Agreements to HPB and HNB, NP/SC 7781 - Defuelling Essential Shutdown Reactor Safety Case and to NP/SC 7786 - Defuelling Fuel Handling Essential Safety Case.

Hinkley Point B and Hunterston B Power Stations
Project Assessment Report

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EXECUTIVE SUMMARY

Title

Agreements to Hinkley Point B (HPB) and Hunterston B (HNB), NP/PC 7781 - Defuelling Essential Shutdown Reactor Safety Case and to NP/SC 7786 - Defuelling Fuel Handling Essential Safety Case.

Permission Requested

Under EDF Energy Nuclear Generation Limited's (EDF NGL) arrangements made under Licence Condition 22(1), EDF NGL has requested that the Office for Nuclear Regulation (ONR) issues Agreements to NP/SC 7781 and NP/SC 7786 which are the HPB and HNB reactor shutdown and fuel handling essential safety cases.

Background

At the End of Generation (EoG) the reactors at HPB and HNB will be shut down and defuelling and decommissioning activities will commence. The first phase, referred to as defuelling, will be to remove all nuclear fuel from the stations. The Defuelling Essential Shutdown Reactor Safety Case, NP/SC 7781, justifies reactor operations during defuelling. This involves the progressive removal of fuel from the reactor and returning Fuel Plug Units (FPUs) to defuelled channels to seal the reactor pressure boundary.

EDF NGL has an existing operational shutdown reactor safety case that justifies operations when the reactors are shutdown, which defines the availability of the required cooling plant for refuelling operations. The approach adopted for NP/SC 7781 therefore has been to retain the justification from the existing operational shutdown safety case and to consider the impact of the proposed defuelling changes. The most significant changes are:

- Isolation and drain down of the Pressure Vessel Cooling Water (PVCW) system – A dropped FPU at the reactor could result in flooding from the PVCW system into the lower reactor plenum resulting in blocking reactor gas flows that could prevent the fuel from being adequately cooled.

- Reactivity control – The control rods will be inserted and isolated, to maximise the subcritical margin (SCM) within the core. The order in which fuel is removed from the core can impact the SCM and the safety case proposes an outside-in defuelling pattern to progressively remove the lower burnup fuel located in the outer regions.

- Containment and structural integrity – Defuelling removes the fuel stringers from the reactor core and returns a FPU to maintain the reactor pressure boundary. The mass of the FPU is suspended from the reactor top cap, instead of being supported by the fuel. This introduces a change to the loading of the reactor structures.

- Cooling – Removing fuel from the reactor creates vacant fuel channels, which affects reactor cooling by diverting cooling flow away from the remaining fuelled channels.

EDF NGL also has an existing refuelling safety case. The Defuelling Fuel Handling Essential Safety Case, NP/SC 7786, considers the key differences between refuelling and defuelling. The entry point to the defuelling process is when the removal of an irradiated fuel assembly commences and a FPU, without an attached fuel stringer, is returned to the shutdown reactor. NP/SC 7786 has identified all new and existing fuel route operations that will be used during the defuelling period. A revised set of operations with the Charge Machine (CM) are defined, but operations at the Irradiated Fuel Dismantling (IFD) facility, the Fuel Storage Pond (FSP) and fuel flask handling operations are unchanged from the existing refuelling safety case activities.

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

In accordance with the regulatory strategy and plan to support closure of AGR stations, ONR has carried out assessment of NP/SC 7781 and NP/SC 7786. The following specialist inspectors have engaged with the EDF NGL in numerous detailed technical discussions and have raised and resolved a number of technical issues throughout their assessments:

- Fuel and core
- Fault studies
- Internal hazards
- Structural integrity
- Mechanical engineering
- Control and Instrumentation
- Probabilistic Safety Assessment
- Electrical engineering
- Human factors
- Chemistry

Matters arising from ONR's work

Following specialist inspector interactions with EDF NGL, a revised consequence argument was prepared for the dropped FPU fault sequence. This changed the basis of the as submitted defuelling fuel handling safety case, NP/SC 7786. ONR is satisfied with the supporting arguments for the revised dropped FPU fault sequence and has concluded that the consequences from failure of a core support plate (CSP), from a dropped FPU, would be tolerable and with the re-classification of the CSP as an ‘infrequent failure’ component.

ONR has acknowledged an EDF NGL commitment to update the basis of NP/SC 7786 and submit the revised safety case to ONR when it has completed due process. A regulatory issue has been raised to monitor delivery against the commitment to update the basis of NP/SC 7786. In all other matters, the ONR specialist inspectors consider that Agreement to the proposed safety cases NP/SC 7781 and NP/SC 7786 to be acceptable.

Conclusions

I am satisfied with the claims, arguments and evidence laid down within:

- NGL’s Defuelling Essential Shutdown Reactor Safety Case NP/SC 7781. I judged that the proposal is adequate to justify the issue of Licence Instruments for ONR’s Agreement under arrangements made under Licence

Condition 22(1) that the HPB and HNB reactors can be shut down in accordance with NP/SC 7781.

- NGL's Defuelling Essential Fuel Handling Safety Case NP/SC 7786. I judged that the proposal is adequate to justify the issue of Licence Instruments for ONR's Agreement under arrangements made under Licence Condition 22(1) that defuelling operations may commence at HPB and HNB in accordance with NP/SC 7786.

Recommendation

It is recommended that:

- Licence instrument 566 is granted to Hinkley Point B to allow implementation of Defuelling Essential Shutdown Reactor Safety Case NP/SC 7781, EC 363701.
- Licence instrument 567 is granted to Hinkley Point B to allow implementation of Defuelling Fuel Handling Essential Safety Case NP/SC 7786, EC 363993.
- Licence instrument 571 is granted to Hunterston B to allow implementation of Defuelling Essential Shutdown Reactor Safety Case NP/SC 7781, EC 364023.
- Licence instrument 572 is granted to Hunterston B to allow implementation of Defuelling Fuel Handling Essential Safety Case NP/SC 7786, EC 363991.

