

Westinghouse Traveller Transport Package License Amendment Revision 13 Submittal

February 28, 2017



Participants

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Our vision is to be the
first to innovate the next
technology, practice or solution that
helps us help customers generate safer,
cleaner, more reliable energy for more
people and a better planet.

Agenda

- Record of Revision for Revision 13 of the Traveller SAR
- Full discussion of the new criticality safety analysis method, detailed in SAR Section 6
- Licensing

Note:

- No technical information has changed since prior meeting in September 2016
- Slides now include SAR Revision 13 Section references

Record of Revision – Revision 13

- Complete revision of Section 6, including development of Categorized Fuel Assemblies (CFA) (Sections 6.2, 6.9.2)
 - Bounding fuel parameters
 - Represent a combination of fuels
- Method for establishing subcriticality revised (Section 6.3.4)
 - Evaluation of uncertainties as independent sensitivities
 - Accumulation of penalties
- Updated code version to SCALE 6.1.2 and SCALE model
 - Discussed in Section 6.3

Record of Revision – Revision 13

- Clarifications added to Sections 1, 4, 5, 7, and 8
 - Major details have not changed
 - Sections 1, 4, 5, 7, and 8 are fully updated to Revision 13
- Sections 7 and 8 include additional details
 - Represents current usage of packages and activities that are applicable to all sites using the packages
- Sections 2 and 3 have revised reference sections that address the update of IAEA regulations, as incorporated by 49 CFR 171.7

Record of Revision – Revision 13

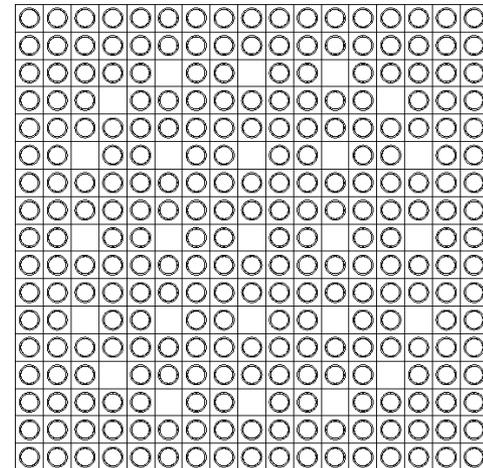
- Section 2:
 - Section 2.12.8.3 added expected VVER fuel assembly performance following HAC drop tests using VVER stiffness properties and previous FEA results
 - Section 2.12.9 added the HAC drop test mechanical performance comparison of Zirconium alloys
- Section 3:
 - Section 3.2.1 added additional material property references to Tables 3-2 and 3-3A
 - Section 3.3.1 added a statement that the initial ambient temperature of 38°C is an analysis input
 - Section 3.6.5.1 added additional details of the moderator blocks' post fire test condition, used as justification to support the evaluations in Section 6.3.4.3.3

Engineering Analysis Overview

- Two Categorized Fuel Assembly (CFA) analyses (Section 6.3.4):
 1. Limiting CFA determination (Section 6.9.2)
 - Model overview
 - How fuel assemblies are binned
 - Bounding parameter determination
 - Results
 - Conclusions
 2. Package assessment with CFAs in Traveller
 - 2a. Baseline cases
 - 2b. Sensitivity studies
 - Conclusions
- Loose Rod Contents (Section 6.3.4.2.2)
- USL (Sections 6.1.2, 6.8)

Part 1: Intro to Categorized Fuel Assemblies (CFA)

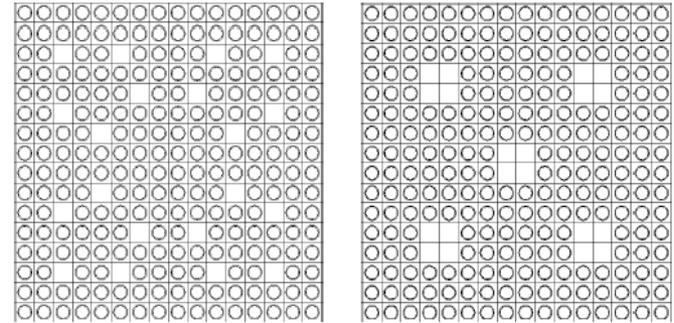
- (Section 6.9.2)
- New methodology groups 17 fuel designs into 11 fuel assembly “bins”
 - Binned based on shared primary parameters
 - Secondary parameters define limit of bin
- Increased CSI:
 - 0.7 → 1.0 for 9 of 11 Bins
 - 0.7 → 4.2 for 2 of 11 Bins
- Representing 17 fuel assemblies with 11 Bins:
 - Removes proprietary information
 - Makes CoC more robust



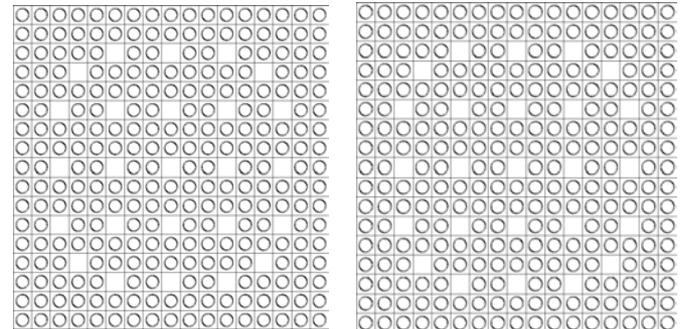
Fuel rod pattern

1. CFA Method Discussion – Grouping Assemblies

- Fuel assembly binning
 - Each bin shares three primary parameters:
 - Array size (e.g. 17x17)
 - Fuel rod pattern
 - Given an array size, fuel rod/non-fuel hole locations
 - Nominal fuel rod pitch
 - Tolerance examined in package assessment
- Each bin is analyzed individually to find its bounding configuration



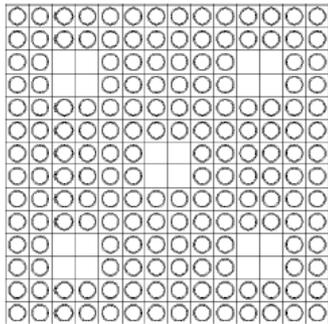
Both assemblies are 16x16 but have different fuel rod/water hole patterns. These are separate bins.



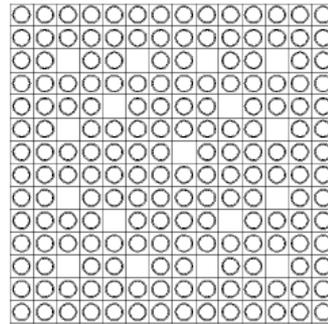
These two assemblies have different nominal pitch values. These are separate bins.

1. Basis for Bin Grouping

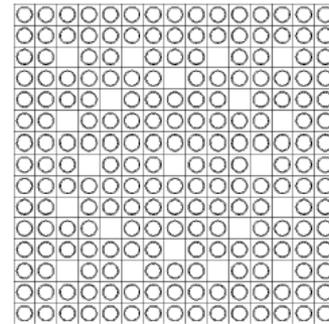
14		15	
Bin 1	Bin 2	Bin 1	Bin 2
One design	Two designs	One design	One design



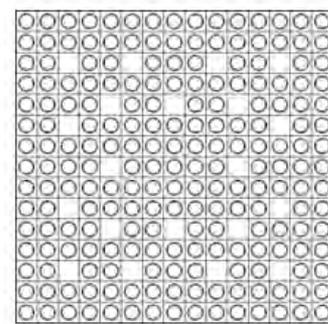
14 Bin 1



14 Bin 2



15 Bin 1

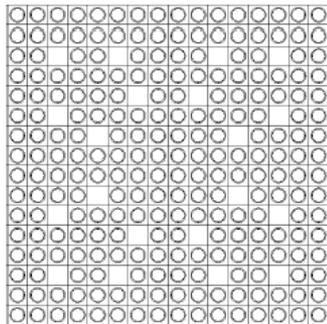


15 Bin 2

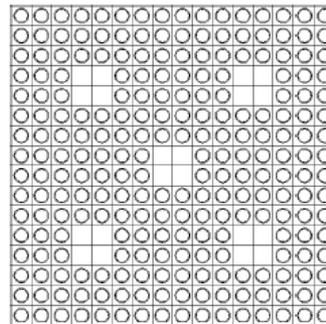
Fuel designs provide the basis for bins

1. Basis for Bin Grouping

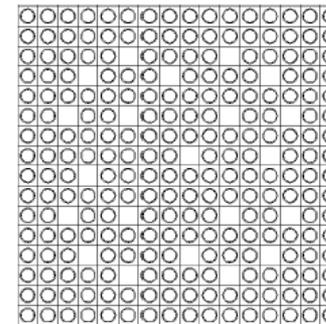
16		
Bin 1	Bin 2	Bin 3
One design	Three designs	Two designs



