Office for Nuclear Regulation

Sizewell B Periodic Shutdown 2021 (Refuelling Outage 17)

Consent to Start-Up the Reactor Under Licence Condition 30(3)

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EXECUTIVE SUMMARY

Consent to Start-Up the Reactor Under Licence Condition 30(3)

Permission Requested

EDF Energy Nuclear Generation Limited (NGL), the holder of nuclear site license number 63 for Sizewell B power station, has requested that the we grant consent to start-up the reactor following its periodic shutdown, as required by licence condition 30(3) of said nuclear site license.

Background

Sizewell B's operating cycle lasts approximately 18 months, after which it is required to shut down so that it can be refuelled. When refuelling is undertaken, some of the fuel assemblies (around one-third) are replaced with new ones. The existing fuel assemblies are returned to the core in a rearranged array to ensure optimum fuel utilisation.

To continue to operate safely and reliably the reactor plant requires regular examination, inspection, maintenance and testing (EIMT). The specific requirements for EIMT are captured in the plant maintenance schedule, made under LC 28 (at Sizewell B, this terminology is not used, and the licensee instead refers to "surveillance programmes" which satisfy the same requirements). Continuous improvement also requires plant upgrades to be implemented where deemed to be reasonably practicable. Whilst some of these activities can safely take place when the reactor is operating at power, many of them require the reactor to be shut down. The refuelling outages at Sizewell B provide the opportunity for undertaking such activities.

The requirement to shut down periodically for the purposes of EIMT is captured in LC 30. LC 30(1) states that "when necessary for the purpose of enabling any examination, inspection, maintenance or testing of any plant or process to take place, the licensee shall ensure that any such plant or process shall be shut down in accordance with the requirements of its plant maintenance schedule referred to in [licence] condition 28". LC 30(3) further states that "the licensee shall, if so specified by ONR, ensure that when a plant or process is shut down in pursuance of paragraph 1 of this condition it shall not be started up again thereafter without the consent of ONR".

In licence instrument (LI) number 4 of nuclear site licence number 63, dated 27 March 1996, we specified that the licensee shall seek its consent to start-up a reactor at Sizewell B power station whenever it is shut down under licence condition 30(1).

The reactor at Sizewell B was shut down on 16 May 2021 for its seventeenth refuelling outage (RO17). With refuelling and all required EIMT now complete, EDF NGL has applied to us for consent to restart the reactor, as required by LC 30(3) and LI 4.

Assessment and inspection work carried out by ONR in consideration of this request

Our business management process for the planning and management of periodic shut downs is described in NS-INSP-GD-030. Our inspection and assessment activities during a power reactor outage are to establish that:

- Requirements set out in the station's maintenance schedule have been complied with;
- Work has been carried out in accordance with arrangements for identified structures, systems and components (SSC); to the required quality; and by competent persons;

- Safety issues identified during the reactor outage have been adequately addressed with suitable and sufficient justification provided to allow a regulatory judgement to be made that start-up of the reactor is safe and will remain safe until the next outage.

The scope of the interventions and assessments was determined by conducting reviews of:

- Scope of work for the outage as indicated by the outage intentions document.
- Results of the pre-outage inspections;
- Previous outage reports and actions;
- Operating experience and outstanding issues recorded in the regulatory issues database;
- Other areas of interest which could only be assessed during an outage period.

Our following specialisms were identified as required for the RO17 project:

- Structural integrity;
- Mechanical engineering;
- Electrical engineering;Control and instrumentation systems;
- Civil engineering;
- Radiological protection;
- Quality assurance/supply chain;
- Security;
- Site inspection oversight.

The inspection activity carried out by inspectors from these specialisms can be summarised as follows:

- Assessment of the licensee's readiness to commence the outage through:
    - Pre-outage fuel route inspections;
    - Attendance at the outage intentions meeting;
    - Observation of the licensee's pre-outage training programme;
    - Inspection of the licensee's arrangements for managing covid during the outage.
- Engineering assessments of maintenance, modifications and other work during the outage covering the following areas:
    - Structural integrity;
    - Fuel performance;
    - Mechanical engineering;
    - Electrical engineering;
    - Control and instrumentation;
    - Civil engineering.
- Assessment of the safety management of the outage including:
    - Early outage safety review;
    - Quality assurance;
    - Radiological protection;
    - Conventional health and safety.
- Oversight of the licensee's response to emergent issues
    - Auxiliary cooling water system pipework leak;

- Thermal sleeve failure;
- Rod control cluster assembly quality assurance issue.

- Consideration of the licensee's overall performance by attendance at start-up meeting.

Matters arising from ONR's work

Towards the start of the outage, following the removal of the reactor pressure vessel head, inspections identified that one of the thermal sleeves had become detached from the head assembly and was resting on the upper internals. Subsequent examination of the remaining thermal sleeves identified additional locations where the sleeve had dropped, although the sleeves were still retained within their adaptor tubes. These, and a further two thermal sleeves that were deemed most at risk of falling, were subsequently replaced.

The thermal sleeves do not in themselves fulfil a significant nuclear safety function (they principally protect the control rod drive mechanism against thermal transients), but failure of a thermal sleeve has the potential to leave a remnant that can adversely affect control rod drop times. Our structural integrity specialist assessor for the outage undertook an assessment of the licensee's repair strategy and safety cases, and of the repair itself. The specialist inspector was satisfied that the risks associated with return to service and subsequent operation until the next refuelling outage had been reduced so far as is reasonably practicable, on the basis that:

- Those worn thermal sleeves that had the potential to fail during operation before the next refuelling outage have been replaced;
- The repair process for removal and replacement of the thermal sleeves was adequately controlled, and subsequent inspections provided assurance that the removal and replacement of the worn thermal sleeves had not challenged the integrity of the pressure boundary;
- The plant is tolerant to failure of a small number of control rods to insert on reactor trip, and the licensee has confirmed that the control rod drop times have been tested and are within the safety case limits.

