NUVIA

The Windscale Pile 1 Accident in ‘57, subsequent clean-up & decommissioning

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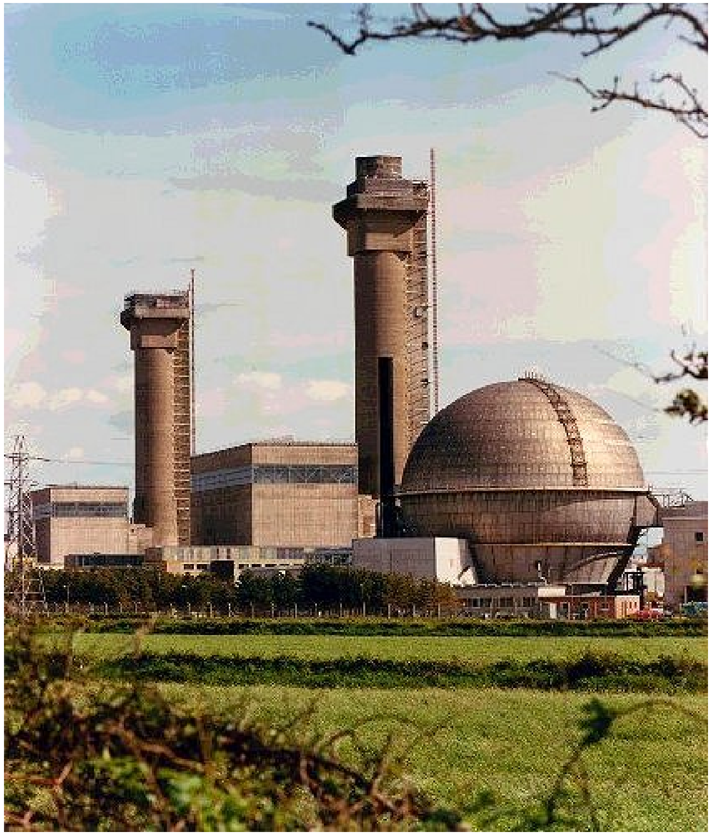
March 2014

A SUBSIDIARY OF SOLETANCHE FREYSSINET

Introduction



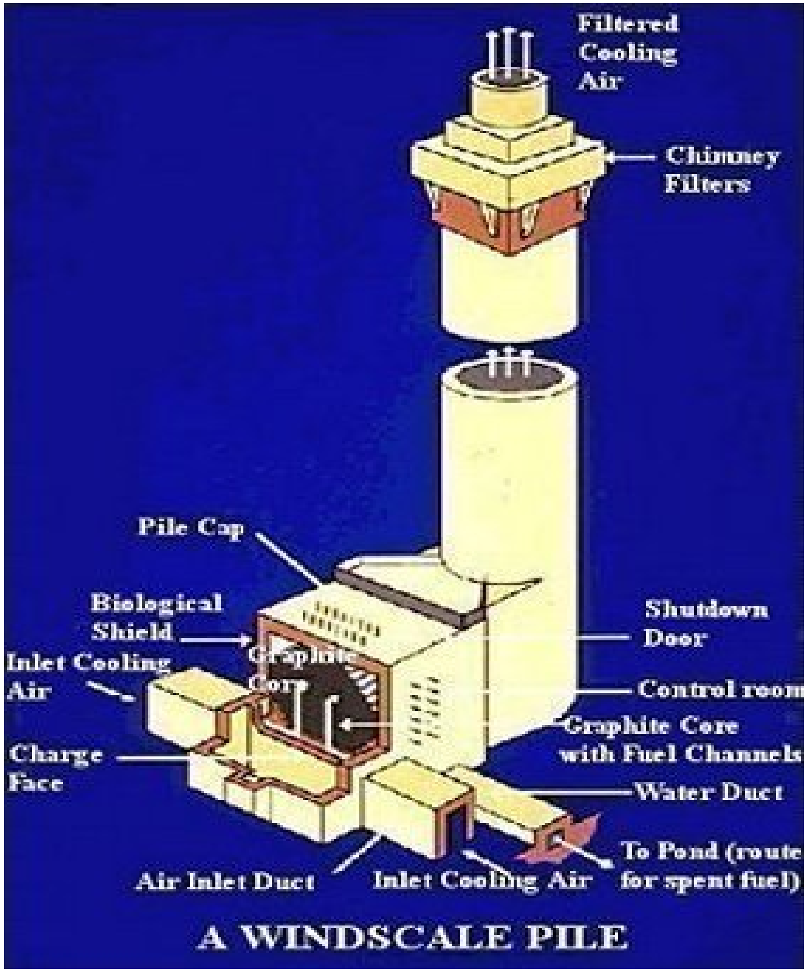
- The piles, their structure & history – the ’57 accident
- Early clean-up operations
- Present condition and uncertainties for decommissioning
- Conclusions
- Lessons learned

Background

- **Non-conventional large decommissioning project (one accident-damaged reactor with fire damaged core, not all fuel removed)**
- **2 reactors in safestore since core fire in Pile1, 1957**
- **Characterisation issues dominate**
  - some unique considerations
  - intrusive inspection of fire-damaged region now carried out