16 Bin 1



16 Bin 2

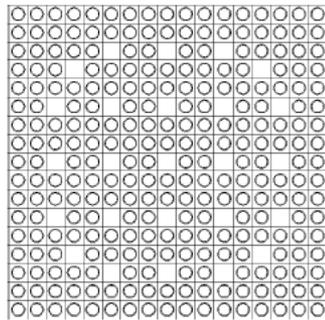


16 Bin 3

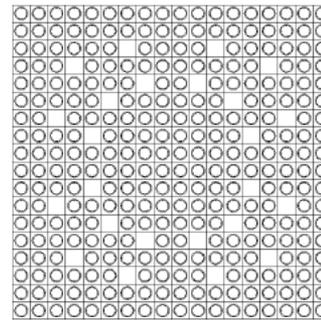
Fuel designs provide the basis for bins

1. Basis for Bin Grouping

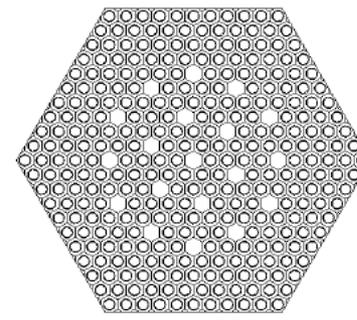
17		18	VVER
Bin 1	Bin 2	Bin 1	Bin 1
Three designs	One design	One design	Two designs



17 Bin 1 / Bin 2



18 Bin 1



VVER Bin 1

Fuel designs provide the basis for bins

CFA Method Discussion – Bounding Configuration

- Three secondary parameters determine the range of acceptability for a given bin
 - Fuel pellet diameter
 - Cladding ID
 - Cladding thickness
- Range of examination based solely on the fuel assembly designs of a bin
 - Includes min/max tolerance from fuel assemblies of bin
 - Including tolerances slightly extends examination ranges and adds robustness

1. CFA Method Discussion – Bounding Configuration

Dimensions	Bin Example		
	Design 1	Design 2	Design 3
Fuel assembly parameters			
Fuel Diameter (in.)	0.3225	0.3250	0.3255
Fuel Diameter Tolerance (in.)	0.0005	0.0005	0.0005
Fuel tolerance band			
Minus Diameter (in.)	0.3220	0.3245	0.3250
Nominal Diameter (in.)	0.3225	0.3250	0.3255
Plus Diameter (in.)	0.3230	0.3255	0.3260
Evaluated bin parameter range			
Lower Limit (in.)		0.3220	
Interval 1 (in.)		0.3233	
Interval 2 (in.)		0.3247	
Upper Limit (in.)			0.3260

1. CFA Method Discussion – CFAs analyzed

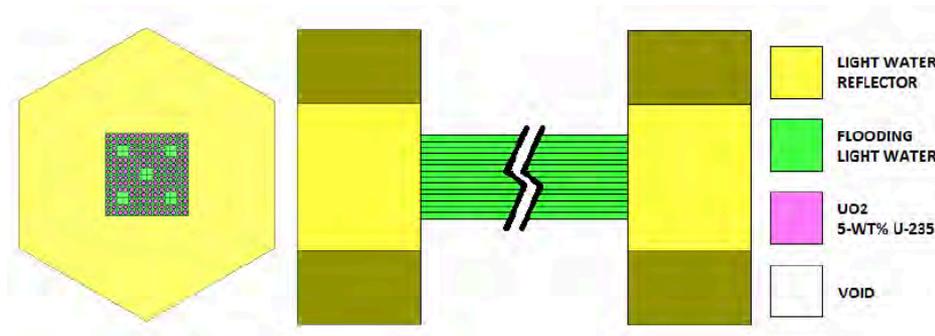
- Each secondary parameter is examined by holding two parameters constant (e.g., cladding ID and OD) and examining the remaining value's effect (e.g., fuel diameter) on k-eff.
- Every permutation of parameters is examined for each bin

Bin Parameter Example

Index	Fuel Diameter (in.)	Fuel-Clad Gap (in.)	Cladding Thickness (in.)
1	0.3220	0.00225	0.02100
2	0.3233	0.00300	0.02292
3	0.3247	0.00375	0.02483
4	0.3260	0.00450	0.02675

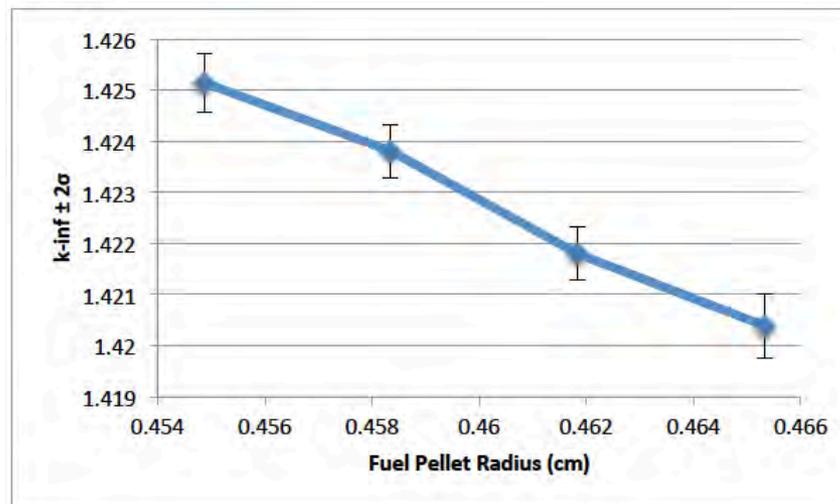
1. CFA Method Discussion – Model

- Bare fuel lattices modeled – no packaging materials modeled
 - No guide/instrument tubes modeled
 - No structural elements modeled
- Package Outer Diameter defines array pitch
- Infinite hex array in x-y plane with 20 cm of water reflection in z (axial) direction (k-infinite)
- Active fuel length of 168.5 in. (max of fuel designs + tolerance)
- Strict comparison of fuel assemblies
- (Section 6.9.2.5)



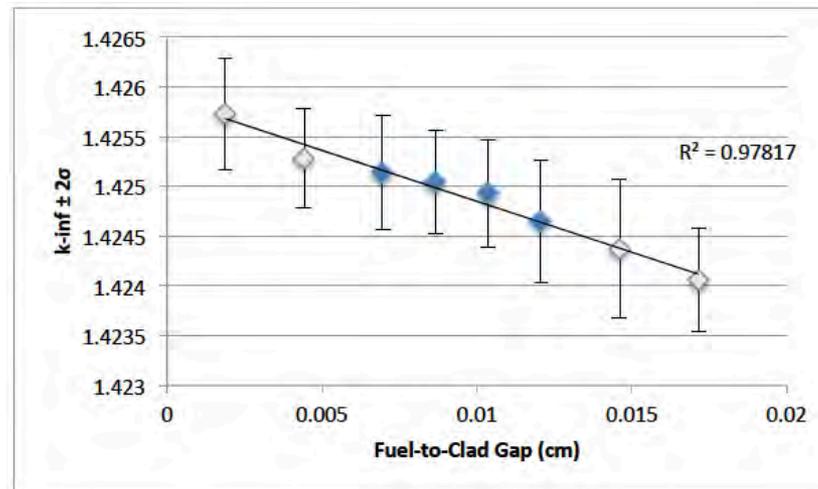
1. CFA Method Discussion – Fuel Pellet Diameter

- For each bin analyzed, decreasing the fuel pellet diameter results in increased reactivity
 - Fuel assemblies are under-moderated by design. Increasing moderator-to-fuel ratio increases reactivity
- Significant effect on k_{eff}



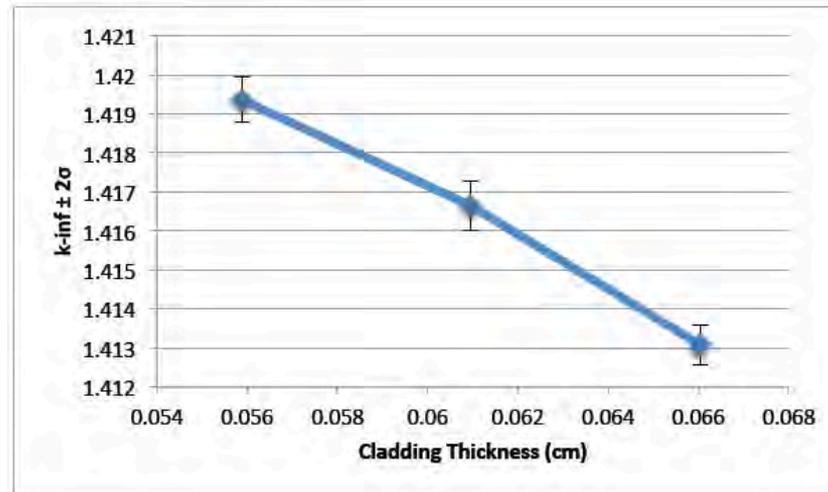
1. CFA Method Discussion – Fuel-clad gap

- Cladding ID is examined by adjusting fuel-clad gap
- Decreasing the fuel-clad gap, while holding fuel diameter and cladding thickness constant, increases reactivity
 - Increasing moderator-to-fuel ratio
- Small effect on k_{eff}



1. CFA Method Discussion – Cladding Thickness

- Decreasing the cladding thickness, while holding cladding ID and fuel pellet diameter constant, increases reactivity
 - Increasing moderator-to-fuel ratio
- Significant effect on k_{eff}



1. CFA Method Discussion – Conclusion

- All minimized secondary parameters result in the most reactive CFA configuration (Section 6.9.2.1)
 - Fuel pellet diameter
 - Cladding ID
 - Cladding thickness
- Allows for more water in fuel lattice under HAC
 - Under-moderated: increasing moderator-to-fuel ratio increases reactivity
- Most reactive configuration bounds fuel assemblies of a bin
- These results define contents specification in Section 6.2 and CoC

