Office for Nuclear Regulation

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Agreements to revised safety case for graphite core and core restraint: operation after onset of keyway root cracking, for Hunterston B and Hinkley Point B power stations.

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EXECUTIVE SUMMARY

Title

Agreements to revised safety case for graphite core and core restraint: operation after onset of keyway root cracking, for Hunterston B and Hinkley Point B power stations.

Permission Requested

EDF Nuclear Generation Limited (NGL) has requested two agreements under its arrangements as part of LC 22(1) for the implementation of the new Safety case NP/SC 7716 for Hunterston B and Hinkley Point B Power Station

Background

Keyway root cracking has been observed at Hunterston B reactor 3 and reactor 4, but not at Hinkley Point B reactor 3 and reactor 4. However, the extant safety case (NP/SC 7662), which covered Hunterston B and Hinkley Point B, was limited up to the onset of keyway root cracking. As a result of observing the phenomenon, EDF NGL has produced a revised safety case with new limits and conditions of operation in response to keyway root cracking of the graphite in the core for the two power stations together with a revised inspection and monitoring strategy to provide more comprehensive evidence of core condition and has requested ONR's agreement in line with its arrangements under LC 22(1).

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

ONR has undertaken specialist assessments in the following areas: structural integrity, fault studies associated with the reliability of the Primary Shutdown system, thermal hydraulics associated with cooling of fuel elements post core distortion, and seismic criteria to confirm that the input values used by NGL were adequate.

The outcome of each of the assessments was that the specialist inspectors had no objections to the granting of the two licence instruments. However, there were a number of recommendations from the assessments, which are captured in appendix 1 and will be aggregated into an ONR level 3 issue for endorsement by the relevant Delivery Management Group (DMG) and communicated to NGL. The thrust of the recommendations is around future submissions and the determination of the life limiting conditions for the core, the ability to ensure adequate and explicit inclusion of all areas within future safety submissions and finally improvement of the graphite core modelling and validation.

Matters arising from ONR's work

There were three points arising from the assessment that will generate further work for ONR and its technical support contractors. These were: the need for the graphite technical advisory committee to review NGL's fuel sleeve impact tests and consider the applicability of the level of uncertainty associated with the impact velocities used in determining crack initiation and gross cracking during a seismic event, for the graphite technical advisory committee to undertake a review of NGL's current seismic validation findings and provide ONR with its assessment of them, and for ONR to carry out a compliance inspection of the use of the Fuel Grab Load Trace Technique in monitoring core distortion.

Conclusions

I conclude that a suitable and sufficient assessment has been carried out on NGL's safety case submission (NP/SC 7716) and that there are no objections from the specialist inspectors in undertaking the permission.

I also conclude on reviewing the assessments that the permission should be granted and the Licence instruments granted.

Recommendations

I recommend that:

- The Superintending Inspector should sign this Project Assessment Report to confirm support for the technical and regulatory arguments to grant the licence instruments in line with NGLs arrangements under LC 22(1) to implement safety case NP/SC 7716 at Hunterston B and Hinckley Point B.
- Licence instrument 556 is granted to Hunterston B to implement NP/SC 7716
- Licence Instrument 556 is granted to Hinkley point B to implement NP/SC 7716
- The recommendations made in the assessments are aggregated into a suitable level 3 issue and this is placed on the issues database for endorsement by the sub-programme and the issue is communicated to NGL via letter.

LIST OF ABBREVIATIONS

OFP	Operating Facilities Programme
EC	Engineering Change
GTAC	Graphite Technical Advisory Committee
INSA	Independent Nuclear Safety Assessment
JPSO	Justified Period of Safe Operation
KRC	Keyway Root Cracking
LC	Licence Condition
LCO	Limiting Condition of Operation
NGL	EDF Energy Nuclear Generation Limited
NSC	Nuclear Safety Committee
NSR	Nuclear Safety Requirement
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
PSD	Primary Shutdown System
PML	Principia Mechanic Limited

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1 PERMISSION REQUESTED

1. This project assessment report presents the basis and rationale for issuing agreements in line with the Licensee's arrangements under Licence Condition 22(1) of the nuclear site licenses for Hunterston B and Hinkley Point B power stations.

