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URINE SAMPLE COLLECTION PROTOCOLS FOR BIOASSAY SAMPLES

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Introduction

In vitro radiobioassay analyses are used to measure the amount of radioactive material excreted by personnel exposed to the potential intake of radioactive material. The analytical results are then used with various metabolic models to estimate the amount of radioactive material in the subject's body and the original intake of radioactive material. Proper application of these metabolic models requires knowledge of the excretion period represented by the samples analyzed, and it is normal practice to design the bioassay program based on a 24-hour excretion sample.

The Hanford bioassay program administered by Pacific Northwest Laboratory (PNL) simulates a total 24-hour urine excretion sample with urine collection periods lasting from one-half hour before retiring to one-half hour after rising on two consecutive days. Because the voided urine has been accumulating in the bladder since the last voiding, the excretion period is assumed to be close to 24-hours. Urine passed during the specified periods is collected in three 1-L bottles. Because the daily excretion volume given in Publication 23 of the International Commission on Radiological Protection (ICRP 1975, p. 354) for Reference Man is 1.4 L, it was proposed to use only two 1-L bottles as a cost-saving measure. This raised the broader question of what should be the design capacity of a 24-hour urine sample kit.

Methods and Discussions

A retrospective study of the volumes of urine samples submitted by personnel working on the Hanford Site was conducted. Over 7000 samples from a three-year period were categorized by the donor's age and gender, and the type of analysis to be performed on the sample. First, frequency distributions were prepared for samples collected from men and women during each of the three years covered by the study. The number of samples falling in discrete volume ranges of 100 mL increments were tallied and then normalized by dividing by the total number of samples in the category (see Figures 1 and 2).

The distributions were consistent enough to allow the data for all years to be combined. The three years of combined data were then similarly analyzed by the type of radiochemical analysis for which they were collected (see Figures 3 and 4), and finally by the age of the worker (see Figures 5 and 6).

Based on Figure 4, samples collected for tritium analysis were determined to show a unique volume distribution and were removed from the sample set. The data for women (Figure 3) were less conclusive due to smaller volumes and fewer results, but the same procedure was followed. The assumed reason for the difference is the worker's knowledge that only a small volume is required for tritium analysis.

The data minus the tritium samples were then analyzed by the age of the worker. Both the under-25 and 25-to-50 age groups showed a 1000-mL mode for men and 800 mL for women, but the younger group also showed indication of a bimodal distribution with a second peak around 1900 mL for men and 1700 mL for women. This observation could result from a subpopulation of workers showing signs of polyuria due to multiple causes, such as diabetes, increased fluid intake, and intake of diuretics in coffee and alcohol. The distribution for workers over 50 was similar in shape to the 25-to-50 age group, but for both men and women the curve was shifted toward higher volumes. This is counter to the trend shown in Figure 71 of ICRP 23 (ICRP 1975, p. 355).

Conclusions and Recommendations

About 7% of the samples from women and 15% of the samples from men exceeded the practical capacity of two 1-L bottles (1.8 L). The average sample volume for samples greater than 1.8 L was 2076 mL for women and 2095 mL for men. The consequence of using only two bottles in the collection kit would therefore be that the daily excretion for 7% of the women and 15% of the men would be underestimated by an average of about 14%.

A more significant potential error that affects all samples, results from the sample collection protocol used by PNL. In this study, excretion volumes for both men and women showed approximately lognormal distributions with modes of 1000 and 800 mL, respectively. These excretion values are 20% less than the ICRP 23 reference values of 1400 and 1000 ml (ICRP 1975, p. 354), although the upper limit of 2900 mL was the same. A similar result was found by Duane Medley in his master's thesis (Medley 1992). Medley showed that the simulated 24-hour urine sample proposed by National Council on Radiation Protection and Measurements (NCRP 1987) and adopted by PNL, collected only 84% of the actual volume excreted in 24 hours. There are at least two explanations for this bias. Firstly, because the time from retiring to rising varies from person to person and day to day there is no way to ensure that the excretion period for a sample is correct. Also, ICRP 23 (ICRP 1975) states that the greatest rate of urine flow is between 3:00 and 6:00 p.m. and the smallest flow is between 3:00 and 6:00 a.m. Sampling only during the night will therefore include a negative bias.

Although a 2-L sample collection volume will bias internal dosimetry calculation for a small portion of the population, the present collection protocol may introduce an even larger bias for the entire population. The PNL internal dosimetry program will therefore investigate enhancements to the collection protocol to remove this bias.

