ADDITIONS TO THE ICSBEP AND IRPHEP HANDBOOKS SINCE NCSD 2009

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ICSBEP Handbook

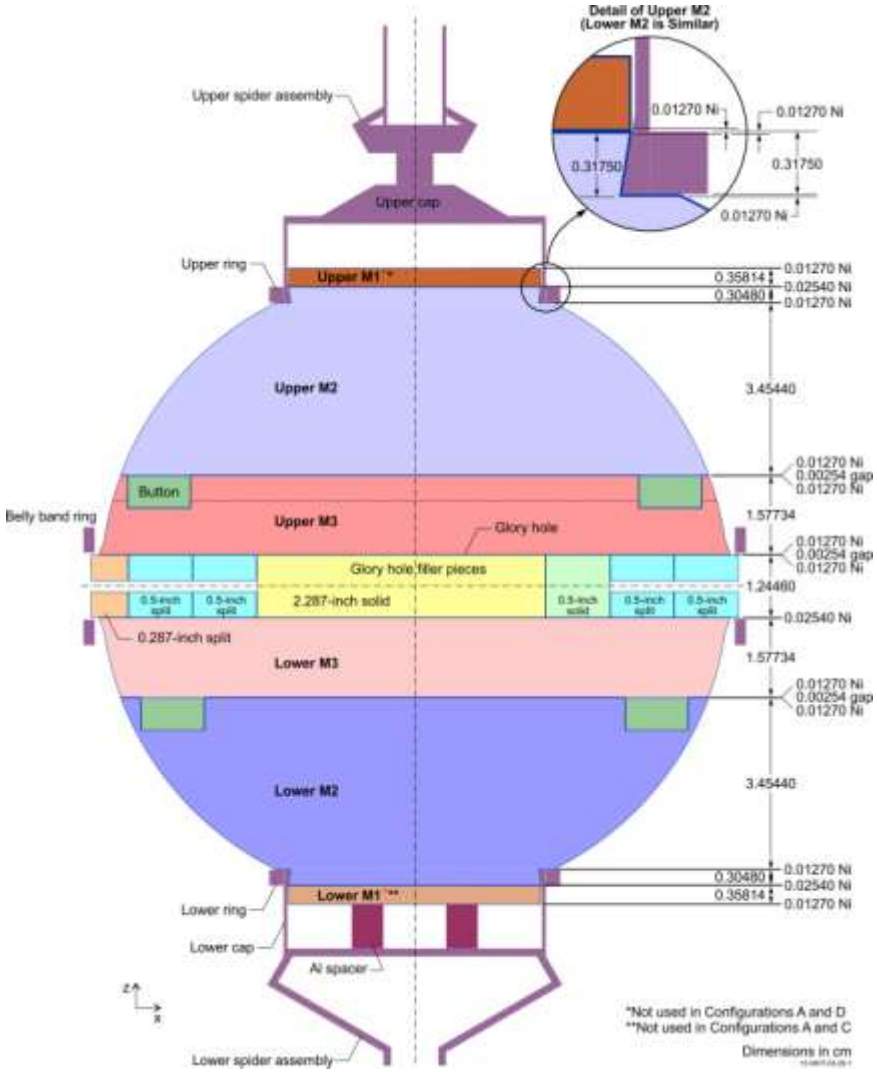
	2009 →	2013	Increase
Evaluations →	510	568	58
Configurations →	4283	4798	515
Pu→	697	734	37
HEU→	1329	1414	85
IEU →	119	267	148
LEU →	1404	1595	191
U-233 →	243	244	1
MIXED →	471	524	53
SPEC →	20	20	0
Alarm/Shielding →	24	24	0
Fundamental Physics →	200	200	0

Plutonium Benchmarks

37 Plutonium Benchmarks:

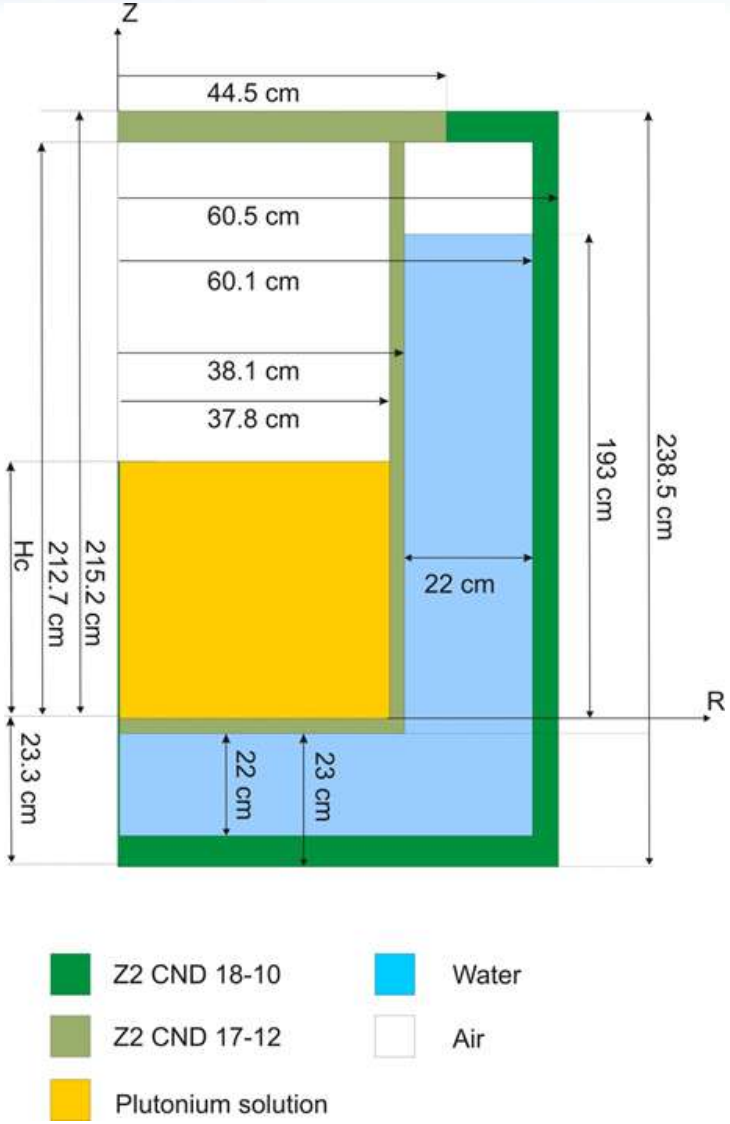
- Los Alamos National Laboratory (LANL) in the United States
- Valduc Nuclear Center in France
- Bhaba Atomic Research Center (BARC) in India

Bare Sphere of Plutonium-239 Metal
[PU-MET-FAST-001 Revisions 3]



Plutonium Temperature Effect Program - Low Concentrated Plutonium Nitrate Solutions at Temperatures Varying from 28°C to 40°C

[PU-SOL-THERM-039]