LIST OF ABBREVIATIONS

ALARP	As low as reasonably practicable
BSL	Basic Safety level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
BUCS	Back Up Cooling System
BUFS	Back Up Feed System
C&I	Control and Instrumentation
CM	Charge Machine
CNS	Civil Nuclear Security (ONR)
CSP	Core Support Plate
EA	Environment Agency
EC	Engineering Change
EDF NGL	EDF Energy Nuclear Generation Limited
EMI&T	Examination, Maintenance, Inspection and Testing
EoG	End of Generation
FHC	Flask Handling Crane
FPU	Fuel Plug Unit
HPB	Hinkley Point B
FFV	Fuel Free Verification
FSP	Fuel Storage Pond
GC	Gas Circulator
HOW2	(Office for Nuclear Regulation) Business Management System
HNB	Hunterston B
HRA	Human Reliability Analysis
HSE	The Health and Safety Executive
IAEA	The International Atomic Energy Agency
IFA	Irradiated Fuel Assembly
IFD	Irradiated Fuel Dismantling facility
LAC	Limit and Condition
NDA	Nuclear Decommissioning Authority
ODD	Off-Load Depressurised Defuelling
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PSA	Probabilistic Safety Analysis

PVCW	Pressure Vessel Cooling Water
RGP	Relevant Good Practice
SAP	ONR's Safety Assessment Principle
SCC	Shutdown Cooling Criteria
SCM	Subcritical Margin
SEPA	Scottish Environment Protection Agency
SSC	Structure, System and Component
TAG	Technical Assessment Guide (ONR)

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1 PERMISSION REQUESTED

1. Under EDF Energy Nuclear Generation Limited's (EDF NGL) arrangements made under Licence Condition 22(1) [1], EDF NGL has requested [2, 3, 4 and 5] that the Office for Nuclear Regulation (ONR) issues Agreements to NP/SC 7781, which is the Hinkley Point B and Hunterston B Defuelling Essential Shutdown Reactor Safety Case [6] and to NP/SC 7786, which is the Hinkley Point B and Hunterston B Defuelling Fuel Handling Essential Safety Case [7].

2 BACKGROUND

2. The AGR Fleet is coming towards the end of their operational lives, entering their end-of-generation (EoG) phase. In recognition of this, and in preparation for both Hinkley Point B (HPB) and Hunterston B (HNB) EoG, EDF NGL has produced a Defuelling Essential Shutdown Reactor Safety Case (NP/SC 7781) [6] and a Defuelling Essential Fuel Handling Safety Case (NP/SC 7786) [7]; two separate cases detailing the arrangements for both HPB and HNB. The "Essential Cases" are to be implemented at the respective sites through:

- HPB Engineering Change (EC) No: 363701 Revision 000 Proposal Version No: 06 [Shutdown Reactor].
- HPB EC No: 363993 Revision 000 Proposal Version No: 08 [Fuel Handling].
- HNB EC No: 364023 Revision 000 Proposal Version No: 06 [Shutdown Reactor].
- HNB EC No: 363991 Revision 000 Proposal Version No: 08 [Fuel Handling].

<u>Defuelling Essential Shutdown Reactor Safety Case, NP/SC 7781</u>

3. At the EoG the reactors at HPB and HNB will be shut down and defuelling and decommissioning activities will commence. The first phase, referred to as defuelling, will be to remove all nuclear fuel from the stations. The Defuelling Essential Shutdown Reactor Safety Case, NP/SC 7781, (ECs 363701 & 364023) justifies reactor operations during defuelling. This involves the progressive removal of fuel from the reactor and returning Fuel Plug Units (FPUs) to defuelled channels to seal the reactor pressure boundary.

4. Defuelling is defined to start when a fuel assembly is removed and the first FPU, without an attached fuel stringer, is returned to the fuel channel to seal the pressure vessel of the shutdown reactor.

5. The existing operational shutdown reactor safety case justifies operations when the reactors are shutdown and defines the availability of the required cooling plant for refuelling operations. The approach adopted for NP/SC 7781 therefore has been to retain the justification from the existing operational shutdown safety case and to consider the impact of the proposed defuelling changes. The most significant changes are:

- Pressure Vessel Cooling Water (PVCW) isolation and drain down – Defuelling requires the handling of FPUs without the fuel attached. A dropped FPU at the reactor could result in flooding of the lower reactor plenum resulting in blocking reactor gas flows that could prevent the fuel from being adequately cooled. To remove the risk of flooding NP/SC 7781 proposes that the PVCW system will be isolated and drained as a prerequisite to defuelling.

- Reactivity control – The control rods will be inserted and isolated, to maximise the subcritical margin (SCM) within the core, prior to commencement of defuelling. It is important to further control the degree to which the reactor remains below the point of criticality during defuelling. Irradiated fuel at the end of its fuel cycle acts as a net neutron absorber and therefore, removing the highly irradiated fuel first may result in an erosion in the SCM. Whereas leaving low burnup, higher reactivity fuel in the core could increase the risk of a localised criticality event potentially resulting in clad melt and a release of activity into the primary circuit. The safety case proposes an outside-in defuelling pattern to progressively remove the lower burnup fuel located in the outer regions and hence increase the reactivity SCM.

- Containment and structural integrity – Defuelling removes the fuel stringers from the reactor core and returns a FPU to maintain the reactor pressure boundary. The mass of the FPU is suspended from the reactor top cap, instead of being supported by the fuel, which rests on the floor of the reactor. This introduces a change to the loading of the reactor structure which is required to be maintained to prevent degradation of the reactor internal structures.

- Cooling – Removing fuel from the reactor creates an increasing number of defuelled channels, which affects reactor cooling by diverting cooling flow away from the remaining fuelled channels. This has potential to result in fuel failures and to increase the risk of a radiological release.

<u>Defuelling Fuel Handling Essential Safety Case, NP/SC 7786</u>

6. The Defuelling Fuel Handling Essential Safety Case, NP/SC 7786 (ECs 363993 & 363991) compliments the Shutdown Reactor Safety Case, NP/SC 7781.

7. This safety case presents the case for all fuel route operations associated with Off-Load Depressurised Defuelling (ODD) of the reactors. This involves the removal of Irradiated Fuel Assemblies (IFAs) from the shutdown reactors, the associated operations to dismantle the IFAs into individual fuel elements, the transfer of fuel elements to the fuel storage ponds and the loading and dispatch of flasks off-site. This case also presents the justification for returning FPUs to the reactor to seal the pressure boundary of the defuelled channels once the fuel has been removed.

8. The entry point to the defuelling process (the point at which the ODD safety case is applied) is when the removal of a fuel assembly or fuel channel closure has commenced and a FPU, without an attached fuel stringer, is returned to the shutdown reactor. All fuel handling operations undertaken before this entry point continue to be justified under the existing refuelling safety case.

