International Conference on the Management of Spent Fuel from Nuclear Power Reactors - an Integrated Approach to the Back-End of the Fuel Cycle

James Fisher Nuclear

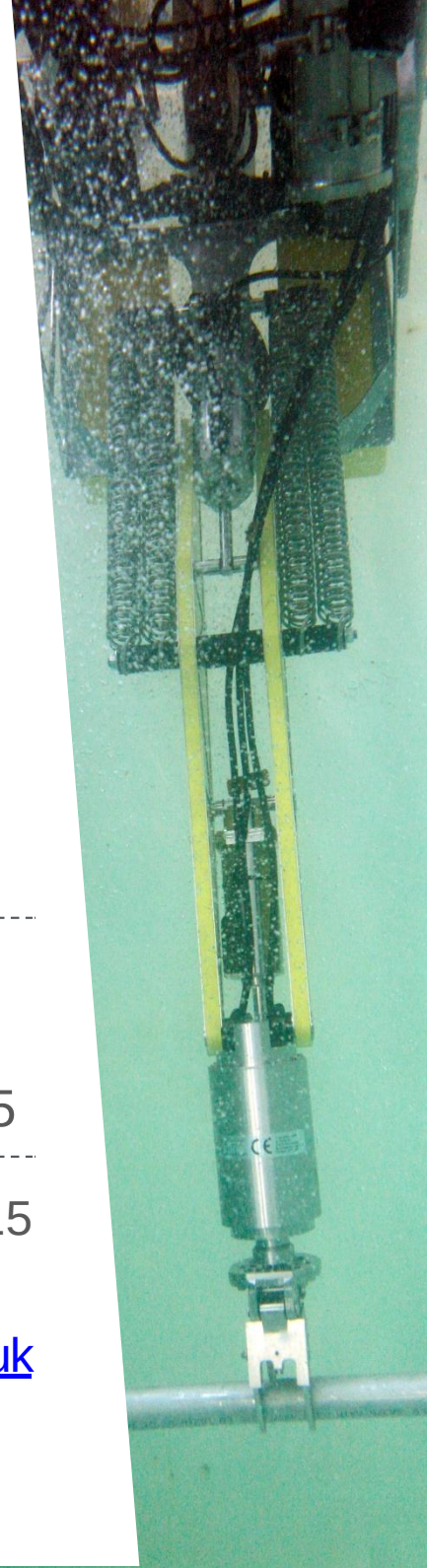
Retrieval of Damaged Fuel from Wet and Dry Storage using Innovative Remote Handling Techniques

IAEA-CN-226-135

June 2015

Geoff Ashworth – James Fisher Nuclear

www.jfnl.co.uk



Introduction

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- Britain's Magnox Reactors
- Magnox Fuel
- Stuck Fuel Recovery from the Calder Hall and Chapelcross Reactors
- Corroded Fuel Recovery from the First Generation Magnox Storage Pond
- Stuck Fuel Recovery from the Primary Dry Storage Cells at the Wylfa Nuclear Power Station

Britain's First Nuclear Power Station - Calder Hall

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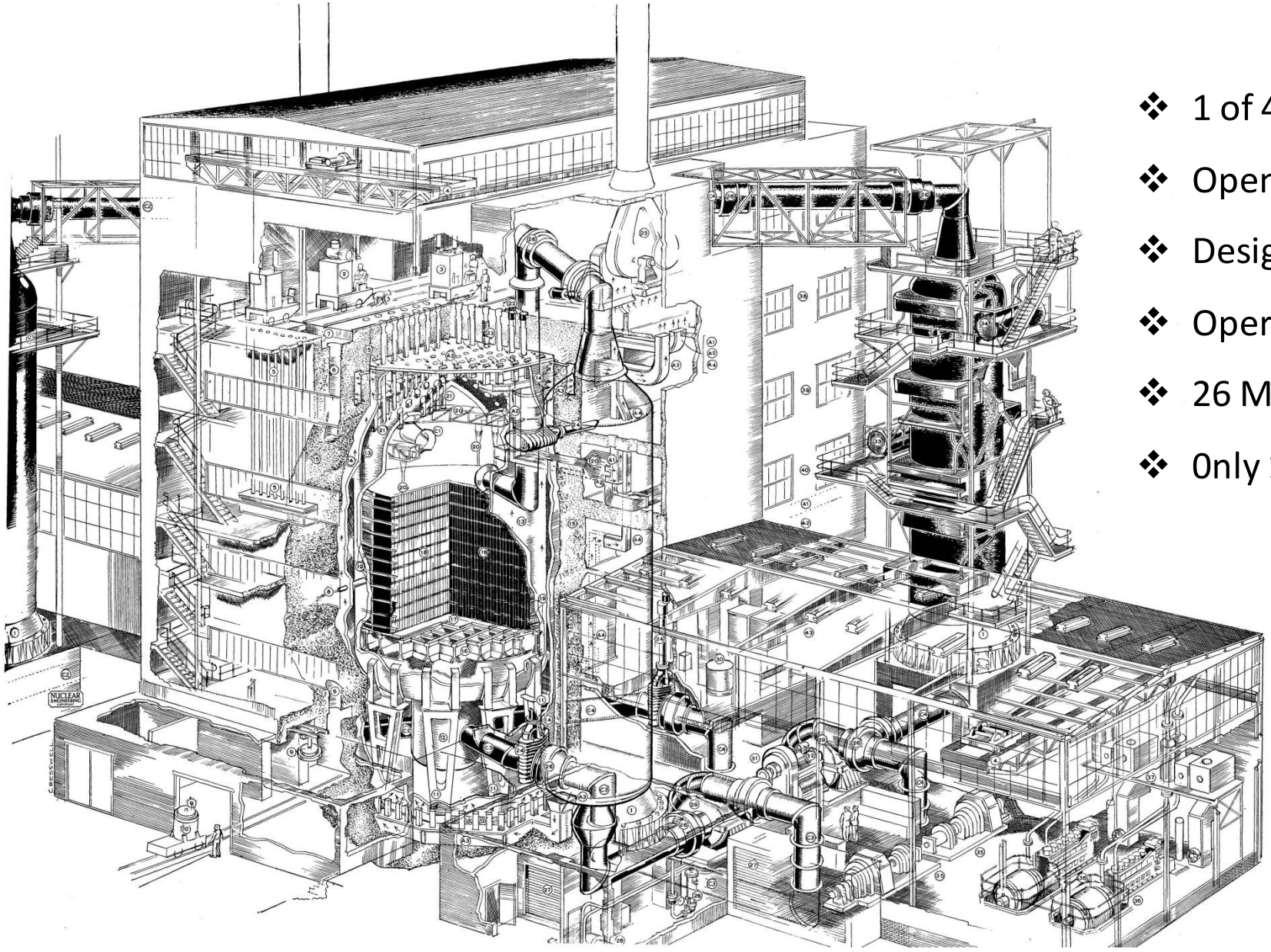
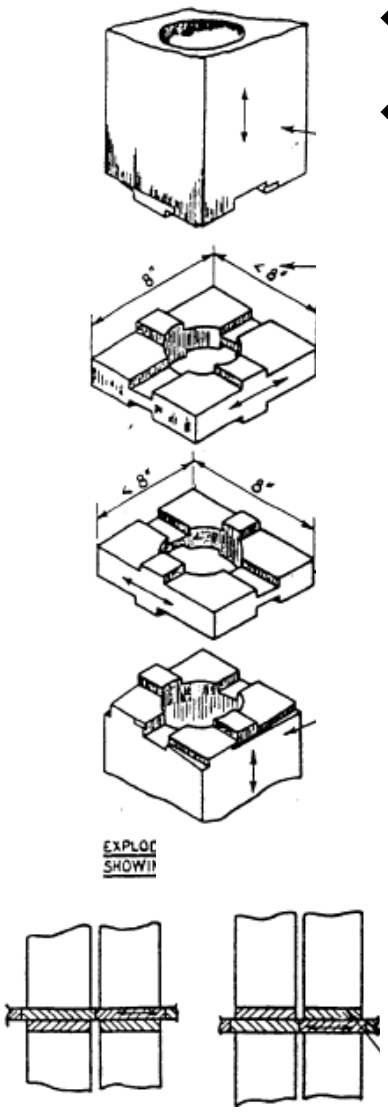


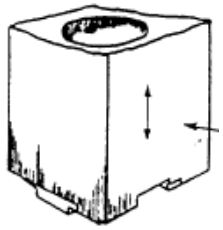
- 1 of 4 @ Calder Hall
- Opened in 1956
- Design Life 20 Years
- Operated for 47 Years
- 26 Magnox Reactors
- 0nly 1 still in operation

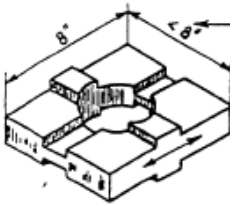
Calder Hall Graphite Core

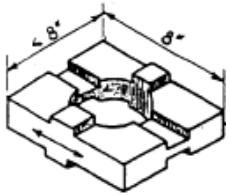


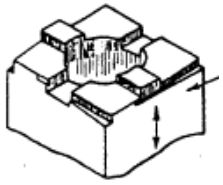
- Individual Graphite Blocks
- Alternate Layers of Blocks & Tiles

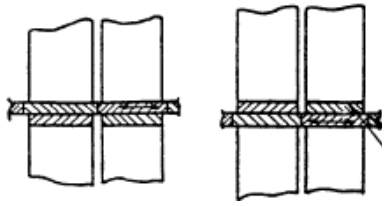
Calder Hall Graphite Core



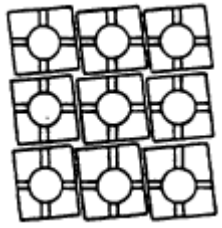




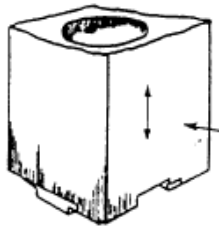


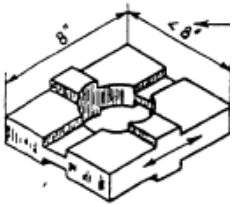


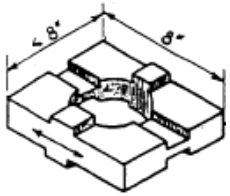
- Individual Graphite Blocks
- Alternate Layers of Blocks & Tiles
- Arranged to form 1696 Vertical Fuel Channels