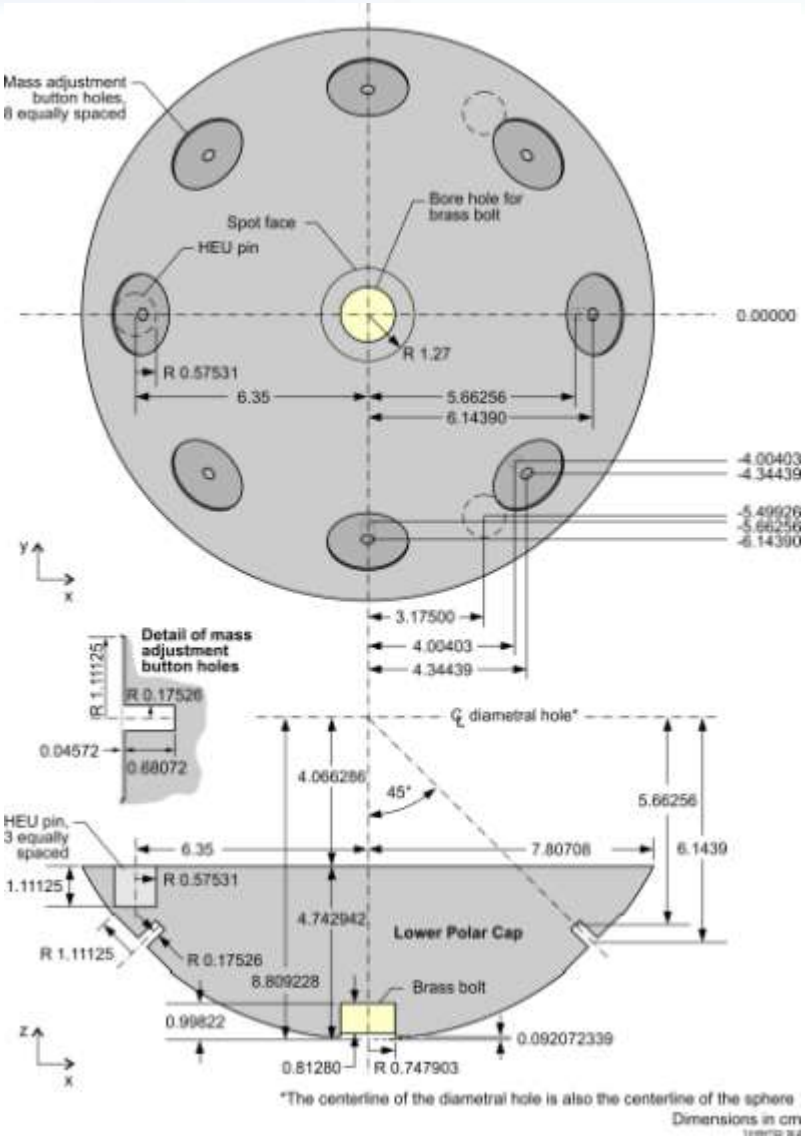


Highly Enriched Uranium Benchmarks

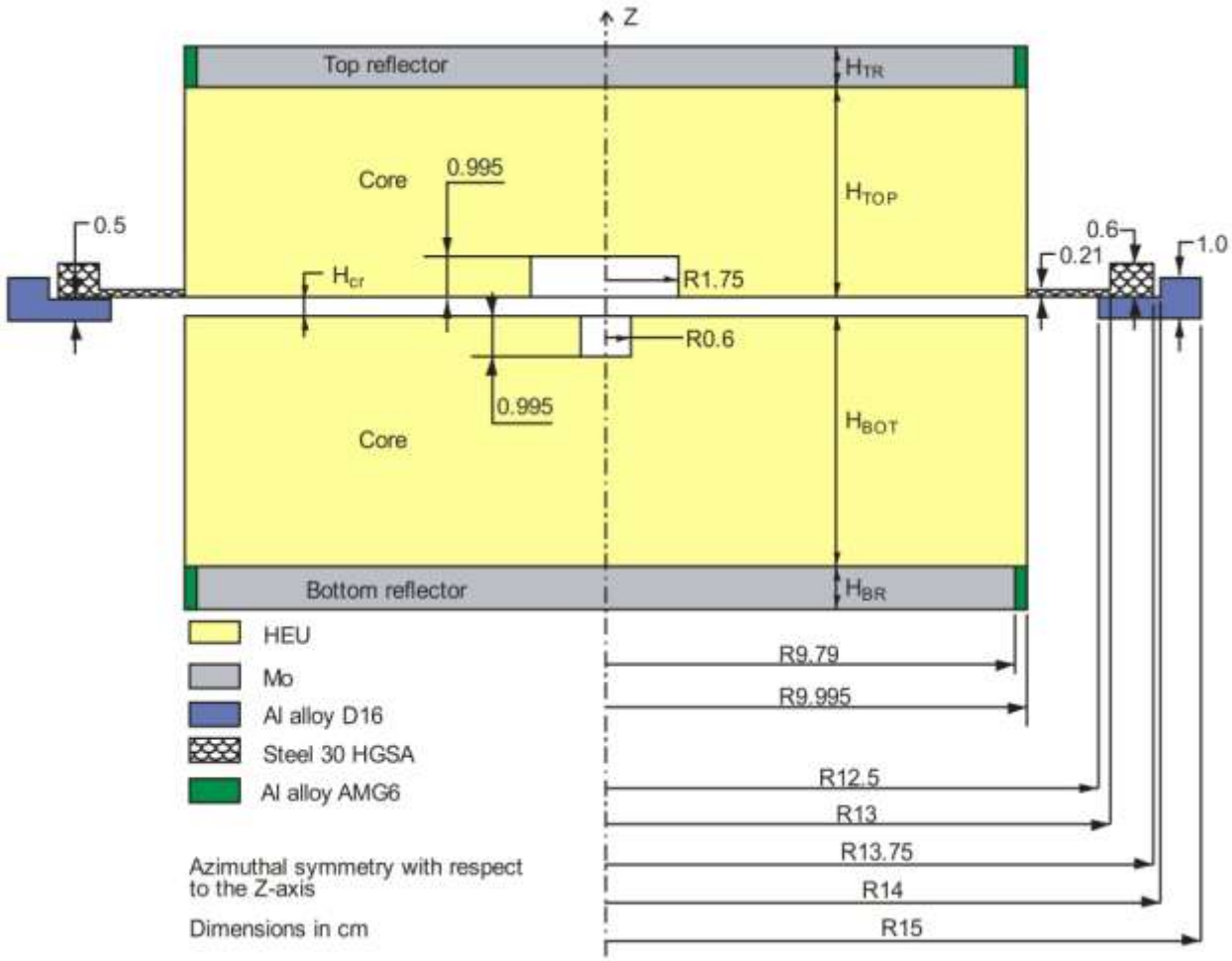
85 Highly Enriched Uranium Benchmarks:

- Los Alamos National Laboratory (LANL) in the United States
- Oak Ridge National Laboratory (ORNL) in the United States
- Bettis Atomic Power Laboratory (BAPL) in the United States
- Russian Federal Nuclear Center Institute of Technical Physics (VNIITF) in the Russian Federation

