LLNL-TR-661851

Final Design for an International Intercomparison Exercise for Nuclear Accident Dosimetry at the DAF Using GODIVA-IV

IER-148 CED-2 Report

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Auspices

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Disclaimer

Executive Summary

This document is the Final Design (CED-2) Report for IER-148, "International Inter-comparison Exercise for Nuclear Accident Dosimetry at the DAF Using Godiva-IV." The report describes the structure of the exercise consisting of three irradiations; identifies the participating laboratories and their points of contact; provides the details of all dosimetry elements and their placement in proximity to Godiva-IV on support stands or phantoms; and lists the counting and spectroscopy equipment each laboratory will utilize in the Mercury NAD Lab. The exercise is tentatively scheduled for one week in August 2015.

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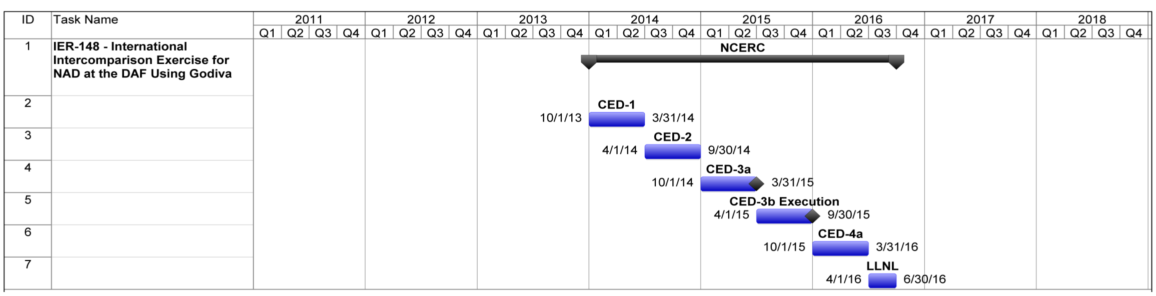
1.0 Introduction

IER-148 (included as Attachment A) was submitted in support of the proposal "Non-Classified Research Program under the CEA-DOE Agreement, Cooperation in Fundamental Science Supporting Stockpile Stewardship," for a joint US/French nuclear accident dosimetry (NAD) exercise in the DAF following start-up of the Godiva reactor (IER-194) and establishing reference values for the mixed neutron and photon radiation field of Godiva in the DAF (IER-147).

There are ten participating laboratories in the first NNSA NAD exercise at the NNSS including all six US participants (LANL, LLNL, PNNL, SNL, SRS and Y12) in the previous SILENE and CALIBAN exercises at CEA-Valduc. The additional participants are the Atomic Weapons Establishment (United Kingdom) under the auspices of JOWOG 30, and the Institute for Radiological Protection and Nuclear Safety (France), Knolls Atomic Power Laboratory (KAPL) and Nevada National Security Site (NNSS) by special invitation. CEA (Valduc) had to decline their invitation to participate due to recent changes to their mission.

2.0 Schedule, Scope and Responsibilities for IER-148

Final (CED-2) Design of IER-148 is scheduled for completion on September 30 (Q4) in FY2014 with the actual exercise (CED-3b) scheduled for FY2015 (Q4) early July as shown in the Execution Plan GANNT chart and reproduced below.



Upon completion of IER-147 high-power supercritical pulse measurements on May 31, 2014, to provide the reference values for the GODIVA radiation field, it was decided that the NAD Lab in Mercury was too small to accommodate all the currently planned participants for IER-148. Therefore, the NAD Lab is to be expanded to support IER-148 and future exercises. These construction activities (described in detail in Section 3.3) will be completed by the end of April 2015.

The scope of the actual exercise consists of two major activities:

- LANL will provide irradiation services using GODIVA in DAF
- LLNL will provide NAD laboratory accommodations at Mercury

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

Retrieval and transport of the irradiated NADs and phantoms is a joint LANL, LLNL and NNSS responsibility. NNSS will provide radiological control support services for all IER148 activities.

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 Doug McAvoy (LLNL) and Gary Slavik (LLNL) assisted by David Hickman (LLNL) and Jennifer Burch (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 and receipt of all NAD system components including counting equipment. 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.

3.0 Final Design (CED-2) Accomplishments

Final design consists of three elements; namely,

- Final design of the exercise
- Final design of each participant's nuclear accident dosimetry system
- Final design of the nuclear accident dosimetry laboratory

3.1 Final Design of the Exercise

The exercise will consist of three GODIVA burst irradiations at 70, 250 and 150 °C. The first two bursts are training exercises. During these bursts each laboratory has their dosimeters placed in known locations. The intent of these two exercises is to provide an opportunity to practice using their unique laboratory equipment, personnel and methods to determine and refine the performance of their nuclear accident dosimetry systems. Finally, each laboratory will compare their measurement results to those of the other laboratories and to the reference values. The third and final burst represents a "blind" performance test to the requirements of ANSI/HPS-N13.3-2013, Dosimetry for Criticality Accidents. For this portion of the exercise, the participants will not know the reference values or where their equipment was placed until after submitting their final results to LLNL.

For each burst, dosimeters may be placed on stands for "free-in-air" dose measurements or placed on bottle manikin (BOMAB) phantoms or acrylic (PMMA) slab phantoms.

The NAD stands will accommodate up to 10 dosimeters per plate for a total of 40 dosimeters on the stands that have 2 plates (A-D locations only) or 80 dosimeters on the stands that have 4 plates (A-H locations). Each laboratory team will have the opportunity to place 4 dosimeters per NAD stand that are configured with 2 plates (A-D locations only) and 8 dosimeters per NAD stand that are configured with 4 plates (A-H locations).

The BOMAB will accommodate up to 10 dosimeters on the front and 10 dosimeters on the back for a total of 20 dosimeters per BOMAB. Each laboratory team will have the opportunity to place one dosimeter on the front and one dosimeter on the back of each BOMAB. The BOMABs will contain saline solution simulating blood and small packets containing hair may be taped to the surface of the BOMAB to test biological dosimetry methods.

The acrylic (PMMA) slab phantoms will accommodate up to 5 dosimeters on the front and 5 dosimeters on the back for a total of 10 dosimeters per slab phantom. Each laboratory team will have the opportunity to place one dosimeter either on the front or back of a slab phantom.

The stands and phantoms will be positioned on locations where reference values have been established in IER-147, which is in progress. As shown in Figure 3.1.1, there will be six NAD stands positioned anterior/posterior [AP] to GODIVA, two BOMABs AP, and two acrylic (PMMA) slab phantoms AP on the first training burst at 70 °C. As shown in Figure

3.1.2, there will be five NAD stands AP, two BOMABs AP, two PMMAs AP, and one Bonner Single Sphere Spectrometer (BSSS) with gold foils on the second training burst at 250 °C. As shown in Figure 3.1.3, for the third final exercise burst at 150 °C, there will be four NAD stands AP, three BOMABs AP, one BOMAB LAT (positioned laterally to Godiva), and 2 PMMAs AP.

Therefore, the exercise can accommodate up to ten laboratories with each laboratory deploying up to 102 individual dosimeters.

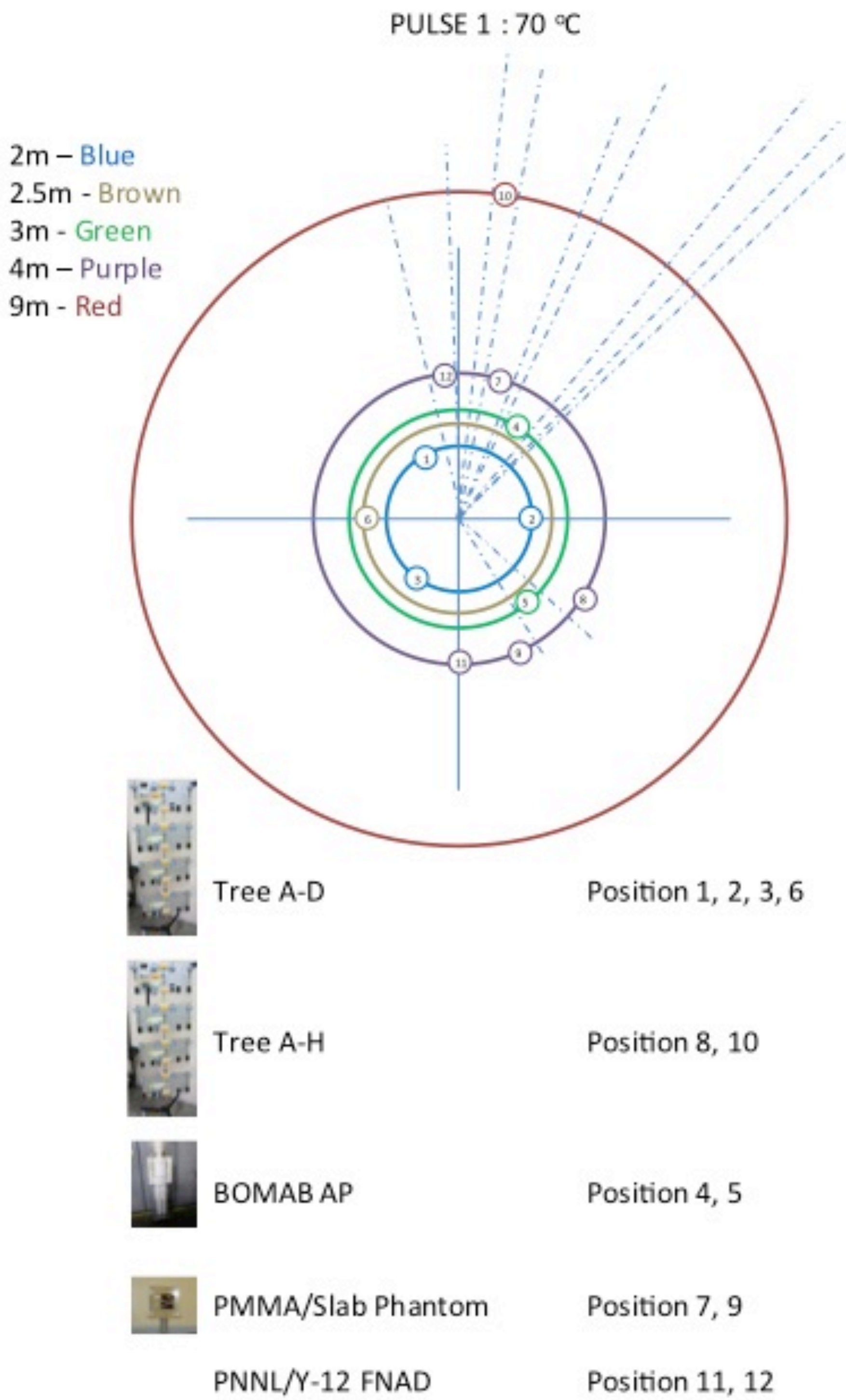
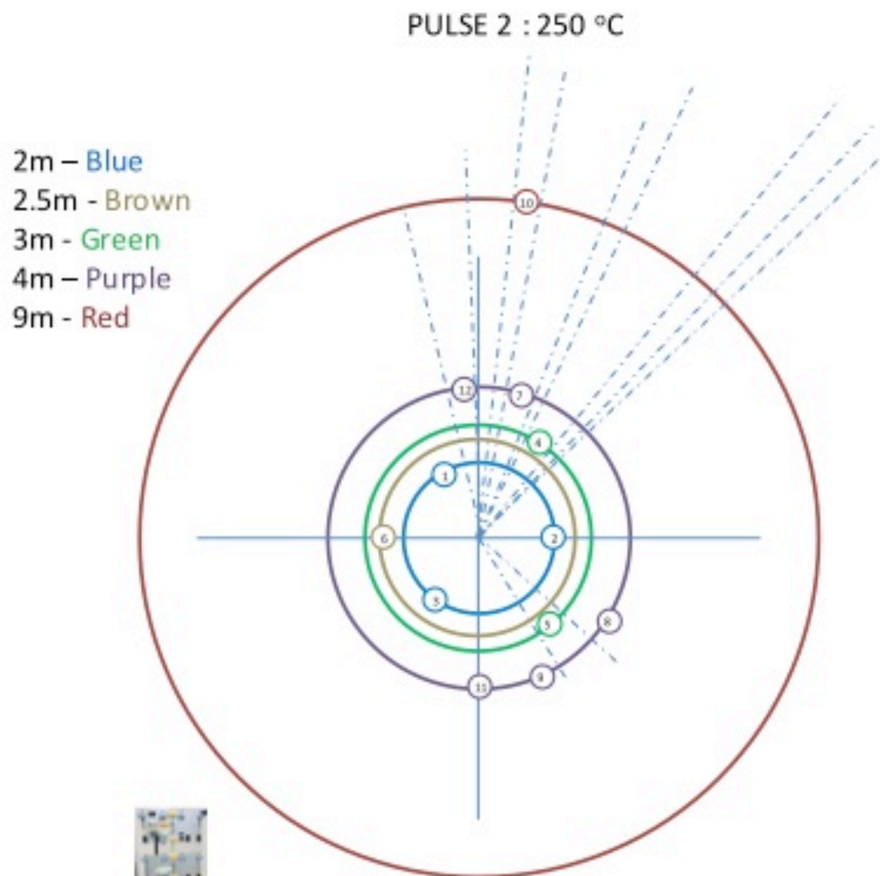