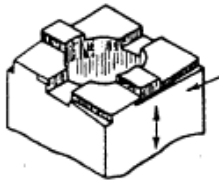


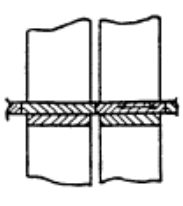
Calder Hall Graphite Core

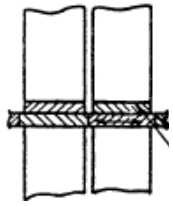




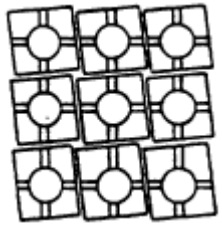


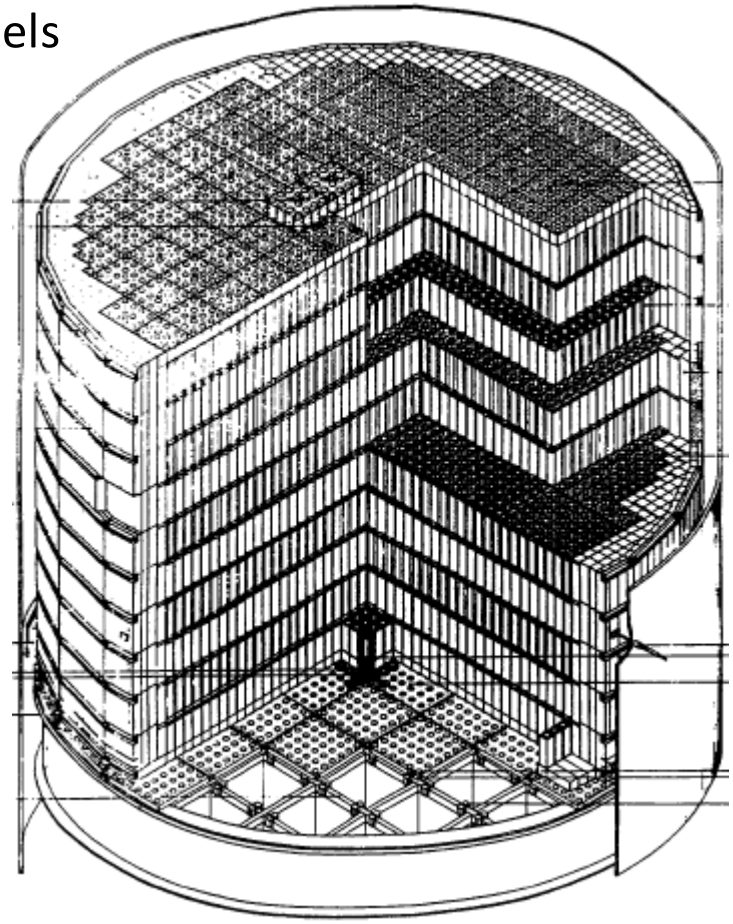






- Individual Graphite Blocks
- Alternate Layers of Blocks & Tiles
- Arranged to form 1696 Vertical Fuel Channels
- 24 Sided Prism, 8.2m High, 10.8m A/F
- Over 1000 Tonnes
- CO2 Cooled





Magnox Fuel

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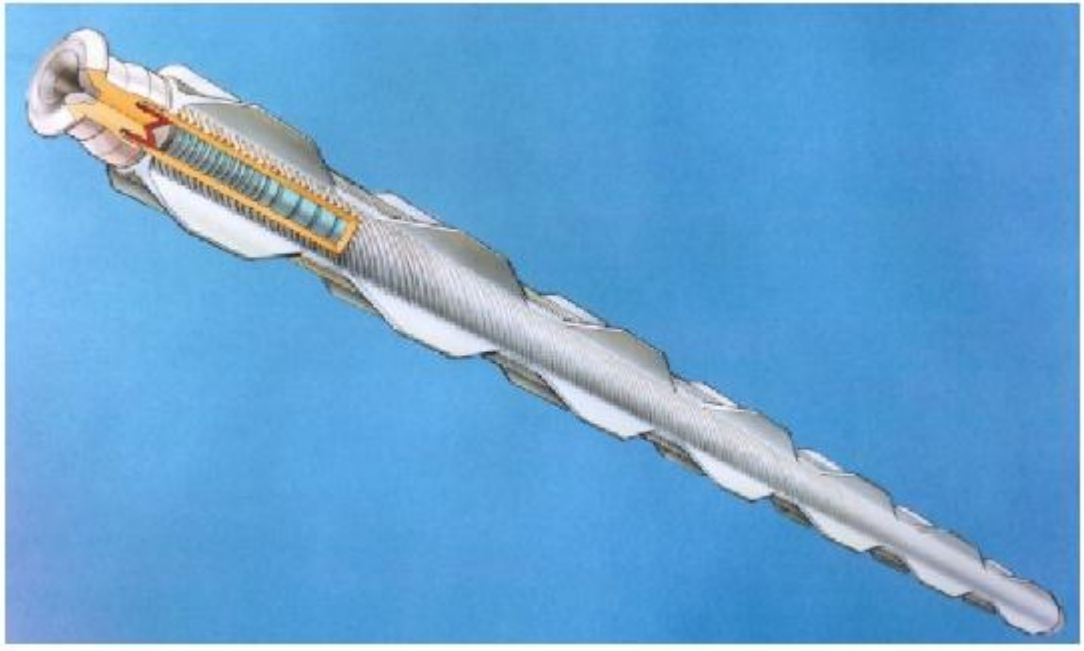
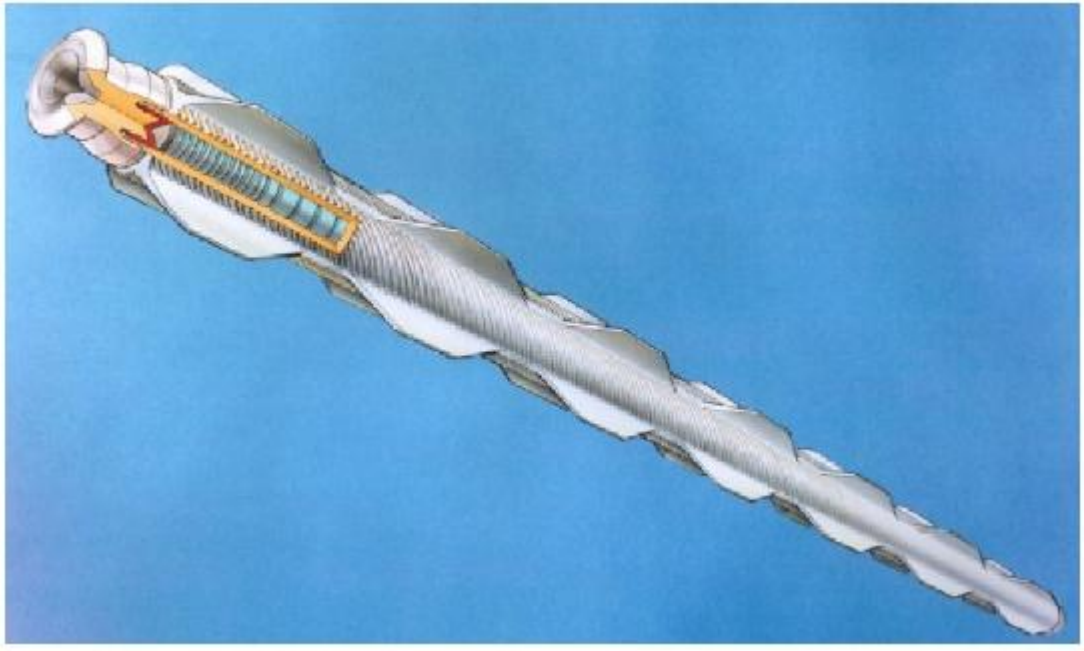
- Natural Uranium Bar



