A VERTICAL SCANNING GERMANIUM WHOLE BODY COUNTER: THE ACCUSCAN-II

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INTRODUCTION

The ACCUSCAN-II was designed to fulfill the needs of two types of users. Nearly all nuclear power plants require two WBC systems for redundancy. One of these counters should be like the Canberra FASTSCAN (contains two large 4" × 4" × 16" NaI detectors) for rapid processing of the vast majority of the workers who have little internal deposition, or have uptakes that are simple to interpret. The ACCUSCAN-II is the ideal second counter and allows the user to more easily interpret these few, but very important situations where uptakes do exist.

For the second type of user, facilities that only need one WBC system, the ACCUSCAN-II is a perfect choice. It can be operated in a high sensitivity mode, with the subject's lung (or thyroid, GI, etc.) in contact with a non-moving detector for maximum sensitivity. Subjects can be quickly screened this way. When activity is found worth investigating further, the subject can be recounted in the total body scanning mode for better accuracy and to determine the precise source location.

FIGURE 1 - MODEL 2280C2 ACCUSCAN-II

The ACCUSCAN-II uses one or two germanium detectors (Figure 1). The inherently superior energy resolution makes it easy to separate isotopes that are difficult to resolve with NaI detectors, and to quickly identify new or unusual nuclides. The detectors generally scan during the count. As the detector moves, a positional spectrum can be simultaneously acquired. This positional spectrum will aid the user to determine the organ of location, or reduce the interference from external contamination, as an aid to more accurate dose determinations. A third advantage of germanium detectors is their wide dynamic range. This is especially important in emergency situations where large internal depositions or contamination (e.g. one MPBB of ^{137}Cs) will render high sensitivity NaI counters useless.

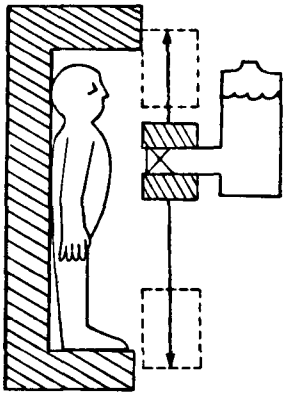
ACCUSCAN-II COMPONENTS AND SYSTEMS

The shield is a full 4" of low background steel around the subject and 2" lead around the detectors. It is a complete 4 pi shadow shield and can be used in elevated background areas. There is an optional cryostat design which includes external lead shielding between the detector and the dewar. The shield weighs about 9000 lbs (4000 kg), but is in small enough components to allow manual assembly, if necessary. The subject can be counted standing (for full body scans), or seated (for longer count times of a limited portion of the body). When standing, counts can be done from the front and then from the back to achieve the maximum accuracy and independence of source location. The subject can stand or sit against the back wall for best accuracy, or can lean against the detector in a high sensitivity mode. Figure 2 shows these various ways the ACCUSCAN-II can be used.

The ACCUSCAN-II is available in three basic versions. Model 2280A is the most basic and least expensive. It has the full complete shielding, an adjustable speed motor drive for the detector, a 25% relative efficiency detector, and a Series 35 PLUS 2048 channel MCA. The internal firmware of the MCA is used to find peaks, determine their energy, determine their identity, and to determine net peak area. This is an ideal system for those facilities which have few people to count, or limited funds. As needs change, the system can be upgraded.

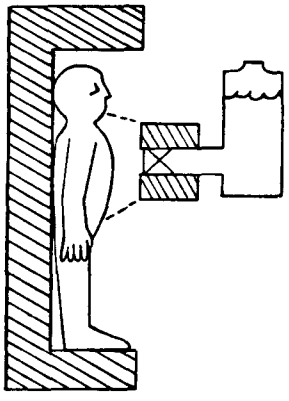
Model 2280B includes a DEC computer and the ABACOS-II software. It is delivered as a turnkey system, with phantoms, sources, factory calibration, all parameters in the software loaded, and is ready to count. The standard computer is the MicroVAX-II, however the MicroPDP 11/53 is a less expensive alternative.