9. This ODD fuel handling safety case has identified all new and existing fuel route operations that will be used during the defuelling period, allowing the defuelling

process to be clearly defined. The defuelling process presents a revised set of operations with the Charge Machine (CM), but operations at ex-reactor facilities such as the Irradiated Fuel Dismantling (IFD) facility, the Fuel Storage Pond (FSP) and flask operations are unchanged from the existing refuelling safety case activities.

10. A schedule of defuelling faults has been identified and the corresponding protection systems available for each defuelling fault have been defined. The majority of the faults are common with the current refuelling safety case. In particular a new CM protection system has been introduced to provide appropriate CM hoist underload protection in the event of snags when lowering FPUs at the reactor.

11. This safety case has reviewed fuel route handling equipment and demonstrated it will retain adequate lifting integrity over the defuelling period. Similarly, it shows that adequate integrity of pressure boundary components will remain in place during defuelling.

12. A bespoke defuelling Probabilistic Safety Assessment (PSA) has been produced, that provides an estimation of the defuelling off-site nuclear safety risk. This has been used to demonstrate that the risks to the public and workers are tolerable and As Low As Reasonably Practicable (ALARP).

13. The key nuclear safety issues considered by NP/SC 7786 to justify defuelling under for ODD conditions are:

- Returning FPUs to the reactor is a new operation. The key issue is the risk posed to the reactor core support structure and potential consequential damage to the remaining fuel in the event of a dropped FPU.
- Due to the large number of fuel channels in each reactor, a significant number of defuelling operations will be taking place until the reactor can be declared ‘fuel free’. Hence, a key issue is to ensure that the total risk to the public and to workers over the defuelling period remains ALARP.
- Following completion of defuelling, a robust means of confirming the station is free of all fuel (both new and irradiated fuel elements) is required in order to declare the site ‘fuel free’. If this is inadequate, it could result in leaving significant latent risks to workers and public during the subsequent decommissioning phase.

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

14. In accordance with the regulatory permissioning strategy for EoG [8] ONR has carried out assessment by the following specialisms of the key nuclear safety requirements of NP/SC 7781 and NP/SC 7786:

- Fuel and core
- Fault studies
- Internal hazards
- Structural integrity
- Mechanical engineering
- Control and Instrumentation
- Probabilistic Safety Assessment

- Electrical engineering
- Human factors
- Chemistry

15. The scope and conclusions of these assessments is described for each specialism below. It should also be noted that, in order to support the assessment of NP/SC 7781 and NP/SC 7786, ONR specialist inspectors have engaged with the EDF NGL in numerous detailed technical discussions and have raised and resolved a number of technical issues throughout their assessments. This report does not attempt to summarise all of the questions raised and answers provided.

3.1 ASSESSMENT FINDINGS

3.1.1 FUEL AND CORE

16. The scope of the Fuel and Core assessment [9] considered the following for the Defuelling Essential Shutdown Reactor Safety Case:

- Arrangements for reactivity control
- Conditions that fuel is stored within the reactor

17. The Defuelling Essential Fuel Handling Safety Case assessment considered:

- Arrangements for removing fuel from the reactor (defuelling regime); and
- Changes to fuel storage to ensure the fuel remains in an appropriate condition for storage off-site.

18. The fuel and core inspector concluded that when all safety rods are fully inserted, their combined worth is high, leading to a large subcritical margin (SCM), which is the degree to which the reactor remains below the point of criticality during defuelling.

19. The inspector supported the intension to defuel the reactors using an outside-in approach and agreed that it will tend to increase SCM as the defuelling progresses. The permitted level of flexibility, allowing some deviations from the outside-in defuelling approach, was also considered and the inspector concluded that this did not prejudice the required SCM.

20. The effects of core-chemistry on fuel assemblies during in-reactor storage was considered and the inspector was content, because of the lack of air ingress, comparably low reactor temperatures during defuelling, and unlikelihood of fuel failures, that the reactor conditions should not have any long-term deleterious effect on the fuel condition or its suitability for handling, transport and/or storage off-site.

21. The inspector considered the fuel element decay heat limit at which defuelling would commence. This limit is set at 8kW peak channel decay heat which is equivalent to a reactor decay heat of ~2MW and occurs around 50 days post shutdown. The inspector was satisfied that the 8kW decay heat limit constituted a suitable threshold for isolating the pressure vessel cooling water system, as it is less than the decay heat limits placed upon the down-stream fuel handling facilities, and the potential to produce U_3O_8, should failed fuel exist and be exposed to air, would be low. The inspector considered storage of the fuel elements within the fuel storage pond (FSP).

He was satisfied there was adequate storage capacity and the heat generation and criticality limits were appropriate.

22. In conclusion, the specialist fuel and core inspector was satisfied with the claims, arguments and evidence laid down within the shutdown reactor and fuel handling safety cases and recommended that the HPB and HNB reactors can be shut down and defuelling can commence in accordance with NP/SC 7781 and NP/SC 7786.

3.1.2 FAULT STUDIES

23. The fault studies assessment report [10] considered the following with its scope:

- Whether sufficient fault identification has been undertaken to define a comprehensive range of faults for the defuelling regime.
- Whether fault analysis of potential fault sequences has been conducted appropriately to identify the conditions and limits necessary in the interests of safety for defuelling operations.
- Whether the fundamental safety functions are maintained following postulated faults.
- Whether risks have been reduced to ALARP.

24. The fault studies inspector was satisfied that the following potential fault sequences are the key new aspects of the reactor shutdown and defuelling safety cases:

- The introduction of vacant channels and defuelled channels which can change the coolant flow pattern within the core. When FPUs are loaded into the reactor the gags, which control coolant flow, should be closed. Should a gag remain open then flow diversion away from the remaining fuelled channels may occur.
- Irradiated fuel at the end of its fuel cycle acts as a net neutron absorber. Removing the highly irradiated fuel first may result in an erosion to the sub-critical margin.
- The loading of FPUs without fuel into the reactor. To account for this new activity, the Licensee has added the new fault of dropped FPU to the fault schedule.

