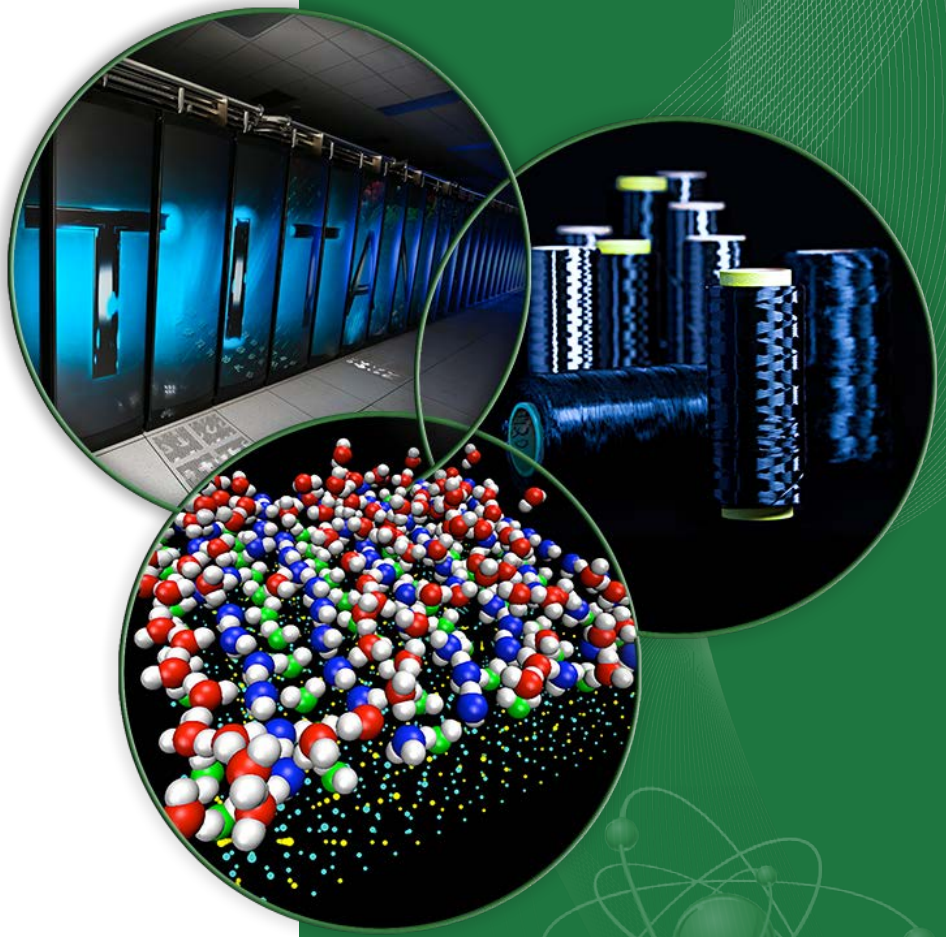
U.S. Dependency on Critical Isotopes from Foreign Producers



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NIDC NATIONAL ISOTOPE DEVELOPMENT CENTER

U.S. DEPARTMENT OF ENERGY | Office of Nuclear Physics

Outline

- How dependent is the U.S.?
- Historical perspective on how U.S. became dependent
- Specific isotopes imported to the U.S.
- Negative consequences of dependency
- U.S. mitigation of supply disruptions
- Current U.S. production activities

How dependent is the U.S. on foreign suppliers for isotopes?

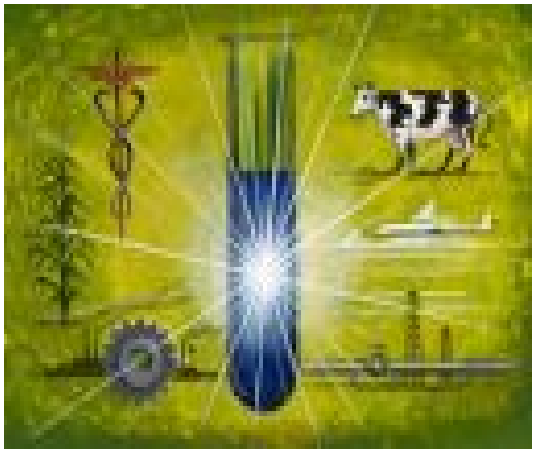
Cited from a U.S. International Trade Commission 2009 report:

For the period 2003 through 2007:

- "There is no domestic source of most of the raw (bulk) radioisotopes used in medical precursors.
- The U.S. currently imports close to 90% by volume of the raw isotopes consumed domestically.
- DOE's world market share was estimated to be less than 5% and its share of major commercially important isotopes was limited.
- Raw isotope imports are transformed by U.S. industry into high-value finished products."

