RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**47-7959**
SRP Section:	**04.03 – Nuclear Design**
Application Section:	**4.3.3**
Date of RAI Issued:	**06/23/2015**

Question No. 04.03-1

TECHNICAL ISSUE ---------AREA OF APPLICABILITY OF THE DIT/ROCS CODE BENCHMARKING TO APR1400 NUCLEAR DESIGN

REQUIREMENTS

10 CFR Part 50 Appendix A, General Design Criterion (GDC) 10 requires the reactor core to include appropriate margin to assure that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation or anticipated operational occurrences (AOOs). GDC 11, “Reactor Inherent Protection,” requires that, in the power operating range, the prompt inherent nuclear feedback characteristics tend to compensate for a rapid increase in reactivity. GDC 20, “Protection System Functions,” requires automatic initiation of the reactivity control systems to assure that SAFDLs are not exceeded as a result of AOOs and that automatic operation of systems and components important to safety occurs under accident conditions. In addition, GDC 28, “Reactivity Limits,” requires that the effects of postulated reactivity accidents neither result in damage to the reactor coolant pressure boundary greater than limited local yielding nor cause sufficient damage to impair significantly the capability to cool the core. To assure safety, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 4.3, item 8 explicitly requires the staff to verify if correct code and cross section library are used in the nuclear design calculations and the analytical methods are compared with measured data.

ISSUE

The applicant states in Section 4.3 of the DCD that it used the DIT/ROCS computer code suite in its nuclear design calculations. The NRC approved this code package in 1983 for use for PWR core design. However, there is no information in the DCD on whether this code package was benchmarked against experimental data for the PLUS7 fuel with gadolinium poison, particularly the complex fuel/poison loadings as shown in Figure 4.3-2 and 4.3-3 of the DCD. In addition, in Section 4.3.4 of the DCD, the applicant states: “The APR1400 plant nuclear design

is very similar to the System 80+ design, having the same core size and fuel lattice type (16 × 16 C-E fuel type), which was licensed [certified] by the NRC in 1997. There is no significant nuclear design change compared to the System 80+ design." The staff, however, notes that the System 80+ design approved by the NRC uses erbium as burnable poison. Therefore, it was not clear if the codes are adequately benchmarked for the new APR1400 reactor design, including fuel enrichment, poison loads, and fuel/poison loading patterns in the various fuel assembly designs as shown in Figures 4.3-2 and 4.3-3 of the APR1400 DCD, Rev. 0. The applicant is requested to provide detailed information on code benchmarking data and justification for the applicability of the codes to the APR1400 nuclear design. The information should include, but are not limited to:

1. Experimental data used to benchmark the code and justifications to demonstrate that the selected experiments are applicable to the APR1400 with the PLUS7 fuel design. The information should include fuel enrichments, rod pitches, assembly pitches, fuel/moderator ratio, gadolinium poison loads that cover the range of the fuel assembly designs;
2. Provide the bias and bias uncertainty of the codes as the results of the code benchmarking analyses;
3. Provide trending analyses and results of the benchmarking results against, but are not limited to, fuel enrichment, burnable poison loading, and fuel burnup (up to 60 GWd/MTU); and
4. Explain how the bias and uncertainty obtained through code benchmarking are applied in the APR1400 nuclear design.

INFORMATION NEEDED

Using measurement data from operating reactors to benchmark code is a reasonable approach. However, when using this type of data, the applicant needs to demonstrate:

i. The fuel assembly designs are sufficiently similar to that of the APR1400 fuel design with respect to:
a. Fuel assembly geometric dimensions, such as fuel load, rod pitch, etc,
b. Fuel enrichment ranges,
c. Assembly fuel/poison loading patterns;

ii. The reactor cycle operating parameters are sufficiently similar with respect to:
a. Power distributions at various core burnup;
b. Average and maximum operating temperatures of the fuel and moderator;
c. Core Doppler reactivity;
d. Reactivity coefficients at various core burnup;
e. Critical soluble boron concentrations; and
f. Core cycle length.

