# HANFORD WHOLE BODY COUNTER 1979 ACTIVITIES

by

H. E. Palmer, G. A. Rieksts, and H. B. Spitz

Personnel Dosimetry Section
Occupational and Environmental Protection Department
Pacific Northwest Laboratories

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## INTRODUCTION

This report describes the routine whole body counting measurement program for the Hanford project personnel during 1979. Special studies and development work performed in conjunction with the whole body counting facilities are also described. A similar report was written for the year 1978 in which the major facilities available for *in vivo* measurement were described. This report will only discuss additions or changes in these facilities during the past year.

## FACILITIES AND EQUIPMENT

The crowded conditions of the main whole body counting laboratory in the 747A Building were relieved in early December when trailer space containing offices, a laboratory, and an instrument shop was installed adjacent to the 747A Building. The laboratory operations at the 3708 Building, 300 Area were also moved to the trailer space. This new space has increased the efficiency of the whole body counting operations and has resulted in better safety and housekeeping practices. Further improvement in the appearance of the facilities was accomplished by adding paneling, carpeting, and new furniture in the waiting room and operations area. Further improvements are planned during 1980 in which the mens shower and change facilities will be reconstructed, a partition will be installed between the routine operations area, and the development and special studies work area, and the main entrance to the building will be remodeled to make it easier to locate and more attractive. These changes will provide a more professional appearance and should create a greater feeling of confidence in the people who come to the counter for *in vivo* measurements.

Construction was started on a second shadow shield counter to be permanently mounted in the 747A Building adjacent to the present shadow shield counter. This counter will contain two 35% Ge(Li) detectors and a 4" x 4" x 16" NaI(Tℓ) detector. Its primary purpose

will be to measure people who contain more than one radionuclide. For gamma ray whole body counting, all people will be measured in the existing shadow shield whole body counter which has a 6" thick by 11½" diameter NaI(Tℓ) detector. This is our most sensitive counter for measuring a single radionuclide in the Hanford workers. If this measurement shows more than 1 radionuclide in a worker, he will then be measured in the new shadow shield counter with the Ge(Li) detectors which can accurately resolve and quantify any number of radionuclides and a direct computer calculation of each radionuclide can be made.

## ROUTINE COUNTING OF PROJECT PERSONNEL

Employees of all the Hanford project contractors are routinely scheduled for whole body and lung counting measurements according to their work location and the potential for receiving an internal deposition of radioactivity. The necessity and frequency for these measurements is determined by the radiation protection management for each contractor. Routine counts are usually done when employee receives an annual physical examination at the Hanford Environmental Health Foundation (HEHF). In addition to the Hanford project contractor employees, Exxon Nuclear Company and Nuclear Engineering Company employees are also routinely measured at the Hanford whole body counting facilities.

More than 95% of the measurements are of the routine type and the number has been increasing each year. Figure 1 shows the whole body and lung measurement for each year since 1971. The total of 7038 reflects an increase of 11.5% over the total measurements in 1978 and an increase of 276% during the past 10 years. The 1872 lung counts done in 1979 are only slightly above the 1838 done in 1978 where as the whole body counts were 15% higher than in 1978. Table 1 shows the number and type of measurement made on the personnel of each Hanford contractor, DOE, and private industries.