2. The agreements were requested by the licensee in line with their arrangements (References 1 and 2) following the safety submission providing the revised safety case NP/SC 7716 for the reactors at Hunterston B and Hinkley Point B (Reference 3).

2 BACKGROUND

3. This project assessment report addresses the requested agreements from EDF Energy Nuclear Generation Ltd (NGL) to implement the latest safety case proposal, NP/SC 7716 (Reference 3), for continued operation of the Hinkley Point B (HPB) and Hunterston B (HNB) AGR graphite cores. NP/SC 7716 supersedes the previous case, NP/SC 7662 Proposal 2 (Reference 4) which was limited up to the onset of keyway root cracking (KRC). This form of graphite brick cracking has been predicted to occur in the latter stages of the reactors' life when stresses at the outside of the brick are such that cracking can occur from the keyways. KRC has now been observed in HNB Reactor 3 (R3) and Reactor 4 (R4) but to date has not been observed in HPB R3 or R4.

4. During the HNB R3 outage of November 2015, KRC was identified in the main population of the core. Consequently NP/SC 7662 became invalid and thus must be replaced, although the reactors were allowed to continue operations under short term justifications (References 5 and 6). NGL now propose NP/SC 7716 as the justification for the longer term continued operation of HNB and HPB. This is the first safety case submission by NGL to address operation following the onset of KRC in the graphite core. KRC has the potential to increase the number of cracked bricks as the core continues to age beyond this point in its operating life. The variability in both graphite material properties and irradiation across the core affects whether individual bricks will develop cracks but it is expected that the number of cracked bricks will gradually increase following KRC onset. Such brick cracking has the potential to give rise to increased distortion of fuel channels and control rod channels. Excessive distortion could prevent the free movement of fuel and control rods and hence challenge the safety requirements associated with the graphite core structure. NGL has, for a number of years, been undertaking significant research to consider the effects of cracking on core distortion and thus determine the tolerance of the core to cracking and distortion.

5. Therefore, NP/SC 7716 implements claims that operational limits can be set on the state of cracked bricks in the core whilst maintaining sizeable margins to any challenge on the safety requirements of the core. This is a similar principle to that implemented in NP/SC 7662, which was assessed by ONR, (Reference 7), but extends the claims to larger numbers of cracked bricks. NP/SC 7716 proposes specific limits and conditions on the number of cracked bricks in the core (termed operational allowances) that NGL consider to be currently supportable based on the experiments, inspections, monitoring and analysis performed. Furthermore, the safety case seeks to demonstrate that there are large safety margins and conservatisms built into the case, in terms of the limits and conditions defined.

6. Finally, NP/SC 7716 proposes a strategy, underpinned by inspection and monitoring, that NGL claims will demonstrate that the operating limits will not be exceeded during the operating period. The strategy recognises the need for increased and more frequent inspections, but also acknowledges that a key aspect is for it to be dynamic in

order to respond to any changing condition within the core. The strategy, therefore, requires the production of a specific safety case for each core to support the periods of operation and these cases will be reviewed and updated at each inspection in light of the results and findings. These cases will also outline the scope of inspection to be conducted on each core and the ongoing core condition based on the inspection and monitoring findings.

7. NGL carried out its own independent consideration of Reference 3 by NGL's Nuclear Safety Committee (NSC) in line with NGL's due process (Reference 8). The consideration of the NSC was that NGL had adequately demonstrated that the performance and safety functional requirements have been met and the inspection and monitoring strategy proposed was acceptable.

8. NGL's Independent Nuclear Assurance (INA) department reviewed Reference 3 and concluded that suitable and sufficient margins of safety and conservatisms have been used in the analysis at the various stages in the process to provide confidence in the safety case. This was confirmed in the issuing of an Independent Nuclear Safety Assessment certificate with no outstanding caveats (Reference 9).

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

9. As part of the consideration of the safety case submission, ONR has undertaken the following assessments of the submission:

- Structural integrity assessment of the safety submission with regard to the ability of the safety functions to be maintained in line with the new limits and conditions of operation defined in the safety case submission.
- Fault studies assessment of the submission with regard to the Primary Shutdown (PSD) system meeting its reliability criteria in line with the new limits and conditions of operation defined in the safety case submission.
- Thermal Hydraulics assessment of the submission considering the impact of potential core distortion and damage on the cooling of the fuel elements as part of the core condition defined in the safety case submission.
- Additionally a brief assessment of the seismic criteria used within the safety case submission was made to consider whether the input values used by NGL in the seismic assessment were adequate.