25. The inspector examined the Shutdown Cooling Criteria (SCC) within the defuelling safety case for a permanently shutdown reactor and noted that the reactor decay heat and inventory of radioactive isotopes reduces with time during defuelling. The bounding fault in terms of fuel temperature is a total loss of forced gas circulation and loss of boiler feed. The minimum acceptable cooling is recovered by restoring boiler feed to two quadrants from the Back Up Feed System (BUFS) / Back Up Cooling System (BUCS), and repressurising the reactor to 10 bar(g) to establish natural circulation and turn over the temperature transient. The fault studies inspector was satisfied with the analysis that confirmed that for a defuelled reactor during a loss of cooling fault, the reactor limits are not reached until after 48 hours. Based on a conservative value of re-pressurisation time, minimum acceptable cooling is restored by 32 hours such that no clad failure is predicted. The inspector judged therefore that a significant margin to the safety limits has been demonstrated.

26. The introduction of vacant channels and defuelled channels can change the coolant flow pattern within the core. The fault studies inspector considered an ‘open gag on a defuelled channel’ fault as this can result in additional flow diversion from the remaining fuelled channels to occur. An analysis has been performed that shows that even if all defuelled channels have fully open gags the cooling capacity would be adequate due to the defuelling decay heat operating rules. The inspector judged that operating within the operating rule, (which allows up to 10 open gags for defuelled channels), does not represent a safety concern and the risk of an open gag on a defuelled channel is tolerable and ALARP.

27. With respect to criticality control, the fault studies inspector noted the view of the fuel and core inspector, (section 3.1.1), that there is an adequate SCM. The fault studies inspector considered several potential reactivity insertion faults in the course of his assessment and did not identify any design basis faults that results in criticality. Furthermore, even if a combination of faults are considered, on a conservative basis, restoration of adequate cooling would reduce the reactivity insertion. The inspector judged therefore that there were no single credible faults that could give rise to an unplanned criticality and that his expectations on criticality control had been met.

28. When a FPU is loaded into the core, it can potentially drop and fall through the vacant fuel channel to the bottom of the core and damage the Core Support Plate (CSP). The FPU may then impact the reactor liner, potentially resulting in failure of the PVCW pipework; water ingress has the potential to obstruct gas cooling flows within the core and ultimately result in a radiological release. For this event to occur (1) the FPU must drop; (2) the standpipe must fail resulting in a breach of the pressure boundary; (3) the tie bars for adjacent fuel assemblies must fail; and (4) the lower core support structure must grossly fail. The fault studies inspector was satisfied with the risk reduction measures; an interlock will be installed on the charge machine hoist mechanism and the PVCW will be isolated and drained down. The dropped FPU scenario was considered a low consequence and low frequency event that met the targets defined in ONR’s Safety Assessment Principles (SAPs) [17]. The primary requirement is the demonstration that risks have been reduced ALARP. EDF NGL identified the potential to increase the quality assurance applied to the dropped FPU consequence estimate and has committed to complete this prior to commencement of defuelling [11]. Given this commitment and the thorough approach to risk reduction adopted by EDF NGL, the inspector judged that risks from the dropped FPU fault sequence had been reduced ALARP.

29. The fault studies inspector considered that the expectations of relevant good practice had generally been met by the Licensee’s safety cases NP/SC 7781 and NP/SC 7786. Where minor potential shortfalls exist, the Licensee has scheduled additional work to provide a remedy. As such from the perspective of fault studies, there were no shortfalls that would prevent the issue of the Licence Instruments and the inspector recommended that the HPB and HNB reactors can be shut down and defuelling can commence in accordance with NP/SC 7781 and NP/SC 7786.

3.1.3 INTERNAL HAZARDS

30. The internal hazards assessment report [12] did not review the Defuelling Essential Shutdown Reactor Safety Case, NP/SC 7781, as the inspector did not consider it had sufficient relevance to internal hazards. Instead, the interactions between NP/SC

7781 and the fuel handling safety case NP/SC 7786 were considered. The operations and plant/equipment used during defuelling are similar to those in refuelling. The inspector agreed with the licensee's judgement that the internal hazard sources of fire, gas release and internal flooding were unlikely to change significantly during defuelling and are broadly the same as the existing refuelling safety case.

31. The internal hazards inspector therefore focussed their attention on the:

- Increases in frequency of fuel handling operations;
- Changes to reactor operating conditions during defuelling, where reactor gas is being maintained at 75°C and to less than 2 barg under all normal defuelling operating conditions; and
- Changes in ambient conditions.

32. Internal hazards associated with the dropped FPU fault and the isolation and drain down of the PVCW system were not reviewed as these issues were addressed by the other assessments detailed in this report.

33. The internal hazards inspector considered the increased probability and consequence of dropped flasks associated with the flask handling crane (FHC). A dropped flask has potential to damage the FSP structure or pond pipework leading to a loss of pond water, which if not maintained, could lead to an off-site release. The inspector was satisfied with the modifications to the FHC, including replacement of the ageing control panel and installation of interlock protection, which will reduce the potential risk of a dropped load event to ALARP.

34. The reactor operating conditions during defuelling will be constrained to 75°C and to less than 2 barg under all normal operating conditions and are significantly more benign than when a reactor is operating. The licensee submitted modifications to declassify the high integrity claims placed upon the operating reactor systems. The internal hazards inspector was satisfied that the nuclear safety risks from potential indirect consequences (e.g. pipe whip, missile, jet and blast impacts) of failure of the pressure boundary and associated steam and feed systems were significantly reduced during defuelling. These modifications were separately assessed and permissioned by ONR [13,14].

35. The inspector considered the potential for low ambient temperatures, arising from significant reduced heat generation from the reactor, to affect plant and/or personnel. The inspector judged that the licensee had adequately considered the impacts of changes to ambient conditions on safety related plant and that where additional heating was required to mitigate any impact on electrical equipment that it would be adequately controlled through the EC process.

36. In conclusion, the specialist internal hazards inspector was satisfied with the claims, arguments and evidence laid down within the fuel handling safety case, NS/PC 7786, and did not identify any further matters that would prevent ONR issuing Licence Instruments to commence defuelling operations at HPB and HNB.

3.1.4 STRUCTURAL INTEGRITY

37. In the structural integrity assessment report [15], the inspector focused his assessment on sampling the structural integrity of systems, structures and components (SSC) that are required to fulfil a nuclear safety function. The following were considered in the assessment:

- The metallic structures and components forming the reactor internals and boiler components, gas baffle and other components within the primary circuit.
- The structural integrity of the graphite core.
- The adequacy of the licensee's assessment of age-related degradation mechanisms and the examination, maintenance, inspection and testing (EMI&T) regimes applied.
- The adequacy of the licensee's structural integrity claims for a postulated FPU drop.
- The adequacy of the licensee's determination of the future condition of SSCs during the period of the safety case and whether they support the safety case requirements.

