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Data uncertainty analysis for the proposed benchmark exercise using ERANOS by comparing COMMARA-2.0 and BOLNA covariance libraries

Methodology

Deterministic ERANOS (Version 2.2-N) in conjunction with the following basic/covariance data libraries:

•JEFF-3.1/COMMARA2.0 (unadjusted).

•ENDF/B-VI.8/COMMARA2.0 (unadjusted),
since COMMARA2.0 should be used in conjunction with ENDF/B-VII.0 (no ENDF/B-VII.0 based library available with this edition of ERANOS).

ERANOS format for COMMARA-2.0: Gerardo Aliberti's work + Small in house program for generating all data available, based on the dedicated format kindly provided by NEA to the to SG33 members shortly after the May meeting.

Due to some modified quoted experimental values and correction factors after the May meeting, revised values are additionally given referring to calculations with:

•JEFF-3.1/BOLNA (unadjusted).
BOLNA: **B**rookhaven, **O**ak Ridge, **L**os Alamos, **N**RG and **A**rgonne: One of the predecessors of COMMARA.

Methodology (continued)

Just for completeness, without further comments, presented are also revised results for
•JEF-2.2/JEF-2.2 (unadjusted), called JEF-2.2.

•ERALIB-1/ERALIB-1 (adjusted), called ERALIB1.
ERALIB-1: Eric Fort, adjustment made with respect to several sodium-cooled fast spectrum system experiments.

As suggested:

•33 group discrete-ordinates transport-theory (BISTRO for cylindrical geometry), with P_1S_4 approximations (symmetric weight set) + given correction factors.

•Same meshing as in the benchmark specifications, when available.

Sensitivity coefficients and uncertainty analysis, and representativeness calculations for JEFF-3.1/ and ENDF/B-VI.8/ COMMARA-2.0: Thereby use is made of perturbation theory ($|k_{eff} - k_{eff}\,adj| < 0.0001$). No condensation of the sensitivity coefficients to 15 groups needed for calculations based on COMMARA-2.0.

JEZEBEL-Pu239

JEZEBEL-Pu239/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*1.00264*	*0.99713*	*0.421*	1.00000/0.2
JEFF-3.1/ COMMARA2.0	*1.00493*	*0.99941*	*0.415*	
JEFF-3.1/BOLNA			0.417	
JEF-2.2	1.00163	0.99613	2.34	
ERALIB1	1.00767	1.00214	0.35	
F28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.200*	*0.205*	*2.89*	0.2133/1.1
JEFF-3.1/ COMMARA2.0	*0.204*	*0.210*	*2.43*	
JEFF-3.1/BOLNA			2.45	
JEF-2.2	0.199	0.204	2.55	
ERALIB1	0.196	0.201	0.98	

JEZEBEL-Pu239 (continued)

JEZEBEL-Pu239/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
F37/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.938*	*0.947*	*3.42*	0.9835/1.4
JEFF-3.1/ COMMARA2.0	*0.975*	*0.984*	*3.16*	
JEFF-3.1/BOLNA			6.68	
JEF-2.2	0.914	0.922	9.01	
ERALIB1	0.916	0.924	8.87	
F49/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*1.422*	*1.425*	*0.79*	1.4609/0.9
JEFF-3.1/ COMMARA2.0	*1.436*	*1.439*	*0.72*	
JEFF-3.1/BOLNA			0.72	
JEF-2.2	1.429	1.432	3.53	
ERALIB1	1.440	1.443	0.70	

JEZEBEL-Pu239 (continued)

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.98827
F28/F25	0.99291
F37/F25	0.99035
F49/F25	0.98712

Common 1σ confidence interval (min/max)	
k_{eff}	0.99526/1.00133
F28/F25	0.205/0.211
F37/F25	0.953/0.979
F49/F25	1.4286/1.4363

Red: does not overlap with the 1σ experimantal confidence interval

JEZEBEL-Pu239 (continued)

Most important contributions to the data uncertainty of k_{eff}:
JEFF-3.1/COMMARA2.0: Pu239 fission: 0.3%.
JEFF-3.1/BOLNA: Pu239 fission: 0.3%.

Most important contributions to the data uncertainty of F28/F25:
JEFF-3.1/COMMARA2.0: Pu239 inelastic scattering: 2.4% (*neither U238 fission nor U235 fission*).
JEFF-3.1/BOLNA: Pu239 inelastic scattering: 2.5%.