The applicant is requested to assess the accuracy of the current nuclear design and key core parameters such as power distribution, reactivity coefficients, and they impacts on core safety provide adjustments to the core design and safety analyses if necessary. The applicant should provide detailed information on the code benchmarking analyses for the APR1400 nuclear design in its response to this RAI. The applicant is expected to provide a revised DCD to provide a high level summary on what has been done to address this issue.

The staff needs this information to determine if the nuclear design of the APR1400 meets the regulatory requirements

Response

As described in subsection 4.3.3.1.2 of the DCD, the DIT/ROCS code's analytical design methods were checked against a variety of critical experiments and operating power reactors. The comparison of predicted values served not only to verify the code's analytical design methods but also to provide a set of biases and uncertainties. While the licensed version of the DIT/ROCS code remains virtually unchanged, the bias and uncertainties have been occasionally updated to incorporate a new trend of deviations between measurements and predictions and/or to account for a new fuel design for which the impact is deemed considerable. For instance, upon having received the license for the gadolinia bearing fuel design (DCD 4.3 Reference 9) on the bases of three benchmark analyses, the fuel-vendor of the time, ABB-CE, accordingly updated the bias and uncertainties to account for the Gd design effect. As a result, the subsequent revisions made since then took into account the Gd design effect.
The bias and uncertainty (B/U) manual, which is given as Reference 12 in the DCD section 4.3 and called the APR1400 B/U hereafter, also accounts for the Gd design effect. The B/U manual being used for reload core designs at OPR1000 plants, which has a core design similar to Arkansas Nuclear One Unit 2, is identical to the APR1400 B/U except for a reactivity bias at the end of reload cycles. It should be noted that none of the measured data from OPR1000 plants including reload cores with PLUS7 fuel and initial cores with Guardian fuel were directly used to evaluate or update the APR 1400 B/U. In fact, the APR1400 B/U was developed from statistically evaluating the deviations of predictions from measurements, which were all taken from 8 US plants including the 3 Palo Verde plants. All results predicted for OPR1000 cores by using the DIT/ROCS code with the APR1400 B/U were acceptable against measurements and met the relevant acceptance criteria. This shows that the DIT/ROCS with the B/U is applicable to APR1400 core design. Below is the information to support its applicability to APR1400.

1.

Table 1 and 2 show comparisons of core and fuel designs between APR1400 and US Plants selected for the B/U evaluation, respectively. It can be seen that the B/U evaluation covers a wide range of core and fuel designs, for instance, thermal power from 2,570 to 3,817 MW, cycle length from 8,027 to 21,939 MWD/MTU, core average enrichment from 2.63 to 3.96 w/o and H/U ratio from 1.97 to 2.09. From a design point of view, the APR1400 core with PLUS7 fuel is considered to fall within the applicable range of the DIT/ROCS with the B/U. Table 3, Figure 1 and Figure 2 show comparisons of fuel design specifications between APR1400 and OPR1000 to find virtually no difference as compared with the range of design variations of US plants selected for the B/U. This provides a justification for utilizing the DIT/ROCS experience of OPR1000s to extend its applicability to APR1400.

2.

Table 4 summarizes the DIT/ROCS biases and uncertainties used for the APR1400 core design.

3.

Figures 3 through Figure 6 show trends of ITC (Isothermal Temperature Coefficient) deviations with critical boron concentration, core burnup, moderator temperature and enrichment, whereas Figure 7 and Figure 8 show trends of reactivity deviations with core moderator temperature and enrichment. All figures include the deviation data from the OPR1000 plants indicating that the DIT/ROCS code with the B/U predicts design parameters for OPR1000 cores to have deviations within the uncertainty band, with the exception of a few outliers. In addition, all other design parameters subject to physics test and surveillance were acceptable and met the relevant criteria as shown in Tables 6 through 11. This justifies the application of the DIT/ROCS code with the B/U to an APR1400 core design. Table 5 lists an exemplary fuel specifications used for OPR1000 cores, which include transition cores from Guardian to PLUS7 cores and initial cores with Guardian fuel.

4.

The DIT/ROCS biases and uncertainties summarized in Table 4 are used for the nuclear design of APR1400 cores in accordance with the bias and uncertainty manual given as Reference 12 in the DCD section 4.3.