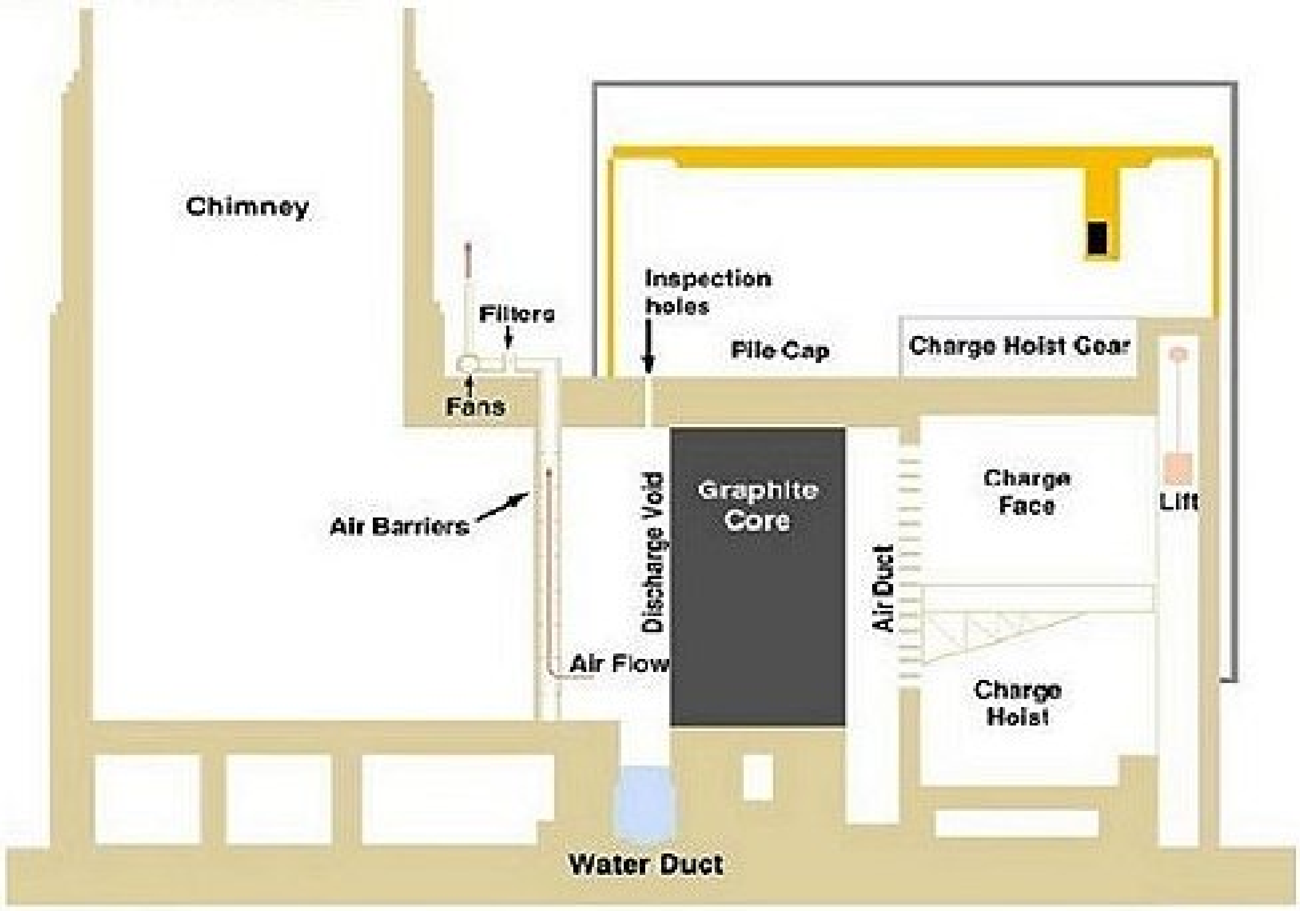
The decommissioning problem has been dominated by the lack of a detailed knowledge of the state of the core

