FIELD INSTRUMENTS DEVELOPED FOR RADIATION MEASUREMENTS ON THE UMTRA PROJECT

H.R. Meyer, C. Begley, C. Daily
Chem-Nuclear Systems, Inc.
P.O. Box 9136
Albuquerque, New Mexico 87119
Subcontractor to
MK-Ferguson Company
Contractor to
U.S. Department of Energy

ABSTRACT

The Uranium Mill Tailings Remedial Action (UMTRA) Project requires cost-effective field instrumentation to implement standards under diverse conditions at 24 different sites. Numerous formal USDOE audits are performed annually to ensure that these requirements are met. Chem-Nuclear Systems (CNSI) and MK-Ferguson (MK-F) have responded by developing or adapting unique systems for rapid and auditable analysis of Ra-226, Th-230 and other radionuclides, under difficult field conditions. The resulting calibrated and traceable field measurements (backed by DOE-prescribed, independent vendor quality control analysis), have been accepted by federal, state and tribal authorities for official certification of Project results. The instruments developed include the opposed crystal system (OCS), a semi-portable, shielded gamma spectrometer: the Remedial Action Contractor (RAC) Delta system, an interference-corrected, shielded portable scintillation counter; and the field analysis system for Th-230 (FAST), a thin-sample alpha counter. Under development are additional systems to improve UMTRAP data collection efficiency and accuracy, while reducing costs. The results of application of these devices are summarized here, and demonstrate that Project standards are capable of accurate verification through their use. Some 10,000 certification-quality measurements have been made to date at completed UMTRA Project sites, using this equipment.

INTRODUCTION

Chem-Nuclear Systems, Inc. (CNSI) became actively involved in the UMTRA Project in June of 1983. CNSI provides MK-Ferguson, the USDOE's prime remedial action contractor (RAC) with health physics protection and radiation measurements services at all UMTRAP sites. Figure 1 locates those sites designated by Congress for UMTRAP remedial action.

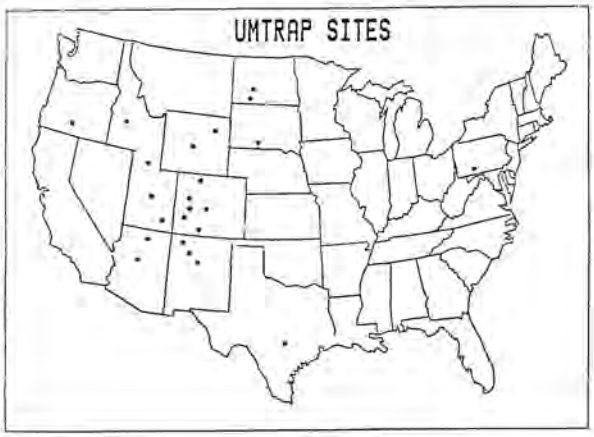

Fig. 1. UMTRAP Designated Sites

Typically, CNSI staff at an operating site consists of from 9 to 16 personnel, including a site health physics manager, one or more supervisors, HP-qualified technicians, and locally hired and trained HP assistants. These staff, supported by a small team at the Project office in Albuquerque, New Mexico, provide health physics and environmental protection and monitoring services to all contractor and subcontractor personnel involved in site or vicinity property remedial action. Site staff also perform all radiation measurements necessary to demonstrate that Project standards have been met. The USDOE and its technical assistance contractors routinely audit these measurements, and analyze split samples to evaluate the accuracy of CNSI's instrumentation and procedures. A recent paper (1) summarizes the quality control procedures developed by CNSI for use on the Project. The purpose of the current paper is to describe several instruments developed specifically for use under field conditions for UMTRA. It is our opinion that these field instruments and procedures provide an unusual combination of accuracy, sensitivity, portability and cost-effectiveness, required to meet difficult conditions on the project. In addition, these instruments and techniques provide rapid analyses, essential to the support of schedules involving movement of millions of tons of contaminated material in a short period.

