



| PROJECT ASSESSMENT REPORT | | | |
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Hunterston B Reactor 3 Periodic Shutdown 2015

**EDF Energy Nuclear Generation Limited (NGL) – Hunterston B –
Consent under Licence Condition 30(3) to start-up Hunterston B
Reactor 3 following the 2015 Periodic Shutdown**

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EXECUTIVE SUMMARY

Title

EDF Energy Nuclear Generation Limited (NGL) – Hunterston B – Consent under Licence Condition 30(3) to start-up Hunterston B Reactor 3 following the 2015 Periodic Shutdown

Permission Requested

EDF Energy NGL, the operator and licensee of Hunterston B power station, has written to the Office for Nuclear Regulation (ONR) requesting consent under Licence Condition 30(3) to start-up Reactor 3 on completion of its periodic shutdown (also known as its statutory outage). This project assessment report presents ONR's consideration of this request and recommends that consent is granted to start-up R3 through the issuing of Hunterston B Licence Instrument 549.

Background

NGL is licensed to operate two advanced gas-cooled reactors, known as Reactor 3 and Reactor 4 at Hunterston B Power Station.

To continue to operate safely and reliably, the reactor plant requires examination, inspection, maintenance and testing. Continuous improvement also requires plant safety improvements to be implemented where these are deemed to be reasonably practicable. Whilst some of these activities can take place when the reactor is at power, many of them require it to be shut down. The licensee's arrangements require that periodic shutdowns, as required by Licence Condition 30(1), are carried out every three years on each reactor at Hunterston B. The previous start-up consent for Reactor 3 was granted on 5 October 2012. On completion of a periodic shutdown, the reactor concerned cannot be started up without consent from ONR under Licence Condition 30(3).

The current Hunterston B Reactor 3 outage commenced on 2 October 2015. During this periodic shutdown, the licensee has conducted:

- Examinations, inspections, maintenance and testing activities in accordance with the Station Maintenance Schedule;
- Inspections to support the station safety case;
- Work to comply with statutory requirements;
- Remedial work to rectify adverse plant conditions and emergent work;
- Plant safety improvements where these are deemed to be necessary and reasonably practicable.

Where inspection work revealed the potential for an adverse plant condition, the licensee has assessed the inspection results in accordance with their arrangements, and taken appropriate remedial action as necessary, or provided an appropriate safety justification for continued operation, prior to ONR granting consent to reactor start-up.

Towards the end of the periodic shutdown, the Hunterston B station director wrote to ONR requesting consent to start-up Reactor 3. In that letter, the station director confirmed that all maintenance required for start-up would be completed and that actions requiring closure before start-up would be completed, as controlled by the operational safety review committee (OSRC), and evidence will be provided within 28 days of start-up.

The Pressure Systems Safety Regulations 2000 (PSSR) competent persons for the pre-stressed concrete pressure vessel and the reactor penetrations have each confirmed that they are content for Reactor 3 to start-up. The third party PSSR competent person has issued a preliminary inspection report that is included in the licensee's request for consent. The final

inspection report will be included in the licensee's final outage report to be issued within 28 days of start-up.

The licensee's internal regulator, Independent Nuclear Assurance (INA), has indicated there are no issues that prevent the start-up or continued operation of Reactor 3. It has issued its Concurrence Part B which is a requisite component that informs the OSRC's decision to authorise return to service.

This ONR project assessment report presents the basis for ONR granting consent for the licensee to start-up Reactor 3 at Hunterston B and operate to the next periodic shutdown.

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

ONR inspectors have sampled the licensee's arrangements for controlling and completing the examination, inspection, maintenance and testing requirements of the maintenance schedule, and other plant modifications of nuclear safety significance, as identified within the licensee's outage intentions document. This has included attending the significant outage planning and progress meetings and visiting site to inspect samples of the licensee's implementation of their arrangements. ONR inspectors have undertaken compliance inspections and produced reports; assessment reports have been written by specialist inspectors pertinent to statutory elements of work undertaken during the periodic shutdown. These reports have been used in the production of this project assessment report.

The main issues during the periodic shutdown which required additional safety justification, related to:

- Detection of suspect thermal fatigue cracking in several of the twelve hot air reheat release branches.
These components had been previously modified to remove the suspected previously identified cracking mechanism but recent inspections have shown a further degradation mechanism may be present. Investigation has revealed a new potential mechanism for cracking and a modification has been proposed to prevent it from occurring. ONR's structural integrity inspector considers the proposed modification to be reasonable and supports the station in having continued to monitor this issue.
- The observation of three keyway root cracks (KRC) in the graphite core of Hunterston B R3. This marks a significant point in the lifecycle of the graphite fuel bricks of the reactor. This onset is earlier by some years than the dates predicted in the safety cases.
- Discovery of five new bore cracks, three of which were observed in newly inspected channels, and two in previously inspected channels. It is unusual for graphite bricks to have formed bore cracks this late in life and is not obviously consistent with NGL's theory of bore cracking. Two of the cracks occurred in peripheral channels which challenges the existing explanations of brick stresses and requires further analysis.

It has been judged that there are no significant issues that should prevent ONR giving consent for the return to service of Hunterston B Reactor 3. However, it is not possible to state that there is high confidence that the amount of cracking will be less than the axially cracked graphite bricks operating limit in twelve months, although ONR is sufficiently confident that it will not be so in six months. ONR considers that NGL may be able to justify operation for longer than six months and notes that within six months there will be information from Hinkley Point B R3 and Hunterston B R4 scheduled inspection shutdowns that may contribute information to strengthen their justification. Accordingly, ONR has supported return to service for an initial six month period whilst NGL provides further safety analysis and inspection data. ONR will consider before the end of May 2016 whether an additional period of operation of Hunterston B Reactor 3 can be justified before further inspections are undertaken.

The regulatory interventions carried out by ONR inspectors have not identified any other issues that would prevent ONR from issuing its consent to start-up Reactor 3 under Licence Condition 30(3).

Matters arising from ONR's work

The licensee has confirmed to ONR that the requisite periodic shutdown related work has been successfully completed and that all actions identified by ONR, other than those mentioned above, for resolution prior to consent have been addressed. The actions agreed for the longer term have been included in the relevant station processes, and will be tracked to completion within its arrangements to ensure risks continue to be reduced as low as reasonably practicable.

No matters preventing the granting of consent to start-up arose from the work undertaken by ONR inspectors in relation to the Hunterston B Reactor 3 2015 periodic shutdown.

Conclusions

Following assessment and inspection of matters arising in relation to this Hunterston B Reactor 3 periodic shutdown, ONR was satisfied that the licensee's justification to start-up the reactor and operate to the next shutdown was adequate; consequently, consent to start-up should be granted. However, uncertainties relating to the progression of graphite brick cracking have led ONR to seek a shutdown for further inspections after a period of six months unless further safety analyses and results from inspections to be carried out during this period at Hinkley Point B Reactor 3 and Hunterston B Reactor 4 make this unnecessary.

Recommendations

It was recommended that, in accordance with the request from the licensee, ONR should grant consent under Licence Condition 30(3) attached to Nuclear Site Licence No: Sc.13 for Reactor 3 at Hunterston B nuclear power station to start-up following the 2015 periodic shutdown.

It was also recommended that ONR should write to NGL promptly to set out the regulatory concerns raised by the specialist inspector relating to the graphite safety case. The letter should:

- State that NGL will be required to shutdown Reactor 3 no later than six months after start-up in order to undertake further core inspections, unless it can be demonstrated that an adequate safety case can be made to substantiate operation up to a maximum of twelve months. In developing such a case, ONR will expect NGL to take cognisance of the inspection findings in the forthcoming Hinkley Point B Reactor 3 periodic shutdown and interim outage at Hunterston B Reactor 4.
- Provide clarity on the nature (and mechanism for release) of regulatory hold points at six months and, should a satisfactory case subsequently be made, at no more than twelve months from restart.

