Sellafield Ltd

Decommissioning and Remediation after a Nuclear Accident, 3 Case Studies

A Nuclear Management Partners company
operated under contract to the NDA

Sellafield Ltd and INES

- Site has been operational for 67 years.
- The site covers an area of $6Km^2$.
- There are over 1300 buildings on the site.
- Over 95% of the UKs legacy radioactive materials reside on the site.

Sellafield Ltd INES rated events

Totals since Nov 1990	INES level 3	INES level 2	INES level 1
1990 – 2012 (Jul)	2	12	249

- Events which pre-date the INES scale have been rated retrospectively.
  - Pile one fire INES Lv5
  - Caesium Extract Plant INES Lvl3

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Caesium Extraction Plant Event

INES Level 3 Event

A remote decommissioning activity undertaken in an extremely high dose areas

Steve Slater
Date: 30th January 2013

Caesium Extraction Plant

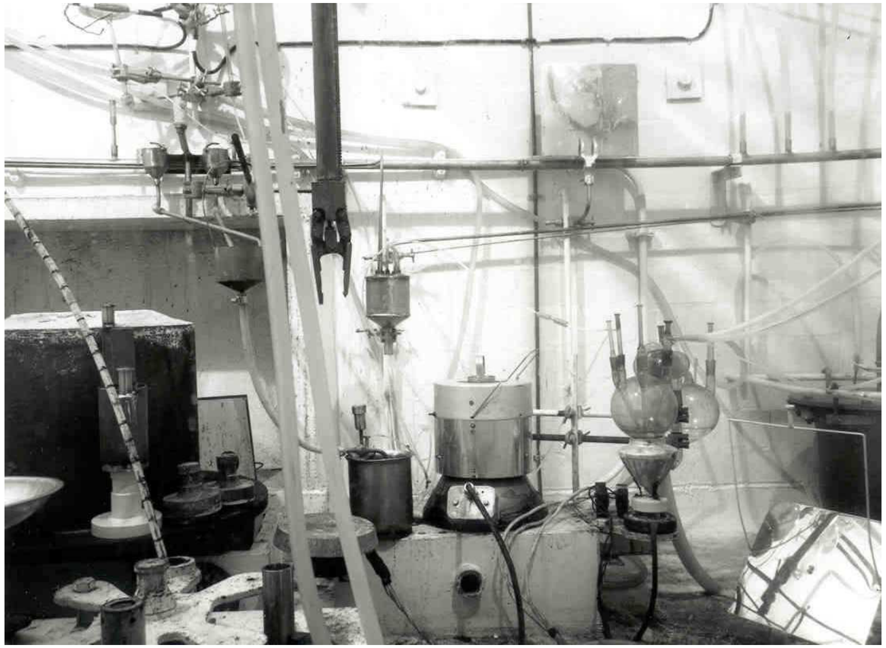
The Caesium extraction plant was built in the mid 1950s to produce Kilo Currie sources for medical use.

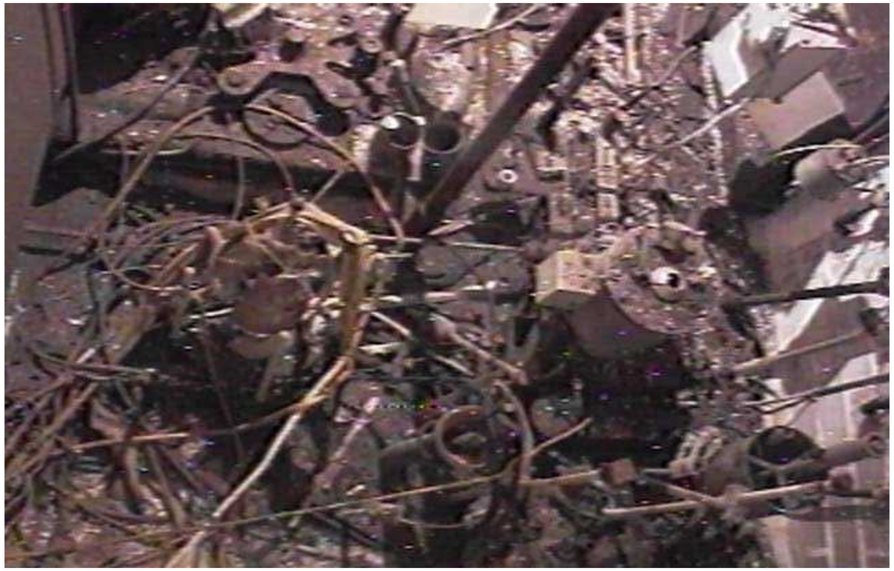
It was built in 3 void areas above a Highly Active waste tank farm which housed 6 1000m3 highly active liquor tanks.

The tank farm remains operations to this day and is close to other key plant areas.

Accident in Cell 3

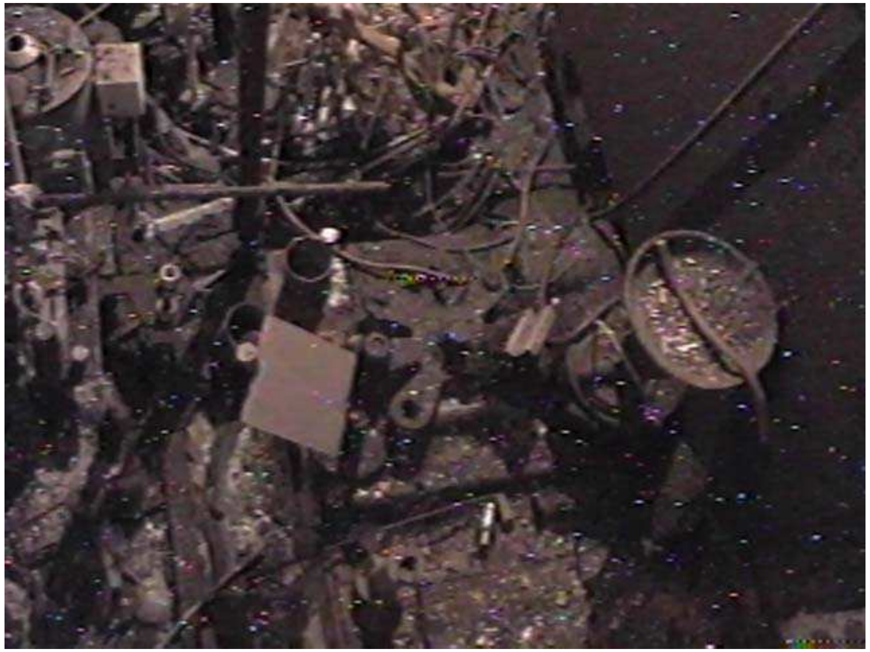
- Cell 3 contained furnaces used to concentrate the caesium source and encapsulate into a platinum container.