Figure 3.1.1: Design of the Training Exercise for Pulse 1 (70 °C)



	Tree A-D	Position 1, 2, 3, 6
	Tree A-H	Position 8
	BOMAB AP	Position 4, 5
	PMMA/Slab Phantom	Position 7, 9
	Single Sphere Spectrometer (SSS AWE)	Position 10
	PNNL/Y-12 FNAD	Position 11, 12

Figure 3.1.2: Design of the Training Exercise for Pulse 2 (250 °C)

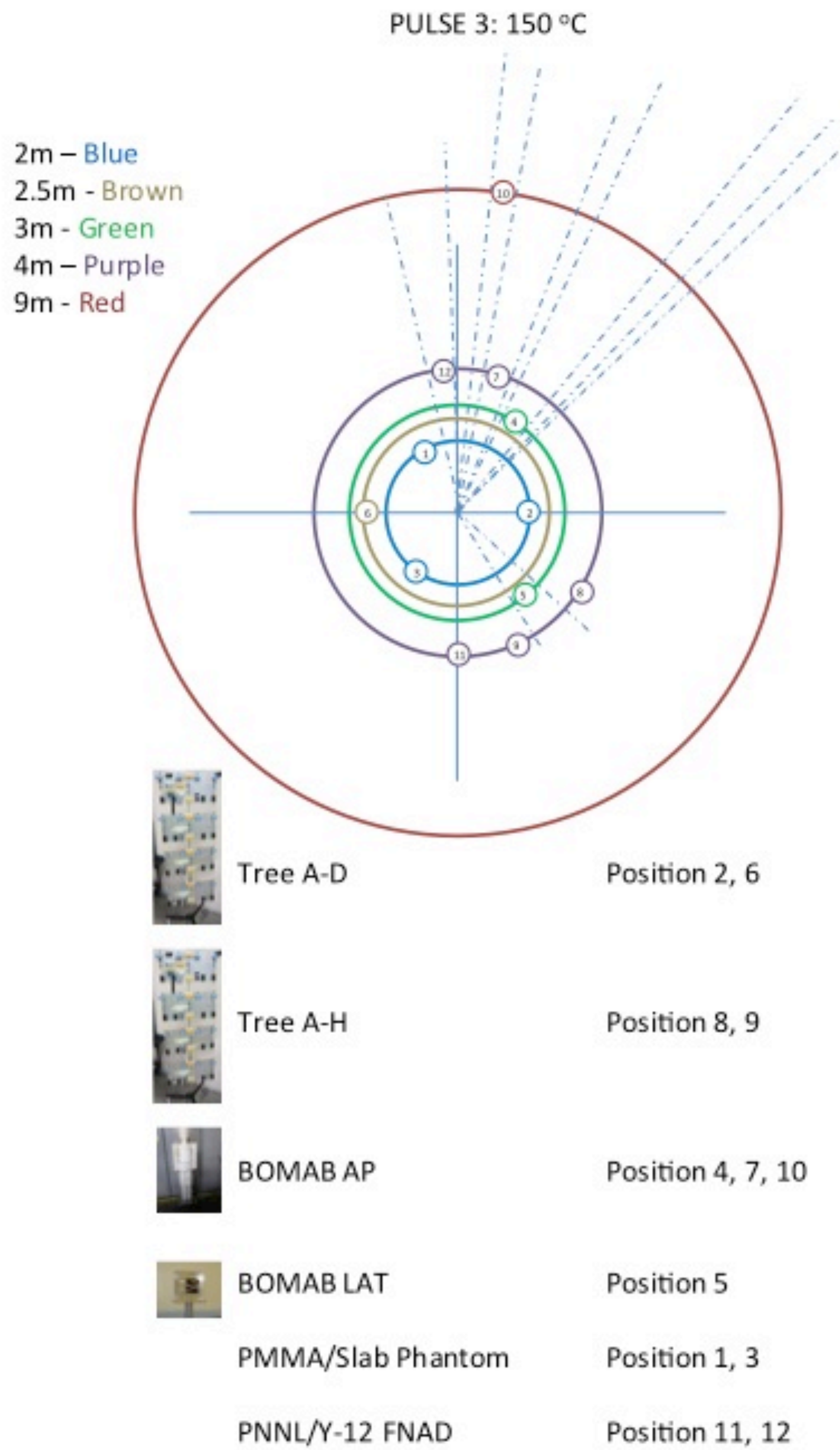


Figure 3.1.3: Design of the Final Performance Exercise for Pulse 3 (150 °C)

3.2 Final Design of the NAD Systems

There are nine laboratories selected to participate in the first NAD exercise at NNSS using Godiva-IV. For each participating laboratory, the subsections below provides:

- 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, LANL, SNL, and AWE for use by all participants in DAF and at the Mercury NAD Laboratory.

3.2.1 Atomic Weapons Establishment

Chris Wilson is the point-of-contact for the Atomic Weapons Establishment (AWE). His contact information together with that of the other AWE participants is specified below.

- Chris Wilson (POC), email: Chris.Wilson@awe.co.uk, tel. 0118 98 24428
- Phil Angus, email: Philip.Angus@awe.co.uk, tel. 0118 98 25572
- Liam Buchanan, email: Liam.Buchanan@awe.co.uk, tel. 0118 98 25475
- Leo Clark, email: Leo.Clark@awe.co.uk

The AWE NAD[1] to be placed in close proximity to Godiva-IV is the Harwell Mark IV Criticality Package (Figure 3.2.1.1) consisting of a Mark III Criticality Locket and a Harshaw DN-56 silicon diode. The elements of the locket consist of sulfur, indium, gold, cadmium and plastic (Figure 3.2.1.2). Criticality packages will be irradiated free-in-air on stands or mounted front and back on a plastic belt for irradiation on an LLNL BOMAB or acrylic slab phantom.

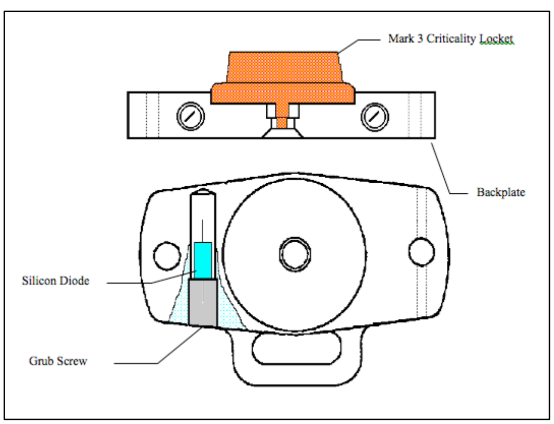


Figure 3.2.1.1: Mark IV Criticality Package   Figure 3.2.1.2: Criticality Package Contents

[1] Statement of Service for External Accident Dosimetry, EDMS1/80119B86/DRMS

Photon measurements will be performed with a Harshaw Type 8814 thermo-luminescent dosimeter (TLD) (Figure 3.2.1.3), which will be mounted close to the locket.

Figure 3.2.1.3: Harshaw Type 8814 TLD

AWE is in the final stages of development and commissioning of their new passive single sphere spectrometer[2] (BSSS). This instrument contains gold foils at different depths in a polyethylene sphere and will be used to efficiently characterize one additional location as shown in Figure 3.1.2.

In addition to irradiated criticality packages, AWE requires the following equipment to be present in the Mercury NAD Laboratory:

- John Caunt Scientific Positive Intrinsic Negative (PIN) diode reader.
- BP4 GM tube connected to an RM5/1 rate-meter or a PDM/1 dosemeter.
- Canberra Industries iSolo[3] Alpha/Beta Counting System
- High-purity germanium (HPGe) gamma-ray spectrometer
- Laptop computers for data storage and analysis

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[2] Nuclear Instruments and Methods in Physics Research A 677 (2012) 4-9, *Designing an Extended Energy Range Single-Sphere Multi-Detector Neutron Spectrometer*, J. M. Gómez-Ros et al.
[3] http://www.canberra.com/products/radiochemistry_lab/pdf/iSolo-SS-C38306.pdf

3.2.2 Institut de Radioprotection et de Sûreté Nucléaire

Matthieu Duluc and François Trompier are the point-of-contacts for the Institut de Radioprotection et de Sûreté Nucléaire (IRSN). The contact information is specified below.

- Matthieu Duluc, email: matthieu.duluc@irsn.fr, tel. +33 1 58 35 85 66
- François Trompier email: francois.trompier@irsn.fr, tel. +33 1 58 35 72 41

IRSN will deploy the following PNAD and FNAD[4]:
- SNAC 2 (Neutron spectrometer with activation foils) shown in Figure 3.2.2.1;
- New IRSN CAD (Criticality Accident Dosimeter)[5] shown in Figure 3.2.2.2, including alanine, bare and cadmium-covered gold foils, CR-39 and RPL dosimeter;
- Criticality belt;
- Radiophotoluminescence dosimeter (RPL);
- Chemical Dosimeter;
- Silicon Diode shown in Figure 3.2.2.3;
- Thermoluminescent dosimeter (TLD);
- Sulphur pellets covered by cadmium.

