Radioactivity in Carbon Black used in AV covers by γ-ray counting

P. Jagam and J. Law
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Introduction

It is proposed that the upper hemisphere of the acrylic vessel (AV) be covered while the lower half is being assembled. The material chosen for the AV cover is white on one side and black on the other side in order to serve as a light shield for the photomultiplier tubes (PMTs) when the light covers are taken off. It was also observed that the black material rubs off a few days after cleaning the surface. For this reason a sample of the raw material used in the AV cover was obtained for assaying the radioactivity by direct γ-ray counting using the PGT germanium detector at the 4600 level of the INCO Creighton mine.

Experimental details

The raw material used in the AV cover turned out to be ordinary carbon black in the form of 3 mm diameter pellets. The raw material was packed for γ-ray counting by pouring it from the shipping container directly into a one litre acrylic Marinelli container. The container was carried underground in a air-tight double bag to avoid plate out of radon daughters from the air. It was installed on the shielded PGT high resolution germanium detector shortly after reaching the underground laboratory. Evaporating nitrogen from a LN_2 storage tank was used to provide a continuous nitrogen flush of the shielded counting cavity at the rate of about 8 lpm.

Pulse height spectra in the energy interval 40 keV to 3 MeV were recorded on a 4096 channel computer based multichannel analyzer coupled to the detector. Data acquisition was commenced immediately after the purge gas was installed. Individual spectra were automatically saved once every 12 hours. Spectra were acquired over a six day period.

Spectral data were inspected daily for radon ingress into the counting cavity around the germanium detector. A computer link[1] set up in the Guelph SNO apartment was used for this purpose as well as data retrieval from the surface without going to the underground site.

Results and discussion

The gross counts in ten spectra except the first two averaged 0.3 cps and were within one sigma of each other over the entire counting period. However, the first two spectra were higher than the average but within two sigma of the average. This may indicate a small amount of plate out activity from radon daughter products in the air, and for this reason they are omitted from the sum spectrum from the carbon black sample.

Prior to counting the sample a one litre MnO standard of mass 2905 g was also counted for a 6 h period for use as a comparator to determine the Th, U, and K concentrations by weight. The respective concentrations in MnO standard are Th=4.624 ppm, U=2.887 ppm and K=0.7958%.

A composite spectrum from the carbon black sample was obtained by summing the later ten spectra while not including the first two spectra. Counts from this composite spectrum in the full-energy peak regions at the γ-ray peaks of interest together with the corresponding counts from the standard are given in the table below together with the calculated concentrations in the last column of the table. The concentrations were calculated by normalizing the corresponding counts from the sample with reference to the standard for counting time and weight. No absorption corrections are applied for differences between the compositions of sample and standard.

Table of experimental data obtained from the carbon black sample and the MnO standard of one litre volume each recorded with the PGT high resolution germanium detector at the 4600 level of INCO Creighton mine.

	carbon black sample		MnO standard		concentration in sample
Live time (h)	120		6		
Mass (g)	1000*		2905		
E (keV)	Net counts	+- 2σ%	Ne counts	+- 2σ%	ppb
Thorium:					
583	19	283	4583	4.2	2
911	15	74	3339	4.7	3
2614	10	63	2034	4.5	3
Uranium					
186	146	92	3894	8.9	16
609	59	89	14771	1.9	2
1001	Gross=10		222	42	
1764	15	52	2940	3.9	2
Potassium					
1461	153	17	14405	1.7	0.001%

* Nominal weight of the sample

Contributions from the blank background to the sample spectrum were found to be negligible, and were not taken into account in calculating the concentrations given in the last column of the above table.

From the concentrations calculated in the above table it can be seen that thorium and uranium are present at a concentration of about 3 ppb by weight. The weight of the acrylic in AV is about 30 tons (30E6 g). At a nominal value of 1 ppt thorium or uranium there are 30 μg of each in total. Therefore, the covering material chosen for protecting the AV must shed a total of 10 kg of carbon black in order to produce the same level of contamination as in the acrylic. This seems to be very unlikely.

The total weight of the covering material is estimated to contain at most 2-3 kg of carbon black and is very sturdy mechanically. Although there may be some shedding if the black side of the covering material is rubbed hard, the amount will not be appreciable to warrant concern from a radioactivity point of view.

However, the amount of carbon black getting into the light water may be of concern with respect to the carbon load that can be handled by the water purification systems. In addition, if the rubbed off carbon black sticks to the AV surface and does not come off into the water the light transmission properties of the vessel may be affected significantly.

A possible solution to all these concerns is to make the AV covers with the black side sandwitched between the white so that none of the black is visible or comes into contact with the AV while deployed in position.

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References

1. P. Jagam and J. Law, SNO-STR-94-003, *Communications and control of remote PC for gamma-ray spectrometry.*