Sellafield Ltd

A Novel Approach to Criticality Accident Detection for a Legacy Facility

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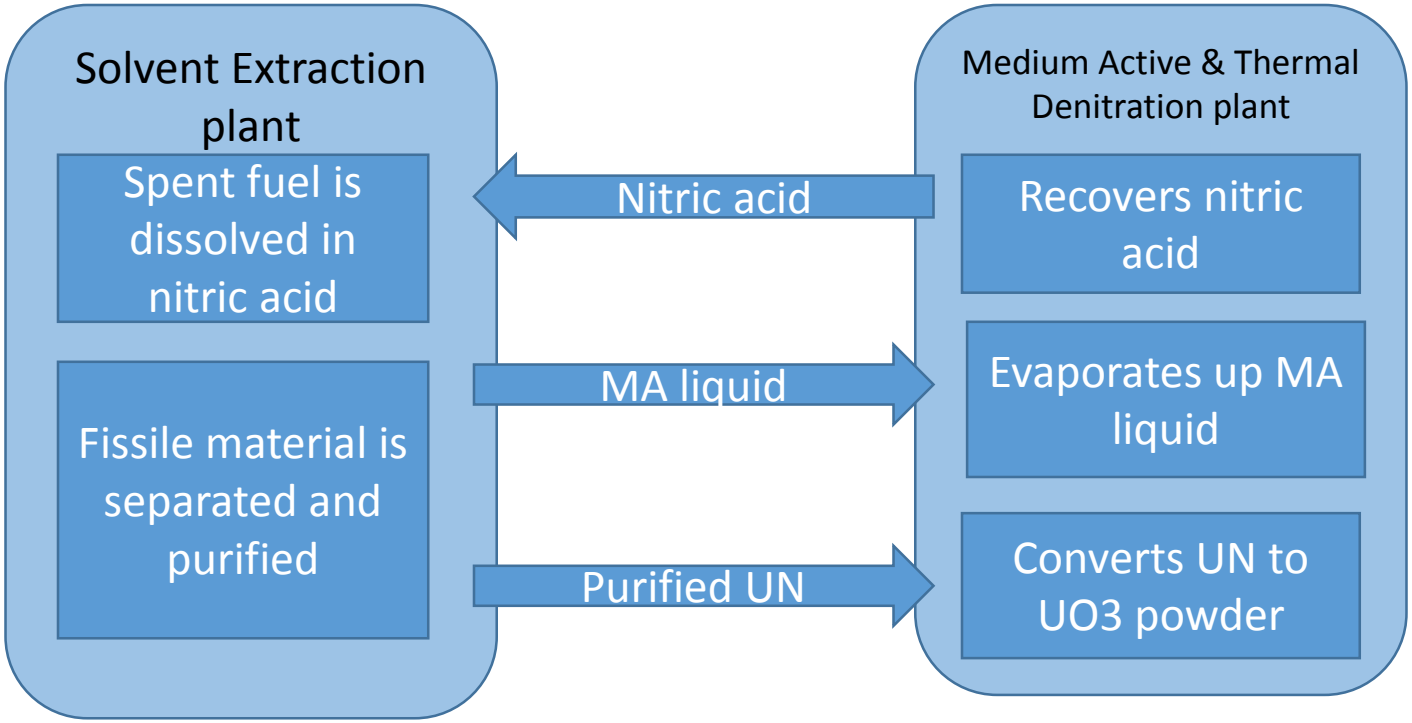
Magnox Reprocessing - Operating since the 1960s

