PRACTICAL MEASUREMENT PROBLEMS ASSOCIATED WITH ALPHA SURFACE CONTAMINATION CONTROL IN THE DECOMMISSIONING ENVIRONMENT- THE NEED FOR OPERATIONAL MATRIX METROLOGY STANDARDS

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ABSTRACT

An operational end point, alpha contamination response, intercomparison has been undertaken within an AWE facility subject to long term contamination build up prior to it's Post Operative Clean Out (POCO). This study involved scintillation based probes, in common use throughout the nuclear industry, calibrated by recognised Qualified Persons, using procedures and fully traceable reference sources, that meet all current statutory requirements.

The results of the study, which was designed to confirm contamination control measurement and end point agreement between a decommissioning contractor and local AWE Health Physics Groups, highlighted significant variations in instrument contamination responses (cps per Bq cm^{-2}). In the most extreme cases, these could have potentially led to inconsistent clearance of material from designated areas

Investigations into the origins of the response variation have confirmed that the alpha detection threshold energy varied significantly between instruments, with potential for non-detection of degraded spectrum alpha contamination present in the decommissioning environment. The need for practical, pragmatic, nuclear industry accepted annual instrument tests, that ensure that instruments consistently detect degraded alpha surface contamination, is discussed.

INTRODUCTION

The need for continued monitoring of designated contamination areas and items requiring movement from them is as old as the nuclear industry itself. The underpinning instrument and contamination metrology science however remains much as it has always been, with instrumentation test requirements[1] and designs dating back at least twenty years. Recent revisions of ISO standards[2-3] are based on metrological standards which equate as closely to the "perfect source" as possible. The latter have a ratio of area normalised surface alpha activity to emission rate, or P factor, of 2, with little or no emission spectrum degradation.

AWE plc was granted a NII site licence in 1997 and is currently undergoing a significant review of it's Radiological Protection Standards. These now extend to Radiological Protection Monitoring and auditing of performance of decommissioning contractors by independent measurements of survey acceptability.

Operational surface contamination monitoring is not a metrological science in the strictest sense and reference standards and associated instrumentation performance need to reflect the requirement for robust, cost effective testing and operational measurements which can be undertaken swiftly and with reasonable accuracy.

The derivation and application of self-absorption factors to correct observed counts to the required Bq cm^{-2} response , and statutory testing of monitors for response to *real* contamination scenarios, is supported by minimal open literature work.

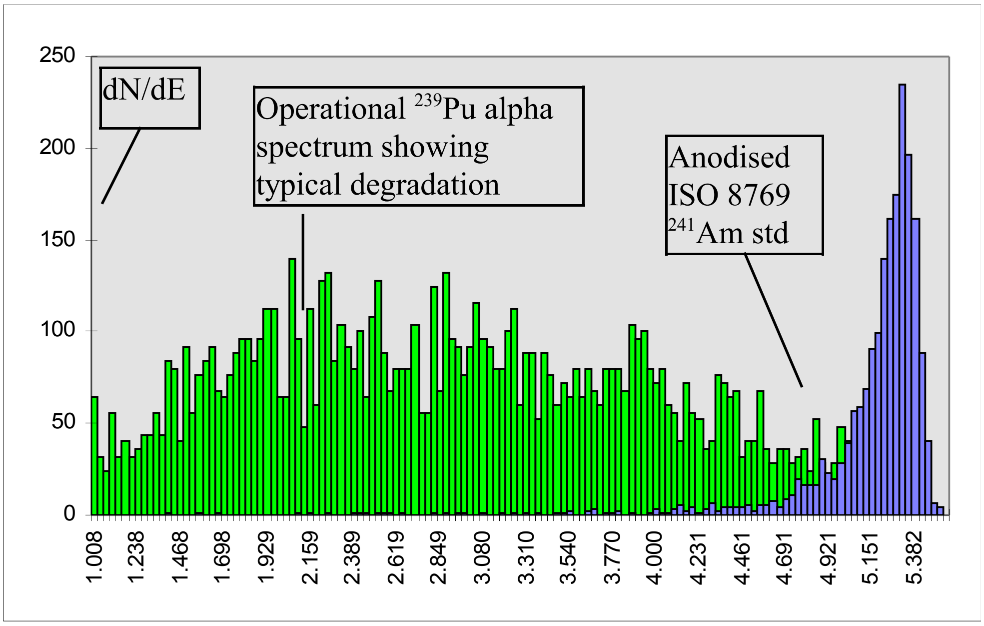
This move into significant decommissioning programmes and the wide range of surface contamination monitors in use by contractors and local Health Physics Groups at AWE, prompted an audit programme to establish consistency of clearance end point measurements. The need was further highlighted following a safety related incident report into foot contamination that was only detected at the entrance to a change room instead of on exit from decommissioning work areas.

METHOD

The monitoring process instrumentation selected for the audit or intercomparison were a number (14) of locations associated with designated area exit monitoring points, within a facility which had been through it's POCO stage. The instruments, 10 from AWE and 13 from the decommissioning contractor selected for the intercomparison, were all based on NE Technology AP2 alpha detectors. All instruments selected were covered by current calibration certificates, provided by the parent test houses under Qualified Person Supervision. They were all tested with sources that met traceability requirements and guidance given in HS(G) 49 [4] .

Two simple tests formed the basis of the intercomparison, a 2π efficiency measurement using a commercial anodised ^{241}Am source in semi-infinite plane geometry and a spatial response test across the detector using a ^{238}U *belt source.* The former has an emission spectrum that closely matches that of the perfect source, the latter matching a typical degraded alpha emission spectrum found in the decommissioning environment. Spectra for calibration and operational scenarios were measured using a 2π PIPS detector of 5000 mm^2 area, see Figure 1 below.

