

HANFORD WHOLE BODY COUNTER 1980 ACTIVITIES

by

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COLLECTION DOE READING ROOM - WHOLE BODY

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HANFORD WHOLE BODY COUNTER 1980 ACTIVITIES

INTRODUCTION

This report describes the routine whole body counting measurement program for the Hanford project personnel during 1980. Special studies and development work performed in conjunction with the whole body counting facilities are also described. Similar reports have been written since 1978 in which the major facilities available for in vivo measurement were described. This report will discuss additions or changes in these facilities.

FACILITIES AND EQUIPMENT

The mens shower and change facilities were reconstructed during 1980 which has alleviated previous crowded and sometime inefficient conditions where both men and women used the same facilities.

The mobile whole body counter unit #1, which had not been used for several years, was reconstructed and placed into service. It is more useful than mobile unit B for making measurements at N Area because it has room for people to change clothes. In previous years an extra trailer was necessary for a clothes change area. Mobile unit #1 is also temporarily being used for emergency preparedness and is being equipped with special radiation measurement instruments in addition to those existing for whole body counting facility.

Two special detector holders were installed in the lead room for positioning detectors on any part of the body. At the present time two phoswich detectors are mounted on them for use in measuring special cases of uranium, thorium, or transuranic elements in the lungs or other organs of the body. These two holders are used in conjunction with a third holder to position three detectors around the head for measuring bone seeking radionuclides. Head counting has been shown to be a reliable and sensitive method for measuring the total skeletal content of radionuclides such as ^{241}Am , ^{210}Pb which have photon energies high enough to penetrate the bone.

The two 35% Ge(Li) detectors were installed in the shadow shield whole body counter and calibration studies have been completed for them. These have been especially useful in identifying

and quantifying mixtures of radionuclides in the body. They will soon replace the 6" x 11½" NaI(Tl) detector as the primary detector for whole body counting.

A new Nova 4 Data General Computer was ordered and received and is presently being interfaced with our Whole Body Counter instrumentation. This computer has a much larger capacity and dual user capability. The greater storage capacity will allow all of our data files and programs to remain on disc storage for rapid access. At the present time many of our files which are used less frequently are purged to make room for routine results and then must be reloaded and recompiled when needed again. The dual user capability will allow plotting, printing, computing, or running other programs on one half of the computer while the other half is operating the routine counting program.

Routine Counting of Project Personnel

Figure 1 shows the whole body and lung measurements made for each year since 1971. The whole body section of the bargraph includes all types of counts except lung counts. The total of 6,924 measurements reflect a slight decrease in both whole body and lung counts over those made in 1979. Table 1 shows the number and type of measurements made on the personnel of each Hanford contractor, DOE, and the private industries, Exxon Nuclear, Nuclear Engineering Company, and Washington Public Power Supply System.

TABLE 1. In Vivo Measurements Made in 1980

<u>Contractor</u>	<u>Whole Body Counts</u>	<u>Lung Counts</u>	<u>Thyroid</u>	<u>Wound</u>
BSC	0	0	0	0
DOE	9	3	0	0
RHO	1389	361	1	1
UNI	887	7	1	1
HEDL	1122	772	0	0
HEHF	1	1	0	0
JAJ and Subcontractors	337	4	0	1
PNL	1144	448	28	10
Vitro	7	1	0	0
Private Industries	<u>116</u>	<u>146</u>	<u>126</u>	<u>0</u>
TOTALS	5012	1743	156	13

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The reduced number of measurements in 1980 marks the first time in more than 10 years that the number of measurements did not increase. This was due partly to the labor strike which reduced the measurements on J.A. Jones Company employees to half that in 1979, to the reduced summer hiring by all contractors, and to reduction in requests for measurements by private industries. The number of measurements made for the four major users of the whole body counting facilities was 6% higher in 1980 than in 1979.

In Vivo Measurement of Incident Cases

The number of Hanford project employees measured as a result of radioactive contamination incidents during 1980 was 73. This is a significant reduction over the 196 measured in 1979 and slightly less than those in 1978. Table 2 summarizes the type and contamination level of these cases.

TABLE 2. Incident Cases in 1980

<u>Type of Count</u>	<u>Internal Contamination Level</u>		<u>Greater Than 10 nCi</u>
	<u>Less Than Minimum Detectable Amount</u>	<u>Measurable But Less Than 10 nCi</u>	
Whole Body Count	5	8	27
Lung	15	5	0
Wound	10	1	0
Thyroid	2	0	0

NEW PROCEDURES

Several new operational procedures were adopted during 1980. A unit cost financing was started wherein each contractor is charged a fixed amount for each type of measurement. Previously each contractor was billed for their fraction of the operating costs which was determined quarterly according to their past usage of the whole body counting facilities. From January through September 1980 the unit costs were \$36 for a whole body count, \$62 for a lung count, and \$50 for all other types of counts such as thyroid, head, wound, etc. At the beginning of FY-81 the rates were changed to \$40, \$69, and \$55 for the three classifications of counts.

