Conveyor Mounted Radiation System Work Plan

Thorium Remediation Project
Tulsa, Oklahoma

April 2004

Prepared by:

Shonka Research Associates, Inc.

For:

RECON
Remedial Construction Services, L.P.

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Approved Bill Vinzant ___________ 4-22-04 ___________
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Kaiser Aluminum & Chemical Corporation

Revision 00
Effective Date April 2004

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Acronyms:

Acronym	Description
cps	Counts per Second
$DCGL_{EMC}$	Derived Concentration Guideline Level – Elevated Measurement Comparison
$DCGL_W$	Derived Concentration Guideline Level - Wilcoxon Rank Sum
DOE	Department of Energy
DP	Decommissioning Plan
Kaiser	Kaiser Aluminum and Chemical Corporation
MCA	Multi-Channel Analyzer
NaI	Sodium Iodide
NASVD	Noise Adjusted Single Value Decomposition
NIST	National Institute for Standards and Technology
NRC	Nuclear Regulatory Commission
RCT	Radiological Control Technician
RECON	Remedial Construction Services, L.P.
SMC	Standard Magnesium Corporation
SMCM	Sub-Surface Multi-Spectral Contamination Monitor
SRA	Shonka Research Associates

1. PREFACE

The Shonka Research Associates, Inc. (SRA) conveyor mounted radiation system work plan involves three items.

- Setup, operate and maintain a radiation system mounted over a conveyor.
- Summarize the data collected from the radiation detection system mounted over the conveyor for a paper report handed to Remedial Construction Services, L.P. (RECON).
- Setup, operate and maintain additional radiation detector systems used for waste characterization.

2. BACKGROUND

The Kaiser Aluminum & Chemical Corporation (Kaiser) plant in Tulsa, Oklahoma was built by the Standard Magnesium Corporation (SMC) in the early to mid-1950s to manufacture magnesium products. Kaiser purchased the facility in 1964.

The Kaiser facility is located at 7311 East 41st Street in Tulsa, Oklahoma. It is situated in Tulsa County, Oklahoma, about 5 miles southeast of the downtown center of the city of Tulsa. An approximate 14-acre pond parcel north of the railroad contains a retention pond, the flux building, a former freshwater pond area, and a segment of Fulton Creek. The remediation area is bounded by the south fence line, the freshwater pond embankment on the west, Fulton Creek ditch on the north, the east fence line, and the northern and western edges of the flux building and paved area. The areas to be remediated include a portion of the 4-acre operational area south of the railroad, and a large portion of the 14-acre pond parcel located north of the railroad. The pond parcel is divided into three parts--the non-impacted former freshwater pond to the west 4 acres, the affected retention pond/reserve pond area to the east approximately 9 acres, and the area containing the flux building and paved area approximately 1 acre.

3. INTRODUCTION

RECON will utilize a system of conveyors and radiation monitors to sort the soil and dross (material) and to document that the material is below the limits dictated in the facility Decommissioning Plan (DP) filed with the Nuclear Regulatory Commission (NRC) and is ready for the Final Status Sampling (FSS) Survey. Radiation characterization tools will be utilized and include: walk-over monitors and excavator bucket monitor. SRA was contracted to build and operate radiation monitors or systems.

SRA utilizes a system called the Subsurface Multi-spectral Contamination Monitor (SMCM), which was developed with funding from the NRC (NRC-04-92-096. "Continued Development of a High Sensitivity Landfill Monitor: The Results of a Phase II SBIR Grant". December, 1994). SMCM combines into one instrument the capabilities of both scanning (rolling) detection with *in situ* gamma spectrometry. The SMCM is a scanning spectrometer. The data is processed with Noise Adjusted Single Value Decomposition (NASVD) algorithms originally developed for sonar. This treatment of the data greatly reduces the statistical fluctuation normally encountered in scanning detection.

The SMCM controls the operational flow of the material to sort the raw material into 2 piles, On-Site Piles (O-Pile), < 31.1 pCi/g of Th-232 net or Landfill Piles (L-Pile) ≥ 31.1 pCi/g of Th-232 net. The established background level for the Thorium Remediation Project is 1.1 pCi/g. The SMCM sorting logic setpoint is 31.1 pCi/g of Th-232 net. The setpoint for the SMCM sorting logic may vary during the sorting operations if necessary.

The O-Piles will be used as onsite backfill. The L-Piles will be transported to US Ecology Inc., Simco, Idaho (Waste Transfer Facility) with final disposal at US Ecology, Inc Grandview Operations Facility, Grandview, Idaho.

The SMCM system will be operated with alarm setpoints. The raw material flow is controlled by the RECON excavator operator. The SMCM will control diversion parts of the conveyor system.

4. METHODOLOGY

4.1 The Conveyor Mounted SMCM

The SMCM utilizes a radiation detection system that is a fixed platform mounted over a conveyor. The Thorium Remediation Project will make use of a single thallium-doped sodium iodide (NaI (Tl)) detector. Spectra in a pre-defined energy range will be collected successively over a fixed time via a Multi-Channel Analyzer (MCA).

The detector will be placed into a protective enclosure. The detector will have thermal protection for temperature stabilization and will be shielded to reduce the radiation background as well as reducing any variability from changes in background due to radon in air, moving vehicles, and changes in nearby material. A trailer will be used as a mobile command center for the SMCM electronics and the process computer system.

Prior to deployment, the detector will be calibrated. Appropriate calculations will be performed to establish a calibration in an equivalent manner to the method of Helfer and Miller: "Calibration factors for Ge Detectors used for Field Spectrometry (*Health Physics* Vol. 55 No.1 (July), pp 15-29 1988).

The SMCM includes a sensor to verify that the conveyor speed is 250 fpm (feet per minute). The sensor is monitored (and the conveyor speed is calculated) during data collection.

The SMCM is equipped with a level switch to verify the material depth.

All measurements will be recorded to the process computer's hard drive and backed up on a CD. The SMCM operator controls the starting and stopping of the recorded data. All the recorded data between the starting of the recorded data and stopping of the recorded data is called a "survey strip." Data collected when the belt is stationary or with no material present is recorded but not reported.

The SMCM is equipped with a number of alarm enunciators. When material ≥31.1 pCi/g of Th-232 net is detected, the operation screen changes color. A remote day light readable monitor is available for the conveyor operator. The SMCM process computer activates a radiation diversion alarm light to the operator.

4.2 Establishment for Sorting Units

The raw material from the 9-acre pond parcel, the 3-acre area south of the railroad tracks and the area under the Flux Building define the excavation areas. The excavation area will have a grid system as shown in RECON's Work Plan, Figure WP B 2, to define the origin of materials.

4.3 Presorting Activities

Excavated material will be presorted prior to being separated by the Conveyor Mounted SMCM. The presort will be a rough cut for the purpose of providing a relatively consistent feed to the Conveyor Mounted SMCM. Material presorted as above 31.1 pCi/g of Th-232 net will be fed to the conveyor system separately from material presorted as below that criterion. Campaigning above and below criterion material separately will prevent the sorter from cycling excessively during operation. The bucket monitor described in Section 6.2 will be used to perform the presort. Decisions on which material will need to be disposed of off site and which material is suitable for backfill will be based on detailed data collected from the Conveyor Mounted SMCM as discussed in Section 4.4.

If the bucket monitor fails to perform as expected or becomes unavailable, hand-held meters or other methods will be used for the rough presort.

4.4 Performing the Sorting

RECON's excavator will place material on a vibrating screen to remove all debris and any material over 6 inches in diameter. The material that is less than 6 inches in diameter will pass thru the vibrating screen and will be carried to the Conveyor Mounted SMCM conveyor. Before it passes under the Conveyor Mounted SMCM, material will be leveled with a leveling bar placed across the conveyor to ensure that material is spread evenly across the conveyor belt and that only 6-8 inches of material will pass under the Conveyor Mounted SMCM. Once material is found to be either < 31.1 pCi/g of Th-232 net or ≥ 31.1 pCi/g of Th-232 net, it will fall into a pant leg chute. The SMCM sorting logic setpoint is a derated value from 31.1 pCi/g of Th-232 net. The Conveyor Mounted SMCM process computer will electronically control the gate inside the chute. Depending on the pCi/g, the material will fall onto one of two stacker conveyors creating an L-Pile or O-Pile described below.

Onsite Pile (O-Pile) - These raw materials will be sorted into piles of approximately 2000 ton sorting units (sorting units may vary and should not be considered a change to the plan). Note: The number of piles is based on the quantity of materials sorted with a value of < 31.1 pCi/g of Th-232 net. Material < 31.1 pCi/g of Th-232 net will be placed in piles with identification numbers such as; O-1, O-2, O-3, etc. Note: "O" – represents Onsite Pile, "1" representing an incrementing number based on the number of piles generated.

Landfill Pile (L-Pile) - These raw materials will then be sorted into piles of various ranges in pCi/g. Note: The number of piles and ranges selected to associate with those piles is based on the quantity of materials in various ranges of value of pCi/g in the L-Pile material. Material less than or equal to the derived concentration cut-off levels (ranges in pCi/g) will be placed in piles with naming conventions such as:

L-1-A	31.2pCi/g – 35 pCi/g of Th-232 net
L-1-B	35.1pCi/g – 45 pCi/g of Th-232 net
L-1-C	45.1pCi/g – 55 pCi/g of Th-232 net
L-1-D	55.1pCi/g – 100 pCi/g of Th-232 net

Note: "L" represents (L-Pile), "1" representing an incrementing number based on the number of L-Piles produced, and the "A", "B",- "Z", will represent the range of values of Th-232 pCi/g present. Depending on the actual materials encountered, the number of piles and ranges of activities will vary throughout the project. With this data the process computer creates a standardized pick list that will be utilized to create approximate 100 ton stockpiles <55 pCi/g for loading into railcars as described in Section 4.5.2. During the sorting for creating approximate 100 ton stockpiles, the pant leg chute will divert material under the direction of the SMCM computer if the stockpiled material will exceed 55 pCi/g averaged over a total of 100 tons. Diverted materials will be resorted with materials that will meet the offsite acceptance criteria (<55pCi/g).

