North Anna Power Station
Criticality Analysis Checklist
New Fuel Storage Rack and Spent Fuel Pool
Proposed License Amendment Request

Subject	Included	Justification / Explanation
1.0 Introduction		
Purpose of submittal	YES	Increase enrichment to 5 w/o
License changes requested	YES	
Summary of physical changes	YES	Two regions, remove cell blockers
Summary of analytical scope	YES	New and spent fuel racks
2.0 Acceptance Criteria and Regulatory Guidance		
Summary of requirements and guidance	YES	
Requirements documents referenced	YES	
Guidance documents referenced	YES	
Acceptance criteria described	YES	
3.0 Storage Rack Description		
New fuel storage rack description	YES	
Nominal and tolerance dimensions	YES	
Spent fuel storage rack description	Yes	
Nominal and tolerance dimensions	YES	
4.0 Fuel Design Description		
Describe all fuel in pool	YES	Range of key parameters all past and present fuel designs
Nominal and tolerance dimensions	YES	
Describe future fuel to be covered	NO	None proposed
Describe all fuel inserts	YES	
Nominal and tolerance dimensions	YES	
Describe non-standard fuel	YES	
Describe non-fuel items in fuel cells	YES	
Nominal and tolerance dimensions	YES	Bounding approximation
5.0 Overview of the Method of Analysis		
New fuel rack analysis description	YES	
Storage geometries	NO	Single region, no blocked cells
Bounding assembly design(s)	YES	
Integral absorber credit	NO	
Accident analysis	YES	Flooded & Optimum Moderation
Spent fuel storage rack analysis description	YES	
Storage geometries	YES	Two regions
Bounding assembly design(s)	YES	Bounds old and new fuel designs
Soluble boron credit	YES	
Boron dilution analysis	NO	Previously approved analysis referenced

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Spent fuel storage rack analysis description (cont'd.)		
Burnup credit	YES	One burnup curve
Decay time credit	YES	One burnup curve
Integral absorber credit	NO	
Other credit	NO	
Fixed neutron absorbers	NO	
Aging management program	NO	
Accident analysis	YES	
Temperature increase	YES	
Assembly drop	YES	
Multiple misload	YES	Bounding accident
Boron dilution	YES	
Other	NO	
Fuel out of rack analysis	YES	
Handling	YES	
Movement	YES	
Inspection	YES	
6.0 Cross Sections, Computer Codes, and Validation		
Code/Modules Used for Calculation of k_{eff}	YES	SCALE6.0/CSAS5 – KENO V.a
Cross section library	YES	ENDF/B-VII 238 Group
List all the isotopes used	YES	Section 8.0
Convergence checks	YES	Source, histories, trends
Code/Module Used for Depletion Calculation	YES	SCALE6.0/T5-depl – KENO V.a
Cross section library	YES	ENDF/B-VII 238 Group
List all the isotopes used	YES	All SCALE 6.0 (T5-DEPL addnux=3)
Convergence checks	YES	Step size, histories, rack k_{eff}
Validation of Depleted Fuel Isotopic Content	YES	Use ISG 2010-01 (5% burnup worth)
Validation of Code and Library	YES	
Major Actinides and Structural Materials	YES	Appendix A
Minor Actinides and Fission Products	YES	1.5% bias (NUREG/CR-7109)
7.0 Criticality Safety Analysis of the New Fuel Rack		
Rack model	YES	Full storage area (126 cells plus structure and concrete)
Boundary conditions	YES	Void
Source distribution	NO	Uniform in fissile material
Geometry restrictions	NO	

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Limiting fuel design		
Fuel density	YES	Bounding high
Grids	NO	Not modeled
Burnable Poisons	NO	No credit
Fuel dimensions	YES	Multiple recent designs considered, bounding
Axial blankets	NO	No blankets have been used
Fuel plenum and end plug region	NO	No credit, modeled as moderator
Limiting rack model		
Storage area walls	YES	Bound-water concrete
Temperature	YES	Flooded 32° to 100°F Optimum Moderation 32° to 100°F
Multiple regions	NO	New 5.0 w/o fuel allowed in all cells
Flooded	YES	Bias and uncertainty calculated
Low density moderator	YES	Bias and uncertainty calculated
Asymmetric fuel placement	YES	Offset all assemblies towards middle of storage area in rack model
Tolerances		
Fuel geometry		
Fuel pin pitch	YES	
Fuel pellet OD	YES	
Fuel clad ID	YES	
Fuel clad OD	YES	
Guide tube ID	YES	
Guide tube OD	YES	
Axial fuel position	YES	
Axial Fuel Length	YES	
Fuel content		
Enrichment	NO	5.0 w/o is bounding
Dish and Chamfer	NO	Included in Density
Density	YES	
Rack geometry		
Rack pitch	YES	
Cell wall thickness	YES	
Concrete Composition	NO	Bounding Composition
Code uncertainty	YES	EALF extrapolation
Absorber geometry and content	NO	No absorber credit
Biases		
Temperature	YES	From code benchmarking
Code bias	YES	EALF extrapolation
Absorber geometry and content	NO	No absorber credit
Accident analysis		
Flooding (water and low density moderator)	YES	