Magnox Fuel

- Natural Uranium Bar
- **Mag**nesium **N**on **Ox**idising Cladding



Magnox Fuel

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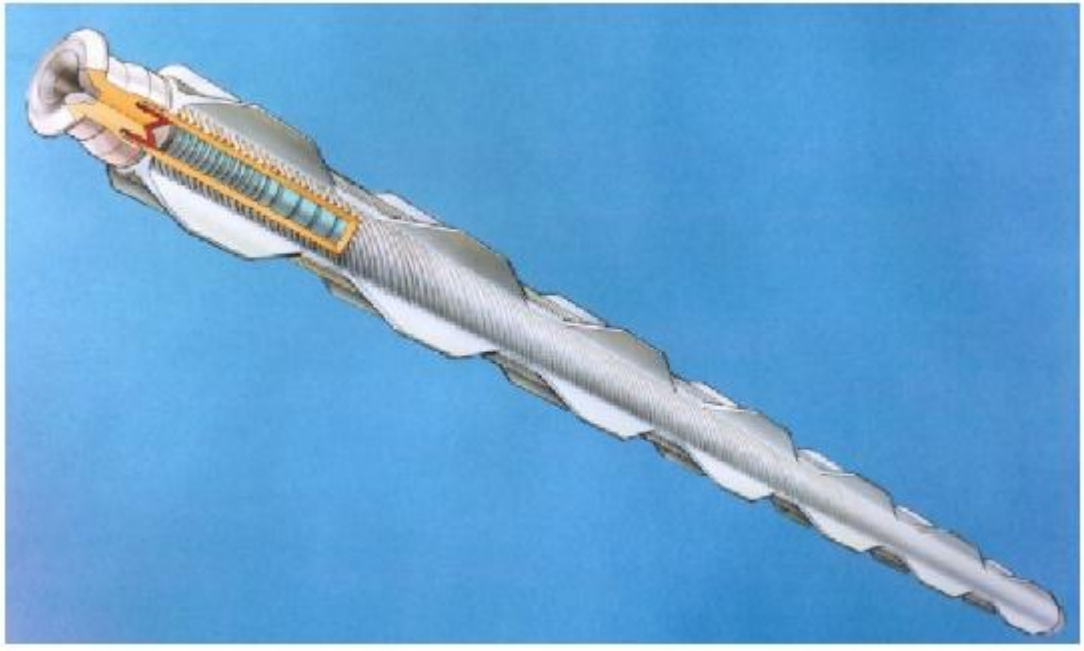
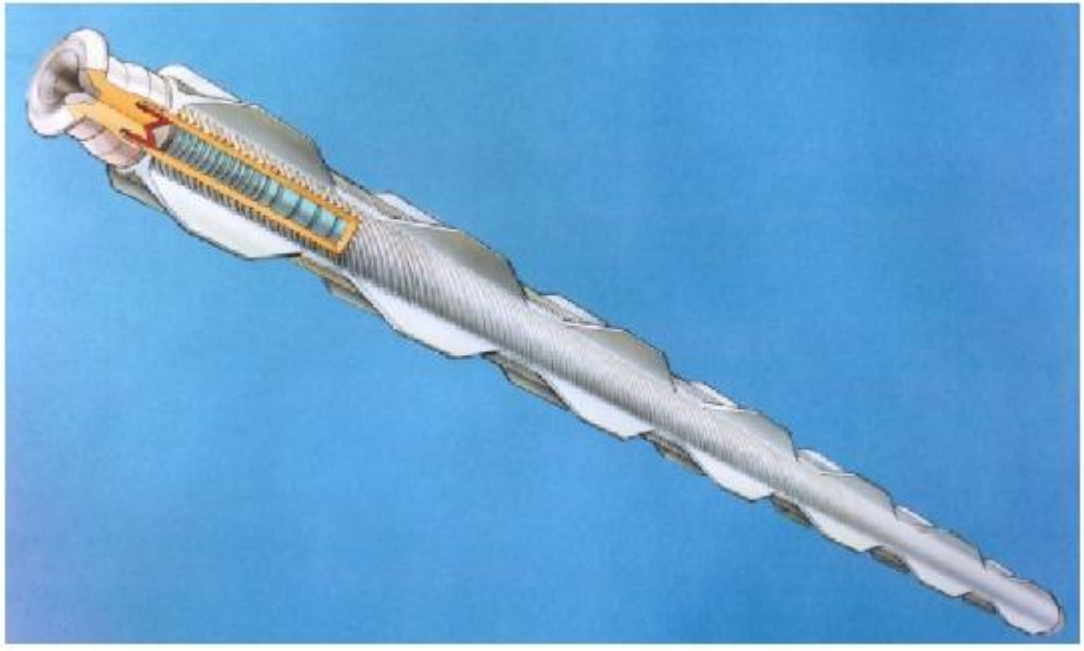
- Natural Uranium Bar
- **Mag**nesium **N**on **Ox**idising Cladding
- Approx 1000mm long, 100mm diameter, 18 Kg



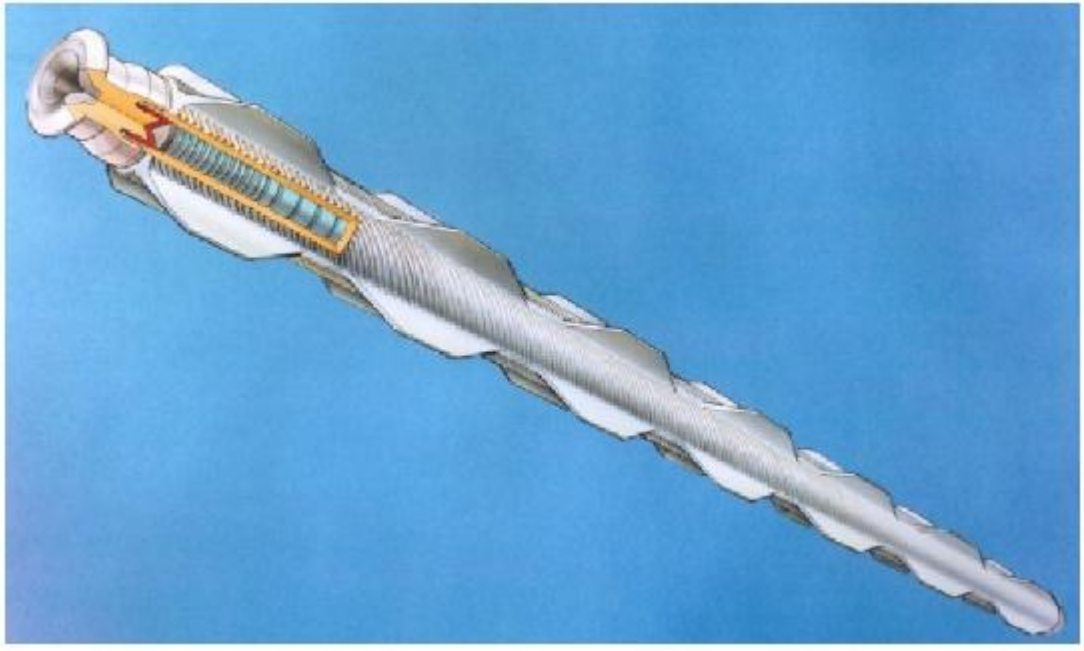
Magnox Fuel

- Natural Uranium Bar
- **Mag**nesium **N**on **Ox**idising Cladding
- Approx 1000mm long, 100mm diameter, 18 Kg
- Lifting Spider / Button

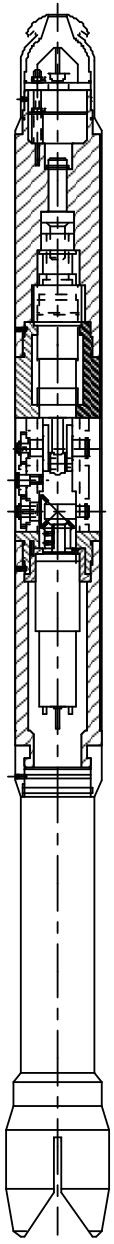


Magnox Fuel

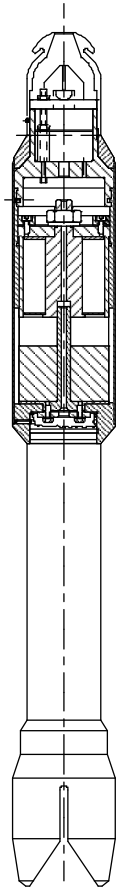
- Natural Uranium Bar
- **Mag**nesium **N**on **Ox**idising Cladding
- Approx 1000mm long, 100mm diameter, 18 Kg
- Lifting Spider / Button
- Stacked 6 - 10 elements high



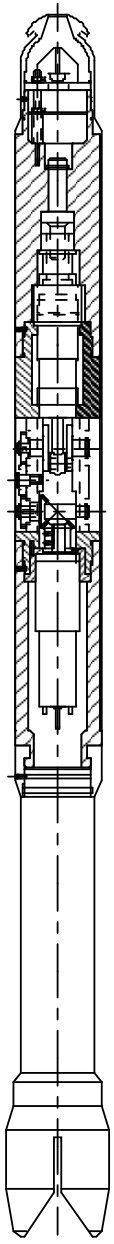
Calder Hall Stuck Fuel Recovery Development



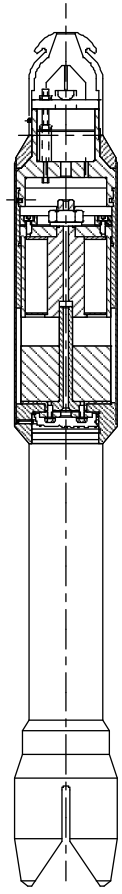
- Extensions to Discharge Grab
- “Kango” Hammer Drill
- Electro Magnet Slide Hammer



Calder Hall Stuck Fuel Recovery Development



- Extensions to Discharge Grab
- “Kango” Hammer Drill
- Electro Magnet Slide Hammer



- The “Savage” Grab

Calder Hall Stuck Fuel Recovery Development

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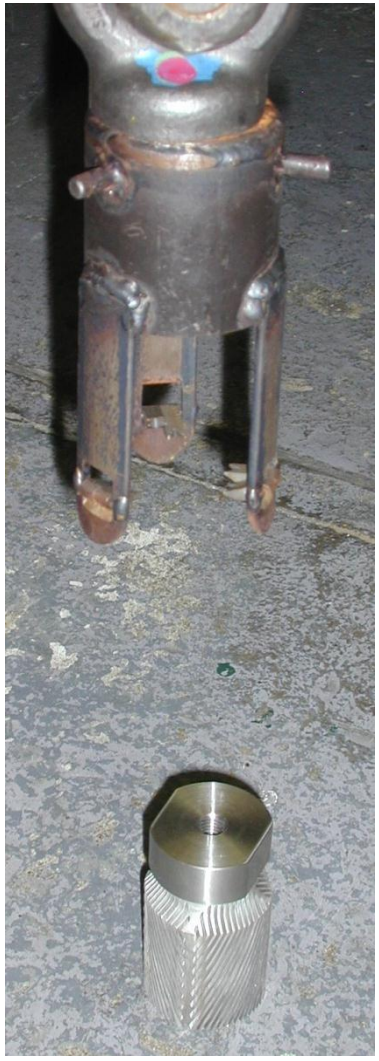
- "Savage" Grab Trials