LIST OF ABBREVIATIONS

| | |
|-------|---|
| AGR | Advanced Gas Cooled Reactor |
| ALARP | As low as reasonably practicable |
| AMS | Asset Management System |
| APEX | Appointed Examiner |
| AR | Assessment Report |
| BAP | Boiler Assessment Panel |
| C&I | Control and Instrumentation |
| CCR | Central Control Room |
| CHS | Conventional Health & Safety |
| CNRP | Civil Nuclear Reactor Programme |
| CNS | Civil Nuclear Security (ONR) |
| COP | Cross Operational Programme (ONR) |
| CR | Contract Record |
| CRA | Control Rod Assembly |
| DAP | Duly Appointed Person |
| DCI | Deputy Chief Inspector |
| EC | Engineering Change |
| EIM&T | Examination, Inspection, Maintenance and Testing |
| FAC | Flow Assisted Corrosion |
| GAP | Graphite Assessment Panel |
| GSRV | Gas Safety Relief Valve |
| HDPE | High Density Polyethylene |
| HNB | Hunterston B |
| HSAW | Health and Safety At Work Act 1974 |
| HuP | Human Performance |
| HYB | Heysham 2 |
| IIS | Integrated Intervention Strategy (ONR intervention rating system) |
| INA | Independent Nuclear Assurance |
| INSA | Independent Nuclear Safety Assessment |
| IR | Intervention Record |
| IRR99 | Ionising Radiations Regulations 1999 |
| ISI | In-Service Inspection |
| JCO | Justification for Continued Operation |
| JPSO | Justified Period of Safe Operation |
| KRC | Keyway Route Crack |
| LC | Licence Condition |
| LCO | Limiting Condition of Operation |
| LI | Licence Instrument |
| LEV | Local Exhaust Ventilation |
| MBFP | Main Boiler Feed Pump |
| MITS | Maintenance Inspection and Test Schedule |
| MOM | Mid-Outage Meeting |

| | |
|-------|---|
| MS | Maintenance Schedule |
| NDT | Non-Destructive Testing |
| NGL | EDF Energy Nuclear Generation Limited |
| NICIE | New In-Core Inspection Equipment |
| OAP | Outage Assessment Panel |
| OFI | Opportunities for improvement |
| OIM | Outage Intentions Meeting |
| OIR | Outage Intentions Report |
| ONR | Office for Nuclear Regulation |
| OSRC | Operational Safety Review Committee |
| PAR | Project Assessment Report |
| PCPV | Pre-stressed Concrete Pressure Vessel |
| PECIT | Prototype Eddy Current Inspection Tool |
| POMP | Pre-Outage Milestone Plan |
| PSSR | Pressure Systems Safety Regulations 2000 |
| RCA | Radiation Controlled Area |
| RTR | Rapid Trending Review |
| RTS | Return To Service |
| SACI | Significant Adverse Condition Investigation |
| SEPA | Scottish Environment Protection Agency |
| SUM | Start-Up Meeting |
| SUV | Start-up Vessel |
| TSSM | Technical Safety and Support Manager |
| TS | Task Sheet |
| VWSG | Vibrating Wire Strain Gauge |

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1 PERMISSION REQUESTED

1. EDF Energy Nuclear Generation Limited (NGL), the operator and licensee of Hunterston B power station, has written [1] to the Office for Nuclear Regulation (ONR) requesting consent under Licence Condition (LC) 30(3) to start-up Reactor 3 (R3) on completion of its periodic shutdown (also known as its statutory outage). This project assessment report (PAR) presents ONR's consideration of this request and recommends that consent is granted to start-up R3 through the issuing of Hunterston B Licence Instrument (LI) 549 [2].

2 BACKGROUND

2.1 GENERAL

2. The nuclear site licence issued to NGL for Hunterston B power station requires the licensee to periodically shut down the reactor plant under LC30. This is to enable examination, inspection, maintenance and testing to take place in accordance with the requirements of the station's plant Maintenance Schedule (MS) under LC28. At Hunterston B power station, reactor periodic shutdowns are undertaken triennially as specified in the MS Preface, which is an approved document under LC28(4) [3]. The licensee also undertook work during the shutdown associated with the requirements of the Pressure Systems Safety Regulations 2000 (PSSR), previous commitments, and plant safety improvements/ modifications.
3. The licensee requires consent from ONR under LC30 (3) to start-up R3 on completion of its periodic shutdown [4]. The previous consent to start-up R3, Hunterston B LI 532 [5], is dated 5 October 2012. The R3 periodic shutdown 2015 commenced on 2 October 2015.
4. During the R3 periodic shutdown 2015, the licensee undertook the following work:
 - Maintenance inspection test schedule (MITS) and Statutory work including graphite and boiler inspections;
 - Boiler inspection and repair work;
 - Exchange of two gas circulators;
 - Addressed a number of operational focus defects;
 - Performance improvements;
 - Material condition enhancement; and
 - Equipment reliability / improvements.

2.2 OUTAGE PLANNING AND MANAGEMENT

2.2.1 Licensee's Management

5. NGL began planning the R3 periodic shutdown two years prior to its start. Progress was monitored by NGL with the aid of their pre-outage milestone plan (POMP).
6. NGL produced an outage intentions report (OIR) [6] for R3 periodic shutdown 2015. This outlines the outage organisation, infrastructure and management arrangements to deliver the planned safety-related activities. The OIR, which has included learning from the 2014 R4 outage lessons-learnt report [7], together with the referenced scope-related supporting documents comprised the outage intentions for R3.
7. The licensee's outage process has planned into it a series of meetings with ONR, these being the outage intentions meeting (OIM), the mid-outage meeting (MOM) and the start-up meeting (SUM).

8. NGL provided ONR with a copy of the OIR prior to holding the OIM on 22 April 2015 which was distributed to ONR specialist inspectors assigned to Hunterston B power station R3 outage 2015. The organisational arrangements and programme of work for the shutdown were discussed at the meeting.
9. NGL held the MOM and SUM on 26 October 2015 and 4 November 2015 respectively. ONR inspectors attended both meetings. The purpose of the MOM was to allow the station and ONR to review the progress and developments of the periodic shutdown against the MS. The purpose of the SUM was for the licensee to demonstrate it had adequately met the requirements of the MS, dealt with emergent issues and demonstrated the safety of R3 for the next operational period.
10. On 25 November 2015, the Hunterston B Station Director wrote to ONR requesting consent to start-up R3 on completion of the periodic shutdown [1].
11. The letter states that the status of all outage modifications have been reviewed to confirm that the plant will be in a satisfactory condition for return to service. In addition, all maintenance schedule work will be completed, subject to monitoring by the operational safety review committee (OSRC), excepting those items that which can only be carried out during return to service.
12. No issues that would prevent a return to service have been identified by the boiler assessment panel (BAP), the graphite assessment panel (GAP), the appointed examiner or under PSSR (with reference to the Bureau Veritas memorandum - attachment 1 to the letter [1]).
13. Further work noted by the GAP regarding the most appropriate time for the next graphite core inspections is considered and it is stated that NGL will provide ONR with a review of the justified period of safe operation in light of the core inspection evidence from Hinkley Point B Reactor 3 2016 statutory inspection and Hunterston B Reactor 4 2016 interim inspection. This will be provided within six months of the return to service of Hunterston B Reactor 3.
14. The licensee's internal regulatory process requires that the internal regulator, Independent Nuclear Assurance (INA), independently supports the application for reactor start-up. INA seeks assurance by undertaking a series of activities both before and during the outage. The scope of these activities for the current outage is defined in the INA Concurrence Part A [8]. On completion of these activities, INA issues a report, Concurrence Part B, which presents the findings of their work and includes a statement supporting the start-up.
15. On 26 November 2015, INA issued Concurrence Part B [9] for Hunterston B power station R3 statutory outage 2015 return to service. The report states that INA considers that there were no issues remaining with respect to the requirements of Concurrence Part A and they are content for start-up and subsequent operation of R3 within the constraints of the current safety case
16. The licensee produced three return to service engineering changes (EC's) [10], [11] & [12] that approve the results of inspections completed in the R3 outage inspection programme. INA has issued an independent nuclear safety assessment (INSA) approval statement [13], [14] & [15] for each of the return to service EC's with no caveats.
17. During the reactor start-up and raising to full power, there are further tests and inspections which can only be conducted at this time. The results of these, and of other inspections conducted during the shutdown which required further analysis, will be published in the licensee's '28-day report' as required under its compliance arrangements.