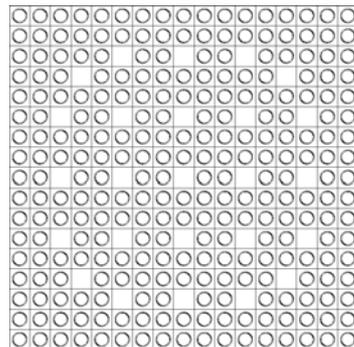
Description	17 Bin 1
Array Size	17x17
Fuel Rods	264
Non-Fuel Holes	25
Nominal Pitch (in.)	0.496
Minimum Fuel Pellet OD (in.)	0.3083
Minimum Cladding ID (in.)	0.3125
Minimum Cladding Thickness (in.)	0.0210
Cladding Material	Zirconium Alloy
Maximum Active Fuel Length (in.)	168.50

Minimized secondary parameters bound a bin

1. Current CoC vs. Proposed CoC

Fuel Assembly Description	17 x 17	17 x 17
Fuel Assembly Type	W-STD/XL	W-OFA
No. of Fuel Rods per Assembly	264	264
No. of Non-Fuel Rods	25	25
Nominal Guide Tube Wall Thickness	0.041/0.051 cm (0.016 /0.020 in.)	0.041 cm (0.016 in.)
Nominal Guide Tube Outer Diameter	1.204/1.224/1.24 cm (0.474/0.482/0.488 in.)	1.204 cm (0.474 in.)
Nominal Pellet Diameter	0.819 cm (0.323 in.)	0.784 cm (0.309 in.)
Nominal Clad Outer Diameter	0.950 cm (0.374 in.)	0.914 cm (0.360 in.)
Nominal Clad Thickness	0.057 cm (0.023 in.)	0.057 cm (0.023 in.)
Clad Material	Zirconium alloy	Zirconium alloy
Nominal Assembly Envelope	21.39 cm (8.42 in.)	21.39 cm (8.42 in.)
Nominal Lattice Pitch	1.260 cm (0.496 in.)	1.260 cm (0.496 in.)

Description	17 Bin 1
Array Size	17x17
Fuel Rods	264
Non-Fuel Holes	25
Nominal Pitch (in.)	0.496
Minimum Fuel Pellet OD (in.)	0.3083
Minimum Cladding ID (in.)	0.3125
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Cladding Material	Zirconium Alloy
Maximum Active Fuel Length (in.)	168.50



Fuel pellet OD tolerance: -0.0005 in.
 Cladding ID tolerance: -0.002 in.
 Cladding thickness tolerance: -0.002 in.
 Pitch tolerance: +0.00394 in.
 Active fuel length tolerance: +0.5 in.

Part 2: Package Assessment with CFAs

- Traveller STD, XL, and VVER examined
 - Three fuel Group contents
 - Group 1 can be shipped in the STD or XL
 - Group 2 can only be shipped in the XL
 - Group 3 can only be shipped in the VVER
- 2a. Establish baseline cases (Section 6.3.4.2)
 - Bounding CFA / package configuration
 - Includes cumulative effects of lattice expansion, flooding, and position of fuel assembly in Clamshell
 - One baseline for each fuel group/condition of transport
- 2b. Sensitivity studies (Section 6.3.4.3)
 - Baseline case used as starting point
 - Examined independently of one another
 - Increases in k-eff added to baseline case for final k-eff

Part 2: Package Assessment with CFAs

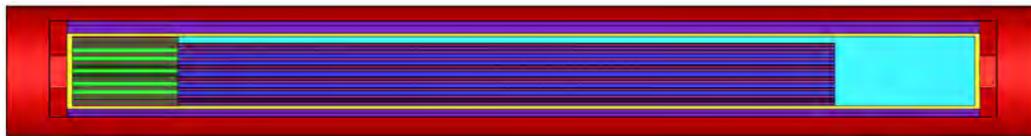
- Formula for determining maximum multiplication factor (Section 6.1.2):

$$\text{Maximum } k_{eff} = k_p + 2\sigma_p + \Delta k_u$$

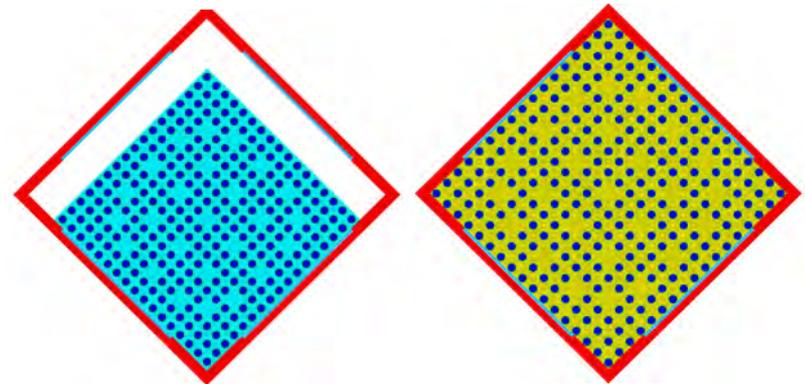
- Where,
 - $k_p + 2\sigma_p$ represents $k_{eff} + 2\sigma$ of the baseline case
 - Δk_u represents the sum of all penalties, which represent increases in k_{eff} because of a sensitivity study

2a. Bounding CFA for Baseline Case

- For each Traveller variant, all relevant CFAs modeled
 - Most reactive CFA(s) selected for baseline studies (Section 6.3.4.2)
- Lattice expansion bounding test damage (Section 6.3.4.2.1.3)
- Flooding study to determine most reactive flooding (Sections 6.3.4.2.1.4, 6.3.4.3.13)
- Axial position study to determine most reactive position of fuel assembly (Section 6.3.4.2.1.2)