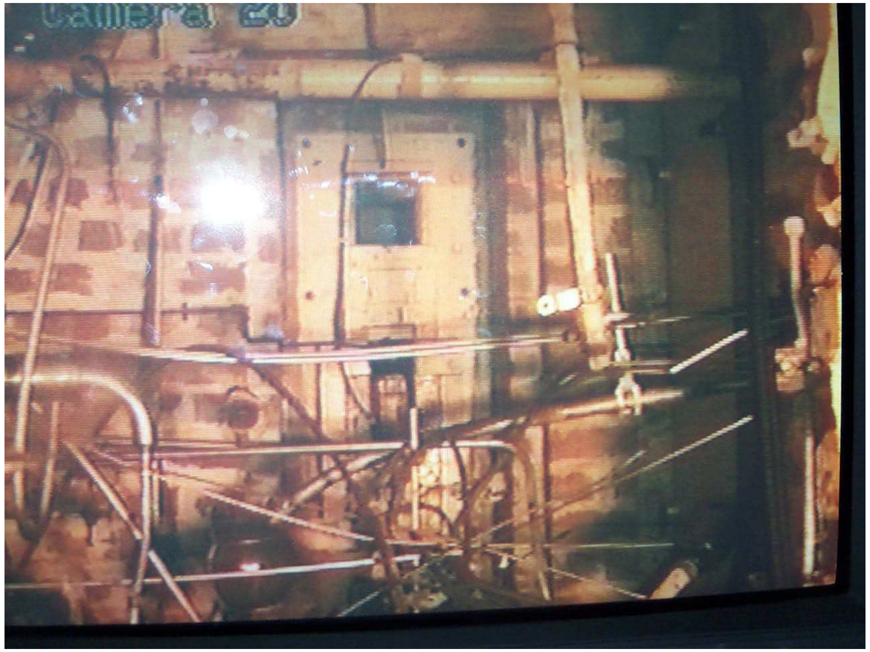




- An in cell explosion resulted in significant levels of Caesium and other debris being released to the cell area.
- Other ‘non standard’ wastes were also created mercury contaminated materials etc.

Accident in Cell 3





Main Building Hazards

- High Radiation Levels
    - **LEVELS OF UP TO 7 Sv/Hr Gamma were present within the cells and up to 100mSv/hr in the void areas surrounding the cells.**
    - **Man entry was only possible for very limited periods of time and only within certain void areas.**
- High levels of loose contamination
- Poor building condition
- Poor building ventilation

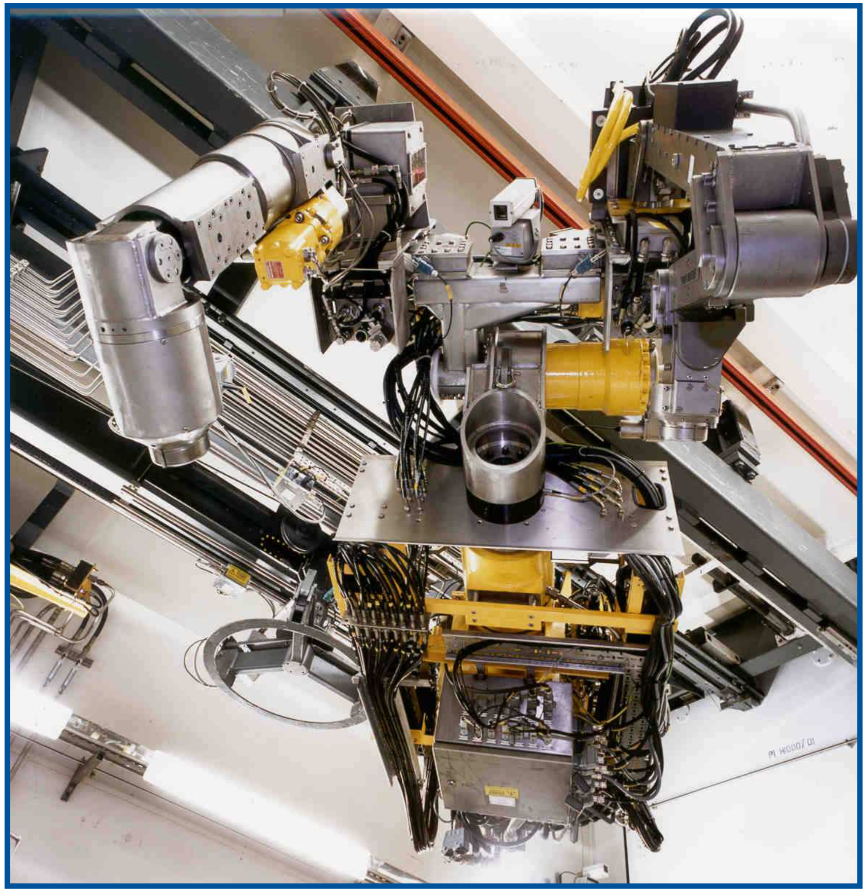
Solution – Self Contained Decommissioning Module

- The design solution was a 900 tonne mobile module that could enter the B212 building at 4 separate locations.
- The module was simply moved with hydraulic rams and travel along rails fitted to the concrete raft.

Decommissioning Machine

- Within the module is a self contained tool deployment system mounted on a large hydraulic ram and slewing ring which provides full reach capabilities.

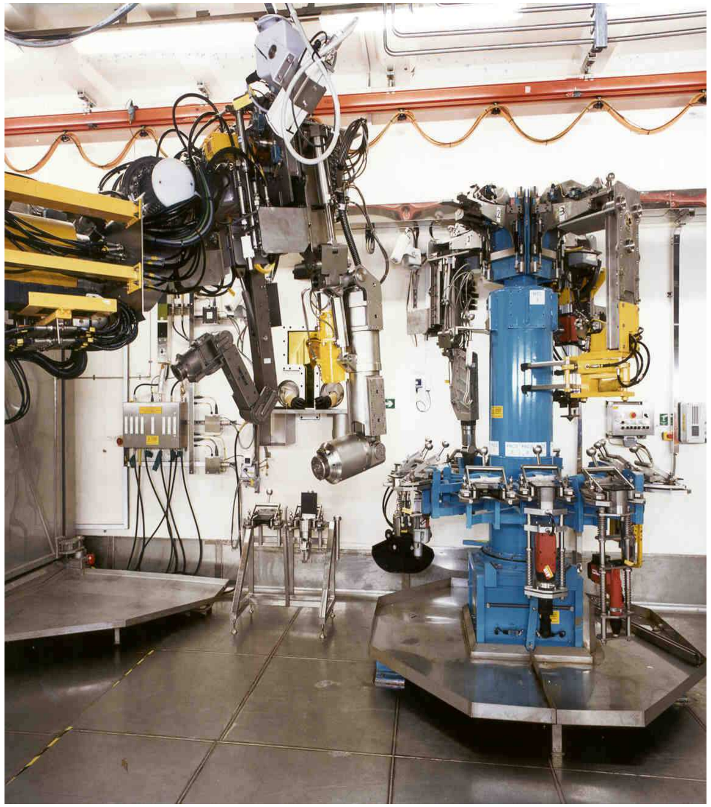
- This whole assemble is attached to 5m cantilever boom allowing the front end of the machine to enter the building without putting the building itself under any undue stress, hence protecting this compromised structure.



