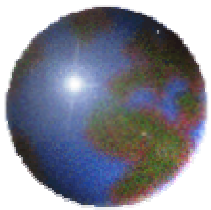

Lessons Learned During Implementation of MARSSIM from an Independent Verification Perspective

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Lessons Learned Overview

- Insufficient Characterization Efforts
- MARSSIM Survey Design Issues
- Survey Instrumentation Challenges
- Future MARSSIM Needs

Incomplete/Inadequate Characterization

- Mean and standard deviation (σ) of contaminant in survey unit should be used to determine relative shift (Δ/σ):

  ($\Delta = DCGL_W$ - LBGR), where the LBGR should be set at mean concentration
- However, poor characterization has resulted in inaccurate estimates of mean and std dev (even guesses at σ)

Example: Effect of Poor or Limited Characterization

- Survey design using WRS test for Th-232, assume $DCGL_W$ = 8 pCi/g
- "Limited" characterization data result in 4.8 pCi/g mean and 1.7 pCi/g std dev in survey unit; bkg had Th-232 conc of 1.1 pCi/g (net 3.7 pCi/g in survey unit)
- Relative shift: $\Delta/\sigma = (8-3.7)/1.7 = 2.5$; Type I error = 0.025; Type II error = 0.1
- N/2 = 10 samples

Example: Effect of Poor or Limited Characterization (cont.)

- Final status survey design was implemented, but……actual standard deviation was 2.85 pCi/g, NOT 1.7 pCi/g as planned
- Better characterization would have indicated true $\Delta/\sigma = 1.5$, and N/2=17
- Poor characterization has resulted in **reduced probability** for passing survey unit (due to reduced sample size)

Limited Characterization Data used to Establish Radionuclide Ratios

- Using one radionuclide to infer the presence of another requires estimate of radionuclide ratios
- $C_{Ni\text{-}63}$ /$C_{Co\text{-}60}$ is key to modified DCGL for Co-60

$$DCGL_{Mod,Co} = DCGL_{Co} * \left[\frac{DCGL_{Ni}}{((C_{Ni} / C_{Co}) * DCGL_{Co}) + DCGL_{Ni}}\right]$$

Limited Characterization Data used to Establish Radionuclide Ratios (cont.)

- Need sufficient characterization data to establish radionuclide ratios

Identified Problems:

1) Data were not sufficient to determine ratio given its variability, and
2) Data from one area of site were used to obtain ratio for entire site

Limited Characterization Data used to Establish Radionuclide Ratios (cont.)

- $DCGL_{Co\text{-}60}$ = 8 pCi/g; $DCGL_{Ni\text{-}63}$ = 50 pCi/g
- Area #1 ratio of $C_{Ni\text{-}63}$ / $C_{Co\text{-}60}$ is 2.1, then modified DCGL for Co-60 is 6 pCi/g
- Area #2 ratio of $C_{Ni\text{-}63}$ / $C_{Co\text{-}60}$ is 4.1, then modified DCGL for Co-60 is 4.8 pCi/g
- Consider need to develop multiple ratios and specify site areas where they apply

Handling Multiple Radionuclides

- Each radionuclide was individually compared to the $DCGL_W$ rather than using the unity rule
- The unity rule must be used when more than one measurement is performed at a location
- Sum-of-the-fractions is calculated at each location:

$$\frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \ldots + \frac{C_n}{DCGL_n}$$

Instrument Calibration Using ISO-7503

- ISO-7503 guidance has **not** been consistently applied; some MARSSIM users continue to use the conventional 4π total efficiency
- Not using ISO-7503 has resulted in surface activity levels for alpha and low-energy beta emitters being underestimated

ISO-7503 Approach

- Separate total efficiency into instrument and surface efficiency components:

$$A_s = \frac{R_{S+B} - R_B}{(\varepsilon_i)(\varepsilon_s)(W)},$$

where:

ε_i is the instrument or detector efficiency,

ε_s is surface or source efficiency,

W is the physical probe area

Other Survey Design/Procedure Issues

- Gamma fixed point readings at discrete locations rather than scanning
- Not listening to audio response while scanning
  - Relying on visual needle deflection
  - Different person listening
- Survey unit misclassification – most common is contamination exceeding $DCGL_W$ in Class 2

