The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Radioactive Sources: Applications and Alternative Technologies

Virtual Meeting

PUBLIC AGENDA

September 9, 2020, Eastern Time (ET)

Virtual Committee Meeting
June 2020

Wednesday, September 9, 2020, Times are ET

Connection details for September 9:

Link: https://nas-sec.webex.com/nas-sec/j.php?MTID=mb49792a6218edf3ca216ffe293c79943
Meeting ID: 199 938 9641
Password: sbGB733uiUp (72427338 from phones and video systems)
Telephone: +1-415-527-5035 or +1-929-251-9612
Access code: 199 938 9641

PUBLIC SESSION 1: Disposition and Tracking of Radioactive Sources

10:00 am – 10:15 am	**Call Open PUBLIC SESSION 1 to Order and Welcome** Bonnie Jenkins, Committee Chair and Charles Ferguson, Study Director
10:15 am – 10:35 am	**1.1: IAEA's Programs for Disposition of Radioactive Sources** Ian Gordon, Head, Waste Technology Section, IAEA
10:35 am – 10:50 am	**Q+A and Discussion on Presentation 1.1**
10:50 am – 11:10 am	**1.2: NNSA Programs for End of Life Management for Radioactive Sources** Sarah Norris, Regional Officer and International Remove Coordinator, and John Zarling, Off-Site Source Recovery Program, Office of Radiological Security (ORS)/NNSA
11:10 am – 11:25 am	**Q+A and Discussion on Presentation 1.2**
11:25 am – 11:45 am	**1.3: Source Collection and Threat Reduction Program** Charles Meyer, Technical Assistant, Conference of Radiation Control Program Directors
11:45 am – 12:00 pm	**Q+A and Discussion on Presentation 1.3**
12:00 pm – 12:20 pm	**1.4 Physical Source Tracking Program** Brian Higgins, Operations Manager and Fredrick Mauss, Pacific Northwest National Laboratory
12:20 pm – 12:35 pm	**Q+A and Discussion on Presentation 1.4**
12:35 pm	**Adjourn PUBLIC SESSION 1**

Wednesday, September 9, 2020, Times are ET (cont.)

PUBLIC SESSION 2: Perspectives from the Research Community

2:00 pm – 2:05 pm	**Call Open PUBLIC SESSION 2 to Order and Welcome** Bonnie Jenkins, Committee Chair and Charles Ferguson, Study Director
2:05 pm – 2:25 pm	**2.1 Replacing Cesium-137 Irradiators at Mount Sinai** Jacob Kamen, Senior Director, Chief Radiation & Laser Safety Officer, Mount Sinai Health System
2:25 pm – 2:40 pm	**Q+A and Discussion on Presentation 2.1**
2:40 pm – 3:00 pm	**2.2 Replacing Cesium-137 Irradiators at University of California, Los Angeles** Kei Iwamoto, Director of the Radiation Oncology Animal Core, UCLA
3:00 pm – 3:15 pm	**Q+A and Discussion on Presentation 2.2**
3:15 am – 3:30 am	**2.3 Replacing Cesium-137 Irradiators at University of California, San Francisco** Byron Hann, Researcher, Laboratory Director for the UCSF Preclinical Therapeutics Core
3:30 am – 3:40 pm	**Q+A and Discussion on Presentation 2.3**
3:40 pm – 3:45 pm	**Adjourn PUBLIC SESSION 2**