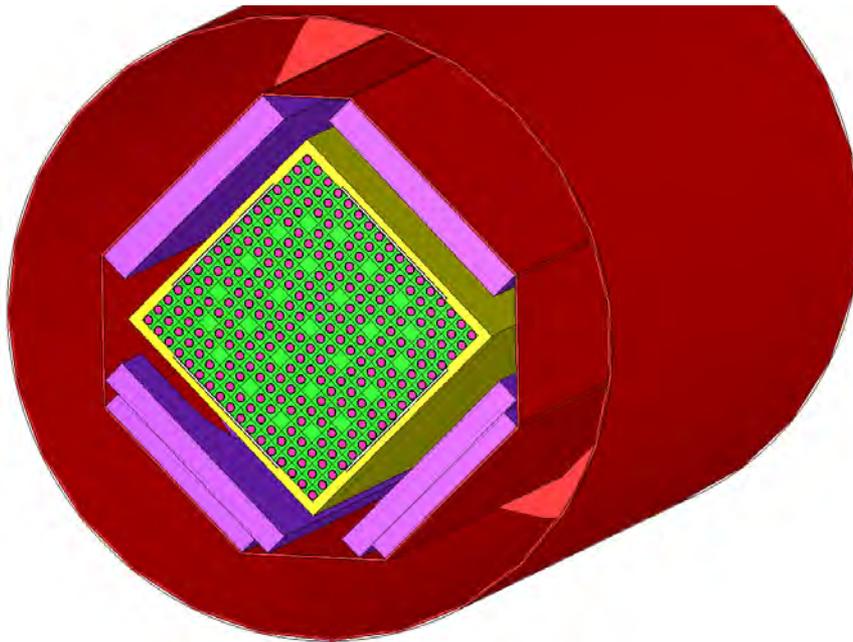
Side view of lattice expansion



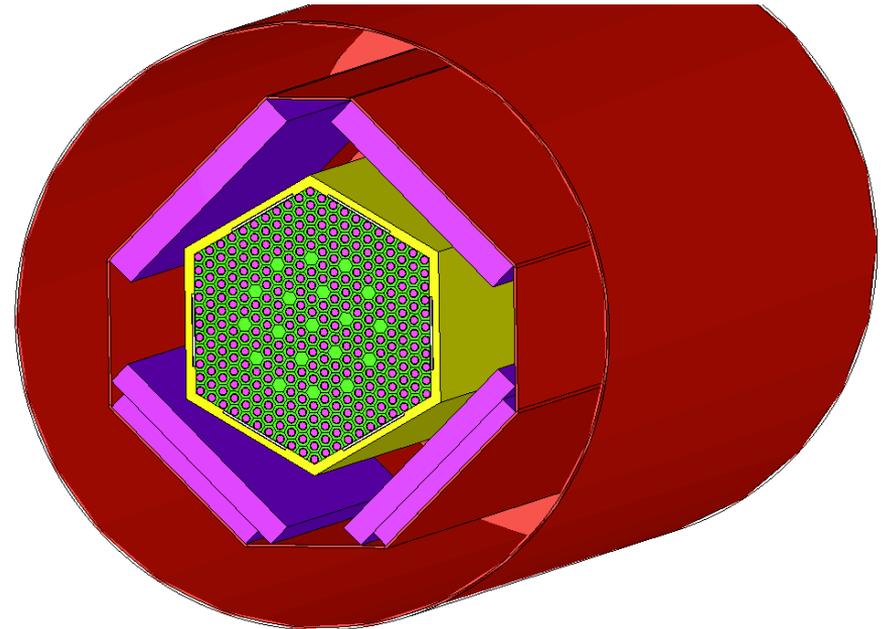
Nominal lattice

Expanded lattice

Package Models

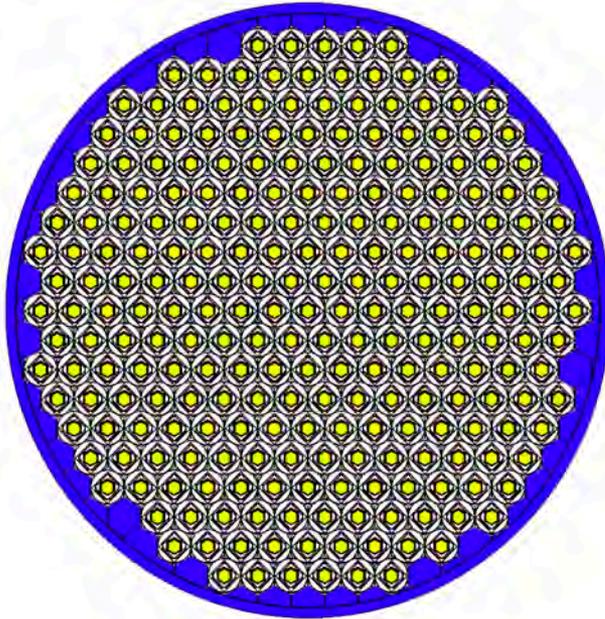


Traveller STD/XL



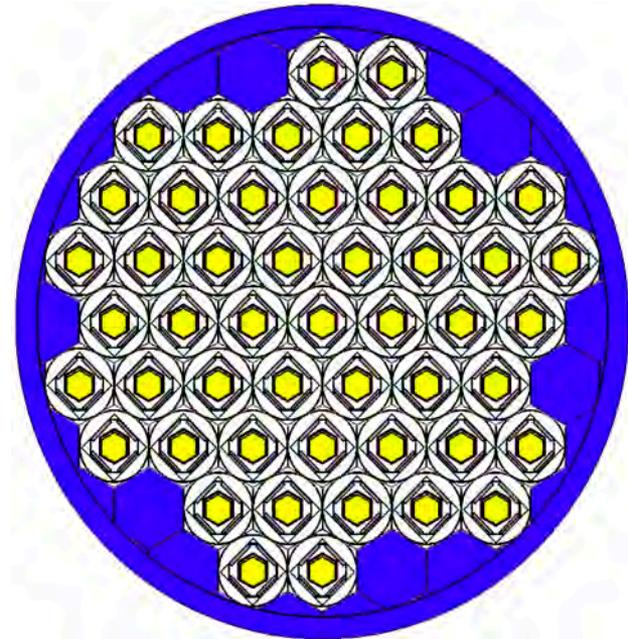
Traveller VVER

Package Models - Arrays



Top View

NCT Array



Top View

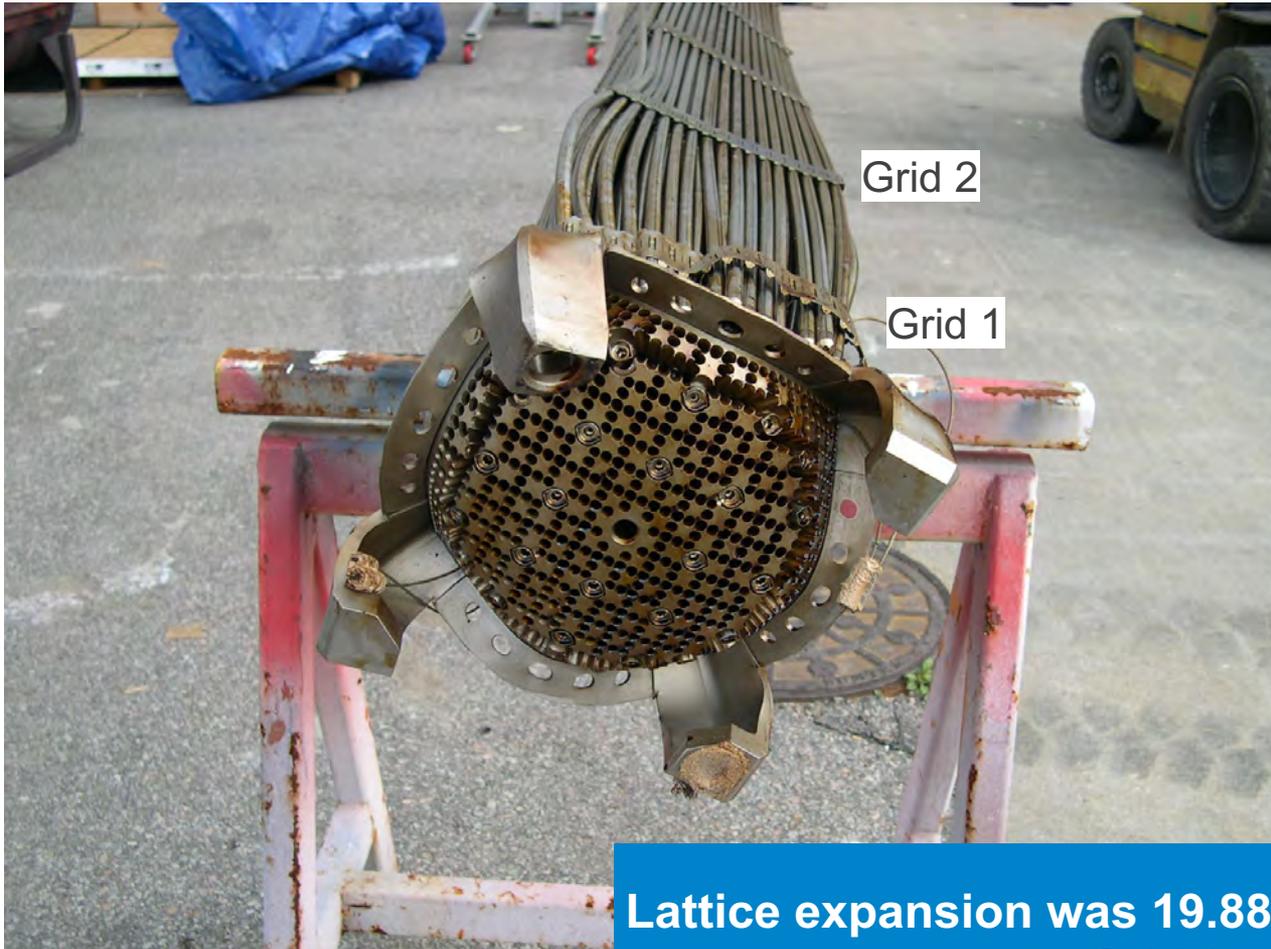
HAC Array

Two CSIs based on fuel types

2a. Lattice Expansion

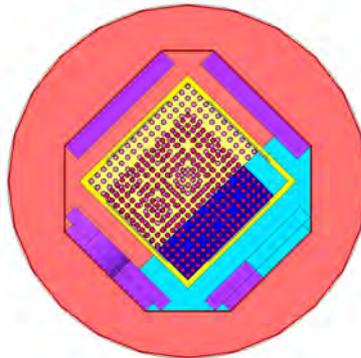
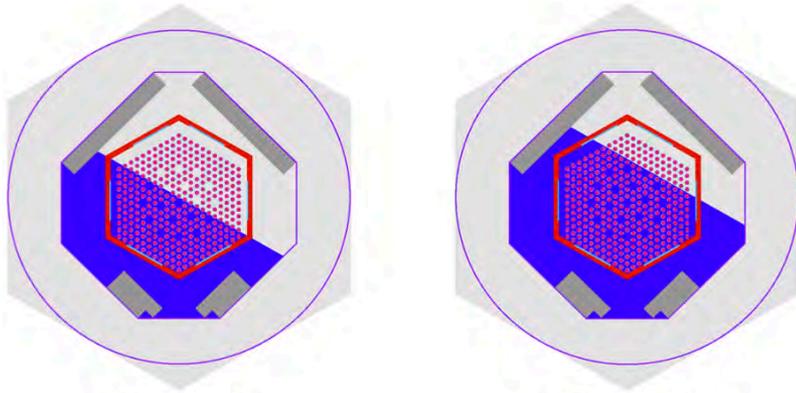
- (Section 6.3.4.2.1.3)
- From 9-m end drop, test assembly experienced lattice expansion in bottom 19.88 in. (50.5 cm) of the assembly.
 - One rod was expanded to the Clamshell inner boundary
 - A few other rods saw local lattice expansion
 - Remaining rods in assembly experienced lattice compression
- For analysis, lattice expansion bounded:
 - 20.0 in. (50.8 cm) long
 - Full, uniform lattice expansion to the Clamshell inner boundary
 - Conservative modeling decision over damage experienced

