

## **ENGINEERING SUBSTANTIATION - A TOOL FOR MANAGING AGEING AND OTHER DEGRADATION EFFECTS**

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UKAEA's site at Harwell was established in 1946 as the UK's centre for nuclear R&D. Some facilities are still operating but decommissioning has always been a feature of the changing response to nuclear programmes, the need to make space for new facilities or simply dealing with redundant plant. In the extreme, reactors and nuclear plant have been moved to other UKAEA sites.

Two of the early reactors at Harwell, BEPO and GLEEP have been in Care and Maintenance (C&M) for some time - BEPO was shut down in 1968 as was GLEEP in 1990. Decommissioning began at a new pace in the early '90s, when PLUTO and DIDO, the two Materials Test Reactors, went through the first two stages of decommissioning and were placed in long term C&M. Other facilities, including the Variable Energy Cyclotron, the LIDO reactor and the Chemical Engineering Building were cleared of radiological and chemotoxic hazards and demolished. Some of these buildings contained facilities that themselves had been in various forms of C&M (including virtual abandonment) for several decades.

So at Harwell, UKAEA have gained significant experience of early and delayed decommissioning, over five decades, will be keeping some facilities in C&M for four more decades and then will be continuing to operate waste storage facilities for several more decades.

Modern Safety Cases are being developed for the operating nuclear facilities at Harwell (including the reactors in C&M). Engineering Substantiation supports the deterministic element required in a safety case and is there to underpin the safety arguments. Engineering Substantiation requires attention to the detail of design or operational intent, tracks the lifecycle of the safety-related Structure, System or Component (SSC) against modern standards and compares the expectation with observation of the real situation in the operating facility. The process considers explicitly the potential for ageing and other degradation effects on the reliability of any of the plant items (SSCs) that must perform a safety function. The results are presented in Engineering Substantiation Reports (ESRs) as support files within the new Safety Cases.

The paper will present the features of the Engineering Substantiation process at Harwell and highlight the arrangements that are being put in place to establish configured sets of knowledge, including design and safety information. Forward actions, plant condition and performance constraints will be recorded as baselines for future safety reviews. The retention and maintenance of plant knowledge will ensure that future safety managers and decommissioning teams will be able to understand the condition of their facility and its sensitivity to physical, environmental and any external influences that could contribute to ageing or other degradation effects.



## Engineering Substantiation - A Tool for Managing Ageing and Other Degradation Effects

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## Engineering Substantiation - A Tool for Managing Ageing and Other Degradation Effects

- Past experience
- Future Plans
- Engineering Substantiation
  - Background
  - Definitions
  - Process
  - Structured records
  - Contribution to long term safety



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## Past Experience at Harwell (i) - Background

- Site established in 1946 as UK's Centre for Nuclear Research
- Variety of nuclear R&D facilities
- Decommissioning has always been a feature of facility renewal
- Reactors and nuclear plant mothballed or moved to other sites as well
- In '90s Decommissioning began in earnest



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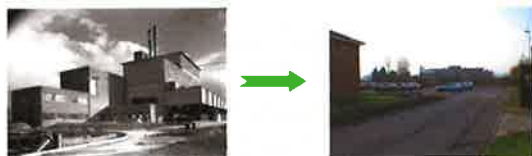
## Past Experience at Harwell (ii) - Reactor types

Reactor	Power (kWth)	Type	Start up Date	Status
GLEEP	50	Graphite	1947	sd 1990, #2 C&M
BEPO	6,500	Graphite, Air	1948	sd 1968, #2 C&M
DIMPLE	0.1	Pool	1954	sd 1960 moved to Winfrith, space reused, base concrete remains
ZEPHYR	0.0	Crit. Fast	1954	sd 1958, #3, space reused, base concrete remains
ZETR	0.0	Homog(L)	1955	sd 1957, converted to HAZEL, equipment moved to Dounreay
ZEUS	0.1	HEU core	1955	sd 1957, #3, space reused, base concrete remains
LIDO	340	Pool	1956	sd 1974, #3, green field
DIDO	25,000	Heavy Water	1956	sd 1990, #2 C&M
NEPTUNE	0.1	LWR	1957	sd 1959, moved to Derby
NERO	0.0	Graphite	1957	sd 1959, moved to Winfrith, space reused, base concrete remains
HAZEL	0.0	Homog(L)	1957	sd 1958, #3, space reused, preceding building demolished
PLUTO	25,000	Heavy Water	1957	sd 1990, #2 C&M
DAPHNE	0.1	Heavy Water	1962	sd 1967, #3, space reused, base concrete remains



