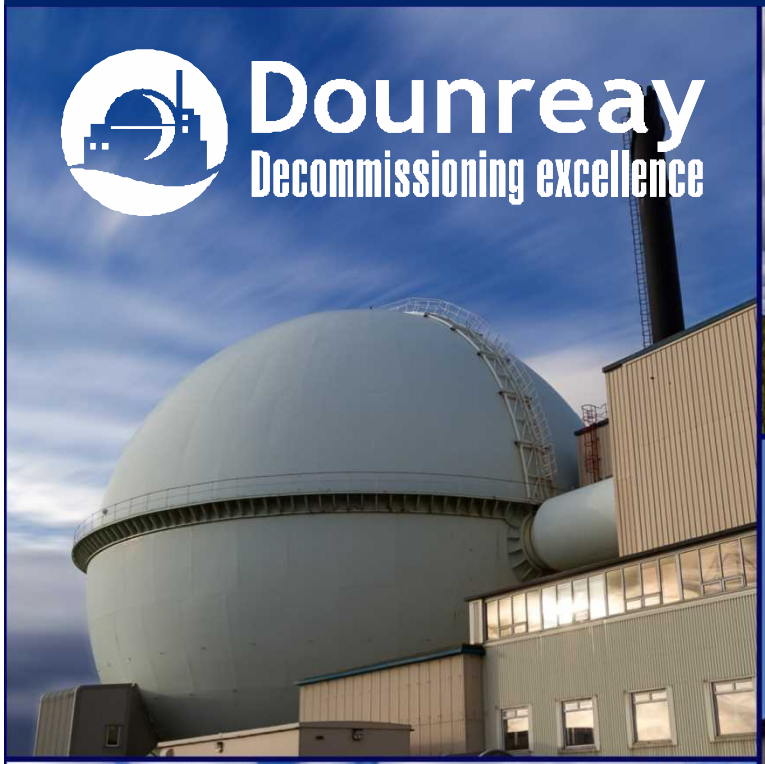

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Dounreay
Decommissioning excellence

Expert Panel on Monju Decommissioning
6th March 2018

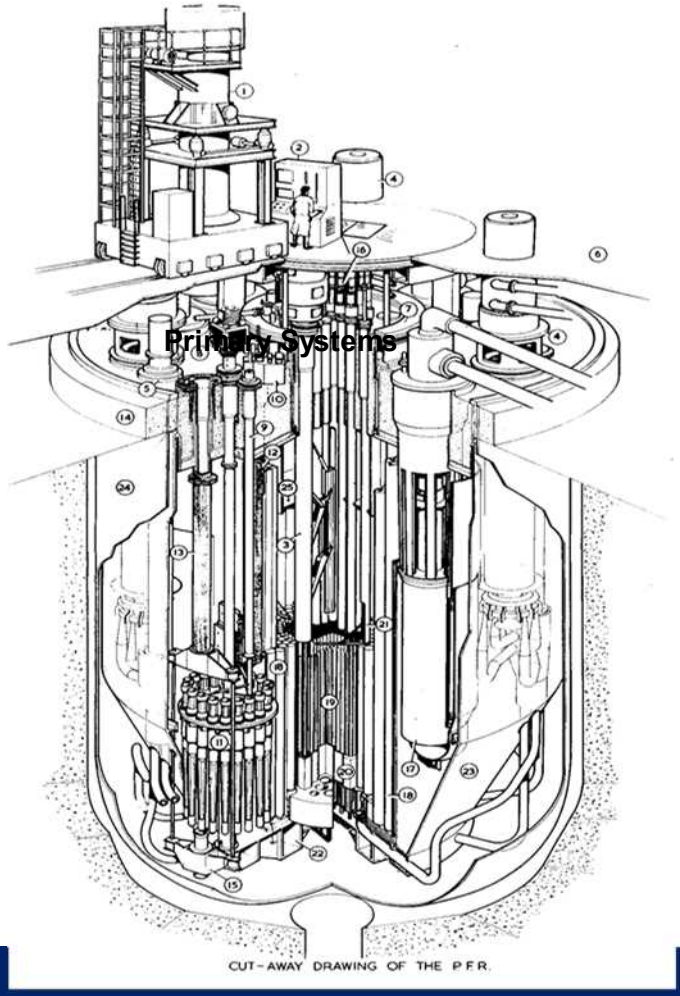
Steve Beckitt

Chief Nuclear Officer

DSRL

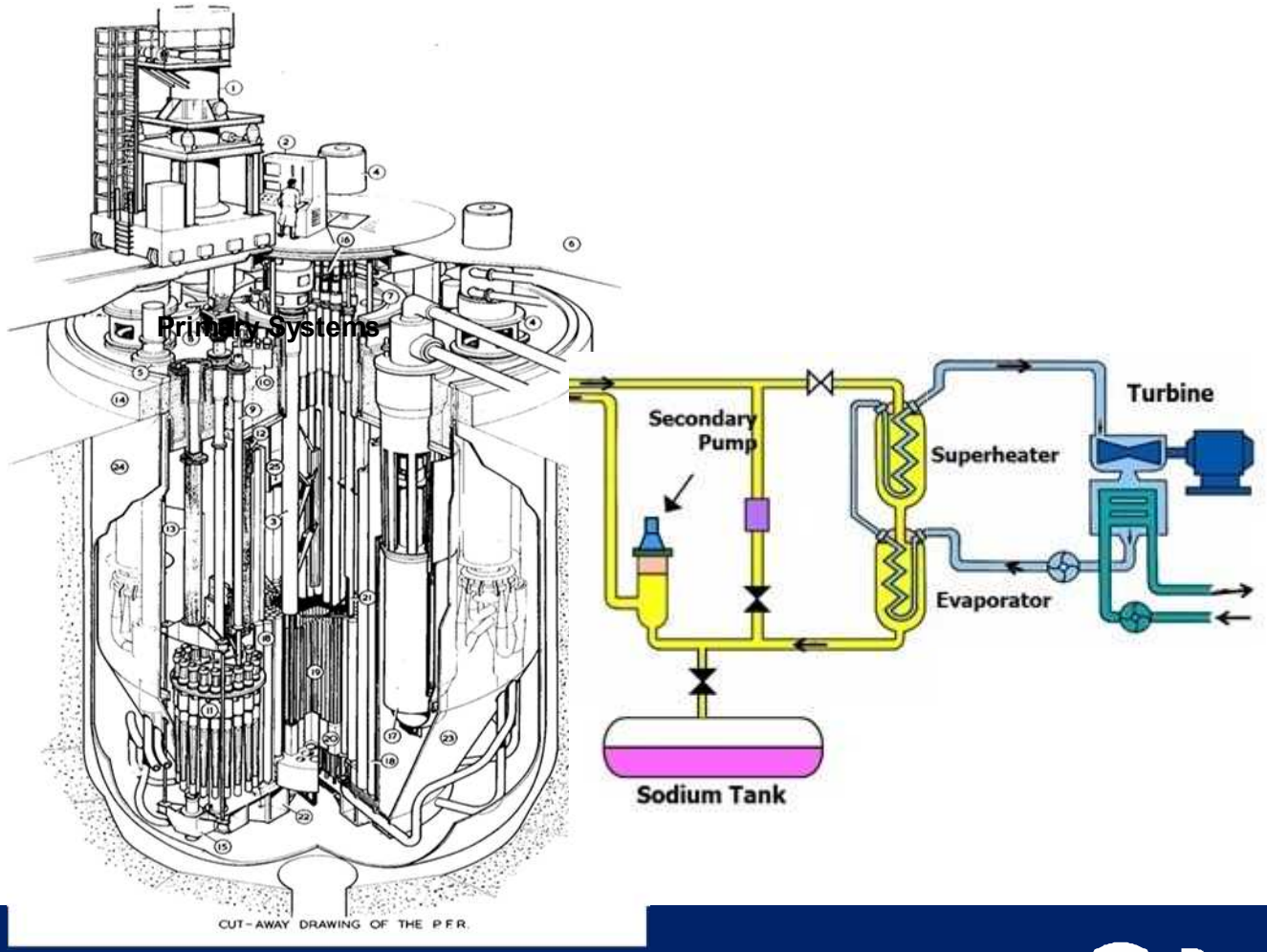
PFR Decommissioning Dounreay

Decommissioning Synergies



CUT-AWAY DRAWING OF THE P.F.R.