Tooling Solutions

- The decommissioning machine can be withdrawn into the module to allow for tooling changes, clean down and maintenance activities.

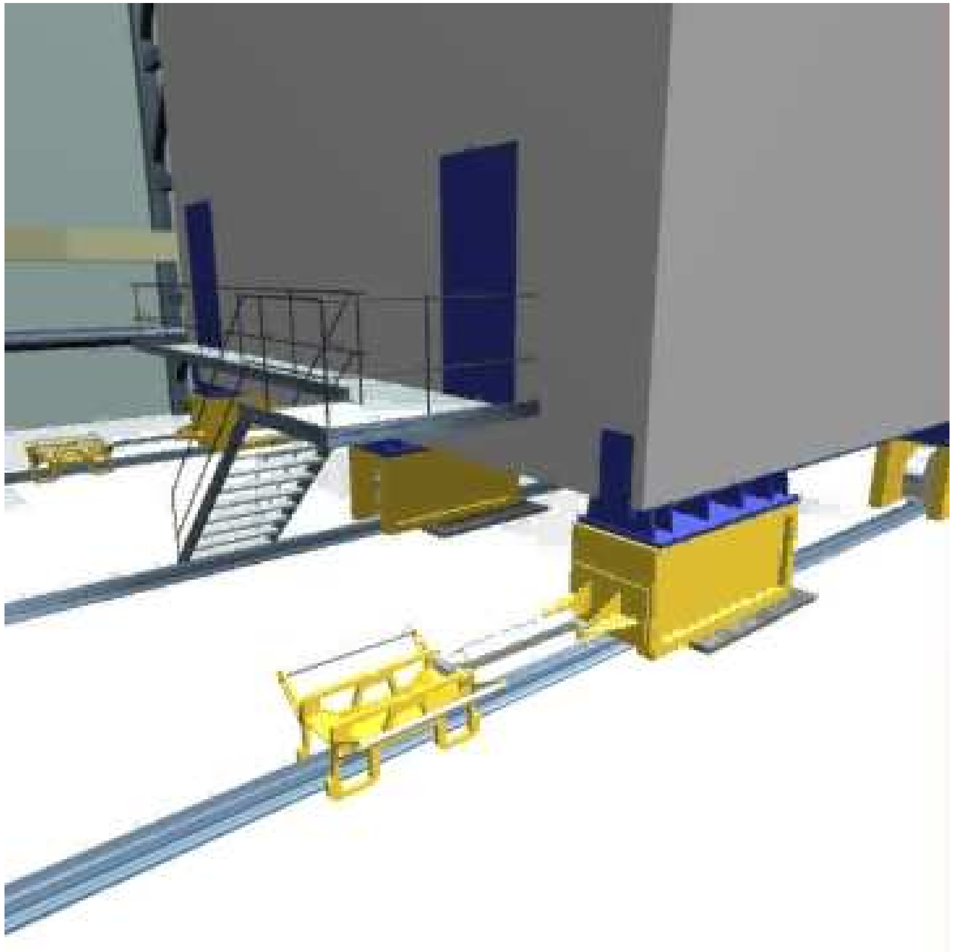
- Larger manipulators, as well as smaller tooling can be changed in this area also.



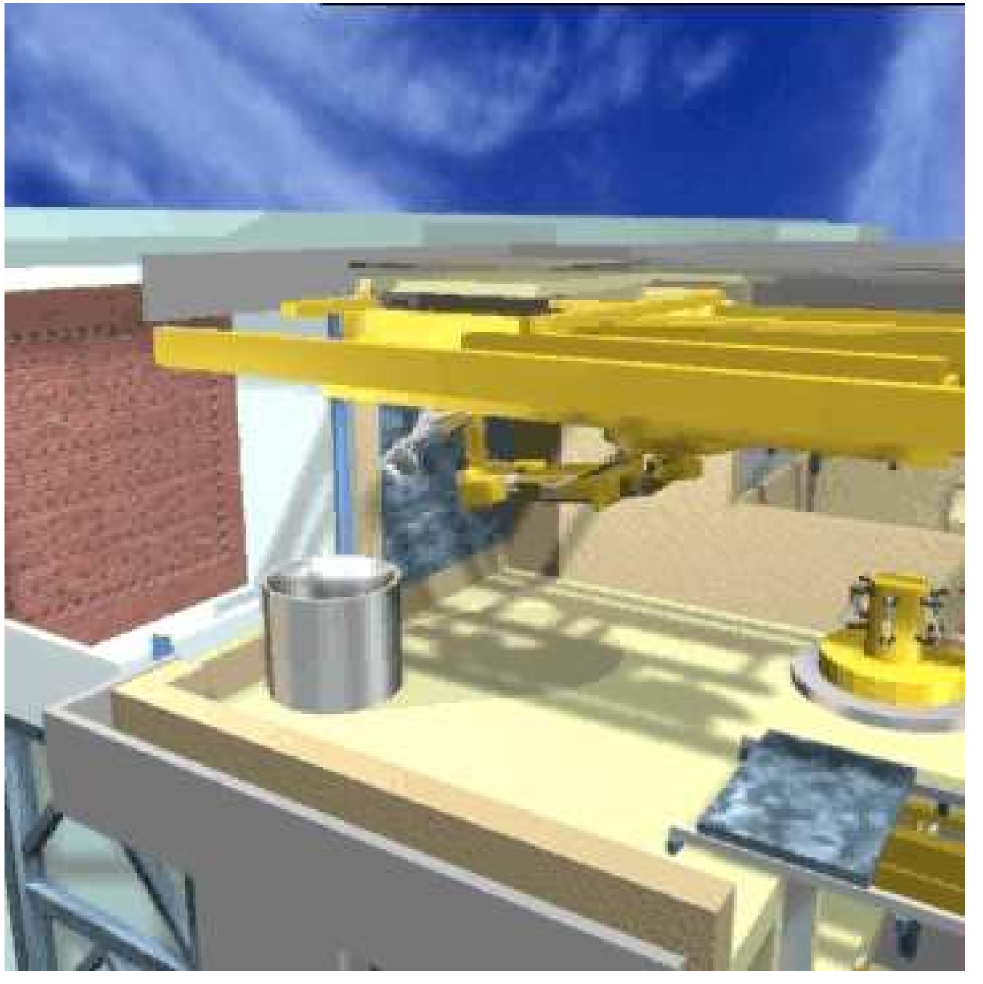
Control Room

- All remote operations are undertaken from a small control room located near by.
- One operator is responsible for operating the machine with the other acting as the camera operator.
- Many cameras within the workplace and the module area allow flexible use and deployment of the tolling equipment.

