Office for Nuclear Regulation

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ASSESSMENT REPORT

Civil Nuclear Reactors Programme

NNB GenCo Ltd: Hinkley Point C Pre-Construction Safety Report 2012 – Assessment Report for Work Stream Fuel and Core (Including Criticality Safety)

Assessment Report: ONR-CNRP-AR-13-076
Revision 3
Version 2
February 2014

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EXECUTIVE SUMMARY

This assessment report (AR) reviews that portion of the Hinkley Point C (HPC) pre-construction safety report 2012 (HPC PCSR 2012) falling within the scope of the fuel and core work stream. The topic of criticality safety has also been included within the review. Most of the material I have reviewed lies in HPC PCSR 2012 chapter 4 (i.e. "Reactor and Core Design"), although the criticality safety analysis information lies in sub-chapter 9.1 ("Fuel Handling and Storage"), which I have accordingly also reviewed.

The assessment informs my judgments as to the licensee's progress in constructing an adequate safety case (in the above technical areas) and in defining suitable limits and conditions to maintain safety within that safety case (i.e. compliance with Licence Condition 23 – "Operating Rules").

A final version of the Generic Design Assessment (GDA) PCSR, issued in November 2012, formed the basis for issue by the Office for Nuclear Regulation (ONR) on 13 December 2012 of a Design Acceptance Confirmation (DAC) for the UK EPR™ design. The GDA PCSR addressed only the key elements of the design of a single UK EPR™ unit (the generic features on "the nuclear island") and excluded ancillary installations. Certain matters were also deemed to be outside the scope of the GDA PCSR (e.g. whether spent fuel from HPC should be interim stored wet or dry on the site, prior to ultimate disposal to a geological disposal facility).

In contrast HPC PCSR 2012 addresses the whole HPC licensed site, comprising the proposed twin UK EPR units and all ancillary installations some matters that were outside the scope of GDA PCSR are also addressed. As the generic features were addressed in the GDA process, the focus of ONR assessments of HPC PCSR 2012 was intended to be on any new site-specific information that has not been formally assessed previously. However, some of the information, presented in HPC PCSR 2012, is a direct copy from GDA PCSR 2011. In the case of this assessment report, I found that HPC PCSR 2012 contains no new information on either criticality safety, or on fuel and core (i.e. within sub-chapters 4.1 – 4.5 and 9.1). I have confirmed this to be the case via direct comparison of the GDA PCSR 2011 information and HPC PCSR 2012 information. Accordingly, I have not conducted an assessment of HPC PCSR 2012 in these technical areas.

However, nonetheless, via programmed level 4 meetings with key personnel from Nuclear New Build Generating Company Ltd - NNB GenCo Ltd (i.e. the licensee) I have been monitoring progress in defining the fuel design requirements. I am content that adequate progress has been made by the licensee in this area i.e. in defining a series of demonstrably conservative and underpinned fuel design criteria, based upon a review of French versus UK criteria.

Little additional progress has been made in the criticality safety area (i.e. since GDA PCSR 2011), although a list of future work has been generated, which is awaiting the financial investment decision on the project before it is progressed. I judge this current position to be acceptable as GDA PCSR 2011 (and hence HPC PCSR 2012) has already highlighted some of the key areas of concern with respect to criticality safety. These areas of concern appear sensible and adequately comprehensive and are the subject of suitable forward work actions.

GDA recorded a total of eight assessment findings (AFs) against the fuel and core topic area and I have ensured that there is a shared understanding between the licensee and ONR as to the purpose of the AFs and as to what evidence ONR is expecting to permit eventual closure of the AFs. All the AFs against fuel and core are required post the pouring of first nuclear island concrete

(i.e. AF closure is generally required before receipt of fuel on site, or prior to first fuel load) and hence there is a comfortable time margin before the licensee must present evidence for closure of these AFs. Nevertheless, the licensee has made some limited progress on the production of resolution plans (RPs) and one RP has already been provided with another due shortly. I am hence content with progress in this area.

A group of five AFs, currently 'owned' by other NNB GenCo Ltd technical areas, have been identified recently as more logically sitting in the fuel and core area (I accept this logic) and ownership has now been taken over by the NNB GenCo Ltd fuel and core design team. Again, closure of these five AFs is required some time into the future (i.e. after first nuclear concrete). There are a further seven AFs relating to criticality safety and three of these require closure prior to the pouring of nuclear island concrete. I am content that the licensee is making satisfactory progress with the generation of RPs for these three findings.

The fuel and core design is being conducted by a French design team and I am content at this juncture that the NNB GenCo Ltd fuel design team in the UK is exercising an appropriate intelligent customer role with respect to these design activities.

The above reported work by the licensee since HPC PCSR 2012, although ongoing (e.g. in defining key fuel requirements to permit fuel ordering to proceed) and the licensee's engagement on the AFs, allows me to make the judgement that in my opinion the licensee is making adequate progress in the fuel and core technical area towards defining an adequate safety case, together with appropriate operating rules. In addition the licensee's intended forward work plan in the criticality safety area appears sensible and allows me again to make a judgement that the licensee is making satisfactory progress towards the generation of a robust criticality safety case. I hence see no evidence that the licensee will not meet the LC 23 requirements and judge that no regulatory action is presently required in this area.

