# 4 - Introduction to Sealed Radioactive Sources

SAND2011-2049P

*Defense Nuclear Nonproliferation*


## Search and Secure Workshop

# Definitions

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- **Active Use Source-** A radioactive source under regulatory control that is actively being used and is stored when not in use in a safe and secure manner

- **Disused Source-** A radioactive source, which is no longer used, and is not intended to be used, for the practice for which an authorization has been granted

# IAEA Categorization Table

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Increasing Risk

| Category | Practice |
|---|---|
| 1 | RTG's; Irradiators;<br>Teletherapy; Gamma Knife |
| 2 | Gamma radiography<br>Brachytherapy (high and medium dose) |
| 3 | Fixed industrial gauges; calibration sources<br>(e.g.: level, dredger, conveyor gauges)<br>Well logging |
| 4 | Brachytherapy (low dose except eye plaques & perm implants)<br>Portable gauges; Static eliminators; Bone densitometers |
| 5 | Brachytherapy (eye pl. & perm implants); XRF; ECD |

See IAEA TecDoc 1344 & 1388 for further details

# IAEA Category 1

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- **Applications:**
  - Radioisotopic thermoelectric generators (RTG's)
  - Industrial Irradiators (sterilizers and food irradiators, etc.)
  - Teletherapy and gamma knives
  - Fixed multi-beam teletherapy (gamma-knife)
  - Seed irradiators
  - Blood irradiators

# Teletherapy



- Used for treating tumors
- Found in medical clinics
- Typically contains $^{60}Co$ or $^{137}Cs$
- Activity ranges from:
  - $^{60}Co$ 1,000–15,000 Ci (37–560 TBq)
  - $^{137}Cs$ 500–1,500 Ci (19–56 TBq)

# Radioisotope Thermoelectric Generators (RTGs)

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- Devices that used sources to generate heat that is converted to electricity to power various devices
- $^{90}$Sr Activity ranges from:
  - $^{90}$Sr 90,000–680,000 Ci or (330–25 PBq)

# Blood Irradiators

- Used to sterilize blood
- Found in medical or research applications
- Typically $^{60}Co$, $^{137}Cs$, $^{170}Tm$
- Activity ranges from:

  $^{60}Co$ 1,500–3,000 Ci (56–111 TBq)

  $^{137}Cs$ 1,000–12,000 Ci (37–440 TBq)

# Industrial Irradiators

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Typically Cs-137 or Co-60 in excess of 1,000 Ci (37 TBq)

# IAEA Category 2

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- Applications:
  - Industrial gamma radiography
  - High and medium dose rate brachytherapy
  - Instrument calibration

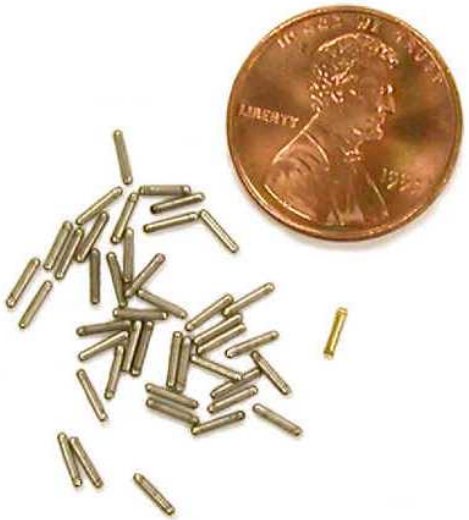
# Brachytherapy



- Sources placed inside or near a tumor to deliver a large dose to the tumor tissue

- Radionuclide and activity depends varies based on type of tumor i.e.,

| | |
|---|---|
| $^{137}Cs$ | $^{125}I$ |
| $^{60}Co$ | $^{226}Ra$ |
| $^{192}Ir$ | $^{252}Cf$ |




# Industrial Radiography Sources

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- Used to take pictures of dense objects
- Portable
  - $^{192}Ir$ ,$^{60}Co$,$^{75}Se$,$^{169}Yb$,$^{170}Tm$
- Typical activities are
  5–200 Ci (0.19–7.4 TBq)


# Radiography Cameras

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Co-60 or Ir-192
Usually 150 Ci (5,000 GBq) or less