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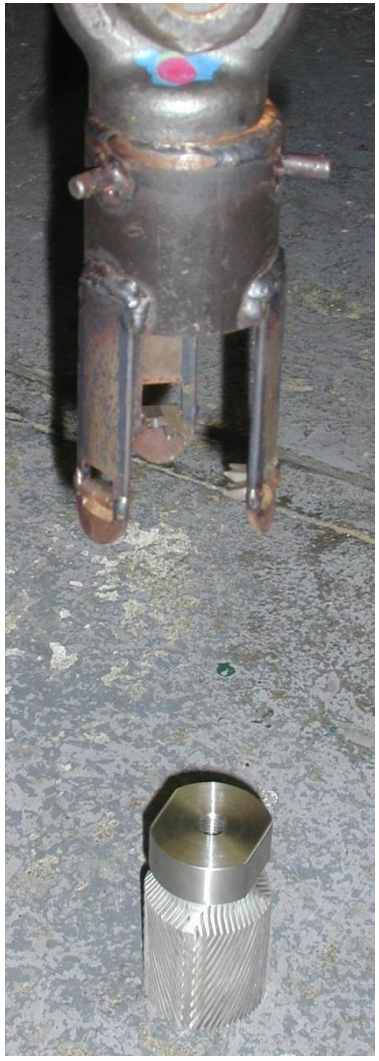
- "Savage" Grab Trials



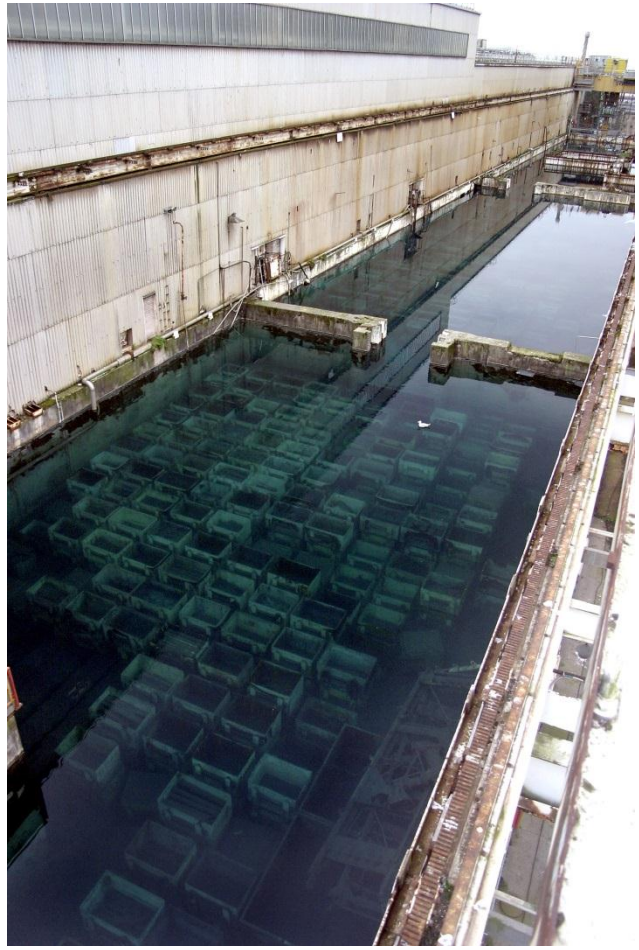
- JFN Prototype Grab Trials

Calder Hall Stuck Fuel Recovery Development

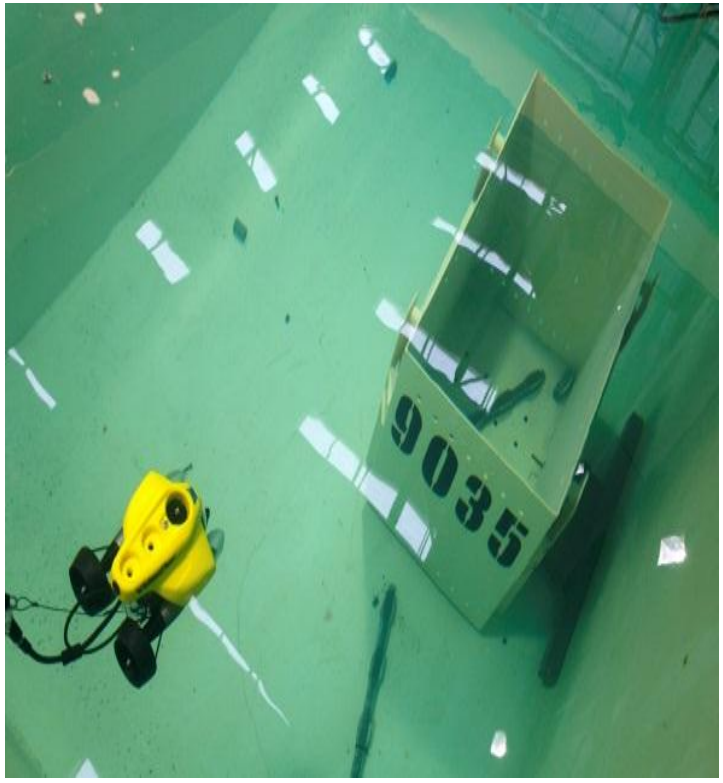
- The Final Gab

Corroded Fuel Recovery from Storage Ponds

- FGMSP
- Built in the 1950's
- Irradiated Magnox Fuel
- Open Topped Skips
- Managed by Skip Handler
- 5m Deep
- Currently 1200 Skips
- 1500m^3 of Sludge
- 14000m^3 of Contaminated Water