Additional Information

Figures 9 through 16 showing assembly-wise power and burnup distributions are provided to help show the similarity between APR1400 and OPR1000 plants.

Table 1 Comparison of Core Designs between APR1400 and US Plants Selected for B/U

TS

Table 2 Comparison of Fuel Designs between APR1400 and US Plants Selected for B/U

TS

Table 3 Comparison of Fuel Designs between APR1400 and OPR1000s (1/2)

TS

Table 3 Comparison of Fuel Designs between APR1400 and OPR1000s (2/2)

TS

TS

Figure 1 Fuel and Burnable Absorber Rod Arrangement for OPR1000 Initial Cycle

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Figure 2 Fuel and Burnable Absorber Rod Arrangement for OPR1000 Equilibrium Cycle

Table 4 Summary of DIT/ROCS Biases and Uncertainties for APR1400

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Figure 3 Trend of ITC Deviations with Critical Boron Concentration

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Figure 4 Trend of ITC Deviations with Core Average Burnup

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Figure 5 Trend of ITC Deviations with Core Average Moderator Temperature

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Figure 6 Trend of ITC Deviations with Core Average Enrichment

TS

Figure 7 Trend of Reactivity Deviations with Moderator Temperature for Initial Cycle, BOC

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Figure 8 Trend of Reactivity Deviations with Core Average Enrichment for Reload Cycle, BOC

Table 5 Exemplary Specifications of Feed fuels for OPR1000

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Table 6 Comparison of HZP CBC Predictions with Measurements of OPR1000s

TS

Table 7 Comparison of HZP ITC Predictions with Measurements of OPR1000s

TS

Table 8 Comparison of HZP IBW Predictions with Measurements of OPR1000s

TS

Table 9 Comparison of Rod worth Predictions with Measurements of OPR1000s

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Table 10 Summary of RMS Differences on Radial Power Distributions of OPR1000s

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Table 11 Summary of RMS Differences on Axial Power Distributions of OPR1000s

TS

				FA Type and Box No. - FA Power - Fxy - FA Burnup -	B 1 0.65 1.14 32	B 2 0.91 1.34 45	C 3 1.07 1.52 53
			B 4 0.62 1.09 31	C 5 1.03 1.54 51	C1 6 1.09 1.41 54	C1 7 1.22 1.51 61	B1 8 1.24 1.49 62
		C 9 0.75 1.22 37	C1 10 1.04 1.42 52	A 11 0.90 1.03 45	B2 12 1.21 1.41 60	A 13 0.93 1.03 46	A 14 0.93 1.03 46
	B 15 0.62 1.09 31	C1 16 1.04 1.42 52	B1 17 1.19 1.40 60	B2 18 1.24 1.45 62	A 19 0.93 1.07 47	C1 20 1.24 1.47 62	A 21 0.90 1.03 45
	C 22 1.03 1.55 51	A 23 0.90 1.03 45	B2 24 1.24 1.46 62	A 25 0.95 1.09 48	B1 26 1.25 1.48 62	A 27 0.90 1.05 45	B1 28 1.19 1.42 60
B 29 0.65 1.14 32	C1 30 1.09 1.41 54	B2 31 1.21 1.42 60	A 32 0.93 1.07 47	B1 33 1.25 1.48 62	A 34 0.89 1.05 44	C1 35 1.15 1.43 57	A 36 0.82 0.98 41
B 37 0.91 1.34 45	C1 38 1.22 1.51 61	A 39 0.93 1.04 46	C1 40 1.24 1.47 62	A 41 0.90 1.05 45	C1 42 1.15 1.43 57	A 43 0.77 0.92 38	A 44 0.74 0.89 36
C 45 1.07 1.52 53	B1 46 1.24 1.49 62	A 47 0.93 1.03 46	A 48 0.90 1.03 45	B1 49 1.19 1.42 60	A 50 0.82 0.98 41	A 51 0.74 0.89 36	A 52 0.68 0.80 34

