NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

LLNL-PRES-651860

IP&D New ICSBEP Benchmarks

Presented at the Nuclear Criticality Safety Program (NCSP) Technical Program Review
March 26-27, 2014 at Los Alamos National Laboratory

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Outline

- Last year's accomplishments (FY2013)
- Overview of new ICSBEP 2013 content
- This year's work in progress (FY2014)

FY2013 Accomplishments

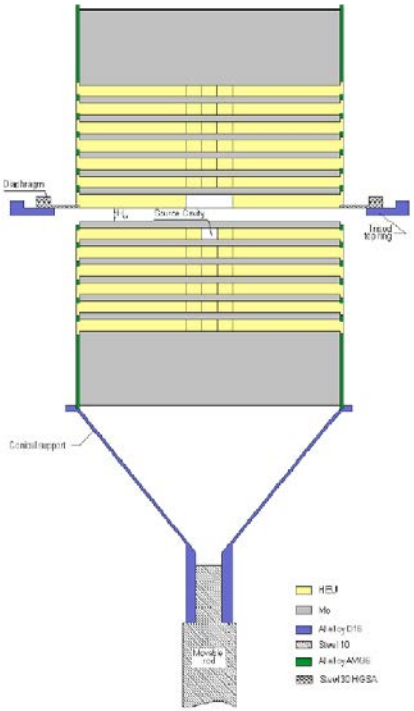
- Five new NCSP evaluations published in ICSBEP Handbook (CED4b)
  - HMM020 - VNIITF HEU/Mo experiments 17.3 and 17.4 (IER-129)
  - HMF094 - VNIITF HEU/Mo experiments 17.1 and 17.2 (IER-129)
  - HMF093 - VNIITF HEU/Mo experiment 18.1 (IER-129)
  - LCT078 - SNL 7UpCX 0.855 (IER-159)
  - PMF001 - LANL Jezebel major revision
- Assisted ICSBEP (OECD) with peer reviews of five other evaluations from INL (3), IRSN (2) and IPEN (1) plus IRPhEP (3) and Rejects (1)
- ORNL provided S/U files for the NCSP evaluations (516 in DICE)
- OECD NEA provided additional S/U files (2850 in DICE)
- Updated ICSBEP webpage to include all new 2013 content

~75% of ICSBEP

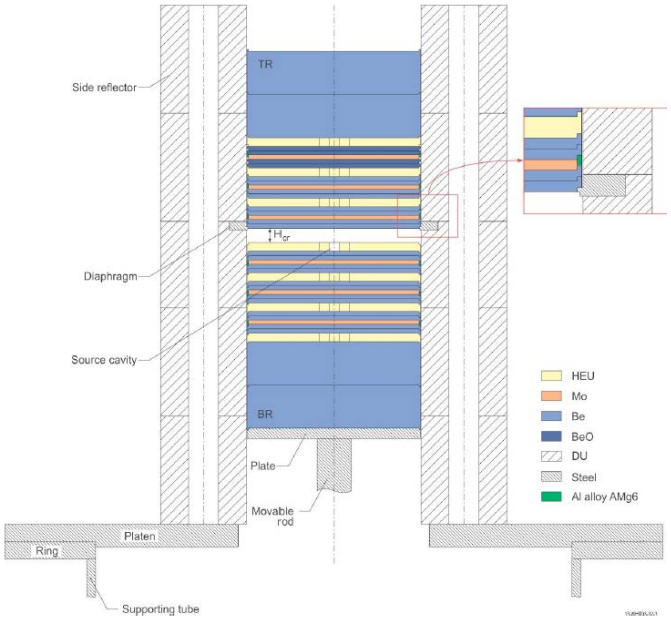
NCSP Evaluations

HMF093, HMF094 (and HMM020)

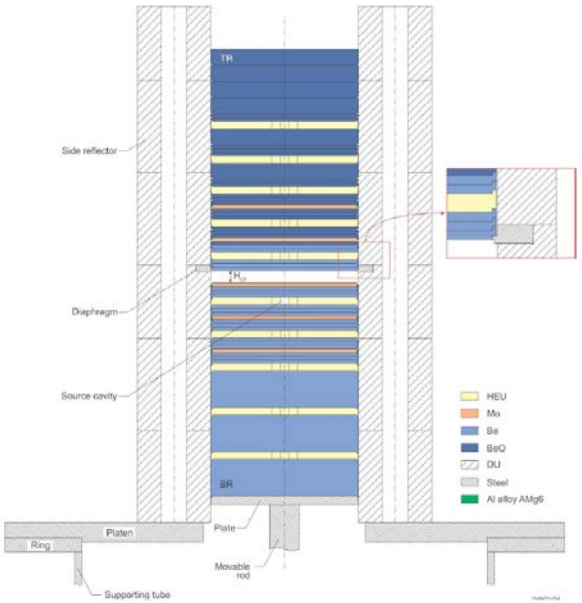
- Final VNIITF experimental series for NCSP of five benchmarks
- HEU metal diluted by Mo and reflected axially by Mo
- HEU moderated by Be/BeO, diluted by Mo, reflected by Be (axial) and D38 (radial)