- Need both running to support UK reprocessing operations



A number of credible criticality faults

No criticality hazard – U enrichment too low

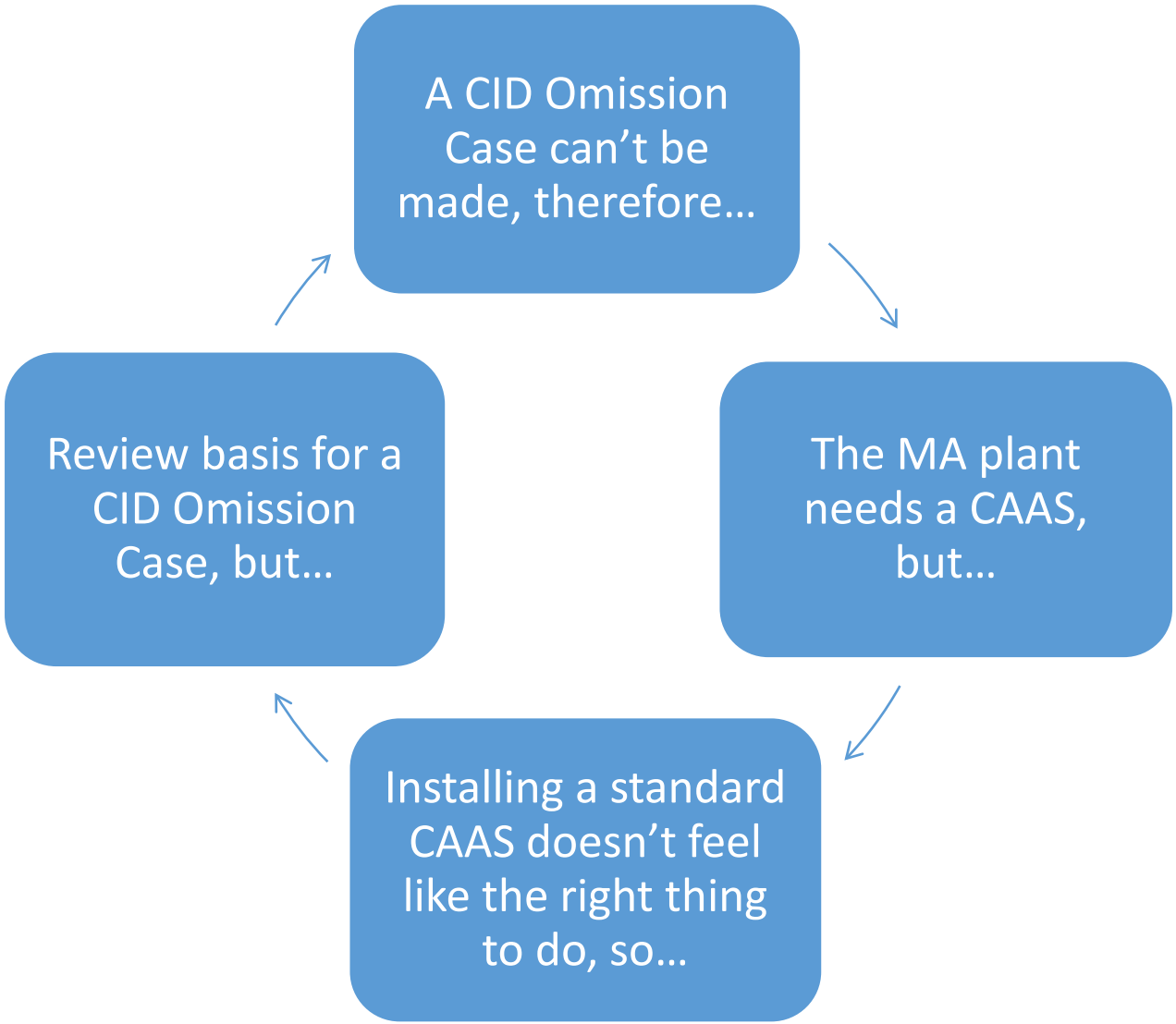
Historic Position for MA plant

- No criticality hazard expected in MA plant, so no standard Criticality Accident Alarm System (CAAS) installed
- Review of faults in Solvent Extraction Plant identified existing credible scenario (with suitable protections already in place) resulting in potential criticality hazard downstream in MA plant
- UK custom and practise is to then install a standard CAAS, or justify why one is not required – Criticality Incident Detection (CID) Omission Case

CID Omission

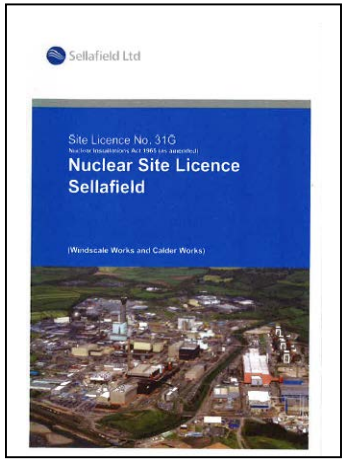
- Standard CAAS is not required if
  - i) In the absence of all controls, a criticality will not reasonably be expected
  - ii) In the event of the maximum foreseeable excursion the dose to operator <100mSv
- CID Omission Case couldn't be made
  - Criticality reasonably expected
  - No bulk shielding, operators in plant areas routinely
- Old plant, not designed with standard CAAS in mind
  - Very low risk of criticality (significant defence in depth)
  - Very difficult, time consuming and expensive to install one
  - Remaining plant lifetime < 5 years