Figure 9 Radial Power Distribution for OPR1000 Initial Cycle, ARO, Eq. Xe, BOC

				FA Type and Box No. - FA Power - Fxy - FA Burnup -	B 1 0.59 1.02 5292	B 2 0.78 1.12 7247	C 3 0.88 1.23 8314
			B 4 0.58 0.99 5132	C 5 0.90 1.29 8302	C1 6 1.12 1.41 9551	C1 7 1.23 1.42 10682	B1 8 1.18 1.33 10610
		C 9 0.73 1.20 6367	C1 10 1.09 1.40 9244	A 11 0.91 1.05 8125	B2 12 1.20 1.36 10763	A 13 0.95 1.06 8535	A 14 0.93 1.02 8460
	B 15 0.58 0.99 5136	C1 16 1.09 1.40 9246	B1 17 1.24 1.39 10875	B2 18 1.23 1.41 11224	A 19 0.97 1.10 8828	C1 20 1.27 1.46 11520	A 21 0.94 1.07 8565
	C 22 0.90 1.29 8306	A 23 0.91 1.04 8131	B2 24 1.23 1.42 11235	A 25 0.98 1.12 9038	B1 26 1.23 1.39 11478	A 27 0.96 1.10 8773	B1 28 1.21 1.37 11177
B 29 0.59 1.02 5293	C1 30 1.12 1.41 9562	B2 31 1.20 1.36 10777	A 32 0.97 1.10 8837	B1 33 1.23 1.39 11488	A 34 0.96 1.10 8760	C1 35 1.24 1.44 11065	A 36 0.90 1.05 8103
B 37 0.78 1.12 7251	C1 38 1.23 1.42 10679	A 39 0.95 1.06 8547	C1 40 1.27 1.46 11529	A 41 0.96 1.10 8775	C1 42 1.24 1.44 11069	A 43 0.84 1.00 7554	A 44 0.78 0.91 7151
C 45 0.88 1.23 8314	B1 46 1.18 1.33 10610	A 47 0.93 1.02 8460	A 48 0.94 1.07 8565	B1 49 1.21 1.37 11177	A 50 0.90 1.05 8103	A 51 0.78 0.91 7151	A 52 0.73 0.81 6633

Figure 10 Radial Power Distribution for OPR1000 Initial Cycle, ARO, Eq. Xe, MOC

<table>
<tr><td></td><td></td><td colspan="3">FA Type and Box No. -
FA Power -
Fxy -
FA Burnup -</td><td>B 1
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0.99
8173</td><td>B 2
0.78
1.07
10999</td><td>C 3
0.86
1.17
12477</td></tr>
<tr><td></td><td></td><td></td><td>B 4
0.60
0.98
7947</td><td>C 5
0.90
1.24
12618</td><td>C1 6
1.10
1.33
14897</td><td>C1 7
1.19
1.35
16502</td><td>B1 8
1.14
1.27
16198</td></tr>
<tr><td></td><td></td><td>C 9
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1.15
9910</td><td>C1 10
1.08
1.32
14471</td><td>A 11
0.92
1.04
12522</td><td>B2 12
1.16
1.28
16437</td><td>A 13
0.96
1.06
13134</td><td>A 14
0.94
1.03
12943</td></tr>
<tr><td></td><td>B 15
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0.98
7952</td><td>C1 16
1.08
1.32
14472</td><td>B1 17
1.19
1.30
16720</td><td>B2 18
1.18
1.31
17007</td><td>A 19
0.97
1.07
13487</td><td>C1 20
1.25
1.37
17571</td><td>A 21
0.96
1.06
13130</td></tr>
<tr><td></td><td>C 22
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12621</td><td>A 23
0.92
1.04
12526</td><td>B2 24
1.18
1.31
17021</td><td>A 25
0.98
1.08
13732</td><td>B1 26
1.20
1.31
17287</td><td>A 27
0.99
1.08
13453</td><td>B1 28
1.21
1.31
16969</td></tr>
<tr><td>B 29
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0.99
8174</td><td>C1 30
1.10
1.33
14909</td><td>B2 31
1.16
1.29
16453</td><td>A 32
0.97
1.07
13498</td><td>B1 33
1.20
1.30
17301</td><td>A 34
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1.07
13434</td><td>C1 35
1.25
1.38
17027</td><td>A 36
0.96
1.05
12546</td></tr>
<tr><td>B 37
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11004</td><td>C1 38
1.19
1.35
16495</td><td>A 39
0.96
1.06
13151</td><td>C1 40
1.25
1.37
17582</td><td>A 41
0.99
1.08
13455</td><td>C1 42
1.25
1.37
17032</td><td>A 43
0.92
1.04
11760</td><td>A 44
0.88
0.97
11121</td></tr>
<tr><td>C 45
0.86
1.17
12477</td><td>B1 46
1.14
1.27
16198</td><td>A 47
0.94
1.03
12943</td><td>A 48
0.96
1.06
13130</td><td>B1 49
1.21
1.31
16969</td><td>A 50
0.96
1.05
12546</td><td>A 51
0.88
0.97
11121</td><td>A 52
0.85
0.91
10364</td></tr>
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Figure 11 Radial Power Distribution for OPR1000 Initial Cycle, ARO, Eq. Xe, EOC