2a. Lattice Expansion

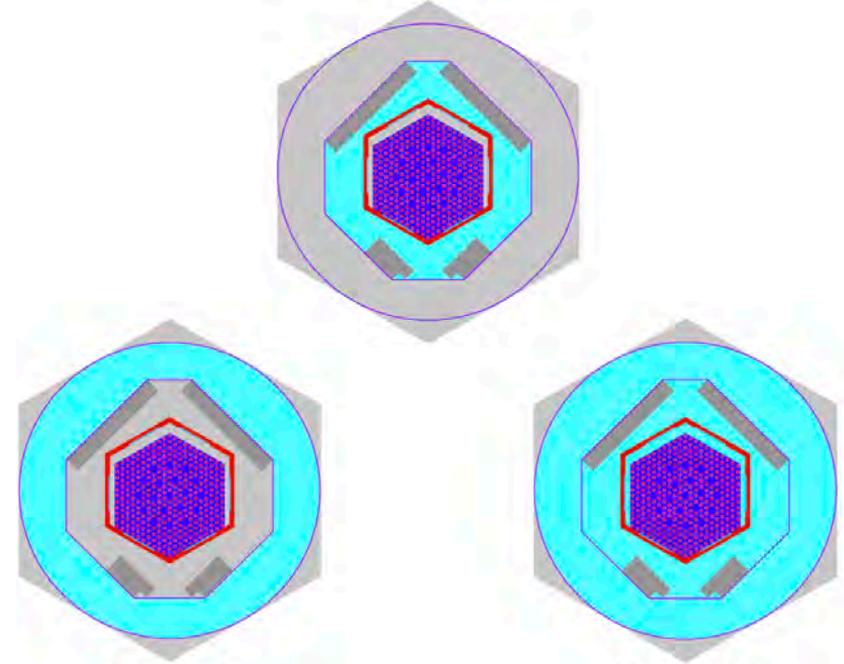


Lattice expansion was 19.88" from Grid 1 to Grid 2

2a. Flooding Configurations Examined



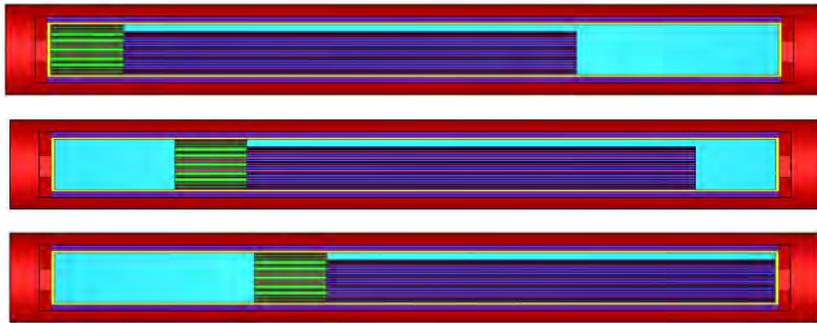
Partial Flooding



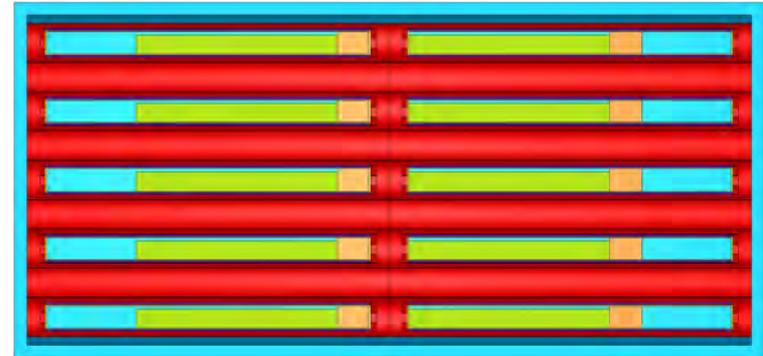
Preferential Flooding

Clamshell + fuel envelope preferential flooding is most reactive

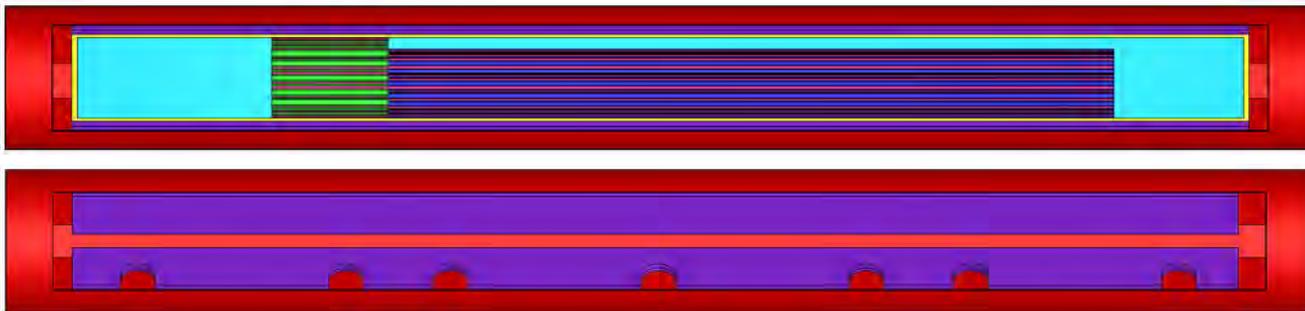
2a. Fuel Assembly Axial Position



Array Height = 1 Fuel Assembly Axial Position Sensitivity



Array Height = 2 (Z2) Most Reactive Axial Configuration



Array Height = 1 Most Reactive Axial Configuration with Lattice Expansion over Shock Mount Cutouts

k_{eff} driven by: changes in axial reflection, expanded lattice over shock mount cutouts