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## Past Experience at Harwell (iii) - B351

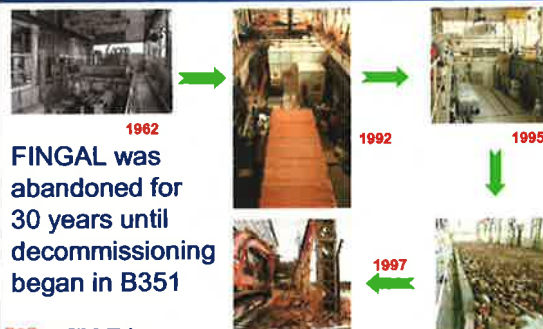


B351 operated for 40 years, took 7 years to decommission & demolish



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## Past Experience at Harwell (iv) - FINGAL

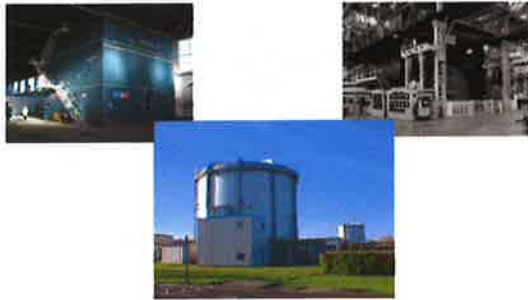


FINGAL was abandoned for 30 years until decommissioning began in B351



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## Past Experience at Harwell (iv) - 4 Research Reactors left



## Past Experience at Harwell (vi) - Lessons Learnt

- Remaining reactors safely in C&M, some already for > 30 years
- Reactor records kept by project teams and operational records in Corporate Archive
- Maintaining knowledge is a long term commitment and must be adequately funded
- Despite poor records and abandonment of old plant, have demonstrated successful decommissioning of complicated buildings

## Future Plans at Harwell

- Decommissioning well advanced, new waste facilities under construction for long term storage of ILW on site
- Delicensing ultimate objective for most of site by 2025
- All nuclear facilities to have modern Safety Cases with Engineering Substantiation
- Consolidation of site records to maintain knowledge upkeep and transfer

## Engineering Substantiation - Background (i)

### ■ Licence Conditions and the SAPs

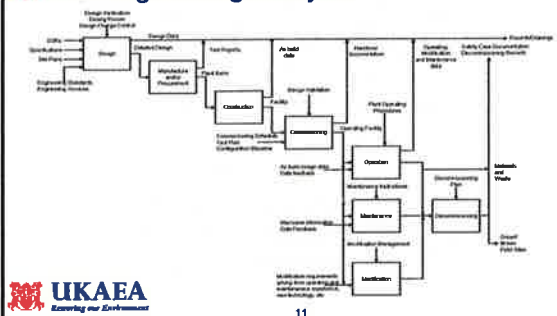
#### Licence Condition 27:

*"The Licensee shall ensure that a plant is not operated, inspected, maintained or tested unless **suitable and sufficient** safety mechanisms, devices and circuits are properly connected and in **good working order**."*

About ¾ of the SAPs are concerned with Engineering Principles

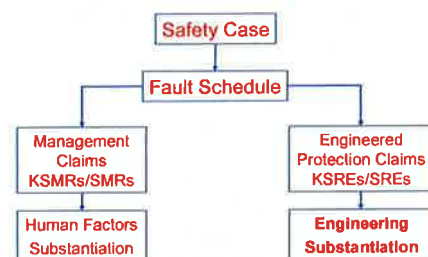
## Engineering Substantiation - Background (ii)