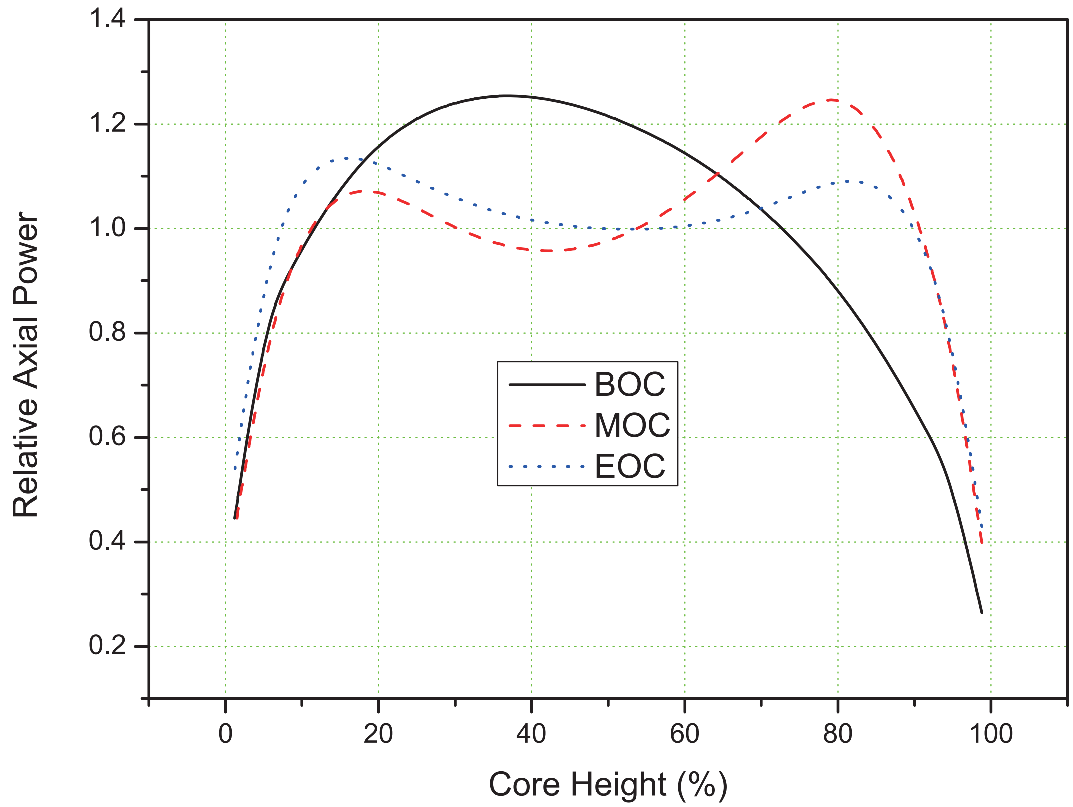

Figure 12 Axial Power Distribution for OPR1000 Initial Cycle, ARO

Underline indicates the maximum value					O1 1 0.314 0.643 38842	O0 2 0.407 0.723 37043	P4 3 0.485 0.807 21673
FA Type and Box No. — FA Power — Fxy — FA Burnup —			O2 4 0.378 0.802 38438	Q0 5 1.025 1.504 0	Q2 6 1.119 1.489 0	Q1 7 1.209 1.537 0	P6 8 1.008 1.238 21932
		O4 9 0.385 0.744 42049	Q1 10 1.101 1.527 0	P2 11 1.191 1.391 19275	P1 12 1.256 1.381 18162	P4 13 1.161 1.270 22288	Q6 14 1.326 1.530 0
	O2 15 0.377 0.804 38404	Q1 16 1.099 1.527 0	Q6 17 1.330 1.557 0	P6 18 1.166 1.280 22858	Q4 19 1.284 1.503 0	O1 20 0.925 1.081 38439	P4 21 1.050 1.209 22065
	Q0 22 1.022 1.502 0	P2 23 1.190 1.387 19256	P6 24 1.167 1.282 22777	O4 25 0.919 1.087 38785	P1 26 1.212 1.410 20135	Q6 27 1.328 1.557 0	O6 28 0.881 1.027 41484
O1 29 0.314 0.643 38827	Q2 30 1.117 1.486 0	P1 31 1.256 1.383 18170	Q4 32 1.283 1.501 0	P1 33 1.214 1.409 20162	P6 34 1.218 1.370 22333	P0 35 1.274 1.397 16157	Q6 36 1.274 1.476 0
O0 37 0.406 0.721 37024	Q1 38 1.209 1.536 0	P4 39 1.159 1.264 22290	O1 40 0.926 1.084 38411	Q6 41 1.328 1.556 0	P0 42 1.275 1.398 16202	O4 43 0.868 1.179 30859	O4 44 0.686 0.967 39054
P4 45 0.485 0.807 21673	P6 46 1.008 1.238 21932	Q6 47 1.326 1.530 0	P4 48 1.050 1.209 22065	O6 49 0.881 1.027 41484	Q6 50 1.274 1.476 0	O4 51 0.686 0.967 39054	O4 52 0.523 0.656 42082

Figure 13 Radial Power Distribution for OPR1000 Equilibrium Cycle, ARO, Eq. Xe, BOC

Underline indicates the maximum value

