UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BLVD.
KING OF PRUSSIA, PA 19406-2713

June 22, 2018

James Olthoff, Acting Associate Director
for Laboratory Programs
U.S. Department of Commerce
National Institute of Standards
and Technology
100 Bureau Drive
Gaithersburg, MD 20899-1730

SUBJECT: NRC INSPECTION REPORT NO. 07000398/2017001, U.S. DEPARTMENT OF COMMERCE, GAITHERSBURG, MARYLAND SITE AND NOTICE OF VIOLATION

Dear Mr. Olthoff:

On September 13 and 16-17, 2017, November 1-2, 2017, February 14, 2018, and May 7-8, 2018, an inspection team from this office conducted a special inspection at the above address of activities authorized by the listed NRC license. The inspection was limited to a review of two events reported to NRC on August 14 and August 19, 2017, involving a lost sealed source and an unplanned contamination event, respectively. This inspection examined your licensed activities as they relate to radiation safety and to compliance with the Commission's regulations and the license conditions. The inspection consisted of observations by the inspectors, interviews with personnel, and a selective examination of procedures and representative records. Additional information provided during weekly telephone conversations held between December 2017 and April 2018 between Manuel Mejias and others of your organization, your internal dose consultants and this office was also examined as part of the inspection. The findings of the inspection were discussed with you and other managers and staff of your organization at the conclusion of the inspection.

Based on the results of this inspection and in accordance with the NRC Enforcement Policy, the NRC has determined that four violations of NRC requirements occurred. The violations involved: 1) the failure to use procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are as low as reasonably achievable; 2) the failure to make, or cause to be made, surveys necessary to assure compliance with the occupational dose limits; 3) the failure to perform an annual physical inventory of a sealed source that was required to be leak tested and, 4) the failure to leak test a sealed source for contamination from an appropriate accessible surface of the container where the sealed source is stored in which one might expect contamination to accumulate.

The violations are cited in the enclosed Notice of Violation (Notice), because the violations were identified by the NRC. The NRC expects licensees to conduct their programs high standards of safety and compliance. Because of the potential for radiation exposure to employees and the public which could result from failure to comply with NRC requirements, you must conduct your program according to NRC regulations, the conditions of your NRC license, and the representations made in your application.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response, will be made available electronically for public inspection in the NRC Public Document Room or from the NRC document system (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction.

Current NRC regulations and guidance are included on the NRC's Web Site at www.nrc.gov; select **Nuclear Materials; Med, Ind, & Academic Uses;** then **Regulations, Guidance and Communications.** The current Enforcement Policy is included on the NRC's Web Site at www.nrc.gov; select **About NRC, Organizations & Functions; Office of Enforcement; Enforcement documents;** then **Enforcement Policy (Under 'Related Information').** You may also obtain these documents by contacting the Government Printing Office (GPO) toll-free at 1-866-512-1800.

If you have any questions regarding this matter, please contact Donna Janda of my staff at (610) 337-5371 or via electronic mail at Donna.Janda@nrc.gov.

Thank you for your cooperation.

Sincerely,

/RA JNick for/

James M. Trapp, Director
Division of Nuclear Materials Safety

Docket No. 07000398
License No. SNM-362

Enclosures:
1. Notice of Violation
2. Inspection Report 07000398/2017001

cc w/Encls: Manuel Mejias, RSO
State of Maryland

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cc w/Encls: Manuel Mejias, RSO
State of Maryland

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DATE	6/21/18		6/22/18		6/22/18			

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NOTICE OF VIOLATION

U.S. Department of Commerce
Gaithersburg, Maryland

Docket No. 07000398
License No. SNM-362

During an NRC inspection conducted on September 13 and 16-17, 2017, November 1-2, 2017, and May 7-8, 2018, four violations of NRC requirements were identified. In accordance with the NRC Enforcement Policy, the violations are listed below:

A. 10 CFR 20.1101(b) requires, in part, the licensee use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are as low as reasonably achievable (ALARA).

   Contrary to the above, on August 17, 2017, the licensee did not use procedures, based on sound radiation protection principles, to achieve occupational doses that were as low as reasonably achievable. Specifically, a radiation worker handled radioactive material without donning proper protective clothing (in this case a protective glove) and failed to perform a survey of the work area prior to handling radioactive material without a protective glove, which resulted in the worker receiving a committed effective dose to the bone surface of 3.68 rem. The dose was avoidable had the licensee used procedures based upon sound radiation protection principles and therefore not ALARA.

   This is a Severity Level IV violation (Section 6.7).

B. 10 CFR 20.1501 requires, in part, that:

   (a) Each licensee shall make, or cause to be made, surveys that –
      (1) May be necessary for the licensee to comply with the regulations in this part, and
      (2) Are reasonable under the circumstances to evaluate –
         (i) The magnitude and extent of radiation levels; and
         (ii) Concentrations or quantities of residual radioactivity; and
         (iii) The potential radiological hazards of the radiation levels and residual radioactivity detected.

   Contrary to the above, as of August 16, 2017, the licensee failed to make, or cause to be made, surveys necessary to assure compliance with the occupational dose limits in 10 CFR Part 20.1201 and were reasonable to evaluate the magnitude and extent of radiation levels; the concentrations or quantities of residual radioactivity; the potential radiological hazards of the radiation levels and residual radioactivity detected; and the potential radiological hazards of the long-term storage of high specific activity alpha solutions in glass ampoules. Specifically, as of August 16, 2017, licensee personnel detected unexpected and anomalous contamination in and near a source storage room in Building 245 and did not sufficiently evaluate the magnitude of residual alpha contamination present to adequately characterize the radiological hazard of the residual contamination present.

   This is a Severity Level IV violation (Section 6.3).

C. License Condition 10 of NRC License No. SNM-362 requires, in part, that licensed material be used in accordance with statements, representations, and conditions of the licensee's renewal application dated March 23, 2011. Section 10.3, page 18, of the application dated March 23, 2011, requires that a Source Custodian perform an annual physical inventory of all sealed sources that are under their responsibility that are required to be leak tested.

Contrary to the above, a Source Custodian did not perform an annual physical inventory of a sealed source that was under the custodian's responsibility that was required to be leak tested. Specifically, since 2005 when a Source Custodian was assigned responsibility for a Cf-252 sealed source designated as RS# 75-0086, no physical inventory of the source was performed because the custodian did not visually verify nor confirm with a radiation measurement that the source was in its shielded drum.

