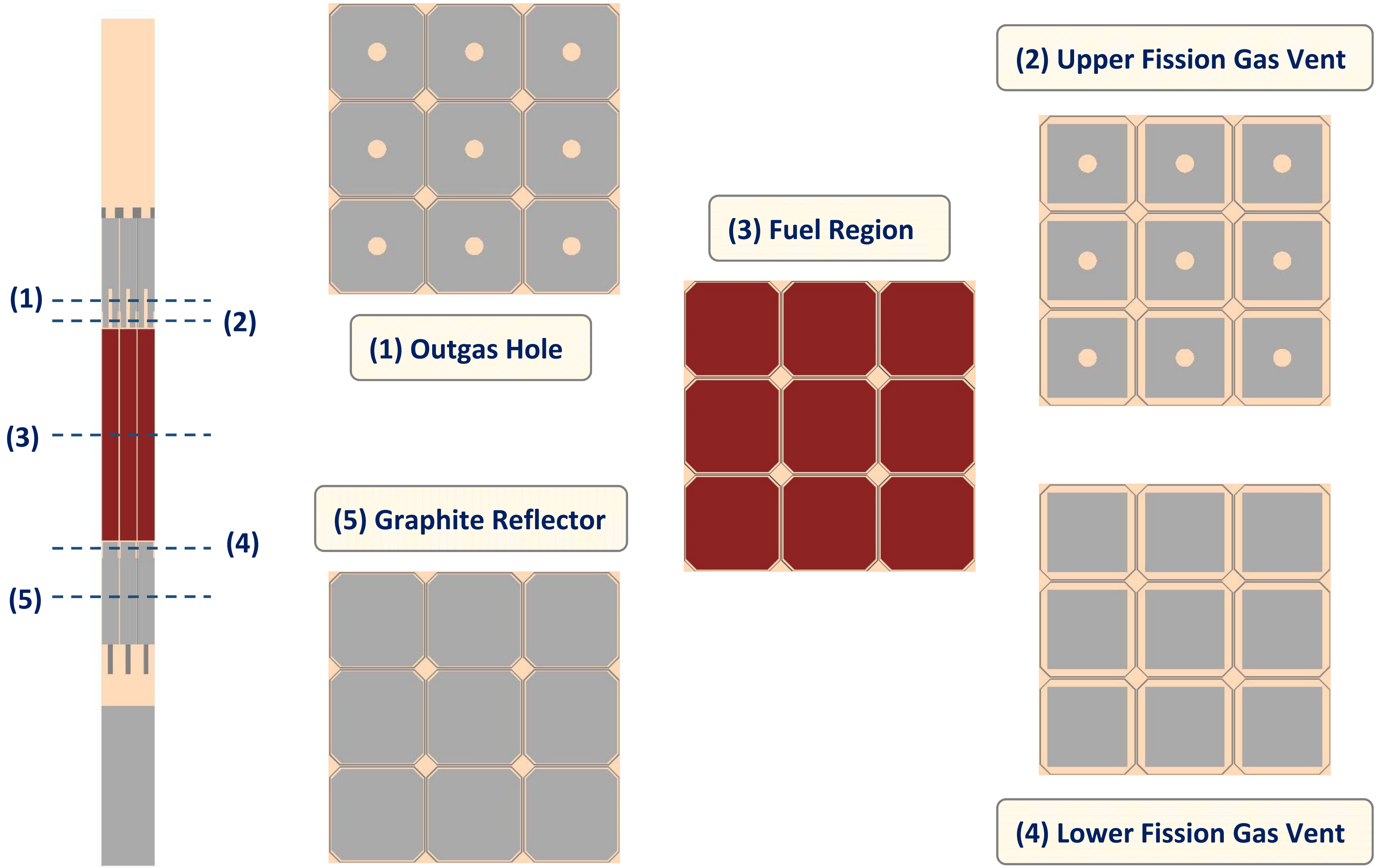
OpenMC Infinite Fuel Lattice Model

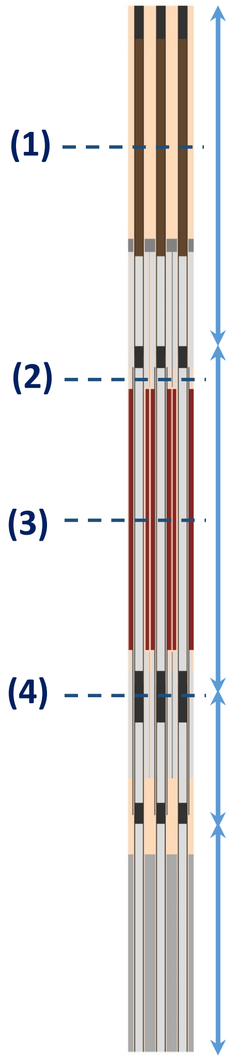


Parametric Results (Fuel Lattice)

No.	Infinite Fuel Lattice Case	k_inf	Reactivity (pcm)
0.	**Base:** ENDF/B-7.1 5.9 ppm Boron and 267 ppm Iron **100% Graphitization** **970 ppm Hydrogen in Fuel** **0.1% wt. Hafnium in Zr-3 Clad**	**1.39696 ± 0.00023**	N/A
1.	**Base + 0% Graphitization** (No Sab for the graphite in "Fuel")	**1.40467 ± 0.00032**	+ 392.9
2.	**Base + No Hydrogen Impurity in Fuel** (Replacing H-1 and H-2 with C-Nat)	**1.41551 ± 0.00022**	+ 938.1
3	**Base + No Hafnium Impurity in Zr-3 Clad** (Replacing Hf with Zr)	**1.42744 ± 0.00020**	+ 1528.5

- **Infinite fuel lattice model for TREAT has been completed using OpenMC, focuses being primarily placed on material impurities. Reasonable geometrical descriptions are adopted in the current model.**