38. Degradation of the reactor is a function of temperature, irradiation levels, applied stress and the composition of the cooling medium; CO_2 for the primary circuit and steam for the secondary circuit and ambient air elsewhere. Degradation of the plant is also influenced by the primary and secondary circuit coolant chemistries. During defuelling, EDF NGL will maintain the shutdown reactor in a controlled CO_2 atmosphere in temperature and pressure conditions close to ambient which will significantly reduce degradation. The effects of ageing and degradation on metallic structures will therefore be significantly reduced compared to normal operating conditions. The structural integrity inspector was satisfied that the degradation mechanisms were understood, the controls to be applied were adequate and furthermore that the measures in place to detect, identify and remediate to boiler tube leaks were appropriate.

39. The inspector assessed the ability of the core support structure to withstand a drop of a fuel plug unit (FPU). The core support structure is composed of the diagrid, which is a large, highly redundant 'eggbox' structure, upon which sit a number of CSPs. Each CSP provides support to 4 fuel channels. It and the diagrid structure are subject to irradiation damage and a FPU impact at ambient temperature is potentially of concern due to the potentially low toughness of the core support structure.

40. The inspector considered the diagrid material properties, loading conditions, design code compliance, defect tolerance, impact damage assessment and redundancy arguments for a dropped FPU. He was satisfied that EDF NGL had presented suitable safety arguments for the integrity of the diagrid and that there is significant redundancy in the diagrid structure which would likely preclude complete collapse of the diagrid during a dropped FPU event.

41. For the CSP, the licensee originally assumed that gross failure of a CSP under FPU impact would likely be tolerable. During ONR's assessment of NP/SC 7781 and NP/SC 7786, EDF NGL informed ONR that gross failure of the CSP due to a dropped FPU may lead to graphite bricks falling below the core along with the fuel elements

and potentially lead to a re-criticality event. There were some concerns in the methodology used and the inspector considered that crack propagation by brittle fracture beyond the impact location could not be discounted. To address this concern, the licensee revised the structural integrity claim for the CSP to demonstrate a highest reliability claim. The structural integrity inspector again concluded that the evidence provided by EDF NGL was insufficient to support the new 'highest reliability' classification for the CSP. ONR therefore wrote to EDF NGL [16] to advise that the classification of the CSP be revised down to an 'infrequent failure' component.

42. EDF NGL provided a revised consequence argument that supported the position that the consequences from failure of a CSP, from a dropped FPU, would be tolerable. The evidence supporting the revised consequence argument was reviewed by the fault studies inspector, and he was satisfied that the argument met ONR's numerical safety targets defined in the SAPs [17].

43. The structural integrity inspector recognised that, as the consequences of a gross failure of the CSP were deemed tolerable and the classification of the CSP as an 'infrequent failure' component, it was now appropriate to support the NP/SC 7781 claims for the CSP.

44. From a structural integrity perspective, the inspector was satisfied with the claims and arguments and evidence presented in the defuelling safety cases and did not object to the shutdown of the HPB and HNB reactors in accordance with NP/SC 7781 and to the commencement of defuelling in accordance with NP/SC 7786.

3.1.5 MECHANICAL ENGINEERING

45. The scope of the mechanical engineering assessment report [18] considered the following for the Shutdown Reactor Safety Case:

- Shutdown reactor cooling equipment and provision during defuelling operations; and
- Equipment reliability and plant lifetime arrangements.

46. For the Defuelling Fuel Handling Safety Case the report considered the lifting integrity arrangements and provisions for loading a FPU into the reactor.

47. For the shutdown reactor case, NS/PC 7781, the inspector focused his attention on the maintenance regime applied to the Gas Circulators (GCs), which provide forced gas cooling during the defuelling period. The inspector was satisfied with the evidence, consisting of relevant GC operational data and Operational Experience (OPEX) and the fact that only four of eight GCs are required to be available to support all normal and fault conditions, to justify and ensure adequate cooling would be provided during defuelling.

48. The mechanical reliability of safety related plant has been maintained throughout the generating period by application of appropriate engineering arrangements. The inspector confirmed, through a sample of various plant systems important to safety, that these extant arrangements will continue to be applied during the defuelling phase.

49. For fuel handling, the mechanical engineering inspector reviewed the lifting integrity report and was satisfied that, the recommendation to monitor and record FPU load traces when the FPU is set down at the reactor, would be implemented. The inspector sampled the testing and commissioning of the CM underload protection, which protects against FPU ledge faults, and was satisfied the modification provided the desired level of protection. NS/PC 7786 acknowledges the fuel handling and fuel route lifting equipment will experience a significant increase in operational duty during defuelling operations. The inspector examined the EMI&T regime supporting defuelling operations and was satisfied that, essential recommendations to improve equipment reliability were being appropriately addressed.

50. From a mechanical engineering perspective, the inspector judged that EDF NGL had demonstrated the risks associated with the defuelling operations were adequately understood, will be appropriately controlled and have been reduced ALARP. The inspector recommended the issue of Licence Instruments for ONR's Agreement under arrangements made under Licence Condition 22(1) that the:

- HPB and HNB reactors can be shut down in accordance with the Defuelling Essential Shutdown Reactor Safety Case NS/PC 7781; and
- Operations may commence at HPB and HNB in accordance with the Defuelling Fuel Handling Essential Safety Case NS/PC 7786.

3.1.6 CONTROL AND INSTRUMENTATION

51. The scope of the control and instrumentation (C&I) assessment report [19] considered both NS/PC 7781 and its interactions with NS/PC 7786. For the Shutdown Reactor Safety Case the C&I inspector considered the:

- Secure insertion of the control rods in the EoG shutdown reactor core in order to prevent a re-criticality.
- Isolation and drain-down of the PVCW system in order to reduce the potential consequences of a dropped FPU at the reactor.
- Arrangements for ensuring adequate performance of C&I systems on the EoG shutdown reactors during defueling, given the changed long-term conditions on the reactors.

52. For the Fuel Handling Safety Case the inspector considered the adequacy of the:

- Maintenance arrangements and service life of the fuel route plant C&I systems given the increased frequency of fuel handling operations during defueling.
- FPU underload protection for controlling the risk associated with the new dropped FPU at reactor fault.
- Upgrades to the FHC control panel as a means of reducing defueling risks to ALARP by reducing the frequency of a dropped flask fault.