This is a Severity Level IV violation (Section 6.3).

D. License Condition 10 of NRC License No. SNM-362 requires, in part, that licensed material be used in accordance with statements, representations, and conditions of the licensee's renewal application dated March 23, 2011. Section 10.7, page 28, of the application dated March 23, 2011, requires the following:

- Each sealed source containing more than 100 microcuries of beta and/or gamma emitting material or more than 10 microcuries of alpha emitting material, other than H-3, with a half-life greater than 30 days and in any form other than gas, shall be tested for leakage and/or contamination semiannually, unless otherwise specified by the source's respective SSD registration certificate.

- The sample must be taken from the sealed source or appropriate accessible surfaces of the container or from the device where the sealed source is mounted or stored in which one might expect contamination to accumulate.

Contrary to the above, a Cf-252 source (22 uCi of Cf-252, 5.3 mCi of Cf-250, and 8.5 uCi of Cm-248) designated as RS# 75-0086, was tested for leakage and/or contamination in March and September of 2015 and 2016, and the sample was not taken from the sealed source or appropriate accessible surfaces of the container where the sealed source is stored in which one might expect contamination to accumulate. Specifically, the employee who collected the leak test sample indicated that the smear(s) were collected on the top surface of the shielded drum and just beneath the plug; considering the source had not been removed from the shield since 2005, these were not surfaces where one would expect contamination to accumulate.

This is a Severity Level IV violation (Section 6.7).

Pursuant to the provisions of 10 CFR 2.201, the U.S. Department of Commerce is hereby required to submit a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555, with a copy to the Regional Administrator, Region I, within 30 days of the date of the letter transmitting this Notice of Violation (Notice). This reply should be clearly marked as a "Reply to a Notice of Violation" and should include for each violation: (1) the reason for the violation, or, if contested, the basis for disputing the violation, (2) the corrective steps that have been taken and the results achieved, (3) the corrective steps that will be taken to avoid further violations, and (4) the date

when full compliance will be achieved. Your response may reference or include previous docketed correspondence, if the correspondence adequately addresses the required response. If an adequate reply is not received within the time specified in this Notice, an order or a Demand for Information may be issued as to why the license should not be modified, suspended, or revoked, or why such other action as may be proper should not be taken. Where good cause is shown, consideration will be given to extending the response time.

If you contest this enforcement action, you should also provide a copy of your response to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001. Under the authority of Section 182 of the Act, 42 U.S.C. 2232, any response which contests an enforcement action shall be submitted under oath or affirmation.

Your response will be placed in the NRC Public Document Room (PDR) and on the NRC Web site. To the extent possible, it should, therefore, not include any personal privacy, proprietary, or safeguards information so that it can be made publically available without redaction. However, if you find it necessary to include such information, you should clearly indicate the specific information that you desire not to be placed in the PDR, and provide the legal basis to support your request for withholding the information from the public.

In accordance with 10 CFR 19.11, you may be required to post this Notice within two working days of receipt.

Dated This 22nd day of June 2018

U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Docket No.	07000398
License No.:	SNM-362
Report No.:	2017001
Licensee:	U. S. Department of Commerce National Institute of Standards and Technology (NIST)
Facility:	National Institute of Standards and Technology
Location:	Gaithersburg, Maryland 20899-1731
Dates:	September 13, 2017 through May 8, 2018
Inspectors:	Donna Janda, Chief, Medical and Licensing Assistance Branch (MLAB) Robin Elliott, Health Physicist, MLAB Todd Jackson, CHP, Senior Health Physicist, Commercial, Industrial, R&D, and Academic Branch (CIRDAB) John Miller, Regional Agreement State Program Officer Michael Reichard, Health Physicist, CIRDAB Betsy Ullrich, Senior Health Physicist, CIRDAB
Approved By:	James M. Trapp, Director Division of Nuclear Materials Safety, Region I
Attachment:	Supplemental Inspection Information

EXECUTIVE SUMMARY

On August 9, 2017, the National Institute of Standards and Technology (NIST) Radiation Safety Officer (RSO) was informed by staff members that, following a routine leak test, a californium-252 (Cf-252) sealed source was missing from its storage location in Building 245 on the NIST Gaithersburg Campus. This source had not been used in over 10 years. After an extensive search of records that did not support the prior shipment of the source, an in-depth physical search resulted in the source being found on August 16, 2017. The source was found on the floor near the original storage location. A subsequent investigation determined that the source had always been stored in the storage container's removable plug and likely dropped out during one of the recent removals of the plug.

During the routine leak testing and search for the Cf-252 source, on August 18, 2017, NIST Gaithersburg Radiation Safety Division (GRSD) staff identified contamination in another laboratory located in Building 245 at the NIST campus in Gaithersburg, Maryland. Specifically, the licensee identified that a flame-sealed glass ampoule that had contained a solution of americium-241 (Am-241) with an activity of approximately 47.6 megabequerels (MBq) (1.29 millicuries (mCi)) had broken, resulting in contamination of the lead-shielded storage area on top of the countertop and other surfaces within the room. The licensee reported that the probable cause of the rupture was catastrophic failure of the ampoule, resulting from gas over-pressurization and/or a chemical reaction caused by the high alpha activity. The licensee immediately restricted access to the contaminated room. The licensee identified six workers who could have been exposed to the contamination. After consulting with Department of Energy (DOE) Radiation Emergency Assistance Center/Training Site (REAC/TS), the licensee obtained bioassay samples from each of the potentially-affected individuals. The bioassay results received on September 7, 2017, indicated that one of the workers had received internal exposure. For this individual, the licensee initially assumed an inhalation pathway, resulting in a potential estimated committed dose equivalent (CDE) of 9.1 rem whole body dose and 87 rem to an organ (bone surface). Based on information received the following day regarding the individual not wearing gloves during handling of the contaminated sources, the licensee determined that the uptake could have been through an ingestion pathway. A revised dose assessment in early September 2017 estimated a potential dose from ingestion up to 120 rem whole body and 2200 rem to the bone surface. At this time, a third "wound" pathway was not yet considered. NIST obtained additional bioassay samples from the individual. The individual was also admitted to a hospital on September 9, 2017, to undergo diethylenetriamine pentaacetate (DTPA) treatment (which binds to some amount of the ingested radionuclide, causing it to pass through the body more rapidly; potentially reducing the CDE). Ultimately, based on multiple bioassay results over a four month period, and an intake and dose assessment performed by two internal dosimetry experts obtained by NIST to evaluate the individual's dose, NIST determined that the wound pathway was the most likely route of intake and the individual's final estimated dose was 157 millirem whole body and 3.68 rem to the bone surface, both of which are less than the regulatory limits.

