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Gamma Radiation Shielding Analysis for ClearView Radiation Shielding®

Attenuation capability of ClearView Radiation Shielding (ClearView RS) was performed at the Wisconsin Institute of Medical Research. ANSI N13.11 standard was references using a 3000 Curie Co-60 irradiator and PMMA phantom (as recommended by ICRU47) effectively mimicking the scattering of a human body tissue. The source strength was calibrated 2 days before the experiment and measures were taken to ensure the perpendicular incidence of the beam. Conversion factors of Air Kerma to shallow and deep dose equivalent were referenced from the NIST Beam Code ^{60}Co. The results are shown in figure 1 and table 1, and measurements were performed using Thermoluminescent dosimeters or *TLD*. *Cs-137 measurements done with Exrdain A4 spherical ion chamber, without PMMA, 400 Ci Cs-137 irradiator.

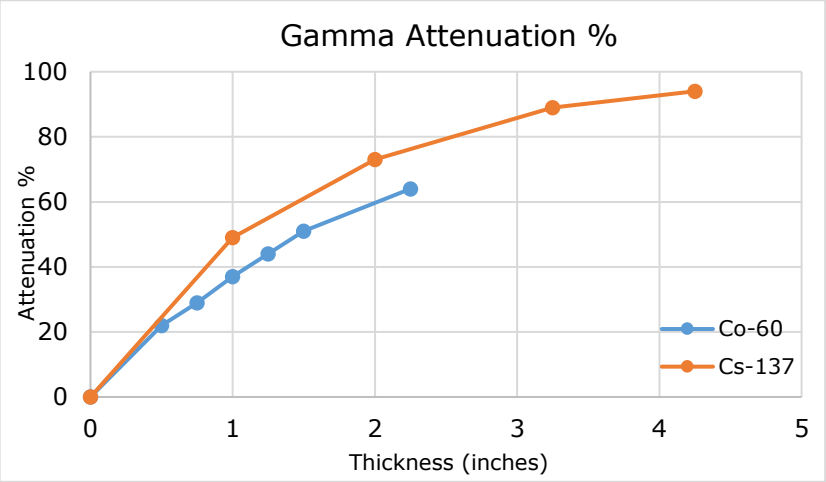

Figure 1. Gamma Attenuation with ClearView RS

Cs^{137}* ($E\gamma$ = 661 keV)			Co^{60} ($E\gamma_{avg}$ =1.25 MeV)	
Thickness ClearView	Attenuation %		Thickness ClearView	Attenuation %
1.0''= HVL	50%		0.5''	22%
1.5''	63%		1.5'' = HVL	51%
2.5''	81%		2.5''	68%
3.5''= TVL	90%		4.8''= TVL	90%

Table 1. Attenuation of Cesium 137 and Cobalt 60 with ClearView RS*

Multiple Source Testing performed at Memorial Sloan Kettering Cancer Center

ClearView RS shields of dimensions 6'' x 6'' and multiple thicknesses was tested against multiple sources at Memorial Sloan Kettering Cancer Center, New York. The testing was done with the source and detector in contact on each side of the test shield surface. Contact testing was performed to ensure that the ion chamber detected attenuation radiation coming through the shield and eliminating scatter. Distance between source, shield and detector leads to sky shine effects and scatter errors accounted in readings. Measurements were performed using a Fluke Biomedical 451P ionization chamber. The results are shown in table 2.

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ISOTOPE	Energy	Attenuation	Attenuation	Attenuation	Attenuation	Attenuation
	(keV)	0.5″	0.75″	1.5″	2.5″	3.0″
I - 125	35	99.83 %	99.83 %	99.95 %	99.95 %	99.83 %
Ba – 133	80, 356	71.88 %	87.27 %	93.1 %	96.1 %	98.14 %
Tc – 99	140	99.79 %	97.69 %	99.63 %	99.75 %	99.79 %
I-131	361	65.9 %	79.3 %	88.8 %	95.9 %	97.6 %
F-18	511	49.20 %	70.56 %	85.59 %	90.74 %	94.50 %
Cs – 137	661	35.15 %	53.38 %	71.8 %	83.83 %	90.9 %
Zr – 89	909	46.34 %	58.54 %	73.17 %	87.8 %	90.24 %
I - 124	1899	52.69 %	67.45 %	78.52 %	90.55 %	91.31 %

Table 2. Attenuation of multiple isotopes with ClearView RS.

I^{131} and Lu^{177} Testing performed at C. S. Mott Children's Hospital, Ann Arbor, MI

ClearView RS shielded waste container is being used at the children's hospital at the University of Michigan as a foley bag container to shield hospital staff from radioactive body waste. This container is a 1″ ClearView cylinder and is mounted on a roller with telescope handling with inner diameter 15 cm and height 30 cm. During the testing, I^{131} and Lu^{177} sources were placed 13.5 cm high the base of the shield and measurements were taken with Eberline R02 ionization chamber. The results are shown in table 3.