10. The assessments were undertaken in line with ONR's due process (Reference 10). There was significant engagement with NGL in terms of clarification of the submission and numerous examples of additional information being submitted to support the safety submission.

3.1 SPECIALIST ASSESSMENT

11. This section considers the individual assessments carried out by the relevant specialist inspectors and covers their engagement, findings and recommendations associated with their assessments. The assessments are considered in reverse order to that presented above as the seismic criteria assessment, thermal hydraulics assessment and fault studies assessment all support in one form or another the structural integrity assessment, which is the most significant and thus is taken last for the purposes of presentation to the reader.

3.1.1 SEISMIC CRITERIA ASSESSMENT

12. The full details of the seismic criteria assessment produced by the external hazards specialist inspector is provided in the assessment note produced (Reference 11). The assessment considers the site response spectrum used by NGL to ensure that it

bounds the condition appropriately for both sites. The report concludes that the bounding seismic criterion used by NGL, the Hinkley Point B Principia Mechanic Limited (PML) hard site response spectrum, is an appropriate basis for the seismic analysis for the graphite core response for both sites.

3.1.2 THERMAL HYDRAULICS ASSESSMENT

13. The full details of the thermal hydraulics assessment produced by the fault studies specialist inspector is provided in the assessment report (Reference 12). The fundamental issue of the assessment is the ability of the fuel in the channels to be kept cool by the carbon dioxide (CO_2) coolant gas in both normal and fault operations.

14. The assessment considered three mechanisms by which the state of the graphite core could affect fuel cooling, and these are; inter sleeve gapping, fuel brick cracking and distortion and the potential effects of debris. These are described below:

- Inter sleeve gapping: Fuel assemblies are held inside graphite sleeves. The graphite sleeves are stacked one on top of the other with a shouldered interface at the end of each sleeve to assure alignment and create a convoluted path to deter flow leakage. CO_2 coolant flows through the fuel assembly inside the fuel sleeves. If two fuel sleeves tilt relative to each other as a result of fuel channel distortion, the end-to-end interface can be angled open into an “inter sleeve gap” leading to the potential for coolant flow to bypass the lower part of the fuel.
- Fuel brick cracking: Fuel brick cracking is the cracking of bricks such that the coolant can flow through non-designed flow paths affecting the overall flow of coolant around the reactor core with the potential to affect core temperatures.
- Effects of debris: Cracking of bricks increases the potential for debris to be generated and this debris could fall into the channels, thus restricting the flow of coolant by providing an obstruction and therefore giving rise to a potential increase in core temperature.

15. The specialist inspector’s assessment considered how NGL had addressed these aspects and found the effects on core temperature behaviour to be within the established safety margins. However, the assessment considered that NGL should provide further justification on the potential level of debris generation and the level, in the future, where this could become a nuclear safety concern. On this basis, a recommendation has been raised within the assessment on NGL.

16. Additionally, the specialist inspector noted that the thermal hydraulics arguments in the case did not cover post-trip cooling or cooling post a fault event. Subsequent investigations into these areas did not identify any safety concerns. Although the position is not a challenge within the submitted case, the regulatory expectation is that these types of plant conditions would be covered explicitly within the submission. On this basis a recommendation has been raised within the assessment on NGL.

17. On this basis, two recommendations are recorded in Appendix 1 to address both the debris evaluation and also the need to explicitly address coolant flows in all operations and faults within the submission. These recommendations will form part of a regulatory issue to be communicated to NGL post completion of this assessment.

18. Overall, from a thermal hydraulic perspective, the specialist inspector has no objection to the granting of the LI for the implementation of the revised case NP/SC 7716.

3.1.3 FAULT STUDIES ASSESSMENT

19. The full details of the fault studies assessment produced by the fault studies specialist inspector is provided in the assessment note (Reference 13). The focus of the assessment is the reliability of the Primary Shutdown (PSD) system as the reliability of

this system is fundamental to the reactor safety case. Consequently, it is important to understand the impact of the new limits and conditions with regard to brick condition and the associated core distortion on the claimed reliability of the PSD system.