On September 20, 2017, NRC Region I established a special inspection team in response to the notification of a potential worker overexposure involving approximately 1.3 mCi of Am-241 at the NIST facility in Gaithersburg, MD. In addition, the inspection team reviewed the circumstances surrounding the event reported to NRC by NIST on August 14, 2017, related to a lost 24.9 microcuries (uCi) Cf-252 sealed source. The inspection team conducted several site visits to the NIST Gaithersburg campus, toured the facilities and interviewed managers and staff regarding the circumstances surrounding the two events. The team also conducted weekly conference calls with the NIST radiation safety officer and other parties as warranted. The

inspection team reviewed the NIST internal investigation reports for both the lost Cf-252 sealed source event and the Am-241 contamination event and also reviewed the NIST consultants' report on the intake and dose assessment for the Am-241 contamination event. The team also reviewed the NIST corrective action plans for both events.

Based on the inspection findings, the team determined that four violations of NRC requirements occurred. The violations involved: 1) the failure to use procedures and engineering controls based upon sound radiation safety protection principles to achieve occupational doses that are as low as reasonably achievable; 2) the failure to make, or cause to be made, surveys necessary to assure compliance with the occupational dose limits; 3) the failure to perform an annual physical inventory of a sealed source that was required to be leak tested and, 4) the failure to leak test a sealed source for contamination from an appropriate accessible surface of the container where the sealed source is stored in which one might expect contamination to accumulate.

1.0 Report Overview

1.1 Inspection Scope

The inspection was limited to the events reported by the US Department of Commerce, National Institute of Standards and Technology (NIST) of a lost californium-252 (Cf-252) source, and the subsequent americium-241 (Am-241) contamination event that was identified during the search for the source. The team reviewed the event reports; the license, the application and supporting documents related to training of personnel, sealed source inventory, leak testing, surveys and other relevant procedures; surveys and bioassay data following the events; and the licensee's investigation and corrective action plans. The team also interviewed personnel and observed licensee activities. The team reviewed Inspection Procedures: 87103, "Inspection of Material Licensees Involved in an Incident or Bankruptcy Filing," 87126, "Industrial/Academic/Research Programs," 87125, "Materials Processor/Manufacturer Programs," and Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program" to assist the team in analyzing the sequence of events leading to the incident, the conditions that existed at the time the incident occurred, and identification of contributing and root causes.

During this inspection, the team:

- Developed a clear understanding of the circumstances surrounding the events including development of a chronology of events leading up to the contamination event and follow up actions taken by NIST.

- Assessed the adequacy of the initial response to the contamination event including an evaluation of the efforts to identify the source and cause of contamination and an assessment of the adequacy of immediate actions taken to prevent similar occurrences.

- Evaluated dose assessment methods and results including an evaluation of the actions taken pertaining to the identification of the event and initial dose assessment, effectiveness of the decontamination of affected staff, performance of independent dose assessments, and the final dose estimates.

- Evaluated the adequacy of the NIST radiation safety program for any potential deficiencies that may have led to the loss of the Cf-252 source and the Am-241 event, including an assessment of the following: level of compliance with applicable NRC requirements; operability and adequacy of radiation safety procedures and equipment that was available and/or in use at the time of the incident; and the effectiveness of radiation safety program oversight activities.

1.2 Observations and Findings

The inspection team conducted several site visits to the NIST Gaithersburg campus, toured the facilities and interviewed managers and staff regarding the circumstances surrounding the two events. The team also conducted weekly conference calls with the NIST Radiation Safety Officer (RSO) and other parties as warranted. The inspection team reviewed the NIST internal investigation reports for both the lost Cf-252 sealed source event and the Am-241 contamination event and also reviewed the NIST consultants' report on the intake and dose assessment for the Am-241 contamination event. The team also reviewed the NIST corrective action plans for both events.

The licensee is authorized under License No. SNM-362, in part, to use byproduct, source, and special nuclear material in manufacturing and research related to development and maintenance of standards for measurement. During routine leak-testing activities in August 2017, a Cf-252 source could not be located in its shielded container. During the search for the source and routine leak-testing activities, a radiation safety staff member became contaminated with Am-241 due to a previously undiscovered shattered glass ampule containing a solution of Am-241 of very high specific activity. Details of the two events and NIST's follow-up activities are described in this report.

The NIST license is a broad scope, Type A. Licensed activities are authorized by the NIST Ionizing Radiation Safety Committee (IRSC). The radiation safety program is implemented by the staff of the GRSD which is part of the Office of Safety, Health, and Environment which is headed by the Chief Safety Officer. The GRSD staff includes a RSO, who is supported by approximately twelve health physicists and health physics technicians. The radiation safety organization was found to be as described in the license application.

Approximately 200 radiation workers perform activities with licensed materials in multiple buildings, although the majority work in Building 245 where Radiation Physics is located. Work with licensed materials occurs daily.

The team gathered information from interviews with NIST personnel, and review of records and reports to develop the overall timeline of the events:

- 8/9/17 – NIST staff performs routine leak testing; cannot find Cf-252 source reported to be in its assigned storage area

- 8/10/17 – NIST staff performs out-of-cycle physical inventory looking for Cf-252 source; all Source Custodians (persons responsible for specified sources of licensed materials) involved, multiple locations involved including the rooms designated in this report as Room CF252 (the room where the Cf-252 source was lost/found) and Room AM241 (the room where the Am-241 contamination event occurred)

- 8/11/17 - NIST staff began to identify a series of unusual leak test results, and unusual hand/foot monitor alarms in area near Room AM241

- 8/14/17 - NIST staff reported to NRC that a Cf-252 source was lost; source had been stored in Building 245, Room CF252

- 8/16/17 - NIST RSO reported to NRC that the Cf-252 source was found in Room CF252

- 8/17/18 - While investigating leak test/contamination issues, NIST GRSD staff identify problem in lead-shielded storage area for high activity sources in Room AM241

- 8/18/17 - Radiation Work Permit (RWP) developed by NIST GRSD staff for entry to determine scope of problem in Room AM241. GRSD staff find a shattered glass ampule of very high specific activity Am-241 solution, still within its lead pig. Observation of the lid not being properly in place and the presence of glass shards indicated that it may have exploded.

