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Mixed Uranium-Plutonium Solution Validation of KENO V.a and KENO-VI in SCALE 6.1.2 and 6.2b3 Using Multigroup and Continuous-Energy ENDF/B-VII.0 Libraries

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Outline

- Introduction
- Code Description
- Description of MST Experiments
- Method for Comparison
- Results
- Conclusions
- Future Work

Introduction

- SCALE 6.1 was assessed at ORNL for hundreds of critical benchmarks from a range of different types of systems
- Benchmarks are from IHECSBE and included in the VALID library maintained at ORNL
- The purposes of this study:
 - Quantify KENO performance for MSTs
 - Compare SCALE 6.1.2 and SCALE 6.2b3 for MSTs
- Study parameters:
 - MST-002, MST-004, MST-005
 - KENO V.a and KENO-VI codes and ENDF/B-VII.0 data
 - Continuous-energy libraries
 - 238-group for SCALE 6.1.2, 252-group for SCALE 6.2b3

Code Description

- SCALE 6.1 has two 3D Monte Carlo transport codes for calculation of k_{eff}
- KENO V.a
 - Simple descriptions of complex systems using repeating Cartesian arrays and holes
 - No intersections and all objects parallel to a major axis
- KENO-VI
 - Contains SCALE Generalized Geometry Package
 - Uses mostly pre-defined geometry objects to define regions
 - Allows Cartesian, hexagonal, and dodecahedral arrays as well as holes
 - Supports intersections and rotation

Description of MST-002

Vertical plan view for the model geometry of MST-002



- 3 critical experiments
- Plutonium fraction of 0.2 and 0.5 in a large cylindrical tank with water reflection
- Consists of a cylindrical reaction vessel with a 68.68 cm ID
- Height of the reaction vessel is ~108.5 cm
- Model did not include the concrete room
- Cases differ due to varying fissile solution compositions, critical solution heights and reflector temperatures
- Calculations performed in KENO V.a

Description of MST-005

Elevation view for part of the model geometry of MST-005



- 7 critical experiments
- Plutonium fraction of 0.4 in slab geometry
- Slab tank has square stainless steel walls ~107.3 cm in height and width
- A support grid reinforces the faces of the tank
- Cases differ due to varying solution compositions, critical solution heights and widths
- Three experiments are bare, four cases are water reflected
- Water-reflected cases are modeled with only the tank, the support grid, and the reflector tank
- Bare cases include room to capture room return
- Calculations performed in KENO V.a

Description of MST-004



- 9 critical experiments
- Plutonium fraction of 0.4 in a small cylindrical tank with three different reflectors
- Model consists of a cylindrical reaction vessel with a 35.39 cm ID
- Reaction vessel is ~108.5 cm tall
- Bare and concrete-reflected models include the auxiliary empty cylinder, water reflector tank, and the room
- Cases differ due to varying solution compositions, reflectors, and critical solution heights
- 3 bare, 3 water-reflected, and 3 concretereflected experiments
- Calculations performed in KENO-VI

Description of MST-004 Cont.



Elevation view and plan view of the more complicated, concrete reflected cases

Method for Comparison

- Performance reported in terms of calculated-to-experiment ratio (C/E)
 - Average C/E values are determined for each version of KENO for both SCALE 6.1.2 and 6.2b3
- Propagation of uncertainty in C/E: $\sigma_{\frac{C}{E}} = \left(\sqrt{\left(\frac{\sigma_{\exp}}{k_{\exp}}\right)^2 + \left(\frac{\sigma_{KENO}}{k_{KENO}}\right)^2} \right) \times \frac{C}{E}$
 - Uncertainty in benchmark model $k_{\rm eff}$ is 20 to 80 times larger than KENO $k_{\rm eff}$ uncertainty
- The results are generated and reported for each nuclear data library
 - Allows comparison of multigroup and continuous-energy performance

Results



Difference from unity of average C/E values by SCALE version for KENO V.a (Δk_{eff})

Results



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C/E CSAS5 Results for SCALE 6.1.2



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C/E CSAS5 Results for SCALE 6.2b3



C/E CSAS6 Results for SCALE 6.1.2



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C/E CSAS6 Results for SCALE 6.2b3



