Ionizing Radiation in Conservation Labs Part 2: Radioactive Objects

Haddon Dine and Cassia Balogh

Straus Center for Conservation and Technical Studies, Colonial Williamsburg Foundation

September 2020

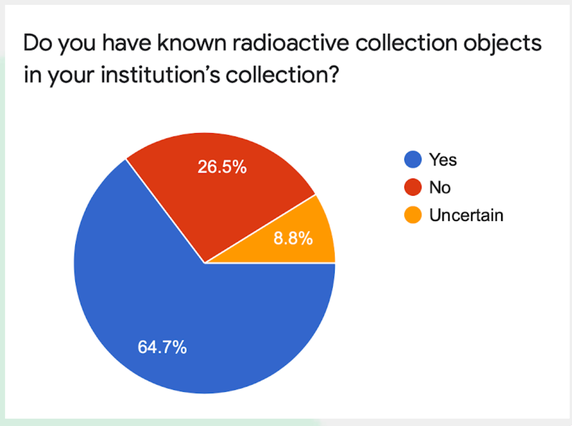
Introduction

Ionizing radiation can be a concern for conservation professionals, not only because it is emitted by some of the instruments used to conduct analysis but also because some collection items are radioactive. Collections and instruments emit different kinds of radiation; these radiations present different dangers, can be blocked by different materials, and require different detectors to monitor for them. Everyone already accrues naturally occurring radiation and some from medical procedures, but it is important to aim to receive an annual dose that is as low as reasonably achievable (ALARA). This poster presents information focused on safety in relation to radioactive collection objects, from a survey distributed to the conservation community via the AIC Global Forum in 2020, alongside general related information for reference. The survey asked about awareness of and precautions taken with radioactive collection objects, as well as use of ionizing radiation producing equipment and radiation monitoring equipment (covered in Ionizing Radiation in Conservation Labs Part 1: Monitoring Equipment). The aim of this poster is to promote thinking about all aspects of safety when it comes to radioactive collection objects. It is hoped that this will encourage safe practices in storage, handling, treatment, staff training, and more.

Concern and Awareness

Survey respondents' concerns about radioactive collection materials vary from minimal/no concern to high concern based on what collection objects they have to deal with, their knowledge of them, and in some cases their experience working with other, more dangerous sources of radiation.

While 64.7% of respondents have known radioactive objects in their collections, only 46.9% feel that they have a good awareness of the extent of radioactive objects in their collection.



Radioactive Collection Items

Survey respondents are aware of radioactive materials in their collections in decorative arts, industrial objects, historic medical and scientific laboratory equipment, war artifacts, musical instruments, and scientific specimens, including the following:

radium paint on gauges and dials on watches, clocks, compasses, radios, aircraft, and other vehicles
uranium glass (both decorative arts and industrial/musical instruments)
spinthariscopes
mineral/geological/fossil specimens
radiated water samples
uranium-containing enamel
ceramics
gas mantles
material from Hiroshima
thoriated glass
pharmaceutical/apothecary materials
medical equipment
historic laboratory equipment
camera lenses
uranyl nitrate
thermometers
tritium-containing instruments

Private collection of uranium glass (aka vaseline glass) illuminated with UV light © Marion Swart

Other possible radioactive collection objects:

- There is an array of products from the early to mid-20th century that unexpectedly (to us) contain radioactive elements. This was due to the fascination with, and illusory health benefits of, radiation. Radioactive products eventually fell out of favor when the biological effects of radiation became better understood. Some of these products include but are not limited to toothpaste, soap, chocolate, water, and condoms. Luckily, if these objects exist within your collection or practice they likely clearly state on the packaging that they contain radioactive substances (sometimes a false claim) because that was a marketable feature at the time! However, know that even unmarked household objects from this period may pose a danger. (Orci 2013)
- Objects might be assumed safe if they pre-date the radium craze, but if they were refurbished in the 1930's through 1970's the materials used for restoration may include radioactive materials. (Rowe 2018)
- Uranotypes are photographs produced by making uranium nitrate impregnated photographic paper, and uranium nitrate was also used as a toner for photographs. Uranotypes are still produced today by some artists.
- Cobalt-containing materials (such as pigments in paintings) that have been exposed to a neutron source may remain radioactive for years afterwards. (Sayre and Lechtman 1968)
- Some glass companies in the United States still produce decorative uranium-containing glass.
- Many products still produced today contain small amounts of radioactive material, such as luminous watches and gun sights, incandescent gas mantles, irradiated gemstones, welding rods, and smoke detectors. (Schneider et al. 2001)
- Remember that radioactive objects might not always be what you expect. While bright-colored glazes such as those on Fiestaware might be what comes to mind when thinking of radioactive ceramics, in a recent ICOM-CC article the authors identified a radioactive bronze-green matte glaze on a ceramic. They knew uranium-containing red and orange glazes were used, but discovered that the green also contained uranium. (Baas and Megens 2019)

Finding Radioactive Collections

Since there can be unexpected radiation sources in a collection, or if you suspect anything might be radioactive, using a Geiger counter or survey meter is a quick way to give collections a check. However, remember that most commonly used Geiger counters cannot give dose numbers.