- 8/19/17 - NIST staff reported to NRC occurrence of unplanned contamination event in Room AM241 due to broken vial of Am-241

- 8/22/17 - NIST staff determines bioassay may be needed for one or more GRSD staff members

- 9/6/17 - NIST staff updates the Am-241 event report to inform NRC that potential doses from uptake could be in 100s of rem if the route was ingestion

- 9/13/17 - Two NRC inspectors visit NIST to discuss events and follow-up actions taken by NIST

- 9/26/17 - NRC team inspection begins

- 9/17 – 4/18 - NIST staff perform:

    - Extent of contamination surveys of Building 245 with assistance from Department of Energy (DOE) Radiological Assistance Program (RAP) team
    - Bioassay of potentially exposed persons with assistance from Department of Energy (DOE) Radiation Emergency Assistance Center/Training Site (REAC/TS)
    - Root cause investigation of both events
    - Updates to NRC, including bioassay data
    - Weekly calls with NRC to review dose assessment and root cause progress

- 1/21/18 - NIST issues “NIST IRSC Investigation of the August 2017 Am-241 Event”

- 2/26/18 - NIST issues “NIST IRSC Investigation of August 2017 Lost Cf-252 Source”

- 3/9/18 - NIST consultants issue “Intake and Dose Assessments for the Am-241 Broken Ampoule Contamination Event at the National institute of Standards and Technology, Gaithersburg, MD”

- 5/7-8/18 - NRC follow-up and exit meeting

2.0 Event Response – Loss of Cf-252 Source

2.1 Inspection Scope

The team observed and interviewed NIST staff, and reviewed relevant procedures and records to determine contributing factors that led to the loss of the Cf-252 source. The team also interviewed NIST staff and reviewed documentation of follow-up activities to find the source, and the NIST investigation of the loss and planned corrective actions. The team observed and reviewed NIST procedures for physical inventory of sealed sources, and leak-testing of sealed sources.

2.2 Observations and Findings

The Cf-252 source, designated as NS-86, was originally received at NIST in 1975 with an activity of 1.14 curies of Cf-252. The Cf-252 source was re-designated by NIST staff as RS# 75-0086 and stored in a shielded drum container at least since 2004. The drum was

stored in Building 245, Room CF252. In 2015, a locked cage was constructed within Room CF252, and the Cf-252 source as well as other sources were moved into the caged enclosure. The cage was assigned the separate room designation, and was maintained locked and monitored with video surveillance. The cage is a restricted area because access is limited for purposes of protecting individuals against undue risks from exposure to radiation and radioactive materials.

On August 8, 2017, a GRSD supervisor and a GRSD health physics (HP) technician were performing sealed source leak tests. In their attempt to leak test the Cf-252 source, RS# 75-0086, stored in a locked cage within Room CF252, the GRSD staff were unable to locate the source. A survey conducted by GRSD personnel of the drum opening was unable to confirm its presence in the drum shield.

On August 9, the RSO and the Radiation Physics Division (RPD) staff were notified that the source could not be located. Efforts to locate the source continued, including an out-of-cycle physical inventory of all sources. On August 10, 2017, the RSO reported to the Director of NIST that the source was lost. Further, the investigation revealed that the current Source Custodian never visually verified the presence of the source. This triggered the NIST Director, on August 11, 2017, to order RPD to conduct an accounting of all sealed sources by September 29, 2017. The Cf-252 source was reported missing to the NRC on August 14, 2018, Event No. 52900.

On August 16, 2017, the Source Custodian and GSRD HP entered the cage area in Room CF252 to conduct another search. At that time, all neutron emitting sources were removed to reduce the background and to allow for greater sensitivity of detection. This allowed the HP to locate the source on the floor inside the cage of Room CF252. The RSO reported to the NRC on August 16, 2017, that the source was found. Later investigation identified that the source storage configuration in its container was unusual, in that the source was stored in a removable tube attached to the container plug; NIST staff believe that it is likely that the source fell out of the tube on August 8, 2018, when GRSD staff removed the plug to which it was attached, in the attempt to observe the source.

While investigating the circumstances associated with the lost Cf-252 source, the inspection team determined that NIST procedures require the Source Custodians to perform an annual physical inventory of all sources under their responsibility. The current Source Custodian is the third person assigned responsibility for the source since it was received. The current Source Custodian stated he did not have any reason to use this source, was not aware that anyone had used the source since his tenure as Custodian, and he performed the physical inventory only by noting that the source container was still present. The current Source Custodian did not visually observe the source, nor did the Source Custodian use a radiation survey meter to verify by radiation measurement that the source was located in the container.

The licensee's application dated March 23, 2011, Section 10.3 requires that a Source Custodian perform an annual physical inventory of all sealed sources under their responsibility that are required to be leak tested. This application is referenced in Condition 10 of NRC License No. SNM-362. Contrary to the licensee's application, a Source Custodian did not perform an annual physical inventory of a sealed source that was under the Custodian's responsibility that was required to be leak tested. The Source Custodian never performed a physical inventory of the source because the Custodian did not visually verify nor confirm with a radiation measurement that the source was in its shielded drum.

The last verified documentation of the presence of the Cf-252 source was in a GRSD staff quarterly audit performed in 2012, in which dose measurement verified that the Cf-252 source was present in the drum. Inventory spot checks performed by GRSD staff of the Cf-252 source in 2012, 2013, 2014 and 2015 did not describe how verification was made. These spot checks are referenced in the "NIST IRSC Investigation of August 2017 Lost Cf-252 Source" dated February 26, 2018 [NIST Cf-252 report] which states: "There was no written procedure for inventory spot checks during this time, but the expectations were that the presence of the source would be verified. Records do not indicate how the spot check was performed."

The Cf-252 source was leak-tested every 6 months by GRSD staff in February and August each year between 2008 and 2017. NRC team determined that GRSD staff collected leak test samples in 2015, 2016 and 2017 by smearing the top surface of the shielded container, and just beneath the plug. Considering that the source had not been removed for use since 2005, these are not surfaces that would be expected to become contaminated if the source were leaking, and therefore not a valid leak test. In addition, GRSD staff who performed those leak tests stated that they did not remove the source from shielded drum for leak testing, or document during the leak test, any verification of the presence of the source.