All materials that have been scanned and placed into 100-ton piles will have a unique pile name as discussed above. For O-Piles, a number of piles may be treated as a sorting unit. For L-Piles there is only one pile that is equal to the sorting unit. Each L-Pile sorting unit is summarized in a Sorting Release Record Report that will accompany manifests for offsite material. Sorting release records will be generated upon request by the site management team members. A sample copy of the Sorting Release Record Report is located in Attachment No. 1.

4.5 Sorting Methods

The conveyor mounted SMCM collects data over a fixed time period as the material moves at 250 fpm (feet per minute). The collected data is termed an acquisition. During each acquisition, the process computer records the following: a spectra and live time from the MCA, the distance traveled, the average height of the material and the average density. Periodically during the operation, the operator records the system status information such as temperature in a field notebook or other means. Although all of these signals are collected and monitored during operations, the system's most important function is the real time low-level radiation alarms based on the data analysis. A brief description of the real time data analysis, alarms, and investigative measures is given below.

The spectra will be converted from units of counts to count per second (cps) by dividing by the live time. The net value in each region of interest is determined. The regions of interest of concern will be for potassium (K-40 @ 1461 keV), uranium (U-238 using Bi-214 @ 1764 keV), and thorium (Th-232 using Tl-208 @ 2614 keV). The monitoring of K-40 and U-238 helps assure the conveyor spectra is being recorded correctly when comparisons are made with the off-site lab as discussed in Section 5.1. A Cs-137 density gauge is used as described below. A source response check will be performed whenever the belt is empty.

The net Cs-137 is required for the density measurement and is calculated by removing the contribution to the Cs-137 region of interest from each of the primordials: K-40, U-238, and Th-232. To strip a spectrum (window) means to remove the contributions to an energy window from radionuclides emitting gammas of higher energies. Only a fraction of the emitted gamma photons register as full energy photons. Scattered photons originating from higher energy photons are measured in lower energy windows. The contribution from those scattered photons is removed when stripping the spectra.

4.5.1 On-Site (O-Pile) DCGLemc Diversion Alarms

Alarm logic drives the sorting mechanism. A moving window that averages the material on the conveyor belt will be set to divert material that is ≥ 31.1 pCi/g of Th-232 net.

4.5.2 Landfill (L-Pile) DCGLw Diversion Alarms

The conveyor will divert material if the average of a railcar will exceed 55 pCi/g averaged over a total of 100 tons. A pick list (a list that contains the various pCi/g levels in each L-Pile) will be provided for the heavy equipment loader operator so that the loads can be fed in a manner that ensures the 55 pCi/g is not exceeded. For example, alternating loads of 45 and 65 pCi/g materials should average 55 pCi/g and no material will be diverted as long as the 45 pCi/g hopper load is used first to start the averaging process. As the total reaches the 100-ton railcar load, the influence on the average from alternating higher range pCi/g materials and lower range pCi/g materials will diminish.

4.6 Quality Control

Quality control and quality assurance for the laboratory environment has been studied for some time and is well established in the nuclear industry for radiation detection equipment. However, quality control associated with the operation of radiation detector in the field is not generally established with the same degree of rigor. To attain lab-like stability in the field, rigorous quality control and quality assurance measures are required that go beyond common practice. The following text outlines the traditional quality control measures for gamma spectrometers when operated in a laboratory environment. The remaining controls that are imperative to proper field operation have been integrated into Section 4.7.

Prior to deploying, the NaI detector will be calibrated at SRA's laboratory in Marietta, Georgia. The MCAs will be aligned to ensure a linear relationship, with a zero offset, between channels and energy. The internal computer-controlled digital gain in all MCAs is adjusted to align 1461 keV (K-40 photo peak) into channel 250. This calibration (5.844 keV per channel with 512 channels or 0 to 3 MeV) is used in order to resolve the 2.614 keV photon from the Tl-208 daughter product in the Th-232 decay chain. The detector will be calibrated to determine their intrinsic efficiency by placing National Institute for Standards and Technology (NIST) traceable button sources, Co-60 (nominal 0.5 μCi) or Cs-137 (nominal 9.0 μCi), one meter below the front face of the detector.

During operation, source response checks will be performed at the beginning and end of each day and at least once during the day (typically every five hours throughout the day). The source response checks will be performed by recording data over a fixed time while check sources are present. The sources will be mounted to a removable source response check fixture, which is mounted to the detector enclosure. The sources used for the source response checks are not typically NIST traceable. The sources are only intended to act as a stable artifact and not as a means of calibration. The source response checks are the same checks performed with hand-held instruments. In the case of the SMCM, the source response checks serve as a measure of the condition of the detector, preamps, and MCAs. Quality control charts for the source response checks will be maintained for each detector.

A density gauge will be used, and source response checks will be performed by the SMCM software whenever the belt is free of material.

4.7 Data Analysis

Implementation of a laboratory radiation detector in the field requires that added quality control / quality assurance measures be taken. Some of these added measures, as the standard measures described above in section 4.6, can be taken and evaluated before processing. However, the source of information for the majority of these measures comes from the data itself. The measures can only be evaluated after processing. The post analysis and data processing are described below; collectively, the two are commonly referred to as post processing.

4.7.1 Recorded Data

In order to achieve the needed detection limit and throughput, a large number of parameters will be recorded and analyzed by the SMCM system. For each acquisition, the live time and raw spectra is recorded for the detector. During operation, a summary file is also generated which records virtually every parameter that was collected or calculated for each acquisition.

The NASVD algorithms will be performed during the post processing. NASVD is a spectral component analysis procedure for the removal of noise from gamma-ray spectra. The procedure transforms observed spectra into orthogonal spectral components. The lower-order components represent the signal in the original observed spectra, and the higher-order components represent uncorrelated noise. Noise is removed from the observed spectra by rejecting noise components and reconstructing the spectra from lower-order components. The raw spectra files will be loaded for a particular data set and the NASVD software determines the principal components. Identification of point sources is one of the tasks for which NASVD is very efficient.

5. SORTING RESULTS

Summary reports for each L-Pile and O-Pile will be documented on the form "Sorting Release Record" as shown in Attachment #1.

Table 5-1 presents the proposed summary of the laboratory radiological information collected for random verification.

Table 5-1. Typical summary of laboratory radiological information collected.

Lab [pCi/g]				
Pile Name	**Value**	**2 Sigma**	**Detect**	**Sample Log Number**
O-1-B	2.0	0.0	No	123456
L-41-A	55.0	1.0	Yes	513274
O-12-A	30.0	1.0	Yes	113280

5.1 SMCM vs. Lab

The sorting data will be analyzed for any indication of bias between the SMCM and lab reported Tl-208. Sources of bias may be attributed to several sources: additional background counts come from the lower energy and add counts to the Tl-208 window from the material underneath and around the conveyor. Another contributing factor may be the use of a window that includes some Compton scattered photons as well as the primary photons assumed in the calibration model.

6. MARK III CONTAMINATION MONITORS

The characterization toolset is comprised of two tools: walk over activity monitor and an *in situ* contamination bucket monitor. The Mark III Contamination Monitor consist of a 3x3 NaI detector with a single channel analyzer. These tools have associated check-out and usage procedures, record the data for later analysis on a computer and have automated tools to gather and report the data.

6.1 Activity Monitor

This tool will be used in two modes: for walk over measurements and for static *in situ* measurements.

Walk-Over Mode: This tool utilizes the SRA model Mark III Contamination Monitor. This tool performs surface scans using an unshielded (or minimally shielded) detector. In this configuration the detector mounts to a hand-operated distance measuring device and is carried by the technician. This unit allows for quick monitoring where shine from nearby radiation sources is not of concern and where surface conditions are safe for workers to enter. This tool can also be used to screen the 2-foot lifts during backfill operations.

Static or Direct Push Mode: This tool utilizes the SRA model Mark III Contamination Monitor. This tool performs a spot check of the raw material "drying pile" or other areas in the raw material pond. In this configuration the detector is pushed into the raw material with raw material backfilled over the entire detector. This tool will be used in conjunction with the Walk-Over mode to subtract shine.

6.2 *In Situ* Bucket Monitor

This tool utilizes the SRA model Mark III Contamination Monitor. This tool provides 3 types of information: optimizes where to stop digging, allows the operator to identify levels of Th-232 in the material being excavated, and gives a rough analysis of the material being placed into a dump truck. A totalizer on the excavator will count each bucket going into a dump truck. The total will be manually reset with the information transferred by voice radio to the dump truck driver to indicate where the load should be dumped. This tool also reduces the volume of material that needs to be shipped off-site by pre-sorting into 2 piles: either < 31.1 pCi/g of Th-232 net or ≥ 31.1 pCi/g of Th-232 net.

7. RESPONSIBILITIES

SRA will be responsible for data collection and analysis from the SMCM and operated by a single Radiological Engineer or technician.

Quality control checks and data review will be done by an SRA engineer located in Marietta, GA.

Maintenance and repair of SRA equipment will be handled by an SRA mechanical engineer.

RECON's radiological control technicians (RCTs) and equipment operators will be trained to use the Mark III Contamination Monitors.

8. MOBILIZATION

Currently, mobilization by SRA to the Tulsa job site is planned for April 26th, 2004. The conveyor system will be installed and commissioned before SRA's arrival. The SRA system should take one week to install, calibrate and run a performance test on the SMCM system.