FIGURE 1. IN VIVO MEASUREMENTS

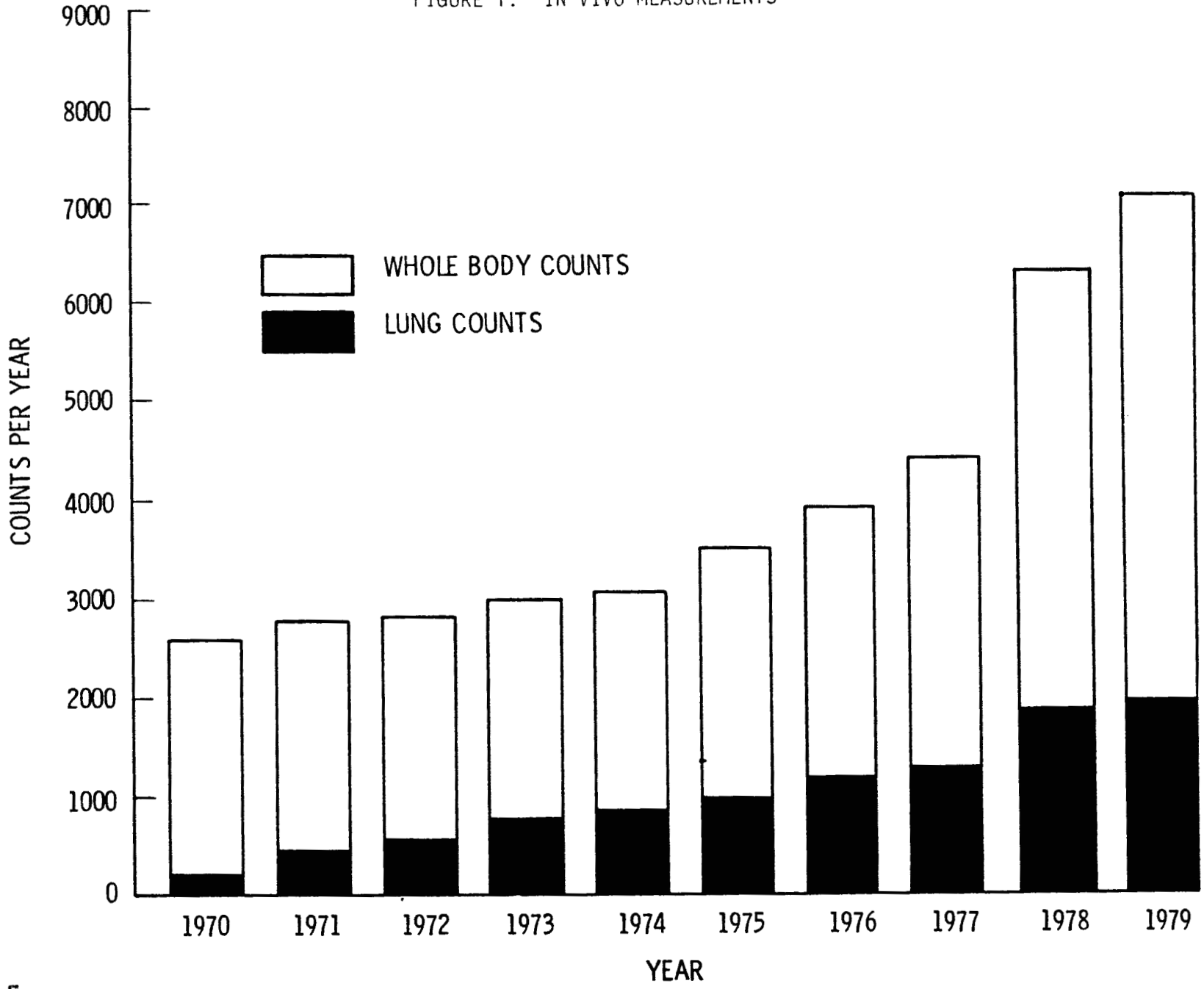

TABLE 1. In Vivo Measurements Made in 1979

| Contractor | Whole Body Counts | Chest Counts |
|---|---|---|
| BSC | 0 | 0 |
| DOE | 8 | 3 |
| UNI | 853 | 17 |
| HEDL | 881 | 680 |
| HEHF | 3 | 0 |
| JAJ and Subcontractors | 671 | 38 |
| PNL | 1126 | 519 |
| Vitro | 41 | 5 |
| Private Industries | 159 | 263 |
| TOTALS | 5133 | 1872 |

During the summer of 1979, 321 whole body counts were made on J. A. Jones Company employees at N Area during the summer repair outage using the mobile whole body counter. All other measurements were done at the 747A Building facilities except for a few special counts done at the radiosurgery facility. The average routine workload during 1979 was 21 whole body counts and 7 lung counts. The highest number of total routine counts in a day was 58 consisting of 39 whole body counts and 19 lung counts. The highest counting loads occur during the hiring and termination periods for summer employees.

## IN VIVO MEASUREMENT OF INCIDENT CASES

During the year 196 project employees were scheduled into the Whole Body Counter as a result of known radioactive contaminants released in a working environment. This was 2.3 time the number measured in 1978 for similar reasons. Of the 190 people measured 62 showed a deposition of internal radioactivity. These are summarized in Table 2.

Those employees having significant internal radioactivity were measured periodically to determine the retention time in the body.

TABLE 2. Incident Cases Resulting in Measurable Internal Radioactivity

| | Measurable But Less Than 10 nCi | Greater Than 10 nCi But Less Than 1% a MPBB | Greater Than 1% of a MPBB |
|---|---|---|---|
| Whole Body Counts (Mixed Fission Products of Corrosion Products) | 17 | 26 | 11 |
| Lung Counts $^{234}Pu$ or $^{241}Am$ | 3 | - | - |
| Wound Counts | 4 | - | - |
| Eye Count | 1 | - | - |

## NEW PROCEDURES

There were no major changes in the routine methods and procedures for in vivo measurements during 1979. Measurements for plutonium in wounds are still decreasing and only 6 measurements were requested during the year compared to several per month during the years of plutonium production at Hanford. There is an increasing demand for thyroid measurements to detect $^{125}I$. This results from increased use of this isotope in research studies and an NRC regulation which requires employees working at nuclear waste disposal sites to have a monthly check for $^{125}I$ content in the thyroid gland.