Decommissioning Synergies



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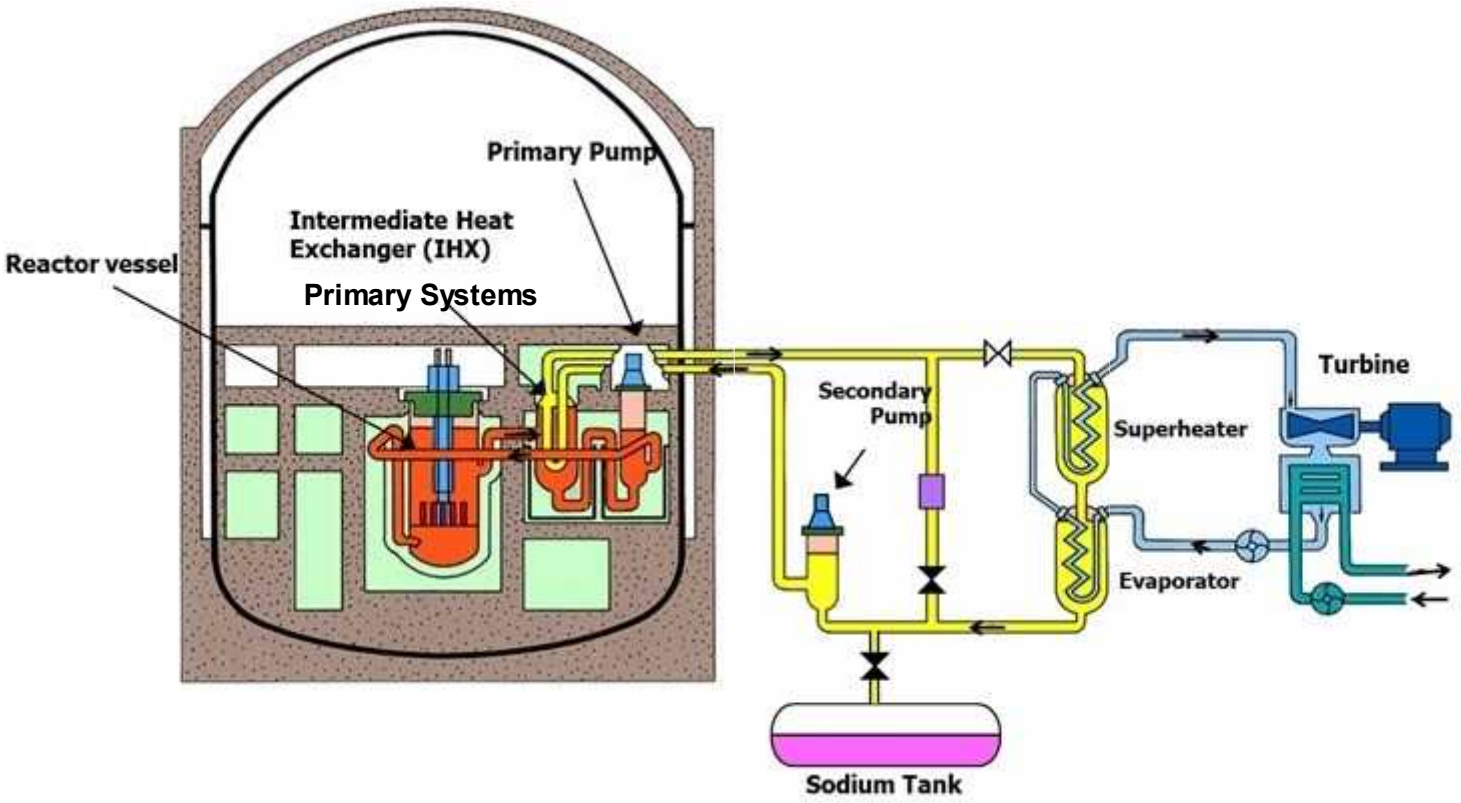

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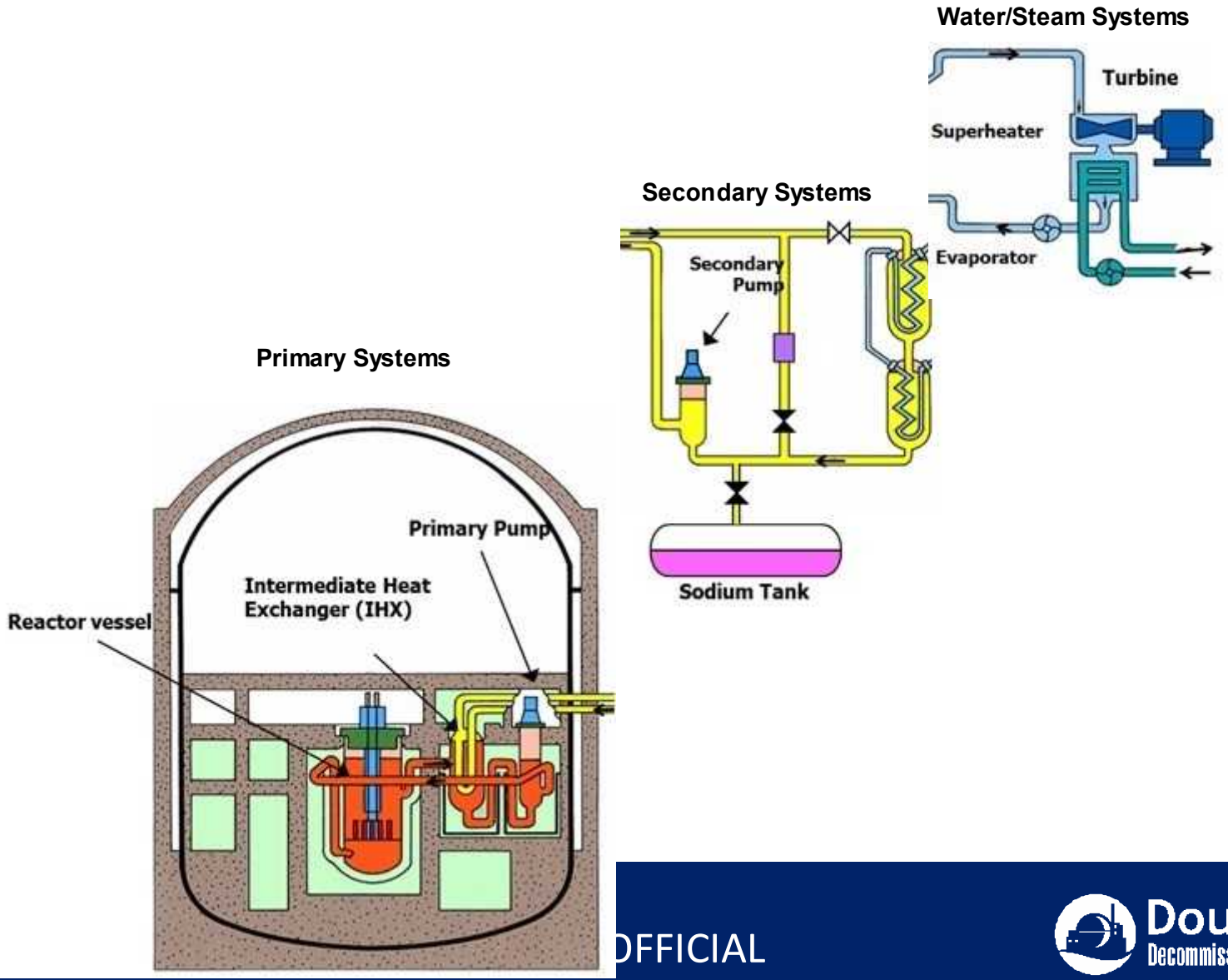


PFR Fact and Figures

- PFR operated from 1974 – 1994
- 600MW heat, 250MW electrical
- Achieved full power in 1977
- Generated 9250GWh of electricity
- Maximum burnup 23%
- 500Sv/h dose rate in core after over 20 years cooling
- 170te ILW
- 4200te LLW
- 22,000te clean & exempt waste
- 1500te sodium removed and destroyed from reactor systems
  - 1kBq/g Cs-137 and 2kBq/g H-3 in coolant
  - Coolant destroyed by NOAH process and liquors discharged to sea
  - 78 fuel elements and 51 radial breeder elements removed between 1994 - 1996
- Steam cleaning routinely used to clean fuel elements

