

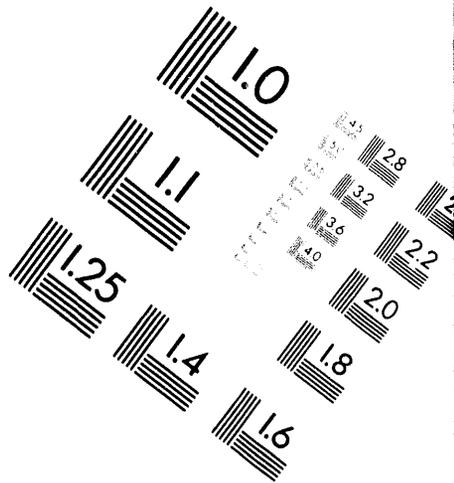
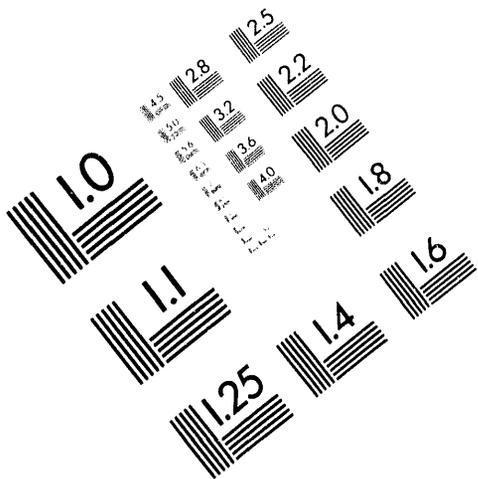


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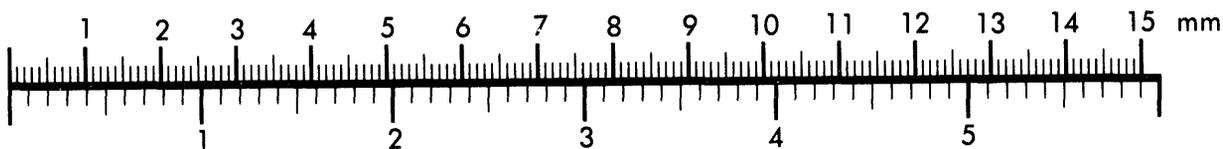
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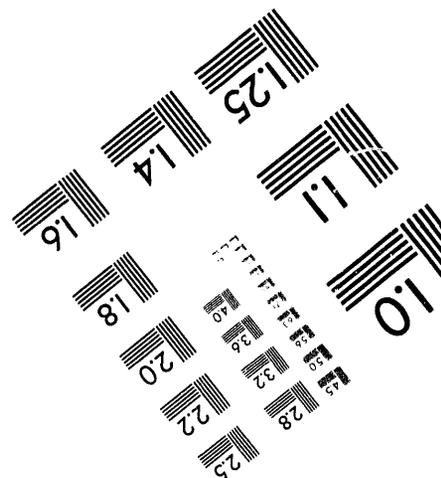
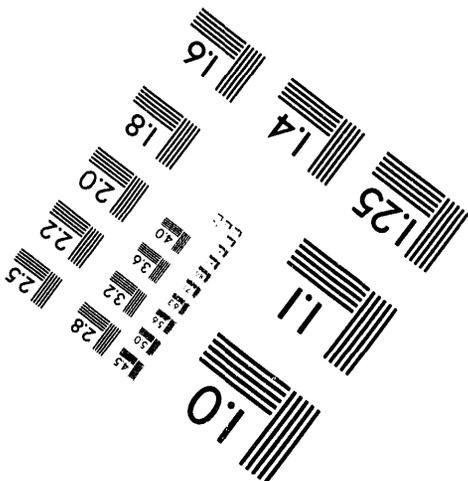
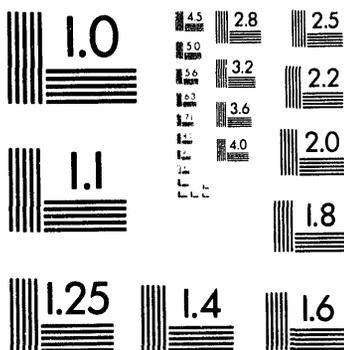
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Status Report on the TSA Systems, Ltd., MCA465 Gamma-Ray Confirmation Instrument

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ABSTRACT

The TSA Systems, Ltd., MCA465 is hand-portable, low resolution, gamma-ray instrument for confirming special nuclear materials (SNM) and related applications. The instrument evolved from earlier TSA Systems hand-held instruments, and, since its inception in 1991, it has been undergoing cycles of evaluation and then repair or redesign to correct problems. Through the efforts of Los Alamos, Rocky Flats, and TSA Systems, the MCA465 now has achieved commendable progress toward achieving quality performance as a rapid confirmation tool for SNM.

