2. BENCHMARK SPECIFICATION

The purpose of this calculational benchmark problem is to compare nuclide concentrations computed by all participants for depletion in a simple pin-cell model. The fuel pin-cell description is given in Table 1. The fuel sample assay at MCC was from a Combustion Engineering 14 × 14 assembly design. For the purposes of this benchmark, actual pin dimensions were used but the fuel pin pitch was modified such that the fuel-to-moderator ratio matched that of the actual two-dimensional (2-D) assembly. The fuel sample was burned for four complete cycles; the length of the burn time and subsequent down time for each reactor cycle are given in Table 2. This benchmark consists of three cases, corresponding to fuel samples taken from three different axial locations in the reference fuel pin, each with a different total burnup. The specific power for each cycle and the final (cumulative) burnup are given in Table 3 for each of the three cases. Table 4 lists the initial isotopic concentrations to be used for the fuel material for all three cases. Table 5 provides the isotopic composition of the moderator for cycle 1. Note that boron concentrations given in Table 5 are for cycle 1 and should be modified by the cycle-specific relative boron concentrations given in Table 2 for subsequent cycles. Finally, Table 6 provides a list of those isotopes for which concentrations are desired at specified burnups and cooling times. The goal of this study is to compare the isotopic concentrations calculated by the study participants using various codes and data libraries.

Table 1. Physical data for benchmark problem pin-cell calculation

Parameter	Data
Type fuel pellet	UO_2
Fuel density	10.045 g/cm^3
Rod pitch	1.5586 cm
Rod OD	1.118 cm
Rod ID	0.986 cm
Fuel diameter	0.9563 cm
Active fuel length	347.2 cm
Effective fuel temperature	841 K
Clad temperature	620 K
Clad material	Zircaloy-2 (97.91 wt % Zr, 1.59 wt % Sn, 0.5 wt % Fe)
Water temperature	558 K
Water density	0.7569 g/cm^3

Table 2. Operating history data for benchmark problem pin-cell calculation

Operating cycle	Burntime (days)	Downtime (days)	Boron concentration (ppm)	Boron concentration (% of cycle 1)
1	306.0	71.0	331.0	100.0
2	381.7	83.1	469.7	141.9
3	466.0	85.0	504.1	152.3
4	461.1	1870.0	492.5	148.8

Table 3. Specific power for the three benchmark cases

	Specific Power (kW/kgU)		
Operating cycle	Case A (final burnup = 27.35 GWd/MTU)	Case B (final burnup = 37.12 GWd/MTU)	Case C (final burnup = 44.34 GWd/MTU)
1	17.24	24.72	31.12
2	19.43	26.76	32.51
3	17.04	22.84	26.20
4	14.57	18.87	22.12

Table 4. Initial fuel composition and number densities

Nuclide	Number density (atoms/b-cm)
^{234}U	6.15165×10^{-6}
^{235}U	6.89220×10^{-4}
^{236}U	3.16265×10^{-6}
^{238}U	2.17104×10^{-2}
^{12}C	9.13357×10^{-6}
^{14}N	1.04072×10^{-5}
^{16}O	4.48178×10^{-2}

Table 5. Cycle 1 coolant number densities

Nuclide	Number density (atoms/b-cm)
^{1}H	5.06153×10^{-2}
^{16}O	2.53076×10^{-2}
^{10}B	2.75612×10^{-6}
^{11}B	1.11890×10^{-5}

Table 6. Benchmark nuclides

Actinides	Fission products
^{234}U	^{95}Mo
^{235}U	^{99}Tc
^{236}U	^{101}Ru
^{238}U	^{103}Rh
^{238}Pu	^{109}Ag
^{239}Pu	^{133}Cs
^{240}Pu	^{147}Sm
^{241}Pu	^{149}Sm
^{242}Pu	^{150}Sm
^{241}Am	^{151}Sm
^{243}Am	^{152}Sm
^{237}Np	^{143}Nd
	^{145}Nd
	^{153}Eu
	^{155}Gd