Fuel Removal

Spent Fuel Removal

Fuel Removal

Spent Fuel Removal

Fuel Removal

Spent Fuel Removal

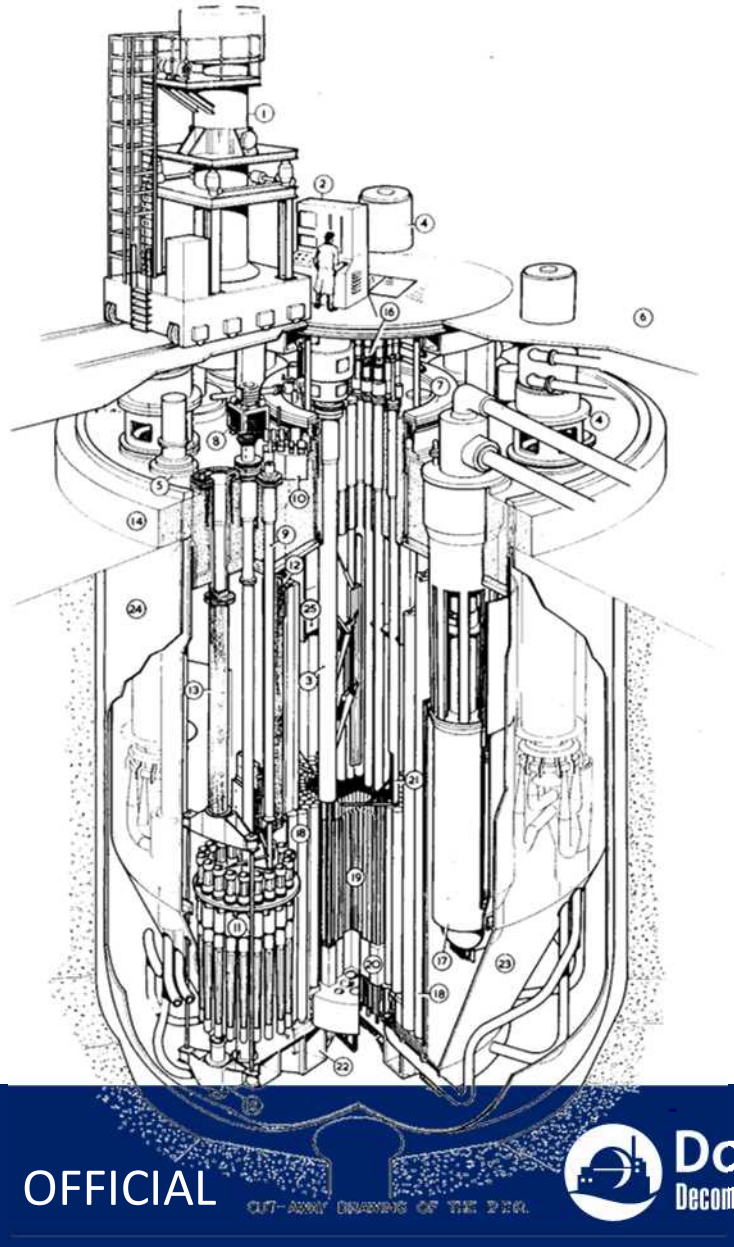
Fuel Removal

Spent Fuel Removal

Sodium Destruction

Extract Pump

In Place of the Vickers Plug



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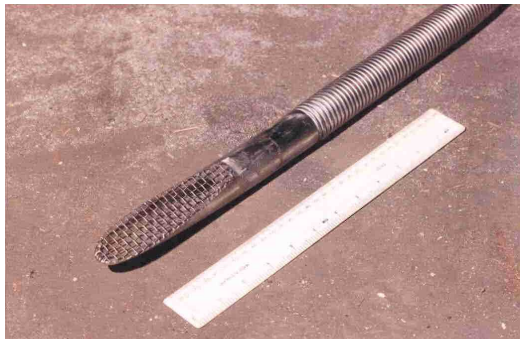

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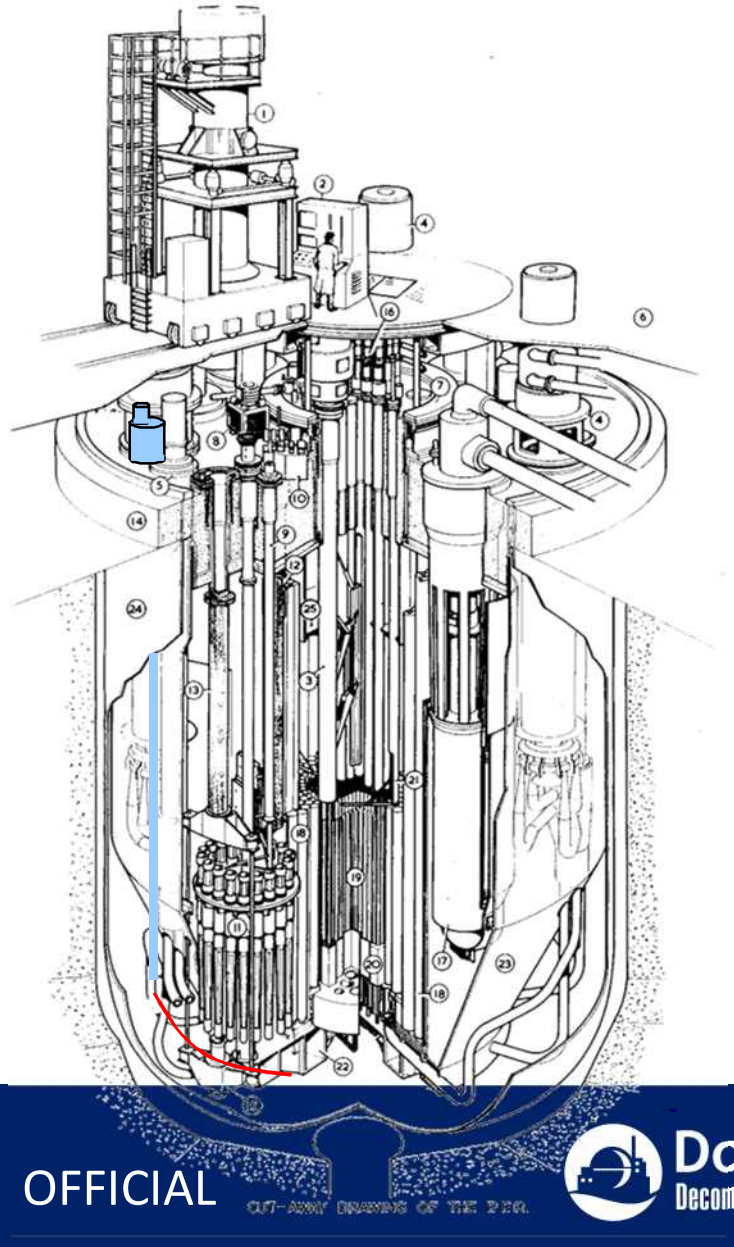