Schematic structure



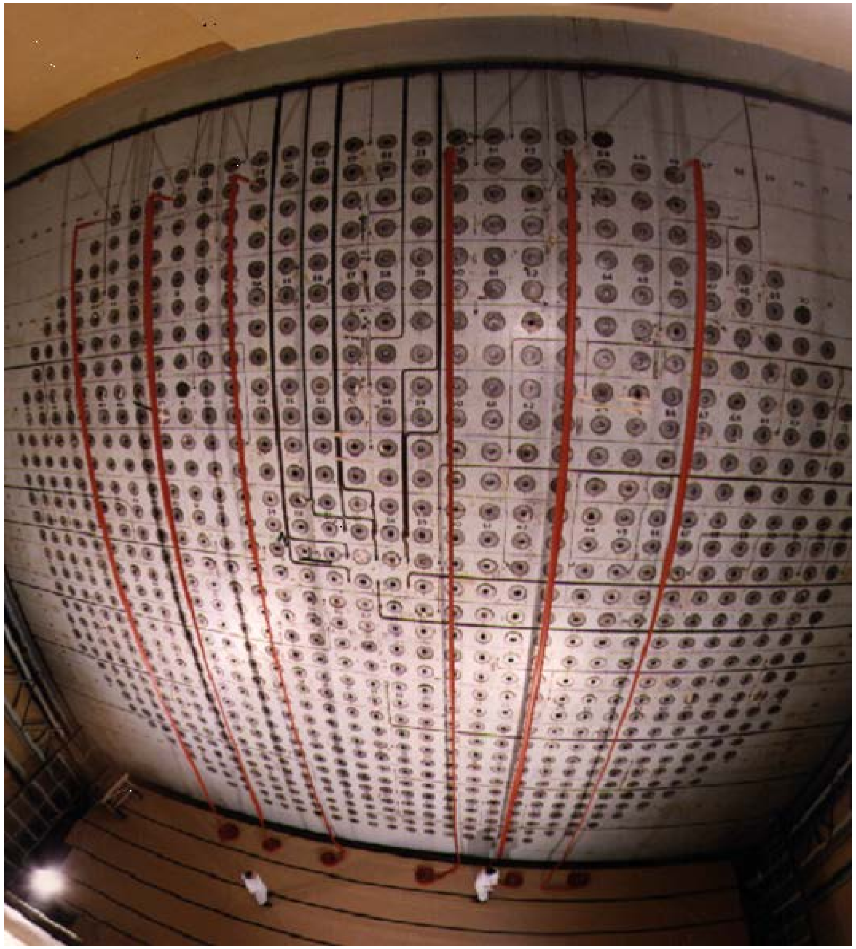
A WINDSCALE PILE

Lateral cross-section

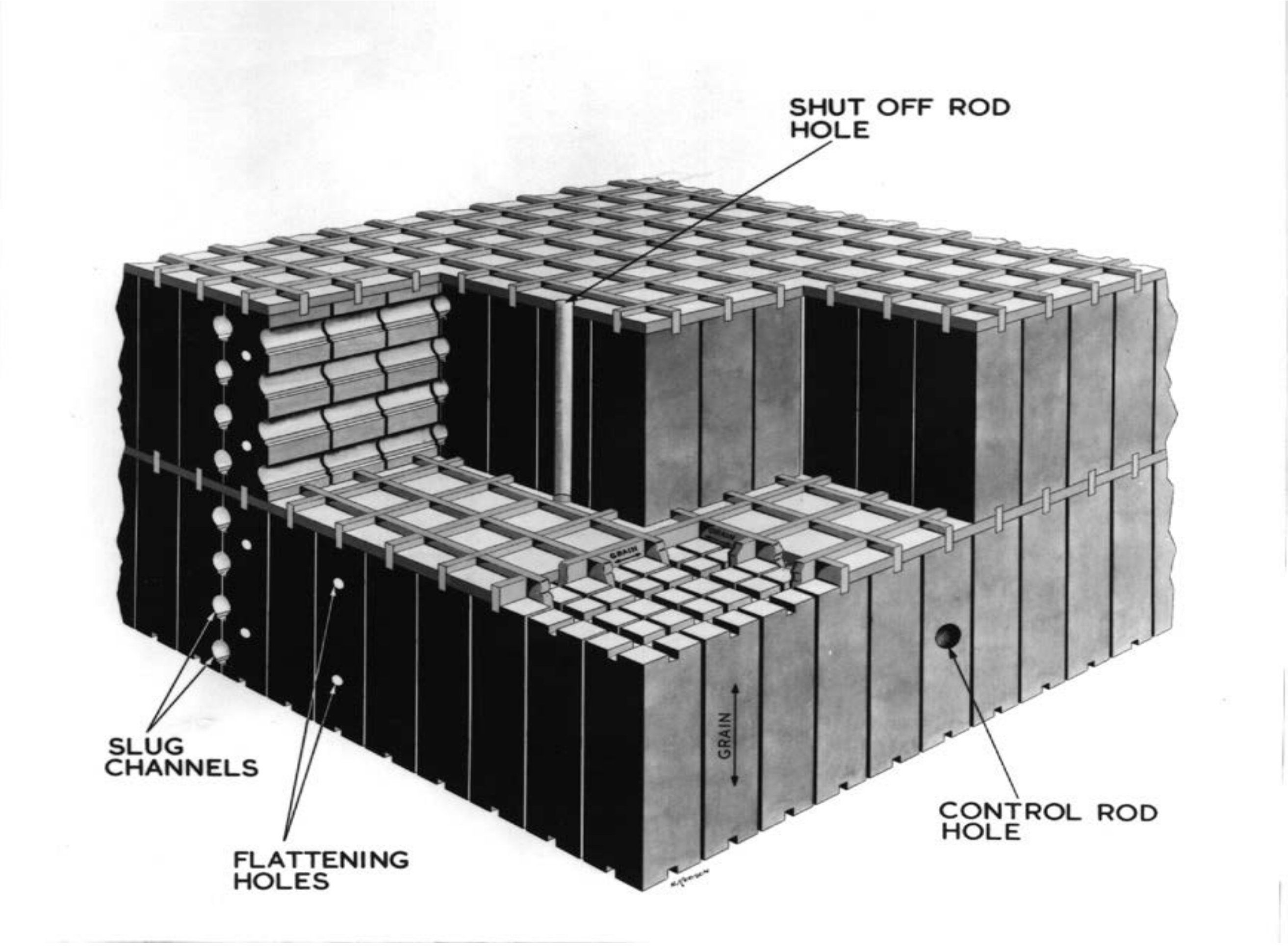


Pile parameters

- **Graphite moderated, 2000 te**
- **180 MW$_t$, air-cooled, once-thru, no PV, 200 °C outlet temp**
- **3444 horizontal fuel channels**
- **977 horizontal isotope channels**
- **Fuel:**
  - natural uranium metal rods, 21 elements per channel
  - later used 0.92% U-235
  - clad in finned aluminium
  - 70, 000 elements, 180 te U full charge



