Innovative Survey Techniques Using Position-Sensitive Gas Flow Proportional Counters and Real Time Location System (RTLS) Technology

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Advanced Survey Technology

Hardware: Surface Contamination Monitor (SCM)
Software: Survey Information Management System (SIMS)
SCM / SIMS Overview

• Developed under NRC SBIR program & presented in NUREG/CR-6450
• Design Goals
  – Measure & Record 100% of area surveyed
  – Minimize Human Factors
  – Detect / Sort / Measure
• Named “Blue Chip Technology for Schedule & Performance” by the USDOE
• SCM uses Position Sensitive Proportional Counters
• Creates easy to understand digital images & graphical depictions of survey data (SIMS)
• Accepted by the USNRC, USDOE, USDOD, EPA, State Regulators, & ORISE (IVT)
SCM Detector
Position Sensitive Proportional Counter (PSPC)

• Functions like any proportional counter
• Uses P-10 gas
• Single anode wire
• Uses principal of charge division to determine where along the anode wire an event occurs
• Large detector behaves like a series of aligned 5 cm detectors
• Allows correlation of survey data with position / location
• Detectors can be fabricated to any size
  – Use 1 and 2 m lengths
SCM Platforms

- **Floor Monitor**
- **Mobile Monitor**
- **Conveyorized Monitor**
- **Wall & Ceiling Monitor**
SCM / SIMS Features & Advantages

• Designed to eliminate human factors that introduce errors
  – Constant survey speed maintained by drive motor
  – Data logged directly to computer
  – Detector mount maintains fixed source to detector distance
  – Not subject to grid registration errors
  – Critical for detection of low levels of activity (especially alpha)

• Bins survey information in 25 cm$^2$ pixels
  – 5 cm of forward travel by 5 cm along the anode wire

• Backgrounds associated with small area detectors

• **400 Measurements taken per square meter**

• Two modes of operation – Dynamic & Static
WHEN DETERMINING MAXIMUM ACTIVITY - EACH 25 cm$^2$ PIXEL IS ACTUALLY 25% OF 4 OVERLAPPING 100 cm$^2$ AREAS.
SCM Modes of Operation

Dynamic / Rolling Mode

Static Mode
SCM OPERATIONS
Dynamic Mode

**Position Correlated**

- Scan speed controlled by drive motor
- Encoder based data acquisition for position correlation
- “Strips” stitched together to produce one survey
SCM OPERATIONS
Static (Corner) Mode

- Fixed measurement with timer based acquisition
- Used for areas inaccessible to the cart
- Survey data can be “stitched” to data obtained in the dynamic (position correlated) mode
- Typical applications
  - Floor / wall joints
  - Stairs
  - Overheads
SCM OPERATIONS
Display

Operator Display Shows Location & Intensity of Activity
SIMS Features
Survey Reports

• Summary of survey parameters
• Data summary – mean, max, min, standard deviation
• 2-D color image of survey area results
• Exception report with 2-D display of areas over action levels (both 100 cm² and 1 m²)
• Cumulative frequency distribution (CFD) plot
Cumulative Frequency Distribution

• Includes large number of individual measurements
• X-axis presents cumulative number of times counts up to the value have been observed
• Y-axis is the percent of each value of the total number of observations
• Y-axis is a standard deviation scale
• Value at 50\text{th} percentile represents average value of the data
• Standard error of average value extremely small
SIMS Features

Cumulative Frequency Distribution Plot

CFD Shows Normal Distribution Indicative of Background

CFD From Sample Report of Contaminated Area
SIMS Features
Sample Survey Report

2-D Display Allows Visualization of Patterns of Contamination
SIMS Features
Sample Survey Report
SIMS Features
Sample Survey Report
Technology is extremely effective in the identification of discrete particles.
SIMS Features
Sample Survey Report
100 CM$^2$ - Beta

DCGLemc Comparison - Beta

MDC dpm/100cm$^2$

SCM SPEED (in/sec)
100 CM² - Alpha

DCGLemc Comparison - Alpha

MDC dpm/100cm²

SCM SPEED (in/sec)
SCM/SIMS Sample Project

Rocky Flats Environmental Technology Site, Golden, CO
Radionuclides of Concern: Pu-239, Sr-90, Cs-137

• Designed and performed final status surveys for Plutonium (low level alpha) using SCM / SIMS at Buildings 123 and 779
• SCM only technology to volunteer & pass blind test for detection of low level alpha activity
• Interfaced with IVT, regulators, and stakeholders
• Site Closure Achieved
• Also provided RP program assessment for Building 371 / 374
SCM/SIMS Sample Project

BNFL 3-Building Project (K-33, K-31, K-29)
Radionuclides of Concern: Pu-239, Sr-90, Cs-137

- Development of dose based endpoint criteria
- Development of survey plans and procedures
- Development of Technical Basis Documents
- Served as key technical interface between BNFL and DOE
- Designed, managed, and conducted Characterization, Remedial Action Support and FSS surveys using SCM/SIMS
- Surveyed over 120 acres of floor space and corresponding overheads
- Obtained over 200 million measurements
- Survey results collaborated by DOE’s IVT

“The team consistently produced technically sound surveys at high production rates, while always working safely.” BNG America
SCM/SIMS
Sample Project

Former Naval Air Stations Alameda, Brunswick, & Willow Grove
Radionuclides of Concern: Ra-226, Pu-239, U-238, Sr-90, Cs-137, H-3