Sodium Destruction

Extract Pump

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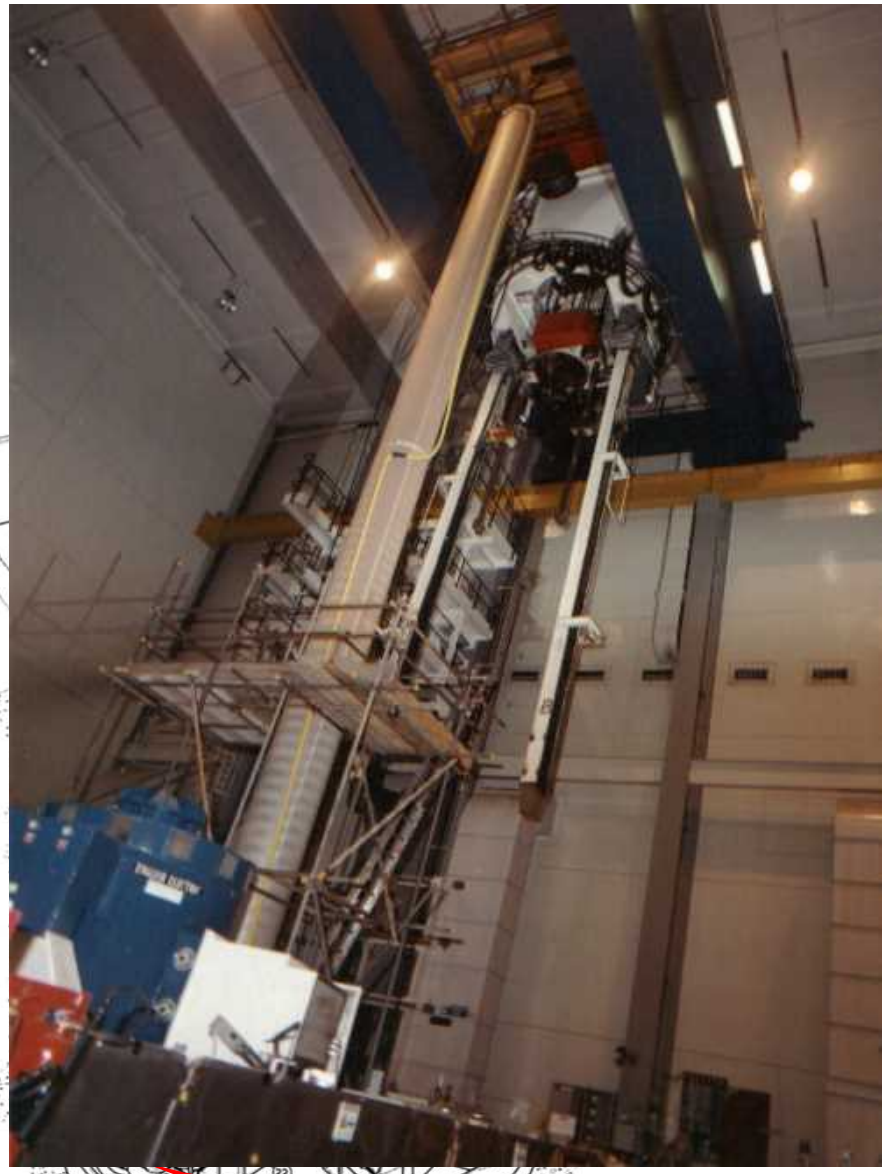
Electrical Heater

Installed in the Reactor Transfer Port & Rotor



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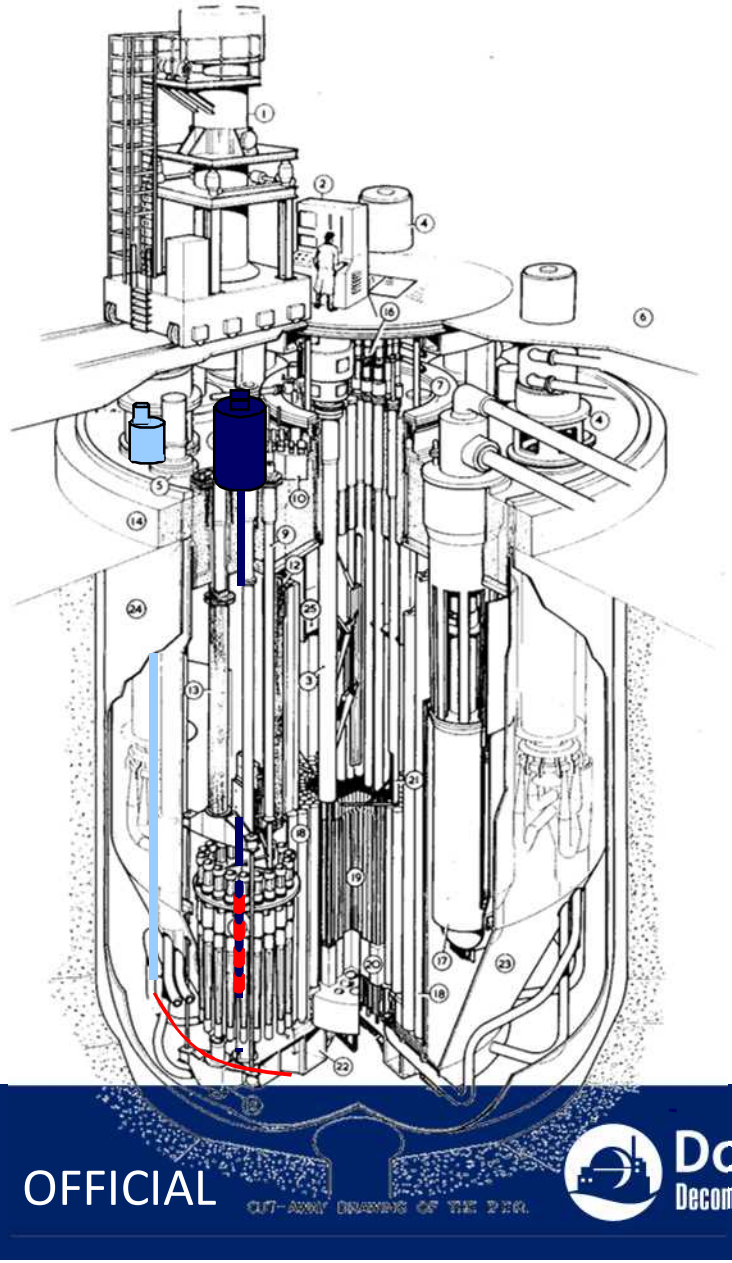

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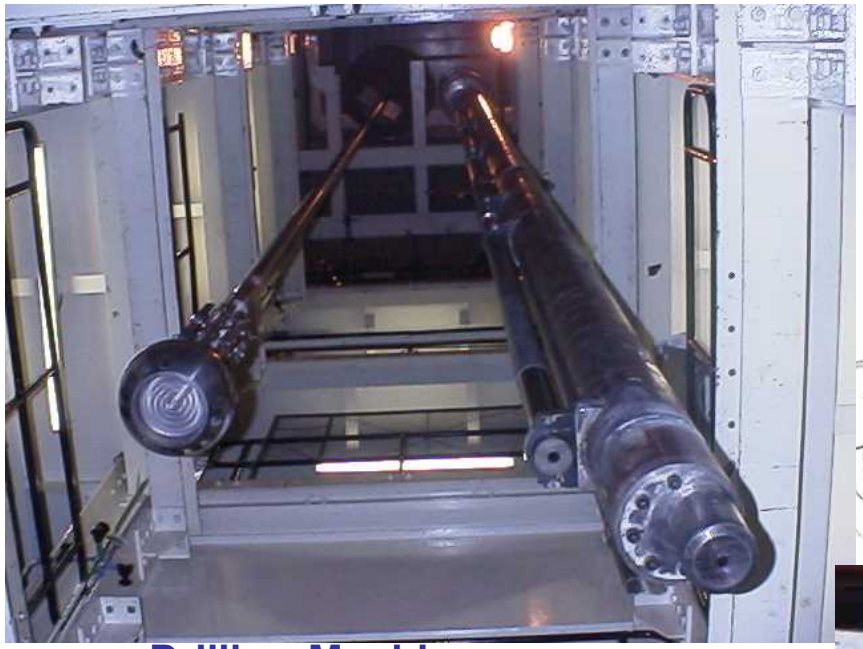
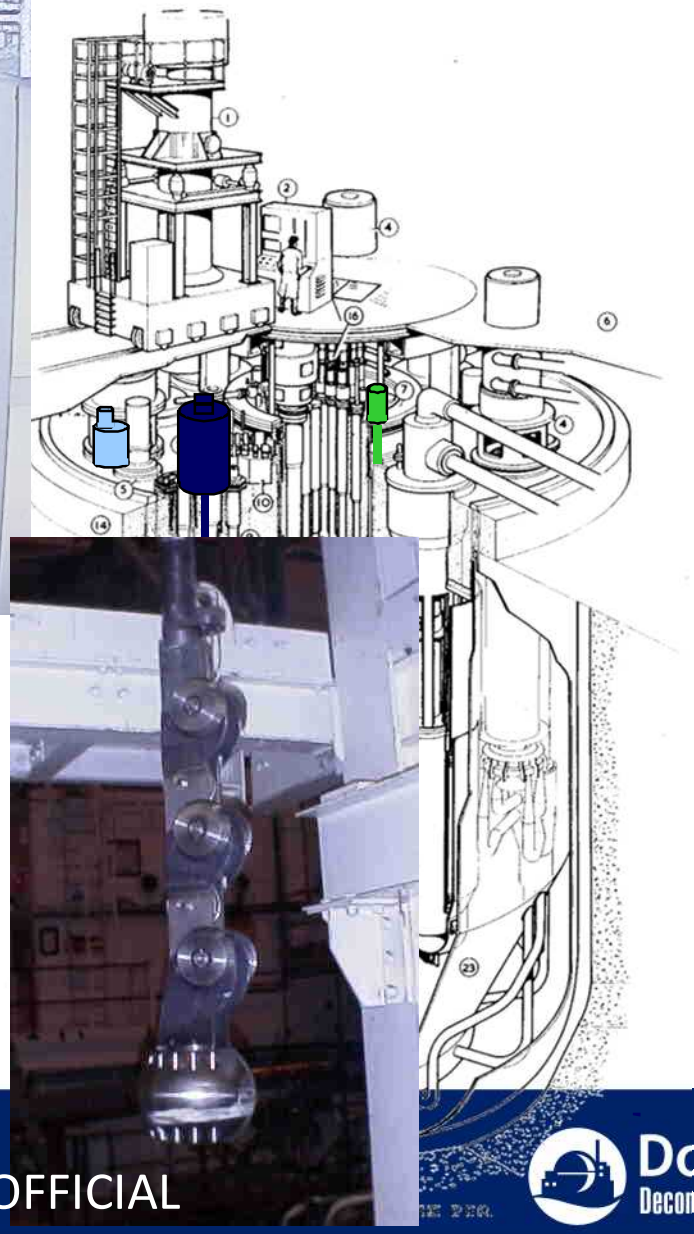