53. All control rods, including the safety group which are normally held outside the core when the reactor is shutdown during outages, need to be inserted into the core and securely isolated prior to defuelling in order to provide adequate SCM. Whereas the principal means of isolating the control rods is by electrical/mechanical means, the C&I inspector was satisfied that it is not necessary to supplement these isolations

with C&I-based measures. The inspector was also satisfied that although the control rod position indication systems will remain operational during defuelling, there will be no safety claims placed upon these and no requirement to retain them on the maintenance schedule. After liaising with the electrical engineering inspector, he was also content that if a fault occurred on the energised control rod position indication circuits, this would not cause control rod movement. He was therefore satisfied, from a C&I perspective, with EDF NGL's proposal to insert and isolate the control rods.

54. The isolation of the PVCW system includes C&I requirements that principally involve modification and removal of alarms to prevent false and non-relevant indications of the PVCW system condition, and also to reflect revised reactor limits and conditions. The inspector was satisfied that EDF NGL has identified the alarms that require modification or removal and that these changes, including the amended maintenance requirements, will be implemented under appropriate EC control. He was therefore satisfied, from a C&I perspective, with EDF NGL's proposal to isolate and drain-down the PVCW system.

55. The shutdown reactors will generate significantly less heat and the resultant lower environmental temperatures may impact the reliability and the operating range suitability of C&I equipment. The inspector was satisfied that EDF NGL has considered relevant operating experience from the recent extended graphite outages, coupled with experience from Magnox stations, to determine arrangements for ensuring the continued suitability and reliability of C&I equipment on the shutdown reactors, including the use of space heating systems.

56. The reactor defuelling programme increases the demand placed on existing C&I systems on fuel route equipment. The inspector was content that existing engineering processes for managing system health, which includes reviewing trends in plant performance, would continue throughout defueling. The inspector was satisfied that fuel route maintenance requirements have been reviewed and noted that the only C&I related maintenance change required was an increase in the maintenance frequency of the irradiated fuel dismantling (IFD) platform drive train. He was satisfied with the EDF NGL arrangements for maintaining and monitoring the fuel route C&I equipment during defuelling and he noted that these arrangements also take account of the need for the fuel route plant availability to support defueling timescales.

57. The inspector considered the modification to install an underload protection system to protect against the dropped FPU fault. He sampled the design substantiation report and was satisfied that the installed system was suitable for the intended purpose and met the C&I requirements defined in relevant ONR's SAPs [17]. He was also satisfied that the commissioning records confirmed that all tests had been completed satisfactorily and that the required functionality was proven, and also that suitable maintenance arrangements are in place to ensure continued safety performance of the system.

58. The C&I inspector reviewed the modification to upgrade the FHC control panel, and particularly the additional lines of (interlock) protection that are required to reduce the dropped flask fault frequency. He was content that the additional lines of protection satisfied a specific requirement for them to be physically separate and diverse to the combined control/protection circuits and that they also met C&I requirements defined

in relevant ONR SAPs [17]. The inspector was also satisfied that the upgraded FHC control panel had been successfully commissioned and that maintenance procedures had been updated to reflect the modification.

59. From a C&I perspective, the inspector was satisfied with the claims, arguments and evidence presented in the defuelling safety cases, and noted that the areas sampled demonstrated an adequate level of compliance with relevant ONR SAPs [17]. The inspector did not object to the shutdown of the HPB and HNB reactors in accordance with NP/SC 7781 and to the commencement of defuelling in accordance with NP/SC 7786.

3.1.7 PROBABILISTIC SAFETY ASSESSMENT

60. The PSA assessment report [20] focussed on the Defuelling Fuel Handling Safety Case (NP/SC 7786) and associated PSA. The level of risk when a reactor is shutdown is considerably lower than when at power and large grace times are available for operators to respond to faults. PSAs for shutdown reactor safety cases have not therefore been developed for AGRs and this position has historically been accepted by ONR.

61. A PSA is used to support safety cases by considering probabilistic insights and claims and then making comparison against numerical targets to determine whether risks have been reduced ALARP. The PSA assessment scope therefore considered:

- The scope and quality of the defuelling PSA
- New faults in the defuelling PSA
- Use of defuelling PSA results
- Updates to Human Reliability Analysis (HRA)

62. The defuelling PSA is an updated version of the refuelling PSA. The PSA inspector was satisfied that the scope and level of detail in the defuelling PSA was comparable to that of the extant refuelling PSAs, whilst noting some conservatisms were present related to decay heat of fuel during different handling operations.

63. The inspector noted an additional fault has been added to the defuelling PSA related to dropped FPUs at the reactor, and following discussions with structural integrity and fault studies inspectors, was satisfied that the risk from this fault is low.

64. The PSA inspector reviewed the use of the PSA to inform identification of reasonably practicable plant modifications to the FHC and control and instrumentation system improvements to reduce dropped flask frequency at the cooling pond. Following discussions with the human factors and control and instrumentation inspectors, the PSA inspector was satisfied with the process followed and considered no further modifications to the FHCs were readily identifiable as reasonably practicable from a PSA perspective.

65. The HRA was examined and those defuelling faults sequences, where the claim on operator actions was potentially in excess of reliability limits, were identified. The inspector sampled the methodology used to risk rank the human error contribution to defuelling faults and was satisfied that the significant sources of risk were identified and that the risk was well below ONR’s numerical targets [17].

66. The PSA inspector was satisfied with the adequacy and use of PSA and probabilistic insights within the licensee's fuel handling safety cases, and was satisifed that defuelling risks have been reduced ALARP from a PSA perspective. The overall risk of defuelling and refuelling are broadly similar, with defueling having the benefit of moving the stations to a safer state. The PSA inspector did not object to commencement of defuelling in accordance with NP/SC 7786.

3.1.8 ELECTRICAL ENGINEERING

67. The electrical engineering assessment report for the shutdown reactor safety case, NS/PC 7781 [21] reviewed:

- The proposals for the electrical isolations required for both the PVCW and control rod systems prior to the commencement of defuelling and any changes to maintenance schedules for affected equipment;
- How ambient arrangements in terms of heating and humidity for electrical plant and equipment previously subject to operating reactor conditions, will be maintained during the defueling period; and
- The substantiation of the GC main motor stator windings thermal life expectancy for the defuelling period until the reactors are verified as fuel free.

