# Pre-Submittal Meeting for

# Duane Arnold Energy Center
# Spent Fuel Pool Criticality Analyses

December 10, 2015

# Purpose

- Describe the NextEra Energy (NEE) criticality analyses methodology for the proposed Duane Arnold Energy Center (DAEC) License Amendment Request (LAR)

- Seek feedback on the approach from NRC staff

# Agenda

- **Background**
- Criticality Analysis Methodology
- Technical Specification Changes
- Closing Summary

# Background – Spent Fuel Pool

- The Duane Arnold Energy Center (DAEC) spent fuel pool is composed of ~50/50 split of original PaR racks and Holtec racks

- Both rack types use Boral as neutron absorber

| Rack | Absorber Type | Areal Density (gm-B10/cm$^2$) | Spacing (in) |
|---|---|---|---|
| PaR | Boral | 0.0250 +/- 0.0018 | 6.625 |
| Holtec | Boral | 0.0162 +/- 0.0012 | 6.060 |

# Background – Current Technical Specification

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having the following limits for maximum k-infinity in the normal reactor core configuration at cold conditions and maximum lattice-average U-235 enrichment weight percent:

| | | k-∞ | wt % |
|---|---|---|---|
| i) | 7x7 and 8x8 pin arrays (Holtec and PaR racks) | ≤1.31 | ≤4.6 |
| ii) | 9x9 and 10x10 pin arrays (Holtec racks) | ≤1.29 | ≤4.95 |
| iii) | 9x9 and 10x10 pin arrays (PaR racks) | ≤1.39 | ≤4.95 |

b. keff ≤ 0.95 if fully flooded with unborated water, which includes an allowance for uncertainties as described in 9.1 of the UFSAR; and

c. A nominal 6.060 inches for HOLTEC designed and 6.625 inches for PaR designed center to center distance between fuel assemblies placed in the storage racks.

# Background – Current State

- **In 2013, DAEC performed BADGER measurements on spent fuel pool PaR racks**
  - Results did not support PaR rack areal density used in spent fuel pool criticality analysis

- **DAEC currently operating with non-conservative TS for PaR racks**
  - Instead of $k_\infty$ limit of 1.39, using same limit of 1.29 as for Holtec racks

- **DAEC has a commitment to submit a license amendment request with a new spent fuel pool criticality analysis by 3/15/2016**

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# Criticality Analysis Methodology

- **DAEC performing new spent fuel criticality analysis for entire pool**
  - Performing in-house

- **Will follow NRC Guidance DSS-ISG-2010-01, "Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools"**

- **Main codes will be CASMO4 and MCNP6.1 with ENDF/B-VII.1**

# Criticality Analysis Methodology

- **Will model most reactive lattice over entire axial length**
  - No blankets

- **Will establish maximum in-core k-infinity so that k95/95 < 0.95 for normal and accident conditions**

# Criticality Analysis Methodology

- **No significant changes or factors to address**
  - No change in fuel design
  - No change in operating conditions
  - No rack design changes
  - No burnup credit
  - No Boraflex
  - No loading patterns
  - No inserts
  - No new SFP loading restrictions
  - No New Fuel Vault analysis

# Criticality Analysis Methodology

- **Fuel Assembly Selection (IV.1)**
  - Analysis will address all fuel designs used at DAEC
    - 7 X 7
    - Various 8 X 8 designs
    - Various 10 X 10 designs

- **Depletion Uncertainty (IV.2.a)**
  - Will use 5 percent  to cover uncertainty in isotopic number densities, per ISG and Kopp memo

# Criticality Analysis Methodology

- **Reactor Parameters (IV.2.b)**
  - Bounding values for moderator temperature, fuel temperature, and power density
  - Evaluated at multiple void conditions

- **Rodded Operation (IV.2.d)**
  - Included with Reactor Parameters

# Criticality Analysis Methodology

- **Rack Model (IV.3.b)**
  - Reduced B-10 areal density for PaR racks (lower than minimum)
  - Minimum B-10 areal density for Holtec racks
  - Conservative modeling of small amount of blisters
  - Will demonstrate Holtec rack is limiting, and

- **Normal Conditions (IV.3.d)**
  - Will address normal fuel handling configurations
  - Will address eccentricity, orientation, de-channeled assemblies

# Criticality Analysis Methodology

- **Area of Applicability (IV.4.a)**
  - HTC experiments will be included
  - Will include >200 experiments from International Handbook of Evaluated Criticality Safety Benchmark Experiments, September 2014
- **Trend Analysis (IV.4.b)**
  - Will perform for all experiments combined, and also for subsets based on various parameters (e.g., HTC cases, non-HTC cases, square lattices)
    - Biases and uncertainties will be based on most limiting result

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# Technical Specification Changes

- **It if can be supported by analysis results, will simplify TS 4.3.1.1.a to read as follows:**

  Fuel assemblies having a maximum k-infinity of *TBD* in the normal reactor core configuration at cold conditions.

- **Otherwise, TS 4.3.1.1.a will remain split by rack design and fuel design, with update limits**

- **Additionally, will modify TS 4.3.1.2 to prohibit loading the New Fuel Vault**

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# Closing Summary

- **Review action items**
- **Summary of path forward**
- **Schedule for LAR submittal**
  - Commitment to submit LAR by 3/15/2016

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# Questions