Nuclear Accident Dosimetry Exercises at CEA-Valduc

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INTRODUCTION

Lawrence Livermore National Laboratory led a team of United States (US) participants in Nuclear Accident Dosimetry exercises in 2009 using the SILENE reactor and in 2010 using the CALIBAN reactor at CEA-Valduc. The other US participants included: Los Alamos National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratory, Savannah River Site, and Y-12 National Security Complex.

The exercises were held at CEA-Valduc because at the time the US had no operating reactors that could simulate the pulse of a criticality accident. Both the SILENE solution reactor (71 g/L uranyl nitrate solution with 93% enriched uranium) and CALIBAN metal reactor (10 fuel discs and 4 rods of 93.5% enriched uranium alloyed with 10% molybdenum totaling 113 kg) were operated in pulse mode to simulate a neutron spectrum similar to that of a criticality accident. The SILENE reactor provided a softer neutron spectrum similar to that seen in a solution criticality accident while the CALIBAN reactor provided a harder spectrum like what would be seen in a metal criticality accident. The goal of the experiments was to test the US dosimetry systems currently in place across the Department of Energy complex.

DESCRIPTION OF THE ACTUAL WORK

Each participant set up their dosimetry system, most of which included foils or other materials for activation analysis (Fig. 1), at varying distances from the reactor core in an effort to measure the dose from the reactor pulse. The reactor was then pulsed by the CEA-Valduc operators.

The US teams utilized their dosimetry systems in a time sensitive fashion, similar to conditions during a real criticality emergency, to determine approximate yield values for the reactor pulses and personnel dose values at varying distances. The dosimetry systems included the use of foil activation analysis, pocket ionization chambers, and other techniques as well. The following day a different yield was selected and lead reflectors were also added to change the neutron spectrum so the dosimetry systems could be tested again. The exercise provided valuable hands on training for participants and validation that the dosimetry systems meet the standards imposed by ANSI/HPS N13.3.

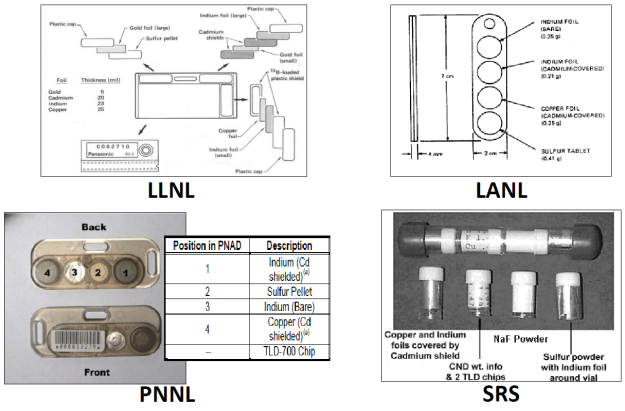


Fig. 1. Dosimetry systems of some US Participants in Nuclear Accident Dosimetry Experiments (Y-12 and Sandia not pictured).

EXERCISE RESULTS

The US Laboratory exercise neutron and photon dose measurement results for the three pulses on the SILENE reactor are provided in Tables 1 - 4. Note that some distances were not measured (NM) by all the laboratories as indicated.

Table 1. Neutron Dose (Rad)

Shield	Dist. (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
Lead	2	690	791	800	650	634	546
	4	190	232	290	270	NM	NM
	6	110	109	160	NM	NM	NM
None	2	320	344	340	310	367	425
None	6	150	159	180	150	78	154

Table 2. Relative Neutron Dose Results to Given Values*

Shield	Dist. (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
Lead	2	1	1.15	1.16	0.94	0.92	0.79
	4	1	1.22	1.53	1.42	NM	NM
	6	1	0.99	1.43	NM	NM	NM
None	2	1	1.08	1.06	0.97	1.15	1.33
None	6	1	1.06	1.2	1	0.52	1.03

Table 3. Gamma Dose (Rad)