List of Sample Questions Sent to the Presenters

IAEA, NNSA, CRCPD

- Please describe your organization's role in radioactive source disposition and the history of your disposition program(s).
- What was the motivation for establishing the disposition program?
- How many and what types of sources have you successfully disposed of the past 10-15 years? If possible, please provide a breakdown by year so that the committee understands the trends over the years.
- To the best of your knowledge what percent of sources in need of disposition does your program help dispose of? Is there a database of your program's activities related to disposition? Is that database publically accessible?
- What are the approximate costs for disposition and what factors drive these costs? Who covers the costs?
- Please describe the process from identifying a source that needs to be disposed, identifying the appropriate path for disposition, to actually disposing that source. What is the associated timeline?
- To your knowledge, what percent of sources are not disposed of appropriately and what are the reasons? What steps is your organization taking to eventually help dispose those sources?
- What assistance, if any, does your organization offer to entities that are unable to dispose of their sources for financial or other reasons? Do you offer financial incentives? Do you help enhance security of those sources?
- What are the challenges related to your program's effectiveness and what are some strengths?
- Please describe efforts to coordinate your program with other international, national, and state programs.

Additional questions to NNSA (new)

- Does NNSA/ORS know how much (order of magnitude amount in Curies) of Am-241 is foreign-origin and is in radioactive sources (used and disused) in the United States?
- What are the disposition options available for disused sources containing foreign-origin americium or other foreign-origin radionuclides? In particular, because Am-241 is a transuranic radionuclide, would the Waste Isolation Pilot Plant be an acceptable disposal option for either U.S.- or foreign-origin material? Would the Nevada National Security Site be acceptable or would another U.S. government disposal or storage facility?
- Can Am-241 be recycled or repackaged such that Am-241 from more than one disused source be combined to form sufficient Am-241 for a new source?
- What is the typical activity of Am-241 sources sent for disposal?
- What is the physical form of the Am-241 in these sources (alloy, powder, etc)?
- What is the approximate breakdown of types of Am-241 sources (e.g. alpha, gamma, neutron) as a percentage of total activity and as a percentage of the number of sources disposed?

- How much Am-241 waste (Curies) is produced by the various industries using it (including end users)?
- What is the volume and activity of Am-241 waste that is produced each year?
- How much Am-241 waste does NNSA believe to be awaiting disposal (e.g. sources no longer in use, but not yet shipped to a disposal site)?
- What fraction of Am-241 waste is disposed of via a government-subsidized program (e.g. OSRP)?
- What would NNSA do, if cost were not an issue, to better secure Am-241 that is no longer in use?

PNNL

- Please describe the motivation for establishing the tracking program and its history.
- Is the program currently implemented and if yes who has enrolled in it and how many sources are tracked?
- Please describe the technologies used for tracking.
- Can you provide real-life examples that prove the effectiveness of your tracking program?
- What sources could the program track?
- Is it currently applied or could it be applied internationally?
- In your view what sources have the biggest need for physical tracking and why?
- What are the strengths and challenges of the program? How do you anticipate you will be improving the program?

Researchers

- Please provide information on the number of irradiators (blood or research) that your organization had and replaced and the year(s) they were replaced.
- What motivated your organization to adopt alternative technologies? If your organization has not adopted alternative technologies, please provide the reasons (e.g., financial, regulatory burden, equivalency issues, challenges with showing equivalency).
- If applicable, please describe the process for replacing the irradiators, for example, if it was done through NNSA's CIRP or with other federal or state assistance.
- Did your organization perform a cost benefit analysis before deciding to replace the irradiators? If yes, please provide a summary of the analysis including factors you considered.
- Did your organization purchase an irradiator (blood or research) the past 10-15 years without having one to replace? What factors did you consider for deciding to purchase a cesium source or x-ray technology?
- Please describe any problems you anticipated/anticipate with a change of radiation source. How were those solved/how do you anticipate they can be solved?
- What assistance/support would be needed from the government or others to adopt alternative technologies for research?

