Fermilab Radioactive Source Training

ES&H Section

Course # FN000048

Introduction

- Fermilab's Radioactive Source Control and Accountability Program allows Fermilab to meet the needs of experiments, protect the health and safety of employees and experimenters, and assures compliance with DOE regulations.

- Fermilab's Radioactive Source Program is administered by the ES&H Section.

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  Source Physicist Back Up: Sue McGimpsey
  Source Technician: Joe Leo
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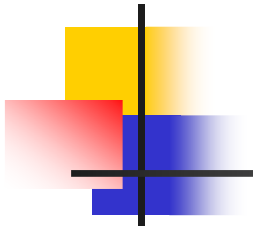
- This training describes Fermilab's radioactive source control program, common configurations of sources used at Fermilab, review of ALARA concepts, source inventory number system, Source Monitor responsibilities, and source use policies.

Objectives

- Identify three source configurations used at Fermilab.
- Review ALARA, radiation exposure reduction principles and units of radioactivity.
- Explain each portion of the source inventory number (source ID).
- Identify Fermilab Source Monitor responsibilities and procedures for proper use of source lock keys.
- Identify Fermilab policies for proper and safe source use.

Common Configurations of Sources Used at Fermilab

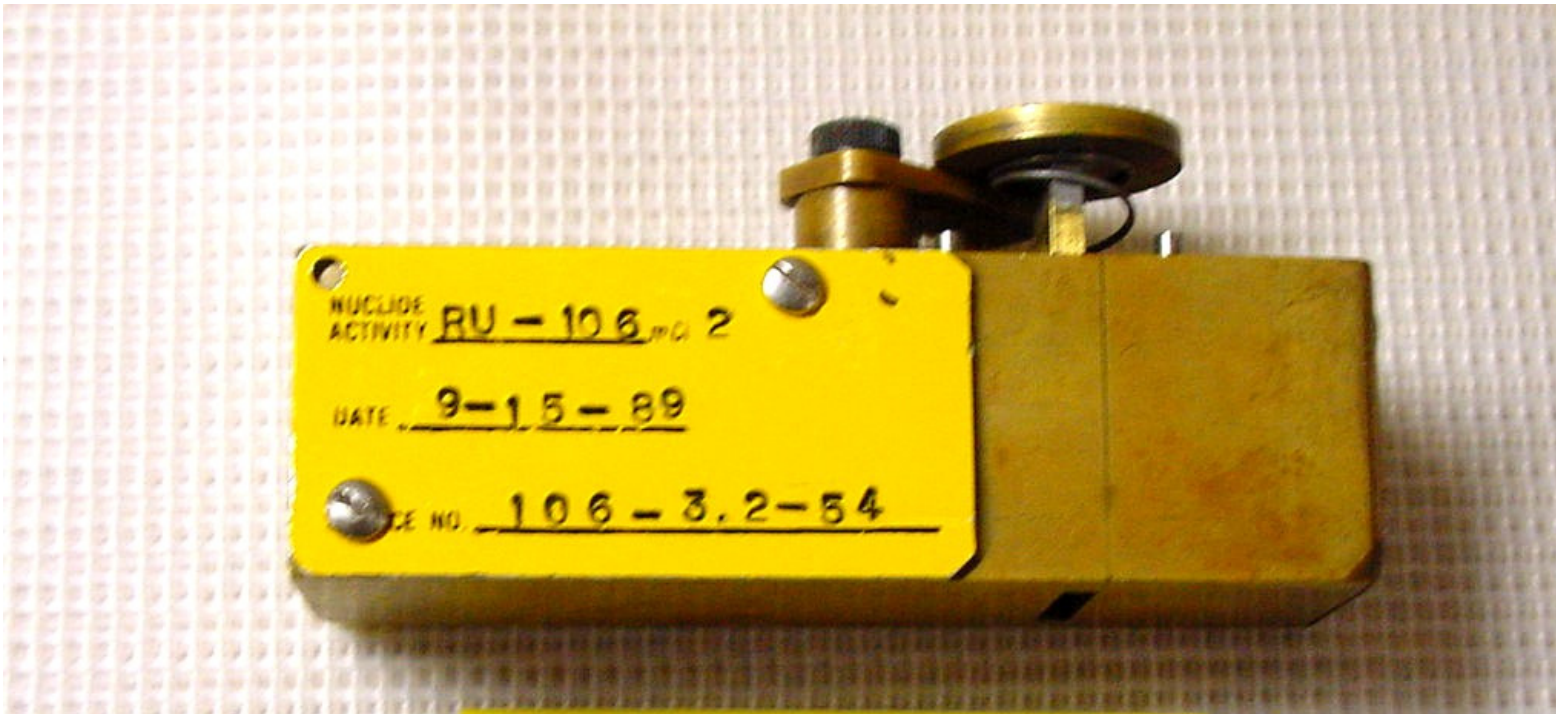


- Beta Gun
- Disk
- Wand

Beta Gun

- Sr-90 or Ru-106 source installed in a brass holder.
- Beta gun has a shutter mechanism on the top of the gun. When the shutter is pushed down, it is open; betas come out the collimated opening at the front end.
- When the shutter is released, it is closed; betas are shielded.
- Bremsstrahlung radiation is produced from betas interacting with the brass holder.

Ruthenium-106 Source in Beta Gun



Disk Configuration

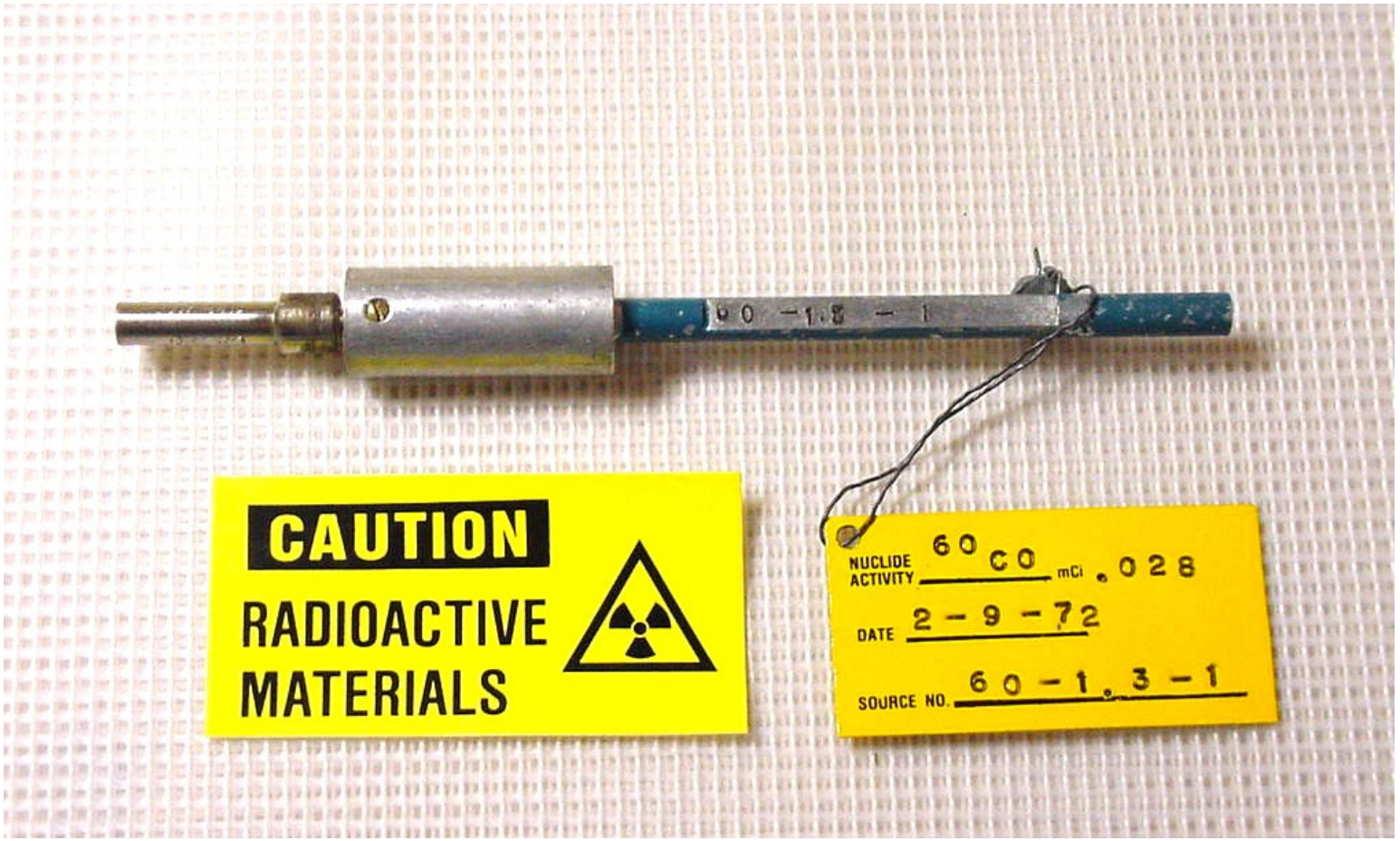
- Fe-55, Sr-90, and Ru-106 are commonly housed in 2 inch diameter aluminum disks.
- There is a cover attached to the disk that should be used when the source is being stored.
- When putting the cover on the disk, do not crimp the wire that attaches the source ID tag to the disk. If you notice damage to the wire, please notify the ES&H Section Source Physicist or Source Technician.