HMF093-1



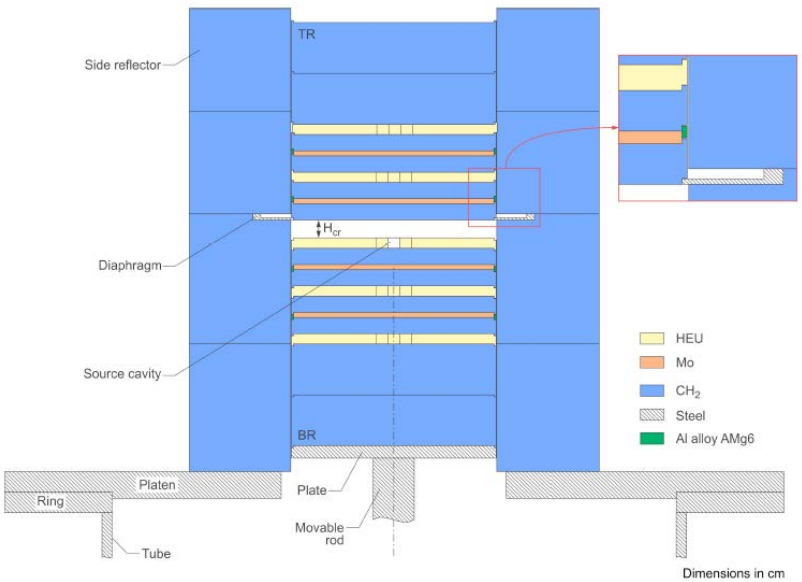
HMF094-1



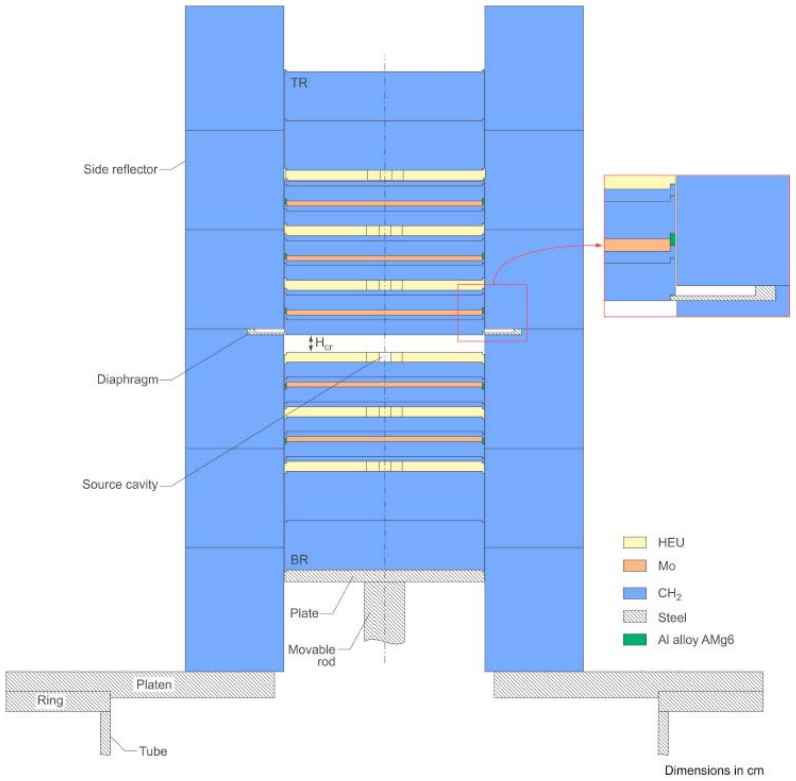
HMF094-2

(HMF093, HMF094 and) HMM020

- HEU metal diluted by Mo and moderated and reflected by CH_2



HMM020-1



HMM020-2

LCT078

- Water-Moderated Square-Pitched U(6.90)O_2 Fuel Rod Lattices with 0.52 Fuel-to-Water Volume Ration (0.855 cm Pitch)
- 15 new experiments by Gary Harms (SNL) that vary the number of fuel rods by removing some (adding water) or replacing by aluminum rods
- Similar to LCT080 experiments at 0.800 cm pitch

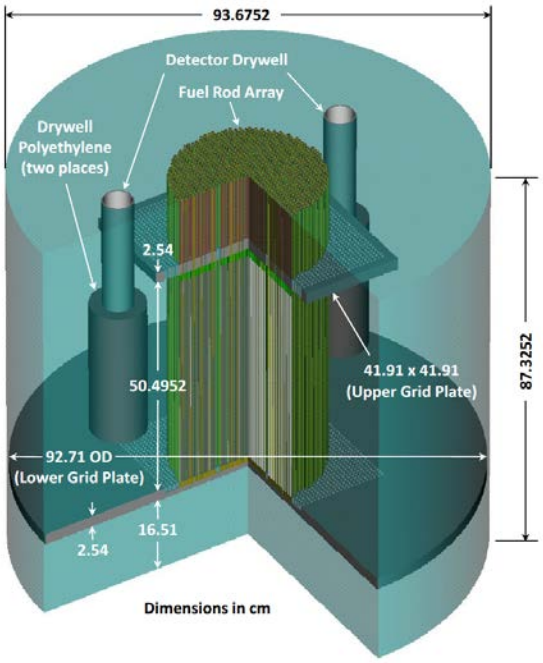


Figure 32. Cut-Away Perspective View of the Benchmark Model of Case 8.

PMF001

- Bare Sphere of Plutonium-239 Metal (4.5 at.% ^{240}Pu, 1.02 wt.% Ga)
- Revision 3 by Jeffrey Favorite (LANL) including four new “detailed” and one revised “simplified” benchmark models

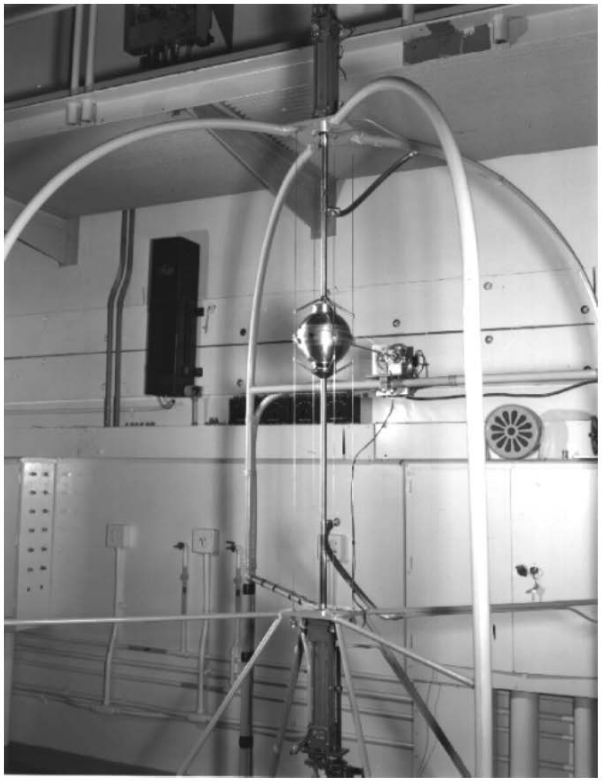


Figure 2. Jezebel Assembled in Kiva 2 at TA-18.[a]

[a] Los Alamos National Laboratory Photo Negative 31643, January 24, 1955.