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The reporting level of radionuclides measured in the body has been significantly reduced during the past two years. For instance any routine measurement showing less than 100 nCi of ^{60}Co (100 nCi is 1% of a MPBB under the old ICRP II limits) was shown as a trace and the actual value was not reported. With new limits and evidence that most of the long term retention ^{60}Co is in the lungs, and the fact that ^{60}Co is an indicator of the presence of other radionuclides such as ^{144}Ce which are difficult to measure, the reporting level is now 2.6 nCi. This requires a much closer evaluation of Whole Body Counter spectra, and background interferences from work related contamination on the skin, hair, and clothing has become a significant problem. Personnel from certain areas on the project are now required to change into clean coveralls. In addition radon daughter products originating from environmental radon in the air are strongly attracted to statically charged polyester clothing and this background interference becomes quite severe during atmospheric inversions. It is planned that all people will change into clean coveralls before their whole body counting measurement. This procedure will become effective during 1981.

A new personnel decontamination procedure has been adopted. Personnel involved in contamination incidents who are found to be externally contaminated during a preliminary survey upon arrival at the Whole Body Counter are now decontaminated at the Emergency Decontamination Center rather than at the whole body counting facilities. This is inconvenient, but it is the only way to effectively stop the spread of contamination into the low level background counting spaces. Although encouragement has been given to have all incident cases shower before arriving at the Whole Body Counter, this is not done very often and external contamination is frequently found in these cases.

RESEARCH AND DEVELOPMENT STUDIES

As nuclear technology increases and work programs change 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

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technology which exists and is developed 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 following pages.

Gas Scintillation Proportional Development

Progress on the development of gas scintillation proportional (GSP) counters was limited in 1980 by both time and funding. Significant progress was made, however, in the development of large photoionization detectors to replace photomultiplier tubes for detection of the xenon scintillation light emitted from the GSP counter. The photoionization detector is a new type which is basically an Argon Methane gas proportional counter containing a few mm pressure of tetrakis-(dimethylamino)-ethylene (TMAE) which is an oxyluminescent compound which is ionized by the u.v. xenon scintillation light. This type of photoionization detector is superior to photomultiplier tubes for this application because of (1) a much more uniform response over the area of the detector since the sensitive material is in a uniform concentration rather than a vaporized photocathode, (2) better efficiency for detecting photons, (3) large area photoionization detectors are easy to construct and therefore less expensive than photomultiplier tubes, and (4) they can be made with CaF_2 or MgF windows which transmit a high percentage of the xenon scintillation light.

A prototype GSP counter using a photoionization detector was constructed and tested during 1980. The counter exhibited excellent resolution. Parts were made for two GSP counters. One of these is 10" in diameter and will be used for lung counting the other is a 4" diameter phase 2 prototype for a neutron spectrometer. These counters are presently being assembled and will be completed and tested in 1981. If the lung counter is as successful as it promises to be it will significantly increase the sensitivity for measurement of plutonium and americium in the body.

Interlaboratory Comparison of Lung Measurements of Transuranic Radionuclides

Battelle is a major contributor and a member of the DOE sponsored Inter-Calibration Committee for Low Energy Photon Measurements and also is one of three U.S. laboratories which participates in an IAEA interlaboratory comparison of measurements made on subjects who have inhaled known quantities of radionuclides which emit low energy photons. The inhalation of these low level radionuclides is done in England. In the current IAEA sponsored study, subjects containing ^{92}Nb are measured. Two of these subjects were extensively studied at the Whole Body Counter during 1980. Niobium-92m emits a 16 KeV X-ray and a 934 KeV gamma-ray. The gamma-ray measurements allow the content of $^{92\text{m}}\text{Nb}$ in the lung to be accurately determined by standard whole body counting methods which allow the number of 16 KeV photons emitted to be calculated. External measurements of 16 KeV photons give the counting efficiency and calibration factor and by using subjects of different chest wall thickness the change in calibration factor as a function of chest wall thickness can be determined. The main purpose of this study is to confirm the accuracy of the tissue-equivalent torso phantom which was developed and tested by the Inter-Calibration Committee for Low Energy Photon Measurements. When this confirmation is complete this phantom will become an international calibration standard.

The Measurement of Low Energy Gamma-Rays in the Lung

Studies were conducted on the detection of radionuclides in the lung which have low energy gamma-ray energies in the range of 80 to 200 KeV in the presence of other high energy gamma emitters. This was done in regards to the current interest in measuring ^{239}Np which emits gamma and X-rays of 106 and 104 KeV respectively and ^{141}Ce and ^{144}Ce with gamma-rays of 145 and 134 KeV respectively. Tests were made with three types of detectors on a mixed radionuclide standard placed in our lung phantom. This approximates the situation where we are trying to measure ^{239}Np and Ce isotopes in the presence of large quantities of high energy gamma emitters such as ^{60}Co , ^{54}Mn , ^{137}Cs , ^{95}Zr , etc.

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These studies clearly show that a planar intrinsic Ge detector is far superior for measuring gamma-rays in the energy region of 80 to 200 KeV. This is due to its excellent resolution of 400 eV as compared to 2600 eV for the Ge(Li) detector and about 11,000 eV for the NaI(Tl) detector for a 100 KeV gamma-ray. To effectively measure these lower energy gamma-rays in a reasonable length of time, one or two arrays of the planar intrinsic Ge need to be procured at a cost of \$40,000 each.