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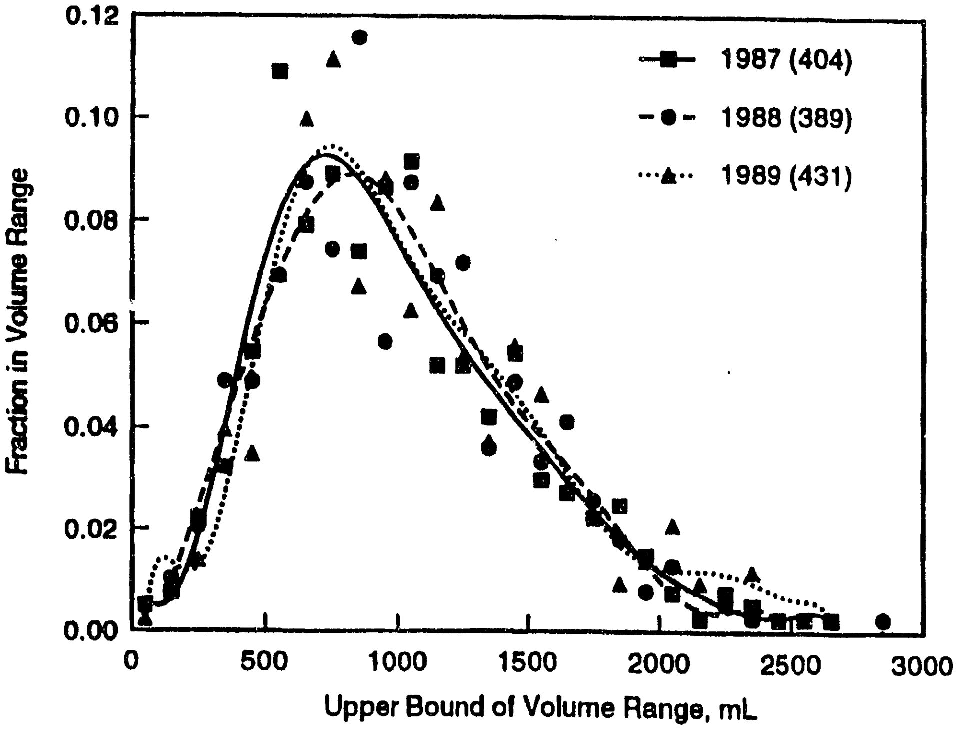

Figure 1. Urine Distribution for Women, by year (Total in Category)

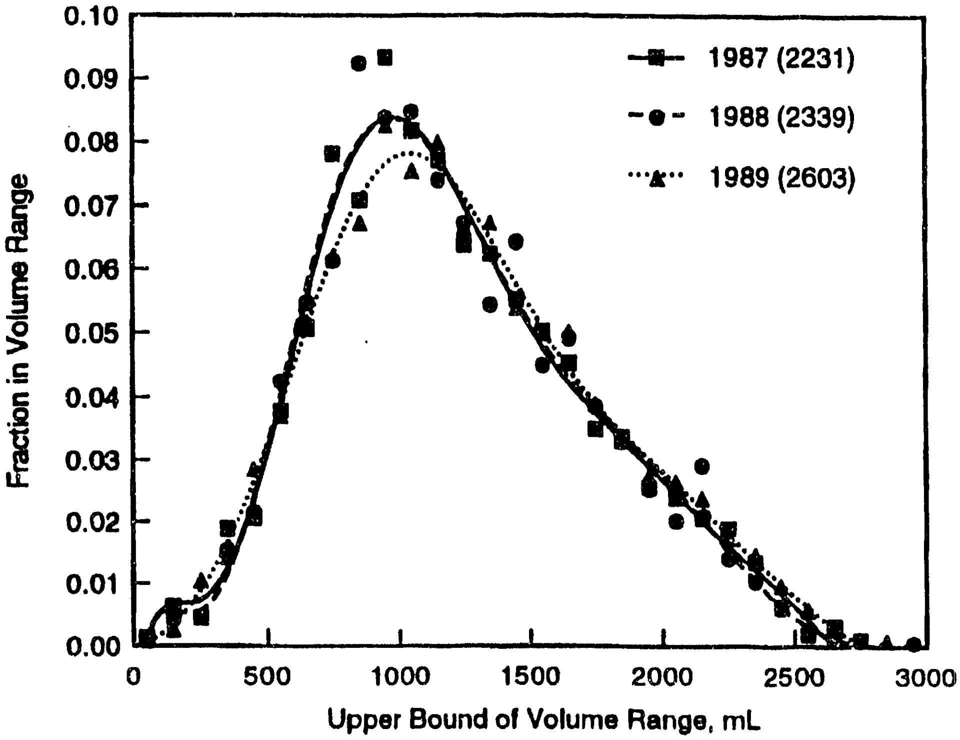

Figure 2. Urine Distribution for Men, by Year (Total in Category)