Conclusions

Following assessment and inspection of matters arising in relation to RO17, we are satisfied that the licensee's justification to start-up the reactor and operate for a further period is adequate. Consequently, consent to start-up the reactor can be granted.

Recommendation

I recommend that, in accordance with the request from the licensee, ONR should issue LI 560 to grant consent under LC 30(3), attached to Nuclear Site Licence No. 63, for the reactor at Sizewell B nuclear power station to start-up following the RO17 periodic shut down.

LIST OF ABBREVIATIONS

ACW	Auxiliary Cooling Water
ASME	American Society of Mechanical Engineers
C&I	Control and Instrumentation
DLA	Dynamic Learning Activity
EATL	Energy Absorbing Torque Limiter
EC	Engineering Change
EIMT	Examination, Maintenance, Inspection and Testing
EOSR	Early Outage Safety Review
INA	Independent Nuclear Assurance
INSA	Independent Nuclear Safety Assessment
IRR17	Ionising Radiations Regulation 2017
ISI	In-Service Inspection
LC	Licence Condition
LI	Licence Instrument
NGL	Nuclear Generation Limited
NSSS	Nuclear Steam Supply System
OID	Outage Intentions Document
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
PSSR	Pressure Systems Safety Regulations
RCA	Radiation Controlled Area
RCCA	Rod Cluster Control Assembly
RCP	Reactor Coolant Pump
RO16	Refuelling Outage 16
RO17	Refuelling Outage 17
RPV	Reactor Pressure Vessel
RTS	Return to Service
SAA	Solid Absorber Assembly
SBI	System-Based Inspection
SIP	Structural Integrity Panel
SSC	Structures, Systems and Components

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1 PERMISSION REQUESTED

1. EDF Energy Nuclear Generation Limited (NGL), the holder of nuclear site license number 63 for Sizewell B power station, has requested [Reference 1] that we grant consent to start-up the reactor following its periodic shut down, as required by license condition (LC) 30(3) of said nuclear site licence.

2. This project assessment report (PAR) presents my consideration of this request and recommends that we grant consent to start-up the reactor by issuing licence instrument (LI) 560.

2 BACKGROUND

3. Sizewell B is a single pressurised water reactor incorporating a nuclear steam supply system (NSSS) based on a Westinghouse standard four loop design. The NSSS comprises of enriched uranium fuel assemblies contained within a steel reactor pressure vessel (RPV) with four associated coolant loops each connected in parallel to the RPV. Each cooling water loop has its own reactor coolant pump (RCP), steam generator and interconnecting pipe work. The primary cooling circuit is closed and pressurised by a single pressuriser vessel which is maintained part filled with water and part with steam in equilibrium. The secondary coolant side is isolated from the primary system by the steam generator tubes that produce steam which is passed to two 630MW turbine generators producing a nominal 1260MW of electricity.

4. Sizewell B's operating cycle lasts approximately 18 months, after which it is required to shut down so that it can be refuelled. When refuelling is undertaken, some of the fuel assemblies (around one-third) are replaced with new ones. The existing fuel assemblies are returned to the core in a rearranged array to ensure optimum fuel utilisation.

5. To continue to operate safely and reliably the reactor plant requires regular examination, inspection, maintenance and testing (EIMT). The specific requirements for EIMT are captured in the plant maintenance schedule, made under LC 28 (at Sizewell B, this terminology is not used, and the licensee instead refers to "surveillance programmes" which satisfy the same requirements). Continuous improvement also requires plant upgrades to be implemented where deemed to be reasonably practicable. Whilst some of these activities can safely take place when the reactor is operating at power, many of them require the reactor to be shut down. The refuelling outages at Sizewell B provide the opportunity for undertaking such activities.

6. The requirement to shut down periodically for the purposes of EIMT is captured in LC 30. LC 30(1) states that "when necessary for the purpose of enabling any examination, inspection, maintenance or testing of any plant or process to take place, the licensee shall ensure that any such plant or process shall be shut down in accordance with the requirements of its plant maintenance schedule referred to in [licence] condition 28". LC 30(3) further states that "the licensee shall, if so specified by ONR, ensure that when a plant or process is shut down in pursuance of paragraph 1 of this condition it shall not be started up again thereafter without the consent of ONR".

7. In LI number 4 of nuclear site licence number 63, [Reference 2], we specified that the licensee shall seek its consent to start-up a reactor at Sizewell B power station whenever it is shutdown under licence condition 30(1).

8. The reactor at Sizewell B was shut down on 16 May 2021 for its seventeenth refuelling outage (RO17). With refuelling and all required EIMT now complete, EDF NGL has applied to ONR for consent to restart the reactor, as required by LC 30(3) and LI 4.

3 ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST

3.1 ONR'S INTERVENTION MANAGEMENT PROCESS

9. Our business management process for the planning and management of periodic shut downs is described in NS-INSP-GD-030, Revision 6, dated June 2019 [Reference 3]. ONR inspection and assessment activities during a power reactor outage are to establish that:

- Requirements set out in the station's maintenance schedule have been complied with;
- Work has been carried out in accordance with arrangements for identified structures, systems and components (SSC); to the required quality; and by competent persons;
- Safety issues identified during the reactor outage have been adequately addressed with suitable and sufficient justification provided to allow a regulatory judgement to be made that start-up of the reactor is safe and will remain safe until the next outage.

10. The scope of the interventions and assessments was determined by conducting reviews of:

- Scope of work for the outage as indicated by the outage intentions document (OID):
- Results of the pre-outage inspections:
- Previous outage reports and actions:
- Operating experience and outstanding issues recorded in the regulatory issues database:
- Other areas of interest which could only be assessed during an outage period.