It is important to note that HPC PCSR 2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of HPC. NNB GenCo Ltd intends to submit a major revision to HPC PCSR 2012 (called PCSR 3) before seeking consent for nuclear island construction, which will fully integrate the final GDA PCSR and will be supported by other documentation.

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LIST OF ABBREVIATIONS

AF	Assessment Finding
BAT	Best Available Technology
BDR	Basic Design Reference
BMS	(ONR) How2 Business Management System
CDC	Cahier des Charges
DAC	Design Acceptance Confirmation
DNB	Departure from Nucleate Boiling
FA 3	Flamanville 3
FSCR	Fuel Safety Case Requirement
GDA	Generic Design Assessment
HSE	Health and Safety Executive
HPC PCSR 2012	Hinkley Point C Pre-Construction Safety Report 2012
IC	Intelligent Customer
IPR	Intervention Project Record
LC	Licence Condition
NNB GenCo Ltd	Nuclear New Build Generating Company Ltd
ONR	Office for Nuclear Regulation (an agency of HSE)
OpEx	Operational Experience
PCSR	Pre-Construction Safety Report
PSBT	PWR Sub-Channel and Bundle Tests
PWR	Pressurised Water Reactor
RD	Responsible Designer
RIA	Reactivity Insertion Accident
RPV	Reactor Pressure Vessel
SAP	Safety Assessment Principle(s)
SQEP	Suitably Qualified and Experienced Person
SZB	Sizewell B
TAG	Technical Assessment Guide(s)

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1 INTRODUCTION

1.1 Background

1 A Generic Design Assessment (GDA) was conducted by the Office for Nuclear Regulation (ONR) on the generic features of the EPR™ design and a final GDA pre-construction safety report (PCSR), produced in November 2012, formed the basis of ONR issuing a design acceptance confirmation (DAC) for the design. However, the safety submissions, assessed during GDA were purposely for the key elements of the design of a single EPR unit (i.e. the generic features of the "nuclear island") and took no account of site specific features and ancillary buildings.

2 NNB Generating Company Ltd (NNB GenCo Ltd) i.e. the licensee has since further developed the EPR design for the UK context and has also further developed the extant safety case to address issues specific to construction of twin EPRs at Hinkley Point C (HPC), including all required associated ancillary buildings to be constructed on the site. This revised safety case was presented in HPC PCSR 2012 (Reference 1), which also considers a number of matters which were deemed to be outside the scope of the GDA exercise (e.g. whether spent fuel from HPC should be interim stored wet or dry on the site, prior to ultimate disposal to a geological disposal facility).

3 ONR specialists have been conducting a formal assessment of HPC PCSR 2012, the focus of which was solely intended to be on any new information supplied by the licensee since GDA PCSR 2011. This report presents the findings from my assessment of Chapter 4 (sub-chapters 4.1 - 4.5) and sub-chapter 9.1 of the HPC PCSR 2012, (Reference 1) i.e. that fall within the scope of the fuel and core work stream (including criticality safety). However, it should be noted that some of the information, presented in HPC PCSR 2012, has utilised data from an earlier GDA PCSR (i.e. GDA PCSR 2011) without change. The "Head Document" i.e. Reference 2 for HPC PCSR 2012 defines which HPC PCSR 2012 chapters present new data/analysis and which chapters are unchanged from GDA PCSR 2011.

4 This assessment report (AR) has been written, as one of a set of technical ARs, to support a Summary Assessment Report that addresses whether HPC PCSR 2012 demonstrates suitable progress (i.e. against Licence Condition LC 23) towards meeting ONR's requirement for an adequate PCSR (to be known as PCSR 3) to support permissioning of start of construction of the nuclear island. In addition this AR summarises the licensee's progress towards closure of a number of GDA assessment findings (AF), in the fuel and core topic area (including criticality safety), which will need to be addressed in HPC PCSR 3.

[Note – as described later in my report, the licensee has produced no new information against the fuel and core and criticality technical areas and hence I have no information to inform my judgements as to the licensee's compliance with LC 14].

5 It is important to note that HPC PCSR 2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of HPC. NNB GenCo Ltd intends to submit a major revision to HPC PCSR 2012 i.e. PCSR 3 before seeking consent for nuclear island construction, which will fully integrate the final GDA PCSR and will be supported by other documentation. [The structure of the safety case is noted to be complex and hence the reader is directed towards TRIM 2013/464607 for further information on the safety case structure moving forwards].

6 It should also be noted the approach to safety function categorisation and safety system classification agreed during GDA is not fully reflected in HPC PCSR2012, which largely uses the approach employed on Flamanville 3 (FA 3). The integration of the methodology agreed during GDA will be demonstrated in the next revision of HPC PCSR (i.e. PCSR 3).

1.2 Scope

7 The scope of this AR covers the fuel and core work stream (which for convenience includes criticality safety). The material constituting the licensee's current safety case, for fuel and core and criticality safety, lies within sub-chapters 4.1 – 4.5 and 9.1 of HPC PCSR 2012 (Reference 1), which were hence the focus of my work.

8 In addition, prior to and following the production of HPC PCSR 2012, I have been engaging with the licensee (via level 4 meetings) to oversee its progress in continuing to develop their safety case in the fuel and core and criticality technical areas. Accordingly, I have reported some of my key findings from this ongoing work i.e. since HPC PCSR 2012.