Piles’ graphite core structure



The 1957 Accident in Pile 1 during a routine Wigner anneal

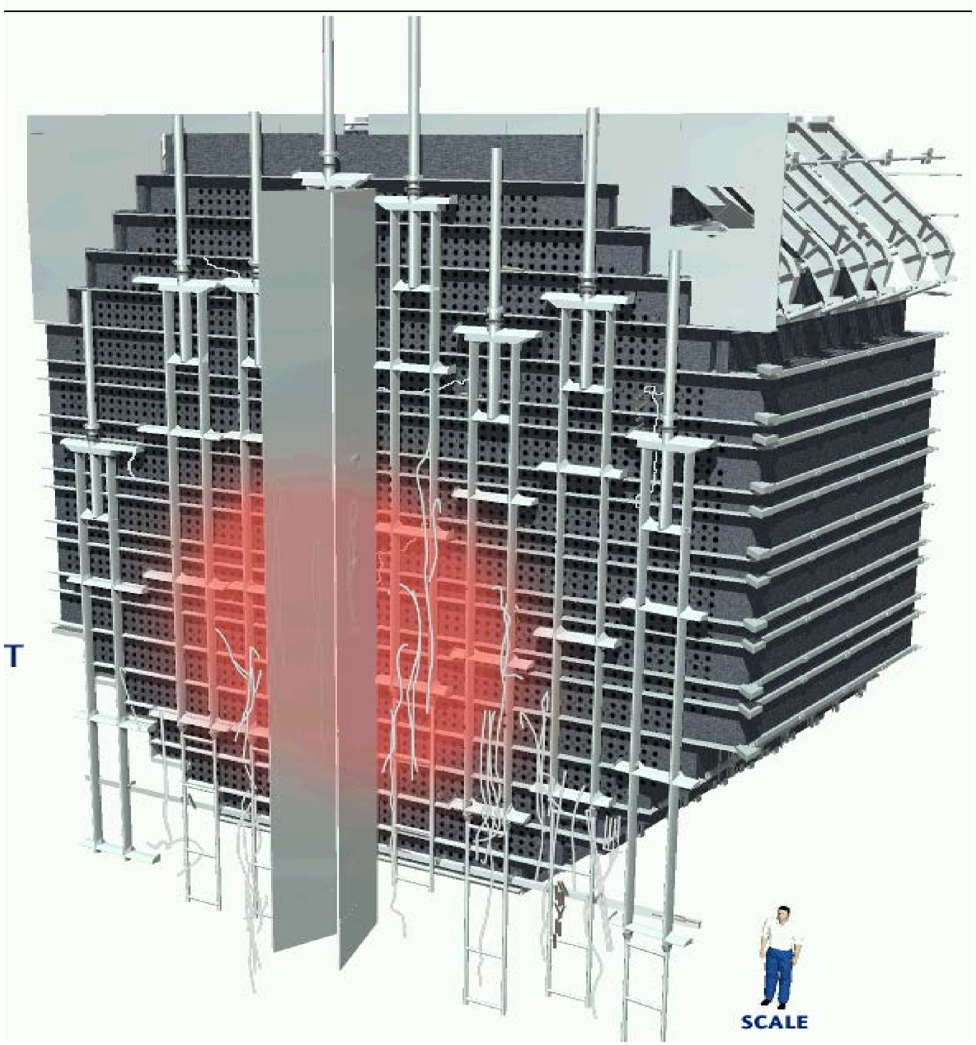
- **9th anneal started 7 October – abnormally high core temps by 10th Oct**
- **Increase in activity on stack monitors**
- **Selected channels at red heat, flames at discharge face**
- **‘Firebreak’ produced around affected zone**
- **Carbon dioxide injection – no effect**
- **Finally, water injection and cooling fans switched off**

Conjectured that inadequate instrumentation led to over temperature and clad failure on cartridges leading to runaway Wigner release and exothermic uranium, isotope and graphite oxidation.

Retrospective level ‘5’ on INES scale

Exact cause still conjectured!

Fire-Affected Zone (FAZ) in Pile 1



Environmental Effects

- Filters on stack retained most Sr-90 and prevented a major disaster
- Most release, I-131 (740-1100 TBq) ~12% of total
- Fallout deposition on local farmland, milk discarded for several months to prevent human consumption over 200 sq. ml. zone
- Excess cancers re-estimated at 240 in 2007
- Several Official Inquiries initiated ‘57, ‘58

