Lawrence Livermore National Laboratory

Experiment Logistics for an International Blind Intercomparison Exercise for Nuclear Accident Dosimetry at Godiva-IV

IER-538 CED-3A Report

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Auspices

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Disclaimer

Executive Summary

This document is the Experimental Set-up and Design (CED-3A) Report for IER-538, “Full Dosimetry Exercise Around Godiva Reactors” The report discusses the structure of the exercise consisting of two critical excursions, identifying the participating laboratories and their points of contact. The report also includes details of all dosimetry each laboratory will submit to be placed in proximity to Godiva-IV on aluminum plates or BOMAB phantoms. Each laboratory list the counting and spectroscopy equipment to be utilized at the LLNL NAD Laboratory in Mercury. The exercise is tentatively scheduled for one week in fiscal year 2022.

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1 Introduction

The purpose of this exercise is to test participants' nuclear accident systems and personnel to the requirements established by ANSI/HPS-N13.3 *Dosimetry for Criticality Accidents*. IER-538 builds upon a series of experiments and previous nuclear accident dosimetry (NAD) exercises at the National Criticality Experiments Research Center (NCERC) in the Device Assembly Facility (DAF):

- Start-up of Godiva (IER-194)
- Reference values of the Godiva radiation field in DAF (IER-147)
- 2012 International Intercomparison Exercise for NAD at the DAF using Godiva (IER-148)
- Start-up of Flattop (IER-195)
- Reference values of the Flattop radiation field in DAF (IER-252)
- International Intercomparison Exercise for NAD using Flattop (IER-253)

There are eleven laboratories participating in this NAD Blind Intercomparison exercise. Seven laboratories are from the Department of Energy (DOE), which includes Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Hanford, Sandia National Laboratory (SNL), Savannah River Site (SRS), Y-12 National Security Complex (Y-12), and Nevada National Security Site (NNSS). The four remaining laboratories are the Atomic Weapons Establishment (AWE), the Institut de Radioprotection et de Sûreté Nucléaire (IRSN), the Naval Dosimetry Center (NDC), and the Norfolk Naval Shipyard (NNSY). Each of these laboratories participated in the previous blind intercomparison using the Flattop assembly (IER-253).

2 Schedule, Scope and Responsibilities for IER-538

CED-3a is scheduled for completion by March 31, 2022. CED-3b is due for completion September 30, 2022, executing the exercise the week of August 22nd. Publishing (CED-4a) of the LLNL report and summary of the exercise is scheduled after the completion of CED-3b. A rough schedule is presented in Table 1. Scheduled dates are pending based on availability of participating laboratories and the status of COVID-19.

Table 1. CED Schedule for FY22 & FY23

FY2022				FY2023			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	CED-3a	CED-3b			CED4a		

The scope of the actual exercise will consist of two major activities:

- LANL will operate the Godiva IV critical assembly to produce radiation fields for two bursts..

- LLNL will provide reference dosimetry values and NAD laboratory accommodations in Mercury.

All activities in the Godiva building at NCERC are the responsibility of the LANL Person-In-Charge (PIC), which includes supervising the set-up of dosimetry equipment including personal nuclear accident dosimeters (PNADs) and fixed nuclear accident dosimeters (FNADs), as well as placement of phantoms and support structures. These responsibilities are currently assigned to Joetta Goda (LANL). Placement will correspond to locations where reference values have been established.

LANL retrieves the irradiated NADs and phantoms and packs them into drums provided by LLNL (Paul Yap-Chiongco). LLNL will coordinate with NNSS for transfers of drums from NCERC to the NAD laboratory. LLNL will prepare the shipping requests and provide calculated activities for the irradiated materials (Daniel Stone). Receipt and breakdown of NAD elements, sample preparation and support with counting equipment in the Mercury NAD Lab is the responsibility of the LLNL Responsible Individual (RI). These responsibilities are currently assigned to Paul Yap-chiongco (LLNL) assisted by Daniel Stone (LLNL) and Becka Hudson (LLNL).

NNSS will receive, breakdown, prepare and count the NNSS NAD elements in its own counting facility in Building 23-650.

As the lead laboratory, LLNL will assist each participating organization with travel logistics, training, NNSS access and receipt of all NAD system components including counting equipment. This responsibility includes providing assistance to foreign national participants, including obtaining access to NNSS. At the conclusion of the exercise, LLNL will return all equipment to the participants. Each participating organization is responsible for providing a summary report of their exercise results.

3 Experiment Logistics

3.1 Exercise Summary

The purpose of this exercise is to examine the performance of each program to ANSI/HPS N13.3-2013 (R2019) *Dosimetry for Criticality Accidents*. This will be a blind exercise, conducted similarly to IER-253, testing the following aspects of a NAD program:

- Quick Sort Performance
- Biological Dosimetry Methods
- Preliminary NAD performance (within 24 hrs)
- Final NAD performance
- Identification and correction of orientation dosimeter response

The exercise will consist of two super-prompt critical bursts conducted on the Godiva critical assembly. The first critical burst will exhibit a "known" location where participants will be given the location, distance, orientation and delivered dose of the dosimeters. This "known" information will be given at the beginning of the exercise. Information for the remaining locations for the first burst and all locations of the second burst will be kept private from the participants for the first 24 hours post irradiation.

Each participant laboratory will submit 20 dosimeters for each irradiation. Each laboratory will submit their uniquely identified dosimetry to the exercise coordinators. The coordinators will place the dosimetry on a Bottle Manikin Absorption (BOMAB) phantoms (Figure 1) and aluminum plates (Figure 2) keeping track of the dosimetry identification and placement locations. Coordinators will be non-participatory in dosimeter readouts and results generation.

Four BOMABs will be deployed. Each phantom can hold up to 22 dosimeters, 11 on the front and 11 on the back. A small number of dosimeters from each participant will be placed in varying orientations, including on the backside of the BOMABs. Two of the BOMABs will be filled with saline solution to simulate sodium concentration in the human body. The remaining two phantoms will contain Ringer's lactate to simulate human blood. The sodium concentrations will be provided to the participants. Additionally, each BOMAB will have small packets of hair taped to the surface of the phantom's head. The body and blood simulation, hair, teeth and nails will be utilized to assess biological dosimetry methods. The BOMABs will be set up for quick sorting measurements and participants will also be given samples of hair and 10 ml samples of Ringer's lactate for analysis.

Four stands will be deployed around Godiva, adjacent to a BOMAB at the same distance. Each stand will hold three aluminum plates where up to 11 dosimeters can be placed on a plate and 3 plates can be placed on a stand, up to 33 dosimeters in total. All dosimeters deployed on a plate will be oriented facing Godiva.