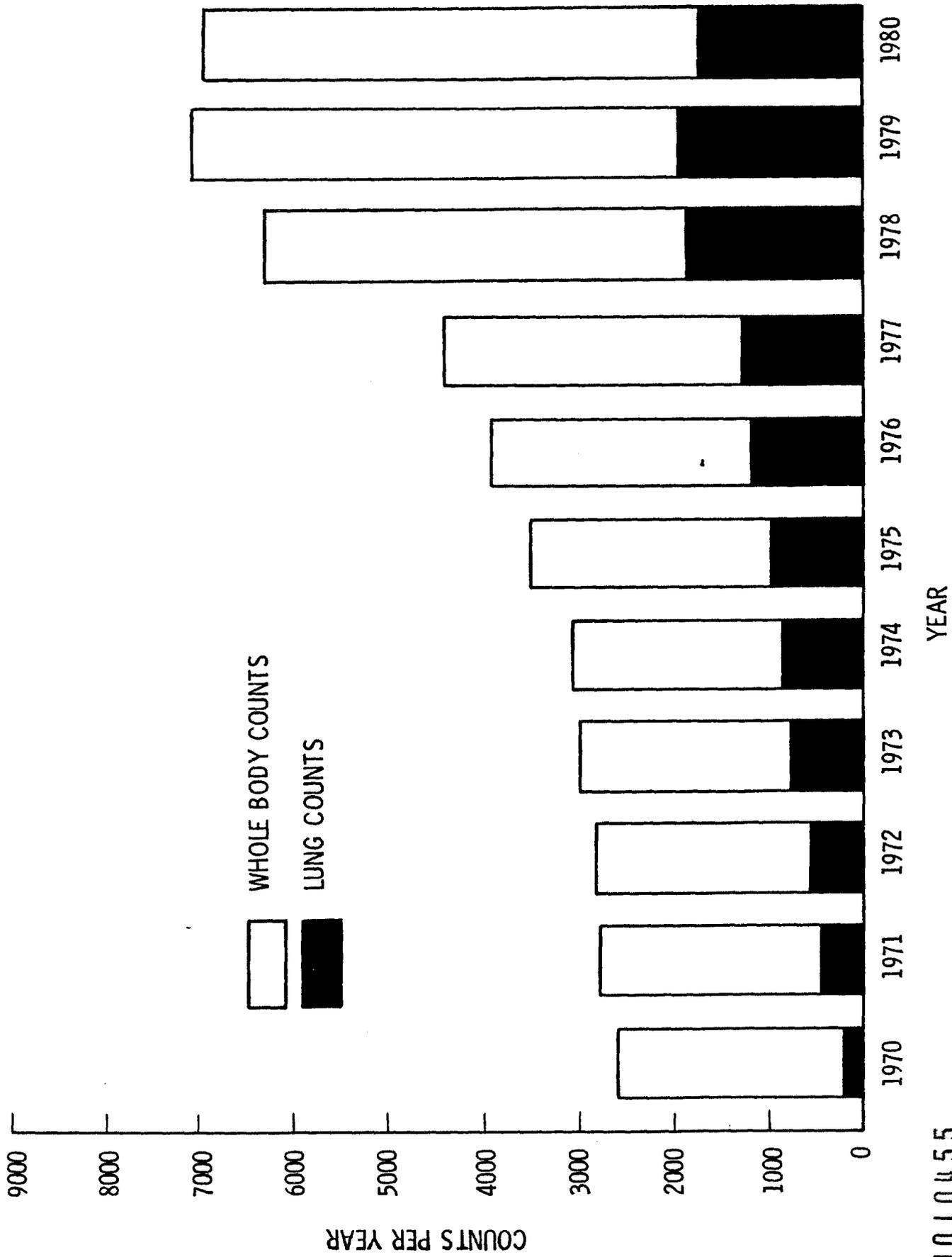
Whole Body Counting Staff

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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 1980

1. H. E. Palmer, G. A. Rieksts, "The Use of M X-Rays From $^{238-239}\text{Pu}$ and ^{241}Am to Study Shallow Depositions in Body Surfaces. Health Physics, Vol. 38, pp 71-73, (1980).

Fig 21



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INTRODUCTION

This report describes the routine whole body counting measurement program for the Hanford project personnel during 1981. Special studies and development work performed in conjunction with the whole body counting facilities are also described. Similar annual reports have been written since 1978 in which the major facilities available for in vivo measurement were described. This report will discuss additions or changes in these facilities during 1981.

FACILITIES AND EQUIPMENT

New computer A new Nova 4 Data General computer and a new 8-track magnetic tape unit were put into operation during the year. The computer has dual user capability and can operate the routine counting program while simultaneously providing plotting, printing, computing and operation of other programs. The larger storage capacity provides rapid access to all of our files and programs. The old Nova 2 computer was retained for backup operation of routine counting in case the Nova 4 shuts down.

New Calibration Phantom A major improvement in the accuracy of measuring radioactivity in the lungs and liver was made possible in 1981 by the purchase of a phantom which very closely simulates a human male torso. The phantom consists of a tissue equivalent polyurethane torso shell with an imbedded bone equivalent rib cage. Tissue equivalent lung and liver organs are removable and can be obtained containing uniformly distributed radionuclides. Tissue equivalent chest plates can be overlaid on the phantom to simulate a range of chest wall thickness from 1.7 to 4.2 cm. The tissue equivalency of the phantom parts is sufficient to give the same absorption of X and gamma ray radiation as human tissue for energies down to 17 keV. Separate radioactivity tagged lung sets containing NBS certified standard amounts of ^{238}Pu , ^{239}Pu ,

^{241}Am , Natural U, 93% enriched U, and natural Th were purchased with the phantom. Radioactively tagged liver organs were obtained with ^{238}Pu , ^{239}Pu , and ^{241}Am . We have made our own lung molds and have also made our own tagged lungs containing high energy gamma ray emitters.