2.2.2 ONR's Intervention Management Process

18. The Hunterston B Site Inspector produced a periodic shutdown control document [16] which defines ONR's proposed resource allocation to the assessment, inspection and permissioning associated with the return to service of Hunterston B R3. In addition, a task sheet (TS) [17] has been produced which justified the resource for ONR activities during the R3 2015 periodic shutdown.
19. The anticipated outcomes of the project included:
 - The licensee delivering a shutdown that is safely managed;
 - Closeout of significant issues raised by ONR interventions to the satisfaction of the inspector raising the issue, prior to the conclusion of the shutdown (or an acceptable plan to address the issue beyond the shutdown);
 - The licensee delivering the required safety-related work activities, enabling ONR to produce a PAR that considers NGL's request to start-up R3 on completion of the shutdown.
20. An action tracking spreadsheet [18] has been maintained for the duration of the outage to monitor progress and status of all significant restart and non-restart related actions.

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

21. The work undertaken by ONR can be summarised as follows:
 - Assessment of safety management during the periodic shutdown including:
 - Outage related compliance inspections;
 - Follow-up to outage-related incidents at Hunterston B in 2014;
 - Outage Organisation: Control and supervision;
 - Radiological protection; and
 - Conventional Health and Safety.
 - Engineering assessments of maintenance, modifications and other work during the outage covering the following specialisms:
 - Civil Engineering;
 - Control and instrumentation systems;
 - Electrical engineering;
 - Graphite core integrity;
 - Mechanical engineering; and
 - Structural integrity.
 - Formal meetings (the OIM, the MOM and the SUM) looking at the preparations, progress and readiness to restart;
 - Emergent issues;
 - Consultation with ONR Civil Nuclear Security (CNS) and the Scottish Environment Protection Agency (SEPA).

3.1 SAFETY MANAGEMENT

3.1.1 Outage related compliance inspections

22. The Hunterston B nominated site inspector undertook a series of inspections associated with the R3 statutory outage, focussing on control and supervision; procedural use and adherence; working time directive and operating rule compliance. His findings are presented in the Intervention Record (IR) [19]. These inspections coincided with the rapid trending review (RTR) programme coordinated by INA. The RTR programme examined a wider range of industrial safety, nuclear safety and quality assurance themes, the outcomes from which the inspector has taken into consideration.
23. This intervention included planned compliance inspections against LC 24 – Operating Instructions. The inspector examined work order cards and work instructions across a number of work-faces during the inspection. Although instructions were generally completed to an adequate standard, the inspector observed some inconsistencies in the use of work instructions and the rigour of check-sheet completion associated with equivalent non-destructive testing (NDT) tasks undertaken by one of the station contractors. The station has since undertaken a reactive quality assurance audit and implemented appropriate corrective measures. The inspector has advised the station of the need for these outage-related procedural inconsistencies to be considered as part of ongoing improvements to procedural use and adherence across the station.
24. The inspector examined central control room (CCR) supervisor log data and limiting condition of operation (LCO) compliance check-sheets to verify that entry into technical specification action conditions is undertaken in accordance with station procedures. He observed that records of such entries are being managed generally well in light of the volume of planned and unplanned entries at the time but with some minor inconsistencies noted.
25. The RTR Review team summarised the three opportunities for improvement (OFI) from its inspections and surveillances. The inspector has taken cognisance of two of these findings in his intervention report [19] due to the overlap in inspection activities:
 - OFI 1 - Inconsistent application of outage protected plant may leave shutdown cooling plant vulnerable. The station was advised to review protected plant status and demarcation for shutdown cooling equipment.
 - OFI 3 - Peers and leaders are not consistently reinforcing high standards and expectations set by Station management. This observation is pertinent to recent enhanced regulatory interest in the effectiveness of use and coaching of human performance tools. Despite this the inspector generally observed improvements to standards of housekeeping during the week and effectiveness of laydown area protocols.
26. The inspector examined the status of adherence of the working patterns of staff and contractors to the working time directive and the risk assessment process used to justify derogations for extended working. Improvements to the risk assessment process are evident through enhanced attention to fatigue and the specific obligation on team leaders to reinforce mitigations to affected personnel.
27. The inspector allocated an IIS rating of 3 (adequate) for LC24 – Operating Instructions, in light of the generally satisfactory standard of procedural use and adherence sampled during the intervention. There are no findings from his inspection that could significantly undermine nuclear safety or prevent issue of the consent to start-up.

3.1.2 Hunterston B 2014 events follow up

28. An intervention was conducted by two ONR specialist inspectors (Leadership and Management for Safety and human factors) approximately one month prior to the R3 outage to follow up on progress towards the implementation of corrective actions to address the findings of several events at Hunterston B during 2014. The findings of this intervention are presented in the IR, reference [20].
29. Of particular focus during this intervention were NGL's significant adverse condition investigations (SACIs):
 - No. 889123 Emergency Breathing Air System - Safety Rule Event, 18 July 2014
 - No. 892100 Unexpected Air Release Whilst Removing Mulsifyre Pipework, 5 August 2014
 - No. 896816 4C1 and 4C2 Gas Circulator Protection trip due to an oil system shutdown, 2 September 2014 and,
 - No. 916899 TG7 Feed Heater Trip (Incorrect operation of Condensate Boiler Pump 7B discharge valve, 25 December 2014.
30. Interventions relating to LC24 - Operating Instructions and LC26 - Control and Supervision of Operations (see section 3.1.3) were also undertaken.
31. From the evidence presented, the inspectors judged that NGL had made good progress towards implementing corrective actions to address issues identified during its SACIs. The station's management recognises the potential severity of the events experienced in 2014 and understands the root causes identified via investigations. The station has commenced multiple initiatives aimed at preventing reoccurrence, including an extensive human performance (HuP) programme. The station management accepts that further work is required to embed the learning from these events and ensure sustained HuP in the longer term. They are committed to developing a longer term programme of work to achieve this.
32. The inspectors found that the personnel questioned at all levels of the organisation had understood the key messages from recent HuP training activities. Also observed was commitment to further learning through planned self-assessments; benchmarking with other stations and identification / sharing of fleet-wide good practice.
33. It was observed that the station's INA team were engaged with these improvement programmes – providing challenge and monitoring progress. It was noted that Hunterston B management took due cognisance of INA input, demonstrating a healthy working relationship.
34. The inspectors judged NGL to be compliant with its arrangements under LC24 and LC26 justifying ratings of 3 (adequate) for both.
35. In conclusion, the inspectors are of the opinion that the station has made significant progress towards implementing the programme of actions to address the findings from the recent SACIs. No further specific regulatory action is required on this matter. ONR will continue to monitor progress in delivering Hunterston B's longer-term plan to confirm appropriate HuP is sustained and good practices are shared.

3.1.3 Outage Organisation: Control and Supervision

36. As part of the intervention detailed in section 3.1.2, the inspectors met with the Station operations manager and the outage shift manager to discuss actions taken to address identified deficiencies in the operations outage organisation.