Participants will have up to 2 dosimeters placed per BOMAB and a maximum of 3 dosimeters per laboratory may be placed on the stand at a height as close as possible to the height of the corresponding dosimetry placed on the adjacent BOMAB phantom. Participants will be informed whether dosimeters were placed on BOMABs or plates upon receipt of the dosimeters post irradiation.

LLNL will place dosimeters on to phantoms and will photograph the placement of all dosimetry on phantoms and plates at the Mercury NAD Laboratory. LLNL will fine tune dosimetry in the DAF hallway, ensuring dosimetry is still in the correct locations. LANL will take the final photos after placement of dosimetry around Godiva, providing to LLNL to hold until after the exercise.

LLNL and AWE will each deploy one passive neutron spectrometer as external field monitor for each burst.

On receipt of the plates and the BOMABs, the coordinators will remove the dosimeters and sort them according to participant. Each participant will then be presented with their irradiated dosimeters and informed of their placement on BOMBABs or plates.

Participants will report dosimetry results as they become available. Limited information will be released by the coordinators during the first 24-hours post irradiation. At the end of the 24-hour period, participants will provide their best dosimetry determinations.

Upon the conclusion of the exercise, the positioning of each participant's dosimeters will be given. The participants will have three weeks after the exercise to perform additional analysis, make corrections (e.g. for shielding, rotation, etc), and provide revised dose estimates. Shielded dosimeter results (e.g., backside of BOMABs) will be required at this time.

Figure 1. BOMAB on stand with dosimetry placed on front and backside.

Figure 2. Dosimetry placed on aluminum plates on a rolling stand.

3.2 Dosimetry Descriptions and Experimental Needs by Laboratory

There are eleven laboratories selected to participate in the IER-538 NAD exercise at NNSS using Godiva-IV. For each participating laboratory, the subsections below provide:

- An official point-of-contact and list of participants
- A description of their equipment to be placed near Godiva-IV for irradiation
- A list of their additional equipment for use in the Mercury NAD Laboratory

An additional subsection describes general equipment that will be provided by LLNL for use by all participants in NCERC and at the Mercury NAD Laboratory.

3.2.1 Atomic Weapons Establishment (AWE)

Philip Angus is the point of contact for AWE. His contact information along with the other AWE participants is specified below:

- Philip Angus, email: Philip.Angus@awe.co.uk
- Nick Vessey, email: Nicholas.Vessey@awe.co.uk
- Kirk Chapman, email: Kirk.Chapman@awe.co.uk
- Emily Cornick
- Gordon McCabe; Gordon.McCabe@awe.co.uk

The primary AWE NAD is the Harwell MKIV Criticality locket. The dosimeter will be deployed free-in-air on aluminum plates and placed on BOMABs. The dosimeter consists of sulfur, indium, gold, cadmium and plastic. AWE will deploy site passes containing indium disks used for triage. AWE will also participate in biological dosimetry methods using blood and hair activation.

Additionally, AWE will deploy their second generation of a passive neutron spectrometer (PNS) along side LLNL's PNS.

AWE will utilize the following equipment in the NAD laboratory:

- 2x Transpec portable gamma spectrometers
- 1x iSolo beta counter
- BP4/19 hand held beta/gamma probes
- 2x laptops

3.2.2 Hanford

Sean Murphy is the program lead for the Hanford external dosimetry program, which includes nuclear accident dosimetry. His contact information as well as the other Hanford participants is below:

- Sean Murphy, sean_j_murphy@rl.gov, 509-396-1253
- Heather Healy, heather_l_healy@rl.gov, 623-800-5852
- Rob Ludwigsen, robert_l_ludwigsen@rl.gov, 509-713-0933

Hanford will deploy their standard PNAD and FNADs for both on-phantom and free in air measurements. The Hanford NAD is a four-foil dosimeter purchased from Shieldwerx, which is comprised of a bare and

cadmium cover indium foil, a cadmium covered copper foil, and a sulfur pellet as shown in the Figure 3. Hanford will also deploy the Hanford Combination Neutron Dosimeter (HCND) as a part of the FNAD assembly.

Figure 3. Shieldwerx NAD

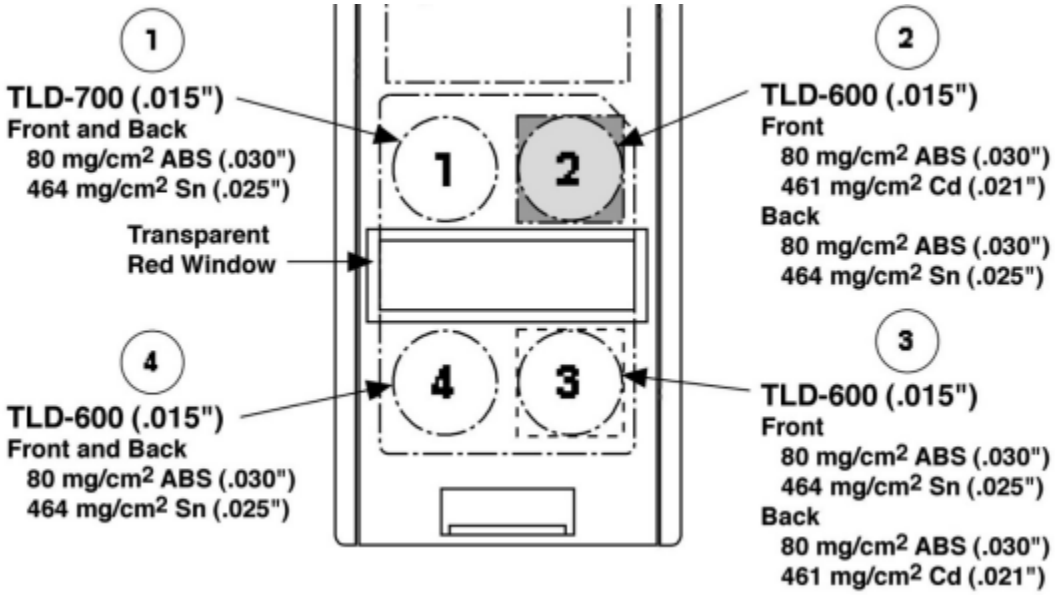

Figure 4. HCND

3.2.3 Institut de Radioprotection et de Sûreté Nucléaire (IRSN)

Francois Trompier is the point of contact for Institut de Radioprotection et de Surete Nucleaire (IRSN). His contact information along with the other IRSN participants is specified below:

- Francois Trompier, email: francois.trompier@irsn.fr
- Yoann Ristic, email: yoann.ristic@irsn.fr
- Amokrane Allaoua

IRSN will deploy the following PNADs and FNADs:

- SNAC 2 (Neutron spectrometer with activation foils) (Figure 5)
- SNAC50
- IRSN CAD (Figure 5)

- Criticality belt
- Radiophotoluminescence dosimeter (RPL)
- Silicon Diode (Figure 3)
- Thermoluminescent dosimeter (TLD)

Figure 5. SNAC 2 (left), IRSN CAD (middle), Silicon Diode (right)

Additionally, IRSN will utilize biological dosimetry methods using tooth enamel fragments and nails to be analyzed by electron paramagnetic resonance spectroscopy (EPR). The tooth enamel consist of small, sterilized and cleaned fragmits sealed in a plastic bag under nitrogen.