Most important contributions to the data uncertainty of F37/F25:
JEFF-3.1/COMMARA2.0: *Np237 fission: 2.7%;* Pu239 inelastic scattering: 1.6%.
JEFF-3.1/BOLNA: *Np237 fission: 6.5%;* Pu239 inelastic scattering: 1.6%.

Most important contributions to the data uncertainty of F49/F25:
JEFF-3.1/COMMARA2.0: Pu239 fission: 0.5%; U235 fission: 0.4%; Pu239 inelastic scattering: 0.4%.
JEFF-3.1/BOLNA: Pu239 fission: 0.5%; U235 fission: 0.4%; Pu239 inelastic scattering: 0.4%.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: Uncertainties slightly smaller (by 10% for spectral indices, representativeness factors of the order of 0.99).

JEZEBEL-Pu240

JEZEBEL-Pu240/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*1.00238*	*0.99764*	*0.592*	1.00000/0.2
JEFF-3.1/ COMMARA2.0	*1.00851*	*1.00374*	*0.583*	
JEFF-3.1/BOLNA			0.667	
JEF-2.2	1.00399	0.99924	2.108	
ERALIB1	1.01062	1.00584	0.344	

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99422

Common 1σ confidence interval (min/max)	
k_{eff}	0.99789/1.00355

JEZEBEL-Pu240 (continued)

Most important contributions to the data uncertainty of k_{eff}:

JEFF-3.1/COMMARA2.0:
Pu239: Fission: 0.27%, inelastic: 0.23%.
Pu240: Fission: 0.18%, ν: 0.37%, inelastic: 0.12%.
(*Pu241: Fission: 0.02%*.)

JEFF-3.1/BOLNA:
Pu239: Fission: 0.27%, inelastic: 0.24%.
Pu240: Fission: 0.29%, ν: 0.35%, inelastic: 0.04%.
Pu241: Fission: 0.29%.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: k_{eff}-uncertainties are similar, consistent with the excellent representativeness factor of 0.994.

FLATTOP-Pu239

FLATTOP-Pu239/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*0.99635*	*0.99769*	*0.747*	1.00000/0.3
JEFF-3.1/ COMMARA2.0	*0.99794*	*0.99929*	*0.725*	
JEFF-3.1/BOLNA			0.711	
JEF-2.2	0.98089	0.98222	2.107	
ERALIB1	0.99323	0.99457	0.252	
F28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.1704*	*0.1755*	*2.27*	0.1799/1.1
JEFF-3.1/ COMMARA2.0	*0.1722*	*0.1774*	*1.95*	
JEFF-3.1/BOLNA			1.95	
JEF-2.2	0.1710	0.1762	2.40	
ERALIB1	0.1681	0.1732	0.87	

FLATTOP-Pu239 (continued)

FLATTOP-Pu239/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
F37/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.8321*	*0.8391*	*3.28*	0.8561/1.4
JEFF-3.1/ COMMARA2.0	*0.8549*	*0.8621*	*3.11*	
JEFF-3.1/BOLNA			6.60	
JEF-2.2	0.8098	0.8166	9.01	
ERALIB1	0.8090	0.8158	8.89	

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99717
F28/F25	0.99099
F37/F25	0.99190

FLATTOP-Pu239 (continued)

Common 1σ confidence interval (min/max)	
k_{eff}	0.99205/1.00514
F28/F25	0.1739/0.1795
F37/F25	0.8419/0.8594

FLATTOP-Pu239 (continued)

Most important contributions to the data uncertainty of k_{eff}:

JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.6%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.6%.

Most important contributions to the data uncertainty of F28/F25:
JEFF-3.1/COMMARA2.0: Pu239 inelastic scattering: 1.7% (*neither U238 fission nor U235 fission*).
JEFF-3.1/BOLNA: Pu239 inelastic scattering: 1.8%.

Most important contributions to the data uncertainty of F37/F25:
JEFF-3.1/COMMARA2.0: *Np237 fission: 2.8%;* Pu239 inelastic scattering: 1.2%.
JEFF-3.1/BOLNA: *Np237 fission: 6.4%;* Pu239 inelastic scattering: 1.2%.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: k_{eff}-uncertainties are similar, consistent with the excellent representativeness factor of 0.997. Uncertainties of spectral indices slightly smaller (representativeness factors of the order of 0.99).