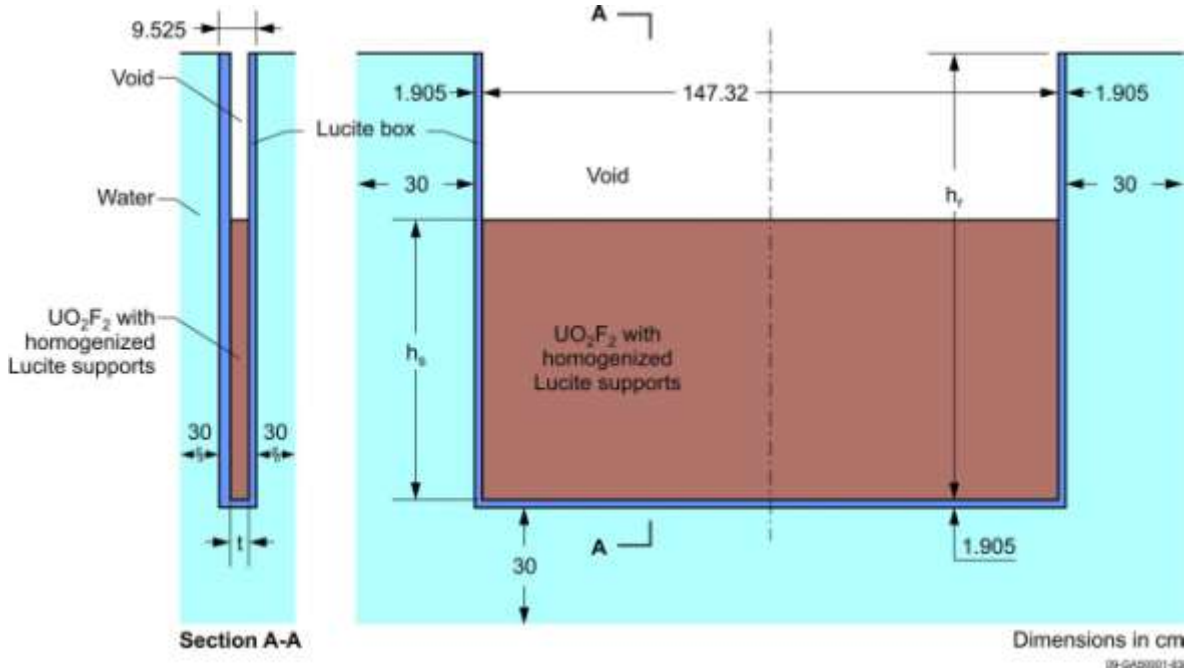
Delayed Critical ORNL Unreflected Uranium (93.2) Metal Spheres
[HEU-MET-FAST-100]

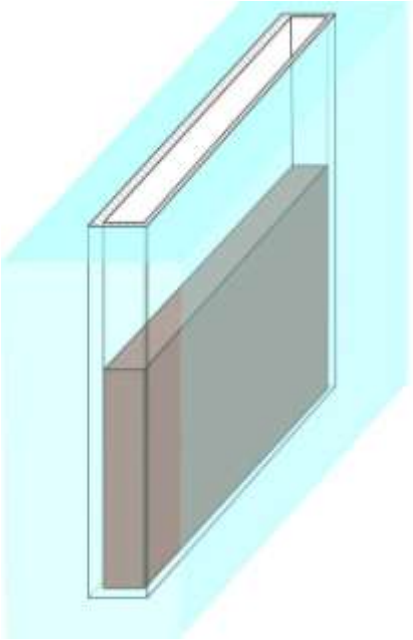


Four Molybdenum-reflected HEU Cylinders
[HEU-MET-FAST-092]



Water–Moderated and –Reflected Slabs of Uranium Oxyfluoride [HEU-SOL-THERM-034]





Perspective view
(Not to scale)

Intermediate and Mixed Enrichment Uranium Benchmarks

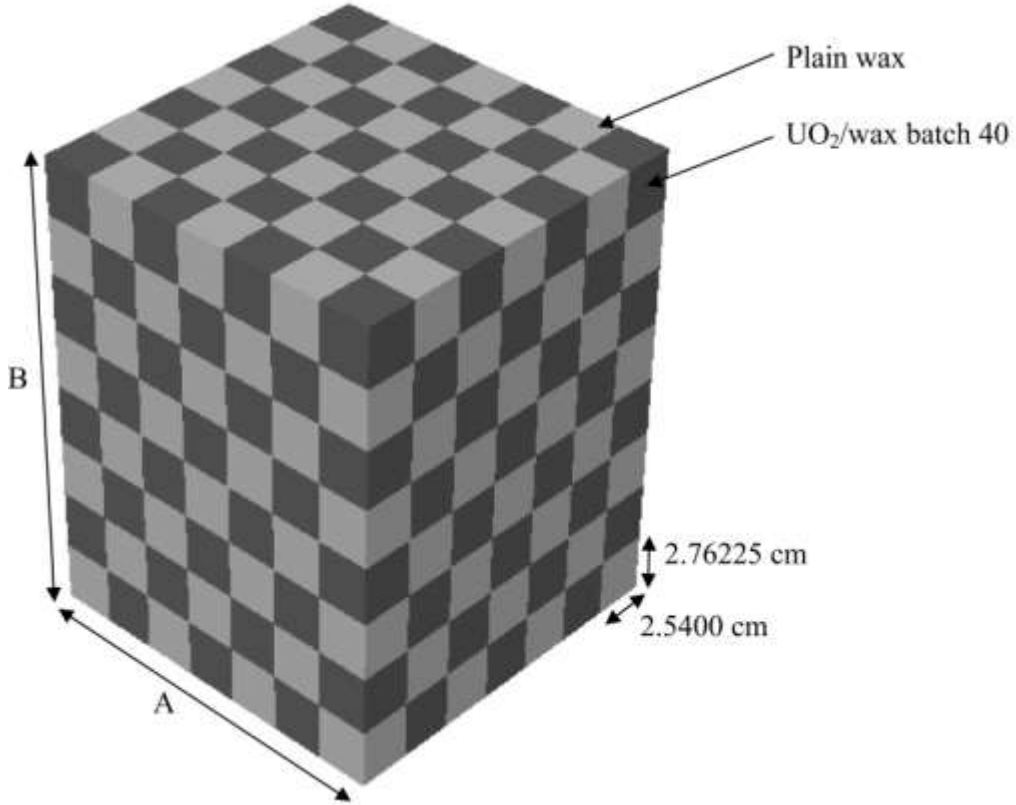
148 Intermediate-Enriched Uranium Benchmarks:

- Argonne National Laboratory – West (ANL-W) in the United States
- Idaho National Laboratory (INL) in the United States
- Institute for Physics and Power Engineering (IPPE)in the Russian Federation
- Aldermaston Atomic Weapons Establishment (AWE)
- Dounreay Facilities in the United Kingdom
- Studsvik Facilities in Sweden
- Centro Atómico Bariloche in Argentina

Bare and Water-Reflected Spheres and Hemispheres of Aqueous Uranyl Fluoride Solutions (30.45% ^{235}U)

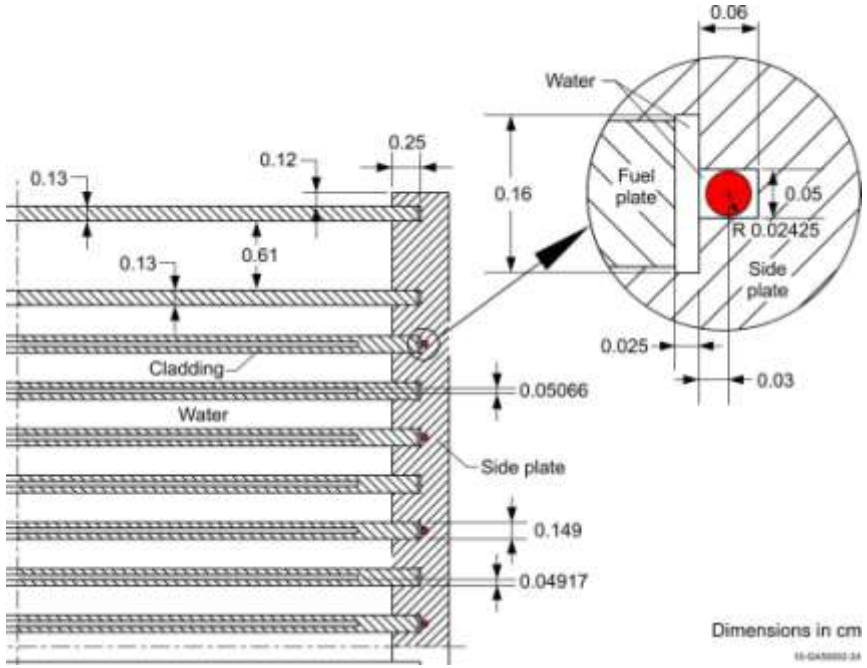
[IEU-SOL-THERM-002]