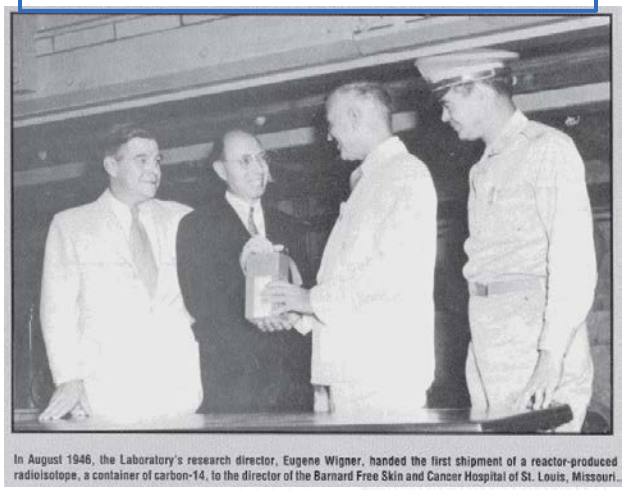
U.S. was Once the Global Leader in Isotope Production and Related Technologies

- Production started in the late 1940s.
- Production expanded rapidly during 1950s and 1960s.
- Wide variety of isotopes produced for research.
- Industrial firms became interested in the commercial applications.
- Commercial markets began to spring up.



Graphite Reactor

1st shipment of reactor-produced radioisotope – August 1946



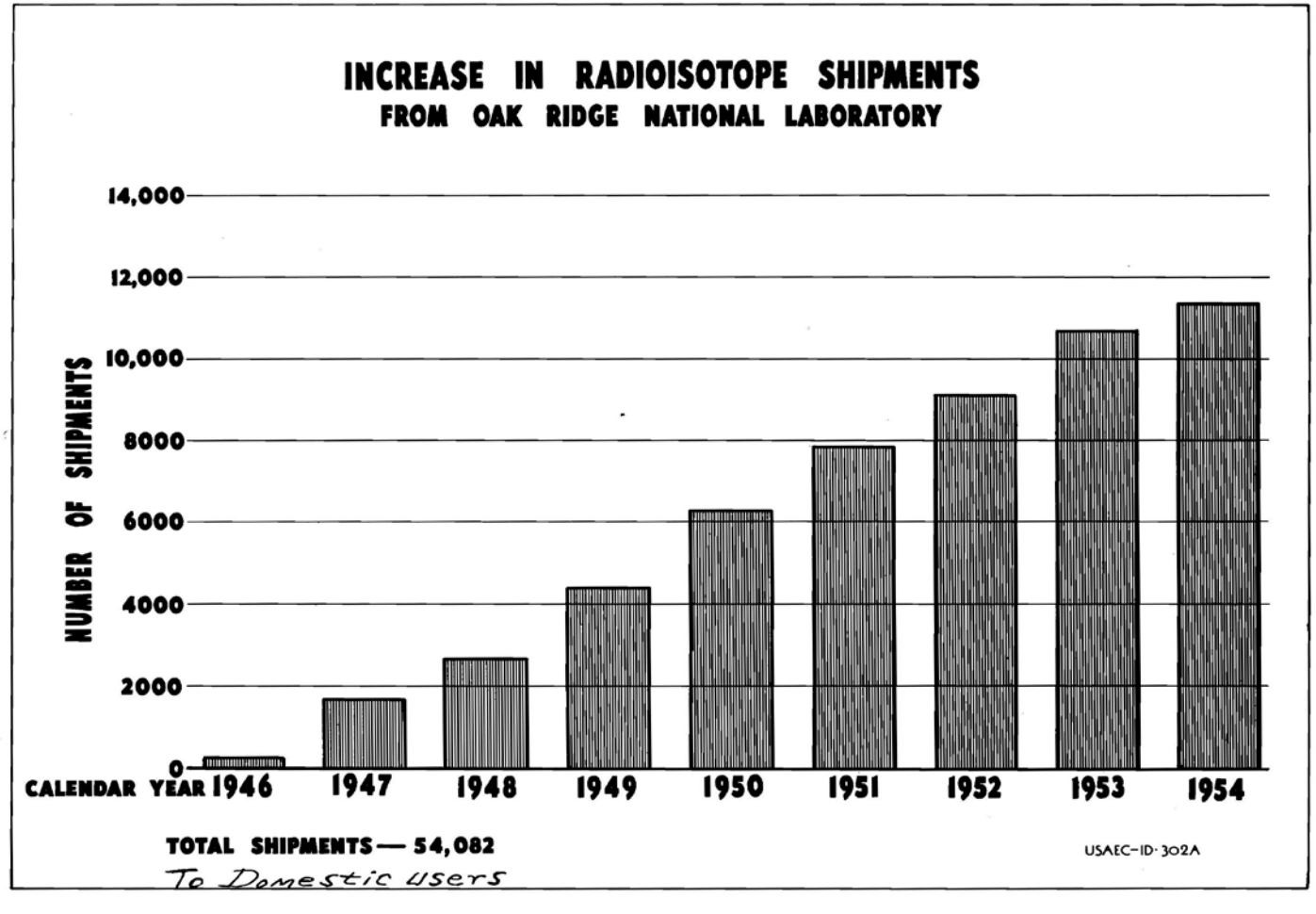
In August 1946, the Laboratory's research director, Eugene Wigner, handed the first shipment of a reactor-produced radioisotope, a container of carbon-14, to the director of the Barnard Free Skin and Cancer Hospital of St. Louis, Missouri.