2a. Baseline Case Flowchart 1

Traveller XL under HAC, Group 1

14 Bin 1	15 Bin 2	17 Bin 1
14 Bin 2	16 Bin 2	17 Bin 2
15 Bin 1	16 Bin 3	

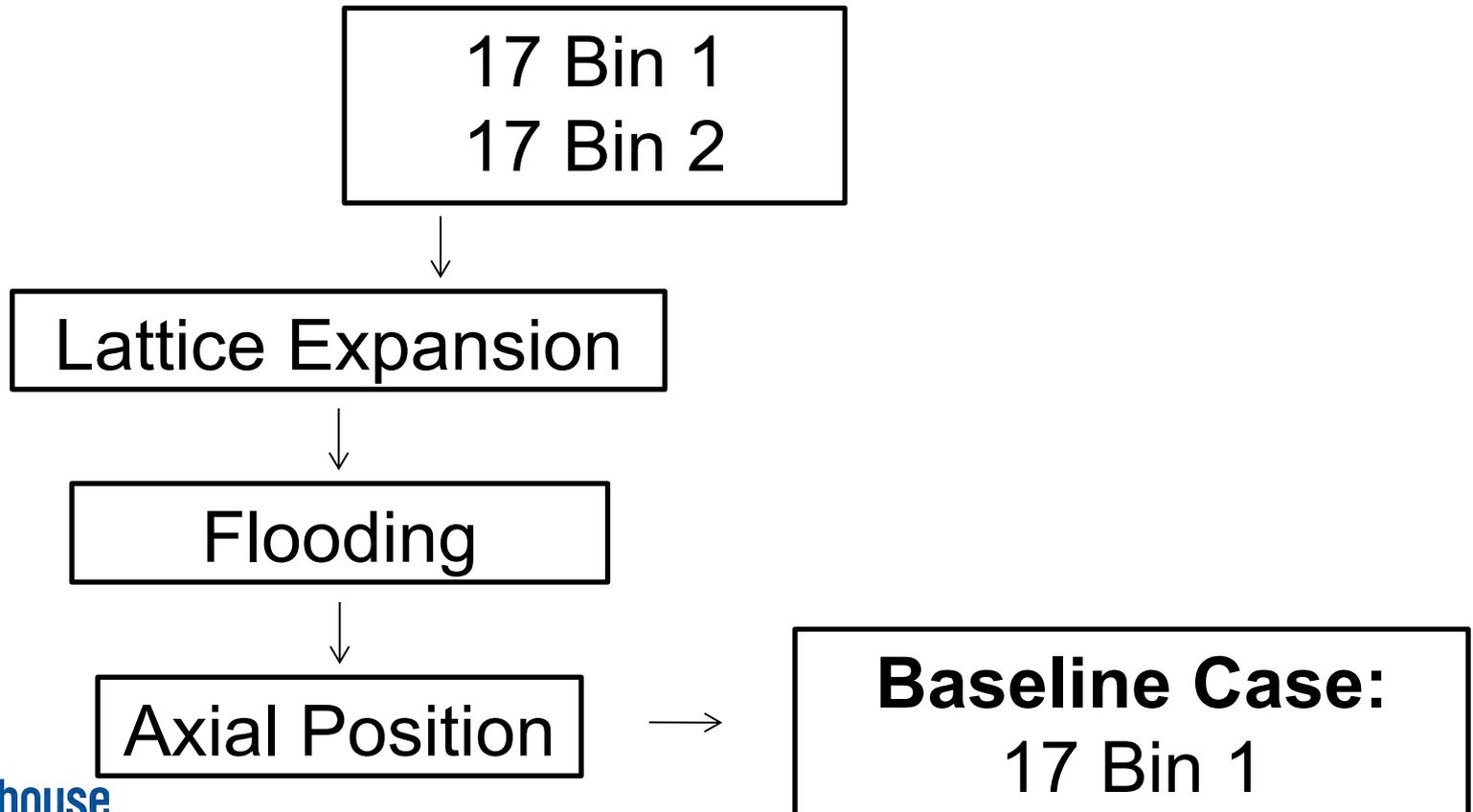


Most Reactive CFAs

17 Bin 1
17 Bin 2

2a. Baseline Case Flowchart 2

Traveller XL under HAC, Group 1 Most Reactive CFAs



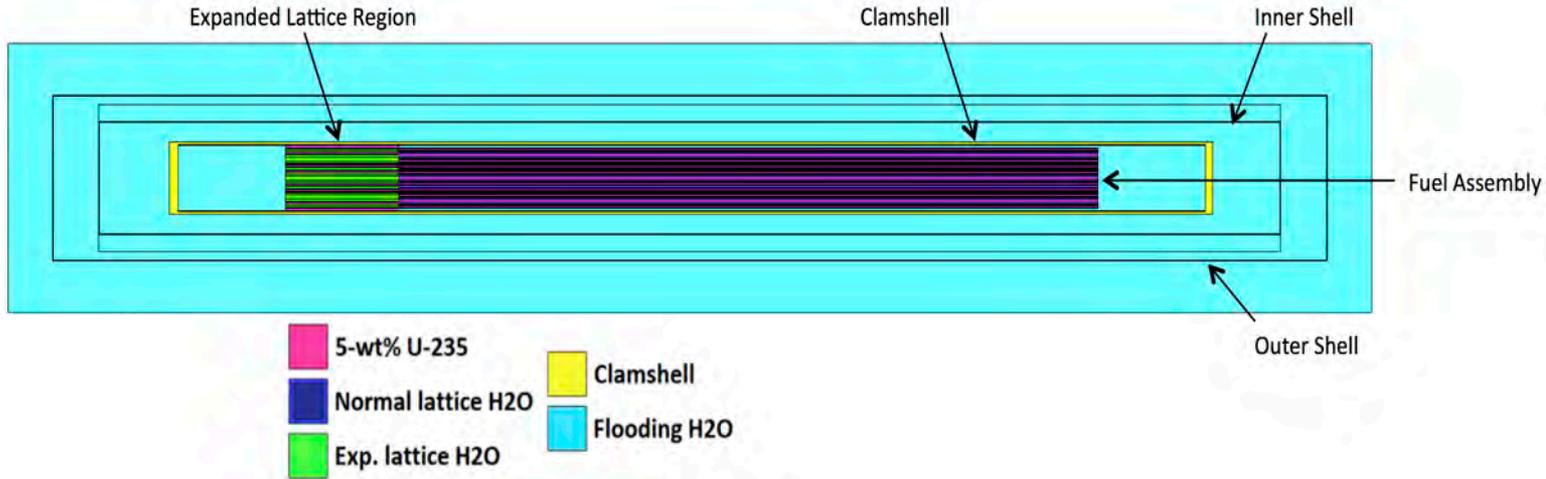
2a. CFA-Package Variant Assessment Results

- Traveller XL bounds Traveller STD (Section 6.3.4.2.1.1)
 - Groups 1 and 2 have their own bounding CFA-package combinations
- Traveller VVER analyzed separately due to differences in packaging design
 - Same baseline method applies
 - Group 3 has its own bounding CFA-package combinations

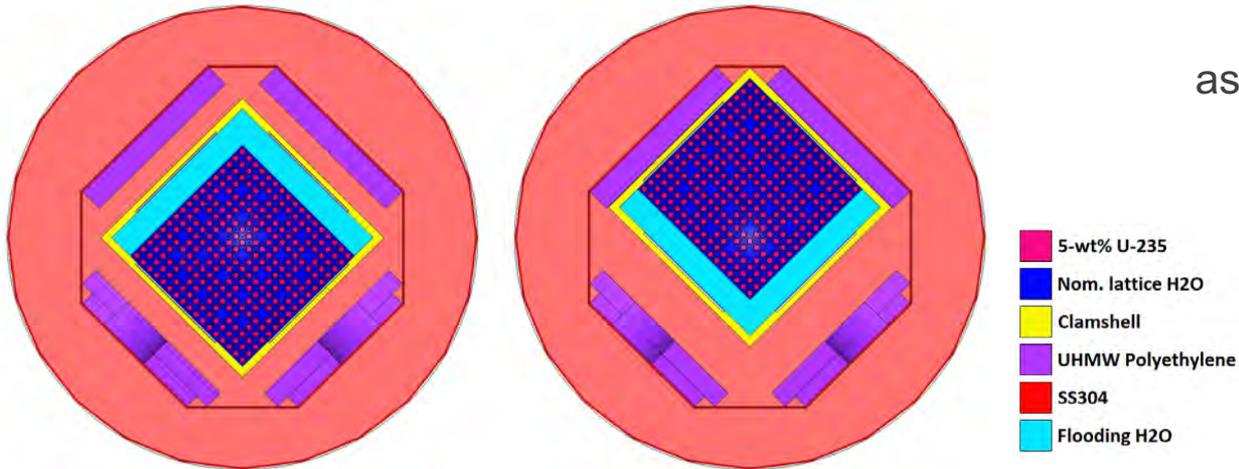
2b. Package Assessment Sensitivity Studies

- Method (Section 6.3.4.3)
 - Baseline is used as starting/comparison point for sensitivity studies
 - Each sensitivity study done independently of another
 - If a sensitivity produces a higher k-eff than baseline, difference in k-eff + 2σ between cases added to baseline result
 - A positive increase is called a penalty (k_u)
- Sensitivity Studies:
 - Fuel assembly tolerances
 - Package outer diameter
 - Clamshell and fuel assembly shift
 - Axial rod displacement
 - Polyethylene packing materials
 - Moderator block polyethylene density
 - Stainless Steel rods
 - Annular fuel pellet blankets
 - Nozzle reflector
 - Group 3 extended active fuel length

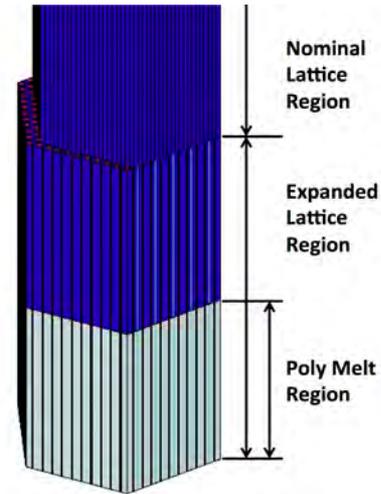
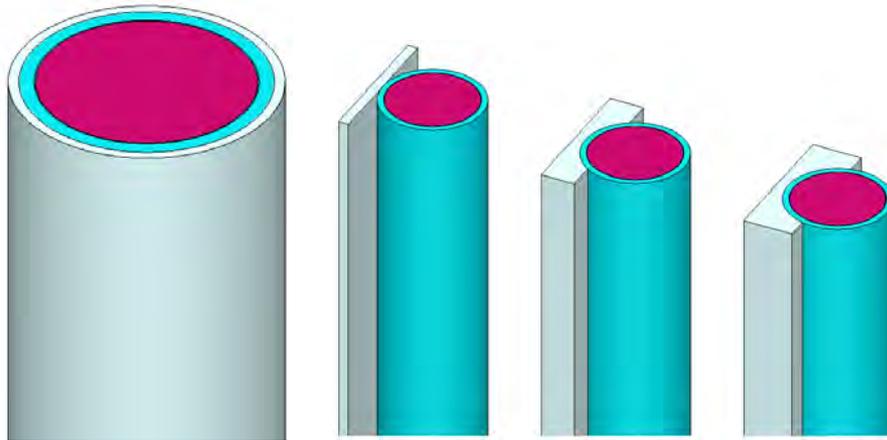
2b. Sensitivity Studies



Clamshell and fuel assembly shift (Section 6.3.4.3.2)



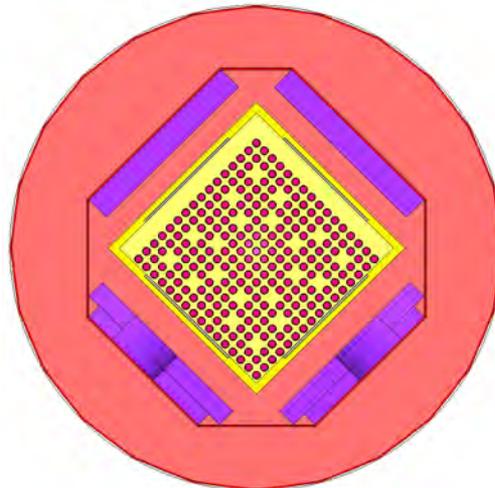
2b. Sensitivity Studies



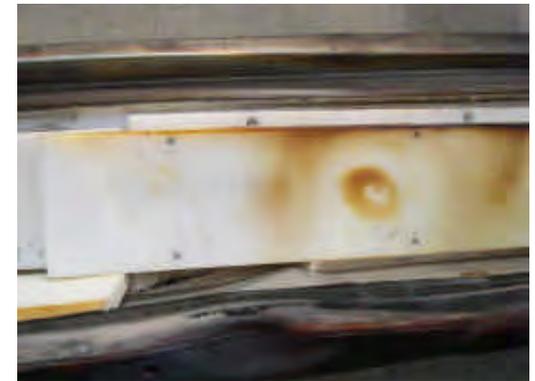
Polyethylene Packing Materials (Section 6.3.4.3.5)