The phantom has been under development for the past several years at Lawrence Livermore National Laboratory under the direction of an intercalibration committee consisting of representatives of the major DOE supported whole body counting facilities. The phantom molds for the body shell and organs were made from a cadaver. The phantom has undergone extensive testing at many whole body counters and is expected to be certified as an international in vivo calibration standard by the IAEA at the completion of some further testing which is described in the research and development studies section of this report. Figure 1 shows some pictures of the phantom and organs. The use of this phantom in conjunction with the ultrasonic method of measuring chest wall thickness has very significantly improved our accuracy in estimating lung and liver burdens of Plutonium, Americium, Uranium and many high energy gamma emitting radionuclides.

Array of Intrinsic Germanium Planar Detectors The experience at the whole body counters at the Rocky Flats Plant and ORNL with arrays of intrinsic germanium detectors has shown that they are more sensitive than phoswich detectors for measuring ^{241}Am in the lungs but less sensitive for determining the ^{239}Pu directly by measuring the 17 keV x-ray. Due to the high cost of these detectors we have delayed purchasing an array since our sensitivity for measuring ^{241}Am was considered adequate. With reduced limits and refinements in lung dosimetry for some of the low energy gamma emitters there is a need to increase our lung counting sensitivity for radionuclides such as ^{144}Ci and ^{239}Np as described in the Hanford Whole Body Count 1980 Activities Report.

An array of three 20 cm² by 1 cm thick intrinsic germanium were ordered in 1981. This array will only be large enough to measure one lung. Additional arrays will be purchased as funding permits until we have 4 arrays so that two people can be monitored simultaneously in both lungs for uranium, transuranic radionuclides, and low energy gamma-ray emitters.

Lung counting at the Emergency Decontamination Center The shadow shield whole body counter was modified so that lung counting for ²⁴¹Am could be done in emergency situations where a person might be externally contaminated at a level which would not be allowed at the main whole body counter facilities. The modification included additional shielding and remodeling to allow phoswich detectors and the intrinsic germanium array to be mounted into the counter.

Gamma Camera Installation at the Emergency Decontamination Center
A medical gamma camera was donated to the University of Washington School of Medicine which has assigned it to Battelle through a professional staff relationship which exists between the two institutions. The main purpose of its location at the emergency decontamination center is for emergency use in imaging and localizing internal contamination associated with radiation contamination accidents. Gamma cameras borrowed from nearby medical institutions have been useful in past accident cases.

New Shielded Room Facilities A new shielded room facility is needed to keep abreast of the increasing whole body counting needs of the Hanford Site. A room made from 2½" thick World War I battleship steel surrounded by 4 inches of lead has been designed during 1981. The steel is available free from Reynolds Electrical and Engineering Company at the Nevada Test Site. This room will be constructed as funding becomes available.

ROUTINE COUNTING OF DOE CONTRACTOR PERSONNEL Figure 2 shows the whole body and lung measurements made for each year since 1971. The whole body section of the bargraph includes all types of counts except lung counts. The total of 8081 measurements reflect a significant increase in whole body counts over those made in all previous years. The number of lung counts has remained about the same over the past 4 years. Table 1 shows the number and type of measurements made on the personnel of each Hanford contractor, DOE, and the private industries which include Exxon Nuclear, Nuclear Engineering Company, and Washington Public Power Supply System.

TABLE 1. In Vivo Measurements Made in 1981

<u>Contractor</u>	<u>Whole Body Counts</u>	<u>Lung Counts</u>	<u>Thyroid</u>	<u>Wound</u>
BSC	0	0	0	0
DOE	4	2	0	2
RHO	1757	355	1	11
UNI	934	14	1	0
HEDL	1240	841	1	2
HEHF	4	0	0	0
JAJ and Subcontractors	801	11	0	0
PNL	1174	446	27	16
Vitro	14	1	0	0
Private Industries	115	128	178	1
TOTALS	6043	1798	208	32

IN VIVO MEASUREMENT OF INCIDENT CASES The number of Hanford DOE Contractor employees measured as a result of radioactive contamination incidents during 1981 was 90. This is slightly higher than the 73 measured for this purpose in 1980 and significantly less than the 196 measured in 1979. Table 2 summarizes the type and contamination level of these cases.

TABLE 2. Incident Cases in 1981

<u>Type of Count</u>	<u>Internal Contamination Level</u>		
	<u>Less Than Minimum Detectable Amount</u>	<u>Measurable But Less Than 10 nCi</u>	<u>Greater Than 10 nCi</u>
Whole Body Count	4	18	25
Lung	29	2	0
Wound	8	3	1
Thyroid	0	0	0

NEW PROCEDURES There were no significant changes in methods or procedures of whole body counting during 1981. However, a major change in the routine gamma ray measurement is anticipated in 1982 and much study and consideration was given to this in 1981. It seems appropriate to discuss this forthcoming change and its need and justification in this report.

It has been demonstrated from recent intakes of activated corrosion and fission product radionuclides that many of these have long retention times in the lung (class Y). Thus with the lung as the limiting organ, interest has increased in lower levels of internally deposited radionuclides in the Hanford personnel over the past few years. To attain the necessary sensitivity a change in the routine whole body counting procedure is needed. This change will result in greater sensitivity and reliability for measuring gamma emitting radionuclides in the lung and still provide adequate measurement of the whole body content. In this change a stationary 10 minute count over the lung with two 35% Ge(Li) detectors will replace the present procedure which provides a 10-minute scan over the entire length of the body with a large 11½" by 6" NaI(tl) detector.