The 2280C1 is a fully automatic system. The scan drive is by means of a computer driven programmable stepping motor. With the added multichannel scaling (MCS) capability, a spectrum containing total counts vs. position is stored in a portion of the MCA memory and displayed. This occurs automatically and simultaneously with the energy spectrum acquisition and display. The information derived from the positional display is useful to properly determine the organ of deposition, which is necessary to correctly calculate dose. The 2280C2 adds a second Germanium detector. This increases efficiency, reduces the LLD or the count-time, and increases reliability through redundant components.



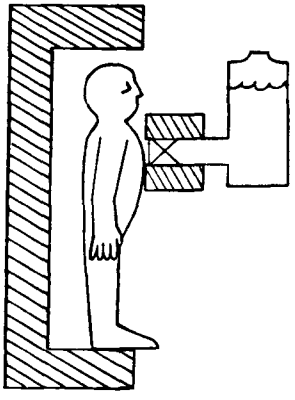
TOTAL BODY SCAN

- Full length scan
- Total body count
- Front/back count
- Diagnostic position for maximum accuracy
- Positional information for proper dose determinations



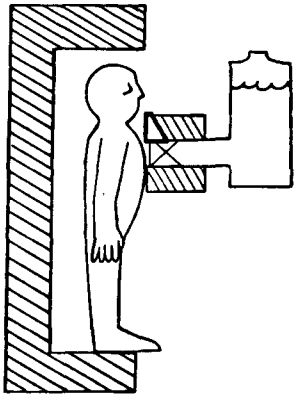
FIXED POSITION-DIAGNOSTIC

- Fixed position count or limited length scan
- Diagnostic mode for accuracy
- Can view thyroid, lung and GI tract
- 3X more sensitive than total body scan
- Can be repeated from back for maximum accuracy



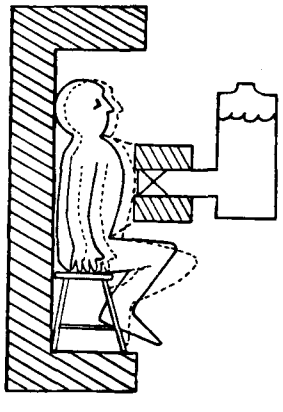
FIXED POSITION-SCREENING

- Fixed position count
- Screening mode for sensitivity
- Can view thyroid, lung or GI tract
- 2X more sensitive than diagnostic mode
- Can be repeated from back for maximum accuracy



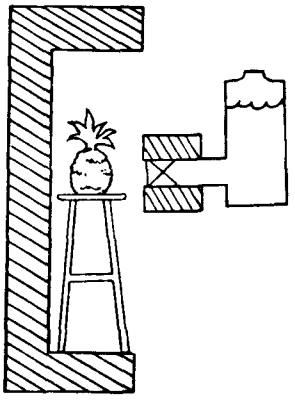
LUNG-THYROID SCREENING

- Lung/thyroid combination screening count
- Removable thyroid shield plug



SEATED COUNTING MODE

- Chair diagnostic mode (against wall)
- Chair screening mode (against detector)
- For longer count times



SAMPLE COUNTING

- Same system can be used to count a wide variety of sample sizes
- Low background shield construction
- Shadow shield construction—no door to open and close
- Virtually same background as full shield for energies > 250 keV

FIGURE 2 - VARIOUS COUNTING GEOMETRIES OF THE ACCUSCAN-II

For the computer based systems, operation with ABACOS-II is extremely simple for the pre-configured routine counting conditions. It is also very flexible when using the special operations mode. Extensive error checking is used to reduce operator input mistakes. The multi-user, multi-tasking software, and the use of a separate stand-alone MCA and computer, allows counting of the next subject while the previous spectrum is undergoing analysis. Furthermore, the separate components make troubleshooting easier, and allows operation using the MCA if the computer is inoperable.

ABACOS-II SOFTWARE

The key element to transform a group of detectors inside a shield to a complete, successfully operating WBC system capable of performing in a production environment is the software program. The software must efficiently convert the spectra into a well documented, reliable, legally defensible record. ABACOS-II has been designed specifically for the unique and demanding purpose of spectral analysis for whole body counting. It is menu driven, and therefore, very easy to learn and to operate. All operator responses are checked for validity, to minimize incorrect data entries. After starting the count, and answering the demographic entries, the entire sequence of STOP/TRANSFER/ANALYZE/REPORT is automatically performed by ABACOS-II. Because of the program structure, a new count can start after the transfer task is complete. The analysis and reporting tasks operate in parallel with the next acquisition.