Most survey meters, like the Geiger counters with Geiger-Müller (GM) tube detectors that many conservation labs have, are good for detecting the presence of radiation and relative levels. If you need to measure dose specifically, something such as a scintillation detector, ion chamber detector, or energy-compensated GM tube is needed. An instant read-out dosimeter could also be used (See Ionizing Radiation in Conservation Labs Part 1). The list is even more limited for dose-measuring equipment that detects alpha radiation (only scintillation counters or specialized alpha detectors). An understanding of calculations and the complicated issues of dose is still necessary to determine actual exposure; whenever possible, it is best to consult a specialist.

Measurements/Numbers

While it is generally accepted that the radiation emitted by most radioactive art objects is so low as to not be a concern, the dose from working on radioactive objects repeatedly for long periods of time is not well understood in the field. Many survey respondents' institutions have done qualitative checks of objects with Geiger counters, and several have had radiation specialists measure the levels.

Example Measurements: The Nuclear Regulatory Commission (NRC) gives example estimated dose rate numbers as part of a report titled "Systematic Radiological Assessment of Exemptions for Source and Byproduct Materials" (NUREG-1717).

For a 10 inch diameter glass disk with 10% uranium content:
-at contact the beta dose rate is 0.27 mSv/h (27 mrem/h).
-at 610cm the beta dose rate is 0.000000032 mSv/h (.0000032 mrem/h).

To get the contribution to the effective dose equivalent, the dose rate number is multiplied by weighting factors for the appropriate exposed organs. At contact, the beta exposure contribution to the Effective Dose Equivalent (EDE) rate is 2.7×10^{-5} mSv/h (2.7×10^{-3} mrem/h). Beta and gamma would need to be combined for overall exposure.

The NRC also gives estimated EDE rates from gamma irradiation from pieces of glassware containing 10% uranium. At 1 cm from the object, the effective dose equivalent rate is 4.3×10^{-5} rem/h for a drinking glass and 7.8×10^{-5} rem/h for a "decorative piece".

Estimates are also provided for the highest individual annual dose from the normal use ("normal use" = the highest dose value from distribution, transport, routine use, and disposal) of a number of source materials, including glass (4 mrem), glazed ceramic tableware (50 mrem), and unrefined ore (300 mrem).

The example numbers above are low, but because radiation exposure is cumulative it is recommended to reduce contact with objects to follow the ALARA principle. For reference, the annual exposure limit in the US for the public and untrained employees is 100 mrem. A chest X-ray will expose you to 10 mrem of radiation. (Environmental Protection Agency 2019)

Keep in mind that uranium content in glass is not always consistent, and objects you encounter may have much higher or lower radioactive element content than estimates assume. If possible, it is best to get measurements from your objects. Additionally, the above numbers are for external exposure. Internal exposure, through inhalation or ingestion of radioactive particles, is much more dangerous because your organs lose the natural shielding of air and skin. Friable objects are particularly hazardous in this way.

Safety Precautions/Working with Radioactive Collections

Most respondents have not worked on radioactive materials or do not take safety precautions when they do, but some have highly developed protocols in accordance with their local regulations. Some respondents' precautions are included in the following list:

Preventive

- staff training and assessments
- risk assessments
- enclosures/isolation/added storage materials
- restricted work/storage areas
- wearing dosimeters around materials
- clear labeling
- ventilated storage

Active Treatment and Handling

- disposable paper lining on work surfaces
- designated work space and tools
- work behind shielding (leaded glass, plexiglass, etc.) and/or increase distance between the object and face by working with magnification
- use of PPE such as: gloves, dust masks or respirators, Tyvek body suits
- limiting time and minimizing handling
- keeping objects inside plastic bags during examination to contain material

Reactive

- clean surfaces, dispose of hazardous waste
- check afterwards for contamination on surfaces and tools with wipe tests or a Geiger counter
- check/document time spent working and dosimeter readings

Different protocols may be necessary for different levels of risk (for example, intact uranium glass does not pose the contamination and inhalation risk of friable radium paint). It is best to know what you are dealing with! If you are dealing with radioactive objects, especially if you will be undertaking a treatment or are uncertain about any aspect of storage, handling, or level of radioactivity etc, it may be best to consult a safety professional. For case studies, refer to published detailed protocols provided by several institutions for working with certain types of objects (Norquest, Kile, and Peters 2016; Rowe 2018).

