



IAEA

Adoption of Non-radioisotope Technologies and the Management of Disused Sealed Radioactive Sources (DSRS)

FASEM2026 for Energy Materials Advanced School, March 19th 2026

Mr Frank Cocina

Nuclear Engineer (Disused Sealed Sources Specialist)

Division of Nuclear Fuel Cycle and Waste Technology

Department of Nuclear Energy

International Atomic Energy Agency

OBJECTIVES

- Define (Disused) Sealed Radioactive Sources (SRS)/ (DSRS) and Alternative Technologies
- Discuss the Pros/Cons, regulatory/end of life management considerations, and some of the motivations to switch to alternatives
- Review the types of sources that become disused with the adoption of alternatives.
- Discuss complications that arise with the management of these types of DSRS
- Review DSRS management Strategies.
- Discuss IAEA efforts to assist member States with DSRS management.

SEALED RADIOACTIVE SOURCES (SRS)

- **Sealed Radioactive Sources (SRSs)** are radioactive material sealed in a capsule or closely bonded and in a solid form and not exempt from regulatory control
- SRSs are used globally in industry, medicine, agriculture and research.
- **A Disused Radioactive Sealed Source (DSRS)** is an SRS that is no longer used, and is not intended to be used, for the practice for which an authorization was granted.



ALTERNATIVES TO SEALED RADIOACTIVE SOURCES

- Alternatives consist of Radiation Generators, typically X-Ray and Accelerators.
- A radiation generator is a device capable of generating ionizing radiation, such as X rays, neutrons, electrons or other charged particles, that may be used for scientific, industrial or medical purposes
- In some cases, non-ionizing techniques can replace SRS.

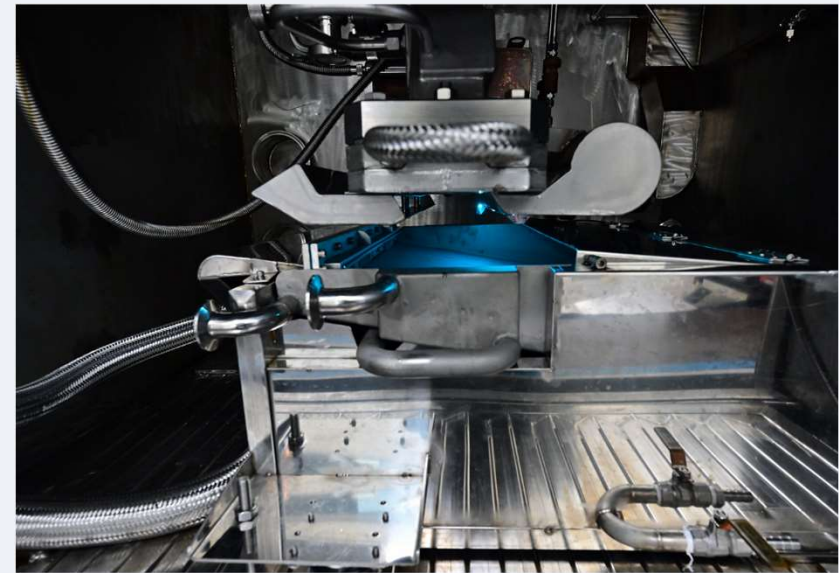


Photo from IAEA Flickr: <https://flic.kr/p/2rt4MGp>

PROS AND CONS SRS VS ALTERNATIVES

- **DSRS**

- PRO: Known energies (long history of use)
- PRO: Low Infrastructure needs
- PRO: Reliability
- CON: Increased Security Concerns
- CON: High Transport and End of Life Management Costs
- CON: NO OFF SWITCH

- **Alternatives**

- PRO: Technological Advantages, quicker through-put.
- PRO: Fewer security concerns.
- PRO: Low end of life management costs.
- CON: High infrastructure demands.
- CON: Higher maintenance costs.



