Spent Fuel Management and Storage Development in UK

ISSF 2010, 15-17 November 2010, Tokyo

Sellafield Ltd

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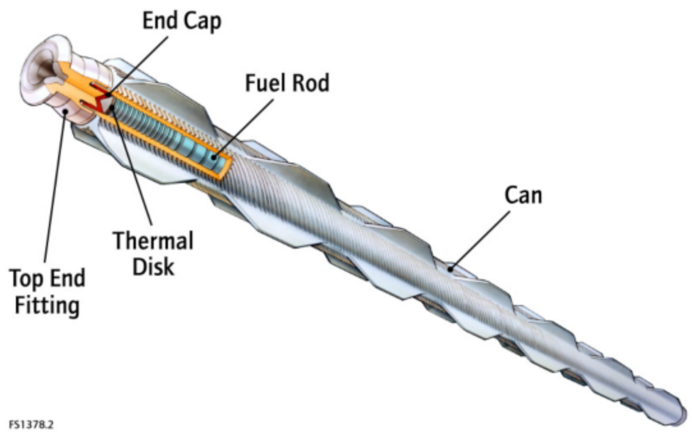
    - Advanced Gas Reactor (AGR) fuel
- Summary

Magnox NPPs – UK 1st Generation

Wylfa NPP
Picture courtesy of Magnox North Ltd

- CO_2 Gas Cooled
- Graphite Moderator
- 2 Operational Stations (4 are being defuelled)

