

Pre-Submittal Meeting for
St. Lucie Unit 2
Spent Fuel Pool Criticality Analyses

April 30, 2018

Purpose

- **Describe the planned scope and methodology for the proposed St. Lucie Unit 2 Spent Fuel Pool Criticality Analysis License Amendment Request**
 - Partial criticality analysis for cask pit rack only
- **Seek feedback from NRC staff**

Agenda



Current Condition

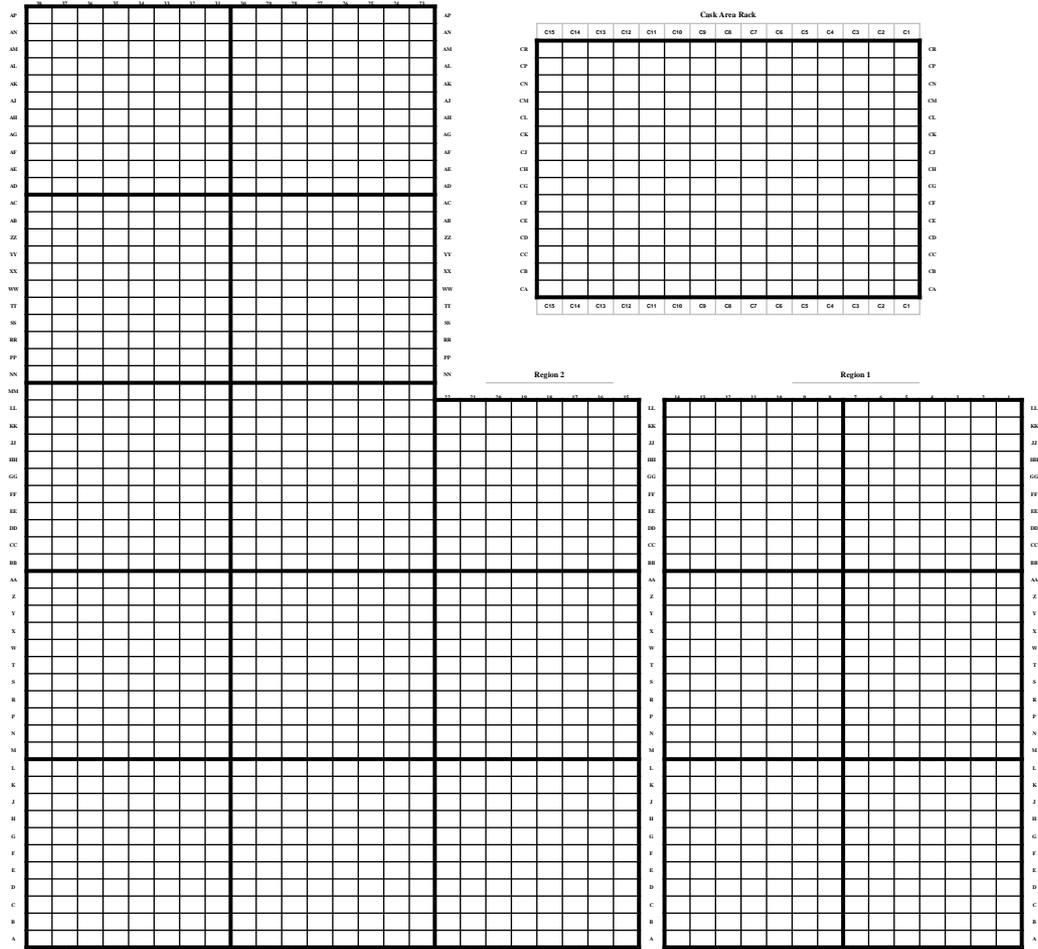
- **New Criticality Analysis**
- **Technical Specification Changes**
- **Closing Summary**

Current Condition – SFP Criticality Analysis

- **Safety Evaluation for St. Lucie Unit 2 Spent Fuel Pool Criticality Analysis LAR was issued in September 2012 (ML12263A224)**
 - Analysis was performed in support of Extended Power Uprate project
- **Analysis performed with CASMO-4 and MCNP5**
- **Analysis complies with DSS-ISG-2010-01**