IAEA Regulations and Guidance: SRS vs Radiation Generators

Category	IAEA Document	Applies to Devices SRS	Applies to Radiation Generators
Governmental, Legal and Regulatory Framework for Safety	IAEA GSR Part 1	✓ Yes	✓ Yes
Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards	IAEA GSR Part 3	✓ Yes	✓ Yes
Occupational Radiation Protection	IAEA GSG-7	✓ Yes	✓ Yes
Radiation Protection of the Public and the Environment	IAEA GSG-8	✓ Yes	✓ Yes
Radiation Safety of Gamma, Electron and X Ray Irradiation Facilities	IAEA SSG-8	✓ Yes	✓ Yes
Radiation Protection and Safety in Medical Uses of Ionizing Radiation	IAEA SSG-46	✓ Yes	✓ Yes
Radiation Safety in Industrial Radiography	IAEA SSG-11	✓ Yes	✓ Yes
Predisposal Management of Radioactive Waste	IAEA GSR Part 5	✓ Yes	● Limited
Security of Radioactive Material in Use and Storage and of Associated Facilities	NSS No. 11G	✓ Yes	✗ No
Regulations for the Safe Transport of Radioactive Material	IAEA SSR-6	✓ Yes	✗ No
Radioactive Source Security Framework	Code of Conduct on the Safety and Security of Radioactive Sources	✓ Yes	✗ No
Categorization of Radioactive Sources	IAEA RS-G-1.9	✓ Yes	✗ No

Industrial Irradiation Co60 to E-Beam

- **Industrial irradiation** is a process that uses ionizing radiation to treat materials for various industrial purposes. This technique is widely applied across sectors like manufacturing, food processing, medicine, and materials science.
- Co60 sources still heavily used especially where deeper penetrating radiation is necessary.
- E-Beam facilities becoming more popular for quick throughput when lower penetrating dose is effective.



Photo Provided by: A. Meleg - Hungary

TELETHERAPY: CO60 TO LINAC

Teletherapy (also called external beam radiotherapy) is a type of radiation therapy in which a high-energy radiation source is positioned at a distance from the patient's body to deliver precise doses of radiation to treat medical conditions, most commonly cancer.



Photo from IAEA Flickr: <https://flic.kr/p/2g9LsUn> and F. Cocina IAEA

COMMON TELETHERAPY DEVICES:

Theratron / Equinox

Full Device



Device Head



Source Holder or Drawer



Alcyon



Picker

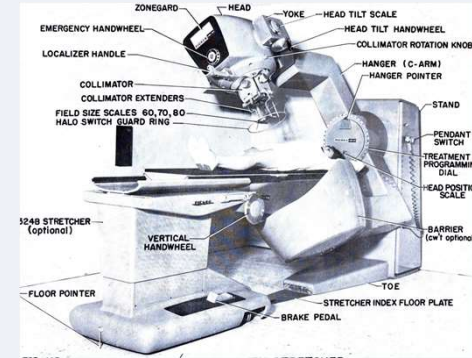
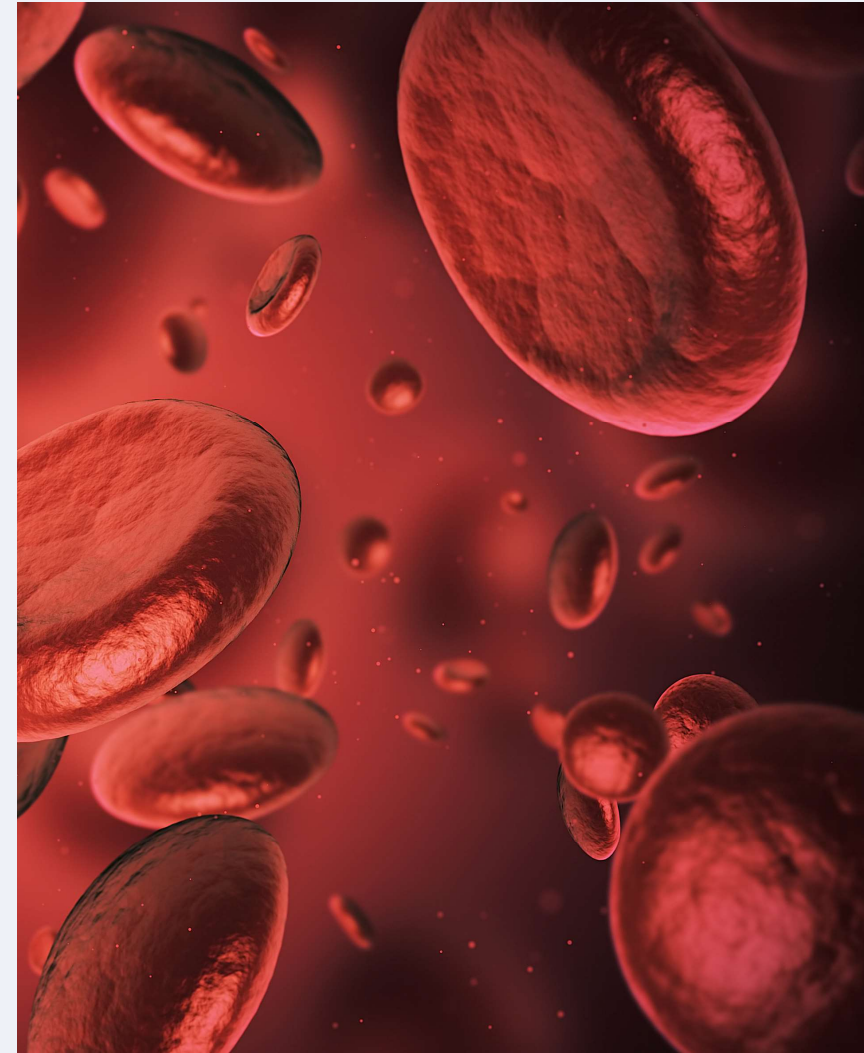


