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Windscale Advanced Gas-Cooled Reactor (WAGR) Decommissioning Project Overview

Andy Pattinson, Lead Project Engineer
BNFL Environmental Services - WAGR Project

BNFL Current Reactor Decommissioning Projects

- Power reactor sites at
  - Berkeley, Trawsfynydd, Hunterston, Bradwell, Hinkley Point.
- UKAEA Windscale Pile 1.
- Research Reactors within UK - Scottish Universities at East Kilbride and ICI (now both complete).
- WAGR.

BNFL Environmental Services' Role

- As a Tier 2 Contractor:
  - Project - Contract Management.
  - Effective Dismantling strategy development.
  - Implementation and Operations.
  - Sentencing, Encapsulation & Transportation of Waste.
- In addition, for our own sites:
  - Strategy Development.
  - Baseline Decommissioning Planning.
  - Site Management and Regulator Interface.

Windscale Advanced Gas-Cooled Reactor (WAGR)

Windscale in Cumbria

Project Objectives

- Safe and Efficient Decommissioning of the WAGR
- Build Good Relationships with Customer
- Reactor Decommissioning Completion -Agreed Target Date 2005

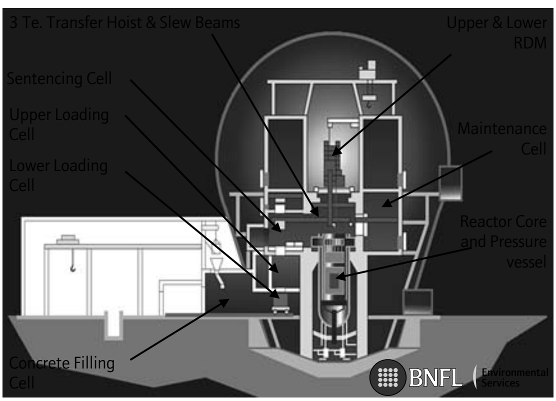
Principles of UKAEA/BNFL Decommissioning Agreement

- UKAEA Nuclear Site Licensee.
- BNFL working for UKAEA under a Fixed Price Agreement.
- BNFL have accepted and are Managing the Technical and Commercial Risks including;
  - Engineering development.
  - Decommissioning Operations.
  - Management of Suppliers and Sub-contractors.

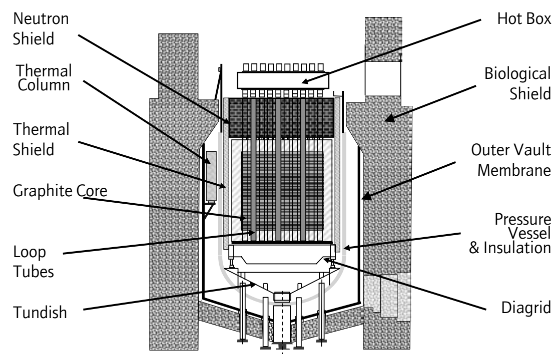
WAGR Basic Design Data

- Reactor first critical 1963
- Reactor Output - 100MW(T) 33MW(E)
- Reactor Graphite Moderated CO_2 Cooled
- Core Dimensions 6m High x 6m Diameter
- Reactor shut down 1981

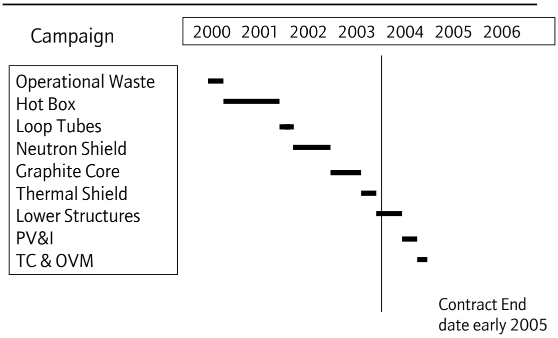
WAGR Facility



WAGR Reactor



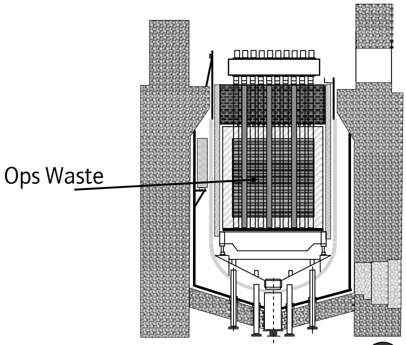
WAGR Decommissioning Programme



WAGR Decommissioning Campaigns

1.	Preliminary Operations	Complete
2.	Operational Waste	Complete
3.	Hot Box	Complete
4.	Loop Tubes	Complete
5.	Neutron Shield	Complete
6.	Graphite Core and Restraint System	Complete
7.	Thermal Shield	Complete
8.	Lower Structures	Current Campaign
9.	Pressure Vessel & Insulation	
10.	Thermal Columns and Outer Vault Membrane	

