HM Nuclear Installations Inspectorate

Report by HM Nuclear Installations Inspectorate on the results of Magnox Long Term Safety Reviews (LTSRs) and Periodic Safety Reviews (PSRs)

REPORT BY HM NII

ON THE RESULTS OF

MAGNOX LTSRs AND PSRs

SUMMARY

The assessment and publication of its findings on the Long Term Safety Reviews and the subsequent Periodic Safety Reviews of the Magnox nuclear power stations have formed a significant part of the Health and Safety Executive's Nuclear Installations Inspectorate's work programme for well over a decade. With the exception of Wylfa nuclear power station, all Magnox stations currently operated by Magnox Electric plc and British Nuclear Fuels plc have completed a second round of major safety reviews. Wylfa is the newest Magnox station and has yet to reach the date for its second major safety review.

This report outlines the regulatory basis for, and the objectives of, the safety review work undertaken. The report also summarises the extensive scope of work, including follow-up work programmes, associated with the licensees completing the Long Term Safety Reviews, Generic Issues programmes, and the Periodic Safety Reviews.

The programmes of work arising from both the licensees' safety reviews, and the Nuclear Installations Inspectorate's assessment of them have been substantially completed. The Nuclear Installations Inspectorate is satisfied that adequate safety cases exist for current operations and that the work which has still to be completed does not undermine the regulatory basis for current operation of Magnox reactors.

Real and significant plant improvements and safety case enhancements have resulted from the rigorous safety review process which has been followed. In addition, the safety reviews have provided confidence in the continued safe operation of the stations. Nevertheless, the Nuclear Installations Inspectorate continues to monitor the safety of the day to day operation of these stations, and every two to three years each reactor is subject to rigorous inspection and maintenance requirements during a statutory outage.

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1. INTRODUCTION

1.1 Purpose of the Report

1. With the completion of its assessment of the Oldbury Periodic Safety Review (PSR) and issue of the associated Press Release in March 1998, the Health and Safety Executive's (HSE) Nuclear Installations Inspectorate (NII) completed its assessment of a second round of major safety reviews for all Magnox nuclear power stations (with the exception of Wylfa which is scheduled for 2004). With the conclusion of this major programme of work, NII decided that it was opportune to review the Long Term Safety Review (LTSR) and PSR processes.

2. This report provides an explanation of the regulatory process associated with both LTSR and PSR assessment and subsequent follow-up. It also summarises the objectives and topics covered by each of the major safety reviews completed for the Magnox stations. Progress is reported on NII's follow-up requirements arising from its assessment of the LTSRs and PSRs, and summarises the safety improvements arising from the reviews. The report concludes by indicating NII's requirements for future PSRs.

3. One of NII's requirements which arose from the planned merger between Magnox Electric plc and British Nuclear Fuels plc was to review the status of relevant LTSRs and PSRs prior to any grant of licences to the revised organisation. This report will contribute to this process.

1.2 Magnox Nuclear Power Generation

4. About 27% of the United Kingdom's (UK) electricity is generated from nuclear power, a quarter of this being provided by 20 Magnox reactors operating at eight nuclear power stations. The remainder comes from 14 Advanced Gas-cooled Reactors (AGR) at seven installations and one Pressurised Water Reactor (PWR).

5. The 20 Magnox reactors currently in service were originally owned by two nuclear site licensees, namely the Central Electricity Generating Board (CEGB) (12 reactors) and British Nuclear Fuels plc (BNFL) (8 reactors). There have been several reorganisations of the nuclear industry in the UK and until recently the ex-CEGB Magnox reactors were owned by Magnox Electric plc (ME). The most recent reorganisation has resulted in the integration of the management of BNFL with that of ME. The final stage in this integration process would require nuclear site licences for the ME sites to be granted to BNFL. On 3 August 2000, Hunterston A was relicensed to BNFL.

6. The first Magnox reactor to go into operation was at Calder Hall, Cumbria, in 1956 and the last entered service at Wylfa, Anglesey, in 1971. Six Magnox reactors at Berkeley, Hunterston A and Trawsfynnyd were shut down between 1988 and 1993 by the CEGB, the South of Scotland Electricity Board (SSEB) and Nuclear Electric plc (NE) because their continued operation could not be justified. These are now being decommissioned.

7. On 1 December 1999 BNFL announced that generation at Bradwell would not continue beyond 31 March 2002. In addition, on 23 May 2000, BNFL announced a programme for the cessation of electricity generation at the eight Magnox stations. For business reasons, Hinkley Point A will not be brought back into service from its current shutdown. As a result of the programme, each of the remaining operational steel pressure vessel reactor stations (Calder Hall, Chapelcross, Dungeness A and Sizewell A) will be permanently shutdown before their next PSR is due. Table 1 lists all the UK Magnox reactors and Figure 1 shows their locations. For Chapelcross, Table 1 gives the latest date for cessation of generation as 2008 - 2009, whereas BNFL's announcement quoted 2008/2010. The difference in dates is due to the fact that the end date given in Table 1 is based on the 50 year anniversary of first power raising, whilst BNFL's is based on the date at which significant power was first produced. Continued operation beyond 2009 will be subject to an appropriate justification from the licensee.

1.3 Safety Reviews to Justify Future Operation

8. The Magnox stations were originally expected (for investment appraisal purposes) to have a minimum safe working life of about 20 to 25 years. It was recognised that their actual working lives would be dependent upon many factors such as their actual operating conditions, the results of maintenance, inspection and testing programmes, the results of safety assessments, and costs of the electricity produced. Towards the end of the 1970s the licensees indicated to NII their wish to extend the period of operation for these plants beyond their initial expectations.

9. NII's agreement to requests for extending the period of operation became dependent upon each licensee completing a safety review. This had to satisfactorily demonstrate the plant's capability to be safely operated for at least the period of further operation being requested by the licensee. These reviews became known as LTSRs and a programme for all the Magnox reactors was agreed. NII published reports of its LTSR findings for Berkeley, Bradwell, Calder Hall and Chapelcross, Hunterston A, Hinkley Point A, Dungeness A, Sizewell A, Oldbury and Wylfa over the period 1987 - 1995 (Refs 1 - 9). The licensee decided to close Trawsfynydd prior to NII completing its assessment and a decision was taken by NII to issue a news release (Ref 10) reporting the extent of its assessment of the plant's LTSR.

10. NII's assessment of the Berkeley and Bradwell LTSRs identified 12 key safety issues which were likely to apply to most, if not all, of the Magnox stations. These became known as Generic Issues. During 1988 the licensees agreed that they would prioritise their resources towards resolution of these Generic Issues on a station - by - station basis. In agreeing to this, the licensees accepted that completion of their station specific LTSRs was still necessary and that this work would continue in parallel. NII reported the outcome of the programme of work on Generic Issues in 1994 (Ref 11).

11. One of the legal requirements for operation of a nuclear power station is that each site requires a licence from HSE (delegated to the Chief Inspector of Nuclear Installations). In 1990 NII replaced the then conditions attached to each nuclear site licence with a set of standard conditions. These licence conditions included a requirement for each licensee to carry out a periodic and systematic review and reassessment of safety cases. NII agreed a programme with the licensees for the submission of PSRs for all operating nuclear power stations. In line with good international practice, it was agreed that these reviews should be carried out at ten year intervals.

12. Operation beyond the agreed expiry date of the period of extended operation justified in the LTSR has become dependent upon NII confirming its satisfaction with the outcome of the PSR. The results of NII's assessment of the PSRs for Bradwell, Hinkley Point A, Dungeness A, Calder Hall and Chapelcross, Sizewell A, and Oldbury were announced in press releases over the period October 1992 - March 1998 (Refs 12 - 18).

13. Table 2 shows the years in which NII reported the outcome of its assessment of the Magnox LTSRs, Generic Issues and PSRs, and indicates the year of the next PSR decision date for Oldbury and Wylfa. The decision date is the date on which NII decides, given the case put forward in the PSR, whether continued operation may or may not continue, with conditions if appropriate. Specific information associated with the results of these safety reviews is provided in Section 5 of this report.

2. DESIGN OF MAGNOX REACTORS

14. Although the basic design concepts and principles of operation are similar, there are considerable differences in the detailed design of each Magnox installation. This reflects the different approaches adopted by the various design and construction consortia and also the advances in reactor technology which occurred over the period.

15. All of the Magnox reactor designs, excepting Oldbury and Wylfa, incorporate a steel reactor pressure vessel (RPV) which is enclosed within a reinforced concrete biological shield. Wylfa and Oldbury represent the last phase of the Magnox programme and their designs are based upon the pre-stressed concrete pressure vessel (PCPV) concept which was later incorporated into the design of the AGRs. The PCPVs are lined with a relatively thin steel membrane and derive their strength from a complex array of pre - stressed steel tendons. The concrete within the PCPV also acts as a biological shield.