Figure: 3.2.2.1 SNAC 2

Figure: 3.2.2.2 IRSN CAD

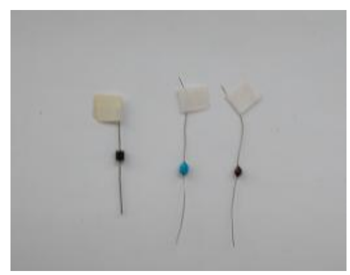

Figure: 3.2.2.3 Silicon Diode

Furthermore, IRSN will deploy radiation protection instrumentation:
- Electronic personal dosimeters (EPD) like DMC 3000, DMC 2000GN, Dosicard, EPD N2, SAPHYDOSE, etc.
- Portable survey meters (FH40G, RADEYE, etc.)

Finally, IRSN will train and maintain expertise in radiobiology with the irradiation of:
- Hair, nails, tooth enamel, etc.

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[4] Examples of publication of the use of these NAD are presented hereafter.
Asselineau, B. et al. Reference dosimetry measurements for the international intercomparison of criticality accident dosimetry SILENE 9-21 June 2002, (2004) Radiation Protection Dosimetry, 110, pp. 459-464.
Trompier, F. et al. EPR dosimetry in a mixed neutron and gamma radiation field (2004) Radiation Protection Dosimetry, 110, pp. 437-442.
Trompier, F. et al. Dosimetry of the mixed field irradiation facility CALIBAN, (2008) Radiation Measurements, 43, pp. 1077-1080.
[5] http://dosimetre.irsn.fr/fr-fr/Documents/Fiches%20produits/IRSN_Fiche_dosimetrie_criticite.pdf

IRSN will also 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;
- EPD and Portable survey meters readers;
- Electrical adaptators and transformers ;
- A beta counter;
- A TLD reader;
- A RPL reader;
- An EPR spectrometer.

For the calibration (in efficiency) of the gamma spectrometers (NaI and HPGe), some foils composing the SNAC2 will be dissolved using chemical reagents.

Eventually, for future experiments beyond IER148, IRSN would like to utilize:

- Ellipsoid phantom filled of water (from the SILENE 2002 intercomparison)
- PLASTINAUT phantom

3.2.3 Knolls Atomic Power Laboratory

Thomas Zieziulewicz is the point-of-contact for Knolls Atomic Power Laboratory (KAPL) representing the Naval Nuclear Propulsion Program (NNPP). His contact information together with that of other KAPL participants is specified below.

- Thomas Zieziulewicz: 518-395-4268, Thomas.Zieziulewicz.contractor@unnpp.gov
- Colby Mangini: 518-395-6987, Colby.Mangini.contractor@unnpp.gov
- Stefan Melnick: 518-395-6520, Stefan.Melnick.contractor@unnpp.gov

KAPL's whole body dosimeter is the NNPP DT-702/PD, which is manufactured by Thermo Fisher Scientific (formerly Harshaw) and is comprised of the Harshaw 8841 dosimeter and Harshaw 8840 holder. Each Harshaw 8841 dosimeter contains one neutron sensitive TLD-600H (4.0% ^{7}Li and 95.60% ^{6}Li) and three neutron insensitive TLD-700H (99.93% ^{7}Li and 0.07% ^{6}Li) Lithium Fluoride (LiF) chips doped with Magnesium (Mg), Copper (Cu) and Phosphorous (P) (LiF:MCP). The Harshaw 8840 holder contains four distinct radiation attenuating filters comprised of various materials and density thicknesses. See Figure 3.2.3.1 and Table 3.2.3.1 for a detailed description and picture of what comprises each individual NNPP DT-702/PD dosimeter position. Together, the DT-702/PD whole body dosimeter provides results, which can be used to determine type of radiation measured (i.e., beta, photon and neutron), type of dose measured (e.g., deep, shallow, etc.) and total dose.

For the following study, all exposures will be performed using the NNPP DT-702/PD whole body dosimeter mounted to the face of an acrylic slab phantom oriented towards the critical assembly. Following exposures, all dosimeters will be returned and processes at KAPL. Results will be used to further establish the response characteristics of the NNPP DT-702/PD dosimeter under these types of exposures and/or conditions.

KAPL will not require any NAD Laboratory support. All dosimeter will be returned and processed at KAPL.

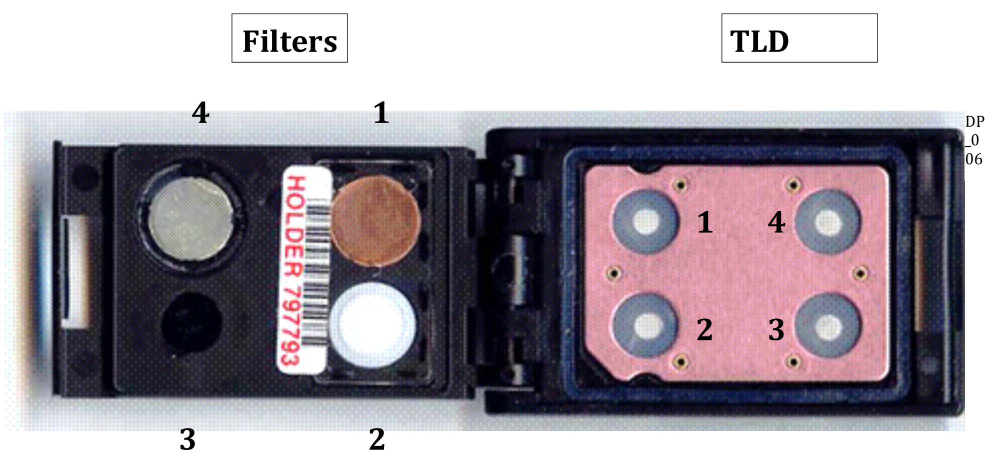


Figure 3.2.3.1: DT-702/PD Dosimeter (Harshaw 8841 dosimeter and Harshaw 8840 holder)

Table 3.2.3.1: Individual DT-702/PD Dosimeter Position LiF Chip and Filter Information

Chip Position	Type of Chip	Filter Material	Filter Material Density Thickness (mg/cm²)	Type of Radiation Measured	Type of Dose Measured	Density Thickness for Dose Type (mg/cm²)
1	^{7}LiF	Clear Acrylic, ABS and Thin Copper	425	photon	Lens of the eye	300*
2	^{7}LiF	ABS and Teflon	1006	photon	Photon deep dose	1000
3	^{7}LiF	Mylar window	6.8	beta, photon	Shallow dose	7
4	^{6}LiF	Clear Acrylic, ABS and Thick Tin	1298	neutron, photon	Neutron deep dose	NA
* Note that 425 is not equal to 300—the copper filter density, although close, was selected for better photon energy discrimination						

*Note: Refers to Chip Position 1 – Lens of the eye

- ^{7}Li = TLD-600H (4.0% ^{7}Li and 95.60% ^{6}Li)
- ^{6}Li = TLD-700H (99.93% ^{7}Li and 0.07% ^{6}Li)

3.2.4 Lawrence Livermore National Laboratory

Dave Heinrichs is the IER-148 point-of-contact. Dave Hickman is the NAD team lead for Lawrence Livermore National Laboratory (LLNL). Jennifer Burch, Doug McAvoy and Gary Slavik are the LLNL points-of-contact for the Mercury NAD Laboratory and LLNL activities in the DAF. Their contact information together with that of the other LLNL participants is specified below.

- Dave Heinrichs, email: heinrichs1@llnl.gov, tel. 925-424-5679
- Dave Hickman, email: hickman3@llnl.gov, tel. 925-422-8958
- Jennifer Burch, email: burch6@llnl.gov, tel. 925-422-7747
- Doug McAvoy, email: mcavoy1@llnl.gov, tel. 925-423-1719
- John Scorby, email: scorby1@llnl.gov, tel. 925-423-4131
- Gary Slavik, email: slavik2@llnl.gov, tel. 702-295-0659
- Jack Topper, email: topper1@llnl.gov, tel. 925-423-8082
- Carolyn Wong, email: wong65@llnl.gov, tel. 925-422-0398

The LLNL dosimetry elements[6] to be placed in proximity to Godiva are PNADs, FNADs, CR-39, personal "pocket" or "pencil" ionization chambers (PICs) and glassine envelopes containing hair samples. These elements will be placed free-in-air on stands (Figures 3.2.4.9-3.2.4.10) or mounted on an LLNL BOMAB phantom (Figure 3.2.4.5-3.2.4.8) filled with water or saline solution. LLNL may also utilize the LANL or SNL acrylic (PMMA) slab phantoms (Figure 3.2.5.3) for comparison purposes.

The LLNL PNAD (Figure 3.2.4.1) consists of a Panasonic TLD, gold, indium and copper foils, a sulfur pellet, cadmium and borated plastic shields, and plastic caps inside a plastic case. The LLNL FNAD (Figure 3.2.4.2) consists of indium, gold and copper foils, a sulfur pellet, cadmium and borated plastic shields inside an aluminum case. The 4 TLD-700 chips are not present. Panasonic TLDs may be placed on top or in proximity to the FNAD.

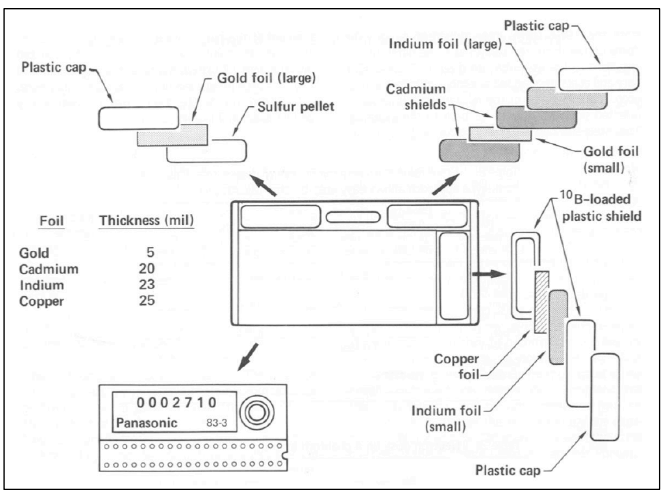


Figure: 3.2.4.1: LLNL PNAD

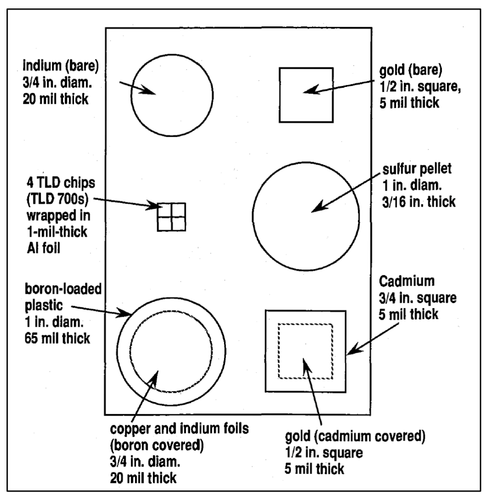


Figure: 3.2.4.2 LLNL FNAD

[6] Evaluation of LLNL's Nuclear Accident Dosimeters at the CALIBAN Reactor, September 2010, D.P. Hickman et al., LLNL-TR-489712; http://ncsp/nad/IM-50067-final_v2.pdf

LAURUS Systems Direct Reading Pocket Dosimeters[7] (Figure 3.2.4.3) Models 740 (0-100 R), 742 (0-200 R) and 746 (0-600 R) will be used to determine photon doses. CR-39 film (Figure 3.2.4.4) may also be used for neutron doses. LLNL will also deploy aluminum capsules containing 1-mg ^{235}U fission deposits developed for IER147 within the Godiva foil holder[8] placed within the GODIVA-IV central cavity.

