5462

Department of Energy

Ohio Field Office
Fernald Environmental Management Project
P. O. Box 538705
Cincinnati, Ohio 45253-8705
(513) 648-3155

MAR 05 2004

Mr. James A. Saric, Remedial Project Manager
United States Environmental Protection Agency
Region V, SR-6J
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

DOE-0242-04

Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402-2911

Dear Mr. Saric and Mr. Schneider:

IMPROVEMENTS TO THE REAL TIME INSTRUMENTATION MEASUREMENT PROGRAM SODIUM IODIDE MEASUREMENTS

Enclosed for your information is a summary of several improvements made to the sodium iodide (NaI) systems used for real time measurement of uranium-238, thorium-232 and radium-226 activities in soil. In particular, the automatic gain tracking and reduction of variation in background counts have improved the detection limits of the mobile NaI systems, which equates to greater reliability in our detection and delineation of hot spots. Additionally, the improvements provide a higher level of confidence in the detection of uranium above-waste acceptance criteria soil. Therefore, DOE will implement the improvements for NaI systems in early May 2004 for the ongoing excavation and precertification activities at the site.

If you have any questions or require additional information, please contact Johnny Reising at (513) 648-3139.

Sincerely,

W J Taylor

William J. Taylor
Director

FCP:Reising

Enclosure: As Stated

Recycled and Recyclable

cc w/enclosure:
N. Akgündüz, OH/FCP
J. Reising, OH/FCP
G. Jablonowski, USEPA-V, SR-6J
M. Cullerton, Tetra Tech
F. Bell, ATSDR
M. Shupe, HSI GeoTrans
R. Vandegrift, ODH
AR Coordinator, Fluor Fernald, Inc./MS78

cc w/o enclosure:
R. Abitz, Fluor Fernald, Inc./MS64
K. Alkema, Fluor Fernald, Inc./MS1
L. Barlow, Fluor Fernald, Inc./MS41
J. Chiou, Fluor Fernald, Inc./MS64
M. Frank, Fluor Fernald, Inc./MS64
T. Hagen, Fluor Fernald, Inc./MS1
W. Hooper, Fluor Fernald, Inc./MS64
S. Lorenz, Fluor Fernald, Inc./MS41
F. Miller, Fluor Fernald, Inc./MS64
T. Poff, Fluor Fernald, Inc./MS65-2
D. Powell, Fluor Fernald, Inc./MS64
ECDC, Fluor Fernald, Inc./MS52-7

IMPROVEMENTS TO FERNALD REAL TIME INSTRUMENTATION MEASUREMENT PROGRAM (RTIMP) SODIUM IODIDE MEASUREMENTS

1. GAIN TRACKING automatically determines sodium iodide (NaI) spectrometry system gain using prominent spectral peaks in real time.

Old Method

A. Due to poor detector resolution and short count time (4 seconds), NaI spectral peaks may not be readily identified because of low counts and poor peak shape.

B. Because of the conditions noted above, the old method used fixed channel regions of interest (ROIs) for isotopic signal windows and background windows rather than industry-standard automated peak search routines. If the system gain drifts, the strip regions may no longer span the entire peak, which will affect the accuracy of measurement results.

Improved Method

A. The system gain is automatically computed from the positions of two prominent photopeaks: the 2614.6 keV peak from Tl-208 and the 1460.8 keV peak from K-40.

B. To improve counting statistics and peak shapes, and thus make a more reliable gain determination, a composite spectrum is constructed by adding multiple spectra together, channel by channel. The system gain is automatically computed from the peak locations in the composite spectrum. The composite spectrum is used purely to establish system gain. Activity concentrations are computed from region-of-interest counts in the individual 4-second spectra.

C. The number of spectra added to construct the composite spectrum can be determined by the user, with a default number of 17 spectra. Thus the system gain is determined approximately every 68 seconds, and that gain value is used to set ROIs for U-238, Ra-226 and Th-232 based on their characteristic gamma energies. Even if the gain drifts, the proper ROI will be selected because the selection is based on current system gain, rather than on fixed memory channels.

2. PEAK SANDING provides more reliable estimate of the background continuum.

Old Method

A. Background counts are determined by summing counts in the MCA memory channels just above and below each analyte ROI, and then normalizing the counts in the background channels to the number of channels in the ROI. For example, 10 channels below ROI give 600 counts and 10 channels above ROI give 400 counts for a total of 1000 counts per 20 channels (50 counts/ channel). This yields a normalized background count of 1500 for an ROI width of 30 channels.

B. Net counts are determined by subtracting the normalized background counts from the gross counts in each ROI.

Improved Method

A. To get a more reliable background estimate, a composite spectrum is constructed by adding multiple spectra together, channel by channel. Normally, 17 spectra (68 seconds) are added together, but the user can select more or less.

