6.6 Method of Determining Calibration Setting Numbers

6.6.1 General

A method of determining a calibration setting number is described in this section.*

6.6.2 Response and Sensitivity

It is very convenient to express the response of the detector to a radioisotope, A, relative to that of a standard reference material, e.g. ^{60}Co.

$$R_A \equiv \frac{\left(\dfrac{\text{Detector Output due to Sample A}}{\text{Activity of Sample A}}\right)}{\left(\dfrac{\text{Detector Output due to SRM}^{60}\text{Co}}{\text{Certified Activity of the SRM}^{60}\text{Co}}\right)} \qquad (1)$$

The sensitivity of the detector for a photon of energy E_i is defined as:

$$S_A \equiv \frac{\text{Detector Output due to } 3.7 \times 10^{10} \text{ Photon of } E_i}{\text{Detector Output due to one curie of } ^{60}\text{Co}} \qquad (2)$$

The detector response and the sensitivity have the following reaction:

$$R_A \equiv \sum_i I_i S_i \qquad (3)$$

Where I_i is the intensity of the photon whose energy is E_i.

The procedure is to measure the response of the detector to all the available primary standard samples and to establish the sensitivity of the detector as a function of photon energy so as to satisfy equation (3) for all standards.

Once the sensitivity curve has been determined, the response of the detector to any radioisotope may be calculated using equation (3), provided that the decay data are known.

The sensitivity curve for a CRC-ionization chamber is given in Figure 6-1.

The figure depicts the sensitivity of the ionization chamber as a function of photon energy up to 1.9 MeV. Above a photon energy of 200 keV, the ionization in the chamber is mainly due to electrons resulting from Compton scattering of photons by the filling gas (argon) and the chamber walls (aluminum).

*See Suzuki, A., Suzuki M.N., and Weis A.M.: Analysis of a Radioisotope Calibrator; Journal of Nuclear Medicine Technology Dec. 1976 for more detailed discussions.

The peak in the low-energy region of the sensitivity curve is due to the rapid increase in photoelectric effect as photon energy decreases and to the attenuation of low energy photons by the sample holder, the chamber liner and the chamber walls, as well as the absorption of photons in the sample material and its container.

Although a significant fraction of photons with energies below 50 keV are stopped in the chamber wall, some photons could enter the sensitive volume of the chamber and could, therefore, contribute to the activity measurement. All photons with energies below about 13 keV are stopped before they reach the sensitive volume of the chamber and, therefore, these photons do not contribute to the activity measurement.