9 During the GDA of the generic EPR design, a number of AFs were recorded in the fuel and core technical area (eight in total). I have hence also reported the licensee's progress in constructing resolution plans (RP) to provide ONR with appropriate information to permit closure of these eight AFs. However, in addition I have presented additional information on the production of RPs for closure of an additional five AFs (which were previously the responsibility of other NNB GenCo Ltd technical areas, but which it has now been recognised most appropriately lie within the fuel and core technical area). Finally, seven AFs relate to criticality safety and I have reported the licensee's progress in the generation of RPs, to provide ONR with appropriate information to permit eventual closure of the criticality AFs.

1.3 Methodology

10 My assessment (which was conducted against my intervention project record – IPR see TRIM 2013/141086) was undertaken in accordance with the requirements of the ONR How2 Business Management System (BMS) procedure AST/003 (Reference 3) and "Guidance on the Mechanics of Assessment".

2 ASSESSMENT STRATEGY

11 My assessment strategy was:-

- To consult Reference 2 to see what data in sub-chapters 4.1 – 4.5 and 9.1 is new information i.e. supplied by the licensee since GDA PCSR 2011.
- To assess any new information in the above sub-chapters against appropriate ONR Safety Assessment Principles (SAPs), Technical Assessment Guides (TAGs), relevant good practice, applicable international standards etc.
- To provide relevant additional information on the licensee's progress in the fuel and core and criticality technical areas (i.e. since HPC PCSR 2012 was published).
- To provide information on the licensee's progress in addressing all AFs relating to fuel and core and criticality.

12 The standards and criteria that have been applied to this assessment scope are described below.

2.1 Standards and Criteria

13 The relevant standards and criteria, adopted within this assessment, are principally the ONR safety assessment principles (SAP) (Reference 4) and internal ONR technical assessment guides (TAG), Reference 5. No relevant national or international standards or other relevant good practice has been used within this assessment. The key SAPs and relevant TAGs are detailed within this section.

2.2 Safety Assessment Principles

14 The key SAPs, applied within the assessment, are included within Table 1 of this report.

2.2.1 Technical Assessment Guides

15 The following Technical Assessment Guides have been used as part of this assessment (Reference 5):

- NS-TAST-GD-051 – "The Purpose Scope and Content of Safety Cases."
- NS-TAST-GD-041 – "Criticality Safety."

2.2.2 National and International Standards and Guidance

16 No national/international standards and guidance have been utilised in this assessment.

2.3 Use of Technical Support Contractors

17 No technical support contractors have assisted in the production of my assessment.

2.4 Integration with other Assessment Topics

18 As noted previously, the topic of criticality safety has also been included within the scope of this report.

2.5 Out-of-scope Items

19 N/A.

3 LICENSEE'S SAFETY CASE

3.1 HPC PCSR 2012 Material Assessed

20 The licensee's safety case for the fuel and core work stream is located within sub-chapters 4.1 – 4.5, whilst the safety case for criticality safety is presented in sub-chapter 9.1 of HPC PCSR 2012 (i.e. Reference 1). Reference 2 confirms that the information in these sub-chapters is unchanged from that presented in GDA PCSR 2011. The licensee's safety case for these sub-chapters has already been adequately described in the relevant Step 4 GDA reports (References 6 and 7) and I have hence not sought to repeat this description here.

21 However, I note that a lot of the material reported in the above sub-chapters represents more of a statement of intent, together with future work areas, rather than the actual complete safety case for fuel and core and criticality safety. It was always the intention of the licensee to continue to develop the safety case in these technical areas in later safety submissions i.e. PCSR 3 and beyond. I have, therefore, reported progress towards the generation of this developed safety case in my assessment (see following Sections).

22 I have also reported the licensee's progress in the production of RPs for the AFs on fuel and core and criticality safety.

4 ONR ASSESSMENT

23 This assessment has been carried out in accordance with ONR HOW2 BMS procedure AST/003 (Reference 3) and the "Guidance on the Mechanics of Assessment."

4.1 Scope of Assessment Undertaken

24 The scope of the assessment has been previously defined within Section 1.2.

4.2 Assessment

25 As described in Section 0.3 of Reference 2, the information presented in Reference 1 (sub-chapters 4.1 – 4.5 and 9.1 i.e. for fuel and core and criticality safety respectively) is consolidated GDA PCSR 2011 data, which has been assessed by ONR previously (see References 6 and 7). I have hence not sought to reassess this information, but I have sampled sub-chapters 4.1, 4.4, 4.5 and 9.1 from the GDA PCSR 2011 and have compared these directly with the information presented in the corresponding sub-chapters in HPC PCSR 2012. My findings from this exercise were:-

- Sub-chapter 4.1 (Reference 8) – this has been directly lifted from PCSR 2011 with no changes.
- Sub-chapter 4.4 (Reference 9) – this has been directly lifted from PCSR 2011 with no changes.
- Sub-chapter 4.5 (Reference 10) – this has been directly lifted from PCSR 2011 with no changes.
- Sub-chapter 9.1 (Reference 11) – this has been directly lifted from PCSR 2011 with no changes.