Photo Provided by: F. Cocina - IAEA

BLOOD IRRADIATION: CS137 TO X-RAY

Blood irradiation is a medical technique used to prevent a rare but deadly complication known as Transfusion-Associated Graft-versus-Host Disease (TA-GvHD) by exposing blood products to ionizing radiation. 15 – 25Gy is typically required.



COMMON BLOOD IRRADIATION DEVICES:

Gammacell 1000/3000

IBL 437c

Bio Beam

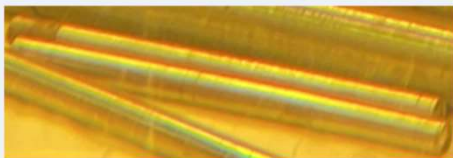
Full Device



Device Head/ Shield

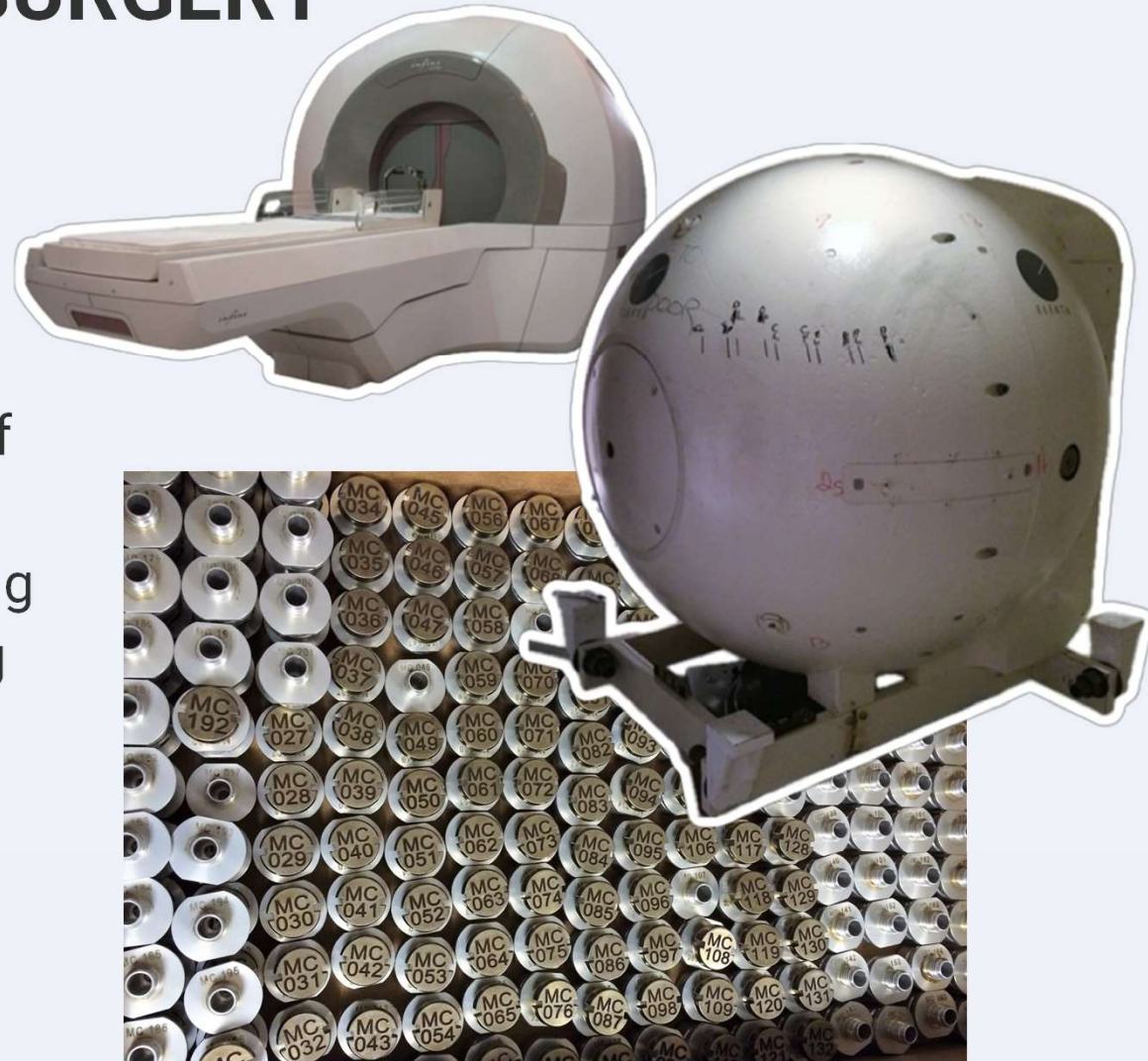


Sources



STEREOTACTIC RADIOSURGERY

- **Stereotactic Radiosurgery** uses focused beams of high-dose ionizing radiation to precisely target a defined area for treatment. Focused beams of radiation are delivered from multiple angles intersect at the target, delivering a high dose to the lesion while sparing nearby tissues.
- Commonly known as a “Gammaknife”



Photos Provided by: F. Cocina - IAEA

RESEARCH IRRADIATORS: CO60/CS137 TO X-RAY

Research Irradiators are typically self-shielded irradiators used to expose biological samples, materials, or small animals to ionizing radiation for research or testing purposes. They are widely used in bio-sciences, medical research, agriculture, and materials testing.