- **Very limited geometrical simplifications have been used in fuel and reflector regions. Greater simplifications have been made to the upper and lower structural fittings and the regions further away, but negligible neutronic effect is expected.**
- **The "Reference" k_inf value given by BATMAN Report is 1.44057± 0.00002, where "59% graphitization", "no hydrogen impurity", and "close to zero hafnium impurity" are considered.**

Control Rod Fuel Assembly Lattice

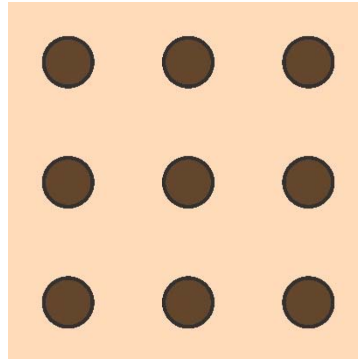


Poison Section*
(60 inches)
* B4C section is shortened for MCC.

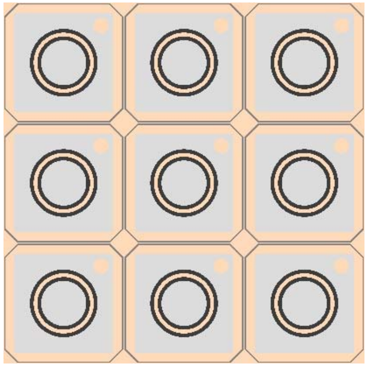
Zirco. Follower
(60 inches)

Upper Follower
(24 inches)

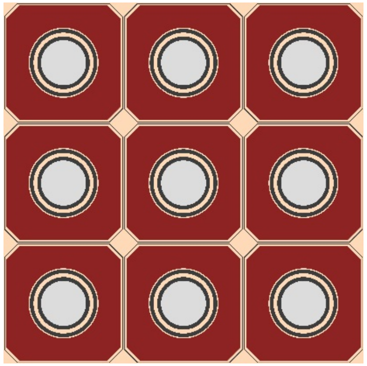
CR Follower
(60 inches)