Cell legend: FA Type and Box No. — / FA Power — / Fxy — / FA Burnup —

					O1 1 0.364 0.702 41522	**O0 2** 0.464 0.774 40499	**P4 3** 0.543 0.861 25800
			O2 4 0.396 0.785 41522	**Q0 5** 0.993 1.417 8071	**Q2 6** 1.205 1.560 9225	**Q1 7** 1.283 1.555 9924	**P6 8** 1.035 1.238 30111
		O4 9 0.425 0.787 45262	**Q1 10** 1.140 1.513 8899	**P2 11** 1.129 1.322 28561	**P1 12** 1.209 1.331 28023	**P4 13** 1.141 1.246 31527	**Q6 14** <u>1.382</u> <u>1.563</u> 10838
	O2 15 0.396 0.787 41483	**Q1 16** 1.139 1.514 8891	**Q6 17** 1.372 1.548 10757	**P6 18** 1.118 1.226 32011	**Q4 19** 1.349 1.508 10536	**O1 20** 0.927 1.058 45833	**P4 21** 1.036 1.176 30457
	Q0 22 0.991 1.417 8054	**P2 23** 1.128 1.316 28534	**P6 24** 1.119 1.229 31940	**O4 25** 0.886 1.006 46052	**P1 26** 1.132 1.284 29550	**Q6 27** 1.337 1.475 10684	**O6 28** 0.879 0.991 <u>48531</u>
O1 29 0.363 0.703 41501	**Q2 30** 1.203 1.555 9206	**P1 31** 1.209 1.334 28032	**Q4 32** 1.349 1.505 10532	**P1 33** 1.134 1.283 29589	**P6 34** 1.093 1.226 31674	**P0 35** 1.163 1.263 25940	**Q6 36** 1.270 1.413 10217
O0 37 0.464 0.772 40474	**Q1 38** 1.284 1.559 9927	**P4 39** 1.139 1.241 31515	**O1 40** 0.928 1.062 45811	**Q6 41** 1.337 1.489 10683	**P0 42** 1.165 1.264 26000	**O4 43** 0.820 1.055 37688	**O4 44** 0.676 0.902 44561
P4 45 0.543 0.861 25800	**P6 46** 1.035 1.238 30111	**Q6 47** 1.382 1.563 10838	**P4 48** 1.036 1.176 30457	**O6 49** 0.879 0.991 48531	**Q6 50** 1.270 1.413 10217	**O4 51** 0.676 0.902 44561	**O4 52** 0.532 0.641 46362