IRSN will utilize the following equipment in the NAD laboratory:

- A Silicon Diode reader
- A manual Chemical Dosimeter reader
- A small electrical oven
- A NaI gamma-ray spectrometer
- A Ge gamma-ray spectrometer
- Laptop computers
- Electronic personal dosimeter (EPD) and portable survey meters readers
- Electrical adaptators and transformers
- A beta counter
- A TLD reader
- A RPL reader
- An EPR spectrometer

3.2.4 Naval Dosimetry Center

Alex Romanyukha is the point of contact for Naval Dosimetry Center (NDC). His contact information along with the other NDC participants is specified below:

- Alex Romanyukha, email: alexander.a.romanyukha.civ@mail.mil
- LT David Boozer, email: david.l.boozer6.mil@mail.mil

Naval Dosimetry Center will deploy the NCL-03 neutron criticality dosimeter (Figure 6). This dosimeter is based on the neutron activation of foils consisting of gold, cadmium, indium, and sulfur. NDC will also utilize electron paramagnetic resonance (EPR) analysis of alanine.

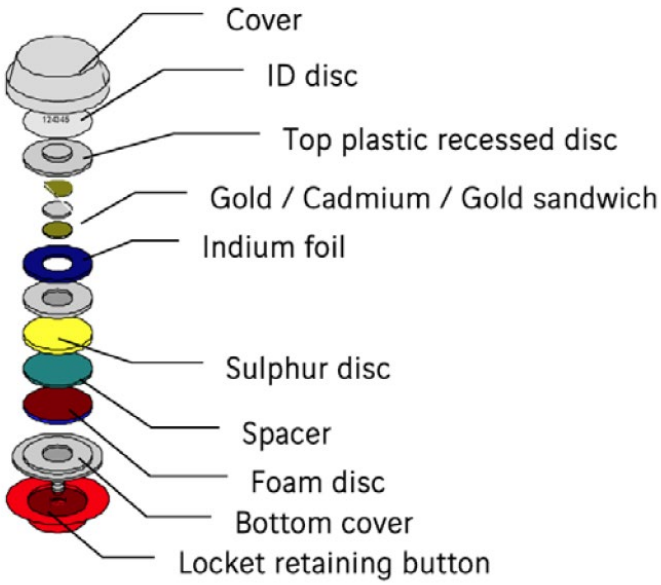

Figure 6. Expanded diagram of NCL-03 neutron criticality dosimeter

NDC will utilize the following equipment in the NAD laboratory:

- 1 Falcon 5000
- 1 iSolo
- 2 laptops
- 1 portable TLD reader (Harshaw 3500)
- 1 portable EPR spectrometer

3.2.5 Norfolk Naval Shipyard

Brian Lawson is the point of contact for Norfolk Naval Shipyard. His contact information along with the other NNSY participants is specified below:

- Brian J. Lawson, email: brian.lawson@navy.mil
- Christopher Ward, email: christopher.r.ward1@navy.mil
- Caleb Nixon, email: caleb.nixon@navy.mil

NNSY will submit the DT-702/PD dosimeter for irradiation free in air and on front and back of BOMAB phantoms. The DT-702/PD dosimeter case contains metal radiation filters that will be analyzed by radioactivity measurements for activation by neutrons. The dosimeter elements in the DT-702/PD dosimeter are LiF:MCP. The dosimeters must be processed using a Thermo Model 8800 TLD reader. These readers are available at Navy sites and can process dosimetry within 24 hours of an accident. It is not possible to ship a reader to the Mercury site to support testing in this same time frame. Processing of dosimeters irradiated during the test will be performed at NNSY with data analysis and reporting to LLNL within the prescribed time required by the test. NNSY will provide LLNL two sets of data from the DT-702/PD. The first data set will be an estimated '24 hour' dose using the initial processing results of the dosimeters. These results would normally be available in an actual event because of the immediate availability of Model 8800 readers. The

second set of data will be the final dose estimates for each dosimeter based on detailed analysis with appropriate photon and neutron correction factors applied.

NNSY will utilize the following equipment in the NAD laboratory:

- Canberra Falcon 5000 with an electrically cooled Ge(Li) detector
- Specialized tools to open DT-702/PD dosimeter cases to remove the dosimeter card containing the four LiF:MCP dosimeter elements
- Hand tools to remove metal radiation filters from dosimeter cases for radioanalysis

All required equipment and tools will be provided by NNSY and shipped to the test site in time for the test evolution.

3.2.6 Lawrence Livermore National Laboratory

Daniel Stone is the IER-538 point of contact and program lead for LLNL's NAD program. Catherine Percher is the Nuclear Criticality Safety Program (NCSP) Task Manager for LLNL. Becka Hudson and Paul Yap-chiongco are the LLNL points of contact for the Mercury NAD Laboratory and LLNL activities at NCERC. Their contact information, together with that of the other LLNL participants is specified below:

- Daniel Stone, email: stone57@llnl.gov, tel. 925-422-2582
- Catherine Percher, percher1@llnl.gov, tel. 925-423-9345
- Dave Heinrichs, email: heinrichs1@llnl.gov, tel. 925-424-5679
- Becka Hudson, email: hudson14@llnl.gov, tel. 925-422-6392
- Paul Yap-chiongco, email: Yapchiongco1@llnl.gov, tel. 925-422-1132
- Karen Jeffers, email: jeffers8@llnl.gov, tel. 925-422-8722
- Mike Firpo, email: firpo2@llnl.gov, tel. 925-424-6496
- Sophia Uchiyama, email: uchiyama1@llnl.gov, tel. 925-422-4062
- Logan Anspach, email: anspach1@llnl.gov, tel. 925-424-3017

LLNL will deploy the LLNL PNADs to be placed in proximity to Godiva (Figure 7). LLNL will also utilize the testing of hair sulfur activation and blood sodium activation to estimate dose. The LLNL PNAD consist of a Panasonic UD-810 TLD, gold, indium and copper foils, a sulfur pellet, cadmium and borated plastic shields, and plastic caps inside a plastic case. Arrow-Tec Direct Reading Pocket Dosimeters Models W740 (0 – 100 R) and 742 (0 – 200 R) will also be deployed. LLNL will also include CaF_2:Mn TLDs for measuring gamma dose. The LLNL CaF_2 consists of 5 Thermofisher Harshaw TLD400 chipstrates placed between two 40x63x5cm pieces of Griffith muscle material for charged particle equilibrium as shown in Figure 8.