Custom Cs137 Research Irradiators

Photo Provided by: F. Cocina - IAEA

COMMON RESEARCH IRRADIATORS:

Gammacell 40

Full Device



Device Shield



Source Holder or Drawer



Gammacell 220



Biological Shield



JL Shepherd Mark 1



Biological Shield



Photos Provided by: F. Cocina - IAEA

SEED IRRADIATORS: CS137/CO60 TO X-RAY/EBEAM

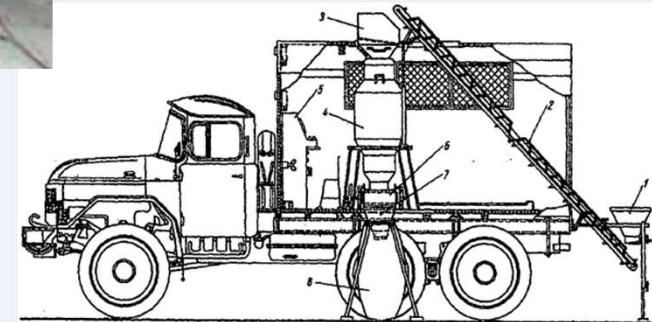
Seed irradiation is the process of exposing seeds to controlled doses of ionizing radiation to induce genetic mutations or achieve sterilization. It's widely used in agriculture, plant breeding, and food security research.



Gammcell 220 (Canada)
Co60
Max: 999TBq
Up to 48 pencil sources



Kolos Facility (USSR)
Cs137
Max: 129TBq



STERILE INSECT TECHNIQUE (SIT): CS137/CO60 TO X-RAY / E BEAM

Sterile Insect Technique (SIT) is used to sterilize insects through controlled exposure to ionizing radiation (90-100Gy). The goal is to induce permanent sterility in male insects without significantly compromising their ability to compete for mates in the wild.