16. Each pressure vessel contains a reactor core. The core is built from graphite bricks, which acts to moderate the energy of the neutron flux in the core, and incorporates a large number (several thousand on the later designs) of vertical channels to accommodate the fuel. The fuel is uranium in the form of metal rods contained within magnesium alloy (Magnox) cans. The heat generated by the fuel is removed by a flow of pressurised carbon dioxide coolant gas which is circulated by blowers. The heated gas then passes through boilers which produce steam to drive turbo alternators. The boilers at Oldbury and Wylfa are contained within the biological shield whereas those in the steel pressure vessel reactors are located outside the biological shield and require steel ducts to carry the coolant gas to and from the boilers.

17. Figure 2 represents a cross section of a steel pressure vessel Magnox reactor showing the more important features. Figure 3 is the corresponding cross section for a concrete pressure vessel reactor. Typical main parameters of the Magnox reactors which are currently in service are given in Table 3.

3 REGULATORY PROCESS

3.1 Statutory Position

18. Safety regulation of the commercial nuclear power programme in the UK has been based on a licensing regime since the government introduced the Nuclear Installations Act, 1959 (NIA). This has subsequently been amended and is now referred to as the Nuclear Installations Act, 1965 (as Amended) (Ref 19). The NIA requires defined categories of activities to only take place on a licensed site. In 1974 the Health and Safety at Work etc. Act (HSWA) (Ref 20) was introduced which created the HSE, with responsibility for ensuring that risks to people's health and safety from work activities are properly controlled. The HSWA designates various parts of the NIA as relevant statutory provisions, and the nuclear licensing powers are vested in the HSE. HSE has delegated these licensing powers to HM Chief Inspector of Nuclear Installations who is also the Director of HSE's Nuclear Safety Directorate (NSD). The NIA gives HSE powers to attach to the licence any conditions that it deems necessary in the interests of safety and for the control of nuclear matter. Again, these powers are delegated to HM Chief Inspector of Nuclear Installations. NII therefore regulates the day-to-day safety of the UK nuclear industry.

19. The UK regulatory approach to maintaining safety at a nuclear power plant is a combination of continuing inspection and assessment, regular and special reviews and periodic safety evaluation such as the PSRs. These arrangements are summarised in Reference 21. The nuclear licensing regime is based upon a non-prescriptive, goal-setting approach which places duties on the licensees through the application of 36 standard conditions which are attached to each nuclear site licence (Ref 22). Licence Condition 15 addresses PSRs and requires the licensee to make and implement adequate arrangements for the periodic and systematic review and reassessment of safety cases. The purpose of this licence condition is to ensure that the licensee, at regular intervals and as necessary, reassesses safety cases to demonstrate that the safety of any operation that may affect safety and the identified conditions and limits in the interest of safety, are adequate and will remain so at least until the next review. This is subject to continuing satisfactory results from NII's routine regulatory inspection and monitoring arrangements.

20. The arrangements require that a PSR is carried out at least once every ten years. There may be circumstances under which NII or the licensee may opt for a periodicity of less than ten years. Examples are cases where a safety case cannot be realistically cleared for ten years because particular ageing mechanisms need more frequent review, cases where operational experience or significant changes in standards indicate that an earlier review may be prudent, or cases where a significant change in operation occurs, e.g. decommissioning. It is important to note that the licensee's PSRs and NII's assessment of them, are over and above the process of continuous review and regulation carried out by NII under the site licence; in particular, the assessment of the licensees' inspection and maintenance activities carried out as part of the statutory outage of each reactor undertaken every two to three years.

21. A central principle which underpins HSE's approach to regulation of safety is derived from the HSWA which requires the safety of workers and the reduction of risk to the public to be ensured "so far as is reasonably practicable" (SFAIRP). The application of this principle to the assessment of nuclear power plants is described in HSE's document "The Tolerability of Risk From Nuclear Power Stations" (TOR) (Ref 23). This sets out a framework for risk management and defines the concept of "as low as reasonably practicable" (ALARP); this is similar to SFAIRP and in most practical applications there is no significant difference. This document has recently been amplified by HSE's discussion document entitled "Reducing Risks Protecting People" (Ref 24)

22. The broad principles stated in the TOR document have been expanded within NII's assessment reference "Safety Assessment Principles for Nuclear Plants" (SAPs) (Ref 25). The SAPs are a set of safety assessment principles applicable to all nuclear plant which provide NII assessors with a framework for making judgements on licensees' safety cases. Although the SAPs are primarily intended for use on new plant, they provide a useful basis for determining the reasonable practicability of making improvements to older plants. The ALARP principle is of particular importance in such assessments with the age of the plant being an important factor to be taken into account when making judgements on the reasonable practicability of improvements.

3.2 NII's Assessment of LTSRs and PSRs

23. NII's assessment of the Magnox LTSRs and PSRs has been thorough and has involved a significant amount of time and effort that has been carried out in parallel with its inspection and assessment duties to regulate the day-to-day operation of the power stations. Project Inspectors were appointed to manage NII's LTSR and PSR assessment process, to negotiate the programme of follow-up work to be undertaken by the licensees and to progress this through to completion.

24. The format for the LTSR and PSR safety cases was not prescribed, and NII's assessment effort was focused on the areas where it required greatest assurance that an adequate justification for continued operation had been made. The safety standards applied during its assessments were those contained in the TOR and SAPs documents. NII assessments were not confined to examining paperwork. They also involved a combination of meetings with the safety case authors, and site inspections to confirm that the significant aspects of nuclear safety associated with each of the safety case reviews were understood and had been appropriately evaluated.

25. The conclusions of each NII LTSR and PSR assessment were reflected in a set of detailed follow-up requirements. These were discussed with the licensees and follow-up programmes of work to resolve the issues were agreed. The assessment findings were then reported in published reports for the LTSRs, and press releases, with technical annexes, for the PSRs (Refs 1 - 18). For the LTSRs and PSRs conducted to date, the overall conclusions were that the reactors were safe for continued operation. These conclusions were subject to continuing

satisfactory results being demonstrated from the regular test and inspection programme that underpins normal regulatory control, and satisfactory progress being maintained on the agreed programmes of follow-up work.

26. Throughout the period of the follow-up work programmes there have been regular interactions with the licensees with the aim of clearing each NII requirement. Technical progress meetings have also been routinely held between NII and the licensees to review the progress being made towards clearing these requirements. These meetings were generally held every quarter to ensure that appropriate momentum was being maintained towards meeting the agreed programme of follow-up work. Any significant problems not cleared through this forum were raised at a higher level meeting with the licensees' senior management.

27. Progress was also reviewed in the course of NII's routine inspection arrangements. For each station the adequacy of the licensees' performance has been discussed both at annual review meetings for each site and also during meetings held prior to a reactor returning to routine operation after its statutory shutdown. This integrated approach provided the means for NII to ensure progress was maintained at an appropriate rate. More importantly, the approach ensured that NII's judgements on the rate of progress towards clearing the work programmes were balanced and consistent.

28. NII's assessment of the LTSRs and PSRs concluded that some degradation processes require more regular reviews than that afforded by the 10 year PSR periodicity to reconfirm the safety case for particular components. Licensees have established common arrangements for each of its licensed sites to undertake this important work and the outcomes have been considered by NII when making regulatory decisions, such as issuing a consent for each reactor to return to routine operation after its statutory shutdown.

4. OBJECTIVES OF MAGNOX SAFETY REVIEWS

4.1 Magnox LTSRs

29. The LTSRs were the primary basis for judging the adequacy of the safety case for operation of the Magnox reactors beyond their initial investment life to 40 years at Calder Hall and Chapelcross, 33 years at Wylfa and 30 years at all the other Magnox nuclear power stations. The LTSRs also provided a basis for licensees to identify and invest in plant improvements which improve safety the most. The main objectives of the LTSRs evolved through discussions between NII and each licensee in turn and were considered and endorsed by the Health and Safety Commission's Advisory Committee on the Safety of Nuclear Installations (ACSNI) in January 1984 (Ref 26). Each licensee was required to:

i) confirm that the plant was adequately safe for continued operation;

ii) identify and evaluate any factors which might limit the safe operation of the plant in the foreseeable future;

iii) assess the plant's safety standards and practices against modern standards and introduce any improvements which were reasonably practicable.

30. For the first objective, the licensees had to consolidate their original safety cases, reflecting not only on the original safety standards, but also the engineering improvements introduced during the reactor's operational lifetime that improved safety. Such improvements may have resulted from progress in the development of safety standards, working practices and actual operating experience together with the safety assessments undertaken throughout the station's life.

31. In order to address the second objective the licensees had to examine all structures, systems and components susceptible to ageing or wear-out and to identify failure mechanisms and life limiting features.

32. With regard to the third objective, the licensee had to demonstrate why it would not be reasonable for older designs of reactor plant to meet modern engineering standards, which continue to develop over time. Compliance with such standards is not absolutely necessary from a regulatory standpoint provided that it could be demonstrated that all reasonably practicable measures to reduce the risk were being implemented. The licensees had to complete a limited probabilistic safety assessment (PSA) to reinforce engineering judgements and agree to complete a formal more detailed PSA as a requirement of any future periodic safety review. This helped to satisfy this third objective by providing a quantitative demonstration of the level of safety of the Magnox plants, which also had the benefit of a proven performance record. Despite this record, the comparison with modern standards of safety had to be completed to help identify where the balance of an old design may need reinforcement, or where back-up systems could usefully be introduced.