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The lung is the limiting organ for most of the fission and activated corrosion products commonly associated with reactor sites. A stationary count over the chest with the high resolution detectors will provide the sensitivity to detect lung burdens well below the required level for almost all gamma emitting radionuclides. Since body tissues of lung, muscle, bone and fat all occur in the chest region, any radionuclide having a distribution throughout the body will also be measured.

If a stationary lung count exceeds a reporting level for any gamma emitter, other measurements will be made to determine the major location of the radionuclides in the body and the appropriate calculation will be done to provide the quantity of a radionuclide present in the organ or total body. If a radionuclide is identified but is less than the reporting level it is reported as a trace with a "less than" value.

The stationary chest count will provide sensitivity for radionuclides in the thyroid, gastrointestinal tract, or skeleton which is as good or better than the presently used scanning whole body counter.

This new procedure will still require all people to change into coveralls before counting. This has been necessary for the past year due to the interference of radon daughter products which accumulate on polyester type personal clothing. If radioactivity is found to be above the reporting level in the whole body count, the person will be recounted after showering and washing the hair.

This new procedure will be used until the new shielded room described in the facilities and equipment section of this report is in place. With this new shielded room we will then be able to have two systems which can each provide a whole body gamma ray scan, a gamma ray lung count, a plutonium americium lung count, and a thyroid count in one 15-minute examination.

RESEARCH AND DEVELOPMENT STUDIES

As nuclear technology increases and work programs change on the Hanford site, 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 and is developed 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 following pages.

Gas Scintillation Proportional Counters Progress of the development of gas scintillation proportional (GSP) counters was again quite limited in 1981 due to manpower availability and funding. This type of detector still has promise of providing a more sensitive detector for measuring plutonium and americium in the lung than other detectors presently available. The main advantage of the detector is its resolution and large size. Other details are presented in previous reports on Hanford Whole Body Counter activities.

The remaining problem of the GSP counter is that of finding a non-conducting material with low vapor pressure and outgassing properties which is free from radioactivity. Excellent stable counters have been constructed using Al_2O_3 ceramic materials for the body of the counter and beryllium for the window. Both of these materials have too much natural radioactivity in them for low background counting purposes. During 1981 a large 10-inch diameter GSP counter was constructed using Teflon for the body and a double window made from thin sheets of "Kapton" plastic. Both of these materials have reasonably low outgassing properties and are free from radioactivity but testing of the counter, which is currently in progress, will determine whether the xenon gas will remain pure enough when contained in these materials.

Several prototypes of photoionization chambers for detecting the scintillation light from GSP counters were constructed and tested. The latest prototype appears to be adequate for use with the 10 inch diameter GSP counter. The development work on GSP counters is to be completed in 1982.

Interlaboratory Comparison of Lung Measurements of Transuranic Radionuclides (See 1980 report for details.) Three more subjects who had inhaled ^{92m}Nb at the Atomic Energy Research Establishment, Harwell, England were measured and studied at the whole body counting facilities. The total number of subjects measured in this study is 6 and there will be one more in June of 1982. A known amount of ^{92m}Nb was also placed in the lungs of our tissue equivalent torso phantom and measured with various chest wall thicknesses. The increased absorption of the 16 keV x-ray with increased chest wall thickness in the phantom agrees well with that measured in the subjects whose chest wall thickness ranged from 2.2 to 3.4 cm. This study may be continued for another year so that several female subjects can also be studied.

Skeletal Distribution of ^{241}Am Studies on the distribution of ^{241}Am in the skeleton were completed on a cadaver (SRG) containing a skeletal burden of ^{241}Am . (See report Hanford Whole Body Counter 1979 Activities.) This whole body donation was made available to us for studies by the U.S Transuranium Registry. Linear scan measurements were made over the total length of the body. This was done by placing two 12.7-cm-diameter Phoswich detectors over a slot collimator with an aperture 5 cm wide and 40 cm long. These detectors contained a 3-mm-thick primary (NaI(Tl)) detector and a 5-cm-thick CsI(Na) anticoincidence detector. The two detectors were placed beside each other and centered over the collimator which runs perpendicular to the length of the body. The distance from the lower surfaces of the collimator to the body was adjusted so that it just cleared the nose. Measurements were made at 2-inch intervals starting with the center of the collimator over the top of the head.

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Figures 3 and 4 show the profile of radioactivity over the length of the body which was obtained by the collimated measurements. The profile is very similar to those obtained by other investigators from other people who have skeletal burdens of ^{241}Am with peak levels over the joints and head and lower values in the bone mid-shaft regions. This agrees with the analysis of the ^{241}Am content of the defleshed bones of SRG. Since the bones were analyzed individually and all the long bones were cut into several sections and analyzed, the area under the curve corresponding to various parts of the body can be compared with the actual measurement of ^{241}Am in that part of the body. Figure 3 shows the comparison of the curve area with the ^{241}Am content in body sections divided at the joints. Figure 4 shows the comparison in body sections divided at points of low activity. In both cases there was good agreement between the area under the curve and the ^{241}Am content when considering the variable thickness of the body and the variable distance from the collimated detectors over different sections of the body. There is undoubtedly a compensating effect in which the thicker sections of the body have more self-absorption of the gamma-rays than do the skeletal parts which are closer to the detector and are measured more efficiently. The percent of bone ash is also listed for the bones in each section of Figures 3 and 4 and the agreement between percent of bone ash and the area under the curve is reasonably good, except in Section F.