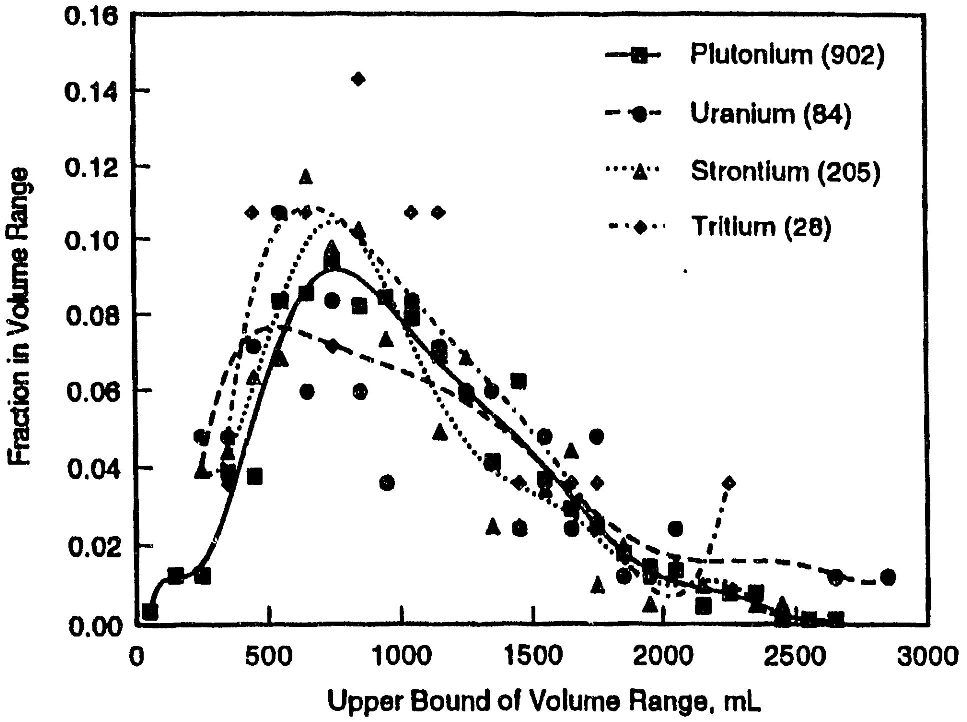

Figure 3. Urine Distribution for Women, by Analysis (Total in Category)

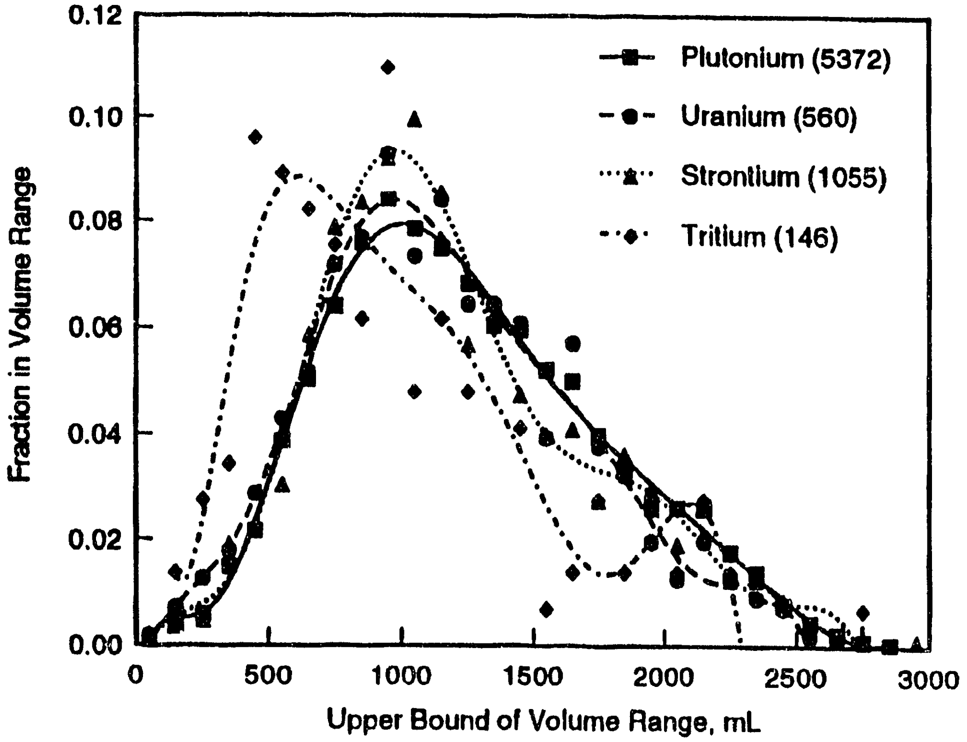

Figure 4. Urine Distribution for Men, by Analysis (Total in Category)

