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NNB GenCo: Hinkley Point C Pre-Construction Safety Report 2012 Assessment Report for Work Stream B5 – Internal Hazards

Assessment Report: ONR-CNRP-AR-13-088
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17 March 2014

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EXECUTIVE SUMMARY

This assessment report (AR) provides the assessment of that portion of the Hinkley Point C Pre-Construction Safety Report 2012 (HPC PCSR2012) that falls within the scope of Work Stream B5. Most of this material lies in Section 13 of the "head document" of HPC PCSR2012 but other material is found in Section 2 and the supporting sub-sections and references of these two sections have also been assessed.

A final version of the Generic Design Assessment (GDA) Pre-Construction Safety Report (PCSR) issued in November 2012 formed the basis for issue by 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 that a potential purchaser of the design could choose after taking the site location into account. Certain matters were also deemed to be outside the scope of the GDA PCSR.

In contrast, HPC PCSR2012 addresses the whole Hinkley Point C 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 in HPC PCSR2012. As the generic features were addressed in the GDA process, my focus is on site-specific documentation that has not been formally assessed by ONR previously. The remaining, GDA safety case documentation, has been copied into HPC PCSR2012 from a version of the GDA PCSR that was issued in March 2011, but this has now been superseded by a version of the GDA PCSR report issued in November 2012.

It is important to note that HPC PCSR2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of Hinkley Point C. The licensee (NNB GenCo – see list of abbreviations) intends to submit a major revision to HPC PCSR2012 before seeking consent for Nuclear Island construction which will fully integrate the final GDA PCSR and will be supported by other documentation

No formal ONR Assessment Findings have arisen from this internal hazards assessment of HPC PCSR2012. I have identified some findings on each of the major supporting references to the PCSR head document, but my overall conclusion is that I am broadly satisfied with the overall approach towards internal hazards within the Licensee's safety case for HPC at this stage of its development.

There remains much work to be done to develop the claims, argument, and evidence for the safety case for internal hazards at future phases of the project. This is particularly in areas of hazards from balance of plant systems and structures, in incorporating necessary changes from ONR's GDA process, and in demonstrating that risks have been reduced SFAIRP. The forward work activities report within the HPC PCSR2012 was a useful starting point, but is now significantly out of date. As a result my recommendation is a confirmation of the need for continuing interactions with NNB GenCo on their internal hazards safety cases during subsequent project phases for Hinkley Point C. This will allow clarity on ONR's regulatory expectations and on NNB GenCo's intentions as licensee. These interactions should include sufficient early engagement throughout the project, and should also be linked to appropriate NNB project hold points.

LIST OF ABBREVIATIONS

AF	Assessment finding
ALARP	As low as reasonably practicable
APC	Air Plane Crash protection shell
BMS	(ONR) How2 Business Management System
BSL	Basic safety level (in SAPs)
BSO	Basic safety objective (in SAPs)
C&I	Control and Instrumentation
DAC	Design Acceptance Confirmation
DIN	Division Ingénierie Nucléaire - nuclear engineering division of EDF SA.
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
EPR™	A Pressurised Water Reactor (PWR) designed by AREVA and EDF
GDA	Generic Design Assessment
HIP	High-intermediate pressure (steam)
HPB	Hinkley Point B, an AGR nuclear power station licensed to EDF Energy Nuclear Generation Limited
HPC HPC1/HPC2	Hinkley Point C First and second units of HPC twin reactor site
HPC PCSR2012	Hinkley Point C Pre-Construction Safety Report 2012
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
LC	Licence Condition
LP	Low pressure (steam)
NNB GenCo	EDF Nuclear New Build Generation Company Limited
NSDAP	Nuclear Safety Design Assessment Principles
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-construction Safety Report
PWR	Pressurised Water Reactor
RD	Responsible designer
RP	Requesting parties for the GDA (i.e. EDF and AREVA)
SAP	Safety Assessment Principle(s) (HSE)
SFAIRP	So far as is reasonably practicable
SSC	System, Structure and Component
TAG	Technical Assessment Guide(s) (ONR)
WENRA	Western European Nuclear Regulators Association

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1 INTRODUCTION

1.1 Background

1 This report presents the findings of the assessment of that portion of the Hinkley Point C pre-construction safety report 2012 (HPC PCSR2012, Ref. 1 and Ref.2) that falls within the scope of work stream B5 – Internal Hazards.

2 Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) procedure AST/003 (Ref. 3). The ONR Safety Assessment Principles (SAP), Ref. 4, together with supporting Technical Assessment Guides (TAGs), Ref. 5, have been used as the basis for this assessment.

3 This assessment report has been written to support a summary assessment report that addresses whether HPC PCSR2012 demonstrates suitable progress towards meeting ONR's requirement for an adequate pre-construction safety report. To this end, it is possible to raise Assessment Findings (AF) on matters that need to be addressed in the next revision of HPC PCSR – although, in fact, no such AF have been raised for work stream B5 – Internal Hazards.

1.2 Scope

4 The scope of this report covers Work Stream B5, Internal hazards. Most of this material lies in Section 13 of the head document to HPC PCSR2012 (Ref.2) but other material found in supporting sub-sections and references has also been reviewed, as has Section 2 covering the plot plan and its supporting references.

5 A final version of the Generic Design Assessment (GDA) Pre-Construction Safety Report (PCSR) issued in November 2012 (Ref.6) formed the basis for issue by 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 that a potential purchaser of the design could choose after taking the site location into account. Certain matters were also deemed to be outside the scope of the GDA PCSR.

6 In contrast, HPC PCSR2012 (Ref.1 and 2 addresses the whole Hinkley Point C licensed site comprising the proposed twin UK EPR™ units and all ancillary installations. Some matters that were outside the scope of GDA PCSR are addressed in HPC PCSR2012. As the generic features were addressed in the GDA process, attention has been concentrated here on site-specific documentation that has not been formally assessed by ONR previously. The remaining, GDA safety case documentation, has been copied into HPC PCSR2012 from a version of the GDA PCSR that was issued in March 2011, but this has now been superseded by a version of the GDA PCSR report issued in November 2012. The generic documentation has only been revisited if recent developments have materially affected the case being made.

7 It is important to note that HPC PCSR2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of Hinkley Point C and NNB GenCo intends to submit other supporting documentation. Note also that HPC PCSR2012 will be superseded by a further site-specific revision intended to fully reflect the final GDA PCSR and other design changes from Flammanville 3 which is the reference design for Hinkley Point C.

8 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 Flammanville 3. The integration of the methodology agreed during GDA will be demonstrated in the next revision of HPC PCSR.

1.3 Methodology

9 The methodology for the assessment follows the requirements of the ONR BMS 'produce assessments' step in the nuclear safety permissioning process and Ref.3 in particular in relation to mechanics of assessment. Further details of the assessment strategy are given in section 2 and a detailed scope in section 4.1.

2 ASSESSMENT STRATEGY

10 My assessment strategy is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been applied.

2.1 Standards and Criteria

11 The relevant standards and criteria adopted within this assessment are principally the SAPs, Ref.4, internal ONR TAGs, Ref. 5, relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant TAGs are detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.2 Safety Assessment Principles

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

2.2.1 Technical Assessment Guides

13 The following Nuclear Safety Technical Assessment Guide has been used as part of this assessment (Ref.5):

- Internal Hazards, NS-TAST-GD-014 Revision 3, April 2013.

2.2.2 National and International Standards and Guidance

14 The following international standards and guidance have elements relevant to the work reported as part of this assessment (Refs 8, 9):

- WENRA Reactor Reference Safety Levels. WENRA. January 2008 (Ref.8).
- International Atomic Energy Agency (IAEA). Safety Standards Series, SSR 2/1, NSG2.1, NSG1.7, NSG1.1 (Ref.9).

They are not explicitly addressed in the remainder of this report, but the standards were reviewed and incorporated in the TAG (NS-TAST-GD-014, Ref.5) to ensure that ONR expectations are benchmarked against international expectations.

2.3 Use of Technical Support Contractors

15 The assessment of internal hazards aspects of HPC PCSR2012 (Ref. 1 and 2) was carried out using internal ONR resource, no technical support contractor has been used.

2.4 Integration with other Assessment Topics

16 No specific interfaces are relevant to this assessment report. In due course, there will be relationships with other assessment areas – e.g. structural integrity with relation to pipework failures and their frequencies, mechanical engineering, electrical engineering, and C&I for the design and adequacy of systems protecting against hazards, and with the probabilistic safety assessment (PSA) analysts. This has already happened for the ONR GDA assessment for nuclear island plant, but integration with other assessment topics is quite limited due to the state of certainty of the balance of plant at the level of design maturity as captured in HPC PCSR2012.