Campaign 2 - Operational Waste



Operational Waste Overview

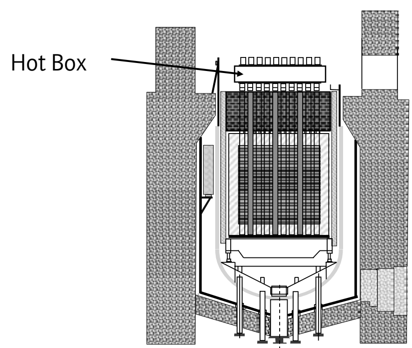
- The WAGR reactor was shut down in 1981 and subsequently de-fuelled. On completion of de-fuelling, various items of ancillary equipment, termed Operational Waste were stored in the vacant fuel channels.
- The waste items, which include Neutron Shield Plugs, Control Rods, Arrestor Mechanisms etc, were shortened where necessary and fitted with lifting adapters prior to them being stored in the reactor.
- A ball grab was used to remove these items from the reactor for encapsulation.

Operational Waste Summary

In total 7 ILW boxes were generated during this campaign and the majority of items of operational waste within the reactor were removed.

Various items which could not be removed, due to them being stuck or having damaged lifting adapters, were removed during subsequent campaigns as they were uncovered.

Campaign 3 - Hot Box



Hot Box Overview

- The Hot Box was a large mild steel flat-ended cylindrical vessel, approximately 5 m in diameter and 0.9 m high, penetrated by the 247 refuelling channels and six loop tube channels.
- Its purpose was to distribute the hot coolant gas emerging from the reactor fuel channels to the four heat exchangers.
- The Hot Box Campaign utilised remotely deployed (and where dose rates allowed, manually deployed) plasma arc cutting equipment for size reduction operations.

Hot Box Overview

- A number of remotely deployed plate grabs and ball grabs were used to remove the cut items.

Hot Box Summary

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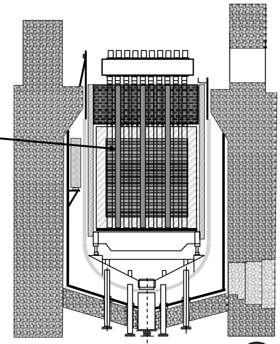
The size reduction & encapsulation of the Hot Box was completed in 14 months.

31 Tonnes of steel waste was removed and 14 Low Level Waste Box were generated during this campaign.

Campaign 4 - Loop Tubes



BNFL Environmental Services

Loop Tube Overview

BNFL Environmental Services

- Loop tubes were stainless steel features incorporated into the reactor for experimental work without affecting the normal operation of the reactors.
- The loop tubes were fully independent of each other with each loop tube equipped with separate services.
- There were a total of six loop tubes, four of which were part of the original design, and two of which were installed in 1972.

Loop Tube Overview

BNFL Environmental Services

- All six Loop Tubes were filled with grout from their base to allow for shearing.
- A 750 te hydraulic shear designed for remote installation and modular assembly was used to shear the Loop Tubes into manageable lengths in a single pass.
- A pneumatic jacking system was used to raise and clamp the Loop Tubes into correct position for shearing.
- Mechanical handling grabs were used to remove the cut sections for encapsulation

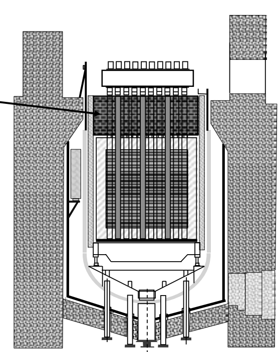
Loop Tube Summary

BNFL Environmental Services

The size reduction & encapsulation of the Loop Tubes was originally forecast as a 93 day programme and was actually completed in 73 days.