Conclusions

- KENO Monte Carlo codes perform well predicting k_{eff} for MST systems in SCALE 6.1.2 and 6.2b3 with ENDF/B-VII.0 cross sections
- The C/E values indicate that the code bias for MST systems is fairly small when using multigroup libraries
- SCALE 6.2b3 provides C/E values closer to unity with continuous-energy physics due to corrections in thermal scattering data

Future Work

- Additional IHECSBE benchmark evaluations
 - MST-007, MST-010
 - LCT-008, HMF-052, HMM-017, MMT-001
 - Generate and verify the sensitivity data files (SDFs) for MST-002, -004 and -005
 - Perform review on SDFs then add evaluations to the VALID library
 - SDF for each case in VALID distributed with IHECSBE

Acknowledgements

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Questions?

Results

Table I: SCALE 6.1.2 V7-238 and CE_V7 Results

		KENO	V.a Evaluatio	ns		
	Benchmark M	lodel Values	CSAS5 V7-	238 Results	CSAS5 CE	V7 Results
Case	kett	σ	C/E	σ	C/E	σ
MST-002-001	1.000	0.0024	1.00232	0.00241	1.00167	0.00241
002	1.000	0.0024	1.00267	0.00241	1.00205	0.00241
003	1.000	0.0024	1.00248	0.00241	1.00155	0.00241
MST-005-001	1.000	0.0037	0.99414	0.00368	0.99032	0.00367
002	1.000	0.0037	1.00013	0.00370	0.99671	0.00369
003	1.000	0.0037	1.00301	0.00371	0.99498	0.00368
004	1.000	0.0037	1.00113	0.00371	0.99317	0.00368
005	1.000	0.0037	0.99039	0.00367	0.98133	0.00363
006	1.000	0.0037	0.99051	0.00367	0.97984	0.00363
007	1.000	0.0037	0.99947	0.00370	0.99030	0.00367
Average:			0.99862	0.00106	0.99319	0.00105
		KENO	-VI Evaluation	ns		
	Benchmark M	fodel Values	CSAS6 V7-	238 Results	CSAS6 CE	V7 Results
Case	Keft	σ	C/E	σ	C/E	σ
MST-004-001	1.000	0.0033	0.99695	0.00329	0.99291	0.00328
002	1.000	0.0033	0.99733	0.00329	0.99329	0.00328
003	1.000	0.0068	0.99950	0.00680	0.99490	0.00677
004	1.000	0.0078	1.00239	0.00782	0.99291	0.00775
005	1.000	0.0029	0.99780	0.00290	0.98889	0.00287
006	1.000	0.0029	0.99713	0.00289	0.98813	0.00287
007	1.000	0.0026	0.99867	0.00260	0.98755	0.00257
008	1.000	0.0026	0.99857	0.00260	0.98825	0.00257
009	1.000	0.0077	1.00102	0.00771	0.98968	0.00762
Average:			0.99882	0.00164	0.99072	0.00163

Results

Table II: SCALE 6.2b3 V7-252 and CE_V7 Results

		KENO V.	.a Evaluations			
_	Benchmark I	Model Values	CSAS5 V7-	252 Results	CSAS5 CE	V7 Results
Case	keg	σ	C/E	σ	C/E	σ
MST-002-001	1.000	0.0024	1.00177	0.00241	1.00143	0.00241
002	1.000	0.0024	1.00228	0.00241	1.00170	0.00241
003	1.000	0.0024	1.00187	0.00241	1.00117	0.00240
MST-005-001	1.000	0.0037	0.99194	0.00367	0.99349	0.00368
002	1.000	0.0037	0.99882	0.00370	0.99921	0.00370
003	1.000	0.0037	1.00103	0.00371	1.00136	0.00371
004	1.000	0.0037	0.99925	0.00370	0.99950	0.00370
005	1.000	0.0037	0.98765	0.00366	0.98906	0.00366
006	1.000	0.0037	0.98793	0.00366	0.98893	0.00366
007	1.000	0.0037	0.99767	0.00369	0.99777	0.00369
Average:			0.99702	0.00106	0.99736	0.00106
		KENO-V	I Evaluations			
	Benchmark N	Model Values	CSAS6 V7-	252 Results	CSAS6 CE	V7 Results
Case	kett	σ	C/E	σ	C/E	σ
MST-004-001	1.000	0.0033	0.99449	0.00328	0.99604	0.00329
002	1.000	0.0033	0.99553	0.00329	0.99586	0.00329
003	1.000	0.0068	0.99722	0.00678	0.99804	0.00679
004	1.000	0.0078	0.99968	0.00780	1.00014	0.00780
005	1.000	0.0029	0.99554	0.00289	0.99599	0.00289
006	1.000	0.0029	0.99438	0.00289	0.99570	0.00289
007	1.000	0.0026	0.99557	0.00259	0.99659	0.00259
008	1.000	0.0026	0.99641	0.00259	0.99646	0.00259
009	1.000	0.0077	0.99808	0.00769	0.99855	0.00769
Average:			0.99632	0.00164	0.99704	0.00164

