NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

The First Nuclear Accident Dosimetry Exercise using Godiva at NCERC

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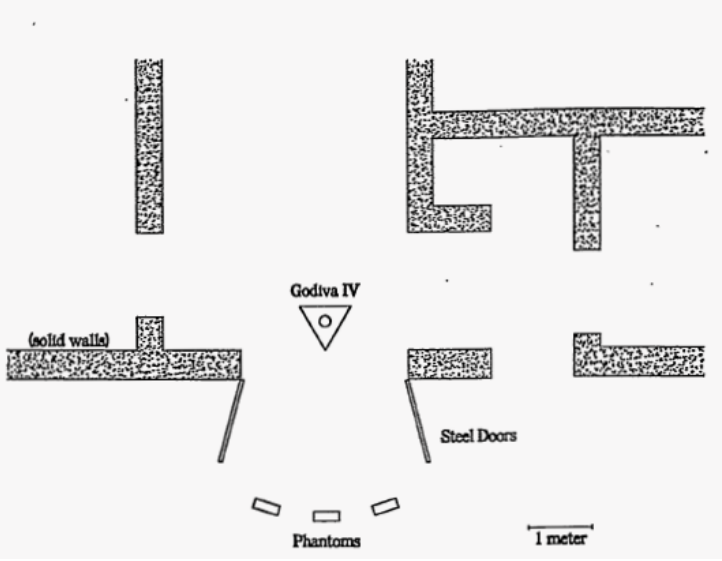
HISTORY OF NAD INTERCOMPARISONS IN THE USA

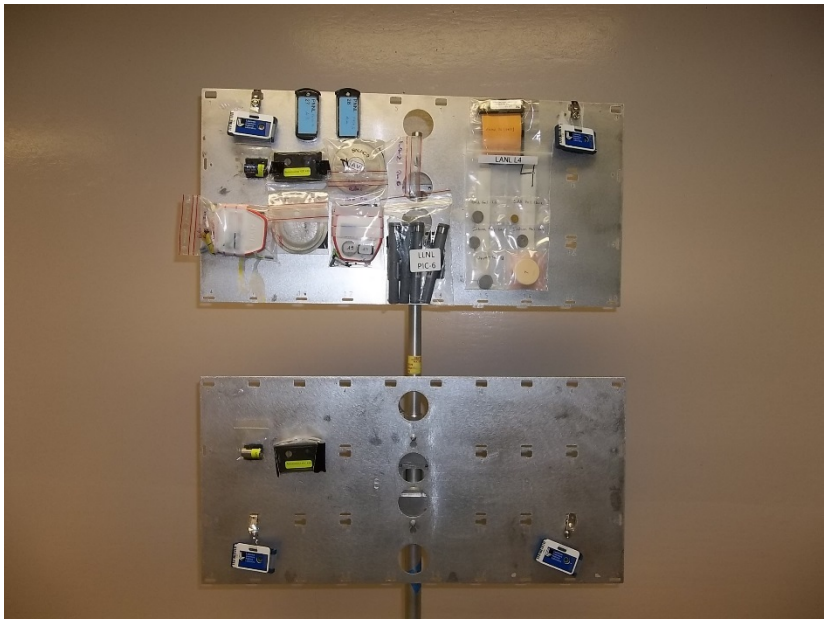
- **1965 – 1989 Health Physics Research Reactor at ORNL**
  - 2,289 dose measurements during these intercomparisons
  - 0.2 – 8.5 Gy neutron doses and 0.1 – 2.0 Gy gamma doses
  - 68% of neutron measurements met the accuracy guidelines (+/- 25%)
  - 52% of gamma measurements met the accuracy criterion (+/- 20%)
  - Percent of dosimeters meeting neutron accuracy criteria decreased with softer spectra (steel, concrete, lucite)

- **1995 GODIVA & SHEBA at LANL**
  - with the “intention to conduct these studies approximately annually for the evaluation of nuclear accident dosimeter systems”
  - 10 Facilities participated.
  - Four Godiva irradiations: bare, concrete, Lucite, and iron shields
  - Thermalized spectra difficult to measure for some NAD designs
  - Conclusion: ‘Results indicate that it is unlikely expertise that is not maintained will provide useful data’



FAST FORWARD 21 YEARS

- Godiva operational at NCERC
- CEA (France) reactors previously used for NAD intercomparisons (Caliban, Prospero, and Silene) no longer operational
- IER 147 Godiva dose characterization is completed
- NAD LAB at NNSS established to host participants
- IER 148 NAD Intercomparison funded and performed in May 2016



NAD Testing Requirements

- ANSI N13.3-1969 to 2013
  - ± 25% response from 0.1Gy to 10 Gy
  - Provide dose information within 24 hours*
  - Shall have quick sort techniques
  - Personnel dosimeters as well as fixed station dosimeters*
  - Use of fixed dosimeters only, requires ability to extrapolate to personnel dose
  - Dosimetry instruments & techniques shall be maintained
  - Shall be able to determine orientation

- ANSI/HPS 13.3-2013 to Present
  - ± 25% response from 1 to 10 Gy
  - ± 50% response from 0.1 to 1 Gy
  - Provide dose information within 24 hours
  - Shall have quick sort techniques for >0.5 Gy
  - Specified minimum throughput
  - System performance shall be verified (range 0.1 to 10 Gy)
  - Shall replicate configuration of normal use
  - Orientation corrections
  - Methods for handling partial body exposure and biological dosimetry methods*

* "Should" requirement

What did the May 2016 NAD Intercomparison Test?