Figure 3.2.4.3: Pocket Dosimeters

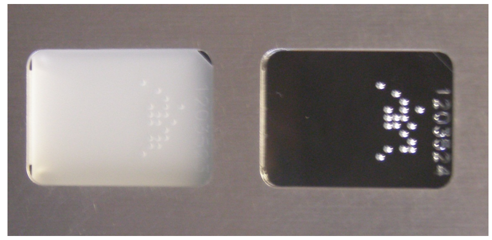


Figure 3.2.4.4: CR-39 after high dose (left) and low dose (right)

LLNL will place PNADs and pocket dosimeters on the LLNL Seamless Bottle Manikin Absorption (BOMAB) phantom[9] (Figure 3.2.4.5) for irradiation in the Godiva building. The BOMAB consists of ten bottles each of which has a recessed screw-type fill port and screw cap that is leak proof when securely tightened. These bottles will be filled with water or saline solution (simulating blood) prior to receipt in the DAF. The bottles will remain closed in the DAF at all times. The BOMAB phantom may be dressed in anti-C's with glassine envelopes containing hair taped in various places.

The LLNL Seamless BOMAB

The **BO**ttle **M**anikin **AB**sorption (BOMAB) Phantom is used to calibrate whole body counters. The seamless BOMAB consists of ten bottles with dimensions as given in Table 1. The seamless BOMAB is composed of polyethylene plastic and constructed without seams in any of the ten bottles. The volumes of the manufactured version are within 20% of the values specified in Table 1 for cylindrical parts. The total volume of manufactured phantoms tend to have an overall tolerance of 10%. Each bottle has a recessed screw-type fill port. The screw cap is provided with each bottle and is leak proof when securely tightened.

Table 1. BOMAB Dimensions

	Shape	Cross Section (cm)	Vertical Height (cm)	Fill Volume (cm3)
Head	Elipsoid	19 x 14	20	3525
Neck	Cylinder	13 (diam)	10	1030
Upper Torso	Elipsoid	30 x 20	40	16970
Lower Torso	Elipsoid	36 x 20	20	9990
Thighs (2x)	Cylinder	15 (diam)	40	12100
Lower Legs (2x)	Cylinder	12 (diam)	40	7490
Arms (2x)	Cylinder	20 (diam)	60	7600

Figure 3.2.4.5: LLNL Seamless BOMAB Phantom

7 http://www.laurussystems.com/products/products_pdf/Direct_Reading_Dosimeters.pdf

8 LANL Drawing No. 128Y-271216.

9 https://wbc.llnl.gov/bomab.php

The LLNL-designed BOMAB original fill port (Figure 3.2.4.6) has been re-designed (Figure 3.2.4.7) to enable removal of liquid samples using a syringe.

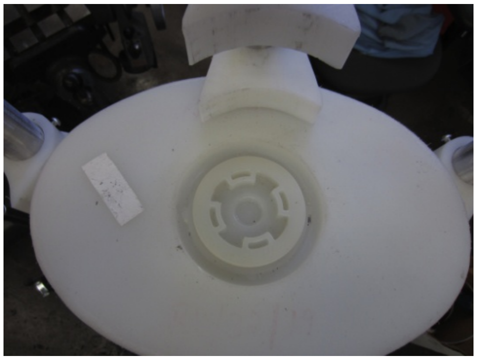


Figure 3.2.4.6: Original BOMAB Port Design

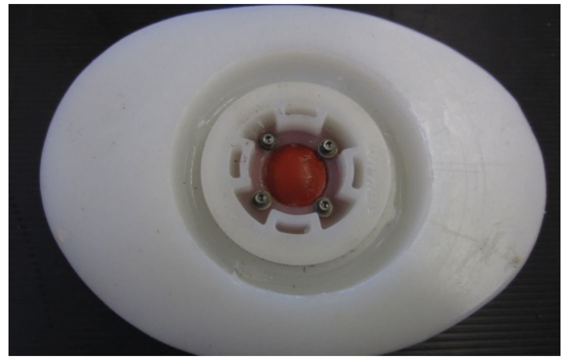


Figure 3.2.4.7: New BOMAB Port Design

LLNL will procure 8 BOMAB phantoms for use at NNSS in both the DAF and NAD Lab. LLNL has designed and fabricated a stand (Figure 3.2.4.8) to secure the BOMAB phantom to preclude its toppling over onto or near the GODIVA-IV assembly. LLNL will fabricate 7 more stands for the BOMAB phantoms. LLNL will provide small (~10 ml) sample vials of activated saline solution from the BOMABs for laboratories wanting to participate in simulated biological dosimetry.

LLNL will also attach NAD elements on the Hopewell Designs acrylic (PMMA) slab phantom (Figure 3.2.5.3) for comparison purposes to the BOMAB.

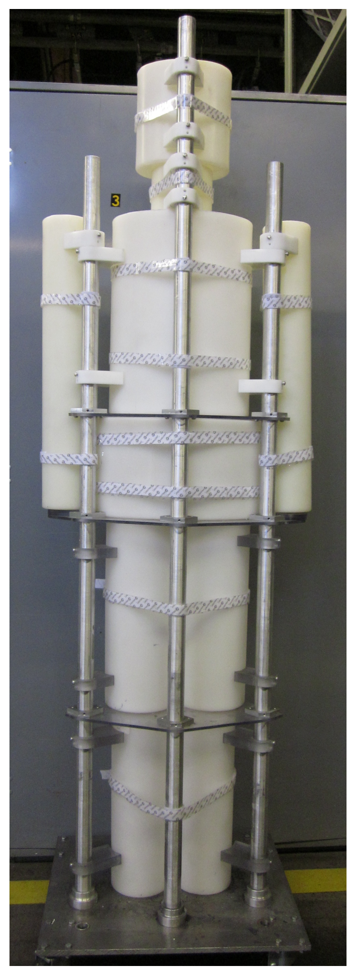
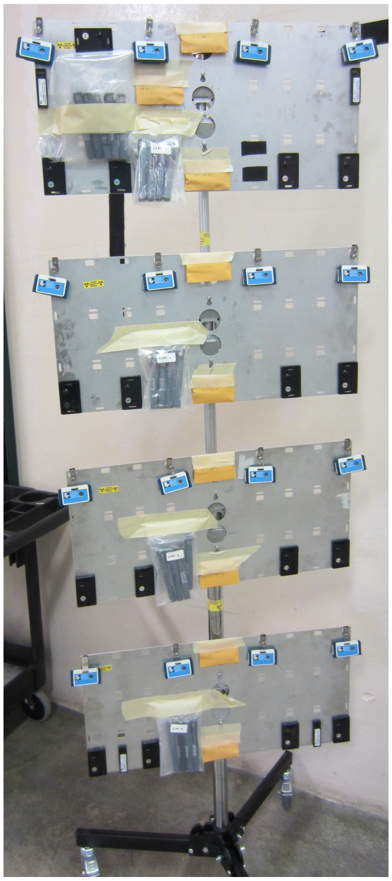


Figure 3.2.4.8: BOMAB and Stand

For free-in-air dose measurements, LLNL will place NAD elements on movable Avenger A5033 Roller 33 Folding Base support stands[10] (Figure 3.2.4.9) with 2 or 4 (shown) aluminum plates for mounting NAD elements (Figure 3.2.4.10).



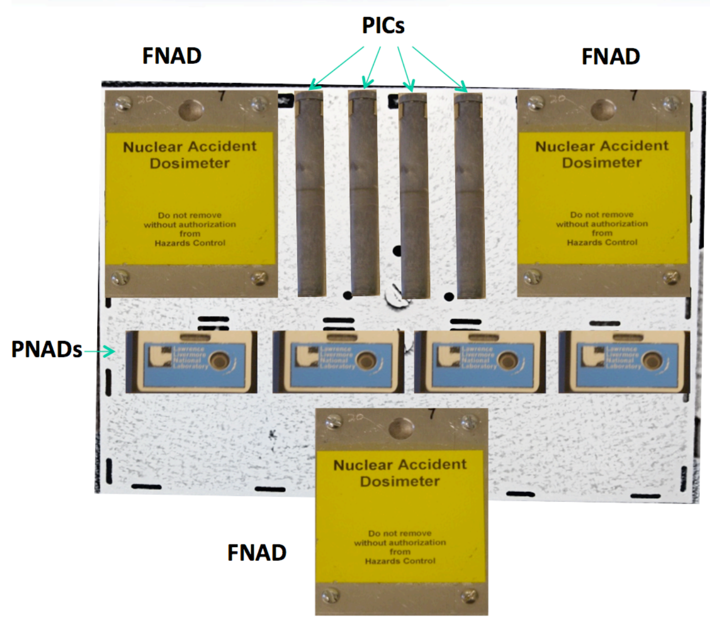


Figure 3.2.4.10: Mounting Plate for NADs

Figure 3.2.4.9: Adjustable Rolling NAD Stand

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

- Ludlum Model 12[11] GM counter with a Model 44-38[12] GM probe (battery powered)
- Eberline E120[13] with a Model 177 GM probe (battery powered)
- Canberra Industries Falcon 5000[14] Portable HPGe Gamma Spectroscopy System
- Canberra Industries iSolo[15] Alpha/Beta Counting System
- Charger for personal ionization chambers (uses a single “D” cell battery)
- Laptop computers

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[10] http://www.avenger-grip.com/cms/site/avenger/home/search_product/product_user_search

[11] Ludlum Model 12 Count Ratemeter, Revised July 1999, Ludlum Measurements Inc., Sweetwater, TX

[12] http://www.drct.com/dss/INSTRUMENTATION/Ludlum/Ludlum_Probes/Ludlum_Model_44-38_probe.htm

[13] E-120/E-120E Geiger Counter Technical Manual, Thermo Electron Corp. RM&P, Santa Fe, NM

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

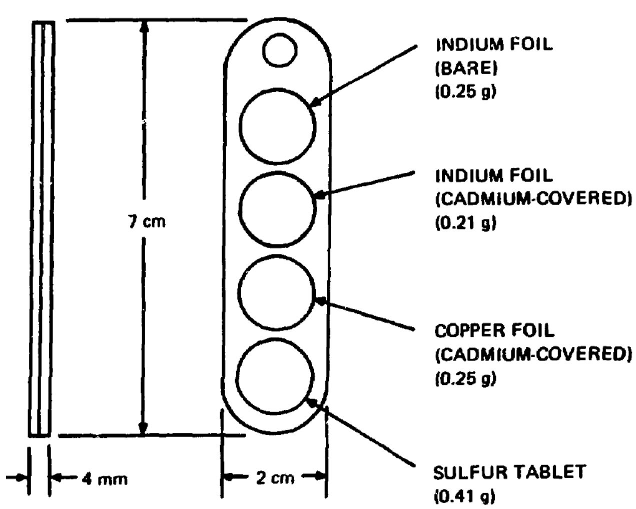
[15] http://www.canberra.com/products/radiochemistry_lab/pdf/iSolo-SS-C38306.pdf

3.2.5 Los Alamos National Laboratory

Los Alamos National Laboratory (LANL) will provide irradiation services using the Godiva-IV pulsed reactor. Joetta Goda is the Principal Investigator for Godiva. Either she or Dave Hayes will be the crew chief and person-in-charge (PIC). Rene Sanchez or John Bounds will be the crew member. Tim Beller is the Deputy Group Leader of NEN-6 and is permanently stationed at the DAF. He handles scheduling and interfaces with the DAF Facility. Milan Gadd is the LANL program lead for LANL's criticality accident dosimetry program. Their contact information together with that of the other LANL participants is specified below.