SCALE 6.1.2 Results Compared to IHECSBE Section 4 Results

				KEN	O V.a Eva	luations					
Benchmark Model Values		CSAS5 V7-238		CSAS5 CE_V7		KENO (Hansen- Roach)		KENO (27-Group ENDF/B-IV)		MCNP (Continuous Energy ENDF/B-V)	
k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ
1.000	0.0024	1.00232	0.00010	1.00167	0.00010	1.01890	0.00100	1.00960	0.00090	1.00820	0.00020
1.000	0.0024	1.00267	0.00010	1.00205	0.00010	1.02030	0.00090	1.01150	0.00090	1.00740	0.00050
1.000	0.0024	1.00248	0.00010	1.00155	0.00010	1.02020	0.00090	1.01160	0.00100	1.00790	0.00040
1.000	0.0037	0.99414	0.00010	0.99032	0.00010	0.99910	0.00040	1.00290	0.00040	1.00150	0.00080
1.000	0.0037	1.00013	0.00010	0.99671	0.00010	1.00480	0.00150	1.00530	0.00150	1.00340	0.00070
1.000	0.0037	1.00301	0.00010	0.99498	0.00010	1.01090	0.00140	1.01020	0.00150	1.00190	0.00080
1.000	0.0037	1.00113	0.00010	0.99317	0.00010	1.01210	0.00150	1.00680	0.00160	1.00000	0.00080
1.000	0.0037	0.99039	0.00010	0.98133	0.00010	0.99970	0.00040	0.99790	0.00040	0.99340	0.00090
1.000	0.0037	0.99051	0.00010	0.97984	0.00010	1.00580	0.00040	0.99720	0.00040	0.99020	0.00080
1.000	0.0037	0.99947	0.00010	0.99030	0.00010	1.01600	0.00150	1.00390	0.00160	0.99900	0.00080
Popel				KEN	O-VI Eva	luations	Uancon	KENO (2	7 Crown	MCNP (C	ontinuous
Benchmark		CEASC V7 229		CSASS CE V7		Rench)		ENDE/R-D/D		Fnergy ENDE/R VA	
Model	Mark	CEASE	V7 229	CEASE	CE V7	RENU ((ab)	ENDE		France F	UDE/D VA
Model	Values	CSAS6	V7-238	CSAS6	CE_V7	Roa	ich)	ENDE	/B-IV)	Energy El	NDF/B-V)
Model k _{eff}	Values o	CSAS6 k _{eff}	V7-238 σ		CE_V7 σ	Roa keff	ch) σ		/B-IV) σ	Energy El	DF/B-V) σ
Model k _{eff} 1.000	Values σ 0.0033 0.0022	CSAS6 k _{eff} 0.99695	V7-238 σ 0.00010	CSAS6 k _{eff} 0.99291	CE_V7 σ 0.00010	Ref 1.00380	σ 0.00040	ENDF. k _{eff} 1.00630	/ B-IV) σ 0.00040	Energy EN k _{eff} 1.00250 1.00150	NDF/B-V) σ 0.00130
Model k _{eff} 1.000 1.000	Values 0.0033 0.0033 0.0068	CSAS6 k _{eff} 0.99695 0.99733	V7-238 σ 0.00010 0.00010	CSAS6 k _{eff} 0.99291 0.99329 0.09400	CE_V7 σ 0.00010 0.00010 0.00010	Reff Roa 1.00380 1.00270	τch) σ 0.00040 0.00150 0.00040	ENDF. k _{eff} 1.00630 1.00390	/ B-IV) σ 0.00040 0.00140 0.00040	Energy EN k _{eff} 1.00250 1.00150 1.00660	NDF/B-V) σ 0.00130 0.00110
Model k _{eff} 1.000 1.000 1.000 1.000	Values σ 0.0033 0.0033 0.0068 0.0078	CSAS6 k _{eff} 0.99695 0.99733 0.99950	V7-238 σ 0.00010 0.00010 0.00010	CSAS6 k _{eff} 0.99291 0.99329 0.99490	CE_V7 σ 0.00010 0.00010 0.00010	Reff Ros k _{eff} 1.00380 1.00270 1.00410	σ 0.00040 0.00150 0.00040	ENDF k _{eff} 1.00630 1.00390 1.00800 1.00820	/ B-IV) σ 0.00040 0.00140 0.00040 0.00040	Energy EN k _{eff} 1.00250 1.00150 1.00660 1.00400	NDF/B-V) σ 0.00130 0.00110 0.00120
Model k _{eff} 1.000 1.000 1.000 1.000 1.000	Values σ 0.0033 0.0033 0.0068 0.0078 0.0020	CSAS6 k _{eff} 0.99695 0.99733 0.99950 1.00239 0.99780	V7-238 σ 0.00010 0.00010 0.00010 0.00010	CSAS6 k _{eff} 0.99291 0.99329 0.99490 0.99291	CE_V7 σ 0.00010 0.00010 0.00010 0.00010 0.00010	Reff Ros k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730	σ 0.00040 0.00150 0.00040 0.00040 0.00040	ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830 0.00840	/B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00040	Energy E! k _{eff} 1.00250 1.00150 1.00660 1.00400 0.00040	NDF/B-V) σ 0.00130 0.00110 0.00120 0.00110
Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000	σ 0.0033 0.0033 0.0068 0.0078 0.0029	CSAS6 k _{eff} 0.99695 0.99733 0.99950 1.00239 0.99780 0.99712	V7-238 σ 0.00010 0.00010 0.00010 0.00010 0.00010 0.00000	CSAS6 k _{eff} 0.99291 0.99329 0.99490 0.99291 0.98889 0.98812	CE_V7 σ 0.00010 0.00010 0.00010 0.00010 0.00010	Read Roa k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970	σ 0.00040 0.00150 0.00040 0.00040 0.00040 0.00040 0.00040 0.00150 0.00040	ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830 0.99840 1.00440	/B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00160 0.00040	Energy E! k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.99660	OF/B-V σ 0.00130 0.00110 0.00120 0.00110 0.00120 0.00120
Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000 1.000	σ 0.0033 0.0068 0.0078 0.0029 0.0029	CSAS6 k _{eff} 0.99695 0.99733 0.99950 1.00239 0.99780 0.99713 0.99867	V7-238 σ 0.00010 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009	CSAS6 k _{eff} 0.99291 0.99329 0.99490 0.99291 0.98889 0.98813 0.98755	CE_V7	Refr Ros k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970	σ 0.00040 0.00150 0.00040 0.00040 0.00040 0.00040 0.00150 0.00150 0.00040 0.00150 0.00040	ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830 0.99840 1.00440 1.00560	/B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00040 0.00040 0.00040	Energy E! k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.99660 0.99720	σ 0.00130 0.00110 0.00110 0.00110 0.00110 0.00120 0.00120 0.00130 0.00130
Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	σ 0.0033 0.0033 0.0068 0.0078 0.0029 0.0026	CSAS6 k _{eff} 0.99695 0.99733 0.99950 1.00239 0.99780 0.99713 0.99867 0.99857	V7-238 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009 0.00009	CSAS6 k _{eff} 0.99291 0.99329 0.99490 0.99291 0.98889 0.98813 0.98755 0.98825	CE_V7 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009 0.00009	Read Roa k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970 1.01790	σ 0.00040 0.00150 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040	ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830 0.99840 1.00440 1.00560 1.00600	/B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040	Energy E! k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.999660 0.99720 0.99880	σ 0.00130 0.00110 0.00120 0.00110 0.00120 0.00130 0.00130 0.00130 0.00130 0.00130 0.00130
	Bencl Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	Benchmark Model Values k _{eff} σ 1.000 0.0024 1.000 0.0024 1.000 0.0024 1.000 0.0024 1.000 0.0037 1.000 0.0037 1.000 0.0037 1.000 0.0037 1.000 0.0037 1.000 0.0037 1.000 0.0037 1.000 0.0037	Benchmark CSAS5 k _{eff} σ k _{eff} 1.000 0.0024 1.00232 1.000 0.0024 1.00267 1.000 0.0024 1.00267 1.000 0.0024 1.00248 1.000 0.0037 0.99414 1.000 0.0037 1.00013 1.000 0.0037 1.00301 1.000 0.0037 0.99039 1.000 0.0037 0.99051 1.000 0.0037 0.99947	Benchmark Model Values CSAS5 V7-238 k _{eff} σ k _{eff} σ 1.000 0.0024 1.00232 0.00010 1.000 0.0024 1.00267 0.00010 1.000 0.0024 1.00248 0.00010 1.000 0.0037 0.99414 0.00010 1.000 0.0037 1.00113 0.00010 1.000 0.0037 1.00113 0.00010 1.000 0.0037 0.99039 0.00010 1.000 0.0037 0.99051 0.00010 1.000 0.0037 0.99947 0.00010 1.000 0.0037 0.99947 0.00010	Benchmark CSAS5 V7-238 CSAS5 keff σ keff σ keff 1.000 0.0024 1.00232 0.00010 1.00167 1.000 0.0024 1.00267 