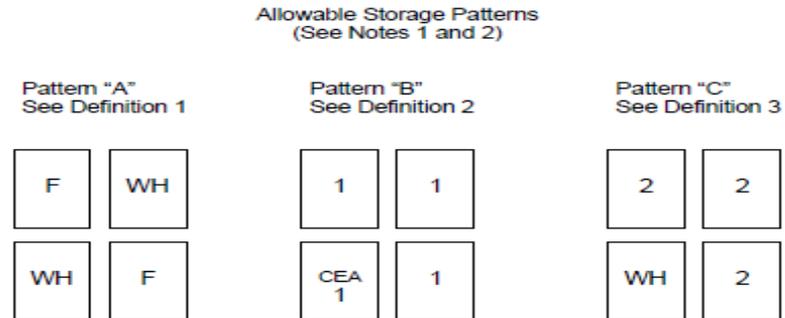
Current Condition – Spent Fuel Pool

- Analysis covers three regions in the St. Lucie Unit 2 Spent Fuel Pool
 - Region 1
 - Region 2
 - Cask Pit Rack



Current Condition – Technical Specifications

- **Technical Specifications contains allowable storage patterns for each region**



DEFINITIONS:

1. Allowable pattern is fresh or burned fuel checkerboarded with completely water-filled cells. Diagram is for illustration only, where F represents Fuel and WH represents a completely water-filled cell.
2. Allowable pattern is placement of fuel assemblies that meet the requirements of type 1 in each 2x2 array location with at least one full-length full-strength CEA placed in any cell. Minimum bumup for fuel assembly type 1 is defined in Table 5.6-1 as a function of maximum initial planar average enrichment. Diagram is for illustration only.
3. Allowable pattern is placement of fuel assemblies that meet the requirements of type 2 in three of the 2x2 array locations in combination with one completely water-filled cell. Minimum bumup for fuel assembly type 2 is defined in Table 5.6-1 as a function of maximum initial planar average enrichment. Diagram is for illustration only.

NOTES:

1. The storage arrangements of fuel within a rack module may contain more than one pattern. Each cell is a part of up to four 2x2 arrays, and each cell must simultaneously meet the requirements of all those arrays of which it is a part.
2. Completely water-filled cells within any pattern are acceptable.

**FIGURE 5.6-1
Allowable Region 1 Storage Patterns and Fuel Arrangements**

Current Condition – Fuel Storage Limitations

- **Storage patterns included in criticality analysis were developed based on estimates for future storage needs under EPU conditions**
- **Current storage patterns are not optimal**
 - Reliance on empty cells limits capacity
 - Not aligned with fuel storage needs under EPU conditions

Current Condition – Options

- **NextEra Energy considered various options to improve storage capacity**
 - new cask pit rack
 - additional dry storage casks
 - full criticality re-analysis
 - partial criticality analysis

Agenda

- Current Condition



New Criticality Analysis

- Technical Specification Changes
- Closing Summary

New Criticality Analysis

- **Our plan is to perform a partial criticality analysis that will fully replace the parts of the current analysis addressing the cask pit rack only**
 - Follows precedent from Duane Arnold criticality analysis
- **All other parts of current analysis remain the same**
 - No changes to current Technical Specifications for Regions 1 and 2
- **Partial criticality analysis will be performed in-house**

New Criticality Analysis

- **Partial criticality analysis will follow**
 - NRC Guidance DSS-ISG-2010-01, “Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools”
 - NEI 12-16, “Guidance for Performing Criticality Analyses of Fuel Storage at Light-Water Reactor Power Plants”
- **Codes will be PARAGON 1.2.0b and MCNP6.1 with ENDF/B-VII.1 cross section library**
- **As for current analysis, the partial analysis will ensure that $k_{eff} \leq 0.95$ with the pool flooded with borated water, and $k_{eff} \leq 1.0$ with unborated water, with 95% confidence / 95% probability**

New Criticality Analysis

- **No significant changes or factors to address**
 - No change in fuel design
 - No change in operating conditions
 - No change in rack design
 - No Boraflex
- **Will revalidate all analysis parameters**
 - Reactor depletion parameters
 - Boron areal density
 - Axial burnup shape