Instruments and techniques developed specifically for UMTRAP include:

1. The Opposed Crystal System (OCS), a semi-portable, shielded, high-efficiency gamma spectrometer,

2. The RAC Delta System, a portable, interference-correlated scintillation counter designed to quickly approximate residual soil contamination, and

3. The field analysis system for Th-230 (FAST), a gross-alpha counting system designed to provide quick estimates of residual Th-230.

In addition, progress on RTRAK, an automated gamma-scanning device intended to become a principal tool during the next construction season, is briefly described.

THE OPPOSED CRYSTAL SYSTEM

The OCS was developed at Argonne National Laboratory, for field use on remedial action projects. CNSI/MK-F, with the assistance of the DOE and the Jacobs-Weston UMTRAP team, modified the original device to produce a workhorse gamma spectrometer currently used for all soil verification measurements on the project. The system, diagrammed in Fig. 2, uses two, 3"x3" NaI gamma detectors on either side of a 500 g sample. Principal hardware modifications made to the Argonne system include deletion of separate multichannel analyzers (MCA's) in favor of a single unit, use of a self-contained, computerized MCA rather than separate computer and analyzers, and inclusion of Th-232 Compton and background spectrum-stripping capability. The cylindrical shields for UMTRAP OCS units are poured and cut by a local Albuquerque firm.

Standards for UMTRAP are set by the USEPA, implemented by the USDOE through its project office in Albuquerque, and are subject to compliance review and final certification by the USNRC. The OCS is used primarily to demonstrate compliance with the USEPA UMTRAP soil Ra-226 standard, which requires that residuals after remedial action be less than 5 pCi/g soil above background in the first 15 cm layer, and less than 15 pCi/g above background below 15 cm depth.

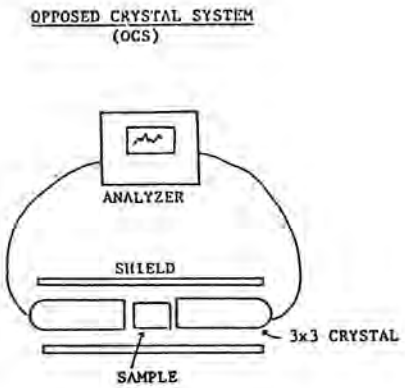

Fig. 2. The Opposed Crystal System (OCS)

Background Ra-226 in U.S. soil generally ranges from 1 to 2 pCi/g. Remedial action at a typical UMTRAP site generally involves stripping tailings to a depth at which Ra-226 concentrations are below the standards, then backfilling with clean fill to grade. Certification by the USDOE and USNRC that the USEPA standards were met does not occur until well after final completion of the site. One to two years may elapse between actual backfill of an area, and final review/certification that soil standards were met at a particular location. For this reason, it is imperative that the measurement of final residual concentration meets strict accuracy requirements. Minimum detectable activity for the OCS units in use by CNSI at UMTRAP sites is generally 1 pCi/g Ra-226, or about 20% of the most restrictive standard.

To demonstrate that any individual measurement of residual radium meets the US DOE requirement of overall +/- 30% accuracy, a system of routine energy calibration and standards counting was developed by CNSI for the project. Because a spectrometry system operated in a field environment is subject to electronic and thermal drift, a daily peak energy recalibration using Co60 is performed. This setup procedure is followed by region-of-interest calibration using a National Bureau of Standards (NBS) traceable 50.2 pCi/g standard provided by the UNC Technical Measurements Center in Grand Junction, CO. Finally, several times a day during peak operation of a specific OCS, a 5.12 pCi/g traceable standard is counted on the unit and results recorded and plotted for review. Figure 3 represents a standard plot of these latter readings, from OCS units at the Shiprock NM UMTRAP site during peak operations in 1985. Routine audits of soil sampling, preparation, and counting performance are performed by the USDOE during operations at each remedial action site. Audit reports, and realtime records of OCS unit performance, are available for USNRC inspection during remedial action, and at the time of review and certification following site completion.