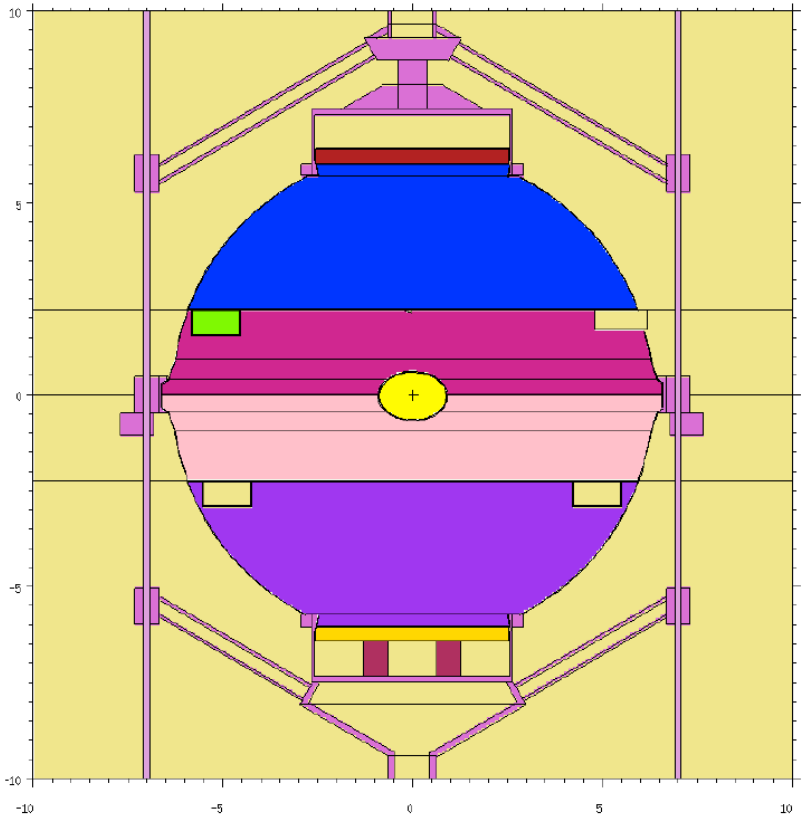


Figure 32. Central Slice of Case 2 (Configuration B) Showing the Assembly Parts.

Non-NCSP Evaluations

HMF100

- ORSPHERE: Critical, Bare, HEU(93.2)-Metal Sphere

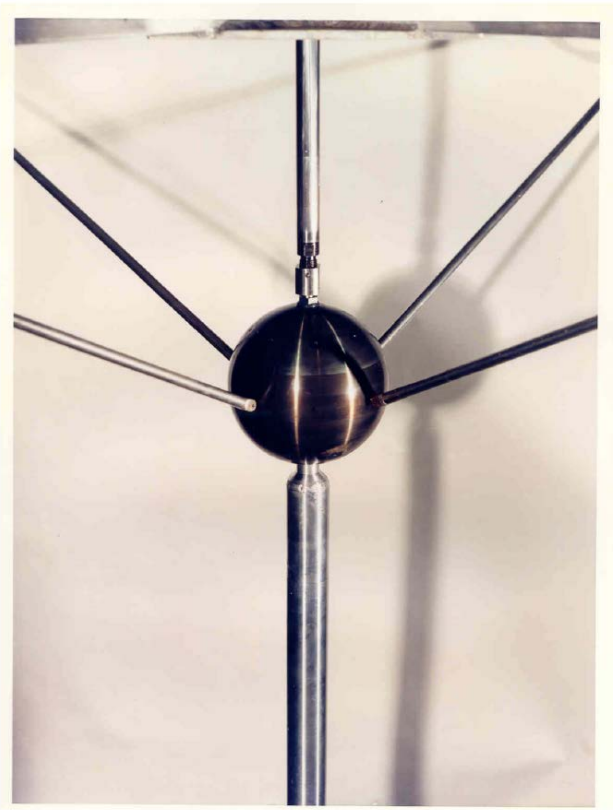


Figure1-3. Photograph of the Assembled Three Part Sphere (3.4665-in.-radius).

