Materials and waste characterisation

Dealing with difficult waste

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CEWG NICOP

- A UK success story
- A simple guide to sentencing waste
- Much easier to use than MARSSIM
- NOT tied to a particular level
- Also applicable to materials which are not waste
- Nuvia are part of the group

Clearance and Exemption
Principles, Processes and Practices
for Use by the
Nuclear Industry

A Nuclear Industry Code of Practice

This Issue of the Nuclear Industry Code of Practice on Clearance and Exemption Principles, Processes and Practices was published on behalf of the Nuclear Industry Safety Directors Forum in July 2005

The really important aspects

- **“Waste is a quality product” – Paul McClelland, major instigator of the NICOP**
- **We need to understand what the material is and why it is radioactive**
- **Don’t be afraid to spend a lot of money for fingerprinting and monitoring if it looks cost effective overall**
- **Be imaginative**
  - use existing equipment in unusual ways
  - buy new equipment
  - explore new techniques

Fingerprint

- **There is no such thing as a Bq meter!**
- **The radioactive content of a material will often contain:**
  - Easily directly detectable nuclides
  - Nuclides directly detectable with less efficiency and possibly with interference from other nuclides
  - Ones that can only be detected by sampling followed by radiochemistry

Zoning

- **Separate the materials into zones where the activity may well vary but the fingerprint is likely to be stable**
- **Good likely examples**
  - Cell walls, once hot spots are removed
  - Anything with only a single nuclide
- **Difficult examples**
  - Soil contaminated by leaks from fuel cooling ponds
    - Chemistry can result in Sr-90 running in front of the Cs-137
  - Anything with local chemical action
  - Multi-use radiochemistry laboratories
  - Waste bags with poor history

Derivation of the fingerprint

- **What should be there**
  - Based on the operational history of the facility, what nuclides would we expect from contamination and activation, if relevant?
  - Decay corrected from the end of operations
- **What is there**
  - Detection in situ
  - Followed by sampling, gamma spectrometry and radiochemistry
- **Do they agree?**
- **If so, happiness!**

What to look for

- **Consistent list of nuclides present at a reasonably constant ratio**
- **An easily detectable nuclide suitable for the activity assessment process**
  - For bulk materials, an energetic non-natural gamma
    - Cs-137, Co-60
  - For surface contamination, an energetic beta emitter
    - Sr-90 + Y-90
    - Pa-234m (from U-238)

Things likely to upset fingerprint stability

- **Plant maintenance, leading to different periods of exposure**
  - Trunking and piping replaced
  - Patchy chemical cleaning
- **For steel activation, variation in the concentration of easily activated elements such as cobalt and nickel**
- **For contamination, the influence of the local chemistry and physics**
  - pH
  - Water flow
  - Particle sedimentation
    - Paint flakes in flask loading areas

Unexpected nuclides

- **Right back to the planning stage!**
- **If you didn't expect it, you don't understand what was happening**
- **Look at the history**
- **Find the cause**
  - Tc-99 from recycled uranium
  - Alpha activity in a nominally beta only laboratory
    - Poor record keeping 50 years ago
  - Ra-226 from luminising residue
- **Rework the analysis**

Order of desirability

- Materials are best evaluated in situ
- Next best is to be moved directly to a measurement point
- If that is impossible, loaded into a container and immediately monitored somewhere else
- Worst is monitoring after a significant delay

Evaluation in situ

- **Sentence as standing waste**
- **Direct measurement with a suitable detector**
  - Hand held gamma spectrometer
  - Hand held gross gamma monitor
  - Hand held surface contamination monitor
- **Problems are**
  - Poorly defined averaging volume
  - Interference from local background, both natural and artificial
  - Access

Moved directly

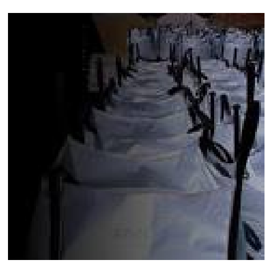
- **Grabbed out using an excavator bucket**
- **Swung round to a monitoring station**
  - Volume defined
  - Background can be much reduced
  - Site can be picked
  - Larger detectors can be used
- **Problems**
  - Surface is lost where concrete has broken up or soil dug out
  - Bucket attenuates the signal, even for gammas
  - Not great monitoring geometry

Immediate monitoring in a separate container

- **Soil or crushed concrete loaded into a builders bag placed on a turntable**
- **Gamma spectrometry using a sodium iodide or hpGe detector**
  - Background further reduced
  - “bulk average” reading obtained
- **Problems**
  - Double handling