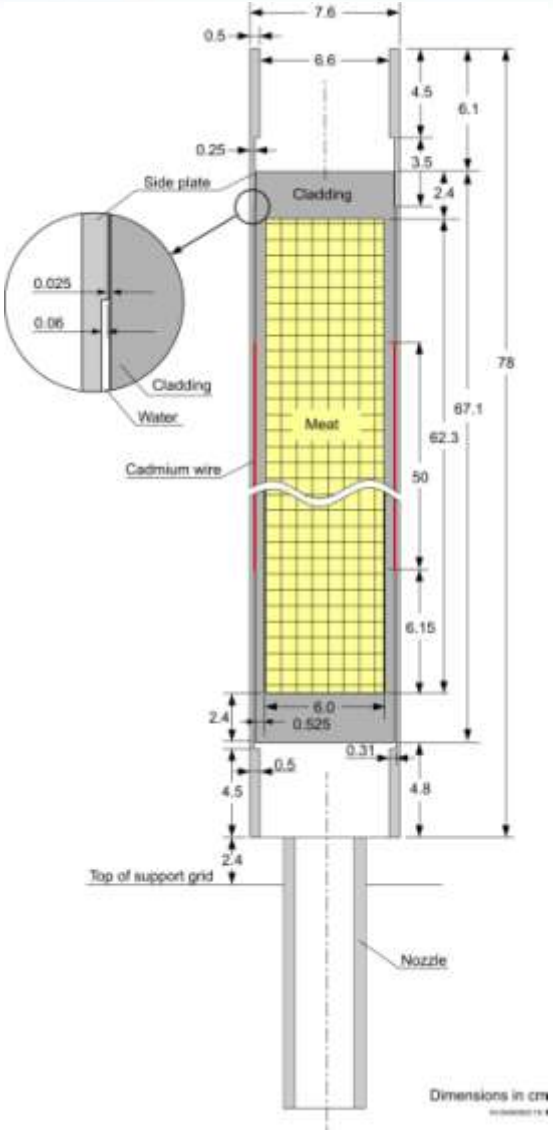
Single Cores of 30.14% ^{235}U Enriched UO_2 / Wax Mixtures – Bare and with Single Reflector Materials [IEU-COMP-THERM-015]



RA-6 Reactor: Water Reflected, Water Moderated $U(19.77)_3Si_2$-Al Fuel Plates

[IEU-COMP-THERM-014]





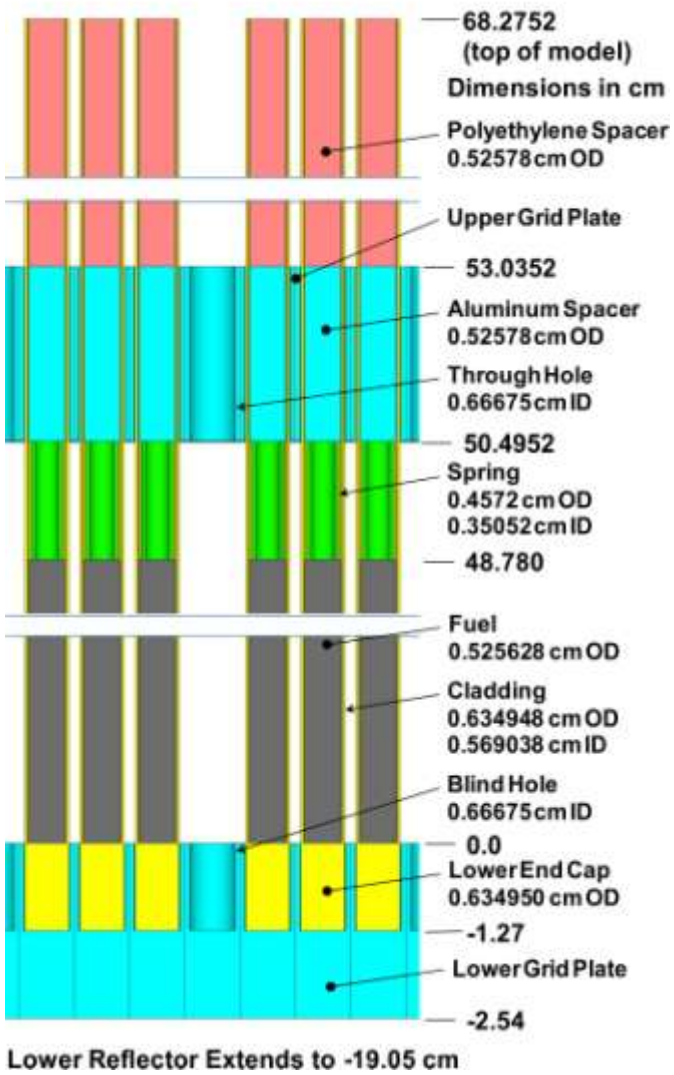
Low Enriched or Natural Uranium Benchmarks

191 Low-Enriched or Natural Uranium Benchmarks:

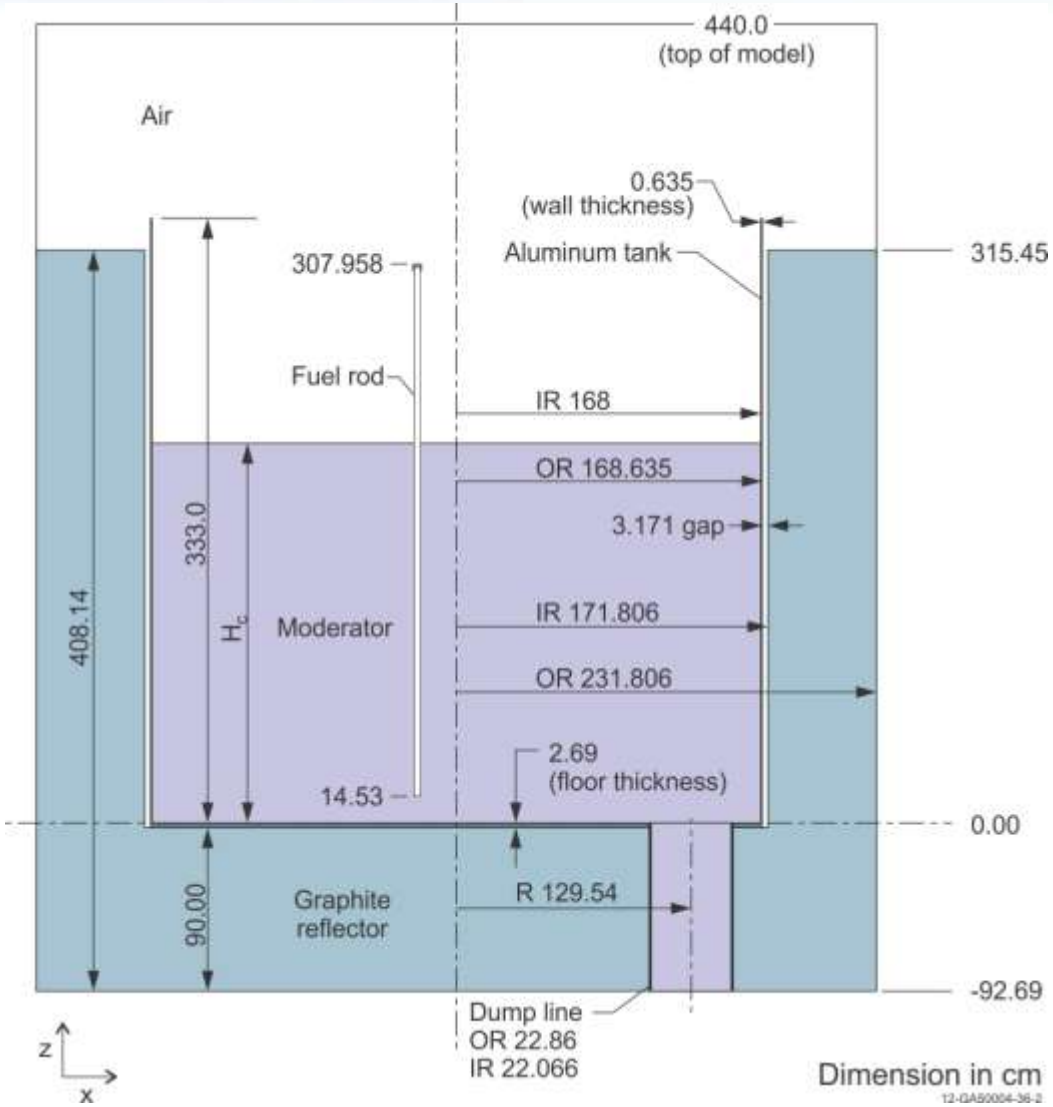
- Oak Ridge National Laboratory (ORNL) in the United States
- Sandia National Laboratories (SNL) in the United States
- Institute de Pesquisas Energeticas e Nuclearesthe (IPEN) in Brazil
- Valduc Nuclear Center in France
- Japan Atomic Energy Agency (JAEA) in Japan
- Kyoto University in Japan
- Atomic Energy of Canada, Limited (AECL) Chalk River Laboratories in Canada
- Russian Research Center “Kurchatov Institute” (RRC KI) in the Russian Federation

