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HANFORD WHOLE BODY COUNTER 1978 ACTIVITIES

by

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INTRODUCTION

This report describes the work, studies and measurements performed at the whole body counter and other associated studies during 1978. This type of report was written each year for a few years starting in 1959 after the iron room whole body counter was first constructed[1, 2, 3]. Since that time the number and type of counts done each year have greatly increased and new counting facilities have been added. Several research and development activities are also conducted with these facilities. This report will be the first of this series of annual reports which will be written in a concise and informative style that will, hopefully, require a minimum of writing time and can be read in a short period of time.

FACILITIES

The whole body counting facilities include the following major items of equipment:

1) Four shadow shield type whole body counters.

   These are used for measuring total body or organ content of gamma emitting radionuclides. One of these is permanently installed in the 747A Building and more than 90% of the whole body count measurements are done in this counter. Two of these counters are mounted in mobile truck units for use at any area on the Hanford Project or for emergency or research study use off the project. A fourth shadow shield type of counter is located in the Hanford Environmental Health Foundation (HEHF) radiosurgery facility.

2) Two shielded room facilities.

   The iron room which has 10 in thick iron walls, ceiling and floor is divided into two compartments. A lung counter is installed in each compartment and measurements of plutonium,

americium, uranium and other transuranic radionuclides can be determined in the chests of two people simultaneously.

A lead room which has 4 in. thick walls is used for special types of counts in contamination incidents and is used in the development of improved instrumentation for *in vivo* measurement of radionuclides.

3) State-of-the-art radiation detection and electronic equipment are maintained at these facilities to provide the most sensitive and accurate measurements possible for the Hanford project personnel. Counting operations are controlled by a minicomputer which also provides instantaneous calculation of counting results, plots of unusual spectra, and standardizes the outputs of four different types of analyzers.

4) An ultra-sound system is used for measuring the chest wall thickness of those employees having measurable amounts of radioactivity in the chest. This thickness measurement is used to correct for chest wall attenuation of the radioactivity.

5) Equipment and capability is maintained for particle size measurement of plutonium on air filter samples and for measuring the activation of foils and dosimeters in the Hanford Criticality Monitors.

ROUTINE COUNTING OF PROJECT PERSONNEL

Employees of the various Hanford project contractors are routinely scheduled for whole body 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. Chest counting is scheduled through the schedule coordinator in the Pacific Northwest Laboratory (PNL) Personnel Dosimetry section. If a routine count is needed, it is usually done at the time they receive their annual physical examination at Hanford Environmental Health Foundation (HEHF). In addition to the Hanford project contractors, Exxon Nuclear Company and Nuclear Engineering Company employees are also measured routinely at the Hanford Whole Body Counter.

Most of the measurements are of the routine type and these have been increasing each year. Figure 1 shows the whole body and chest count measurements for each year since 1970. The 6,313 total routine measurements made in 1978 represent a 42% increase over the 4,447 measurements made in 1977. The 4,475 whole body gamma ray measurements in 1978 are an increase of 38% and the 1,838 chest measurements are 52% increase over those made in 1977. Table 1 shows the number of measurements made on the personnel of each Hanford contractor and employees of the Department of Energy and other companies.

TABLE 1. In Vivo Measurments made in 1978

Contractor	Whole Body Counts	Chest Counts
BCS	9	1
DOE	5	2
UNI	815	83
HEDL	775	539
HEHF	3	-
JAJ	409	14
PNL	1175	598
RHO	1050	262
VITRO	15	6
Private Industries	219	333
TOTALS	4475	1838

During the summer of 1978, 251 whole body counts were made on J.A. Jones employees at N Area during the summer repair outage using the mobile whole body counter. The remainder of the counts were made at the 747A Building facilities. The average counts per working day were 7 chest counts and 18 whole body counts. The highest number of routine counts made in any one day were 14 chest counts and 35 whole body counts. The highest counting load occur during the period of hiring and termination of summer employees.