2.5 Out-of-scope Items

17 GDA assessment and GDA Issues discussed in the HPC PCSR2012 are not within the scope of this assessment since these were addressed within GDA close out processes.

3 Licensee's Safety Case

18 Section 13 of the PCSR head document (Ref.2), *Hazards protection* provides a high level summary of material relating to internal hazards.

19 Other relevant material is contained in Section 2, of the PCSR head document (Ref.2), *Site Data and Bounding Character of GDA Site Envelope*, in particular sub-section 2.1.3 - *Justification that the Site is of a Sufficient Size*.

20 This section only gives a brief summary of the various documents, More specific details of the case are included as part of the discussion on ONR assessment in section 4.

3.1 Summary of HPC PCSR2012 Section 13: Hazards Protections

21 Section 13 of HPC PCSR2012 covers both internal and external hazards. Section 13 of the head document is relatively short – 8 pages – and acts as a summary of the two following sub-sections, namely: 13.1 and 13.2.

22 The head document describes a general approach to hazards, consisting of:

- Hazards identification – including hazard combinations, and screening,
- Establishment of basis safety requirements,
- Hazard consequence assessment / setting of design basis load cases to ensure protection of systems, structures and components (SSCs),
- Design verification against hazards, covers building and equipment responses, functional impact analyses (including consideration of consequential faults) and probabilistic analysis of relevant hazards.

23 The remainder of Section 13 describes lower tier documents (sub-sections and references) that constitute the substantive information available at that time on the protection against hazards. The references relevant to internal hazards are listed below:

- UK EPR™ Hinkley Point Project: "*Hazard Listing Identification and Confirmation*", Issue 4 (July 2012). HPC-NNBOSL-U0-000-RET-000021 (Ref.10).
- *Hinkley Point C - Internal Hazards Protection Summary Document*. Issue 5 (August 2012). HPC-NNBOSL-U0-000-RET-000053 (Ref.11).
- Consolidated GDA PCSR Sub-Section 13.2, "*Internal Hazards Protection*". Issue 03 March 2011. UKEPR-0002-132 (Ref.12).
- *HPC PCSR2 Forward Work Activities*, Issue 1.0, Nov 2012. HPC-NNBOSL-U0-00-RES-000082 (Ref.13).
- UK EPR™ Hinkley Point Project: "*Identification and Review of the Safety Implications of a Twin Reactor Design for HPC*", Issue 6, May 2012. HPC-NNBOSL-U0-000-RET-000020 (Ref.14).
- HPC PCSR2 Sub-section 2.3 – "*Site Plot Plan Summary Documen*t." Revision 2.0 June 2012. HPC-NNBOSL-U0-ALL-RET-000001 (Ref.15).
- *Assessment of Turbine Missile Impact Frequencies on Hinkley Point C Building Structures*. Issue E-BPE (12/04/2011). 16281-709-HPC-RPT-001 (Ref.16).

24 The conclusions of this section are (précised):

- *The internal […] hazards that may affect the proposed UK EPR™ units at HPC have been identified and characterised using information from both the GDA and the site-specific hazard identification and characterisation studies.*

- *Assessments have been made of the adequacy of the protection and mitigation measures that will exist within the proposed design of the UK EPR™ units.*
- *The hazard protection philosophy is to design plant to withstand the applicable hazards, wherever this is reasonably practicable. Where damage cannot be prevented the design ensures that there is redundancy and/or diversity in provision of the required safety functions.*
- *Forward Work Activities […] have been proposed […] that will ensure the detailed design process incorporates all hazard protection and mitigation requirements for each of the safety classified SSCs. The Forward Work Activities also provide further detail on the combination of reasonably foreseeable hazards. This process will ensure that the risks from hazards will be reduced to ALARP for the design of the UK EPR™ units at HPC.*

3.2 Summary of relevant parts of HPC PCSR2012 Section 2, Site data and bounding character of GDA site envelope

25 Section 2 of the HPC PCSR2012 head document is mainly about site details that are of significance to the external hazards, including comparison between site specific hazard data with the "GDA site envelope". The only part of Section 2 that is relevant to internal hazards is covered by a short section entitled "*2.1.3 Justification that the site is of a sufficient size*" which relates to the "*Plot Plan Summary Report*" of HPC PCSR2012 Sub-section 2.3 (Ref.15). This supporting reference has already been identified as a reference to Section 13.

26 The conclusions of HPC PCSR2012 section 2 relevant to internal hazards are (précised):

- *the site is of a sufficient size to construct, commission, operate and decommission the proposed twin UK EPR™ unit design,*
- *the site layout has been optimised in order to reduce the risks to ALARP.*

4 ONR Assessment

27 This assessment has been carried out in accordance with ONR HOW2 BMS policy (Ref.3). The main Nuclear Safety Technical Assessment Guide relevant to Internal Hazards is the following (Ref.5):

- Internal Hazards, NS-TAST-GD-014 Revision 3, April 2013.

The major way in which this TAG has been used is in providing additional guidance on each of the hazard SAPs; so that I have interpreted these consistently to the way these would be interpreted by other ONR assessors.

4.1 Scope of Assessment Undertaken

28 The scope of the assessment is strongly influenced by the coverage of previous ONR assessments:

- The ONR GDA assessment, step 4 was carried out while the March 2011 GDA PCSR was being collated, and sections were provided to ONR as reference material. The assessment report (Ref.17) from the GDA assessment raised a number of GDA issues, and assessment findings. The ONR assessment of later pjoject phases will include sampling how the project has addressed these assessment findings, and NNB GenCo is ensuring that these will be covered by their forward work plan.
- The DAC for the UK EPR™ design required the resolution of a number of GDA issues. For internal hazards aspects of the design, four additional assessment reports (Ref.18, 19, 20, and 21) were issued, which showed acceptance by ONR of satisfactory closure of the GDA issues by the requesting party (RP), but which also identified additional assessment findings. A collated list of assessment findings from the GDA process (i.e. from Ref.17 to 21) is provided as Table 2 of this report.
- The November 2012 GDA PCSR (Ref.6) includes changes necessary for satisfactory closure of GDA issues, and also commitments for changes that will follow as part of the detail design. This however is not reflected in the HPC PCSR2012 (Ref.2).
- ONR also issued an assessment report for internal hazards (Ref.22) as part of the nuclear site licensing process. This report was written in advance of receipt of the HPC PCSR2012, so NNB GenCo provided the so-called “early batches” of supporting material to the site specific PCSR (e.g. Ref.23). This included much of the reference material to Section 2 and Section 13 of the PCSR head document (Ref.2).

29 It can be seen that much of the material has already been considered in existing assessment reports. The scope of the assessment undertaken for this current report therefore is to collate key findings from previous assessments, and look for any new material not previously assessed in case this requires a view from ONR.

4.2 Assessment

4.2.1 Head document to the HPC PCSR2012 – Section 13 and Section 2

30 Both Section 13 and Section 2 of the PCSR head document (Ref.2) provide no real new information in themselves, they simply summarise information from the seven supporting references (Refs.10 to 16).

4.2.2 Hazard Listing Identification and Confirmation *(Ref.10)*

31 This reference is new, and was not reviewed either as part of the GDA process or as part of the initial nuclear site licensing for HPC. It describes a process whereby a variety of different source documents were reviewed to identify a potential list of hazards, which were then subject to a screening and bounding approach. The screening and bounding was however only to identify the following:

- if the potential hazard had been sufficiently covered by the GDA PCSR so as not to require further consideration within site-specific assessments.
- Whether the nature of the HPC site allows hazards to be screened out based on low frequency, low consequence, or because they cannot occur at this particular site.
- Whether hazards require splitting or combining to aid analysis and understanding – an example of the latter being for coastal flooding where tidal effects, storm surges and waves are to be assessed in combination.

32 The net result is a list of hazards to be addressed in future safety cases. The characterisation of each hazard is not covered by this reference, instead the intention is that this is covered in future references.

33 In the reference (Ref.10), the only significant screening of internal hazards is that dropped loads due to collapse of structures are screened out. The argument is that these will either feature as a consequence of other hazards or through the safety classification of structures. This is a reasonable approach in general – well built and well maintained buildings don't just fall down, although they can fail in seismic, high wind, or due to subsidence. The only quibble would be whether this approach may lead to decisions on plant layout that could be less hazard tolerant than if the specific sensitivity were more visible, but experience suggests that for designs with adequate plant redundancy and segregation this will not significantly increase the overall plant risk.