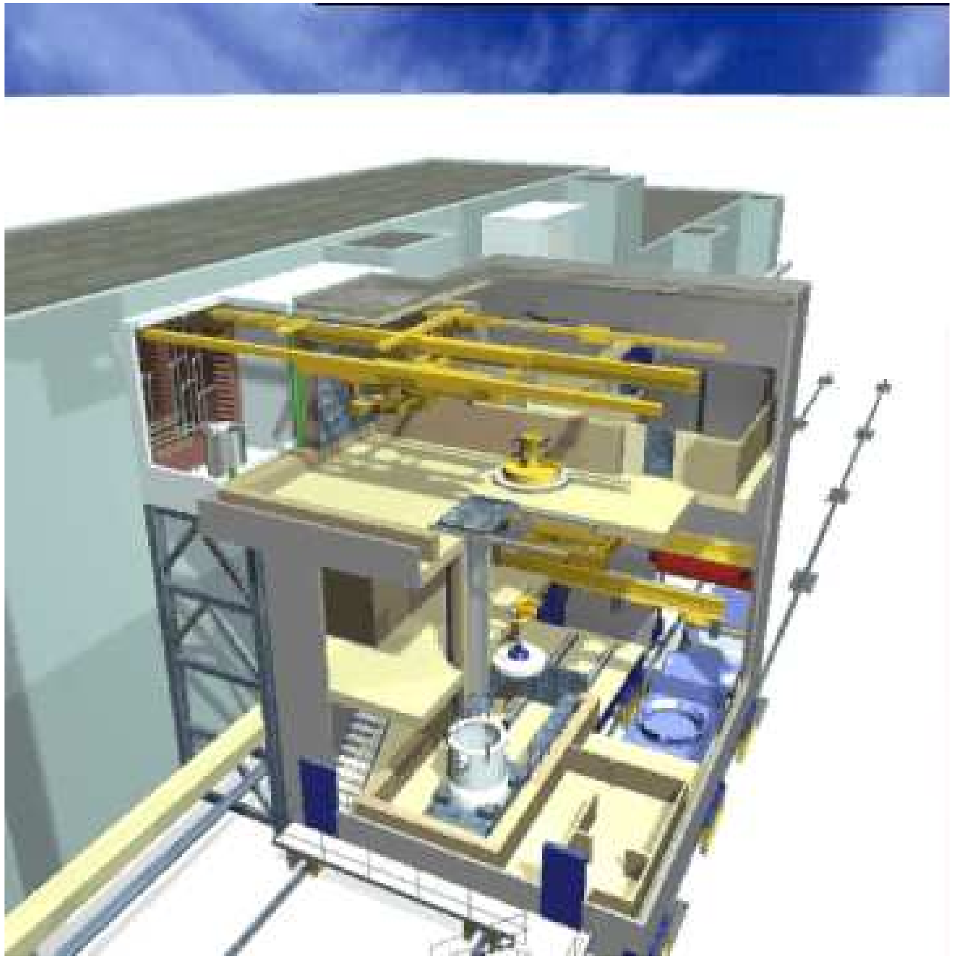
Module Move



Breach of West Wall



ILW Recovery



Key Lessons

Design

- Development of the module was undertaken with the operations team who operate the equipment this resulted in pragmatic designs.
- Maintenance of the tooling was not considered and an oversight in the design, flexible working has ensured this has not become a problem.
- Cascade vent system designed drawing active back into the decommissioning facility prevented large migration of activity to the module area.

Commissioning

- A Period of ‘offsite trials’ proved the equipment prior to deployment at site, this also served as an excellent training rig for the team.

Operations

- The operators were responsible for maintain the equipment hence they look after the tooling.
- Clean down of tooling every Friday preventing large doses and contamination issues building.
- Take as much tooling ‘off the shelf’ as possible, try not to design your own tooling, often did not work or was less effective than planned, spares are difficult to buy and resulted in plant down time.
- A quick release tooling deployment system allowed two arms to be produced and whilst one was in maintenance the other was working – this optimised operations time.

Conclusion – the project will complete this year after 12 years of active and successful operations.

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Pile One Chimney

INES Level 5 Event

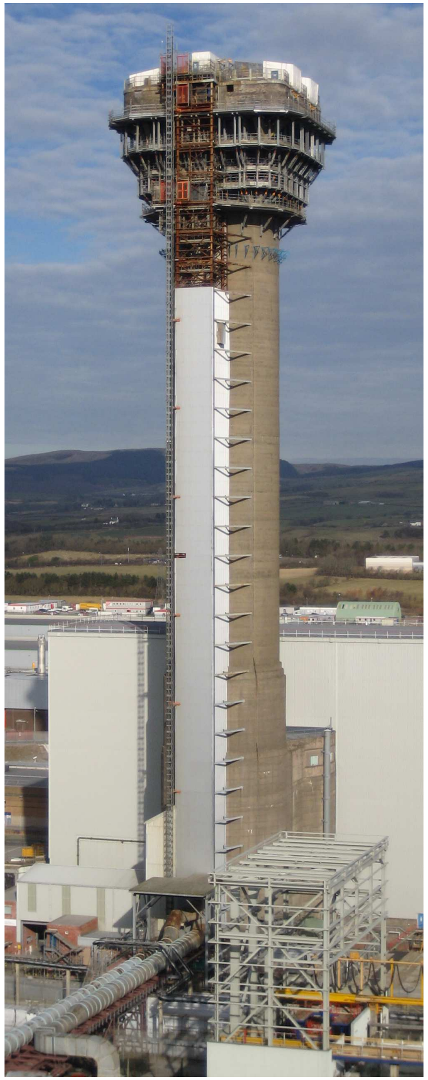
A unique decommissioning activity which illustrate the challenges of decommissioning and demolishing large structures and the resultant waste related issues

Steve Slater

Date: 30th January 2013

Pile One Chimney

- B6 is Ventilation Stack for Pile 1 Reactor
  - 1957 Fire in Pile 1 Reactor led to significant contamination of chimney
  - 120 metre tall, 14 metre diameter concrete structure
  - Highly constrained site location
  - Decommissioning commenced 1988
    - Upper Concentrator
    - Filters and support structure
    - Insulation (fibrous & molar brick)
    - Lining Boxes and support steelwork
  - Decommissioning stopped in 2003 following fatal accident.
  - Decommissioning restarted 2007



Physical Characteristics

- The Filter Gallery & Diffuser section do not meet modern design seismic event criteria (0.125g)
- Deteriorating condition of the chimney with spalling of concrete leading to safety concerns and increased asset care costs
- Structures in support of the chimney are deteriorating rapidly (RMD, head gear platform etc)

Practical Characteristics

- Highly constrained site

Practical Characteristics

- Scale of decommissioning problem unique – 120m up in the air!