26 Accordingly, on the basis solely of the information presented in paragraph 25 it would appear that the licensee has made little progress in the definition of the safety case in the fuel and core and criticality safety technical areas. However, I have been holding regular level 4 technical meetings with the licensee's fuel and core design team (some of the meetings have also included representatives from the licensee's responsible designer – RD i.e. SEPTEN) and the licensee's criticality suitably qualified and experienced person (SQEP) covering both fuel and core and criticality safety (see References 12 – 15). [Note – Prior to my taking over as topic lead for fuel and core, my predecessor had also been monitoring licensee progress in the fuel and core technical areas via programmed level 4 meetings with key licensee staff. I have not referenced these previous meetings since they represent a much earlier stage in the design maturity].

27 Accordingly, I can report (on the basis of the evidence provided by the licensee at these level 4 meetings) that:-

- Work is well advanced to define the key parameters for the fuel and decisions have been taken on the majority of the fuel safety case requirements (FSCR), which have been chosen and justified in a draft "Synthesis Report" (which outlines the fuel design criteria relevant for HPC). The FSCRs were programmed for completion by 31/10/2013 and have been closed out for the fuel but not for core components and hence the report has not yet been finalised.
- I am content that the FSCRs have been chosen via careful comparison between UK values (i.e. for the fuel at Sizewell B, SZB) for key parameters and the corresponding French parameter. The chosen value has generally been the most conservative of the two (unless a specific justification has been provided).
- I am also satisfied that the comparison exercise has been wide-ranging (having also considered the fuel safety parameters currently being developed for the SZB dry fuel store which may be relevant for HPC).
- Once the final FSCRs have been chosen, the "Synthesis Report" will be completed and will in turn inform the Cahier des Charges (CDC) – the CDC was due to be sent to Areva circa 15/1/2013, permitting the fuel to be ordered from Areva. The CDC has been completed and agreed between Areva SA and EDF SA. It is my expectation (which I have communicated to the licensee) that the "Synthesis Report" will identify where the UK context FSCRs are covered within the French fuel documentation. [The licensee does not intend to present a list of FSCRs, as was done for SZB, but instead intends to use the Synthesis Report to demonstrate that the FSCRs for SZB have been considered and that they are covered by French fuel design requirements and specifically where they are covered within French fuel documentation. Where there are differences between French and UK requirements, the Synthesis Report will identify which has been chosen by the licensee and where this will be demonstrated in the licensee's fuel documentation. Going forward, any changes to the fuel design requirements will be made via updates to the CDC and RCC-C documentation].
- The licensee is well engaged with a number of important international fora that allows it direct access to key global operational experience (OpEx) on fuel. In my opinion the licensee is making good and extensive use of this valuable global OpEx. The recent new investment partners for HPC should further increase the potential for the licensee to access global OpEx.
- The fuel design for FA 3 has not yet been finalised and some design changes are being progressed (e.g. to mitigate the fuel assembly bow experienced in some of EDF France's other Pressurised Water Reactors – PWR). The lead time for actual delivery of HPC fuel is long (fuel production will not actually commence until circa 11 months before it is actually required on site) and the HPC fuel and core design team will consider modifications made to the FA 3 fuel and the operational experience eventually gained from this fuel in making design modifications to their own fuel design.
- I am content that NNB GenCo Ltd has appropriate plans in place to address the forward work areas (identified within HPC PCSR 2012 for the fuel and core and criticality technical areas) within PCSR 3 and future safety documentation.
- Whilst little progress has been made in the area of the criticality safety case, I am confident that this does not pose a serious threat to the HPC design and its corresponding safety case. In addition I am satisfied (i.e. from the information

provided in Reference 11) that the licensee has a comprehensive understanding of those topics which need to be addressed within the criticality safety case.

28 Overall, I judge that the licensee is making adequate progress with respect to the generation of a robust safety case for fuel and core and criticality safety and hence I presently see no evidence that the licensee will not meet the requirements of LC 23.

29 As noted previously within this AR, during GDA of the generic EPR design a series of eight AFs were recorded in the fuel and core technical area and when I took over as topic lead, the licensee lacked a clear understanding as to the meaning of some of the AFs (i.e. why they had been recorded and what information ONR was expecting to permit the AFs to be closed). Accordingly, I convened a meeting with the licensee (i.e. Reference 12) to which I invited the ONR GDA inspector who had originally recorded the AFs. The meeting was successful in that a shared understanding was achieved between both ONR and the licensee as to what work was required to enable closure of each of the eight AFs. Since this agreement, I have been monitoring the licensee's progress with the generation of RPs, (which are intended to define how and when each AF will be closed) via my programmed level 4 meetings (see References 13 – 15).

30 Since the meeting reported in Reference 12, it has become apparent that a further five AFs (which were previously the responsibility for closure of other NNB GenCo Ltd technical disciplines) fit more logically within the fuel and core technical area and responsibility for closure of these AFs has duly been transferred within NNB GenCo Ltd, I am therefore also monitoring the generation of RPs for these addition five AFs.

31 Finally, there are currently seven AFs relating to criticality safety and again I have been monitoring the licensee's progress in the production of RPs in relation to these AFS.