- Joetta Goda, email: jgoda@lanl.gov, tel. 505-667-2812
- Dave Hayes, email: dkhayes@lanl.gov, tel. 505-667-4523
- Rene Sanchez, email: rgsanchez@lanl.gov, tel. 505-665-5343
- John Bounds, email: jbounds@lanl.gov, tel. 505-665-0446
- Tim Beller, email: beller@lanl.gov, tel. 702-794-5334
- Milan Gadd, email: milang@lanl.gov, tel. 505-667-2713
- Victoria Homan, email: vhoman@lanl.gov, tel. 505-665-0713

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 3.2.5.1. Figure 3.2.5.2 shows the Los Alamos Criticality Dosimeter (LACD), which is deployed in fixed locations where there is a potential for criticality accidents. Elements of the LACD are bare and cadmium-covered indium and gold foils, a cadmium-covered copper foil, a sulfur tablet, and a Harshaw/Bicron 6776 TLD card. Some LACD packets also contain other elements, such as Phylatron diodes and glass rods, however these are no longer used for dose estimations.



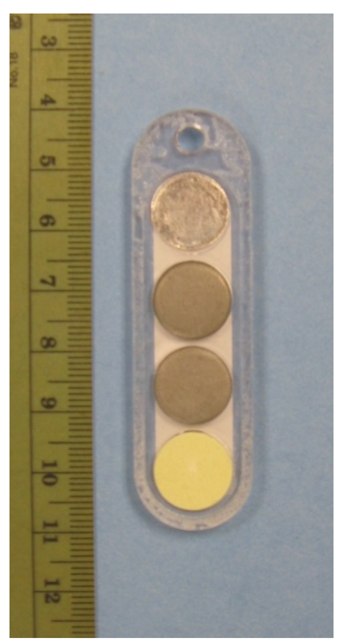


Figure 3.2.5.1: LANL Personal Nuclear Accident Dosimeter

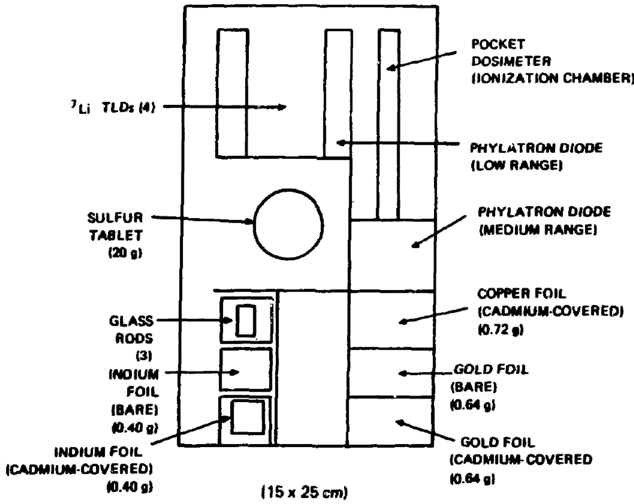


Figure 3.2.5.2: Los Alamos Criticality Dosimeter

LANL will attach PNADs to an acrylic (PMMA) slab phantom on a removable plate or sheet for rapid removal without having to move the entire phantom. The phantom is 30 cm x 30 cm x 15 cm or 40 cm x 40 cm x 15 cm[16,17]. A photograph of a typical phantom is shown in Figure 3.2.5.3. Alternatively, LANL may utilize the acrylic (PMMA) slab phantoms provided by SNL.

Figure 3.2.5.3: Hopewell Designs Acrylic (PMMA) Slab Phantom

[16] Drawing No. 3502 R2 - 30 cm Body Phantom, Hopewell Designs, Inc., September 28, 2011.
[17] Drawing No. 4148 R1 - 40 cm Body Phantom, Hopewell Designs, Inc., September 28, 2011.

Each Acrylic Slab Phantom will be placed on a horizontal platform fixed to a Genie® Super Hoist™ CO_2 portable pneumatic lift [18] or it will be placed on a stand that is typically used with the slab phantoms.

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), a Canberra $LaBr_3$(Ce) detector, and Bicron 2XM.75BC408/2A plastic scintillator. Data acquisition will be performed using Canberra Inspector-2000, Ortec DigiBase, and/or Ortec EasyMCA multi-channel analyzers controlled by Canberra Genie-2000 or Ortec GammaVision MCA emulation software installed on a laptop computer. All detectors will be shielded by 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 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-260 Geiger-Mueller detector connected to an Eberline ESP-1 or RadEye digital survey meter.
- Laptop computers

[18] http://www.genielift.com/en/products/new-equipment/material-lifts/super-hoist/index.htm

3.2.6 Nevada National Security Site

Nevada National Security Site (NNSS) will provide Radiological Control services including the shipment and initial contamination surveys of NADs. Pam McGinley is the NNSS primary contact for the criticality accident dosimetry program. Rick Cummings is the senior scientist providing technical support to Pam. Their contact information is specified below.

- Pam McGinley, email: mcginlpk@nv.doe.gov, tel. 702-295-0521
- Rick Cummings, email: cumminfm@nv.doe.gov, tel. 702-295-1393

NNSS will deploy Personnel Neutron Dosimeters for on-phantom measurements and Nuclear Accident Dosimeters (NADs) for free-in-air measurements. The NNSS NAD consists of bare and cadmium-covered indium foils, a cadmium-covered copper foil, and a sulfur tablet as shown in the sketch and photograph provided as Figures 3.2.6.1 and 3.2.6.2, respectively.

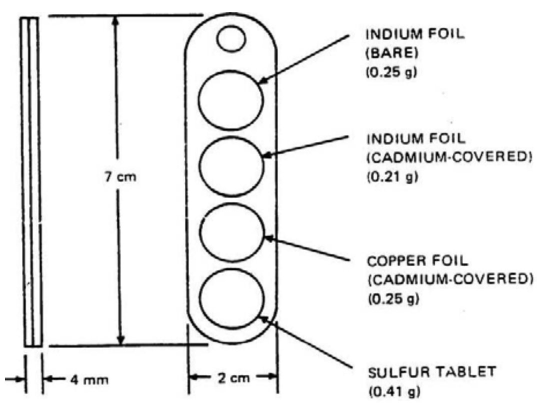


Figure 3.2.6.1: NNSS NAD Elements

Figure 3.2.6.2: NNSS NAD Photograph

NNSS will also irradiate two NNSS personnel combination dosimeters shown in Figure 3.2.6.3. The combination dosimeter comprises two Panasonic thermoluminescence dosimeters, the beta/gamma portion using a UD-812 dosimeter and the neutron portion using a UD-809 dosimeter. Irradiations will be conducted on PMMA phantoms provided by LLNL. Velcro strips are affixed to the rear of the dosimeter to facilitate attachment to the PMMA phantom.

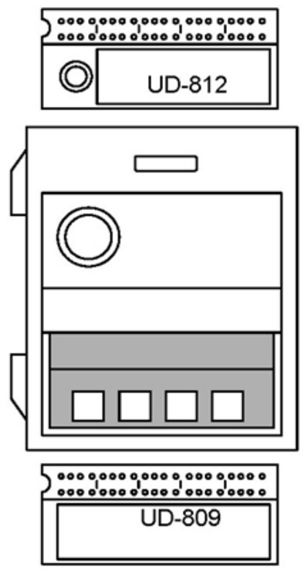


Figure 3.2.6.3: NNSS UD-812/809 Combination Dosimeter

3.2.7 Pacific Northwest National Laboratory

Bruce Rathbone is the point-of-contact for the Pacific Northwest National Laboratory (PNNL). His contact information together with that of the other PNNL participant is specified below.

- Bruce Rathbone (POC), email: Bruce.Rathbone@pnnl.gov, tel. 509-375-7325
- Shannon Morley, email: Shannon.Morley@pnnl.gov, tel. 509-375-1968
- Richard Pierson, email: Richard.Pierson@pnnl.gov, tel. 509-371-7815

Dosimeters to be deployed for each pulse, by PNNL are the Hanford FNAD, Hanford, PNAD, and PNNL PNAD. Samples to be irradiated during the exercise include saline solution in BOMAB phantom, and hair samples in glassine envelopes. The PNADs will be mounted on the NAD stands, BOMAB phantoms and PMMA phantoms provided for participants. PNNL plans to fully utilize the number of dosimeter irradiation positions made available to each participant. For each pulse, an FNAD, will be placed on a stand at a location designated for this purpose (assuming that locations will be made available).

The Hanford PNAD is based on the outer dosimeter packet of the Hanford FNAD design (and the PNAD used at LANL). Figure 3.2.7.1 shows the Hanford PNAD in current use and Figure 3.2.7.2 shows the modified design to be used for these experiments. In both cases, the PNAD consists of bare and Cd shielded In foils, a Cd shielded Cu foil, a S pellet and a TLD-700 chip. The only differences between the designs are: (1) the outer Plexiglas case is held together by nylon screws for easy disassembly instead of a glued case in the deployed Hanford PNAD; (2) the fragile S pellet is encased in heat-sealed plastic to maintain its physical integrity during handling and counting; and (3) two TLD-700 chips are included in the test PNAD rather than just the one in the Hanford PNAD to improve counting statistics.

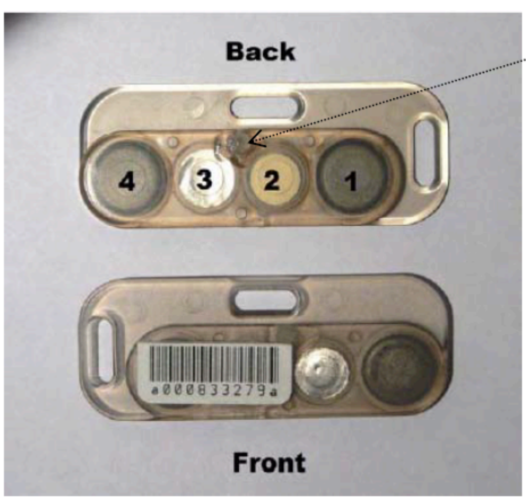


Figure 3.2.7.1: Hanford PNAD

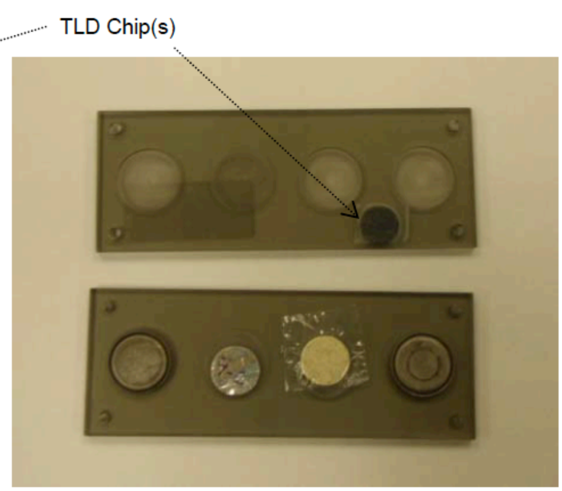


Figure 3.2.7.2: Hanford Test PNAD

The Hanford FNAD is shown in Figures 3.2.7.3 and 3.2.7.4. In addition to the TLD chips shown in Figure 3.2.7.2, the FNADs to be used in the exercise will include a pair of OSL/OSLN nanoDots in the outer dosimetry package and a pair in the inner dosimetry package. The nanoDots are manufactured by Landauer Inc. and will be read using a specially modified microStar Reader manufactured by Landauer, Inc., that is suitable for accident level dosimetry. Among other modifications, this reader has a neutral density filter inserted in the optical path to reduce the amount of light reaching the PM tube. The OSL nanoDots are sensitive to gamma radiation only. The OSLN nanoDots are sensitive to gamma and neutron radiation. The nanoDots are being included in this exercise in anticipation of eventual replacement of the TLD chips with OSL/OSLN nanoDots in the FNADs deployed in PNNL facilities.