## RESEARCH AND DEVELOPMENT STUDIES

As nuclear technology increases and changes on the Hanford project, new methods are needed for in vivo measurements and in the case of the transuranic nuclides, there is a continuing need to improve the sensitivity and accuracy of their measurement. The technology which exists at the whole body counting facilities is also applicable to other areas of nuclear energy. The research and development studies associated with the Whole Body Counter are described on the next page.

## Gas Scintillation Proportional Counter Development

The development of gas scintillation proportional (GSP) counters has not reached the state where they can be used for routine measurement of $^{239}Pu$ in the lung. A counter which has excellent resolution and good counting efficiency has been built but the background of its construction materials was too high. As funding and time permits work and studies are continuing towards using low background materials and increasing the efficiency of the counter. This type of counter still has the highest potential of any type of detector for providing increased sensitivity for $^{239}Pu$ measurement.

Other research is being done at the whole body counter facilities on GSP counters for use in neutron spectroscopy. This work is funded by DOE Division of Nuclear Sciences for a project for measuring delayed neutron spectra at the TRISTAN isotope separator. Eight thousand dollars was used for this purpose in 1979. Twenty thousand will be available for this in 1980. Most of the development of GSP counter for this study will also be applicable to counters for in vivo measurement of $^{239}Pu$.

## $^{90}Sr$ Measurement in Bone

Due to lack of time, very little effort was devoted to this work during 1979. Some progress was made on the construction of special gas flow coincidence proportional counters which will be used. A skull phantom containing a known amount of $^{90}Sr$ uniformly distributed in the bone needs to be constructed for calibration purposes. It is planned to use a bone equivalent plastic developed by Lawrence Livermore Laboratory for making the skull phantom. One of our goals is to complete this work during 1980.

## New Ge(Li) Detection System for Whole Body Gamma Counting

A second shadow shield whole body counter is being constructed adjacent to the present counter. The detectors for this counter will be both a 4" x 4" x 16" inch NaI(Tℓ) detector and two 35% GeLi detectors. The use of the Ge(Li) will allow direct computer calculation of multiple radionuclides as they often exist in UNI maintenance workers. This project has been delayed by late delivery of one of the Ge(Li) detectors and a special liquid nitrogen Dewar. The counter should be in operation by September 1980.

## $^{241}$Am Calibration Studies

A cadaver containing $^{241}$Am deposited in the skeleton became available for study during 1979. The body was willed to the U.S. Transuranium Registry (USTR). They allowed us to study the body and skeletal parts in some detail before they sent the right half of the skeleton to Los Alamos for analysis for the $^{241}$Am content. We have carefully determined that each bone from the right side of the body has the same relative count rate as the same bone from the left side. When the analysis is complete for each bone of the right side, we will know the exact amount in each bone from the left side. The USTR is willing to give us the left side bones for the purpose of making a phantom when the right side analysis is complete, which should be sometime during the summer of 1980.

The $^{241}$Am in the bones exists as a natural distribution which is essentially impossible to duplicate artifically. The quantity in the skeleton is easily measured and is sufficient to provide excellent calibration if the bones were reconstructed into a tissue-equivalent phantom. A proposal has been submitted to DOE headquarters for support funds to construct this phantom. When completed the phantom will be used as a national calibration phantom for $^{241}$Am in the skeleton and it will be shipped to various DOE and other laboratories throughout the country for intercalibration studies.

## IMPROVED METHODOLOGY FOR MEASURING URANIUM IN THE LUNG

A unique application of the dual crystal detector to the in vivo measurement for uranium in the lung provides a mechanism to distinguish external uranium contamination from that actually deposited in the lung tissue. The thin (3 mm) NaI(Tℓ) scintillator in the dual crystal detector can identify the presence of uranium on the skin by measuring the ∿16 KeV X-rays from U, Pa, and Th. Using this same scintillator, the 63 KeV and 93 KeV $^{234}$Th photons indicate the presence of $^{238}$U. The thicker (5 cm) CsI(Tℓ) scintillator simultaneously detects the $^{235}$U photons at 186 KeV.

