Operational Experience during the replacement of Pressuriser Heaters in Forced & Planned Outages

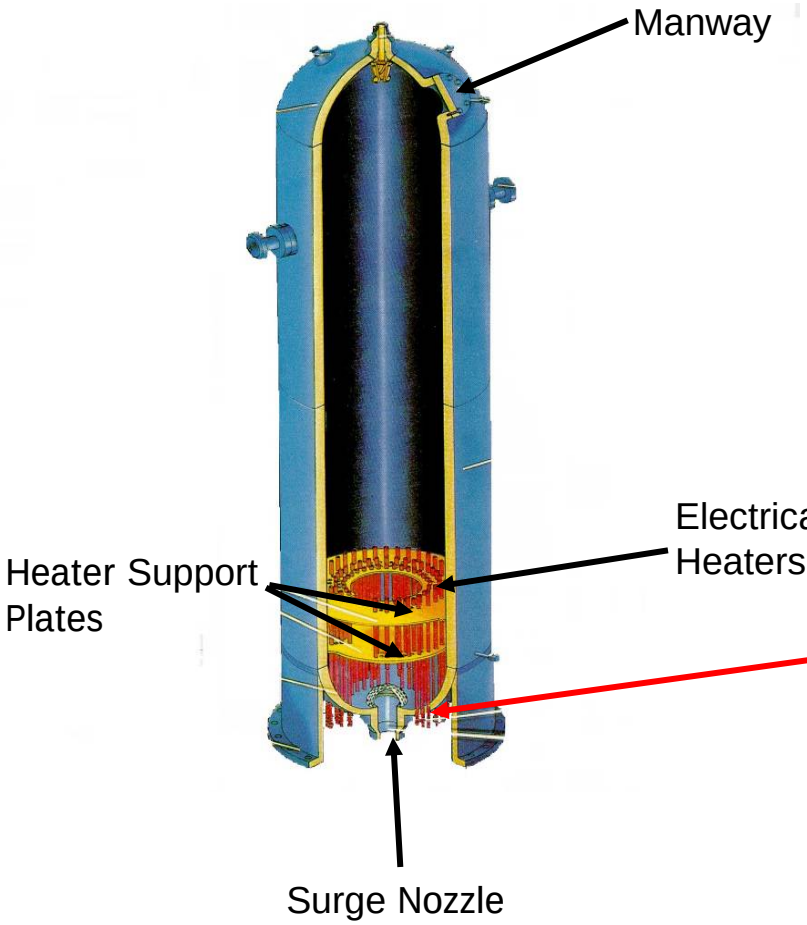
Sizewell B Power Station

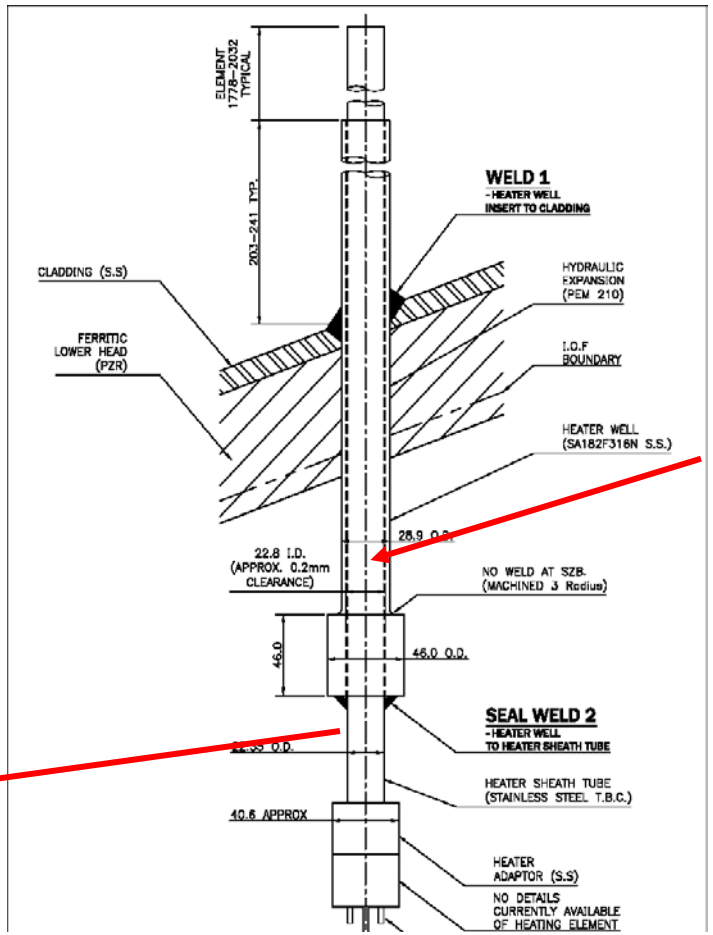
- Four loop Westinghouse design PWR (W42 Sister Group).
- Nett output of 1200 MW(e) – around 3% of the peak UK electricity demand.
- 18 month operating cycles, now in cycle 12.