9. PROCEDURES

SRA will use the following SRA procedures:

Subsurface Multi-spectral Contamination Monitor (SMCM)

- SMCM Procedure 004

- o Source Response Checks and Performance Based Checks of any NaI Detector Configuration Installed on the SMCM
- SMCM Procedure 005
  - o Calibration and Confirmation of a SMCM Incremental Encoder
- SMCM Procedure 006
  - o Requirements for Completion of a Survey Using the SMCM
- SMCM Procedure 007
  - o Calibration of NaI Detector

Mark III Contamination Monitor

- Mark III Contamination Monitor Procedure 001
  - o Calibration of Mark III Contamination Monitor NaI Detector
- Mark III Contamination Monitor Procedure 002
  - o Requirements for Completion of a Survey Using the *In Situ* Bucket Monitor
- Mark III Contamination Monitor Procedure 003
  - o Requirements for Completion of a Survey Using the Walk/Roll Over Activity Monitor (ROAM)
- Mark III Contamination Monitor Procedure 004
  - o Requirements for Completion of a Survey Using the Subsurface Contamination Radiation Activity Monitor (SCRAM)
- Mark III Contamination Monitor Procedure 005
  - o Source Response Checks and Performance Based Checks of any Mark III Contamination Monitor NaI Detector

SRA will adhere to the following RECON plans:

RECON Radiation Health and Safety Plan (RHASP) Revision 01, April 2004

RECON Environmental Health and Safety Plan (EHASP), February 2004

All applicable RECON procedures

Sorting Release Record

Pile Name	L-0001-A
Sorting Equipment	Sub-Surface Multi-Spectral Contamination Monitor
Sorting Date	12-May-2004 15:29:52, 12-May-2004 14:41:48
Sorter Operator	K. Murray
Sorted Material	Soil and Dross
Criteria	55.0 pCi/g
Number of Measurements	921
Tons Sorted	100.0

Table 1. SMCM Concentrations reported in pCi/g.

Isotope	Mean	Median	Maximum	Minimum	2-Sigma
Th-232	45.9	43.0	79.2	25.5	0.13

Procedures

PROCEDURE: SMCM 004

Source Response Checks and Performance Based Checks of any NaI Detector Configuration Installed on the SMCM

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 04

EFFECTIVE DATE: APRIL 2004

Approved, Bill Vinzant 4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation Date Approved:

PROCEDURE: SMCM 004

Source Response Checks and Performance Based Checks of any NaI Detector Configuration Installed on the SMCM

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 04

EFFECTIVE DATE: APRIL 2004

4/27/04 4/22/04

Reviewed by: Date: Quality Control Manager: Date:

Control Copy #______

Shonka Research Associates, Inc.
4939 Lower Roswell Road, Suite 106
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770-509-7606

Subsurface Multi-spectral Contamination Monitor

SMCM Procedure 004, Rev4

Source Response Checks and Performance Based Checks of any NaI Detector Configuration Installed on the SMCM

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES
001	M. Marcial	11/5/01	Style
002	D. Debord	11/25/01	Equation 1 and Grammatical
003	M. Marcial	2/14/03	Added to Project Manager responsibilities. Added conditions to be followed when the SMCM Process Software is configured to report net values. Added the option to use the SMCM Process Software PBC feature for SRCs and PBCs.
004	K. Murray	4/1/04	Added exemption for PBCs when conditions warrant.

REVIEWED BY: Michael Marcial		DATE:
QA REVIEW BY: Deborah Shonka	Deborah B. Shonka	DATE:

EFFECTIVE DATE: 4/1/04

1. Purpose

This procedure details the requirements for baseline Source Response Checks (SRC), daily SRCs, and Performance Based Checks (PBC) of any NaI detector configuration installed on the SMCM.

2. Scope and Limitations

This procedure applies to version 1.0 or later of the SMCM process software.

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
SMCM	The Subsurface Multispectral Contamination Monitor is a mobile platform containing detectors, support electronics, and data logger used for conducting radiological surveys.
SIMS	Survey Information Management System – SIMS is flexible and comprehensive interfacing software for the SRA SMCM. SIMS processes the SMCM instrument data with a sophisticated data parser, integrated spreadsheet, and powerful special functions such as spatial data filters. SIMS provides the most flexible reporting system available for printing survey records or complete stand-alone survey reports. SIMS contains all the tools needed to meaningfully communicate between the SMCM and the data analysis team.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.
PBC	Performance Based Check – Provides measurement of the system's performance in field conditions.
ROI	Region of Interest – Channels assigned to a particular isotope.

4. General Information

Normal operation of the SMCM with a NaI requires daily SRCs to assure that the NaI is performing within acceptable limits. Perform this procedure at the beginning and end of each shift for each detector in use. Compare the results of the daily SRC to the baseline SRC for this project. Use the initial daily SRC for a project as the baseline SRC.

Any time a system component or operating parameter changes, take a new baseline SRC for comparison with proceeding days. Examples of altered parameters would be:

1. Calibration source changed.
2. Detector replaced.

Perform Performance Based Checks (PBC) at a minimum of approximately every 5 hours during performance of the survey. The PBCs confirm constant system performance. The measurements are used to bound surveys. Failure of a PBC constitutes rejection of the surveys it bounds.

5. Materials, Equipment, and Supplies.

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
SMCM	Platform and with detector height and width specifications as determined by Project Manager.
SMCM Process Software	Version 1.0 or later.
MCA Process Software	Maestro, ScintiVision, or equivalent.
SIMS	Current approved version.
NaI	Insulated Sodium Iodide detectors with mu and low energy gamma ray shields.
Check Source	As determined by Project Manager.

6. Responsibilities

6.1. Project Manager

6.1.1. Determines the check source type and activity to use

6.1.2. Determines the ROIs to be used for the SRCs.

6.1.3. Evaluates SRCs that fail the acceptance criteria

6.1.4. Determines if the SMCM Process Software will be configured to report net values using active background subtraction.

6.1.5. Has successfully completed SMCM Level II Training.

6.2. Operator

6.2.1. Reads and becomes familiar with this procedure before performing calibration.

6.2.2. Performs all measurements in accordance with this procedure.

6.2.3. Has successfully completed SMCM Level I training.

7. Procedure

7.1. Background Spectra Check Measurement

7.1.1. If the SMCM Process Software is configured to report net values, then take a 10-minute background spectra using ScintiVision. Compare the shape of the whole spectra to previously stored spectra. Perform this measurement before the SRC and PBC measurements.

7.2. Source Response Check Measurement using MCA Software

7.2.1. If this is a baseline SRC, use the form in Appendix A, "Baseline Source Response Check Form"; otherwise, use the form in Appendix B, "Daily Source Response Check Form." Use this procedure for all detectors regardless of configuration. Perform all Source Response Checks with the detector and source stationary. Use the source placement jig on the detector.

Note: Check sources are matched to each detector at the beginning of the survey. For each detector use only check sources that have been specifically assigned to that detector.

7.2.2. The Project Manager will provide a list of Isotopes and corresponding ROIs as well as count times for the sources. Generally, count times are 1 to 5 minutes yielding 10,000 to 100,000 net cpm.

7.2.3. Launch MCA software and select detector of interest.

7.2.4. Make sure that there are no unshielded sources near the detector.

7.2.5. Clear the display and initiate a count.

7.2.6. When the count is complete, integrate each ROI and record the number of background counts for each isotope.

7.2.7. Record the measured background on the appropriate form in the column labeled "ROI Background Counts" and the corresponding isotope row.

7.2.8. Place the appropriate check source in the source jig on the detector.

7.2.9. Clear the display and initiate a count.

7.2.10. When the count is complete, integrate each ROI and record the number of source counts for each isotope.

7.2.11. Record the measured source counts on the appropriate form in the column labeled "ROI Source Counts" and the corresponding isotope row.

7.2.12. Repeat Steps 7.2.8-7.2.11 for each isotope of interest.

7.2.13. Repeat Steps7.2.3-7.2.12 for each detector in the NaI array. If more than one detector is used and more than one check source is available, then multiple detectors may be counted in step 7.2.12 by placing a source on each detector.

7.3. Source Response Check Measurement using SMCM Process Software

7.3.1. If the SMCM Process Software is configured to report net values and the only isotope of concern is Cs-137, then this section may be used to measure and track the SRCs. There must be as many check sources available as detectors in the SMCM detector array.

7.3.2. The Project Manager will provide a list of Isotopes and corresponding ROIs as well as count times for the sources. Generally, count times are 1 to 5 minutes yielding 10,000 to 100,000 net cpm.

7.3.3. Perform all Source Response Checks with the detector and source stationary. Use the source placement jig on the detector.

Note: Check sources are matched to each detector at the beginning of the survey. For each detector use only check sources that have been specifically assigned to that detector.

7.3.4. Place the appropriate check sources in the source jig on each detector.

7.3.5. Launch SMCM Process software and execute the PBC feature and follow the on screen prompts.

7.4. Source Response Check Evaluation

7.4.1. If section 7.3 was used to take the SRCs, then follow this step and skip the rest of this section. Otherwise, skip this step. The SMCM Process software uses a stored spreadsheet that updates with the new count values and displays a graph. Compare the graph values with the acceptance criteria contained in Step 8.1.2. If the value is greater than the acceptance criteria, notify the Project Manager.

7.4.2. For each ROI, subtract the recorded background entered in the data table in the column labeled "ROI Background Counts" from the recorded "ROI Source Counts" for each detector, and enter the result in the "ROI Net Counts" column.

Note: If this procedure is being done to establish a baseline, it is now complete. If this is a comparison to baseline, proceed to step 7.4.3

7.4.3. Copy values in the column labeled "ROI Net Counts" from the baseline form for each detector onto the form "Daily Source Response Check Form" in the column labeled "Baseline Net Counts" provided in Appendix B.