Photos Provided by: F. Cocina - IAEA

SEALED RADIOACTIVE SOURCES (SRS)

IAEA Safety Standards Series No. RS-G-1.9

Source categorization is based on the radioactive content and its capability to cause deterministic health effects (i.e., tissue damage from acute exposure).

- The **A/D** ratio is used to assess how dangerous a source is: the higher the A/D ratio, the greater the potential hazard.
- **A** is the activity of the source (in terabecquerels or curies), and
- **D** is the “D-value”, which is a radionuclide-specific value representing a dangerous activity level for that radionuclide.
- **D Values are listed in Table II-2 of RS-G-1.9**

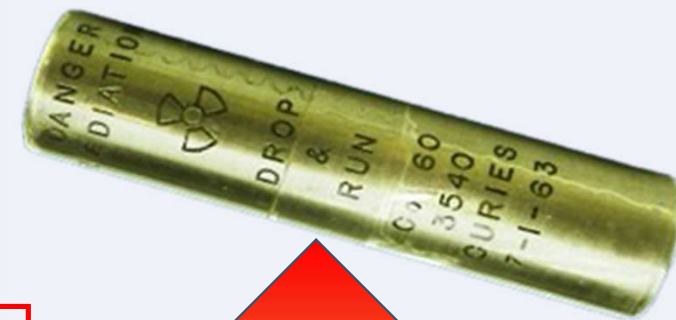
TABLE II-2. ACTIVITY^a CORRESPONDING TO A DANGEROUS SOURCE (*D* VALUE^b) FOR SELECTED RADIONUCLIDES, AND MULTIPLES THEREOF

Radionuclide	1000 × <i>D</i>		10 × <i>D</i>		<i>D</i>		0.01 × <i>D</i>	
	TBq	Ci ^c	TBq	Ci ^c	TBq	Ci ^c	TBq	Ci ^c
Am-241	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Am-241/Be	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Au-198	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Cd-109	2.E+04	5.E+05	2.E+02	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Cf-252	2.E+01	5.E+02	2.E-01	5.E-00	2.E-02	5.E-01	2.E-04	5.E-03
Cm-244	5.E+01	1.E+03	5.E-01	1.E+01	5.E-02	1.E+00	5.E-04	1.E-02
Co-57	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
Co-60	3.E+01	8.E+02	3.E-01	8.E+00	3.E-02	8.E-01	3.E-04	8.E-03
Cs-137	1.E+02	3.E+03	1.E+00	3.E+01	1.E-01	3.E+00	1.E-03	3.E-02
Fe-55	8.E+05	2.E+07	8.E+03	2.E+05	8.E+02	2.E+04	8.E+00	2.E+02
Gd-153	1.E+03	3.E+04	1.E+01	3.E+02	1.E+00	3.E+01	1.E-02	3.E-01
Ge-68	7.E+01	2.E+03	7.E-01	2.E+01	7.E-02	2.E+00	7.E-04	2.E-02

IAEA SOURCE CHARACTERIZATION

IAEA Safety Standards Series No. RS-G-1.9

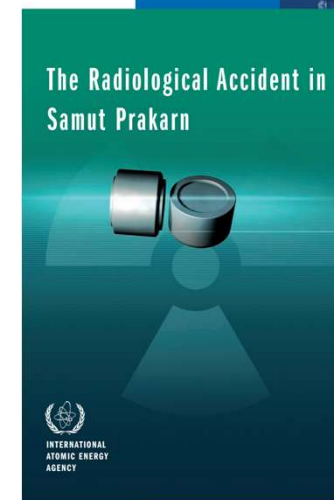
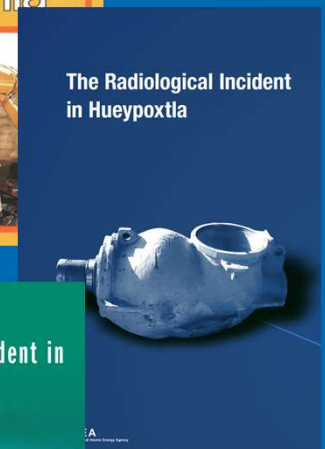
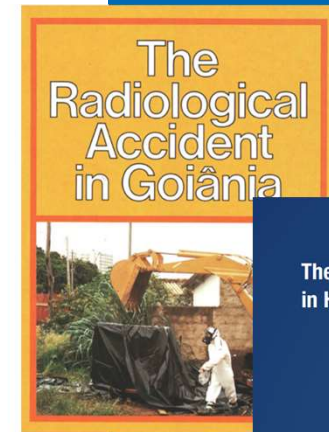
Category	Description	Hazard Level	Examples of Use	Potential for Harm
1	Extremely dangerous to the human body	Very High	Radiotherapy (teletherapy, irradiators), industrial irradiators	Can cause death or serious injury in minutes to hours
2	Very dangerous to the human body	High	Brachytherapy, industrial radiography, high-dose rate equipment	Can cause death or serious injury in hours to days
3	Dangerous to the human body	Moderate	Fixed industrial gauges (e.g., level gauges), well logging	Could cause injury after hours of exposure
4	Unlikely to be dangerous	Low	Thickness or moisture gauges, low-activity sources	Unlikely to cause significant harm unless misused
5	Most unlikely to be dangerous	Very Low	Smoke detectors, check sources, low-activity educational sources	Very low risk, not dangerous under normal handling conditions