32 Annex 1 provides a full listing of all 20 AFs relating to fuel and core and criticality.

33 Reference 16 explains that the licensee's strategy at the moment has been to prioritise the AFs and provide the timescales for completion. The priority AFs that have been identified are those posing a higher risk to the design, which must be resolved either for Basic Design Reference (BDR) – which forms the basis of the design which is to be constructed at HPC, or first nuclear island concrete. Those that are deemed not to pose a risk or pose little risk to the design are given a lower priority and RPs will be provided later. None of the fuel and core AFs have been identified as requiring resolution before first nuclear island concrete; however three of the AFs which have a criticality safety element have been identified as having the potential to impact the design and therefore must be delivered before first nuclear island concrete. The AFs concerned are:

- AF-UKEPR-CSA-22 – Requirement for the licensee to provide a comprehensive examination of re-criticality for all reasonably foreseeable conditions during the transient progression and within the CMSS.

- AF-UKEPR-RC-05 – Requirement for the licensee to clearly identify the Boron metering system used for safety and to specify procedures that ensure common mode calibration errors do not arise.
- AF-UKEPR-RC-54 – Requirement that the licensee shall report the analysis of re-criticality in the corium in more detail to include effects such as Boron mixing and volatility.

Annex 1 provides a more detailed description of what all the assessment findings, relating to fuel and core and criticality, relate to.

34 A combined RP has been drafted for CSA-22 and RC-54; this is expected to be issued by the end of Quarter 1 2014. The RP for RC-05 is also expected to be issued on the same timescale.

35 All of the other GDA AFs (listed in Annex 1 – Reference 16) are deemed to pose a low risk to the design and the licensee has chosen not to provide deliverable dates for these, as the strategy for the project is to provide RPs for the AFs which pose a higher risk to the design as a priority. I support this decision. However, the licensee has provided an RP for review for AF-UKEPR-FD-01 and will also shortly provide the Resolution Plan for AF-UKEPR-FD-04 when it has been issued.

36 Given that few of the AFs have a high priority attached to them, I am content with the information that the licensee has provided in Reference 16 (see Annex 1) and will be reviewing the RPs submitted to date.

37 The fuel design is being progressed in France by SEPTEN and hence it is important that the NNB GenCo Ltd team in the UK has the ability to function as an intelligent customer (IC) for this design service. From my observations made to date at level 4 meetings, I am content that the UK team has a good working relationship with the French RD and is maintaining close over-sight and control of their work. Accordingly, it is my judgement that NNB GenCo Ltd is satisfactorily discharging its IC role in the fuel and core technical area. I will continue to monitor this IC role at future level 4 meetings.

4.3 Comparison with Standards, Guidance and Relevant Good Practice

38 As noted earlier, I did not perform a formal assessment of the information regarding the fuel and core and criticality safety in HPC PCSR 2012, since this information has been directly lifted from GDA PCSR 2011, which was assessed by ONR during the GDA process. Nonetheless, from the picture I have obtained from my level 4 meetings as to licensee's progress since HPC PCSR 2012, I have made some judgments below as to the licensee's compliance with the key ONR SAPs listed in Table 1.

39 **ERC.1** – It is my judgment that the licensee has been undertaking a very comprehensive exercise to ensure conservative, robust and underpinned FSCRs are set, which will deliver confidence in the performance of the fuel and the reactor core during the permitted reactor operating modes. Furthermore the licensee has provided adequate evidence that it is making extensive and appropriate use of international OpEx to inform its design process in the fuel and core area. I am hence content that the licensee's safety case work is cognisant of the guidance provided by ERC.1.

40 **ERC.3** – Whilst the detailed design of the reactor core and hence its operation across a range of operating parameters is not yet mature, I have confidence (obtained from the evidence provided by the licensee) that the current conservative approach to core design and the use of international OpEx will ultimately enable the licensee to produce a sound safety case in this area. Nonetheless I will continue to monitor the licensee in this area as the design continues to evolve and mature.

41 **SC.2** – Whilst the safety case for fuel and core and criticality safety is currently far from complete, I am again satisfied with the progress the licensee is presently making and see no evidence that suggests that the licensee's eventual safety case will not fully meet the guidance provided by this SAP.

42 **SC.5** – The licensee has been very open in its sharing of the considerations in the setting of the FSCRs (which are key to the required safety performance of the fuel in the core) and generally appears to be making conservative decisions when setting parameters. However, I have made it clear to the licensee that I wish to see each parameter choice fully justified and underpinned. I hence currently see no evidence to suggest that the licensee will not comply with the guidance provided by this SAP.

43 **ECR.1** – The licensee has made little progress with the development of the criticality safety case since the publication of GDA PCSR 2011. However, sub-chapter 9.1 of HPC PCSR 2012 (based entirely on the GDA PCSR), allows me to judge that the licensee is focused on the topics posing the greatest potential threat to criticality safety and has appropriate forward work plans in place to address these topic area. Again I am content that the licensee will, in due course, comply with the guidance presented in this SAP.

44 **ENM.2** – The licensee has recognised that several of the AFs will require resolution before fuel can safely be brought onto the site and is also making suitable provision within its design for the safe storage of fresh fuel on the site. Whilst recognising that much design work remains to be concluded in this area, I am content that the licensee recognises the importance of this SAP and is working to satisfy the guidance provided by the SAP.

45 **NS-TAST-GD-051** – I have used this TAG in ensuring that the licensee has used a systematic process in the definition of the key hazards in both the fuel and core technical areas and has identified the failure modes of the fuel, plant and equipment (again utilising a thorough and systematic process). In addition I have ensured that the licensee's

designs in the two technical areas I have studied show evidence of having defence in depth and that the designs conform to good engineering practice and sound safety principles. I am content that the licensee's work to date demonstrates that the licensee is working to the principles presented in the TAG.