The legal aspects of having radioactive collection objects will differ depending on what country you are in, but you may need a license if you have more than a certain number of radioactive objects. If so, you probably are aware and are working with a safety organization to comply with regulations. Make sure you are in compliance with local or federal regulations (this may require consulting an outside safety professional if your institution is not under the purview of a safety organization). Radiation safety regulations may affect surveys, safety training, and protocols for treatment, display, storage, labeling, packing, and shipment.

Conclusion

Radioactive objects pose a small but real risk, and can be found in some unexpected places. If you are working with radioactive objects, risk assessments should be done to consider all possible methods of exposure, contamination, and waste. Taking measurements and consulting a professional are always options if you are unsure. Consider what practices and precautions might need to be implemented; this could affect your storage, handling, treatment, staff training, and more.

It is worth remembering that you are accumulating naturally occurring ionizing radiation every day, and even non-ionizing radiation can cause biological damage (e.g. UV light causing skin cancer). However, awareness, monitoring, and preventive measures can help reduce excess exposure to radiation and limit negative health effects. Check your local laws and recommendations for your occupational regulations, but always aim for minimal exposure.

References

Baas, B. and L. Megens. 2019. Analysis of the Microstructure and Elemental Composition of Uranium-Containing Microcrystals Observed in the Characteristic Bronze-Green Matte Glaze of Rhodian-Type Gouda Pottery from the Early 20th Century. In *Recent Advances in Glass and Ceramics Conservation 2019: Interim Meeting of the ICOM-CC Glass and Ceramics Working Group and Icom Ceramics and Glass Group Conference Preprints, London, 5-7 September 2019,* ed. J. Mandrus and V. Schussler. London: International Council of Museums.

Environmental Protection Agency (EPA). n.d. "Radiation Sources and Doses." Last updated on August 6, 2019. https://www.epa.gov/radiation/radiation-sources-and-doses.

Government of Canada, Canadian Centre for Occupational Health and Safety. 2016. "Radiation - Quantities and Units of Ionizing Radiation: OSH Answers." Canadian Centre for Occupational Health and Safety. Accessed December 28, 2020. https://www.ccohs.ca/oshanswers/phys_agents/ionizing.html.

Nondestructive Testing Resource Center (NDT). 2012. "Introduction to Radiation Safety." https://www.nde-ed.org/EducationResources/CommunityCollege/RadiationSafety/cc_rad-safety_index.htm

Norquest, Sharon, Amelia Kile, and David Peters. 2016. "Working with a collection of radioactive aircraft instruments." In Objects Specialty Group Postprints, Volume Twenty-Two, 2015, edited by Emily Hamilton, Kari Dodson, Sarah Barack and Kate Moomaw, 169-180. Washington, DC: The American Institute for Conservation of Historic & Artistic Works.

Oak Ridge Associated Universities (ORAU). 1999. "Health Physics Historical Instrumentation Museum Collection: Museum Directory." Last updated January 3, 2012. https://www.orau.org/ptp/museumdirectory.htm

Orci, Taylor. "How We Realized Putting Radium in Everything Was Not the Answer." The Atlantic. Atlantic Media Company, March 7, 2013. https://www.theatlantic.com/health/archive/2013/03/how-we-realized-putting-radium-in-everything-was-not-the-answer/273780/.

Rowe, S., 2018. Managing Small Radioactive Collections in the UK: Experiences from the Polar Museum, Cambridge. Journal of Conservation and Museum Studies, 16(1), p.4. DOI: http://doi.org/10.5334/jcms.166

Sayre, Edward V., and Heather Lechtman. 1968. "Neutron activation autoradiography of oil paintings". Studies in Conservation. 160-184.

Schneider, S., D.C. Kocher, G.D. Kerr, P.A. Scofield, F.R. O'Donnell, C.R. Mattsen, S.J. Cotter, J.S. Bogard, J.S. Bland, C. Wiblin. 2001. Systematic radiological assessment of exemptions for source and byproduct materials. Washington, DC: Division of Risk Analysis and Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission. https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1717/nureg-1717.pdf

United States Department of Labor, Occupational Safety and Health Administration. n.d. "Ionizing Radiation." Accessed January 10, 2021. https://www.osha.gov/SLTC/radiationionizing/introtoionizing/ionizinghandout.html.