To date, a certification report has been submitted for the completed site in Canonsburg, PA, and more recently for Shiprock, NM. Final certification has been received from the USNRC for the Canonsburg site, and is anticipated shortly for Shiprock. Figure 4 presents all final verification Ra-226 data produced by CNSI for certification of the adequacy of remedial action at the Shiprock site. Notable during the intensive review of both certification reports has been the absence of problems concerning accuracy of the Ra-226 concentration data. This indicates that the detailed record of daily NBS traceable standardization provides adequate assurance to both the USDOE and USNRC of CNSI measurement accuracy.

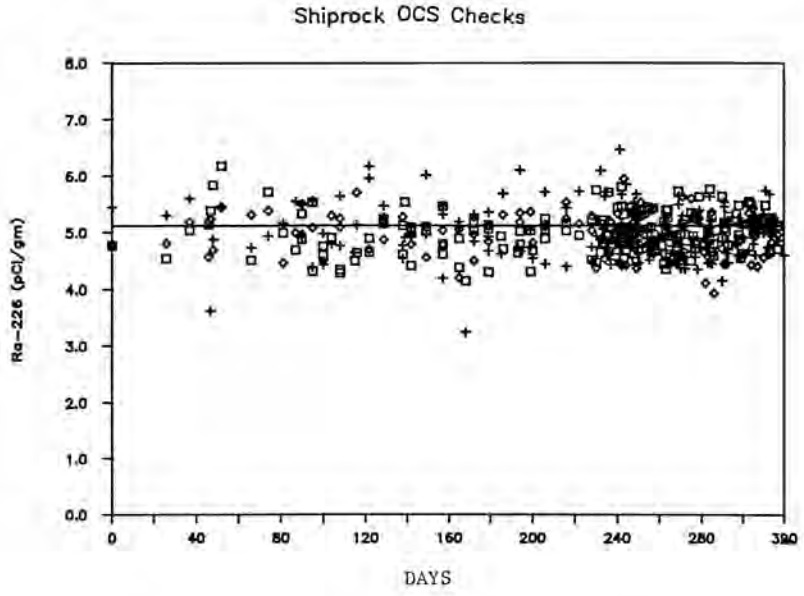

Fig. 3. Record of OCS Standards Calibration - Shiprock

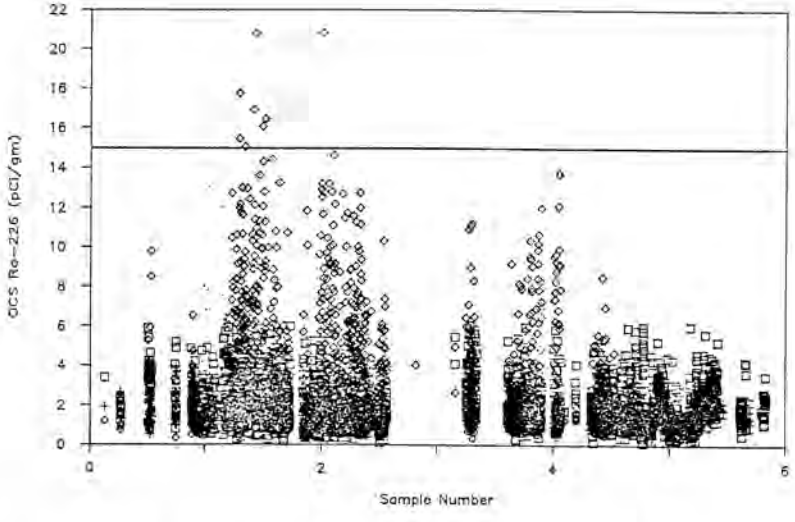

Fig. 4. Shiprock, NM Final Verification Data - OCS

RAC DELTA SYSTEM

Prior to verification of final residual Ra-226 concentrations at an UMTRAP site, it is necessary to use handheld gamma scintillators to provide an indication that the standards will be met. This is necessary because the final soil sampling procedure is quite time-consuming, involving extraction of 20, 6" deep plugs from each 100 square meter area being evaluated. These soil samples are composited, rough-homogenized, and gamma counted on the OCS as discussed above. Because the daughter of Ra-226 (Bi-214) grows to equilibrium with its parent Rn-222 over a period of time, each verification sample must be counted a second time, after 20 days ingrowth, to ensure acceptable accuracy. To avoid repetition of final soil sampling, a relatively accurate measurement of residual radium using direct gamma scanning with handheld instruments is necessary. A 2x2" NaI scintillator and portable scalar/ratemeter are used on UMTRAP for such scanning, and are effective unless high interference from a nearby tailings pile exists. When significant interference is determined to exist, a shielded gamma

scan device, the RAC Delta system, is used. The Delta system involves a 2x2" NaI detector, shielded by a vertically-oriented, cylindrical lead tube. A 1/2 inch lead shutter can be inserted at the base of the cylinder (see Fig. 5). A pair of 1/2 minute counts taken with the shutter in place, then removed, results in a differential or "delta" count which is representative of the concentration of gamma emitter in soil under the detector. The system shows a reasonably linear relationship between Ra-226 in soil and the Delta count under conditions of low gamma interference.

If relatively high gamma interference is present, the Delta reading increases, presumably due to scattered radiation from soil beneath the detector. Figure 6 demonstrates the linear relationship between soil Ra-226 concentration and Delta counts under conditions of low interference. Figure 7 presents data scattered due to interference from a nearby tailings pile. Because the error in the delta reading under conditions of high interference is proportional to the intensity of the interfering radiation, a correction factor may be developed to allow field use of the Delta system under interfering conditions. Figure 8 illustrates a correction factor developed for field use.

Compensation may be easily made only for gamma interference; additional variables, including inhomogeneity of radium and daughter concentrations