Photos Provided by: F. Cocina - IAEA

THE NEED FOR MANAGEMENT OF CAT 1 AND 2 DSRS

- The Radiological Accident in Goainia
Brazil, 1987
- The Radiological Accident in Samut Prakarn
 - Thailand, 2000
- The Radiological Incident in Hueypoxtla
Mexico, 2013



MANAGEMENT OF DSRS

According to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, Member states are encouraged to manage disused sources by:

Reuse and Recycle- Reuse the source/device for the original licensed purpose at another facility, licensee, or another MS or harvest the radioactive material from the source and create a new source with a new serial number

Return to a Supplier - DSRS may be returned to the original or alternative supplier/manufacturer for further management.

Storage Awaiting Disposal- Sources may be stored to allow the radioactive decay of short-lived radionuclides in order to simplify the disposal arrangements or may be stored while disposal arrangements are being made. Storage is always temporary with the intent of final disposal.



Photos Provided by: F.Cocina - IAEA / W. Stewart - USA

COMPLICATIONS: DECOMMISSIONING

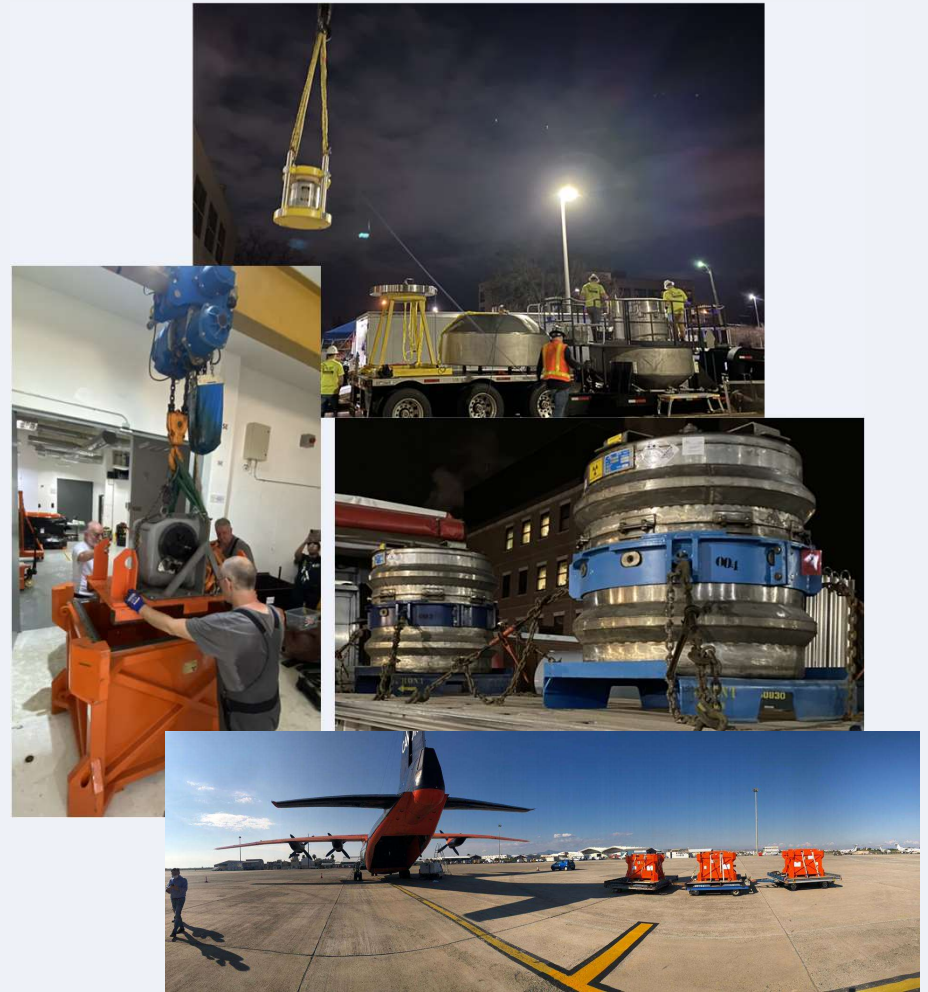
- Being Category 1 and 2 (Extremely/Very Dangerous), Source handling requires specialized expertise and equipment.
- Very few service providers have the skills, expertise and authorization to handle these sources.
- Some older devices may not have any service provider available.