HMF100-1

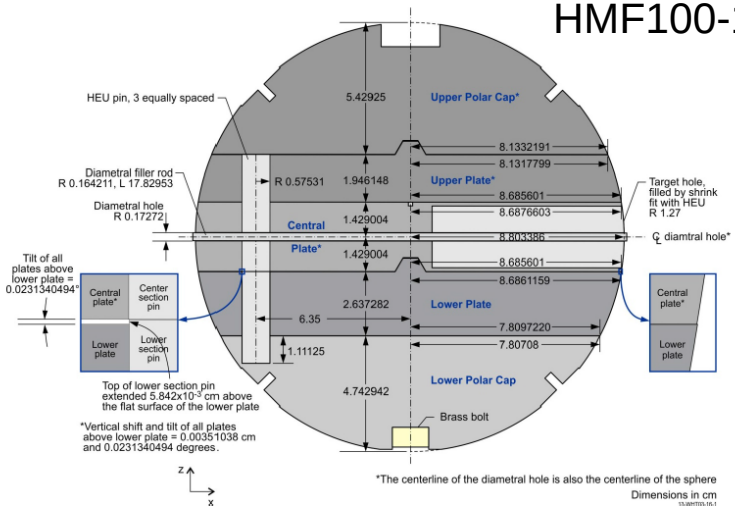
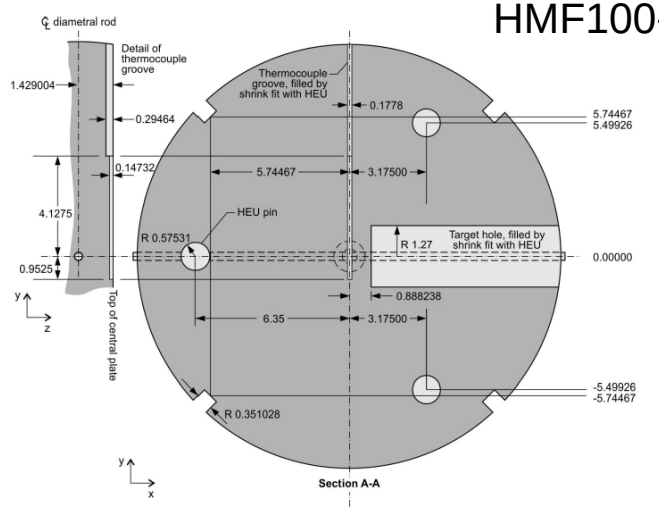


Figure 3-4. Tilt Between Lower Plate and Center Plate, Case 1(Detailed Benchmark Model).[a]

HMF100-2

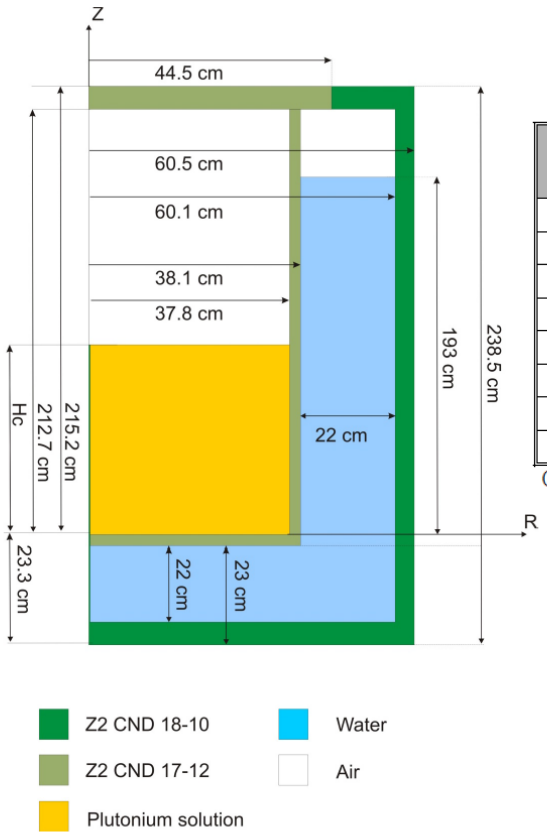


Two “detailed” (shown) and two “simplified” models for the 3.4665” and 3.4420” radius spheres

PST039

- IRSN Plutonium Temperature Effect Program – Low Concentrated (20, 16, or 14.3 g/L) Plutonium Nitrate Solutions at Temperatures Varying from 28 to 40 °C

Apparatus B at CEA Valduc



Case	Experiment	Temperature of the solution (°C)	MCNPX 2.6[(a)] ENDF/B-VII.0 $k_{eff} \pm 1\sigma$
1	2999B	39.84	1.00427 ± 0.00010
2	3001B	40.00	1.00198 ± 0.00010
3	3002B	39.97	0.99955 ± 0.00010
4	3005	39.99	1.00116 ± 0.00010
5	3006	30.09	1.00117 ± 0.00010
6	3007B	28.14	1.00184 ± 0.00010
7	3008	28.13	1.00256 ± 0.00010
8	3009	40.01	0.99620 ± 0.00010

(a) S(α, β) data are not given at the temperature of the experiment.

Figure 3-1. The Benchmark Model for the Plutonium Temperature Effect Experimental Program.

MMT006

- Arrays of UO2-PuO2 Phenix Pins in a Mixed Uranium-Plutonium Nitrate Solution (IRSN)

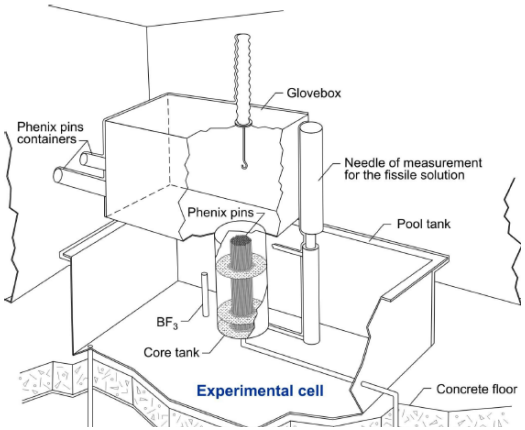


Table 3-3. Characteristics of the Basket and the Array, Critical Height. [a]