7.4.4. For each detector perform the calculation shown in Equation 1 and record the value in block "Percent Difference from Baseline Measurement" on the form in Appendix B.

$$100 \times \left| \frac{\text{Daily NetCounts} - \text{Baseline NetCounts}}{\text{Baseline NetCounts}} \right|$$

Equation 1

7.4.5. Compare these values with the acceptance criteria contained in Step 8.1.2. If the value is greater than the acceptance criteria, notify the Project Manager.

7.5. Survey Performance Based Checks

Note: Perform Performance Based Checks (PBCs) with the detectors operating in the mode in which the surveys bounded by the Performance Based Checks will be performed.

7.5.1. Perform periodic PBCs during the performance of the survey, unless conditions prevent the PBC from being implemented. Perform PBCs at the beginning of the shift, approximately every 5 hours of surveying, and at the completion of each shift.

7.5.2. Document if conditions prevent PBCs from being performed.

Note: Check sources are matched to each detector at the beginning of the survey. For each detector use only check sources that have been specifically assigned to that detector. The source used for efficiency determination is acceptable but not required to be used.

7.5.3. Obtain PBCs in the same performance manner as normal surveys, i.e. detector height, heating, amplifier gain.

7.5.4. If the SMCM Process Software is configured to report net values, you may skip steps 7.5.5 through 7.5.8 and use the SMCM Process software PBC feature by following all steps in section 7.3. This technique will graph the initial daily SRC and all subsequent daily PBCs on the same chart.

7.5.5. Place each source onto its corresponding detector.

7.5.6. Press the <Record> button. Continue the strip until at least 20 acquisitions have been logged.

7.5.7. Record the time, filename, strip numbers, and the source used in the logbook or survey form.

7.5.8. Repeat 7.5.6 through 7.5.7 without the sources present to establish a background for the PBC.

7.5.9. Evaluation of the PBCs for the duration of the survey occurs in the survey report issued upon completion of the survey.

8. Acceptance Criteria

8.1. SRC

8.1.1. For baseline SRCs, there is no acceptance criterion.

8.1.2. Daily SRCs are acceptable if all "Percent Difference from Baseline Measurement" values are less than 20%

8.2. PBC

8.2.1. Use SIMS to process the PBC data files. Optionally, if the PBC option within the SMCM Process software was used to collect and generate the control charts, the data has already been processed into a control chart. Establish a control chart indicating the mean and "2-sigma" and "3-sigma" values. Evaluate subsequent PBCs against the "2-sigma" and "3-sigma" criteria and for indications of adverse trends. If two consecutive measurements obtained during a PBC are greater than the "2-sigma" or if any measurement is greater than "3-sigma", the PBC fails.

8.2.2. Surveys bounded by a failed PBC are considered suspect. The nature of the failure must be determined. The Project Manager has the option to invalidate surveys bounded by a failed SRC.

9. References

N/A

10. Required Records

The forms in Appendix A and B shall be kept with the survey documentation.

If the SMCM Process software was used to generate spreadsheets and graphs, the Excel files are required to be kept with the survey documentation.

11. Appendices

11.1. Appendix A: Baseline Source Response Check Form

11.2. Appendix B: Daily Source Response Check Form

Appendix A

Baseline Source Response Check Form

Baseline Source Response Check Form

SMCM CONFIGURATION: ________________ SMCM SERIAL NUMBER: ________________

DETECTOR SERIAL NUMBER OR ID: ______

ISOTOPE / SERIAL NUMBER	ROI CHANNELS	ROI BACKGROUND COUNTS	ROI SOURCE COUNTS	ROI NET COUNTS

NOTE: ENTER N/A FOR ALL NON-EXISTING ISOTOPES

PERFORMED BY: ________________________________ DATE: ________________

REVIEWED BY: ________________________________ DATE: ________________

Appendix B

Daily Source Response Check Form

Daily Source Response Check Form

BASELINE SOURCE RESPONSE CHECK CONFIGURATION DATE: ______________

SMCM CONFIGURATION: ______________ SMCM SERIALNUMBER: ______________

DETECTOR SERIAL NUMBER OR ID: ________

ISOTOPE / SERIAL NUMBER	ROI CHANNELS	ROI BACKGROUND COUNTS	ROI SOURCE COUNTS	ROI NET COUNTS	BASELINE NET COUNTS	PERCENT DIFFERENCE FROM BASELINE MEASUREMENT

ENTER N/A FOR ALL NON-EXISTING ISOTOPES

INITIALS ___ NO MEASUREMENT VARIES MORE THAN 20% FROM BASELINE

INITIALS ___ PASSED

PERFORMED BY: ______________________ DATE: ______________

REVIEWED BY: ______________________ DATE: ______________

PROCEDURE: SMCM 005

Calibration and Confirmation of a SMCM Incremental Encoder

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 03

EFFECTIVE DATE: APRIL 2004

Approved, Bill Vinzant   4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation   Date Approved:

PROCEDURE: SMCM 005

Calibration and Confirmation of a SMCM Incremental Encoder

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 03

EFFECTIVE DATE: APRIL 2004

[signature]	4/22/04	[signature]	4/22/04
Reviewed by:	Date:	Quality Control Manager:	Date:

Control Copy #______

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Subsurface Multi-spectral Contamination Monitor

SMCM Procedure 005, Rev3

Calibration and Confirmation of a SMCM Incremental Encoder

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES
001	M. Marcial	11/5/01	Style
002	D. Debord	11/25/01	Added Definition
003	M. Marcial	2/14/03	Added encoder confirmation when the platform is stationary and the material to be surveyed is moving. Unified names and Appendix A, Appendix B and the procedure text.

REVIEWED BY: Javid Kelley		**DATE:**
QA REVIEW BY: Deborah Shonka		**DATE:**

EFFECTIVE DATE: 3/6/03

1. Purpose

The purpose of this procedure is to establish the methods for calibration and verification of the incremental encoder included on the SMCM.

2. Scope and Limitations

Any SMCM used to conduct a rolling survey must have completed a valid encoder confirmation. A new encoder confirmation must be performed IF any of the following occur.

1. Maintenance on the encoder.
2. Disassembly/re-assembly of the system or platform.
3. A new computer, software, or encoder is added to the cart.
4. 24 months since last confirmation.
5. Anomalies in the reported strip distance are noticed by the operator.

Calibration should be performed whenever the mean of an encoder confirmation exceeds 1% error.

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
SMCM	The Subsurface Multispectral Contamination Monitor is a mobile platform containing detectors, support electronics, and data logger used for conducting radiological land surveys.
Incremental Encoder	Electronic device used to measure distance via rotation.
Target Survey Speed	Maximum survey speed determined to support required MDA.
MDA	Minimum Detectable Activity.
TTL	Transistor Transistor Logic

4. General Information

The incremental encoder provides a method of determining the distance traveled by the SMCM. As the encoder turns, TTL level pulses are generated at regular intervals. A calibration factor in pulses per inch allows the SMCM to determine distance by number of pulses. This calibration factor could be determined by dividing the pulses per rotation by the circumference of the wheel. To reduce the impact of measurement error this procedure determines the calibration factor by rolling the cart a known distance and dividing by the pulses received by the counter card in the SMCM to get a pulse/in factor. The user must be cautious to operate the SMCM in straight lines. Failure to do so can result in distance errors of more than 1%.

5. Materials, Equipment, and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
SMCM Platform with installed incremental encoder	Any Model
SMCM Software	Version 2.0 or later
Tape Measure or Laser Range Finder	100 m or Suitable Equivalent
Location marking	Flags or Poles
Survey Documentation	Survey Logbook

6. Responsibilities

6.1. Operator

6.1.1. Reads and becomes familiar with this procedure before performing calibration.

6.1.2. Has successfully completed SMCM I training.

6.1.3. Ensures the measurements are performed according to this procedure.

7. Procedure

7.1. Encoder Confirmation for Moving Platforms

7.1.1. Mark a beginning position by placing a marker directly beneath the centerline of the detector array.

7.1.2. Place a second marker at a distance of 30m for user-propelled systems or 100m for vehicular-propelled systems.

7.1.3. Initiate the measurement by pressing the "Record" button.

7.1.4. Begin moving the SMCM platform toward the second flag.

Note: The platform must be kept traveling in a straight line or the reported distance may be misreported in relation to the actual distance.

7.1.5. Stop the platform when the centerline of the detector array lines up with the second flag.

7.1.6. Complete the measurement by pressing the "Stop" key.

7.2.Encoder Confirmation for Stationary Platforms

7.2.1. If a conveyor is used to transport material by the stationary SMCM then follow this section.

7.2.2. Measure the distance of the conveyor belt that the wheel encoder will ride on.

7.2.3. Mark the belt. This mark will be used to start and end the recording of a strip.

7.2.4. Initiate the measurement by pressing the "Record" button when the mark passes by a reference point.

7.2.5. Record a strip that is at least 75 meters. The belt may need to make more than 1 revolution.

7.2.6. Stop the measurement by pressing the "Stop" button when the mark passes by the starting reference point.

7.2.7. Calculate the actual distance the mark traveled.

7.3.Encoder Confirmation Evaluation

7.3.1. Record the reported and actual distances (in meters) in Appendix A "Incremental Encoder Calibration Verification Data Sheet."

7.3.2. Repeat steps 7.1 or 7.2 two additional times for a total of three measurements.

7.3.3. Calculate the mean and the percent deviation from the mean for each of the three measurements using Equation 1. Record the mean and percent deviation from the mean for each measurement in Appendix A "Incremental Encoder Calibration Verification Data Sheet."

Equation 1

$$Deviation\% = \left|\frac{Mean - Measurement}{Mean}\right| * 100$$

7.3.4. If the mean of the three measurements differs from the actual distance by more than 1%, proceed to 7.4 and perform an encoder calibration.

7.3.5. Calculate the percent deviation of the mean from the actual distance using Equation 2. Record the value in Appendix A "Incremental Encoder Calibration Verification Data Sheet."