Photos Provided by: F. Cocina - IAEA

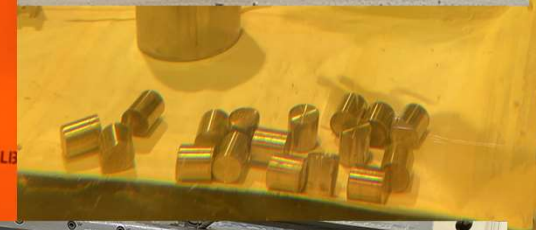
COMPLICATIONS: TRANSPORTATION

- Per the IAEA's Regulations for the Safe Transport of Radioactive Material (SSR-6) DSRS of these Isotope and activities require Type B(U) transport packages.
- Type B(U) packages are packages certified by a member state's competent authority to safely transport radioactive materials in high quantities.
- There are very few Type B(U) available and rental fees can be costly.
- Commercial carriers accepting Class 7 (radioactive) shipments have become fewer.



COMPLICATIONS: INFRASTRUCTURE

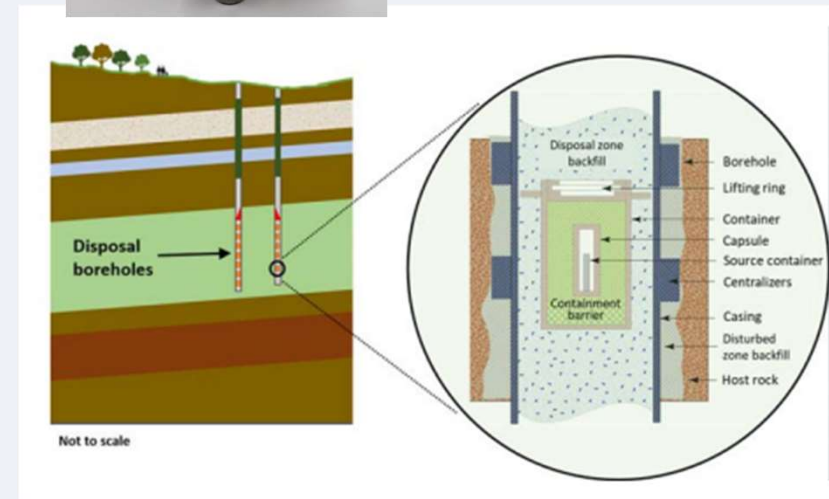
- In order to recycle sources or to reduce volume and condition sources for storage or disposal sources are typically removed from original shielding and repackages.
- This requires Hot Cell facilities to Safely Handle Category 1 and 2 sources.
- These facility are costly and can be challenging to gain authorization for operations.
- Few member states expertise, facilities and authorizations to perform this work.