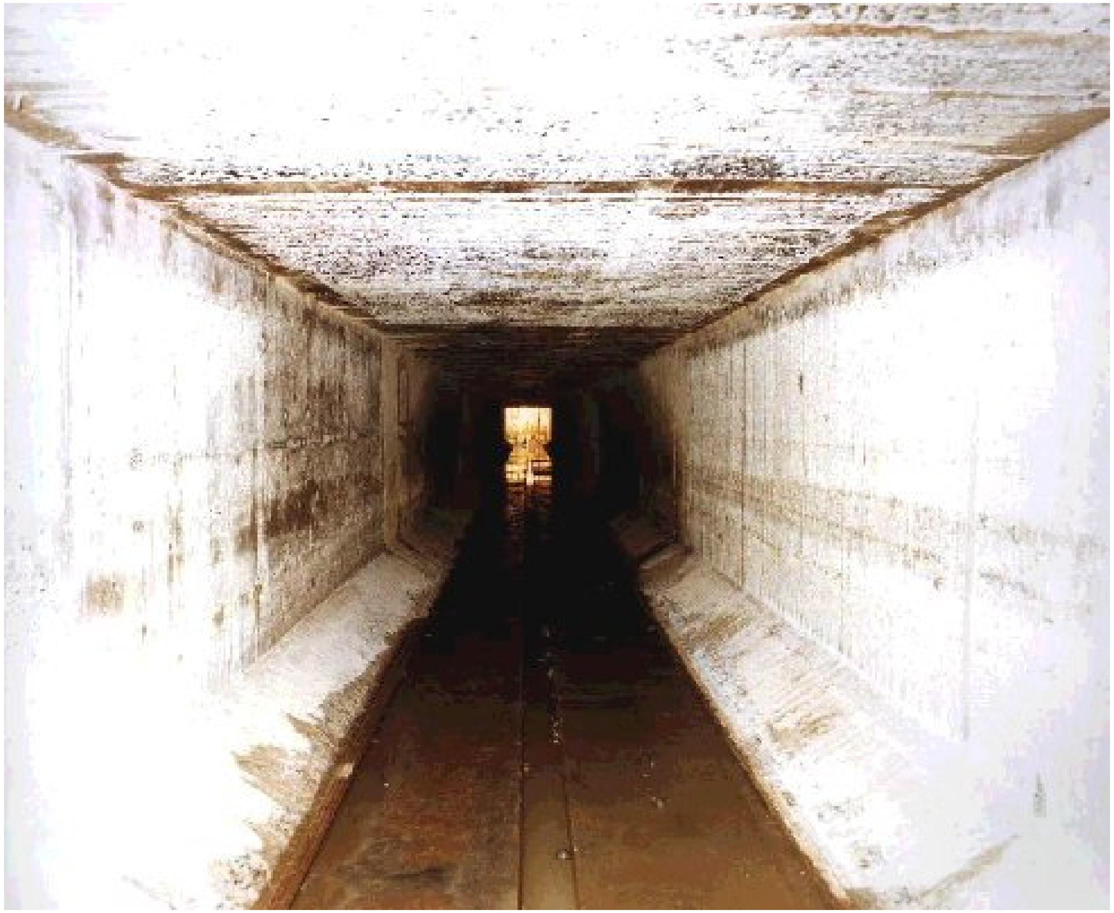
Early Decommissioning, Phase I - securing the safety of the facility

- **After initial clean-up 57-60, Phase 1 decommissioning commenced early 1980’s**
  - Sealing of bioshield
  - Installation of ventilation and monitoring
  - Loose fuel removal from outside core
  - Drain-down of water duct
  - Core removal option studies
  - Completed June 1999