Lastly, LLNL will deploy their PNS spheres with TLDs for comparison with AWE (Figure 9).

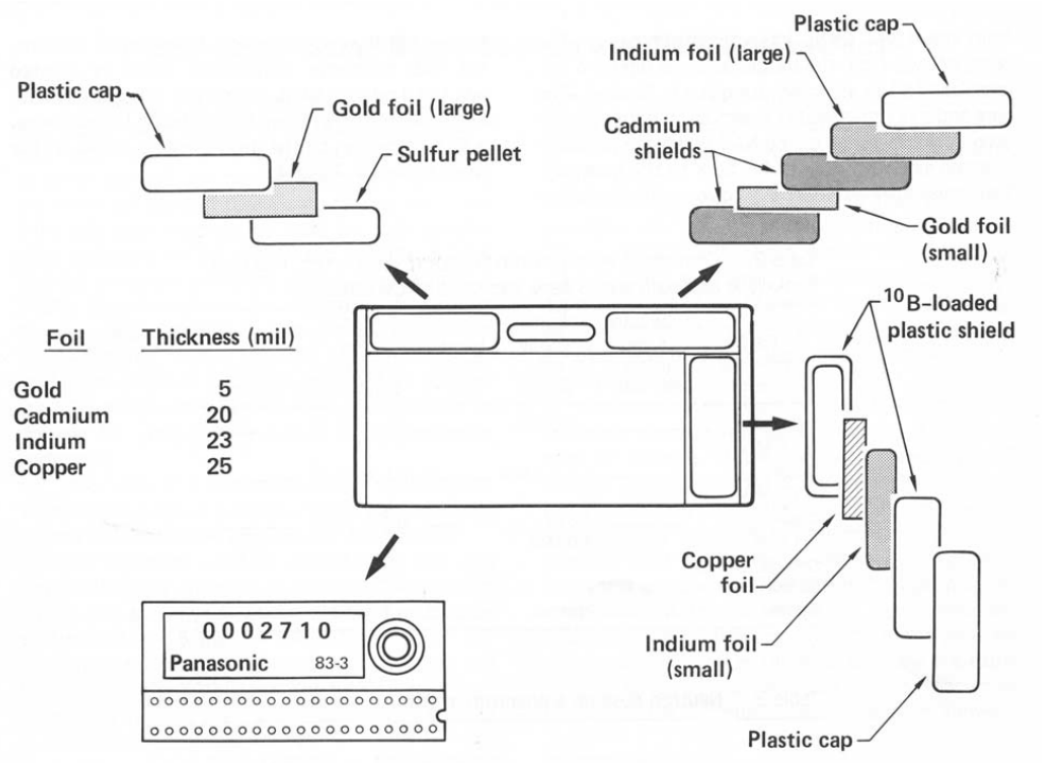

Figure 7. LLNL Personal Nuclear Accident Dosimeter

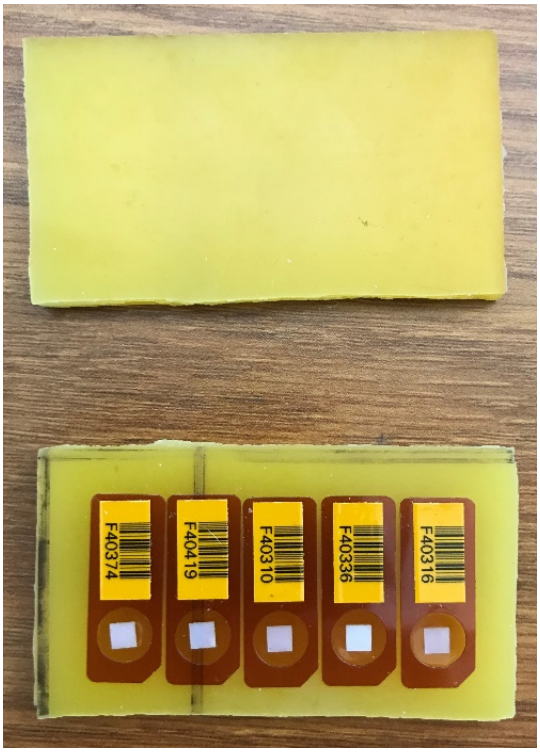

Figure 8. LLNL CaF_2 Photon Dosimeter

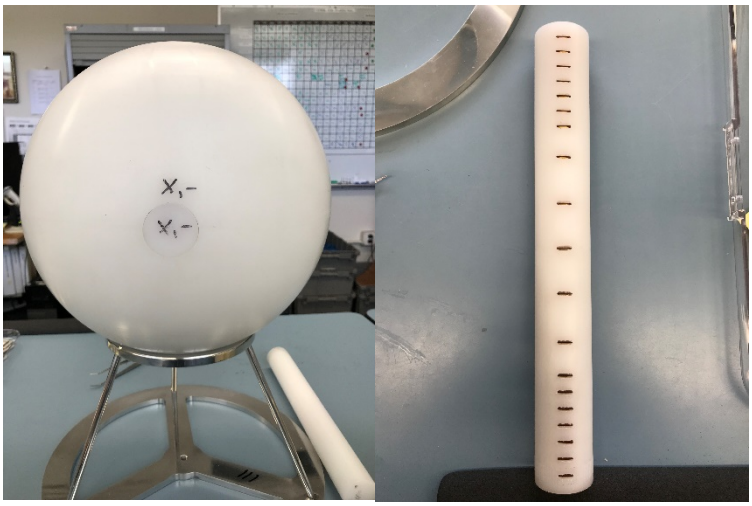

Figure 9. LLNL PNS (left) with X-axis TLD insert (right)

LLNL will also utilize the following equipment in the NAD laboratory:

- Canberra Industries Falcon 5000 Portable HPGe Gamma Spectroscopy System
- Canberra Industries iSolo Alpha/Beta Counting System
- Panasonic UD-710 TLD reader
- Laptop computers

3.2.7 Los Alamos National Laboratory

Milan Gadd is the LANL program lead for LANL's criticality accident dosimetry program. His contact information together with that of the other LANL participants is specified below:

- Milan Gadd, email: milang@lanl.gov, tel. 505-667-2713
- Betsy Hillmer, email: emeek@lanl.gov, tel. 505-665-1302
- Francisco Garcia, email: garciaf@lanl.gov, tel. 505-665-8888
- Josh Chandler, email: jchand20@lanl.gov, tel. 505-665-9731

Los Alamos will deploy PNADs and FNADs on movable stands for free-in-air measurements. The LANL Personal Nuclear Accident Dosimeter (PNAD) consists of bare and cadmium-covered indium foils, a cadmium-covered copper foil, and a sulfur tablet as shown in Figure 10. LANL 8823 whole-body dosimeters (see Figure 11) will be deployed with the PNADs to determine photon dose. The 8823 dosimeter contains two 4-element Harshaw thermoluminescent dosimeter cards. One card contains three TLD-700 elements and one TLD-400 element. The second card is contained in a cadmium "box" in an albedo/anti-albedo configuration and uses a combination of TLD-600 and TLD-700 elements. The Los Alamos Criticality Dosimeter (LACD), which is deployed in fixed locations where there is a potential for criticality accidents. Figure 12 shows the dosimeter package used for intercomparison exercises. This package differs in appearance but not function from the LACD deployed at LANL facilities. Elements of the exercise LACD are bare and cadmium-covered indium and gold foils, a cadmium-covered copper foil, and a sulfur tablet.