Drilling Machine

Replacing Neutron Shield Rod



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Extract Pump

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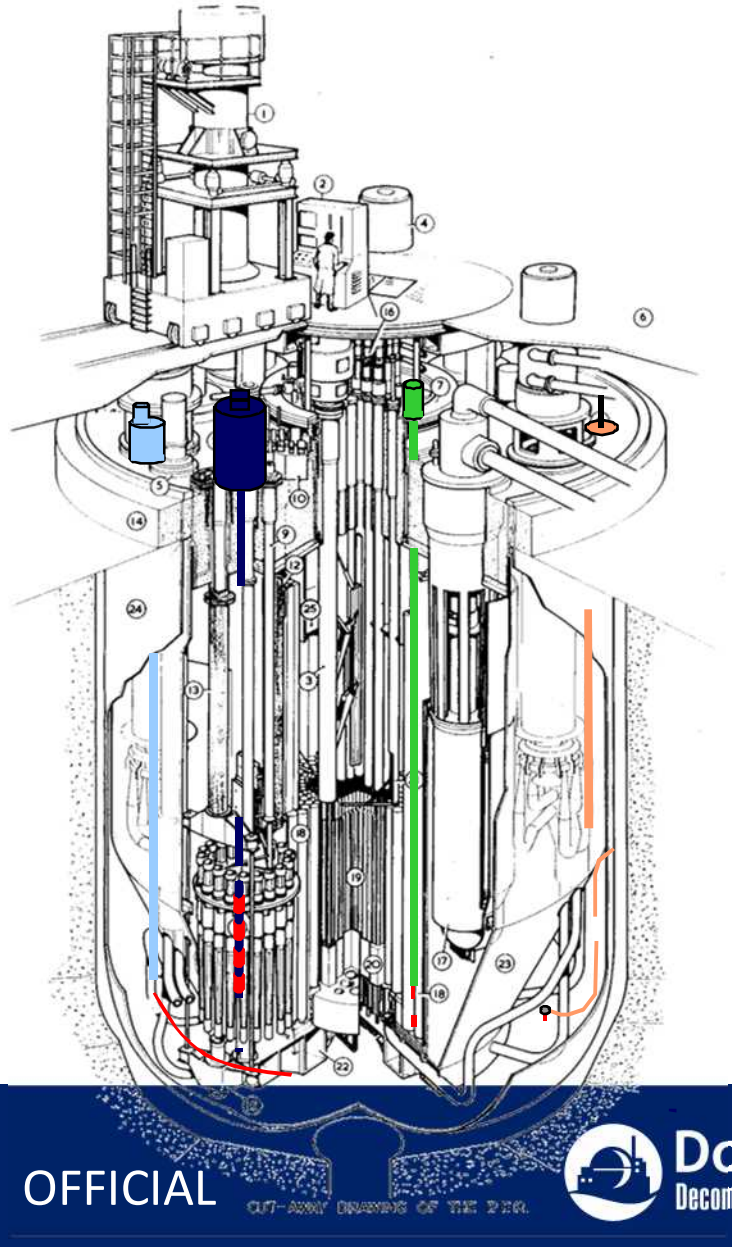
Drilling Machine

Replacing Neutron Shield Rod

Pipe Piercing Machine

Lowered below primary sodium Pump Valve



NOAH Process Experience

- Continuous destruction process required since 1500te sodium
- Areva system purchased as a turn-key destruction rig
- Plant installed where turbine was located
  - Adjoining caesium removal plant required for Cs-137 abatement
  - Alkali metal analytical facility installed to support work

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Heat and hydrogen managed in inert gas
Caustic product neutralised with hydrochloric acid
Caesium removed with CsTreat ion exchange resin
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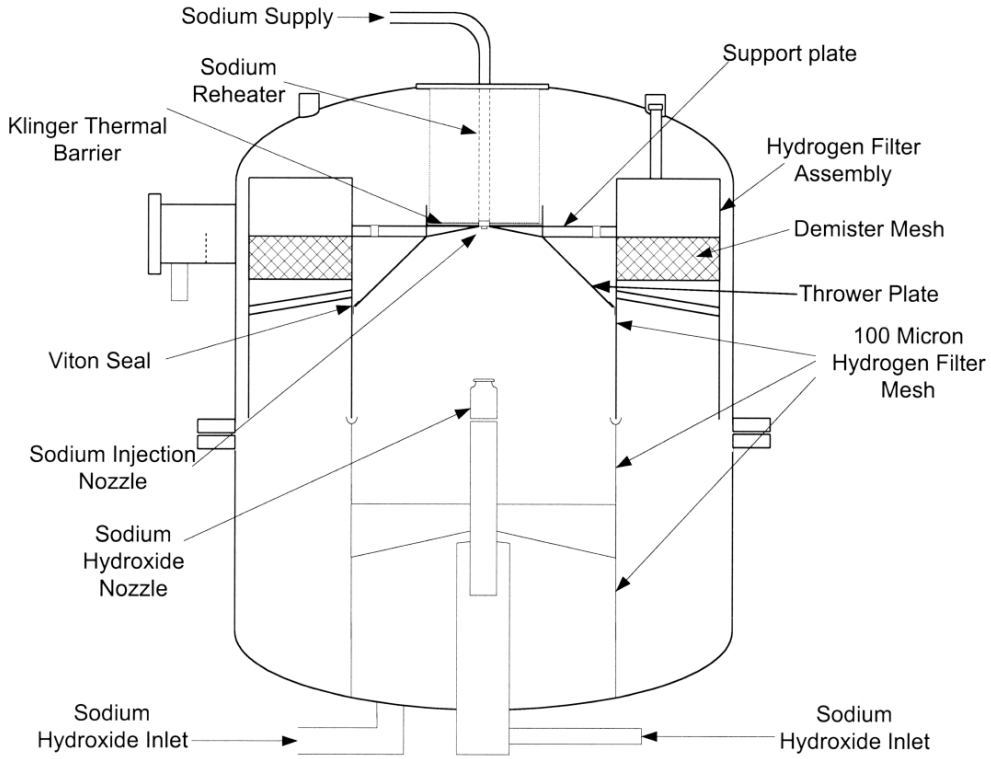