33. The licensees satisfied the above objectives by undertaking a substantial programme of safety case assessment, supporting analysis and where appropriate reasonably practicable modifications and improvements to the plant. They reported the outcome of this work to NII and identified the supporting references to justify the claims made in the safety case review.

34. Appendix A provides an example of the detailed headings used by a licensee to report an LTSR for a steel pressure vessel Magnox reactor.

4.2 Magnox LTSR Generic Issues

35. As a result of its early findings on the Berkeley and Bradwell LTSRs, a number of Generic Issues were identified; NII considered that major safety benefits would result at all the Magnox stations if the licensees gave priority to addressing these Generic Issues. The overall objective was to achieve these improvements without waiting for each station specific LTSR to be completed.

36. The specific objectives of the generic issues programme were:

i) to examine issues of concern identified from NII's findings on the early LTSRs in relation to their applicability to all other Magnox reactor installations;

ii) to compare existing standards of safety with modern standards and practices in the identified areas;

iii) to implement worthwhile improvements as soon as practicable to enhance safety;

iv) if appropriate following consideration of the issues, to identify and plan a follow-up programme of work.

37. In order to meet these objectives, NII required the licensees to make reasonably practicable improvements to the safety of their Magnox stations, either by carrying out modifications to plant and / or procedures, or by the introduction of programmes of work in the identified areas, except where it could be demonstrated to NII's satisfaction that a particular issue was not applicable to a particular station. Appendix B lists the topics covered by the Generic Issues and provides more detail on the issues under each topic which the licensees were required to address. For obvious reasons, many of the general headings are common to those listed for the LTSRs in Appendix A, but the additional detail shown in Appendix B makes the requirements much more specific.

4.3 Magnox PSRs

38. The LTSRs not only provided a comprehensive safety case to support operation up to 30 years (33 years for Wylfa and 40 years in the case of Calder Hall and Chapelcross) but were capable of providing a basis to demonstrate safe operation beyond that period. There were a number of detailed factors which NII expected the licensees to take into account when producing its PSRs; these were reflected in NII's summary objectives for the Magnox PSRs as:

i) to review the total current safety case for the station and extend its applicability for a further period of operation;

ii) to compare the plant and safety case against current standards and working practices, evaluate any deficiencies and implement any reasonably practicable improvements;

iii) to carry out a systematic review of age-related degradation which may limit the life of the plant and ensure that suitable monitoring and surveillance schemes are in place;

iv) to revalidate the safety case until the next PSR, subject to the outcome of intermediate inspection and reassessment which has been agreed with NII.

39. Due to the comprehensiveness of the LTSRs and the relatively short period between the publication of NII's LTSR findings and the PSR decision dates for continued operation, the Magnox PSRs concentrated on the following key safety areas:

- Reactor pressure circuit;
- Reactor internals;
- Ageing studies;
- Fault studies and PSA;
- Human factors analysis;
- Internal hazards;
- External hazards - seismic margins;
- Radioactive waste and fuel storage ponds.

40. The PSRs also had to address progress on NII's LTSR findings, including the Generic Issues, in addition to revisiting the range of topics addressed in the LTSRs. It also became apparent that with respect to some ageing mechanisms, clearance of the PSR would be on the basis that intermediate reviews would be carried out justifying further periods of operation. Typical examples are the structural integrity safety case for the steel reactor pressure vessels and graphite cores, and the results of targeted inspections such as those to check for the effects of oxidation and creep.

5. RESULTS OF MAGNOX LTSRs AND PSRs

5.1 LTSRs

41. With the exception of Trawsfynydd (see paragraph 49), NII's assessment of the LTSRs for each of the Magnox stations concluded that the reactors were adequately safe to allow their period of operation to be extended beyond their initial investment life. These judgements were based on the licensees satisfactorily completing agreed programmes of work to address the follow-up requirements which arose from NII's assessment of the LTSRs. In addition, each licensee was also expected to complete its own programme of work identified through the LTSR process. The overall conclusion assumed continued satisfactory results from intermediate inspections, for example during statutory outages, which would continue to be subject to NII's routine regulatory monitoring and control arrangements.

42. No aspect was identified at any Magnox station currently operating which caused NII to prevent continued reactor operation whilst the follow-up work was being completed. However, only limited clearance was initially given for the RPV at Hinkley Point A, (see Appendix E).

43. NII's key requirements for LTSR follow-up work were summarised in its reports (Refs 1 -9), published as shown in Table 2. With the exception of Wylfa, which was the last of the LTSRs to be carried out, the LTSRs have been fully cleared at each station. The follow-up work has either been satisfactorily completed or progress and programmes subsumed into the subsequent PSR which in some cases followed the LTSR after a relatively short period.

44. The LTSR follow-up programmes resulted in a number of plant modifications, additional inspection and safety analyses which significantly enhanced the overall safety case for continued operation of the reactors at each station. These included:

- modifications to reactor protection systems;
- provision of improved shutdown diversity;
- improvements to the electrical, instrumentation and control systems;
- improvements to the emergency feed systems;
- provision of improvements to protect against hot gas release;
- modifications to improve protection against a seismic event;
- additional programmes of inspection to allow better monitoring of the effects of ageing in several areas such as those associated with the reactor pressure circuit and reactor internals;
- completion of additional safety analyses to support the safety case for plant such as RPV, reactor internals and graphite core, mitigation against a seismic hazard, fault studies and PSA.

45. Statements on the outcome of the LTSRs for Bradwell, Calder Hall and Chapelcross, Hinkley Point A, Dungeness A, Sizewell A and Oldbury are summarised in Appendices C - H, respectively. A statement on the progress with Wylfa's LTSR follow-up work, is summarised in Appendix I.

5.2 LTSRs for Decommissioning Stations Berkeley, Hunterston A and Trawsfynydd

46. The Magnox nuclear power stations at Berkeley, Hunterston A and Trawsfynydd are now all in the process of being decommissioned under the regulation of NII. In common with the other Magnox stations, the licensees carried out a LTSR for each station and these were assessed by NII.

47. NII's report (Ref 1) on Berkeley was issued in 1988 and identified a number of hardware modifications and complex in-service inspections where a satisfactory position on the programme to complete this work would be required by March 1989. The majority of these improvements were taken forward at other Magnox stations through the LTSR Generic Issues programme. However in the case of Berkeley, the licensee decided that for economic, not safety, reasons it was no longer viable to continue to operate the reactors and 27 years of electricity generation ended on 31 March 1989. Consequently the programme of follow-up work associated with continued operation was not completed.

48. In 1989 NII reported (Ref 4) its assessment findings of the Hunterston A LTSR which concluded that the installation had, by and large, stood up well to the LTSR examination and its safety record had been good. No life limiting features which might have precluded operation up to 1994 had been identified. However the report did identify a programme of follow-up work that would need to be completed if the station was to have substantial future life. A position had been agreed which would allow operations to continue up to March 1990 but operation beyond that date required all the key requirements identified in the report to be fully resolved in order to gain NII's consent to operate up to 1994. In March 1989 the licensee announced that for economic reasons 24 years of electricity generation by Hunterston A would come to an end by March 1990. Consequently it was not necessary to complete the programme of follow-up work identified in NII's report.

49. Routine operation of the uniquely designed Trawsfynydd reactors led to its RPVs receiving more than twice the neutron dose of any other steel Magnox vessel. This impaired the materials properties of the steel by a process of irradiation embrittlement and hence the pressure vessel operating conditions needed to ensure safety margins against the onset of this brittle behaviour. One of NII's requirements for LTSR acceptance was for the licensee to provide an improved safety case for the RPV. On 20 July 1993 the licensee issued a press release to announce that the station, whose reactors had been shutdown since February 1991 pending demonstration of an improved RPV safety case, would not be restarting due to the economic penalties associated with maintaining adequate safety margins on the RPV. In November 1993 NII issued a news release (Ref 10) which summarised the progress that had been made towards resolving the key safety issues arising from its

assessment of the Trawsfynydd LTSR together with the outstanding issues. NII had concluded that, with the exception of the RPV safety case issues, clearance of all the remaining outstanding LTSR requirements for follow-up work would not have prevented NII agreeing to the reactors returning to service.

5.3 LTSR Generic Issues

50. NII reported the outcome of this very extensive programme of work in 1994 (Ref 11). The report concluded that the strategy agreed with the licensees during 1987/88 had proved to be successful and a cost effective use of resources. Many worthwhile gains in safety had been achieved well in advance of the planned date for reaching agreement on NII's requirements arising from its assessment of the individual LTSRs for each station.

51. Each Generic Issue has been addressed and, with the exception of seismicity, has now been fully cleared at each station. Completion of the generic programme of work represents a major success story and provides a good demonstration of the licensees' commitment towards completing reasonably practical plant modifications, safety analyses and inspection as part of the periodic review process. In the report, the cost of the licensees' work on the Generic Issues programme was at that time estimated to be of the order of £100 million.