37. The inspectors had reviewed the 2014 gas circulator protection trip SACI (No. 896816) and considered that organisational issues contributing to the event had been adequately captured in the corrective action together with other measures needed to address human performance issues; adequacy of operational instructions; a review of critical outage tasks; a design review of an electrical interlock and measures to address worker fatigue.
38. During their visit to the station, the inspectors were provided with a description of the organisational changes to the operations outage team structure. This included: a broader structure with appointment of an outage co-ordinator; a recommissioning operations controller and a central control room (CCR) outage duly appointed person (DAP) to co-ordinate release of plant at busy times; and the creation of two new lead senior authorised person (SAP) roles to provide oversight of reactor and turbine operations respectively.
39. Other changes included; the introduction of a twelve hour continuous rota to facilitate 24 hour working; reinforced standards for pre-job briefs; handover arrangements; introduction of two specific operations outage meetings; and a review of training with a plan for simulator based control room course.
40. The inspectors were given a copy of an operations department procedure entitled 'Operations Outage Team Organisation During Major Outages'. It sets out the team structure and their responsibilities to ensure supervision, oversight and capture key communications activities. It was observed to be clearly set out and addresses many of the actions raised in the various SACIs.
41. Measures the station is taking to address overtime working and fatigue were reviewed during discussions with an HR business partner and the HU performance lead and the inspectors considered that the station has made reasonable plans to address the issue, that plans have been made to embed the fatigue risk assessment process and monitor compliance and is engaging with the rest of the NGL fleet to share and develop good practice.
42. The inspectors recommended to the station that;
 - following completion of the planned self-assessment exercise/ effectiveness review, that the outage structure and its justification be captured in the station's nuclear baseline;
 - the station considers using its LC36 arrangements to assess the change, since their management of change procedure provides for a structured approach for risk assessment; and
 - the arrangements be updated to include reference to the new worker fatigue risk assessment form being piloted during the R3 outage.
43. Overall the inspectors were satisfied with the measures the station is taking to address the operations outage organisation. An IIS rating of 3 (adequate) was assigned

3.1.4 Radiological Protection

44. The IR [21] and subsequent contact record (CR) [22] present the findings of the radiological protection inspector.
45. The radiological protection inspector conducted an intervention on 23 September 2015 to establish NGL's on-going compliance with the Ionising Radiations Regulations 1999 (IRR99) in relation to the matters investigated following local exhaust ventilation (LEV) adverse conditions that arose during vessel entry work during the Reactor 4 statutory outage in 2014. It follows on from a previous ONR intervention in April 2015 [23],

where a review of NGL's own investigation confirmed a number of actions needed to be carried out prior to the R3 outage. In addition, the intervention sought to achieve confidence in the overall radiological protection arrangements for the R3 outage. This was achieved by a review of the LEV issue described above, a review of the overall planned vessel entry campaign (prior to and during the outage), and inspections of the vessel-entry complex, pile-cap/ charge hall area and gas circulation hall.

46. NGL have completed their review of the LEV systems and have made various improvements to processes, systems and plant. They also had a plan in place to complete this work soon after commencement of the R3 outage. Subsequent communications with station during the vessel entry campaign in November 2015 [22] showed that the measures taken were proving to be effective and the inspector was of the opinion that no further intervention during the R3 outage was necessary.
47. During the intervention, no other issues were identified that would question confidence in the overall radiological protection arrangements planned for the R3 outage.

3.1.5 Conventional Health and Safety

48. The IR [24] presents the findings of the ONR non-nuclear health and safety inspector. The inspection focussed on NGL's arrangements for managing conventional health and safety (including contractor management), focusing on working at height and the nature of improvements to the R3 and R4 cooling tower legionella risk management arrangements following inspection in 2013.
49. Key locations visited included:
 - R4 cooling tower and dosing station.
 - Turbine hall basement and 20ft levels.
 - Joiner's workshop roof.
 - Hunterston B work at height training facility
 - Outage control centre
 - Charge Hall (R3 side)
50. Walk downs of a number of radiation controlled area (RCA) and non-RCA locations were undertaken to sample outage activities underway at the time of the visit and inspect the management arrangements in place, focussing on working at height. A number of work at height activities/locations were seen which provided insight into NGL's management of working at height.
51. Areas of good or best practice observed by the inspector during the visit included: the integrated outage safety team meetings, the in-house work at height training facility, the dynamic learning assessment induction system, the good use of scaffolding to facilitate work at height activity in the turbine hall, and the use of industrial rope access trade association level 3 staff for rope access work.
52. Areas the inspector identified as requiring improvement included: identification of areas where potentially fragile roof elements may exist, elimination/reduction of rust sediment within the R3 and R4 cooling tower sump, and a review of the methods currently used to cover gaps on scaffold work platforms.
53. The overall impression gained from the inspection was generally a positive one. The station appears to have a very positive attitude towards managing conventional health and safety (CHS) on site and has clearly put a significant amount of effort into managing CHS hazards present as a result of the various outage activities. However, a number of priority actions were identified during the inspection, and in some cases compliance with legislative requirements was not currently being met. The station committed to take prompt action to rectify the deficiencies identified.

54. Based on an assessment that it was necessary for the station to address one or more shortcomings by ONR giving formal instructions for remedial actions to be taken, the inspector has assigned a Health and Safety at Work Act 1974 (HSAW) IIS topic rating of '4 – below standard' for the visit. The formal instructions were provided at the hot feedback meeting with the station on the 6 November 2015 [24]. The station agreed to write a formal response letter to ONR by the end of December 2015 setting out their actions taken to resolve the matters identified.
55. Based on strong evidence that NGL management are up to the task of managing CHS and there is potential for good performance the inspector assigned a HSAW IIS management rating of 2 (good standard) for the visit.
56. The inspector has confirmed [25] that his inspection did not identify any CHS issues that prevent the return to service of R3.

3.2 ENGINEERING ASSESSMENTS

3.2.1 Civil Engineering

57. The CR [26] and Assessment Report (AR) [27] present the findings from the inspector's pre-outage visit and of the ONR assessment of the pre-stressed concrete pressure vessel (PCPV) appointed examiner's (APEX) statutory examination report [28] and a selection of supporting documents.
58. The scope of the ONR assessment covered inspections and tests of certain key safety-related components of the reactor pressure vessel including, tendon loads, tendon anchorages, tendon corrosion, concrete surfaces, foundation tilt and settlements, vibrating wire strain gauges (VWSG), vessel concrete liner temperatures, reactor coolant leakage, top cap deflections, tendon tensile strength and pressure vessel cooling water leakage. The key findings from the intervention were as follows:
 - NGL's APEX has planned the surveillances, inspections and tests in accordance with their branch instructions.
 - Settlement and tilt survey points, E and F, have been re-established and surveyed. These survey points allow the licensee to measure any tilt of the reactor. These points were last measured in 1985, and the initial results appear satisfactory.
 - The tendon load tests, anchorage inspections, metallurgical examinations and tensile tests on the tendons have been completed in advance of the outage. The results from these inspections are satisfactory.
 - A thorough survey to determine the available number of tendons was carried out as a result of the finding of empty ducts during a previous ONR inspection. The total number of tendons was found to be 2810, instead of 2816 as stated in the safety case. Nevertheless the PCPV has enough redundancy to accommodate this reduction.
 - The insufficient and poor quality of the insulation of the superheater pipework is heating local areas of the external face of the PCPV to temperatures above the station limits for bulk concrete temperature. The station has planned to improve the insulation of the pipework during this outage. The APEX will inspect these areas of the PCPV during the outage to identify the impact of these temperatures on the concrete.
59. The statutory examination report describes NGL's progress with the statutory surveillances, inspections and tests, prescribed in the branch instructions that include

the requirements of the MITS. Its purpose is to confirm the condition of the PCPV for start-up and it will be re-issued following start-up, which will be reflected in the '28 day report'. It concludes from the data obtained so far that R3 PCPV is in good condition with sufficient pre-stress available to resist imposed loads, and is fit for continuing service for a period of three years.

60. The inspector's assessment has led to him making the following eight recommendations, none of which prevent the start-up of the reactor. These have been captured in the ONR issues database:

- Station to include tendon grease sampling in the next statutory outage for Hunterston B R3.
- APEX to examine "Demec" gauge (dismountable mechanical strain gauges) readings and discuss their significance in the next Statutory Examination Report
- NGL to provide guidance in interpreting the concrete crack inspection results and specifying action levels. This recommendation should be completed within three years.
- Station to address the safety concerns expressed by BALVAC (a contract partner) in their tendon load check report, namely the capping of the ends of the tendons in the lower stressing gallery and the safety of the access platform. This recommendation should be completed before the next periodic tendon stress checks.
- Station to ensure that inspection procedures require the contractor to examine anchorages for tendons which are being withdrawn for examination. This recommendation should be complete before the next statutory outage for Hunterston B R3.
- Station to establish local PCPV temperature limits and methods of measurement which should include taking account of VWSG readings. This recommendation shall be completed within twelve months.
- Station to re-measure the surface temperatures local to the superheater penetrations following return to power to confirm that the modifications to the pipework lagging have been effective. This recommendation shall be completed within three months of return to power of Hunterston B R3.
- APEX to update the PCPV written scheme of examination to ensure it correctly reflects the current legal owner of the PCPVs. This recommendation should be completed within six months.