Reading Material

1.1

- IAEA Public outreach videos on Rad. Waste Management (including some references to DSRS)
- Longer version (10 mins) - https://www.youtube.com/watch?v=3QXSkXHDZgU&t=384s
- Shorter version (2.2 mins) - https://www.youtube.com/watch?v=4j_wptct7kA&t=60s
- Policies and Strategies for RWM - https://www.iaea.org/publications/8116/policies-and-strategies-for-radioactive-waste-management
- Management of DSRS - https://www.iaea.org/publications/10582/management-of-disused-sealed-radioactive-sources
- Code of Conduct on Safety and Security of SRS (especially noting the recent Supplementary Guidance) - https://www.iaea.org/topics/codes-of-conduct
- Generic Post-closure Safety Assessment for Disposal of Disused Sealed Radioactive Sources in Narrow Diameter Boreholes
  - https://www.iaea.org/publications/12263/generic-post-closure-safety-assessment-for-disposal-of-disused-sealed-radioactive-sources-in-narrow-diameter-boreholes
- Model Regulations for Borehole Disposal Facilities for Radioactive Waste
  - https://www.iaea.org/publications/12284/model-regulations-for-borehole-disposal-facilities-for-radioactive-waste
- New CRP: (Coordonated Research Project). Developing a Framework for the Effective Implementation of a Borehole Disposal System (T22002)
  - https://www.iaea.org/newscenter/news/new-crp-developing-a-framework-for-the-effective-implementation-of-a-borehole-disposal-system-t22002
- BOSS: Borehole Disposal of Disused Sealed Sources(A Technical Manual)
  - https://www.iaea.org/publications/8207/boss-borehole-disposal-of-disused-sealed-sources

1.2

- IAEA Code of Conduct on the Safety and Security of Radioactive Sources - Supplementary Guidance on the Management of Disused Radioactive Sources: https://www.iaea.org/publications/13380/guidance-on-the-management-of-disused-radioactive-sources
- IAEA Nuclear Energy Series – Management of Disused Sealed Radioactive Sources: https://www.iaea.org/publications/10582/management-of-disused-sealed-radioactive-sources
- ORS Remove fact sheet: https://osrp.lanl.gov/Documents/Removing%20Disused%20Radioactive%20Sources.pdf
- INFCIRC 910 on Strengthening Security of High Activity Sealed Radioactive Sources: https://www.iaea.org/sites/default/files/publications/documents/infcircs/2017/infcirc910.pdf
- WINS Best Practice Guide on Security Management of Disused Radioactive Sources: https://wins.org/document/5-5-security-management-of-disused-radioactive-sources-2/
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management – Documents & National

Reports: https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents

- https://nucleus.iaea.org/sites/connect/DSRSpublic/Pages/default.aspx

1.3

- https://www.crcpd.org/page/SCATR
- Explanation for Prospective Participants in Collection, Revised December 9, 2019
- SCATR tri-fold

1.4

- ORS, Mobile source security initiative: Reducing risk in energy and infrastructure
- ORS, Radioactive source security for radiography: managing potential risk today
- ORS, Radioactive source security for well logging: managing potential risk today
- PNNL, 2020, Mobile Source Tracking for the Well Logging and Industrial Radiography Industries