Section 10.8 of the licensee's application dated March 23, 2011, referenced in Condition 10 of NRC License No. SNM-362, requires that leak tests be taken from the sealed source or appropriate accessible surfaces of the container or from the device where the sealed source is mounted or stored in which one might expect contamination to accumulate. A Cf-252 source designated as RS# 75-0086, was leak tested for contamination in March and September of 2015, 2016, and 2017, and the sample was not taken from the sealed source or appropriate accessible surfaces of the container where the sealed source is stored in which one might expect contamination to accumulate.

2.3 Conclusions

A Cf-252 source was missing for a period of at least 8 days. The last known date that the source was verified to be present was in 2012, by dose measurement of the container. The annual physical inventory by the Source Custodian verified only that the source container was present, and did not include a visual confirmation of the source, or dose measurement confirmation. Records of the four times the source was part of the spot inventory between 2012 and 2015 did not indicate how the presence of the source was verified, nor did the procedure for performing spot check inventory describe acceptable methods of verification. Leak test samples collected since 2015 were taken from an area of the source container that would not likely have been contaminated had the source been present and leaking.

The following violations were identified:

- License Condition 10 of NRC License No. SNM-362 requires, in part, that licensed material be used in accordance with statements, representations, and conditions of the licensee's renewal application dated March 23, 2011. Section 10.3, page 18, of the application dated March 23, 2011, requires that a Source Custodian perform an annual physical inventory of all sealed sources that are under their responsibility that are required to be leak tested.

  Contrary to the above, a Source Custodian did not perform an annual physical inventory of a sealed source that was under the custodian's responsibility that was required to be leak tested. Specifically, since 2005 when a Source Custodian was assigned

responsibility for a Cf-252 sealed source designated as RS# 75-0086, no physical inventory of the source was performed because the custodian did not visually verify nor confirm with a radiation measurement that the source was in its shielded drum.

- License Condition 10 of NRC License No. SNM-362 requires, in part, that licensed material be used in accordance with statements, representations, and conditions of the licensee's renewal application dated March 23, 2011, representations, and conditions of the licensee's renewal application dated March 23, 2011. Section 10.7, page 28, of the application dated March 23, 2011, requires the following:

  - Each sealed source containing more than 100 microcuries of beta and/or gamma emitting material or more than 10 microcuries of alpha emitting material, other than H-3, with a half-life greater than 30 days and in any form other than gas, shall be tested for leakage and/or contamination semiannually, unless otherwise specified by the source's respective SSD registration certificate.

  - The sample must be taken from the sealed source or appropriate accessible surfaces of the container or from the device where the sealed source is mounted or stored in which one might expect contamination to accumulate.

  Contrary to the above, a Cf-252 source (22 uCi of Cf-252, 5.3 mCi of Cf-250, and 8.5 uCi of Cm-248) designated as RS# 75-0086, was leak tested for contamination in March and September of 2015, 2016 and 2017, and the sample was not taken from the sealed source or appropriate accessible surfaces of the container where the sealed source is stored in which one might expect contamination to accumulate. Specifically, the employee who collected the leak test sample indicated that the smear(s) were collected on the top surface of the shielded drum and just beneath the plug and considering the source had not been removed from the shield since 2005, these were not surfaces where one would expect contamination to accumulate.

NIST staff identified a number of corrective actions needed to address the program deficiencies that led to the violations, some of which are: (1) a procedure for source turnover from one Source Custodian to another needs to be developed; (2) a source verification method was added to the inventory response forms and training on conducting physical inventories was provided; and (3) Source Custodians should always be notified prior to all leak tests or when a new procedure is being pursued.

3.0 Event Response – Am-241 Contamination

3.1 Inspection Scope

The team observed and interviewed NIST staff, and reviewed relevant procedures and records to determine contributing factors that led to the Am-241 contamination event. The team also interviewed NIST staff and reviewed documentation of activities NIST staff performed to determine the scope of the contamination, and the NIST investigation of the contamination event and planned corrective actions. The team observed and reviewed NIST procedures for radiation safety personnel qualifications and training; radioactive materials receipt, use, controls, inventory, and disposal; and various types of surveys and monitoring. The team also observed surveys performed by NIST staff and reviewed records of surveys relevant to the Am-241 contamination event.

3.2 Observations and Findings

On August 18, 2017, GRSD staff identified a broken vial of Am-241 solution that caused contamination of stored sources and several areas within Room AM241 in Building 245. Room AM241 is a small room that contained multiple radioactive sources under the responsibility of multiple Source Custodians. Because of the search for the Cf-252 source that was discovered to be missing on August 8, 2017, multiple Source Custodians entered Room AM241 at different times during the period between August 8 and August 18 to perform the out-of-cycle physical inventory of their sealed sources. In addition, GRSD staff performing routine leak-testing of sealed sources also entered Room AM241 during that period.

During the period of time between August 8 and August 18, GRSD staff noted unusual leak test results from multiple sources. The unusual leak test results were re-analyzed; wipe counters were re-calibrated; and wipe tests were re-done under the potential concern of cross-contamination due to radon in the basement laboratories, as well as a previously-identified problem due to out-gassing by another source.

In addition, on August 10, 15 and 17, 2017, there were multiple personnel contamination alarms at the hand and foot monitors. NIST had one hand and foot monitor located near Room AM241 in the C-wing, and a second hand and foot monitor in the B-Wing. Both monitors alarmed at a designated set-point which GRSD staff considered “contaminated.” Personnel apparently doubted whether monitors were correct rather than believing results until proven false, which delayed identification of the circumstances regarding the ruptured source and a comprehensive response. One of the hand and foot monitors used had no alpha detectors incorporated into it, further delaying identification of the alpha contamination. NIST procedures for response to alpha contamination events such as this were general in nature and contributed to the delayed response period. As a result, GRSD staff were slow in developing an understanding of the scope and magnitude of the contamination event and the risk it presented.