Water-moderated Square-pitched U(6.90)O_2 Fuel Rod Lattices with 0.67 Fuel to Water Volume Ratio

[LEU-COMP-THERM-080]

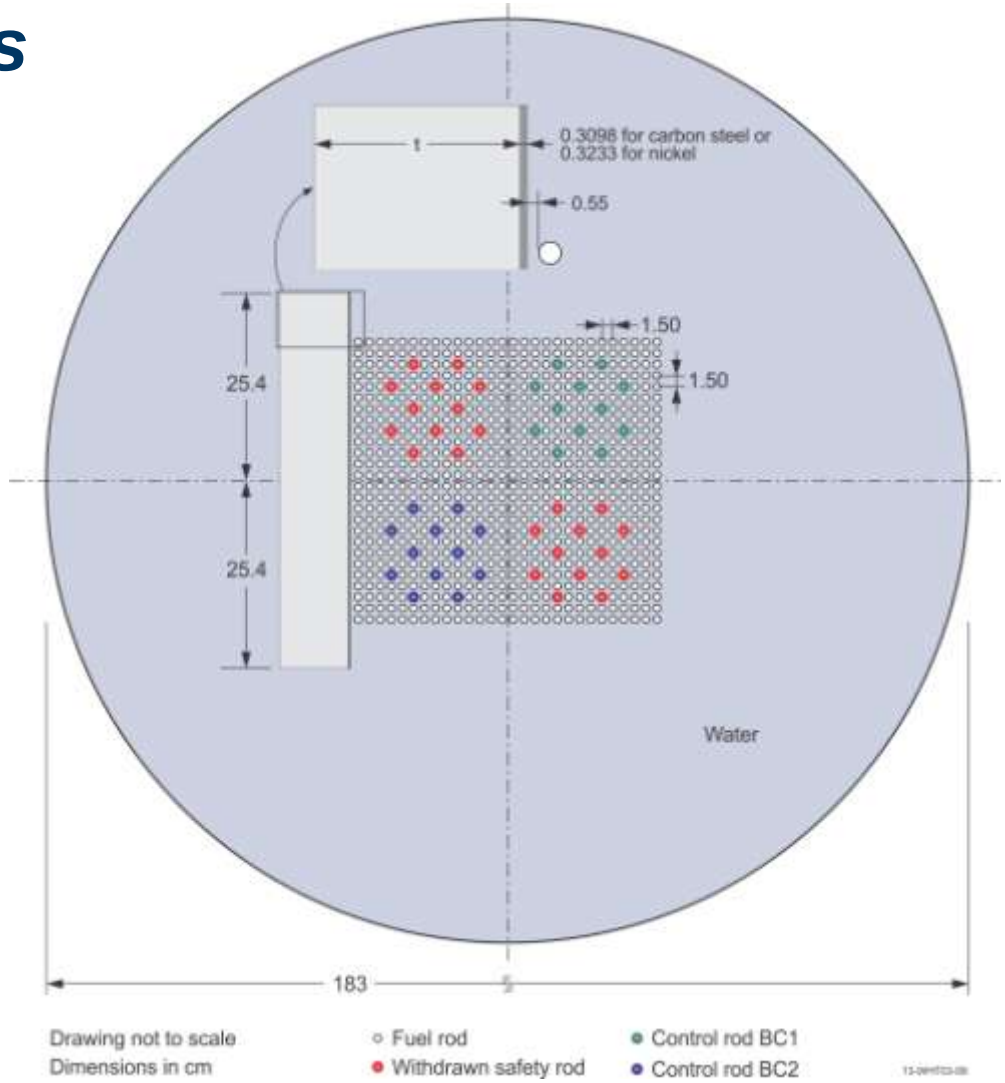


ZED-2 Reactor: Natural-uranium Metal Fuel Assemblies in Heavy-water
[LEU-MET-THERM-003]



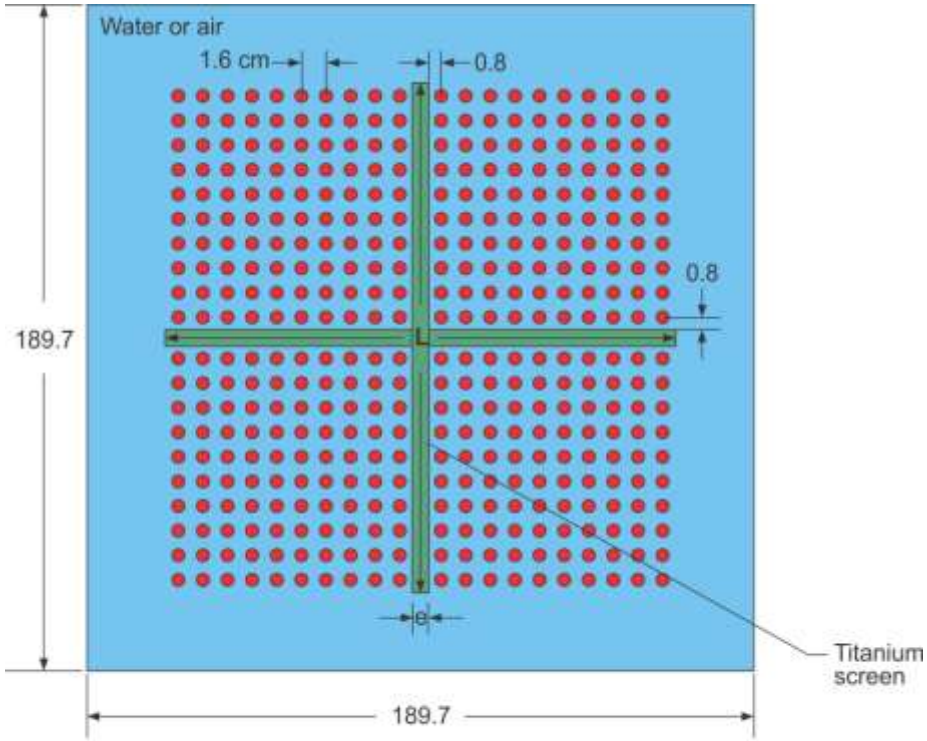
Critical Configurations of the IPEN/MB-01 Reactor with Heavy Reflectors Composed of Carbon Steel and Nickel