# Instrument Calibration Sources

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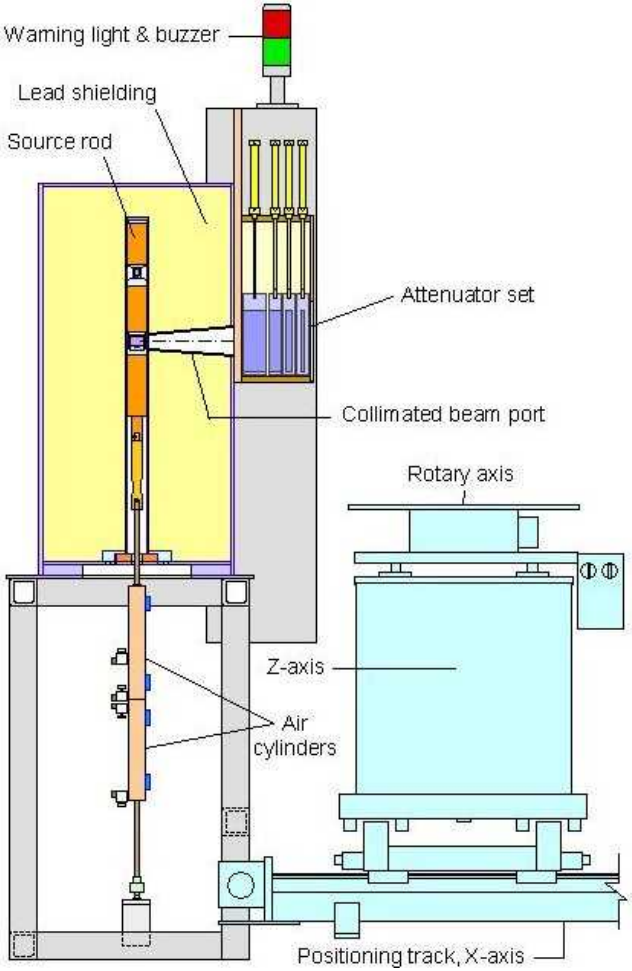
Cs-137, Co-60, Am-241
Typically less than 100 Ci (3700 GBq)




# IAEA Category 3



- Applications:
  - Fixed industrial gauges
    - level gauges
    - dredger gauges
    - conveyor gauges containing large sources
    - spinning pipe gauges
  - Well logging gauges

# Industrial Gauges

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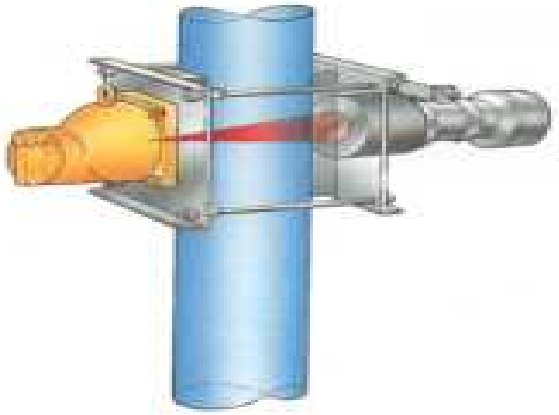
- Common $^{137}Cs$ 1-5 Ci (37-185 GBq)




# Petroleum Well Logging

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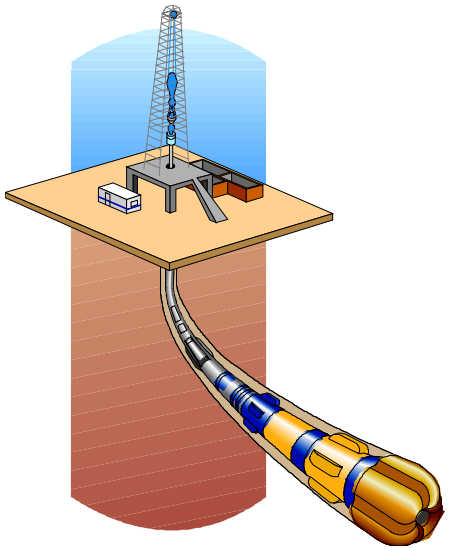
- $^{241}$Am/Be 5-20 Ci (185-740 GBq)
- Neutron and gamma dose rate