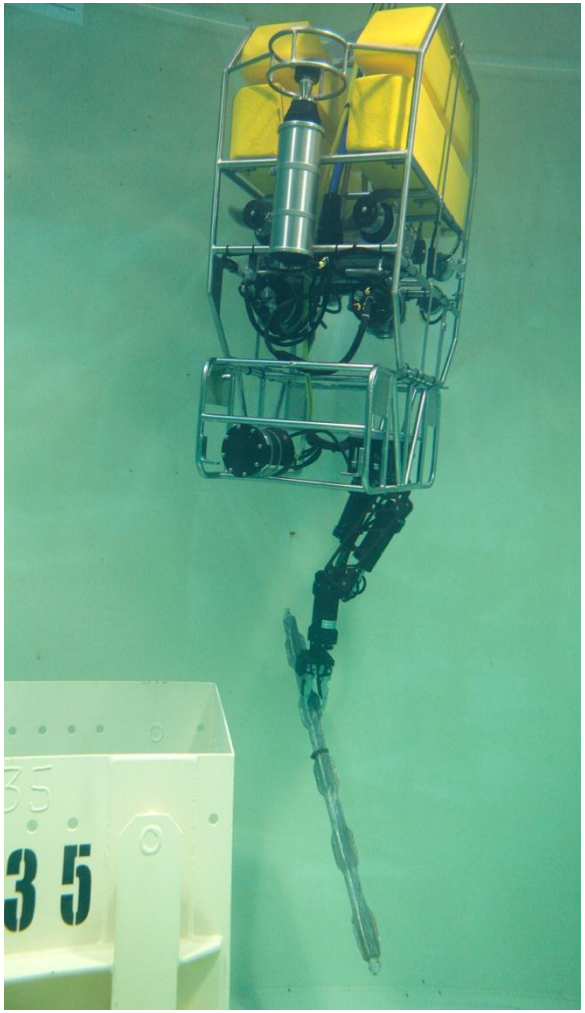


Corroded Fuel Recovery from Storage Ponds

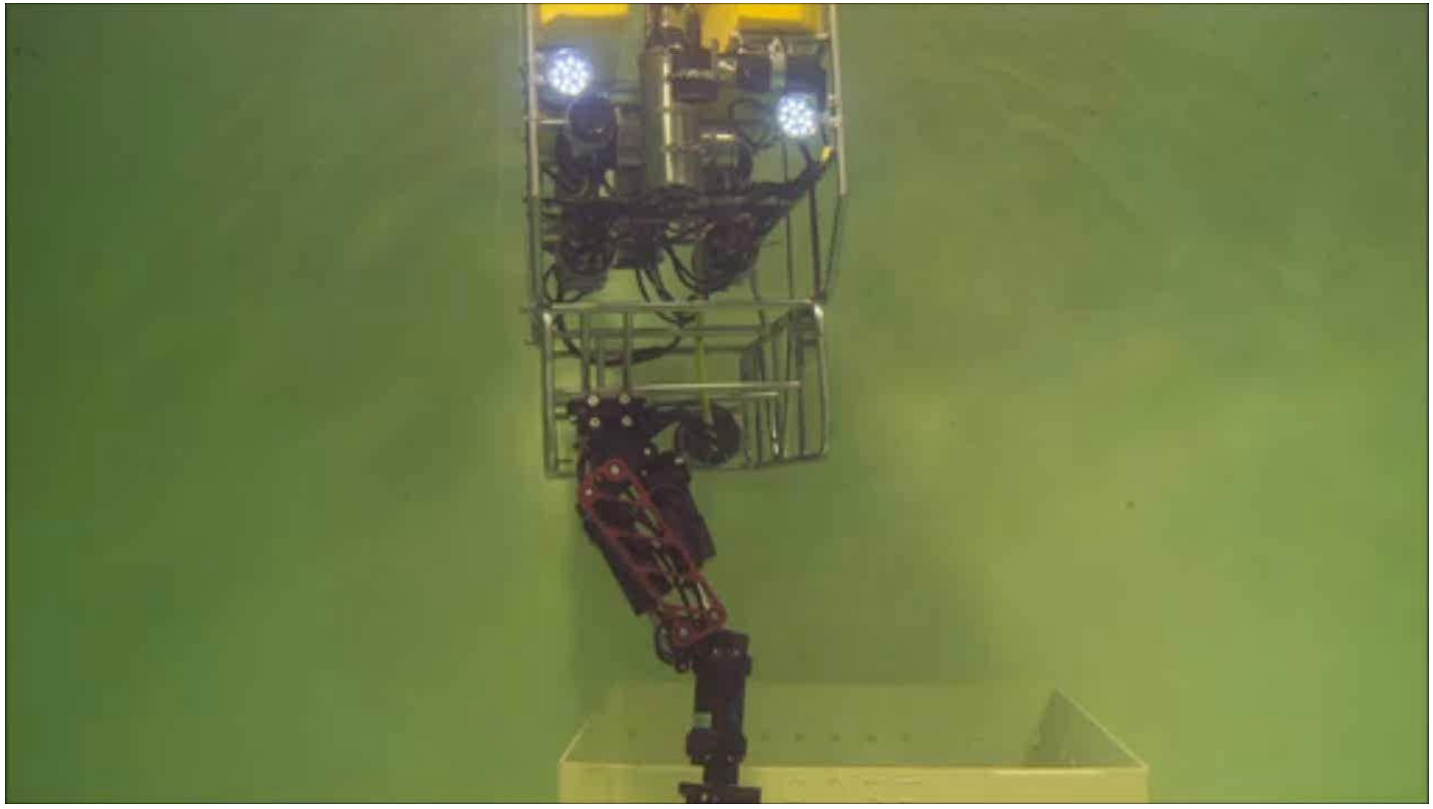


- Radiation
- High PH
- Deployment & Umbilical Management
- Compatibility with Pond Water
- Compliance with Nuclear Safety Regulations

Corroded Fuel Recovery from Storage Ponds



- Tooling Skids (Sludge Pumping, Shearing etc)
- Manipulator – Pick & Place Operations



Corroded Fuel Recovery from Storage Ponds

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Corroded Fuel Recovery from Storage Ponds

Corroded Fuel Recovery from Storage Ponds

Stuck Fuel Recovery at Wylfa Nuclear Power Station

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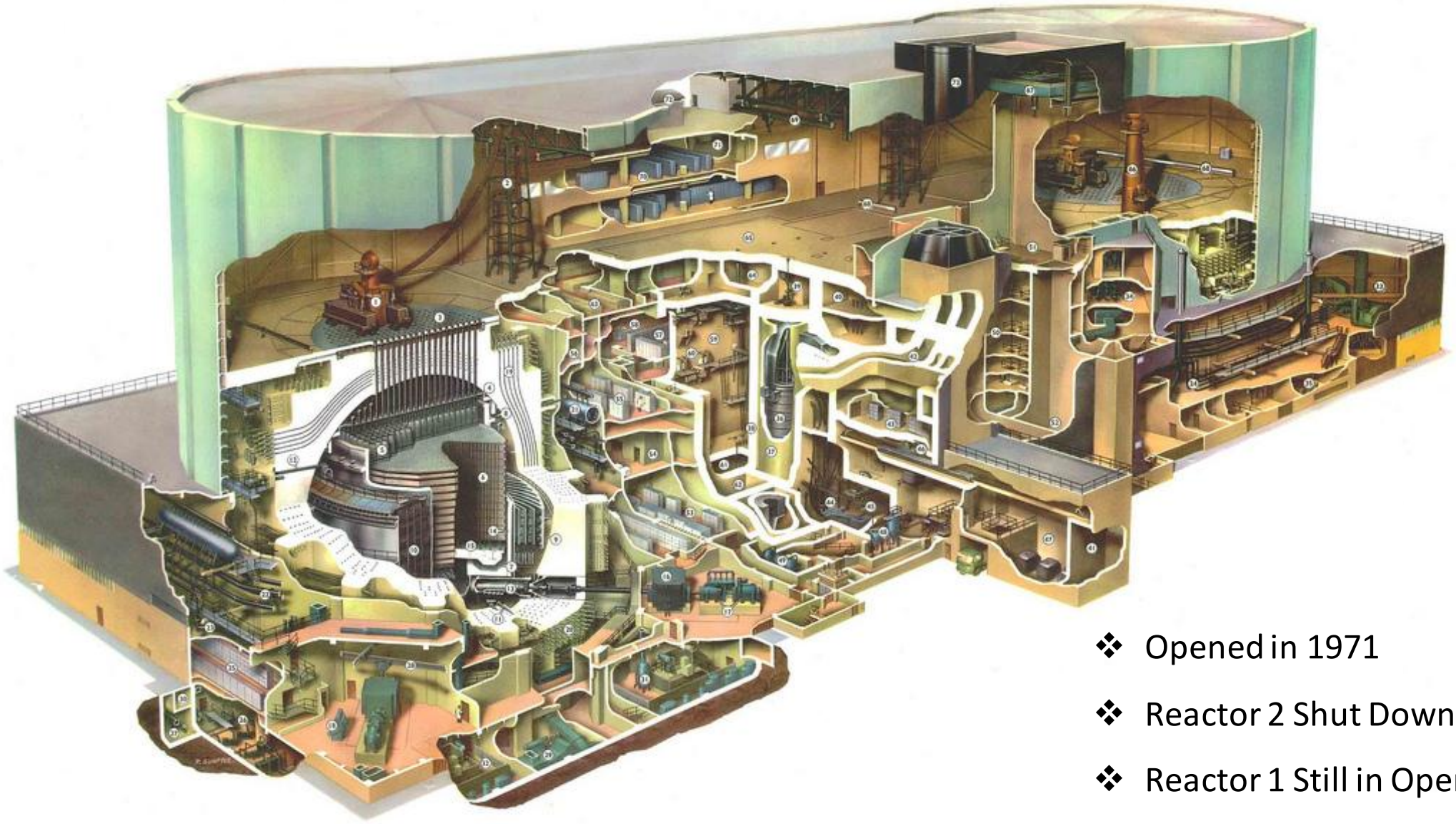
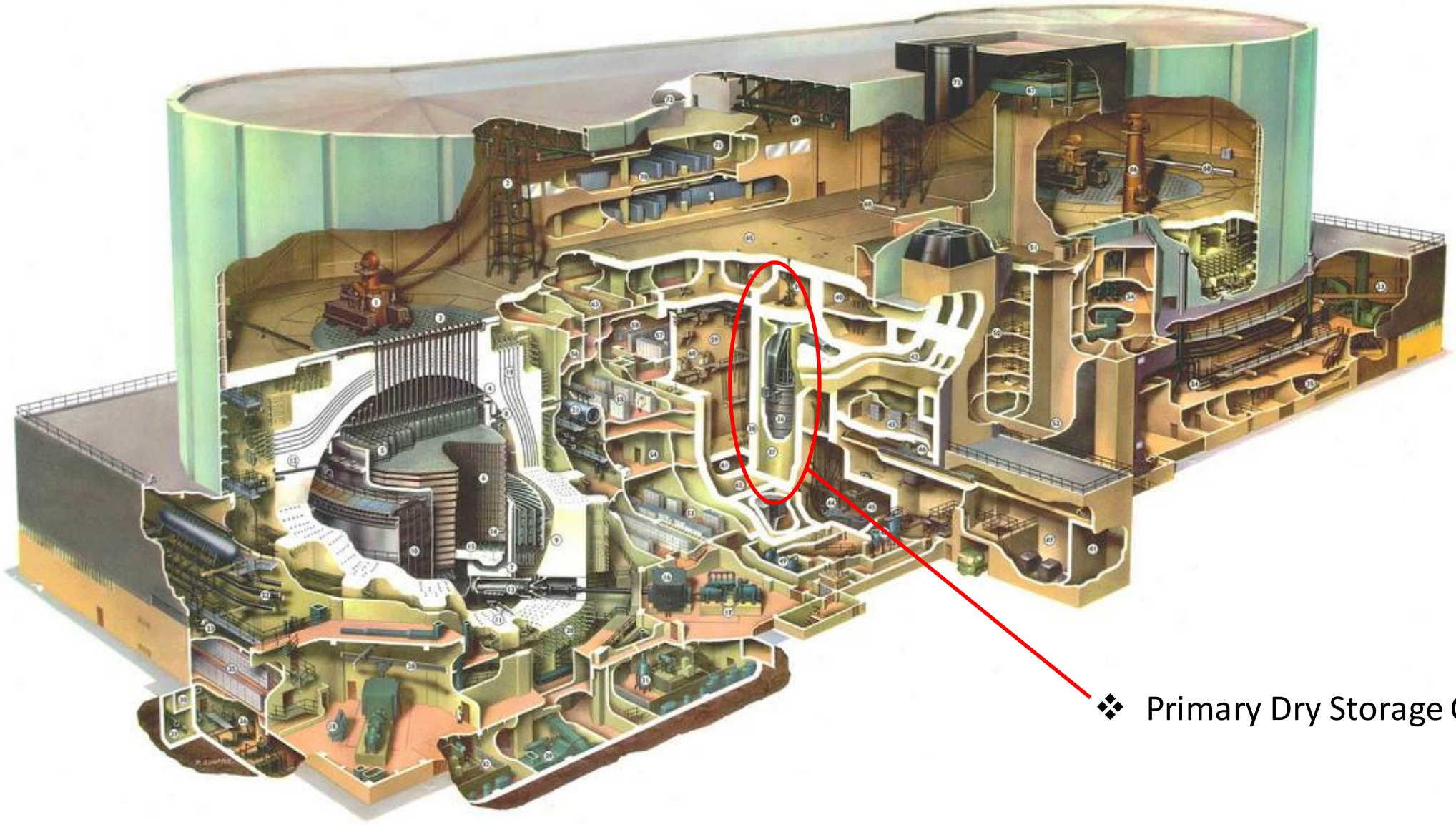