ZPR6-7 (standard configuration)

ZPR-6 Assembly 7/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*0.99263*	*1.00447*	*1.022*	1.00051/0.23
JEFF-3.1/ COMMARA2.0	*0.99015*	*1.00195*	*1.084*	
JEFF-3.1/BOLNA			1.178	
JEF-2.2	0.98274	0.99446	1.595	
ERALIB1	0.99060	1.00241	0.144	
F49/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.9272*	*0.9132*	*0.80*	0.9435/2.1
JEFF-3.1/ COMMARA2.0	*0.9190*	*0.9051*	*0.83*	
JEFF-3.1/BOLNA			0.85	
JEF-2.2	0.9183	0.9044	2.52	
ERALIB1	0.9357	0.9216	0.38	

ZPR6-7 (standard configuration), continued

ZPR-6 Assembly 7/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
F28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.0226*	*0.0232*	*5.62*	0.0223/3.0
JEFF-3.1/ COMMARA2.0	*0.0218*	*0.0224*	*6.40*	
JEFF-3.1/BOLNA			6.54	
JEF-2.2	0.0224	0.0230	3.76	
ERALIB1	0.0224	0.0230	0.57	
C28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.1384*	*0.1333*	*1.49*	*0.1323/2.4*
JEFF-3.1/ COMMARA2.0	*0.1380*	*0.1329*	*1.49*	
JEFF-3.1/BOLNA			2.18	
JEF-2.2	0.1390	0.1339	1.53	
ERALIB1	0.1388	0.1337	0.41	

ZPR6-7 (standard configuration), continued

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99470
F49/F25	0.99355
F28/F25	0.99688
C28/F25	0.99851

Common 1σ confidence interval (min/max)	
k_{eff}	0.99420/1.01281
F49/F25	0.9059/0.9126
F28/F25	0.0219/0.0238
C28/F25	0.1313-0.1349

ZPR6-7 (standard configuration), continued

Most important contributions to the data uncertainty of k_{eff}:
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.9%; U238 capture: 0.3%
(*Pu241 fission: 0.01%, O16 capture: 0.2%*).
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.8%; U238 capture: 0.5%
(*Pu241 fission: 0.1%, O16 capture: 0.3%*).

Most important contributions to the data uncertainty of F49/F25:
JEFF-3.1/COMMARA2.0: U235 fission: 0.5%; Pu239 fission: 0.4%; U238 inelastic: 0.4%; U238 capture: 0.2%.
JEFF-3.1/BOLNA:U235 fission: 0.5%; Pu239 fission: 0.4%; U238 inelastic: 0.5%; U238 capture: 0.1%.

Most important contributions to the data uncertainty of F28/F25:
JEFF-3.1/COMMARA2.0:U238 inelastic scattering: 6.2% (*neither U238 fission nor U235 fission*).
JEFF-3.1/BOLNA: U238 inelastic scattering: 6.1%.

ZPR6-7 (standard configuration), continued

Most important contributions to the data uncertainty of C28/F25:
JEFF-3.1/COMMARA2.0: *U238 capture: 1.5%*.
JEFF-3.1/BOLNA: *U238 capture: 2.1%*.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: Slightly larger uncertainties, the maximum deviation being 15% for the F28/F25 value and this despite the excellent representativeness factor of 0.997.

ZPR6-7 (high Pu240 content)

ZPR-6 Assembly 7 High Pu240/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*0.99157*	*1.00398*	*1.028*	1.00080/0.220
JEFF-3.1/ COMMARA2.0	*0.98933*	*1.00171*	*1.091*	
JEFF-3.1/BOLNA			1.192	
JEF-2.2	0.98123	0.99350	1.576	
ERALIB1	0.98917	1.00154	0.141	

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99495

Common 1σ confidence interval (min/max)	
k_{eff}	0.99366/1.01264

ZPR6-7 (high Pu240 content), continued

Most important contributions to the data uncertainty of k_{eff}:

JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.9%; U238 capture: 0.5%, (*Pu241 fission: 0.02%, O16 capture: 0.16%*).