34 An issue identified as outside the scope of this reference (Ref.10), was the need to complete the analysis of combined and consequential events. This has been entered into the HPC PCSR2012 *Forward Work Activities* report (Ref.13) and NNB GenCo and the RD (the responsible designer) are further developing their methodology for combined and consequential hazards, taking account of current knowledge and international and national guidance.

35 From the internal hazards perspective, I judge that the resulting list of internal hazards is non-contentious, including all the hazards that feature in ONR guidance (Ref.4 and 5).

4.2.3 Hinkley Point C - Internal Hazards Protection Summary Report *(Ref.11)*

36 This reference is identified as "complementing" sub-chapter 13.2 of the GDA PCSR (Ref.12) with Hinkley Point C PCSR site-specific activities. It addresses aspects to internal hazards other than those that were covered in the GDA PCSR. The detailed design of the HPC buildings and many of the plant systems are not finalised – in particular GDA concentrated on the nuclear island and nuclear safety systems, but did not cover "balance of plant", grid connection and heat sink – these are more site-specific.

37 NNB GenCo's executive summary includes a summary of the purpose and objectives of this reference document, which states:

Internal hazards are dealt with in Sub-chapter 13.2 of the Generic Design Assessment (GDA) PCSR for the generic UK EPR™. The GDA Sub-chapter forms the basis for the assessment of internal hazards at HPC.

This report complements the GDA PCSR Sub-chapter 13.2 (Internal Hazards Protection) with HPC site-specific information, and is to be read alongside it. The intention is that the information in this report will be absorbed into Sub-section 13.2 of a later version of the HPC PCSR.

This report has four objectives:

1. To confirm the continuing applicability of the GDA PCSR with respect to internal hazards.

2. To identify changes to the GDA design and any consequences on the applicability of the GDA PCSR.

3. To present the preliminary safety arguments associated with the early concept designs of site specific structures which are additional to the GDA.

4. To compile a list of outstanding issues to be addressed during further development of the design.

38 The current state of design and approach of the document is summarised:

The design of the HPC twin-reactor site is currently on-going. Early concept-designs of the site specific buildings are available. Preliminary safety arguments are presented for the ISFS [interim spent fuel store], ILWS [intermediate level waste store], heat sink, and technical galleries for each hazard where applicable information is available. The requirement for hazard protection during construction is also highlighted.

Each internal hazard as ratified by the Hazard Listing Identification and Confirmation report is considered. A distinction is drawn between the effects which are localised to the building or system, and non-localised effects, based on engineering judgement. For localised effects it has been determined that the GDA analysis is applicable currently. The non-localised effects potentially jeopardise the continuing applicability of the GDA PCSR analysis for each unit and need to be assessed further as the site-specific design develops.

39 Finally, the executive summary includes the main findings and conclusions:

It is concluded that a comprehensive analysis of internal hazards is required for the site-specific buildings for both normal operation and during construction. Bounding cases for each hazard should be identified and assessed to determine if there will be any consequential hazards to other facilities.

A number of internal hazards specific outstanding issues have been raised and are reported. These issues will be resolved during design development.

There is no reason to expect that the internal hazards associated with the HPC station design cannot be addressed satisfactorily by appropriate engineering design.

40 I viewed the report (Ref.11) as clearly written, with clear objectives. The current state of hazard safety case arguments are placed in the current context of design – i.e. detailed design is still ongoing, so that definitive analysis is not yet possible.

41 In several places within the report (Ref.11) consideration of the internal hazards stops at the basic principle level: i.e. with statements such as

- there will be "*adequate redundancy*",
- "*levels of defence in depth in place*",
- "*break exclusion*" on *certain equipment*,

- "*risks … are likely to be acceptable*", and similar statements.

This may be appropriate for a PCSR in areas where design is ongoing, but it indicates work for design and safety case justification, and a potential area with further regulatory risks. This is in agreement with the findings of the reference report (Ref.11) – it recognises that issues are to be resolved in detailed design. In many cases, the report refers to "additional analysis" that will be required as the design becomes more advanced.

42 ONR have been meeting regularly on internal hazards with NNB GenCo (Level 4 meetings). The situation described in the report is compatible with the situation described in these progress meetings. NNB GenCo and RD have clarified that many of the internal hazard studies cannot be carried out until mid-late 2015, since a settled design is needed as a basis of the studies. This is why NNB GenCo current priorities for internal hazards work include finalising hazard methodologies, design reviews, and addressing GDA assessment findings.

43 The bulk of the report (Ref.11) includes discussion of each of the internal hazard.

- The GDA hazard management strategies and design methodologies are described.
- There is a comparison of the HPC site envelope to the GDA. This includes a discussion on:
  - the heat sink specific hazards,
  - ILWS specific hazards,
  - ISFS specific hazards,
  - Inter-facility hazards (i.e. the other unit at HPB and the consequence of having some site-based systems as well as unit-based systems).
- The construction considerations are discussed and, in particular, potential risks from the construction of the second unit (HPC2) whilst the first unit (HPC1) is operating.
- A concluding section describes the risks and outstanding issues.

44 On individual sections of the report covering individual hazards, I had some points to note:

- Internal Missiles
  - The issue of potential missiles from turbine disintegration on the second unit is noted, and an argument provided based upon low frequency and acceptable consequences of these impacts. It concludes that this risk "*is likely to be acceptable*".
- Internal explosions
  - This section recognises that much of the assessment is still to be carried out, and that this will be in a later issue of the HPC PCSR.
- Internal Fires
  - This section includes some good basic hazard management strategy, including the recognition of measures to prevent, contain, and control potential fires. With much of this however, it will be how these are worked out in detail design – for example, prevention includes limiting combustible material, but how this is achieved will come down to other processes within NNB GenCo such as design selection and design review.

45 The report (Ref.11) provides a lust of outstanding issues from the detailed section covering each hazard, and these are carried forward for potential inclusion in the *Forward Work Activities* report (Ref.13).

46 The report appears to provide NNB GenCo with good visibility of the then-current status of issues related to the protection against internal hazards, so NNB GenCo can develop the safety case against internal hazards into the next stages of the project. It is also useful as part of the process by which NNB GenCo assume sufficient "ownership" of their safety case. The true test of its usefulness will be if NNB GenCo and RD can use the work to assist them in determining work packages over the next few years.

4.2.4 Consolidated GDA PCSR Sub-Chapter 13.2, Internal Hazards Protection *(Ref.12)*

47 This document was submitted to ONR by the RP (requesting party - vendor) as part of the GDA process, and was assessed within ONR's GDA assessment. The 2011 GDA PCSR is recognised as a significant reference within the main Step 4 assessment report for internal hazards (this is reference 22 of Ref.17). I have checked, and sub-chapter 13.2 (Ref.12) was at the same revision status (Issue 03, March 2011) within the March 2011 GDA PCSR (Ref.7) as in the HPC PCSR 2012 (Ref.2).

48 In the GDA step 4 assessment report (Ref.17), the following issues should be noted:

- Sub-chapter 13.2 (Ref.12) was recognised within GI-UKEPR-IH-02, as a vehicle for reporting additional substantiation - outstanding verification and validation for internal flooding, cable routing, high energy line break, and internal missiles.
- Sub-chapter 13.2 (Ref.12) was also discussed in the context of GDA Issue GI-UKEPR-IH-04 (see para 197-200 of Ref.17), which requires substantiation of the consequences of missile generation arising from failure of RCC-M components. (Note: RCC-M is the *Design and Construction Rules for Mechanical Components of PWR Nuclear Islands* and is a design code used by the EPR RP.)

49 Both GDA issues have been closed out following completion of their resolution plan. A revised version of the sub-chapter was issued by the RP to reflect the completion of the substantiation studies. An ONR internal hazards assessment report was issued in each case.

50 Given the rigorous assessment of sub-chapter 13.2 carried out in the ONR GDA step 4 assessment, and the updates to the sub-chapter provided to support the GDA Issues closeout process, I judge that there is no further benefit in reviewing this, now out-of-date, reference.

4.2.5 HPC PCSR2 Forward Work Activities*, (Ref.13)*

51 The purpose and nature of this report (Ref.13) is described in its general introduction (extracts follows):

[…] HPC PCSR2 identifies a number of Forward Work Activities that are required to fully develop the safety case.

This document presents a summary of the main Forward Work Activities, completion of which is required to develop the safety case as the HPC design matures […] These Forward Work Activities are organised under the relevant chapter of HPC PCSR2. Resolution of these Forward Work Activities is being scheduled by NNB GenCo as part of normal engineering sequence activities […].