Iron-55 Source Installed in a Disk

Wand Configuration

- Higher energy gamma emitters such as Cesium-137, Cobalt-60, and Sodium-22.
- Delivered in a brass shielded container called a “pig”.
- Source should remain in the brass shield during storage and transport to location of use.

Cobalt-60 Wand Source



ALARA and Methods of Radiation Dose Reduction

- ALARA stands for As Low As Reasonably Achievable. It is a radiation safety principle for keeping radiation exposures as low as reasonable achievable.

- Use time, distance and shielding to keep exposures ALARA.

ALARA Continued

- Time: **Minimize** the time spent in the vicinity of a source.

- Distance: **Maximize** the distance between you and a radioactive source. The inverse square law applies to point sources: $1/r^2$ where r is the distance from the source. If distance is doubled between you and the source, the exposure rate is reduced by a factor of four.

ALARA Continued

- Shielding: **Maximize** shielding. Use appropriate shielding for the type of radiation emitted from the source. Aluminum or plastic can be used for beta radiation and lead or some other high-density material can be used for gamma or x-ray radiation.

Units of Radioactivity

Radioactivity is expressed in units of either Curie (Ci) or Bequerel (Bq). Fermilab uses units of curie or subunits such as millicurie ($1x10^{-3}$ Ci) and microcurie ($1x10^{-6}$ Ci).

- 1 Curie = $3.7x10^{10}$ disintegrations per second (dps).
- 1 millicurie = $3.7x10^{7}$dps
- 1 microcurie = $3.7x10^{4}$ dps
- 1 Bequerel = 1 dps

Radioactive Source Inventory Number System

- Fermilab has a unique system of source identification. Upon arrival at Fermilab, the Source Technician assigns each source an individual inventory number (source ID).

- The inventory number is the atomic mass followed by representation of the initial radioactivity (activity) in microcuries (rounded to one significant figure). The last number is a sequential serial number denoting the number of sources of that atomic mass and activity that are in the inventory to date.

Source inventory number (source ID) examples:

1. 90 - 3.1 – 51

   90 = Radionuclide identified by atomic mass (Sr-90)
   3.1 = Initial activity = $1x10^3$ or 1000 microcuries
   51 = Sequential serial number

2. 137 - 2.5 – 1

   137 = Radionuclide identified by atomic mass (Cs-137)
   2.5 = Initial activity = $5x10^2$ or 500 microcuries
   1 = Sequential serial number

3. 241 (-1.4) 9

   241 = Radionuclide identified by atomic mass = Am-241
   (-1.4) = Initial activity = $4x10^{-1}$ or 0.4 microcuries
   9 = Sequential serial number

Source Monitor Program

1. Source Monitors are assigned keys for designated source storage box/cabinets.
2. If you are **not** a Source Monitor, you must contact the Source Monitor designated for the particular box containing the source that you will use. You should ensure that a Source Monitor will be available at the time you return the source to storage.
3. In the event that a Source Monitor cannot be contacted, return the source to the lower box, close the lid and contact a Source Monitor as soon as possible. The Source Monitor will retrieve the source, return it to the main source box and complete the source access log.