[LEU-COMP-THERM-088]



MIRTE Program Four 4.738-WT.%-Enriched Uranium-Dioxide Fuel-Rod Arrays in Water Separated by a Cross-Shaped Screen of Titanium (5 mm and 10 mm Thick)

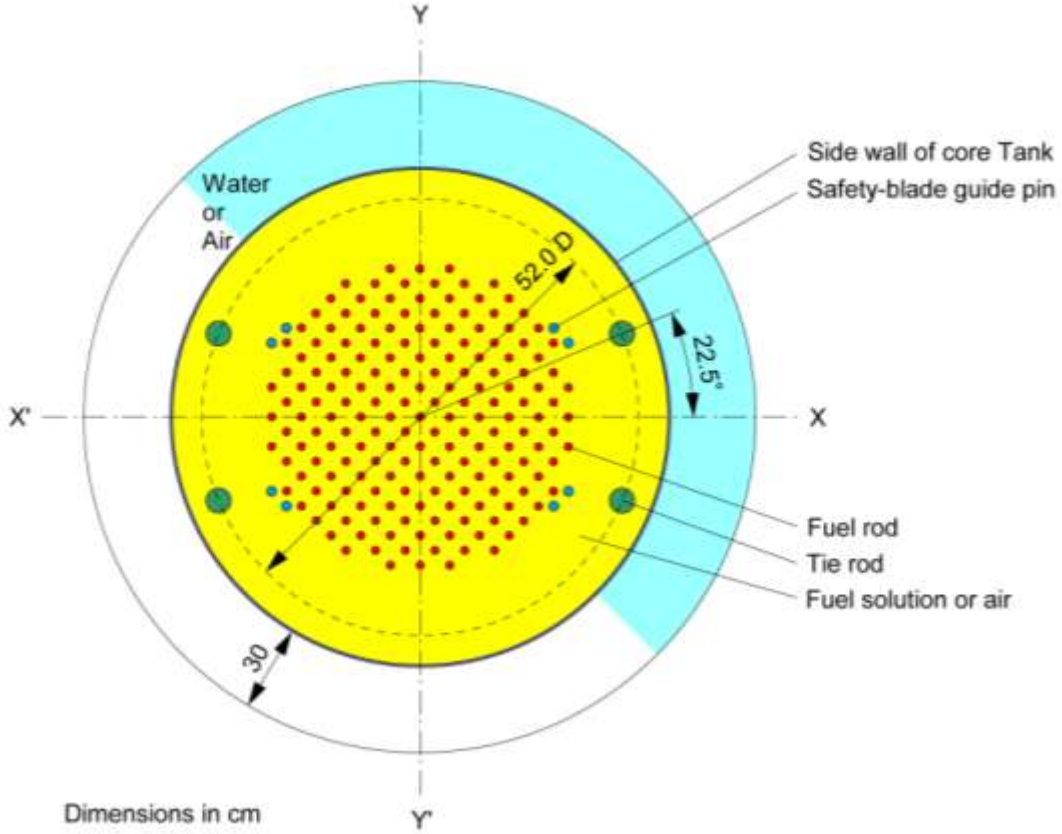
[LEU-COMP-THERM-074]



e: thickness of the screen: 0.5025 cm
L: length of the screen
Array size: 10 x 10
Total number of fuel rods: 400

Drawing not to scale
Dimensions in cm

STACY: A 60-cm-Diameter Tank Containing 5%-Enriched UO_2 Fuel Rods in 6%-Enriched Uranyl Nitrate Solutions, Unreflected and Water-Reflected [LEU-MISC-THERM-007]