2.1

- Kamen, Jacob; Hsu, Wen-ya; Boswell, Brandon; Hill, Colin "Successful Migration from Radioactive Irradiators to X-ray Irradiators in One of the Largest Medical Centers in the US". Health Physics 117 (5): 558-570; 2019
- Mount Sinai Experience in Migrating From Radioactive Irradiators to X-ray Irradiators for Blood and Medical Research Applications. **https://www.nti.org/media/documents/Mt._Sinai_Final_Report.pdf**
- Murphy MK, Kamen J; Deciding between an X-Ray and 137Cs Irradiator - It's not just about Energy Spectra; Radiation Research 2019 Nov;192(5):493-506
- B. Dodd and R.J. Vetter. Replacement of ^{137}Cs Irradiators with X-ray Irradiators. Health Phys. 2009 Feb; 96(2 Suppl):S27-30. doi: 10.1097/01.HP.0000334555.78657.bc.
- Gibson, BW; Boles, NC, Souroullas, GP, Herron, AJ, Fraley, JK, Schwiebert, RS, Sharp, JJ, Goodell, MA. Comparison of Cesium-137 and X-ray Irradiators by Using Bone Marrow Transplant Reconstitution in C57BL/6J Mice Comparative Medicine, Vol 65, No 3, Pages 165–172, June 2015.
- Janatpour K, Denning L, Nelson K, Betlach B, MacKenzie M, Holland P. Comparison of x-ray vs. gamma irradiation of CPDA-1 red cells. Vox Sanguinis 89:215219; 2005.
- Nuclear Threat Initiative. Radiological Security Progress Report. Available at https://www.nti.org/media/pdfs/NTI_Rad_Security_Report_final.pdf?_=1458750009 Accessed 20 June 2018.
- Pomper M, Murauskaite E, Coppen T. Promoting Alternative to High-Risk Radiological Sources: The Case of Cesium Chloride in Blood Irradiation. Washington D.C.: James Martin Center for Nonproliferation Studies, 2014
- United States Nuclear Regulatory Commission. U.S. Radiation Source Protection and Security Task Force 2010 Report. Available at: https://www.nrc.gov/security/byproduct/2010-task-force-report.pdf Accessed 20 June 2018.
- Mehta K, Parker A. Characterization and dosimetry of a practical X-ray alternative to self-shielded gamma irradiators. Radiation PhysicsandChemistry80(2011)107–113
- Kamen J; Reducing and removing the risks of terrorist use of radioactive materials; Journal of Healthcare Protection Management Volume 35 Number 1:13-25; 2019

2.2

- MacKenzie et al., 2019, Health Physics, University of California Replacement of Cesium Irradiators with Alternative Technologies, https://pubmed.ncbi.nlm.nih.gov/31869317/

Presenter Biographies

Ian Gordon leads Waste Technology Section at the IAEA. This Section assists the 171 Member States of the IAEA in the management of radioactive waste resulting both from the nuclear fuel cycle and from nuclear applications in health, industry, science and agriculture. Before joining the IAEA, Ian worked at Sellafield in the UK, leading various projects on the manufacturing of Mixed Oxide Fuel and on radioactive waste management. In his early career, Ian worked in design and project management in mass-manufacturing industries.

Dr **Byron Hann's** work focuses on the development and application of animal models of human cancer for the purpose of evaluating experimental anti-cancer therapeutics. As Laboratory Director of a the UCSF Cancer Center core, the Preclinical Therapeutics Core, he supervises a group that seeks to provide validated animal models as an in vivo testing platform for translation of novel therapeutics. His group acts to help to design, execute and interpret preclinical studies, typically testing in vivo hypotheses that have been generated in vitro. His laboratory also serves as a repository of validated cancer cell lines, tissue lines, engineered and immuno-deficient mice, and specialized surgical techniques. The research focus is therefore a combination of model development and experimental optimization to align with investigative goals. Another area of investigation is the use of molecular imaging modalities as a non-invasive way to measure tumor burden. This is particularly useful for orthotopic and metastatic xenograft tumor models in which tumor assessment would otherwise require animal sacrifice and complex dissection.

Brian Higgins is the PNNL Operations Manager and Program Lead for the Mobile Source Transit Security project sponsored and led by the Department of Energy's National Nuclear Security Administration's (DOE/NNSA) Office of Radiological Security (ORS). He leads a technical team of engineers, researchers, and subject matter experts to plan and execute scope funded by the DOE/NSSA to mitigate the risk of theft or loss of radiological material that could be used in the construction of a Radiological Dispersal or Exposure Device. Brian has been working at PNNL and involved with DOE/NNSA's Nuclear Non-Proliferation and Response efforts for over a decade and has primarily focused on new/emerging technologies that better enable the department to mitigate the risk of radiological and nuclear terrorism.

Kei Iwamoto received his Ph.D. in radiobiology and experimental radiation oncology from UCLA. He studied as a post-doctoral fellow and then as a senior scientist funded through the U.S. National Academy of Sciences (NAS) at the Radiation Effects Research Foundation in Hiroshima, Japan, a binational foundation supported by the Japanese Ministry of Health and Welfare and the US Department of Energy through the NAS. He is currently a Professor in the Division of Molecular and Cellular Oncology in the Department of Radiation Oncology at the David Geffen School of Medicine at UCLA.