Figure 14 Radial Power Distribution for OPR1000 Equilibrium Cycle, ARO, Eq. Xe, MOC

Underline indicates the maximum value

FA Type and Box No. —
FA Power —
Fxy —
FA Burnup —

					O1 1 0.401 0.738 44488	O0 2 0.503 0.804 44244	P4 3 0.584 0.878 30186
			O2 4 0.425 0.789 44712	Q0 5 0.974 1.331 15743	Q2 6 1.189 1.449 18667	Q1 7 1.247 1.438 19873	P6 8 1.015 1.176 38149
		O4 9 0.463 0.802 48741	Q1 10 1.144 1.438 17903	P2 11 1.086 1.246 37244	P1 12 1.154 1.274 37297	P4 13 1.097 1.187 40338	Q6 14 1.352 1.479 21701
	O2 15 0.424 0.790 44672	Q1 16 1.144 1.440 17889	Q6 17 1.352 1.481 21601	P6 18 1.089 1.178 40707	Q4 19 <u>1.364</u> <u>1.492</u> 21400	O1 20 0.938 1.037 53163	P4 21 1.034 1.136 38621
	Q0 22 0.972 1.332 15714	P2 23 1.086 1.240 37211	P6 24 1.090 1.181 40646	O4 25 0.889 0.966 53037	P1 26 1.113 1.212 38391	Q6 27 1.355 1.482 21422	O6 28 0.914 0.990 <u>55611</u>
O1 29 0.400 0.739 44464	Q2 30 1.188 1.445 18635	P1 31 1.154 1.277 37309	Q4 32 1.363 1.487 21392	P1 33 1.115 1.211 38443	P6 34 1.073 1.150 40181	P0 35 1.160 1.236 35054	Q6 36 1.327 1.488 20552
O0 37 0.503 0.801 44215	Q1 38 1.248 1.442 19882	P4 39 1.096 1.183 40315	O1 40 0.939 1.040 53147	Q6 41 1.354 1.491 21421	P0 42 1.163 1.238 35132	O4 43 0.869 1.012 44296	O4 44 0.748 0.909 50124
P4 45 0.584 0.878 30186	P6 46 1.015 1.176 38149	Q6 47 1.352 1.479 21701	P4 48 1.034 1.136 38621	O6 49 0.914 0.990 55611	Q6 50 1.327 1.488 20552	O4 51 0.748 0.909 50124	O4 52 0.617 0.680 50815

Figure 15 Radial Power Distribution for OPR1000 Equilibrium Cycle, ARO, Eq. Xe, EOC