JEFF-3.1/BOLNA: U238 inelastic scattering: 0.9%; U238 capture: 0.5%, (*Pu241 fission: 0.2%, O16 capture: 0.24%*).

ZPPR-9

ZPPR-9/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*0.99425*	*1.00652*	*1.198*	1.00106/0.117
JEFF-3.1/ COMMARA2.0	*0.98882*	*1.00102*	*1.299*	
JEFF-3.1/BOLNA			1.379	
JEF-2.2	0.98327	0.99540	1.622	
ERALIB1	0.99119	1.00342	0.144	
F28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.0206*	*0.0209*	*6.88*	0.0207/2.7
JEFF-3.1/ COMMARA2.0	*0.0196*	*0.0199*	*7.74*	
JEFF-3.1/BOLNA			7.80	
JEF-2.2	0.0205	0.0208	3.73	
ERALIB1	0.0204	0.0207	0.52	

ZPPR-9 (continued)

ZPPR-9/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
F49/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.9189*	*0.9003*	*0.81*	0.9225/2.0
JEFF-3.1/ COMMARA2.0	*0.9095*	*0.9002*	*0.85*	
JEFF-3.1/BOLNA			0.89	
JEF-2.2	0.9099	0.9006	2.49	
ERALIB1	0.9257	0.9163	0.38	
C28/F25 (at core center)				
ENDF/B-VI.8/ COMMARA2.0	*0.1367*	*0.1304*	*1.52*	0.1296/1.9
JEFF-3.1/ COMMARA2.0	*0.1364*	*0.1301*	*1.52*	
JEFF-3.1/BOLNA			2.25	
JEF-2.2	0.1373	0.1310	1.53	
ERALIB1	0.1374	0.1311	0.40	

ZPPR-9 (continued)

Most important contributions to the data uncertainty of k_{eff}:
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 1.1%; U238 capture: 0.4%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 1.1%; U238 capture: 0.6%.

Most important contributions to the data uncertainty of F28/F25:
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 7.6%; *O16 elastic scattering: 0.3%;* Fe56 inelastic scattering: 0.7% (*neither U238 fission nor U235 fission*).
JEFF-3.1/BOLNA: U238 inelastic scattering: 7.5%; *O16 elastic scattering: 1.3%;* Fe56 inelastic scattering: 1.1%.

Most important contributions to the data uncertainty of F49/F25:
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.5%; U235 fission: 0.4%; Pu239 fission: 0.4%.
JEFF-3.1/BOLNA:U238 inelastic scattering: 0.5%; U235 fission: 0.5%; Pu239 fission: 0.4%.

Most important contributions to the data uncertainty of C28/F25:
JEFF-3.1/COMMARA2.0: *U238 capture: 1.4%*.
JEFF-3.1/BOLNA: *U238 capture: 2.5%*.

ZPPR-9 (continued)

ZPPR-9/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment (pcm) /1σ-uncertainty (%)
Na void (Step 3)				
ENDF/B-VI.8/ COMMARA2.0	*115*	*115*	***54.7***	104/1.73
JEFF-3.1/ COMMARA2.0	*107*	*107*	***63.5***	
JEFF-3.1/BOLNA			**67.6**	
JEF-2.2	115	115	**74.1**	
ERALIB1	100	100	7.51	
Na void (Step 5)				
ENDF/B-VI.8/ COMMARA2.0	*157*	*121*	***71.8***	112/1.70
JEFF-3.1/ COMMARA2.0	*141*	*109*	***86.0***	
JEFF-3.1/BOLNA			**91.4**	
JEF-2.2	155	120	**97.4**	
ERALIB1	134	104	10.0	

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 3 (ENDF/B-VI.8/COMMARA2.0)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	0.8				0.1	0.8
U238	***17.5***		**46.2**	2.3	**8.4**	**50.1**
Pu239	**12.9**		4.0	**12.9**	***3.2***	**17.4**
Pu240	2.1			1.7	**3.0**	4.1
Pu241				*0.4*	0.2	0.5
Cr52	0.8	0.6	*1.2*			1.6
Ni58	1.5					1.7
Fe56	4.1		**6.0**			**7.4**
Na23		3.1	4.6			5.5
O16	**7.1**	*3.5*	*0.1*			**7.9**