Air Duct Clearance

Water Duct Clearance - Before

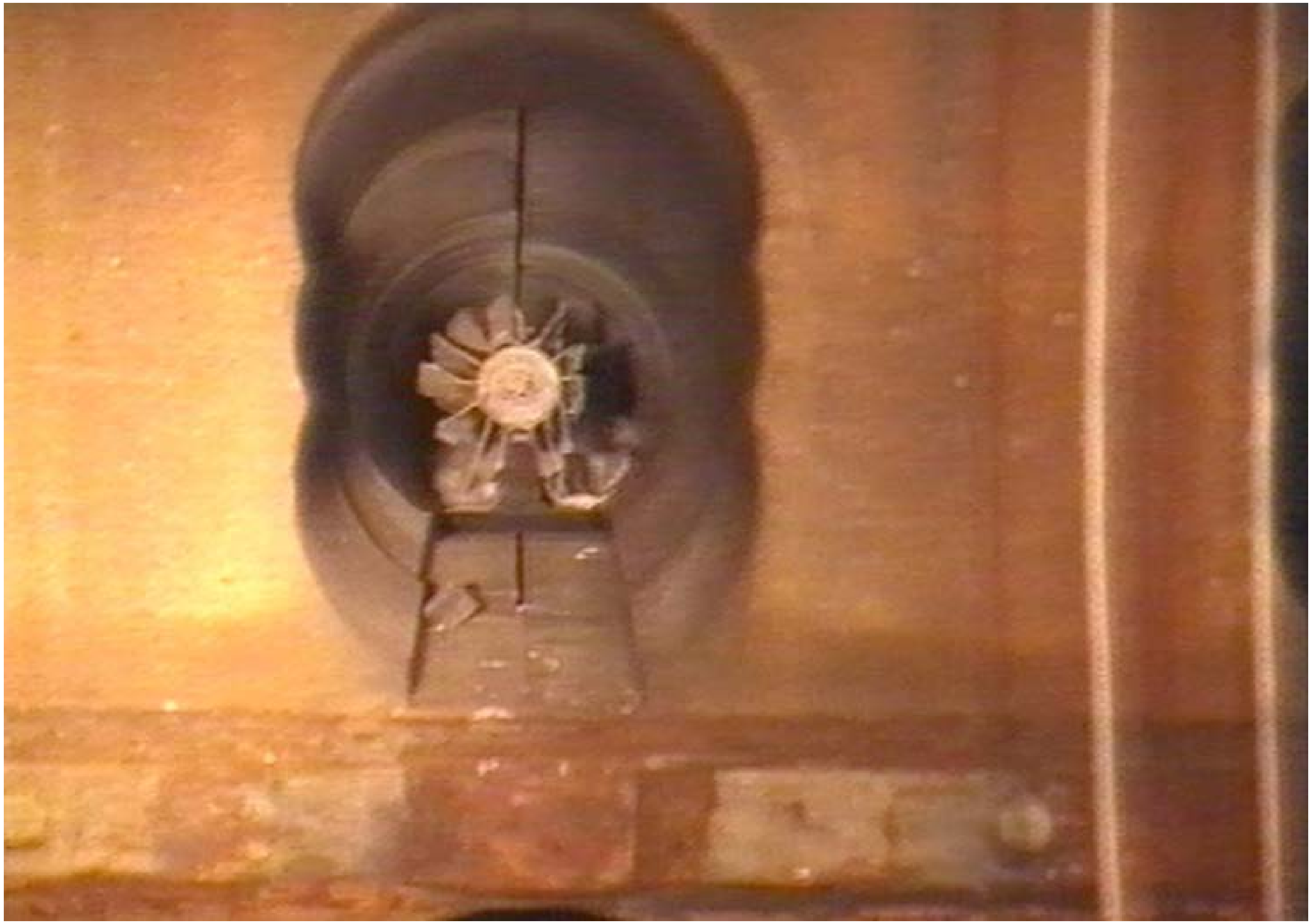
Water Duct Clearance - After



Present condition of Pile 1

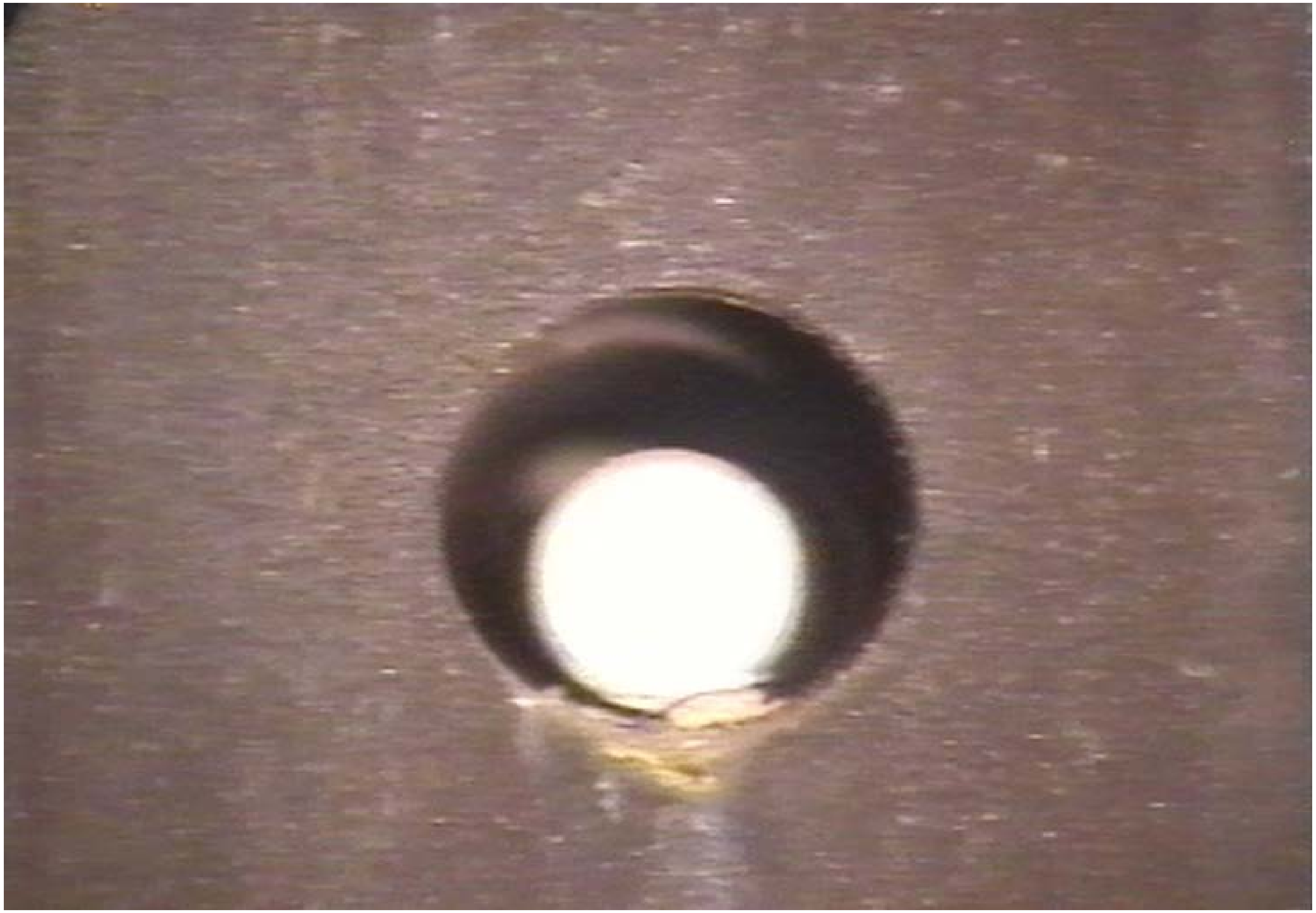
Apparently Pristine Fuel

Slightly Damaged Fuel



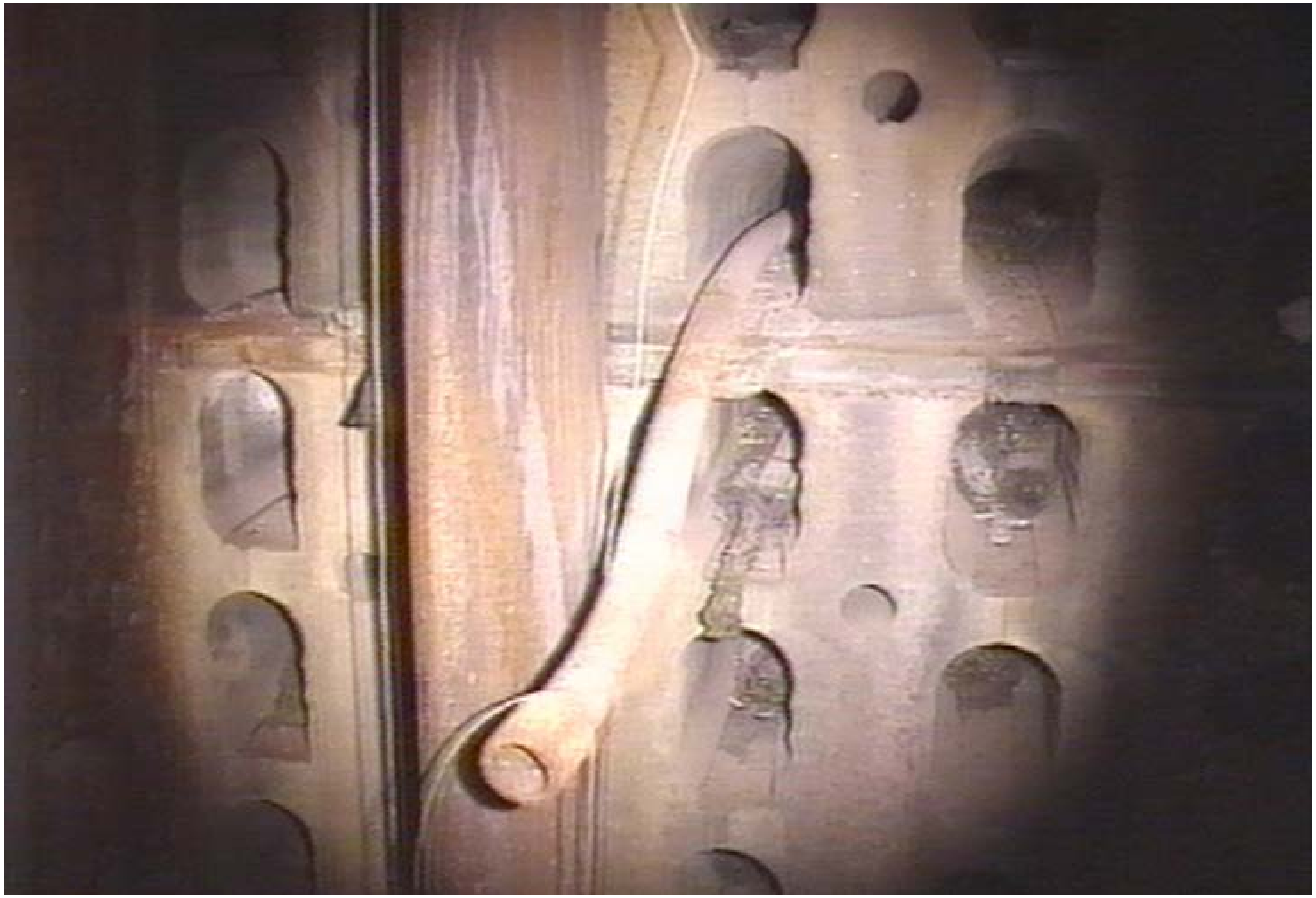
Destroyed Fuel – Channel 23.54

Intact Isotope Cartridge



Damaged Isotope Cartridge

Metal Pipe - channel 21.55



Hazards and decommissioning issues