The PNNL PNAD is shown in Figures 3.2.7.5 and 3.2.7.6. This dosimeter includes the same activation foil materials as the Hanford PNAD and an InLight LDR Model 2 OSLN dosimeter which is capable of providing both gamma and neutron dose results. The OSLN dosimeter will be read on the specially modified microStar reader described above. The indium and copper activation foils in the PNNL PNAD differ from those in the Hanford PNAD in that they are thicker than the foils in the Hanford PNAD. The cadmium filters and sulfur pellets are identical to those in the Hanford PNAD. The PNNL PNAD design is included in this exercise in anticipation of implementation for PNNL employees who are required to wear PNADs. Table 3.2.7.1 provides the dimensions of the Hanford and PNNL PNAD components.

	Hanford PNAD				PNNL PNAD			
Detector Position	1	2	3	4	1 (top)	1 (bottom)	2	3
detector composition	Cu	S	In	In	In	S	In	Cu
detector thickness (mm)	0.127	2.92	0.127	0.127	0.254	2.92	0.254	0.254
detector dimensions (cm)	1.27	1.27	1.27	1.27	1.27 x 1.57	1.27	1.27	1.27
filter composition	Cd	none	none	Cd	none	none	Cd	Cd
filter thickness (mm)	0.533	none	none	0.533	none	none	0.533	0.533

Table 3.2.7.1 PNAD Component Dimensions

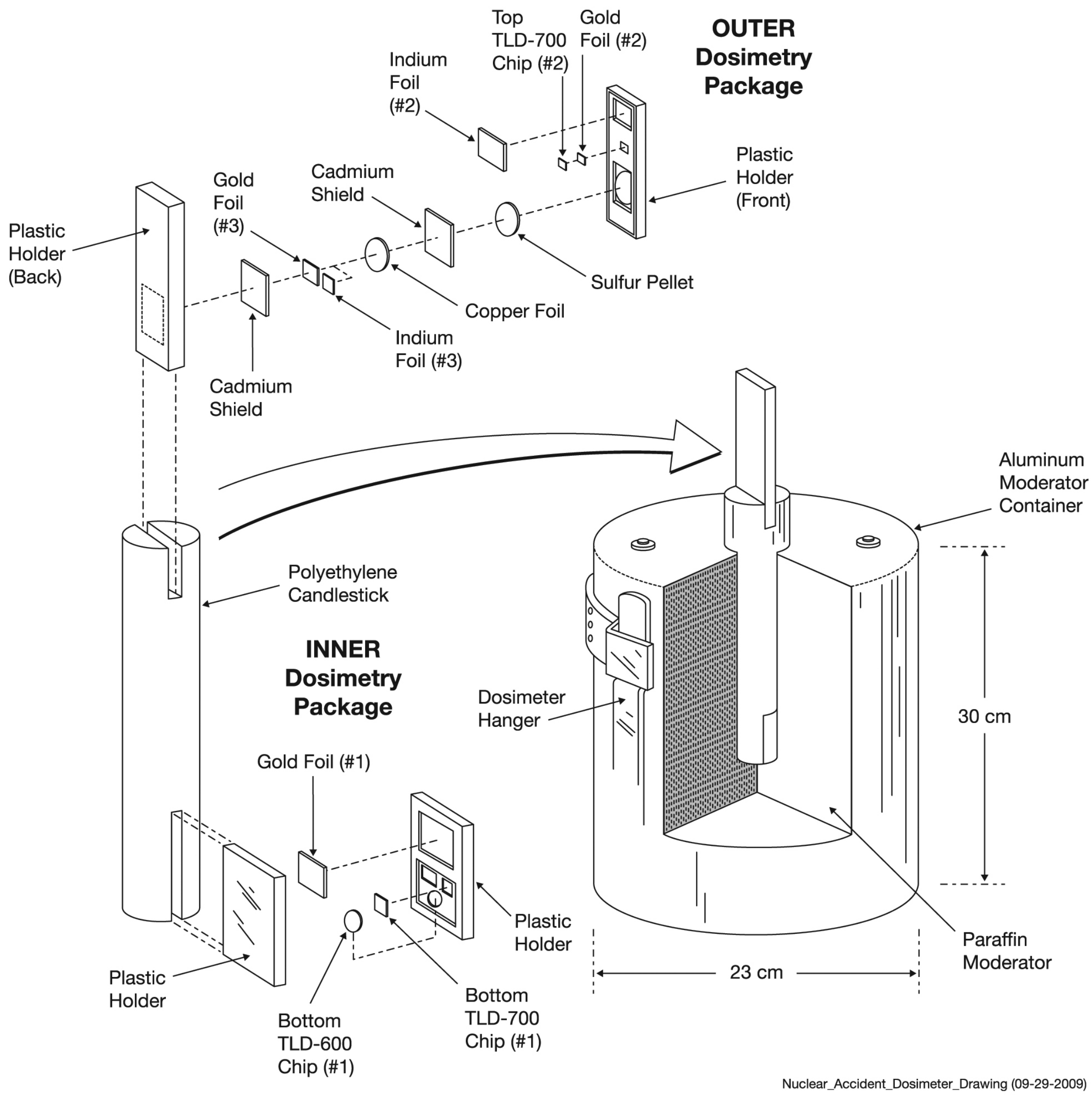


Figure 3.2.7.3: Hanford FNAD Components

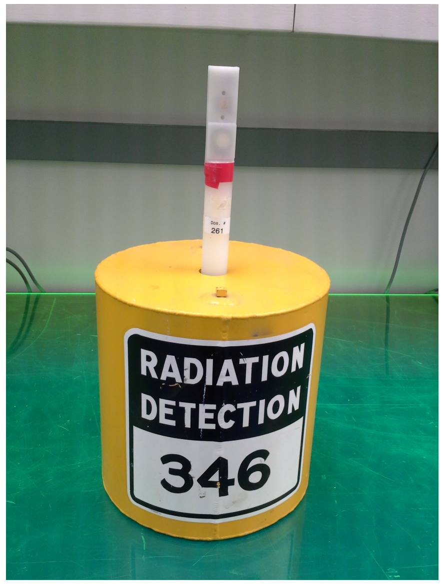


Figure 3.2.7.4 Hanford FNAD

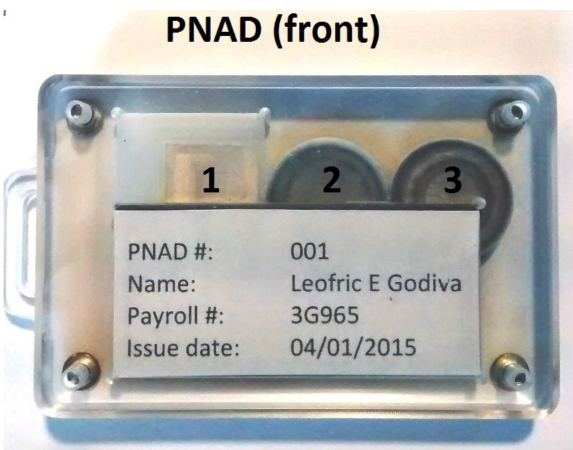


Figure 3.2.7.5: PNNL PNAD (front)

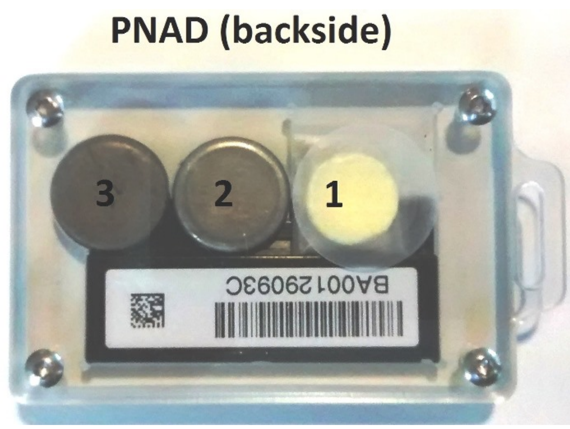


Figure 3.2.7.6: PNNL PNAD (backside)

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

- Canberra Industries Falcon 5000 Portable HPGe Gamma Spectroscopy System
- Ortec Detective-200 Transportable HPGe Radionuclide Identification System
- LN cooled Canberra or Ortec HPGe Gamma Spectroscopy System (Dewar, detector, and cave table)
- Canberra Industries iSolo Alpha/Beta Counting System
- Landauer microStar InLight dosimeter reader with laptop
- Laptop computers
- Hot plates

Other supplies that PNNL will bring to the NAD laboratory include:

- Pb bricks to construct a cave to shield detector(s) and samples from surrounding emissions
- Pancake GM counter (e.g. An Eberline E600[19] with a Model SHP270 Geiger-Müller probe)
- 2-dram poly snap-cap vials
- Plastic bags and heat sealer
- Glass beakers/evaporating dishes and watch glasses
- Stainless steel planchets
- Tongs/tweezers
- Hot plate temperature spot checker
- Al absorbers for beta measurements

The TLDs will be returned to PNNL for analysis using a Harshaw Model 5500 TLD reader.

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

3.2.8 Sandia National Laboratories

Dann Ward is the point-of-contact for Sandia National Laboratories (SNL). His contact information together with that of the other SNL participants is specified below.

- Dann Ward (POC), email: dcward@sandia.gov, tel. 505-844-8325
- Elliott Leonard, email: ejleonard@sandia.gov, tel. 505-284-2917
- David Vehar, email: dwvehar@sandia.gov, tel. 505-845-3414

SNL will deploy their Personal Nuclear Accident Dosimeter (PNAD) and Whole Body Dosimeter. The PNAD[20] is the SNL Criticality Dosimeter, which is a sealed plastic housing containing a NaF pellet, Al, Ni, Ti and In bare foils, and a Cd covered Cu foil (Figure 3.2.8.1). The TLD is a Thermo Electron Type 8825 whole-body dosimeter consisting of a four-element aluminum TLD card holder containing three TLD-700 (7LiF:Mg,Ti) chips and one TLD-600 chip surrounded by a polyethylene case with Cu/ABS plastic, PTFE/ABS, aluminized Mylar and Sn/ABS filters as shown in Figure 3.2.8.2. SNL will also deploy their CaF_2:Mn TLDs. The whole body dosimeters and CaF_2 TLDs will be returned to SNL for analysis.