61. The Inspector discussed the recommendations within the previous '28-day report', from the 2012 R3 outage with the APEX. All but one of those had been closed out. The remaining recommendation with regard to the sealing of historic pressure cooling water leaks remains open as the leaks are considered too small to seal. This has been justified by six monthly inspections and the APEX has advised that no measurable sign of continuing leakage is present at the sites in question. The '28-day report' will update this recommendation. The inspector considered the proposed approach to be reasonable.

62. From the results of the surveillances, inspections and tests as reported in the documentation provided, the inspector is content to support the return to service of the Hunterston B R3 PCPV for a period of three years, subject to normal in-service surveillance. This judgement is based on the inspector's assessment of the data and information presented in the documents provided, and an acceptance of the judgements made by the APEX. He has assigned an LC28 IIS rating of 3 (adequate).

3.2.2 Control and Instrumentation Systems

63. The IR [29] and AR [30] present the findings of the ONR inspection and assessment of control and instrumentation-related outage activities.
64. This assessment covers outage related maintenance activities, including relevant documentation, that have been applied to reactor safety circuits (RSCs) and other control and instrumentation (C&I) equipment and systems that are important to nuclear safety at R3. This includes NGL's compliance at Hunterston B with relevant LCs, notably, LC22 (Modification or experiment on existing plant), LC27 (Safety mechanisms, devices and circuits), LC28 (Examination, inspection, maintenance and testing) and LC30 (Periodic shutdown).
65. In support of the assessment, the inspectors visit to the station during the outage covered the following plant, systems and equipment:
- Reactor safety circuits covering:
 - Maintenance, Inspection and Test Schedule (MITS) activities;
 - Neutron flux detectors;
 - Boiler Trip Logic – functional testing;
 - Guardline systems testing; including final break contactor;
 - Calibration and testing of reactor protection equipment.
 - Gas Circulator instrumentation systems covering:
 - MITS activities;
 - Calibration and testing of instrumentation on gas circulators;
 - Reactor shutdown sequence equipment (RSSE), including:
 - Functional testing and maintenance of C&I equipment,
 - Current status of investigation into failure of gas circulator 3B2 to start from the RSSE.
 - Relevant ECs, including:
 - Gas circulator over frequency trip (EC350777)
 - Gas circulator lubrication oil and differential pressure trip relay replacement (EC353712)
 - T2 Controller loop 1 servo replacement (EC 335142 & EC 350948).
66. This assessment has found that, for those areas sampled, the commitments made in the OIR [6] for C&I systems and equipment important to nuclear safety at R3 have been satisfied. The inspection of the work activities covered during the associated intervention has, generally, found that the workmanship applied was adequate and consistent with the standards expected from C&I suitably qualified and experienced personnel.
67. Five C&I related ECs were intended to be completed during the outage. Of these, one was not able to be undertaken and a second had to be modified prior to the outage to reduce its scope, due to the relevant equipment supplier going out of business. NGL informed the inspector that negotiations with were underway to rectify the situation. Although this has caused a delay at Hunterston B, it is a cross the fleet issue and it will be followed up through normal regulatory business.
68. Two actions were raised during the inspections which have been captured on the Hunterston B R3 Outage 2015 action tracking sheet [18]. The first concerned the R3 neutron flux detector results and the second related to plots taken from the guardline Ladic units. Neither of these actions require resolution prior to return to service of R3 and are being managed through normal business.

69. The inspector considered the issue of gas circulator (3B2) not starting, which was diagnosed to an earth fault trip relay operating. An investigation has taken place and the inspector is content with the arguments made and considered the outcome to be satisfactory.
70. The inspection of the maintenance documentation and records within the station asset management system (AMS) highlighted that a number of the paper maintenance records had not been scanned into it. The samples were taken over a nine month period; NGL investigated this and reported that the problem was loss of resource within the administration staff in the records office. The inspector was informed that this is being addressed in the short term by using staff from elsewhere within the business, on an overtime basis, to scan the backlog of documentation. The inspector noted that this problem had existed for some time and fed back that he considered that further mitigating actions were required to resolve this issue. Discussion with the nominated site inspector has shown that this is a wider issue which has been raised with the station previously. The specialist inspector is therefore content that this action is being taken forward as normal business for the site inspector.
71. The overall outcome from the safety inspection of the Hunterston B R3 outage related C&I work on R3, is that their implementation of the LC22, LC27 and LC28 arrangements for the C&I equipment are deemed to be satisfactory. The inspection carried out found that no issues have been identified from HNB C&I work that should affect the return to service of R3, on completion of the planned and emergent work.
72. Some activities remained outstanding at the time of the assessment. However, the inspector has received assurance from the station that the remaining work will be completed in full before return to service of R3 and is therefore content to recommend that ONR grants consent for R3 at Hunterston B to start-up following the 2015 periodic shutdown.
73. The inspector assigned an IIS rating of 3 (adequate) to LC22, LC 27 and LC28.

3.2.3 Electrical Engineering

74. The IR [31] and AR [32] present the findings of the ONR inspection and assessment of the electrical engineering work conducted during the outage period. It sought to confirm that the planned examination, maintenance, inspection, test and modification activities are undertaken during the outage period and considered the electrical work being undertaken as part of the R3 outage. This focused mainly on the following planned work detailed in the outage intentions document [6].
 - Essential supplies (MITS section 9).
 - Gas circulators.
 - Generator transformer 7 replacement.
75. The majority of outage-related electrical work was directed towards electrical switchboards, switchgear, generator transformer 7 replacement, station and auxiliary transformer maintenance and gas circulator maintenance activities.
76. For the areas sampled, the inspector was satisfied that the station is maintaining its electrical plant and equipment in accordance with its arrangements.
77. The inspector's sampling of the documentation associated with maintenance activities did not identify any issues of an electrical engineering nature that should delay completion of the R3 outage. Some emergent activities remain outstanding and the inspector has received assurance from the station that the remaining work will be completed in full, or the proposed way forward will be recorded under the station's

outage arrangements. ONR electrical specialists will follow up progress to complete any outstanding electrical work as part of normal regulatory business.

78. The station has identified the following emergent issues:
 - Condition reports were raised in relation to the irregular behaviour of 3B/4B and 7A diesel generators and 3B2 gas circulator during reactor shutdown sequencing equipment functional testing immediately following R3 shutdown.
79. The station has investigated the matters surrounding these anomalies and implemented remedial measures to address them. This has included: carrying out a review of the governor settings for the diesel generators; contacting the original equipment manufacturer for technical support; and carrying out diesel generator operational tests to prove availability for safety duty functions. Furthermore the station proposes to carry out a repeat test of diesel generator 7A prior to R3 start-up and with a vessel pressure greater than 26 bar.
80. The inspector has examined the station safety submission in relation to these anomalies and discussed various aspects of the proposals with station's electrical engineering staff. In conclusion the inspector is content with implementation of the proposed measures, subject to the work being managed under the established outage arrangements.
81. The overall outcome from the safety inspection of the outage related electrical engineering work on R3 is that the implementation of the LC 22, LC 23, LC 28 and LC 30 arrangements for the electrical equipment are deemed to be satisfactory. The inspector did not identify any issues of significance that should prevent ONR from granting consent to allow R3 to restart. Therefore, he recommended that consent was granted for R3 to start-up following its 2015 outage. He has assigned an LC28 IIS rating of 3 (adequate).