Investigators at New York University (NYU) have described a good method for estimating the skeletal content of ^{241}Am as well as other transuranic radionuclides. This is done by measuring the ^{241}Am content in the head. The total skeleton content is then estimated by assuming the head contains approximately 15% of the bone mineral mass and also 15% of the ^{241}Am deposited in the skeleton. Their calibration phantom consists of two matched dry human skulls to which 9.76 and 10.84 nCi of ^{241}Am have been applied. One skull has the activity painted on the external bone surfaces and the other on the internal surfaces. Each skull is then covered with dental wax to provide attenuation of low-energy photons similar to that of skin covering the head. The thickness

of the wax is anthropometrically determined according to typical forensic parameters. The calibration procedure required the measurement of both skulls and the calculation of the geometric mean of the two results to approximate the manner in which activity is actually deposited within the bone matrix.

The calibration skulls were borrowed from NYU to compare their counting rate with that from the skull of SRG using the same detector system. The detector system was composed of two Phoswich detectors positioned on each side of the head. The calibration factor obtained from the NYU skull phantom was 75.7 counts per minute per nCi of ^{241}Am and from the head of SRG (which contained 18.3 nCi) it was 75.5. The energy region used for this calibration is from 40 to 67 keV. The head, therefore, is an ideal site for the in vivo measurement of bone-seeking, low photon energy radionuclides deposited in the body.

The bones of the left side of the skeleton are available for other studies. Since the ^{241}Am exists in a natural distribution and in known quantities for each bone we still plan to incorporate them into phantoms for use in calibration work. This will be done as time and funding becomes available.

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Whole Body Counting Staff

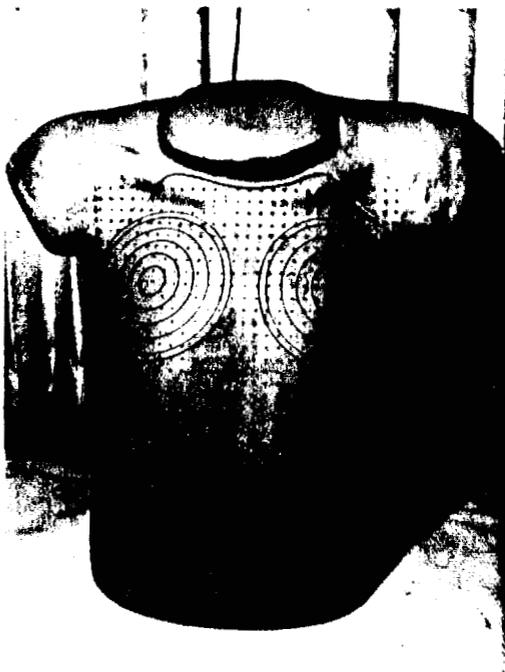
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J. M. Mackliet	Technician
B. W. Perkins	Electronic Technician (assigned from Craft and Operation Services Department)

Presentations and Publications During 1981

H. E. Palmer, B. Robinson, K. R. Heid and G. A. Rieksts, "1976 Americium Exposure Incident: Metabolism and Radiation Dose Estimates." Presented at the International Conference on the Radiobiology of Radium and Actinides in Man, Lake Geneva, Wisconsin, October 11-16, 1981.

H. E. Palmer, H. B. Spitz, and G. A. Rieksts, "U. S. Transuranium Registry Report on the Americium Content of a Whole Body Part IV: Gamma Ray Measurements." Presented at the International Conference on the Radiobiology of Radium and Actinides in Man, Lake Geneva, Wisconsin, October 11-16, 1981.