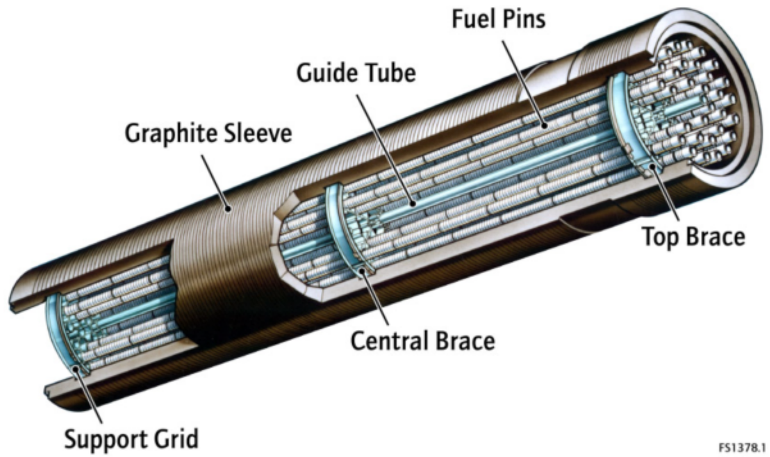


- Uranium Metal Fuel
- Magnesium Alloy Clad

Advanced Gas Reactor (AGR) – UK 2nd Generation

Hunterston B
Picture courtesy of British Energy Group plc

- CO_2 Gas Cooled
- Graphite Moderator
- 7 Operational Stations



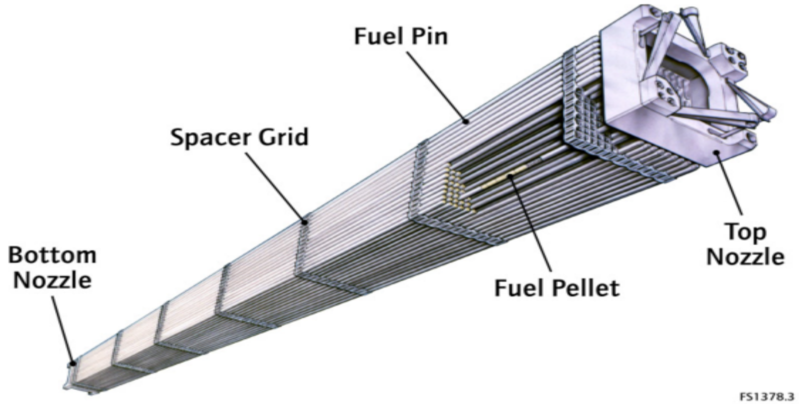
- UO_2 fuel
- Stainless Steel Clad

Pressurised Water Reactor (PWR)- UK 3rd Generation

Sizewell B

Picture courtesy of British Energy Group plc

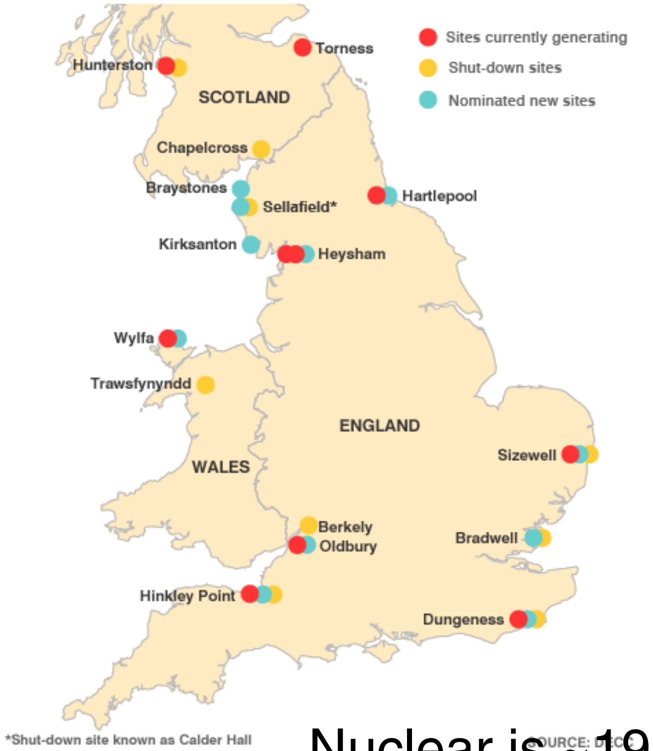
- Light Water Cooled and Moderator
- 1 Operating Station



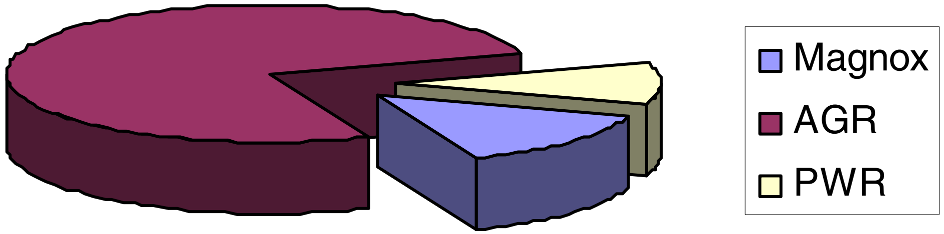
- UO_2 fuel
- Zircaloy Clad

Share of Nuclear Electricity Generating Capacity

NOMINATED SITES FOR NEW NUCLEAR POWER STATIONS



% of capacity



Nuclear is ~19% of UK Electricity Generating Capacity

(10 sites announced for new nuclear build by the Energy and Climate Secretary (09.11.09))

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Experimental Spent fuel from the UK Power Development Programmes

Steam Generating Heavy Water Reactor – Winfrith Site

PFR – Picture courtesy of DSRL/NDA

Windscale AGR

DFR – Picture courtesy of DSRL/NDA

Spent Fuel Management Strategies - UK

- PWR (Managed by British Energy -EDF)
  - **Open Cycle**
- Magnox (Managed by Sellafield Ltd)
  - **Closed Cycle**
- AGR (Managed by Sellafield Ltd)
  - **Closed Cycle** (Until end of Thorp Operations)
  - **Open Cycle** (Non-reprocessed AGR fuel)
- Exotics (Various e.g. Dounreay Site Restoration Ltd)
  - Closed Cycle (e.g. Dounreay Fast Reactor)
  - Open Cycle (e.g. Prototype Fast Reactor fuel)
- New Build
  - Closed Cycle (Planning assumption)

UK Strategy for Spent Fuels Management

- February 2006 the Nuclear Decommissioning Authority (NDA) announced the intention to undertake a comprehensive long term spent fuel management review
- Objective
  - To identify the key issues associated with the management of spent fuel and to propose an approach that will lead to the development of a long term integrated plan
- NDA has established
  - Topic Overview Group for ‘Nuclear Materials and Spent Fuel’
    - Spent Fuels Management is subdivided into three further topics
      - Magnox Fuel
      - Oxide Fuel
      - Exotic Fuel
  - National Stakeholder Group (NSG)
  - Site Stakeholder Group (SSG)