As noted in the HPC PCSR2 Head Document [Ref. 1], there are five main inputs to the engineering and safety case development that initiate the requirement for Forward Work Activities. These are as follows:

1) Generic Design Assessment (GDA) Issues,

2) GDA Assessment Findings,

3) GDA Out-of-scope Items,

4) Fukushima related recommendations,

5) Other Forward Work Activities.

52 It should be noted that at the time of preparing the report (Ref.13), the RP had not completed the GDA Issues resolution plans. The report recognised that "*these could generate additional Assessment Findings that NNB GenCo will be required to address*" (see next paragraph).

53 I have reviewed all internal hazard related items in the *Forward Work Activities* report (as submitted at the time of collating HPC PCSR2012), and have attached this as Table 3 to this report. I judge that there are no surprises in this list, The HPC site specific project was running in parallel with GDA close out activities, so as a result the list was incomplete and slightly out of date even when issued – for example it only includes the ONR assessment findings from the ONR Step 4 GDA assessment report for internal hazards (i.e. the 9 findings from Ref.17), and not the additional findings from the four ONR assessment reports on the GDA Issue Close out (Ref.18, 19, 20, and 21).

54 The work list for internal hazards within the *Forward Work Activities* report (Ref.13) also does not align well with NNG GenCo's current strategy for hold points, which has continued to develop since the preparation of HPC PCSR2012. The current work plans form part of the agenda for continued dialogue with NNB GenCo within both project level interactions and level 4 meetings for the individual assessment area – including for internal hazards.

4.2.6 Identification and Review of the Safety Implications of a Twin Reactor Design for HPC *(Ref.14)*

55 As part of the information provided by NNB GenCo in support of their application for a site license for two EPR™ reactors at Hinkley Pint B, "early batch" submissions of parts of HPC PCSR2012 were provided. This included "*Batch 3.1 submission: Justification that the site is of a sufficient size*". This batch of documents formed part of the evidence examined in the ONR internal hazards assessment report (Ref.22) supporting granting of the licence. I have looked at ONR assessment as part of earlier assessment in support of the initial site licensing decision, and taken the opportunity to view this in the context of other material provided as part of HPC PCSR2012. Previous assessments are described in paragraphs 57 to 59, and these are considered further from paragraph 61.

56 The Batch 3.1 submission (Ref.23) includes two reference documents, *Safety Implications of a Twin Reactor Design* and *Site Plot Plan Summary Documen*t. These are identical, including in issue number, with those provided later as part of HPC PCSR2012 (Ref.14 and 15).

57 For the twin reactor design review (Ref.14), the ONR internal hazards assessment report (Ref.22) said (précised):

- *ONR internal hazards assessors have […] looked at their content, scope and conclusions […].*

- *The documents in these submissions look at the whether the site size is adequate for the plant intended, and include consideration of various hazards. […] the general approach has been to follow established UKEPR™ layout principles, allowing for the exigencies of the site […]*
- *As with the other safety submissions from NNB the internal hazards claims and arguments are fairly broad and little evidence is provided at this stage. […]*

58 Another paragraph (not précised) discussed whether the siting decision that turbines will be located parallel to each other would lead to the best potential risk reduction for missiles resulting from the low probability initiating fault of major turbine disintegration. It is recognised however that it is likely that the nuclear risks will be demonstrated to be very low (para 68 of Ref.22). The arguments within the twin reactor review (Ref.14) are supplemented by the turbine missile impact assessment (Ref.16), so further discussion will occur later (section 4.2.8).

59 The executive summary of the twin reactor review (Ref.14) includes the following:

- *This document provides a qualitative assessment of the hazards specifically associated with the HPC twin-unit configuration and determines whether the twin-unit configuration significantly changes the risk to nuclear safety associated with the generic site presented in the GDA PCSR.*
- *[…] a unit interactions completeness workshop was held to identify all shared facilities and shared services at HPC. […]*
- *A qualitative assessment of the changes to risk as a result of a twin-unit site configuration for each hazard identified in the GDA was carried out. […]*
- *The potential hazards associated specifically with a twin-unit configuration, and therefore not included in the GDA, were identified and assessed.[…]*
- *The specific issues related to a multi-unit site that were identified in the Health and Safety Executive (HSE) report on the recent nuclear incident at the Fukushima plant in Japan were reviewed. […]*
- *A number of issues have not been completely resolved within this report. Five areas for further assessment have been identified.[…]*

60 Within the report, the hazard assessment method includes a view that since internal hazards are “generally” caused by malfunction of the plant equipment or operator errors, their frequency and consequences are more related to the physical property of the plant rather than the location. It notes that “significant internal hazards” potentially affected by the twin reactor concept are internal missiles from turbine failure, fire spread, and internal flooding. Arguments for the acceptability of each are summarised:

- Internal missiles from turbine failure
  - *This report identified an increase in risk from internal (turbine) missiles, as the GDA does not consider the possibility of turbine missiles from one unit impacting upon the other. However, the Air Plane Crash (APC) shell is able to provide defence against turbine missile impact for some safety critical plant such that nuclear safety should not be compromised.*
  - *It has been shown […] that the initiation frequency of this hazard is tolerable. […] identified a strike frequency on the order of 10^{-7} per year or lower for each of the HPC targets […] important for safety, with one exception which experiences an impact frequency on the order of 10^{-5} per year.*

- Fire Spread
  - *[…] Technical galleries that run between the two units, provid[es] a potential path for a fire to spread from one unit to the other. These galleries contain no equipment that performs a safety function and where they cross into fire compartments they contain fire barriers that are designed to the same standards of fire protection as for the other fire compartment barriers. This provides protection against the risk of fires spreading from one unit to the other through these galleries.*
- Internal Flooding
  - *There is […] the potential for the technical galleries to transport water between units should a leak occur in close proximity to them. However, the galleries, which do not contain any safety related equipment, offer the same level of flood protection as the segregated nuclear safety trains; thus preventing floodwater from one unit posing a safety risk to the other.*

61 My judgement is that on the first of these issues – internal missiles from turbine failure – the safety case has reached a level of development that gives confidence in the low risks from such low frequency events (see also para 78). The approach in this report works less well for the other two "significant internal hazards" - fires and internal flooding. This is because there is much plant excluded from GDA, and the internal hazards safety cases need to be addressed in the detailed design phases for the "balance of plant". Nevertheless, I consider that the basic conclusion that good processes in the detailed design phases are capable of leading to a twin reactor power station whose unit risk is not significantly higher than that from a single reactor power station is sound.

62 Recommendations from the report included several with implication to internal hazards (both have been captured in the *Forward Work Activities* report):

- *Consideration should be given to the risks associated with the construction of HPC2 while HPC1 is undergoing commissioning. […]*
- *A full ALARP assessment for the HPC site should be conducted. […]*

4.2.7 HPC PCSR2 Sub-section 2.3 – Site Plot Plan Summary Document*. (Ref.15)*

63 Quoting the "Purpose" of the site plot plan summary document (Ref.15):

- *The purpose of this report is to provide a summary of the site plot plan for the proposed Hinkley Point C Power Station, in support of the Pre-Construction Safety Report. The report also contributes to the demonstration that the site plot is of sufficient size to accommodate a twin UK EPR nuclear power station and that the layout of the buildings has been optimised to ensure that any risks which could be initiated through the layout of the site have been reduced so far as is reasonably practicable.*

64 The site plot plan summary document includes "*Criteria for location and installation relating to internal hazards*". This is general guidance for application in developing the site plot plan:

- *The design requirement is that internal hazards […] must not propagate from one safety train to another or from one division of the Fuel Building to a safety train. Geographical and/or physical separation criteria are applied to prevent propagation of hazards.*

- *For example, the spread of internal fire or flood is prevented by construction provisions such as separation walls, fire barriers and sealing devices applied to openings between rooms.*
- *Design provisions prevent the propagation of hazards from the conventional island to the nuclear island (particularly missile propagation).*
- *The design provisions used for protection against internal hazards are described […]*

65 The site plot plan summary document (Ref.15) refers back to the PCSR (HPC PCSR2012 (Ref?)) and to supporting references such as the *Forward Work Activities* report(Ref.13) and the twin reactor review (Ref.14).