UNUSUAL RADIOACTIVITY MEASURED DURING ROUTINE MEASUREMENTS

Most of the routine whole body and chest count measurements do not show any detectable radioactivity in Hanford workers other than naturally occuring ^{40}K and a small amount of ^{137}Cs from nuclear test fallout. Examinations may in a few employees detect small quantities (less than 1% of a maximum permissible body burden) of activated corrosion products such as ^{60}Co, ^{65}Zn, ^{54}Mn, ^{59}Fe, and ^{51}Cr which clears rapidly from the body.

Occasionally unsuspected radioactivity is discovered in employees who come to the whole body counter for a routine measurement and this gives an indication of some uncontrolled radioactivity in their working environment. One laboratory employee was found to have a thyroid burden 25 nCi of ^{125}I during 1978. Upon further investigation ^{125}I was found in other employees working in the same laboratory. After investigation and correction of the problem, the laboratory manager expressed the following in a letter: "We all wish this uptake has never occurred, but are truly thankful that the body counting aspect of our health and safety program uncovered the problem before it became too severe." Other unsuspected and unusual burdens of ^{137}Cs and ^{85}Sr were detected and reported back to the field by the exposure evaluator so that the source of the contamination could be investigated.

WHOLE BODY COUNTING OF INCIDENT CASES

Eighty-five project employees were scheduled into the whole body counter as a result of known radioactive contaminants released in a working environment. Thirty-two of these were for both chest and whole body measurements, 41 for whole body measurement only and 12 for wound counts. Those employees having a significant internal burden of radioactivity were counted periodically to determine the retention time of the radioactivity in the body or particular organ. Many additional measurements were made in 1978 on the worker involved in the 1976 americium accident to monitor the changes in his relatively high body burden of ^{241}Am.

NEW PROCEDURES AND FACILITIES

During the latter part of 1977 the permanent shadow shield counter was installed adjacent to the iron room. The gamma ray whole body count measurements were transferred from the old tilted chair geometry in the iron room to this shadow shield counter. The lung counter was moved from the lead room to the iron room and the lead room was made available for special counting procedures and research and development studies which will be described in the next section.

The demand for chest counts began to exceed the capacity of the single lung counter in early 1978. A lead brick partition was placed in the iron room and a second lung counter was installed so that two people could be measured simultaneously. The daily capacity for scheduled chest counts is now about twenty (33 minutes each) during the regular day shift.

A new ultrasound system for measuring chest wall thickness was purchased. This unit has a 64 element transducer for phased array scanning which gives a real-time image over a distance of 8.5 cm. A picture of an image of a typical chest wall thickness is shown in Figure 2. The interface of the lung and inner chest wall surface is clearly visible and the calibrated 1 cm depth marks along the right side of the picture allow the chest wall thickness to be easily determined. This increased capability allows an accurate correction to be made for the attenuation in the chest wall of low energy x-rays and gamma-rays originating in the lung.

A tissue-equivalent-human-torso phantom which was constructed at the Lawrence Livermore Laboratory (LLL) became available for calibrating the Hanford lung and liver counters. This phantom was made from a cadaver mold and was designed according to recommendations of an intercalibration committee composed of whole body counting specialists from the major DOE contractors throughout the U.S. which included two people from Pacific Northwest Laboratories.[4] It closely simulated the counting geometry of internally deposited radionuclides and is made of materials which simulate the photon attenuation properties of human tissue (muscle, bone, adipose tissue, cartilage, and lung) at energies below 20 keV. Several sets of lung, liver and pulmonary lymph node organs are available which contain accurately known quantities of

^{239}Pu, ^{238}Pu, ^{241}Am and natural uranium. The phantom also has a set of chest plates to simulate various chest wall thickness of muscle or adipose tissue from 2-4 cm. The Hanford counters are now well calibrated for the above radionuclides in the lung and liver and correction factors have been determined for interferences of lung to liver counts and liver to lung counts. These calibrations combined with the chest wall thickness measurement described above allow us to make a good determination of lung radioactivity if it is detectable. The real need now in lung counting of transuranic elements is an increase in sensitivity so that lower amounts can be detected.