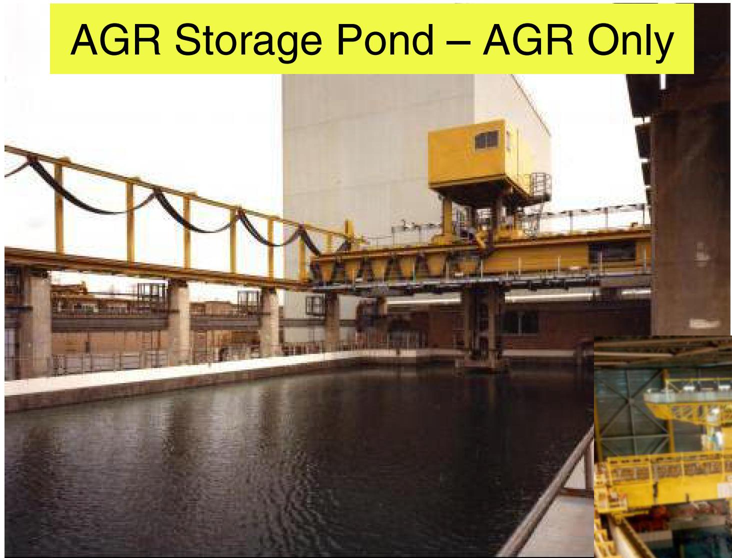
SFM – PWR (Sizewell B)

Example - Ventilated Dry Cask System

- At Reactor storage capacity is expected to be full around 2015
- 2009, Public consultation of the options

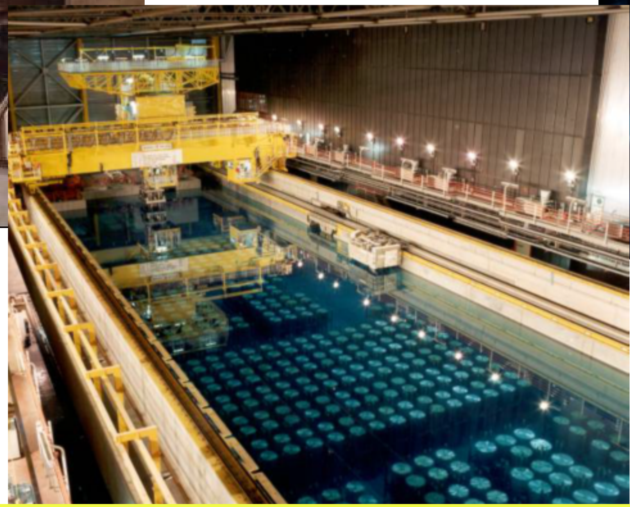
  ('Sizewell B Dry Fuel Store' www.british-energy.com)
- Preferred option was to dry store spent fuel in casks in a purpose built building
  - Capacity for up to 3,500 SFAs/200 containers
- February 2010, Planning application was made to the Secretary of State for the Department of Energy and Climate Change (DECC)
- June 2010, Holtec International was awarded a contract to manage the safety case production

SFM at Sellafield – Magnox, AGR & LWR



AGR Storage Pond – AGR Only

Fuel Handling Plant – Magnox & AGR



Thorp Receipt & Storage – LWR & AGR

SFM at Sellafield – Magnox, AGR & LWR

- Containerised Storage
  - **LWR** is stored in Multi-element Bottles (MEBs)
    - Boral
    - Boronated Stainless Steel (BSS)
  - **Magnox & AGR** are stored in skips and containers

SFM- Magnox Operating Plan (MOP 8)

- Wet Fuel Stock Policy
- Limit amount in wet storage to 800tU +/- 50tU by April 2010
- Recognises that prolonged storage could result in fuel deterioration which leads to slower reprocessing and increased discharges
  - $Mg + H_20 \rightarrow Mg(OH)_2 + H_2 \uparrow$

Site	Start Bulk Defuelling	Last Fuel Off-site
Calder Hall	October 2012	May 2015
Chapelcross	April 2008	August 2011
Dungeness A	April 2008	March 2011
Oldbury	April 2011	September 2013
Sizewell A	July 2009	June 2012
Wylfa	August 2011	January 2015
Sellafield	completes reprocessing around January 2016	

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SFM Sellafield Ltd – Examples of R&D

Hanford Multi Canister Over-pack (MCO)
Picture courtesy of Hanford.gov

- Development of a Contingency Option for the management of Magnox Fuel
  - The reference case position is Magnox fuel is reprocessed
  - The current plant is 46 years old and has reprocessed >44,000tU
  - Given the age of the plant there is a risk that some Magnox fuel may not be reprocessed
  - There is a need for a contingency to be available that could be deployed in a relatively short time frame
  - Build-on developed technology for metal fuel. In this case a variation to the Hanford MCO