- Opened in 1971
- Reactor 2 Shut Down 2012
- Reactor 1 Still in Operation

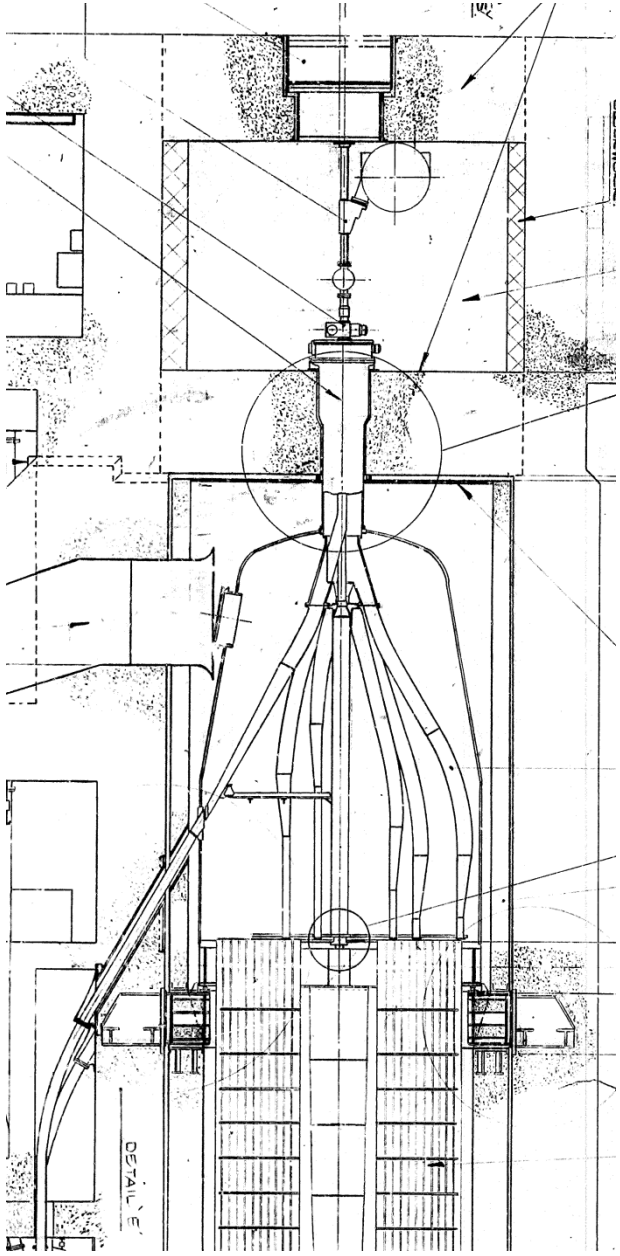
Stuck Fuel Recovery at Wylfa Nuclear Power Station

James Fisher Nuclear



❖ Primary Dry Storage Cells

Stuck Fuel Recovery at Wylfa Nuclear Power Station



- Primary Dry Storage Cell
- 3 in Total (+2 Secondary DCS's)
- 588 Tubes, Ø105mm
- 11 Concentric Pitches
- Ø 4.5m
- Elements Stacked 12 High
- CO2 Cooled

Stuck Fuel Recovery at Wylfa Nuclear Power Station

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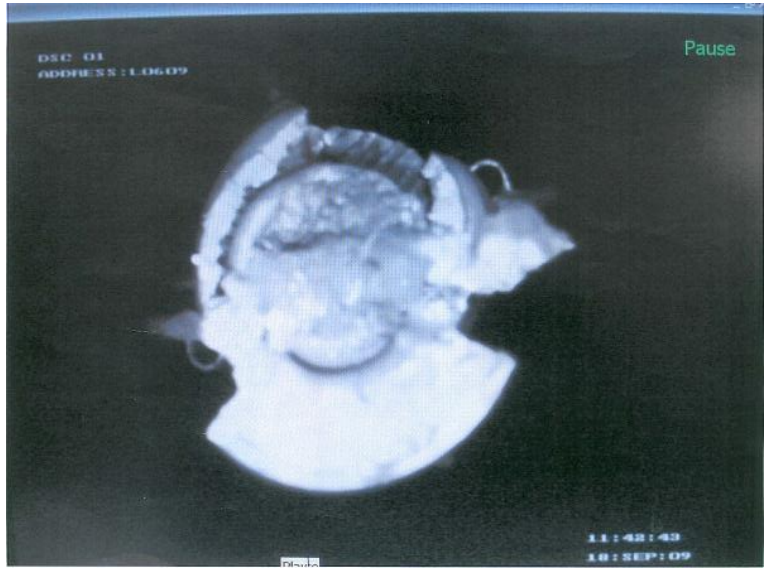

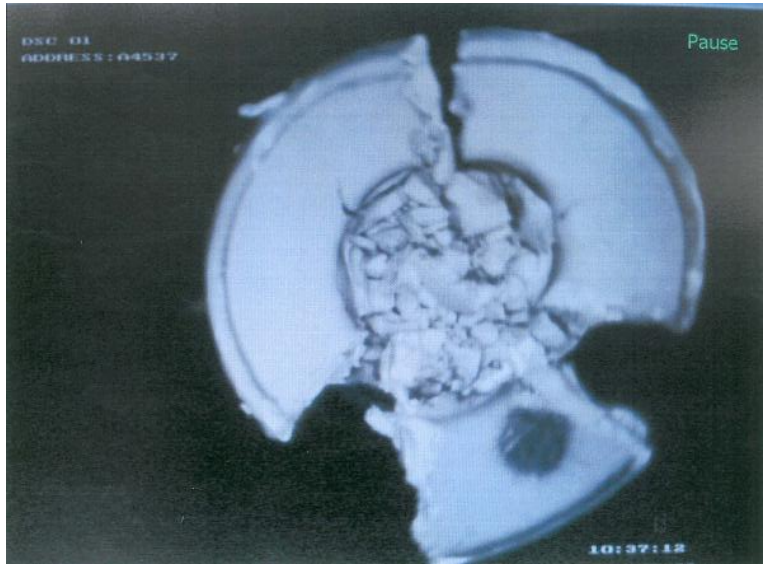

Stuck Fuel Recovery at Wylfa Nuclear Power Station

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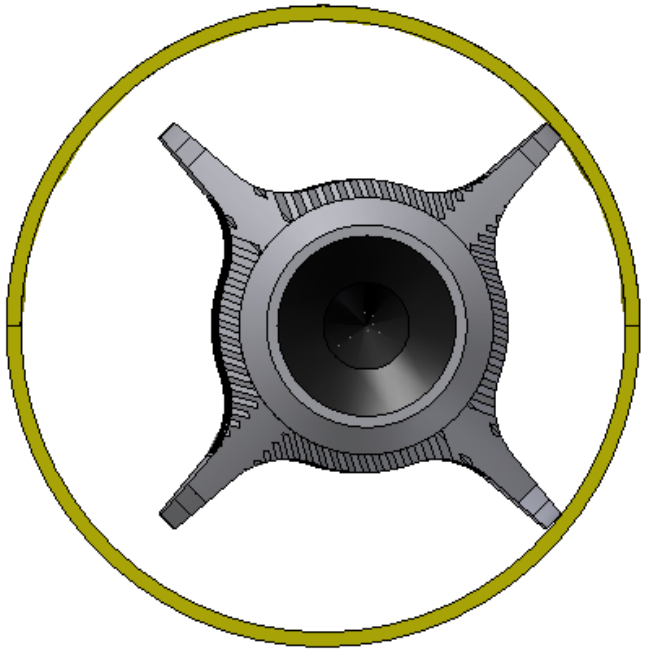

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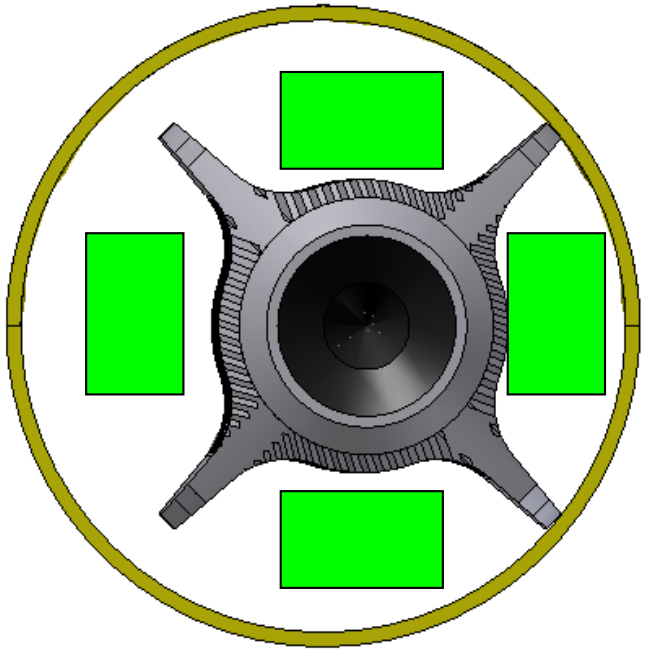