U.S. Invested in Infrastructure to Process Isotopes

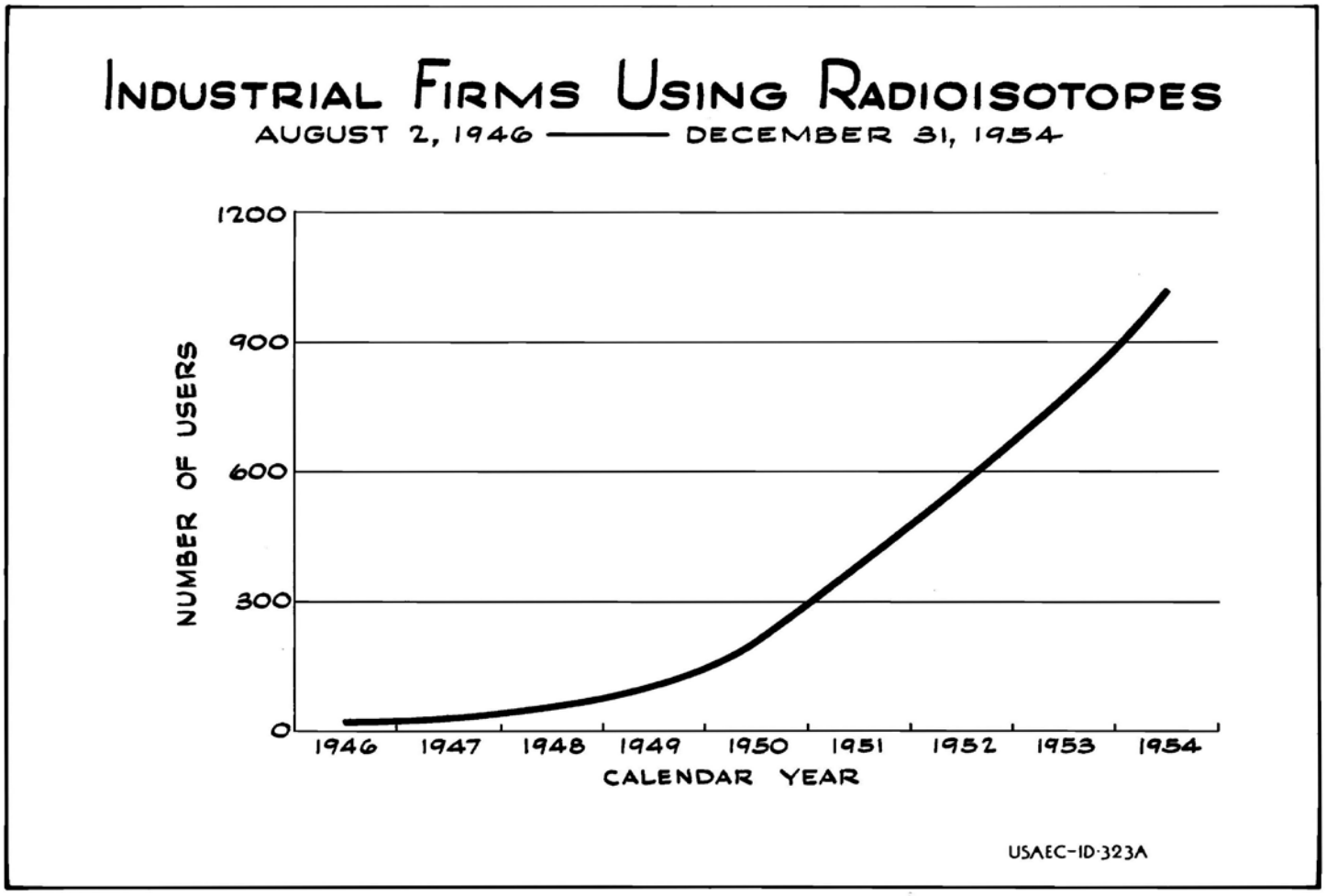
- Hot cell facilities were built to process a variety of isotopes.
- Developed staff of chemists and engineers to manage production and processing.
- Developed business operations, packaging and transportation, and logistics.