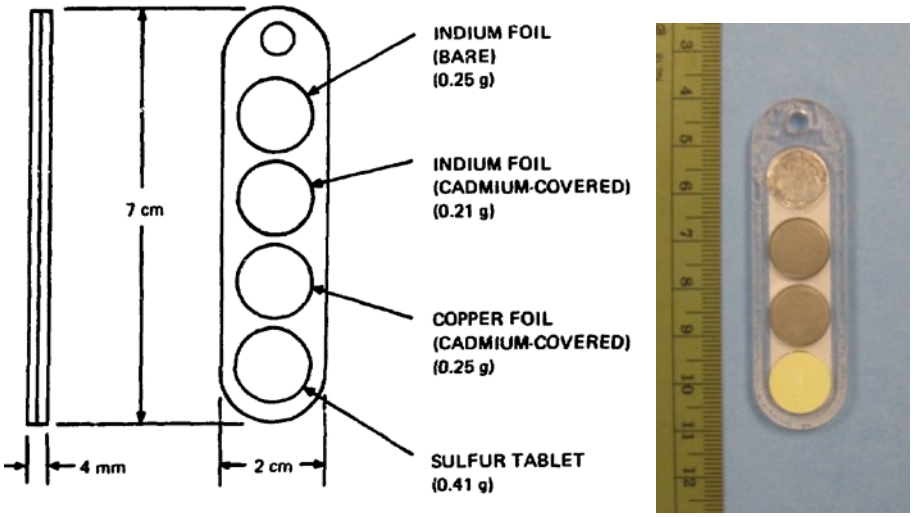

Figure 10. LANL Personal Nuclear Accident Dosimeter

Figure 11. LANL 8823 Whole-Body Dosimeter

Figure 12. Los Alamos Criticality Intercomparison Dosimeter

LANL will also utilize the following equipment in the NAD Laboratory requiring 110 VAC power (nominally 114-126 VAC) outlets:

- Model 2M2/2 Saint-Gobain Crystals 2x2 NaI(Tl), Kromek GRA1+ CZT detector, and Bicron 2XM.75BC408/2A plastic scintillator. Data acquisition will be performed using Canberra Inspector-2000, Ortec DigiBase, Kromek K-Spec, Canberra Genie-2000, or Ortec GammaVision MCA emulation software, as appropriate, installed on a laptop computer. The photon detectors are shielded by steel or 1" thick lead collimators lined with copper.
- A Ludlum Instruments Model 44-1 plastic scintillator detector connected to an Eberline E-600 Digital Survey Meter (battery power)
- A Canberra iSolo or similar alpha/beta counting system
- A SHP-380AB (dual scintillator) detector connected to a Thermo/Eberline E-600 or RadEye digital survey meter (battery power)
- A SHP-270 Geiger-Mueller detector connected to an Eberline E-600 or RadEye digital survey meter (battery power)
- Laptop computers

3.2.8 Nevada National Security Site

The Nevada National Security Site will provide radiological control services including shipment and initial contamination surveys of NADs. Jeff Gill is the NNSS primary contact for the criticality accident dosimetry program. Jon Conde is the subject matter expert providing technical support to Jeff. Their contact information is specified below:

- Jeff Gill; gilljw@nv.doe.gov
- Jon Conde; condejc@nv.doe.gov

NNSS will deploy their standard nuclear accident dosimeters for both on-phantom and free in air measurements. The NNSS NAD is a four foil dosimeter from Shieldwerx consisting of bare and cadmium covered indium foils, a cadmium covered copper foil, and a sulfur pellet as shown in Figure 13. Additionally NNSS will deploy the Landauer OSL dosimeters with neutron measurement capability. NNSS also elects to participate in blood sodium analysis.

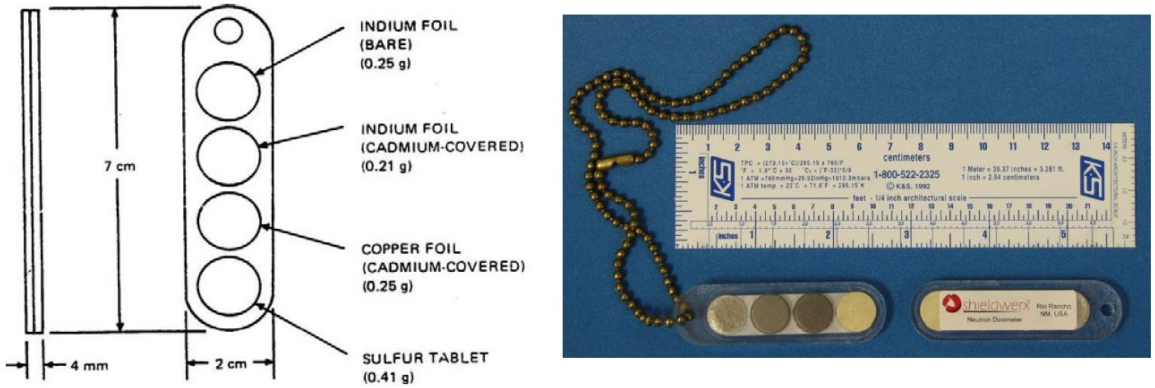

Figure 13. NNSS NAD Elements (left) and Photograph (right)

3.2.9 Sandia National Laboratories

Dann Ward is the point-of-contact for Sandia National Laboratories (SNL). His contact information is specified below:

- Dann Ward (POC), email: dcward@sandia.gov, tel. 505-844-8325

SNL will deploy the SNL Criticality Dosimeter (Figure 14) and CaF_2:Mn TLDs (Figure 15). The CaF_2 TLDs will be returned to SNL for analysis. SNL will also deploy Arrow-Tec Direct Reading Pocket Dosimeters (Figure 16) Models W740 (0 – 100 R) and 742 (0 – 200 R). The SNL Criticality Dosimeter[1] is a sealed plastic housing containing a NaF pellet, Al, Ni, Ti and In bare foils, and a Cd covered Cu foil.