RESEARCH AND DEVELOPMENT STUDIES

The three areas of in vivo counting which need improved capability are: 1) greater sensitivity for measuring transuranic elements (especially plutonium) in the lung, liver and skeleton, 2) greater sensitivity for measuring ^{90}Sr in the lung and skeleton in the presence of other long lived fission products such as ^{137}Cs and 3) more rapid and accurate calculation of the content of gamma emitting nuclides when several of them are present in the body. Studies are being conducted to meet these needs and are briefly described below:

Gas Scintillation Proportional Counter Development

This type of counter offers the advantage of superior resolution and large area. One of the main contributors to the background is the human body itself and improved resolution of the photopeak energies of Pu x-rays is the only way to discriminate against this background. This work is being funded by the Nuclear Regulatory Commission (NRC) and is being done at Hanford at the whole body counter facilities. Significant progress has been made during 1978, and a counter having increased sensitivity for measuring Pu in the lung is expected to be in use by the end of 1979.

^{90}Sr Measurements

Measurements on the skull have been shown to be a good method for measuring bone seeking radionuclides [5, 6]. Studies are being done to determine whether the measurement of beta particles or bremsstraklung provide the most sensitive method. A bone equivalent head phantom is being constructed which will contain a known amount of ^{90}Sr in the skull. This

phantom will be used to determine the best type of counter to use and to calibrate the counter for making quantitative measurements in humans. The skull is an especially good place to count for ^{90}Sr when ^{137}Cs is present since the ^{137}Cs deposits predominates in muscle tissue and the head can be shielded from the major muscle mass regions of the body.