New Criticality Analysis

- **Will re-perform all analyses for cask pit rack**
 - Design basis assembly
 - Tolerances
 - Uncertainties
 - Accidents
 - Code validation
- **No interfaces with Region 1 nor Region 2 will need to be addressed**

New Criticality Analysis

- **New storage patterns have been preliminarily developed**
 - 3 out of 4 fresh assemblies, crediting integral burnable absorber
 - 4 out of 4 irradiated assemblies with one CEA, burnup credit
 - 3 out of 4 irradiated assemblies, burnup credit
 - 1 fresh and 2 irradiated assemblies
 - To address interface between first two patterns

F _{BA}	
F _{BA}	F _{BA}

1	1
1	1

	1
F _{BA}	1

New Criticality Analysis

- **For the fresh fuel category crediting integral burnable absorber, it would require n number of rods at a minimum concentration**
 - If condition is not met, fresh assembly would then be stored in current 2 out of 4 configuration in Region 1

New Criticality Analysis - Implementation

- **As done today for all NextEra Energy PWRs, PISCES code will be used as supplementary verification tool**
 - After move plans are prepared and reviewed
- **PISCES code**
 - Determines fuel category for all fuel assemblies & non-fuel items
 - Tracks all inserts and panels (credited and non-credited)
 - Evaluates configuration/proposed moves against Technical Specification requirements
 - Provides summary & graphical output files

Agenda

- Current Condition
- New Criticality Analysis
- **Technical Specification Changes**
- Closing Summary



Technical Specification Changes

- **Technical Specification Figures 5.6-4, “Allowable Cask Pit Storage Rack Patterns,” will be replaced**
 - New storage patterns, definitions and notes will be added
- **Technical Specification Table 5.6-1, “Minimum Burnup Coefficients,” will be modified**
 - Values for fuel type 8 will be modified
 - New fuel types will be added
 - Values for fuel types 1-7 will NOT be modified

Technical Specification Changes

Allowable Storage Patterns
(See Notes 1 and 2)

Pattern "A"
See Definition 1



Pattern "B"
See Definition 2



DEFINITIONS:

1. Allowable pattern is fresh or burned fuel checkerboarded with completely water-filled cells. Diagram is for illustration only, where F represents Fuel and WH represents a completely water-filled cell.
2. Allowable pattern is placement of fuel assemblies that meet the requirements of type 8 in three of the 2x2 array locations in combination with one completely water-filled cell in any location. Minimum burnup for fuel assembly type 8 is defined in Table 5.6-1 as a function of maximum initial planar average enrichment. Diagram is for illustration only.

NOTES:

1. The storage arrangements of fuel within a rack module may contain more than one pattern. Each cell is a part of up to four 2x2 arrays, and each cell must simultaneously meet the requirements of all those arrays of which it is a part.
2. Completely water-filled cells within any pattern are acceptable.

FIGURE 5.6-4
Allowable Cask Pit Storage Rack Patterns

Technical Specification Changes

TABLE 5.6-1
Minimum Burnup Coefficients

Fuel Type	Cooling Time (Years)	Coefficients		
		A	B	C
1	0	-33.4237	25.6742	-1.6478
2	0	-25.3198	14.3200	-0.4042
3	0	-23.4150	16.2050	-0.5500
4	0	-33.2205	24.8136	-1.5199
	2.5	-31.4959	23.4776	-1.4358
	5	-30.4454	22.7456	-1.4147
	10	-28.4361	21.2259	-1.2946
	15	-27.2971	20.3746	-1.2333
	20	-26.1673	19.4753	-1.1403
5	0	-24.8402	23.5991	-1.2082
	2.5	-22.9981	21.6295	-1.0249
	5	-21.8161	20.5067	-0.9440
	10	-20.0864	19.0127	-0.8545
	15	-19.4795	18.3741	-0.8318
6	0	-18.8225	17.7194	-0.7985
	2.5	-32.4963	25.3143	-1.5534
	5	-30.6688	23.6229	-1.4025
	10	-29.2169	22.5424	-1.3274
	15	-27.2539	21.0241	-1.2054
	20	-25.7327	19.8655	-1.1091
7	0	-25.2717	19.5222	-1.1163
	2.5	-24.6989	24.1660	-1.2578
	5	-23.0399	22.3047	-1.0965
	10	-21.2473	20.6553	-0.9403
	15	-20.1775	19.5506	-0.9015
8	0	-19.4037	18.6626	-0.8490
	20	-18.3326	17.7040	-0.7526
	0	-43.4750	11.6250	0.0000