[1] *Personal Nuclear Accident Dosimetry at Sandia National Laboratories*, SAND96-2204.

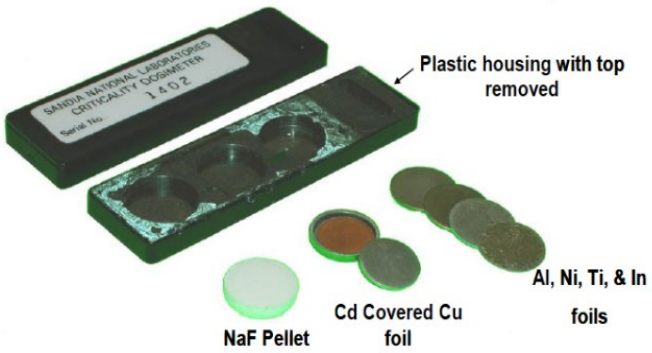

Figure 14. SNL Criticality Dosimeter

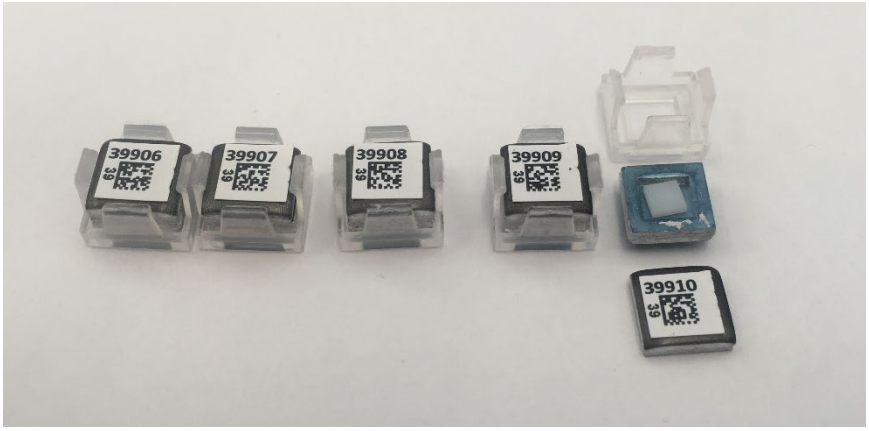

Figure 15. CaF2 TLDs showing aluminum buildup material around the chip.

Figure 16. Examples of Arrow-Tec Direct Reading Pencil Chambers

SNL will also utilize the following equipment in the NAD Laboratory requiring 110 VAC power (nominally 114-126 VAC) outlets:

- Canberra Industries Falcon 5000[2] Portable HPGe Gamma Spectroscopy System
- An Eberline E600[3] with a Model SHP270 Geiger-Müller probe

3.2.10 Savannah River Site

David Roberts is the SRS program lead for the SRS criticality accident dosimetry program. His contact information together with that of the other SRS participants is specified below:

- David Roberts, email:david-w.roberts@srs.gov, tel. 803-507-6907
- Elaine Brown, email: elaine.brown@srs.gov, tel. 803-676-9203
- Francisco Garcia

SRS will deploy Criticality Neutron Dosimeters (CND), InLight Model 2T dosimeters, nanoDot dosimeters and blood sample tubes filled with Ringer's lactate solution. Dosimeters will be placed BOMAB phantoms as wells as movable stands for free-in-air measurements. Blood samples will be obtained from BOMAB phantoms and used to perform ^{24}Na analysis.

The SRS uses a three-phase criticality dosimetry system established to respond to a criticality accident. In the first phase, all potentially exposed personnel are screened by probing the worker's abdomen since sodium in the blood would be activated by neutron exposures. The second phase involves determining the preliminary neutron dose by analytically quantifying ^{24}Na activation in blood. The third and final phase consists of a more accurate dose determination using a criticality neutron dosimeter capable of measuring dose over a wide range of energies.

Specifications for the CND's components are described in Table 3. A diagram of the current CND is shown in Figure 17. The CND's components are assembled in a 3-5/8 inch long by 1/2 inch diameter mylar tube. A clip is attached so it can be placed on the wearer's pocket. Indium, copper, and cadmium foils were shaped into hollow cylinders to lessen directional effects. These foils, along with specific amounts of sodium fluoride, sulfur and TLD-700 chips, are contained in four small polystyrene vials.

[2] http://www.canberra.com/products/hp_radioprotection/pdf/Falcon-SS-C38597.pdf

[3] http://www.equipcoservices.com/pdf/manuals/eberline_e-600.pdf

Table 2. CND Components

Vial No.	Material Contained	~Size (in.) or Weight (g)
1	Cadmium shield*	1 piece of 1 x 5/8 x 1/32 in. 2 pieces of 3/8 dia. x 1/32 in.
	Indium foil* (Cd-covered)	15/16 x 5/8 x 0.005 in.
	Copper foil* (Cd-covered)	15/16 x 5/8 x 0.005 in.
2	Sodium fluoride powder	1.50 gram ± .20 gm**
3	Indium foil (bare foil around outside of vial)	1 7/16 x 5/8 x 0.005 in.
	Sulfur powder	1.00 gram ± .20 gm**
4	Paper (not shown)	~1.2 x 5/8 in.
	Harshaw TLD-700 chips	2 chips

Plastic tube (UV resistant polycarbonate):	3.8 ± .2 " long 0.5" ± 0.05" inside diameter 0.062" ± .005 wall thickness Acutech Inc. or Equivalent
Vials (with caps):***	5/8" to 1"-long 3/8" minimum inside diameter 1/2" maximum outside diameter
Tube Caps (2):	.625" inside diameter x .5" inside length, Black StockCap Inc. P/N 064062 or Equivalent
Tube Clip:	Dosimeter Type Clip J. F. Maguire P/N 6203 w/black strap or Equivalent

* The weight of each foil will be permanently inscribed on each foil to the nearest hundredth of a gram.