3.2.4 Graphite Core Integrity

82. During the periodic shutdown, NGL has undertaken inspections, measurements and taken samples of the reactor graphite core, as required by the plant maintenance schedule. A specialist graphite inspector examined how the licensee was performing the various periodic shutdown-related activities necessary to ensure the integrity of the graphite core. The findings of his inspection are given in his intervention record [33] and further developed in his assessment report. [34]
83. NGL inspected and measured the dimensions of twenty-six central and five peripheral fuel channels and a single control rod channel was visually inspected. Trepanning took place in six fuel channels and thirty-five trepanned samples were removed, one short of the target number but five more than required by the plant maintenance schedule in compliance with LC28. Measurements performed on these samples to determine their physical properties will not be available for several months and are not required to support return to service. Although not a requirement of the plant maintenance schedule, seven channels were inspected using the prototype eddy current inspection tool (PECIT) to determine the capability of the tool to detect sub-surface defects and measure graphite density.
84. The specialist inspector reports that five new bore cracks were observed including one full height axial crack. He further reports that the inspections found three bricks containing single full height keyway root cracks (KRC).
85. NGL have concluded that the observed level of bore and keyway root cracking is low, the cracks have not opened and that the core is essentially intact. The cracks have not resulted in any additional core distortion and no other significant observations were made in any other channels.

86. It is believed that most, if not all other cracks that have been discovered at Hunterston B and the other AGRs, have originated at the brick bore. These are a consequence of early life ageing behaviour, when the contraction of the graphite is such that the bore is in tension. Most cracks are smaller than full height, some run circumferentially. Both of these categories are of lesser concern than ones that extend the full axial height. These cracks sometimes occur singly, but occasionally as double cracks normally 180° apart.
87. The origin of KRCs is different. Their occurrence has only been postulated until their detection during the previous R4 outage, although these were considered to be in a small population of high shrinkage bricks. These cracks are characteristic of later life behaviour, when the stresses have reversed and the graphite at the outer surface of the moderator fuel bricks, rather than the inner surface, is in tension. A full height bore crack and a KRC are believed to have the same structural significance, the importance of the latter type is that there may eventually be many more of them. The observation of three KRCs in the core of Hunterston B R3 during this periodic shutdown therefore marks a significant point in the life cycle of the graphite fuel bricks of the reactor and is the first such observation in the main population of bricks.
88. In his assessment report, the specialist inspector presents his views on the claims, arguments and evidence of NGL's safety case. ONR has already written to NGL [35] to state that it appears that operation can currently only be justified for a limited period, perhaps as little as six months.
89. The inspector concludes that there are no significant issues that should prevent ONR giving consent for the return to service of Hunterston B Reactor 3. However, it is not possible to state that there is high confidence that the amount of cracking will be less than the axially cracked bricks operating limit in twelve months, although he is reasonably confident that it will not be so in six months. In addition NGL may be able to justify operation for longer than six months and it is noted that within six months there will be information from Hinkley Point B R3 and Hunterston B R4 scheduled inspection shutdowns that may contribute information to strengthen their justification. He therefore recommends the need for a regulatory hold point on operation after six months, with a further one after no more than twelve months from the current restart. On this basis it seems desirable that the licensee plans on a further inspection being necessary after six months unless there are significant safety case related developments.
90. The inspector allocated an IIS rating of 3 (adequate) for this intervention based on the conclusion that the case does adequately support return to service of HNB R3 with high confidence for six months and recognises that beyond that period further substantiation of the safety case is required.

3.2.5 Mechanical Engineering

91. IR [36] and AR [37] present the findings of the ONR assessment of the adequacy of the mechanical engineering-related activities conducted by the licensee to comply with the requirements of LC28 – Examination, Inspection, Maintenance and Testing (EIM&T) against a sample of nuclear safety-significant reactor components.
92. The scope of the inspection and subsequent assessment included:
- EIM&T of main and emergency boiler feed pumps;
 - EIM&T of gas circulators;
 - EIM&T of safety significant valves;
 - EIM&T of control rod assemblies.

93. In December 2013, the impeller of the main boiler feed pump (MBFP) disintegrated. The root cause of the failure was attributed to the growth of a fatigue crack and the NGL SACI recommended that manufacturing quality assurance standards should be improved. Subsequently the impeller has been redesigned to increase its fatigue life and its quality assurance level has been raised from three to one. NGL had intended to replace the existing R3 impeller cartridge during this outage. However, the manufacturer had not achieved the new more stringent quality assurance level. Consequently, main boiler feed pump impeller cartridge will not be replaced during the R3 outage but will be soon after return to service whilst the reactor is under power.
94. The inspector reviewed the LCO for the boiler feed pumps and was satisfied that this is permissible under the current nuclear safety case. In addition the inspector has reviewed the outage scope deletion for the replacement of the MBFP pressure stage cartridge and is satisfied that NGL has justified why it can be deleted from the outage scope and that no inspection will be required for a further 145 days of operation.
95. The inspector was satisfied that EIM&T of the main and emergency boiler feed system is being adequately controlled.
96. The station has taken the decision to exchange gas circulators 3C1 (service life of four and a half years) and 3D2 (service life three years) earlier than the standard interval of twelve years required by the MITS. This is in support of a thermocouple installation (covered by EC 352543) that will be carried out this outage and Hunterston B's ongoing programme for management of stator life.
97. The inspector observed good practice in the effective use of a spreadsheet for the tracking of the EIM&T status of all the gas circulators used at the station.
98. The inspector sampled a number of quality plans, non-destructive testing reports, work order cards (WOCs) and job instructions relating to the gas circulators and found them all to be in order, providing confidence that work undertaken has been carried out in an appropriate manner.
99. During the Hunterston B R4 outage in 2014, the gas circulator lubricating oil system in quadrant 4C was taken out of service while its gas circulators were running, which resulted in bearing damage. During his intervention the inspector reviewed NGL's progress in implementing an engineering solution to prevent a future occurrence. He was provided with an overview of an electrical interlock system that will be implemented on all AGR gas circulators, with modification of the R4 gas circulator lubrication system scheduled for the next intermediate (graphite inspection) outage. In addition to the physical modifications, NGL stated that it has carried out a human performance review and had introduced new procedural changes to prevent a recurrence.
100. The inspector was satisfied that NGL had taken appropriate action across its AGR fleet to reduce the risk of the gas circulator lubrication systems being taken out of service whilst the gas circulators are running and in conclusion was satisfied that EIM&T associated with the gas circulators was being adequately controlled.
101. During this outage, all five gas safety relief valves (GSRVs) and two out of three isolating valves will be removed and replaced with overhauled valves. The inspector reviewed the completed job instructions for the GSRV's and noted the use of a hand drawn sketch which he considered to be an indication of the fitter being unsure whether the correct measurement was being taken – this had been signed off as correct by the relevant system engineer. In the inspectors opinion the fitter was demonstrating good behavioural performance through a questioning attitude. The system engineer was informed that a similar example of an added sketch had been observed during a recent outage inspection at Dungeness B power station. It was

- indicated that this is an example of where job instructions could be improved by the use of diagrams to reduce the risk of error.
102. The inspector discussed the arrangements for ensuring that the minimum required number of GSRVs were available and functional within the specified outage timescales with the system engineer and was provided with an explanation that demonstrated that satisfactory arrangements are in place.
 103. The existing 20 bar(g) bursting discs in the GSRV filters are being replaced with 5 bar(g) bursting discs following a reassessment of the filter differential pressure withstand. The Inspector reviewed the manufacturing quality documentation for the new bursting discs which showed that destructive testing of a sample of five discs had produced satisfactory results. The inspector was also provided with an explanation of how the job instruction requires a check to confirm that the bursting discs had been fitted in the correct orientation.
 104. The inspector was satisfied that EIM&T associated with the safety-significant valves was adequately controlled.
 105. The inspector received an overview of the EIM&T arrangements carried out on the control rod assemblies (CRA) from the fuel route systems engineer. From the information provided it was shown that control rod drop test times have been consistent over several years and that there has been no observed performance reduction at Hunterston B.
 106. The inspector was satisfied that EIM&T associated with the CRAs was adequately controlled. He is satisfied that the control rod drop tests are carried out in line with the requirements of the safety case, through the relevant technical specification and suitable and sufficient records are been kept and monitored to identify problems both re-actively and pro-actively.
 107. Overall, the mechanical engineering inspector was satisfied that the LC28 arrangements in place are adequate and have been adequately implemented. He had no objection to the proposed activities associated with the release of hold point for Hunterston B R3 to return to power for the next operating cycle. He assigned an LC28 IIS rating of 3 (adequate).