Case Number	Basket		Pin Array			Critical Height (cm) [b]
		Grid thickness (cm)	Type	Pin Number	Pitch (cm)	
1	No					28.7
2	Yes	0.1335				29.7
3	**Yes**	**0.135**	**C**	**40**	**3.0**	**29.8**
4	**Yes**	**0.141**	**D**	**241**	**3.0**	**29.8**
5	**Yes**	**0.139**	**A**	**161**	**1.5**	**30.81**
6	**Yes**	**0.136**	**B**	**91**	**2**	**30.09**
7	No					28.01
8	Yes	0.1335				29.13
9	Yes	0.1335				29.42
10	No					28.16
11	No					30.37
12	Yes	0.1335				31.82
13	No					33.17
14	Yes	0.1335				34.75
15	No					40.12
16	Yes	0.1335				41.96
17	Yes	0.1335				48.43
18	No					46.36
19	**Yes**	**0.136**	**B**	**91**	**2.0**	**35.50**
20	**Yes**	**0.135**	**C**	**40**	**3.0**	**38.77**
21	**Yes**	**0.139**	**A**	**161**	**1.5**	**35.47**
22	**Yes**	**0.141**	**D**	**241**	**3.0**	**29.79**

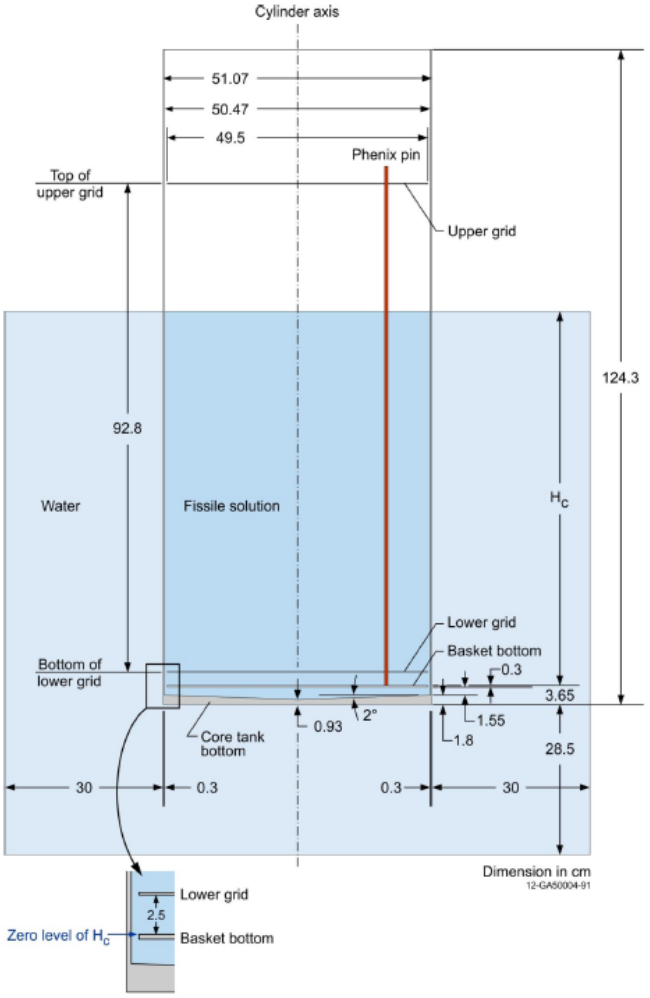
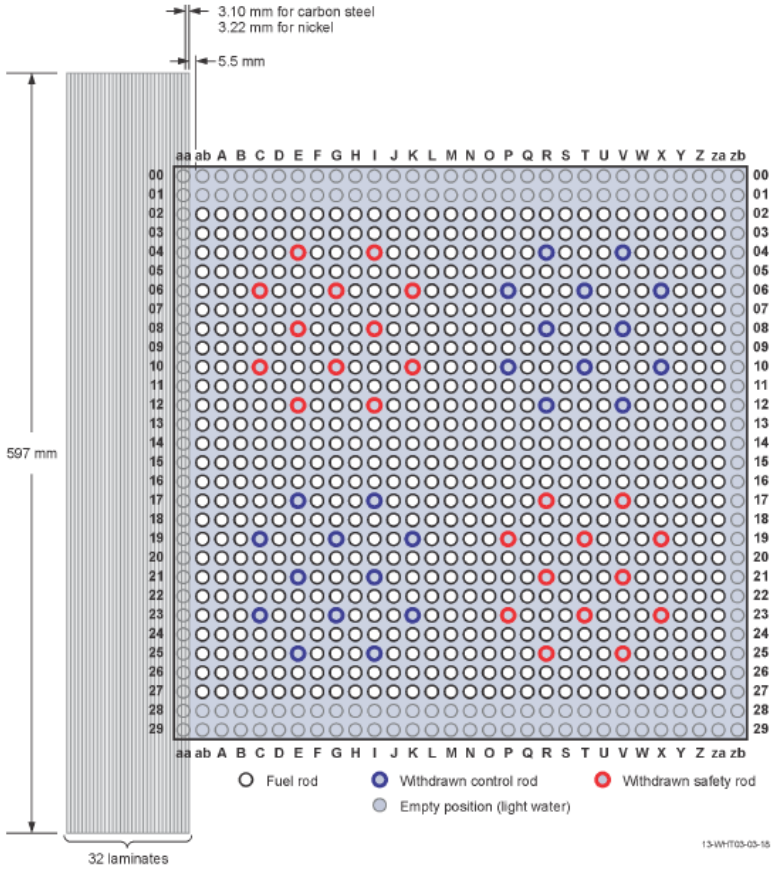


Figure 3-1. Benchmark Model.