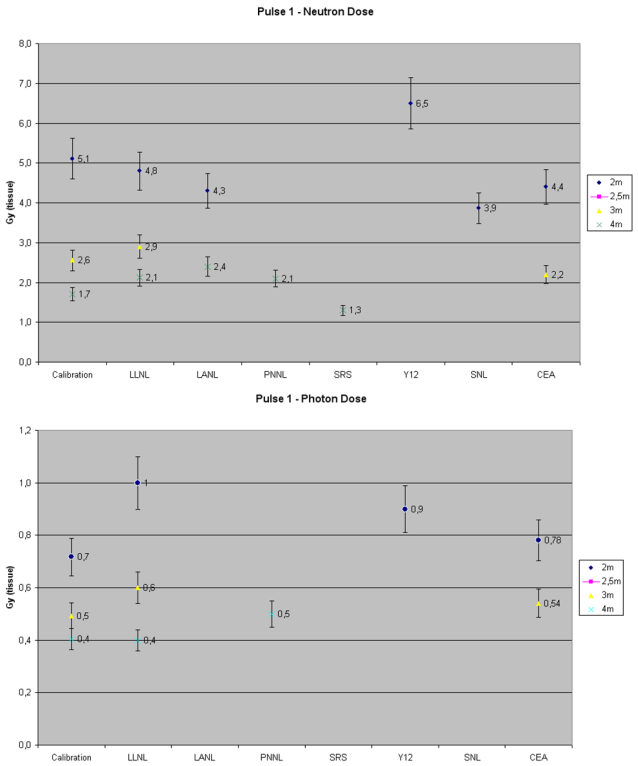
Shield	Dist. (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
Lead	2	50	221	180	420	276	262
	4	30	46	80	160	NM	NM
	6	20	28	50	NM	NM	NM
None	2	380	432	330	420	467	494
None	6	210	172	160	180	187	295

Table 4. Relative Gamma Dose Relative to Given Values*

Shield	Dist. (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
Lead	2	1	4.42	3.6	8.4	5.52	5.24
	4	1	1.53	2.67	5.33	NM	NM
	6	1	1.4	2.5	NM	NM	NM
None	2	1	1.14	0.87	1.11	1.23	1.3
None	6	1	0.82	0.76	0.86	0.89	1.4

* According to ANSI/HPS N13.3, *Dosimetry for Criticality Accidents*, nuclear accident dosimetry systems should be able to provide sufficient data to calculate the dose within ± 25%. Results in green meet this performance criterion while results in red do not.

The US Laboratory exercise preliminary neutron and photon dose measurement results for the two pulses on CALIBAN are provided in Fig. 2. Note that some distances were not measured by all the laboratories



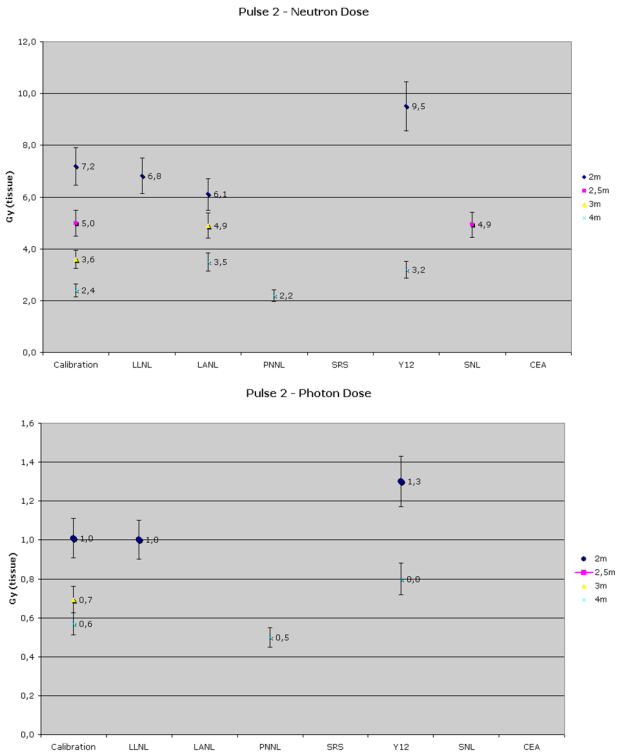


Fig. 2. Preliminary Exercise Results for Neutron and Photon Dose

CONCLUSION

The results of these experiments and what areas need improvement are currently being studied by the US Laboratory participants. These reports will provide analyzed results as well as lessons learned topics from the experiment such as: operational experience, detector technology, gamma dose TLDs, throughput of activated foils, and reoccurring testing programs. Additionally, recommendations for future exercises including the potential nuclear accident dosimetry exercise using Godiva at the Critical Experiments Facility at the Nevada National Security Site will be provided by LLNL.