52. Some of the most important safety improvements were associated with strengthening the safety case of pressure circuit components, carrying out plant modifications to improve the level of diversity in the shutdown and post trip cooling systems, and the provision of emergency indication centres to mitigate against a control room becoming untenable in an extreme accident.

53. With respect to the LTSR Generic Issue requirement for further seismic analysis, clearance of this requirement has been transferred into, and is being progressed as part of, the programmes of work being undertaken to address NII's requirements for PSR follow-up work (for Wylfa, this is the LTSR). Paragraphs 60 to 63 of this report provides a status report on this Generic Issue which considers NII's requirement for seismic analysis and associated plant modifications.

5.4 PSRs

54. The outcome of NII's assessment of the Magnox PSRs was reported through HSE news releases (Refs 12 -18) each of whose technical annexes identified the main areas requiring further follow-up work. The conclusion of NII's assessment of each Magnox PSR, with the exception of Sizewell A Reactor 2 (which required some boiler shell weld repairs - see Appendix G), was that the reactors were adequately safe to allow their continued operation beyond the PSR decision date (see Table 2). NII's agreement to continued operation was dependent upon the licensee maintaining acceptable progress on the programmes of follow-up work, as well as continued satisfactory results being demonstrated from the regular inspections and demonstrations of safety which would continue to be subject to NII's routine regulatory monitoring and control arrangements.

55. Through analyses against more modern standards, the PSR process has further improved the overall level of safety at each Magnox station above that achieved by the LTSRs, and this will be further enhanced by the completion of the programmes of follow-up work which are now substantially complete. Progress towards completion of the residual PSR follow-up work is being regularly reviewed and monitored through the arrangements summarised in paragraphs 26 and 27 of this report.

56. As the key safety issues, including the comparisons against current standards had only recently been addressed in the LTSRs, the plant modification work arising from the Magnox PSR programme was not so extensive as that associated with the original Generic Issues and LTSR programmes. NII's main findings have consequently been directed primarily towards achieving improved analytical assurance to underpin the PSR safety submissions in such areas as:

- reactor pressure circuit and foundations;
- reactor internals;
- fault studies and PSA;
- human factors;
- internal hazards - fire and hot gas and steam release;
- external hazards - seismic margins;
- radioactive waste and storage ponds.

57. In many of the areas examined by NII the licensees had been able to make a satisfactory case for operation up to 40 years (50 years for Calder Hall and Chapelcross). In other areas, such as materials properties associated with the RPV and graphite cores, it was difficult to make predictions for this length of time. For these items of plant NII concluded that the arrangements for monitoring the effects of ageing degradation and giving an early warning of any potentially unsafe conditions provided an adequate basis for safe extended operation. The NII continues to keep these aspects under review through its normal regulatory processes associated with the reactor statutory outage programmes and annual site review meetings.

58. Statements on the outcome of the PSRs for Bradwell, Calder Hall and Chapelcross, Hinkley Point A, Dungeness A, Sizewell A and Oldbury are summarised in Appendices C - H, respectively. Operation beyond 33 years for Wylfa and 40 years for Oldbury will be dependent upon a satisfactory outcome of further PSRs.

59. Although the PSR follow-up work programmes are substantially complete, all have taken somewhat longer to complete than was originally expected. It is a fact that, like all work programmes, the PSR follow-up work programmes are subject to continuous review and on occasions higher priority operational work has taken precedence, in accordance with the safety significance. In addition, some of the

analytical work has turned out to be more technically complex than first anticipated therefore leading to extended timescales. In some cases the analytical work has resulted in emergent issues which required to be addressed and resolved, thereby further extending the completion timescales. A further contributory factor to the delays in the programme was the limited resource available in some specialist areas within the licensees' organisation to produce safety submissions and also within NII to assess the submissions. Despite these delays to the completion of the PSR follow-up work programmes, NII is satisfied, through continuous monitoring and periodic enhanced assessment and inspection at statutory outages, that the safety of the stations has not been compromised.

5.5 PSR Generic Issues

5.5.1 Seismic

60. NII's report on LTSR Generic Issues (Ref 11) identified the need for further detailed seismic assessment submissions. At that time the licensees were finalising their results and predicting the plants' capability to remain safe in a 0.1g seismic event. The additional work was intended to demonstrate safe shutdown and cooling for more remote and infrequent events, i.e. a margin was required above the 0.1g level. For each station, Magnox Electric decided to demonstrate this seismic capability by considering the plants' performance using a 1 in 10,000 year seismic event as a reference level. Any reasonably practicable plant modifications that could be provided to ensure that plant required for shutdown and cooling had this capability, were identified.

61. The PSRs for all Magnox stations used more modern methodologies for seismic assessment than those used at the time of the LTSRs. This change of approach has led to the licensee having to reassess the safety case to demonstrate the seismic capability of all the safety related components, systems and structures. Greater research is now available both nationally and internationally on this topic and in the intervening period, methodologies have been developed in the UK and abroad which provide a more comprehensive study. The application of these new methodologies will enhance and benefit the present examination of this issue. In order for the stations to benefit from these improved methodologies and research, and due to the technical complexity of the issues, NII has extended the timescales for clearing the seismic requirement.

62. However, a considerable programme of analysis work has already been completed to provide better demonstration of the extent to which the Magnox stations have the capability to safely withstand a seismic event of greater magnitude than 0.1g. In addition, an extensive range of plant modifications has been carried out aimed at improving the seismic capability of the stations. Due to the fact that in some cases the modifications can only be implemented during reactor outages, NII has agreed to an extension in timescales for clearing the seismic requirement.

63. In addition, Magnox Electric undertook to complete a seismic ALARP assessment of their plant with the detailed scope of work being first established at Hinkley Point A. The ALARP assessment reviews safety related plant and

determines whether any additional reasonably practicable modifications can be undertaken to enhance seismic capability. This exercise will confirm the robustness of the seismic safety case. A programme for similar exercises at other stations has been agreed and is due for completion by the end of 2000.

5.5.2 Radioactive Waste

64. In response to NII's PSR findings (LTSR for Wylfa), the licensees have submitted improved radioactive waste safety cases for each station which show that the risk to nuclear safety is acceptably low. Since then there has been considerable dialogue with Magnox Electric on NII's generic requirement for the licensee to provide consolidated and enhanced radioactive waste safety cases which comprehensively draw together all aspects associated with the design, operation and maintenance of radioactive waste facilities and which improve the degree of engineering substantiation presented in the cases. Sizewell A is the lead station for this work and an enhanced radioactive waste safety case has been completed and submitted to NII. The safety case is currently undergoing assessment within NII.

65. NII's agreement to the production of a lead enhanced radioactive waste safety case for Sizewell A resulted in an extension to the timescale required to provide equivalent safety cases at the remaining Magnox stations. This decision was justified on the basis that the existing safety cases available at each installation showed that the risk to nuclear safety associated with plant failure was acceptably low. In addition, NII's routine regulatory arrangements for site inspection and reactor outages allow it to continue to monitor the licensee's strategy for managing radioactive waste and the operation of these plants to confirm these are satisfactory. The licensees' performance at each Magnox installation has confirmed the judgement made at the time of agreeing to the lead safety case strategy.

66. The current position on the other stations is that the licensee has submitted enhanced radioactive waste safety cases for Bradwell, Hinkley Point A, Dungeness A, Oldbury and Wylfa to NII. Similar enhanced radioactive waste safety cases for Calder Hall and Chapelcross are due to be submitted to NII in January 2001.

6 FUTURE MAGNOX PSRS

67. Within the UK nuclear industry, PSRs have now become a well established process for regulatory control aimed at providing confidence in the continued longer term safety of nuclear installations. With some nuclear power plants already having completed two reviews, considerable experience has been gained in the overall process and the lessons learned from the previous reviews can therefore be fed back into the regulatory requirements for future PSRs. The following sets out in general terms NII's proposals for future regulatory requirements for a nuclear plant undergoing a safety review. These proposals are currently under discussion with the licensees.

68. The scope should continue to cover, as a minimum, the topics reported in previous LTSRs/PSRs, with the objective of revalidating the existing total safety case to confirm that it remains adequate, or revising it as appropriate, in the light of modern standards and criteria, changes in technology and knowledge, and taking account of experience and changes since the last review; and to look forward over planned future operation for the period of the next PSR.

69. In carrying out future PSRs, a primary objective will be to identify shortfalls against modern standards and deal with them by making appropriate plant improvements or operating changes, or justify their current safety. Factors such as developments and advances and in the licensees' own safety standards, in relevant national and international nuclear safety standards, in inspection techniques, and in analytical methodologies, should be addressed.

70. Consideration of ageing processes is another important element, especially those structures, systems and components which require a robust justification in the safety case in order to demonstrate that risks from continued operation will be tolerable and reduced to as low a level as is reasonably practicable. In addition, the PSR should identify those ageing features that require attention at intervals of less than ten years, and ensure that they are addressed by appropriate interim reviews.