46 **NS-TAST-GD-041** – The criticality safety case for HPC is at a relatively immature stage, however, I have used this TAG to ensure that the licensee is making adequately pessimistic assumptions in the criticality analysis work conducted to date (e.g. in terms of isotopic compositions assumed for the fuel) and that suitable moderation conditions etc. have been applied. I have also ensured that the licensee is proposing passive engineered criticality safety controls, wherever possible, in preference to (for instance) administrative measures. Again I am content that the licensee's work to date demonstrates that due cognisance is being given to the guidance provided by the TAG.

5 CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

47 In the fuel and core and criticality topic areas, HPC PCSR 2012 (i.e. sub-chapters 4.1 – 4.5 and 9.1) presents no new information i.e. the information presented has been lifted directly and accurately from GDA PCSR 2011. Accordingly, I have not conducted any new assessment work in these two technical areas.

48 However, from a series of programmed level 4 meetings with the licensee I have been able to conclude that the licensee is making adequate progress with the definition of key fuel safety parameters, which in turn will support fuel ordering and will permit the licensee to conduct detailed work on the actual core design. In addition, I judge that the licensee's work in this area will allow it ultimately to make a sound safety case for the reactor and core and hence I see no evidence that the licensee will not meet the requirements of LC 23.

49 Whilst progress has been less marked, than that in the fuel and core technical area, on the definition of the criticality safety case since GDA PCSR 2011, I nonetheless see no evidence to suggest that this poses a threat to the HPC design and am confident that the licensee's criticality safety case (when eventually presented) will focus on the key threats to maintaining criticality safety. I am also content that the licensee has suitable forward work activities specified to support the generation of a sound and well underpinned criticality safety case. Again I see no evidence to suggest that the licensee will not meet the requirements of LC 23 in this technical area.

50 With respect to the GDA AFs in both the fuel and core and criticality safety areas, I am content that the licensee understands these findings and has a suitable and timely programme in place to generate RPs to show how the AFs will be closed. Many of the AFs in the core and fuel area will rely upon the provision of suitable OpEx for their closure and I am pleased that the licensee has set up a good network to allow it to access the OpEx data it will require.

51 Whilst no new information in the fuel and core and criticality technical areas is presented in HPC PCSR 2012, nonetheless the licensee has made some progress in particularly the fuel and core area since HPC PCSR 2012. From my level 4 engagements with the licensee since HPC PCSR 2012 was issued I have identified no new issues i.e. since the GDA AFs in either the fuel and core or criticality technical areas.

52 Whilst the licensee has presented no new information within HPC PCSR 2012 in the fuel and core and criticality technical areas, I am nonetheless content that the licensee continues to make an adequate level of progress in defining the safety case in these areas and hence consider that an IIS rating of **3** i.e. **"Adequate"** is appropriate.

5.2 Recommendations

53 I have no Recommendations to record as a result of the work I have reported in this AR.

6 REFERENCES

1. Letter NNB-OSL-RIO-000322, ONR-HPC-20337N – "NNB Genco Submission of PCSR 2012," 6 December 2012, TRIM 2013/16143 (see TRIM 2013/23292 for full HPC PCSR 2012 documents)

2. HPC-NNBOSL-U0-000-RES-000076 – "NNB Generation Company Ltd – Hinkley Point C Pre-Construction Safety Report 2012 – Head Document," December 2012 (TRIM 2013/23292)

3. AST/003 – "Guidance on Production of Reports," Revision 7, September 2013

4. "Safety Assessment Principles for Nuclear Facilities," 2006 Edition, Revision 1, HSE January 2008, www.hse.gov.uk/nuclear/SAP/SAP2006.pdf

5. "Technical Assessment Guides" (TAGs) www.hse.gov.uk/nuclear/tagsrevision.htm

NS-TAST-GD-051 – "The Purpose Scope and Content of Nuclear Safety Cases," Revision 3, July 2013

NS-TAST-GD-041 – "Criticality Safety," Revision 3, April 2013

6. ONR-GDA-AR-11-021 – "Step 4 Fuel and Core Design Assessment of the EDF and Areva UK EPR," Revision 0, 10/11/2011 (TRIM 2010/581511)

7. ONR-GDA-AR-11-025 – "Step 4 Radiological Protection Assessment of the EDF and Areva UK EPR Reactor," (Appendix A), 16/11/2011 (TRIM 2011/36614)

8. UKEPR-0002-041 – "PCSR – Sub-Chapter 4.1 – Summary Description," Issue 03, 26/3/2011 (TRIM 2011/204358)

9. UKEPR-0002-044 – "PCSR – Sub-Chapter 4.4 – Thermal and Hydraulic Design," Issue 03, 26/3/2011 (TRIM 2011/204361)

10. UKEPR-0002-045 – "PCSR – Sub-Chapter 4.5 – Functional Design of Reactivity Control," Issue 03, 26/3/2011 (TRIM 2011/204362)