• Review HSA, develop work & task specific plans
• Design and perform scoping, characterization & final status surveys
• Develop characterization & final status reports
• Assist with stakeholder relations
• Surveyed over 1.3M ft² and obtained over 49M measurements with SCM

Team received safety award from Navy
SCM/SIMS
Sample Project

USDOE, Fernald Site
Radionuclides of Concern: U, Th, Ra

- Developed survey plans
- Designed and performed scoping, characterization & final status surveys
- Developed characterization & final status reports
- Performed walkover gamma surveys
- Compressed project schedule
SCM/SIMS Sample Project

TVA Watts Bar Nuclear Plant
Radionuclides of Concern: Fission & Activation Products

• Developed Survey Plan for the Unconditional Release of the Unit 2 Containment & Annulus from Unit 1 RCA (Rezoning)
• Developed survey plans
• Designed, managed, and conducted free release surveys to “indistinguishable from background” endpoint criteria using SCM/SIMS & portable survey instruments
• Provide radiological engineering support
• Developed final report to support release of the areas, materials and equipment
• Provided technical supervision
SCM/SIMS Sample Project

South Texas Project Nuclear Plant

Radionuclides of Concern: Fission & Activation Products

- Designed comprehensive survey and sampling plan for free release of 1,900 ft of roadway
- Surveyed more than 48K ft² in 1 week (1.7M measurements)
- High / variable ambient background
- Generated final report supporting free release of road
STP Survey Information

- Release Criteria: IE 81-07
  - Indistinguishable from Background
- Isotope of Concern: Co-60
- Scan Rate: 2” per second
- Minimum Detectable Count Rate
  - <4,000 dpm/100 cm² (standard background)
  - ~7,500 dpm/100 cm² (elevated background)
    - Additional asphalt samples analyzed in those areas
SCM/SIMS Sample Project
South Texas Project Nuclear Plant
Radionuclides of Concern: Fission & Activation Products
Real-Time Locating System (RTLS)

- Indoor GPS
- Provides 3-dimensional information within rooms or areas
- Hardware Used
  - Anchors – fixed locations in a room or area
  - Tags – attached to mobile people or things
- Provides real-time location information plus other information
RTLS Technologies

- Radiofrequency Identification (RFID)
- Optical Locating
- Ultrasound ID
- Bluetooth
- Near Field Electromagnetic Ranging
- **Ultra Wideband (UWB)**
UWB Technology

• Ultra-Wideband RF
  – decaWave DW1000 chip
  – CMOS IC based on 802.15.4-2011 standard

• Applications
  – Real-time location systems - RTLS
  – Two-way ranging – current SIM-Teq use

• Benefits of UWB
  – Position accuracy ~10 cm
    • SIM-Teq app ~15 cm
  – Range potential 290 m (LOS)
    • SIM-Teq app ~35 m
    • Transmits through non-metallic objects
  – Low power consumption
SIM-Teq Survey Meter Training Using TWR

- Two-Way-Ranging (TWR) Application
  - Calculates distance between devices
  - Source configurable (1 mR/hr – 99,000 R/hr @ 1 ft)
  - $1/r^2$ meter response
  - ~100’ range
  - *Excellent positioning resolution in all axis (~6” resolution)*

- Manual Control with SCC App
- Retain full functionality of instrument
  - OEM meter movement and selector switch
  - Functional window response

- Adjustable background
- Open Architecture
Electronic Dosimetry Training Devices

**OEM Components**
- Case
- Speaker
- Display
- Push Button(s)
- ISO Connector (DMC2000)

• Fully Configurable (except histogram)

• Features and Functions:
  - Turn on/off (autonomous and ‘fast-entry’ mode)
  - All display functions
  - All alarm functions
  - All faults (plus blank screen)

• Supports Accessories
  - Telemetry (2000 and 3000)
  - PAM
  - iMUX
  - LED
  - Earphone
Basic UWB RTLS Network
Current RTLS System

• Wired Anchors – LAN used for both communication and POE power
  – Standard POE (1 Anchor per line)
  – Custom POE (12-15 Anchors per line)

• Independent Tags
  – Tags are serialized but incapable of connecting to external equipment
  – Tags are rechargeable

• 3000-5000 Tags per Location Area
  – i.e. Floor, Building, etc.

• TCP/IP based communication
  – Internal to system
  – External output to End User Application

• Accuracy – Depends on Anchor density
  – High density <10 cm
  – Low density ~30 cm
Future RTLS System Applications

• Embedded Modules in Electronic Dosimeters
  – Mirion-RSCS Collaboration for DMC 3000, WRM2, and RTLS
  – Demonstration at 2 Canadian sites in June/July
  – Potential for all Rad Workers wearing RTLS-equipped dosimeters providing real-time dose rate information (radiation ‘heat mapping’ display)

• Embedded Modules in Survey Meters
  – Automated survey documentation
  – Faster and more reliable information

• Embeddable Modules in SCM
  – Use of positioning system for automated documentation of detector location
Other RTLS Applications

- Personnel location and monitoring
- Inventory Control
- Equipment tracking
- FME
- Waste tracking
- Confined space environmental measurement
- Tools that identify specific requirements by location (i.e. torque wrench near specific bolts will know proper foot-pounds)
RTLS Challenges

• Infrastructure
  – Anchor installation
  – Network installation
  – Location Survey/Mapping

• Backend Customization
  – User interface
  – Existing system integration

• Location Resolution
  – Use case dependent e.g. Radiation survey data

• Instrument Integration

• Funding
Questions?

THANK YOU