LA-UR-17-23788

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Title: DOE-JAEA Collaboration: Criticality Experiments

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Intended for: Report

Issued: 2017-05-09

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DOE-JAEA Collaboration: Criticality Experiments

Device Assembly Facility (DAF)
Nevada Test Site (NTS)

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March 2, 2017

FCA全景
Over view of FCA

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JAEA Interest in Partitioning & Transmutation of Spent Fuel

- Extract and recycle uranium and plutonium
- Transmute minor actinides (MA) : Np, Am, Cm
 - Japanese preferred approach is accelerator driven system (ADS)
- Technical challenges to ADS approach
 - Target fuel characteristics
 - Lead-Bismuth Eutectic (LBE) characteristics
- JAEA has planned Transmutation Experimental Facility (TEF)
 - Transmutation Physics Experimental Facility (TEF-P)
 - Accelerator-Driven System Target Test Facility (TEF-T)
- JAEA faces challenge due to return (to US) of FCA fuel (HEU and Pu) before availability of TEF-P

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Experiments at the Fast Critical Assembly (FCA) in Japan

- Lead
 - Lead-Bismuth is planned coolant for ADS.
 - Effect of void is important for regulatory approvals
 - “What happens if coolant is lost in various core regions?”
 - Lead cross sections changed between JENDL 3.3 and JENDL 4.0 data libraries so experimental validation is key.
- Minor Actinides
 - High burnup fuel has many minor actinides: Np-237, Pu-240, Am-241, Am-243...
 - MA cross sections are source of uncertainty in calculations

固定側1/2集合体密着面(51行×51列)

Cross section of fixed half assembly (51 by 51 tubes)

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Experiments at National Criticality Experiments Research Center (NCERC) in Nevada

- FCA has not returned to operation
 - Accelerated shipping schedule has returned HEU to US.
 - Some planned experiments cannot be performed.
 - HEU and LEU cores were planned to emphasize differences in Pb cross sections at energy above 1 MeV.
- NCERC is the primary US capability for criticality experiments
 - Focus on using existing fuel on Comet to produce comparable data for JAEA
 - US has interest in lead cross section for data libraries

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Joint US – Japan Research Collaboration

- Los Alamos National Laboratory (LANL) supporting since March 2014
 - Direct engagement with JAEA for criticality experiments
 - July 2014, JAEA visit to NCERC July 2014
 - September 2014, LANL visit to FCA in Tokai in conjunction with PHYSOR
 - HEU/Lead Experiments at NCERC
 - July 2015, 2 JAEA researchers participated
 - March 2016, 3 JAEA researchers participated
 - LEU/Lead Experiments at NCERC
 - September 2016, 2 JAEA researchers participated
 - November 2016, 2 JAEA researchers participated
 - January 2017, 2 JAEA researchers participated
 - Pu/Lead Experiments at NCERC
 - May/June timeframe for experiments utilizing ZPPR plates.

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Experiments at National Criticality Experiments Research Center (NCERC) in Nevada

- Comet
 - Vertical Assembly Machine
 - Lower fuel is placed on moveable platen and lifted towards an upper fuel stack.
- Zeus Series of Experiments
 - Copper reflector
 - HEU fuel
 - Various interstitial material (graphite, iron, poly) to modify spectrum
- For JAEA experiments
 - Perform similar experiment with lead
 - Began in July 2015

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HEU/Lead Core

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A-A

Region where voids are introduced

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HEU/Lead Void Experiments

HEU core (not to scale)
Void is 10" diameter

green/blue=HEU
orange=lead
yellow=copper
magenta=steel
blue=aluminum

Removed lead to measure
change in reactivity

2V—One void above and one
void below U plate.

4V—Void above and below two U
plates.

Void with aluminum piece (Al
spacer mass equal to Al
plates removed with Lead)

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HEU/Lead Experiment Results and Comparison to Model

Case	keff	Calculated (ENDF/B-VII.1)				Calculated		Measured	
		+/-	delta-k	+/-	pcm	cents	+/-	cents	+/-
Base	1.01931	0.00007							
2V	1.01881	0.00007	-0.00048	0.00010	-48.15	-7.41	1.523	-2.5	0.38
4V	1.01816	0.00007	-0.00111	0.00010	-110.81	-17.05	1.523	-10.81	0.84
								-9.36	0.47
6V	1.01758	0.00007	-0.00167	0.00010	-166.79	-25.66	1.523	-18.45	0.76
								-16.23	0.66
8V	1.01673	0.00007	-0.00249	0.00010	-248.95	-38.30	1.523	-28.45	0.61
								-28.05	1.01

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LEU/Lead Void Experiments

LEU core (to scale)

- LEU Core
 - Natural uranium plates interleaved with HEU plates
 - Effective enrichment ~21%
 - Similar measurements to HEU core
 - NU plates surrounded by Al rings
 - Positive Void Coefficient (HEU system has negative coefficient)

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LEU Core Lead Void Experiments

Void region
6V case
shown

green/blue=HEU
orange=lead
yellow=copper
magenta=steel
blue=aluminum

LEU Core

- Void with aluminum spoked spacers, as done in March 2016 HEU Core
- One Void equals 2 lead plates (half as many as HEU core)

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LEU Core Calculations

For absolute reactivity (k_{eff}), ENDF calculates significantly higher than JENDL

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Plutonium/Lead Experiments: Unit Cell

PU06 Unit Cell:

dark blue=Pu; green= ZPPR
cladding; orange= lead;
turquoise= Al frame/ box; red=
copper

- Comet with ZPPR fuel and Cu reflector
 - Welded nickel-plated stainless steel
 - 3" x 2" x 0.25"
- Design in progress
 - Holding matrix and inner reflector designed and out for bid
 - Heat calculations being performed
 - Plates shipping from INL
 - All configurations are much smaller than FCA.

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Plutonium/Lead Experiments: Full Configuration

Z-1

Z-2

Z-3

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This work was supported by the DOE Office of Material Management and Minimization and by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

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