Installation of Ge(Li) Detection for Whole Body Gamma Counting

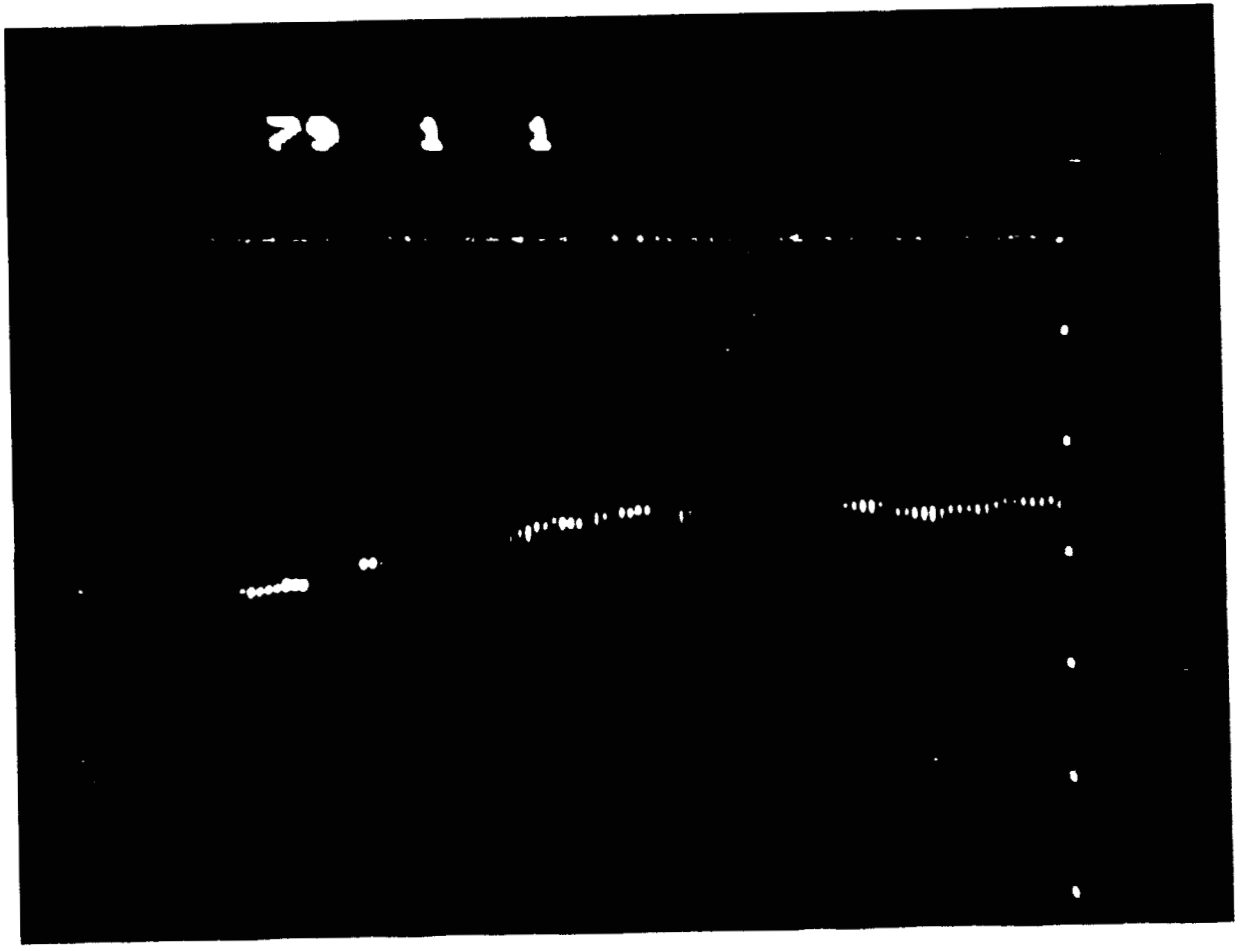
The resolution of the large NaI(Tl) detector which has been used for whole body counting for the last 20 years is not sufficient to resolve all the photopeaks measured where a person contains several radionuclides. A good example is the activated corrosion products in N Area maintenance workers who often have small quantities of ^{60}Co, ^{65}Zn, and ^{59}Fe which all have gamma-ray energies between 1.1 and 1.33 MeV. A direct computer calculation is difficult because of the similarity in the gamma-ray energies. Two large Ge(Li) detectors are being installed which have energy resolutions 20 times better than the NaI(Tl) detectors. With these new detectors the sensitivity for a single radionuclide will not be as good as the 11-1/2 in. diameter NaI(Tl) detector presently in use, but for multiple radionuclides the sensitivity is better and a direct computer calculation of an unlimited number of radionuclides is possible. The two large Ge(Li) detectors have been purchased but one of them did not meet specifications and was returned. A replacement should arrive in early 1979 and this sytem will be in routine use by late 1979.

Other Research Activities

Whole body counting personnel are periodically involved in other research studies. Some of these are in cooperation with the medical institution of HEHF and the University of Washington School of Medicine. Several studies of methods for measuring body composition changes during space flight were concluded during 1978. Some of these studies will resume when longer term experiments are available in the NASA Space Lab project. Some whole body equipment is used in these studies. Some work on improved neutron spectroscopy was done at the whole body counting facilities using the newly developed gas scintillation proportional counter. This work looks very promising and will continue for the next two years. Other applications of the gas scintillation proportional counter will be developed as outside funds become available.