66 Section 6 of the site plot plan summary document (Ref.15) includes a survey of the internal hazards. Three are identified as influencing the site layout – Missiles, explosions and fire:

- Missiles:
  - Turbine missiles are identified as influencing the orientation of the turbines relative to the reactor buildings, the distance between units, and the separation distance from the HPB site.
  - There is reference to the turbine missile impact frequency report (Ref.16). Changes to layout since that study had been carried out were recognised, so that the forward action plan will include looking at the assessment of missiles onto oxygen and hydrazine stores, and an update to the hazard analysis report.
- Explosions:
  - Building layout rules used by the HPC project are claimed to be compatible with Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR), and require separation distances for storage areas, gas bottle stores, gas storage vessels, etc.
  - The structural design and physical separation of all buildings, and the aircraft protection shell to the reactor building are viewed as providing significant protection against explosions as well as aircraft impact.
  - Further analysis is identified as necessary for PCSR3.
    (Note: PCSR3 is short form for the next version of the PCSR for HPC, similarly, within the project HPC PCSR2012 was referred to as PCSR2 prior to submission)
- Fire:
  - In general the layout principles will lead to flammable materials being located away from buildings containing nuclear safety related equipment and/or nuclear material.
  - There is much yet to be determined – including the volumes and nature of flammable materials stored within the plant, and the storage provisions – this is again an item on the plan for HPC PCSR2012 forward work activities (Ref.13)
  - The issue of the potential for fires to migrate via technical galleries is discussed. The layout principles will mean that where the galleries cross fire compartments, they will contain fire barriers designed to the same standards of fire protection as other fire barriers for those compartments.
  - The on-site diesel fuel storage facilities will be separated from the nuclear island buildings either by a distance or by a firewall, in each case sufficient to prevent propagation of any potential large fuel fires. The plan for HPC PCSR2012 forward

work activities (Ref.13) includes defining and justifying these diesel storage provisions.

67 As in the case of some of the other references to HPC PCSR2012, the site plot plan summary document (Ref.15) identifies that there is a need for the hazards to the operating HPC1 from the construction of HPC2 to be identified, analysed and justified. These hazards are consequence of project phasing, where the start of the construction of HPC2 may not commence until 18 months after that for HPC1. This is identified on the plan for HPC PCSR2012 forward work activities (Ref.13).

68 The conclusions of the site plot plan summary document (Ref.15) are:

- *This report has presented the HPC site layout for the reference design used within [HPC PCSR2012]. The standards and guidelines used in the development of the site layout have been identified as well as those hazards applicable to the layout design. […] The report has shown the design optioneering process which has been undertaken for the various facilities on the site, thus demonstrating that the design of the site layout has been optimised wherever possible.*
- *The analysis has shown that the size of the proposed Hinkley Point C site is sufficient to safely accommodate and operate two UK EPR units and their associated support facilities and services.*
- *Furthermore, this report has demonstrated that the layout of the site has been designed to ensure that the risks from the layout have been reduced to ALARP.*

69 In my judgement the conclusions are slightly overstated. I believe that the document does show that the HPC site is sufficient in size for the proposed development, but don't believe that the detailed design is yet sufficiently defined to claim that risks have been reduced so far as is reasonably practicable (SFAIRP) by appropriate choice of plant and building layout – which is what is implied by the claim that risks are ALARP This is recognised though all the HPC PCSR2012 reports, and in the forward action plan. In my view the report shows that NNB GenCo are aware of he importance of layout decisions as part of hazard management strategies, but also recognise that this is a live issue during the detailed design of the HPC EPR power station.

4.2.8 Assessment of Turbine Missile Impact Frequencies on Hinkley Point C Building Structures*. (Ref.16)*

70 As has been already discussed, as well as being a reference to Section 13 of the head document of the HPC PCSR2012, it is also a supporting reference to some of the other references (e.g. the twin reactor review (Ref.14) and the site plot plan summary (Ref.15)).

71 The purpose and scope are described in the introductory text to the turbine missile impact report (Ref.16) (précised):

- *[…] This study analyses the risks arising from this hazard and attempts to assess them against the HSE Safety Assessment Principles for Nuclear Facilities [1].*
- *The study presents the frequencies of missiles generated by a turbine disintegration event within either of the HPC or HPB turbines striking a safety critical building on the HPC site, and assesses these against a strike frequency criterion of 10^{-7} $year^{-1}$. [..]*
  - *Consideration has been taken of two alternate turbine designs, in which the rotors are attached to the turbine shaft using either welded or shrunk-on technology.*

- *[…] Details of the locations of each of the LP rotors have been made available for both rotor technology options, and these have been used as the departure points of the turbine missiles.*
- *The velocity ranges of ejected missiles have been revised based on more detailed information on the masses and dimensions of the turbine discs.*
- *Buildings which are protected by an aircraft shell are assumed to be shielded against the consequences of turbine missile impact. They are also assumed to shield other buildings from low trajectory (LT) missiles. […]*

■ *The scope of the work is to assess the turbine missile strike frequencies experienced by buildings and structures on the HPC site which perform safety important (IPS) functions. […T]he IPS structures […] fall into the following three categories :*

- *1. Emergency shutdown, cooling of reactor and maintaining the safe shutdown*
- *2. Containment and storage of spent fuel*
- *3. Treatment and storage of radioactive waste*

■ *The beneficial effects of aircraft protection have been considered. The energy of aircraft impact is assumed to bound that of the most energetic credible turbine missile. […A]ircraft protected buildings […] are therefore assumed to be invulnerable to damage from turbine missiles [… and] to provide a shielding effect on other buildings within the site.*

72 The analysis in the turbine missile impact report (Ref.16) starts from basic failure rate data of:

■ For “normal” overspeed failure.

- 1.0×10^{-4} per turbine year for “older technology” turbines such as HPB – based upon a 1973 reference.
- 2.5×10^{-5} per turbine year for “newer technology” turbines such as SZB – which is assumed to also apply to HPC.

■ For “runaway” overspeed failure, which includes loss of trip and overspeed protection of the turbine.

- 1.0×10^{-5} per turbine year – applied to both older (HPB) and newer (HPC) technology turbines.

73 In the case of a “normal” overspeed failure it is assumed that 12 missiles will be ejected, whereas 36 missiles are assumed for the runaway overspeed failure. All missiles are assumed to relate to LP (low pressure) rotor failures – this is because of the HIP (high-intermediate pressure) rotors have lower diameters and stored energy, thicker casings and lower key-root stresses and failure rates,

74 A proprietary computer programme – IMPACT - is used to calculate the missile strike probabilities. These depend upon the location of potentially impacted plant, the probability of missile being generated at particular initial ejection directions and any shielding the aircraft shielded structures if they are between the turbine and the potentially affected plant.

75 The initial distribution of missiles uses methods and assumption compatible with a previous study carried out for Sizewell B nuclear power. Some information has been provided by EDF to allow the study to look at two options for turbine construction

(whether rotors are either welded to the shaft or shrunk on). However, since details of the HPC turbine and casing are not available, the analysis at present contains a mix of design data for HPC turbines and data used in the previous Sizewell B analysis. I judge that this is acceptable for the current application, especially as the report contains sensitivity studies to some of the more important assumptions.

76 The results of the turbine missile impact report (Ref.16) are fairly much as expected. Low frequencies are predicted for all turbine missiles strikes on buildings containing plant important to safety (IPS). The results show that strikes from the other unit's missiles (i.e. strikes from the HPC1 turbine of HPC2, or *vice versa*) are much more likely than strikes from HPB – which is not a surprise given how far away it is. At the current state of analysis of this hazard, the radiological consequences of these potential strikes have not been developed to any great extent.

77 The conclusions from the study (Ref.16) were (précised):

- *All IPS targets identified within the HPC site have been shown to experience strike frequencies of the order of 10^{-7} $year^{-1}$ or lower, with the exception of the contaminated tool storage building […], which experiences an impact frequency of the order of 10^{-6} $year^{-1}$.*
- *[…T]he radiological consequences of turbine missile impact on the [contaminated tool storage building…] is very low (below 0.001 mSv) […and] can therefore be screened out.*
- *If the conservative assumption is made that the dose […] from each strike is [.., a dose corresponding to Dose Band 5 in ONR SAPs], then the summed contribution […of] 1.4×10^{-6} $year^{-1}$ […] may be compared with the Basic Safety Level (BSL) […for DB4] which is 1.0×10^{-4} $year^{-1}$. […T]his result remains acceptable, subject to a demonstration that the risk is ALARP.*
- *Target strike frequencies have been shown to be insensitive to the turbine rotor technology option. […]*
- *The study has assumed that the kinetic energy of a missile lost due to casing perforation is […compatible with that] used for other UK turbine disintegration studies. […] A sensitivity study […] shows that the conclusions of the study will remain unchanged when detailed design information on the selected UK EPR turbine becomes available, and this can be confirmed by further analysis.*

78 I judge that although the model is fairly crude, and some of the data needs to be confirmed, the conclusions from the study are sound. The turbine missile impact report (Ref.16) is compatible with the state of knowledge of the design and the site at the time it was carried out, and is suitable for a reference report to the HPC PCSR2012. I also agree with the conclusion that further work, including a demonstration that risks are ALARP, should be carried out at a later stage of development of the HPC design.