B. Sanding consists of removing the peaks to obtain a background spectrum. The following steps are performed for each channel in the composite spectrum.

i. For channel j, average the counts in w channels above and below channel j, where the sanding window width, 2w+1 channels, corresponds approximately to the base width of a photopeak in this region of the energy spectrum.

ii. Compare the average just computed to the actual counts in channel j of the composite spectrum. Replace the counts in channel j by the average just computed if the average is lower. Otherwise retain the original counts in channel j.

iii. Move to the next channel (channel j+1) and repeat the process. Repeat this process for every channel in the composite spectrum to construct a sanded spectrum. Because of the averaging and replacement process, the sanded spectrum will have lower peaks than the original composite spectrum (Figure 1).

iv. Repeat the entire sanding process 20 times, each time starting with the spectrum from the prior sanding iteration. The result will be a smooth continuum spectrum with no spectral peaks (Figure 1).

v. Scale the counts in the final sanded spectrum to match the data acquisition time of the spectrum to be background corrected. For example, a composite spectrum consisting of 17 spectra would be scaled to the spectrum of interest by multiplying the counts by 1/17.

C. Net counts are determined by subtracting the scaled sanded spectrum from the analysis spectrum. The activity in the soil is proportional to the net counts in each analyte ROI.

D. Improvements result from using sanding to determine background.

i. Using multiple spectra in the sanding process to determine background reduces fluctuations, improves counting statistics and results in a better estimate of the background because of the averaging process.

ii. Reduced variability in the background results in lower measurement uncertainties (Figure 2).

iii. One large contributor to the measurement uncertainty for the old method of background subtraction (involving fixed background windows) has been eliminated. It is no longer necessary to include a multiplicative factor for scaling the counts in the narrower background windows to the wider signal window (see 2 A, Old Method under PEAK SANDING).

iv. Reduced measurement uncertainty gives rise to a lower detection limit, because of lower measurement uncertainty at or near the background concentration of the radionuclide of interest.

	Fixed BKG Windows	Peak Sanding
U MDC (ppm)	231 (8 sec.)*	102 (4 sec.)+
Ra-226 MDC (pCi/g)	11.1 (8 sec.)*	1.7 (4 sec.)+
Th-232 MDC (pCi/g)	1.1 (8 sec.)*	0.7 (4 sec.)+

* Highest of the MDC values listed in Users Manual Table 5-2 for the various NaI systems.

\+ Highest of the MDC values listed in NaI Uncertainty Report (May 2004) Table 5.1 for the various NaI systems.

v. Based on the equation defining a trigger level (NaI Uncertainty Report, May 2004):

$T = L - k \times \sigma_{WAC}$ (where L is the regulatory limit and T is the trigger level),

the reduced measurement uncertainty at or near the total uranium waste acceptance criteria (WAC) level also allows establishment of a more reliable trigger level for NaI systems, which is based on experimentally determined measurement uncertainties. In the past, the arbitrary trigger level of 721 ppm (i.e., 70% of 1030 ppm) was used for the WAC trigger level, but the revised NaI measurement uncertainty analysis shows the WAC trigger level for NaI systems to range from 890 to 910 ppm for a 4-second measurement (Table 6.1, NaI Uncertainty Report, May 2004). Therefore, the uranium WAC trigger level will be set at 875 ppm, which is below the lowest value for the NaI systems.

3. NaI FIELD OF VIEW RADIUS more accurately determined. Field of View (FOV) is defined as the ground area from which 90% of the photons that strike the detector are emitted.

Old Method

A. Initial estimate of NaI FOV radius was 1.2 meters. This was a non-rigorous estimate based on point source measurements assuming a NaI detector angular response having cylindrical symmetry, although this was not strictly true.

B. This FOV radius was for a 31-cm detector height and 1000 keV photons.

Improved Method

A. NaI FOV radius was reevaluated in 2004. Point source measurements were made at multiple angles in two perpendicular planes to evaluate the actual detector angular response. These measurements made it unnecessary to assume cylindrical symmetry for the detector angular response.

B. The more rigorous evaluation revealed that the angular response functions of the various NaI detectors were nearly identical. Using an average angular response function, it was determined that the FOV radius for the NaI detectors in use at Fernald is 2.3 meters for 1000 keV photons when the detector is 31 cm above a flat homogeneously contaminated volume of soil.

C. NaI scans have typically been conducted with a spacing of 2.4 meters (i.e., twice the initial estimate of FOV radius) between adjacent passes. Given that a more accurate estimate of the NaI FOV radius is 2.3 meters, it is evident that there has been a substantial degree of overlap in all of the NaI measurements performed by the RTIMP. The RTIMP has made nearly two times as many passes with NaI instruments over areas scanned as was necessary for 100% coverage.

D. Using the old FOV radius of 1.2 meters, a 2.4 meter spacing between adjacent passes results in nearly a 100% rescan of the area (i.e., the true FOV radius is 2.3 meters). Therefore, RTIMP will be using a less conservative separation distance between adjacent NaI passes. Increasing the normal separation distance between adjacent NaI passes to 4 meters will produce increased operating efficiency (i.e., achieve 100% coverage with fewer passes) while maintaining 0.6 meters of overlap (2*2.3 – 4 = 0.6 meters of overlap).