- 5-wt% U-235
- H2O
- Polyethylene

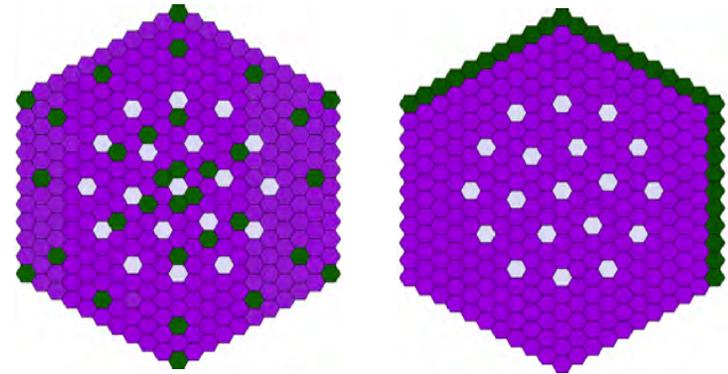
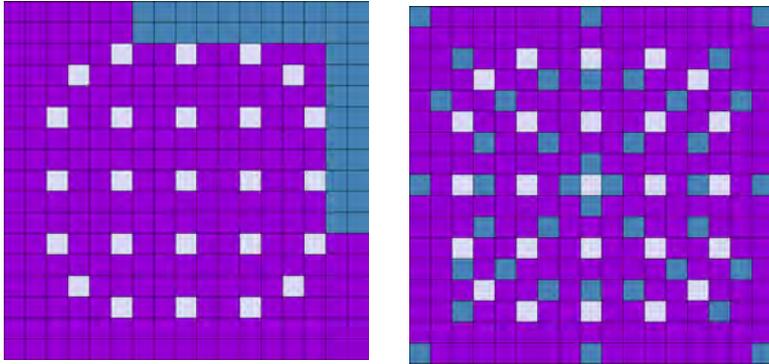
Moderator Block polyethylene density (Section 6.3.4.3.3)



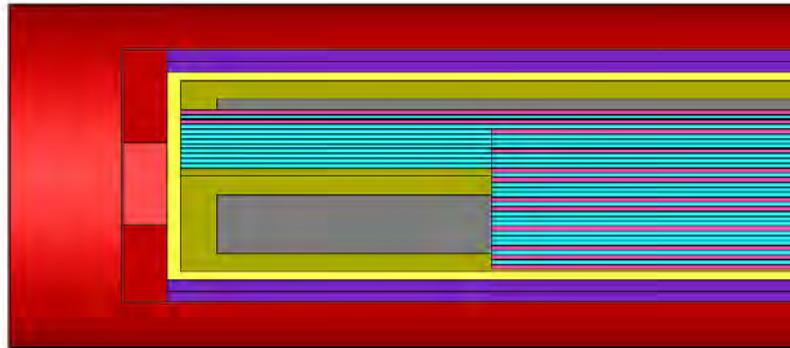
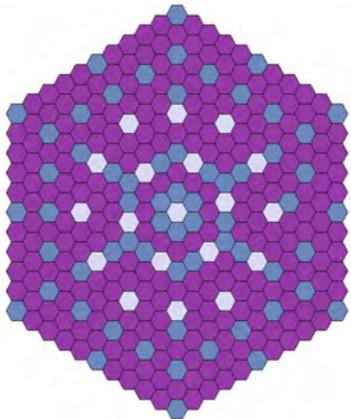
- 5-wt% U-235
- Nom. lattice H2O
- Clamshell
- UHMW Polyethylene
- SS304
- Flooding H2O



2b. Sensitivity Studies

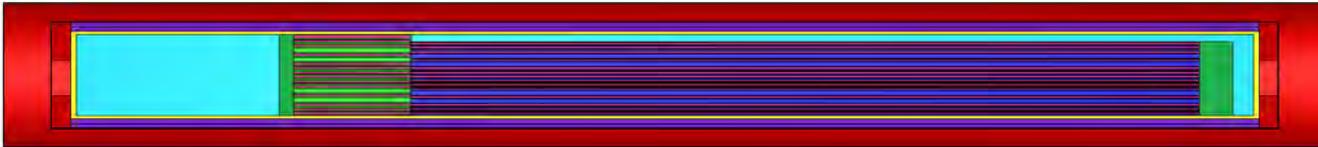
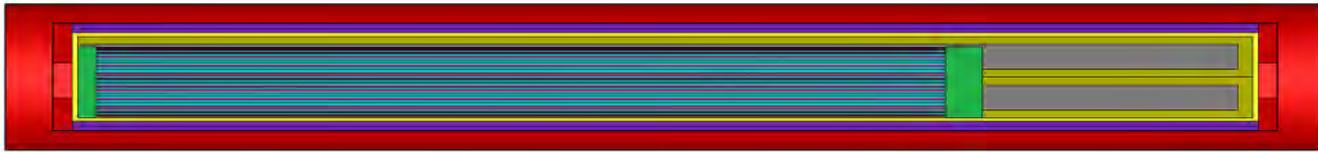


SS Rod Replacement
(Section 6.3.4.3.7)



Axial Rod Displacement
(Section 6.3.4.3.6)

2b. Sensitivity Studies



Steel Nozzle Reflector
(Section 6.3.4.3.11)

2b. Sensitivity Results – Groups 1, 2 Single Package

- Groups 1 and 2 (Traveller STD/XL)
 - (Section 6.4.2.1.1)
 - NCT *Maximum* $k_{eff} = 0.92151$
 - HAC *Maximum* $k_{eff} = 0.93193$ USL = 0.93902

Sensitivity Study	Penalty Assessed	
	Groups 1 and 2	
	NCT	HAC
Annular Fuel Pellet Blanket	0.01273	0.0
Centered Fuel Assembly	0.00202	--
Moderator Block Density	--	0.00157
Polyethylene Packing Materials	0.00168	0.02068
Axial Rod Displacement	--	0.0
Stainless Steel Rods	0.0	0.0
Cladding Dimensions Tolerance	0.00529	0.00495
Fuel Pellet Diameter Tolerance	0.0	0.0
Fuel Rod Pitch Tolerance	0.01362	0.00457
Extended Active Fuel Length	--	--
Total Penalty (Δk_u)	0.03534	0.03177

2b. Sensitivity Results – Package Array Group 1

- Traveller STD/XL Group 1
 - (Section 6.5.2.2.1, 6.6.2.2.1)
 - NCT *Maximum* $k_{eff} = 0.30995$
 - HAC *Maximum* $k_{eff} = 0.93824$ USL = 0.94093

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Annular Fuel Pellet Blanket	0.0	0.0
Clamshell/Fuel Assembly Shift	0.0	0.00353
Moderator Density	-	0.00041
Package OD Tolerance	0.0	0.0
Axial Rod Displacement	-	0.0
SS Rods	0.0	0.0
Cladding Tolerance	0.0	0.00310
Fuel Pellet Diameter Tolerance	0.0	0.0
Fuel Rod Pitch Tolerance	0.00053	0.00291
Polyethylene Wrap	0.0	0.00079
Steel Reflector	0.0	0.0
Total Penalty	0.00053	0.01074

2b. Sensitivity Results – Package Array Group 2

- Traveller XL Group 2
 - (Section 6.5.2.2.1, 6.6.2.2.1)
 - NCT *Maximum* $k_{eff} = 0.31425$
 - HAC *Maximum* $k_{eff} = 0.93831$

USL = 0.93948

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Annular Fuel Pellet Blanket	0.0	0.0
Clamshell/Fuel Assembly Shift	0.0	0.00351
Moderator Density	--	0.00037
Package OD Tolerance	0.00046	0.0
Axial Rod Displacement	--	0.0
SS Rods	0.0	0.0
Cladding Tolerance	0.00084	0.00451
Fuel Pellet Diameter Tolerance	0.0	0.0
Fuel Rod Pitch Tolerance	0.00293	0.01098
Polyethylene Wrap	0.0	0.00154
Steel Reflector	0.0	0.0
Total Penalty	0.00423	0.02091

2b. Sensitivity Results – Group 3 Single Package

- Group 3 (Traveller VVER)
 - (Section 6.4.2.1.1)
 - NCT *Maximum* $k_{eff} = 0.88932$
 - HAC *Maximum* $k_{eff} = 0.91702$

USL = 0.93824

Sensitivity Study	Penalty Assessed	
	Group 3	
	NCT	HAC
Annular Fuel Pellet Blanket	0.02048	0.00749
Centered Fuel Assembly	0.0	--
Moderator Block Density	--	0.0
Polyethylene Packing Materials	0.00077	0.02151
Axial Rod Displacement	--	0.0
Stainless Steel Rods	0.0	0.0
Cladding Dimensions Tolerance	0.00419	0.00395
Fuel Pellet Diameter Tolerance	0.0	0.0
Fuel Rod Pitch Tolerance	0.00137	0.0
Extended Active Fuel Length	0.0	0.00116
Total Penalty (Δk_{eff})	0.02681	0.03411

2b. Sensitivity Results – Group 3 Package Array

- Group 3 (Traveller VVER)
 - (Section 6.5.2.2.1, 6.6.2.2.1)
 - NCT *Maximum* $k_{eff} = 0.39042$
 - HAC *Maximum* $k_{eff} = 0.93010$

USL = 0.93824

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Moderator Density	-	0.00082
Stainless Steel Rods	0.00000	0.00000
Annular Fuel Pellet Blanket	0.00000	0.00089
Cladding Dimensions	0.00042	0.00421
Fuel Pellet Diameter	0.00050	0.00052
Assembly Pitch	0.00000	0.00117
Polyethylene Wrap	0.00000	0.00154
Axial Rod Displacement	-	0.00529
Centered Fuel Assembly	0.00000	-
Clamshell Shift	-	0.00094
Package OD	0.00090	0.00051
Nozzle Reflection	0.00000	0.00000
Total Penalty	0.00182	0.01589