Monitoring after a significant delay

- **Materials stockpiled in bags**
- **Sampled and radiochemistry**
- **As good an analysis as you can get**
- **Problems**
  - Delay, no chance to feed back the results into the monitoring process quickly
  - Cost
  - Potential loss of history
  - Wash-out if stored outside



Categories of materials

- **Surface contaminated**
  - Not exposed to neutrons
  - Potential contamination by activity from fission, activation etc elsewhere
  - Impervious surface
    - Trunking, cell furniture
- **Bulk or diffused in contamination**
  - As above, except that activity can be expected to diffuse in
    - Stacks, pond furniture, soil
- **Activated**
  - Exposed to neutrons – reactor and accelerator components

Some examples

- **A building that had contained active effluent tanks**
- **To which some idiot had added an external overflow**
- **End result – part of one wall contaminated by fission products**
- **Also, to make it more fun, surrounded by active buildings**

Approaches

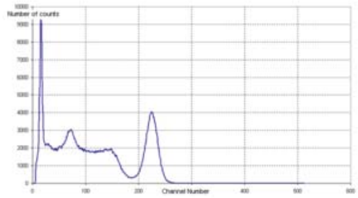
- **Initially – "It's all too difficult, we'll knock the whole thing down and send to Drigg in HHISOs"**
- **Project manager decided this was:**
  - Expensive
  - Unenterprising
  - A totally inappropriate use of a limited resource

What did we do?

- **Took samples to look at the fingerprint**
- **Looked at the depth of penetration into the brickwork**
- **Fortunately we had:**
  - Cs-137 as a major and stable fraction
  - A shallow depth of penetration which was easy to allow for
  - A thick wall which allowed a large averaging mass per unit area
  - A local disposal route for the lightly contaminated material
  - Clearly localised contamination

Monitoring

- Used a hand held gamma spectrometer with simple collimation for most active areas
- Other areas confirmed as inactive using the same detector shielded
- All simple stuff using common instruments, lead blocks and a cherry picker for access
- One or two very limited areas which were too close to very active facilities went as LLW



Result

- **An increased monitoring cost**
- **2 HHISOs instead of 21 originally forecast**
- **But an overall huge saving in costs**

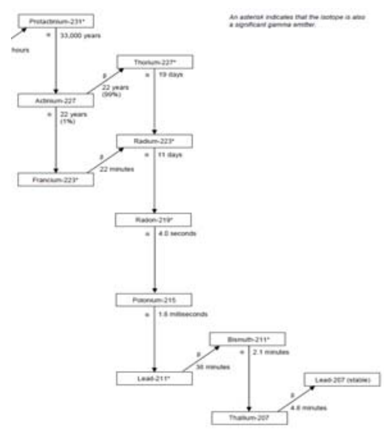
Trunking contaminated with Pa-231

- The stack from a radiochemistry laboratory connected to a glove box used for Pa-231 chemistry in the 1960s/1970s
- Made from asbestos cement, and hence hazardous waste
- Diffusion expected into the stack lining
- A complicated decay scheme with alpha, beta and gamma emissions

Nuclides and gamma energies expected

- Actinium-227 has a half life of 22 years
- Age of activity is about 40 years
- About 70 % grown in

Gamma energy (keV)	Fraction (%)
50 – 100	16
100 - 150	10
200 - 300	44.5
300 – 400	23.7
400 – 500	11
800	4.5



Actions

- **Material sampled and subjected to gamma spectrometry**
- **No gamma emissions detected other than those expected - fingerprint confirmed**
- **Impervious surfaces sentenced by beta emission**
- **Influence of alpha and low energy (thus easily attenuated) beta emissions removed by making the detector window thicker**
- **Much less influenced by grime and dust**
- **Bulked waste (rubble, gloves, coveralls etc) sentenced by gamma emission**
- **Material was being disposed of as hazardous waste so full use could be made of the Exemption Orders**

Alpha contaminated material

- The problem was a process line contaminated with plutonium
- The surfaces had significant chemical contamination and were curved
- Hence direct alpha monitoring was not feasible.
- Not aiming to get down to exemption levels
- Solution?

Solution

- **Use the L X-ray emissions in the 11 to 20 keV range**
- **Sodium iodide thin scintillator attached to an Electra ratemeter with the beta channel set up to view the X-rays**
- **Acceptable background and sufficient sensitivity**

Final thought

- Work out how much waste is likely to be in the grey area – possibly but not definitely above the limit
- This has to be treated as above the limit
- That region can often be narrowed by:
  - Spending longer on the measurement
  - Using more expensive monitoring equipment
  - Moving further down the in-situ/in bucket/in bag/by sampling line
  - The trick is to be able to justify any change by reduced overall cost, reduced dose or better stakeholder acceptance