Photos Provided by: F.Cocina - IAEA

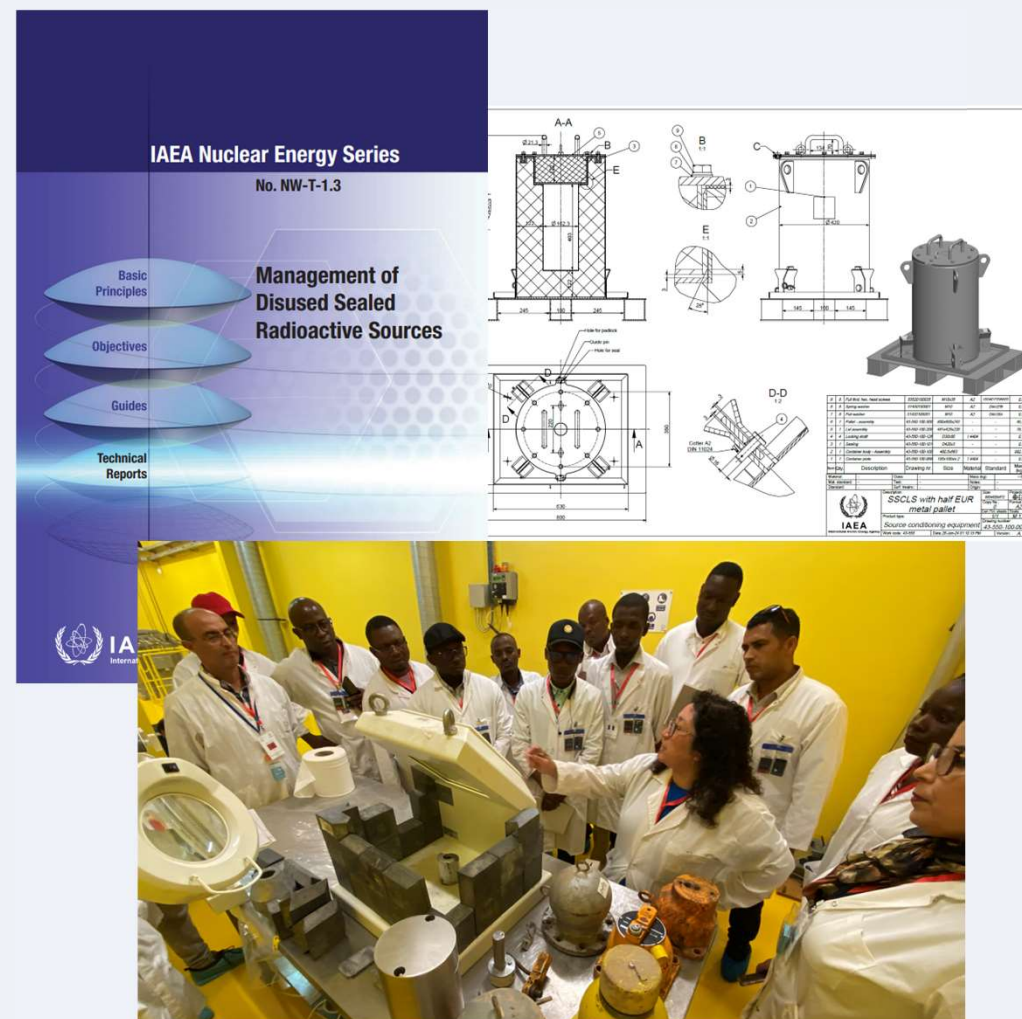
COMPLICATIONS: DISPOSAL

- DSRS pose unique disposal issues being point sources (concentrated radioactive materials).
- Very few Member States have a disposal facility for Radioactive Waste.
- Major considerations are the half-life of the Isotope, intruder scenarios (intentional or accidental) and exposure to the public.
- Can be a number of design options from near surface burial, borehole, or deep geologic repositories and are dependent on the characteristics of the waste.
- Safety Case and Assessment of the disposal facility drives the waste acceptance criteria (WAC). Without a WAC, sources cannot be fully conditioned for disposal.



IAEA ASSISTANCE IN DSRS MANAGEMENT

- Technical Documents and Publication on the Management of DSRS.
- Expert Missions in Trainings in DSRS Management from inventory management to dismantling and consolidations.
- IAEA contracted removals / return to a supplier of Category 1 and 2 DSRS
- Assistance in Policy and Strategy development for the Management of Radioactive Materials / DSRS.
- Procurement and development of source storage solutions.



Photos Provided by: F.Cocina - IAEA

THANK YOU

Mr. Frank Cocina

Nuclear Engineer (Disused Sealed Sources Specialist)

Waste Technology Section

Division of Nuclear Fuel Cycle and Waste Technology

Department of Nuclear Energy |

Email: F.Cocina-JR@iaea.org | Office: +43 1-2600-22699