LCT088

- IPEN MB-01 U(4.3)O2 reactor fuel lattices reflected by carbon steel or nickel on one side
- Other evaluations with this fuel published as LCT077, 088, 083, 084, 089, 090, 091



Reactor Experiments

- HCF001 – U(93)O2 pins (1.27 cm pitch) reflected by graphite (IRPhEP)
- HCF002 – U(93)O2 pins (1.506 cm pitch) reflected by graphite
- HCF004 – U(93)O2 pins (1.506 cm pitch) reflected by beryllium
- ICT013 – Neutron Radiography reactor, U(20)-Er-Zr-H fuel (IRPhEP)

HCF002-1

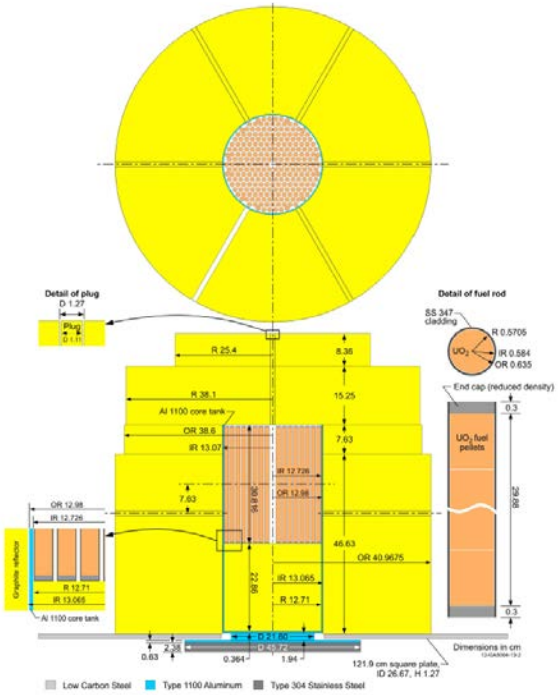
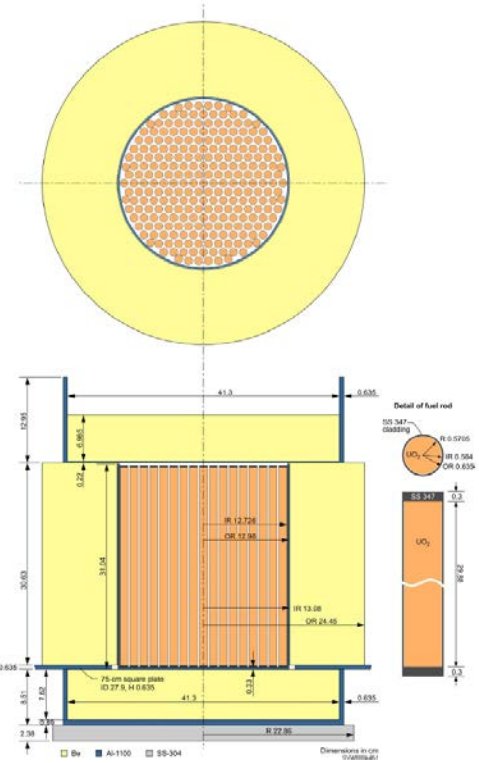
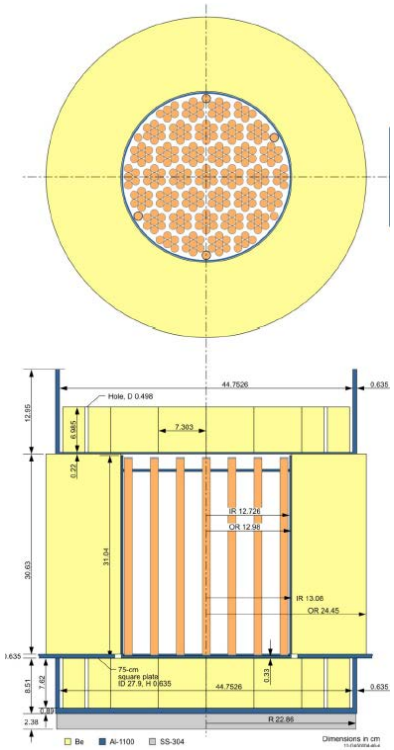


Figure 3-3. Reflector Dimensions in Detailed Benchmark Model.

HCF004-1



HCF004-1



Work in Progress

FY2014 Work in Progress

- Three new NCSP evaluations scheduled for ICSBEP 2014
  - PMF047 - ANL ZPR-3/58 (IER-215) — CED4b in progress
  - PMI003 - ANL ZPR-3/59 (IER-221) — CED4b in progress
  - SUB-PMF003 - LANL BeRP/Ni (IER-161) — CED4a in progress
- NCSP team will assist ICSBEP (OECD) as peer reviewers
- ORNL will provide S/U files for the NCSP evaluations
- LLNL will update NCSP ICSBEP webpage with all new 2014 content (as it becomes available)

PUMF047

- ZPR-3 Assembly 58: A Cylindrical Assembly of Plutonium Metal and Graphite with a Thick Depleted Uranium Reflector

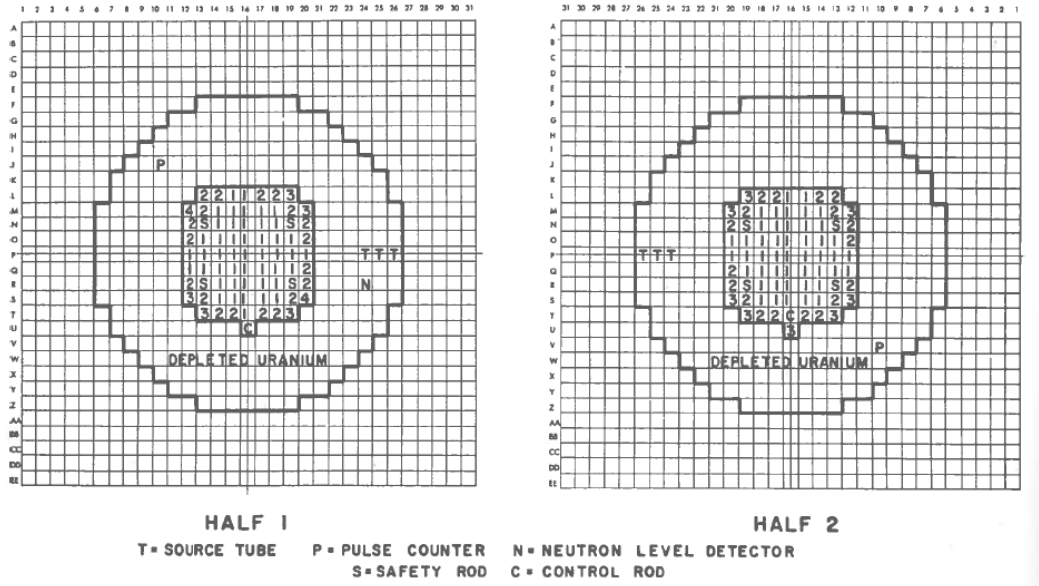


Fig. 2. Reference Core Loading for Assembly 58.
ANL Neg. No. ID-103-2988.