NIST’s investigation identified the failed source as source #1872R, which contained 47.6 megabequerels (MBq) (1.29 millicuries [mCi]) of Am-241 stock solution. The source was comprised of the Am-241 solution contained in a 5 milliliter (ml) borosilicate glass ampoule which was flame-sealed on October 3, 2006, and stored within a lead shield. This source was stored in a lead-shielded area on an open bench top in Room AM241 on or around August 14, 2015, when it was assigned to a new Source Custodian, and given a new identification number, RS-15-0272B. This source was subsequently assigned an authorized use of “storage only” and was the sole source with that designation stored in Room AM241. NIST procedures showed that the designation as “storage only” was likely to result in the item being stored for extended periods without much attention, with the assumed expectation that the source would be of value at some time in the future. This source became a significant hazardous material due to the high specific activity of the alpha-emitting material in the glass ampoule, which generated gases during radioactive decay and resulted in over-pressurization of the container. NIST staff calculations indicated that this source could have developed internal pressure of 15-49 atmospheres (atm). NIST personnel stated the ampoule was nominally capable of holding 2 atm pressure, and was expected to be able to withstand internal pressure up to 5-6 atm without failure. NIST GRSD personnel were aware in 2017 of a presentation by the International Atomic Energy Agency (IAEA) about a similar event that occurred in August 2008 in which a high specific activity alpha-emitting plutonium-240 (Pu-240) source built up an internal pressure of hydrogen gas and apparently exploded. One of the proposed corrective actions described in the IAEA follow-up was the potential need to periodically relieve the built-up pressure. Although NIST staff were interested to see if risks similar to the Pu-240 source in 2008 might be

applicable to some sources at NIST, unfortunately, the NIST Am-241 contamination event occurred before that was done.

During the inspection, NIST staff stated they were considering methods to publicize their experience to alert other holders of high-specific activity alpha sources of the hazard. NIST scientific staff believed that potentially affected laboratories around the world could still be unaware of the failure mechanism and experience, and stated their intent to communicate the risk and the NIST experience with their colleagues around the world.

Once GRSD personnel understood that a significant source of alpha contamination existed in Room AM241 on August 18, 2017, the room was sealed and personnel were not allowed to enter. Surveys were conducted over the next several weeks of the entire Physical Measurements Laboratory (Building 245), which is also where the GRSD staff is located. Detailed planning was performed to enable a safe radiological survey, and a Radiation Work Permit (RWP) RWP-170007 was issued to cover the physical survey and investigation of conditions on the bench in Room AM241 that was identified as the source of the Am-241 contamination, and of the room in general. NIST staff requested assistance of the DOE RAP team, who performed comprehensive surveys of Building 245 to assure all contaminated areas were identified. The DOE RAP team performed surveys on September 13 through 15, 2017. Those surveys were completed before Physical Measurements Division (PMD) staff were permitted to start working with radioactive materials again.

Bioassay samples were first collected on August 22, 2017, and on August 23, 2017, NIST contacted the DOE Radiological Emergency Assistance Center/Training Site (REAC/TS) to discuss handling of internal Am-241 exposure. On September 7, 2017, GRSD staff noted that the Room AM241 radiological survey and physical conditions observed were not consistent with dispersal of an aerosol. By September 11, 2017, NIST staff evaluation of the conditions in Room AM241 determined that ingestion would be a more likely exposure pathway than inhalation. That change resulted in a revised assessment of potential personnel exposure and conditions, prompting immediate consideration of chelating agent diethylenetriamine pentaacetic acid (DTPA) administration to minimize the associated internal radiation exposure. Later that day, the licensee determined that pharmaceutical DTPA was not readily available. This added an additional delay in response to the potential exposure, which could have made a significant difference in the ability to minimize potential internal exposure. Additional aspects of the bioassays performed and the dose assessment are discussed further in Section 4.0 of this report.

By September 13, 2017, it was determined that 28 additional radioactive sources at NIST could have the potential to be at risk due to similar characteristics of higher alpha-emitter activity, and all of these were placed into robust pressure containers and safely stored, pending further evaluation. NIST staff plan specify that sources which present significant hazard potential will be screened, properly disposed if not needed, and subjected to a more detailed hazard analysis before being put back into use. The identified sources as of September 13, 2017, were part of the large number of sources in NIST inventory (about 47% of total inventory, or about 1000 sources) that were considered “legacy” sources and had not yet been subjected to a more thorough and detailed hazard/safety evaluation in accordance with procedures of the Ionizing Radiation Safety Committee (IRSC).

NRC inspectors interviewed GRSD staff and other NIST staff members involved in the leak-testing of sources, and the search for the lost Cf-252 source, who had been in Room AM241. Inspectors learned that, as early as August 16, 2017, licensee personnel detected unexpected

and anomalous contamination in and near Room AM241 in Building 245 but did not sufficiently evaluate the magnitude of residual alpha contamination present, or adequately characterize the radiological hazard of the residual contamination present. Inspectors also learned that, on August 17, 2017, a GRSD staff member handled radioactive material without donning proper protective clothing (gloves) and failed to perform a survey of the work area prior to handling radioactive material without a protective glove, which resulted in the worker becoming contaminated and receiving a committed effective dose to the bone surface of 3.68 rem. The dose was avoidable had the licensee used procedures based upon sound radiation protection principles and therefore not as low as reasonably achievable (ALARA).

3.3 Conclusions

While the NIST staff response to the contamination event was ultimately thorough and comprehensive, it was slow to develop. Initial indications of unexpected alpha contamination were questioned, and there was insufficient awareness of the potential magnitude of the hazard presented by the Am-241 source in storage in Room AM241. Room AM241 was used to store sources commonly used as gamma spectrometry sources. While some of the sources did contain materials that were alpha-emitters, all were in containers and did not typically present conditions of loose contamination while intact. Personnel first used a hand-and-foot monitor located near Room AM241 which did not have an alpha detector in it, so challenges were present in initially making alpha measurements. NIST staff generally expressed concern that insufficient alpha personnel monitoring instrumentation was immediately available, contributing to the delay in understanding the scope of the event. Bioassay sampling was not immediate when alpha contamination was suspected, nor continuous throughout the period following confirmation of internal contamination. When REAC/TS was consulted and a decision made to employ DTPA, NIST staff discovered that pharmaceutical DTPA was not readily available and extraordinary efforts, associated with potentially significant delay, were necessary to obtain the material. Advance arrangements for bioassay and DTPA could have accelerated the response and improved the quality of the exposure assessment.