Jacob Kamen is the Senior Director of Radiation Safety and the Chief Radiation Safety Officer for the Mount Sinai Health System (MSHS). He has direct oversight of all clinical and research

activities involving the use of radiation and radioactive materials for over 40,000 employees spread over nine MSHS hospital campuses. His Radiation Safety program provides surveillance for the largest healthcare institution in the United States, which cares for over 80,000 patients per week. Presently, Dr. Kamen serves as Professor of Radiology at the Icahn School of Medicine at Mount Sinai, however, he has also held faculty appointments with both Manhattan College and New York University. He is board certified by the National Registry of Radiation Protection Technologist (NRRPT), American Board of Health Physics (ABHP) and Board or Laser Safety (BLS). He is also an instructor in radiation safety for the Society of Nuclear Medicine as well as the annual International Cardiology Board Review, a preparatory seminar for board-eligible physicians. Dr. Kamen earned his doctoral degree in Nuclear Engineering at Columbia University where he was the president of the American Nuclear Society (ANS) University Chapter. He has been strong advocate of using alternative technologies to migrate from high activity radioactive sources to alternative technologies since 2010. He has published articles as how hospitals should respond to a dirty bomb in a congested area (i.e. for Non-Conventional Threat). He has also been publishing many articles on how to migrate from radioactive irradiators to x-ray irradiators.

Fred Mauss is a project manager for the Office of Radiological Security Program. He leads technical research and design teams by directing key development areas; concept generation, integration and test plans, and implementation strategies. He provides technical design guidance during the development cycles which encompass prototypes, engineering units, and final products. Typical product development projects range from low powered stand-alone electronic devices to complex multi-subsystem development which requires integration of electrical, mechanical, firmware, and software solutions for production and field use. He is currently developing systems for tagging and tracking mobile radiation sources.

Charles Meyer has been employed by the Conference of Radiation Control Program Directors, Inc. (CRCPD) since July 30, 2010. His responsibilities consist of providing technical and administrative assistance on matters related to general health physics, conducting research and providing general technical information and administrative services on radiation protection matters to staff in the Office of Executive Director (OED), to commercial firms, government agencies, members of the CRCPD, other professional associations and the general public. He also serves as OED's technical expert in radiation protection; evaluates the technical accuracy of CRCPD information relating to general health physics matters; keeps abreast of technical developments and innovations in the field of radiation protection; and, responds to diverse inquiries regarding radiation sources and radiation control programs. Lastly, he manages the technical component of the CRCPD National Orphan Radioactive Material Disposition Program and the Source Collection and Threat Reduction Program.

Sarah Norris is a Foreign Affairs Specialist in the DOE/NNSA's Office of Radiological Security. For four years, she has led ORS' engagements with countries of South-Central Asia and the Caucasus, as well as served in the role of International Remove Coordinator. In her role as International Remove Coordinator, she works with DOE/NNSA management to shape policy and guidance surrounding international disused source management efforts, collaborates with technical experts to identify new projects and opportunities that enhance end of life management, supports ORS meetings with the IAEA on topics of disused source management, and provides removal guidance to ORS project managers.

John Zarling has over ten years of experience at Idaho National Laboratory in the field of sealed radioactive source packaging, transportation and disposal. Currently he is supporting

the National Nuclear Security Administration Office of Radiological Security (ORS) in Washington D.C. as a technical expert for the safe and secure handling of disused sealed sources. Previously he served as the Program Manager for the Off-Site Source Recovery Project that is tasked with recovering and securely dispositioning excess, disused, unwanted, or abandoned radioactive sources domestically and overseas for ORS. Dr. Zarling has participated in numerous IAEA consultancies for the end of life management of disused sealed radioactive sources and has led multiple domestic and international sealed radioactive source packaging recoveries for ORS.