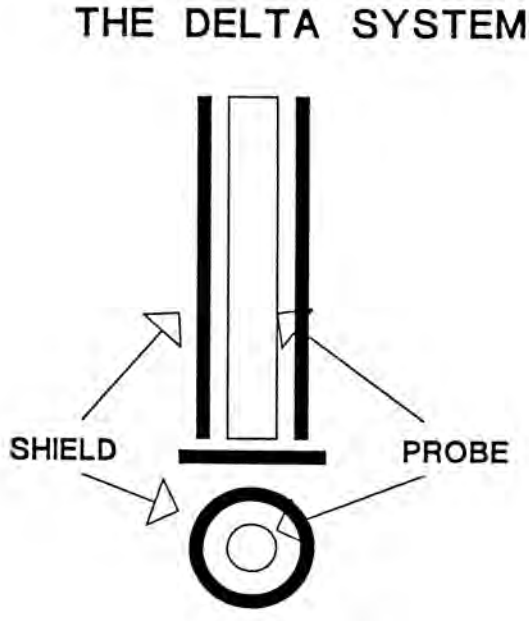

Fig. 5. The Delta System

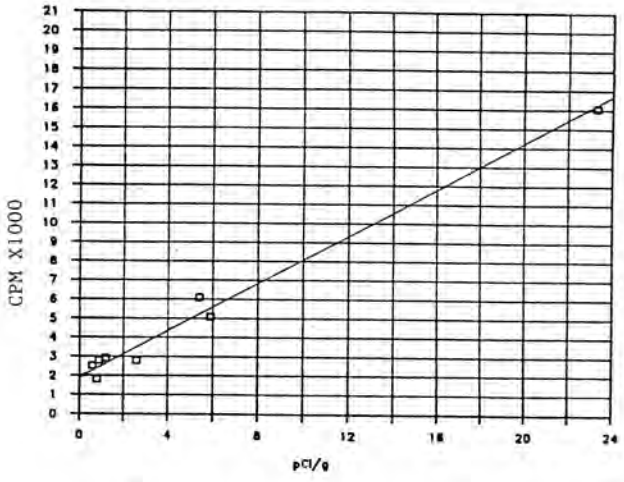

Fig. 6. Low Interference Delta Correlation

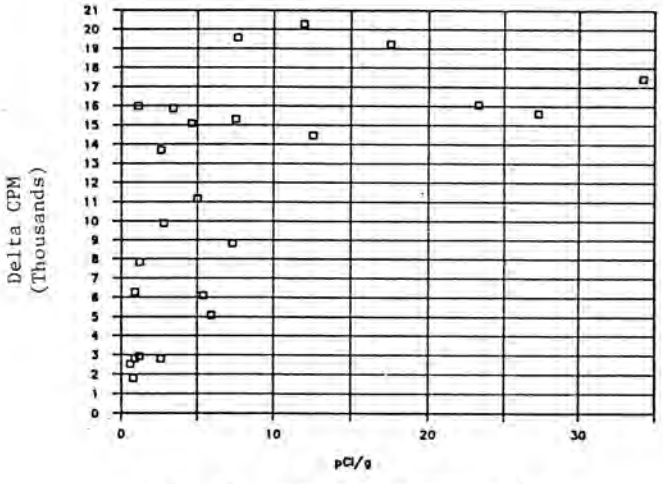

Fig. 7. High Interference Delta Correlation

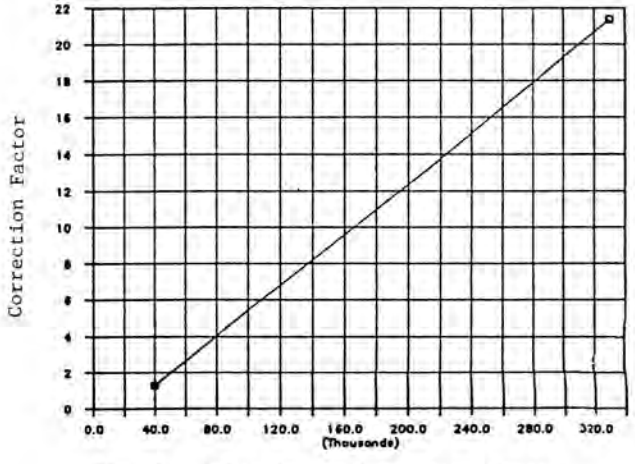

Fig. 8. Delta System Correction Factor

within a given depth of soil, radon emanation fraction, and geometry factors associated with the scattered interfering radiation, remain uncorrected. Because the Delta is used only for excavation measurements, with final verification data based on actual soil sampling and analysis, the corrected Delta technique has proved adequately accurate as an estimator of residual radium for UMTRAP. In many cases, the collimated probe alone is adequate for a quick determination of the need for additional cleanup of a given area.

FIELD ANALYSIS SYSTEM for Th-230 (FAST)

Uranium ore generally contains U-238 and its daughters, through Ra-226, in equilibrium. During processing of the ore and the production of mill tailings, Th-230 may be selectively deposited, particularly in sections of settling ponds. Th-230 emits no significant gamma radiation: detection with conventional handheld or spectroscopic instruments is not feasible. CNSI therefore is developing the FAST technique, utilizing gross alpha analysis of a thin layer of finely divided soil sample placed on scintillator material. Calibration of the system is achieved through independent vendor analysis of Th-230 and Ra-226 concentration in the sample. When Ra-226 alpha emitters are present at low concentrations, the gross alpha measurement is found to be proportional to Th-230 concentration. Because the concentration of radium and uranium in tailings is variable, the technique is only marginally accurate, and must be supplemented with 10-20% QC analysis by independent vendor. In addition, excavation must be extended to somewhat greater depths than would be required for a more accurate system, to ensure that the applicable guideline for Th-230 (35 pCi/g residual) is met. Figure 9 illustrates that accuracy associated with the FAST technique is relatively low. The Figure plots the ratio of CNSI FAST results with independent analysis, minus 1; perfect correlation is represented by a result of zero on the scale. For the 52 soil samples compared, excavation was carried out to a depth satisfying the applicable criterion, and QC analysis indicates that soil concentrations greater than 35 pCi/g Th-230 are being removed in all cases. While greater accuracy is certainly desirable, the quick sample turnaround permitted through use of fast is essential to on-schedule completion of the work at UMTRA sites.