The following violations were identified:

- 10 CFR 20.1101(b) requires, in part, the licensee use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are ALARA.

  Contrary to the above, on August 17, 2017, the licensee did not use procedures, based on sound radiation protection principles, to achieve occupational doses that were as low as reasonably achievable. Specifically, a radiation worker handled radioactive material without donning proper protective clothing (in this case a protective glove) and failed to perform a survey of the work area prior to handling radioactive material without a protective glove, which resulted in the worker receiving a committed effective dose to the bone surface of 3.68 rem. The dose was avoidable had the licensee used procedures based upon sound radiation protection principles and therefore not ALARA.

- 10 CFR 20.1501 requires, in part, that:

  (a) Each licensee shall make, or cause to be made, surveys that –
  (1) May be necessary for the licensee to comply with the regulations in this part, and
  (2) Are reasonable under the circumstances to evaluate –

(i) The magnitude and extent of radiation levels; and
(ii) Concentrations or quantities of residual radioactivity; and
(iii) The potential radiological hazards of the radiation levels and residual radioactivity detected.

Contrary to the above, on August 16, 2017, the licensee failed to make, or cause to be made, surveys necessary to assure compliance with the occupational dose limits in 10 CFR Part 20.1201 and that were reasonable to evaluate the magnitude and extent of radiation levels, the concentrations or quantities of residual radioactivity, and the potential radiological hazards of the radiation levels and residual radioactivity detected. Specifically, on August 16, 2017, licensee personnel detected unexpected and anomalous contamination in and near Room AM241 in Building 245 and did not sufficiently evaluate the magnitude of residual alpha contamination present to adequately characterize the radiological hazard of the residual contamination present.

4.0 NRC Assessment of Radiological Consequences

4.1 Inspection Scope

The team observed and interviewed NIST staff, and reviewed relevant reports and records prepared by NIST staff and contractors to determine the extent of internal contamination and the adequacy of dose assessments.

4.2 Observations and Findings

NIST's consultants concluded that the most likely intake was 56 picocuries (pCi) of Am-241 on August 17, 2017, resulting in a Committed Effective Dose Equivalent (CEDE) of 157 mrem and a Committed Equivalent Dose (CEqD) to the bone surfaces of 3.68 rem, the highest organ dose. NIST's consultants believed that the intake was best characterized by the "strongly retained wound" model described below. The NRC independently reviewed the licensee's intake and dose assessments and determined that the licensee's assessments were the most likely given all available information, including timeline, radiological survey data, and bioassay data. Based on initial in-vitro bioassay information and the fact that an ingestion could not be ruled out, in early September 2017, NIST estimated that a CEDE of 120 rem and a CEqD to the bone surfaces of 2200 rem was possible. In response, NIST hired consultants with extensive internal dosimetry experience, placed the individual in question on a routine in-vitro bioassay program, and had in-vivo bioassay measurements performed at the Naval Dosimetry Center in Bethesda, Maryland and the Lawrence Livermore National Laboratory in Livermore, California. The results from both in-vivo measurements were below the Minimum Detectable Activity (MDA) for Am-241, but the missed dose (the dose associated with results immediately below the MDA) for Lawrence Livermore National Laboratory, which had superior MDAs, was 33 rem CEDE and 615 rem CEqD (Bone Surfaces). The results from the in-vitro bioassay results allowed for analysis of smaller intakes, compared to the in-vivo measurements, and were the focus of the internal dosimetry analysis.

Ingestion and inhalation intakes on or before August 18, 2017, were ruled out because subsequent in-vitro bioassay results were substantially lower than would be expected if intakes were earlier. Additionally, the intake quantities would need to be of substantially greater magnitudes than were observed during surveys of the laboratory or other areas in question. Later intake dates are unrealistic, because the individual was restricted from radiological work at

that time, and additional controls were implemented by NIST for the contaminated area in question.

The NRC team reviewed the strongly retained wound model and reviewed National Council on Radiation Protection (NCRP) Report No. 156, “Development of a Biokinetic Model for Radionuclide Contaminated Wounds and Procedures for Their Assessment, Dosimetry and Treatment.” Though initially considered counter-intuitive, considering that there was not a significant, noticeable wound, the NRC team determined that the strongly retained wound model was appropriate to consider. Discussions in NCRP 156 regarding lacerated, abraded, and intact skin allow for consideration of the strongly retained wound model. Specifically, the discussion regarding absorption through intact skin is described as adhering to wound models. The NRC team determined that the use of a wound model was appropriate in the cases of absorption through intact skin, injection with small shards of glass, or intake through small cuts. NCRP 156’s discussions regarding Am-241 conclude that the strongly retained wound model is the most commonly observed pathway for Am-241.

NIST’s consultants’ intake and dose assessments were based on the results from 18 urine bioassay samples and one fecal bioassay sample collected between August 22 and December 28, 2017. They used Integrated Modules for Bioassay Analysis (IMBA) v. 4.1.1.8, an internal dosimetry software package, to perform their intake and dose assessments. They used the International Commission on Radiological Protection (ICRP) 30 dose coefficients and the ICRP 26 tissue weighting factors. Statistical analysis (Intake Route Least Squares Fit) determined that a strongly retained wound on August 17, 2017, best fit the bioassay data. A review of radiological survey data and a review of the event timeline supports the intake date, quantity, and route selection.

4.3 Conclusions

The NRC team determined that NIST’s intake and dose assessments were reasonable.

SUPPLEMENTAL INSPECTION INFORMATION

Partial List of Persons Contacted

+*Manuel Mejias, Radiation Safety Officer, Gaithersburg Radiation Safety Division
+*Steven Dewey, Group Leader, Dosimetry Program, Gaithersburg Radiation Safety Division
+*Alan Thompson, Ionizing Radiation Safety Committee
+*Michael Mitch, Radiation Physics, Headquarters
*Janna Shupe, Group Leader, Inventory Program, Gaithersburg Radiation Safety Division
*Richard Kayser, Chief Safety Officer
*Tom O'Brien, Gaithersburg Radiation Safety Division
*Patricia Retka, Health Physicist, Gaithersburg Radiation Safety Division
+Delwin Brockett, Associate Director for Management Resources
+Greg Strouse, Deputy Associate Director for Management Resources
+Jim Olthoff, Acting Associate Director for Laboratory Programs
+Henry Wixon, Chief Counsel, Director's Office, Headquarters
+Stephen Banovic, Acting Chief Safety Officer
+Mike Spady, Supervisory Health Physicist, Gaithersburg Radiation Safety Division
Name withheld, Health Physics Technician 1, Gaithersburg Radiation Safety Division
Name withheld, Health Physics Technician 2, Gaithersburg Radiation Safety Division
Name withheld, Health Physics Technician 3, Gaithersburg Radiation Safety Division
Lisa Karam, Chief, Division of Physics, Radiation Physics Department (RPD)
Name withheld, Source Custodian, Cf-252
Name withheld, Source Custodian, Am-241