Radioactive Source Storage Box

Source Monitor Program Con't.

4. Source Monitors are responsible to:

- Ensure that his/her name is posted near the source box.
- Lock and unlock source storage boxes.
- Complete the source access log sheet each time a source is removed and returned to the storage box.

Source Monitor Program Con't.

- Verify that the source user requesting a source is qualified to use sources. A current list of persons qualified to use sources is on the ES&H Section web page.

- Return source lock keys to the Source Physicist if he/she leaves Fermilab or for any reason, or no longer chooses to be designated as a monitor.

- Ensure source users display a "Caution, Radioactive Material" and either "Caution, Controlled Area" or "Caution, Radiation Area" sign (if not already posted) during source use. These signs are usually kept in source storage boxes.

Source Monitor Program Con't.

5. Keys to source box/cabinet locks should **not** be transferred to persons who are not Source Monitors. In some cases, Source Monitors may share a source lock key. For example, if a source lock key is kept in a key box with other keys, all Source Monitors for a particular source box may use the key.

6. Source lock keys shall **not** be duplicated. The Source Physicist coordinates duplication of keys.

General Source Use Policies

1. To obtain a radioactive source that is not currently located in a source storage box, contact the Source Physicist (or designee). The Source Physicist will complete the radioactive source loan form and the user shall sign the form.

2. Sources with exposure rates high enough to cause Radiation Areas to exist require specific written work authorization. This work approval requires signatures of authorized users and Source Monitors. The exposure rate at one foot from the source is recorded and special precautions for source use are documented. Division/Section Head signature is required to authorize the use of this type of source.

General Source Use Policies Con't.

3. A list of sources that cause Radiation Areas is posted inside each source box. The source user should refer to this list as a reminder to determine whether the source they are using causes a Radiation Area.

General Source Use Policies Con't.

4. Requests for source installation or modification of source holders must be discussed with ES&H Section personnel.

5. Purchase requisitions for radioactive sources should be forwarded to the ES&H Section Source Physicist or designee for proper approval and signatures.

6. Sources and source boxes/cabinets shall be accessible to ES&H Section personnel for monthly inventory and leak testing.

Radioactive Source Controls

1. Do not destroy, alter, or disassemble sources or their housing.

2. Do not detach the "Caution, Radioactive Material" label or the source identification tag from the source.

3. Immediately notify the ES&H Section Source Physicist or Source Technician if a source appears to be missing.

Source Controls Continued

4. Call x3131 immediately if you suspect that a source is damaged in a way that could cause contamination. Do **not** handle or allow others to handle the source. If you think you may have radioactive contamination on your body or clothes, ask someone to dial x3131 and stay where you are.

Source Controls Continued

5. Do not leave sources unattended. Sources shall be constantly attended or secured in a way that prevents unauthorized use.

- If you leave for lunch, either return the source to its storage box or arrange for another qualified source user to oversee the source during your absence.

- If you leave for a few minutes for a phone call or a break, you must either secure the source or have a qualified source user oversee the source.

Source Controls Continued

6. Contact the ES&H Section Source Physicist if a source needs to be in use for an extended period of time (several hours, days) without returning it to its storage box/cabinet. Special arrangements will be made to ensure that the source is secured in a way that prevents unauthorized use.

7. Keep radioactive sources in a locked box/cabinet when not in use. The storage box/cabinet shall be labeled "Caution, Radioactive Material." Portable source storage containers are unacceptable.

Source Posting Requirements

1. Always display a "Caution, Radioactive Material" sign near the source during use. Return this sign to the source box when source is no longer in use.

Controlled Area Posting Requirements

2. If the exposure rate from a source does **NOT cause a Radiation Area**, then post all access points where the source is used and stored as follows:

"Caution, Controlled Area"

and

"Caution, Radioactive Material" or

"Caution, Radioactive Material Area"

Controlled Area Posting

Controlled Area Posting

Radiation Area Posting Requirements

3. A Radiation Area exists when the exposure rate is equal to or greater than 5 mR/hr at 30 cm (1 foot) from the source.

   If a source causes a **Radiation Area**, the user shall:

- Wear a dosimetry badge.