Stuck in a Safety Assessment loop



Legal requirements

- As part of the Nuclear Site License Conditions, required to have an Emergency Plan
- MA plant didn't have one for criticality
  - Regulator interest
- Decision taken that plant would not restart without emergency plan in place



Emergency Plan

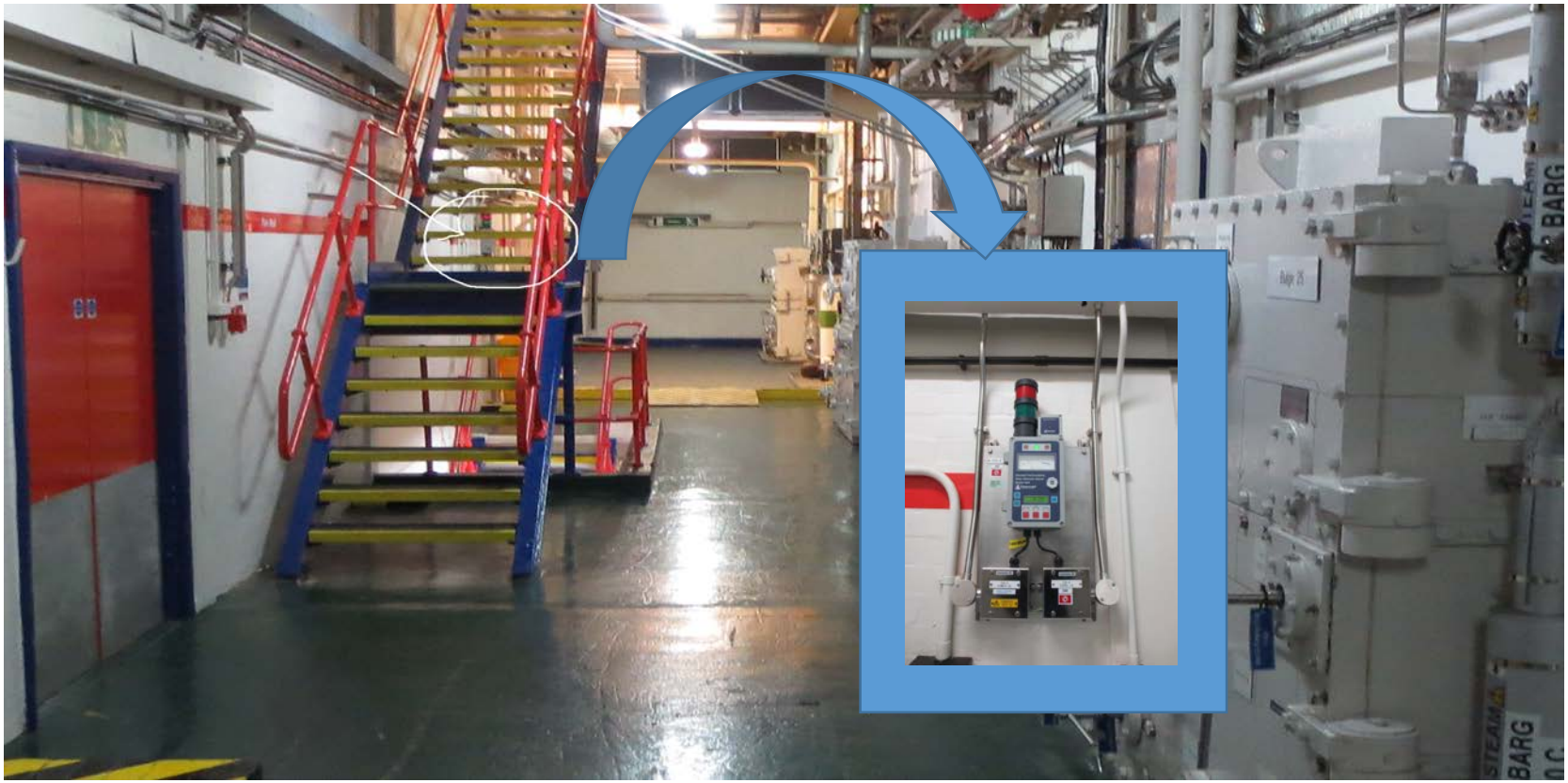
- Emergency plan *could involve* response to standard CAAS

- Still didn't feel like the right thing to do
  - Major work, time challenges, cost vs. remaining plant lifetime of <5 years

- BUT, still need emergency plan to restart
  - Can't reprocess Magnox fuel without MA plant
  - Reprocessing this fuel represents major risk reduction for UK