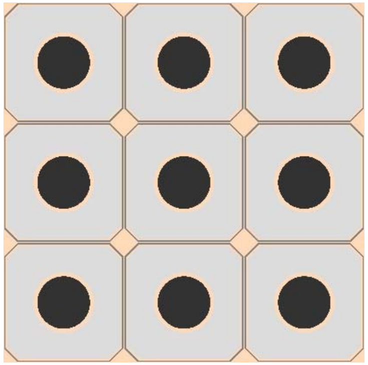
(1) Poison Section at Upper Parking Position



(2) Zirco. Follower in CR Assembly Vent Section

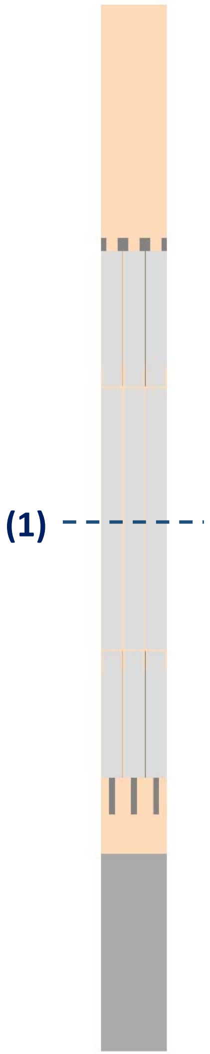


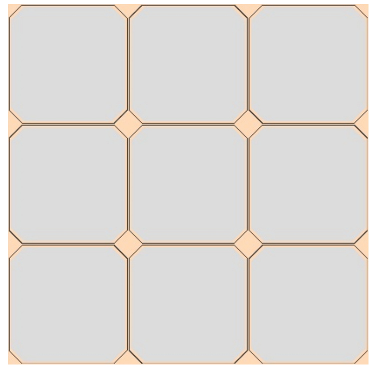
(3) Zirco. Follower in CR Assembly Fuel Section



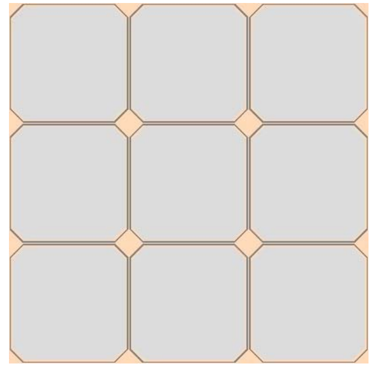
(4) Mild Steel Section in CR Fuel Assembly