20. The fault studies specialist inspector noted that the safety case, NP/SC 7716, does not explicitly demonstrate that the claimed reliability of the PSD system is unaffected by reactor operations, even at the new limits and conditions. Alternatively the safety case considers that there are sufficient conservatisms and margins included in the analysis at every point such that the overall PSD reliability as currently claimed is not threatened. With regard to this position, the fault studies specialist inspector considered the conservatisms and margins in three areas of the safety case; the core distortion analysis, the control rod insertion analysis and the shutdown and hold down requirements.

21. With regard to the core distortion analysis, the fault studies specialist inspector has undertaken discussion with the structural integrity specialist inspector on NGL's claims that the results of the physical testing show that in all cases, the computational modelling is conservative and that there is a high degree of confidence that the potential core distortions are not under-predicted. The structural integrity specialist inspector is content with the claims made and the fault studies specialist inspector has proceeded on this basis. This is referred to in the assessment note (Reference 13).

22. Similarly, the fault studies specialist inspector has discussed the control rod insertion analysis with the structural integrity specialist inspector. Again the structural integrity specialist inspector is content with the claims made regarding the minimum safety margins and the overall conservatism of the analysis, noting the number of conservative assumptions made by NGL. This is also referred to in the assessment note (Reference 13).

23. Finally, the fault studies specialist inspector has considered the shutdown and hold down requirements for the core and the various conservatisms and safety margins present within the shutdown and hold down analysis. In particular, NGL has undertaken a number of sensitivity studies based on different scenarios, such as the failure of a number of control rods to enter the core in a random distribution. The specialist inspector considered that these studies indicate that there are significant shutdown and hold down margins within the analysis.

24. Furthermore the fault studies specialist inspector has noted that the introduction of Super Articulated Control Rods (SACR) and their ability to meet a short term shutdown requirement as well as the nitrogen hold down system have provided valuable defence in depth.

25. The conclusion of the report is that on the basis of the analysis and assessment presented by NGL, it is reasonable to claim that there are sufficient margins and conservatisms included in the analysis at every point to ensure that the overall PSD system reliability is not threatened by the new limits and conditions associated with cracked bricks in the core as defined in the revised safety case, NP/SC 7716. Consequently, the fault studies specialist inspector has no objections to the granting of the LI's to implement the revised safety case. However, the specialist inspector noted that in future NGL should provide additional discussion and analysis for future graphite safety cases to explicitly demonstrate the PSD reliability. This recommendation is recorded in Appendix 1 and will form part of a regulatory issue to be communicated to NGL post completion of this assessment.

3.1.4 STRUCTURAL INTEGRITY ASSESSMENT

26. The full detail of the structural integrity assessment produced by the structural integrity specialist inspector is provided in the assessment report (Reference 14). The structural integrity assessment covered the five claims made in the post-onset KRC safety case. The claims propose the implementation of revised limits and conditions of safety (termed operational allowances) with regard to the number cracked bricks, the type of cracking associated with these bricks (both singly and double axially cracking from both bore cracking and keyway root cracking, termed morphologies) and the size of the cracks within the bricks. The claims made seek to demonstrate that there are large margins of safety for levels of cracking both at and beyond the limits and conditions defined. The claims also propose a strategy of core inspection and monitoring which aims to demonstrate with high confidence that limits and conditions of operation will not be exceeded during the Justified Period of Safe Operation (JPSO). The JPSO is the period of operation justified within the current safety case between shutdown for inspections.

27. The structural integrity assessment was supported by the seismic criteria assessment, thermal hydraulics assessment and fault studies assessment. The structural integrity inspector took cognisance of the outcomes of these assessments as part of the overall judgement.

28. The assessment considered the differences between the post-onset KRC safety case (NP/SC 7716) and the previous pre-onset KRC safety case (NP/SC 7662) to minimise repetition of work and assessment of methodologies and positions already accepted by ONR.