### ■ The Engineering Lifecycle



## Engineering Substantiation - Background (iii)

### ■ Engineering and the Safety Case



#### Engineering Substantiation - Background (iv)

- INSAG-8\* suggests deterministic methods as well as probabilistic methods should be used for in-depth safety assessment of a plant
- Licence Conditions and the Safety Assessment Principles have always stressed the need for accurate plant knowledge

\* "A Common Basis for Judging the Safety of Nuclear Power Plants Built to Earlier Standards", INSAG-8, IAEA, 1995



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#### Engineering Substantiation - Definitions (i)

- **SSCs:**  
*Structures, systems and components which perform a safety function*
- **Engineering Substantiation:**  
*The demonstration that there is adequate confidence in the ability of SSCs to deliver their required safety functions with sufficient reliability*



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#### Engineering Substantiation - Definitions (ii)

- **Engineering Substantiation Report (ESR)**  
*The means by which the Engineering Substantiation process is reported in the Safety Case.*
- **ESR**
  - is a Safety Case Support File or files
  - has well defined stages
  - involves design review and plant walkdown
  - classifies SSCs according to their failure consequence
  - considers ageing and degradation effects



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#### Engineering Substantiation - Process (i)

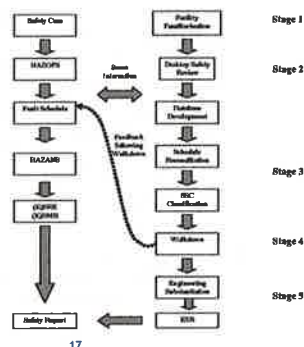
- **Typical disciplines**
  - Structural (including shielding)
  - Vessels & Pipework
  - Ventilation
  - Services
  - Mechanical Handling
  - C&I (including computing)
- **competency assessment based on IEE/BCS/HSE model**
  - Expert
  - Practitioner
  - Supervised Practitioner



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#### Engineering Substantiation - Process (ii)

##### Methodology



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#### Engineering Substantiation (iii) - Process

- **Engineering Recommendations**
  - Agreed with facility ATO Holder, Safety Case Authors and facility Safety Advisor
  - urgency of resolution prioritised
  - options suggested
  - may change as safety case updates and/or more information is forthcoming
  - identify underlying engineering weaknesses



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### Engineering Substantiation - Structured Records (i)

#### ■ Sources of existing records



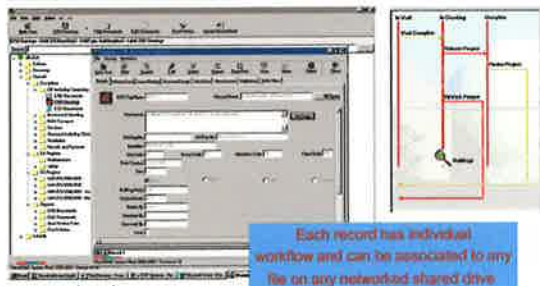
### Engineering Substantiation - Structured Records (ii)

#### ■ Engineering Substantiation Database

- variety of records sets => configured sets
- consolidates/links to all sources of records
- incorporates document management with traceable workflow
- eases future changes/modifications
- transparency to all users
- intent to collapse back to central system as facilities are decommissioned

### Engineering Substantiation - Structured Records (iii)

#### ■ Engineering Substantiation Database



### Engineering Substantiation - Contribution to Long Term Safety (i)

- Benchmarking of engineering status at fixed points in time allows design revisiting
- Can be directly linked to plant/site PSRs
- Regular professional review - trend tracking detects degradation
- Engineering Recommendations will capture need for action and identify weaknesses

### Engineering Substantiation - Contribution to Long Term Safety (ii)

- Intelligible archive and record resource tied to delicensing activities
- Consistent application of reference to modern standards
- ATO Holders and Safety managers fully involved in process

### Conclusions

- Eng Sub is an appropriate tool to capture plant degradation and review the impact on safety
- Assists normal C&M activities
- provides focused professional engineering expertise