personnel are familiar with the installed hardware on Unit 1 and will require limited training to implement DSS-CD
  - BFN Units 2 and 3 require complete upgrade
    - EPROM software and firmware plus voter hardware
  - Adds a new stability analysis algorithm
    - Confirmation Density Algorithm
  - Retains current Option III algorithms as defense-in-depth backups
  - GEH will determine DSS-CD set points and provide process for cycle specific validation for AREVA reloads

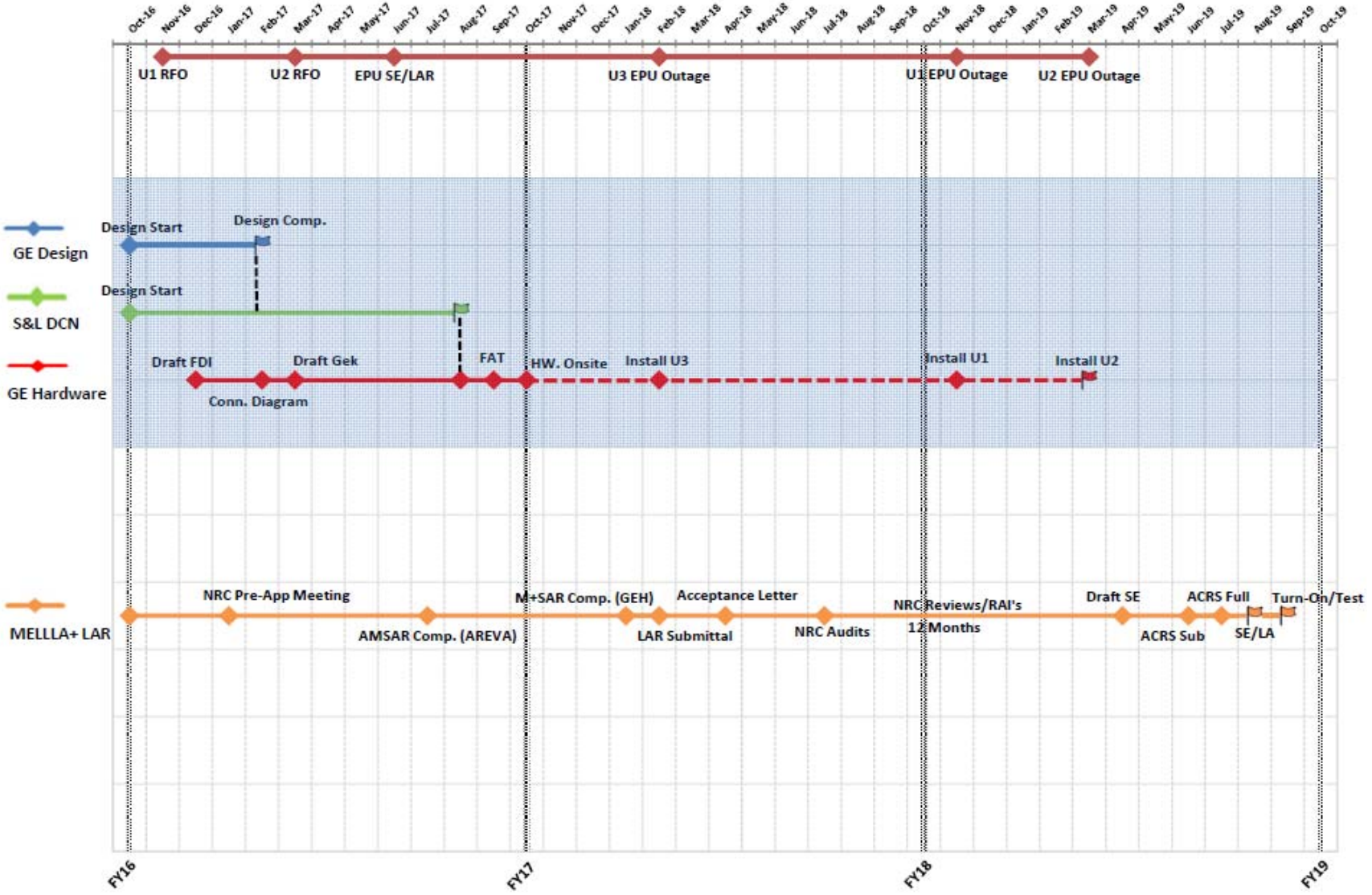
BFN MELLLA+
Approach to ATWS Analyses

- BFN EPU increases Standby Liquid Control (SLC) System Boron-10 (B-10) enrichment to 94 atom percent
- Long term ATWS MELLLA+ margin will be demonstrated with ATRIUM 10XM specific analyses
  - SLC System B-10 enrichment increase should offset MELLLA+ heat load increase
- NEDC-33006P-A Generic MELLLA+ Licensing Topical Report and Safety Evaluation Report
  - Best estimate TRACG or equivalent analysis of post depressurization ATWS required if Hot Shutdown Boron Weight (HSBW) not injected before shutdown/Heat Capacity Temperature Limit (HCTL) is reached
  - Due to SLC system B-10 enrichment increase, HSBW expected to be injected before shutdown/HCTL reached

BFN MELLLA+
Approach to ATWS Analyses

- ATWS Instability
  - GEH will explicitly analyze ATRIUM 10XM fuel for ATWS-I
    - Treatment of uncertainties associated with modeling AREVA fuel will follow the conservative approach used for Brunswick
    - Demonstrate that coolable geometry is maintained
- ATWS Overpressure mitigation
  - Existing AREVA methodology will provide analysis of record
  - Safety Relief Valve Out of Service analysis is expected to be supported for MELLLA+
  - Analysis will apply 95/95 Safety Relief Valve upper setpoint tolerance
    - Different than Technical Specification requirement
    - Based on plant performance

BFN MELLLA+ Schedule



BFN MELLLA+ Acronym List

- AMSAR – AREVA MELLLA+ Safety Analysis Report
- ATWS – Anticipated Transient Without Scram
- ATWS-I – ATWS Instability
- B-10 – Boron-10
- BFN – Browns Ferry Nuclear Plant
- CRDA – Control Rod Drop Accident
- DSS-CD – Detect and Suppress Solution – Confirmation Density
- ELLLA – Extended Load Line Limit Analysis
- EPU – Extended Power Uprate
- GEH – General Electric Hitachi
- HCTL – Heat Capacity Temperature Limit
- HSBW – Hot Shutdown Boron Weight
- ICF – Increased Core Flow
- LAR – License Amendment Request
- LOCA – Loss of Coolant Accident
- MAPLHGR – Maximum Average Planar Linear Heat Generation Rate
- MELLLA – Maximum Extended Load Line Limit Analysis
- MELLLA+ – MELLLA Plus
- M+SAR – MELLLA+ Safety Analysis Report (GEH)
- NRC – Nuclear Regulatory Commission
- OLTP – Original Licensed Thermal Power
- RAIs – Requests for Additional Information
- RIAs – Reactivity Initiated Accidents
- SE – Safety Evaluation
- SLC – Standby Liquid Control
- SPU – Stretch Power Uprate

BFN MELLLA+ Questions/Comments