Key quantities

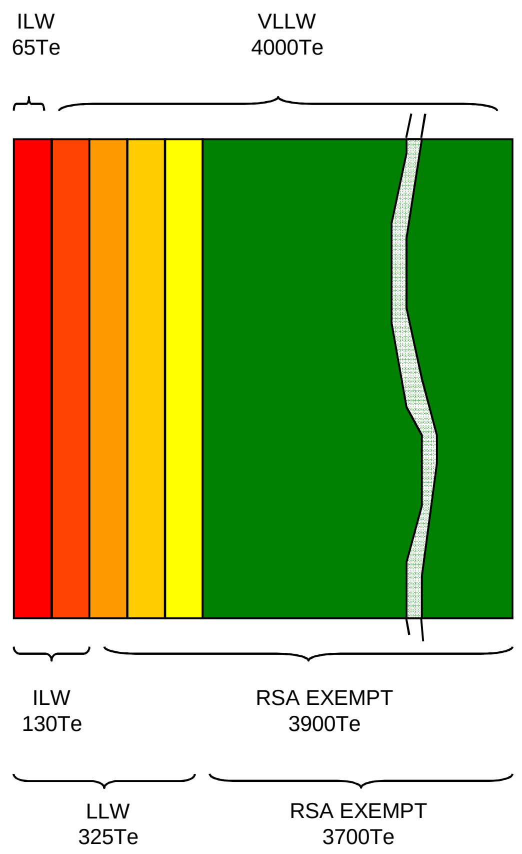
- 5000 tonnes of concrete (main flue)
- 100 tonnes of reinforcement bar (main flue)
- 600 tonnes of concrete (diffuser)
- 15 tonnes of reinforcement bar (diffuser)
- 750 tonnes of concrete (filter)
- 20 tonnes of reinforcement bar (filter

Radiological Challenge

- Radiation & contamination problems from Pile fire in 1957
  - Average doserate in chimney base 433µSv/hr
  - Average doserate in chimney 250µSv/hr
- Whilst not significant doserates the durations of the work will result in significant individual doses.

- Problem is essentially a waste problem and the significant quantities of waste.

  Tritium:
  - Exterior levels of H-3 exceed current exemption limits.
  - Therefore all material may have to be disposed of as radwaste.
  - This has the potential of overwhelming the Low Level Waste Repository and cost will be significant



Inside the Chimney - Top



Inside the Chimney - Bottom

- Restart of decommissioning 2007
  - 78 tonnes steelwork, rubble, lead and aluminium within chimney base
  - Remote retrieval of debris required

The Proposed Solution

Key Learning

Radiological v Conventional

- A pre-occupation with the radiological challenges of the stack resulted in the management team not recognising conventional safety drift which resulted in a fatality.
- Following the fatality all work was stopped and the stack fell into disrepair, only now are we beginning to recover from this.

Waste

- Fundamentally this is a waste management project.
- Characterisation was flawed and did not recognise the H3 element.
- Solutions were developed prior to characterisation being complete which resulted in abortive work.
- Waste routes are starting to show some definition but will stop the project unless these are fully defined within the next 12 months. Get these agreed up front.
- The creation of an interim ILW waste store has allowed the project to continue whilst the UK policy on ILW is resolved.

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Highly Active North Outer (HANO)

Whilst this is strictly not an event the outcome is very similar to plant post a nuclear emergency and illustrates some of the challenges that could be faced by plant operators and recovery teams.

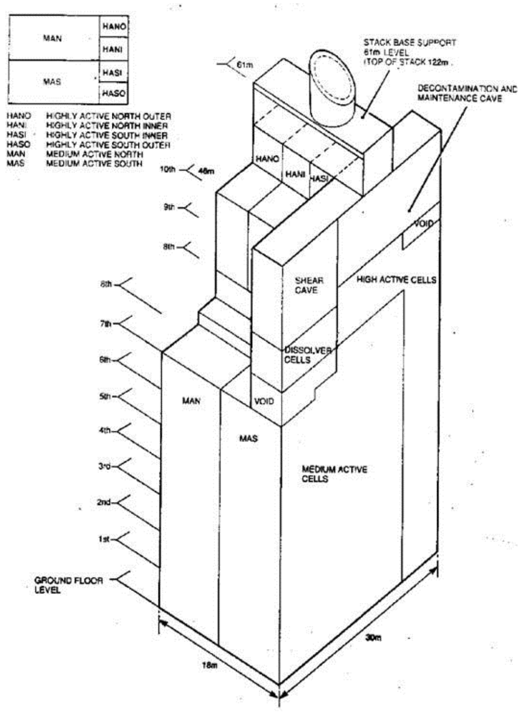
Steve Slater
Date: 30th January 2013

HANO

B204 – SEP Head End Plant

- Opened in 1952.
- Modified to carry out oxide fuel processing operations which ceased in 1973
- Several modifications to improve throughput however facility finally mothballed in 1979