LIFE Magazine, May 1950: Isotope Circle at Oak Ridge National Laboratory

The number of shipments rapidly expanded from 1946 thru 1950s



Industrial isotope markets began to take shape.



U.S. has transitioned from a primary producer to an importer of bulk-quantity isotopes

1946-1985

U.S. production increased and then leveled out during this period.

- Cinticem in New York produced isotopes until 1989.
- National Labs are producing isotopes for research and industry.

1986- 2000

Foreign producers take advantage of losses in U.S. production capabilities.

- HFIR reactor at Oak Ridge was shutdown from 1986 to 1990.
- ORR reactor at Oak Ridge shutdown in 1986 and never restarted.
- Fall of the Soviet Union in 1991. Russia enters market.
- Calutrons used for stable isotope enrichment shutdown in 1999.

2001 to Present

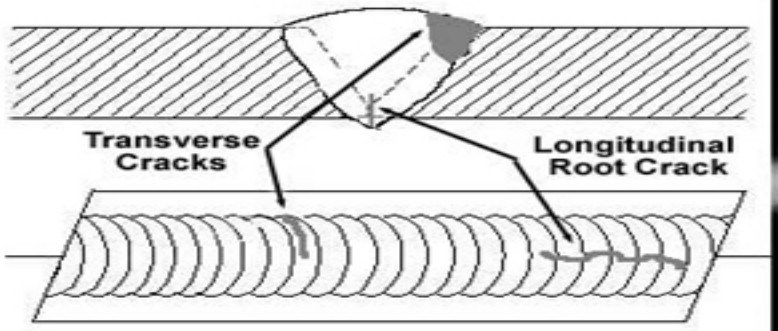
U.S. production is limited and it imports most bulk isotopes used in industry, research, and medicine.

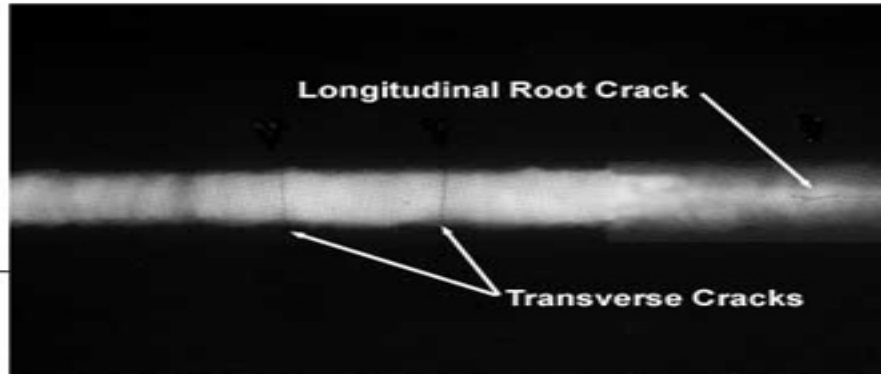
- U.S. currently relies on foreign sources for bulk isotopes.
- U.S. industry refines foreign-supplied bulk isotopes into finished end-use products.
- Russia, Belgium, and Netherlands are now primary suppliers of bulk isotopes.