68. The electrical engineering aspects of the isolation of the PVCW system and control rod systems are justified by separate ECs that are subordinate to NS/PC 7781. The electrical engineering inspector was satisfied with the electrical safety standards and controls planned to be applied to the PVCW system and control rod isolations. A further inspection is planned, as part of normal regulatory business, to verify the isolation of the PVCW and to ensure that control rod ECs have been implemented satisfactorily.

69. NS/PC 7781 identifies that during defuelling, reduced heat generation from the reactor, low temperatures and potentially increased levels of condensation in some buildings may be a concern for electrical plant. The inspector was satisfied that EDF NGL had considered relevant OPEX to assure the reliable operation of electrical equipment and plant for the differing ambient conditions that may be experienced during defuelling operations.

70. The function of the GCs is to provide sufficient forced gas flow to maintain acceptable fuel and reactor component temperatures and minimise any risk of fuel damage. Following discovery of accelerated thermal ageing of GCs, EDF NGL commissioned testing to further substantiate and extend the thermal life expectancy of the GC main motor stator windings. The electrical engineering inspector was satisfied with substantiation that shows the installed GC main motor stator windings have sufficient thermal life remaining to support defuelling operations until the reactors at each station are verified as fuel free.

71. The electrical engineering inspector did not identify any further matters in relation to electrical engineering that would prevent ONR issuing Licence Instruments to agree to the shutdown of the HPB and HNB reactors in accordance with NS/PC 7781.

72. The electrical engineering assessment report for the fuel handling safety case NS/PC 7786 [22], reviewed the maintenance and service life of fuel route electrical plant and

equipment during the defuelling period given the increased number and frequency of fuel handling operations. The inspector was satisfied that there would be no change in plant availability requirements at the fuel route facilities during defuelling, including the charge machine, compared to those stated in the existing refuelling safety cases.

73. The inspector confirmed that only a small number of fuel route items of equipment require extra maintenance, and that none of these are explicitly electrical. The inspector confirmed that the service life of electrical equipment remains suitable. The electrical plant will therefore continue to be subject to system health monitoring, which will inform any required changes to the EIM&T schedule during the defuelling period.

74. The electrical engineering inspector did not identify any further matters in relation to electrical engineering that would prevent ONR issuing Licence Instruments to agree to the defuelling of the HPB and HNB reactors in accordance with NS/PC 7786.

3.1.9 HUMAN FACTORS

75. The human factors assessment report [23] considered the ‘deltas’ between the current shutdown and refuelling activities, which detail how to safely move fuel under various reactor conditions and for which EDF NGL has safety cases which have been subject to previous regulatory scrutiny, and the proposed defuelling activities. An extensive programme of Human Factors work has been carried out to support the development and implementation the defuelling safety cases.

76. The human factors inspector focused on the adequacy of the human factors work programme to support identification, assessment and implementation of safety management arrangements which ensure limits and conditions (LACs) derived from these cases are complied with at all times. The inspector was satisfied that the significant changes had been identified; namely the handling of FPUs, Fuel Free Verification (FFV) and increased fuel route throughput.

77. The inspector considered that EDF NGL had undertaken an appropriate programme of work to support the development and implementation of its defuelling safety cases, and that it had underpinned the safety case claims and arguments in a proportionate yet robust way. Human actions that can impact safety have been analysed; the dependence on human action has been reduced where reasonably practical to do so; the residual safety actions demonstrated to be effectively implemented through appropriate Human Machine Interface design and the operations and the workspaces were confirmed to be well maintained and free from environmental hazards.

78. The inspector was satisfied, for the handling of FPUs, FFV and increased fuel route throughput, that the human contribution to safety had been understood and suitably substantiated.

79. From a Human Factors perspective, the inspector was satisfied with the claims and arguments and evidence presented in the defuelling safety cases and did not object to the shutdown of the HPB and HNB reactors in accordance with NP/SC 7781 and to the commencement of defuelling in accordance with NP/SC 7786.

3.1.10 CHEMISTRY

80. This chemistry assessment report [24] reviewed:

- The chemistry limits and conditions required to be retained to ensure safety of the reactor safety systems including gas circulators boilers and cooling water;
- The environmental conditions during defuelling to prevent significant risk of corrosion to fuel; and
- The chemistry limits and conditions required to be maintained for the FSP and Pond Water Treatment Plant.

81. The chemistry inspector examined the control of oxygen in the reactor coolant gas. Oxygen acts as an oxidant with potential to corrode graphite and steels and can promote the breakdown of UO_2 in any failed fuel, increasing the potential for a radiological release. The reactor defuelling temperature and pressure conditions are less than 0.5 barg CO_2 with less than 2% air and a maximum channel outlet temperature of 75 °C. The inspector was satisfied that the shutdown limits for temperature, pressure, oxygen and moisture levels are benign and are well below the level where a detrimental impact can occur. He was content with the proposed controls and satisfied that risks associated with oxygen and moisture in reactor gas will continue to be managed ALARP.

82. The FSP chemistry was examined and the inspector considered that the most significant change during defuelling is the increased demands placed upon the fuel route & FSP. The chemistry inspector was satisfied that the existing measures for monitoring and controlling FSP chemistry, would continue to be appropriate. The major contributor to long-lived activity in the FSP is anticipated to be via import of Cs-137 from Sellafield Ltd and the inspector was satisfied that the expected contamination levels within the FSP would not challenge the existing clean-up systems.

83. The inspector reviewed the storage capacity of the FSP and the potential for fuel clad failure to occur if fuel is held in the FSP for prolonged periods. The inspector did not identify any evidence of the chemistry of AGR FSP leading to fuel degradation and was content that the proposed approach to reduce the risks to fuel, when stored in the FSP, was ALARP.

84. The chemistry inspector was content that EDF NGL had adequately justified its approach to the control of chemistry within the EoG essential shutdown and essential fuel handling safety cases for HPB and HNB. The inspector therefore recommended, from a chemistry perspective, that ONR agree to the proposals for the shutdown and defueling at HPB and HNB respectively as described in NS/PC 7781and NS/PC 7786.

4 MATTERS ARISING FROM ONR'S WORK

85. I have confirmed that EDF NGL has followed its own due process. INSA statements for NP/SC 7781 and NP/SC 7786 and respective Nuclear Safety Committee (NSC) meeting minutes have been submitted [2,3,4 and 5].