Forced Outage 43

- On 17th March 2010;
  - Unidentified Reactor Coolant leakage
  - Increasing Containment activity-in-air
  - Reactor was promptly shutdown
- Investigation found a split in Pressuriser Heater Well Insert (HWI) # 42, an electrically-defective heater that had failed in service.

The Event - Initial indications





12-15mm approx defect

Cause of the leak

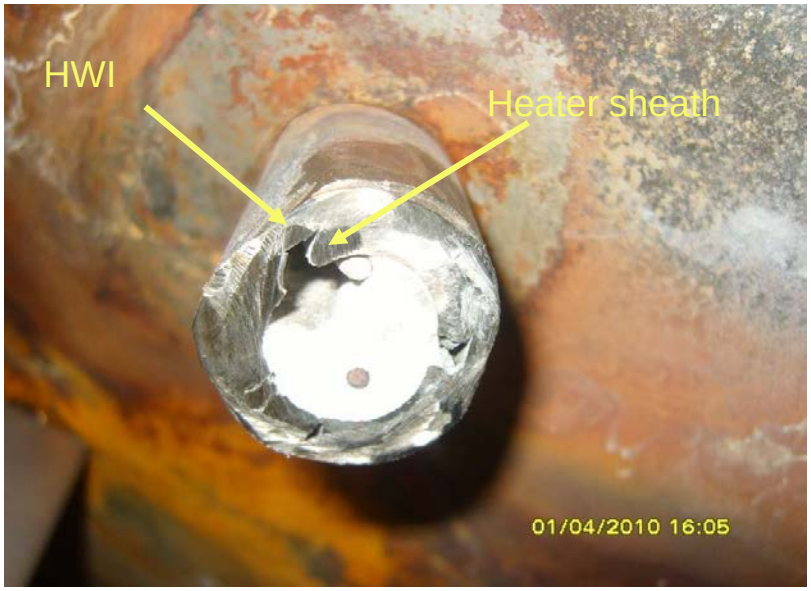
- Radiography confirmed that heater well insert (HWI) 42 had failed because of the expansion of the heater.
- All the other HWIs were radiographed and HWI 70 was also found to be expanded - both were electrically failed heaters.

Heater 42 Radiograph showing disruption to the heater and the HWI

Heater 72 Radiograph showing a normal heater and HWI

Cause of the leak

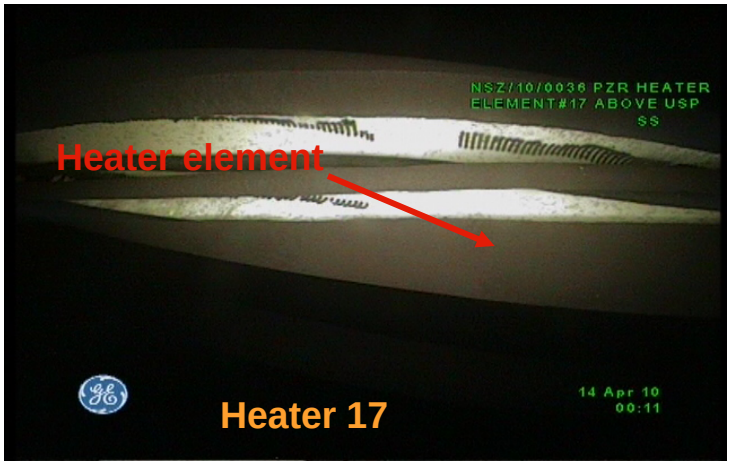
- HWIs 42 & 70 were cut which showed the heater sheaths were cracked and fully expanded into the wells.

