Sellafield Ltd

Recent CAAS Experience at Sellafield

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Fred Winstanley / David Kirkwood
S&RM, Sellafield Ltd, UK

Overview

- Some background information
- A different kind of CAAS
- Over response to low energy gamma
- Testing the CAAS ‘Non-Trigger Zone’
- CAAS substitution arrangements

Background – CAAS Characteristics

- Gamma only (Geiger-Muller Tube)
- Simple electronic components (enhanced reliability)
- Will detect fast, transient accidents as well as slow, delayed excursion
- 2 out of 3 detector alarm logic
- No follow up radiation measurements
- Radiation tolerance established under real criticality conditions
- Remote Electronics Processing Unit
- Not installed inside ‘Hot’ cells
- Low false alarm rate (by design and actual observation)

Background – Emergency Plan vs CAAS

Two Stage approach to criticality emergency planning:

- Make a judgement if a Criticality Emergency Plan (CEP) is required, or not
- If a CEP is required, determine what its content should be

A Different Kind of CAAS (1)

- Fissile liquor evaporator – 50 year old facility
- Review of criticality safety analysis – CEP now required
- Potential for serious deterministic injuries
- CAAS required
- Plant shutdown as a result

    - ➢Significant impact on UK hazard reducing programme

A Different Kind of CAAS (2)

CEP utilised existing Area Gamma Monitor network

- Criticality detection (MAC)
- Survivability (fission neutron & gamma irradiation)
- Notification (not automatic – operator reliance)

Justification - Holistic ALARP argument

- Increased UK hazard associated with prolonged shutdown
- Very limited plant lifetime
- Risk gap – gamma system vs traditional CAAS – is small
- Low probability of criticality accident

(Further information: Proceedings of the ANS 2017 Nuclear Criticality Safety Division (NCSD) Topical: A Novel Approach to Criticality Accident Detection for a Legacy Facility)

Low Energy Gamma Over Response (1)

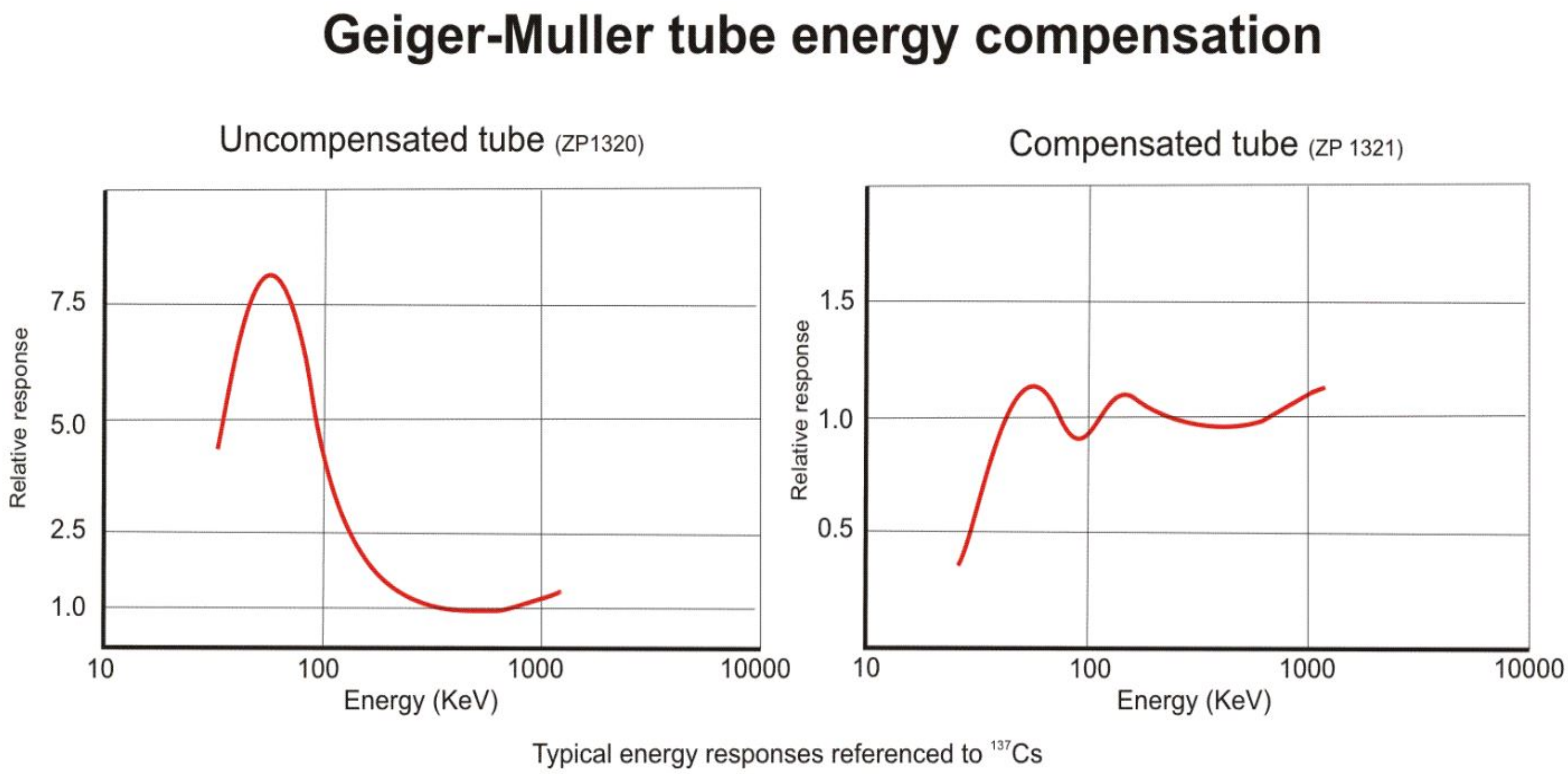
- Plutonium storage facility
- Single corridor detector tripped 5 times in a 3 week period
- Plant engineers focused on faulty detector