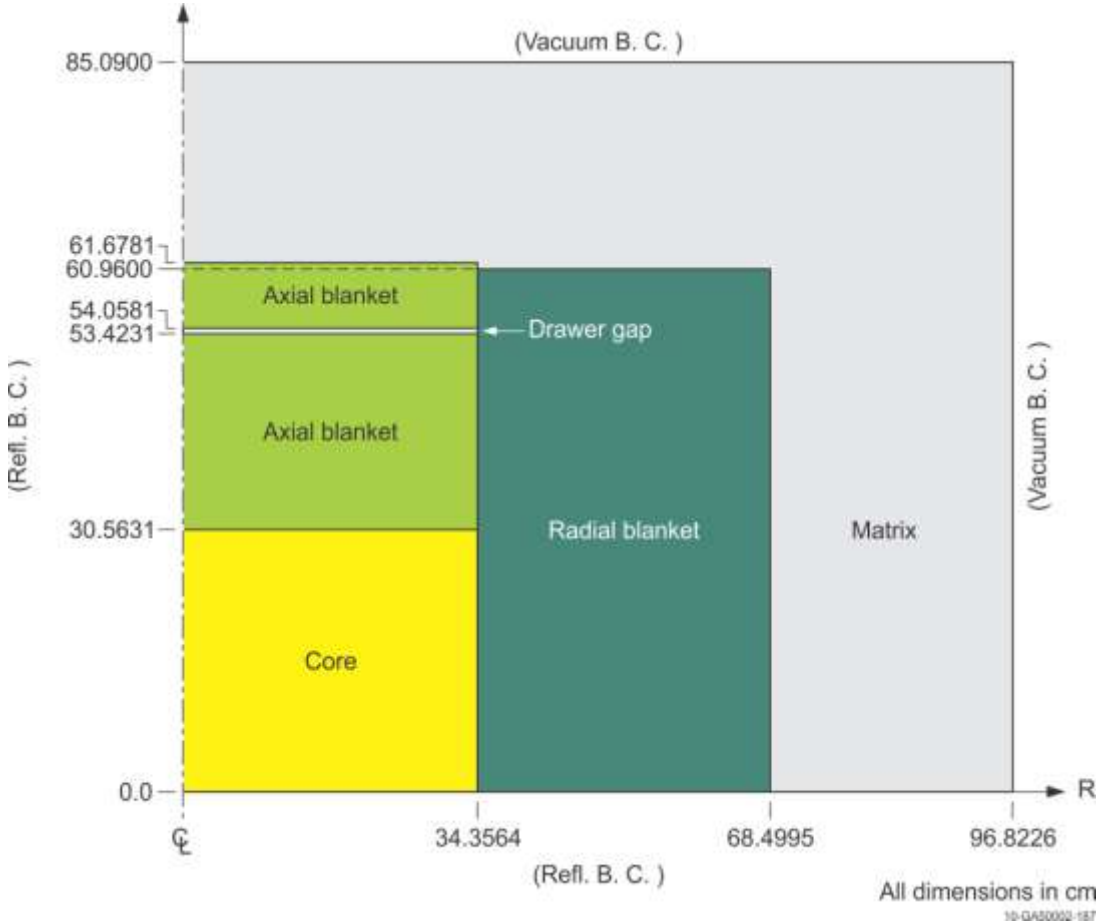


Mixed Plutonium/Uranium Benchmarks

53 Mixed Uranium/Plutonium Benchmarks:

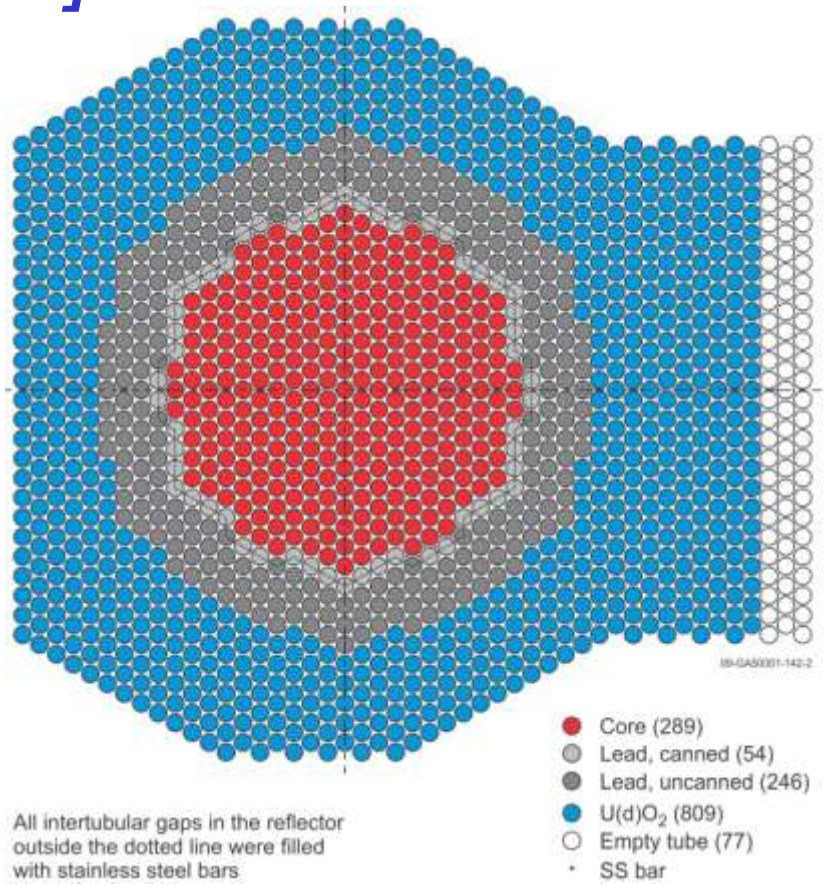
- Argonne National Laboratory (ANL) in the United States
- Argonne National Laboratory – W (ANL-W) in the United States
- Institute for Physics and Power Engineering (IPPE) in the Russian Federation
- Valduc Nuclear Center in France

ZPR-3 Assembly 53: a Cylindrical Assembly of Plutonium Metal, Depleted Uranium and Graphite with a Thick Depleted Uranium Reflector [MIX-MET-INTER-004]



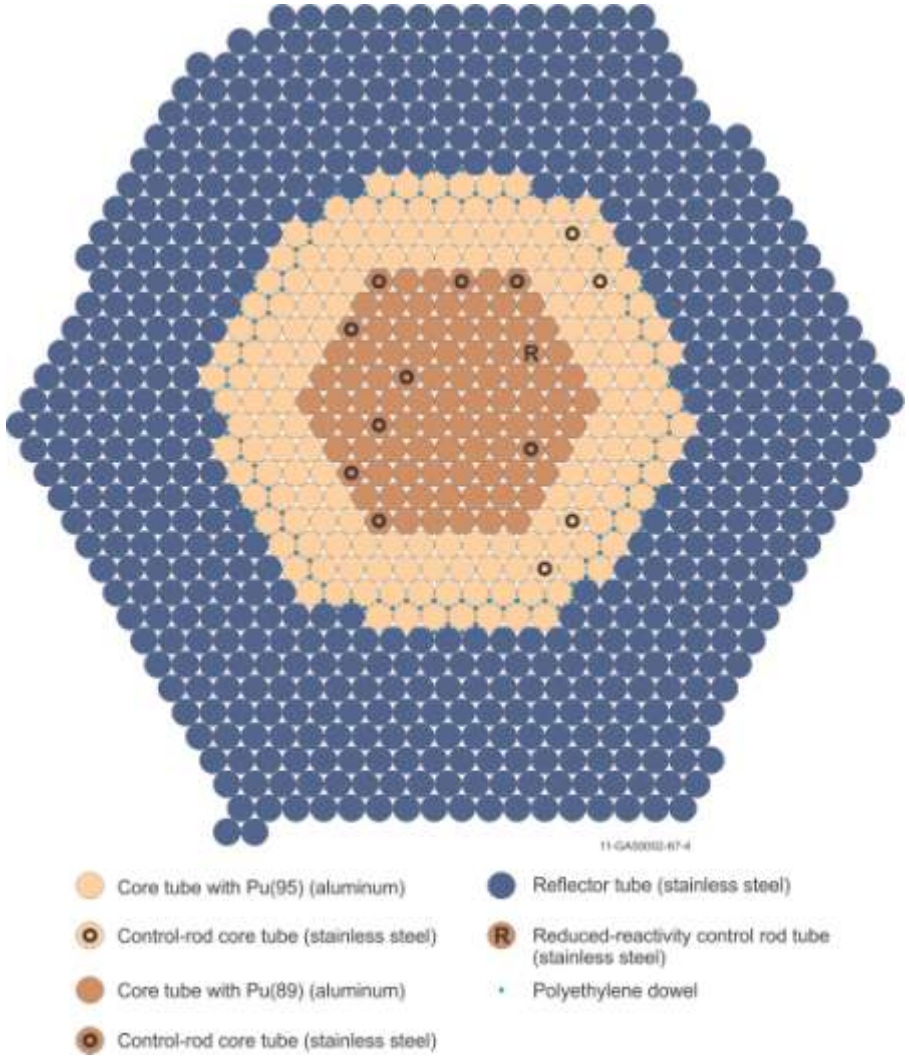
BFS-61 Assemblies: Critical Experiments of Mixed Plutonium, Depleted Uranium, Graphite and Lead with Different Reflectors

[MIX-MET-FAST-006]



BFS-97, -99 Assemblies: Critical Experiments with Heterogeneous Compositions of Plutonium, Depleted-Uranium Dioxide, and Polyethylene

[MIX-MISC-FAST-004]