3.2.6 Structural Integrity

108. The IR [38] and AR [39] present the findings of the ONR assessment of the structural integrity aspects of the licensee's examination, maintenance, inspection and testing of components with a nuclear safety function during the 2015 outage (including welds, pipework, vessels, components and metallic reactor internal structures but excluding those associated with inspection of the graphite core).
109. The inspector identified the following areas for sampling during the site inspection which was conducted approximately half way through the periodic shutdown:
 - reactor seawater cooling system inspections (including high density polyethylene (HDPE) and other pipework replacement programs);
 - steam and feed system in-service inspections;
 - reactor internal inspections (steel components);
 - pipe hanger and restraint inspections (steam and feed pipework);
 - flow assisted corrosion inspections;
 - boiler inspection and monitoring; and
 - attendance at the fourth outage assessment panel (OAP) meeting.

110. The inspector observed good progress with work to replace pipework in the wash water part of the reactor seawater cooling system. External corrosion had been identified on existing pipework which was being replaced and re-lined.
111. The only flow assisted corrosion (FAC) reported by the station was a small section of pipework associated with a vacuum system which had broken through as a small diameter hole (approximately 1 cm), which the inspector judged as being unlikely to have a direct impact on nuclear or personnel safety. The inspector was content that the FAC inspection program was being adequately managed and conducted by the FAC co-ordinator and OAP.
112. With regard to pipe hanger and restraint inspections the inspector reviewed the pre-outage hot hanger survey report, carried out EASL (a contract partner). The inspector observed that although the audit body were generally content that the survey was completed as required, there were some deficiencies in the quality of the hot survey. EASL suggested that this was due to inexperience of the team. At the time of the inspection the inspector was told by the hanger survey project manager that despite the team's inexperience, he had no issues in how the team were performing the cold survey. In spite of this the inspector was satisfied that the pipework and hanger system inspection programme was being adequately controlled.
113. The inspector was provided with an overview of the intended work on the boilers, which had not started at the time of the inspection. The inspector noted that the reactor systems group head (also the boiler assessment panel (BAP) chairman) did not have a detailed knowledge of the internal inspections due to be performed on the boiler. He also noted that the chair of the OAP had changed mid outage. The inspector raised these concerns with the technical safety and support manager (TSSM) at his inspection close out meeting. Overall, the inspector was satisfied that the boiler inspection program is being adequately controlled.
114. The inspector noted that the PSSR competent person (CP) was not aware of the full extent or repair work to the start-up vessel (SUV) – he raised this with the OAP chair. The inspector has since reviewed OAP minutes which show that the CP has noted they were not made aware of this repair and it was carried out without their consultation. This has been flagged as a communications failure and will be dealt with outside the OAP. The OAP accepted the SUV for return to service at this same meeting with the PSSR CP present. Despite this issue the inspector was satisfied that the PSSR inspections were being adequately executed and controlled by the Licensee.
115. The inspector attended an OAP meeting and was satisfied that due process was being followed.
116. With respect to steam and feed system in-service inspections the inspector was content that the inspection programme was being conducted in accordance with the OIR, with any indications of note dealt with appropriately by the licensee via the OAP.
117. Subsequent to the inspectors visit, the station entered an event recovery following the detection of suspect thermal fatigue cracking in a number of the twelve hot air reheat release branches. Following discussion with the OAP chair, the inspector is satisfied with the proposed solution to the issue and observed good practice in continuing to monitor for thermal fatigue cracking after earlier remedial action to mitigate against the overall cause of the problem.
118. Overall, the inspector was satisfied that the licensee has undertaken sufficient inspection and assessment to support the safe return to service of Hunterston R3 from a structural integrity perspective, and no issues have been found that would prevent Hunterston R3 from returning to service for the next operational period. He has assigned an LC28 IIS rating of 3 (adequate).

119. This conclusion was based on an amount of advance information that had yet to complete due process, and was therefore contingent on receiving a number of additional documents and assurances. The inspector made a number of recommendations in respect of this which have been included in, and managed via, the ONR Hunterston B R3 outage action tracking sheet [18]. These include the requirement to demonstrate satisfactory completion of the Pressure Systems Safety Regulations (PSSR) inspections and statements from the competent person, which have now been submitted as part of the application for consent to return to service [1].

3.3 MEETINGS

3.3.1 Outage Intentions Meeting (OIM)

120. On 22 April 2015 the site inspector and superintending inspectors attended the OIM [40] for statutory outage of R3 at Hunterston B. The purpose of the meeting was for the station to present the scope of work intended to be carried out in the R3 2015 statutory outage to ONR.
121. The ONR inspectors and the station agreed the importance of ensuring mutual understanding of regulatory expectations in respect to the possible detection of keyway root cracking in the graphite core, thus to ensure efficient decision making during the statutory outage. ONR advised at the time that the contingency safety case, to be invoked in the event of detecting a main population keyway root crack, had not been formally assessed by ONR; ONR advised the timely assessment of this case would represent a programme priority and the outcome of an assessment would be reported to NGL before the start of the outage at Hunterston B.
122. The OIM for the Reactor 3 statutory outage provided sufficient information against which to plan ONR specialist inspection resources.

3.3.2 Mid-Outage Meeting (MOM)

123. The MOM [41] was held on 26 October 2015, day 25 of the outage programme. ONR was represented by the site inspector, the outage project inspector and the structural integrity inspector. The INA was also present.
124. The purpose of the meeting was to discuss: progress of the outage so far; understand the remaining validity of assumptions leading to ONR providing consent for return to service; and to discuss any regulatory issues.
125. The progress against the critical path was reported (as of day 25 of the outage).
126. A brief review of the actions captured to date was carried. All six of the actions were currently in progress so there was no requirement for further action resulting from this brief review. It was noted that as all of the interventions had not been completed that further actions may be raised.

3.3.3 Start-Up Meeting (SUM)

127. The SUM [42] took place on day 33 (of an expected 57) of the planned outage. The civil nuclear reactor programme head of assessment represented ONR with support from the nominated site inspector and a specialist structural integrity inspector.
128. The meeting was preceded by a plant walk down which included the cooling water pump-house; generator transformer compound and the reactor charge hall. The following observations were made:

- There was evidence of significant investment in the cooling water system, notably improvements to drum screen performance that will enhance management of marine ingress, and also to the main cooling water pumps;
 - A successful replacement of the three generator transformer phases, a complex work site that has been managed safely and to a high standard;
 - Effective management of various competing work-faces at the R3 3 pilecap and judicious use of C2 classified contamination controlled areas;
 - A good standard of housekeeping and material condition of plant in the areas inspected;
 - Observations that a small number of staff were not wearing correct personal protective equipment in designated areas of the radiological controlled area. The station management were notified during the visit.
129. The station had submitted in draft a start-up report in prior to the meeting [43] which provided an adequate point-in-time record of outage activities and results at the time of the meeting. Key points from the meeting are as follows:
- The planned programme of 31 fuel channel inspections in the graphite core is complete and all results sentenced appropriately through the station's GAP. The GAP sentenced four full height axial bore cracks, three of which were classified as keyway root cracks under its arrangements. This is the first discovery of this mechanism in the main population of bricks across the four Hunterston and Hinkley Point B cores which have occurred several years earlier than materials property models previously indicate.
 - Outside the start-up meeting, the nuclear safety group head advised preliminary intentions to undertake up to four additional targeted fuel channel inspections using NICIE 2 equipment. The purpose of those inspections would be to potentially identify additional key way root crack bricks and thus provide the station a larger sample size to provide representative information on crack growth rate; this will be beneficial to its understanding of the safe operational envelope going forward. It was emphasised that NGL considered that the additional inspections would not enhance to any deterministic level the confidence in the core at this time nor the validity of the return to service safety case.
 - ONR specialist inspectors are continuing to review the results from these inspections which will inform ONR's consideration for consent to return to service.
 - ONR emphasised concern over the equipment reliability issues encountered with NICIE 2 equipment and the short-ported plug during this outage, particularly the reliability of spares.
 - ONR was encouraged by the observation of the use of PECIT on seven fuel channels - extended from six channels in order to test the tool on a channel with a confirmed keyway root crack.
 - There has been minimal deviation in outage scope so far which ensures confidence that the full scope of planned outage activities will be undertaken.
 - The station appears to have been successful in applying learning from incidents which occurred during the periodic shutdown of Reactor 4 during 2014.
 - In-vessel inspections of the first two (of four) boiler quadrants have led to a number of repairs which are within the expectations of the station.