FIGURE 2

ULTRA SOUND MEASUREMENT OF CHEST WALL THICKNESS



SKIN SURFACE

CHEST WALL - LUNG INTERFACE

1 cm CALIBRATION MARKS

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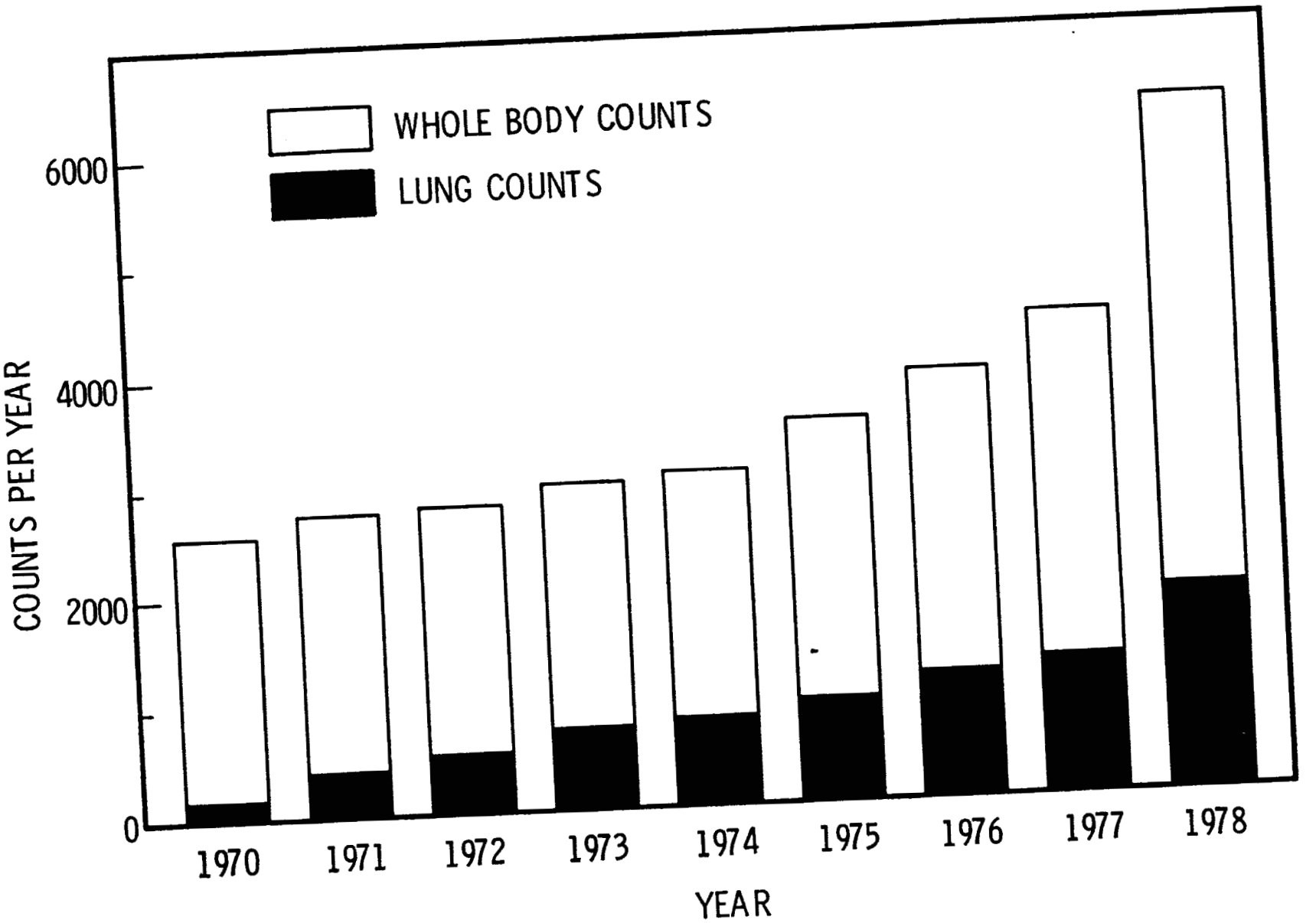
IN VIVO MEASUREMENTS

FIGURE 1



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Whole Body Counting Staff

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G. A. Rieksts	Physicist
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Presentations and Publications During 1978

H. E. Palmer and D. F. Anderson. "Large Area Gas Scintillation Proportional Counters for In Vivo Measurement of Plutonium and Americium." Proceedings of IAEA Symposium on Advances in Radiation Protection Monitoring, Stockholm, Sweden, June 26-30, 1978. (Presented by L. W. Brackenbush). (In Press).

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