USNRC Workshop on the Security and Continued Use of Cs-137 Chloride Sources

Issue 1.2 - Feasibility of the Use of Isotopes Other than Cs-137

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Grant I. Nixon, Ph.D., P.Phys.
Senior Radiation Physicist

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Q1.2-1.(a) Can Co-60 be substituted for Cs-137-Cl for any application?

- **YES** as far as the radiation physics/dosimetry is concerned
  - esp. self-contained irradiators (SCI's)
- **NO** in terms of current/existing designs
  - e.g., dedicated blood SCI's (shielding)
- Roughly 1000 Cs-137-Cl SCI's in USA

Feasibility of Isotopes Other than Cs-137 and Co-60

- Co-60 is the only viable alternative to Cs-137 for most applications
- isotopes such as Eu-152 can theoretically substitute for Co-60 but:
  - such isotopes are of limited availability
  - special spectrum filtering requirements due to lower-energy components
  - special processing and handling requirements
  - impractical and non-viable for the foreseeable future

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Q1.2-2. Can the shielding challenges for Co-60 be addressed by switching from lead shields to more effective tungsten or DU shielding?

- ~2X more shield mass vs. Cs-137-Cl
  - Ratio of HVL shield thicknesses:
  - HVL (Co-60/Cs-137)=(2/1)
  - Note: shield volume~HVL^3
  - Ratio of dose rates per unit activity
  - (Cs-137/Co-60)=1/4=$(1/2)^2$
  - → shielding for equivalent dose rate using Co-60:
  - $\sim(2/1)^3\times(1/2)^2=2$
- The strategic use of tungsten shielding can help to reduce this 2-fold mass increase, but only marginally-so and at increased cost

Q1.2-3. What are the attendant risks associated with Co-60 source transportation?

- Isotope transport likely represents the most vulnerable aspect of radioisotope technology
- Enhanced security/ resource requirements for transport (GPS tracking, pre-determined / frequent communication, escorted shipments, securing routes, etc.)
- Potential accidents (traffic accidents, etc.)
- Rigging-associated dangers with high-load crane-assisted movements
- ALARA associated issues

Special Requirements for Research Applications

- X-ray based self-contained irradiator designs cannot, at present, meet the needs of biotech applications such as stem cell research due to low energy photons (<=320 kV_p machines)
- heavy photoelectric contribution to overall absorbed dose for x-ray tubes is a **major issue for existing x-ray tube based designs**
  - chest x-ray radiographs are only useful because of the absorbed dose differentiation between bone and tissue
  - (contrast is due to photoelectric effect)
  - By the same token, dose uniformity is consequently poor at these low ortho-voltage or kilovoltage energies for mixed tissue applications
  - Photoelectric absorption strength goes as a power law in (effective) atomic number
    - $Z^{3.8}$ for low-Z materials
    - Z^{3} for high-Z materials
  - This fact is almost never mentioned by competitor SCI manufacturers whose sole offering is x-ray based
  - Best Theratronics offers both x-ray and Cs-137 based SCI's and will continued to guide the industry in making the best choices for their needs

Special Requirements for Research Applications

- GC-40 research irradiator is Cs-137 chloride based and represents the industry golden standard in terms of reliability and dose uniformity

Research applications (cont.)

- No Co-60 SCI's currently available
- We have previously designed and built Co-60 based research SCI's
  - (e.g., GC-500, GC-220)
- New manufacturing is possible subject to markets and government incentives

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