0.00010 1.00205 1.000 0.0024 1.00267 0.00010 1.00155 1.000 0.0037 0.99414 0.00010 0.99032 1.000 0.0037 1.0013 0.00010 0.99671 1.000 0.0037 1.00301 0.00010 0.99498 1.000 0.0037 1.00113 0.00010 0.99317 1.000 0.0037 0.99039 0.00010 0.98133 1.000 0.0037 0.99051 0.00010 0.99030 KEN KEN	Benchmark CSAS5 V7-238 CSAS5 CE_V7 k _{eff} σ k _{eff} σ 0.000 0.0024 1.00232 0.00010 1.00167 0.00010 1.000 0.0024 1.00267 0.00010 1.00205 0.00010 1.000 0.0024 1.00267 0.00010 1.00205 0.00010 1.000 0.0024 1.00267 0.00010 1.00205 0.00010 1.000 0.0024 1.00248 0.00010 1.00155 0.00010 1.000 0.0037 0.99414 0.00010 0.99671 0.00010 1.000 0.0037 1.00113 0.00010 0.99498 0.00010 1.000 0.0037 0.99039 0.00010 0.99317 0.00010 1.000 0.0037 0.99051 0.00010 0.99133 0.00010 1.000 0.0037 0.99947 0.00010 0.99030 0.00010 1.000 0.0037 0.99947 0.00010 0.99030 0.00010 <tr< td=""><td>Benchmark KENO V.a Evaluations Model Values CSAS5 V7-238 CSAS5 CE_V7 Roa k_{eff} σ k_{eff} σ k_{eff} σ k_{eff} 1.000 0.0024 1.00232 0.00010 1.00167 0.00010 1.01890 1.000 0.0024 1.00267 0.00010 1.00205 0.00010 1.02030 1.000 0.0024 1.00267 0.00010 1.00155 0.00010 1.02020 1.000 0.0037 0.99414 0.00010 0.99032 0.00010 0.99910 1.000 0.0037 1.0013 0.00010 0.99471 0.00010 1.01480 1.000 0.0037 1.00301 0.00010 0.99478 0.00010 1.09901 1.000 0.0037 1.0013 0.00010 0.99317 0.00010 1.01210 1.000 0.0037 0.99039 0.00010 0.99133 0.00010 1.01580 1.000 0.0037 0.99947 0.00010 0.99030</td><td>KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 KENO (Hansen- CSAS5 CE_V7 KENO (Hansen- Roach) k_{eff} σ k_{eff} σ k_{eff} σ k_{eff} σ oppose space space</td><td>KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (2 k_{eff} σ k_{eff} σ k_{eff} σ keff δ keff σ keff σ keff σ keff σ keff δ δ δ</td><td>KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (Z7-Group ENDF/B-IV) k_{eff} σ k_{eff} σ k_{eff} σ k_{eff} σ keff g keff σ keff σ keff σ keff σ keff σ keff σ<</td><td>KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (Z7-Group ENDF/B-IV) MCNP (C0 Energy EN Keff k_{eff} σ k_{eff} β δ δ δ δ δ δ δ δ δ δ δ <t< td=""></t<></td></tr<>	Benchmark KENO V.a Evaluations Model Values CSAS5 V7-238 CSAS5 CE_V7 Roa k _{eff} σ k _{eff} σ k _{eff} σ k _{eff} 1.000 0.0024 1.00232 0.00010 1.00167 0.00010 1.01890 1.000 0.0024 1.00267 0.00010 1.00205 0.00010 1.02030 1.000 0.0024 1.00267 0.00010 1.00155 0.00010 1.02020 1.000 0.0037 0.99414 0.00010 0.99032 0.00010 0.99910 1.000 0.0037 1.0013 0.00010 0.99471 0.00010 1.01480 1.000 0.0037 1.00301 0.00010 0.99478 0.00010 1.09901 1.000 0.0037 1.0013 0.00010 0.99317 0.00010 1.01210 1.000 0.0037 0.99039 0.00010 0.99133 0.00010 1.01580 1.000 0.0037 0.99947 0.00010 0.99030	KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 KENO (Hansen- CSAS5 CE_V7 KENO (Hansen- Roach) k _{eff} σ k _{eff} σ k _{eff} σ k _{eff} σ oppose space space	KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (2 k _{eff} σ k _{eff} σ k _{eff} σ keff δ keff σ keff σ keff σ keff σ keff δ δ δ	KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (Z7-Group ENDF/B-IV) k _{eff} σ k _{eff} σ k _{eff} σ k _{eff} σ keff g keff σ keff σ keff σ keff σ keff σ keff σ<	KENO V.a Evaluations Benchmark Model Values CSAS5 V7-238 CSAS5 CE_V7 KENO (Hansen- Roach) KENO (Z7-Group ENDF/B-IV) MCNP (C0 Energy EN Keff k _{eff} σ k _{eff} β δ δ δ δ δ δ δ δ δ δ δ <t< td=""></t<>