- Main Focus:
  - ± 25% response from 1 to 10 Gy
  - ± 50% response from 0.1 to 1 Gy
  - Provide dose information within 24 hours
  - System performance shall be verified (range 0.1 to 10 Gy)
  - Realistic criticality exposure configuration
- Additional Opportunities:
  - biological dosimetry methods (simulated blood – Ringers Lactate)
  - quick sort techniques for >0.5 Gy
  - orientation corrections
  - training

Three Irradiations for the NAD Intercomparisons

- First two irradiations:
  - Doses were provided to participants immediately after irradiation
  - Participants allowed to practice and verify procedures and performance
  - Practice reporting results within 24 hours
- Last irradiation was unknown to participants and had to be reported within 24 hours

Burst Data for the NAD Intercomparisons

Burst	Date	Time	ΔT (°C)	Period (ms)	Reactivity (cents)	FWHM (ms)
1	24-May-16	10:11	68.5	40.4	102.9	155.5
2	25-May-16	9:42	244.8	9.5	112.4	
3	26-May-16	11:35	147.7	14.3	108.3	

Provided by Joetta Goda

Neutron Tissue KERMA Dose First Reported from 1st Irradiation

	Distance from Core (m)				
	2	2.5	3	4	9
Known Value (Gy)	**1.57**	**1.17**	**0.91**	**0.66**	**0.13**
Facility:					
LLNL	**2.78**[1]/1.57	**2.56**[1]/1.25	**1.57**[1]/0.94	**1.42**[1]/0.70	**0.48**[1]/**0.23**
LANL	1.7/1.3	1.4	**1.4/1.95**	NM/NR	NM/NR
SRS	NM/NR	NM/NR	NM/NR	**1.32**	0.14
PNNL	1.38	**1**	0.7	0.52	NM/NR
US Navy	1.55/**2.31**	NM/NR	NM/NR	NM/NR	NM/NR
AWE	**2.0**	NM/NR	1.00/0.64	0.73	NM/NR
SNL	**3.8**	**2.61**	**1.75**	**1.18**	NM/NR
IRSN	1.61/1.64/1.40/1.39	1.27/1.27/1.17	1.05/0.85/0.9	0.93/0.70/0.53	**0.59**/**0.26**/0.07

red signifies value outside ANSI/HPS 13.3 – 2013 limits

[1] over corrected for foil decay

Neutron Tissue KERMA Dose Results First Reported from 2nd Irradiation

	Distance from Core (m)			
	2	2.5	3	4
Known Value (Gy)	**5.62**	**4.17**	**3.26**	**2.35**
Facility:				
LLNL	5.69	4.41	3.38	2.46
LANL	NM/NR	**5.52**	**4.33**	**3.1/2.69**
SRS	NM/NR	NM/NR	**2.26**	2.05
PNNL	NM/NR	NM/NR	NM/NR	NM/NR
US Navy	**4.11**	**5.52**	NM/NR	**2.97**
AWE	5.88	NM/NR	**2.3**	NM/NR
SNL	**3.8**	**2.61**	**1.75**	**1.18**
IRSN	5.86/5.66/6.73	4.31/4.53/5.15	2.92/3.24/3.67	2.09/2.29/2.2

red signifies value outside ANSI/HPS 13.3 – 2013 limits

Neutron Tissue KERMA Dose Results Reported within 24 hours after 3rd 'Unknown' Irradiation

	Distance from Core (m)				
	2	2.5	3	4	9
Known Value(Gy)	**3.39**	**2.52**	**1.97**	**1.42**	**0.27**
Facility:					
LLNL	3.37	2.74	1.54	1.49	NM/NR
LANL	**4.58**	**3.16**	1.84/**2.6**	1.23	0.30
SRS	**2.51/4.72**	NM/NR	NM/NR	NM/NR	0.243*
PNNL	**13.68**	**7.59**	**10.91**	**4.81**	NM/NR
US Navy	**4.24**	**4.04**	NM/NR	**2.41**	NM/NR
AWE	3.2	2.55	**1.38**	1.09/1.10	NM/NR
SNL	4.1	2.78	1.87/2.13	1.33	0.256/**2.85***
IRSN	3.25/3.9/3.55	2.75/2.9/2.7	2.0	1.3/1.1	**0.54**/0.30/0.26*

red signifies value outside ANSI/HPS 13.3 – 2013 limits

* Based on blood tube (Ringers Lactate) evaluation

Results Summary – Final Test – 3rd Irradiation

- 66% of the reported results meet the accuracy requirements
- Majority of facilities were able to report doses within 24 hours
- Facilities were able to verify procedures and operations for dose determination
- One facility (not listed) was not able to report any results within 24 hours
- Gamma doses were not typically reported in 24 hours
- US facilities appeared to have the majority of difficulties (but were also the majority participants)
- Possible reasons for US facility difficulty are:
  - Inability to routinely test at high doses
  - Lack of practice
  - Time crunch (24 hour reporting)
  - Some dosimeter designs are insufficient

What NEXT?

- IER 252 & 253 Flattop dose characterization and intercomparisons
  - Flattop with its surrounding sphere will have a “softer” spectrum.
  - Remember from previous experiences (first slide): ‘Percent of dosimeters meeting neutron dose criteria decreased with softer spectra (steel, concrete, lucite)’
- Training of new personnel on NAD dosimetry methods
- More opportunity for routine testing at high doses
- Better quick-sort testing (time factor, equipment, & personnel issues)
- Biological dosimetry testing
- New design of a standardized dosimeter that is accepted across the DOE complex (‘super-NAD’) and easy/quick to operate and manage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QUESTIONS?