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A HUMAN RADIOACTIVITY COUNTER AND MEDICAL VAN

LEROY E. HOWARD, JR., JOHN H. SPICKARD and MACK WILHELMSEN
Health Services Laboratory, U.S. Atomic Energy Commission, Idaho Falls, Idaho

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Abstract—A mobile Human Radioactivity Counter and Medical Van was designed to reduce the cost of whole-body counting and to increase general health surveillance at the National Reactor Testing Station by bringing laboratory facilities to the work areas. The van is scheduled at each of the main reactor areas on a routine basis, which eliminates the employee from having to travel up to 70 miles for monitoring checkups. The whole-body counter utilizes the minimal shielding concept as well as the rotational counting technique that permits the simultaneous quantification and localization of gamma-emitting nuclides from a single count. Calibration of the counter was accomplished by using human volunteers who had ingested single radionuclides. The detection limit for most gamma-emitting nuclides is well below the maximum permissible body burdens recommended by the ICRP. Over 5000 individuals have received whole-body analyses, laboratory and X-ray examinations since this van was put into operation. This mobile instrument has proven to be an effective and economical addition to the health services program.

INTRODUCTION

IN THE VICINITY of nuclear reactors and hot cell facilities, inhalation of insoluble radioactive particulates is probably the most likely source of internal contamination with the respiratory and gastrointestinal tracts generally being the critical organs. Several years' experience has demonstrated conclusively that urinalysis is grossly inadequate as a general monitoring technique to detect and/or evaluate these exposures.[1] Consequently, whole-body counting has become the principal personnel monitoring method at the National Reactor Testing Station (NRTS) for detecting internal gamma-emitters.

A major cost consideration in whole-body counting (as well as for certain periodic medical procedures such as blood counts, clinical urinalyses, and chest X-rays) is the time loss of the worker, especially when he is required to travel up to 35 miles one way at the NRTS to a central medical and counting facility. In an effort to reduce this time loss and to facilitate general health surveillance, a mobile Human Radioactivity Counter and Medical Van was designed by Health Services Laboratory personnel. The van is shown in Fig. 1. Because of the mobility of this unit, routine plant visits have become an efficient and economical procedure that eliminates much of the workers' travel time for monitoring checkups. The vehicle is also adaptable for field use in emergency situations.

DESIGN AND CONSTRUCTION

Whole-body counting is used throughout the world to determine radioactivity in man. Most whole-body counting facilities utilize massive high density radiation shields to reduce background. However, experience over a 9 yr period at the NRTS shows that massive shields and sophisticated instrumentation are not required to detect body burdens well below the maximum permissible level recommended by the ICRP. PARKER and ANDERSON[2] demonstrated that portable whole-body counters with minimal shielding are both adequate and effective in many practical programs for personnel monitoring. Whole-body counting using a rotational technique developed by ANDERSON and OLSON[3] improves the reliability of assessing quantity and distribution of body radioactivity.

The medical van was designed to utilize both the portable whole-body counter with minimal shielding concept as well as the rotational technique that permits the simultaneous quantification and localization of gamma-emitting

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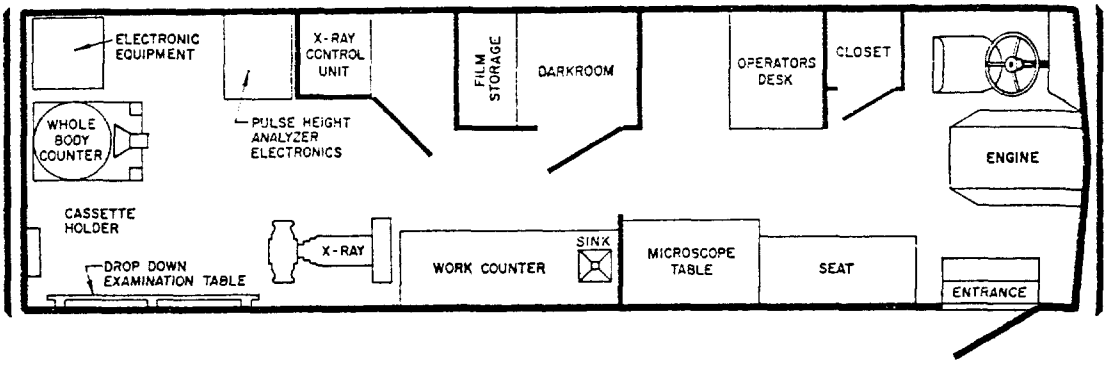