U.S. Role has Changed

- U.S. was once the primary producer of isotopes.
- Perfect storm of U.S. facility shutdowns and Russia entering global market diminished the role of the U.S.
- Difficult for U.S. to reenter the market. Can't compete with discount pricing for long-term foreign supply contracts and foreign government subsidies. U.S. companies must rely on foreign suppliers to get their raw materials.
- U.S. is limited to producing bulk products requiring unique capabilities or those in short supply. (Cf-252, Bk-249, Sr-82, high specific activity Se-75 and Co-60

Iridium-192: Gamma radiography applications



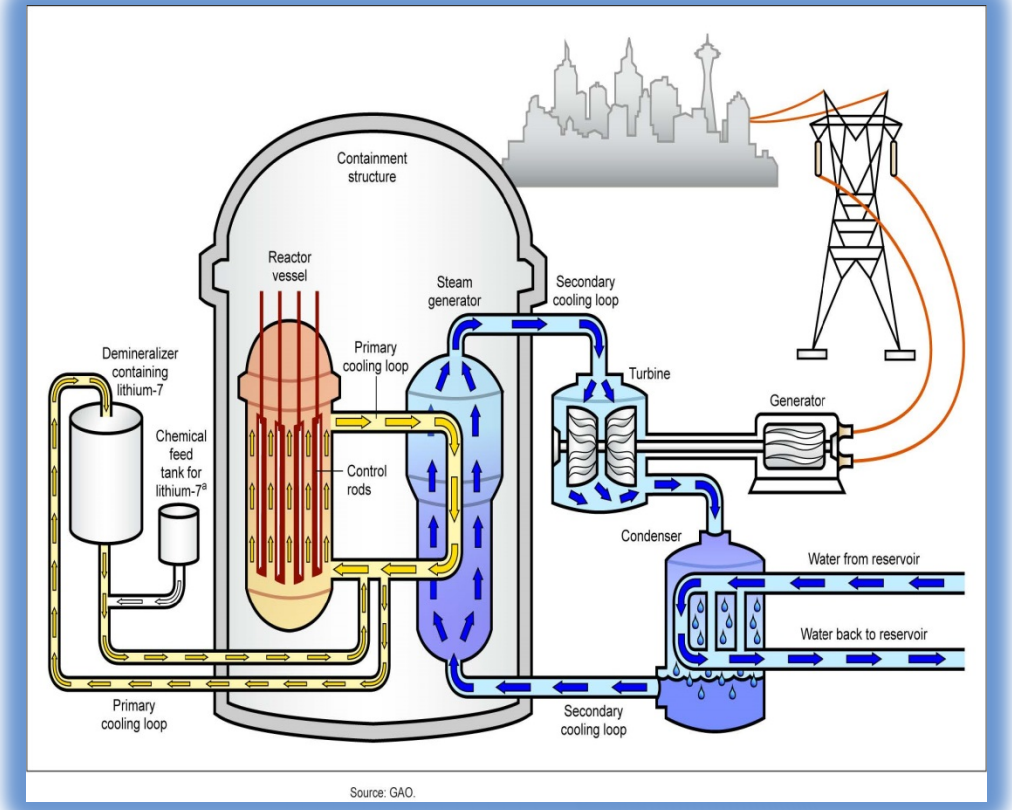


Nondestructive testing for U.S. Infrastructure

- ~800,000 curies of Ir-192 are imported into U.S. annually.
- Enough bulk radioisotope to build ~8000 individual sources.
- Industrial applications include shipbuilding, boiler manufacturing, and oil/gas pipeline inspections.
- U.S. dominated production in this market up until 1986.
- Currently imported primarily from Russia, Belgium, and Netherlands.

Lithium-7: Power Reactor Corrosion Inhibitor

- Commercial Pressurized Power Reactors (PWRs) depend on lithium-7 for reliable operations.
- Lithium-7 is used to buffer reactor coolant and prevent corrosion.
- The U.S. has ~65 operating PWRs generating ~13% of the U.S. electric power needs.
- ~500 kilograms are imported into the U.S. annually.
- The primary supplier is Russia.