SCALE 6.2b3 Results Compared to IHECSBE Section 4 Results

					KENO	O V.a Eva	luations					
Benchmark Model Value		hmark Values	CSAS5 V7-252		CSAS5 CE_V7		KENO (Hansen- Roach)		KENO (27-Group ENDF/B-IV)		MCNP (Continuous Energy ENDF/B-V)	
Case	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ	k _{eff}	σ
MST-002-001	1.000	0.0024	1.00177	0.00010	1.00143	0.00010	1.01890	0.00100	1.00960	0.00090	1.00820	0.00020
002	1.000	0.0024	1.00228	0.00010	1.00170	0.00010	1.02030	0.00090	1.01150	0.00090	1.00740	0.00050
003	1.000	0.0024	1.00187	0.00010	1.00117	0.00010	1.02020	0.00090	1.01160	0.00100	1.00790	0.00040
MST-005-001	1.000	0.0037	0.99194	0.00010	0.99349	0.00010	0.99910	0.00040	1.00290	0.00040	1.00150	0.00080
002	1.000	0.0037	0.99882	0.00010	0.99921	0.00010	1.00480	0.00150	1.00530	0.00150	1.00340	0.00070
003	1.000	0.0037	1.00103	0.00010	1.00136	0.00010	1.01090	0.00140	1.01020	0.00150	1.00190	0.00080
004	1.000	0.0037	0.99925	0.00010	0.99950	0.00010	1.01210	0.00150	1.00680	0.00160	1.00000	0.00080
005	1.000	0.0037	0.98765	0.00010	0.98906	0.00010	0.99970	0.00040	0.99790	0.00040	0.99340	0.00090
006	1.000	0.0037	0.98793	0.00010	0.98893	0.00010	1.00580	0.00040	0.99720	0.00040	0.99020	0.00080
007	1.000	0.0037	0.99767	0.00010	0.99777	0.00010	1.01600	0.00150	1.00390	0.00160	0.99900	0.00080
					KEN	O-VI Eva	luations					
	Bencl	hmark					KENO (Hansen-	KENO (2	27-Group	MCNP (Continuous
	Bencl Model	hmark Values	CSAS6	V7-252	CSAS6	CE_V7	KENO (Ros	Hansen- ach)	KENO (2 ENDF	27-Group /B-IV)	MCNP (Energy F	Continuous NDF/B-V)
Case	Bencl Model k _{eff}	hmark Values σ	CSAS6 k _{eff}	V7-252 σ	CSAS6 k _{eff}	CE_V7 σ	KENO (Ros k _{eff}	Hansen- ach) σ	KENO (2 ENDF k _{eff}	27-Group //B-IV) σ	MCNP (C Energy F k _{eff}	Continuous NDF/B-V) o
Case MST-004-001	Bencl Model k _{eff} 1.000	hmark Values o 0.0033	CSAS6 k _{eff} 0.99449	V7-252 σ 0.00010	CSAS6 k _{eff} 0.99604	CE_V7 σ 0.00010	KENO (Ros k _{eff} 1.00380	Hansen- ach) σ 0.00040	KENO (2 ENDF k _{eff} 1.00630	27-Group //Β-ΙV) σ 0.00040	MCNP (C Energy H k _{eff} 1.00250	Continuous CNDF/B-V) o 0.00130
Case MST-004-001 002	Benci Model k _{eff} 1.000 1.000	hmark Values σ 0.0033 0.0033	CSAS6 k _{eff} 0.99449 0.99553	V7-252 σ 0.00010 0.00010	CSAS6 k _{eff} 0.99604 0.99586	CE_V7 σ 0.00010 0.00010	KENO (Roa k _{eff} 1.00380 1.00270	Hansen- ach) σ 0.00040 0.00150	KENO (2 ENDF k _{eff} 1.00630 1.00390	27-Group //B-IV) σ 0.00040 0.00140	MCNP (Energy F k _{eff} 1.00250 1.00150	Continuous NDF/B-V) o 0.00130 0.00110
