Radioactive Samples

Changes made in this revision:

- No changes made to this procedure since its last review

Prepared by:

Steve Davey, AES

Reviewed by:

Argonne Health Physics
PSC/EFOG Group Leader
HSE - XSD/ESH Coordinator

Approved by:

AES/Division Director
APS/Deputy Director, X-ray Science
PSC/Safety Manager

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POLICY

This policy reflects the basic Argonne philosophy that in non-controlled areas, such as the APS experimental floor, there should be no release of radioactivity. Any significant release could pose a health hazard to APS users and a risk to APS operations. The policy described below is meant to prevent radioactive releases and to limit the consequences of a potential release.

Radioactive Samples

All experiments involving radioactive samples must be identified as Experiment Hazard Class 8.1 on the ESAF and are categorized as *High Risk*.

Any radioactive sample that a user is considering bringing to the APS must be declared on an ESAF. Triggered by the ESAF submission, the APS Radioactive Sample Safety Review Committee (RSSRC) and the experimental facilities management (CAT, CDT, or APS Group) will review the plans. Approval by both the RSSRC and the experimental facilities management is required to bring radioactive samples on to the Argonne site and use them at the APS.

New experiments should be submitted through an ESAF at least two months before the expected scheduled date of the experiment. Previously approved containment, isotopes, and weights can be submitted as late as two weeks in advance. Sample size/number of samples may be limited depending on the isotope(s) in use by this experiment and the amounts of other radionuclides in use at the APS site at the same time.

Triggered by the ESAF review, the APS will generate a standard operating procedure (SOP) for handling of the sample during the experiment. The SOP includes: a description of the required engineered and procedural controls; the role of Argonne Health Physics Group (HP); specific personal protective equipment (PPE) requirements, and sample handling before, during, and after the experiment.

Due to the minimal risks associated with some naturally occurring background levels of some uranium and transuranic isotopes in soils (including ore, rock, sand etc.), some soil samples may not require radiologically specific controls. Soil samples, that come from sources identified in the Appendix or exceed isotopic concentrations listed in the Appendix, must be identified as radioactive materials on the ESAF and appropriate radiological controls will be required. Other soil samples, with natural background levels and not otherwise a radioactive sample, need not be declared as radioactive materials on the ESAF. In any case, all samples must be identified and characterized for the ESAF and if there are questions about requirements (or if in doubt) contact the APS User Safety Officer.

All radioactive materials must arrive through Argonne Receiving in Building 46 and the Argonne Material Control & Accountability Group (MC&A). Contact the APS User ESH Group for the correct shipping address. Radioactive samples may not be shipped to the APS without prior approval by the APS. After being received in Building 46, all on-site movement of

radioactive materials will be arranged by and transported by designated Argonne personnel. Users are not allowed to transport radioactive materials on the Argonne site.

All signs and postings required for the experiment station will be supplied by HP. Beamline to make arrangement for storage safe for samples. Procedures for sample handling must be posted at the experiment station.

Training required of experimenter using radioactive samples:

- Argonne Radiation Worker I (ESH 700) with an Argonne site-specific practical training for all experiment participants that will handle the radioactive material.
- Argonne Radiation Worker II (ESH 702) may be required for certain experiments, dependent on results of the review by the APS RSSC.

All users involved in the experiment will be required to wear a dosimeter during the experiment, unless otherwise noted in ESAF. HP is responsible for all monitoring of samples.

Containment requirements:

- Solid samples must have at least one acceptable containment enclosure unless a specific exemption has been granted by the RSSRC. In general, no credit shall be allowed for a sample holder as containment. This will be determined by the RSSRC after a review of the proposed experiment.
- Powder and liquid radioactive samples will be allowed provided they have a minimum of two containment enclosures.

Gaseous radioactive samples are prohibited. These requirements must be followed unless a specific exemption has been granted by the RSSRC.

If multiple samples are each individually contained within separate primary barriers, they can have a common secondary and tertiary barrier. Fragile materials used as containment must be approved by the RSSRC. Upon request the experimenter must provide a physical example of the containment proposed and be available to meet with the RSSRC.

The following must be provided for each sample:

- Sample information
    - Total sample matrix, weight, and dimensions
    - The amount (**weight**) of each radioactive isotope in the sample
    - A detailed description of the sample containment.
    - Any data on the integrity of the sample, the sample holder, and containment under the expected experiment conditions (e.g., heating, cooling, pressure, etc.)
    - Special training requirements, in reference to handling, accountability, transport, etc. of the samples.