11. The following ONR specialisms were identified as required for the RO17 project:

- Structural integrity;
- Mechanical engineering;
- Electrical engineering;
- Control and instrumentation systems;
- Civil engineering;
- Radiological protection;
- Quality assurance/supply chain;
- Security.;Site inspection oversight.

12. The inspection activity carried out by inspectors from these specialisms can be summarised as follows:

- Assessment of the licensee's readiness to commence the outage through:
  - Pre-outage fuel route inspections;
  - Attendance at the outage intentions meeting;
  - Observation of the licensee's pre-outage training programme;
  - Inspection of the licensee's arrangements for managing covid during the outage.

- Engineering assessments of maintenance, modifications and other work during the outage covering the following areas:

  - Structural integrity;
  - Fuel performance;

- Mechanical engineering;
- Electrical engineering;
- Control and instrumentation (C&I);
- Civil engineering.

- Assessment of the safety management of the outage including:

  - Early outage safety review;
  - Quality assurance;
  - Radiological protection;
  - Conventional health and safety
  - Security.

- Oversight of the licensee's response to emergent issues:

  - Auxiliary cooling water system pipework leak;
  - Thermal sleeve failure;
  - Rod control cluster assembly quality assurance issue.

- Consideration of the licensee's overall performance by attendance at start-up meeting.

3.2 ASSESSMENT OF THE LICENSEE'S READINESS TO COMMENCE RO17

3.2.1 Pre-outage fuel route inspections

13. Prior to the outage, we carried out two system-based inspections (SBI) to assess EDF NGL's readiness.

- Foreign material retrieval and fuel operability inspection;
- Fuel route inspection.

14. The foreign material retrieval and fuel operability inspection is described in [Reference 4]. The inspection was carried out remotely by a team of fuel and core specialist inspectors, supported by the nominated site inspector. The intervention was undertaken because EDF NGL proposed the remediation and use of two new fuel assemblies in cycle 18 (the period of operation following RO17) that had previously been embargoed in refuelling outage 14 as a result of finding foreign material during core offload (subsequently removed). Cycle 18 will be the first time that fuel assemblies previously embargoed due to the presence of foreign material have been re-used at Sizewell B following retrieval activities.

15. The inspection involved sampling procedures and reports, discussions with NGL staff and examination of completing records and confirmed that, on the basis of the information sampled, EDF NGL was adequately implementing its arrangements for:

- Visual inspection of fuel assemblies for foreign material during offload;
- Retrieval of any such foreign material when appropriate;
- Determining the operability of fuel assemblies.

16. Some minor shortfalls were identified during the inspection, but none were judged to have significant nuclear safety implications.

17. The fuel route SBI is described in [Reference 5]. The inspection was carried out by a team comprising mechanical engineering and control and instrumentation specialists, supported by the nominated site inspector. It focussed on the following systems:

- Reactor building polar crane;
- Pond fuel handling machine;
- Fuel building crane.

18. The polar crane and pond fuel handling machine are used extensively during refuelling. The fuel building crane is in the same general area as the pond fuel handling machine, and interlocks prevent the two cranes from interfering with one another.

19. The inspection comprised discussions with the licensee staff remotely and a desktop review of the licensee's records and other associated safety documentation. On the basis of the sample inspected, the inspectors agreed that the safety case requirements for the various systems were being met, with only minor areas for improvement noted.

20. Overall, the two inspections provided confidence in some of EDF NGL's key processes and equipment for carrying out refuelling operations. No issues were identified that would prevent or delay the commencement of refuelling.

3.2.2 Outage intentions meeting

21. EDF NGL's planned outage work programme was outlined in the Sizewell B outage intentions document, [Reference 6]. This was examined by our specialist inspectors and the nominated site inspector in preparation for the outage intentions meeting held on 22 September 2020, [Reference 7], which was attended by the nominated site inspector, the civil nuclear security site inspector and the lead project inspector.

22. At the outage intentions meeting, EDF NGL set out its intended scope of work, identifying the EIMT requirements as well as other work to be carried out in support of safety. The OID also identified the Sizewell B approach for managing safety (both nuclear and non-nuclear) and quality during the outage which was to be delivered by processes set out in corporate and local arrangements.

23. Our inspectors present did not raise any specific issues relating to the content of the OID but sought clarification on some topics which were subsequently satisfactorily addressed by EDF NGL.

24. The outage intentions meeting was held during the Covid-19 pandemic. At that time, the licensee was still proposing to deliver the full scope of the OID. However, as the station approach the planned start of the outage and the impact of restrictions on travel into and around the country became apparent, EDF NGL produced a justification to reduce the scope of the outage, [Reference 8]. The justification also proposed moving the start of the outage from 19 March to 16 April 2021, to give time for the pandemic to ease. This has a subsequent impact on the core reload safety case, which was assessed in a separate safety case (see section 3.3.2).

25. The justification made the claim that scope should be deferred from RO17 to the next refuelling outage on the basis that:

- It would not be possible to mobilise sufficient resources to safely perform all of the originally planned maintenance activities. Sizewell B relies on a significant number (more than 200) of foreign nationals to support its outage. Most of those come from the United States, France and South Africa. With Covid-19 restrictions in place, it would not be possible to bring some of those into the country (travel from South Africa was forbidden), it would be difficult to house those who did come into the country (as many accommodation providers were closed), and those that did come in would risk transmitting the virus to the local community and to site;

- A systematic review of the maintenance schedule demonstrated that many activities proposed for RO17 that are heavily reliant on foreign contract support could be deferred using the flexibilities within the appropriate design codes or equipment qualification programmes. Where this is not the case, the justification presents arguments based on previous reliable operation of the system, structure or component in question, coupled with reassurance from other tests or monitoring that are done at power, to conclude that it is safe to operate until the next refuelling outage;
- Maintenance for which a justification cannot be made on the above bases, or which it is practicable to carry out without the support of foreign contractors, would still be carried out in RO17.