29. The assessment considered the claims regarding the tolerance of the core to cracking, and the structural integrity specialist inspector noted that the majority of the supporting evidence for the claims regarding core tolerance was derived from the Whole Core Models (WCM). This modelling considered the ability of the control rods, fuel stringers and fuel sleeves to be operated effectively and/or impacted by core distortion during normal operation, fault conditions and design basis seismic event.

30. The assessment considered the various sensitivity analyses undertaken by NGL to support the safety case and provide confidence that there are no cliff edge effects in the revised limits and conditions of operation proposed. The assessment noted the position was acceptable for the proposed new limits and conditions and that NGL had shown that safety margins exist at core degradation levels substantially greater than those proposed in the new limits and conditions of operation. This mitigates some of the uncertainties within NGL's submission. However, a number of recommendations are made with regard to the NGL approach. Although these recommendations do not necessarily impact on the proposed safety case (NP/SC 7716), if NGL do not address these recommendations, it may have impact on future submissions. These recommendations are recorded in Appendix 1 and some are discussed below.

31. The assessment also considered the claims now being made on inspection of the core during shutdown and monitoring of the core condition during operation. These parts of the assessment were carried out by specialist inspectors in inspection strategy (Reference 15) and monitoring strategy (Reference 16) and were incorporated into the overall structural integrity assessment to allow a judgement of the structural integrity case to be taken as a whole. The inspection and monitoring approach provides confidence in the condition of the core and that the limits and conditions of operation, with respect to brick cracking, have not been exceeded.

32. The inspection strategy specialist inspector found that overall NGL has proposed a dynamic inspection strategy with an increase in the amount of inspection performed when compared to the pre-KRC case. The strategy is non-prescriptive to provide flexibility to address inspection findings that may be outwith expectations and

predictions. The strategy incorporates the requirement for specific safety cases for each core and the need to review and update these based on the findings of the inspections. The inspection strategy specialist inspector considered the inspection strategy defined in NP/SC7716 and found no reason to object to the granting of the LI's.

33. However, the inspection strategy specialist inspector made two recommendations regarding the safety cases NGL will make as part of the ongoing work. These recommendations relate to the need for NGL to fully justify the level of confidence that the new limits and conditions will not be exceeded during operations and that the inspection intervals are less than the JPSO. These recommendations should be addressed by NGL as part of the forthcoming safety submissions for inspection of the reactor cores at HNB and HPB.

34. The monitoring strategy specialist inspector found that the various monitoring techniques identified have significance regarding core monitoring and that NGL has assembled significant experimental evidence regarding the capability of the monitoring techniques to detect cracking in the core. However, apart from the Fuel Grab Load Trace (FGLT) technique, they are all lagging indicators. The FGLT technique may provide leading indicators capable of demonstrating the absence of significant axial cracking or core distortion, although it is trying to detect an absence of abnormality which is challenging. Therefore, the monitoring specialist inspector considered that validation of the FGLT technique is necessary to provide increased confidence in core condition during operation. The monitoring specialist inspector made a number of recommendations that are captured in the structural integrity assessment (Reference 14) regarding the validation of the FGLT technique and introduction of procedures on plant regarding use of the FGLT technique and these are presented in Appendix 1.

35. Finally, the structural integrity assessment considered the NGL claim that the operational risks were ALARP, and found that these were dominated by the installation of Super Articulated Control Rods and the diverse hold down system. These have previously been assessed by ONR (References 17 and 18) and thus the structural integrity specialist inspector was content with the claims made.

36. The structural integrity specialist inspector concluded that there are no objections to the granting of the LI's to implement the revised safety case. However, the assessment raises a significant number of recommendations. Some of these recommendations are for ONR to undertake or initiate and these will be discussed in section 4, matters arising from ONR's work. The remaining recommendations are on NGL and are made with regard to reducing the uncertainties within the safety case. Although these recommendations do not necessarily impact on the proposed safety case, NP/SC 7716, owing to the large margins of safety applied, if NGL do not address these recommendations, it may have an effect on the acceptability of future submissions. These recommendations will form part of a regulatory issue to be communicated to NGL.