6 Intermediate Level and one Low Level Waste Box were generated during this campaign.

Campaign 5 - Neutron Shield



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Neutron Shield Overview

- The Neutron Shield comprised of two sections, Inner and Outer, both sections being located above the Reactor Core.
- Its purpose was to reduce the passage of neutrons from the core to an acceptable level at the pile cap and to allow the passage of core re-entry coolant gas from the top of the reactor through the shield.

Neutron Shield Overview

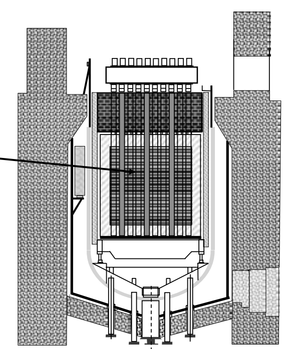
- A number of manually and remotely deployed cutting tools were used to size reduce various components and ball grabs, vacuum grabs, magnetic grabs and a drill/tap work package were used to remove the components from the reactor.

Neutron Shield Summary

The Neutron Shield campaign was planned as a 10 month programme and was actually completed in 8 months.

In total, 73 tonnes of Graphite, plus 35 tonnes of steelwork were packaged into 20 Low Level and 12 Intermediate Level Waste boxes.

Campaign 6 - Graphite Core



Graphite Core Overview

- The Graphite Core was constructed from 3344 graphite bricks in eight layers, each layer being held together by a tensioned steel restraint band.
- Core bricks had vertical holes to form 253 channels. 247 contained fuel elements, control rods and other associated components and 6 channels were for the Loop Tubes. Each brick was attached to its vertical neighbour via a graphite spigot located in recesses in the top and bottom of each brick.

Graphite Core Overview

- Reflector bricks around the core did not contain fuel elements and acted as a neutron reflector. The top outer edge of each outer reflector brick contained a recess, which carried a restraint band assembly.
- Layer 1 incorporated a gas seal consisting of 2 sets of 12 plates supported off channel sections bolted to the thermal shield.

Graphite Core Overview

- Remotely deployed ball grabs were used to remove core bricks
- A remotely deployed drill/tap work package was used to remove reflector bricks
- A remotely deployed reciprocating saw and a magnetic grab were used to size reduce and remove the restraint band.
- A remotely deployed plasma cutter was used to cut the gas seals from their support channel.

Summary of Components Removed

- 245 Stainless Steel Spigots
- 1976 Fuel Channel Core Bricks
- 48 Loop Channel Core Bricks
- 1104 Reflector Bricks
- 96 Cut Restraint Band Sections
- 24 Cut Gas Seal Sections
- Thermocouples & Flux Scanning Tubing
- 1764 Graphite Spigots
- 7 Carbon Steel Spigots
- 337 Core Support Bearings
- 45 Items of Operational Waste

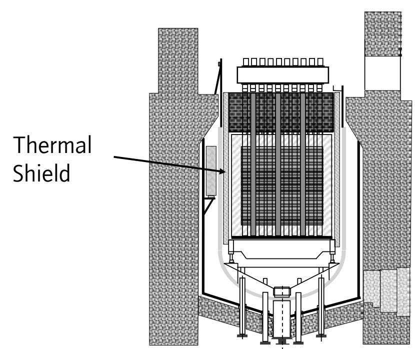
Graphite Core Summary

The removal of the Graphite Core & Restraint System commenced on 2 May 2002

In total 210 tonnes of graphite and 25 tonnes of steelwork were packaged into 17 Intermediate Level and 42 Low Level Waste Boxes

18 months declared programme completed in 10 months

Campaign 7 - Thermal Shield



Thermal Shield Overview

- The thermal shield comprised of fourteen courses of steel 'bricks' arranged in a circular fashion between the inside of the pressure vessel and the outside of the graphite core.
- Bricks were radially constrained by fishplates and each had a dovetail type feature that keyed each brick to its neighbour.
- Flux Scanning Tubes and Thermocouples were attached to the inner face of the Thermal Shield and Pressure Measurement Tubing was attached to the outer face.

Thermal Shield Overview

- Bricks were removed using remotely deployed magnetic grabs, trunnion lifting grabs and plate grabs.
- Fishplates were removed using remotely deployed fishplate removal tools.
- Pressure measurement tube brackets were detached from the outer edge of the thermal shield using a remotely deployed reciprocating saw.
- All tubing and thermocouples were cut and removed using a Schilling Manipulator deployed shear.