11. UKEPR-0002-091 – "PCSR – Sub-Chapter 9.1 – Fuel Handling and Storage," Issue 03, 31/3/2011 (TRIM 2011/204390)

12. ONR-NNB-GenCo-IR-12-217 – "Level 4 Meeting on Hinkley Point C Fuel and Core Design," 5/12/2012 (TRIM 2012/497512)

13. ONR-NNB-IR-12-243 – “Level 4 Meeting on HPC Fuel and Core Design/Safety Assessment,” 14/3/2013 (TRIM 2013/125002)

14. ONR-CNRP-CR-13-017 – “Informal Update Meeting on Fuel and Core Matters with NNB Genco Ltd,” 30/5/2013 (TRIM 2013/247964)

15. ONR-NNB-IR-13-075 – “Level 4 Meeting on Hinkley Point C (HPC) Safety Assessment of Fuel and Core and Criticality,” 29/10/2013 (TRIM 2013/408627)

16. E-mail – “Re-Assessment Findings and Resolution Plans,” 6/12/2013 (TRIM 2014/0020797)

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
ERC.1	Design and operation of reactors	The design and operation of the reactor should ensure the fundamental safety functions are delivered with an appropriate degree of confidence for permitted operating modes of the reactor.
ERC.3	Stability in normal operation	The core should be stable in normal operation and should not undergo sudden changes of condition when operating parameters go outside their specified range.
SC.2	Safety case process	The safety case process should produce safety cases that facilitate safe operation.
SC.5	Safety case characteristics	Safety cases should identify areas of optimism and uncertainty, together with their significance, in addition to strengths and any claimed conservatism.
ECR.1	Safety measures	Wherever significant amounts of fissile materials may be present, there should be a system of safety measures to minimise the likelihood of unplanned criticality.
ENM.2	Control of Nuclear Matter	Nuclear matter should not be generated on the site, or brought onto the site, unless sufficient and suitable arrangements are available for its safe management.

Annex 1

Licensee's Plan/Strategy for Issue to ONR of Resolution Plans for GDA Assessment Findings Relating to Fuel and Core and Criticality

GDA finding no.	Assessment finding	Progress Statement	Timescales
AF-UKEPR-AF-03	Future operators shall keep the removal of secondary neutron sources (to further minimise creation of tritium) under review. EDF and AREVA should provide future operators with relevant EPR operational information when available to facilitate their reviews of Best Available Technology - BAT.	The requirement for secondary neutron sources is under review. If these sources are removed from the design, this AF will no longer be applicable.	There is no formal milestone for this GDA AF but this is expected to be addressed by the end of Cycle 1.
AF-UKEPR-FD-01	The licensee shall review the fuel assembly measurements taken from the first core offload at Flamanville and determine the impact that the data has on the safety justification of the proposed core management.	Draft resolution plan provided to ONR. Fuel assembly design to be confirmed in the near future, taking into account the product developments for FA3.	This is required before receipt of fuel on site.
AF-UKEPR-FD-02	The licensee shall review the results of available EPR physics testing and confirm uncertainty allowances in the safety case.	Core physics testing data from FA3 has been requested. The availability of this data is dependent upon the FA3 construction and commissioning schedule.	This is required before first fuel load.
AF-UKEPR-FD-03	The licensee shall demonstrate that the procedures proposed for loading the reactor core with fuel will ensure that an uncontrolled criticality is incredible or that all reasonably practical measures have been taken to prevent this.	Procedures to ensure correct loading of fuel are a normal requirement and will be developed later in the project. Ensuring avoidance of criticality is a key safety requirement during fuel loading activities. Adequate measures are already in place at operating PWRs (such as Sizewell B) and therefore this AF is considered to be low risk.	This is required before first fuel load.

GDA finding no.	Assessment finding	Progress Statement	Timescales
AF-UKEPR-FD-04	The licensee shall acquire and report data on hydride reorientation to demonstrate that irradiated cladding with predominantly radially-orientated hydride precipitates can retain adequate ductility at the hydride levels proposed.	Draft resolution plan expected to be available soon. This AF was raised based on the assumption that HPC would have a dry store facility. Since the project has chosen a wet spent fuel store this AF is not applicable to fuel storage. However, consideration will be given to this AF if spent fuel transport is undertaken in dry conditions.	This is required before receipt of fuel on site.
AF-UKEPR-FD-05	The licensee shall repeat the recent Organisation for Economic Cooperation and Development - OECD benchmark studies on boiling flow in rod bundles and update the FLICA qualification documents.	PWR Sub-Channel and Bundle Tests (PSBT) test confirmed as suitable for benchmark studies. Work to be performed by AREVA.	This is required before by first fuel load.
AF-UKEPR-FD-06	The licensee shall review as-built flow rates and reflect conclusions for flow-induced wear in the maintenance schedule for affected components.	As-built flow rates of reactor coolant pumps will be reviewed compared to specification as part of commissioning testing.	This is required before power raise
AF-UKEPR-FD-07	The licensee shall revise their reported analysis of the RIA fault to demonstrate that no fuel breaches the clad temperature limits designed to ensure residual ductility and provide an assessment of whether it may be reasonably practical to change the rod insertion limit to prevent any fuel entering the DNB condition.	A sensitivity study has been requested to explore the effect on fuel in De-nucleate Boiling - DNB in relation to a small change of the rod insertion limits. It is not expected to be possible to avoid fuel going into DNB, so focus will be given to demonstrating the coolability of the fuel remains adequate to meet the safety requirements.	This is required before the Reactor Pressure Vessel - RPV is installed. Agreement has been reached that a more relevant milestone is fuel on site.
AF-UKEPR-FD-08	The licensee shall review the derived criteria for cladding failure in RIA faults in the context of the results of the relevant experiments in the current CABRI programme if they become available.	It is not clear when results might be available from the CABRI programme (due to significant delays), but it is highly unlikely that it will be prior to the start of operation. The Reactivity Insertion Accident - RIA topic is currently an international topic of interest, which is likely to result in the availability of relevant OPEX.	This is required During Operational phase. Agreement has been reached that in order to be able to close out this AF, an overview of relevant OPEX on this topic