4.3 Comparison with Standards, Guidance and Relevant Good Practice

4.3.1 Safety Assessment Principles

79 Relevant safety assessment principles are attached as table 1.

Engineering Principles: External and internal hazards - EHA1 to EHA17

80 Within the assessment report for new site licensing (Ref.22), we commented on the then current state of the design with relation to a comparison with the expectations within these SAPs.

- *Although internal hazards have been considered in detail as part of the GDA, this only addressed the Nuclear Island and diesel buildings. The NNB site specific design is still being developed, so the internal hazards safety cases that deal with site specific aspects are not yet available.*
- *[…] work seen to date […] has shown that elements of these SAPs have been considered, but there is an absence of detail and there is still significant work required to fully address the SAPs. However, NNB [GenCo] have adopted the PCSR for the generic design and are fully aware of the internal hazards requirements for the development of a complete and comprehensive site specific PCSR for HPC.*
- *This position is considered to be sufficient for the licensing phase but more detailed and comprehensive safety cases will be required prior to construction activities taking place.*

81 In my view, the additional information provided for HPC PCSR2012 does not change this position on the comparison with these SAPs.

Siting: ST5 and ST6

82 Two of the SAPs covering siting (ST.5 - Effect on other hazardous installations, and ST.6 - Multi Facility Sites) are relevant to internal hazards, and are included within Table 1.

83 The assessment report for new site licensing (Ref.22) says that:

- *[…] NNB [GenCo] have produced preliminary cases that consider the interactions that Hinkley Point C may have with the other sites and facilities adjacent to it, and also the interaction those adjacent facilities may have upon HPC from an internal hazards perspective. NNB[GenCo] have not currently identified any significant issues, although there have been some areas that require further detailed development. […]*
- *No threats from internal hazards have currently been identified that I consider provide issues that would prevent the construction of twin UKEPR™ units at Hinkley Point C.*

84 Since most of the critical additional information provided in HPC PCRS2012 was made available to ONR in preparing the assessment report for new site licensing (Ref.22), I view these statements as still valid.

5 Conclusions and Recomendations

5.1 Conclusions

85 This report presents the findings of the ONR assessment of internal hazards aspects of HPC PCSR2012. In particular I was asked to comment on internal hazards aspects of Section 13 (*Hazards protection*) and Section 2 (*Site data and bounding character of GDA site envelope*).

86 I found that the majority of information provided within HPC PCSR2012 had already been examined, either in the ONR internal hazards assessment report (Ref,17) at step 4 of the GDA process, or in the ONR internal hazards assessment report (Ref.22) as part of new site licensing for a twin reactor site at Hinkley Point B.

87 The two sections of the head document were summaries of supporting references, the consideration of which takes up the majority of this assessment report. Detailed conclusions from each of these appear below:

- *Hazard Listing Identification and Confirmation* (Ref.10)
  - I judge that the resulting list of internal hazards is non-contentious, including all the hazards that feature in ONR guidance.
- *Internal Hazards Protection Summary Document* (Ref.11)
  - I noted that the current state of hazard safety case arguments are placed in the current context of design – i.e. detailed design is still ongoing, so that definitive analysis is not yet possible.
  - Consideration of internal hazards stops at the basic principle level: i.e. with statements such as "*risks … are likely to be acceptable*", and similar statements. This is appropriate for a PCSR in areas where design is ongoing, but it indicates work for design and safety case justification, and a potential area with further regulatory risks.
  - I judge that the report appears to provide NNB GenCo with good visibility of the then-current (Dec 2012) status of issues related to the protection against internal hazards, so NNB GenCo can develop the safety case against internal hazards into the next stages of the project.
- GDA PCSR Sub-Chapter 13.2, *Internal Hazards Protection* (Ref.12)
  - This was subject to rigorous ONR assessment carried out as part of the GDA process. I judge that that there is no further benefit in reviewing this, now out-of-date, reference.
- G*HPC PCSR2 Forward Work Activities*, (Ref.13)
  - I have reviewed all internal hazard related items in the *Forward Work Activities* report and I judge that these are no surprises in this list, which is necessarily incomplete and out of date – given that it does not include the additional ONR assessment findings from the four ONR assessment reports on the GDA Issue close out.
  - The work list has developed to align with NNG GenCo's current strategy for hold points since the preparation of HPC PCSR2012, and current work plans form part of the agenda for level 4 meetings with NNB GenCo – including for the internal hazards assessment work stream.

- *Identification and Review of the Safety Implications of a Twin Reactor Design for HPC* (Ref.14)
  - My judgement is that for internal missiles from turbine failure the safety case has reached a level of development that gives confidence in the low risks from such low frequency events.
  - The other two internal hazards identified as “significant internal hazards” in this report are fires and internal flooding. In these cases work will be needed in the future to demonstrate low risks, partly because that there is much plant excluded from GDA. The internal hazards safety cases need to be addressed in the detailed design phases for the balance of plant.
  - I agree however with the overall conclusion from this report in that good processes in the detailed design phases are capable of leading to a twin reactor power station whose unit risk is not significantly higher than that from a single reactor power station.
- HPC PCSR2 Sub-section 2.3 – *Site Plot Plan Summary Documen*t. (Ref.15)
  - I believe that the document demonstrates that the HPC site is sufficient in size for the proposed development, but I don’t believe that the detailed design is yet sufficiently defined to claim that risks have been reduced so far as is reasonably practicable (SFAIRP) by appropriate choice of plant and building layout.
  - I believe that NNB GenCo are aware of the importance of layout decisions as part of hazard management strategies, and that this is a live issue during the detailed design of the balance of plant facilities additional to the nuclear island.
- *Assessment of Turbine Missile Impact Frequencies on Hinkley Point C Building Structures*. (Ref.16)
  - I judge that the conclusions from the study are sound - although the model is fairly crude, and some of the data needs to be confirmed. This feeds into the judgement from the twin reactor review that risks from turbine missiles are low.
  - I agree with the conclusion that further work, including a demonstration that risks are ALARP, should be carried out at a later stage of design development.
- *Safety Assessment Principles*
  - In the licensing phase of the HPC project ONR viewed that work seen to date had shown that elements of the SAPs relevant to internal hazards (EHA.1, EHA.3 to EHA.6, EHA.13 to EHA.17) have been considered, but there was an absence of detail and there was still significant work required to fully address the SAPs.
  - In my view, the additional information provided for HPC PCSR2012 does not change this position on the comparison with these SAPs.

88 To conclude, I am broadly satisfied with the overall approach towards internal hazards within the Licensee’s safety case for HPC at this stage of its development. There remains much work to be done to develop the claims, argument, and evidence for the safety case for internal hazards at future phases of the project. This is particularly in areas of hazards from balance of plant systems and structures, in incorporating necessary changes from ONR’s GDA process, and in demonstrating that risks have been reduced SFAIRP.

5.2 Recommendations / further work

89 I have no recommendations.

6 References

1 NNB GenCo Submission of HPC PCSR 2012, Letter NNB-OSL-RIO-000322, ONR-HPC-20337N, 6 December 2012, TRIM 2013/16143

2 NNB Generation Company Ltd, *Hinkley Point C Pre-Construction Safety Report* 2012: Head Document. HPC-NNBOSL-U0-000-RES-000076 Version 1.0, Provided with Ref.1 TRIM 2013/16152

3 *ONR How2 Business Management System. Purpose and Scope of Permissioning.* PI/FWD Issue 3. HSE. August 2011. www.hse.gov.uk/nuclear/operational/assessment/index.htm. ONR How2 Business Management System. Guidance on Production of Reports, AST/003 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 ONR Technical Assessment Guides within ONR How2 Business Management System:
Nuclear Safety Technical Assessment Guide: Internal Hazards, NS-TAST-GD-014 Revision 3, April 2013
Nuclear Safety Technical Assessment Guide: The purpose, scope, and content of safety cases, NS-TAST-GD-051 Revision 3, July 2013
www.hse.gov.uk/nuclear/operational/tech_asst_guides/index.htm.

6 *GDA Submission #28: Final Consolidated UK EPR GDA Safety Security and Environmental Report*, Letter, Unique number EPR01483N, 30 November 2012 TRIM 2012/470
(GDA PCSR is one of the attachments to this letter)

7 *UK EPR GDA Step 4 Consolidated Pre-construction Safety Report – March 2011.* EDF and AREVA. Detailed in EDF and AREVA letter UN REG EPR00997N. 18 November 2011. TRIM 2011/552663.