26. I was satisfied with the arguments presented by the licensee, on the basis that I agreed that Covid-19 presented both a logistical and a safety challenge, and that the deferrals that were being proposed were not associated with plant that gave me cause for concern. In addition, the discipline-specific work scope was reviewed by the individual specialist inspectors as part of their assessments, and no specific concerns were raised.

3.2.3 Pre-outage training

27. During refuelling outages, a large number of contractors are brought onto the site, many of whom may be unfamiliar with the site (and, indeed, the UK operating context). The licensee has therefore developed “dynamic learning activity” (DLA) training, which is required to be completed before an unescorted site pass can be issued. The nominated site inspector attended a DLA training session, to confirm that it adequately covers the risks and hazards associated with the site. His observations are recorded in [Reference 9]. In summary:

- The training started with a presentation of the site’s Covid-19 arrangements. A video was shown demonstrating the process for entering the site, and the steps shown were then discussed;
- Delivery of the course was clear, and the trainer recognised that there were non-native English speakers present. He paused frequently to test their understanding;
- The training did not cover entry into radiation-controlled areas (RCA), other than by recognising that a radiological work permit would be required to do so, along with additional training. The site inspector considered this to be appropriate, since completion of the DLA alone would not allow unescorted access to the RCA;
- Following the classroom session, the group was taken into the “flow loop simulator”. The simulator contains tanks, pipework, valves and raised working platforms. There is also a mock-up of a radiography site, a mock-up of an office area or portacabin, and a mock-up of a spill area (with a drain and a drain cover);
- The simulator was used very effectively to demonstrate common hazards on site, the arrangements in place for their mitigation and, in particular, the associated signage (and other visual indication). Once again, the trainer used a variety of techniques to test the knowledge and understanding of the participants, particularly the non-native English speakers.

28. Overall the site inspector considered that the DLA training comprehensively covered the (non radiological) risks and hazards associated with the site, local arrangements for the mitigation of those risks and hazards, and the required responses to the site alarms (there is an additional training course required for access to radiologically controlled areas). The use of the flow loop simulator was seen as particularly beneficial.

3.2.4 Covid arrangements

29. Recognising the significant and unusual nature of the impact of Covid-19 on the outage, the nominated site inspector undertook an intervention to review the control and mitigation measures in place for RO17, as reported in [Reference 10].

30. EDF NGL has initiated a number of workstreams looking at the management of Covid-19 at Sizewell B, consisting of:

- Covid hub and testing;
- Site cleaning and catering;
- In-processing (the logistics of getting staff and – particularly – contractors through induction and onto site);
- Covid risk assessment;
- Containment arrangements;
- Site layout;
- Temporary accommodation.

31. The nominated site inspector held discussions with the workstream leads, examined risk assessments and guidance documentation, and visited a number of facilities to confirm compliance with the Covid-19 arrangements. He was satisfied that the licensee had put a significant amount of effort into managing covid on the site, learning from other stations in outage (Heysham 1 and Torness) and from Hinkley Point C, which is managing a large number of contractors. The arrangements were robust, were monitored throughout the outage, with compliance generally being high.

3.3 ENGINEERING ASSESSMENTS

3.3.1 Structural integrity

32. The structural integrity assessment for RO17 is summarised in [Reference 11]. The assessment considers:

- The conduct and adequacy of the inspections of all components required by the American Society of Mechanical Engineers (ASME) boiler and pressure vessels code, section XI;
- Any additional EDF NGL EIMT requirements needed to comply with LC28;
- Compliance with Pressure Systems Safety Regulations (PSSR).

33. The assessment summarises the results of three categories of inspection activity;

- Routine meetings on structural integrity-related maintenance schedule work streams and a review of the outage intentions proposals (including attendance at the outage intentions meeting);
- A visit to site during the outage to assess the adequacy of the inspections in progress and the licensee's delivery of the commitments provided in the outage intentions document;
- Monitoring of the Sizewell B Structural Integrity Panel (SIP) through attendance and reading the minutes throughout the outage to identify how the inspections are progressing and how any issues identified are managed and resolved;
- Review of the safety cases for the key systems and components, in particular the steam generator drain plug, condensate storage tanks and control rod drive mechanism thermal sleeves (this latter being discussed more fully in section 3.5.2).

34. As a result of the above activities, the structural integrity specialist inspector concluded that the licensee is following the ASME code and is compliant with both LC 28 and PSSR. He was satisfied that he had found no issues that would prevent Sizewell B

from returning to service for the next operational period. He did, however, make the following recommendations:

- Confirm that the Independent Nuclear Safety Assessment (INSA) certificate for the return to service (RTS) engineering change (EC) is submitted as part of EDF NGL's application for consent to return to service, to demonstrate satisfactory completion of the steam system inspection programme and completion of the work of the SIP;
- Confirm that a RTS statement from the competent person is submitted as part of EDF NGL's application for consent to return to service, to demonstrate satisfactory completion of the PSSR inspections;
- Consult with structural integrity specialist inspectors prior to granting consent to confirm that there have been no emergent issues from the inspection programme that would prevent RTS;
- Ensure that the licensee provides us with an approved copy of the RTS EC report and the 90 day report, when available.

35. I have confirmed that statements from the competent person and INSA have been attached to the application for consent to return to service (attachments 4 and 5 of [Reference 1] respectively). The structural integrity specialist has been informed of, and consulted on, the emergent issues described in section 3.5, particularly the thermal sleeve issue (the ONR response to which was led by the specialist); there are no other emergent issues of nuclear safety significance. The return to service EC has been provided as part of the request for consent in [Reference 1], and the 90 day report is provided as matter of course, as part of normal regulatory business.