Emergency Plan (2)

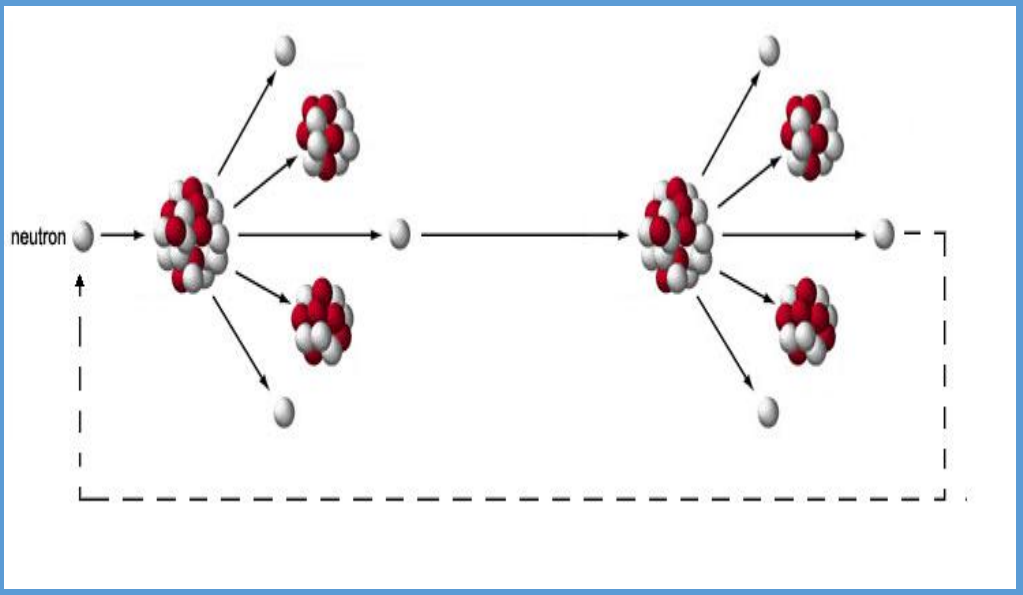
- MA plant has existing Area Gamma Monitor Network…
- At Sellafield, criticality detectors are gamma monitors…



Developing an Emergency Plan (1)

- Seemed most appropriate to use existing gamma monitor system to provide novel CAAS
  - Very unusual as accepted custom and practise is to install a standard CAAS if CID Omission Case cannot be made
- Some issues to resolve first
  - Can monitors detect all incidents of concern?
  - Can they survive long enough to alarm?
  - Can they resolve difference between criticality and radiological event?
- Remember, no MA plant no Reprocessing
  - Questions need to be answered swiftly

Developing an Emergency Plan (2)



$1x10^{18}$

10Gy

10 min

- Normally assume $2x10^{19}$ total fission yield for CAAS deployment
- Low reactivity insertion rate, historical evidence from solution accidents, likely plant conditions
- Hence existing gamma monitors would detect criticality

Developing an Emergency Plan (3)

- Next question – how to broadcast evacuation signal?
- Current gamma monitors not linked to existing MA plant loudspeakers

- Linked recording of criticality evacuation alarm to system
  - Control Room Operator initiated rather than automatic
- Off-the-shelf MP3 player used!

Developing an Emergency Plan (4)

- How do operators know a criticality event has occurred?

Smallest criticality event

Alarms sound on two floors

Bigger criticality event

Alarms sound on multiple floors

Criticality risk vs. other risks

- Criticality risk in MA evaporator low
  - Defence in depth in Reprocessing Plant (both safety case and operational) to prevent losses to MA plant
  - MA routes to MA evaporator known, robust protections in place to prevent high fissile content
- Significant impact on UK risk reduction if no Magnox Reprocessing
- Installation of standard CAAS would have large impact in terms of time and cost, further delaying overall risk reduction
- Gap in proposed novel CAAS and standard CAAS small
- Remaining operational lifetime of MA plant <5 years

Final Decision

- Argument presented to plant owner to make informed decision to restart plant under the novel CAAS arrangements.
- Also endorsed by UK regulator

Overall timescale

- From start to finish ~3 weeks

Emergency Instructions

Criticality Contour

Emergency Exercise

Evacuation Signage

Audibility Tests

Alarm Response Instructions

Safety Case Review

Training and Briefing

Criticality Alarm Broadcast

Safety Committee

Evacuation Zone

Evacuation Routes

Integrate - Site Arrangements

Criticality Yield Analysis

Questions?