SFM Sellafield Ltd – Examples of R&D

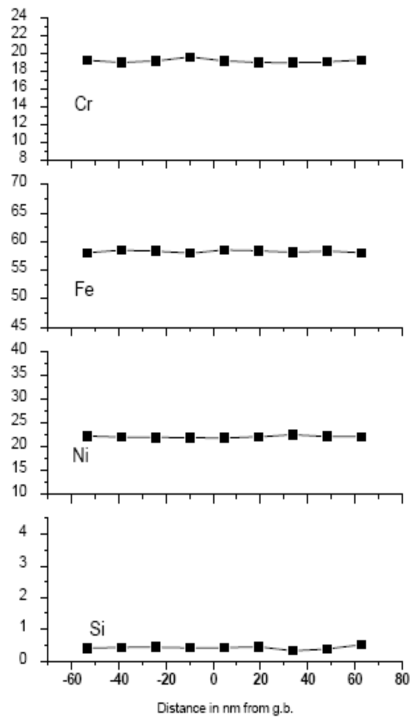
- Hanford MCO developed for degraded Zirconium clad uranium metal fuel

- Development of a Magnox fuel canister
  - 26 intact fuel elements

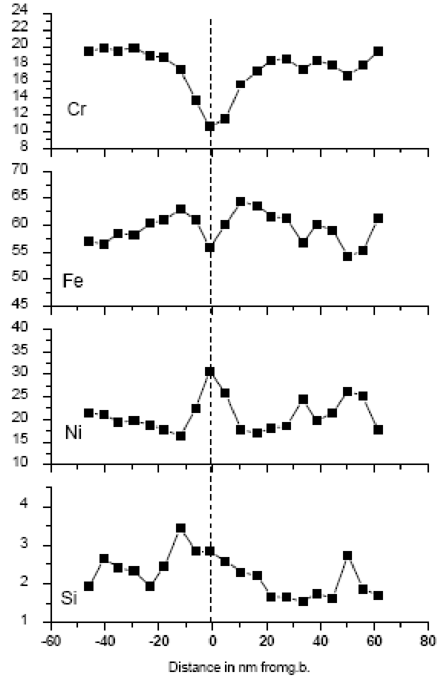
- Resolution of Technical Issues
  - Drying of wetted Magnox fuel
    - Free Water
    - Physically adsorbed water
    - Chemically adsorbed water (tightly bound to $Mg(OH)_2$)
  - Canister Chemistry Evolution

SFM Sellafield Ltd – Examples of R&D

- At the beginning of storage some irradiated AGR fuel pins and structural components are left sensitised
  - In wet storage sensitised pins are susceptible to corrosion through inter-granular attack (iga)
- Pre-requisites for iga
  - Must have a sensitised microstructure (through wall to lead to failure)
    - Radiation Induced Segregation (RIS) is observed to occur on 20Cr/25Ni/Nb stainless steel cladding in the temperature range 350ºC to 520ºC; peak effect at 420ºC
    - Some elements of a 7-8 element stringer affected
  - Linked to an applied mechanical stress
    - Failure sites normally associated with areas of stress
  - Must be exposed to a corrosive environment
    - For example Chloride



Unirradiated Steel



Irradiated Steel (350-450° C)

