Further Safkeg HS Calculations Phase 3

Title	**Monte Carlo Modelling of Alternative Point Sources in the Safkeg HS Container**
Prepared for	Croft Associates Ltd
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1. Background

A previous report [1] presents the results of MCBEND [2] calculations of external dose rate from a 3kCi Cs-137 point source in various locations within the Safkeg HS container, both with and without a tungsten insert. Calculations were carried out for the following combinations of tungsten insert and source position.

- No tungsten insert, large cavity tungsten insert (HS-31x114-Tu), or small cavity tungsten insert (HS-12x95-Tu)
- Source in the following position in the HS cavity (with no tungsten insert present) or within the insert cavity: top centred, bottom centred, mid-height eccentred and top eccentred.

Maximum dose rates were determined on contact with the HS container and at a distance of 1m, in the following positions:

- The bottom surface
- The side surface
- The top surface

This study presents the results of MCBEND calculations of external dose rates within the Safkeg HS container with the two tungsten inserts (HS-31x114-Tu, HS-12x95-Tu). The following four alternative sources have been specified, all with an activity of 3kCi:

- Th-228 (decay to 28 days taking into account dose from daughters)
- Ir-192
- Pb-210 (decay to 810 days taking into account dose from daughters)
- Tl-201

The point source was located in the insert cavity at the following two positions:

- tungsten insert touching top of containment vessel; source at top eccentred (closest to lid cut-out)
- tungsten insert touching bottom of containment vessel; source at bottom centred.

MCBEND calculations have been carried out to determine the following:

- The maximum dose rate on contact with the Safkeg HS container, on the top, side and bottom surfaces.
- The ratio of the maximum side to maximum bottom dose rate.

Dose rates were calculated using dose conversion factors based on ANSI/ANS-6.1.1 1977. The Thick Target Bremsstrahlung option was used in the MCBEND calculations to include the effect of Bremsstrahlung.

2. Geometry and Source Terms

The geometry of the MCBEND model is shown in Figure 1. Note that the top eccentred source was modelled with the tungsten insert raised up to the top of the HS cavity, whereas the bottom centred source was modelled with the tungsten insert at the bottom of the HS cavity as shown.

The source spectra were calculated automatically by MCBEND, using the current versions (cs180v5 and csdecayv4) of the Activation and Fission Product and decay libraries. In the case of the two nuclides for which a decay time was specified, the source strengths were specified as 3kCi before the decay. The activities of Th-228 and Pb-210 after their decays were applied are 2.92 and 2.80kCi, respectively. The activities of daughter nuclides were accurately represented in the source spectra.

3. Results

The results of the calculations are shown in Table 1 to Table 4 for the nuclides Cs-137, Th-228, Ir-192 and Pb-210. The results shown in Table 1 are taken from Reference [1].

Dose rates for the Tl-201 source could not be calculated by MCBEND because the highest line energy is relatively low at 0.1675MeV. The resulting attenuation through tungsten and uranium reduces the dose rate through too many orders of magnitude for a successful calculation, even when acceleration is used.

The results show that the other sources under consideration (Th-228, Ir-192 and Pb-210) give a lower side/bottom dose rate than Cs-137.

4. References

1 David Picton, Monte Carlo Modelling of Safkeg HS Container, AMEC/SF6652/001 Issue 2, August 2013.

2 "MCBEND - A Monte Carlo Program for General Radiation Transport Solutions. User Guide for Version 11". ANSWERS/MCBEND/REPORT/008.

Table 1. Maximum dose-rate for a Cs-137 source

Source - Eccentred at top of cavity

Maximum dose-rate is at same azimuthal region as source

HS-31x114-Tu insert		HS-12x95-Tu insert	
Side - Surface	**sd%**	**Side - Surface**	**sd%**
3.06E+03	0.1	2.84E+02	0.2
Top - Surface	**sd%**	**Top - Surface**	**sd%**
1.54E+03	0.1	1.66E+02	0.3

Source - Centred at bottom of cavity

HS-31x114-Tu insert		HS-12x95-Tu insert	
Bottom - Surface	**sd%**	**Bottom - Surface**	**sd%**
8.17E+02	0.2	1.66E+02	0.2

Ratio - side surface max to bottom surface max

3.74	**1.72**

Table 2. Maximum dose-rate for a Th-228 source

Source - Eccentred at top of cavity

Maximum dose-rate is at same azimuthal region as source

HS-31x114-Tu insert		HS-12x95-Tu insert	
Side - Surface	**sd%**	**Side - Surface**	**sd%**
4.95E+06	0.0	2.33E+06	0.0
Top - Surface	**sd%**	**Top - Surface**	**sd%**
2.05E+06	0.1	1.04E+06	0.1

Source - Centred at bottom of cavity

HS-31x114-Tu insert		HS-12x95-Tu insert	
Bottom - Surface	**sd%**	**Bottom - Surface**	**sd%**
5.12E+06	0.0	2.51E+06	0.0

Ratio - side surface max to bottom surface max

0.97	**0.93**

Table 3. Maximum dose-rate for an Ir-192 source

Source - Eccentred at top of cavity

Maximum dose-rate is at same azimuthal region as source

HS-31x114-Tu insert		HS-12x95-Tu insert	
Side - Surface	**sd%**	**Side - Surface**	**sd%**
5.73E+02	0.1	1.19E+02	0.1
Top - Surface	**sd%**	**Top - Surface**	**sd%**
2.65E+02	0.1	4.34E+01	0.3

Source - Centred at bottom of cavity

HS-31x114-Tu insert		HS-12x95-Tu insert	
Bottom - Surface	**sd%**	**Bottom - Surface**	**sd%**
3.50E+02	0.1	1.07E+02	0.3

Ratio - side surface max to bottom surface max

1.64	**1.11**

Table 4. Maximum dose-rate for a Pb-210 source

Source - Eccentred at top of cavity

Maximum dose-rate is at same azimuthal region as source

HS-31x114-Tu insert		HS-12x95-Tu insert	
Side - Surface	**sd%**	**Side - Surface**	**sd%**
3.88E-01	0.1	6.49E-02	0.1
Top - Surface	**sd%**	**Top - Surface**	**sd%**
1.73E-01	0.1	2.50E-02	0.2

Source - Centred at bottom of cavity

HS-31x114-Tu insert		HS-12x95-Tu insert	
Bottom - Surface	**sd%**	**Bottom - Surface**	**sd%**
2.10E-01	0.1	5.53E-02	0.1

Ratio - side surface max to bottom surface max

1.85	**1.17**

Figure 1: MCBEND model for Safkeg HS container with tungsten insert

Note that the tungsten insert is raised to the top of the HS cavity in top source cases. In other cases the insert is in the position shown.