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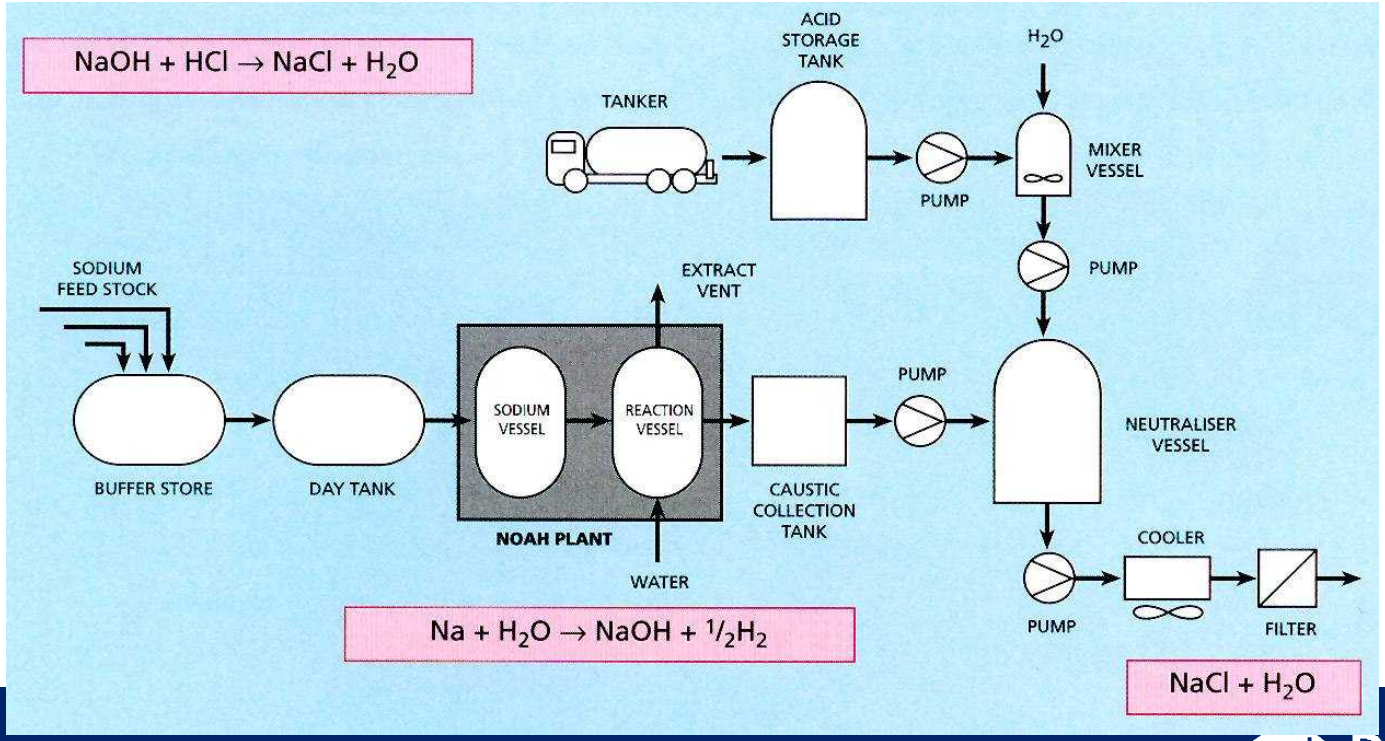
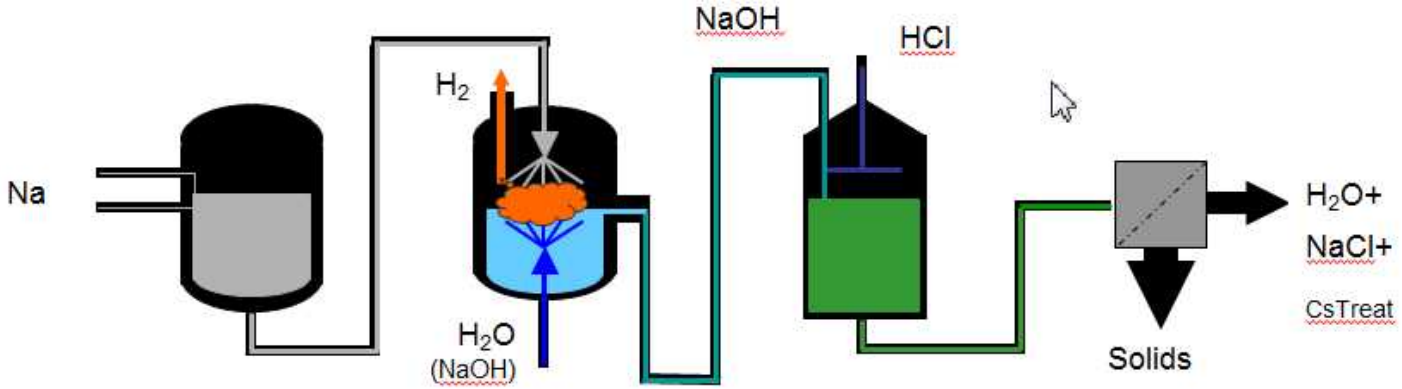


WVN Process Overview

- NOAH Process (Sodium Hydroxide)
  - Sodium heating to 350 °C
  - Sodium pressurised transfer and diffusion
  - Sodium / sodium hydroxide reaction
  - Sodium hydroxide and hydrogen separation

- Neutralisation Circuits (Sodium Chloride)
  - Sodium hydroxide / hydrochloric acid neutralisation
  - Filtration, sampling and discharge



History of WVN at Dounreay

- Laboratory work on WVN process had demonstrated that:
  - WVN process would be suitable for sodium frosts.
  - WVN process does not necessarily react sodium deposits in inaccessible areas.
  - When treating sodium pools WVN process can lead to:
    - Periods of vigorous reaction
    - Pressure transients
    - Temperature transients

- Work required to:
  - Scale-up the process
  - Demonstrate applicability on real plant
  - Quantify pressure and temperature transients during WVN treatment of sodium pools

Timeline for Sodium Destruction Work

Off-Site - complete

- Small quantity of sodium (5 kg)
- *through to*
- Large quantity of sodium (1000 kg)

Sodium tank farm - complete

- Large tanks (no internal geometry)
- Clean sodium (tritiated)
- Sodium quantity 100 kg to 300 kg.

Secondary sodium circuits - complete

- Large diameter pipework
- Complex geometry.
- Clean sodium (tritiated)
- Sodium quantity 100 kg to 200 kg.

Dirty Dump Tanks -complete

- Large tanks (no internal geometry)
- Clean sodium (tritiated)
- Sodium quantity 2 tonnes - 8 tonnes.

Primary Vessel - pending

- Very large vessel.
- Complex internal geometry.
- Contaminated sodium.
- Sodium quantity estimated at 15 tonnes

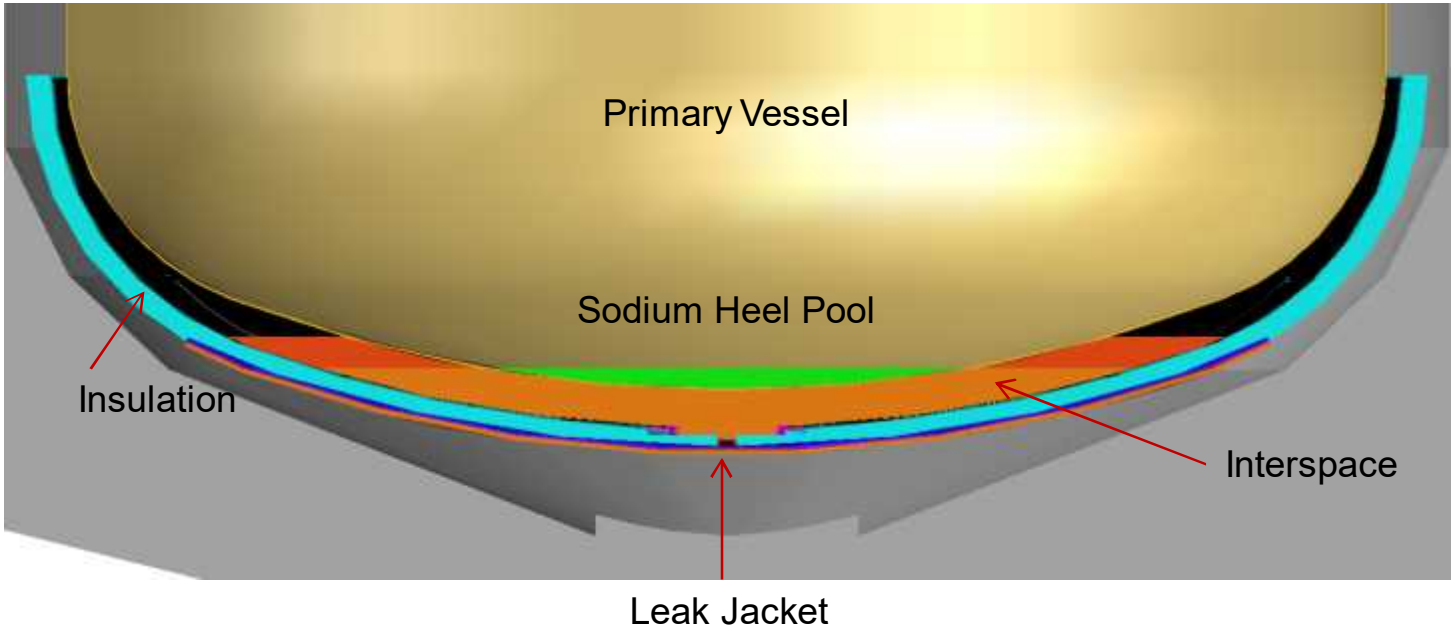
PFR RV Treatment – Heel Pool Removal

- Modelling indicates an upper limit of 157kg for safe WVN of RV. 1.2 tonnes estimated to remain in the heel pool
- A new heel pool pump based on the existing design of pump is being manufactured
- Targeted heating of heel pool to be achieved using heater arrays deployed from reactor vault, through RV
- Heaters have been prototyped, tested, manufactured and delivered
- Heater installation in progress in 2018
- Recovered sodium to be collected in new tank for storage.
- Recovered sodium to be processed in Bulk Alkali metal destruction facility.