  Remember to wear your dosimetry badge between your neck and waist. Dosimetry badge wear period is for 3 months at a time. Therefore, badges must be exchanged every January 1st (or first working day after New Year's holiday), April 1st, July 1st, and October 1st. Dosimetry badges shall not be taken off site.

- Post all access points to the area where the source is used as follows:

  "Caution, Radiation Area"
  AND
  "Caution, Radioactive Material" or
  "Caution, Radioactive Material Area"

Radiation Area Posting

Source Posting Requirements Con't.

4. If the source will be used in an open area, ropes, chains and/or stanchions should be used to post each access point. When a source is returned to storage, these postings should be removed.

Source Posting Requirements Con't.

5. If the source is used inside a room, every door or the outside wall next to each door should be posted.

6. When sources are contained within experimental apparatus, a clearly visible "Caution, Radioactive Material" label indicating the source ID shall be attached to the outside of the apparatus.

Sources installed in experimental apparatus

On Site Source Transfers

1. The user shall contact the ES&H Section Source Physicist or Source Technician to arrange for on site source transfers.

2. ES&H Section personnel deliver, pick up, and transport sources in government vehicles.

3. Transport of sources in private vehicles is prohibited.

On Site Source Transfers

4. Contact the ES&H Section Source Physicist or Source Technician when the source is no longer needed. ES&H Section personnel will pick up the source and return it to ES&H Section storage.

5. The user may carry sources on foot from one building to another as long as the source is returned to its designated storage box after use.

Off Site Source Transfers

1. Radioactive sources shall not be brought on or taken off Fermilab site unless approved in advance by Fermilab's Senior Radiation Safety Officer (SRSO) or designee. Fermilab's SRSO is the ES&H Section Head.

2. To ship a source off site, contact the Source Physicist. A material move request form must be completed before the source can be shipped. The Source Technician will pick up the source, package it in accordance with Department of Transportation (DOT) regulations, and deliver it to Fermilab's Shipping/Receiving Department.

Radioactive Source Lessons Learned

- A technician punctured an Americium-241 source capsule. Damage to this source resulted in contamination in Wilson Hall and in the individual's house. It also resulted in an internal radiation dose to the individual.

- Several Iron-55 foil sources were destroyed because the foil was torn away from the source. A worker was instructed to remove layers of aluminum foil that had been used to shield the sources. Because the surface of the source is also foil, the worker was unaware that he was tearing the source material. This incident resulted in contamination on the worker and the workbench.

Lessons Learned Continued

- A Cobalt-60 wand source capsule was removed from the aluminum handle and was never found. An Iron-55 source was removed from its aluminum disk holder and never recovered.

- Workers were cleaning an area and piled scrap on top of a wooden box. During a safety walk through, it was noticed that the box was marked as containing radioactive material. Further investigation showed that there was a Ruthenium-106 radioactive source installed the box. The source was removed to prevent it from being tossed out with the rest of the scrap.

Lessons Learned Continued

- There have been instances where radiological signs have not been posted properly.

Lessons Learned Continued

- A 5 millicurie Strontium-90 source was left in a pedestal drawer of a workbench instead of being returned to the source storage box.

Lessons Learned Continued

- A Cs-137 source was used in a motorized source scanner for two years. A new source scanner was built with the "identical design" to the old source scanner. Without properly determining whether the new and old source scanner were identical, the source was put in the new scanner, and the scanner was turned on. In fact, the new scanner had a support beam the old scanner did not have, and the source was damaged when it hit the support beam.

Lessons Learned Continued

- A Ru-106 disk source was removed from experimental apparatus and left in an unsecured location instead of being returned to the source box.

Source Policy Violations

- If violations of source control policies occur, sources are confiscated and returned to ES&H Section storage. In general, Division/Section Head approval is required before the sources may be reissued.

- If repeated source use policy violations occur, the user's source use privileges may be revoked.

Questions

- If you have any questions regarding this training or other questions regarding the use of radioactive sources, please contact Kathy Graden of the ES&H Section at graden@fnal.gov or x4939.