Stuck Fuel Recovery at Wylfa Nuclear Power Station

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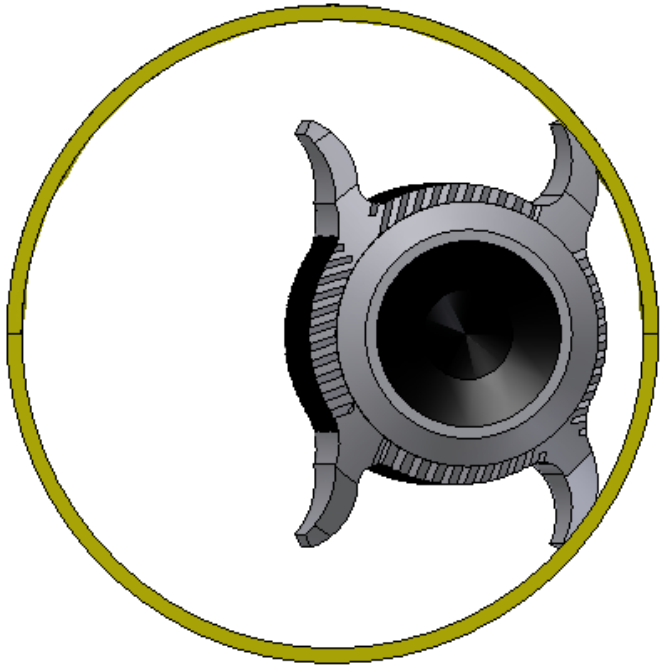
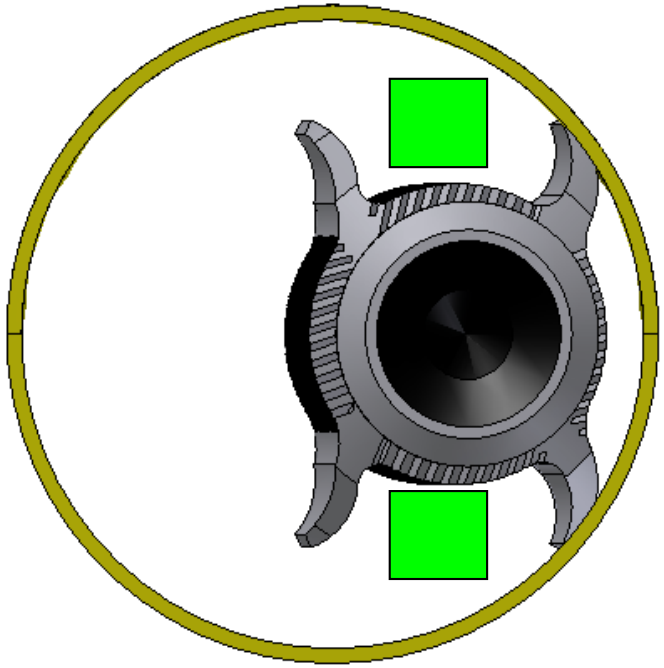


Stuck Fuel Recovery at Wylfa Nuclear Power Station



Stuck Fuel Recovery at Wylfa Nuclear Power Station

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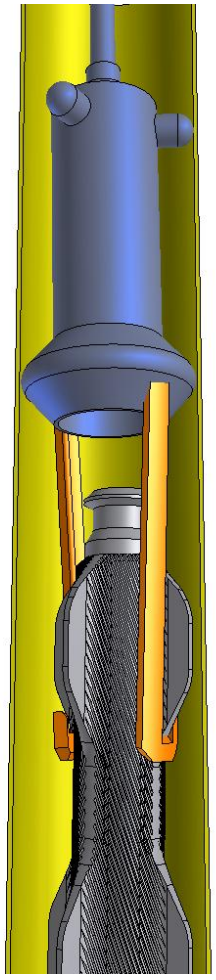
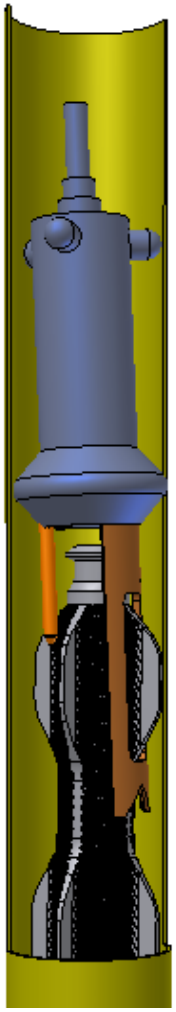
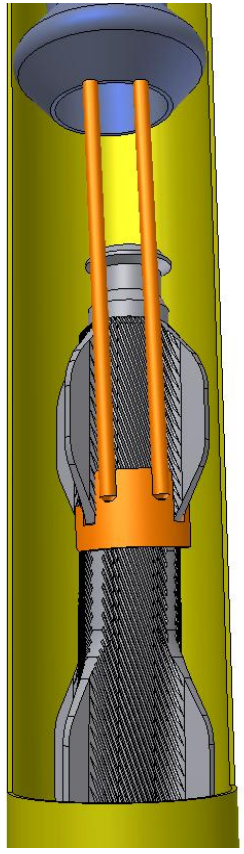
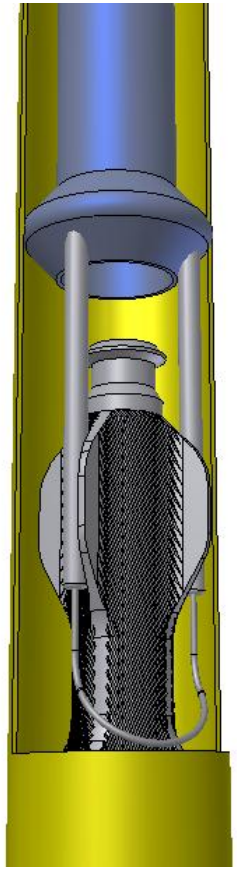
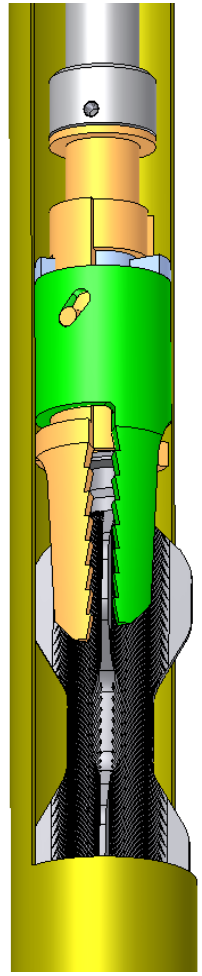
- Optioneering











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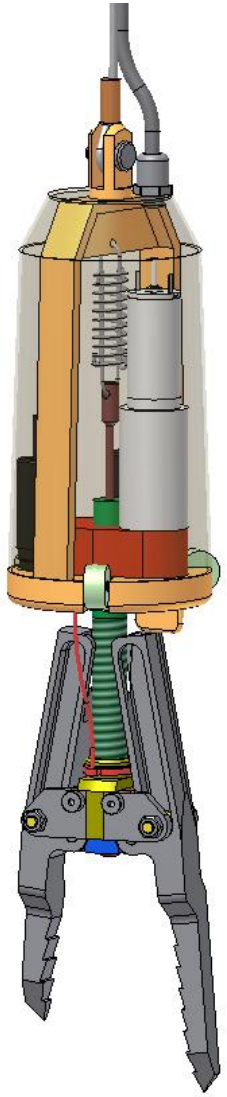
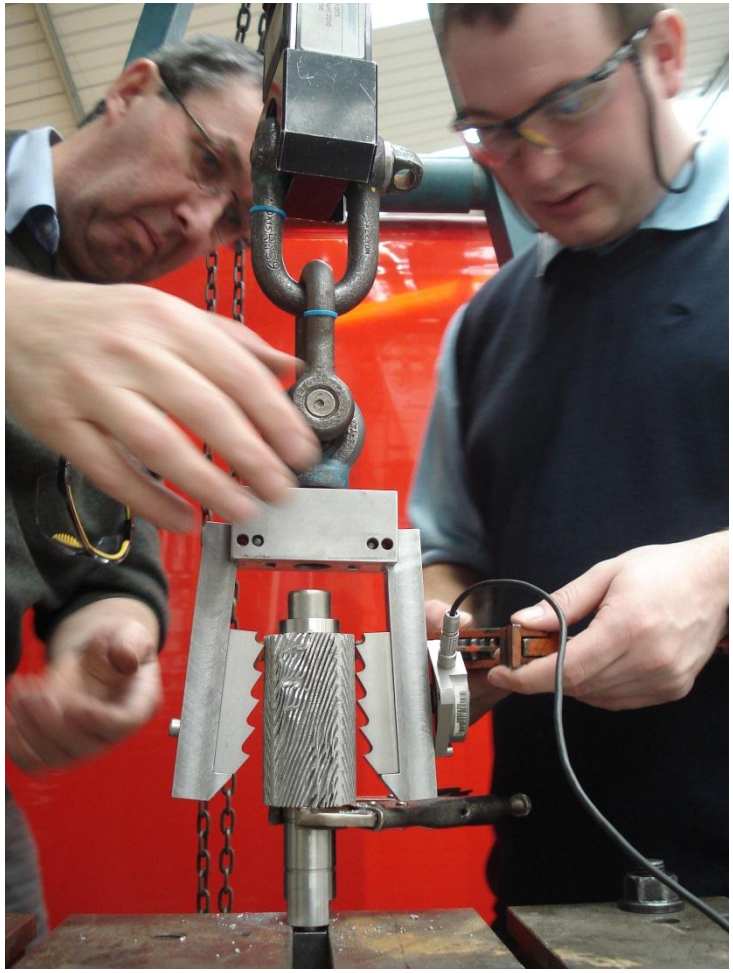
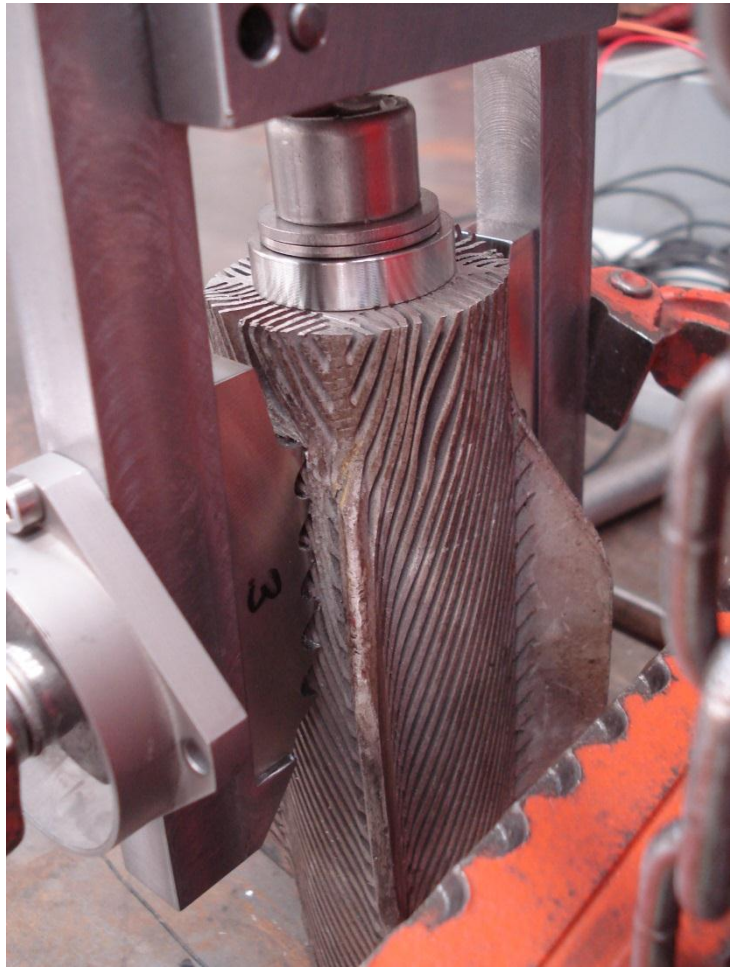