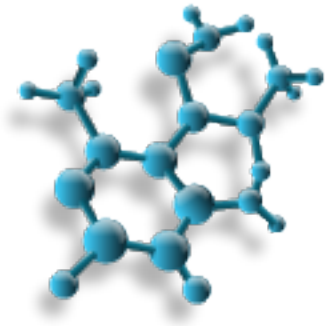
Heavy Water (D_2O): Deuterated Compounds for Research and Medicine

- Primarily used as moderator for heavy water nuclear power reactors in foreign countries.
- Excess production from Canada, India, and Argentina has been made available to U.S. commercial markets.
- The U.S. imports ~75 metric tons per year.
- The primary application in the U.S. is nuclear magnetic resonance (NMR) and mass spectroscopy (MS) instrumentation. Powerful analytical tools at major research and medical institutes.
- Also used to label proteins for research and in solvent preparation.
- Prominent radiopharmaceutical companies use deuterated compounds in their drug discovery and development programs.

CANDU Power Reactors
(**CAN**ada **D**euterium **U**ranium)

Carbon-14: Carbon labeling for research & medicine

- U.S. market is ~60 to 80 curies per year.
- Global market is ~1,500 to 2,500 curies per year.
- Russia is currently the sole supplier of C-14.
- C-14 labeled pharmaceuticals are key to new drug development.
- C-14 labeled new drug candidates offer unsurpassed sensitivity and specificity for FDA required administration, distribution, metabolism, and excretion (ADME) studies.



Amercium-241: Oil & gas exploration

- U.S. demand is ~200 grams (~600 curies) per year.
- Global demand is ~650 grams (~2000 curies) per year.
- Primary application is for AmBe neutron sources used in oil and gas exploration.
- Small quantities used for smoke detectors.
- Russia is the sole supplier.

Cobalt-60: Gamma surgery and sterilization

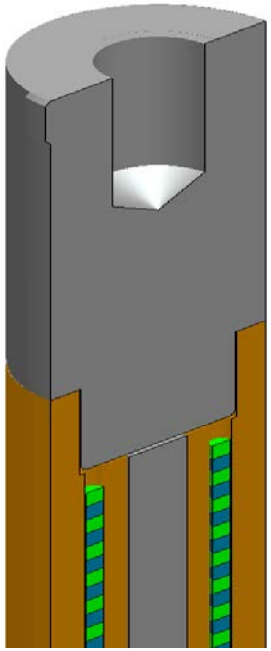
Low Specific Activity (LSA) Co-60

- Gamma sterilization facilities throughout the U.S. utilize mega-curie quantities of low specific activity Co-60.
- Sterilize single-use medical supplies and other consumer products.
- All LSA Co-60 is imported from Canada and Russia.

High Specific Activity (HSA) Co-60

- ~500 kilocuries of HSA Co-60 is deployed throughout the U.S. medical therapy devices.
- Used for gamma surgery in treatment of brain tumors.
- Currently all HSA Co-60 is imported from Canada and Russia.