Equation 2

$$Deviation\% = \left|\frac{Mean - ActualLength}{Mean}\right| * 100$$

7.3.6. If the deviation from the mean is larger than 3% for any measurement, repeat the confirmation test or troubleshoot encoder.

7.4. Encoder Calibration

7.4.1. Perform confirmation measurements outlined in 7.1 or 7.2.

7.4.2. Record the mean of the three confirmation measurements in the logbook.

7.4.3. Calculate a new encoder calibration constant based on the confirmation measurements average. Record the following on the Appendix B "Encoder Calibration Data Sheet":

- Enter the old encoder calibration constant in $Constant_{old}$
- For conveyor systems, enter the actual distance the mark traveled in *ActualDistance.*
- For user-propelled systems, enter the 30 in *ActualDistance.*
- For vehicular-propelled systems, enter 100 in *ActualDistance.*
- Enter the value shown on the SMCM Process software screen labeled "Distance Traveled [m]" in *REportedDistance.*

7.4.4. Set software to new encoder calibration constant.

7.4.5. Perform encoder confirmation in Section 7.1 to verify new encoder calibration constant.

8. Acceptance Criteria

Completion of a successful encoder confirmation routine.

All encoder confirmation and/or calibration information has been recorded in the survey logbook.

9. References

9.1.SMCM Procedure 006, "Requirements for Completion of a Survey Using the SMCM."

10. Required Records

10.1. Survey Logbook

11. Appendices

11.1. Appendix A: Incremental Encoder Calibration Verification Data Sheet

11.2. Appendix B: Encoder Calibration Data Sheet

Appendix A

Incremental Encoder Calibration Verification Data Sheet

Appendix A

Incremental Encoder Calibration Verification Data Sheet

Date: ___________ SMCM S/N: _____________

SMCM Speed: ___________

Note: The test should be performed at the intended survey speed.

Table 1: Strip Distances

Measurement	Distance (Meters)	Dev. From Mean (%)	Dev. From Mean Limit (%)
1			3
2			3
3			3
Mean		N/A	N/A
Actual Distance*		N/A	N/a

*Distance between flags for moving platforms or marks on a conveyor for stationary platforms.

Mean deviation from actual distance: _______ %

Init ____ **Mean Deviation from Actual Distance less than 1%**

Init ____ **Deviation from Mean for each Measurement within 3% of the Actual Distance**

Performed By: ______________________ Date: ___________ Time:__________

Reviewed By: ______________________ Date: ___________ Time:__________

Appendix B

Encoder Calibration Data Sheet

Appendix B

Encoder Calibration Data Sheet

Date: ____________ SMCM S/N: ______________

SMCM Speed: ____________

Note: The test should be performed at the intended survey speed.

ReportedDistance (this is the value shown on the SMCM Process software screen labeled "Distance Traveled [m]") Enter the mean of 3 distance measurements.	__________ m
$Constant_{Old}$	__________ pulse/m
ActualDISTANCE (Distance between flags for moving platforms or marks on a conveyor for stationary platforms.)	__________ m

$$Constant_{New} = \frac{Constant_{Old} * ActualDISTANCE}{REportedDistance}$$

$Constant_{New}$: _____________ pulse/m

Init ____ **SMCM Process software updated with *$Constant_{New}$***

Init ____ **Perform encoder confirmation.**

Performed By: ________________________ Date: ____________ Time:__________

Reviewed By: ________________________ Date: ____________ Time:__________

PROCEDURE: SMCM 006

Requirements for Completion of a Survey Using the SMCM

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 03

EFFECTIVE DATE: APRIL 2004

Approved, Bill Vinzant 4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation Date Approved:

PROCEDURE: SMCM 006

Requirements for Completion of a Survey Using the SMCM

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 03

EFFECTIVE DATE: APRIL 2004

4/22/2004 4/22/04

Reviewed by:	Date:	Quality Control Manager:	Date:

Control Copy #______

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Subsurface Multi-spectral Contamination Monitor

SMCM Procedure 006, Rev 3

Requirements for Completion of a Survey Using the SMCM

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES
000	M. Marcial	11/12/01	Major Revision to 001
001	D. Debord	11/25/01	Stop Work Conditions
002	M. Marcial	2/14/03	Added section when SMCM platform is used in stationary mode and a conveyor transports material by the system.
003	K. Murray	4/1/04	Added assessment of Stop Work Conditions.

REVIEWED BY: Michael Marcial		**DATE:**
QA REVIEW BY: Deborah Shonka	Deborah B. Shonka	**DATE:**

EFFECTIVE DATE: 4/1/04

1. Purpose

The purpose of this procedure is to detail the requirements for completion of a survey using the SMCM.

2. Scope and Limitations

This procedure applies to version 1.0 or later of the process software.

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
SMCM	The Subsurface Multispectral Contamination Monitor is a mobile platform containing detectors, support electronics, and data logger used for conducting radiological surveys.
SIMS	Survey Information Management System – SIMS is flexible and comprehensive interfacing software for the SRA SMCM. SIMS processes the SMCM instrument data with a sophisticated data parser, integrated spreadsheet, and powerful special functions such as spatial data filters. SIMS provides the most flexible reporting system available for printing survey records or complete stand-alone survey reports. SIMS contains all the tools needed to meaningfully communicate between the SMCM and the data analysis team.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.
PBC	Performance Based Check – Provides measurement of the system's performance in field conditions.
ROI	Region of Interest – Channels assigned to a particular isotope.
MCA	Multi-Channel Analyzer-Equipment used to view spectral data.

4. General Information

4.1. Scanning Mode

Upon arrival on site, the encoder will be checked per SMCM Procedure 005 and the NaIs will be source checked per SMCM Procedure 004 and calibrated per SMCM Procedure 007.

The array mounted NaI detectors can be used for both scanning and *in situ*. Survey speed will be established by the Project Manager based on the isotopes of concern and sensitivity to be attained.

For Moving Platforms: A survey is conducted in a series of strips, which can be reassembled in SIMS to provide complete documentation of a survey without requiring any manual transfer of data. To accomplish a survey an operator first makes a crude sketch of the area and indicates the direction and start point of each strip. The file name of the survey should be recorded on the sketch and a reference coordinate for the South West corner of the survey area should be noted. The survey is divided into strips by placing large markers and flags on opposing edges of the survey area. The operator starts the SMCM software if it is not already active and enters the survey parameters: Survey Name (File Name), and Operator ID. The SMCM platform scans strait strips of the survey area. Once the entire accessible survey area has been covered by the SMCM, the survey is complete. *In situ* measurements may be incorporated into the survey in areas that are not accessible to the SMCM.

For Stationary Platforms: A survey is conducted in a series of strips, which can be reassembled in SIMS to provide complete documentation of a survey without requiring any manual transfer of data. To accomplish a survey an operator decides what a collection of strips will represent, i.e., a 250-ton pile of material, a B-25 container, etc. The filename of the survey should be recorded in the logbook. The operator starts the SMCM software if it is not already active and enters the survey parameters: Survey Name (File Name), and Operator ID. The SMCM platform scans strips of the survey material. This procedure will reference the movement of the material past the SMCM platform as a conveyor. Other conveying mechanisms may be used besides a typical conveyor with belt. Once the entire collection of strips area has been covered by the SMCM, the survey is complete.

4.2. *In situ* mode

In situ surveys using the SMCM platform should be performed per SMCM Procedure 002.

5. Materials, Equipment, and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
SMCM platform	Any platform with detector heights and spacing as determined by survey team leader.
Software	SMCM Process
Field Notes	Logbook
Reference markers	Existing landmarks or identified known GPS locations
Strip markers	Flags or Equivalent
Differential GPS (if available)	Any device capable of outputting NEMA strings that the SMCM Process software can interpret

6. Responsibilities

6.1. Operator

6.1.1. Reads and becomes familiar with this procedure before performing calibration.

6.1.2. Ensures all surveys are performed according to this procedure.

6.1.3. Operates the SMCM during the survey.

6.1.4. Guides and Monitors the SMCM's speed throughout the surveys.

6.1.5. Has successfully completed SMCM I training.

6.2. Project Manager

6.2.1. Reads and becomes familiar with this procedure.

6.2.2. Confirms the quality of SMCM operations.

6.2.3. Periodically confirms quality of collected SMCM data.

6.2.4. Has successfully completed SMCM II Training.

6.2.5. Establish SMCM survey speed and NaI temperatures.

7. Procedure

7.1. Initial SMCM Preparation

7.1.1. Confirm the survey platform is in good working condition and is setup appropriately for the survey area environment.

7.1.2. *For Moving Platforms:* Establish a reference heading e.g. Magnetic, True, or Map North, or a direction based on permanent site landmarks. All data strips will be taken parallel or perpendicular to the reference heading.

7.1.3. Turn detector heaters on and set thermostat to temperature determined by Project Manager.

WARNING
The temperature of the NaI detectors should not exceed 100° F.

7.1.4. *For Moving Platforms:* When available, turn differential GPS on.

7.1.5. Calibrate SMCM encoder per SMCM Procedure 005.

7.1.6. If not already done, calibrate NaI detectors per SMCM Procedure 007.

7.2. Survey Setup

7.2.1. If using a gas generator, ensure there is enough gas in the generator to complete the survey area.

7.2.2. If using the radon detector, start the pump 20 minutes before data collection.

7.2.3. If using the detector thermal stabilizers, start the electronics 20 minutes before data collection.

7.2.4. Start the SMCM software if it was not already running.

7.2.5. Align detectors using the SMCM Process software alignment feature.

7.2.6. If this is the beginning of a shift, perform daily Source Response Check and Performance Based Check per SMCM Procedure 004.

7.2.7. *For Moving Platforms:* Establish a survey grid. The edges of the survey grid must be parallel or perpendicular to the established reference heading. Square or rectangular (with the longer edge being the primary direction of travel) survey grids are generally more efficient. The time of the survey generally increases with the number of strips required to cover the grid.

