RAS 6981 50-213-OLA Exhibit 17. Rec'd 3/11/03
CY-5-GEC

To: Robert K. Gad III
From: George Chabot
Date: Mar.7, 2003
Subject: Dose from Hot Particle in Extrathoracic Region ET2 of Respiratory Tract

As I had observed in my rebuttal testimony, I did not then have time to make a reasonable calculation aimed at evaluating the effective dose equivalent from inhalation of a 10 micron diameter hot particle. I did express my opinion that Dr. Resnikoff's approach, using ICRP-72 dose conversion factors, was not appropriate for inhalation of a single particle. I also expressed confidence, in my rebuttal testimony, based on my familiarity with the dosimetry involved, that effective dose equivalent from inhalation of such a particle would be significantly less than 0.5 mrem. I have since had the opportunity to perform a demonstrative calculation, which I am including below. Note that I am using the term effective dose, the current analog of effective dose equivalent, in the analysis, which uses the current ICRP respiratory tract model and tissue weighting factor (for ET2) as well as the current ICRP dose conversion factors.

The ET2 region, as defined in ICRP Report 66, represents the interior posterior nasal tissues, the pharynx, and larynx tissues. It was selected as the deposition site for the inhaled 10 micron diameter particle because it represents the portion of the extrathoracic region that is most subject to cancer induction and has the highest tissue weighting factor, 0.025. The thoracic region of the respiratory tract was not selected as a deposition site because of the extremely high probability that a 10 micron particle would not penetrate to the deeper sections of the tract. The following assumptions and parameter values apply to the dose estimation.

1. The dose equivalent to region ET2 for an adult subject was calculated by assuming an insoluble, stationary particle residing on the tissue surface for a time period equal to the mean residence time of particles in region ET2.
2. The mean residence time in ET2 is equal to 0.01 days (14.4 minutes), obtained from the reciprocal of the removal rate constant of 100 day^{-1} as given in ICRP Report 66. Clearance from the ET2 region is to the GI tract via swallowing.
3. Total surface area of ET2 region is 450 cm^2, as per ICRP 66.
4. Thickness of mucous layer is 15 microns and depth of basal cell target nuclei is 45 microns below epithelial surface, as per ICRP 66. The combined thickness is 60 microns, 0.006 cm, assumed to be unit density tissue equivalent material.
5. The dose averaged over all the target tissue area of the ET2 region was calculated for two individual point isotropic sources, one being Sr-90, with an equilibrium quantity of daughter Y-90 present, chosen because of its significant potential for delivering dose to basal cells through high energy beta radiation; the second source was Co-60, selected because of its potential for delivering gamma dose over a greater expanse of tissue compared to beta radiation.
6. The sources noted in item 5 were individually taken to represent the 10 micron particle source; no self attenuation of radiation within the source was calculated.
7. The beta dose calculation was done using the VARSKIN MOD2 computer code by assuming the area of the target tissue could be represented by a disk 450 cm^2 in area (radius of 11.97 cm). Dose was evaluated at a depth of 0.006 cm, based on a 14.4 minute exposure time. The gamma dose component was evaluated, assuming no photon attenuation and a respective source position 0.006 cm above the 450 cm^2 disk.
8. Doses were calculated for nominal 1 microcurie sources and were scaled to provide doses that would be consistent with the dose calculated by Dr. Resnikoff for his hot particle, taking into account his use of 1 micron AMAD DCFs for his dose determination.
9. Dose resulting from passage of the particle through the GI tract has not been included. This scenario has previously been investigated by Bechtel/CYAPCO.

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^{90}Sr VARSKIN results: Dose averaged over 1 cm^2 = 1.35 rads
Dose averaged over 450 cm^2 = 0.0030 rads
^{90}Y VARSKIN results: Dose averaged over 1 cm^2 = 1.60 rads
Dose averaged over 450 cm^2 = 0.0046 rads

Total dose averaged over 450 cm^2 = 0.0030 + 0.0046 = 0.0076 rads

Effective dose, $E = w_T H_T$ = (0.025)(0.0076 rads)(1000 mrads/rad)(1 mrem/mrad)
= 0.19 mrem.

If a calculation, similar to that done by Resnikoff for his particle, was applied to the Sr-Y particle, an effective dose would be obtained using the ICRP 72 DCF for Sr-90 (Type M 1 micron AMAD aerosol is recommended default) as follows:

$E_{1\mu m\ AMAD} = (3.68\times10^{-4}\ Sv/Bq)(3.7\times10^{4}\ Bq/\mu Ci)(1\ \mu Ci)(10^{5}\ mrem/Sv) = 136$ mrem.

The adult dose that Resnikoff calculated for his 12 year decay-corrected particle was 15.7 mrem. Scaling above results, using this value, we may obtain an adjusted value for effective dose;

E/0.19 mrem = 15.7 mrem/136 mrem, and

<u>E = 0.022 mrem</u>.

^{60}Co VARSKIN results: Beta dose averaged over 1 cm^2 = 1.00 rads
Beta dose averaged over 450 cm^2 = 0.0022 rads = 2.2 mrem
Gamma dose averaged over 450 cm^2 = $(\pi\Gamma AT/450)\ \ln((H^2+R^2)/H^2)$
3.36×10^{-4} rem = 0.336 mrem,
where Γ = 13.2 rem h^{-1} mCi^{-1} cm^2,
A = 10^{-3} mCi,
T = 0.24 hours,
H = 0.006 cm, and
R = 11.97 cm.
Total dose = 2.2 mrem + 0.34 mrem = 2.54 mrem

E = (0.025)(2.54 mrem) = 0.064 mrem.

Again, applying the Resnikoff methodology, based on ICRP-72 DCFs we would obtain

$E_{1\mu m\ AMAD} = (1.0\times10^{-8}\ Sv/Bq)(3.7\times10^{4}\ Bq/\mu Ci)(1\ \mu Ci)(10^{5}\ mrem/Sv) = 37$ mrem.

Scaling as previously, we obtain

E/0.064 mrem = 15.7/37, and

<u>E = 0.027 mrem</u>.

Given the above dose estimates, recognizing simplifications in the dose calculation, especially as related to receptor geometry, I would judge that it would be extremely unlikely that the effective dose to any individual from inhalation of a single 10 μm diameter particle, of the approximate type described by Resnikoff, would exceed 0.5 mrem (excluding contribution from passage through GI tract).