FIG. 2. Floor plan (3.3 ft/in.).

nuclides from a single count. In addition to the whole-body counting equipment, an X-ray unit and laboratory work area were incorporated into the design. Figure 2 shows the floor plan of the laboratory. The darkroom door serves the double purpose of separating the examining area from the reception area. An electric typewriter located on the operator's desk is used for clerical work and data output from the analyzer. The counting chamber for measurement of *in vivo* radioactivity is an upright cylinder fabricated from $\frac{3}{4}$ in. sheetlead and clad with aluminum. The shielded chamber has a $23\frac{1}{4}$ in. inside dia. and is 79 in. high, with a 14 in. full length opening as shown in Fig. 3. The person being monitored stands on a turntable in the base of the enclosure. A 5 × 4 in. NaI(Tl) detector is housed in a bell-shaped lead shield mounted on a frame that can position the detector at any location from the floor to the ceiling. The speed of the turntable and the scanning rate of the detector are independently variable.

Figure 3 also shows the 400 channel pulse-height analyzer with its auxiliary equipment. An electric typewriter, X–Y plotter, and paper-tape perforator are used to read out data from the analyzer. The capability for reading background data and calibration spectra into the analyzer from paper-tape records is provided by the tape reader unit. A count-rate meter coupled to the X–Y plotter records the gross output of the 5 × 4 in. detector to plot a helical scan. Changes in the background are plotted by a recording count-rate meter which is connected to a separate unshielded NaI(Tl) detector. Special outlets have been installed at each NRTS plant location to supply power and communication to the van. Power may also be provided by a gasoline generator which can be towed behind the van for field use in areas remote from a source of electric power.

CALIBRATION

Calibration of this instrument was accomplished by counting 8 human volunteers who had ingested insoluble capsules containing a single radionuclide at a time. The guidelines for internal administration of radioactive material outlined by SILL[4] were followed. Average-sized volunteers, with chest depth of 22–23 cm and weight between 160 and 190 lb, were chosen for this study. Five years of prior experience with rotational counting had shown that an absorption factor was needed to allow for attenuation of gamma-rays in tissue because of variability in body builds. However, since this routine counting program does not require a high degree of sensitivity, no correction factor is applied. The error for ^{144}Ce, with a 134 keV gamma, is only 30% for a person with a chest depth as small as 18 cm or as large as 28 cm. When allowance for body build is desired, factors described by OLSON[5] to correct for gamma-ray absorption in bone and tissue are used. Isotopes used in this calibration were ^{144}Ce, ^{131}I, ^{106}Ru, ^{137}Cs, ^{95}Zr/Nb, ^{110m}Ag, ^{65}Zn and ^{60}Co. The gamma energy of these isotopes from 0.134 to 1.33 MeV covers the range of most gamma-emitting nuclides encountered at the NRTS. Calibration constants normalized for photon yield were plotted in Fig. 4 as a function