7.2.8. *For Moving Platforms:* Make a crude sketch of the survey area including distances.

7.2.9. *For Moving Platforms:* Identify SW corner on drawing and provide a reference coordinate, if available.

7.2.10. *For Moving Platforms:* When available, take a differential GPS reading in the South West corner of the survey grid.

7.2.11. Record the date, time, location, and detector temperatures in the logbook.

7.2.12. *For Moving Platforms:* Indicate strip locations and directions on sketch with arrows.

7.2.13. *For Moving Platforms:* Identify and mark the first survey lane using a tape measure and stake or other markings. Center a stake at the end of the first strip.

7.3. Scanning Survey Operations

7.3.1. When prompted by the SMCM software, enter a survey name and record the name on the sketch of the survey. For stationary platforms, there is no sketch of the area.

7.3.2. *For Moving Platforms:* When possible, move the SMCM platform to the South West corner of the survey grid. Else, move to the most easily accessible corner, and align the detector array even with the edge of the survey grid, pointed in the direction of travel.

7.3.3. Start recording the strip by hitting the <Start> button in the SMCM software. For Stationary Platforms, assure the conveyor is clear of material. After pressing the start button, the SMCM process software will indicate it is ready for material after its internal filters are conditioned. The initial conditioning of the filters happens only when the software is first started or the operator performs a filter reset.

7.3.4. *For Moving Platforms:* Using a marker at the other side of the survey grid as a target, drive the array across the survey area at the speed determined by the Project Manager.

7.3.5. *For Moving Platforms:* If obstacles prevent completing the strip, stop the strip by hitting the <Stop> button in the SMCM software, note on survey sketch, start a second strip on the other side of the obstacle, or turn the platform around and repeat steps 7.3.3 through 7.3.5.

7.3.6. For Stationary Platforms: After a pre-determined time or if the conveyor is out of material, stop the strip by pressing the <Stop> button. The Project Manager determines the pre-determined time of a typical strip. The SMCM software may stay in record mode when no material is present. However, it is not recommended to un-necessarily record background data.

7.3.7. For Stationary Platforms: If the SMCM Process software indicates an alarm, then wait for the conveyor to stop, and then stop the strip by pressing the <Stop> button. Use the SMCM Process software post-visualization feature to identify the type of alarm and its location along the conveyor.

7.3.8. *For Moving Platforms:* Once the array is over the marker at the opposite edge of the survey grid, hit the <Stop> button to complete the survey strip.

7.3.9. *For Moving Platforms:* Turn the array around and align it next to the previous one.

7.3.10. Monitor the SMCM Process software alignment peak window after every strip, every 30-minutes or whenever it is suspected that the system is becoming misaligned. Mis-alignment is typically seen when the ambient temperature is changing.

7.3.11. Repeat 7.3.3 through 7.3.7 until all accessible areas of the survey grid have been surveyed.

7.3.12. Record the stop time in the logbook.

7.3.13. Perform Performance Based Checks in accordance with SMCM Procedure 004

7.4. Stop work conditions

Note: Under the following conditions, an assessment shall be made that evaluates if these conditions impact survey data.

7.4.1. Onset of moderate rain or snowfall that removes radon daughters from air and their impact on product measurement.

7.4.2. Standing water in excess of .5 inches deep or snow in excess of 6 inches deep over areas larger than 10 m^2, unless specifically approved by the Project Manager.

7.4.3. Movement of sources greater than 50 nCi at a distance of 1 meter from a detector. The activity shall be adjusted for inverse square relation.

7.4.4. Rapid change in ground level radon daughter product concentration due to inversion.

7.4.5. Large temperature changes.

8. Acceptance Criteria

None, outside of the reference procedures.

9. References

9.1. SMCM Procedure 005 "Calibration and Confirmation of Incremental Encoder"

9.2. SMCM Procedure 004 "Source Response Checks and Performance Based Checks of any NaI Detector Configuration Installed on the SMCM"

9.3. SMCM Procedure 007 "Calibration of NaI detector"

10. Required Records

N/A

11. Appendices

N/A

PROCEDURE: SMCM 007

Calibration of NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 02

EFFECTIVE DATE: APRIL 2004

Approved, Bill Vinzant 4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation Date Approved:

PROCEDURE: SMCM 007

Calibration of NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 02

EFFECTIVE DATE: APRIL 2004

Reviewed by:	Date: 4/22/04	Quality Control Manager:	Date: 4/22/04

Control Copy #______

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Subsurface Multi-spectral Contamination Monitor

SMCM Procedure 007, Rev2

Calibration of NaI Detector

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES
000	M. Marcial	11/5/01	Major Revision to 003
001	D. Debord	11/25/01	Added Calibration Stickers
002	M. Marcial	2/14/03	Added Project Manager responsibilities. Added required records.

REVIEWED BY: Javid Kelley		**DATE:**
QA REVIEW BY: Deborah Shonka	Deborah B. Shonka	**DATE:**

EFFECTIVE DATE: 3/6/03

1. Purpose

The purpose of this procedure is to define the operational methods and requirements for performing a detector/source calibration with any MkIII.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
SMCM	The Subsurface Multispectral Contamination Monitor is a mobile platform containing detectors, support electronics, and data logger used for conducting radiological surveys.
SIMS	Survey Information Management System – SIMS is flexible and comprehensive interfacing software for the SRA SMCM. SIMS processes the SMCM instrument data with a sophisticated data parser, integrated spreadsheet, and powerful special functions such as spatial data filters. SIMS provides the most flexible reporting system available for printing survey records or complete stand-alone survey reports. SIMS contains all the tools needed to meaningfully communicate between the SMCM and the data analysis team.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.
PBC	Performance Based Check – Provides measurement of the system's performance in field conditions.
ROI	Region of Interest – Channels assigned to a particular isotope.

4. General Information

Before any gamma spectroscopy in support of land surveys are performed with NaI detectors, all detectors must be calibrated. The data collected from the calibration will be used to calculate calibration factors for the duration of the survey. The calibration factor will convert count rate into planar or deposited concentrations.

5. Material Equipment and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
Detector	Any size NaI or equivalent gamma detector.
Software	MCB software
NIST traceable Check Sources	^{60}Co, ^{137}Cs & other if Scope requires.
Hardware	µAce or µNomad MCA
Computer	Desktop PC or PocketPC
Field Notes	Log Book

6. Responsibilities

6.1. Technician

6.1.1. Reads and becomes familiar with this procedure.

6.1.2. Ensures that all measurements are made in accordance with this procedure.

6.2. Project Manager

6.2.1. Determines the calibration source and count times to use.

6.2.2. Ensures that all measurements are made in accordance with this procedure.

7. Procedure

7.1. Alignment of NaI Spectrum

7.1.1. Prior to performing the calibration, alignment of the spectrum channels shall be performed.

7.1.2. Alignment shall occur for each detector in use.

7.1.3. The alignment is typically performed using the ^{40}K background peak.

7.1.4. The alignment is performed by adjusting the gain in the SMCM or MCA software to shift the ^{40}K peak until the center of the 1461 keV peak is centered in channel 250, when the multi-channel analyzer is set to a conversion gain of 512 channels.

7.2. Calibration of NaI Detectors

7.2.1. Prior to field use, each NaI detector will be calibrated to NIST traceable sources. Calibrations will include ^{60}Co and ^{137}Cs sealed sources, or other isotopes approved by the Project Manager based on the specific survey requirements.

7.2.2. Calibration of the NaI detector will be performed by taking a 10-minute background using the NaI detector/MCA system.

7.2.3. Then take a 10-minute count with the source exactly 1 meter below the bottom face of the crystal. The count time may be varied based upon the source strength. (determined by the Project Manager).

7.2.4. Visually inspect the recorded peak and record the net counts, center channel and FWHM in the logbook.

7.2.5. Record the background and source spectra in the computer as a *.CHN file.

7.2.6. Perform Source Response Check and Performance Based Check in accordance with SMCM Procedure 004 to establish traceability to the calibration measurement.

7.2.7. Affix a calibration sticker to the detector. The due date shall not exceed 6 months from the current date.

7.2.8. Repeat steps 7.2.2 to 7.2.7 for each detector to be used.

8. Acceptance criteria

8.1. Reported source to NaI crystal distance is within ±5mm.

9. References

N/A

10. Required Records

10.1. Background and Source *.CHN files.

11. Appendices

N/A

PROCEDURE: Mark III Contamination Monitor 001

Calibration of Mark III Contamination Monitor NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: APRIL 2004

Approved Bill Vinzant 4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation Date Approved:

PROCEDURE: Mark III Contamination Monitor 001

Calibration of Mark III Contamination Monitor NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: APRIL 2004

[signature] 4/22/04 [signature] 4/22/04

Reviewed by:	Date:	Quality Control Manager:	Date:

Control Copy #______

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MkIII Contamination Monitor

MkIIICM Procedure 001, Rev0

Calibration of MkIIICM NaI Detector

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES

REVIEWED BY:		DATE:
QA REVIEW BY:		DATE:

EFFECTIVE DATE: 4/1/04

1. Purpose

The purpose of this procedure is to define the operational methods and requirements for performing a detector/source calibration with any MkIII. The MkIII is a Sodium Iodide (NaI) detector and electronics encased in a protective housing.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.
PBC	Performance Based Check – Provides measurement of the system's performance in field conditions.

4. General Information

Before any gamma spectroscopy in support of land surveys are performed with NaI detectors, all detectors must be calibrated. The data collected from the calibration will be used to calculate calibration factors for the duration of the survey. The calibration factor will convert count rate into planar or deposited concentrations.