Case MST-004-001 002 003	Benci Model k _{eff} 1.000 1.000 1.000	hmark Values σ 0.0033 0.0033 0.0068	CSAS6 k _{eff} 0.99449 0.99553 0.99722	V7-252 σ 0.00010 0.00010 0.00010	CSAS6 k _{eff} 0.99604 0.99586 0.99804	CE_V7	KENO (Ros k _{eff} 1.00380 1.00270 1.00410	Hansen- ach) σ 0.00040 0.00150 0.00040	KENO (2 ENDF k _{eff} 1.00630 1.00390 1.00800	27-Group //B-IV) σ 0.00040 0.00140 0.00040	MCNP (0 Energy F k _{eff} 1.00250 1.00150 1.00660	Continuous NDF/B-V) σ 0.00130 0.00110 0.00120
Case MST-004-001 002 003 004	Bencl Model k _{eff} 1.000 1.000 1.000 1.000	hmark Values σ 0.0033 0.0033 0.0068 0.0078	CSAS6 k _{eff} 0.99449 0.99553 0.99722 0.99968	V7-252 σ 0.00010 0.00010 0.00010 0.00010	CSAS6 k _{eff} 0.99604 0.99586 0.99804 1.00014	CE_V7	KENO (Roa k _{eff} 1.00380 1.00270 1.00410 1.01260	Hansen- ach) σ 0.00040 0.00150 0.00040 0.00040	KENO (2 ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830	27-Group /B-IV) σ 0.00040 0.00140 0.00040 0.00040	MCNP (0 Energy F k _{eff} 1.00250 1.00150 1.00660 1.00400	Continuous NDF/B-V) σ 0.00130 0.00110 0.00120 0.00110
Case MST-004-001 002 003 004 005	Bencl Model k _{eff} 1.000 1.000 1.000 1.000	hmark Values σ 0.0033 0.0033 0.0068 0.0078 0.0029	CSAS6 k _{eff} 0.99449 0.99553 0.99722 0.99968 0.99554	V7-252	CSAS6 k _{eff} 0.99604 0.99586 0.99804 1.00014 0.99599	CE_V7	KENO (Roa k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730	Hansen- ach) σ 0.00040 0.00150 0.00040 0.00040 0.00150	KENO (2 ENDF k _{eff} 1.00630 1.00800 1.00830 0.99840	27-Group /B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00160	MCNP (0 Energy F k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940	Continuous CNDF/B-V) σ 0.00130 0.00110 0.00120 0.00110 0.00120
Case MST-004-001 002 003 004 005 006	Bencl Model k _{eff} 1.000 1.000 1.000 1.000 1.000	mark Values σ 0.0033 0.0068 0.0078 0.0029 0.0029	CSAS6 k _{eff} 0.99449 0.99553 0.99722 0.99968 0.99554 0.99438	v7-252 σ 0.00010 0.00010 0.00010 0.00010 0.00010 0.00009	CSAS6 k _{eff} 0.99604 0.99586 0.99804 1.00014 0.99599 0.99570	CE_V7	KENO (Roa k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970	Hansen- ach) 0.00040 0.00150 0.00040 0.00040 0.00150 0.00040	KENO (2 ENDF k _{eff} 1.00630 1.00800 1.00830 0.99840 1.00440	27-Group /B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00160 0.00040	MCNP (0 Energy F k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.99660	Continuous NDF/B-V)