Well logging

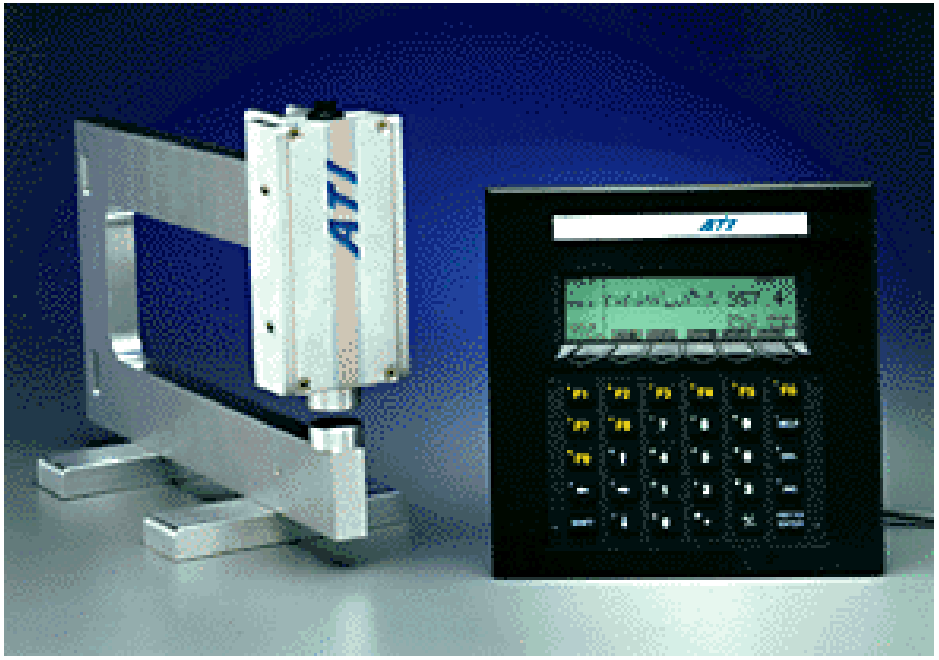
# IAEA Category 4



- Applications:
  - Low dose rate brachytherapy (except $^{90}Sr$ eye plaques and permanent implant sources)
  - Thickness/fill-level gauges
  - Portable gauges (e.g., moisture/density gauges)
  - Bone densitometers
  - Static eliminators
  - High level lightning rod arrestors ($^{154/152}Eu$)

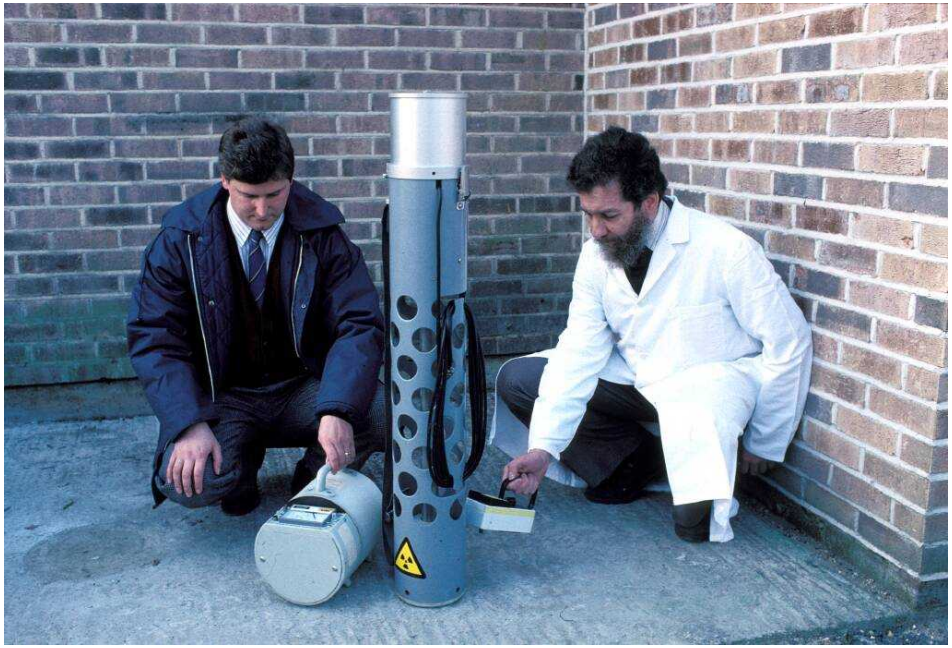
# Beta Thickness Gauges

- Shutter open (beta)
- Typically less than 1Ci (37 GBq)