3.1.5 GENERAL CONSIDERATION OF THE ASSESSMENTS

37. As project inspector, the intent is to consider the totality of the specialist inspector assessments undertaken on the safety submission and draw conclusions and further actions in terms of the permissioning and any follow-up areas. I note the work carried out in the assessments by the specialist inspectors and the level of engagement with NGL to understand and consider the submission and the underlying evidence supporting NGL's position. I also note the collegiate approach taken by the assessment team to deliver a holistic position with regard to supporting each other's assessments and linked nature of issues under consideration and this should be commended. I understand the recommendations and conclusions made by the

individual specialist inspectors and agree with the overall position for the implementation of the revised safety case, NP/SC 7716.

38. However, I also note key themes that seem to be arising from the assessments and their individual recommendation and consider these to be:

- The need for NGL to define the life limiting conditions, features or challenges for the core condition.
- The need for NGL to be more explicit in the totality of the case, to ensure all areas are addressed within the submission.
- Improved modelling and validation of core behaviour.

39. These are taken individually below.

3.1.6 DEFINITION OF LIFE LIMITING CONDITIONS, FEATURES AND CHALLENGES

40. In NP/SC 7716 (Reference 3), NGL identifies limits and conditions necessary in the interests of safety, termed operational allowances, which are defined in terms of number of cracks, morphologies and degree of opening. ONR has previously indicated to the licensee (Reference 19) that it is desirable for end of life criteria to be identified and that these criteria might more usefully be identified in terms that also include core distortion. Although, the number of cracks is the parameter most easily determined by inspection, it is the distortion that potentially arises through the cracking and other ageing mechanisms that provides the challenge to the core's safety functional requirements regarding free movement of fuel and control rods.

41. Furthermore, it is also plausible that the potential formation of graphite debris as a result of ageing could also be a life limiting phenomenon. Such debris could potentially interfere with coolant flow or obstruct fuel movement. Debris formation has been limited so far and whether debris formation could become significant to the extent it is life limiting is not yet known, and work should be undertaken by NGL to understand and bound this position. Indeed, this is one of the recommendations made in the thermal hydraulics assessment; in terms of understanding what life limiting debris would be and whether this could actually be produced.

42. I consider therefore, as part of the overall assessment, NGL should identify the end of life criteria for the core. It is to be expected that inspection and monitoring technology and techniques are developed and deployed as required to provide evidence of the current state of the reactor's core. This would then support the case regarding the condition of the core at the end of the operating period to justify that it will be within the operating limits and conditions and ultimately, with greater confidence, within the end of life limits for the core. Furthermore, it is recognised that the limits and conditions proposed in NP/SC 7716 may change as further analysis, experimental data and inspection evidence becomes available and provides suitable, robust justification. ONR will be writing to NGL to state our expectations in terms of all the recommendations identified within the various assessments in a suitably comprehensive level 3 issue in line with ONR's due process.

3.1.7 EXPLICIT CONSIDERATION OF ALL SAFETY CONDITIONS AND OPERATIONAL POSITIONS

43. The assessments have considered that the original safety submission did not cover all the operational positions and all the safety conditions. ONR would usually expect a comprehensive safety case and so there is a need to ensure that future submissions do address all safety conditions and plant operations. This does not mean that future submissions should have in-depth substantiation on each area, but should show how they have considered the various operational positions, such as post trip cooling and

found that it is not altered from previous submissions and this is appropriately presented and referenced to show that adequate consideration has taken place.

44. The regulatory concern is that if due consideration is not given to these points, such as post trip cooling or the PSD system, then alterations to the safety case, which may seem minor, could have unintended or unexpected consequences as they build up over various safety case revisions. There is a need to make sure the totality of the case is considered to avoid inadvertently exceeding the limits and conditions defined in the safety case. This will be discussed with NGL to ensure future safety case submissions meet the regulatory expectation and avoid time consuming review and engagement.

3.1.8 IMPROVED MODELLING AND VALIDATION OF CORE BEHAVIOUR

45. Significantly a number of the recommendations made within the assessments are seeking improvement in models used by NGL. Given that keyway root cracking was predicted in the model, although later within the timeline than actually found, it is surprising that design and validation of the modelling and the various sensitivity studies should be subject to such a number of recommendations. For example, the recommendations include the need to ensure the internal consistency of whole core models as the model for normal operation and fault conditions and the model for seismic events have slightly different keyway root cracking inputs. Although the difference is slight, it is surprising that the two models are not internally consistent.