** The actual weight will be recorded to the nearest 100th of a gram on a numbered piece of paper inside the CND.

*** Each vial will be labeled with the dosimeter number.

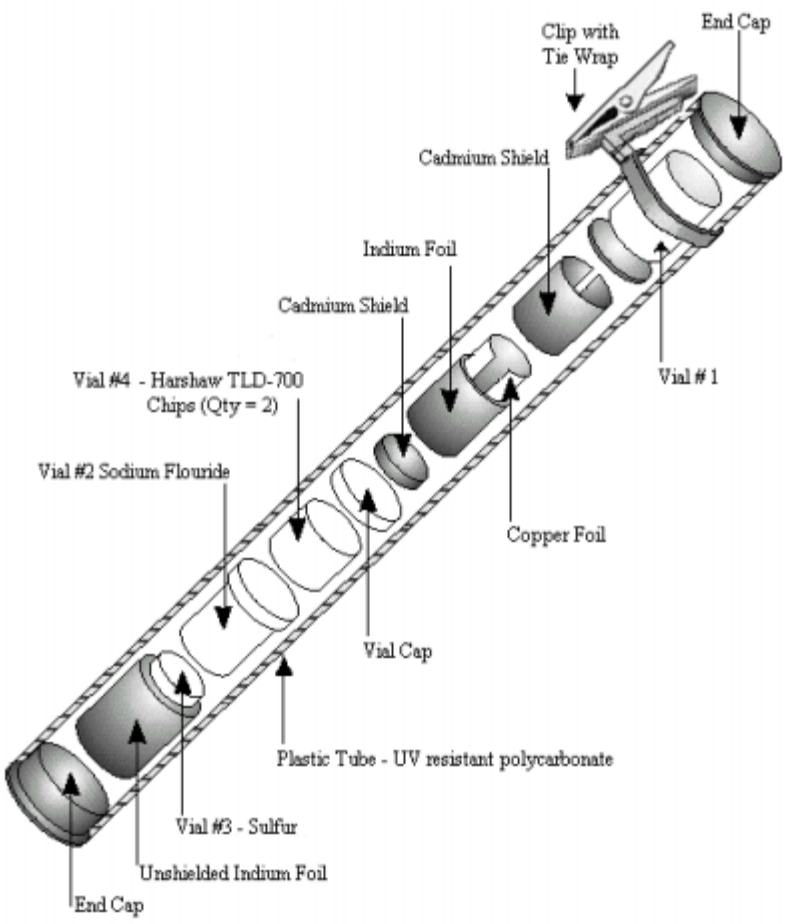

Figure 17. SRS CND

SRS will also utilize the following equipment in the NAD Laboratory:

- Falcon 5000 portable electronically cooled HPGe detector
- Canberra Colibri Easy-Count Alpha-Beta counting system

3.2.11 Y-12 National Security Complex

Ken Veinot is the criticality accident dosimetry team lead for Y-12 with Mike Souleyrette, Kieran McMahon acting as additional subject matter experts. Their contact information together with that of the other Y-12 participants is specified below:

- Ken Veinot: 865-241-6165, Ken.Veinot@pxy12.doe.gov
- Kieran McMahon: 865-241-9480, Kieran.mcmahon@pxy12.doe.gov
- Alexander Detweiler: Alexandra.detweiler@pxy12.doe.gov

The Y-12 National Security Complex criticality accident dosimetry program is comprised of multiple stages. The first is triage-type screening, which includes monitoring for activation of sodium in the body. This screening consists of whole-body surveys using portable field type instrumentation (e.g., G-M instruments) and portable gamma spectrometers (FLIR Identifinder) with customized nuclide libraries to include ^{24}Na peak data.

All personnel entering areas of the facility that have the potential for criticality accidents are required to wear a whole body dosimeter, namely the Harshaw Model 8805 four-element thermoluminescent dosimeter (TLD), as shown in Figure 26. These TLDs include three gamma and one neutron and gamma sensitive elements. Personnel who routinely work in areas having significant neutron fields are also equipped with a Harshaw Model 8806 neutron TLD that includes two gamma sensitive elements and two neutron and gamma sensitive elements, as shown in Figure 18.

Figure 18. Harshaw 8805 Beta-Photon Dosimeter Used at Y-12

Figure 19. Harshaw 8806 Neutron Dosimeter Used at Y-12

In the event of criticality accident alarm system (CAAS) outage personnel are required to wear electronic dosimeters to provide contingency monitoring. The approved dosimeter is the Mirion DMC-3000 shown in Figure 19.

Figure 20. Mirion Technologies DMC-3000 Dosimeter Used at Y-12

Triage-type monitoring is central to the Y-12 criticality accident dosimetry program response plan. These measurements are performed using the Ludlum Model 3 with Model 44-9 pancake-type G-M probe and/or the Ludlum Model 2224 with Model 43-93 dual alpha-beta scintillator. This initial survey of personnel provides adequate measurement of sodium activation following neutron exposures. If this initial survey indicates activity, a screening using the FLIR Identifinder is performed to determine if the source of the activity is contamination or ^{24}Na . Personnel identified to have been significantly exposed to neutron fluence are sent to the REAC/TS facility in Oak Ridge. To test this triage system, Y-12 will perform surveys on BOMAB phantoms containing traceable quantities of sodium (in the form of Ringer's lactate) that were exposed to known-doses

of neutron exposure in the training event. Surveys performed at various times post-accident allows for detection capabilities to be determined since the ^{24}Na has a known half-life. Initial personnel dose estimates will be determined using the Model 44-9 G-M and Model 43-93 detector measurements using established conversion factors and assumptions on neutron:photon dose ratios.

TLD measurements will be performed on phantoms. These TLDs will be processed upon return to the Y-12 site. However, testing from previous inter-comparison studies[4,5] indicates that information on order-of-magnitude exposure can be obtained by surveying the TLD holders using field instruments. Therefore, Y-12 personnel will perform surveys for activated filtration components contained in the dosimeter holders using field survey equipment. This equipment may include the Model 3 with 44-9 detector and the Ludlum Model 2224 with Model 43-93 dual alpha-beta scintillation probe.

Y-12 employs the Mirion DMC-3000 electronic dosimeter for CAAS-contingency monitoring. As part of the inter-comparison LANL personnel will deploy these units at various distances from the critical assembly to validate their use. These irradiations may be performed on-phantom or free-in-air as conditions permit.

Y-12 will also deploy a passive fixed accident dosimeter consisting of a 9 inch diameter polyurethane sphere containing TLD-600 and TLD-700 dosimeters to measure neutron dose and TLD-700 dosimeter for photon dose measurement. The sphere will be supported by an LLNL supplied stand.

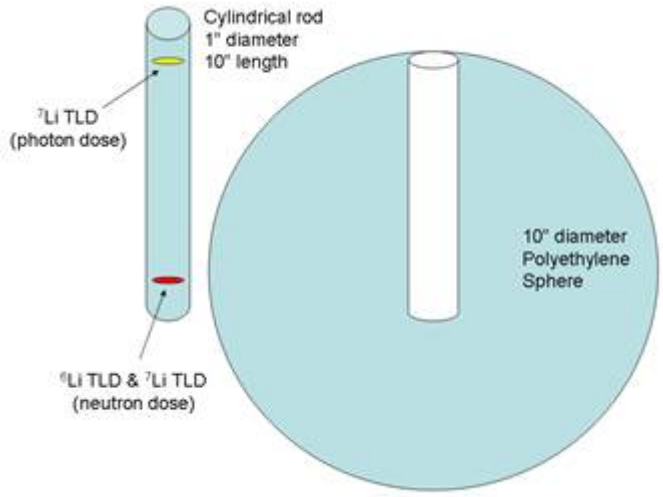

Figure 21. Y-12 Field Accident Dosimeter

[4] RCO/TBD-097 "Results from 2010 Caliban Criticality Dosimetry Intercomparison", K.G. Veinot and M.L. Souleyrette; 2011.