GDA finding no.	Assessment finding	Progress Statement	Timescales
			could be given by fuel on site.
AF-UKEPR-FS-120	The future licensee shall provide a safety analysis bounding limit (SABL) for fission gas pressure distribution as a function of burn-up for incorporation into the technical specifications.	A limit for fission gas pressure will be included as a fuel design requirement.	This is required before receipt of fuel on site.
AF-UKEPR-RC-10	The Licensee shall keep the specification of secondary neutron sources under review and consider suitable alternatives.	The requirement for secondary neutron sources is under review. If these sources are removed from the design this AF will no longer be applicable.	This Assessment Finding should be completed before nuclear operations, as this is when the source becomes activated. Target milestone – Initial criticality.
AF-UKEPR-RC-11	The licensee shall define a surveillance programme for control rods and secondary neutron sources. The programme shall prevent the release of materials such as tritium or silver before there is significant contamination of vessels or pipework.	This is expected to be included in the relevant surveillance programmes.	This Assessment Finding should be completed before nuclear operations, to prevent the release of activatable material. Target milestone – initial criticality.
AF-UKEPR-SI-39	The licensee shall provide more explicit evidence to demonstrate that failure of the core barrel during normal or upset conditions would not lead to unacceptable fuel damage as a result of flow diversion which was not recognised and caused the reactor control system to increase power as a response.	Identified as having low risk to the design. Technical convergence required between NNB, the RD and AREVA on resolution of the fuel & core design aspects of this GDA AF. This relates to the extra analysis required to demonstrate that core barrel failure will note lead to unacceptable fuel damage. Progress expected in 2014.	This is required before the RPV is installed.

CRITICALITY SAFETY RELATED ASSESSMENT FINDINGS

GDA finding no.	Assessment finding	Progress Statement	Timescales
AF-UKEPR-CSA-22	The licensee shall provide a comprehensive examination of re-criticality for all reasonably foreseeable conditions during the transient progression and within the CMSS.	A draft RP specifying the approach and scope of work has been provided to ONR under the Severe Accidents Topic.	Construction – Nuclear island safety related concrete
AF-UKEPR-FD-03	The licensee shall demonstrate that the procedures proposed for loading the reactor core with fuel will ensure that an uncontrolled criticality is incredible or that all reasonably practical measures have been taken to prevent this.	Procedures to ensure correct loading of fuel are a normal requirement and will be developed later in the project. Ensuring avoidance of criticality is a key safety requirement during fuel loading activities. Adequate measures are already bin place at operating PWRs (such as Sizewell B) and therefore this AF is considered to be low risk.	This is required before first fuel load.
AF-UKEPR-RP-18	Criticality control: The licensee shall take steps at the construction stage to assure the presence of borated stainless steel in the fuel pond storage racks in accordance with the design intent.	A draft RP has been produced to describe what measures will be taken to ensure that there is sufficient Boron present in the design of both the dry and wet racking to ensure adequate sub-critical margin under normal and mis-loaded conditions. The draft RP is being reviewed and a final version is expected within 2 months.	This is required before fuel on site.
AF-UKEPR-RP-19	Criticality control: The licensee shall establish systems to monitor the borated stainless steel in the fuel pond storage racks over the lifetime of the plant so as to identify and quantify any degradation.	A draft RP has been produced to describe the process for monitoring Boron degradation in the fuel storage pond racks. Many comments have been received and meetings are required to resolve the best way forward. A final version is unlikely to be agreed before mid-2014.	This is required before fuel on site.
AF-UKEPR-RP-20	Criticality control: The licensee shall establish systems to control and verify the enrichment of the boron used in the fuel pond and its continued presence in the fuel pond	The resolution of this finding is being led by the Reactor Chemistry Topic Area, and is a Priority 2 finding. A kick-off meeting for this finding will be organised in Q1 2014, in order to produce the first	This is required before fuel on site.

GDA finding no.	Assessment finding	Progress Statement	Timescales
	during its operation.	draft of the resolution plan This finding is linked to the resolution of RC-04.	
AF-UKEPR-RC-05	The Licensee shall clearly identify the boron metering system used for safety and specify procedures that ensure common-mode calibration errors do not arise.	The resolution of this finding is being led by the Reactor Chemistry Topic Area, and is a Priority 2 finding. The issued resolution plan for this finding is expected to be available toward the end of Q1 2014.	This Assessment Finding should be completed before the first fuel is brought onto site to ensure rigorous control of borated coolant used for reactivity control. Target milestone - Fuel on-site.
AF-UKEPR-RC-54	The Licensee shall repeat the analysis of re-criticality in the corium, in more detail to include effects such as boron mixing and volatility.	See AF-UKEPR-CSA-22	This Assessment Finding should be completed before first active operation of the plant. Target Milestone – Initial criticality.