FIGURE 1. TISSUE EQUIVALENT TORSO PHANTOM



ASSEMBLED PHANTOM



COVER REMOVED TO SHOW LUNGS, HEART AND ABDOMINAL BLOCKS

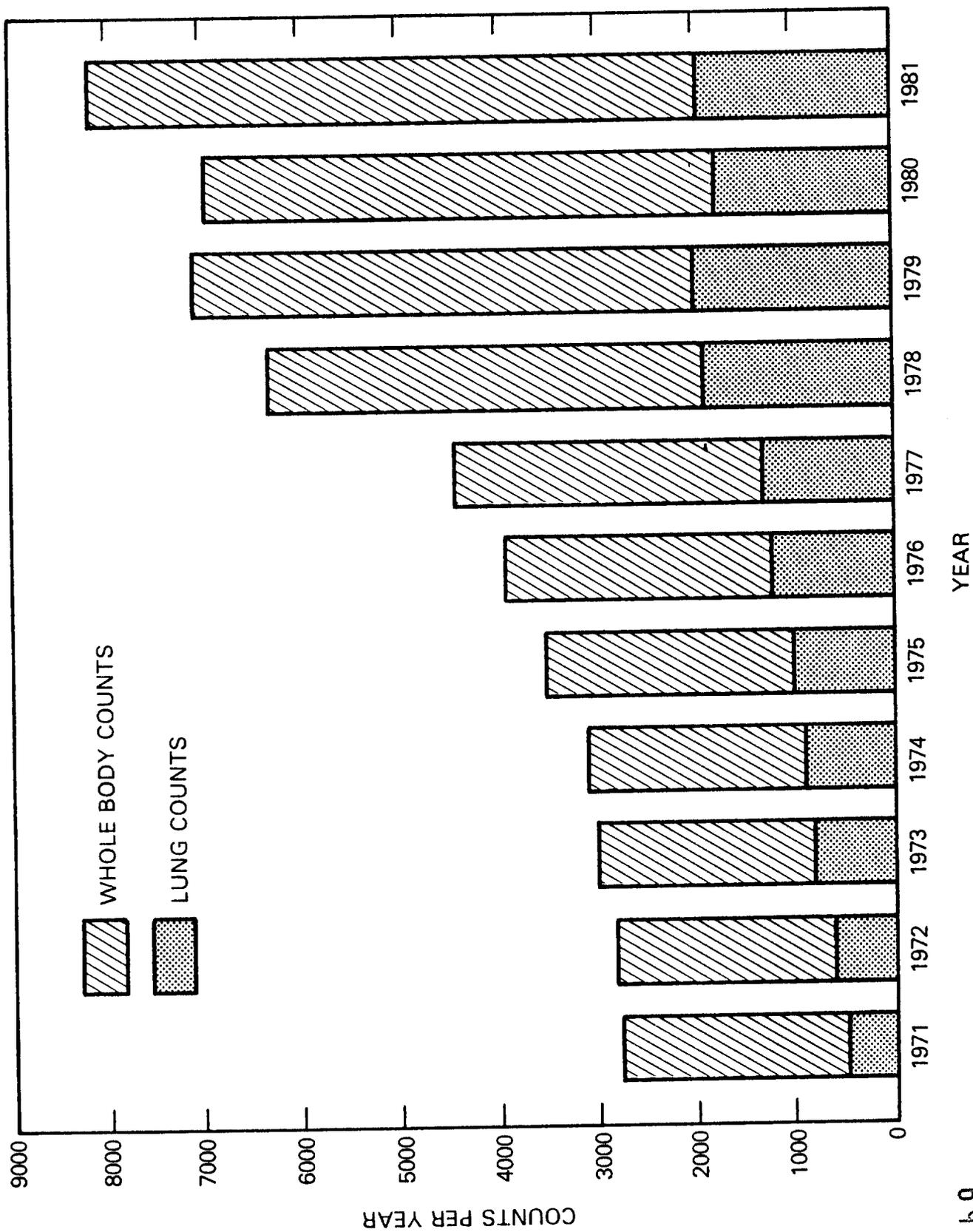


LUNG DENSITY EQUIVALENT LUNGS



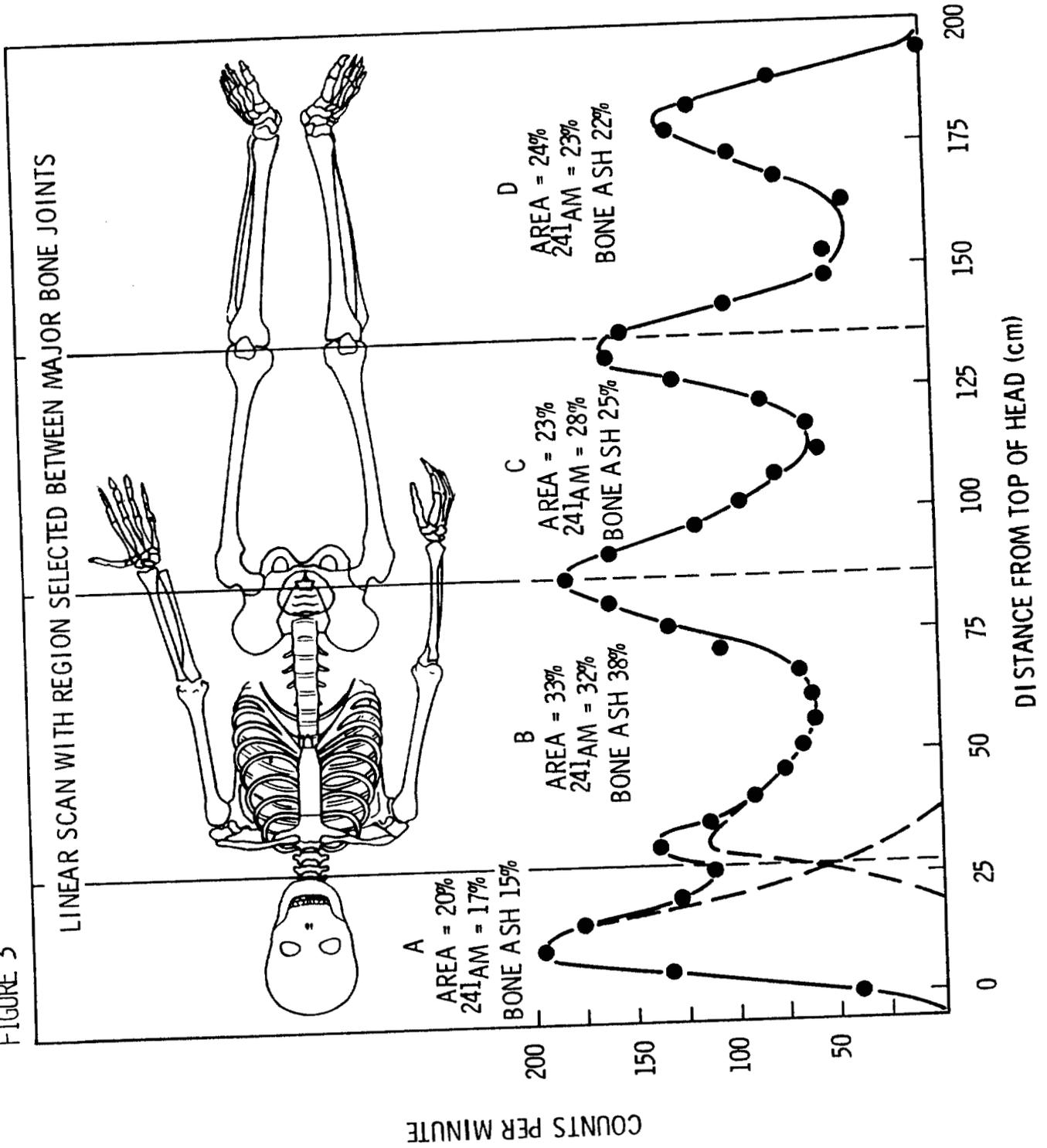
A TISSUE EQUIVALENT CHEST PLATE FOR SIMULATING VARIOUS CHEST WALL THICKNESSES