3.3.2 Fuel performance

36. The fuel performance assessment is summarised in [Reference 12], and is based around consideration of the cycle-specific safety case for cycle 18. Noting the routine nature of the cycle specific safety cases, the assessment focusses on changes introduced since, or as a result of, cycle 17, specifically:

- Incorporation of a new assessment methodology for analysing boron dilution faults (introduced following our assessment of the cycle 17 safety case in RO16);
- The adjusted core configuration, which reduces the consequences of severe core misloading;
- Any residual effects of the extended period of reduced-power operation during the summer of 2020;
- Any changes to the fuel design which may have affected the safety analysis.

37. From sampling the cycle 18 safety case and holding discussion with EDF NGL, the fuel and core specialist inspector concluded that:

- The revised boron dilution fault analysis has been incorporated into the cycle 18 analysis appropriately and demonstrates margin to saturation conditions;
- The core design changes introduced to reduce the consequences of severe core misloading have reduced the risks in so far as is reasonably practicable;
- The extended reduced-power operation during cycle 17 has not resulted in additional constraints being imposed on the cycle 18 core design, noting that should the fuel be de-conditioned again a specific safety justification will be required;
- The changes to the fuel assembly design introduced since cycle 17 will have no effect on the functional or safety performance of the fuel.

38. On that basis, the specialist inspector was content to support Sizewell B's return to power following RO17, providing confirmation could be provided of the fuel's

operability prior to reload (a routine piece of work, but one that had not been completed at the time of assessment). The specialist inspector subsequently confirmed in [Reference 13] that this had been done.

39. However, due to a delay to the scheduled refuelling outage, the assumption used in the cycle 18 reload safety case regarding the cycle 17 end-of-cycle burn-up was exceeded. EDF NGL has arrangements for providing a means of assessing the safety significance of such changes without the need to reproduce the whole reload safety case by using a reduced set of analysis to demonstrate continued compliance with the generic reload safety case. The specialist inspector engaged with the licensee to ensure that these arrangements were applied appropriately and resulted in an acceptable outcome. He reported, also in [Reference 13], that the analysis had been completed satisfactorily, and that the safety significance was such that the existing core design was acceptable for use. He therefore supported granting consent to restart.

3.3.3 Mechanical engineering

40. The mechanical engineering assessment comprised of a site visit by two mechanical engineering specialist inspectors, and is reported in [Reference 14]. The inspection focussed on three areas of particular safety significance:

- Maintenance of the RCPs, which provide the main motive force required to circulate coolant around the primary under normal operations, and which have a safety significant requirement to continue to drive coolant around the system for not less than 45 seconds following trip on loss of power;
- Maintenance of the passive injection subsystem, the high head safety injection subsystem and the low head safety injection subsystem. Together, these comprise the emergency core cooling system;
- Resolution of issues identified in refuelling outage 16 (RO16) with the polar crane and, in particular, the energy absorbing torque limiter (EATL).

41. Based on discussions with licensee personal, examination of procedures and documentations, and a site walkdown the mechanical engineering specialist inspectors were satisfied that the LC 28 arrangements in place for the above plant items were adequate, and had been adequately implemented, with no significant shortfalls. On that basis, they were happy to support the return to service of Sizewell B following RO17.

3.3.4 Electrical engineering

42. A team of electrical engineering specialist inspectors carried out a remote inspection, supported on-site by the nominated site inspector. Their findings are summarised in [Reference 15].

43. The inspection targeted the planned electrical work being undertaken as part of the RO17, including the planned electrical EIMT activities from the OID and any emergent electrical work. The inspectors sampled a number of refuelling outage related electrical activities. They confirmed that EDF NGL had completed all scheduled electrical work activities. They identified some minor shortfalls in compliance with the arrangements established for procedural use and adherence, but were satisfied that the station had acted in a timely manner to address the shortfalls identified.

44. Overall, the electrical engineering specialist inspectors were satisfied that there were no significant shortfalls identified with the implementation of the established arrangements for LC 28 EIMT in relation to the planned electrical work undertaken as part of RO17 and, as a result, were content to grant consent for Sizewell B to return to service.

3.3.5 Control and instrumentation

3.3.6 A C&I specialist inspector visited site to discuss progress with the planned maintenance, and to sample work areas and completed documentation.

3.3.7 He concluded that the commitments made in the OID for C&I equipment and systems important to nuclear safety had been satisfied, and that the workmanship applied was adequate and consistent with the standards expected from C&I suitably qualified and experienced persons.

3.3.8 From the evidence gathered during his inspection, he considered that there were no matters that may significantly impact on nuclear safety, or that would prevent us from issuing a consent to allow Sizewell B to restart (see [Reference 16]).

3.3.9 He did raise a regulatory issue to capture a number of actions related to the polar crane. These were not return-to-service actions and will be monitored as part of normal regulatory business.

3.3.10 Civil engineering

45. A significant amount of civil engineering inspection work was deferred to future refuelling outages in an attempt to reduce the number of non-UK nationals brought into the country during the pandemic. This decision was reviewed by a civil engineering specialist inspector, along with the appointed examiner's report for RO17 (which covers all civil inspection work carried out at power during cycle 17 and while shut down in RO17). The inspector also reviewed the results of previous outage assessments. His findings are captured in [Reference 17]. His conclusions were are follows:

- While the reduction in civil scope inspections for RO17 is not ideal, confidence can be gained from the judgements made by the appointed examiner through his site walkdowns, undertaken with thein-service inspection (ISI) team, as recorded in the appointed examiner's report;
- Postponement of inspection requirements from RO17 to RO18 remains compliant with ASME boiler and pressure vessel code section XI. Due to the postponement of all work for this period to RO18 there will be a significant increase in work in that outage, which we should be cognisant of;
- Our previous civil engineering assessment for RO16 did not raise any areas of concern for future attention.