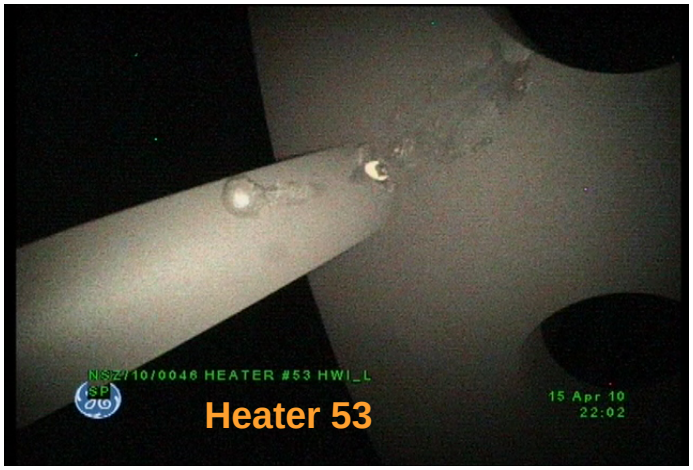


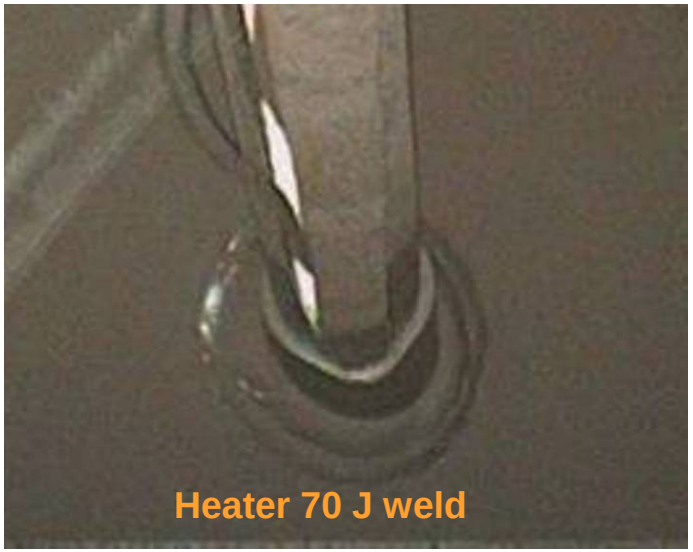
HWI 42 after cutting

HWI 70 after cutting

Results of internal camera inspections







Forced Outage Scope

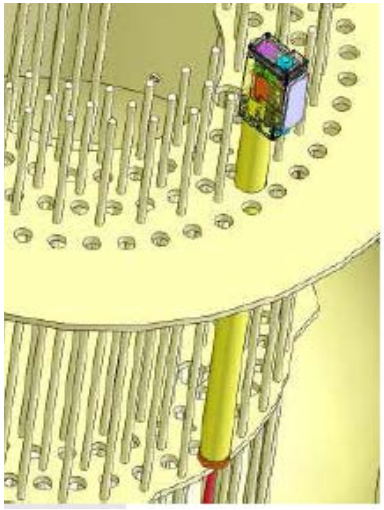
- Emergent work
  - No preparation time like a normal project.
  - In practice safety case & engineering development time was used for rehearsals and mock-up training.
- Early decision taken to off-load core to Fuel Building to protect fuel
  - Temporary Reactor Head used to allow refuelling cavity to remain filled.
- Safety Case accepted by Regulatory Body required replacement of seventeen damaged or electrically failed heaters in the Forced Outage then the remainder of the heaters at the next Refuelling Outage.

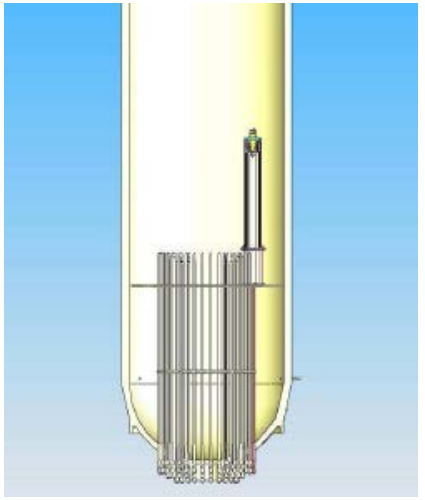
Initial Planning

- RCS water level maintained at top of Pzr surge pipework for shielding.
- Replica of the under-Pressuriser work site was purpose built - used to develop, refine tools & work techniques.
- Both were critical to the overall dose management performance.