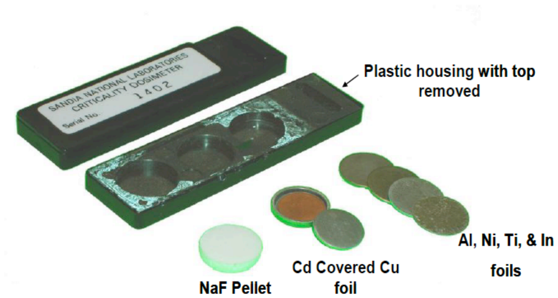


Figure 3.2.8.1: SNL Criticality Dosimeter

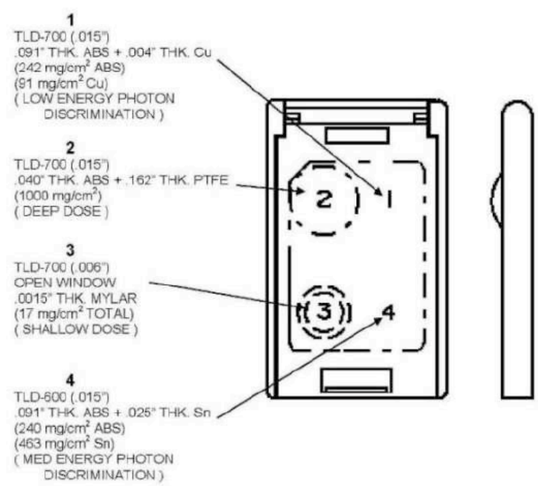


Figure 3.2.8.2: SNL Type 8825 TLD

SNL will also deploy Arrow-Tec Direct Reading Pocket Dosimeters (Figure 3.2.8.3) Models W740 (0 – 100 R) and 742 (0 – 200 R), CaF_2:Mn TLDs (Figure 3.2.8.4) and two 30 x 30 x 15 cm^3 PMMA Slab Phantoms with Stands (Figure 3.2.8.5). The whole body dosimeters and CaF_2 TLDs will be returned to SNL for analysis.

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

Figure 3.2.8.3: Arrow-Tec Direct Reading Pencil Chambers

Figure 3.2.8.4: CaF2 TLDs showing aluminum buildup material around chip

Figure 3.2.8.5: PMMA slab phantom on stand.

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

- Canberra Industries Falcon 5000[21] Portable HPGe Gamma Spectroscopy System
- An Eberline E600[22] with a Model SHP270 Geiger-Müller probe

[21] http://www.canberra.com/products/hp_radioprotection/pdf/Falcon-SS-C38597.pdf
[22] http://www.equipcoservices.com/pdf/manuals/eberline_e-600.pdf

3.2.9 Savannah River Site

Randy Sullivan is the point-of-contact for the Savannah River Site (SRS). His contact information together with that of the other SRS participants is specified below.

- Randy Sullivan (POC), email: randy.sullivan@srs.gov, tel. 803-952-8952
- Scott Dyer, email: scott.dyer@srs.gov, tel. 803-
- Dave Roberts, email: david-w.roberts@srs.gov, tel. 803-

SRS will deploy their Criticality Neutron Dosimeter[23] (CND), which contains four polystyrene vials within a polycarbonate plastic tube with contents as shown in Figure 3.2.9.1.

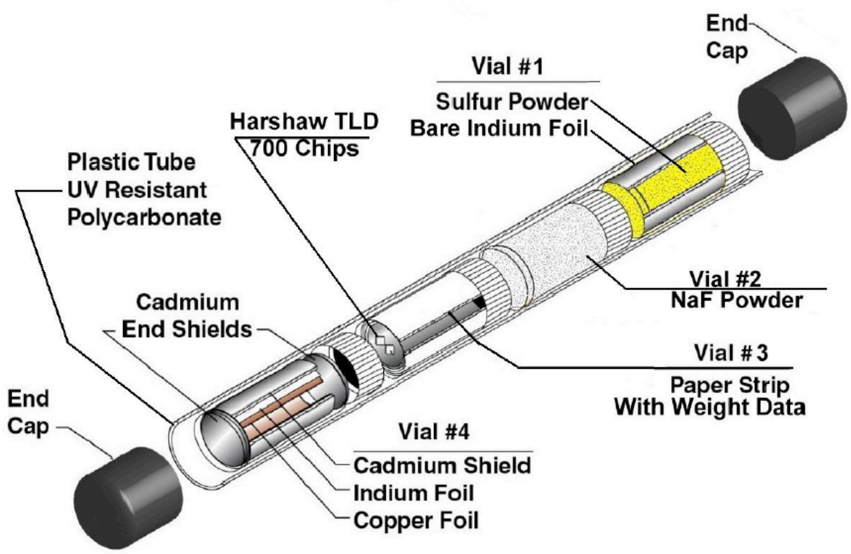


Figure 3.2.9.1: SRS Criticality Neutron Dosimeter

In addition to the SRS CND, SRS will use the Panasonic UD-812AS5 Whole Body TLD. SRS plans to purchase an acrylic slab phantom from Hopewell (see Figure 3.2.5.3). SRS will also utilize the following equipment in the NAD Laboratory requiring 110 power (nominally 114-126 V) outlets:

- Canberra Industries Falcon 5000[24] Portable HPGe Gamma Spectroscopy System
- A ThermoEberline HandECount[25] dual alpha/beta phosphor scintillator controlled by a Palm Personal Digital Assistant (PDA)
- Laptop computers

The Panasonic UD-812AS5 and the Harshaw TLD-700 chips will be returned to SRS for counting.

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[23] *The Savannah River Site Criticality Dosimetry Technical Basis Manual*, WSRC-IM-96-145.
[24] http://www.canberra.com/products/hp_radioprotection/pdf/Falcon-SS-C38597.pdf
[25] http://www.thermo.com/eThermo/CMA/PDFs/Various/File_27104.pdf

3.2.10 Y-12

Ken Veinot is the criticality accident dosimetry team lead for Y-12 with Mike Souleyrette, Boyd Gose, Trevor Davis, and Richard Leach acting as additional subject matter experts. Their contact information is:

- Ken Veinot: 865-241-6165, veinotkg@y12.doe.gov
- Mike Souleyrette: 865-241-4467, souleyrettml@y12.doe.go
- Boyd Gose: 865-574-3550, gosebtjr@y12.doe.gov
- Trevor Davis: 865-241-6241, davistg@y12.doe.gov
- Richard Leach: 865-241-0278, leachrm@y12.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 Na-24 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 3.2.10.1. 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 3.2.10.2.

Figure 3.2.10.1: Harshaw 8805 Beta-Photon Dosimeter Used at Y-12

Figure 3.2.10.2: 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 recently-approved dosimeter is the Mirion DMC-3000 shown in Figure 3.2.10.3.

Figure 3.2.10.3: Mirion Technologies DMC-3000 Dosimeter Used at Y-12

Fixed nuclear accident dosimeters (FNADs) are located in areas with the potential for criticality accidents (see Figure 3.2.10.4).

Triage-type monitoring is performed using the Ludlum Model 3 with Model 44-9 pancake-type G-M probe.[26] 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 Na-24. 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 phantoms containing traceable quantities of sodium 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 Na-24 has a known half-life.

TLD measurements will be performed on-phantom with most oriented toward the critical assembly. Information on TLDs in various angular arrangements would be useful for establishing response characteristics. These TLDs will be processed upon return to the Y-12 site. However, testing from previous inter-comparison studies[27,28] 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.

Y-12 recently received approval to employ the Mirion DMC-3000 electronic dosimeter for CAAS-contingency monitoring. As part of the intercomparison Y-12 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.

The Y-12 FNAD[29], shown in Figure 3.2.10.4, consists of a PMMA moderator with paired ^{6}LiF and ^{7}LiF TLD at the center and activation foils and ^{7}LiF TLDs mounted above the assembly. The TLDs positioned in the center of the sphere are used to estimate the absorbed doses similar to the Rem-ball survey meters. The TLDs positioned above the sphere are located in a 1 cm radius rod to correspond to a 10 mm depth in tissue (e.g. $D_p(10)$). The activation foils provide a means to glean neutron spectral hardness to refine the absorbed dose estimated from the TLDs at the center of the sphere. However, these foils are measured using the high-purity germanium detectors of the Y-12 lung counter facility and therefore will not be measured. Some field measurements of these foils may, however, be performed using portable instrumentation.

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[26] RCO/TBD-083 “Technical Basis for Blood Sodium Activation Measurements at the Y-12 National Security Complex”, K.G. Veinot and B.T. Gose; 2009.

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

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

[29] RCO/TBD-084 “Prototype Fixed Nuclear Accident Dosimeter”, K.G. Veinot, B.T. Gose; 2007.

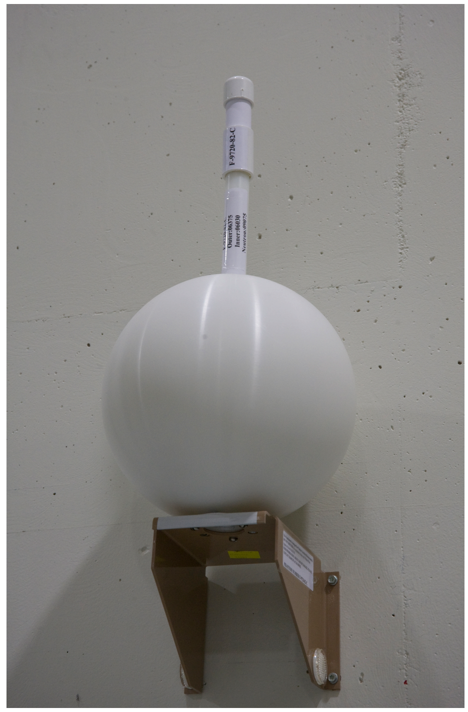

Figure 3.2.10.4: Fixed Nuclear Accident Dosimeter Used at Y-12

Y-12 will also utilize the following equipment in the NAD Laboratory requiring 110 power (nominally 114-126 V) outlets:

- A Ludlum Model 2929 sample counter with Ludlum Model 43-10-1 scintillation detector
- A laptop computer

3.2.11 General Equipment

The following equipment will be provided by LLNL for use by all participants during irradiation measurements near GODIVA-IV in DAF:

- 12 Avenger A5033 Roller 33 stands and mounting plates (Figure 3.2.4.9-3.2.4.10)
- 9 BOMAB phantoms with saline solution and support stands (Figures 3.2.4.8)

The following equipment will be provided by SNL for use by all participants during irradiation measurements near GODIVA-IV in DAF:

- 2 acrylic (PMMA) slab phantoms and support stands (Figure 3.2.5.3)

The following equipment will be provided by AWE with all data provided to all participants during irradiation measurements near GODIVA-IV in DAF:

- Single Sphere Spectrometer and support stand.

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

- Lab benches with adjustable lead shielding
- Static controlled lab chairs
- A balance (0.1 mg - 200 g)
- Mortars and pestles (for crushing sulfur)
- A Captairflex XLS714 ductless fume hood with hot plate (for melting sulfur)
- Planchets, glassine envelopes, pens, tape, plastic bags, lab coats, gloves
- Sample vials containing activated saline solution
- 60 Hz/120V electrical connections (NEMA 5-15R style)
- Digital camera
- Conference/meeting area with computer-based overhead projection and marker boards

3.3 Final Design of the NAD Laboratory

The existing NAD Lab occupies four spaces within Building 23-703 in Mercury with two established radioactive materials areas (RMAs). Experience with three laboratories (AWE, LLNL and SNL) performing measurements in support of IER-147 determined it was necessary to expand the NAD Lab in order to accommodate ten teams participating in IER-148 and future NAD exercises. During IER-147 operations it was further noted that the receiving and breakdown area were too close to the counting area.