46. The specialist inspector was therefore content to support the return to service of the containment vessel and the associated nuclear safety related civil structures following RO17, provided that the licensee could confirm completion of the RO17 local leak rate testing (which was outstanding at the time of his review) with acceptable results. The licensee has subsequently confirmed, in [Reference 18], that local leak rate testing has been completed, with results well below the acceptable limits.

3.4 ASSESSMENT OF SAFETY MANAGEMENT

3.4.1 Early outage safety review

47. The nominated site inspector joined the EDF NGL's independent nuclear assurance (INA) function as they carried out an early outage safety review (EOSR) at Sizewell B, as reported in [Reference 10]. The purpose of the EOSR is to look for potential shortfalls in working practices that could lead to incidents and events during the outage, and address them at an early stage.

48. It was recognised that, because of the scope reduction for RO17, site was relatively quiet compared with previous outages. Nevertheless, the site inspector noted that the

team was focussed in identifying areas where work was most likely to be occurring, or where there were particular risks, and considered that the review was carried out in a focussed and intelligent manner. He observed:

- Use of laydown areas, traffic management and working at height had all improved since RO16;
- Radiation protection support for containment access and egress was good;
- Mask wearing inside containment was variable, with a number of people not properly wearing their masks, sometimes in close proximity to others. Mask wearing elsewhere was generally good.

49. These findings were fed back to station management to allow them to make necessary improvements throughout the remainder of the outage.

3.4.2 Quality assurance

50. A quality assurance and supply chain specialist inspector visited site with the nominated site inspector to carry out an inspection of the licensee's implementation of the quality management arrangements. The inspection was principally carried out in support the thermal sleeve repair programme (see section 3.5.2) but also addressed regulatory issue 7315, which had been raised during RO16 following identification of shortfalls in the use and completion of quality plans and work instructions of various types.

51. The inspection is summarised in [Reference 19]. EDF NGL described the progress they had made to resolve regulatory issue 7315:

- The outage-specific induction training had been updated to include clarification of procedural use and adherence expectations, and issue of updated procedural use and adherence cards to all EDF NGL and contractor staff;
- On-site contractor companies had included updated procedural use and adherence expectations into their own training;
- The investment delivery team had developed its own slide pack highlighting the importance of maintaining accurate lifetime records packs;
- EDF NGL surveillances and observations had noted an improvement in procedural use and adherence.

52. The specialist inspector and nominated site inspector noted that EDF NGL's findings were consistent with their own observations during this inspection, and feedback from our other specialist inspectors throughout RO17. The quality assurance and supply chain specialist inspection was satisfied with the progress of the improvements.

3.4.3 Radiological protection

53. A radiation protection specialist inspector visited site to confirm that the license's work programme for RO17 was being conducted in compliance with the Ionising Radiations Regulations 2017 (IRR17). His findings are summarised in [Reference 20]. The intervention focussed on:

- The EDF NGL radiation protection personnel organisation, including the level of support available;
- Radiation protection input to outage work planning, including risk assessment.
- Operational dose management, specifically day-to-day dose management and profiling during the outage;
- Radiological event investigation and follow-up including response to leakages and spillages of radioactive material;
- Outage contractor selection, training, control, supervision, and competence;

- Radiation survey instrument maintenance and support arrangements including adequate monitoring equipment resources for the outage;
- Radioactive source management;
- Health physics clearance arrangements.

54. The inspection did not reveal any significant nuclear safety concerns relevant to RO17 that required action by the licensee or further follow-up by ourselves , and discussions with the Head of Radiological Protection for Sizewell B gave the radiation protection specialist inspector confidence in the site's radiation protection practices and its compliance with the requirements of IRR17.

3.4.4 Conventional health and safety

55. A conventional health and safety specialist inspector visited site to inspect arrangements for workplace safety, focussing in particular on working at height and workplace transport. There are areas of known risk during outage in general, and were specific areas of concern during RO16.

56. His inspection is reported in [Reference 21]. He sampled work at height activities being carried out, and noted examples of good practice in relation to the three focus areas:

- Planning and supervision;
- Competence of staff;
- Suitability of equipment.

57. He did, however, identify a matter of concern in relation to work at height conducted by a contractor. The work was reliant on the use of personal work restraint equipment which was not being used appropriately. The work party was stood down while suitable actions were agreed to remedy the situation. Following the application of our enforcement management model, the conventional health and safety specialist inspector subsequently wrote to the contractor seeking improvements.

58. The specialist inspector also sampled workplace transport activity, and saw examples of good practice in relation to the three focus areas of safe site, safe vehicle, and safe driver. He also noted comprehensive programme of improvement work EDF NGL is implementing to the site pedestrian routes at Sizewell B.

59. During the inspection the specialist inspector made general observations in relation to Covid-19 control measures and found a satisfactory level of compliance with the site's arrangements for social distancing requirements, use of face coverings and hand washing.

3.4.5 Security

60. Our civil nuclear security specialist inspectors carried out a number of inspections throughout the outage, looking at aspects of physical and personnel security. The lead security inspector for Sizewell B has confirmed, in [Reference 22], that the security inspectors found no issues that required immediate regulatory attention, or that would prevent us from granting consent to restart the reactor.

3.5 EMERGENT ISSUES

3.5.1 ACW pipework leak

61. At the start of the outage, during the process of switching between two trains of the auxiliary cooling water (ACW) system, a failure of the ACW inlet pipework occurred.

62. The ACW is a sea-water system that provides cooling to a number of heat exchangers, most of which are in the turbine hall. It was in the turbine hall that this failure occurred.

Two operators were present at time, carrying out the switching operations, and both received minor scalding as a result of the hot sea water impact. Both have since been able to return to work.