71. The PSR should take account, where appropriate, of the availability of a disposal route for arisings of radioactive waste, and the capability of all the on-site storage facilities to continue to perform their function well beyond the 10 year PSR period. As a guide, the PSR should demonstrate that where a disposal route is not immediately available, there is no likelihood of ageing effects which may jeopardise the safe storage of radioactive waste for up to 50 years.

72. A licensee's management arrangements for safety are subject to regulatory scrutiny under the nuclear site licence conditions and under the Management of Health and Safety at Work Regulations 1999 (Ref 27). In particular, Licence Condition 36 places regulatory requirements on licensees to control organisational changes adequately. However, with the many organisational changes which have taken place in the nuclear industry in recent years, it is important that this topic is revisited in PSRs to cover such areas as technical support capability (retention of

core competencies and abilities to be able to understand the safety cases), staffing levels and capabilities, maintenance and procurement (especially in relation to obsolescent equipment), control of contractors, and learning from experience (incidents, safety performance).

73. The timing of the PSR process should be such that the completed PSR is submitted for NII's assessment 12 months ahead of the decision date. The arrangements should ensure that all plant, analytical, procedural, or other improvements identified by the licensee during the review, are considered and implemented in a timely manner. **The intent should be to fully implement all significant nuclear safety improvements by the time of NII's decision date.**

74. The implication of this requirement is that licensees will need to start the PSR process at least three years ahead of the decision date. This is necessary in order to take advantage of planned shut downs prior to the decision date to implement those significant improvements which can only be done off-line. Licensees will also need to keep NII fully informed through the usual plant modification arrangements so that NII's Specialist Inspectors are able to accept the licensees' safety analyses for such improvements.

75. If this is not reasonably practicable (eg. complexity of the solution), then implementation may extend beyond the decision date and the plant remain operating provided that:

i) an acceptable and achievable programme of work has been identified;

ii) adequate resources are available to resolve the safety issue: and,

iii) an adequate ALARP case for any proposed interim period of operation has been made.

For improvements of lesser nuclear safety significance, which may be considered on an ALARP basis, the licensee should provide a programme for addressing each issue which ensures their timely clearance either by the PSR decision date, or in exceptional circumstances and only with NII agreement, within a maximum period of two years after the decision date.

76. In placing its requirements for further work over and above that identified by the licensee, NII will generally require such work to be completed within two years of the decision date. Exceptions include requirements relating to an agreed ongoing activity (e.g. condition monitoring) which can be incorporated into normal regulatory processes of periodic shutdown, routine site review meetings etc., and requirements that result in major plant modifications or major analytical work, which it may not be reasonably practicable to complete within the stated period.

7 CONCLUSIONS

77. The process of Magnox periodic safety review is now well established and accepted as a sound basis for licensees to demonstrate to both themselves and NII whether further extended periods of operation of a particular station can be justified in safety terms.

78. The approach is consistent with NII's licensing philosophy, which requires the licensee to undertake the safety reviews and satisfy itself as to the continuing safe operation of their plants. NII's role is to agree the scope of the reviews, assess the review and check that it meets its objectives satisfactorily, and question and challenge the adequacy of improvements proposed by the licensee.

79. Since NII started to report the outcome of its assessment of the Magnox LTSRs and subsequent PSRs, the licensees have completed significant programmes of safety case enhancement at each installation. This has been achieved through a combination of plant modifications, safety analysis, and inspection. In addition, arrangements have been established to consider regularly those aspects of a safety case where the assumptions on age degradation effects need to be routinely monitored and reviewed on a shorter cycle than every ten years.

80. The programmes of work arising from both the licensees' periodic reviews and NII's assessments have been substantially completed. NII is satisfied that the PSRs have confirmed that safety cases are adequate for continued operation. The residual work which has still to be completed has been identified and where the timescales for final clearance have had to be extended, satisfactory progress is being assured through NII's routine ongoing inspection and assessment and associated regulatory controls.

TABLE 1

MAGNOX POWER STATIONS CONSTRUCTED IN THE UK

STATION	LOCATION	LICENSEE	CURRENT OPERATING STATUS	START OF GENERATION	LATEST DATE FOR CESSATION OF GENERATION	MAXIMUM LIFETIME (years)
Calder Hall	Cumbria	BNFL	Operating	1956	2006-2008[(i)]	50
Chapelcross	Dumfrieshire	BNFL	Operating	1958	2008-2009[(i)]	50
Berkeley	Gloucestershire	Magnox Electric	Decommisioning	1962		
Bradwell	Essex	Magnox Electric	Operating	1962	2002	40
Hunterston A	Strathclyde	BNFL	Decommisioning	1964		
Hinkley Point A	Somerset	Magnox Electric	Shutdown	1965		
Trawsfynydd	Gwynedd	Magnox Electric	Decommisioning	1965		
Dungeness A	Kent	Magnox Electric	Operating	1966	2006	40
Sizewell A	Suffolk	Magnox Electric	Operating	1966	2006	40
Oldbury	South Glous.	Magnox Electric	Operating	1968	2013	45
Wylfa	Gwynedd	Magnox Electric	Operating	1971	2016-2021[(ii)]	45-50

(i) The PSR decision for Calder Hall and Chapelcross made in 1996 allowed for operation of each reactor up to a maximum of 50 years.
(ii) Wylfa is the newest of the magnox stations and the actual date for cessation of generation has yet to be finally determined.

TABLE 2

STATION SPECIFIC NII ASSESSMENTS COMPLETED AND REPORTED ON MAGNOX LTSRs & PSRs [(i)]

STATION	LTSR PUBLICATION DATE	PSR PRESS NOTICE DATE	NEXT PSR DECISION DATE
Berkeley	1988 (Ref 1)		
Bradwell	1987 (Ref 2)	1992 (Ref 12)	
Hunterston A	1989 (Ref 4)		
Hinkley Point A	1991 (Ref 5)	1995 (Ref 13)	
Calder Hall	1990 (Ref 3)	1996 (Ref 15)	
Chapelcross	1990 (Ref 3)	1996 (Ref 15)	
Trawsfynydd	1993 (Ref 10) [(ii)]		
Dungeness A	1994 (Ref 6)	1996 (Ref 14)	
Sizewell A	1995 (Ref 7)	1996 (Ref 16)	
Oldbury	1995 (Ref 8)	1998 (Ref 17)	2008
Wylfa	1995 (Ref 9)	Not Applicable	2004

(i) A report (Ref 11) was issued in 1994 on LTSR Generic Issues.
(ii) Press notification only.

TABLE 3

MAIN PARAMETERS OF OPERATING MAGNOX REACTORS

Station	Calder Hall	Chapelcross	Bradwell	Hinkley Point A	Dungeness A	Sizewell A	Oldbury on Severn	Wylfa
Year commercial operation started	1956	1958	1962	1965	1966	1966	1968	1971
Net electrical output per reactor (design) (current)	35 50	35 50	150 121	250 235	275 219	290 210	300 217	590 490
Heat output per reactor MW (design) (current)	180 265	180 265	538 500	966 950	840 775	948 800	892 815	1875 1750
Gas inlet temperature oC Gas outlet temperature oC (design) (current)	160 336 345	160 336 345	175 390 360	180 374 370	224 410 371	220 410 360	220 412 365	230 402 360
Pressure vessel: vessel height m vessel diameter m working pressure bar gauge construction	 21.3 11.3 6.9 Steel	 21.3 11.3 6.9 Steel	 20.4 Sphere 9.1 Steel	 20.4 Sphere 12.8 Steel	 19.05 Sphere 18.5 Steel	 19.4 Sphere 19.35 Steel	 18.3 23.5 (77) 24.8 Concrete	 29.3 Sphere 27 Concrete
Core: diameter of active core m height of active core m weight tonne lattice pitch mm	 11 8.2 1140 203	 11 8.2 1140 203	 12.2 7.80 1961 203	 14.9 7.6 1891 196.9	 13.7 7.39 2160 196.9	 13.7 7.93 2237 196.9	 12.8 8.5 2061 196.9	 17.4 9.2 3740 196.9
Fuel: weight tonnes elements per channel number of channels	 110 6/5 1696	 110 6/5 1696	 234 8 2581	 352 8 4500	 305 7 3932	 321 8 3784	 292 8 3308	 595 8 6156
Circulators: number of circulators circulator power (kW) type	 4 2000 Centrifugal	 4 2000 Centrifugal	 6 2462 Axial	 6 5000 Axial	 4 5220 Axial	 4 7348 Axial	 4 5220 Axial	 4 14174 Axial
Boilers: number of boilers HP steam bar LP steam bar	 4 17 4.1	 4 17 4.1	 6 41 12	 6 44 12	 4 68 24	 4 37 16	 - 68 25	 - 38 -

APPENDIX A - LTSR REPORTING TOPICS

REACTOR PRESSURE CIRCUIT

Reactor Pressure Vessel
Gas Ducts
Boilers
Standpipes

REACTOR INTERNALS

Graphite
Core Restraint
Core Support
Other Reactor Internals
Duct Internals
Boiler Internals

EXTERNAL HAZARDS

Aircraft Impact
Hazardous Materials
Off Site Flooding
Seismic Activity
Wind Loading
Extreme Ambient Conditions

INTERNAL HAZARDS

Fire
On Site Flooding
Traffic Accidents
Dropped Loads
Missiles
Hot Gas Release
Steam Release

PROTECTION SYSTEMS

Safety Circuits
Control Rod Systems
Secondary and Tertiary Feed
Presentation of Information
Instrumentation and Control
Electrical Systems

COOLING SYSTEMS

Primary Coolant System
Secondary Coolant System

FAULT STUDIES

Introduction
Symmetric Faults
Asymmetric Faults
Long Term Graphite Transient
Secondary Coolant Faults
PSA

FUEL HANDLING

Fuel Handling
Lifting Equipment

OTHER TOPICS

Operating Rules
Role of the Operator
Health Physics
Radioactive Waste
Ageing
Decommissioning
Summary Paper

APPENDIX B - LIST OF MAGNOX LTSR GENERIC ISSUES

1. Reactor pressure circuit safety case

(a) Consider the reasonable practicability of extending in-service volumetric examination to the pressure vessel welds and ductwork features within the biological shield.