- Deployed from Pile Cap Winching System
- Maximum Pull Force 1000Kg
- CCTV Camera
- Electrically Driven Jaws
- Additional Grip from Winching Action
- 350° Rotation of Jaws
- Serrated “Cranked” Jaws
- Pull Force Measurement
- Height Measurement
- Emergency Release Drive

Stuck Fuel Recovery at Wylfa Nuclear Power Station



- Bench Top Trials
- Range of Profiles
- Range of Materials
- Grip Force Measurement
- Pull Force Measurement
- Cladding Deformation
- Release After Removal



Stuck Fuel Recovery at Wylfa Nuclear Power Station

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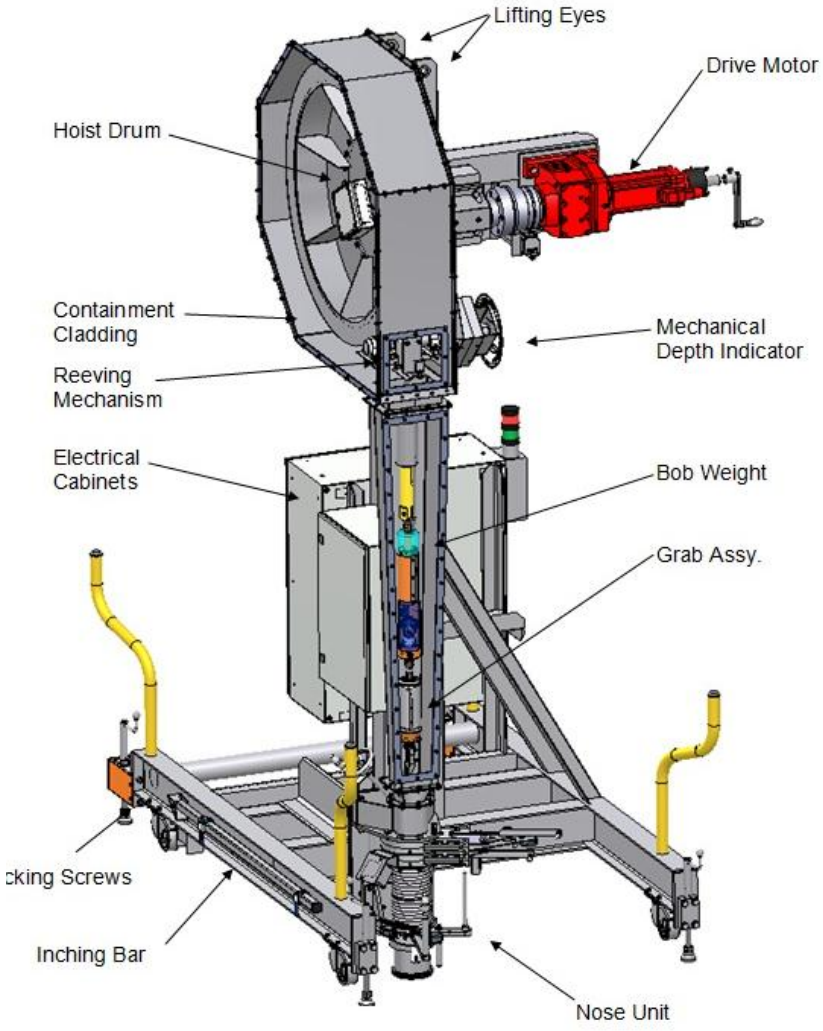

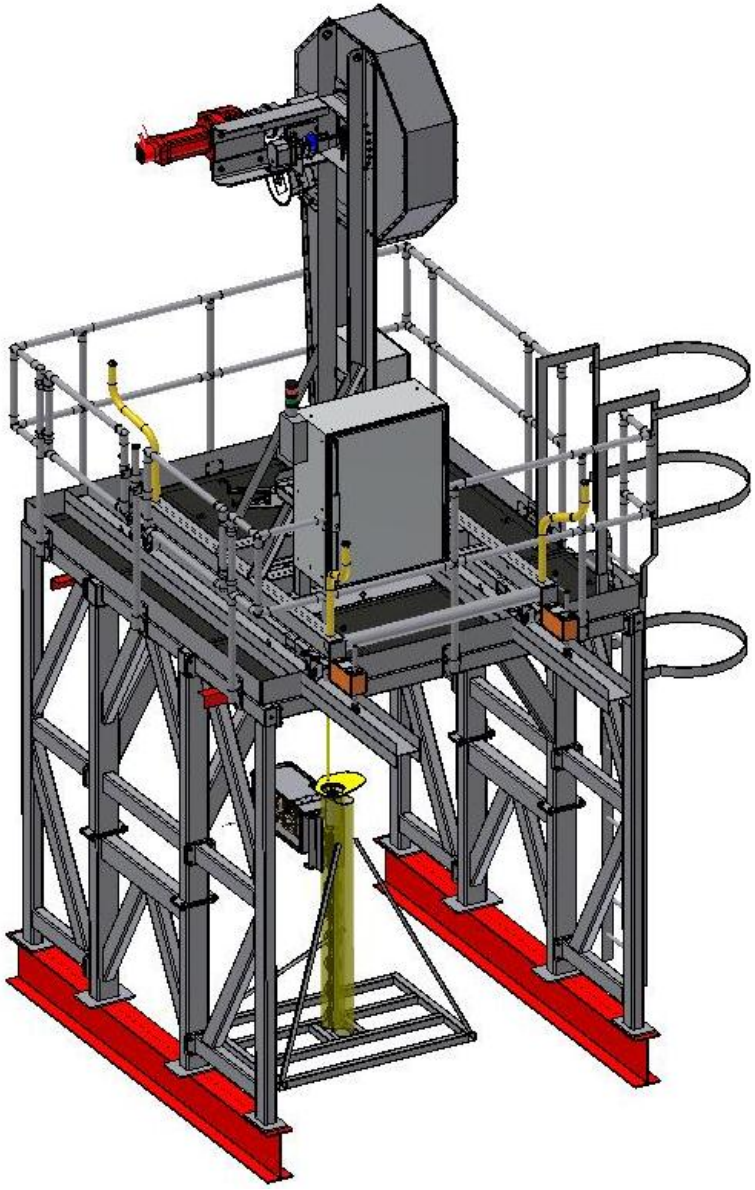

Stuck Fuel Recovery at Wylfa Nuclear Power Station

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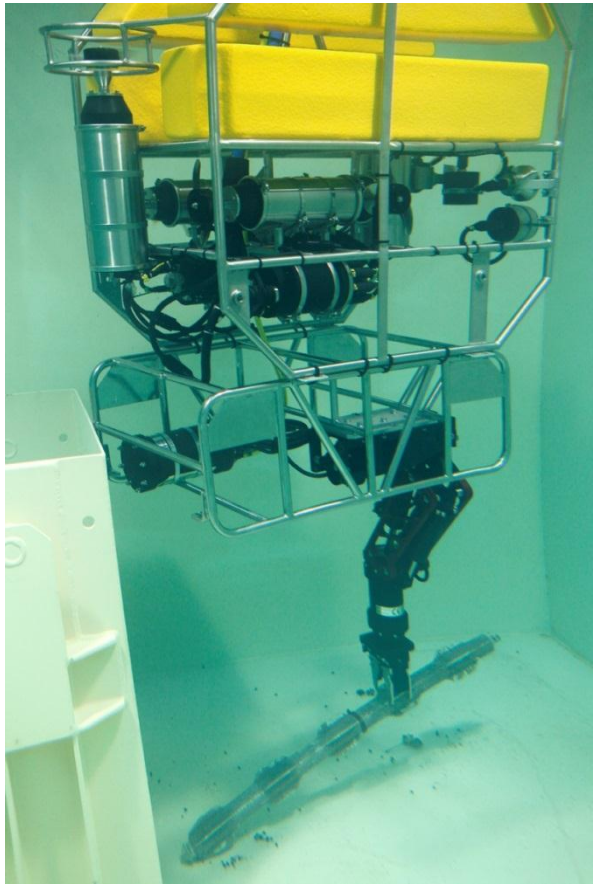
- In Operation on the Wylfa Pile Cap
- Safely Recovered 53 Fuel Elements - so far!
- Key to Facilitate Cross Reactor Refuelling
- Allowing Continued Generation ‘till 2016
- i4 Innovation – Implementation Award

Summary



- Innovative Approach using Standard Engineering Principles
- Never Underestimate the Value of Bench Top Trails & Development
- Full Scale Trials and Early Engagement with the end user are Essential to the Success of any Project of this type
- Risk Mitigation at Early Stages in Design Development
- Progressive Assurance to all Stakeholders