63. The nominated site inspector was informed of the incident by the technical safety and support manager, and attended site to carry out preliminary enquiries, as described in [Reference 10]. There were no immediately obvious breaches and no imminent danger, and use of the plant had been embargoed pending investigation, so the site inspector considered it appropriate to wait for the licensee to complete its own investigation.

64. Once the licensee's investigation was complete, the site inspector discussed the outcome with the lead investigator (see [Reference 23]). The cause of the event was that it was possible to align the system in such a way as to create a closed pipework loop with a heat source at its centre, allowing the water contained therein to boil. When the system was subsequently opened, there was a pressure and temperature excursion. Had the system been open, even if local boiling had occurred, there would not have been a pressure spike that would leak to a pipework failure.

65. The licensee carried out a review of the system and identified a number of improvements to prevent reoccurrence of the incident. Principal among these were changes to the operating instructions, to prevent closing the system and highlight the dangers of doing so, and the introduction of key controls preventing misalignment of the system (the keys are procedurally controlled by the duly authorised person). This, along with the replacement of the affected pipework, gave the site inspector confidence in the system's fitness to return to service. The licensee has also taken a longer-term action to investigate the practicability of introducing engineered, rather than procedural, controls to prevent system misalignment.

66. The site inspector has produced an enforcement decision record, [Reference 24], capturing the interactions and the subsequent enforcement decision. He has recommended raising an issue to track progress with the licensee's exploration of engineered protection for the system. However, this issue is to be resolved in the next period of operation and does not affect the granting of consent to restart.

3.5.2 Thermal sleeve failure

67. Following RPV head removal early in RO17, inspection of the upper internals identified one of the thermal sleeves had become detached from the RPV head assembly, and was resting on the upper internals. Subsequent examination of the remaining thermal sleeves identified three further locations where the thermal sleeve had dropped significantly, although the sleeves were still retained within their adaptor tubes. In all, 13 thermal sleeves identified wear outside of the pre-agreed acceptance criteria. A further two thermal sleeves were recommended for replacement on the basis that they could potentially fail during the next operating period.

68. The thermal sleeves do not in themselves fulfil a significant nuclear safety function (they principally protect the control rod drive mechanism against thermal transients), but failure of a thermal sleeve has the potential to leave a remnant that can adversely affect control rod drop times. The licensee therefore established an event recovery team to develop a strategy to:

- Remove the worn thermal sleeves, and any remnants of the failure thermal sleeves;
- Install replacement thermal sleeves in the same locations;
- Return the plant safely to service until at least the next refuelling outage, giving time for a longer-term solution to be developed.

69. We were informed of the issue with the thermal sleeves almost immediately, and the structural integrity specialist assessor assigned to the outage has undertaken an assessment of the licensee's repair strategy and safety cases, which is reported in [Reference 25]. The specialist inspector supported the licensee's selection and implementation of its chosen repair solution, and was satisfied that the risks associated with return to service and subsequent operation until the next refuelling outage had been reduced so far as is reasonably practicable, on the basis that:

- The repair process for removal and replacement of the thermal sleeves was adequately controlled, and the subsequent inspections and sentencing procedures provided assurance that the removal and replacement of the worn thermal sleeves did not significantly challenge the integrity of the pressure boundary;
- There is adequate understanding of the root cause of the wear mechanism that led to failure of the thermal sleeves, the judgements made regarding the future wear rates of the replacement thermal sleeves are suitably conservative, and the methodology used to establish the extent of condition of the thermal sleeves are similarly conservative. This therefore provides confidence that those worn thermal sleeves that had the potential to fail during operation before the next refuelling outage have been replaced;
- The plant is tolerant to failure of a small number of control rods to insert on reactor trip, and the licensee has subsequently confirmed in [Reference 26] that the control rod drop times have been tested and are within the safety case limits.

3.5.3 Rod control cluster assembly quality assurance issue

70. Towards the end of the outage EDF NGL were made aware of a number of historical quality deviations at the Framatome sub-supplier Aubert & Duval. These had the potential to affect the operability of Sizewell B rod cluster control assemblies (RCCAs) and solid absorber assemblies (SAAs). The quality deviations discussed below related to two orders of bar stock manufactured between 2010 and 2013, but components using that stock had been identified as being present in the cycle 18 core (in the case of the RCCAs) and fuel storage pond (in the case of the SAAs).

71. A meeting was held between EDF NGL, our fuel and core specialist inspector and quality assurance specialist inspector who had been supporting the RO17 assessment, and the nominated site inspector. The meeting is captured in [Reference 27]. At the meeting, EDF NGL explained that they had used their safety case anomalies process to sentence the quality assurance deviations, and had concluded that they still had high confidence in the quality of the material used, based on other tests that had been completed. Our inspectors generally agreed with the arguments presented, and also noted that the consequence of failure if those arguments proved to be wrong was small, as the specific sub-components that were manufactured from the affected stock did not play a significant role in delivering a nuclear safety function. The fuel and core specialist inspector ultimately concluded that EDF NGL had adequately demonstrated the operability of the affected components for use in cycle 18 core design.

3.6 START-UP MEETING

72. The Sizewell B start-up meeting was held on 16 July 2021. It was chaired by the station's technical and safety support manager with presentations from the outage programme leads [Reference 28]. Our attendance at the start-up meeting consisted of the operating reactors head of assessment, the nominated site inspector and a structural integrity specialist inspector. Minutes of the meeting are contained in [Reference 29].

73. The presenters gave a high-level overview of the work that had been carried out during the outage. More detailed discussions were held on areas of concerns, specifically those identified as emergent issues in section 3.5 of this report.

74. No outage actions were raised during the meeting, and it was agreed that the planned work had been delivered successfully, and although the thermal sleeve problems had resulted in a significantly extended outage, the recovery project itself had been managed well.