Heel Pool Removal

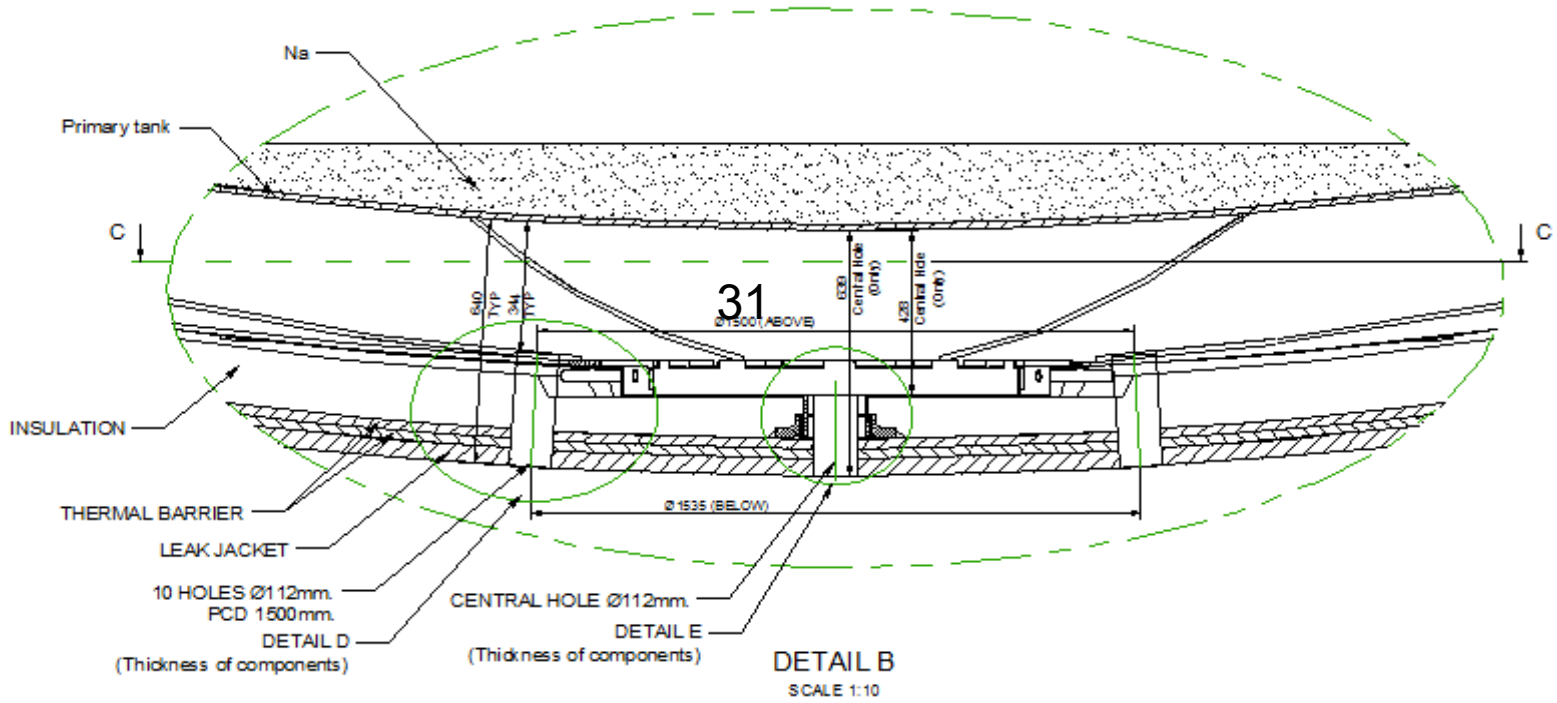
The PFR reactor heel pool contains residual sodium (1,200 kgs) in the base of the primary reactor vessel. The approach is to melt the sodium and remove as much as possible by pumping. The sodium will be transferred into a holding tank for transfer to the bulk sodium disposal facility.

Sufficient sodium needs to be removed so that the amount held within the reactor is reduced to a level which is acceptable within the safety argument(assessed to be 157kgs of bulk Na).



Phase 1.1: Heel Pool Removal

Holes will need to be drilled from the vault through the leak jacket so that heating elements can be deployed under the primary tank vessel.



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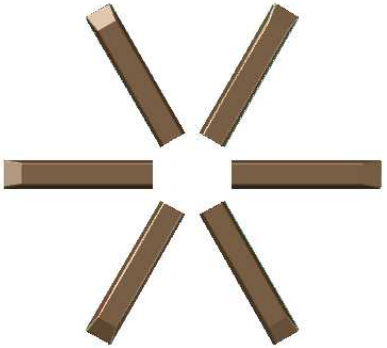
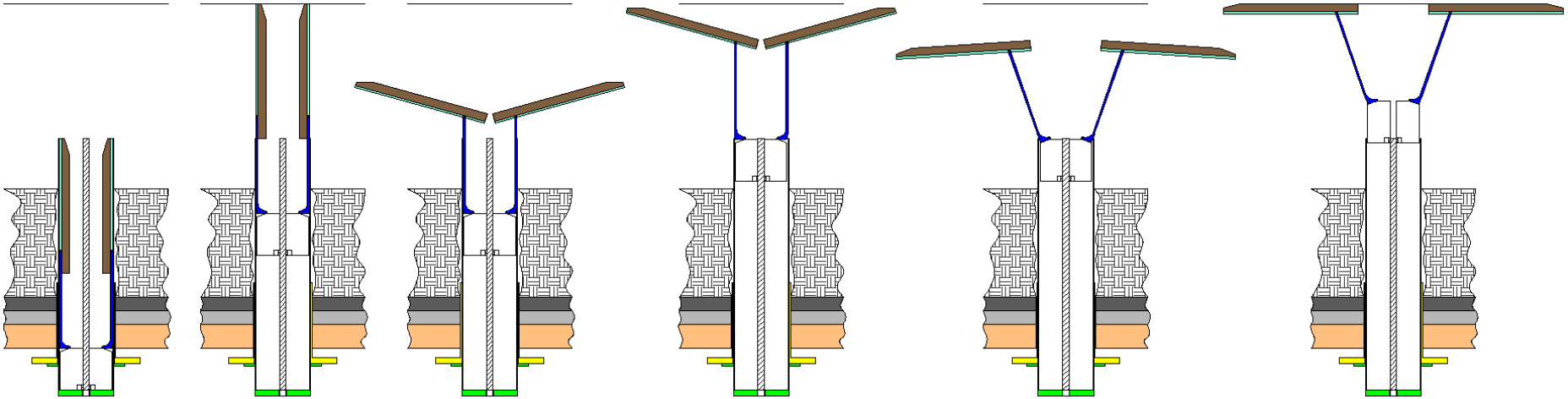
Phase 1.1: Heel Pool Removal

The heating elements are a prototyped and designed unit which will be deployed through holes drilled through the leak jacket and insulation and mounted onto the base of the primary tank. They unfold in a petal formation to ensure that sufficient coverage is achieved across the bottom of the tank. This ensures that the heat is transferred from the electrical elements in an efficient manner through the tank wall and into the sodium pool.

11 elements will be deployed delivering a total of around 270kW of electrical energy.