[5] RCO/TBD-092 "Results from 2002 and 2009 Silene Criticality Dosimetry Intercomparisons", K.G. Veinot and M.L. Souleyrette; 2010.

Y-12 will also utilize the following equipment in the NAD Laboratory:

- Ludlum Model 3 with Model 44-9 pancake-type G-M probe and/or the Ludlum Model 2224 with Model 43-93 dual alpha-beta scintillator
- FLIR Identifinder with customized nuclide libraries to include ^{24}Na peak data

3.3 General Equipment

The following equipment will be provided by LLNL for use by all participants during irradiation measurements near Godiva-IV at NCERC:

- 8 BOMAB phantoms with saline solution or Ringer's Lactate and support stands (Figure 1)
- 8 Avenger A5033 Roller 33 stands with 2 – 4 aluminum mounting plates (Figure 2)

The following equipment will be provided by LLNL for use by all participants in the NAD Laboratory at Mercury:

- Work space for participant quick sort readout activities using participants quick sort equipment/methods
- Lab benches with adjustable shielding
- Static controlled lab chairs
- A balance (0.1 mg – 200 g)
- Mortars and pestles (for crushing sulfur)
- A captair XLS714 ductless fume hood with hot plate (for melting sulfur and handling powders)
- Planchets, glassine envelopes, pens, tape, plastic bags, lab coats, gloves
- Sample vials containing activated Ringer's lactate solution
- 60Hz/120V electrical connections (NEMA 5-15R style)
- Digital Camera
- Conference/meeting area with computer based overhead projection and marker boards

4 Planning for FY-2022

4.1 Experiment Initiation (CED-3a)

At the completion of CED-3a, LLNL will ensure availability of equipment listed in Section 3.3 is available in the NAD laboratory.

Participants will provide LLNL with a complete list of the equipment detailed in Section 3.2 at least 12 weeks prior to the exercise. This will allow the approval process to be completed.

Participants will provide the exercise coordinators with the mass, dimensions, and material compositions of all dosimetry that will be placed near Godiva. Participants can also provide a value for the activity per unit neutron fluence of each activation state in their dosimetry materials. The information is required so that a plan can be created for the transportation of materials from the NCERC to the NAD laboratory.

At least six weeks in advance of the exercise, all participants will ship their equipment to LLNL at the NNSS in two separate shipments. One shipment is for equipment to be irradiated by Godiva in NCERC. The second shipment is for equipment for use in the NAD Lab in Mercury. Participants will ship their equipment to the LLNL NAD Laboratory at NNSS at the address:

Mission Support and Test Services, LLC for USDOE
Attn: Paul Yap-Chiongco/Becka Hudson, LLNL
Warehouse 160, Area 23
Mercury, Nevada 89023

Participants will be allowed to send one or two individuals the week prior to the exercise to setup equipment and lab space to be used at the NAD laboratory during the exercise.

LLNL will assist the participants with the shipping, receiving and return of their equipment. Each laboratory is responsible for unpacking, setup, operation and repackaging of their equipment.

LLNL will coordinate required reviews for security and safety including any required electrical reviews by the Authority Having Jurisdiction (AHJ) prior to equipment being energized at the NAD Laboratory.

The final plan detailing the locations of all dosimetry on plates and BOMAB phantoms, and the placement and orientation of each phantom around Godiva will be sent to LANL for review 6 weeks prior to the exercise.

4.2 Experiment Execution (CED-3b)

Week of August 15, 2022
Tuesday
- A member of each participating laboratory will arrive Tuesday night

Wednesday
- Badge office for participants (if needed)
- Participants will unpack/set up equipment at Mercury NAD Lab
- Participants will assemble/prepare NADs for irradiation;
- Participants submit dosimetry to coordinators; two sets (one for each irradiation)
- Coordinators will fill BOMABs with saline solution and Ringer's Lactate, prepare for shipment.
- Coordinators will mount, photograph and document the placement of dosimetry on the BOMABs and plates

Thursday
- Coordinators will complete placement of dosimetry

- Transport dosimetry from NAD lab to NCERC
- Participants continue equipment setup

Week of August 22, 2022

Sunday
- Participants arrive in LV

Monday
- Badge Office for remaining participants(if needed)
- Brief all participants at NAD lab;
- Participants continue equipment preparation

Tuesday
- Equipment unpacked at NCERC and prepared in hallway
- Godiva building pre-operational checks to readiness for early next day operation

Wednesday
- Prejob brief at NCERC~07:30
- Fine tune dosimetry setup in hallway
- Commence first irradiation at ~10:00
- Prejob brief at NAD lab ~12:00
- NADs received in Mercury at NAD Lab ~ 13:00
- Coordinators will allow participants to make quick sort measurements
- Coordinators to distribute dosimetry to participants
- Count until midnight

Thursday
- Prejob brief at NCERC~07:30
- Fine tune dosimetry setup in hallway
- Commence second irradiation at ~10:00
- Participants report 24 hour dose estimates for first irradiation ~12:00
- NADs received in Mercury at NAD Lab ~ 13:00
- Coordinators will allow participants to make quick sort measurements
- Coordinators to distribute dosimetry to participants
- Count until midnight

Friday
- Finish any remaining counting and analysis
- Participants report 24 hour dose estimates for first irradiation ~12:00
- Prepare non-radioactive dosimetry elements and shipping documents for ASAP return back to participant's laboratory (as needed)
- Pack up equipment for return to home lab (LLNL will send back)

Saturday
- Participants depart LV

4.3 Evaluation and Publication of Data (CED-4a)

LLNL will return all equipment including irradiated dosimetry elements to all participants as soon as possible to enable timely completion of counting measurements that can only be performed at the "home" laboratory (e.g., evaluation of TLDs).

Coordinators will provide dosimetry placement details to participants upon return.

Participants will have three weeks from conclusion of the exercise to report revised results.

After receipt of revised results participants will receive dosimetry placement details and expected doses.

Coordinators will evaluate participant results and release report of the results.

5 Project Risks and Risk Management

IER-538 measurements are tentatively scheduled for FY2022. The scheduled date may change due to US and international policy regarding the COVID-19 pandemic.

The return of activated dosimetry elements is dependent on radionuclide decay rates and pulse yields. LLNL will ship as soon as these elements in their packaging are below the lower limit of detection for shipping and customs.

Transfer of dosimetry elements from NCERC to Mercury can be delayed if the dosimetry elements are contaminated.