Detectors will respond to background gamma radiation

- ➢Guaranteed 'Non-Trigger Zone' below 150µGy/h

- Health Physics dose survey: 20 to 30µGy/h in vicinity

Low Energy Gamma Over Response (2)



Low Energy Gamma Over Response (3)

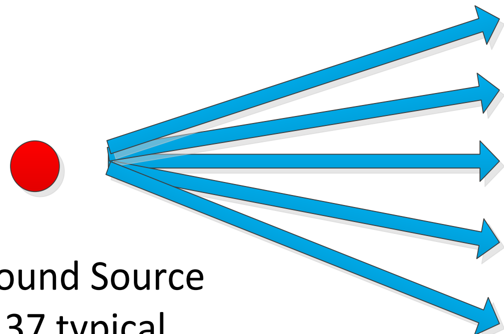
Energy Range of Criticality Accident Gamma

	Prompt Fission	Secondary Gamma	Fission Product	Am-241
Gamma Energy (MeV)	≈10	≈1	≈0.6	60 keV

Am-241 ingrowth in aged plutonium!

Low Energy Gamma Over Response (4)

- HP survey instruments typically use energy compensated detectors. The CAAS detectors were uncompensated
- Hence, HP instrument measurement of doserate in the presence of an Am-241 source will be very different to the CAAS detector



Background Source (Cs-137 typical energy)

		Measures
	HP Instrument • Compensated	20 – 30 µGy/h
	CAAS Detector • Uncompensated • Unshielded	20 – 30 µGy/h

Low Energy Gamma Over Response (5)

