Clearing a recent building – a chance to get as much material out as indistinguishable from background

A rare opportunity

Pete Burgess
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Winfrith EAST building

- **Built to treat 300 m^3 of sludge from the SGHWR**
- **Correctly, the Steam Generating Heavy Water Reactor**
- **Britain's take on the Candu**
- **Very high maintenance, very high operator doses**

A relatively new building

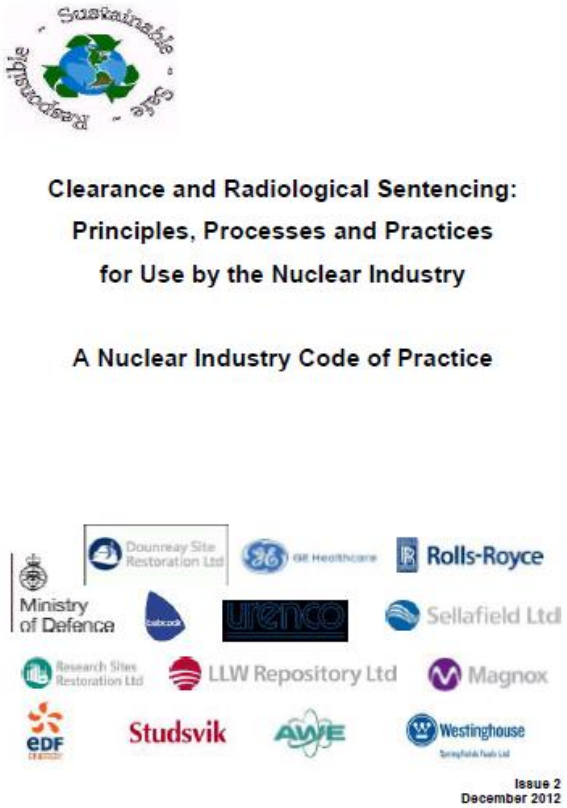
- **Built 2001to process radioactive sludges from existing concrete storage tanks**
- **The sludges were agitated, filtered and concentrated prior to encapsulation in a cement matrix within 500 litre stainless steel drums.**
- **Only a very small number of minor incidents inside the cell line**
- **Finished sludge encapsulation in April 2010**
- **Much considered to be “clean”**

Active areas and components

- Input piping
- Mixing tanks
- Dirty side ventilation
- Some equipment transferred from other buildings
- Removed as far as possible early in the project
- - reducing the chance of cross-contamination and background increase

Clean – the UK's working definition

- Clean can only be by history
- = no reasonable chance of contamination or activation
- It is not possible to declare clean by monitoring only
- See the CEWG NICoP
- http://www.cewg.co.uk/library-2/20-click-here-to-download-the-latest-version-of-the-nicop.html
- "Clean" checked by monitoring
- If anything is active, then there has been a failure in understanding



Aim – to demonstrate that the material is indistinguishable from background

- Conventional monitoring involves a ratemeter based measurement and the user's judgement
- Background or not background?
- Difficult to quantify
- Difficult to audit
- Poor sensitivity

- This project uses integrated counts over a defined area
- Easy to calculate statistical uncertainty

Point of suspicion

- Growing in popularity as an idea in the UK
- Numerically the same as Currie Critical Limit
- But easier language
- “Do we think this might well not be background?”
- Prompts an action – remeasure and average
- This project the point of suspicion is set at the mean + 2 sigma
- Expect 1 measurement in 40 will exceed

Maximum missable activity - MMA

- **Numerically the same as Currie Limit of Detection**
- **Looked at from the right direction – below upwards not top downwards**
- **“Are we confident we’re not above some limit?”**
- **Means we don’t collect particles less than the LoD, which confuses project managers**
- **Approximated to the activity which would give background + 4 sigma on average with Point of Suspicion at mean + 2 sigma**

Currie – the man who brought sense to this sort of measurement

- **Limits for qualitative detection and quantitative determination. Application to radiochemistry**
- **Lloyd A. Currie**
- ***Anal. Chem.*, 1968, *40* (3), pp 586–593**
- **DOI: 10.1021/ac60259a007**
- **Publication Date: March 1968**

Approach

- Identify a fingerprint
- Choose an instrument and detector
- Work out the response to the fingerprint
- Identify clean reference samples for each object category
- Identify a low background area
- Perform a 100 second count
- This becomes the reference for that sort of object and the next 2 hours
- Look up the Point of Suspicion on a spreadsheet
- Any measurement that equals or exceeds that, repeat and average
- If still above the Point of Suspicion, deem it contaminated