Location of Source	Location of Detector	I-131 (68.6 mCi)	Lu -177 (216 mCi)	Attenuation W/ Shielded Waste Container (1″)
On Contact		2000 mR/hr	400 mR/hr	
Middle Center	Shield Top Shield Edge	120 mR/hr 280 mR/hr	7 mR/hr 11 mR/hr	I – 131 80% (edge) – 94% (top) Lu – 177 95% (top) – 99%(side)
Middle Edge	Shield Top Shield Edge	120 mR/hr 390 mR/hr	6 mR/hr 19 mR/hr	

Table 3. Attenuation I-131 and Lu-177 with ClearView RS

Overview

- Raman Spectroscopy and ICP – OES performed for Chemical and Material characterization.
- DOT (US), IATA, IMDG certified non-hazardous and environmentally friendly.
- NFPA, HMIS rating 0 (Fire, Physical Contact and Reactivity)
- TRANSPARENT, TRANSPORTABLE hence PUMPABLE.
- Does not create internal sources of radiation.
- Non-toxic, non-abrasive to human contact.
- Contents safe as per OSHA and EHS regulations.

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Neutron Shielding Analysis for ClearView Radiation Shielding®

ClearView RS was tested against thermal and fast neutrons. The testing was done using a Linear Accelerator (LINAC) operating at Beam Energy of 20X. In a LINAC, electrons are accelerated to high speeds and collide with a heavy metal target. As a result of these collisions, high energy x-rays are scattered from the target. The X-Rays are used for radiation therapy. When the incident electron beam is of higher energies, the X-Rays are accompanied by release of thermal and fast photoneutrons.

ClearView shields of different thicknesses where tested against thermal and fast photoneutrons and Landuaer Luxel+ dosimeter badges were used to measure unshielded and shielded doses. Solid water phantom was used to mimic scatter by a human body. Unshielded badges recorded a mixed source of thermal and fast photoneutrons, and the results from neutrons shielding are shown below.

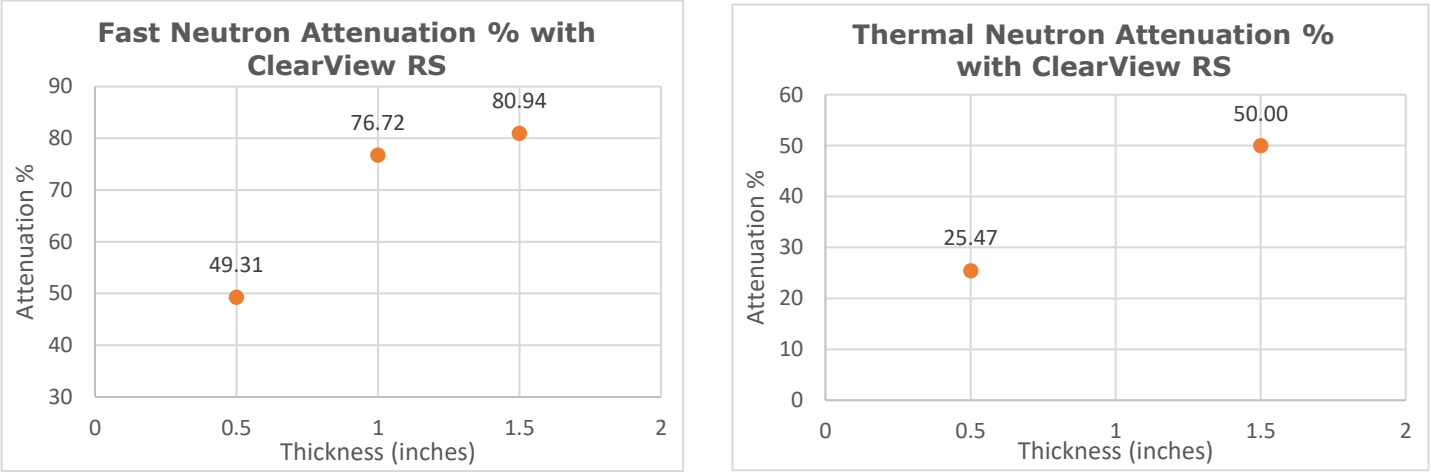

Figure 2. Neutron Attenuation with ClearView RS

Neutron Energy Spectrum

Fast: 40 keV to in excess of 35 MeV
Thermal: under 0.5 eV

Thermal neutrons are expected to be shielded better than fast neutrons at same thickness, but during this testing, thermal neutrons shielding factors were seen to be lower than fast neutrons. Ratio of dose deposited by thermal and fast neutrons was in the ratio 1:10. Neutron shielding occurs in two steps, moderation and absorption. Since the fast neutron dose fraction was significantly higher than thermal neutron dose, we are seeing a large contribution of thermalized fast neutrons in thermal neutron attenuation