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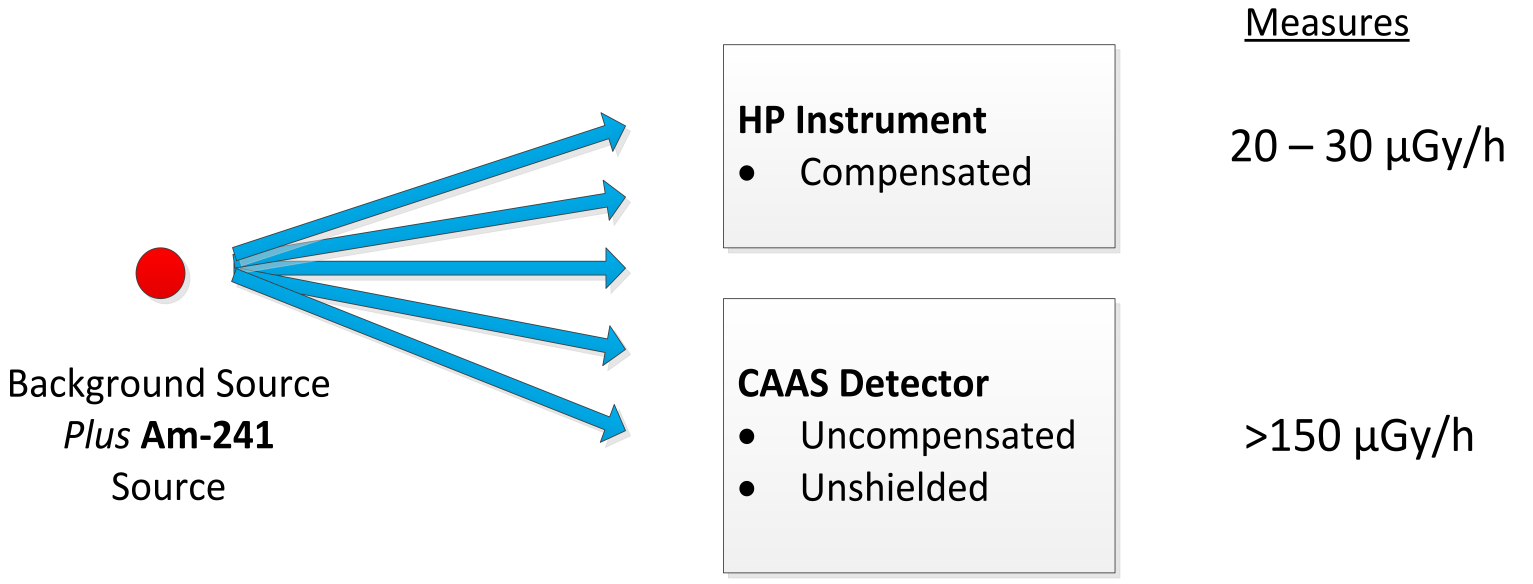


Low Energy Gamma Over Response (6)

- Increase in ambient gamma background radiation traced to the ‘slipping’ of some shielding covering a cell window
  - New shine path created to the detector
  - Significant low energy gamma Am-241 component

Low Energy Gamma Over Response (7)

Another Example:

- Historic plutonium can re-pack – (infrequent operation)
- Detector tripped during trolley to glovebox transfer
- Proposed plant 'workaround' – disable CAAS alarm broadcast
- Criticality engineer advised detector shielding
- Next can tripped 2 detectors separately – but alarm was disabled…..
- Criticality engineer again advised detector shielding
- **Plant mis-understanding that shielding would need to be removed in order to detect a criticality accident**
- Detectors now shielded