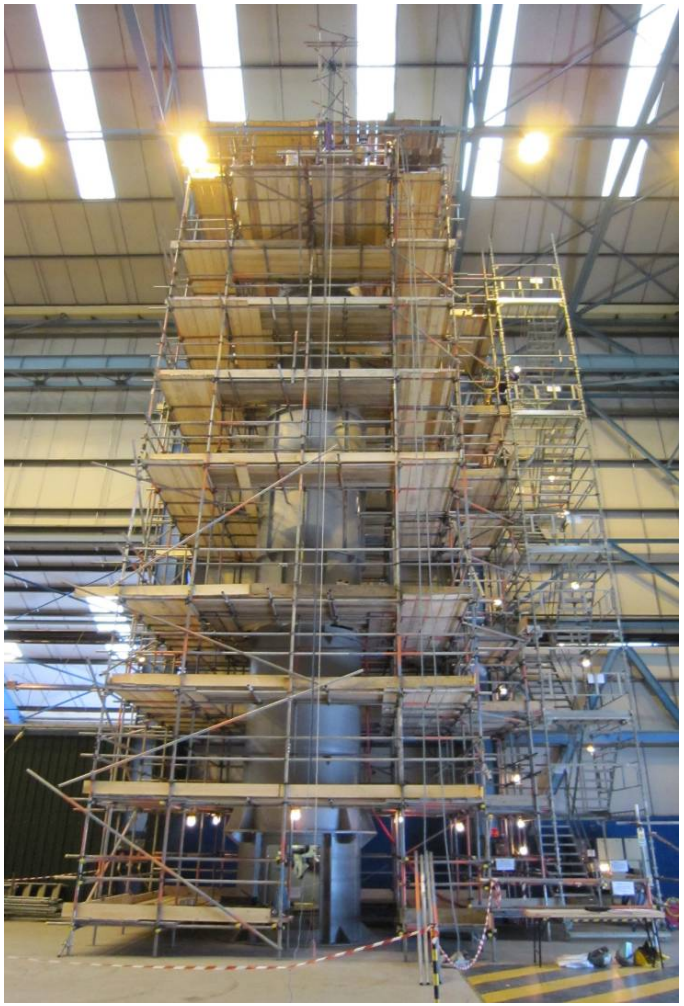
Removal of mechanically damaged heaters

- Removal of damaged heaters using Electrical Discharge Machine tool
  - Manually deployed from internal platform.
- EDM tool used to cut through support plates & “canned” heater then removed.
- Full size mock-up built to practice techniques & man-entry arrangements.



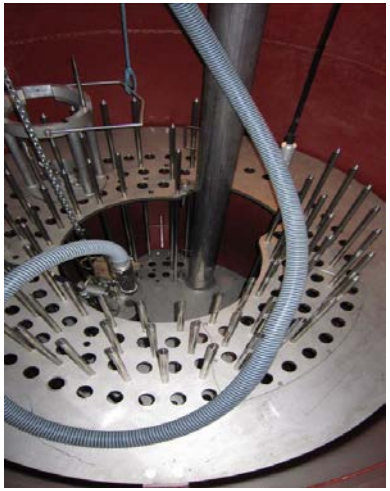


Full Scale Mock-up



Full size Pressuriser mock-up

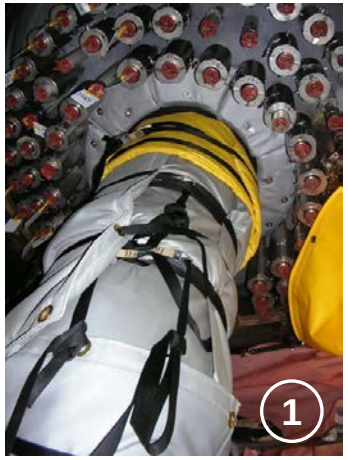
Practising man-entry

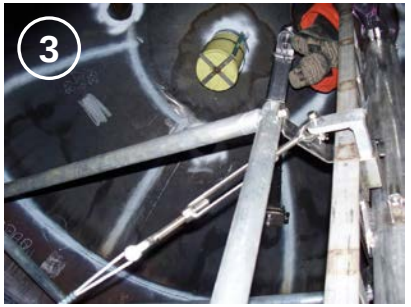


Mock-up of upper support plate with heaters

Shielding

- “Clam shell” style heater shielding packages loaned by Seabrook NPP, USA (1).
- Tungsten heater well shields, magnetic bowl shielding & surge pipework shielding purchased from NPO (2).
- Radishield spray nozzle shield from Mazel (3).
- Standard blanket shielding on Pressuriser spray pipework (4).