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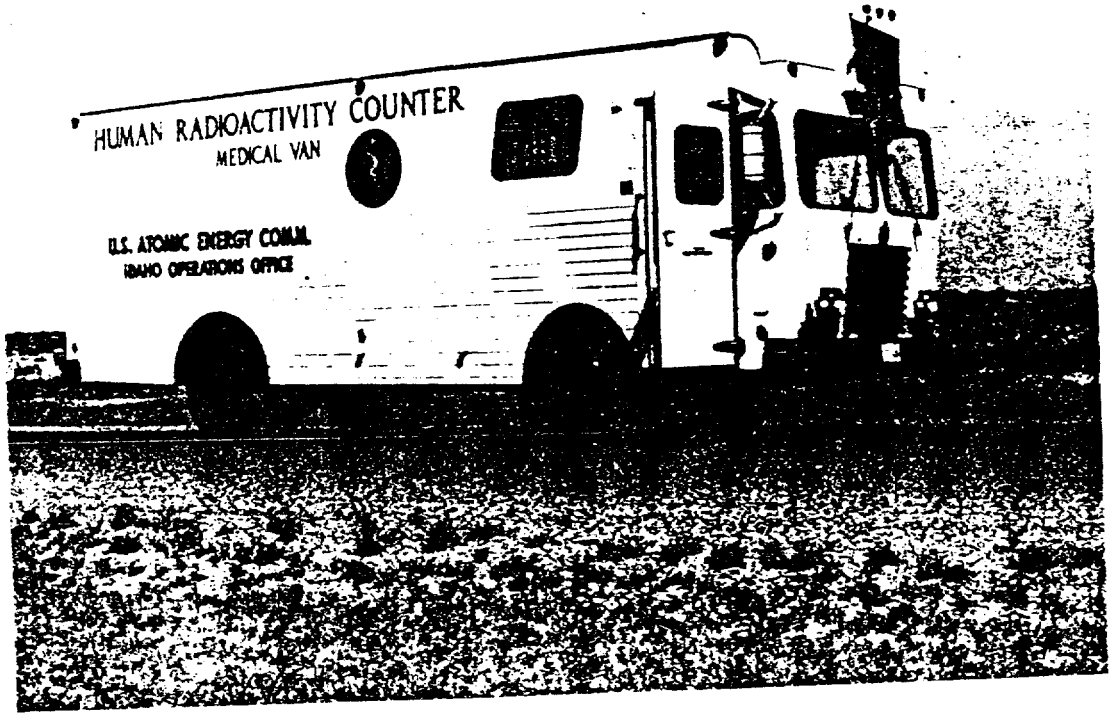

FIG. 1. Human radioactivity counter and medical van.

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FIG. 3. Whole-body counter.

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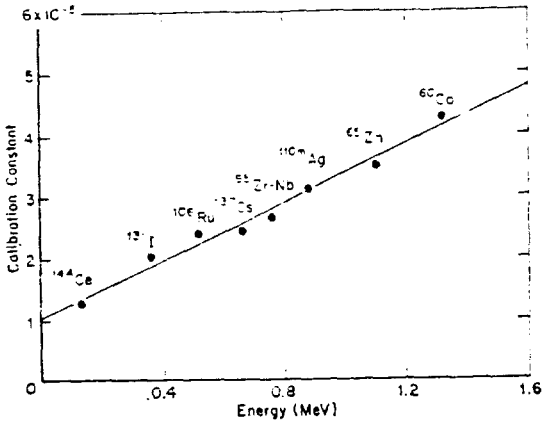

FIG. 4. Calibration curve for the whole-body counter.

of photopeak energy for the selected radioisotopes. When isotopes are identified for which the whole-body counter has not been calibrated, approximate calibration constants for these isotopes can be determined from this plot. Detection limits in microcuries for single isotopes as point sources are ^{144}Ce, 0.1; ^{131}I, 0.03; ^{106}Ru, 0.1; ^{137}Cs, 0.03; ^{95}Zr/Nb, 0.03; ^{110m}Ag, 0.04; ^{65}Zn, 0.05 and ^{60}Co, 0.03.