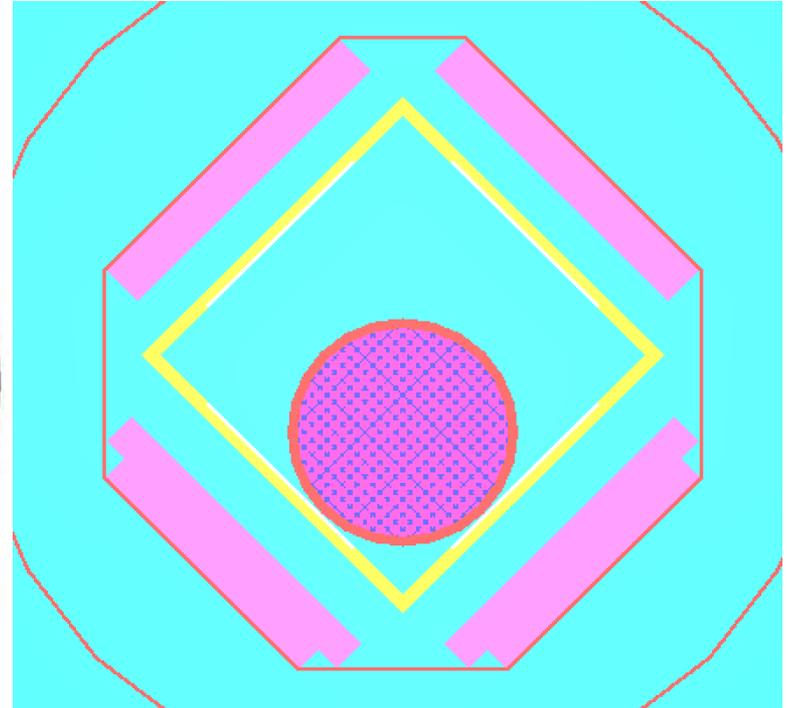
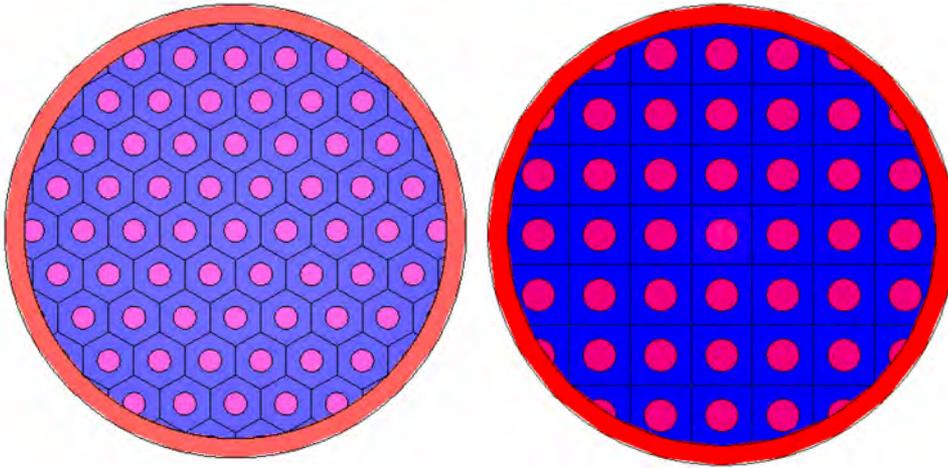
Loose Rod Contents – UO₂ Fuel Rods

- (Section 6.3.4.2.2)
- Traveller STD and XL transport only
- Contents
 - No cladding evaluated
 - Fuel diameter and pitch varied to ensure bounding reactivity and optimized H/U
 - UO₂ fuel diameter range: 0.307 in. – 3.15 in.
 - Pitch geometry varied (hexagonal and square)
- Same method for sensitivity studies applied
- Increased CSI from 0.0 → 0.7
- No restriction on cladding dimensions
- As many rods as can fit in Rod Pipe
- Fuel diameter minimum of 0.307 in.

Loose Rod Contents – U_3Si_2 Fuel Rods

- (Section 6.3.4.2.2)
- Traveller STD transport only
- Contents
 - No cladding evaluated
 - Fuel diameter and pitch varied to ensure bounding reactivity and optimized H/U
 - U_3Si_2 fuel diameter range: 0.308 in. – 0.382 in.
 - Pitch geometry varied (hexagonal and square)
- Same method for sensitivity studies applied
- Increased CSI from 0.0 → 0.7
- No restriction on cladding dimensions
- Limited to 60 fuel rods per Rod Pipe
 - Based on mass
- Fuel diameter minimum of 0.308 in.

Traveller STD/XL – Loose Rod Model



Sensitivity Results – Rod Pipe Single Package, UO₂ Fuel Rods

- UO₂ Rod Pipe (Traveller STD/XL)
 - (Section 6.4.2.2.4)
 - NCT *Maximum* k_{eff} = 0.60036
 - HAC *Maximum* k_{eff} = 0.74609
- USL = 0.93980

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Rod Pipe Position in Clamshell	0	0
Moderator Block Density Reduction	--	0.00080
Annular Blanket Length	0.04313	0.00069
Fuel Pellet Tolerance	0	0
Polyethylene Wrap	0.02729	0.06684
Total Penalty	0.07042	0.06833

Sensitivity Results – Rod Pipe Package Array, UO₂ Fuel Rods

- UO₂ Rod Pipe (Traveller STD/XL)
 - (Sections 6.5.2.2.3, 6.6.2.2.3)
 - NCT *Maximum* $k_{eff} = 0.55421$
 - HAC *Maximum* $k_{eff} = 0.76953$ USL = 0.93980

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Rod Pipe Position in Clamshell	0.00136	0.00123
Moderator Block Density Reduction	--	0.00120
Annular Blanket Length	0.06039	0.00098
Fuel Pellet Tolerance	0	0
Polyethylene Wrap	0.06395	0.08270
Moderation Variation	--	0.06317
Package Outer Diameter Tolerance	0	0.00071
Total Penalty	0.12570	0.14999

Sensitivity Results – Rod Pipe Single Package, U_3Si_2 Fuel Rods

- U_3Si_2 Rod Pipe (Traveller STD)
 - (Section 6.4.2.2.4)
 - NCT *Maximum* $k_{eff} = 0.72879$
 - HAC *Maximum* $k_{eff} = 0.73961$ USL = 0.93873

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Rod Pipe Position in Clamshell	0	0
Moderator Block Density Reduction	--	0
Annular Blanket Length	0.02104	0
Fuel Pellet Tolerance	0.00180	0
Polyethylene Wrap	0.27573	0.06371
Total Penalty	0.29857	0.06371

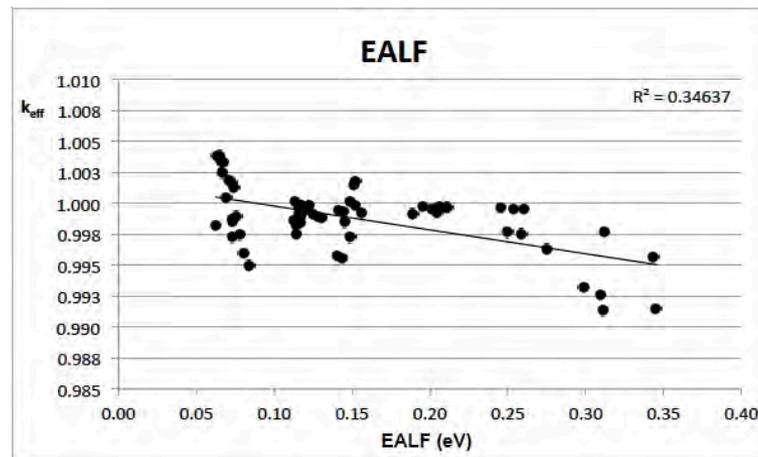
Sensitivity Results – Rod Pipe Package Array, U_3Si_2 Fuel Rods

- U_3Si_2 Rod Pipe (Traveller STD)
 - (Sections 6.5.2.2.3, 6.6.2.2.3)
 - NCT *Maximum* $k_{eff} = 0.69571$
 - HAC *Maximum* $k_{eff} = 0.76836$ USL = 0.93873

Sensitivity Study	Penalty Assessed	
	NCT	HAC
Rod Pipe Position in Clamshell	0	0
Moderator Block Density Reduction	–	0.00102
Annular Blanket Length	0.02234	0
Fuel Pellet Tolerance	0	0
Polyethylene Wrap	0.25634	0.08102
Moderation Variation	–	0.06119
Package Outer Diameter Tolerance	0	0.00101
Total Penalty	0.27868	0.14424

USL and Benchmarking

- (Sections 6.1.2, 6.8)
- USL determined using NUREG/CR-6361
 - Follows ANSI standard
- 68 cases from 9 experiments
- USL calculated using EALF
 - Strongest correlation with $R = 0.58853$
- Administrative margin of 0.05



Traveller Application Timeline

- Criticality safety revision engineering & SAR revision (Ch. 1, 2, & 6 affected)
 - Completion December 2016
- NRC Amendment Application submitted
 - February 10, 2017
- CoC Rev. 8 maintains Rev. 7 valid to 31 Oct 2017
 - CoC Rev. 7 (CAC Rev. 5) are basis for International validations
 - Need to maintain Rev. 7 valid through the NRC review process plus 1 year for validation requests

Closing

- Review
- Questions / Comments

Thank you for your time