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 3 (JEFF-3.1/COMMARA2.0)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	0.8				0.1	0.9
U238	***18.8***		**55.6**	2.4	**8.8**	**59.3**
Pu239	**13.9**		3.1	**11.3**	***3.5***	**18.5**
Pu240	2.2			1.9	**3.2**	4.3
Pu241				*0.1*	0.2	0.6
Cr52	0.8	0.6	*1.1*			1.5
Ni58	1.6					1.7
Fe56	4.1		**5.4**			**7.0**
Na23		3.7	3.8			5.3
O16	**7.7**	*3.8*	*0.1*			**8.6**

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 3 (JEFF-3.1/BOLNA)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	1.3				0.5	1.4
U238	***28.2***		**54.3**	2.4	**8.3**	**61.6**
Pu239	**13.9**		3.1	**11.5**	***6.7***	**19.5**
Pu240	2.8			2.6	**3.2**	5.0
Pu241				*4.7*	0.2	4.7
Cr52	0.3	0.6	*0.4*			0.8
Ni58	1.6					1.8
Fe56	3.3		**7.5**			**8.3**
Na23		2.3	5.4			5.9
O16	**11.7**	*9.9*	*1.7*			**15.3**

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 5 (ENDF/B-VI.8/COMMARA2.0)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	1.0				0.1	1.1
U238	***22.7***		**60.9**	3.0	**10.8**	**65.7**
Pu239	**16.7**		5.4	**13.8**	***4.2***	**22.7**
Pu240	2.7			2.2	**3.9**	5.4
Pu241				*0.4*	0.2	0.7
Cr52	1.0	0.8	*1.6*			2.1
Ni58	1.9					2.1
Fe56	5.2	2.3	**7.9**			**9.8**
Na23		4.2	6.1			7.4
O16	**9.2**	***4.8***	*0.2*			**10.3**

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 5 (JEFF-3.1/COMMARA2.0)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	1.1				0.1	1.2
U238	***25.1***		**75.6**	3.2	**11.6**	**80.3**
Pu239	**18.6**		4.2	**15.2**	***4.7***	**24.9**
Pu240	2.9			2.5	**4.2**	5.8
Pu241				*0.5*	0.2	0.8
Cr52	1.1	0.8	*1.4*			2.0
Ni58	2.1					2.3
Fe56	5.4	2.7	**7.3**			**9.5**
Na23		5.1	5.3			7.3
O16	**10.3**	***5.3***	*0.2*			**11.5**

ZPPR-9 (continued)

Main contributions to the data uncertainty of Na void Step 5 (JEFF-3.1/BOLNA)

Reaction/ Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U235	1.7				0.6	1.9
U238	***37.7***		**73.8**	3.2	**10.9**	**83.4**
Pu239	**18.7**		4.2	**15.5**	***9.0***	**26.2**
Pu240	3.7			3.5	**4.2**	6.6
Pu241				*6.3*	0.3	6.3
Cr52	0.4	0.8	*0.6*			1.1
Ni58	2.2					2.4
Fe56	4.4	1.2	**10.2**			**11.2**
Na23		3.2	7.5			8.3
O16	**15.5**	**13.4**	2.3			**20.6**

ZPPR-9 (continued)

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99559
F28/F25	0.99831
F49/F25	0.99566
C28/F25	0.99900
Na void (Step 3)	0.99535
Na void (Step 5)	0.99541

Common 1σ confidence interval (min/max)	
k_{eff}	0.99446/1.01858
F28/F25	0.0195/0.0214
F49/F25	0.8930/0.9076
C28/F25	0.1284/0.1321
Na void (Step 3)	52/175
Na void (Step 5)	34/203

JOYO

JOYO/ Library	Calculated parameter	Corrected calculated parameter	1σ-uncertainty (%)	Experiment /1σ-uncertainty (%)
k_{eff}				
ENDF/B-VI.8/ COMMARA2.0	*0.99881*	*0.99625*	*0.851*	1.00105/0.18
JEFF-3.1/ COMMARA2.0	*1.00306*	*1.00049*	*0.872*	
JEFF-3.1/BOLNA			1.253	
JEF-2.2	1.00169	0.99913	0.982	
ERALIB1	1.00000	0.99744	0.156	

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99781

Common 1σ confidence interval (min/max)	
k_{eff}	0.99177/1.00473

JOYO (continued)

Most important contributions to the data uncertainty of k_{eff}:
JEFF-3.1/COMMARA2.0: *U235 capture: 0.7%*.
JEFF-3.1/BOLNA: *U235 capture: 1.1%*.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: k_{eff}-uncertainties are similar, consistent with the excellent representativeness factor of 0.998.