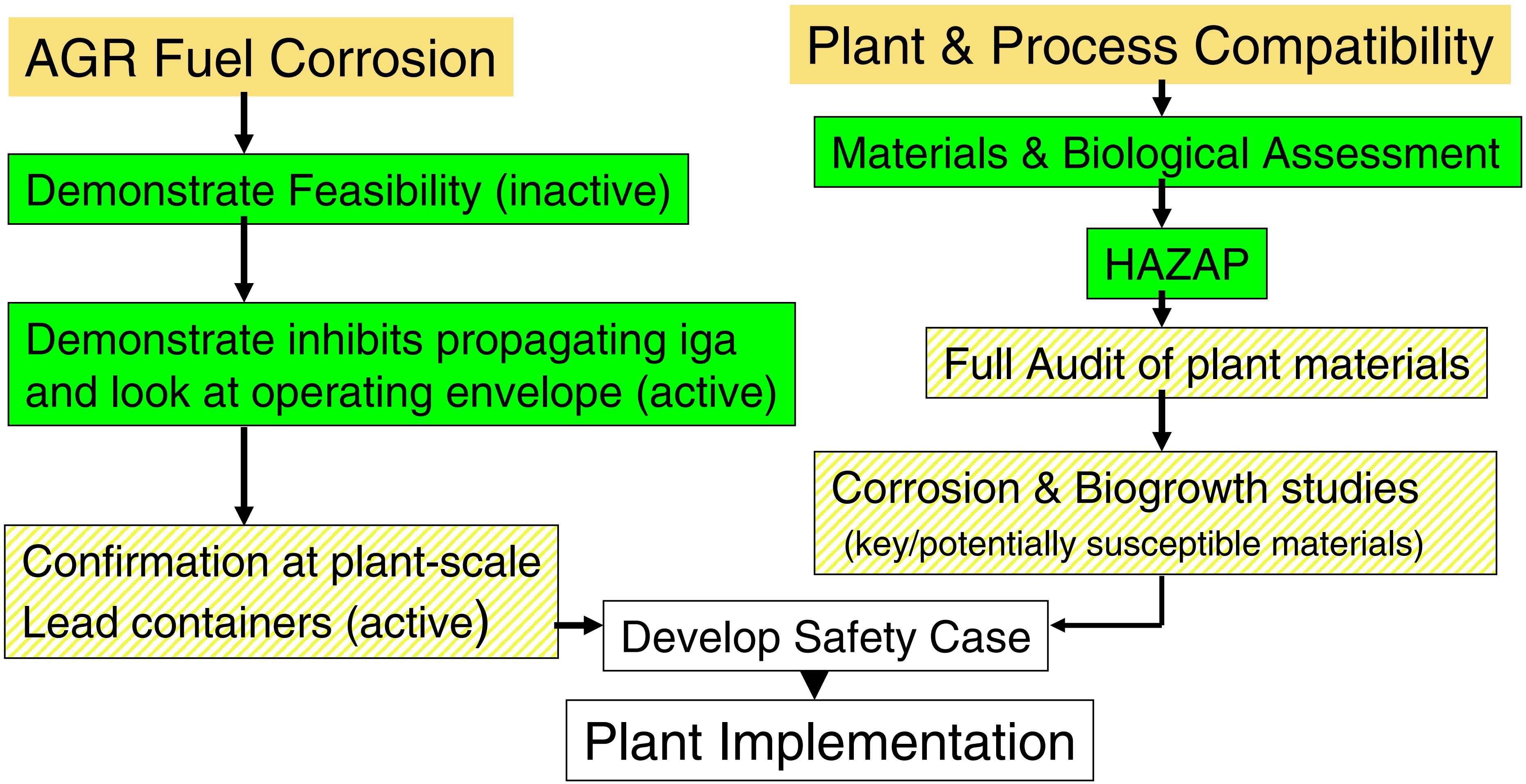
SFM Sellafield Ltd – Examples of R&D

- To prevent the potential for AGR fuel to corrode during wet storage, the corrosion inhibitor sodium hydroxide is deployed at Sellafield where practicable

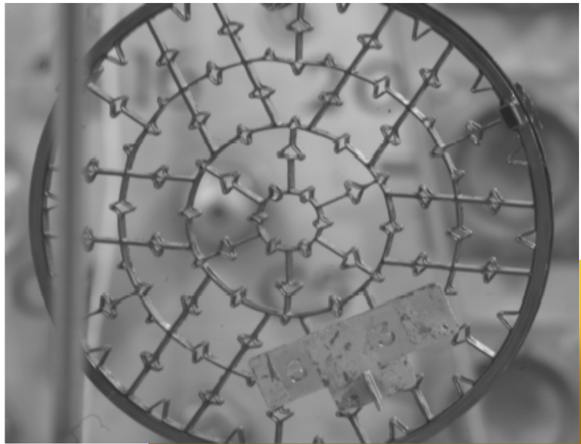
- The exception is Thorp Receipt & Storage (TR&S) where a reprocessing buffer is stored in demineralised water