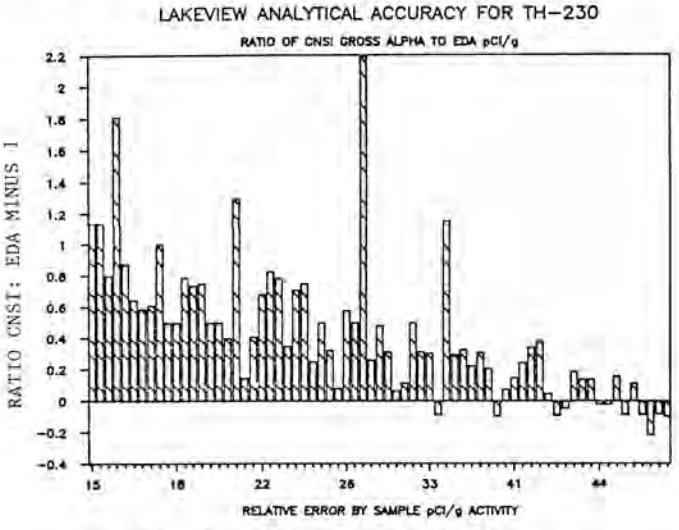

Fig. 9. FAST vs. Vendor QC Data

The FAST system is still subject to development prior to the 1987 construction season, and will be used at both the Lakeview, OR and Durango, CO sites for evaluation of residual Th-230 concentrations. Corrections for variable concentrations of other alpha emitters, using initial gamma spectroscopy, are currently being developed.

RTRAK

While soil sampling and analysis is required under UMTRAP guidelines for verification of residual radium, certain sites contain large areas of contamination caused by wind erosion of the main tailings pile. These areas, known to be surface-contaminated only, could be verified to be clean following remedial action using gamma scan methods. Application of high-speed gamma scanning to such areas could save UMTRAP significant costs, principally in labor required to sample, prepare, analyze and report soil verification results. For example, a site such as Ambrosia Lake, NM, containing up to 700 acres of windblown contamination, would require some 35000 composite verification sample analyses, and some 7,000,000 individual samples for final verification, at an estimated cost of 1.7 million dollars. To make the verification process more efficient, CNSI/MK-F is developing for the USDOE a system capable of motorized gamma scanning of a 10' wide swath, automatically locating itself through ultrasonic time-of-flight triangulation, with direct plotting of gamma contour maps. Feasibility of this system has been demonstrated through a cooperative test using Rockwell/Hanford's MSCM mobile scanner, described at last year's Waste Management 1986 meeting in Tucson, AZ.

RTRAK auto-locating and plotting technology is planned to be similar to that recently developed at Oak Ridge National Laboratory, for the USRADS ultrasonic ranging and display system. Implementation of the RTRAK mobile scanner should provide net savings of 1.25 million dollars on UMTRAP. The two mobile scanners developed by MK-F/CNSI are intended to be useable by other remedial action contractors or national laboratories in later years, if required.

SUMMARY

The team of CNSI/MK-F has developed a number of rapid, accurate, and cost-effective techniques for evaluation of residual radionuclide concentrations for the UMTRA Project. During the remaining years of the project, refinement of these devices, and development of new instruments and techniques, are anticipated to continue with the support of the Department of Energy.

Reference

1. Meyer, H.R. and C. Daily, "QA Verification Procedures in Uranium Mill Tailings Processing Site Remedial Action", Proceedings, American Society for Quality Control Annual Meeting, Las Vegas, Nevada, February 9-11, 1987.