Preparation of Acrylic Encapsulated Radioactive Calibration Sources for SNO

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Introduction

Five radioactive sources have been fabricated with the intent of providing The Sudbury Neutrino Observatory with a means to test the response of the SNO detector to high energy (~2 MeV) gamma rays and neutrons. One source of radium-226, in equilibrium with its daughters was made to give information relative to the tail end of the U-238 decay chain. For the Th-232 chain, two sources of U-232 were made. Because of the relatively short half life of U-232 (70yr) a much smaller mass of parent nuclide could be used than would be the case for Th-232. The fission decay of Cf-252 provides neutrons for the third type of source. Two sources containing Cf-252 were prepared. For the nuclides where two sources were prepared, a “low” and a “high” level source was prepared with an activity difference between the two of about a factor of 10.

Fabrication

Fabrication was done in several steps; first the activity (≤0.1 ml) was carefully placed in the bottom of the smaller inner cup. This cup is shown in the lower part of the figure below. Next, the solution was evaporated at about 80 C for a few hours. The cup was then filled about half full of PS-30 that was prepared with about half the normal amount of activator. This was done to extend the pot life of the PS-30. The PS-30 was also vacuum degassed before use. The PS-30 was allowed to set up overnight in a low temperature oven at about 35 C. The small cup was then cleaned in an ultrasonic bath using alcohol, Alconox, and finally deionized water. This step was done to remove any possible activity that was not completely encapsulated with the PS-30. Next, the small cup was filled with a (degassed) 50% slush of methyl methacrylate and PMMA powder. The slush was then allowed to cure overnight at 70 C in an autoclave pressurized to 150 psia with nitrogen. The next day the temperature was raised to 95 C for two additional hours. The cup was removed from the autoclave, cleaned again with the ultrasonic cleaner and any excess polymer was removed from the top of the cup. Next, the outer container, shown in the upper part of the figure, was prepared by adding enough of the slush mixture to fill to a depth of about 3 mm. The small inner cup with the activity was then added, top down. After it was ensured that there were no bubbles between the inner and outer parts, enough more slush was added to completely cover the inner part but not fill the outer part completely. This was then cured in the pressurized autoclave as done before. After cleaning one more time, the source was overfilled with slush and again cured as before. Finally, the source was machined to get smooth polished surfaces and then it was annealed at 100 C in the pressurized autoclave for at least 4 hours.

Assay

After preparation, the sources were gamma counted to establish the decay rate. Counting was done on two different occasions in several different counting geometries. We have found that it is hard to get very good estimate of the uncertainty in the activity because the counting statistics are a lot better than the systematics. Jerry estimates about 10% for the strong sources and probably 15-20% for the weaker ones.

Our best estimates of the activities are shown below.

Sample	Height (cm)	Activity (June 1,99)	
Hot Cf	2.46	27	n/sec
Weak Cf	2.93	1.5	n/sec
226 Ra	2.99	63	2.45 MeV gam/sec
Hot 232U	2.85	5350	2.6 MeV gam/sec
Weak 232U	2.86	99	2.6 MeV gam/sec