(b) Confirm that defects which could have survived the original proof-pressure test could not propagate to failure within the projected lifetime of the station.

(c) Confirm the adequacy of the leak-before-break case for the pressure circuit and show that procedures and equipment are available to detect sub-critical defects before they could propagate to failure.

(d) Confirm that the material properties during the projected lifetime are adequate for all operating conditions, particularly for start-up and shutdown and for conditions arising when circuits are taken into and out of service while the plant is on-load.

(e) Confirm adequate operating rules are in place to meet the conditions described in (d).

(f) Confirm the extent to which the pressure circuit can withstand boiler tube failures.

2. Biological shield

The capability of the biological shield to withstand the pressure loading arising from duct failure should be demonstrated. In particular the demonstration should show that the function of circuits next to affected ducts is not impaired.

3. Shutdown systems

(a) Confirm the extent to which the overall performance of the shutdown systems complies with modern standards and introduce any reasonably practicable improvements.

(b) A diverse means of shutting down the reactor separate from the control rod system should be installed and must be capable of initiation from the central control room.

4. Post-trip cooling

(a) A diverse means of supplying post-trip cooling water to the boilers should be installed and should, as far as reasonably practicable, meet modern standards.

(b) The capability of natural circulation to cool the reactor following a trip from the most adverse operating conditions for post-trip cooling requirements should be demonstrated.

5. Fire hazard

Consider whether any improvements to fire zoning and equipment are available and confirm the extent to which the installed system complies with modern standards.

6. Resistance to earthquakes

Demonstrate what level of earthquake the plant can withstand without sustaining unacceptable damage.

7. Operator action following faults

(a) The role of the operator under major fault conditions should be considered.

(b) Any actions required by the operator within particular time periods to limit the effects of faults should be shown to be practicable.

8. Reactor control room

Consider the reasonable practicability of providing an alternative emergency indication centre.

9. Ageing

(a) Produce a systematic programme for the examination and monitoring of plant and components for the effects of ageing.

(b) Confirm that no component important to safety will limit the safe operational life to less than the projected life of the station.

10. Reactor refuelling machines

Undertake volumetric non-destructive testing of those parts of the refuelling machine pressure vessel components where access is reasonably practicable.

11. Cranes

Confirm that cranes do not pose an unacceptable risk to plant safety.

12. Radiological protection

(a) Provide a comparison of radiation doses to operators with NII's safety assessment reference levels and make any reasonably practicable improvements if they are not met.

(b) Confirm that direct radiation doses to members of the public comply with the most recent recommendations of the ICRP.

(c) If occupancy factors are claimed in (b), demonstrate by habit surveys that these are soundly based.

(d) Where doses from direct radiation to members of the public are in excess of NII's safety assessment reference levels, consider and introduce any reasonably practicable improvements.

APPENDIX C - BRADWELL

LTSR

1. NII's requirements for the licensee to undertake more work to support operations up to at least 1992 consisted of 17 key requirements grouped under three main headings: reactor pressure circuit integrity, effects of ageing and in-service wear, and the application of modern standards. Subsequent to the publication of the report (Ref 2), the requirement associated with demonstrating the level of earthquake which the plant can withstand without sustaining unacceptable damage became a Generic Issue. It was therefore decided to clear this LTSR requirement on the basis that it would be addressed through the Generic Issues programme of follow-up work which would ensure consistency of approach across all Magnox stations. All of the remaining key requirements have been addressed by the licensee and cleared by NII. The licensee has also completed a programme of work to address its own recommendations made in the LTSR.

2. The safety case for operating Bradwell was significantly strengthened by the completion of plant modifications such as the provision of improved shutdown diversity and additional emergency feed systems, and by completing additional analyses to demonstrate, for example, the effectiveness and reliability of natural circulation to meet the requirements of pressurised post-trip cooling.

PSR

3. In 1992 NII reported (Ref 12) that it had issued consents which allowed both Bradwell reactors to restart and operate beyond 30 years. NII identified 48 requirements for follow-up work in support of its decision to allow operation beyond 30 years and these were subdivided into three categories namely, 9 major, 17 key and 21 minor. The 'major' requirements were completed before the restart of the reactors but the 'key' and 'minor' ones were not specifically required to be cleared prior to the restart. A final requirement was for the licensee to complete its own programme of modifications, studies, and inspections identified in the PSR. All of NII’s follow-up work and the licensee’s own PSR work programme has now been satisfactorily completed and all of the PSR requirements have been fully cleared.

4. The main safety enhancements arising from the PSR and its follow-up programme were achieved within two years of NII's agreement being given to continued operation. In a small number of areas, final NII clearance of the licensee's PSR follow-up work programme took longer than first anticipated. However the extended timescale has not affected basic operational safety and has, in general, been caused by the complexity of some of the work and by unforeseen difficulties associated with completing this programme of ALARP related work.

5. Examples of the main improvements arising from the PSR at Bradwell have been additional pressure circuit inspections, provision of diverse reactor shutdown protection systems, improvements to the electrical back-up system, and improved safety analysis in a variety of areas such as graphite cores, fault study and reliability studies.

6. Preparatory work has been carried out on the scope for the next PSR at Bradwell to justify operation beyond 40 years and potentially up to 50 years operation. However, in December 1999 Magnox Electric announced that due to economic considerations, generation at Bradwell would not continue beyond 31 March 2002. Work on preparing this further PSR has therefore ceased.

APPENDIX D - CALDER HALL & CHAPELCROSS

LTSR

1. The LTSR of Calder Hall and Chapelcross was conducted in two phases over a number of years. NII's assessment of the first phase of the review resulted in recommendations additional to those of BNFL for further analysis, additional inspections and modifications to some systems. The recommendations included a requirement for a further review when the oldest of BNFL's reactors had operated for 30 years. The two reviews together constitute BNFL's LTSR for the two stations which had the objective of justifying operation of the reactors until they are 40 years old.

2. NII's key requirements for LTSR follow-up work to support continued operation of the reactors were summarised in its published report (Ref 3). The report also summarised BNFL's progress towards clearing each of the LTSR Generic Issues. Although not unique to Calder Hall and Chapelcross, the report highlighted a number of improvements to plant and systems which had been generated by BNFL's own arrangements. The improvements were contained in 19 key requirements which overlaid a more detailed set of 65 recommendations which had previously been issued to BNFL following the first phase of the LTSR. These two sets of NII requirements were incorporated into BNFL's own programme of follow-up work which had already led BNFL to introduce improvements to its plants and systems to reflect the Company's own experience of developments in safety standards, working practices and plant operations.

3. All of NII's follow-up work and the licensees own work programme has been satisfactorily completed and all of the LTSR requirements have been fully cleared Typical examples of plant modifications and safety analyses arising from the LTSR process are: improvements in understanding of RPV materials properties; inspection / review of performance of important plant such as the RPVs, control rods and graphite cores; and plant modifications to reactor protection systems by the provision of additional trips, and segregation of some cables and relays in the diverse guardlines. In addition, many improvements to safety related plant and equipment were carried out at each station in order to withstand a seismic event greater than 0.1g.

PSR

4. NII's general satisfaction with the outcome to its assessment of the Calder Hall and Chapelcross PSR was reported in July 1996 (Ref 15). BNFL has provided responses to each of NII's 35 requirements for follow-up work and in general met the target dates or been able to provide reasonable justification for any programme slippage. There is a small amount of work to be completed on two requirements which have yet to be cleared, neither of which affects basic operational safety.

5. One of the two requirements which have yet to be cleared concerns radioactive waste safety cases and is a generic issue for which NII has accepted extended timescales as explained in paragraphs 64 to 66 of this report. BNFL has been requested to provide improved safety cases for its radioactive waste facilities at both stations by January 2001.

6. The other requirement not yet fully completed relates to Probabilistic Safety Assessment (PSA). A large amount of work on PSA has already been carried out in response to this requirement which has provided the additional confidence that NII sought for the continued operation of the reactors. The time required to fully complete this requirement has been longer than originally anticipated due to the licensee's higher priority operational issues taking precedence, in line with the safety significance. Final NII clearance of the requirement is now limited to three specific items. These relate to analysis of post trip cooling issues, analysis of permitted plant outage restrictions, and resolution of various PSA issues raised by NII. Clearance of these is dependent upon NII completing its assessment of the responses to the items provided by the licensee.