## IMPROVED METHODOLOGY FOR MEASURING URANIUM IN THE LUNG (contd.)

In order to take advantage of this technique, a surrogate thorax structure (phantom) is fabricated with a known amount of yellowcake uranium material deposited within the lungs. Two detectors are placed in contact with the surface of the anterior thorax, one detector centered over each lung. A standard ratio of the counts in the X-ray region to the number of counts in the $^{234}Th$ region is determined from a measure of the phantom. A similar ratio is calculated from an *in vivo* measurement of a potentially exposed subject. This ratio is first modified for chest wall attenuation and then compared to the surrogate thorax phantom. Detection of an abundance of 16 KeV X-rays with the exposed subject indicates that skin contamination is present. The subject *in vivo* measurement is corrected to account for surface contamination so that the amount of uranium in the lung can be determined.

Measurement of insoluble uranium material deposited in the respiratory system is performed by simultaneously detecting photon emissions from $^{235}U$, $^{234}Th$, and X-rays from uranium, protactinium, and thorium. Two dual-crystal NaI(Tℓ) scintillation detectors are placed on the anterior thorax of the worker while he lays prone in a shielded room at the laboratory whole body counting unit. An overabundance of the ≈ 16 KeV X-rays in an *in vivo* measurement for uranium in the lung indicates that some fraction of the material is located on the surface of the worker. Evaluation of any internal uranium deposition is adjusted to eliminate the influence of surface contamination on a worker.

## IMPROVEMENTS IN DATA PROCESSING

During 1979 improvements in data processing centered about computer programs developed for the assimilation of spectra derived from counting the Lawrence Livermore Laboratory developed anthromorphic phantom. This series of programs, to store and quickly access spectra for analysis or output, proved invaluable in many other special studies involving spectra throughout the year. The 300 line per minute line printer was the major hardware addition. By increasing the rate of printed output, it allows for more frequent and complete checks of data, speeds some reports to the field by not requiring data to be routed through the Cyber for printout, and lets the computer stay on line more of the time for immediate

IMPROVEMENTS IN DATA PROCESSING (contd.)

analysis of counts. Work was started on computer expansion. The growing workload combined with the increasing number of tasks required of the computer, have mandated a dual user capability and expanded fast access storage if out present capabilities are to be maintained. Incorporation of these improvements is scheduled for the later part of 1980.

Whole Body Counting Staff

| | |
|---|---|
| H. E. Palmer | Staff Scientist and Technical Leader |
| G. A. Rieksts | Development Engineer, Routine Operations |
| H. B. Spitz | Senior Research Scientist, Research Studies |
| M. C. Rhoads | Senior Technician |
| J. M. Mackliet | Technician |
| B. W. Perkins | Electronic Technician (assigned from Craft and Operation Services Department) |

Presentations and Publications During 1979

1. H. E. Palmer, G. A. Rieksts, R. F. Palmer, and M. F. Gilles, "The Use of Na-22 as a Tracer for Long Term Bone Mineral Turnover Studies", Aviation, Space, and Environmental Medicine, Vol. 50, pp 961-965, (1979)

2. H. E. Palmer and G. A. Rieksts, "The Determination of Muscle Mass Changes in Legs from K-40 Measurements", Aviation, Space, and Environmental Medicine, Vol. 50, pp 768-773, (1979)

3. H. E. Palmer and D. F. Anderson, "Large Area Gas Scintillation Proportional Counter for In Vivo Measurement of Plutonium and Americium", Proceedings of IAEA Symposium on Advances in Radiation Protection Monitoring, Stockholm, Sweden, June 26-30, 1978, IAEA, pp 459-467, (1979)

4. T. K. Lewellan, W. B. Nelp, R. Murano, and H. E. Palmer, "A System for Measuring Total Body Calcium in Man Using the Ca-40 (n,$\alpha$) Ar-37", Reaction, Phys. in Biol. and Med., Vol. 24, pp 124-135, (1979)

5. H. E. Palmer, G. A. Rieksts, and E. E. Icayan, "The In Vivo Measurement of Am-241 in the Hanford Americium Accident", Presented at the Health Physics Society Meeting, July 9-13, 1979, at Philadelphia by H. E. Palmer

6. H. B. Spitz and B. Robinson, "Deposition of Plutonium in the Lung of a Worker Following an Accidental Inhalation Exposure", Presented at a Workshop on Measurement on Interpretation of Actinide Accumulation by Man, Salt Lake City, Utah, October 14-18, 1979, (In Press)

Information in Reference 1 and 2 above were also presented as two papers at the 3rd Conference on Progress and Problems of In Vivo Activation Analysis, Newcastle, England, April 3-6, 1979, by H. E. Palmer