HANO

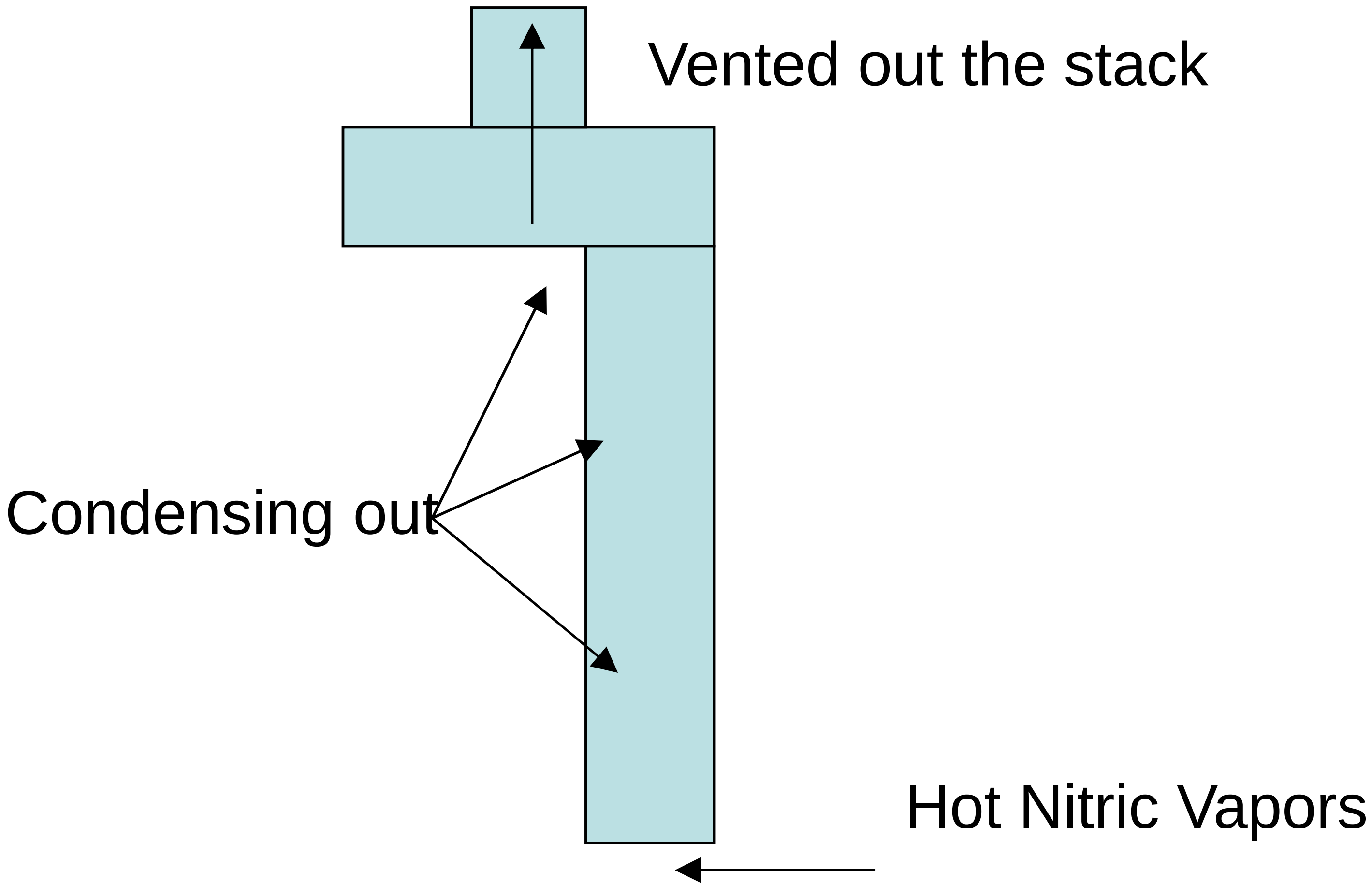


Sketch of B204 Cell Block

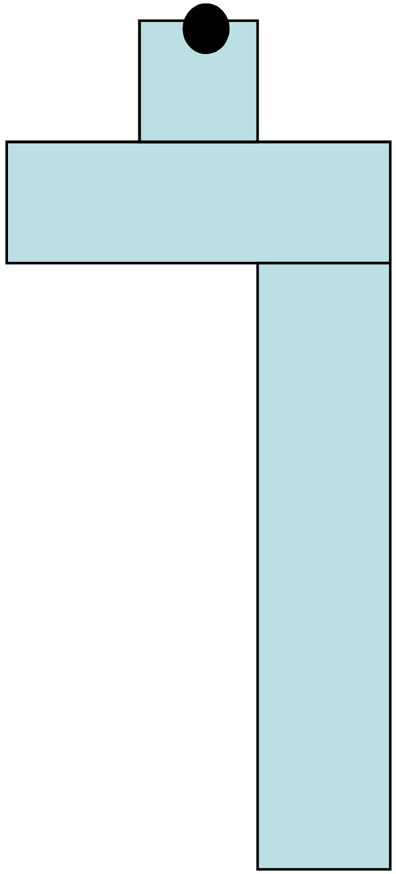
A Nuclear Management Partners company operated under contract to the NDA