The system can be pre-configured by the whole body counting manager in a wide variety of ways. Even if the system is pre-configured for a certain standard set of conditions (library, efficiency, energy range of analysis, etc.), these conditions can be easily changed on a case-by-case basis for further reanalysis of the same spectra, without recounting.

A drawback of most programs for analysis of low intensity peaks has been the peak search routine. It is a well recognized problem that searching for small peaks in low-count spectra is a difficult task. Sometimes the peak search routine is too sensitive, and finds many false positive peaks. Reducing the sensitivity to false positives also makes the false negatives increase, so that peaks near the calculated MDA will not reliably be found. Canberra has solved this probelm by implementing a unique library-driven peak search in ABACOS-II. This technique truly allows near-MDA peaks to be reliably found, even if they are only a few counts in area or on a zero-count background. Furthermore, this technique still allows corrections for interferences from adjacent peaks or from the underlying Compton continuum.

A critical element in an *in vivo* measurement system is Quality Assurance. ABACOS-II has an internal QA program that automatically tracks three types of QA counts (check sources, blanks, and duplicates). Each of these count types has user-adjustable predetermined limits of acceptance. If any of the results is outside its limits, then the operator is notified immediately. Twenty-five different parameters are tracked, and can have high and low warning levels. The results of the QA program can be printed out in a tabular form, and/or plotted on the printer for quick visual review.

To prevent unauthorized changes in parameters, data, or reports, there are six different user definable passwords within ABACOS-II. Each password protects a separate function, and can therefore be distributed to different user levels. ABACOS-II can print out the MDAs (user selectable) for peaks and/or nuclides searched for, but not found. The definition of MDA is also user definable (e.g. 1 sigma, 3 sigma, 4.66 sigma) and allows the use of the 2.71 constant to account for low-count statistics. ABACOS-II also provides spectral and efficiency plots from the computer. The CIMPA plotting package is used by ABACOS-II, and is optionally available, along with the necessary hardware.

PERFORMANCE RESULTS

Figure 3 demonstrates the typical LLDs of the ACCUSCAN-II. The LLD is calculated using 5% probability of type I and type II errors, i.e. the activity equal to $2.71 + 4.66\ (BKG)^{1/2}$. A 5 minute count time was used. Shorter count times can be used, but the LLD is increased accordingly. The efficiency was determined using the Livermore/Humanoid torso phantom. The background is from an average subject containing only ^{40}K. The gamma abundance was assumed to be 100% for the chart. Therefore, divide the LLD shown by the actual gamma abundance of the nuclide of interest. One or two germanium detectors are used, as noted, each 25% relative efficiency.

Curve A represents a total body scan, with the source in either the lung or the total body, and the subject in the diagnostic position. Curve B represents a lung scan, with the source in the lung, and the subject in the diagnostic position. Curve C is a stationary detector, with the source in the lung, and the subject in the screening position.

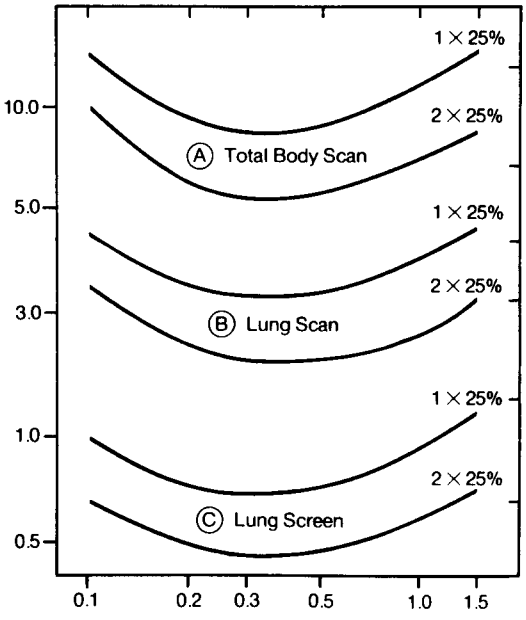


FIGURE 3 - TYPICAL ACCUSCAN-II LOWER LIMIT OF DETECTION