Figure 1: Comparison of 2π alpha emission energy spectra of a common United Kingdom ISO ^{241}Am reference source and a typical decommissioning spectrum



The ^{241}Am 2π efficiency requirement was to be within ± 30% of type test response (26%-48%) using ISO Class 2 Reference Sources. The spatial response test normalised on 10 cm^2 areas across the 50 cm^2 AP2 sensitive area, is one that has been in use for some time at AWE , combining two elements that are a valuable test of a scintillation probe's ability to detect degraded alpha contamination. The test and it's pass criteria are that of a count rate range between 30-50 cps when in virtual contact with the ^{238}U 5cm diameter disc source (mass ~7g) which has an alpha emission spectrum of that of an infinitely thick alpha source. Acceptable and unacceptable responses are illustrated in Table 1 below.

Table 1 Examples of Pass/Fail against AWE AP2 Performance Standard

Probe No and Location	**Response to ^{238}U Belt source (cps)**	**^{241}Am efficiency % 2π**	**Pass or fail**
Corridor	30,30,30,30,30	31	Pass
Exit Monitor	15,5,20,17,17	31	Fail

RESULTS AND FURTHER TESTS

The performance against these test criteria is shown in Table 2 below, for both AWE and contractor instruments. Instruments involved in the original incident relating to non-detection of feet contamination failed the AWE test specification.

Table 2 Test results pre and post provision of standard AWE test protocols

Test Centre	**No of Passes**	**No of Fails**	**% Failure Rate**
AWE	10	0	0
Contractor (pre)	7	6	46
Contractor (post)	12	1	8

A sample of the contractor instruments that failed the AWE test specification were subject to further tests at DRaStaC (AWE's UKAS Accredited Radiological

Instrument Calibration Facility). Tests completed included measuring the operational voltage and position on the alpha plateau for ^{241}Am,^{238}Pu and ^{Nat}U large area ISO Class 1 reference sources. The failing instruments were found to be set at 650-700 Volts , typically 100-150 volts below the AWE instruments and within the lower third of the ^{241}Am plateau with acceptable efficiency, but on the knee of the ^{238}U plateau, with associated inability to detect degraded alphas.

Discussions then took place between the AWE and contractor Qualified Persons, with provision of AWE standard test protocols that optimised low energy response whilst maintaining acceptable low energy photon sensitivity. Instruments were then recalibrated and reassessed with a much improved pass rate against the AWE criteria. A type AP2 was subjected to further tests using an in-house designed variable energy alpha fluence standard(5), this device uses a variable air gap and plane parallel collimated alpha fluence with driver energy of 5.5 MeV, to produce continuosly variable essentially monoenergetic alpha fluences with an energy range of 0.75 to 4.8 MeV . The minimum alpha detection energy variation with operational voltage was plotted together with 2π detection efficiency again for the ISO reference nuclides detailed previously . The results are detailed in Table 3 below.

Table 3 AP2 2π efficiency and energy threshold variation with EHT setting

EHT Volts	**600**	**650**	**775**	**900**
α min MeV	3.0	2.7	2.4	2.35
^{241}Am	36%	40%	43%	44%
^{238}Pu	35%	40%	42%	44%
^{Nat}U	14%	22%	28%	31%

CONCLUSIONS

Analysis of the typical alpha contamination emission spectrum in the decommissioning environment, ie where there is likely to be significant self absorption, highlights the need for contamination monitors to be optimised in terms of their low energy alpha detection threshold.

An AP2 response to a semi-infinite surface contamination of 0.3 Bq cm^{-2} ^{241}Am with a P factor of 6, is only 1 count per second, and loss of any of the emission spectrum from the response function will significantly affect this count rate. Additionally, calculations on spectral distribution over a range of self absorption or P factors[6] confirm that operational surface absorption characteristics can lead to a significant population of degraded alphas in regions below 3 MeV. This further supports the need for instrumentation to be set at a consistent low alpha energy detection threshold. Developments required within the UK Instrumentation and Radiological Standards metrology sector, to ensure uniformity and increased accuracy of end point surveys could usefully include;

- Matrix standards, for both alpha and beta nuclides, with defined P factors or the use of filters to degrade ISO anodised sources with validated low energy alpha emission, with traceability within the UK National Measurement System
- Measurement of typical workplace alpha spectra and P factors within the UK
- The provision of a simple method for determining the low energy alpha detection threshold of contamination monitors
- Guidance on standard tests for degraded alpha response in the replacement for HS(G) 49

REFERENCES

(1) HMSO 1985 The Ionising Radiations Regulations (Under revision 1999)

(2) ISO Reference Sources for the calibration of surface contamination monitors; Beta emitters (maximum beta energy greater than 0.15 MeV) and Alpha emitters *ISO 8769 1988 Geneva 1988*

(3) ISO Reference sources for the calibration of surface contamination monitors Part 2 Electrons of energy less than 0.15 MeV and photons of energy less than 1.5 MeV *ISO 8769-2 1996 Geneva 1996*

(4) The examination and testing of portable radiation protection instruments for external instruments *HMSO Publication HS(G) 49*

(5) Danyluk P Hedley RPL Development of variable energy alpha fluence standards *AWE/DSDG/ADS/181 Feb 1999*

(6) Pierce A; Danyluk P The effect of transmission and energy losses on degraded alpha sources *AWE Report in preparation 1999*