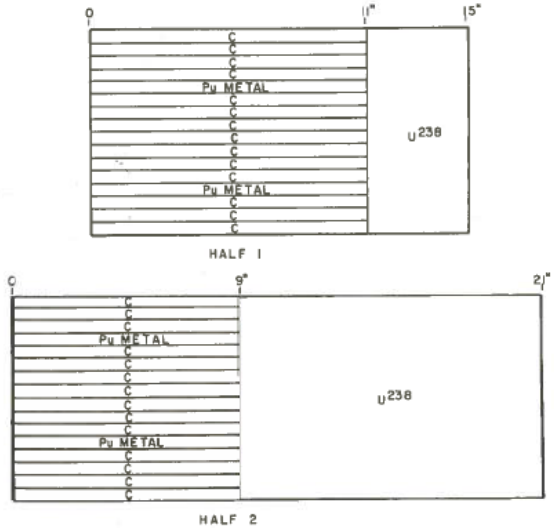


Fig. 1. Core Drawer Loading for Assembly 58.
ANL Neg. No. ID-103-2990.

Code	XS	As-Built k-eff	RZ Benchmark k-eff	Transformation Bias Δk-eff
MCNP5	ENDFB7.1 (NJOY)	1.00357(4)	0.98785(4)	-0.01572(6)
COG11.1	ENDFB7.1 (NJOY)	1.00326(5)	0.98495(3)	-0.01831(6)
COG11.1	ENDFB7.1 (PREPRO)	1.00482(3)	0.98682(3)	-0.01800(4)

Experimental k-eff = 1.0002 +/- 0.0015. Experimental k-eff = 0.9995 +/- 0.0015 when corrected to as-built model.

PMI003

- ZPR-3 Assembly 59: A Cylindrical Assembly of Plutonium Metal and Graphite with a Thick Lead Reflector

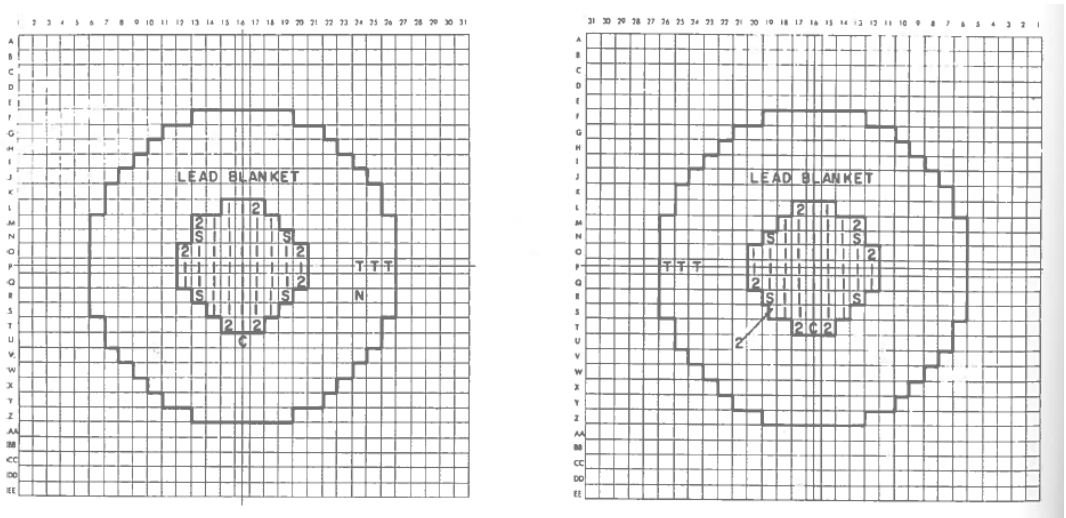


Fig. 3. Reference Core Loading for Assembly 59.
ANL Neg. No. ID-103-A2026.

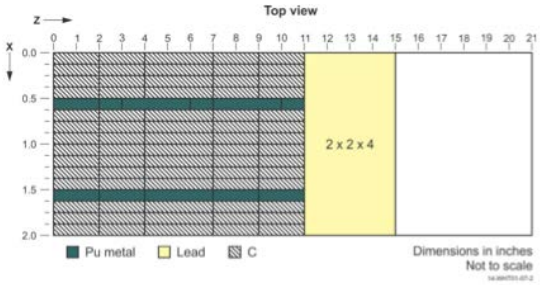


Figure 1-6. Loading Pattern for ZPR-3/59 Normal Core Drawer Master 59-1-100.