Summary of Components Removed

- 12 off course 14 bricks
- 144 standard height bricks (courses 2 - 13). The sections of gas seal channel and remnant connected are fitted to course 2 bricks
- 300 fishplates (three types)
- Thermocouples and flux scanning tubes.
- Pressure monitoring tubes and brackets (12 runs)

Summary of Waste Produced

- 38 Brick Waste Baskets (excludes course 1)
- 1 Flux Scanning Tube Bin
- 2 Fishplate baskets

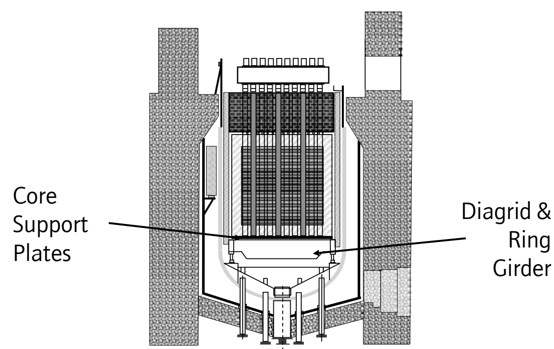
- 16 High Density Waste Boxes
- 5 Normal Density Waste Boxes

Thermal Shield Summary

The Thermal Shield Campaign commenced in February 2003 and was completed within 11 weeks.

In total, 180 tonnes of steelwork were removed and packaged into 20 Waste boxes.

Campaign 8 - Lower Structures



Lower Structures Overview

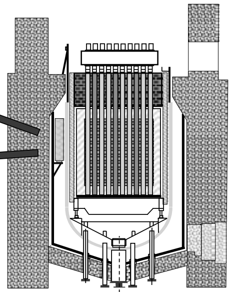
- Current Campaign, split up into two Stages:
  - –Mechanical disassembly of components above and within Diagrid
  - –Oxy-propane size reduction and removal of Diagrid Lattice and Ring Girder, including removal of Rocker Bearings

Lower Structures Inventory

- 330 Core Support Bearing Lower Races, plus 4 remaining from Campaign 6
- 84 Outer Bearing location trays
- 12 Neutron Baffle Plates
- 12 Thermal Shield Course 1 Bricks
- 246 Arrestor Mechanism Housings Tubes, 77 with Specimen Canister Holders
- 24 Core Support Plates
- Diagrid Lattice
- Diagrid Ring Girder
- 12 Rocker Bearings

Waste Disposal

BNFL Drigg LLW Disposal Facility

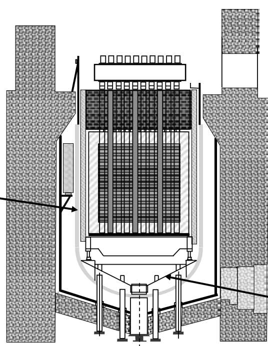


ILW B64 Site Storage Facility

- What's next?

Campaign 9 - Pressure Vessel & Insulation

Pressure Vessel & Insulation



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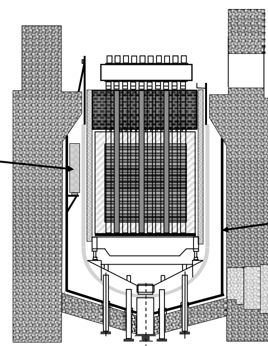
Campaign 10 - Thermal Columns & OVM

Thermal Columns



Outer Vault Membrane

Lessons Learned

- It is possible to decommission a power reactor under a commercial, fixed price agreement
- Customer Relations - Close ties with UKAEA, the customer, have been built and are maintained at WAGR
- Management of Project Risks - A process embedded in the WAGR culture
- Rehearsals - The necessity for exhaustive, realistic trials is an essential part of the WAGR project
- Simplicity - Keep it simple
- Contingency - Always have a plan B and if necessary a plan C!

Is WAGR a Success?

- Safety - Without being safe the project cannot be a success. Seven years without lost time accident
- Dose Uptake - Minimised, in last twelve months less than 1.5mSv to any single individual
- Technical - Fit-for-purpose solutions to arising problems
- Delivery - Project is currently 77% complete, ahead of programme and aiming to finish during 2004
- Commercial - Current forecast is that project will be completed under budget

- To date - YES!