Standard spectra obtained during calibration of the whole-body counter are available to aid in identifying the nuclides present and to assist in stripping the nuclide from a complex spectrum. The area under the photopeak is summed and multiplied by a calibration constant which converts the activity into microcuries present in the body.

OPERATING PROCEDURE

The medical van is scheduled at each of the main reactor areas on a routine basis. When an employee reports to the van, a urine specimen is collected and examined for glucose and albumin. Microscopic examination of the urine specimen can be performed in the van but is not a routine procedure. A blood sample is taken and later evaluated at the main dispensary for hemoglobin, hematocrit, and white blood count. A blood smear is stained and a differential count made if the white blood count is abnormal; otherwise the smear is stored for possible future reference. A standard 14 × 17 in. PA chest X-ray is taken, and is sent to the main dispensary for developing and interpretation. The examinee is then given a whole-body count.

For routine counting, the subject stands within the cylindrical shield facing the detector which is directed toward the thyroid and upper thorax. A gamma spectrum is obtained while the crystal moves 10 in. from the thoracic to the upper abdominal region in a 4 min period, while the person stands as close as possible to the detector. A background count is continuously recorded to detect significant environmental changes which may influence the results. If the operator identifies activity in the spectrum, the employee showers, changes into a paper gown and is reexamined. If activity remains, a rotational whole-body analysis is performed. The subject is rotated 7 revolutions in a 14 min count while the 5 in. crystal moves 35 in. down the body beginning at the level of the nose. Quantitative assessment of the activity and its distribution in the body can be calculated from the data obtained and plotted on an X–Y plot.

More than 5000 whole-body counts and a comparable number of laboratory and X-ray examinations have been conducted during the 4 yr the mobile unit has been in operation. Internal contamination has been detected infrequently and has been of low level. During 1968, 17 ^{60}Co, 5 ^{95}Zr/Nb, 4 ^{137}Cs and 3 ^{131}I cases of low-level internal contamination were identified in 986 whole-body counts. Twenty-six of these individuals were examined because of suspected contamination as a result of minor incidents, and 2 had received radioisotopes for medical diagnostic procedures. Radioisotopes were identified in 33 individuals during the 1159 examinations conducted in 1969. The nuclides were ^{60}Co, ^{137}Cs, ^{95}Zr/Nb and ^{124}Sb with ^{60}Co being the predominate isotope. In all cases, the quantity of radioisotope present was less than 0.1 μCi.

Environmental factors have affected the operation of the van significantly. Whole-body counting must be stopped when the continuous monitor indicates significant changes in the background, such as when prevailing wind conditions carry off-gases from the reactor stack over the counting location, or when highly radioactive shipments are transported past the van.

Although the Human Radioactivity Counter

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and Medical Van serves primarily in a periodic surveillance program, it also has been integrated into the NRTS radiological emergency plan. During plant or site evacuation, the van is operated by a medical technologist or a radiochemist, and its mobilization is coordinated by means of a 2-way radio which is tied into the NRTS communication network.

CONCLUSIONS

The Human Radioactivity Counter and Medical Van was designed to supplement periodic personnel health surveillance and to measure body radioactivity of employees at the NRTS. A reduction in cost and gain in versatility have been made possible by incorporating the use of the recently developed rotational scan technique. This mobile laboratory has proved to be an effective and economical addition to the health services program.

REFERENCES

1. C. W. Sill, J. I. Anderson and D. R. Percival, Comparison of excretion analysis with whole-body counting for assessment of internal radioactive contaminants. *Assessment of Radioactivity in Man*, IAEA, Vienna, 217 (1964).
2. D. Parker and J. I. Anderson, *Health Phys.* **13,** 141 (1967).
3. J. I. Anderson and D. G. Olson, *Health Phys.* **13,** 718 (1967).
4. C. W. Sill, Some guidelines for human studies involving internal consumption of radioactive materials, IDO-12058 Oct. (1966).
5. D. G. Olson, *Health Phys.* **14,** 439 (1968).

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