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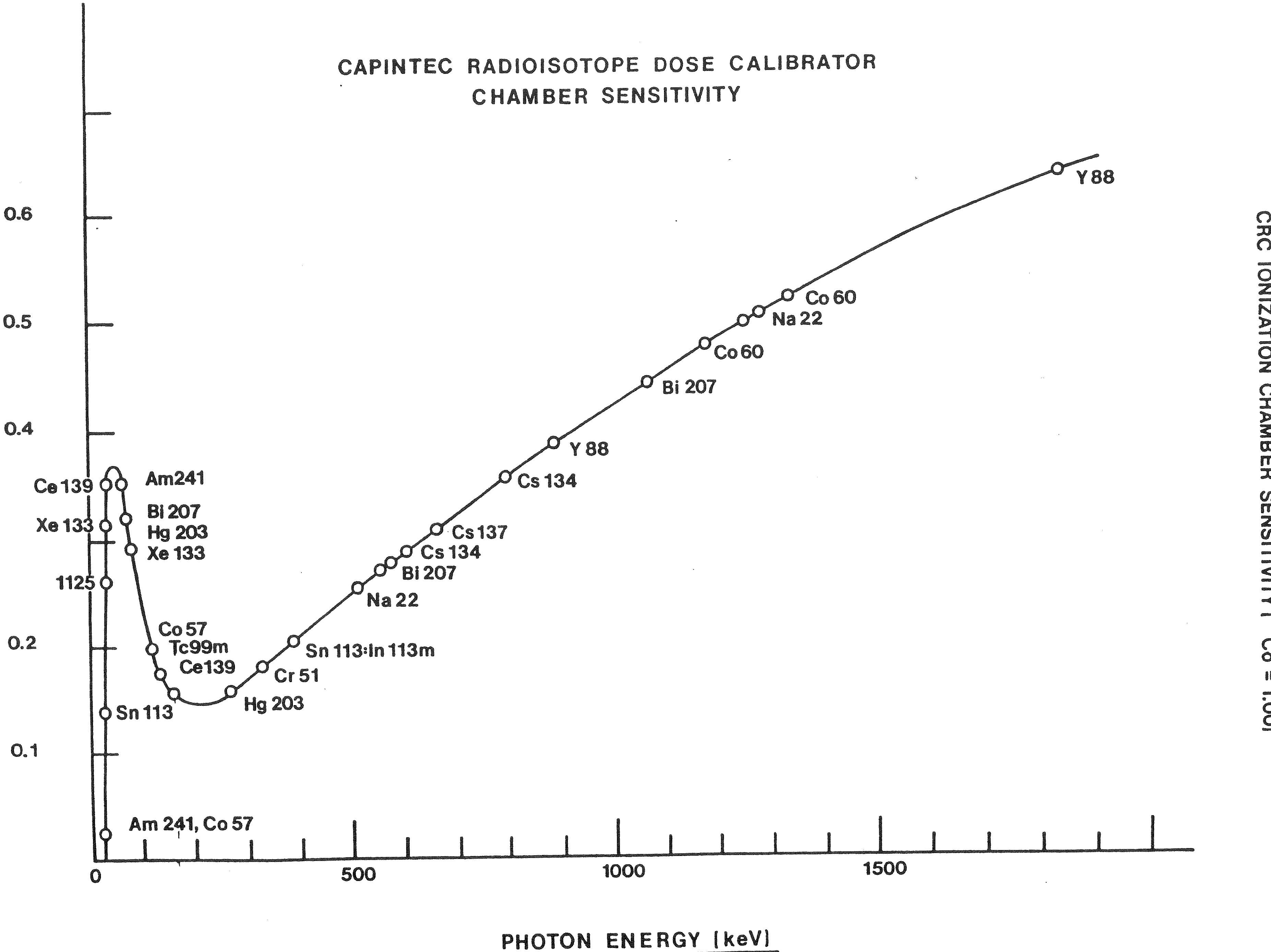

FIGURE 6-1

6.6.3 Calibration Setting Numbers

The relationship between the response of the detector and the gain setting (relative to that for ^{60}Co, in order for the instrument to give a direct reading of the activity) is given by:

$$G_A = \frac{1}{R_A} \qquad (4)$$

The calibration setting number, which indicates the position of the gain setting potentiometer of the CRC calibrator is linearly related to the chamber response.

All the calibrators are calibrated with certified Cobalt-60 and Cobalt-57 standard source.

A calibration setting number of 990 was assigned to ^{60}Co and 112 was chosen for ^{57}Co. The assignments were arbitrary, but they made it possible for the activity of most isotopes for medical use to be read directly on the digital panel meter.

The calibration setting number of CRC Calibrator for radioisotope A, N_A, is given by:

$$N_A = \left\{ R_A - \left[1 - \frac{\left(R_{60_{Co}} - R_{57_{Co}}\right) * N_{60_{Co}}}{\left(N_{60_{Co}} - N_{57_{Co}}\right)} \right] \right\} * \frac{\left(N_{60_{Co}} - N_{57_{Co}}\right)}{\left(R_{60_{Co}} - R_{57_{Co}}\right)} \qquad (5)$$

Entering numerical values:

$N_{60_{Co}} = 990$, $N_{57_{Co}} = 112$, $R_{60_{Co}} = 1.000$, and $R_{57_{Co}} = 0.1839 \pm 2\%$

one obtains: $N_A = 1076\,(R_A - 0.080)$ (6)

The accuracy of the sensitivity curve and the calibration number determination was tested by calculating calibration numbers for all the radioisotope standards used for the studies of the sensitivity. The agreement between the calculated and the observed responses were all within ±3%.

The accuracy of the chamber response calculation for a particular radioisotope, hence the accuracy which can be attained by using a calculated Calibration Setting Number depends not only on the accuracy of the available primary standards used to determine Figure 5-1, on the nuclear data, on the variation in the chamber sensitivity and electrometer gain setting, but also on the sample configuration due to low energy photon absorption.

The calibration Setting Numbers for pure and equilibrium state radioisotopes for the CRC calibrators are listed in Appendix I of this manual. Appendix II contains tables of multiplication factors for obtaining the activity of a parent nuclide when it is not in equilibrium with the daughter nuclide. A general equation for this situation is also given in that appendix.