In Vivo Measurement Sensitivity and Occurrence of Radionuclides in Residents of the Carlsbad, New Mexico Area

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Citizen volunteers from the Carlsbad, New Mexico area were monitored for internally deposited radionuclides, as part of an ongoing study, through a project entitled "Lie Down and be Counted". This project is provided as an outreach service to the public to support education about naturally occurring and man-made radioactivity present in people and the environment prior to the opening of the Waste Isolation Pilot Plant (WIPP). In addition, information obtained from these measurements will be used to evaluate and improve upon the uncertainties associated with bioassay methodologies.

Following the commissioning of the Center's *in vivo* monitoring facility, approximately 275 citizen volunteers were measured during July 1997 to September 1998. The bioassay measurements consisted of a lung and whole body count. Prior to their bioassay, each subject completed a lifestyle questionnaire which included questions regarding their age, sex, weight, height, ethnicity, occupation, foreign travel, wild game consumption, and any nuclear medicine procedures.

Lung and whole body counts are simultaneously performed with the subject positioned horizontally using two arrays of hyper-pure germanium detectors. Each detector array consists of four detectors and represents a specific detector design, low energy (LEGe) and coaxial (COAX). The primary function of the LEGe detector array is lung counting. Each LEGe detector is fitted with a 0.6 mm thick carbon composite entrance window. The active diameter, area, and thickness of the LEGe detectors are 70 mm, 3800 mm^2, and 20 mm, respectively. The function of the second detector array (COAX detectors) is to measure higher energy photons (energies > 100 keV) emitted from radionuclides deposited in the whole body. The active diameter, length, and relative efficiency of the COAX detectors are 75 mm, 76 mm, and 80%, respectively. The counting shield consists of large shielded room measuring 2.7 m wide, 3.0 m long, and 2.7 feet high. It is constructed from 25 cm thick cast iron obtained from pre-World War II iron. A graded-Z liner (Z represents the charge of the liner element) consisting of 64 mm lead, 32 mm tin, and 32 mm stainless steel was added to the inside of the iron walls of the shield, to attenuate photons that are produced within the shield walls.

Radionuclides analyzed for in lungs included Th-232, Ce-144, natural U, U-235 / Ra-226, U-233, Eu-155, Pb-210, Np-237, Pu, Am-241, Cm-244, and Cf-252. Radionuclides analyzed for in the whole body included K-40, Cr-51, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Ru-106, Sb-125, I-131, Ba-133, I-133, Cs-134, Cs-137, Ba-140, Ce-141, Eu-152, Eu-154, Ir-192, and Ac-228. A 30 m count time was applied, and spectral analysis was performed using library driven peak search and region of interest analyses (ABACOS Plus Software, Canberra Industries). Statistical analyses, with respect to radionuclide detection, were consistent with the recommendations of ANSI 13.30 where radionuclide detection was determined using "decision level (L_C)" and program efficacy was evaluated using "minimum detectable amount."

Since it is anticipated that a majority of these radionuclides will not be detectable in an unexposed population, a primary focus of the study is to evaluate the variability of human background and the implications with respect to measurement sensitivity. In addition, the effectiveness of spectral analysis algorithms with regards to Type I (false positive) and Type II (false negative) error rates will be evaluated using a binomial statistical approach. For example, if a particular spectral analysis algorithm should yield a 5 % Type I error rate at L_C, then the frequency of occurrence of results greater than L_C for a non-detectable radionuclide, such as plutonium, should fall within the distribution-free tolerance interval for the number of trials, probability of occurrence and level of confidence (in this case, $n = 275$, $P_O = 0.05$ and $P_C = 0.95$, respectively). The distribution free approach is also used to evaluate if the frequency of cohort results greater than L_C are consistent with the Type I error rate or if they suggest a low frequency baseline occurrence of a particular radionuclide (e.g. Cs-137) in the local population.