7. The PSR has further strengthened BNFL's annual arrangements for plant safety case reviews, particularly in those areas most susceptible to ageing degradation such as the RPVs and graphite cores. Analysis work to date has included a demonstration that the reactor core is able to withstand a seismic event greater than 0.1g. Significant plant modifications have also been undertaken such as those associated with fire protection and seismic capability of the top duct bridges which form supports for parts of the pressure circuit on each reactor. The PSR also resulted in the production of summary safety cases which will be routinely updated in the event of revisions occurring during the next period of extended operation.

APPENDIX E - HINKLEY POINT A

LTSR

1. NII's assessment of the Hinkley Point A LTSR gave initial clearance for operation up to the end of 1991 (Ref 5). Operation beyond this date was dependent upon Nuclear Electric, the licensee at the time, meeting an agreed programme of follow-up work of which the overriding requirement was to provide further evaluation of the RPV weld material data during 1991. Nuclear Electric made sufficient progress towards clearing NII's key requirements and the reactors were allowed to operate beyond 1991.

2. NII's assessment identified that the condition of the RPV weld metal required special attention but was satisfied that adequate arrangements were in place to allow monitoring of the effects of ageing degradation and for providing early warning of any potentially unsafe conditions.

3. NII's assessment of the LTSR identified 49 key requirements for the licensee to undertake further work to support continued operation of the reactors beyond 30 years. NII's assessment also summarised Nuclear Electric's progress towards clearing each of the LTSR Generic Issues and where the work was incomplete, made cross reference to the relevant NII key requirement. All of NII's key requirements for LTSR follow-up work were cleared. In addition, all of the Generic Issues were satisfactorily addressed. Although the requirement for seismic capability originated as a LTSR Generic Issue, its clearance was transferred to the PSR requirement whose current status is reported on below.

4. As well as providing significant improvement to the RPV safety case, the LTSR resulted in plant improvements such as enhancement of the essential electrical supplies system, fire protection, diverse safety line, and tertiary feed system. Additional programmes of inspection were also developed as a result of the LTSR which allowed better monitoring of the effects of ageing, such as that arising from oxidation. A large amount of further analysis to support the safety case for continued operation was also undertaken. A particular example is the additional inspection and analysis carried out to provide an enhanced safety case which took account of standpipe thinning/distortion.

PSR

5. NII reported a satisfactory outcome to its assessment of the Hinkley Point A PSR in April 1995 (Ref 13). All of NII's 20 requirements for further work have been addressed and only the seismic requirement remains to be fully cleared. The seismic requirement is a generic issue for which NII has accepted extended timescales as explained in paragraphs 60 to 63 of this report. At Hinkley Point A, the remaining seismic issue is completion of the ALARP review.

6. The PSR at Hinkley Point A further improved the overall safety case of the station, particularly with respect to the development of fault studies, PSA and the role of the operator. The follow-up programmes of work resulted in:

- improvements to the planned inspection programmes to further monitor ageing degradation and take advantage of improved capabilities that have become available;

- provision of additional safety analysis such as in support of the reactor internals, boiler shells and hot gas release;

- the implementation of plant modifications such as improving the emergency lighting, providing improved mimics and additional alarms in the main control room and completion of the licensee's own programme of PSR follow-up work.

7. Both reactors at Hinkley Point A were shutdown in April 1999 to carry out reinforcement of the boiler tube supports. Following completion of this work, Reactor 2 was returned to service in September. This and other work was completed on Reactor 1 in December 1999. However, since 3 December 1999, both reactors have remained shutdown because of newly identified uncertainties in the RPV material properties which undermined the safety case for operation. In March 2000, the licensee provided NII with a revised RPV safety case to demonstrate how the safety margins could be restored to their previous levels. NII assessment of the case identified some issues requiring additional assurance prior to allowing either reactor to re-start. In the licensee's view this would have required considerable expenditure on additional work to provide further justification and / or inspection. On 23 May 2000, the licensee announced that for business reasons, Hinkley Point A would not be brought back into service from its current outage. As a result, both reactors are now permanently shutdown and preparatory work is in hand to carry out defuelling and decommissioning.

APPENDIX F - DUNGENESS A

LTSR

1. The NII LTSR findings report (Ref 6) highlighted the most significant aspects requiring work to further justify its conclusion that it expected the station to be able to operate safely until each reactor was at least 30 years old. It also gave a summary of ongoing work areas and reflected the successful outcome to work undertaken to address the LTSR Generic Issues. All of NII's 43 key requirements for LTSR follow-up work have been addressed and cleared. Due to the relatively short period between publication of the LTSR report and the PSR decision date, final clearance of a small number of requirements was carried over into the PSR.

2. The work completed as a result of the LTSR process included; modifications to improve the electrical supplies at the station, the introduction of more modern instrumentation to avoid problems of obsolescence or ageing, the introduction of additional inspection requirements such as those associated with the reactor pressure circuit, and completion of additional analysis in support of safety cases for plant such as the RPV, graphite core, reactor protection systems, mitigation against hazards and steel reactor internal components.

PSR

3. NII reported (Ref 14) in May 1996 that it had completed its assessment of the Dungeness A PSR and concluded that the reactors were adequately safe to allow their continued operation beyond 30 years. All the 21 PSR requirements for additional work have been addressed and in general, Magnox Electric has either met its original target dates for providing a response, or has been able to justify any programme slippage. There remain two requirements where the programme is not yet complete. The timescales to address these requirements have been extended because the work associated with their completion was more extensive than originally expected and they became linked to a generic approach across all Magnox Electric stations.

4. The first requires Magnox Electric to provide an improved safety case for the radioactive waste facilities on the station. The reason for the extended timescales for clearance of this requirement is explained in paragraphs 64 to 66 of this report. An associated generic issue is the provision of improved safety cases for the irradiated fuel storage ponds. For Dungeness A, an improved ponds safety case has been submitted to NII and assessed and found to be generally acceptable. There remains a minor technical civil engineering issue relating to the fuel transport crane support structure which requires final resolution. The second generic issue is the seismic requirement for which NII has accepted extended timescales as explained in paragraphs 60 to 63 of this report. Due to emergent problems discovered during routine civil inspections, further seismic analytical and strengthening work associated with parts of the civil structures has been necessary and remains to be completed.

5. Completion of the Dungeness A PSR and programme of follow-up work has resulted in:

- the completion of further plant modifications which included improvements to the station's alarms and carbon dioxide supply system, and seismic strengthening of essential plant;

- additional inspections such as those associated with civil structures and ageing mechanisms;

- providing improvements associated with the role of the operator in normal and emergency situations;

- completion of further analyses to support some parts of the overall safety case such as reactor internals, hot gas release and seismicity.

APPENDIX G - SIZEWELL A

LTSR

1. NII's findings report (Ref 7) highlighted 45 key requirements for further work which were associated with reinforcing the safety case presented in the LTSR. The report also reflected the significant amount of work that had been completed in response to NII's LTSR generic issue requirements. All of NII's 45 key requirements have been addressed and cleared. However, the requirements for seismicity, hot gas release, irradiated fuel storage ponds and radioactive waste were transferred to the PSR programme. This was due to the relatively short period between publication of the LTSR report and the PSR decision date, the extensive nature of the work programmes, and because the work being undertaken was linked to generic programmes of work designed to ensure consistency at all Magnox stations.

2. Typical examples of work, other than that to address the Generic Issues, that has been completed as a result of the LTSR process are structural modifications to improve protection against hazards such as hot gas release, additional safety analyses on for example fault studies, PSA and reactor internals, and further inspection in support of the safety case.

Sizewell A PSR

3. The result of NII's assessment of the Sizewell A PSR was announced (Ref 16) in September 1996. NII concluded that the safety of Reactor 1 (R1) was satisfactory for continued operation. Initially this operation was subject to certain restrictions until NII was satisfied with the outcome of further inspections to support the hot gas release safety case. This assurance was provided by the end of 1996 and the reactor returned to routine operation in February 1997. In addition, NII concluded that further operation of Reactor 2 (R2) was dependent upon Magnox Electric satisfactorily resolving issues associated with weld defects that had been found by PSR inspections in three of the R2 boiler shells.

4. Both reactors had been shut down to carry out PSR related inspections between December 1995 and August 1996. Although R1 was allowed to return to power, R2 remained shut down whilst Magnox Electric developed a repair programme for the defective boiler welds. NII agreed to Magnox Electric’s proposals for the development and implementation of repairs to the R2 boiler shells to modern accepted nuclear design code standards, and actual repair work on the defective welds commenced on site in Summer 1998. The adequacy of the repairs was confirmed by an extensive programme of surface and volumetric inspection. In addition, a large programme of materials property testing, including samples extracted from areas local to the repaired regions, was undertaken.