INTRODUCTION

The TSA Systems², Ltd., MCA465 is a portable, 256-channel, multichannel analyzer (MCA) for use with an internal NaI(Tl) detector and/or certain external detectors. The instrument operates from internal rechargeable batteries, has a large LCD display for displaying spectra and region of interest (ROI) data, and can store spectra and transmit the data to a personal computer (PC). In past years, we have evaluated the MCA465 several times to assist Rocky Flats and other users as part of our Nuclear Materials Detection and Surveillance task for the

Department of Energy, Office of Safeguards and Security. This report covers our latest evaluation of an MCA465 (serial number 465031) that was purchased in May of 1992 and renovated in 1993.

BACKGROUND

The MCA465 evolved from an earlier TSA Systems hand-held MCA (HHMCA) that we evaluated in 1990 and found to suffer from severe differential non-linearity. The first MCA465 instruments were delivered to Rocky Flats in 1991, and when we evaluated one, we found much improved differential linearity. However we also found that it was deficient in detector gain stability, had problems with recording and transferring data, and had many less serious problems. In 1992, TSA Systems altered the design to correct problems and meet specific needs at Rocky Flats, and we purchased an instrument. Our subsequent evaluation of the new MCA465 showed continuing problems with ROI peak stripping, user manuals, data transfer, memory loss, and membrane switches.

Late in 1992, TSA provided new firmware (version 2.07) that included a peak-stripping option, and we conducted a more thorough evaluation. The results

showed adequate pulse-height linearity, but they also showed a gradual loss of pulse height during operation, a large dead time per pulse (44 μ s), major errors in dead time correction, lack of storage for ROI data, and minor problems with peak stripping, data storage, and data transfer. We reported these results and returned our instrument to TSA for upgrading. The instrument now has TSA's MCD-467C digital circuit board and uses their version 2.20 firmware.

FINAL EVALUATION RESULTS

Our final evaluation of the MCA465 in 1994 repeated many of the areas we evaluated previously. We were happy to find many improvements that go a long way toward helping the MCA465 become an effective and reliable confirmation tool for SNM. The major areas that we evaluated are the following.

Detector Pulse Height Linearity. We used selected gamma rays from isotopic sources to measure the pulse height response of the internal sodium iodide detector in the MCA465. For each isotope, we recorded a spectrum with the MCA465, transferred the data to a PC, and then used various PC programs to view the spectrum and determine peak channels for gamma rays. The results, gamma-ray energy and peak channel, are fit by a straight line having a slope of 7.99-keV/channel and an intercept at channel 19.9. The linearity appears adequate as long as the offset is considered when setting ROI boundaries. In any case, ROI boundaries always should be checked with the forms and amounts of SNM to be confirmed. Note that the manufacturer provides a detector

gain of 8-keV/channel, but others may use different values, for example, Rocky Flats uses 5 keV/channel.

Dead Time and Dead Time Correction. We used gamma-ray attenuation measurements to examine the detector count-rate linearity and observe the operation of the MCA465 dead time compensation in live-time operation. Our attenuator was comprised of up to 16 uniformly thick lead sheets interposed between a ^{133}Ba source and the detector. We used both a narrow (plutonium) ROI and a total-count ROI (channel 5 to channel 250) for measurements. As we add lead sheets, we expect an exponential decrease in detected count rate, which will appear as a straight line in a semi-logarithmic plot of count rate against number of lead sheets. Figure 1 shows the total-count ROI data for the internal sodium iodide detector for both this evaluation and the previous one to illustrate the large improvement. Now, there is no longer a noticeable response loss, even at very high count rates. The dead time correction now reflects a dead time of 19 μ s per pulse, which is close to

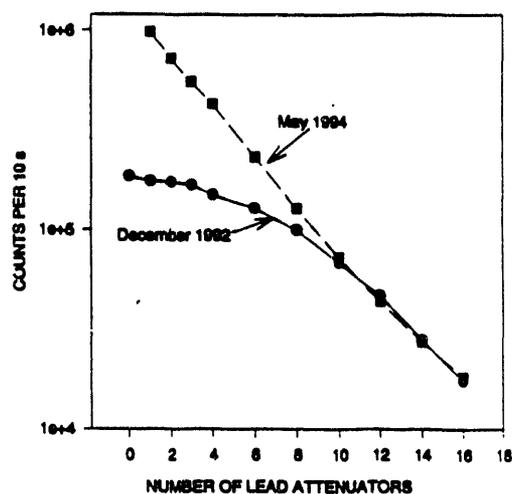


Fig. 1. The count rate linearity problem in 1992 has been much improved.

what the manufacturer originally expected (20 μ s). Data for the narrow ROI are similar, except that pulse-pile up at the highest count rates causes the peak to shift and reduces the ROI count rate. We were able to evaluate the performance of the sodium iodide detector in the MCA465 external probe as well, and the results were similar.