- The station appears to have been successful in minimising positive pressures in the LEV systems as a result of a range of improvements to procedural control and pressure monitoring capability. This has resulted in a notable reduction in vessel-entry related personal contamination incidents during this outage.
 - It is evident that management of worker fatigue is more proactive through targeted risk assessments undertaken for staff and contractors working long hours.
 - The enhanced role of area safety co-ordinators in coaching staff and contractors on industrial safety matters (notably hot-work and working at height) is judged to have been successful in addressing shortfalls in standards early-on in the outage.
130. In addition to the points above a discussion took place with the station on aspects relating to the return to service safety case. It was agreed that further discussions would be required, especially in the light of the emergent graphite issues, as the outage progressed towards completion.

3.4 EMERGENT ISSUES

131. During the outage inspection and maintenance activities, defects in plant condition were identified which required unplanned additional work and safety justification. The emergent issues of significance to return to service were:
- Hunterston B entered an event recovery during this periodic shutdown following the detection of suspect thermal fatigue cracking in several of the twelve (in total) hot air reheat release branches. These components had been previously modified to remove the suspected cause of the cracking mechanism but recent inspections have shown a further degradation mechanism may be present. Investigation has revealed that the new mechanism for the further cracking may be due to a vacuum created in the system post trip when the turbines run down. This would draw condensate from the air release pipework onto the hot pipework at the branch and initiating the cracking mechanism. To mitigate this, a further modification has been proposed to fit isolation valves to this pipework so that during a trip they can be manually closed thereby preventing the condensate draw. The further modification appears to be reasonable and the ONR structural integrity inspector supports the station in having continued to monitor this system despite their previous implementation of the modification.
 - The observation of three KRC in the graphite core of Hunterston B R3. This marks a significant point in the lifecycle of the graphite fuel bricks of the reactor. This onset is earlier by some years than the dates predicted in the safety cases. This issue has been discussed in section 3.2.4 of this report.
 - Discovery of five new bore cracks, three of which were observed in newly inspected channels, and two in previously inspected channels. These observations are not obviously consistent with NGL's theory of bore cracking. Two of the cracks occurred in peripheral channels which challenges the existing explanations of brick stresses and requires further analysis. This issue has been discussed in section 3.2.4 of this report.

3.4.1 Engineering Change Submissions

132. The following three ECs have been submitted to ONR prior to start-up.

- EC353660: Return to Service of Reactor 3 with respect to Boiler NDT inspections and repair in the 2015 statutory outage. [10]
 - EC353661: Return to service of R3 with respect to NDT inspections undertaken during the Reactor 3 2015 outage. [11]
 - EC353707: Justification for the Return to Service of Hunterston B Reactor 3 following the Graphite Core Inspections at the 2015 Periodic Shutdown. ^[12]
133. Receipt of the INSA certificates [13], [14] & [15] confirms that these ECs have passed through INA's due process.

4 MATTERS ARISING FROM ONR'S WORK

134. I have considered the licensee's request to ONR to grant a consent under LC30(3) to start-up Hunterston B R3 on completion of its periodic shutdown. 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 NGL's internal regulator, INA, the statements of the PSSR competent persons and the findings and opinions of ONR specialist inspectors and the ONR site inspector.
135. The Hunterston B station director wrote to ONR on the 25 November 2015 requesting consent to start-up. His letter states that the status of all outage modifications have been reviewed to confirm that the plant will be in a satisfactory condition for return to service. In addition all maintenance schedule work will be completed, subject to monitoring by the operational safety review committee (OSRC), excepting those items that which can only be carried out during return to service.
136. The PSSR competent persons for the PCPV, the reactor penetrations and the balance of plant have each confirmed that they are content for R3 to start-up.
137. ONR specialist assessors from the various disciplines and the site inspector undertook inspections to support my permissioning work.
- 138.** Each discipline has produced a report that presents the inspection findings, inspector's opinions, judgments and recommendations. A number of recommendations and actions arose from the inspectors' work which are recorded in the ONR Hunterston B 2015 R3 Outage Action Tracker, reference [18]. None of the outstanding actions have been deemed sufficiently significant for ONR to withhold consent to start-up R3. All the inspection and assessment reports contain either a statement supporting issuing consent to start-up R3, or note that there is no reason to withhold consent and these have all completed peer review and Professional Lead sign-off where necessary. I consulted with other relevant regulators, SEPA and CNS, to establish if either had any specific objections that would prevent ONR from issuing LI 549, consent to start-up Hunterston B R3. Both the SEPA [44] and CNS [45] have confirmed they do not object to ONR granting consent.

5 CONCLUSIONS

139. The Hunterston B Reactor 3 (R3) periodic shutdown has been undertaken in accordance with the requirements of the work scope outlined within the NGL Outage Intentions Document.
140. The licensee has followed its arrangements in undertaking the periodic shutdown, culminating in the Hunterston B station director writing to ONR requesting consent to start-up R3. He states that on completion of the remaining activities he is satisfied that R3 is safe for return to service and sufficient procedures are in place to assure safe operation through to the next shutdown. In line with NGL due process the completion of the remaining activities will be reported in the '28-day report'.
141. The licensee's internal regulator, Independent Nuclear Assurance (INA), has provided the Concurrence Part B report that supports the return to service of Hunterston B R3 following its statutory outage.
142. The Pressure Systems Safety Regulations 2000 (PSSR) competent persons have each confirmed that they are content for R3 to start-up.
143. ONR inspectors have sampled the safety management and engineering activities throughout the shutdown and judged them to be adequate, and all support issuing consent to start-up R3. All actions raised during their inspections and assessments have been satisfactorily addressed or have acceptable plans for resolution.
144. I consider that the licensee delivered a shutdown that was safely managed and completed the required safety related work activities.
145. I am satisfied that, noting NGL's commitment to present a new safety case argument no later than six months following start-up, the licensee's justification to start-up R3 and operate to the next shutdown is adequate.
146. I have prepared Hunterston B Licence Instrument 549, for Licence Condition 30(3) Consent, in conjunction with this project assessment report. The licence instrument is one of the standard formats given within ONR procedures and does not require review by the Government Legal Office.

6 RECOMMENDATIONS

147. I recommend that the superintending inspector signs this project assessment report to confirm support for the ONR technical and regulatory arguments that justify issuing Hunterston B Licence Instrument 549.
148. I recommend that the deputy chief inspector signs Hunterston B Licence Instrument 549, which grants consent under Licence Condition 30(3) attached to Nuclear Site Licence No. Sc.13 to start-up Hunterston B Reactor 3.
149. I recommend that ONR should write to NGL promptly to set out the regulatory concerns raised by the specialist inspector relating to the graphite safety case. The letter should:
- State that NGL will be required to shutdown Reactor 3 no later than six months after start-up in order to undertake further core inspections, unless it can be demonstrated that an adequate safety case can be made to substantiate operation up to a maximum of twelve months. In developing such a case, ONR will expect NGL to take cognisance of the inspection findings in the forthcoming Hinkley Point B Reactor 3 periodic shutdown and interim outage at Hunterston B Reactor 4; and
 - Provide clarity on the nature (and mechanism for release) of regulatory hold points at six months and, should a satisfactory case subsequently be made, at no more than twelve months from restart.

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