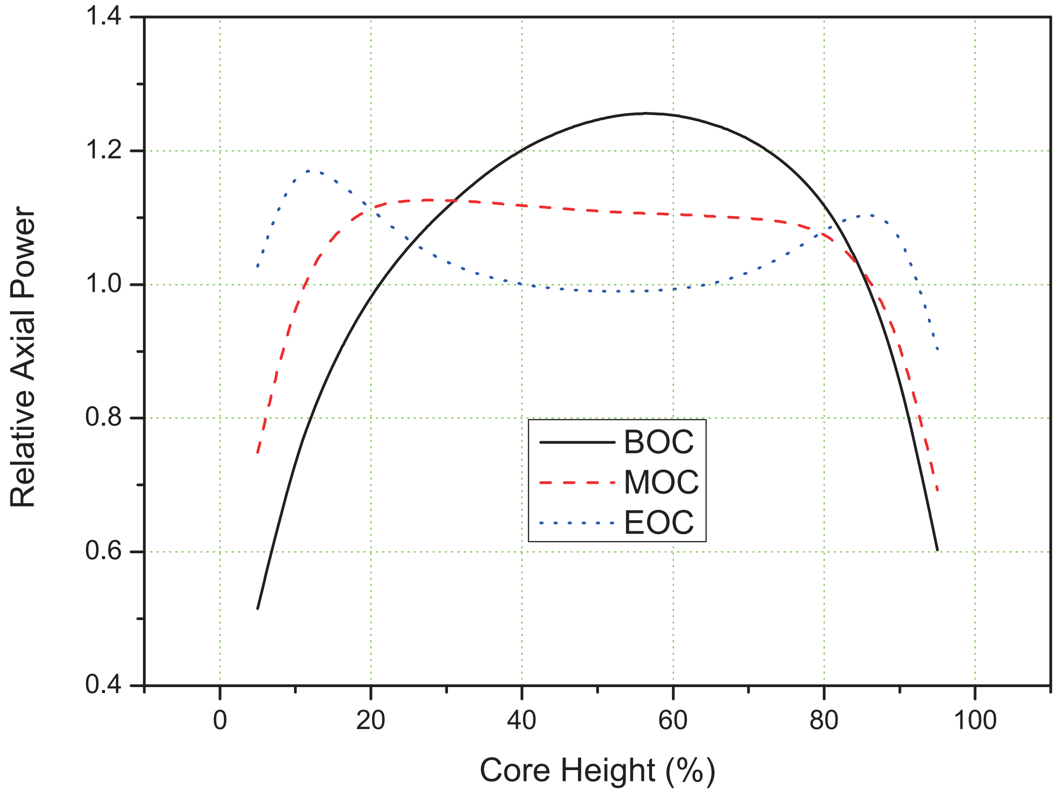

Figure 16 Axial Power Distribution for OPR1000 Equilibrium Cycle, ARO

Impact on DCD

DCD 4.3 will be revised to state how DIT/ROCS is applicable to the APR1400 design with the PLUS7 fuel that uses gadolinium as a poison as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Report

There is no impact on any Technical, Topical, or Environmental Report.

reactivity depletion rate, and CEA worths were analyzed to provide a global verification of the nuclear design package.

The comparison between calculations and measurements served not only to verify the calculation methodology but also provided a set of calculation biases and uncertainties that are applied to the calculation results to yield best-estimate and 95/95 confidence limit predictions for use in the safety analysis. Verification of the basic methodology was demonstrated and approved by the NRC (Reference 5). Biases and uncertainties for the DIT/ROCS code system were also documented and approved (Reference 5). Implementation of the improvements for the core design and accumulation of measurement data necessitated an update of the biases and uncertainties to provide reasonable assurance that 95/95 confidence limits are maintained in all results used for licensing-related analyses. These updated biases and uncertainties are summarized in Reference 12. The revisions do not represent a change in methodology but are intended to maintain the approved level of accuracy in Reference 5.

4.3.3.1.2.1 Critical Experiments

Selected critical experiments have been analyzed with the DIT code. The selection of critical experiments is based on the following criteria:

a. Applicability to Combustion Engineering (C-E) fuel and assembly designs

b. Self-consistency of measured parameters

c. Availability of adequate data to model the experiments

Two groups of critical experiments using rod arrays representative of the 14 × 14 assembly have been used in this evaluation. The first is a series of clean experiments with UO_2 fuel carried out in 1967 (Reference 13), and the second is a set of experiments carried out in 1969 (Reference 5). Tables 4.3-13 and 4.3-14 give the principal parameters for each experimental configuration. The moderator-to-fuel volume ratios were varied by changing the cell pitch of the fuel rod arrangement. The moderator and reflector material for all cores was water.

The applicability of the DIT/ROCS code system to a gadolinium poisoned core was demonstrated by the three benchmark analysis conducted in reference 9. In addition, the comparisons were made to operating plants in Korea and the US that have validated the use of the biases and uncertainties provided in reference 12.