8 *Western European Nuclear Regulators' Association. Reactor Harmonization Group. WENRA Reactor Reference Safety Levels.* WENRA. January 2008. www.wenra.org.

9 IAEA Guidance:
Safety of Nuclear Power Plants: Design Specific Safety Requirements, International Atomic Energy Agency (IAEA). Safety Standards Series No. SSR-2/1, February 2012.
Fire Safety in the Operation of Nuclear Power Plants, International Atomic Energy Agency (IAEA).Safety Guide Series No. NS-G-2.1, September 2000
Protection Against Internal Fires and Explosions in the Design of Nuclear Power Plants, International Atomic Energy Agency (IAEA) Safety Guide Series No. NS-G-1.7, September 2004
Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants, International Atomic Energy Agency (IAEA)Safety Guide Series No. NS-G-1.11, October 2004
www.iaea.org.

10 UK EPR™ Hinkley Point Project: "Hazard Listing Identification and Confirmation", Issue 4 (July 2012). HPC-NNBOSL-U0-000-RET-000021 TRIM 2013/21486

11 Hinkley Point C - Internal Hazards Protection Summary Report. Issue 5 (August 2012). HPC-NNBOSL-U0-000-RET-000053 TRIM 2013/21685

12 Consolidated GDA PCSR Sub-Chapter 13.2, "Internal Hazards Protection". Issue 03 March 2011. UKEPR-0002-132 TRIM 2013/21508

13 HPC PCSR2 Forward Work Activities, Issue 1.0, Nov 2012. HPC-NNBOSL-U0-00-RES-000082 TRIM 2013/16159

14 UK EPR™ Hinkley Point Project: "Identification and Review of the Safety Implications of a Twin Reactor Design for HPC", Issue 6, May 2012. HPC-NNBOSL-U0-000-RET-000020 TRIM 2013/17053

15 HPC PCSR2 Sub-section 2.3 – "Site Plot Plan Summary Document." Revision 2.0 June 2012. HPC-NNBOSL-U0-ALL-RET-000001 TRIM 2013/16342

16 Assessment of Turbine Missile Impact Frequencies on Hinkley Point C Building Structures. Issue E-BPE (12/04/2011). 16281-709-HPC-RPT-001 TRIM 2013/26779

17 Assessment Report: *Step 4 Internal Hazards Assessment of the EDF and AREVA UK EPR™ Reactor*, ONR-GDA-AR-11-017, Revision 0, TRIM 2010/581514

18 Assessment Report: *GDA Close-out for the EDF and AREVA UK EPR™ Reactor - GDA Issue GI-UKEPR-IH-01 Revision 2 – Substantiation and Analysis of the Consequences of Dropped Loads and Impact from Lifting Equipment included within the UK EPR™ Design*, ONR-GDA-AR-12-016, Revision 0A, TRIM 2012/16

19 Assessment Report: *GDA Close-out for the EDF and AREVA UK EPR™ Reactor - GDA Issue GI-UKEPR-IH-02 Revision 2 – Verification and Validation*, ONR-GDA-AR-12-017, Revision 0A, TRIM 2012/17

20 Assessment Report: *GDA Close-out for the EDF and AREVA UK EPR™ Reactor - GDA Issue GI-UKEPR-IH-03 Revision 2 – Internal Flooding Safety Case*, ONR-GDA-AR-12-018, Revision 0A, TRIM 2012/18

21 Assessment Report: *GDA Close-out for the EDF and AREVA UK EPR™ Reactor - GDA Issue GI-UKEPR-IH-04 Revision 2 – Consequences of Missile Generation Arising from Failure of RCC-M Components*, ONR-GDA-AR-12-015, Revision 0A, TRIM 2012/15

22 Assessment Report: *NNB Hinkley Point C: Internal Hazards Workstream Assessment to inform the nuclear site licensing of two UKEPR™ Reactor Units at Hinkley Point C*, ONR-CNRP-AR-12-082, Revision 1, 13 February 2013 TRIM 2012/324747

23 Letter plus attachments, *PCSR Submission of Batch 3.1: Justification that the Hinkley Point C site is of a sufficient size*, Unique number: ONR-HPC-20247N, 18/May/2012 TRIM 2012/213435

Table 1
Relevant SAPS (safety assessment principles) considered during the assessment

SAP No.	SAP Title	Description
EHA.1	External and internal hazards : Identification	External and internal hazards that could affect the safety of the facility should be identified and treated as events that can give rise to possible initiating faults.
EHA.3	External and internal hazards : Design basis events	For each internal or external hazard, which cannot be excluded on the basis of either low frequency or insignificant consequence, a design basis event should be derived.
EHA.4	External and internal hazards : Frequency of exceedance	The design basis event for an internal and external hazard should conservatively have a predicted frequency of exceedance in accordance with the fault analysis requirements (FA.5).
EHA.5	External and internal hazards :Operating conditions	Hazard design basis faults should be assumed to occur simultaneously with the most adverse normal facility operating condition.
EHA.6	External and internal hazards : Analysis	Analyses should take into account simultaneous effects, common cause failure, defence in depth and consequential effects.
EHA.13	Fire, explosion, missiles, toxic gases etc – use and storage of hazardous materials	The on-site use, storage or generation of hazardous materials should be minimised, and controlled and located so that any accident to, or release of, the materials will not jeopardise the establishing of safe conditions on the facility.
EHA.14	Fire, explosion, missiles, toxic gases etc – sources of harm	Sources that could give rise to fire, explosion, missiles, toxic gas release, collapsing or falling loads, pipe failure effects, or internal and external flooding should be identified, specified quantitatively and their potential as a source of harm to the nuclear facility assessed.
EHA.15	Fire, explosion, missiles, toxic gases etc – effect of water	The design of the facility should prevent water from adversely affecting structures, systems and components important to safety.

Table 1
Relevant SAPS (safety assessment principles) considered during the assessment

SAP No.	SAP Title	Description
EHA.16	Fire, explosion, missiles, toxic gases etc – fire detection and fighting	Fire detection and fire-fighting systems of a capacity and capability commensurate with the credible worst-case scenarios should be provided.
EHA.17	Fire, explosion, missiles, toxic gases etc – use of materials	Non-combustible or fire-retardant and heat-resistant materials should be used throughout the facility.
ST.5	Effect on other hazardous installations	The safety case should take account of any hazardous installations that might be affected by an incident at the nuclear facility.
ST.6	Multi Facility Sites	On multi- facility sites, the safety case should consider the site as a whole to establish that hazards from interaction between facilities have been taken into account.

Table 2
Collated GDA assessment findings for internal hazards (including from GDA close-out assessment reports – (Ref.17 to 21))

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UKEPR-IH-01	The Licensee shall provide evidence to support the design change associated with the configuration of the valves, EVU1111VP within Division 1 SAB and EVU4111VP within Division 4 SAB including a demonstration that closure of the valves during normal operations does not have a detrimental effect on the design basis analysis undertaken in support of the safety case.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-02	The Licensee shall provide evidence to demonstrate how the requirements from analyses associated with common mode failure in the event of fire are captured within future revisions of the safety case given the impact changes may have on the overall safety case.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-03	The Licensee shall provide evidence to demonstrate that the design of the doors required to open in the event of increased pressure (due to a steam release) will do so at the requisite pressure and thus allow the steam release path to be realised in accordance with the requirements of the safety case.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-04	The Licensee is required to provide evidence relating to the specification of cables including wrapping and layout to demonstrate that the cables within the cable raceways (HLK/N3403ZL) are able to withstand temperatures of 300^{o}C and pressures of up to 2 bar.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-05	The Licensee shall provide evidence to demonstrate that the design of the doors required to remain intact in the event of increased pressure (due to a steam release) will withstand requisite pressure and ensure that the engineered discharge routes for the steam release to be realised in accordance with the requirements of the safety case.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*

Table 2
Collated GDA assessment findings for internal hazards (including from GDA close-out assessment reports – (Ref.17 to 21))