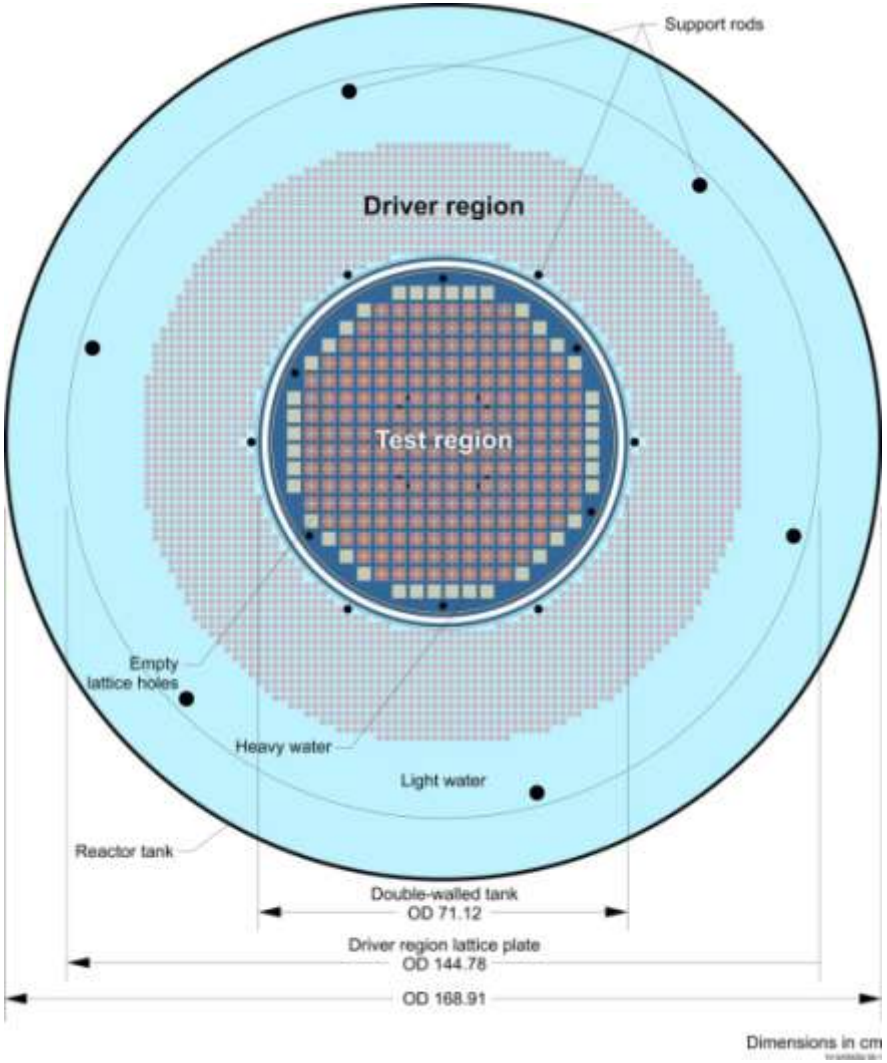


Uranium-233 Benchmarks

1 Uranium-233 Benchmarks:

- Bettis Atomic Power Laboratory (BAPL) in the United States

ETA-II: D2O Moderated Lattice of UO_2-ThO_2
[U233-COMP-THERM-004]



Special Isotope, Criticality Alarm / Shielding, and Fundamental Physics Benchmarks

0 Special Isotope Benchmarks

0 Criticality Alarm / Shielding Benchmarks

0 Fundamental Physics Benchmarks

IRPhEP Handbook

	2009	2013	Increase*
Nuclear Facilities →	21	47	26
Experimental Series →	36	131	95
PWR→	4	11	7
VVER→	2	3	1
BWR →	0	0	0
LMFR →	13	25	12
GCR →	3	10	7
GCFR →	0	0	0
LWR →	7	22	15
HWR →	1	5	4
MSR →	0	0	0
RBMK →	0	1	1
SPACE →	0	11	11
FUND →	5	43	38

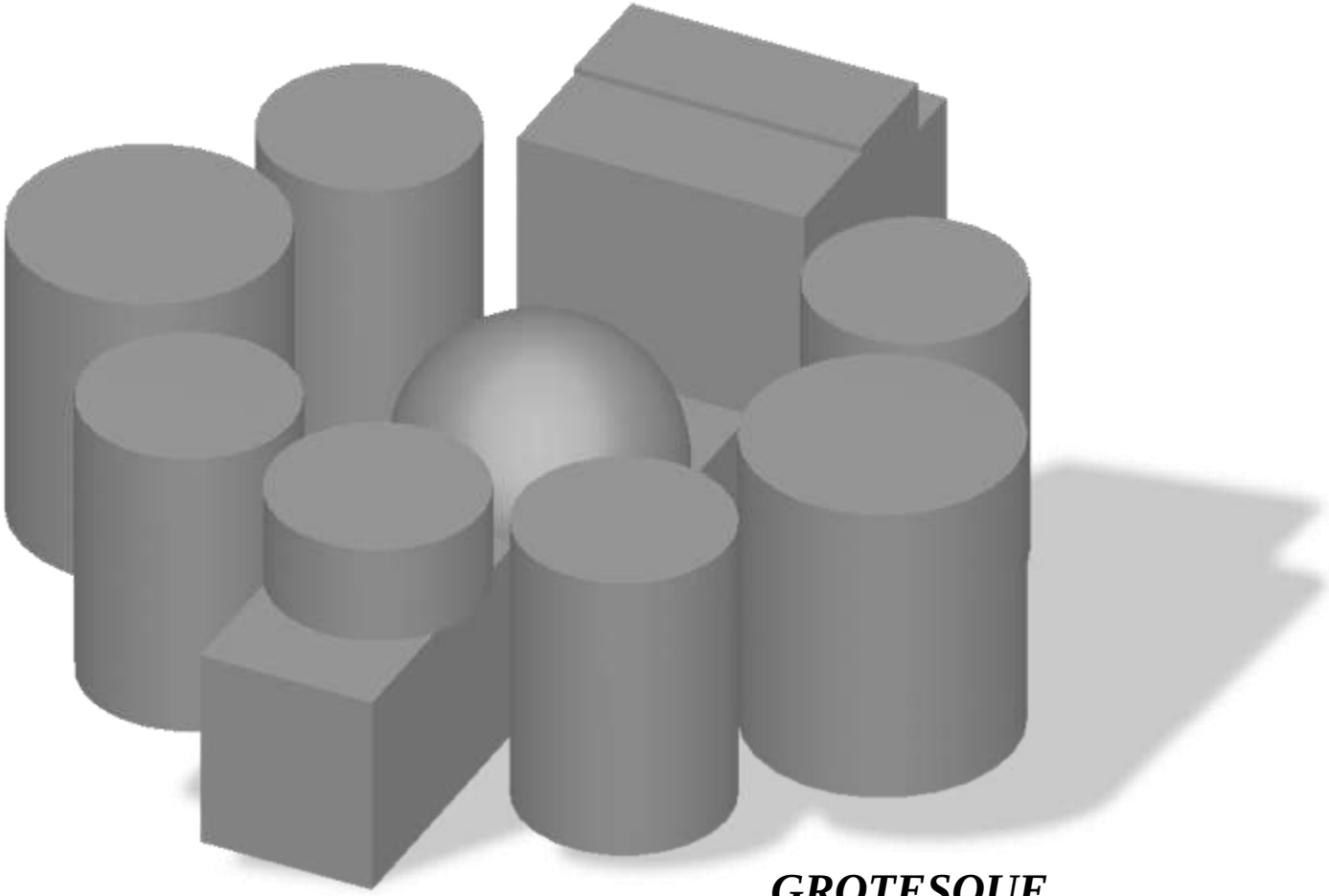
* Includes Reactor Physics Benchmarks copied from the ICSBEP Handbook

Summary and Conclusions

- ✓ Over 400 scientists from 24 different countries have combined their efforts to produce the ICSBEP and IRPhEP Handbooks.
- ✓ Those two handbooks continue to grow and provide high-quality integral benchmark data that will be of use to the criticality safety, nuclear data, and reactor physics communities for future decades.

Acknowledgements

- The ICSBEP and IRPhEP are collaborative efforts that involve numerous scientists, engineers, administrative support personnel and program sponsors from 24 different countries and the OECD NEA. The authors would like to acknowledge the efforts of all of these dedicated individuals without whom those two projects would not be possible.
- Specifically, the authors have made reference to numerous benchmark reports representing hundreds of authors. The reader is referred to the actual evaluations cited within the ICSBEP and IRPhEP Handbooks for complete identification of the respective authors of those benchmark reports.



GROTESQUE

Questions?