Current PFR Position

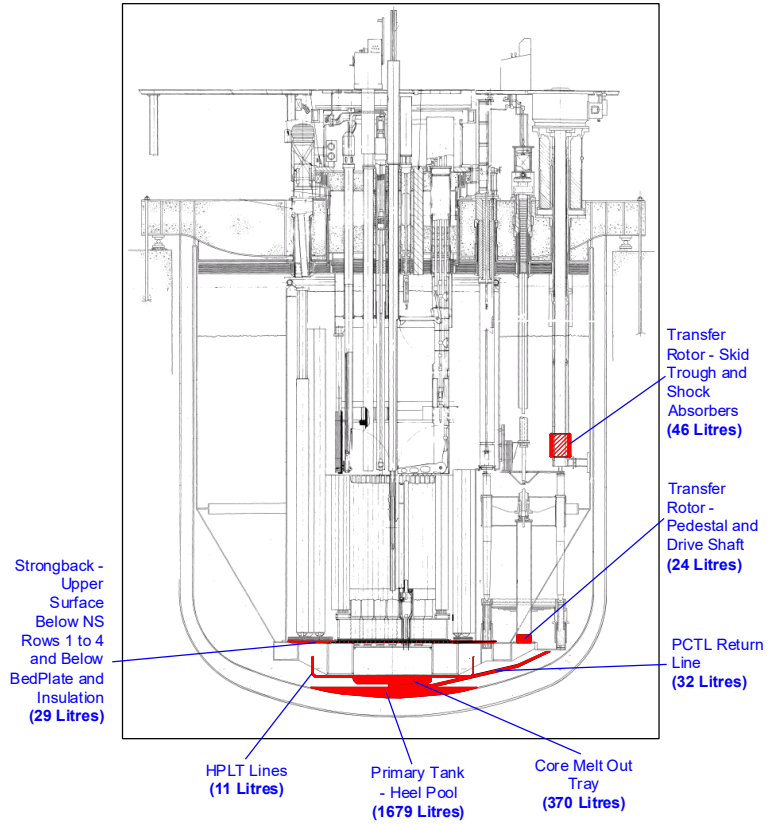
Steam and secondary circuits removed, cleaned and disposed

Primary circuits drained however remaining alkali metal pools too deep to secure safety case for in-situ WVN

Additional heel pool removal now underway

Overall, WVN preferred passivation technique with no pressure excursion

SINGLE AREA SODIUM HOLD UPS
(VOLUMES GREATER THAN 20 LITRES EXCEPT HPLT LINES)



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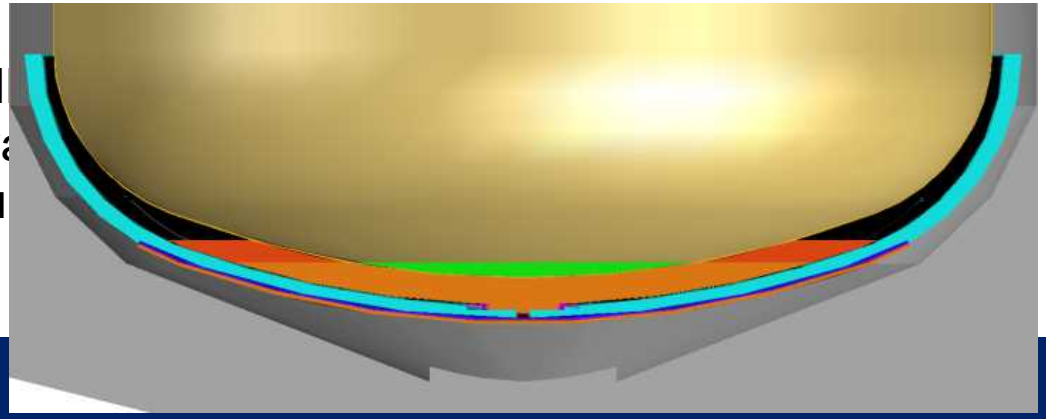

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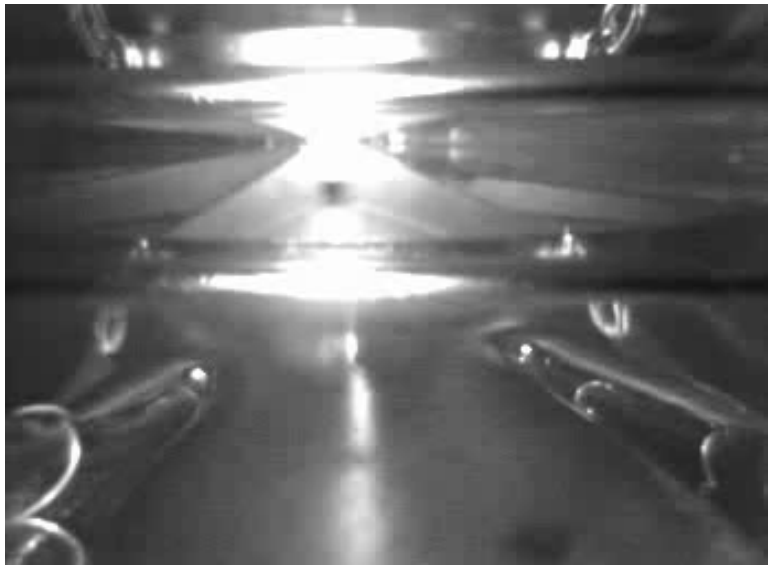

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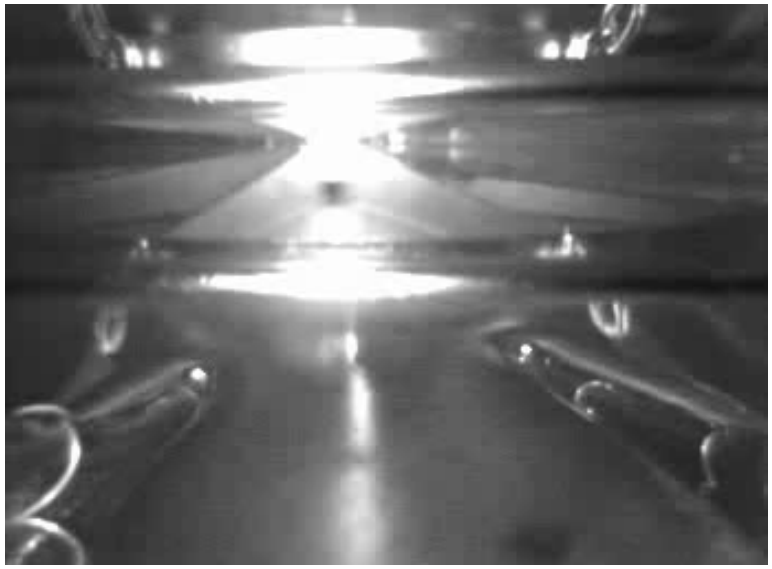

Preferred Sodium Destruction Techniques

1 Water Vapour Nitrogen (WVN)

- Deployed following Bulk removal (Reactor Vessel, Secondary Circuits, IFC & Tank Farm)
  - Highly effective thin films
  - Some hold-ups in capillaries, blank ends etc.

2 Superheated Steam (SHS)

- Deployed for bulk sodium destruction in a new facility.

3 Conventional Steam

- Used within the Decontamination Vessel
  - Cleaning of sodium logged components in Mortuaries
  - Secondary cleaning of suspect components fro ILWSRF

4 Others

  - Fester process
    - Return of systems to air after WVN

PFR Challenges

- Destroy remaining sodium:
  - Remove heel pool from reactor vessel
  - Treat residual sodium in reactor vessel
  - Treat residual sodium in remaining systems
- Dismantle reactor vessel
  - Design and construct supporting facilities (ILWSRF, tooling and flasking)
  - Remove and package the vessel and contents (ILW, tritiated LLW, LLW)
- Dismantle remaining systems and structures
  - PCTL , AGB, Reactor Building Systems and Tank Farm
  - IFC (after fuel removal by Fuels Directorate)
- Process Remaining Bulk Sodium
  - Design and Construct Bulk Sodium Destruction Facility
  - Process Bulk Sodium
- Demolish structures to foundation plinth

Remote Camera Inspection - DFR

The People Journey

Decommissioning Dounreay

- Dismantling a broad complex suite of Nuclear facilities
- Continual improvement of SHEQ performance
- Ageing plant not designed for decommissioning, incomplete records, decommissioning is a sequence of changes
- Requirement for robust processes and “conservative decision taking”
- Transitioning of the workforce
- Stakeholder Communication

Site/Project Organisational Structure

- Right structures with the right people
- Single point accountability
- Flat as possible
- People aligned to the programme/scope
- Clear lines of responsibility
- “Projectised” embedded staff
- Mix of staff and contract personnel
- Transition new decommissioning personnel into operational organisation

Questions?