+ Attended exit meeting conducted on May 8, 2018
*Attended entrance meeting conducted on September 26, 2017

Inspection Procedures and Guidance Documents Used

Inspection Procedure 87103, "Inspection of Material Licensees Involved in an Incident or Bankruptcy Filing"

Inspection Procedure 87126, "Industrial/Academic/Research Programs"

Inspection Procedure 87125, "Materials Processor/Manufacturer Programs"

Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program"

National Council on Radiation Protection (NCRP) 156, "Development of a Biokinetic Model for Radionuclide Contaminated Wounds and Procedures for Their Assessment, Dosimetry and Treatment."

List of Acronyms Used

atm – atmospheres
ALARA – As Low As Reasonably Achievable
CDE – Committed Dose Equivalent
CEDE – Committed Effective Dose Equivalent
CEqD – Committed Equivalent Dose
CIRDAB – Commercial, Industrial, Research & Development, and Academic Branch
DOE – Department of Energy
DTPA – Diethylenetriamine pentaacetate
GRSD – Gaithersburg Radiation Safety Division
HP – health physicist
IAEA – International Atomic Energy Agency
ICRP – International Council on Radiation Protection
IMBA – Integrated Modules for Bioassay Analysis
IRSC – Ionizing Radiation Safety Committee
MBq – Megabequerels
mCi – Millicuries
ml - milliliter
MDA – Minimum Detectable Activity
MLAB – Medical and Licensing Assistance Branch
NCRP – National Council on Radiation Protection
NIST – U. S. Department of Commerce National Institute of Standards and Technology
NRC – Nuclear Regulatory Commission
pCi – picocuries
PML – Physical Measurements Laboratory
PMD – Physical Measurements Division
RAP – Radiological Assistance Program
REAC/TS – Department of Energy Radiological Emergency Assistance Center/Training Site
Rem – Roentgen equivalent man
Room AM241 – room in which Am-241 event occurred
Room CF252 – room in which Cf-252 source was lost/found
RPD – Radiation Physics Division
RSO – Radiation Safety Officer
RWP – Radiation Work Permit
SNM – Special Nuclear Material
uCi - microcuries

Partial List of Documents Reviewed

1. Bioassay / dosimetry documents:
   - GEL Labs Reports dated September 2017 through February 2018
   - Bioassay Results Estimates IND#1 redacted
   - Bioassay Results Estimates IND#2 redacted
   - Dose Estimates Based on LLNL Results Final
   - LLNL IND#1 Results_Redacted
   - LLNL IND#2 Part 2 Results_Redacted
   - NIST bioassay sample tracking spread sheet, with two attached graphs – PII removed
   - LLNL Scan Reports

2. External dosimetry records for 30+ individuals

3. NIST Radiation Safety Instructions (RSI)
   RSI 1-2 Radiation Safety Personnel Qualifications, Duties and Training
   RSI 4-5 Sealed Source Leak Testing
   RSI 7-7 Low-Level Alpha/Beta counting
   RSI B 1-3 Emergency Response to Radiological Incidents
   RSI B 1-4 Radiation Safety Training
   RSI C 2-5 Internal Activity Monitoring & Dose Assessment (2 copies)
   RSI D 4-2 Radioactive Material Package Receipt
   RSI D 4-4 Radioactive Material Acquisition and Usage Control
   RSI D 4-18 Inventory Spot Check Procedure
   RSI D 8-9 Decay-In-Storage
   RSI E 4-1 Radiation Facility Surveys and Audits (2 copies)
   RSI G 7-4 Gamma Survey Instrument Calibration
   RSI G 7-6 Alpha Survey Instrument Calibration
   RSI G 7-11 Pulser Calibration of Count Rate Instruments
   RSI G 7-16 Personnel Contamination Monitors

4. NIST Health Physics Instruction HPI 4-15 Radiological Hazard Review

5. NIST Interdivisional Procedures
   IP 1-1 Radioactive Standard Reference Materials
   IP D 1-5 Material Control and Accounting of SNM
   IP D 8-3 Radioactive Waste Handling and Disposal

6. NIST Personnel Contamination Monitoring Equipment Procedures

7. NIST Surveys
   - Building 245, Room [AM241] Weekly Surveys June 28 through august 15, 2017
   - Building 245, Room [AM241] Quarterly audit surveys, March 2016 through June 2017
   - Building 245 Room surveys performed by NIST August 18 through September 20, 2017; most documented on ”NIST Radiation and Contamination Survey Worksheet” but a few documented by memo

8. Leak test records 2008 through 2017 for selected sources

9. Contamination Control and Incident Response refresher training slides, given Oct/Nov 2016

10. Radiation Work Permits RWP 17-0004 8/18/17; RWP 17-0005 8/22/17; and RWP 17-0007 8/31/17

11. 2017 Radiation Safety Program Status Report presented 8/18/2017

12. Copies of the event website established on the NIST intranet

13. Revised Statement from Health Physics Technician I

14. Final Report on SAL 2008 incident

15. SG-PR-13662 – Cracking of pressurized vials in the NHL---v2

16. OSHE Organization Chart

17. PML Organization Chart

18. RSO Delegation of Authority

19. Building 245 Floor Diagrams

20. Basement B-Wing Hallway Monitor results

21. Hand & Foot Monitor Results Red Square

22. Am241 Liver Phantom

23. “Radiological Assistance Program Region I Report” dated November 24, 2017

24. “NIST IRSC Investigation of the August 2017 Am-241 Event,” dated January 2018

25. “NIST IRSC Investigation of the August 2017 Lost Cf-252 Source,” dated February 26, 2018

26. “Intake and Dose Assessments For the Am-241 Broken Ampoule Contamination Event at the National Institute of Standards and Technology Gaithersburg, MD,” dated March 9, 2018