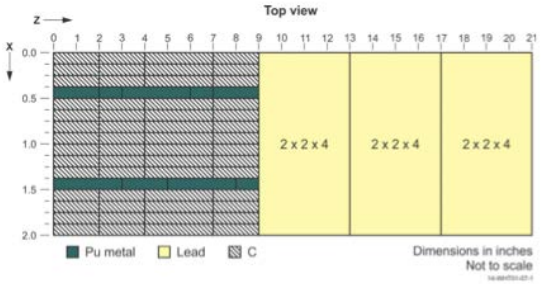


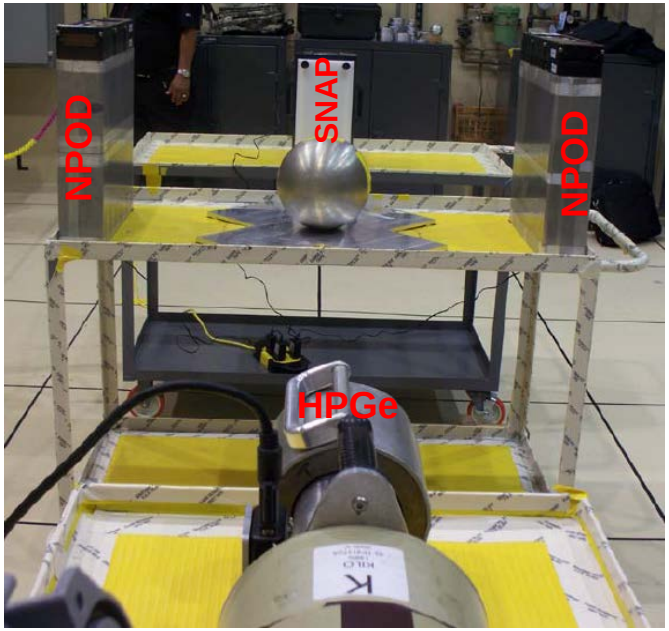
Figure 1-7. Loading Pattern for ZPR-3/59 Normal Drawer Master 59-2-100.

Code	XS	As-Built k-eff	XYZ Benchmark k-eff	Transformation Bias Δk-eff
MCNP5	ENDFB7.1 (NJOY)	0.99646(5)	0.97009(5)	-0.02637(7)
COG11.1	ENDFB7.1 (NJOY)	0.99662(7)	0.97039(3)	-0.02623(8)
COG11.1	ENDFB7.1 (PREPRO)	0.99858(5)	0.97250(3)	-0.02608(6)

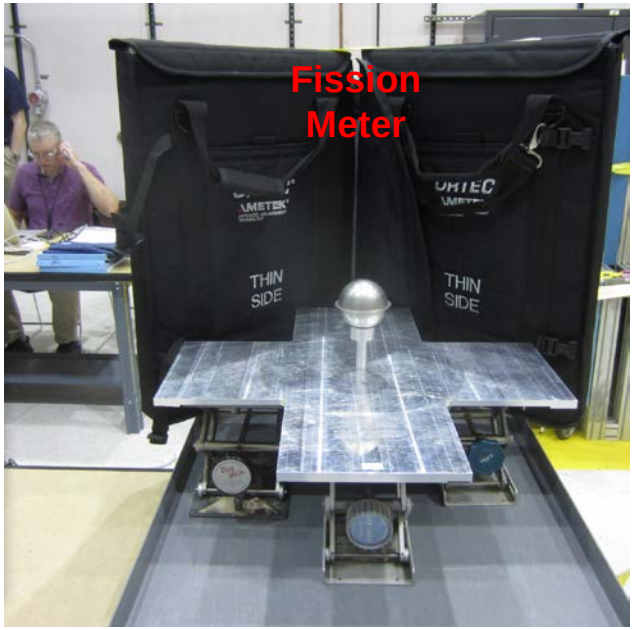
Experimental k-eff = 1.0008 +/- 0.0020. Experimental k-eff = 0.9946 +/- 0.0024 when corrected to as-built model.

SUB-PMF003

- Nickel-Reflected Plutonium Metal Sphere Subcritical Measurements (IER-161)
- 7 configurations reflected by 0, ½”, 1”, 1.5”, 2”, 2.5” and 3” of Ni
- Confirmatory measurements and analysis by LLNL (IER-263)



Los Alamos



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Questions?

Security/Privacy LLNL

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HOME

ICSBEP Handbook
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ICSBEP Database (DICE)
- DICE User's manual
- DICE software
  Dice Data Part 1
  Dice Data Part 2

2012 New Evaluations
2013 New Evaluations

Integral Experiments Request (IER)

DOE Nuclear Criticality Safety Program

International Reactor Physics Evaluation Project

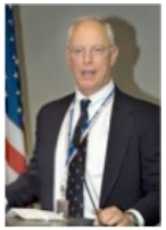
Partners
- OECD
- NEA
- CEA-Valduc
- IRSN
- VNIITF
- WPNCS

Information Preservation & Dissemination (IP&D)
A Brief History of the CSBEP, ICSBEP and NCSP

Mr. Dae Chung
Principal Deputy
Assistant Secretary
United States
Department of Energy

In 1992, the Criticality Safety Benchmark Evaluation Project (CSBEP) was founded under the auspices of US DOE Office of Defense Programs by Mr. Dae Chung with criticality safety experts participating from across the US DOE Complex:

- Argonne National Laboratory
- Hanford
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratories
- Savannah River National Laboratory
- Bettis Atomic Power Laboratory
- Idaho National Laboratory
- Los Alamos National Laboratory
- Pacific Northwest National Laboratory
- Rocky Flats Plant
- Y-12 Plant



Dr. Jerry McKamy
Manager
Nuclear Criticality
Safety Program
Director
Facilities Operations Division
United States
Department of Energy

In 1994, the CSBEP welcomed its first international participants from France, Hungary, Japan, the Russian Federation, and the United Kingdom.

In 1995, to further enhance international participation, the DOE allowed the CSBEP to become an official activity of the Organization for Economic Cooperation and Development (OECD), Nuclear Energy Agency (NEA), Working Party on Nuclear Criticality Safety (WPNCS), and the name was changed to the International Criticality Safety Evaluation Project (ICSBEP).

In 1997, the Nuclear Criticality Safety Program (NCSP) was formally established by DOE under the auspices of the Office of Defense Programs.

Today, the ICSBEP remains an important element of the US DOE NCSP as described by Dr. Jerry McKamy in the NCSP *Mission and Vision.* Current NCSP activities including ICSBEP participation are described in the *Five-Year Execution Plan.*

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