Zr / Al Dummy Assembly Lattice

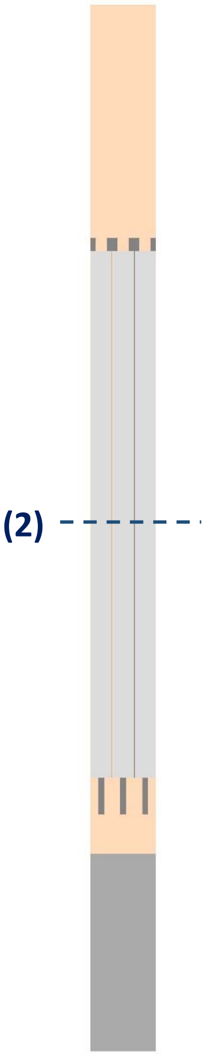




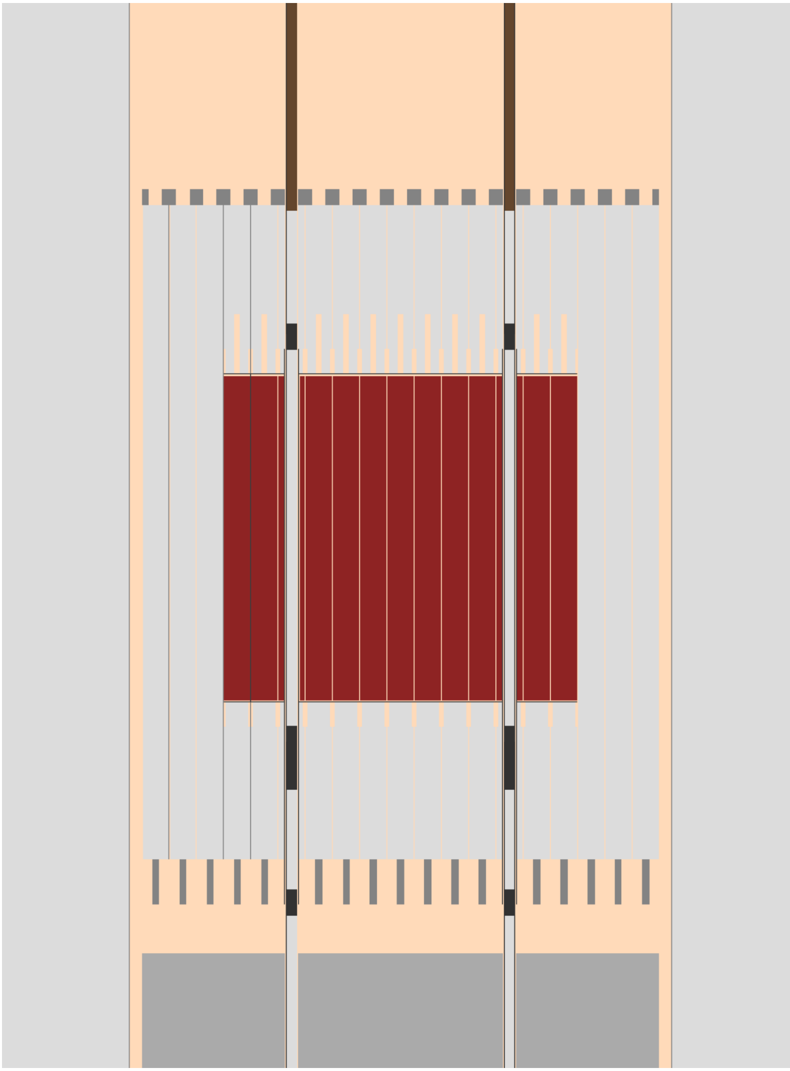
(1) Zicraloy Clad
Dummy Assembly

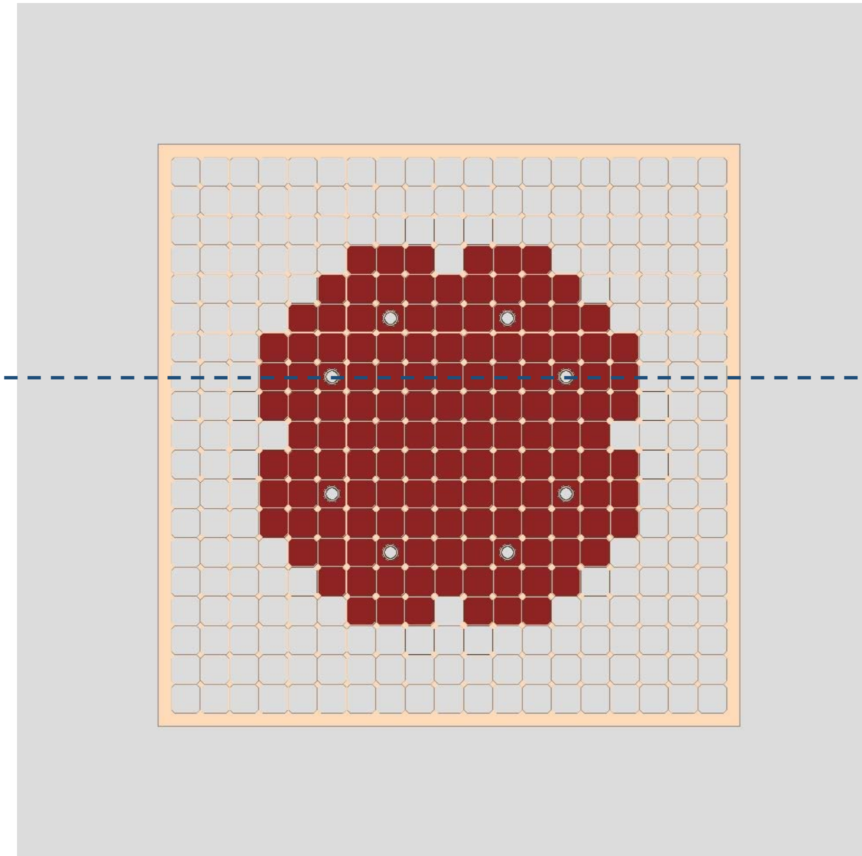


(2) Aluminum Clad
Dummy Assembly



Minimum Critical Core (MCC)





- ✓ 133 Standard Fuel Assembly
- ✓ 8 Control Rod Fuel Assembly (Fully Withdrawn)
- ✓ 16 Zircaloy Clad Dummy Assembly

Parametric Results (MCC)

No.	MCC Case	k_eff	Reactivity (pcm)
0.	**Base:** ENDF/B-7.1 5.9 ppm Boron and 267 ppm Iron **100% Graphitization** **970 ppm Hydrogen in Fuel** **0.1% wt. Hafnium in Zr-3 Clad**	**1.02520 ± 0.00010**	N/A
1.	**Base + 0% Graphitization** (No Sab for the graphite in "Fuel")	**1.03735 ± 0.00016**	+ 1142.5
2.	**Base + No Hydrogen Impurity in Fuel** (Replacing H-1 and H-2 with C-Nat)	**0.99204 ± 0.00015**	- 3260.4
3	**Base + No Hafnium Impurity in Zr-3 Clad** (Replacing Hf with Zr)	**1.04986 ± 0.00014**	+ 2291.1

- **The Minimum Critical Core (MCC) model for TREAT has been completed using OpenMC.**