  - Exposure readings from the sample at contact and at 30 cm and a description of the instruments used to perform the measurements.
  - If there are multiple samples inside a primary containment, the sample masses for each isotope must be summed to give the total mass for each isotope within the primary.

- Beam information
  (Note: Contact the Beamline to obtain the information for items listed below.)
  - Approximate beam size and flux.
  - Beam type (Mono/Pink/White).
  - Beam energies if Mono or ID gap if pink/white.
  - Energy cutoff if pink beam.

It is the policy of Argonne that the maximum a person should inhale from a breach or leak in sample containment should not exceed 2% of the annual limit of intake (ALI) for a given dispersible radionuclide.

Table 1 lists the maximum allowed amount in an APS experiment station of various radionuclides. In the case of multiple radioisotopes, the q_i for each radioisotope must obey

$$\sum_i q_i / (q_{\max})_i \leq 1.0$$

which ensures that committed effective dose does not exceed 100 mrem.

Where:

- q_i is the activity (µCi)of the i^{th} radionuclide and
- q_{maxi} the maximum allowed sample activity (µCi)for a solid sample of the i^{th} radionuclide.

Table 1: Maximum Allowed Solid Sample Activity of Selected Radionuclides*

Nuclide Activity	Specific Solid Sample Activity (Ci/g)	Derived Air Concentration (μCi/cc)	Maximum Allowed Solid Sample Activity (μCi)	Maximum Allowed Solid Sample Weight (g)
Th-229	2.12E-01	4.0E-13	3	1.415E-05
Th-230	2.05E-02	3.0E-12	24	1.17E-03
Th-232	1.09E-07	5.0E-13	4	3.67E+01
U-235	2.15E-06	2.0E-11	163	7.58E+01
U-238	3.35E-07	2.0E-11	163	4.87E+02
Nat-U	6.85E-07	2.0E-11	163	2.38E+02
Dep-U	3.35E-07	2.0E-11	163	4.87E+02
Np-237	6.99E-04	2.0E-12	16	2.29E-02
Pu-238	17.0	3.0E-12	24	1.41E-06
Pu-239	6.19E-02	3.0E-12	24	3.88E-04
Pu-240	2.27E-01	3.0E-12	24	1.06E-04
Pu-242	3.91E-03	3.0E-12	24	6.14E-03
Am-241	3.42	3.0E-12	24	7.02E-06
Am-243	0.198	3.0E-12	24	1.21E-04
Cm-248	4.23E-03	7.0E-13	6	1.42E-03
Cf-248	1.58E03	3.0E-11	244	1.5E-07
Cf-252	5.35E02	8.0E-12	65	1.22E-07
Bk-249	1.63E03	7.0E-10	5691	3.49E-06
Es- 253	2.51E04	2.0E-10	1672	4.6E-8
Sr-90	13.7	8.0E-09	6.5E-04	4.74E-03
Tc-99	1.69E-02	1.0E-7	8.13E5	4.8E1
Tc-99m	5.24E06	1.0E-5	2.69E8	5.13E-5

* The Maximum Allowed Activity is evaluated for one hour duration of stay in the experiment station (hutch), i.e., t=1hr, with an assumed volume of 1.0E08 cc, with an assumed effective number of air exchanges, λ_v =0.05 (1/h), and the total release fraction F=0.001. The total release fraction could be modified on a case by case basis depending on the sample matrix, the nature of the x-ray beam, (unfocused or focused), the proven integrity of the sample holder design and any additional containment provided to the sample. For powder and liquid samples, the maximum allowed activity is reduced by a factor of 10.

References

- A. Brodsky, Radiation Protection Requirements in Relation to the Quantity and Toxicity of the Radioactive Material Processed, Radiation Protection Management, 6 (5), September/October 1989.

- J.D. Constance, Simplified Method for Determining Inhalable Contaminants, Pollution Engineering, July 1972.

- 10 CFR 30.72, Schedule C – Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release, Chapter 1, 1-1-91 Edition.

- E.E. Hickey, G. A. Stoezel, P.C. Olsen & S. A. McGuire. Air Sampling in the Work Place, NUREG-1400 Draft Report for Comment, October 1991.

- V. R. Veluri, Draft Policy on Laboratory Work Place Containment Requirements for Dispersible Radionuclides, Internal Note, Argonne National Laboratory, 1991, Rev-1992.