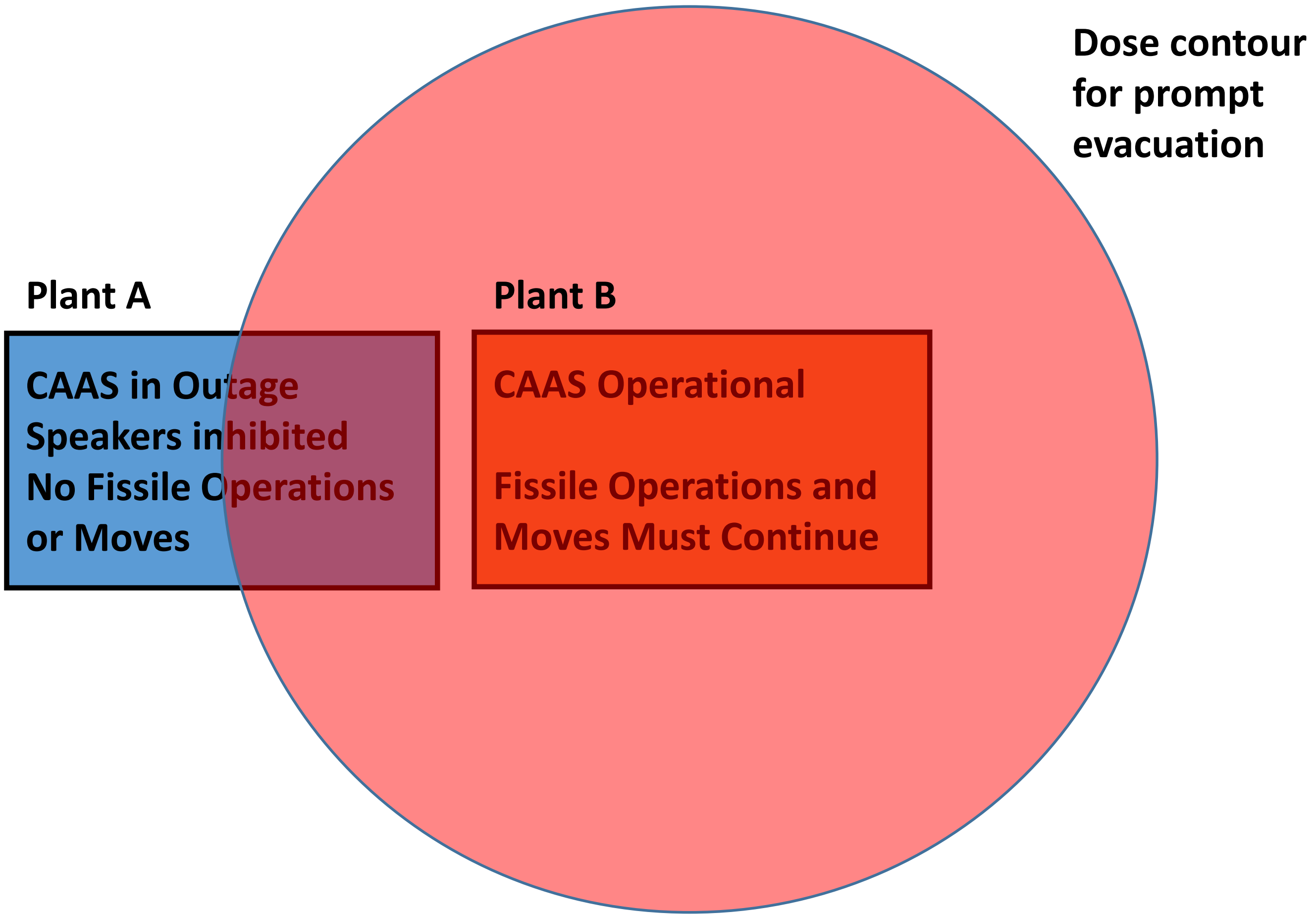
Testing the CAAS ‘Non-Trigger Zone’

- As detectors age there is the potential for change in sensitivity
- Emerging evidence of some installed detectors susceptible to tripping at <150μGy/h
- Increased potential for false CAAS alarm
- Thus, recommended periodic testing arrangement:
  - <u>5 minute</u> test with 150μGy/h gamma incident on detector
  - Cs-137 (or higher energy) test source with any detector shielding **removed**
  - Known combination of source strength and test distance to detector to give 150μGy/h incident gamma (use a jig)

- Some evidence that this test is not widely carried out

CAAS Substitution Arrangements (1)

- Two adjacent facilities with CAAS



CAAS Substitution Arrangements (2)

- Plant A must be promptly evacuated if Plant B CAAS trips
- But, speakers in Plant A inhibited due to outage
- Local safety team advised that operators in Plant A could wear EPDs and perform ‘Criticality Evacuation’ if in alarm
- Use of EPD inappropriate because:
  - EPDs do not perform well in pulsed radiation fields and will under-respond
  - EPDs have not been proven to survive in a criticality radiation field
- Advised use of ‘watch person’ and evacuation alert via airhorn

Summary

- Despite decades of experience there are still emerging issues and practices that can be improved

- Considered important that criticality engineer community continue to have a good understanding of CAAS systems