46. ONR will engage with NGL to ensure that the various recommendations in terms of model validation and sensitivity analyses are taken on board as part of the ongoing work NGL do in maintaining their models and updating them in line with actual data from core inspection and behaviour.

3.1.9 INTERACTION WITH OTHER REGULATORS

47. No consultation with other regulatory bodies was carried out for this PAR as the area of regulatory permissioning was purely within the scope of ONR's remit.

4 MATTERS ARISING FROM ONR'S WORK

48. As a result of the structural integrity assessment, there are a number of internal actions for ONR to initiate to provide further confidence in the safety case arguments being used by NGL now and potentially going forward. The first is for ONR to engage the Graphite Technical Advisory Committee (GTAC) to review the fuel sleeve impact tests and provide a view on the level of uncertainty associated with the impact velocities used to determine crack initiation and gross cracking during a seismic event. This will be added to the scope of work for the GTAC.

49. Further to this, ONR will also require that the GTAC undertake a thorough review of the current seismic validation findings and report back to ONR. This is for the GTAC to consider NGL's validation tests and provide a view as to the adequacy of these validation trials and their applicability to support the output of the whole core model. This will be added to the scope of work for the GTAC.

50. Finally ONR should carry out a compliance inspection into the use of the Fuel Grab Load Trace technique. This is a technique, which may give NGL the ability to detect some forms of cracking as part of the monitoring of the core and ONR needs to undertake an inspection to consider how the data generated is being analysed and utilised by NGL to inform it of the core condition and how this information may then be validated by inspection at a later date. This inspection will be added to the ONR intervention to be carried out in the near future.

5 CONCLUSIONS

51. I conclude that a suitable and sufficient assessment has been undertaken by ONR and that said assessments conclude that there are no objections to premissioning the implementation of the revised safety case, NP/SC 7716 in line with the agreements requested by NGL in line with their arrangements under LC 22(1).

52. On this basis, I conclude that the permission should be granted and the licence instruments issued.

6 RECOMMENDATIONS

53. I recommend that:

- the Superintending Inspector should sign this Project Assessment Report to confirm support for the technical and regulatory arguments to grant the licence instruments in line with NGL's arrangements under LC 22(1) to implement safety case NP/SC 7716 at Hunterston B and Hinkley Point B.
- Licence Instrument 556 is granted to Hunterston B to implement NP/SC 7716
- Licence Instrument 556 is granted to Hinkley Point B to implement NP/SC 7716
- the recommendations made in the assessments are aggregated into a suitable level 3 issue and this is placed on the issues database for endorsement by the sub-programme and the issue is communicated to NGL via letter.

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9. NGL - 7716 Milestone Full INSA Approval Statement, TRIM ref 2016/168300
10. ONR HOW2 Guide NS-PER-GD-014 Revision 4 - Purpose and Scope of Permissioning. July 2014. http://www.onr.org.uk/operational/assessment/index.htm
11. NP/SC 7716 Seismic input motion assessments comments [redacted] TRIM ref 2016/456185
12. NGL - NSS – Assessment Report – 16-044 - Thermal hydraulic assessment of EDF NGL safety case for operation after the onset of Keyway Root Cracking (NP/SC 7716) – 16 December 2016 TRIM ref 2016/419431
13. Fault Studies Assessment Note: NP/SC 7716 Hinkley Point B and Hunterston B Safety Case for the Graphite Core and Core Restraint: Operation after the Onset of Keyway Root Cracking – PSD Reliability TRIM ref 2016/448551
14. NPSC 7716 Assessment Report TRIM 2016/228144
15. Claim 3 (Inspection) for Assessment Report on NP/SC 7716, [redacted] TRIM ref 2016/467319.
16. Claim 4 (Monitoring) for assessment report on NP/SC 7716, [redacted] TRIM ref 2016/453658.
17. ONR-HPB-PAR-13-006 - The Introduction of Super Articulated Bulk Rods: Stage Submission 4: Full Loading Safety Case. Trim ref 2013/174643
18. NGL- HNB-PAR-14-026 Agreement to put the new diverse hold down system into service. Trim ref 2015/10143