- V.R. Veluri, A. Justus, B. Glagola, A. Rauchas & J. Vacca, Experiments with Radioactive Samples at the Advanced Photon Source, Proceedings of the 34th Midyear Topical Meeting, Anaheim, CA, February 2001.

- Calculation of Radioactive Sample Limits, APS document number APS_1412829.

- Argonne Procedure "Managing Radioactive Material Inventories in Radiological Facilities" LMS-PROC-45

- HPTN-2015-02 "Radioactive Samples at User Facilities"

FEEDBACK AND IMPROVEMENT

If you are using this procedure and have comments or suggested improvements for it, please go to the APS Policies and Procedures Comment Form* to submit your input to a Procedure Administrator. If you are reviewing this procedure in workflow, your input must be entered in the comment box when you approve or reject the procedure.

Instructions for execution-time modifications to a policy/procedure can be found in the following document: Field Modification of APS Policy/Procedure (APS_1408152).

* https://www.aps.anl.gov/Document-Central/APS-Policies-and-Procedures-Comment-Form

Appendix A

Identification of soil, ore, rock, sand, etc. samples as radioactive materials, based on Argonne Health Physics Technical Note (HPTN-2015-002), Radioactive Samples at User Facilities (May 1, 2015)

A1) For any given soil, ore, rock, sand, etc. sample, if the answer to any of the following questions is yes, the sample must be identified as a radioactive material on the ESAF:

Is the sample source from any of the following?

i. Ores of uranium or thorium

ii. Mine tailings from mining of any of the above ores

iii. Sands, soils, rocks, or other natural materials from any global locations known to have concentrations of thorium or uranium or thorium/uranium daughters above the background values given in Table A

iv. Soils from the Chernobyl or Fukushima exclusion zones

v. Soils from any site related to nuclear weapons testing or production areas which have not been environmentally remediated

vi. Soils from nuclear waste storage areas which have not been environmentally remediated

vii. Sediments in water outflows from the areas listed in iv, v, and vi above

viii. Materials controlled as radioactive by user's originating USA state laws, USA federal regulations, or user's originating nation's regulations (user's home institute's radiological safety officer should be able to advise on this)

ix. Materials in which a radioactive isotope concentration has been increased by isotopic separation

(Continued)

A2) For any given soil, ore, rock, sand, etc. sample, if the concentrations are greater than those listed below, the sample must be identified as a radioactive material on the ESAF:

Argonne Radiological Background Concentrations in Soil

Radionuclide	Concentration (pCi/g)	Mass Concentration[1]	Equivalent dpm/g
Strontium-90 (Sr90) from Fallout	0.2	1.5fg/g (1.5 ppq)	0.44
Cesium-137 (Cs137) from Fallout	1.0	11 fg/g (11 ppq)	2.2
Other gamma-ray emitting fission and activation products such as europium-152 from Fallout	0.2	-	0.44
Natural uranium (99.28% U238, 0.72% U235)	1.73 U238[2] 0.08 U235	5 µg/g (5 ppm)[2]	3.8 U238[2] 0.18 U235
Individual U238 daughters[3] such as Ra-226	1.73	-	3.8
Individual U235 daughters[4] such as Th231	0.08	-	0.18
Natural thorium (100% Th232)	1.76	16 µg/g (16 ppm)	3.9
Individual Th232 daughters[5] such as Th228	1.76	-	3.9
Plutonium-239 (Pu239) from Fallout	0.03	0.5 pg/g (0.5 ppt)	0.07
Americium-241 (Am241) from Fallout	0.01	3 fg/g (3 ppq)	0.02

1 µg/g = micrograms per gram of sample (parts per million, ppm)
pg/g = pictograms per gram of sample (parts per trillion, ppt)
fg/g = femtograms per gram of sample (parts per quadrillion, ppq)
2 Use for depleted uranium and separated U238
3 U238 principal daughters in sequence of decay are: Th234, Pa-234m, Pa234, U234, Th230, Ra226, Rn222, Po218, Pb214, Bi214, Po214, Pb210, Bi-210, Po-210, Pb206 (stable)
4 U235 principal daughters in sequence of decay are: Th231, Pa231, Ac227, Th227, Ra223, Rn219, Po215, Pb211, Bi211, Tl207, Pb207 (stable)
5 Th232 principal daughters in sequence of decay are: Ra228, Ac228, Th228, Ra224, Rn220, Po216, Pb212, Bi212, Po212 (64% of Bi212 decays), Tl208 (34% of Bi212 decays), Pb208 (stable)