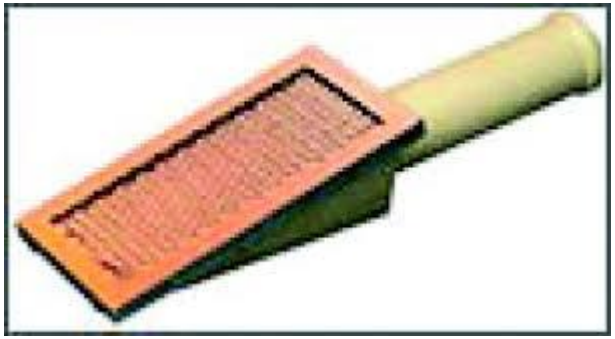
Fingerprint

- A mixture of activation products and fuel leakage
- Modified by the pond water treatment process
- Established by measurement of the sludge
- Only 0.06 % alphas
- 11 % Ni-63 – very difficult to detect beta
- 60 % Cs-137- medium energy beta
- 22 % Co-60 – low energy beta
- 4 % Fe-55 – low energy X-ray
- 3 % minor contributions

- **The Cs-137 is easy to detect**

Instruments used

- **Larger, flat areas – Thermo DP6 dual phosphor scintillator**
  - Convenient area – 100 cm^2
  - Good alpha and medium to high energy beta efficiency
  - About 40 % for alpha and 50 % for beta, 2 π
- **More complicated areas- Thermo BP4 scintillator or HP210 GM**
  - Similar efficiencies but only about 20 cm^2 area
- **Connected to an Electra ratemeter – dual channel, selectable beta channel width and integrating time**
- **RSRL standard instruments**



Performance of the DP6 for direct measurement

- **Averaged over the probe area**
- **DP6 alpha 20 cps/Bq/cm^2**
- **DP6 beta fingerprint 12 cps/Bq/cm^2**
- **Maximum acceptable beta background = 6 cps**
- **For a 30 second count, background mean = 180 counts**
- **1 sigma (σ) = √180 = 13.4 counts = 0.45 cps**
- **MMA corresponds to ≈ 4 σ = 1.8 cps**
- **Corresponding fingerprint activity = 0.15 Bq/cm^2**
- **For all barring thin material, this would meet the then SoLA Exemption Limit of 0.4 Bq/g**

HP260 based direct measurement

- **HP260 beta fingerprint 2.6 cps/Bq/cm^2**
- **Maximum acceptable background = 1 cps**
- **For a 30 second count, background mean = 30 counts**
- **1 sigma (σ) = √30 = 5.5 counts = 0.18cps**
- **MMA corresponds to ≈ 4 σ = 0.7 cps**
- **Corresponding fingerprint activity = 0.28 Bq/cm^2**

Measurement by wipe

- **Useful for smooth complicated surfaces to assess removable activity**
- **10 % pick-up factor assumed!**
- **Probably conservative in this case**
- **Review gave values mostly in the 10 to 30 % range**
- **MMAs were about 0.24 Bq/cm^2 for a 300 cm wipe and 0.08 Bq/cm^2 for a 1000 cm^2 wipe**

Surveyors reaction

- Surveyors initially resisted the approach
- They didn't like the idea of integrating over significant areas having spent their careers surveying small areas by ear
- "But what if all the activity is in one spot"
- Good question – if it is, then ALARP suggests we remove it
- So keep listening – if there seems to be an unusual count rate, check it's real
- If not, just start again!

Operations for objects

- Each object had a unique reference number
- Description recorded – material, form etc
- Measured and weighed
- Select a suitable background object
- Measure the background over 100 seconds
- Look up the corresponding point of suspicion on a spreadsheet
- Divide the object surface into convenient areas, up to about 0.5 m^2 for large, flat things
- Make the measurement
- Record the result
- If it complies, into the acceptable pile for disposal as exempt waste

Operations for buildings

- **Basically the same approach**
- **Identify areas likely to be clean – no history of spills etc**
- **Check the count rate is basically the same over the walls**
- **Check it's the same over the floors**
- **Check it's the same over the steel doors**
- **The major confounding factor were the door apertures**
- **Rooms with small door area had higher backgrounds**
- **K-40 in the building material, checked with an Exploranium GR-135**

Result

- **All the material expected to be clean complied with the criteria**
- **Not as expensive as some people imagined**
- **Possible improvement would be to use a beta detector with a thinner scintillator.**
- **This reduces the background and, hence, the monitoring time for a given MMA**
- **Now we'd work to EPR, which uses nuclide specific Out of Scope Levels**
- **This procedure would still be sufficient**

Acknowledgement

- **Michelle Skelland, RSRL, the lady who turned the theory into a result**