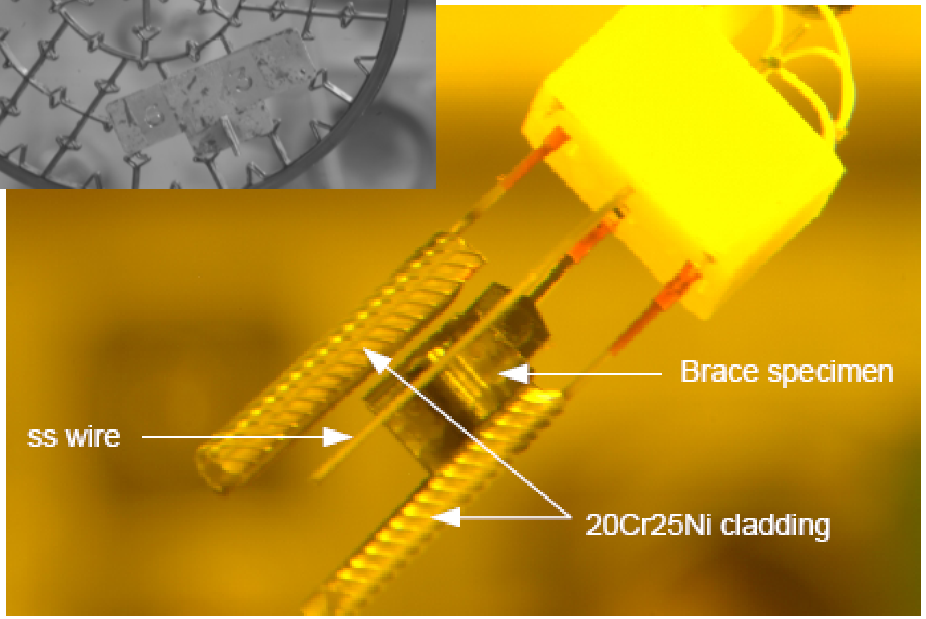
- Sodium Hydroxide cannot be deployed in TR&S due to compatibility issue with LWR MEBs