ABR core

ABR startup oxide core Library	k_{eff}	1σ-uncertainty (%)
ENDF/B-VI.8/COMMARA2.0	*1.01720*	*0.862*
JEFF-3.1/COMMARA2.0	*1.01450*	*0.926*
JEFF-3.1/BOLNA		1.017
JEF-2.2	1.00657	1.661
ERALIB-1	1.01436	0.192
ABR recycled oxide core Library	k_{eff}	1σ-uncertainty (%)
ENDF/B-VI.8/COMMARA2.0	*1.00593*	*1.058*
JEFF-3.1/COMMARA2.0	*1.00574*	*1.140*
JEFF-3.1/BOLNA		1.489
JEF-2.2	0.99078	1.539
ERALIB-1	0.99981	0.384
ABR startup metal core Library	k_{eff}	1σ-uncertainty (%)
ENDF/B-VI.8/COMMARA2.0	*1.00415*	*0.995*
JEFF-3.1/COMMARA2.0	*1.00054*	*1.074*
JEFF-3.1/BOLNA		1.092
JEF-2.2	0.99717	1.817
ERALIB-1	1.00292	0.284

ABR core (continued)

k_{eff} -representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
Startup oxide core	0.99113
Recycled oxide core	0.99104
Startup metal core	0.99320

ABR core (continued)

Most important contributions to the data uncertainty of k_{eff} (oxide core):
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.7%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.7%.

Most important contributions to the data uncertainty of k_{eff} (oxide core, recycled):
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.7%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.7%.

Most important contributions to the data uncertainty of k_{eff} (metal core):
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.9%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.9%.

JEFF-3.1/ versus ENDF/B-VI.8/COMMARA2.0: 10% larger uncertainties; the representativeness factors are of the order of 0.99.

FBR core (RZ simplified model)

FBR core/ Library	Calculated parameter	Quoted value	1σ-uncertainty (%)
k_{eff}			
ENDF/B-VI.8/COMMARA2.0	*1.06110*	1.0522	*1.031*
JEFF-3.1/COMMARA2.0	*1.05838*		*1.128*
JEFF-3.1/BOLNA			1.618
JEF-2.2	1.04856		1.471
ERALIB-1	1.05812		0.187
Na void reactivity ($)			
ENDF/B-VI.8/COMMARA2.0	*4.06*	4.3	*5.96*
JEFF-3.1/COMMARA2.0	*3.89*		*6.15*
JEFF-3.1/BOLNA			8.62
JEF-2.2	4.12		7.06
ERALIB1	3.63		3.71
Doppler constant			
ENDF/B-VI.8/COMMARA2.0	*-0.0099*	-0.01	*4.26*
JEFF-3.1/COMMARA2.0	*-0.0102*		*4.53*
JEFF-3.1/BOLNA			5.18
JEF-2.2	-0.0096		4.97
ERALIB1	-0.0093		2.24

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of k_{eff}:
JEFF-3.1/COMMARA2.0: U238 inelastic scattering: 0.9%; U238 capture: 0.3%.
JEFF-3.1/BOLNA: U238 inelastic scattering: 0.9%; U238 capture: 0.4%.

Representativeness coefficient of JEFF-3.1 with respect to ENDF/B-VI.8 (COMMARA2.0)	
k_{eff}	0.99315
Na void reactivity	0.99442
Doppler constant	0.99393

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the void reactivity, ENDF/B-VI.8/COMMARA-2.0:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	2.1	*0.0*[a]	**4.3**	0.1	0.3	**4.8**
Pu239	0.8	*0.0*[a]	0.7	1.5	0.5	1.9
Pu240	0.8	*0.0*[a]	0.3	0.5	0.7	1.2
Pu241	0.5	0.0	0.3	***0.7***	0.1	***0.9***
Fe56	1.0	0.7	0.5			1.3
Na23	0.0	0.7	1.0			1.2
O16	0.9	1.1	0.0			1.4

[a] Squared uncertainty is slightly negative.