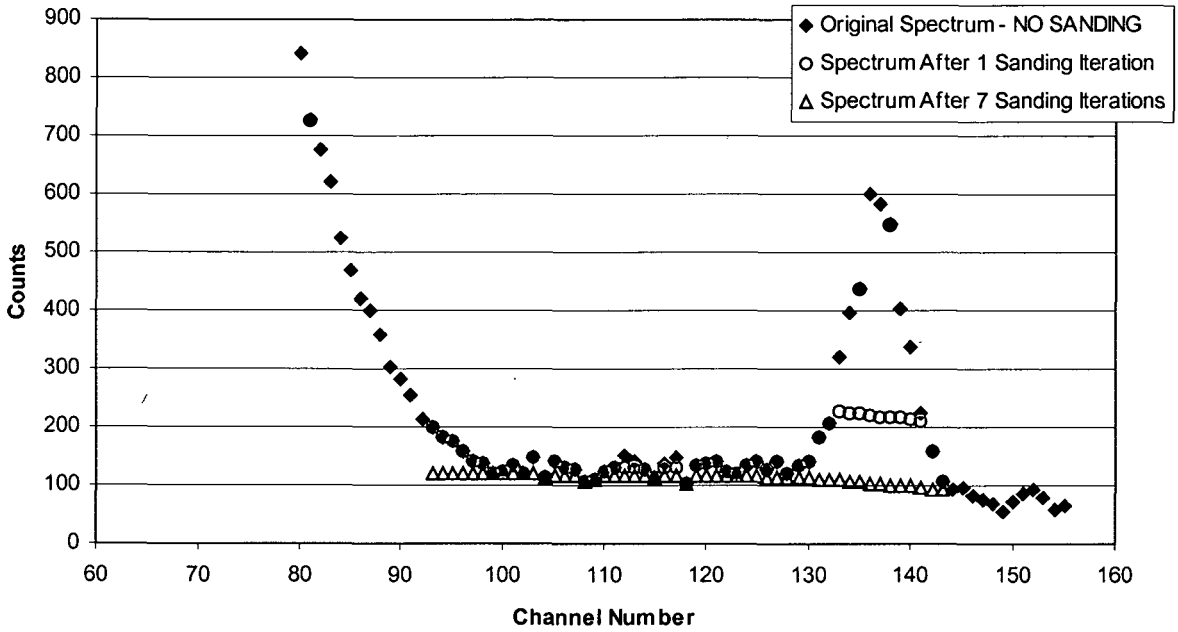

FIGURE 1 Illustration of the Sanding Process for a Synthetic Spectrum with One Prominent Peak. The figure shows the original spectrum and the sanded spectrum after 1 and 7 sanding iterations.

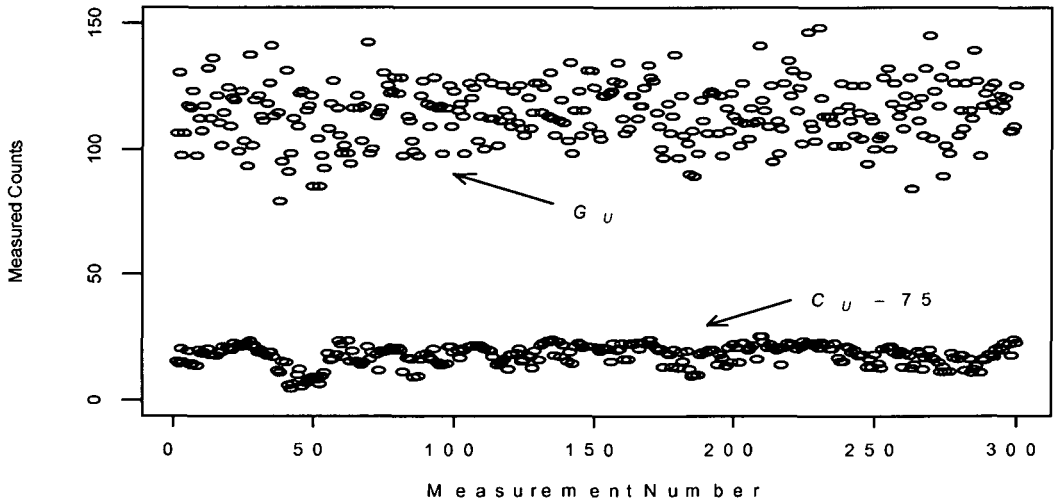

FIGURE 2 Comparison of Variability in Gross and Background Counts. The results shown are for ^{238}U for the RSS-1 for June 24, 2003 (run 0834) for background conditions. G_U identifies the gross counts and C_U identifies the background counts. The background counts have been shifted by 75 counts to avoid overlap with gross counts. NOTE THE DECREASED VARIABILITY IN THE SANDED BACKGROUND AS COMPARED TO THE GROSS SIGNAL.