# Shallow Well (Level) Gauges

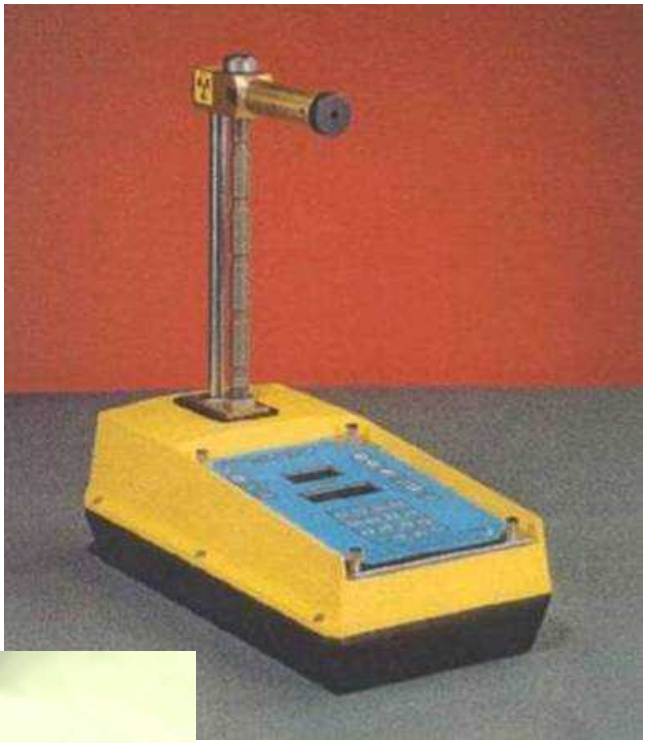
- $^{241}$Am/Be ~50-70 mCi (1.85 – 2.60 GBq)
- Neutron and gamma dose rate



# Moisture Density Gauge



- Unit can have two sources:
  - Photon $^{137}Cs$ or $^{226}Ra$
  - Neutron $^{241}AmBe$ or $^{252}Cf$
- Activities are typically
  - $^{137}Cs$ 8 – 11 mCi
  - (300–410 MBq)
  - $^{241}AmBe$ 10–100 mCi (370–3700 MBq)
  - $^{226}Ra$ 2–4 mCi
  - (74–150 MBq)
  - $^{252}Cf$ 0.3–0.7 µCi
  - (1.1–2.6 MBq)



# High Level Lightning Rod Arrestors

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**$^{154/152}$Eu 50-400 mCi (2-15 GBq )**

# IAEA Category 5

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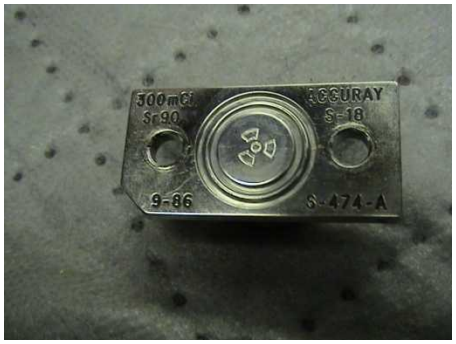
- Applications:
  - Low dose-rate brachytherapy eye plaques and permanent implant sources
  - X-ray fluorescence devices
  - Electron capture devices
  - Mossbauer spectrometry
  - PET check sources
  - Low level lightning rod arrestors

# Sealed Sources








# Low Level Lightning Rod Arrestors

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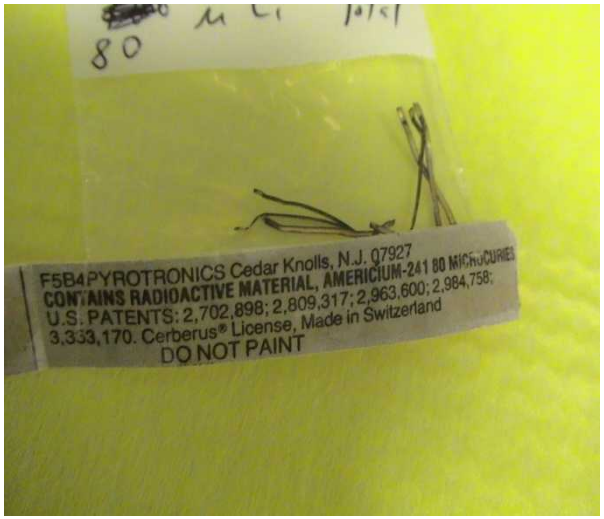
**Fair Raythor**

**Typically**
**Am-241 or Ra-226**
**37-370 MBq (1-10 mCi)**

**Helitita**




**Am-241 foil strip source**

**Nuclear Ibérica**

**Nuclear Ibérica**

# Consumer Products





# Summary

- Sealed radioactive sources come in a variety of shapes and sizes
- Sources manufactured for the same purpose by different companies can be completely different in shape/size