5. Following successful completion of the repair programme of the defective boiler shell welds, NII announced (Ref 17) in March 1999 that it was allowing the start-up of R2. The decision to agree to start-up of R2 was not only dependent upon a successful outcome to the weld repair programme, but also required demonstration that sufficient progress had been made, for the station as a whole, towards clearing all the PSR follow-up requirements identified in 1996. In addition, NII's acceptance of the continued operation of both R1 and R2, potentially up to the age of 40 years, is subject to satisfactory completion, by Magnox Electric plc, of the outstanding PSR follow-up work which will further enhance the safety of the station, and to continuing satisfactory results from the routine test and inspection programme that underpins the normal regulatory control of the station.

6. Magnox Electric has addressed all of NII's 30 requirements for PSR follow-up work and there are only two which are not fully complete. These are generic issues for which NII has accepted extended timescales. The first requires Magnox Electric to provide an improved safety case for the radioactive waste facilities on the station. The reason for the extended timescales for clearance of this requirement is explained in paragraphs 64 to 66 of this report. The second generic issue is the seismic requirement and an explanation for the extended work programme is provided in paragraphs 60 to 63 of this report. At Sizewell A, the remaining seismic work is the fitting of seismic restraints to some of the essential batteries which is scheduled for the next reactor outage, and completion of the ALARP review.

7. The Sizewell A PSR has further reinforced the safety case for the station. A particularly large programme of modification and analysis has already been completed to reinforce the safety cases for hot gas release, fire protection, on-site flooding and oxidation in some above core structures. The PSR has also led to a large amount of additional analysis being undertaken which included RPV foundations, PSA and operator interactions, along with a large programme of additional inspection on components subject to ageing degradation.

APPENDIX H - OLDBURY

LTSR

1. NII's 32 key requirements for follow-up work were summarised in its findings report (Ref 8) and, with the exception of a small number of items, have all been completed by Magnox Electric to NII's satisfaction. The incomplete topic areas were carried forward into the programme of PSR work whose current status is reported below. This decision reflected the short period between the LTSR and the PSR and the fact that the safety issues associated with their clearance were not sufficiently significant to prevent continued reactor operation beyond NII's PSR decision date.

2. Significant safety enhancements brought about by the LTSR process include plant modifications such as the installation of articulated control rods and improvements to the electrical systems. In addition, safety analysis has enabled the objectives of the LTSR to be met by providing more robust demonstration of safety case arguments: these have included the PCPV and pressure circuit. Finally additional inspections have been completed to reinforce major areas of the safety case such as reactor internals.

PSR

3. The Oldbury PSR was the last in the present series of Magnox PSRs to be carried out and the outcome to NII's assessment of it was announced (Ref 18) in April 1998. As a result of the timing there is a larger amount of outstanding PSR follow-up work than at the other Magnox stations. A substantial amount of work has already been carried out and the vast majority of the programme of follow-up work is expected to be complete well before the end of 2000. Progress towards completion is being regularly reviewed and monitored through the arrangements summarised in paragraphs 26 and 27 of this report.

4. Of NII’s 19 PSR follow-up findings, 12 have so far been cleared. Of the remaining seven findings, two are generic for which NII has accepted extended timescales. The first requires Magnox Electric to provide an improved safety case for the radioactive waste facilities on the station. The reason for the extended timescales for clearance of this requirement is explained in paragraphs 64 to 66 of this report. The second generic issue is the seismic requirement and an explanation for the extended work programme is provided in paragraphs 60 to 63 of this report. At Oldbury, the seismic analysis and modification work has progressed very well and a substantial amount of work has already been completed. Seismic work that remains to be completed is the ALARP review, modifications to the fuel storage pond structure, strengthening of some masonry walls, and the erection of a new building to house the gas turbine batteries.

5. The current position on the other five remaining findings is:

(i) IOF Components

The pressure circuit has a number of steel penetrations that are classed as Incredibility of Failure (IOF) components. Magnox Electric has submitted to

NII the technical safety case for the IOF components, however, the safety case still awaits clearance from the licensee's independent assessment process. Due to other higher priority operational demands the independent assessment has been delayed and completion is now expected later in 2000.

(ii) Inspection of Boiler Loading Slot

Inspection of the boiler loading slot closure weld is a difficult task due to problems of gaining access to a reasonable proportion of the weld length. The licensee has submitted a report to NII which concludes that although the existing IOF safety case is multi-legged and robust, options for inspection and providing a more robust safety case have been investigated. The licensee is to carry out further work to determine the feasibility of providing an improved safety case, which may include consequence arguments, and of inspecting the welds during future reactor outages.

(iii) Core Support

The licensee was required to provide an improved safety case for the structural integrity of the core support under off-load conditions. The licensee has submitted reports to NII on the quality of construction and on the degree of redundancy in the core support structure. NII's assessment of these reports has identified a number of significant issues which are currently being discussed with the licensee.

(iv) Magnox's Own PSR Work Programme

Arising from their PSR, Magnox Electric identified a number of necessary assessments, engineering work, amendments to procedures and additional inspections. Progress on this programme of work is proceeding satisfactorily. Some of the remaining work has to be done during reactor outages and therefore completion of it will extend to the next station outage in 2001.

(v) Hot Gas Release

A safety case for hot gas and steam release has been submitted to NII and is presently undergoing assessment within NII. Some issues have been raised with the licensee and discussion on their resolution is progressing.

6. Examples of the significant safety benefits from the PSR and its associated follow-up programme to date include:

- improved analysis in support of the safety cases for the pressure circuit, reactor internals, fault studies, PSA, and human factors;
- completion of seismic modifications and modifications to the boiler feed water system for improved post-trip cooling of the reactors;
- additional inspections associated with ageing mechanisms e.g. graphite core inspections.

APPENDIX I - WYLFA

LTSR

1. Wylfa's was the last of the LTSRs carried out for the Magnox stations, and NII's requirements for further work were identified in its findings report published in 1995 (Ref 9). All of NII's 30 LTSR further work requirements have been addressed and three remain to be fully cleared. A substantial amount of work has already been carried out, and with the exception of seismic modifications, the balance of work outstanding is very limited. Progress towards full completion is being regularly reviewed and monitored through the arrangements summarised in paragraphs 26 and 27 of this report.

2. Of the remaining three requirements, two are generic for which NII has accepted extended timescales. The first requires Magnox Electric to provide an improved safety case for the radioactive waste facilities on the station. The reason for the extended timescales for clearance of this requirement is explained in paragraphs 64 to 66 of this report. The second generic issue is the seismic requirement and an explanation for the extended work programme is provided in paragraphs 60 to 63 of this report. Although presently at the LTSR stage (the PSR is not due until September 2003), the seismic work at Wylfa has been carried out to the methodologies and standards adopted for the PSRs. In addition to the generic seismic ALARP review, a considerable programme of modification work has arisen from the licensee's seismic analyses. The work is being managed at Wylfa by a dedicated project team and NII is satisfied that adequate arrangements have been introduced by the Station to manage this seismic implementation programme which is expected to continue into 2003.

3. The other remaining requirement relates to fuel handling. NII had requested that more comprehensive information be presented in a summary safety case for Wylfa's dry stores. The aim of this summary document is to draw together the various features of the engineering safety case and associated operating and maintenance regime. The safety case has been submitted to NII, and is presently undergoing assessment by NII's Specialist Inspectors.

4. The LTSR process at Wylfa has resulted in a significant programme of work being undertaken by the licensee and led to improvements through plant modifications such as the installation of articulated control rods, the reinforcement of the electrical system and improvements to the tertiary feed pipework. Additional programmes of inspection have also been introduced on items such as the steam drums, and further safety analyses have been completed on a variety of topics such as reactor internals, PSA and the reactor pressure boundary.

PSR

5. Wylfa is the newest of the Magnox generation of nuclear power stations and as such its PSR has yet to be carried out. The PSR decision date is September 2004, with the PSR safety documentation due to be submitted to NII by September 2003.

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GLOSSARY

ACSNI	Advisory Committee on the Safety of Nuclear Installations
AGR	Advanced Gas Cooled Reactor
ALARP	As Low As Reasonably Practicable
BNFL	British Nuclear Fuels plc
CEGB	Central Electricity Generating Board
HSE	Health and Safety Executive
HSWA	Health and Safety at Work etc Act 1974
ICRP	International Commission on Radiological Protection
INSA	Independent Nuclear Safety Assessment
IOF	Incredibility Of Failure
LER	Life Extension Review
LTSR	Long Term Safety Reviews
ME	Magnox Electric plc
NE	Nuclear Electric plc
NIA	Nuclear Installations Act 1965
NII	Nuclear Installations Inspectorate
NSD	Nuclear Safety Directorate
PSA	Probabilistic Safety Assessment
PCPV	Pre-stressed Concrete Pressure Vessel
PSR	Periodic Safety Reviews
PWR	Pressurised Water Reactor
RPCW	Reactor Plant Cooling Water
RPV	Reactor Pressure Vessel
R1 (2)	Reactor 1 (2)
SAPs	Safety Assessment Principles
SFAIRP	So Far As Is Reasonably Practicable
SSEB	South of Scotland Electricity Board
TOR	Tolerability of Risk
UK	United Kingdom

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