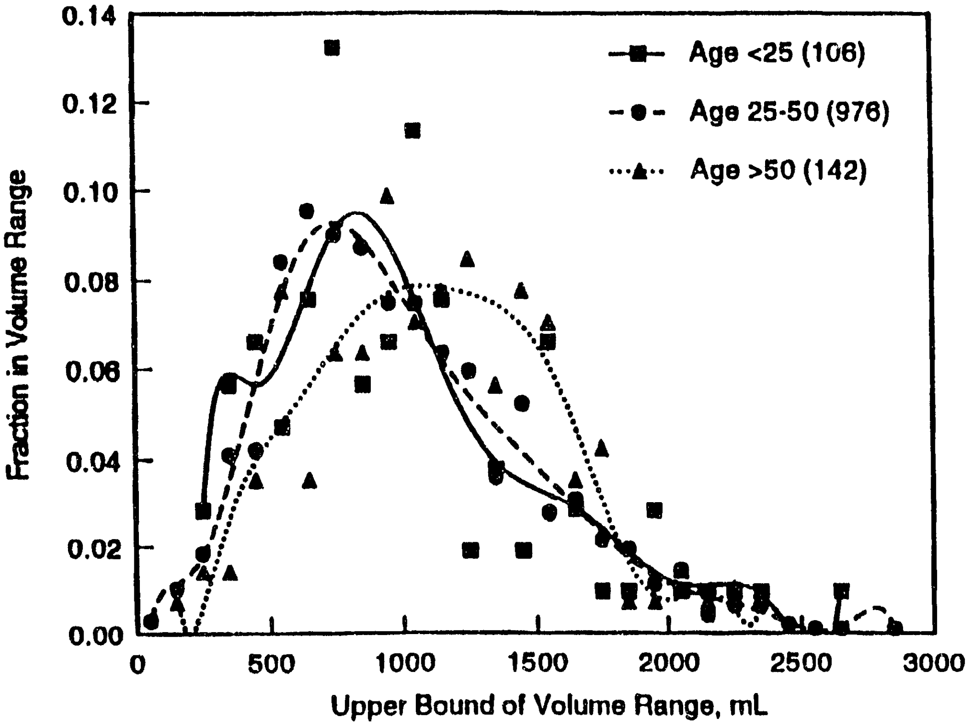

Figure 5. Urine Distribution for Women, by Worker Age (Total in Category)

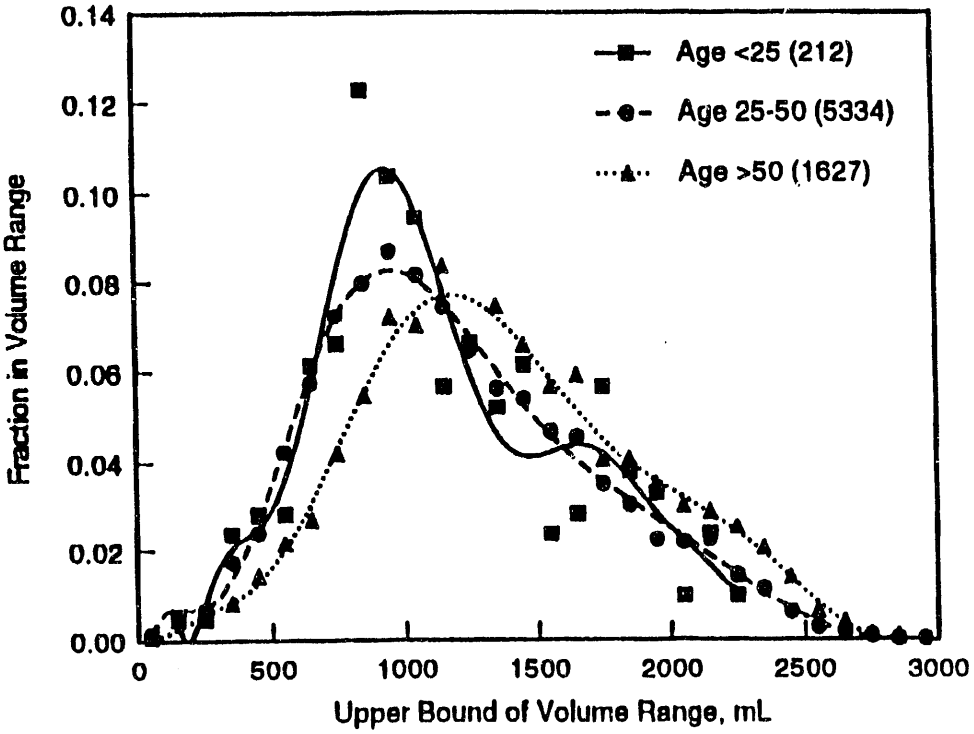

Figure 6. Urine Distribution for Men, by Worker Age (Total in Category)

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