HSA Cobalt-60 Pellets



HSA Co-60 Production Target

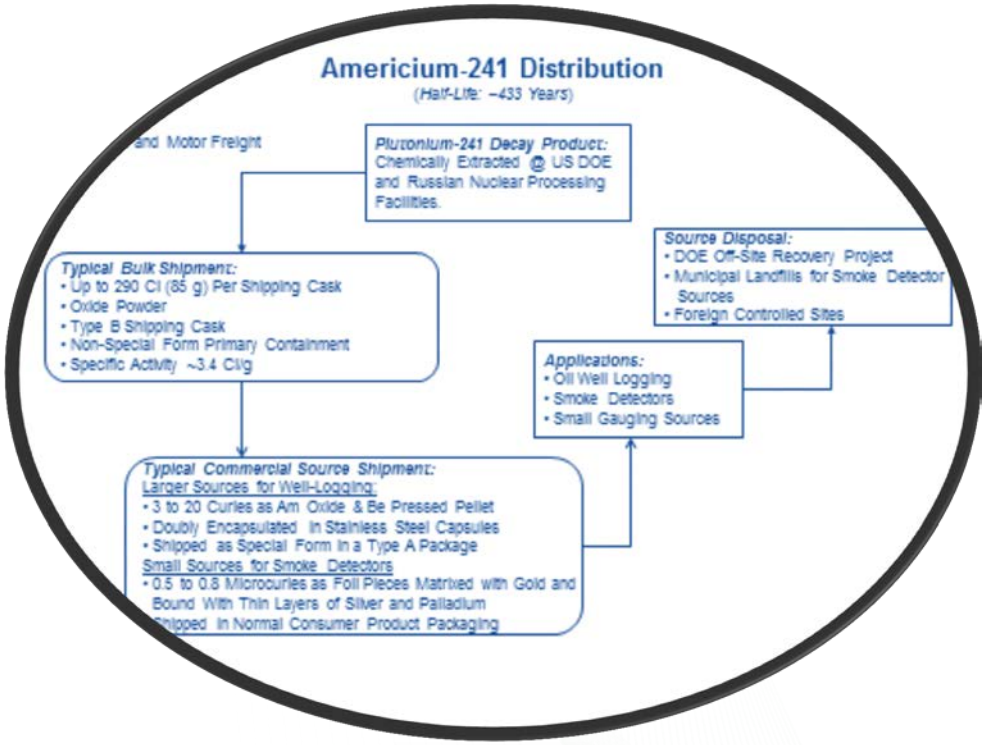
Stable Isotopes: Diverse commercial and research applications

Russia and Netherlands produce kilograms of enriched stable isotopes for U.S. markets

Isotope	Application	Amount
Cadmium-112	Production of In-111 for medical imaging & He/Cd lasers	<100 grams per year
Germanium-67	Nuclear physics (Majorana Collaboration)	~100 kilograms for initial experiment
Zinc, depleted in Zn-64	Zn coolant additive is a corrosion inhibitor in nuclear power plants. Depleting in Zn-64 reduces activation products and lowers personnel exposure during maintenance	Hundreds of kilograms per year used by U.S. nuclear power industry
Molybdenum-98 and -100	Reactor & accelerator production of Mo-99 for medical imaging	Potentially tens of kilograms needed per year to support new production capabilities in U.S.
Strontium-88	Production of Sr-89 for palliative treatment of pain for bone cancer patients	Hundreds of grams per year
Thallium-203	Production of Tl-201 for heart imaging.	~600 grams per year

What are the negative consequences of U.S. dependency on foreign isotope suppliers?

- Political issues can potentially disrupt supplies.
- Foreign producers can establish monopolies on certain isotope products resulting in higher prices and unreliable service.
- Potential erosion of U.S. production capabilities and expertise.
- From a security perspective, the U.S. has minimal influence and control over global distribution of bulk isotope quantities.

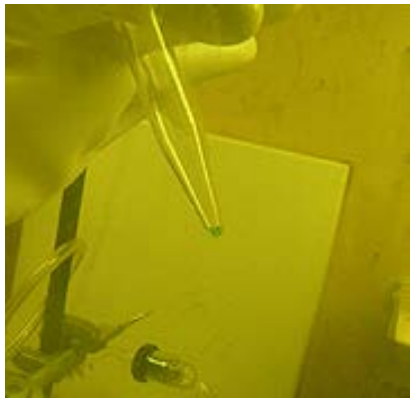


The Isotope Program is taking steps to mitigate potential disruptions in supply

- Continually assessing various isotope markets.
- Developing and installing a prototype stable isotope separator system to produce research quantities.
- Processing Li-7 to establish a reserve inventory and investigating new lithium separation technologies.
- Assessing feasibility of producing C-14. Includes assessing target design, production rates, and cost.
- Reestablishing high specific activity Co-60 production at the ATR to cover a portion of the market.

U.S. continues to maintain production capacity for unique commercial and research isotope activities

- Californium-252 sources for reactor startups, nuclear fuel quality control, and coal/mineral analyzers.
- Nickel-63 for explosives detection instruments.
- Strontium-82 for heart imaging.
- Ac-225 for cancer treatment research.
- Heavy element production for nuclear physics research.
- Research quantities from legacy inventory of ~245 enriched stable isotopes continue to be distributed by the U.S.



April 2010
Discovery of New Element 117

$$^{249}_{97}\mathrm{Bk} + ^{48}_{20}\mathrm{Ca} \xrightarrow{3n,4n} ^{294,293}(117)$$

Supply of ultra-pure Bk-249 a key contribution to this international collaboration