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the void reactivity, JEFF-3.1/COMMARA-2.0:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	2.3	*0.0*[a]	**4.5**	0.1	0.3	**5.0**
Pu239	1.0	*0.0*[a]	0.5	1.6	0.5	2.0
Pu240	0.8	*0.0*[a]	0.3	0.6	0.8	1.3
Pu241	0.6	0.0	0.1	***0.8***	0.2	***1.0***
Fe56	1.1	0.8	0.5			1.4
Na23	0.0	0.8	0.9			1.2
O16	0.7	1.2	0.0			1.3

[a] Squared uncertainty is slightly negative.

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the void reactivity, JEFF-3.1/BOLNA:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	2.6	*0.0*[a]	**4.6**	0.1	0.3	**5.2**
Pu239	1.5	*0.0*[a]	0.4	1.7	0.4	2.3
Pu240	0.3	0.0	0.0	0.8	0.5	1.0
Pu241	0.5	0.0	0.0	***5.7***	0.1	***5.8***
Fe56	1.3	0.2	0.6			1.5
Na23	0.1	0.5	1.4			1.5
O16	1.0	1.3	0.2			1.6

[a] Squared uncertainty is slightly negative.

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the Doppler constant, ENDF/B-VI.8/COMMARA2.0:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	1.8	*0.0*[a]	**2.8**	0.1	0.3	**3.3**
Pu239	0.8	*0.0*[a]	0.6	0.5	0.1	1.1
Pu240	0.8	*0.0*[a]	0.2	0.3	0.4	0.9
Pu241	0.3	0.0	0.2	***0.2***	0.1	***0.4***
Fe56	0.5	0.7	0.4			1.0
Na23	0.0	1.4	0.4			1.5
O16	0.2	1.3	0.0			1.3

[a] Squared uncertainty is slightly negative.

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the Doppler constant, JEFF-3.1/COMMARA2.0:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	1.8	*0.0*[a]	**3.2**	0.1	0.3	**3.6**
Pu239	0.8	*0.0*[a]	0.4	0.5	0.1	1.0
Pu240	0.8	*0.0*[a]	0.2	0.3	0.4	0.9
Pu241	0.4	0.0	0.0	***0.2***	0.1	***0.4***
Fe56	0.5	0.7	0.4			1.0
Na23	0.0	1.5	0.4			1.5
O16	0.2	1.3	0.0			1.3

[a] Squared uncertainty is slightly negative.

FBR core (RZ simplified model), continued

Most important contributions to the data uncertainty of the Doppler constant, JEFF-3.1/BOLNA:

Reaction/Isotope	Capture	Elastic scattering	Inelastic scattering	Fission	ν	Total
Relative 1σ–uncertainty,%						
U238	1.6	*0.0*[a]	**3.1**	0.1	0.3	**3.5**
Pu239	0.8	*0.0*[a]	0.4	0.5	0.2	1.0
Pu240	0.2	0.0	0.1	0.4	0.4	0.6
Pu241	0.3	0.0	0.0	***3.0***	0.0	***3.0***
Fe56	0.6	0.3	0.5			0.9
Na23	0.0	0.8	0.5			0.9
O16	0.3	1.5	0.1			1.5

[a] Squared uncertainty is slightly negative.

Conclusions

The use of COMMARA-2.0 slightly reduces the calculated uncertainties as compared to BOLNA. Particularly smaller in the benchmark are uncertainties resulting from Np237 fission, Pu241 fission, O16 capture and elastic scattering, U238 capture and U235 capture.

However, data uncertainties, especially for k_{eff} in conjunction with U fuels are still much larger than experimental uncertainties. This is because in most cases uncertainties are dominated by U238 inelastic scattering. The significant standard deviation of this cross-section (10-30%) is even slightly larger in COMMARA-2.0 than it is in BOLNA.

COMMARA-2.0 likely provides valuable results also when used in conjunction with JEFF-3.1 cross-sections. Representativeness factors between ENDF/B-VI.8 and JEFF-3.1 are high, namely > 0.99 in most cases, and correspondingly the analytical confidence intervals are partly overlapping.

We might propose that special care in the adjustment exercise be given to U238 inelastic scattering for which more accurate measurements are unlikely to be realized.