Therefore, the final design of the NAD Laboratory includes expanding the footprint to encompass the entire building (Figure 3.3.1) and to make all areas except the office, conference room and bathroom into RMAs. This expansion will create a second counting area and a receiving and breakdown area far from the counting areas. The additional space will allow for storage of sources, irradiated and precious materials and equipment for other programs to be moved into the high bays providing additional floor space in the existing count room.

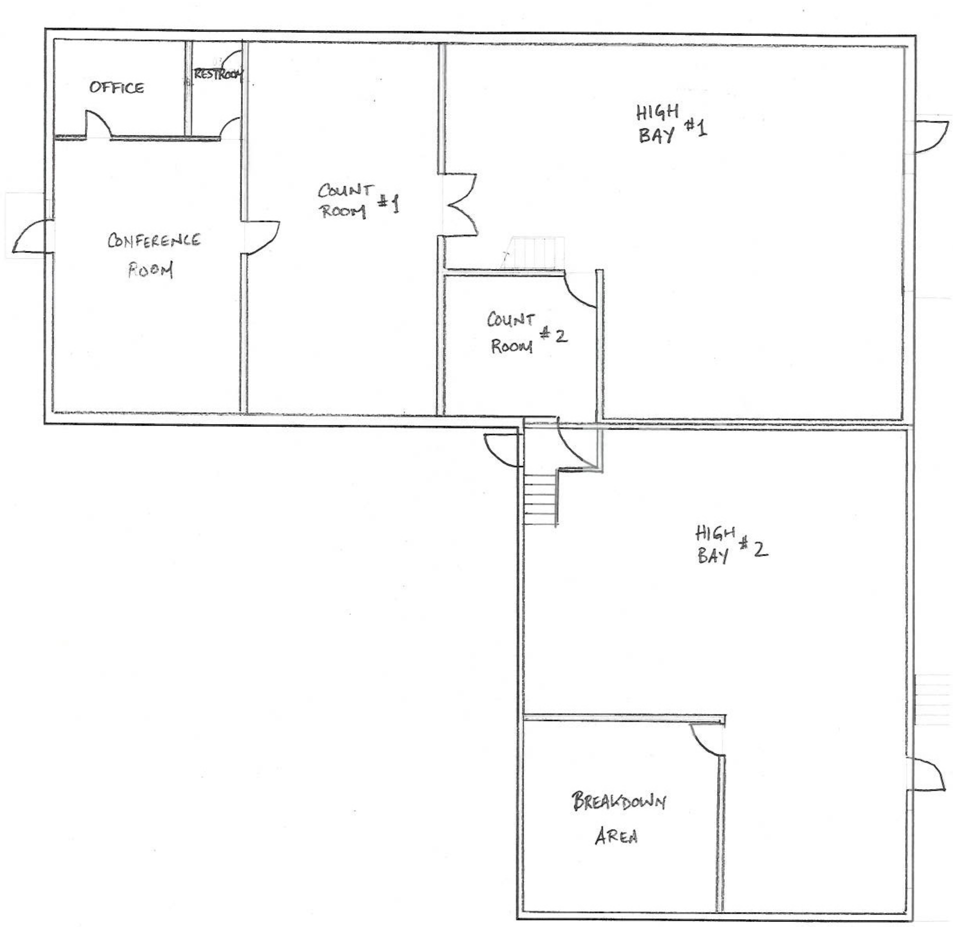

Figure 3.3.1: BUILDING 23-703, FIRST FLOOR, NAD LABORATORY

4.0 Planning for FY-2015 and FY-2016

4.1 Experiment Initiation (CED-3a)

Upon initiation of CED-3a, LLNL will procure, fabricate, receive and install the general equipment identified in Section 3.2.11 and complete the NAD Lab expansion described in Section 3.3. The NAD Lab expansion will include procurement of additional laboratory benches, static controlled chairs, shielding and require additional electrical outlets as well as expansion of web access to all areas of the NAD Lab.

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 DAF. The second shipment is for equipment for use in the NAD Lab in Mercury. 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 Lab.

4.2 Experiment Execution (CED-3b)

LLNL will assist all participants with travel logistics. As stated in Section 3.1, the exercise consists of three irradiations; namely, two training exercises consisting of one low-yield and one high-yield GODIVA burst and the performance testing exercise consisting of one mid-yield GODIVA burst. Each participating laboratory will be asked to provide preliminary dose estimates within 24-hours following each irradiation.

The exercise is tentatively scheduled for August 2015 and the actual date will be finalized following restart of Godiva-IV. The duration of the exercise is limited to one week with a tentative schedule as follows:

SUNDAY:

- Participants arrive in Las Vegas

MONDAY:

- Unpack and setup equipment at Mercury NAD Lab
- Unpack NADs and provide to LLNL as 3 groups; i.e., one for each irradiation
- Godiva building pre-operational checks to readiness for early next day operation

TUESDAY:

- Pre-job brief at 7:30 AM at DAF
- Fine tune dosimetry set-up in hallway
- 70 degree burst at ~10:00 AM
- 12:00 PM Pre-job brief at NAD lab

- NADS received at NAD lab at ~1:00 PM
- Count until midnight

WEDNESDAY:

- Pre-job brief at 7:30 AM at DAF
- Fine tune dosimetry set-up in hallway
- 250 degree burst at ~10:00 AM
- Report 24 hour dose estimates for 70 degree burst at NAD lab at ~12:00 PM
- Give the participants the reference values following the estimate presentation
- NADS received at NAD lab at ~1:00 PM
- Count until midnight

THURSDAY:

- Pre-job brief at 7:30 AM at DAF
- Fine tune dosimetry set-up in hallway
- 150 degree burst at ~10:00 AM
- Report 24 hour dose estimates for 250 degree burst at NAD lab at ~12:00 PM
- Give the participants the reference values following the estimate presentation
- NADS received at NAD lab at ~1:00 PM
- Count until midnight

FRIDAY:

- Finish counting and analysis
- Presentation of preliminary for 150 degree burst results at ~10:00 AM
- Pack up equipment for return by LLNL to home laboratory

SATURDAY:

- Participants depart Las Vegas

4.3 Evaluation of Data (CED-4a)

LLNL will return all equipment including irradiated NAD 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). Each participant will provide LLNL with their final results within 3 weeks following return of their equipment. Upon receipt of these results, LLNL will immediately provide the details regarding the placement of the NADs for the third irradiation together with the corresponding reference values and spectra. Each participating laboratory may utilize this data in re-evaluating their final results.

4.4 Publication of Data (CED-4b)

Participants shall publish their final results as a Laboratory report within 3 months following return of their equipment. LLNL will provide a report, presentation or paper summarizing the results of the exercise and any lessons-learned relevant to future exercises.

5.0 Project Risks and Risk Management

IER-148 measurements are tentatively scheduled for July 2015 to accommodate restart of the Godiva reactor and AWE shipping constraints. Currently, GODIVA operations are shutdown and will require a Federal restart. Scheduling the exercise for July provides nine months for restart and the resumption of operations. Additional time may be required in which case an NCSP BCR (and NSTec SCR) will be submitted with a revised schedule. If restart of GODIVA is delayed beyond FY-2015, then characterization of the FLATTOP radiation field (IER-252) should be accelerated to enable use of FLATTOP for the exercise (IER-253).

The return of activated NAD 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 NAD elements from DAF to Mercury may be delayed in the event of a contamination incident as has recently occurred with Godiva resulting in its being shutdown.

6.0 Recurring Maintenance Costs

As a non-nuclear (radiological) facility, maintenance of the NAD Laboratory is inexpensive with annual costs of approximately $25,000. These costs include:

- Annual certification of the fume hood
- Updating the REOP, Work Package, IWS, and RWO
- Accommodating required inspections and walkthroughs

Note that supplies such as liquid and gaseous nitrogen delivery are not included but are considered a programmatic cost.

Appendix A

IER-148 CED-0 Report

REQUEST FOR INTEGRAL EXPERIMENTS FORM

NOTICE: The End User must verify all information is *UNCLASSIFIED*

Please provide the following information:

Form Status: Final

Requestor Name:
Last Name: Heinrichs **First Name:** David **Middle Name:** Paul

Affiliation: Lawrence Livermore National Laboratory

E-Mail Address: heinrichs1@llnl.gov

Retype E-mail Address: heinrichs1@llnl.gov

Telephone No.: 925-424-5679

Experiment Request Title: 2012[30] International Intercomparison Exercise for Nuclear Accident Dosimetry at the Device Assembly Facility using Godiva

Description of Experimental Application (same level of detail as in DOE-STD-3007-2007): ***[6000 chars max]***

The proposal "Non-Classified Research Program under the CEA-DOE Agreement, Cooperation in Fundamental Science Supporting Stockpile Stewardship" schedules a joint US/French nuclear accident dosimetry exercise in DAF in FY2012 Q2.

Select Those That Apply and Explain:
Efficiency: Utilizing US assets such as the Godiva pulse reactor at the DAF will greatly reduce the cost to the US participants. In addition to the NNSA participants in previous foreign tests, additional new users include the NNSA Naval Reactor laboratories, DOE contractors at EH sites, AWE, and the commercial US nuclear industry.
Regulatory: 10 CFR 835, Section 1304, Nuclear Accident Dosimetry.
Risk: Low.
Compliance: DOE-STD-1098-99, Radiological Control, Section 515, Nuclear Accident Dosimeters, provides performance criteria of ± 25% accuracy for nuclear accident dosimetry systems in the range from 10 to 10,000 rads. Nuclear accident dosimetry exercises are the preferred means of demonstrating competency and compliance.

Programmatic Funding Availability or Identify Funding Source: NNSA NA-16[31]

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[30] Presently scheduled for 2015.
[31] NA-00 (due to reorganization of NNSA).

User Assessment of Available Integral Data (ICSBEP, Published, Unpublished, etc.):

Not applicable. The purpose of the exercise is for the participants to measure integral data using deployed dosimetry systems to demonstrate competency. Many US facilities with deployed nuclear accident dosimetry systems are supported by technical staff with no practical experience in handling and processing irradiated dosimeter elements, measuring decay gammas and betas, and estimation of activity, fluence, and dose.

Suggested Experimental Concept (described measured parameters to meet data needs): ***[6000 chars max]***

The first exercise should be scheduled after reference neutron and photon dose values and their uncertainties have been established for the Godiva radiation field in DAF. A dosimetry laboratory should also be established with sufficient workspace to accommodate at least five teams of participants.

The results of similar exercises performed at CEA-Valduc in France is provided in the following references:

D. P. Hickman et al., “Evaluation of LLNL’s Personal Nuclear Accident Dosimeter at the Silene Reactor, October 2009”, LLNL-TR-433878.

Milan S. Gadd and Victoria M. Ho, “Los Alamos National Laboratory Results for the 2009 SILENE Criticality Accident Dosimetry Exercise: Final Report”, LA-UR-10-03279.

R. L. Hill and M. M. Conrady, “PNNL Results from 2009 Silene Criticality Accident Dosimeter Intercomparison Exercise”, PNNL-19503.

T. R. Sullivan and S. G. Dyer, “Results from the SILENE Criticality Accident Dosimetry Exercise, October 2009”, SRNS-STI-2010-00372.

K. G. Veinot, “Results from 2002 and 2009 Silene Criticality Dosimetry Intercomparisons”, RCO/TBD-092, Rev. 1.

The End User acknowledges all information as approved for public release. [*]
[x] I Agree

ADC Name or Review and Release Number: John C. Scorby

Auspices Statement:

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