5. Material Equipment and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
Detector	Any size NaI or equivalent gamma detector.
NIST traceable Check Sources	^{60}Co, ^{137}Cs & other if Scope requires.
Computer	PocketPC
Field Notes	Log Book

6. Responsibilities

6.1. Technician

6.1.1. Reads and becomes familiar with this procedure.

6.1.2. Ensures that all measurements are made in accordance with this procedure.

6.2. Project Manager

6.2.1. Determines the calibration source and count times to use.

6.2.2. Ensures that all measurements are made in accordance with this procedure.

7. Procedure

7.1. Calibration of MkIIICM NaI Detectors

7.1.1. Prior to field use, each NaI detector will be calibrated to NIST traceable sources. Calibrations may include ^{60}Co and ^{137}Cs sealed sources, or other isotopes approved by the Project Manager based on the specific survey requirements.

7.1.2. Perform a 10-minute background of the NaI detector.

7.1.3. Perform a 10-minute count with the source placed one meter from the center of the detector. The count time may be varied based upon the source strength. (Determined by the Project Manager).

7.1.4. Review the data collected.

7.1.5. Perform Source Response Check and Performance Based Check (if applicable) in accordance with MkIIICM Procedure 005 to establish traceability to the calibration measurement.

7.1.6. Affix a calibration sticker to the detector. The due date shall not exceed 6 months from the current date.

7.1.7. Repeat steps 7.1.2 to 7.1.6 for each detector to be used.

8. Acceptance criteria

8.1. Reported source to NaI crystal distance is within ±5mm.

9. References

N/A

10. Required Records

10.1. Calibration data sheets

11. Appendices

N/A

PROCEDURE: Mark III Contamination Monitor 002

Requirements for Completion of a Survey Using the In Situ Contamination Bucket Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

Approved, Bill Vinzant ____________ 4-22-04 ____________

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation Date Approved:

PROCEDURE: Mark III Contamination Monitor 002

Requirements for Completion of a Survey Using the In Situ Contamination Bucket Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

4/22/04 4/22/04

Reviewed by: Date: Quality Control Manager: Date:

Control Copy #______

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MkIII Contamination Monitor

MkIIICM Procedure 002, Rev0

Requirements for Completion of a Survey Using the ICBM

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES

REVIEWED BY:		DATE:
QA REVIEW BY:		DATE:

EFFECTIVE DATE: 4/1/04

1. Purpose

The purpose of this procedure is to define the operational methods and requirements for using a MkIII as a sub-system in a *In Situ* Contamination Bucket Monitor (ICMB). The MkIII is a Sodium Iodide (NaI) detector and electronics encased in a protective housing.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
ICBM	The *In Situ* Contamination Bucket Monitor containing a NaI detector encased in a protective housing used for estimating activity of the soil excavated or loaded.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.

4. General Information

The *In Situ* Contamination Bucket Monitor optimizes where to stop digging, identification of unknown material, and estimating activity of raw material placed into a dump truck.

5. Material Equipment and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
NaI detector	Model 3
QC Check Source	Typically a Cs-137 source
Field Records	Log book

6. Responsibilities

6.1. Technician

6.1.1. Reads and becomes familiar with this procedure.

6.1.2. Ensures that all measurements are made in accordance with this procedure.

6.2. Project Manager

6.2.1. Ensures proper placement of ICBM on excavator or equivalent.

6.2.2. Reviews the survey information.

7. Procedure

7.1. Calibration of MkIIICM NaI Detectors

7.1.1. Calibration shall be performed per MkIIICM Procedure 001.

7.2. Source Response and Performance Based Check of NaI detectors

7.2.1. The Source Response and Performance Based Checks for the NaI are described in MkIIICM Procedure 005.

7.3. Operation of the ICBM

7.3.1. Turn on Pocket PC to activate the ICBM. This can be done either from the cab of the equipment or from the ground.

7.3.2. Ensure the total is reset for counting bucket loads, for each truck that is.

7.3.3. Start logging data from the ICBM prior to excavating or loading.

7.3.4. Upon completion of excavating or loading stop data logging on the Pocket PC.

7.3.5. Return the Pocket PC to technician if applicable for review of data collected.

8. Acceptance criteria

Surveys performed in accordance with this procedure are designed to identify different levels of radioactivity for possible segregation of soil.

Response check data shall be evaluated for the survey. Control chart data should indicate specific acceptance criteria for the survey being performed. Response check values outside the prescribed acceptance band shall be evaluated for their impact on the survey and dispositioned or those areas impacted re-surveyed.

9. References

9.1. MkIIICM Procedure 001, "Calibration of MkIIICM NaI Detector"

9.2. MkIIICM Procedure 005, "Source Response Checks and Performance Based Checks of any MkIIICM NaI Detector "

10. Required Records

N/A

11. Appendices

N/A

PROCEDURE: Mark III Contamination Monitor 003

Requirements for Completion of a Survey Using the Walk over Activity Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

Approved, Bill Vinzant   4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation   Date Approved:

PROCEDURE: Mark III Contamination Monitor 003

Requirements for Completion of a Survey Using the Walk over Activity Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

4/22/04 4/22/04

Reviewed by: Date: Quality Control Manager: Date:

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MkIII Contamination Monitor

MkIIICM Procedure 003, Rev0

Requirements for Completion of a Survey Using the ROAM

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES

REVIEWED BY:		DATE:
QA REVIEW BY:		DATE:

EFFECTIVE DATE: 4/1/04

1. Purpose

The purpose of this procedure is to define the operational methods and requirement for performing Roll Over Activity Monitor (ROAM) gamma surveys using a Sodium Iodide (NaI) detector.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
ROAM	The Roll Over Activity Monitor is a mobile platform containing NaI detectors and data logger used for conducting radiological surveys.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.

4. General Information

ROAM gamma surveys are performed with NaI detectors set at a constant height above the ground surface. The objective of the survey is to verify when an area is below set site-specific limits.

5. Material Equipment and Supplies

Table 2 . Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
NaI detector	Model 3
QC Check Source	Typically a Th-232 source
Field Records	Log book

6. Responsibilities

6.1. Technician

6.1.1. Reads and becomes familiar with this procedure.

6.1.2. Ensures that all measurements are made in accordance with this procedure.

6.2. Project Manager

6.2.1. Defines locations, count time and detector height for all measurements.

6.2.2. Reviews the net count rates.

7. Procedure

7.1. Calibration of MkIIICM NaI Detectors

7.1.1. Calibration shall be performed per MkIIICM Procedure 001.

7.2. Source Response and Performance Based Check of MkIIICM NaI detectors

7.2.1. The Source Response and Performance Based Checks for the NaI are described in MkIIICM Procedure 005.

7.3. Walkover Mode Surveys

7.3.1. Walkover surveys are performed using a NaI detector mounted to a location-based sensor or distance encoder when applicable.

7.3.2. Perform surveys by walking over designated survey lanes with the detector held at a constant level (typically about 1 meter). Survey lanes are separated by twice the height of the detector above the ground (e.g. if the detector is one meter above ground, survey lanes are 2 meters apart).

7.3.3. Start logging survey information on Pocket PC.

7.3.4. Upon completion of survey stop logging data on Pocket PC.

7.3.5. Review data collected upon completion of survey.

Note: This type of setup allows for quick surveys where backgrounds tend to be low and not influenced by nearby radiation sources. If backgrounds are influenced by nearby radiation sources, use of shielded detectors mounted on a platform used in Drive Over Mode shall be performed.

7.4. Drive Over Mode Surveys

7.4.1. Drive Over surveys are performed using a heavily shielded NaI detectors mounted on a platform that can be carried by a Bobcat or equivalent equipment.

7.4.2. Perform surveys by driving over designated survey lanes with the detector held at a constant level (typically about 1 meter).

7.4.3. Start logging survey information on Pocket PC.

7.4.4. Upon completion of survey stop logging data on Pocket PC.

7.4.5. Review data collected upon completion of survey.

8. Acceptance criteria

Surveys performed in accordance with this procedure are designed to identify areas that are above site-specific limits and not to quantify levels of radioactivity.

Response check data shall be evaluated for the survey. Control chart data should indicate specific acceptance criteria for the survey being performed. Response check values outside the prescribed acceptance band shall be evaluated for their impact on the survey and dispositioned or those areas impacted re-surveyed.

9. References

9.1. MkIIICM Procedure 001, "Calibration of MkIIICM NaI Detector"

9.2. MkIIICM Procedure 005, "Source Response Checks and Performance Based Checks of any MkIIICM NaI Detector "

10. Required Records

N/A

11. Appendices

N/A

PROCEDURE: Mark III Contamination Monitor 004

Requirements for Completion of a Survey Using the Static Contamination Radiation Activity Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

Approved, Bill Vinzant 4-22-04

J. W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation — Date Approved:

PROCEDURE: Mark III Contamination Monitor 004

Requirements for Completion of a Survey Using the Static Contamination Radiation Activity Monitor

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

[signature]	4/22/04	[signature]	4/22/04
Reviewed by:	Date:	Quality Control Manager:	Date:

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MkIII Contamination Monitor

MkIIICM Procedure 004, Rev0

Requirements for Completion of a Survey Using the Subsurface Contamination Radiation Activity Monitor (SCRAM)

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES

REVIEWED BY:		**DATE:**
QA REVIEW BY:		**DATE:**

EFFECTIVE DATE: 4/1/04

1. Purpose

The purpose of this procedure is to define the operational methods and requirements for using a MkIII as a sub-system in a Subsurface Contamination Radiation Activity Monitoring (SCRAM). The MkIII is a Sodium Iodide (NaI) detector and electronics encased in a protective housing.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
SCRAM	The Subsurface Contamination Radiation Activity Monitor containing a NaI detector used for conducting radiological surveys.
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.

4. General Information

SCRAM surveys are performed with NaI detectors for use in the ground or a sample container. The objective of the survey is to verify activity in the soil for areas that may have influence from radioactive sources.