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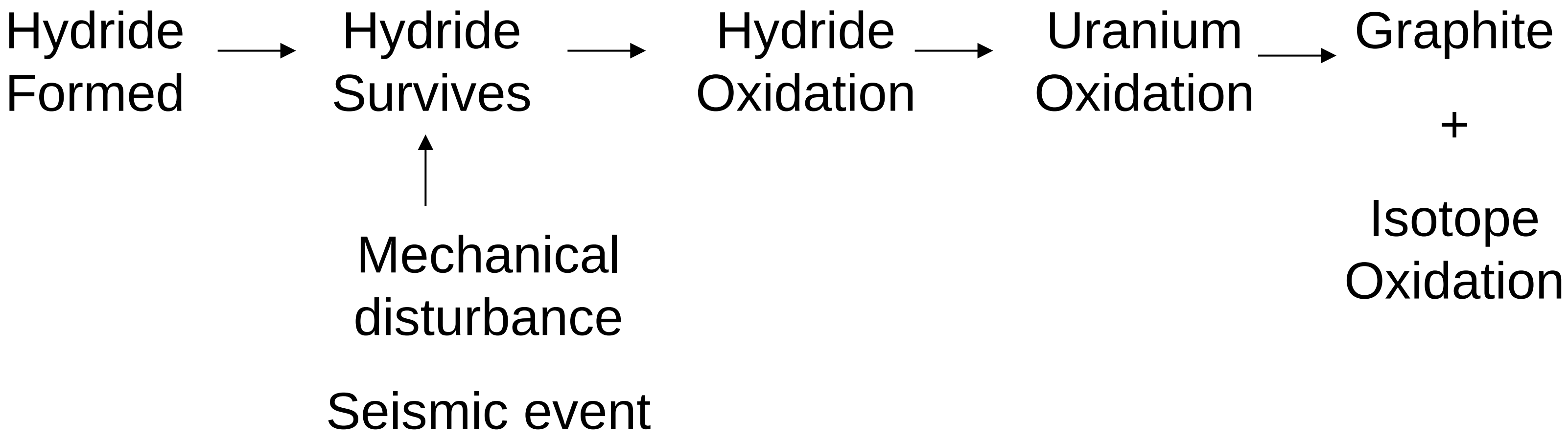
Pile 1 safety issues for decommissioning

- **~15 te fuel still present**
- **Possible core voidage post ‘57 fire - seismic collapse is Design Basis Accident under C&M**
- **Characterisation issues:**
  - ‘hydride event’ (pyrophoric material present?)
  - Wigner energy in graphite?
  - graphite dust explosion?
  - Criticality?