4 MATTERS ARISING FROM ONR'S WORK

75. I have considered the licensee's request for us to grant consent under LC 30(3) to start-up the Sizewell B reactor on completion of RO17. To inform my work I have taken note of the statements associated with safety contained in the request letter, the findings of the periodic shutdown associated work undertaken by EDF NGL's internal regulator, INA, the statements of the PSSR competent persons and the findings and opinions of our specialist inspectors:

- The Sizewell B station director has set out, in [Reference 1], those activities still to be undertaken prior to start-up. These are controlled through the site's mode change process and will be reviewed by the site's operational safety review committee prior to start-up to confirm the fitness-for-service of the plant and endorse return to service. This is usual practice for the return to service of Sizewell B following an outage;
- INA has provided a statement supporting the application for consent, attachment 7 to [Reference 1], which confirms that, based on their assessment activities so far, there are no issues which they are aware of which would prevent their provision of the concurrence part B prior to start up;
- The PSSR competent person has confirmed, in attachment 4 to [Reference 1], that their examinations have been satisfactorily completed and the plant was considered to be acceptable to return to service, subject to the completion of satisfactory plant walkdowns at normal operational temperatures and pressures;
- Our specialist assessors undertook inspections of the activities most significant to nuclear safety to support my permissioning work as described in section 3 of this report. Each discipline has produced an assessment report or intervention record that presents the inspection findings, inspector's opinions, judgments and recommendations. A number of recommendations and actions arose from the inspectors' work, and are referred to in this report. Most of the actions have subsequently been completed, and none of those that remain outstanding have been deemed sufficiently significant for us to withhold consent to start-up the reactor. All the reports contain a statement either supporting issuing a consent to start-up the reactor, or noting that there is no reason to withhold consent.

76. Although there is some work outstanding to complete the outage programme, I am content that the work of greatest significance to nuclear safety has been completed and assessed or inspected by our specialist assessors. The rest can be adequately managed by the licensee's due process, overseen by INA through their concurrence process.

77. I consulted with the other relevant regulator, the Environment Agency, to establish if they had any specific objections that would prevent us consenting to the start-up of the Sizewell B reactor. The Environment Agency confirmed, [Reference 30], they do not object to us granting consent.

5 CONCLUSIONS

78. The Sizewell B reactor periodic shut down, RO17, has been undertaken in accordance with the requirements of the work scope outlined within the OID, as modified by EC 368950.

79. The licensee has followed its arrangements in undertaking the periodic shut down, culminating in the Sizewell B station director writing to us requesting consent to start-up the reactor. His letter stated that subject to the completion of the remaining outage activities, he was satisfied that the reactor was fit for return to service and sufficient procedures were in place to assure safe operation through to the next periodic shut down.

80. The licensee's internal regulator, INA, has provided a concurrence statement that confirmed that it foresees no issues that would prevent the provision of the concurrence part B report in due course to support the return to service of the reactor post its periodic shutdown.

81. The PSSR competent person has confirmed that they are content for the reactor to start up.

82. Our inspectors have sampled the safety management and engineering activities throughout the shut down and judged them to be adequate, and all either support, or have no objection to, issuing consent to start-up the reactor. All actions raised during their inspections and assessments have been satisfactorily addressed or have acceptable plans for resolution.

83. I consider that the licensee delivered a shut down that was safely managed and completed the required safety related work activities. I am therefore satisfied that the licensee's justification to start-up the reactor and operate for a further period is adequate, and consent to start-up the reactor can be granted.

84. I have prepared Sizewell B LI 560, for consent under LC 30(3), in conjunction with this PAR. The licence instrument is one of the standard formats given within our procedures and does not require review by Government Legal Department.

6 RECOMMENDATIONS

85. I recommend that, in accordance with the request from the licensee, we should issue LI 560 to grant consent under LC 30(3), attached to Nuclear Site Licence No. 63, for the reactor at Sizewell B nuclear power station to start-up following the RO17 periodic shut down.

7 REFERENCES

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3. NS-INSP-GD-030, Revision 6. Nuclear Safety Technical Inspection Guide, LC 30, Periodic Shutdown. June 2019.
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5. ONR-OFD-IR-20-137 System Based Inspection SBI-09, Fuel Route Systems. 1 April 2021 (2021/28551).
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7. ONR RO17 Intentions Meeting. 30 September 2020 (2021/58725).
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19. ONR-OFD-IR-21-037 EDF NGL Sizewell B LC 17 Management systems (Thermal Sleeves) intervention. 1 July 2021 (2021/50063).
20. ONR-OFD-IR-21-016 Statutory Outage 2021 Radiological Protection Inspection. 11 May 2021 (2021/38823).
21. ONR-OFD-IR-21-015 Inspection of Work at Height and Workplace Transport Arrangements During Statutory Outage. 26 May 2021 (2021/42222).
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23. ONR-OFD-CR-21-361Sizewell B ACW leak investigation. 20 July 2021 (2021/55829).

24. ONR-EDR-21-018 Sizewell B ACW leak. 12 August 2021 (2021/61392).

25. ONR-OFD-AR-21-014 Sizewell B Nuclear Power Station: Assessment of the Structural Integrity Aspects of the Justification for Return to Service from RO17 following installation of Replacement CRDM Thermal Sleeves. 12 August 2021 (2021/46506).

26. Email from to re Successful Rod Drop Test (RO17 RTS). 10 August 2021 (2021/61415).

27. ONR-OFD-CR-21-375 Sizewell B Cycle 18 (Refuelling Outage 17) RCCA and SAA Quality Issue Update Level-4 Meeting. 26 July 2021 (2021/57048).

28. Email from to re RO17 Start Up Meeting Slide Pack - 12 July 2021 (2021/58728).

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