19. NGL - Hinkley Point B/Hunterston B - Assessment Report - 16-030 - Assessment of the Graphite aspects of the HPB/HNB Periodic Safety Review for the Period 2017 – 2027 - 12 October 2016. Trim ref 2016/298194

20. Recommendation arising from assessment of monitoring leg. TRIM: 2016/498006

APPENDIX 1

Recommendations from specialist assessment reports

Report title	Recommendation	Status
Thermal hydraulics report	EDF NGL should provide further information at what potential debris generation could present a safety concern and identify what the predicted level of debris generation could be within the limits of the safety case	To form part of the level 3 issue going forward
Thermal hydraulics report	EDF NGL should improve the overall structure of future graphite safety cases to ensure that all safety arguments are clearly articulated and linked to the safety functions. This should include but not be limited to; explicit consideration of post trip cooling and cooling post a design basis seismic event.	To form part of the level 3 issue going forward
Fault studies report	EDF NGL should develop a more explicit approach to demonstrating PSD reliability for future graphite safety cases or justify not doing so	To form part of the level 3 issue going forward
Structural integrity report	I recommend that NGL determines, in the long term, end-of-life criteria for the reactors. This is likely to include measures of core distortion as well as numbers and morphology of cracks.	To form part of the level 3 issue going forward
Structural integrity report	That, in future assessments, AGRIGID and GCORE assessments are made consistent with each other and use the same region of the core to apply KRC bricks.	To form part of the level 3 issue going forward
Structural integrity report	That ONR engages GTAC to review the fuel sleeve impact tests and provide a view on the level of uncertainty associated with the impact velocities used to determine crack initiation and gross cracking during a seismic event	See Section 4 of the main report - to be added to scope of future work
Structural integrity report	That NGL develops the real time seismic damage iteration method in order to provide further assurance that the keying system does not present a vulnerability to the graphite core structural integrity during a 10-4 seismic event. NGL has provided a plan to address this recommendation by the end of 2017.	To form part of the level 3 issue going forward
Structural integrity report	To support future claims that propose to extend the Operational Allowances, NGL should demonstrate that a grouping of cracked bricks that is too small to be reliably detected by inspections cannot significantly reduce the damage tolerance levels.	To form part of the level 3 issue going forward
Structural integrity report	That ONR asks GTAC to undertake a thorough review of the current seismic validation findings and report back to ONR.	See Section 4 of the main report – to be added to scope of future work
Structural integrity report	That, before the end of 2017: • NGL increases the currently available pool of validation evidence to include the behaviour of a damaged core during a seismic event. • That NGL consider validation strategies for the behaviour of a core when subject to keying system failures.	To form part of the level 3 issue going forward

	• That NGL update ONR on the future intentions of the alternative WCM methods.	
Structural integrity report	To support future claims that propose to extend the Operational Allowances, NGL should broaden the scope of sensitivity studies to improve the current understanding of the effects of uncertainties on the WCM damage tolerance.	To form part of the level 3 issue going forward
Structural integrity report	NGL should develop a more explicit approach to demonstrating PSD reliability, for future graphite safety cases or justify not doing so.	Copy of fault studies recommendation - will be addressed by it.
Structural integrity report	That the period between inspections is always less than the dynamic JPSO. The margin between the next inspection period and the JPSO needs to be justified by NGL as part of their graphite core inspection process.	To form part of the level 3 issue going forward
Structural integrity report	If the confidence that the operational allowance will not be exceeded drops below 99.9% during a subsequent operational period, then NGL must provide a robust justification of why this is acceptable	To form part of the level 3 issue going forward
Structural integrity report	That NGL should commit to carrying out a validation exercise for the FGLT as part of the forthcoming HNB R3 outage. This should include predictions of whether open cracks are present before the channels are inspected.	Commitment given see Reference 20, delivery to be followed up
Structural integrity report	That NGL should commit to introduce procedures for application of the FGLT on a defined timescale. These procedures should include entering into an unscheduled outage, should FGLT findings suggest that the limits described in claim 1 could be exceeded before the following scheduled inspection. It is understood that the procedures would include consideration of statistical aspects of the likely progression of cracking.	Commitment given see Reference 20, delivery to be followed up
Structural integrity report	That ONR should carry out a compliance inspection into the use of the FGLT.	See Section 4 of the main report – to be added to scope of future work