Physical characterisation dominates.

Uranium Hydride Event Sequence

Conjectured event sequence:



Hydride Formed → Hydride Survives → Hydride Oxidation → Uranium Oxidation → Graphite

+

Isotope Oxidation

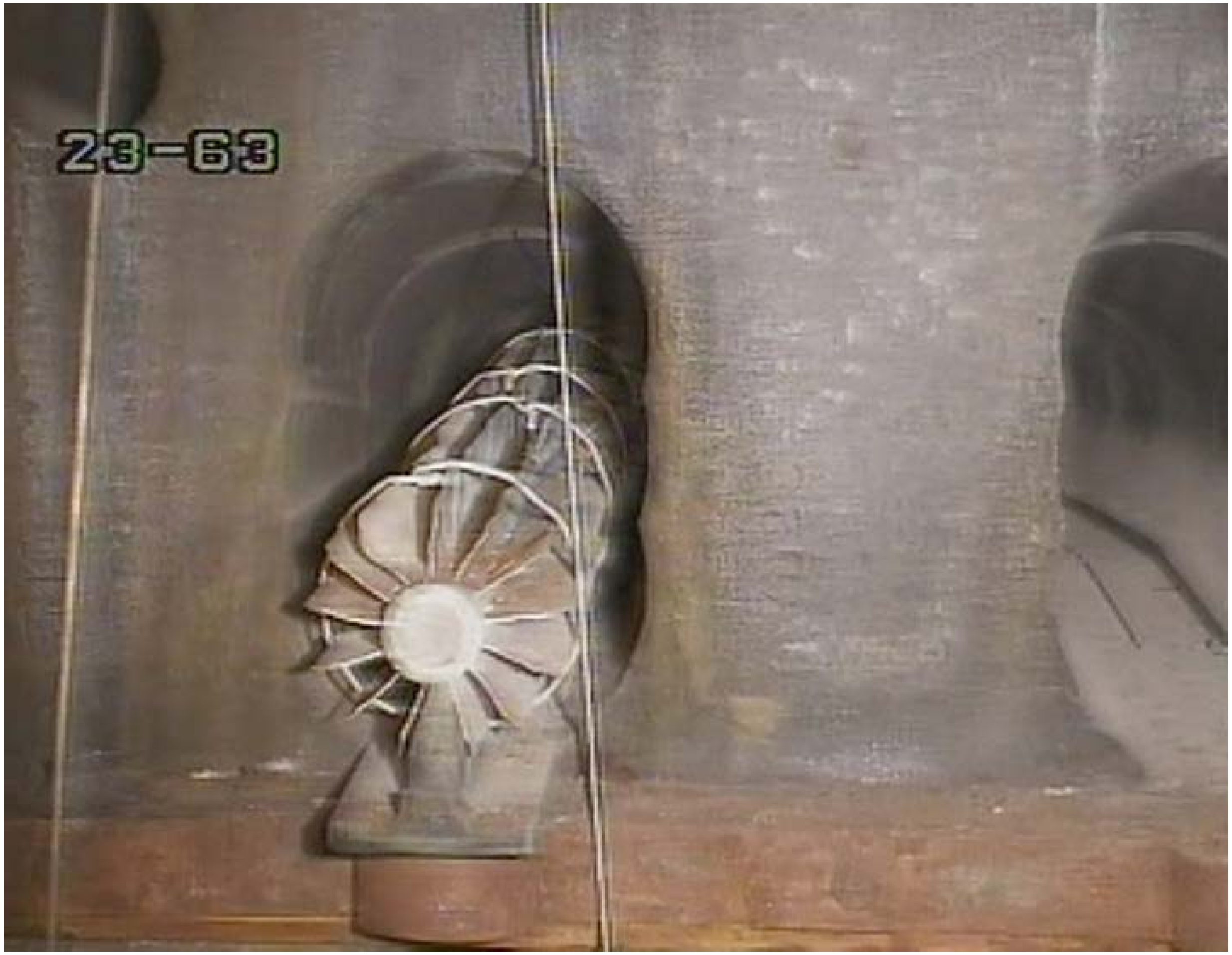
Mechanical disturbance

Seismic event

Fuel element condition - gross corrosion, Channel 21, 58 – hydride unlikely

Fuel element condition - severe fuel damage, Channel 24, 61- hydride unlikely

Fuel element condition - minor fuel damage, Channel 23, 63 –hydride possible?



Conclusions on decommissioning issues

R&D programme demonstrated:

- Hydride will not self-heat to give a propagating thermal event (Ar not required during dismantling)
- Graphite dust is weakly explosible – but Pile conditions rule it out (high concentrations and v. high energy input would be required)
- Direct neutron measurements give improved criticality margin over calculations (margin preserved under DBA, but need to retain Li absorbers during dismantling)

Lessons learned

- **During Pile operations**
  - UKAEA ‘overstretched’ at time of accident – too many commitments
  - Insufficient technical support to what became ‘routine’ operations
  - Committed response of AEA operators averted a larger disaster in ‘57!
- **Decommissioning**
  - Emphasises the need for priorities put on characterisation – unusual problems!
  - Decommissioning problems initially overestimated – over pessimism
  - Lack of continuity - many hiatus’, plans and organisation changes during programme