Detector Pulse Height Droop. In earlier evaluations using the internal sodium iodide detector, we observed that the pulse height measured for a ^{137}Cs source decreased during operation of the MCA465. This time, the initial decrease in pulse height seems to be more rapid, but the long term decrease is much the same as in our previous evaluation (Fig. 2). The latest plot for the internal detector can be fit by the sum of two decaying exponential functions: one having a time constant of 0.15 h that decreases the pulse height by 5 % in a short time, and the other having a time constant of 242 h that leads to a

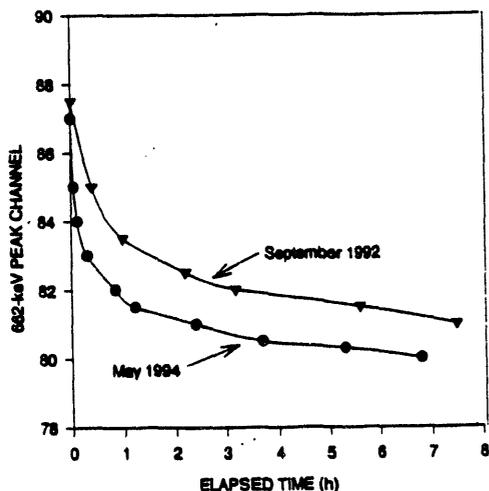


Fig. 2. The MCA465 detector gain decreases during operation, causing the 662 keV gamma-ray peak to move to lower channel numbers.

continuing slow decrease. We found that the external probe detector droop is a little slower, having a short time constant of 0.22 h. Hence, it seems prudent to allow the MCA465 to warm up for a while before using it. After a half hour or so, the detector could be calibrated and then need only minor readjustment during operation. Gain readjustments can now be carried out from the front panel of the MCA.

We do not know the reason for the initial gain droop, but it is not caused by the intrinsic change of light output of sodium iodide with temperature. We measured the internal detector region temperature and found that it warms at a rate of about 7.5 deg F/h, which corresponds to an intrinsic peak droop of 0.7 channel/h, much smaller than the observed droop rate.

ROI Peak Stripping. The ROI peak stripping option is used to estimate counts in gamma-ray peak regions by estimating and subtracting underlying continuum counts. The MCA465 now performs peak stripping and indicates that it is doing so by displaying a P below the spectrum at the right-hand side. However, in the CMP mode discussed later, peak stripping should automatically be enabled, according to TSA, but presently no P appears on the display for confirmation.

Background Subtract. The user can also select subtraction of a stored background spectrum as an option, but there are still some problems with the procedure. When subtracted data are displayed, the original data are still used for calculating ROI results. Hence, a relatively empty ROI on the spectral

display may show an unexpectedly large result in the ROI display. Another possible problem is that live-time data collection is essential to getting correct subtracted results, but the switch to live time is not automatic and users are not told to do so. Similarly, one can select both background subtract and peak stripping, but only one or the other should be done.

Data Transfer and Conversion. We had no problems with data transfer using TSA Systems' MCACOM version 5.12 in this evaluation. All memory locations now seem to work properly. We had very few losses of communication between the MCA465 and a PC, and these were easily corrected by turning the MCA465 off and back on. The membrane switches operated very well this time, and they were sensitive and relatively free of switch bounce.

Spectrum and Data Viewing. The MCA465 display is now more versatile. All information, including ROI data, can be viewed, and cursor motion now includes acceleration to speed up lengthy cursor movements. It also is now possible to view all information for stored files, including ROI data, using MCACOM. Color is used to display the ROIs, and ROI boundaries can temporarily be changed and the results viewed on the PC. The remaining limitations in MCACOM are lack of peak stripping and logarithmic plotting.

CMP Mode. CMP is a mode that is intended to confirm SNM in a container located in a storage area having a significant background from other SNM stored nearby. The user makes a "background" measurement, then

positions the probe for a (signal) measurement. If an ROI net result increases by 3 standard deviations (sd), the corresponding material type for the ROI is confirmed. We found that the mode works properly, and both of the spectra can be displayed and examined using MCACOM. However, the procedure may have some shortcomings for uninitiated users. The two measurements at different distances from an SNM container are both subject to variation in background and signal. Hence, confirmation could result from an appropriate 3 sd variation in either signal or background. It will be necessary for users to study this procedure and perhaps have the firmware modified to use an more appropriate decision threshold if 3 sd is too small.

Operating and Service Manual, Version 2.01. This is the first relatively complete manual that has been available for the MCA465. Most of the information that we have had to ask for is now available in the manual.

SUMMARY

It is gratifying that, after four years, the MCA465 has been improved to the point that it is becoming an effective and reliable confirmation tool for SNM that even incidental users may be able to operate. We hope that TSA Systems will inform existing users of the older MCA465s that improvements have been made in the design and an upgrade would greatly enhance performance.

ACKNOWLEDGMENTS

We appreciate the assistance that we have received from TSA Systems and

Rocky Flats during our efforts to evaluate, troubleshoot, and suggest improvements for the MCA465. Bob Woerner, at Rocky Flats, had a major role in working with Los Alamos, other facilities, and TSA Systems to improve the performance of the MCA465 before his untimely death in an auto accident in May 1993. He was a valuable resource to all for information and interpretation of MCA465 operation and misoperation. Tim Gregorie at TSA Systems also has been a great help in providing information and access to service for correcting problems in the MCA465.

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²TSA Systems, Ltd., 1820 Delaware Place, Longmont, CO 80501. (303) 651-6147.

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