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UKEPR-IH-06	The Licensee shall provide evidence to demonstrate that the potential for a hydrogen explosion within the Battery Rooms during the most onerous operating conditions has been considered within the UK EPR™ design.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-07	The Licensee shall provide evidence to demonstrate that the specification, design and implementation of the door control measures are included within the UK EPR™ design.	*Mechanical, Electrical and C&I Safety Systems, Structures and Components – inactive commissioning.*
AF-UKEPR-IH-08	The Licensee shall ensure that all barriers claimed for the protection of nuclear safety related plant and equipment against the effects of internal missile are specifically identified and documented within the safety case within the site specific design.	*Mechanical, Electrical, and C&I systems – Before inactive commissioning.*
AF-UKEPR-IH-9	The Licensee shall ensure that the further studies in order to support the design modification associated with the manual connection of the LHSI/RHR system are appropriately considered within the site specific design.	*Mechanical, Electrical, and C&I systems – Before inactive commissioning.*
AF-UKEPR-IH-10	The Licensee shall ensure that the design changes arising from the Flamanville 3 Verification and Validation process are appropriately considered within the site specific design.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning".*
AF-UKEPR-IH-11	The Licensee ensure that the further analysis of the options to prevent the spread of flood water from the adjacent technical galleries resulting in loss of safety classified plant and equipment within the Diesel Generator Buildings are captured as part of the site specific design.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning".*
AF-UKEPR-IH-12	The Licensee shall provide a means by which to physically identify individual safety classified cables from different safety divisions within UKEPR™ to ensure that there is visual identification of the different safety class cables for each division on plant.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning".*

Table 2
Collated GDA assessment findings for internal hazards (including from GDA close-out assessment reports – (Ref.17 to 21))

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UKEPR-IH-13	The Licensee shall ensure that the further analyses required arising from the Flamanville 3 Verification and Validation process are appropriately considered within the site specific design.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning".*
AF-UKEPR-IH-14	The Licensee shall ensure that the detailed analysis of the Human Based Safety Claim associated with isolation of the ESWS is undertaken. In the event that it cannot be substantiated the option relating to automatic isolation of the ESWS should adequately consider the balance of risk associated with automatic isolation of a safety system as well as the associated classification of that system.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning"*
AF-UKEPR-IH-15	The Licensee shall review the potential flooding scenarios that require automatic isolation following detection of a leak or break and provide substantiation of the classification and categorisation of those systems.	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning"*
AF-UKEPR-IH-16	The Licensee shall ensure that the site specific safety case for internal hazards captures the need to consider gross failure of classified moderate energy pipework with a nominal diameter greater than 50mm rather than claiming leak equivalent to the diameter multiplied by the thickness divided by 4 (Dt/4).	*"Mechanical, Electrical, and C&I Safety Systems – Before inactive commissioning"*

Table 3
Items from *Forward Work Activities* (Ref.13) related to Internal Hazards

FAP item number	FAP description	Require resolution prior to first nuclear safety-related concrete (Yes/ No)
2.3_FAP_3	Perform hazard identification, analysis and safety justification for construction, commissioning and operation of unit 1 during construction and commissioning of unit 2.	No
2.3_FAP_4	Define method of on-site diesel fuel storage for HPC PCSR3.	No
2.3_FAP_5	Update the turbine missile hazard analysis report using the finalised site plot plan.	No
2.3_FAP_6	Complete hazard analysis for turbine missile impact on the HZO and HZN buildings.	No
Not assigned in version 2 FWP	Future work will involve the development of a fire strategy document for every building on site.	No
Not assigned in version 2 FWP	Technical specifications are to be developed for: • Fire detection systems, • Fire safety equipment.	No
Not assigned in version 2 FWP	A more detailed consideration of the effect of internal hazards (e.g. dropped loads and fire and explosions) on the integrity of the containment and safeguard systems,	Yes
Not assigned in version 2 FWP	A more detailed consideration of the effect of internal hazards (e.g. fire and explosions) on the integrity of the auxiliary systems,	No
Not assigned in version 2 FWP	Ensuring that the provision of fire dampers in the Heating, Ventilation and Air Conditioning (HVAC) systems meet UK fire regulations	No
Not assigned in version 2 FWP	Carrying out a Human Factors review of the fire protection and fire-fighting equipment in order to review its operability and maintainability,	No
Not assigned in version 2 FWP	Confirm that the potential impacts on the adjacent buildings from internal hazards associated with the Nuclear Island Demineralised Water Distribution System (SDA) are tolerable.	No
Not assigned in version 2 FWP	Define the safety function and hazard withstand requirement for the systems in the Raw Water Supply Building.	No
Not assigned in version 2 FWP	Produce a methodology for and undertake the analysis of reasonably foreseeable combined and consequential events.	Yes
Not assigned in version 2 FWP	A complete assessment will be performed for all internal hazards for both units and site-specific SSCs; this will be strongly dependent on the layout of the plant.	No
Not assigned in version 2 FWP	Post Fukushima recommendations include: • Addition of diesel driven fire pumps	No

Table 3
Items from *Forward Work Activities* (Ref.13) related to Internal Hazards

FAP item number	FAP description	Require resolution prior to first nuclear safety-related concrete (Yes/ No)
Not assigned in version 2 FWP	Undertake a comprehensive internal hazard assessment as part of the detailed design of the ISFS.	No
Not assigned in version 2 FWP	A complete assessment will be performed for all internal hazards for the Interim ILW Store, and Interconnecting Technical Galleries.	No
Not assigned in version 2 FWP	The complete assessment of internal flooding for both units and site-specific SSCs.	No
Not assigned in version 2 FWP	The complete assessment of internal fire for both units and site-specific SSCs.	No
Not assigned in version 2 FWP	The impact of a PCC2 to PCC4 on either HPC1 or HPC2 on site-specific SSCs is to be addressed in future studies.	No
Not assigned in version 2 FWP	Identify the bounding scenario for each internal hazard and determine the likely consequences on adjacent safety-related SSCs.	No
Not assigned in version 2 FWP	Undertake a comprehensive internal hazards assessment for the additional risks to HPC1 associated with the construction of HPC2 and site-specific SSCs while HPC1 is undergoing commissioning.	No
Not assigned in version 2 FWP	Undertake a comprehensive assessment of combined and consequential hazards on completion of the assessment of all hazards.	No
Not assigned in version 2 FWP	Assess cliff-edge effects associated with internal hazards.	No
Not assigned in version 2 FWP	A comprehensive risk assessment should be conducted for the Auxiliary Administration Centre (shared service).	No
Not assigned in version 2 FWP	A detailed assessment of safety issues related to staffing of a twin-unit site should be conducted.	No
Not assigned in version 2 FWP	Administration controls will need to be in place to reduce the likelihood and consequences of heavy transport collision with the units.	No
Not assigned in version 2 FWP	Demonstration that the radiological consequences of releases associated with turbine missile strikes on structures containing radioactive material will be ALARP.	No
Not assigned in version 2 FWP	Assess the risk of internal missiles associated with the construction of HPC2 and site-specific SSCs.	No
Not assigned in version 2 FWP	Completion of the detailed assessment for the GDA PCSR for explosions within buildings.	Yes
Not assigned in version 2 FWP	Completion of the detailed assessment of the potential for explosions outside buildings and their potential to impact on both units and safety significant SSCs.	Yes

Table 3
Items from *Forward Work Activities* (Ref.13) related to Internal Hazards

FAP item number	FAP description	Require resolution prior to first nuclear safety-related concrete (Yes/ No)
Not assigned in version 2 FWP	Update the assessment of fire hazard on a single unit using the inventories of the UK EPR rather than generic inventories from NUREG/CR-6850.	No
Not assigned in version 2 FWP	An assessment of fire hazard on site containing site-specific SSCs including fuel and chemical storage facilities.	No
Not assigned in version 2 FWP	An assessment of the risk of internal fires associated with the construction of HPC unit 2 and site-specific SSCs.	No
Not assigned in version 2 FWP	Complete the design of the doorsills and drainage system to show the safety of the HPC site against internal flooding.	No
Not assigned in version 2 FWP	Determine if a blockage or failure of the cooling water system (including the cooling water outfall system) is nuclear safety significant (internal flooding).	No
Not assigned in version 2 FWP	Assessment of the risk posed by chemical release on the HPC site.	No
AF-UKEPR-PSA-032:	The licensee shall ensure that the screening criteria used in the GDA PSA are confirmed to bound specific site hazard characteristics and include in the PSA any hazards and combination of hazards that have been screened in.	No
AF-UKEPR-CC-23	Actions included: • Development of a hazards fault schedule,	No
AF-UKEPR-CE-005	The licensee shall take account of any implications of the outcomes of the Internal Hazards GDA Issues which could affect the design of civil structures.	Yes
AF-UKEPR-CE-006	The licensee shall undertake any necessary fire tests on reinforced concrete walls using the actual materials to be used in the construction in accordance with the requirements of EN1992-1.2.	Yes