Case MST-004-001 002 003 004 005 006 007	Bencl Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000	mark Values σ 0.0033 0.0033 0.0068 0.0078 0.0029 0.0026	CSAS6 k _{eff} 0.99449 0.99553 0.99722 0.99968 0.99554 0.99438 0.99557	v7-252 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009	CSAS6 k _{eff} 0.99604 0.99586 0.99804 1.00014 0.99599 0.99570 0.99659	CE_V7 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009	KENO (Roa k _{eff} 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970 1.01790	Hansen- ach) 0.00040 0.00150 0.00040 0.00040 0.00040 0.00040 0.00040	KENO (2 ENDF k _{eff} 1.00630 1.00800 1.00830 0.99840 1.00440 1.00560	27-Group /B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00040 0.00040 0.00040	MCNP (Energy E k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.99960 0.99720	Continuous NDF/B-V) σ 0.00130 0.00110 0.00120 0.00110 0.00120 0.00130
Case MST-004-001 002 003 004 005 006 007 008	Bencl Model k _{eff} 1.000 1.000 1.000 1.000 1.000 1.000 1.000	mark values o 0.0033 0.0033 0.0068 0.0078 0.0029 0.0026 0.0026	CSAS6 k _{eff} 0.99449 0.99553 0.99722 0.99968 0.99554 0.99554 0.99557 0.99641	v7-252 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009 0.00009	CSAS6 k _{eff} 0.99604 0.99586 0.99804 1.00014 0.99599 0.99570 0.99659 0.99646	CE_V7 σ 0.00010 0.00010 0.00010 0.00010 0.00009 0.00009 0.00009	KENO (Roa keff 1.00380 1.00270 1.00410 1.01260 1.00730 1.00970 1.01790 1.01570	Hansen- ach) σ 0.00040 0.00150 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040	KENO (2 ENDF k _{eff} 1.00630 1.00390 1.00800 1.00830 0.99840 1.00440 1.00560 1.00600	27-Group /B-IV) σ 0.00040 0.00140 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040 0.00040	MCNP (C Energy F k _{eff} 1.00250 1.00150 1.00660 1.00400 0.99940 0.99960 0.99720 0.99880	Continuous NDF/B-V) σ 0.00130 0.00110 0.00120 0.00110 0.00120 0.00130 0.00130 0.00120

C/E CSAS5 Results for SCALE 6.1.2 Compared to IHECSBE Section 4 Results



C/E CSAS5 Results for SCALE 6.2b3 Compared to IHECSBE Section 4 Results



C/E CSAS6 Results for SCALE 6.1.2 Compared to IHECSBE Section 4 Results



C/E CSAS6 Results for SCALE 6.2b3 Compared to IHECSBE Section 4 Results