Sellafield Ltd

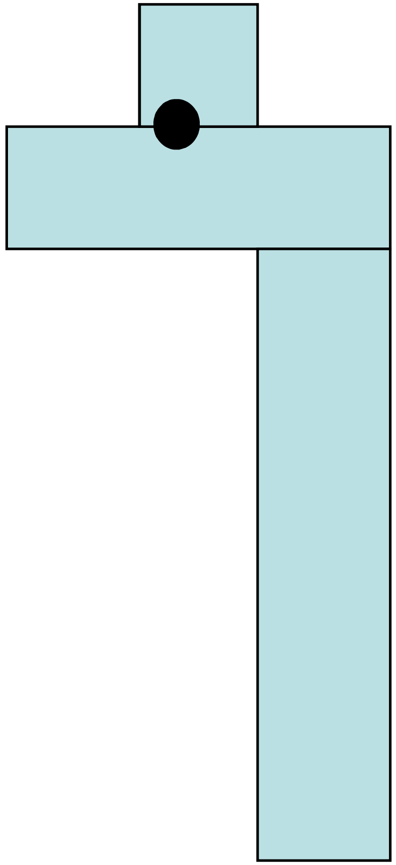
HANO Cell instability



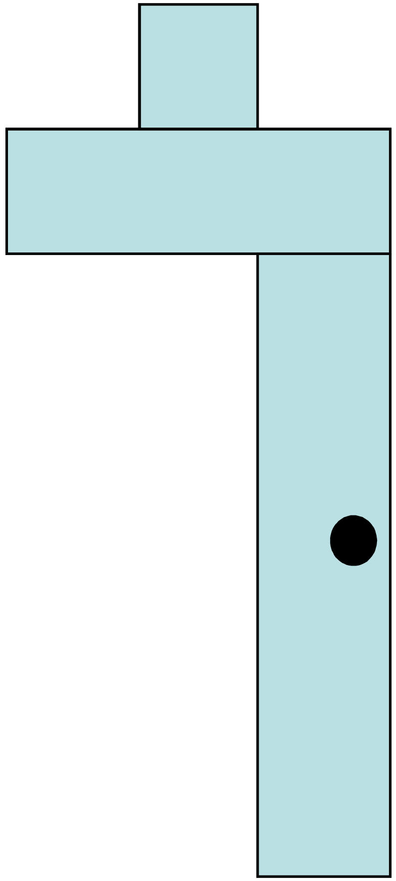
HANO Cell instability



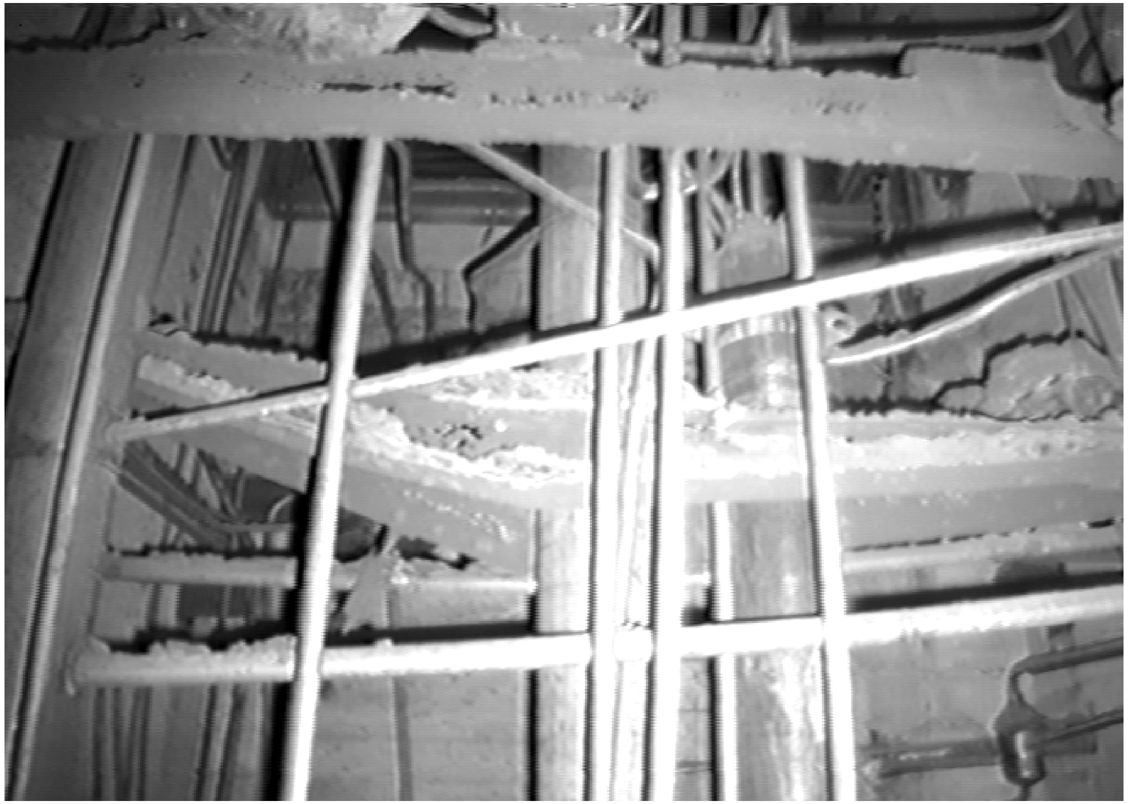
HANO Cell instability

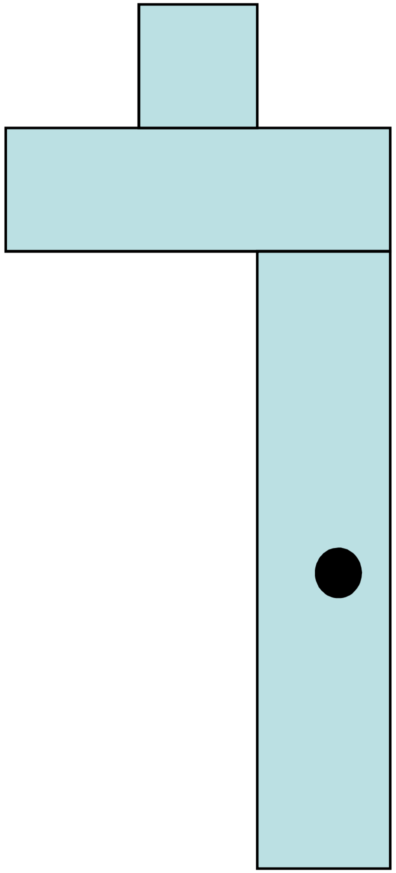


HANO Cell instability



HANO Cell instability





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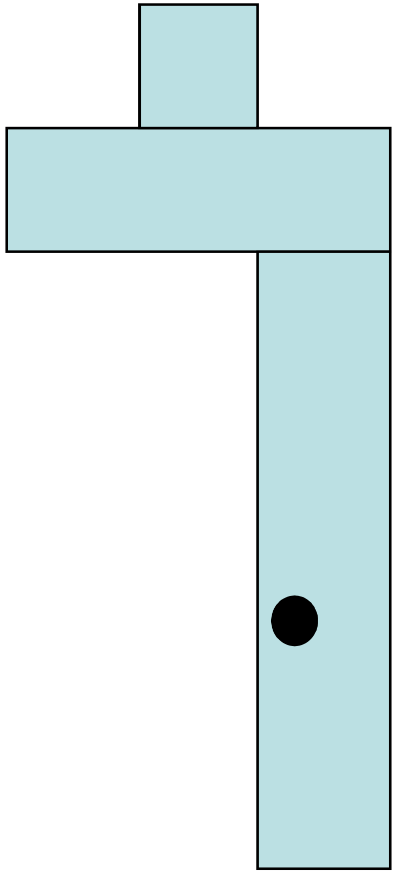