- **The reactivity effects of three considerations (graphitization, hydrogen in fuel, and hafnium in clad) are more pronounced in the MCC case than those in the infinite fuel lattice. In particular, the reactivity effect of removing hydrogen impurity changes from positive to negative. This is most likely due to the spectral shift.**
- **If no hydrogen impurity is considered (the MCNP sample input in BATMAN did so), the OpenMC model for the MCC is close to critical.**

Proposed Benchmark Case

No.	Lattice Case	k_inf	Reactivity (pcm)
0.	**Benchmark:** ENDF/B-7.1 **7.53 ppm Boron** and 267 ppm Iron **No Hydrogen in Fuel** **< 100 ppm Hafnium in Zr-3 Clad** **100% Graphitization**	1.42450 ± 0.00020	N/A
1.	**Benchmark + 0% Graphitization** (No Sab for the graphite in "Fuel")	1.43852 ± 0.00023	+ 684.2

No.	MCC Case	k_eff	Reactivity (pcm)
0.	**Benchmark:** ENDF/B-7.1 **7.53 ppm Boron** and 267 ppm Iron **No Hydrogen in Fuel** **< 100 ppm Hafnium in Zr-3 Clad** **100% Graphitization**	1.00266 ± 0.00016	N/A
1.	**Benchmark + 0% Graphitization** (No Sab for the graphite in "Fuel")	1.02690 ± 0.00009	+ 2354.2

- **It should be highlighted that, without hydrogen impurity in fuel, the reactivity effect caused by graphitization is much pronounced (from 1142.5 pcm to 2354.2 pcm for the MCC case).**