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

Issue No. 2 – Use of Alternative Technologies

September 29, 2008

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

Tom Wasiak, B.A.Sc., P.Eng.
Manager - Engineering

Best Theratronics

Q.2-1 – Are x-ray units already commercially available as substitutes for applications that do not require gamma rays from Cs-137 and Co-60?

- **YES** in the case of **low-volume/low-thruput** self-contained blood irradiators (Raycell)
- **NO** in terms of **high-volume/high-thruput** self-contained blood irradiators (cf. GC-3000 Type II)
- **NO** in terms of **self-contained research irradiators** used for stem-cell research, bone/tissue grafts, etc.

Q2-2 – Are x-ray units cost-effective considering the initial capital cost, operating costs, and increased maintenance requirements w.r.t. replacement parts and periodic calibration?

- Yes but not as cost-effective as Cs-137 units, particularly for high-volume/thruput applications.
- Typical life-spans of 5-10 years **(HV x-ray generator, tubes, etc.) versus 20-30 or more years for useable Cs-137 source output**
- **More servicing for other components as well due to increased complexity (cooling systems, temperature sensors, etc.)**
- **Beam calibration must be twice as frequent for x-ray (bi-annually compared to annually for Cs-137 based units)**
- **Dosimetry is generally more complex and more uncertain for x-rays**

Q2-3 – Is there any indication that the performance of the alternatives will improve/worsen w.r.t. Cs-137?

- Performance can be defined in 3 ways:
  - Thruput (volume/time)
    - **Yes for blood**
  - Reliability (failures)
    - **Yes, but this is limited**
    - the inherent nature of x-ray generation technology is such that it will always be less reliable
    - cannot compete with Cs-137 based units
    - Research applications (>320 kV) available in distant future, reliability is therefore unknown at this time
    - Continuous source output strength monitoring for x-ray desirable (cf. no need for Cs-137 units)

Q2-4 – Regarding the availability of alternative technologies (a) what is the time frame of future availability of each alternative? (b) what is the cost for each of the alternative technologies capital costs, operational costs, end-user costs)?

- It is too early at this stage to speculate on the availability and costs associated with new designs and prototypes that are in the early stages of development

- Ditto for other units only at the conceptual stage (e.g., research application units (> 320 kV).

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**
  - Contrast on chest x-ray radiographs id due to absorbed dose differentiation between bone and tissue (photoelectric effect)
  - dose uniformity of x-rays poor at 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 crucial 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

Special Requirements for Research Applications

- GC-40 research irradiator (Cs-137-Cl-based) represents the industry "**gold standard**" in terms of reliability and dose uniformity

Special Requirements for Research Applications

- No viable x-ray SCI's currently available
- New manufacturing designs are possible but development is subject to market demand and government incentives

Best Theratronics