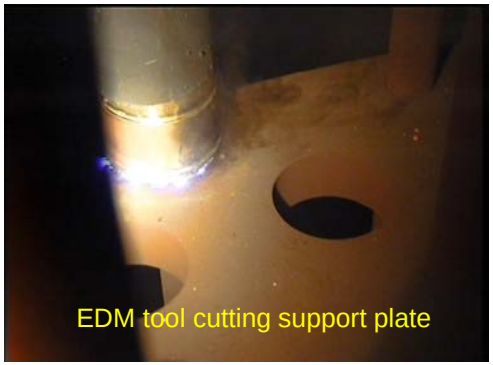




Shown on mock-up

Pzr Heater Removals

- All electrically-failed heaters removed
  - 14 heaters removed from bottom of Pzr via Heater Well Inserts, then plugged.
  - 3 heaters removed from manway after cutting by EDM tool, then plugged.
- Modified Tri-Nuke vacuum used to collect EDM cutting material
  - ~ 6 filters used.
- 120 man-entries inside Pzr
  - ~66 hours inside Pzr.



EDM tool cutting support plate

Ready to enter Pzr

Heater in can being removed

Forced Outage Performance

- Plant returned to service after a 197 day shutdown.
- Seventeen Heaters Removed
- CRE for Pzr repair activities 126 man.mSv.
- Maximum individual dose 4.4 mSv.
- Personal Contamination Events
  - 17 PCEs directly associated with Pzr work.
  - Zero PCEs for entrants inside Pzr.

Refuelling Outage 11 – September 2011
Pressuriser Work Scope

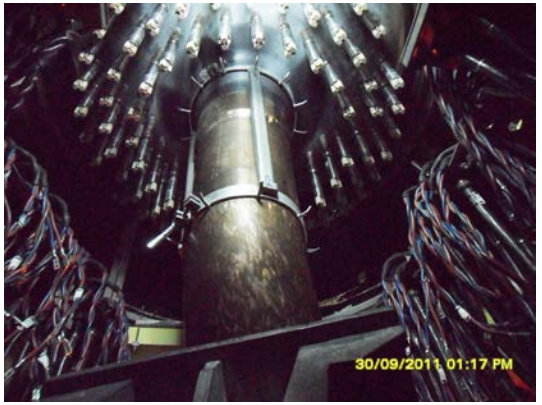
- To replace the remaining 63 heaters using the normal change process from the bottom of the Pressuriser.
- To cut up the old heaters and to place the cut sections in shielded drums.
- Approx. 12 months to prepare between end of Forced Outage and start of Refuelling Outage.
- A specific Project Team was formed.

Pressuriser Heater Replacement Overview

Heater wells with sleeving ready to cut

Cutting old heaters in the glove box

Demobilising a shielded drum of heaters



Pressuriser with new heaters installed

Refuelling Outage Performance

- Pressuriser Heater Project lasted approx. 30 days.
- Sixty three heaters removed and seventy eight installed (replacing those heaters removed in Forced Outage)
- CRE for Pzr repair activities 97.8 man.mSv.
- Maximum individual dose 4.2 mSv.
- Personal Contamination Events
  - 36 PCEs directly associated with Pzr work.

Comparison of Forced Outage & Refuelling Outage Performance

	Forced Outage 43	Refuelling Outage 11
Project Duration (days)	197	30
Number of Heaters Replaced	17	63
Collective Radiation Exposure (man.mSv)	126	97.8
Maximum Individual Dose (mSv)	4.4	4.2
Number of Personal Contamination Events	17	36

Lessons Learned 1

- Investment in a realistic mock-up is worthwhile.
- For maximum effectiveness ensure that the whole RP crew is involved with mock-up training – maybe difficult to achieve for contract RP resources.
- Development & rehearsal of contamination control dressing and undressing sequences is essential to good performance – contract RP technicians arrive with different experiences and practices.
- Apparently small changes in process can have a big impact upon RP – e.g. having multiple open heater well inserts during heater removals.

Lessons Learned 2

- New gamma sensitive Whole Body Contamination Monitors were installed between the two outages – the increased number of PCEs recorded created considerable anxiety in platform workers.
- Use of Pzr heater well shields needs to be carefully planned to avoid “wasted” dose during heater replacements.
- Automated heater well welding equipment worked very well resulting in significant dose savings, due to reduced platform times.


thank you