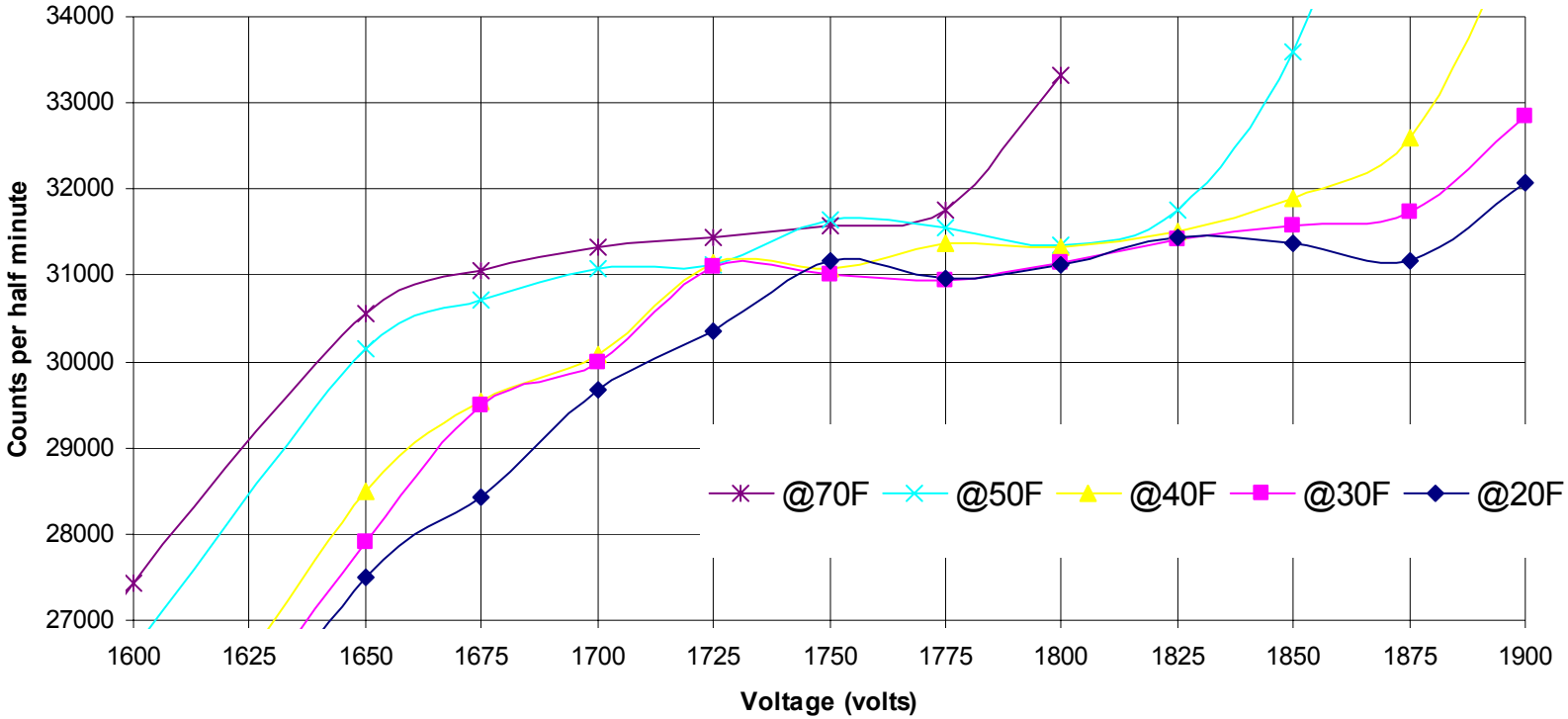
Survey Instrumentation Challenges

- Cold weather effects on gas proportional detectors
  - Start-of-day check-out (room temperature) was within parameters
  - Surveys conducted outdoors on cold days; end-of-day checkouts would then be below established parameters

Survey Instrumentation Challenges (cont.)

- Investigation pointed out that a voltage shift was occurring that caused the instrument to under respond

Temperature Effect on Voltage Plateau for beta sources
using Ludlum 2221 #2 with 43-68 #2 gas proportional detector



Scan MDC Issues

- Not comparing scan MDC to new, modified DCGL when surrogate approach used
- When survey instruments used for scans that have alarm set point – the MARSSIM scan MDC calculation no longer applies
- Determining scan MDCs other than those provided in MARSSIM has been a challenge

Miscellaneous Instrumentation Issues

- Static operation of gas proportional detectors—loss of purge (reduced detector efficiency)
- Long cables—impedance changes impact instrument electronic settings

Future MARSSIM Needs

- Clarification on the use of Sign Test for surface activity assessment
- More examples that cover realistic scenarios – most sites have multiple radionuclides; e.g., scan MDCs for multiple radionuclides