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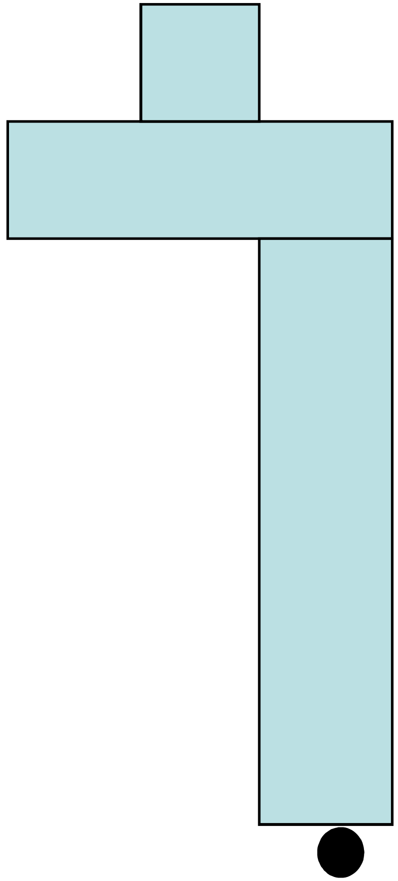
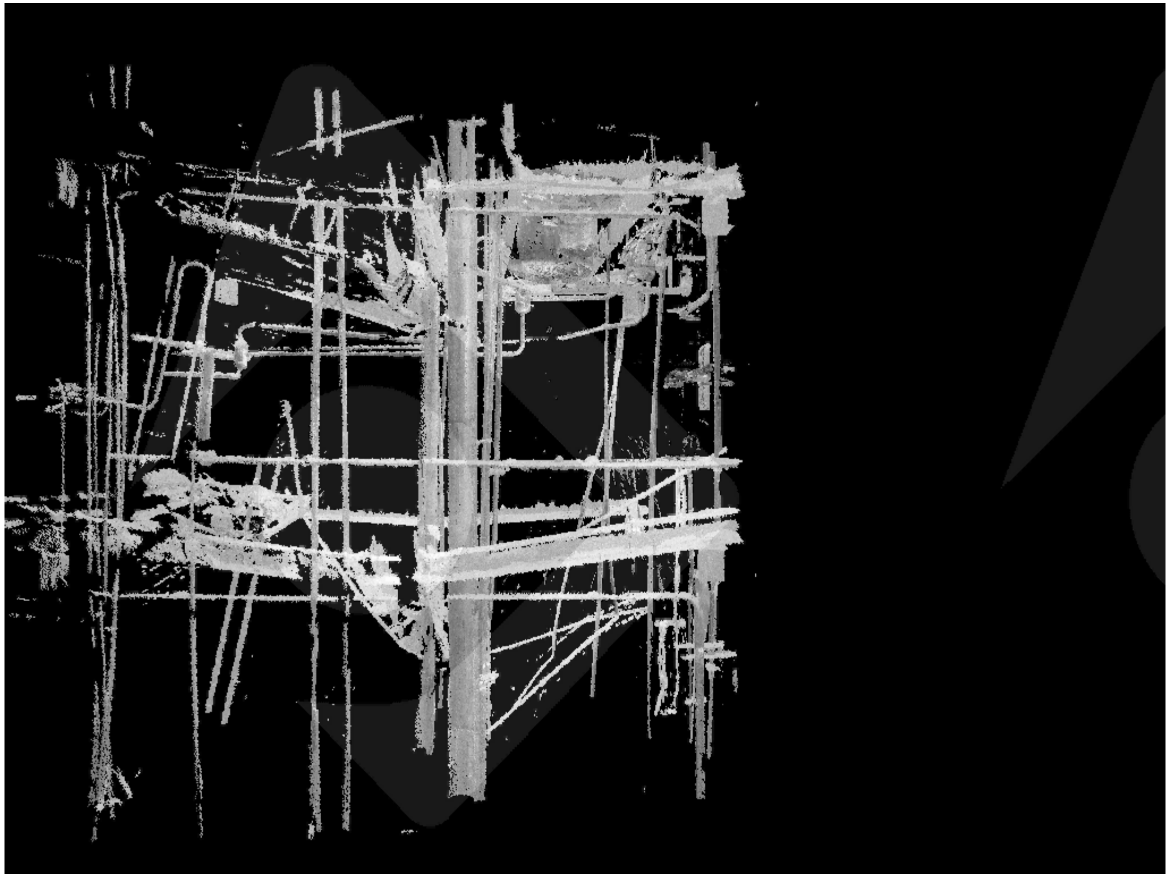
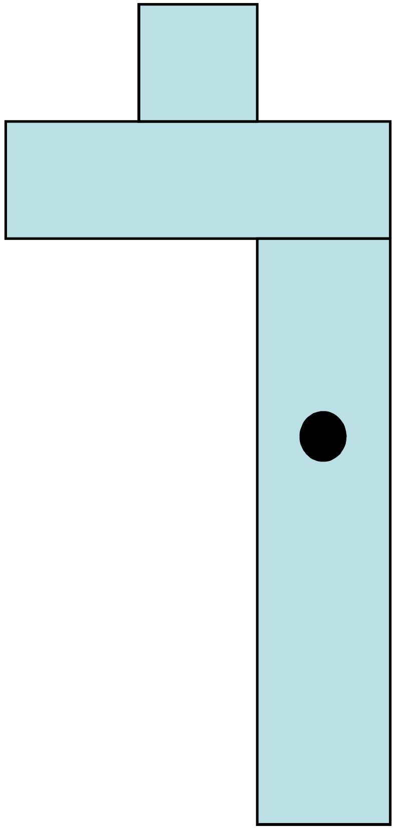


HANO Cell instability

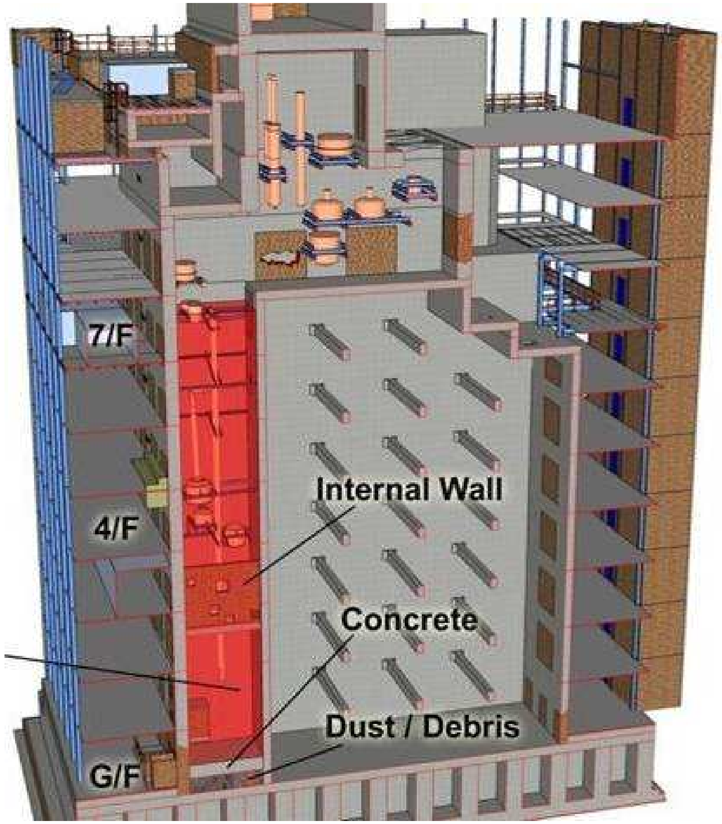




Solution – Encapsulation of the Cell Contents

- A light weight foam grout developed and optimised from the mining industry to capture all the primary vessels and tanks.
- Extensive testing off site as failure could have precipitated a full cell collapse
- Uniquely this will compress to 1/3 its ‘as cast volume hence no more waste generated

Solution – Encapsulation of the Cell Contents



740m3 poured in first column over 6 months.

Top section encapsulated with even lighter grout to protect weak roof.

Key Lessons

Design

- Safety case precluded 're-engineering' of supports – too risky and thought that it may result in cell collapse.
- Personnel access was prohibited due to collapse risk.
- Only real solution was with no personal intervention.

Commissioning

- Extensive 'offsite trials' again proved the equipment prior to deployment at site and served as an excellent training rig for the team.
- The offsite trails proved the pour depths and demonstrated the maximum and minimum operating envelope.

Operations

- Contract team used with site team, trials period allowed the team to gel together.
- Storage of PFA was a problem given the amounts used.
- Dusts became a problem within the mix and pour area.

Future Decommissioning

- A full laser scan of the facility has been undertaken prior to grout fill to future proof decommissioning and aid the next steps

Conclusion – the project completed without incident