FIGURE 2. IN VIVO MEASUREMENTS AT THE HANFORD WHOLE BODY COUNTER FACILITIES



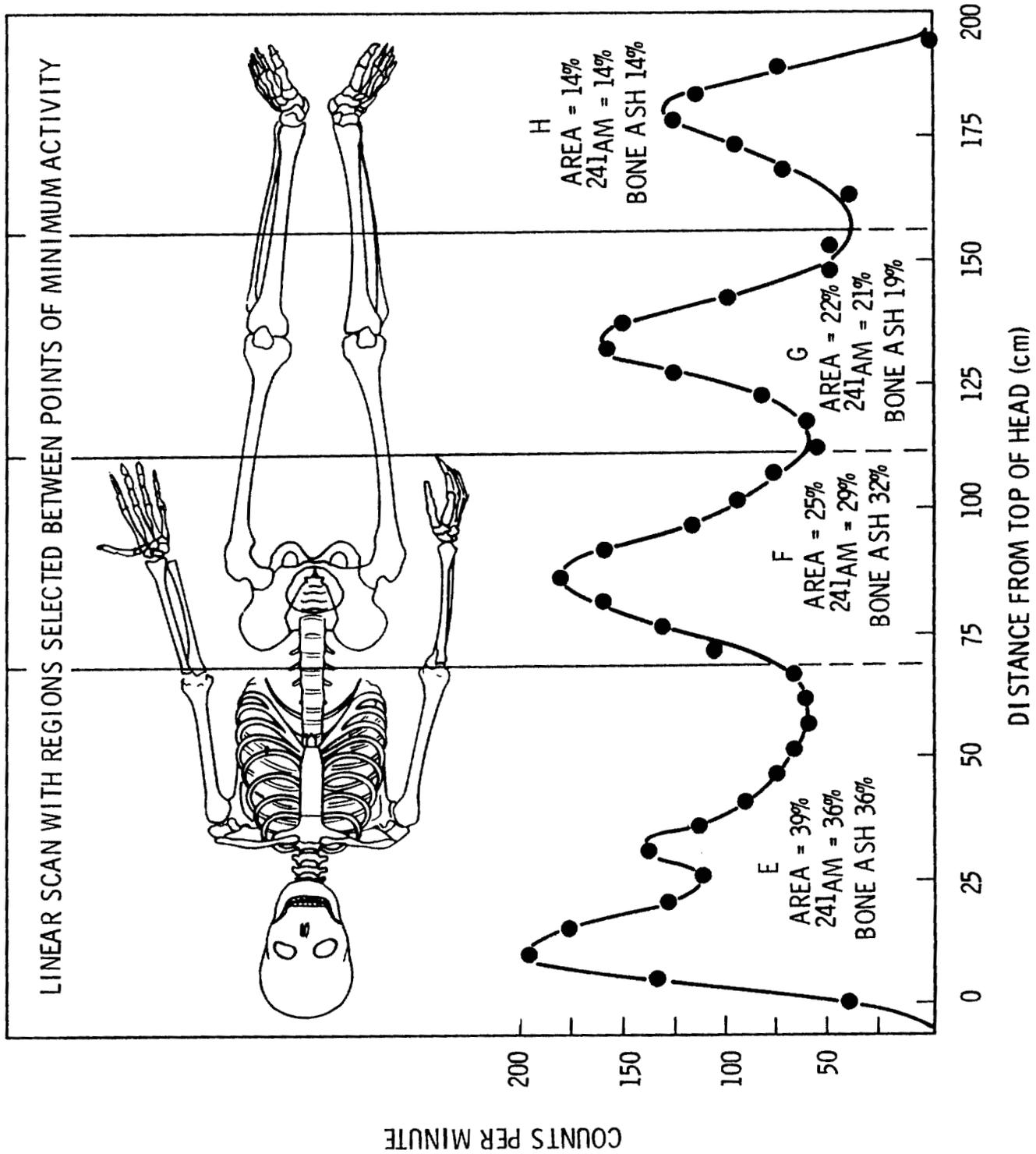
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FIGURE 3



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FIGURE 4



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