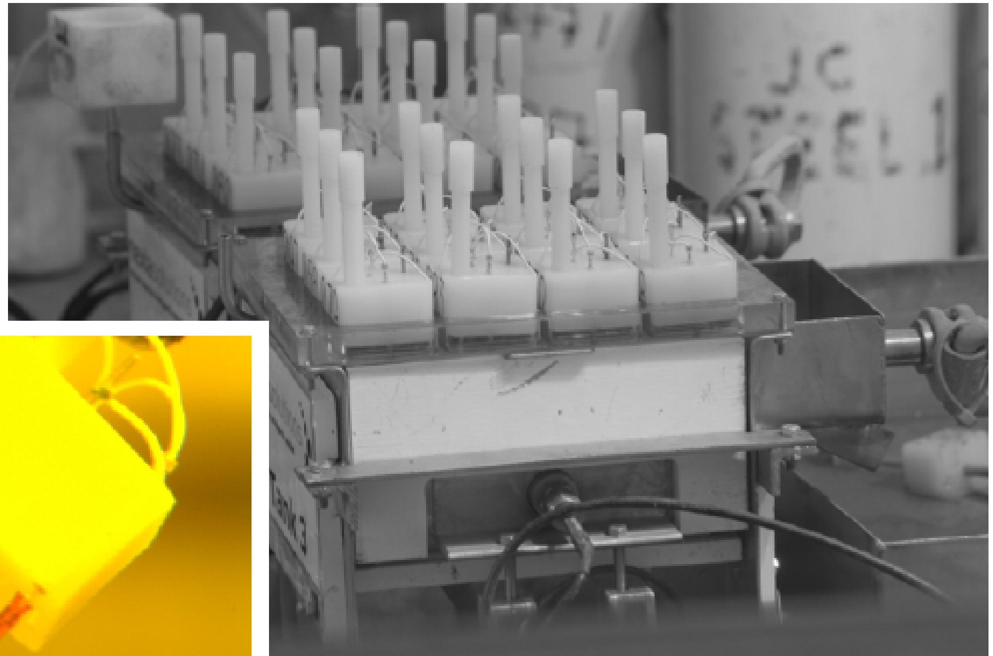
SFM Sellafield Ltd – Examples of R&D



SFM Sellafield Ltd – Examples of R&D







Corrosion testing performed by NNL for Sellafield Ltd

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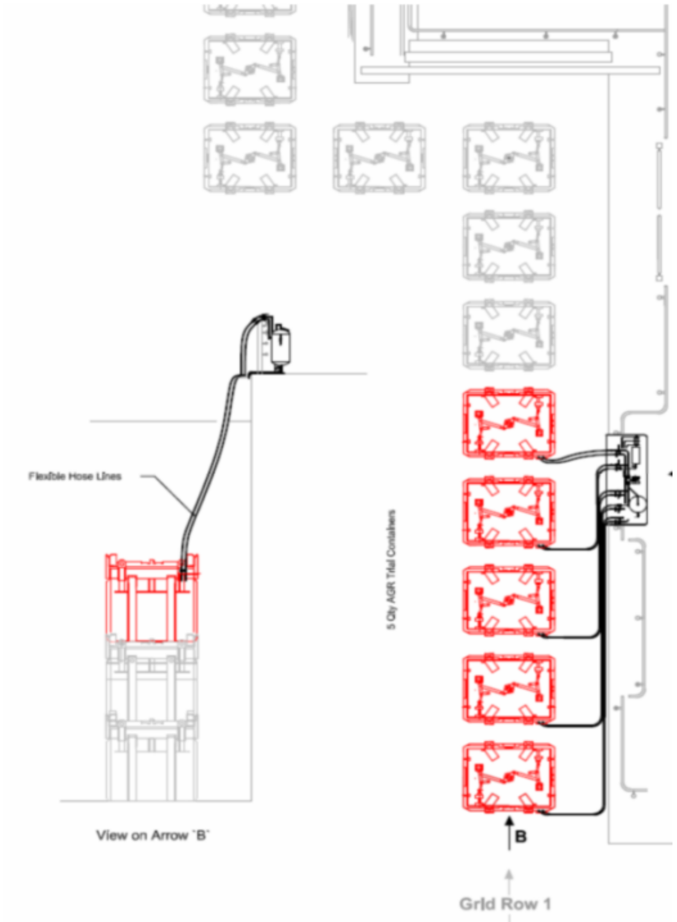
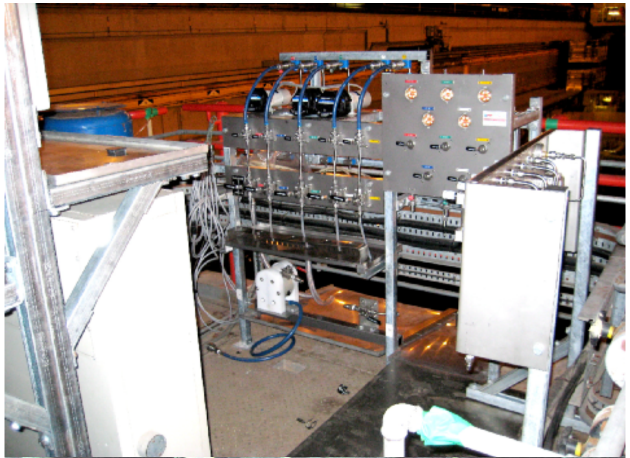
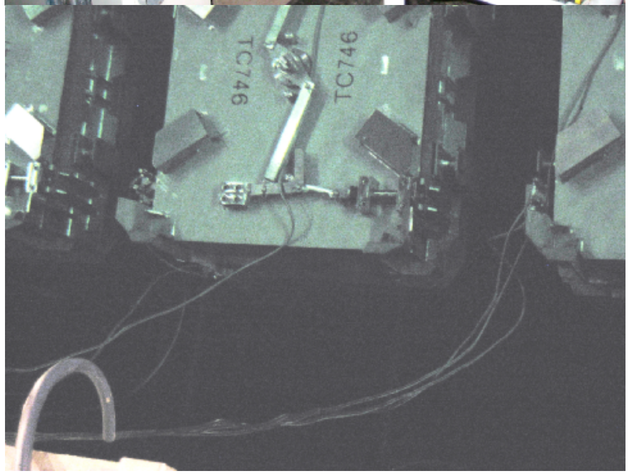
Alternative Corrosion Inhibitor Development

-Hot laboratory studies

SFM Sellafield Ltd – Examples of R&D







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Alternative Corrosion Inhibitor Development
-Plant scale demonstration

Summary

- Provided an over-view of Nuclear Power Generation in the UK
- Out-lined Spent Fuel Management in the UK
  - SFM Strategies
  - SFM Practices
- Given two examples of R&D in support of spent fuel management at Sellafield
- Thank you for listening