NOTES:

- To qualify in a "fuel type", the burnup of a fuel assembly must exceed the minimum burnup "BU" calculated by inserting the "coefficients" for the associated "fuel type" and "cooling time" into the following polynomial function:

$$BU = A + B \cdot E + C \cdot E^2, \text{ where:}$$

BU = Minimum Burnup (GWD/MTU)

E = Maximum Initial Planar Average Enrichment (weight percent U-235)

A, B, C = Coefficients for each fuel type

- Interpolation between values of cooling time is not permitted.

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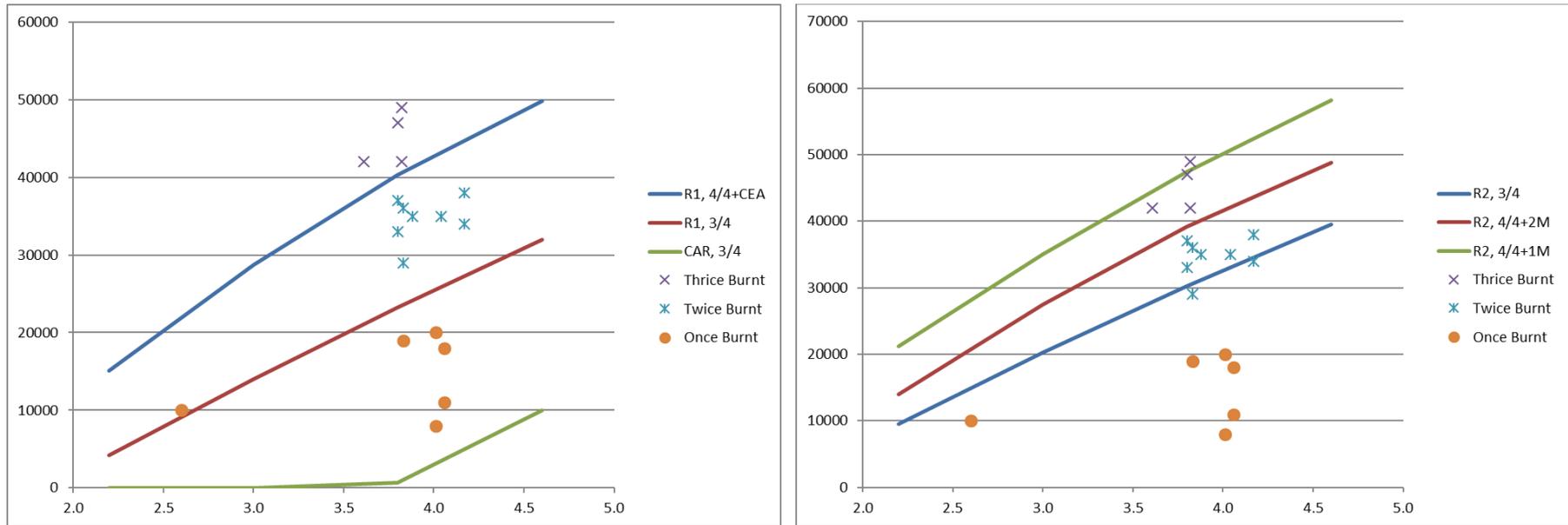
 **Closing Summary**

Closing Summary

- **Schedule of LAR submittal**
 - Plan to submit in December 2018
- **Summary of path forward**
- **Review action items**

Backup Slides

Current Condition – Fuel Storage Needs



- Fresh fuel stored in 2 out of 4 configuration in R1 or CPR
- Once burnt fuel stored in 3 out of 4 configuration in CPR
- Twice burnt fuel stored in 3 out of 4 configuration in any of the three regions

Current Condition – Cask Pit Rack