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8.0 Depletion Modeling and Burnup Effects		
TRITON Depletion Model Considerations		
Time step verification	YES	Adequate for isotopic convergence
Convergence verification	YES	More neutron histories than required for depletion k_{eff} convergence
Simplifications	YES	Described and justified (grids)
Non-uniform enrichments	NO	None present
Nodalization	YES	18 nodes depleted independently
Fuel clad creep and grid growth	YES	Evaluated as a bias
Limiting depletion parameters		Past and present cycles
Burnable Absorbers	YES	Bounding, except for Pyrex (only used in initial cycles)
Integral absorbers	NO	BPRA bounds WABA and IFBA (WABA plus IFBA not analyzed)
Soluble Boron	YES	Bounds all burnup average boron
Fuel and Water Temperature	YES	Node-specific values based on bounding high power history fuel assembly, TS minimum flow, 18 node burnup (power) shape, SIMULATE fuel temp tables
Specific power	YES	Includes all core power uprates, bounding high power assembly history, reduced 50% for last 40 days of depletion, proportional to 18 node burnup shape
Control rod insertion	NO	Bounded by BPRA insertion
Axial burnup shapes	YES	Uniform and NUREG/CR-6801
Grids	YES	Max. volume Zircaloy grids
Depleted fuel content nuclide selection		
Number of nuclides	YES	All TRITON nuclides
Volatile fission products	YES	Reduced based on release fractions
Decay time	YES	5 days (base burnup curve) and 3 years (decay time credit)
9.0 Spent Fuel Rack Analysis		
Rack model	YES	Two configurations (Regions),both infinite lattice (6x6 model with asymmetric fuel placement)
Boundary conditions	YES	Periodic X-Y, mirror Z
Source distribution	NO	Uniform in fissile material
Geometry restrictions	YES	2 out of 4 Region 1, Region interface requirements

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Limiting fuel design		
Fuel density	YES	Bounds all fuel batches
Grids	YES	Min. volume Zr grids
Burnable Poisons	NO	No credit
Fuel assembly inserts	YES	With and without depleted BPRA
Fuel dimensions	YES	All fuel designs in SFP considered
Axial blankets	NO	
Configurations considered	YES	Regions 1 (2/4 fresh 5.0 w/o fuel) and 2 (4/4 with burnup credit)
Borated	YES	Partial bias and tolerance calculations, extra 50 ppm boron, both regions
Unborated	YES	Full bias and tolerance calculations for fresh fuel, most bias and tolerances calculated for depleted fuel, both regions
Multiple rack designs	NO	All racks are the same Boraflex flux trap design
Alternate storage geometry	NO	
Axial burnup shapes		
Non-uniform with justification	YES	NUREG/CR-6801, except shape 9
Uniform	YES	0 to 20 GWd/MTU
Region interface effects (mixed shapes)	YES	Analyzed uniform and non-uniform shapes at minimum and maximum burnup
Tolerances		
Fuel geometry		
Fuel pin pitch	YES	
Fuel pellet OD	YES	Fresh fuel, applied to all burnups
Fuel clad ID	YES	Fresh fuel, applied to all burnups
Fuel clad OD	YES	Fresh fuel, creep bias for depleted
Guide tube ID	YES	Fresh fuel, applied to all burnups
Guide tube OD	YES	Fresh fuel, applied to all burnups
Axial fuel position	YES	
Fuel stack height	YES	Fresh fuel, applied to all burnups
Burnup worth	YES	5% of burnup worth
Measured burnup	YES	4% of burnup worth
Fuel content		
Enrichment	YES	

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Tolerances (cont'd.)		
Rack geometry		
Cell wall thickness	YES	
Rack cell pitch	YES	
Boraflex wrapper thickness	YES	
Boraflex wrapper height	YES	Captured via axial fuel position variation
Rack tie plate thickness and width	YES	
Rack cell pitch	YES	
Code uncertainty	YES	
KENO case uncertainty	YES	2 standard deviations
Biases		
Fuel geometry		
Clad creep	YES	
Grid growth (pin pitch)	YES	
Minimum grid volume	YES	
Minor actinides and fission product worth	YES	1.5% of worth (NUREG/CR-7109)
Code bias	YES	
Temperature	YES	32 F to 170 F plus code benchmark temperature bias
Low power at EOL	YES	
Horizontal burnup tilt	YES	
Incore thimble depletion effect	YES	
NRC administrative margin	YES	1% Δk
Modeling simplifications		
Axial reflectors	YES	Water reflectors above and below active fuel region
10.0 Interface Analysis		
Region interface effects	YES	Calculated
Region 1 interface requirements	YES	Specified
11.0 Normal Conditions		
Fuel handling equipment	YES	Bounding analysis
Administrative controls	YES	Minimum boron, fuel handling restrictions, fuel qualification process, etc
Fuel inspection equipment or processes	YES	Bounding analysis

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12.0 Accident Analysis		
Boron dilution	YES	0 ppm k_{eff} < 1.0 including biases and uncertainties
Normal conditions	YES	k_{eff} < 0.95 with minimum dilution analysis boron
Accident conditions	YES	k_{eff} < 0.95 with TS minimum SFP boron
Multiple fuel misload	YES	Fresh 5.0 w/o fuel in all cells
Dropped assembly	YES	Not limiting
Heavy load drop	YES	Not limiting
Temperature	YES	32 F to 212 F
Seismic event	NO	Infinite lattice with no rack spacing credit, Region 1 contained within rack modules, benign Region boundaries
13.0 Summary and Conclusions		
Summary of results	YES	
Burnup curve interpolation	YES	Bounding cubic equation
New administrative controls	NO	None anticipated
Technical Specification markups	YES	
Appendix A Computer Code Validation:		
Code validation methodology and bases	YES	NUREG 6698 Method
New Fuel	YES	
Depleted Fuel	YES	
MOX critical	YES	Included for spent fuel
HTC critical	YES	Included for spent fuel
High temperature criticals	YES	Included, added bias
Convergence	YES	Source, histories, trends
Trends	YES	
Bias and uncertainty	YES	
Range of applicability	YES	