5. Material Equipment and Supplies

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
NaI detector	Model 3
QC Check Source	Typically a Cs-137 source
Field Records	Log book

6. Responsibilities

6.1. Technician

6.1.1. Reads and becomes familiar with this procedure.

6.1.2. Ensures that all measurements are made in accordance with this procedure.

6.2. Project Manager

6.2.1. Defines locations and count times for all measurements.

6.2.2. Reviews the net count rates.

7. Procedure

7.1. Calibration of MkIIICM NaI Detectors

7.1.1. Calibration shall be performed per MkIIICM Procedure 001.

7.2. Source Response and Performance Based Check of NaI detectors

7.2.1. The Source Response and Performance Based Checks for the NaI are described in MkIIICM Procedure 005.

7.3. Subsurface mode Surveys

7.3.1. Subsurface surveys are performed using a NaI detector encased in a plastic tube.

7.3.2. Perform surveys by inserting the detector into borehole or sample location and start logging information on Pocket PC.

7.3.3. Upon completion of survey count stop logging data on Pocket PC.

7.3.4. Review data collected upon completion of survey.

7.4. Sample mode Surveys

7.4.1. Sample mode surveys are performed using a NaI detector encased in a plastic tube.

7.4.2. Perform surveys by inserting detector into holding fixture and place sample container (large volume Marinelli or equivalent geometry) on detector for counting.

7.4.3. Start logging survey information on Pocket PC.

7.4.4. Upon completion of survey stop logging data on Pocket PC.

7.4.5. Review data collected upon completion of survey.

8. Acceptance criteria

Surveys performed in accordance with this procedure are designed to identify areas that are above site-specific limits and not to quantify levels of radioactivity.

Response check data shall be evaluated for the survey. Control chart data should indicate specific acceptance criteria for the survey being performed. Response check values outside the prescribed acceptance band shall be evaluated for their impact on the survey and dispositioned or those areas impacted re-surveyed.

9. References

9.1. MkIIICM Procedure 001, "Calibration of MkIIICM NaI Detector"

9.2. MkIIICM Procedure 005, "Source Response Checks and Performance Based Checks of any MkIIICM NaI Detector "

10. Required Records

N/A

11. Appendices

N/A

PROCEDURE: Mark III Contamination Monitor 005

Source Response Checks and Performance Based Checks of any Mark III Contamination Monitor NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

Approved, Bill Vinzant 4-22-04

J.W. (Bill) Vinzant / Kaiser Aluminum & Chemical Corporation — Date Approved:

PROCEDURE: Mark III Contamination Monitor 005

Source Response Checks and Performance Based Checks of any Mark III Contamination Monitor NaI Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: April 2004

[signature] 4/22/04 [signature] 4/22/04

Reviewed by: Date: Quality Control Manager: Date:

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MkIII Contamination Monitor

MkIIICM Procedure 005, Rev00

Source Response Checks and Performance Based Checks of any MkIII Detector

Table A 1. Revision Table

REVISION	AUTHOR(S)	DATE	BRIEF SUMMARY OF CHANGES

REVIEWED BY:		DATE:
QA REVIEW BY:		DATE:

EFFECTIVE DATE: 4/1/04

1. Purpose

This procedure details the requirements for baseline Source Response Checks (SRC), daily SRCs, and Performance Based Checks (PBC) of any MkIIICM NaI detector.

2. Scope and Limitations

N/A

3. Definitions and Acronyms

Table 1. Definitions and Acronyms.

ITEM	DESCRIPTION
NaI	M-Style detector with the photo multiplier tube optically coupled to a NaI crystal. A mu-metal magnetic/light shield over the PMT completes the detector. A low energy X-ray lead umbrella shield covers the detector and PMT. The detector is attached to a preamplifier and encased in a thermally insulated electrically shielded container.
SRC	Source Response Check – Determines if the detector is operating the same from day-to-day.
PBC	Performance Based Check – Provides measurement of the system's performance in field conditions.

4. General Information

Normal operation of the MkIIICM NaI requires daily SRCs to assure that the NaI is performing within acceptable limits. Perform this procedure at the beginning and end of each shift for each detector in use. Compare the results of the daily SRC to the baseline SRC for this project. Use the initial daily SRC for a project as the baseline SRC.

Any time a system component or operating parameter changes, take a new baseline SRC for comparison with proceeding days. Examples of altered parameters would be:

1. Calibration source changed.
2. Detector replaced.

Perform Performance Based Checks (PBC) at a minimum of approximately every 5 hours during performance of the survey. The PBCs confirm constant system performance. The measurements are used to bound surveys. Failure of a PBC constitutes investigations of the surveys it bounds.

5. Materials, Equipment, and Supplies.

Table 2. Materials, Equipment, and Supplies.

ITEM	SPECIFICATION
NaI	Insulated Sodium Iodide detectors with mu and low energy gamma ray shields.
Check Source	Th-232 or as determined by Project Manager.

6. Responsibilities

6.1. Project Manager

6.1.1. Determines the check source type and activity to use

6.1.2. Evaluates SRCs that fail the acceptance criteria

6.2. Operator

6.2.1. Reads and becomes familiar with this procedure before performing calibration.

6.2.2. Performs all measurements in accordance with this procedure.

7. Procedure

7.1. Background Check Measurement

7.1.1. Make sure that there are no unshielded sources near the detector.

7.1.2. Perform a 10-minute background check

7.1.3. Retrieve data from Pocket PC.

7.1.4. Record the measured background on the appropriate form in the column labeled "Background Counts".

7.2. Source Response Check Measurement

7.2.1. If this is a baseline SRC, use the form in Appendix A, "Baseline Source Response Check Form"; otherwise, use the form in Appendix B, "Daily Source Response Check Form." Perform all Source Response Checks with the detector and source stationary. Use the source placement tube on the detector.

Note: Check sources are matched to each detector at the beginning of the survey. For each detector use only check sources that have been specifically assigned to that detector.

7.2.2. Make sure that there are no unshielded sources near the detector.

7.2.3. Place the appropriate check source in the source tube on the detector.

7.2.4. Perform 10-minute source check.

7.2.5. Retrieve data from Pocket PC.

7.2.6. Record the measured source counts on the appropriate form in the column labeled "Source Counts".

7.3. Source Response Check Evaluation

7.3.1. For each detector perform the calculation shown in Equation 1 and record the value in block "Percent Difference from Baseline Measurement" on the form in Appendix B.

$$100 \times \left| \frac{Daily\ NetCounts - Baseline\ NetCounts}{Baseline\ NetCounts} \right|$$

Equation 1

7.3.2. Compare these values with the acceptance criteria contained in Step 8.1.2. If the value is greater than the acceptance criteria, notify the Project Manager.

7.4. Survey Performance Based Checks

Note: Perform Performance Based Checks (PBCs) with the detectors operating in the mode in which the surveys bounded by the Performance Based Checks will be performed.

7.4.1. Perform periodic PBCs during the performance of the survey, unless conditions prevent the PBC from being implemented. Perform PBCs at the beginning of the shift, approximately every 5 hours of surveying, and at the completion of each shift.

7.4.2. Document if conditions prevent PBCs from being performed.

Note: Check sources are matched to each detector at the beginning of the survey. For each detector use only check sources that have been specifically assigned to that detector. The source used for efficiency determination is acceptable but not required to be used.

7.4.3. Obtain PBCs in the same performance manner as normal surveys, i.e. detector height, heating, amplifier gain.

7.4.4. Place each source in a position corresponding to actual survey conditions.

7.4.5. Survey the source as dictated by the actual survey platform and survey instructions.

7.4.6. Evaluation of the PBCs for the duration of the survey occurs in the survey report issued upon completion of the survey.

8. Acceptance Criteria

8.1. SRC

8.1.1. For baseline SRCs, there is no acceptance criterion.

8.1.2. Daily SRCs are acceptable if all "Percent Difference from Baseline Measurement" values are less than 20%

8.2. PBC

8.2.1. Use the post-processing software to track the PBC data files. Establish a control chart indicating the mean and "2-sigma" and "3-sigma" values. Evaluate subsequent PBCs against the "2-sigma" and "3-sigma" criteria and for indications of adverse trends. If two consecutive measurements obtained during a PBC are greater than the "2-sigma" or if any measurement is greater than "3-sigma", the PBC indicates change in survey performance. The reason for the change must be evaluated before accepting the survey data. The Project Manager has the option to invalidate surveys bounded by a failed SRC.

9. References

N/A

10. Required Records

The forms in Appendix A and B shall be kept with the survey documentation.

Excel files are required to be kept with the survey documentation.

11. Appendices

11.1. Appendix A: Baseline Source Response Check Form

11.2. Appendix B: Daily Source Response Check Form

Appendix A

Baseline Source Response Check Form

Baseline Source Response Check Form

DETECTOR SERIAL NUMBER OR ID: _______

DATE/ TIME	ISOTOPE / SERIAL NUMBER	BACKGROUND COUNTS	SOURCE COUNTS	NET COUNTS

NOTE: ENTER N/A FOR ALL NON-EXISTING ISOTOPES

PERFORMED BY: ______________________ DATE: ____________

REVIEWED BY: ______________________ DATE: ____________

Appendix B

Daily Source Response Check Form

Attachments

Daily Source Response Check Form

BASELINE SOURCE RESPONSE CHECK CONFIGURATION DATE: ____________________

DETECTOR SERIAL NUMBER OR ID: ________

DATE/TIME	ISOTOPE / SERIAL NUMBER	BACKGROUND COUNTS	SOURCE COUNTS	NET COUNTS	BASELINE NET COUNTS	PERCENT DIFFERENCE FROM BASELINE MEASUREMENT

ENTER N/A FOR ALL NON-EXISTING ISOTOPES

INITIALS ___ NO MEASUREMENT VARIES MORE THAN 20% FROM BASELINE

INITIALS ___ PASSED

PERFORMED BY: ______________________________ DATE: ________________

REVIEWED BY: ______________________________ DATE: ________________