86. The revised consequence argument [11] that supported the position that the consequences from failure of a CSP, from a dropped FPU, would be tolerable and the re-classification of the CSP as an 'infrequent failure' component [16], has changed the basis of the as submitted fuel handling safety case, NP/SC 7786 [7]. Accordingly, ONR has acknowledged that EDF NGL has committed to update the basis of NP/SC 7786 and that this will be submitted to ONR when it has completed due process [25]. I can confirm that a regulatory issue has been raised to monitor delivery against the commitment to update the basis of NP/SC 7786.

87. On all other matters, the ONR specialist inspectors consider Agreement to the proposed safety cases NP/SC 7781 and NP/SC 7786 to be acceptable. On that basis I have prepared Licence Instruments for Agreement to NP/SC 7781 and NP/SC 7786 for HPB and HNB. These have been written according to ONR guidance and are of routine type, for which the text and format have been agreed with the government legal department. Further legal checking of these Licence Instruments is therefore unnecessary.

88. Some other recommendations were raised by specialist inspectors which are discussed in the respective assessment reports. I can confirm that none of these other recommendations prevent Agreement to NP/SC 7781 or NP/SC 7786.

89. I have liaised with the Scottish Environment Protection Agency (SEPA) and the Environment Agency (EA) and they have confirmed that they have no objections to ONR issuing Agreements to implement NP/SC 7781 and NP/SC 7786 at HPB and HNB [26].

5 CONCLUSIONS

90. Based on the work carried out by ONR, I am satisfied with the claims, arguments and evidence laid down within:

- EDF NGL's Defuelling Essential Shutdown Reactor Safety Case, NP/SC 7781. I judged that the proposal is adequate to justify the issue of Licence Instruments for ONR's Agreement under arrangements made under Licence Condition 22(1) that the Hinkley Point B and Hunterston B reactors can be shut down in accordance with NP/SC 7781.

- EDF NGL's Defuelling Essential Fuel Handling Safety Case, NP/SC 7786. I judged that the proposal is adequate to justify the issue of a Licence Instruments for ONR's Agreement under arrangements made under Licence Condition 22(1) that defuelling operations may commence at Hinkley Point B and Hunterston B in accordance with the Essential Fuel Handling Safety Case NP/SC 7786.

6 RECOMMENDATIONS

91. I recommend that:

- Licence instrument 566 is granted to Hinkley Point B to allow implementation of Defuelling Essential Shutdown Reactor Safety Case NP/SC 7781, EC 363701.

- Licence instrument 567 is granted to Hinkley Point B to allow implementation of Defuelling Fuel Handling Essential Safety Case NP/SC 7786, EC 363993.

- Licence instrument 571 is granted to Hunterston B to allow implementation of Defuelling Essential Shutdown Reactor Safety Case NP/SC 7781, EC 364023.

- Licence instrument 572 is granted to Hunterston B to allow implementation of Defuelling Fuel Handling Essential Safety Case NP/SC 7786, EC 363991.

7 REFERENCES

1. BEG/SPEC/DAO/020, Nuclear Generation Limited, Company Specification, Modification process, Revision 012, September 2021.
2. Hinkley Point B, HPB51455R – Application for Agreement, LC22(1) Engineering Change - Defuelling Essential Shutdown Reactor Safety Case, EC363701, NP/SC 7781 - 19 October 2021, CM9 2021/76891.
3. Hunterston B, HNB50586R – Application for Agreement, LC22(1) Engineering Change - Defuelling Essential Shutdown Reactor Safety Case, EC364023, NP/SC 7781 - 21 October 2021, CM9 2021/79005.
4. Hinkley Point B, HPB51456R – Application for Agreement, LC22(1) Engineering Change - Defuelling Fuel Handling Essential Safety Case, EC363993, NP/SC 7786 - 2 November 2021, CM9 2021/81309.
5. Hunterston B, HNB50587R – Application for Agreement, LC22(1) Engineering Change - Defuelling Fuel Handling Essential Safety Case, EC363991, NP/SC 7786 - 2 November 2021, CM9 2021/80104.
6. NP/SC 7781 - Defuelling Essential Shutdown Reactor Safety Case - Modification Submission, Version 6 – 22 September 2021, CM9 2021/79005.
7. NP/SC 7786 - Defuelling Fuel Handling Essential Safety Case – Modification Submission, Version 8 - 29 October 2021, CM9 2021/80104.
8. ONR Regulatory Strategy and Plan to support closure (non-elective or planned) of AGR Stations, Revision 3 – 07 March 2022, CM9 2022/14309.
9. Other Report, Hinkley Point B and Hunterston B Defuelling Cases - Fuel and Core - Other Report - - 4 February 2022, CM9 2021/61568.
10. ONR-OFD-AR-21-17, Fault Studies Assessment - Fuel Handling and Shutdown Reactor Defuelling – 01 February 2022, CM9 2021/50888.
11. HPB/HNB Defuelling Safety Case NP/SC 7781 & 7786 - ONR Position on Core Support Plate (CSP) Integrity Assessment - Updated ALARP and Structural Integrity Documents, email– 17 February 2022, CM9 2022/11678.
12. Other Report, Hinkley Point B and Hunterston B Power Stations Defuelling Essential Fuel Handling Safety Case – NP/SC 7786 - Internal Hazards Assessment - 22 February 2022, CM9 2022/12883.
13. ONR Decision Record - ONR-OFD-DR-21-014 - HNB Removal of Incredibility of Guillotine Failure (IoGF) claims on the Decay Heat Outlet pipework (CM9: 2021/42190
14. ONR Project Assessment Report - ONR-OFD-PAR-21-011 - Declassification of the reactor pressure boundary and associated systems for the post generation phase (CM9: 2021/85297)
15. Assessment of the Structural Integrity aspects of the Shutdown Reactor and Fuel Handling Safety Case NP/SC 7781 and NP/SC 7786 - 18 March 2022, CM9 2021/89638.
16. HPB/HNB Defuelling Safety Case NP/SC 7781 & 7786 - ONR Position on Core Support Plate (CSP) Integrity Assessment. CM9 2022/11023.

17. Safety Assessment Principles for Nuclear Facilities. 2014 Edition, Revision 1. January 2020. http://www.onr.org.uk/saps/saps2014.pdf.

18. ONR-OFD- AR-21-048, Mechanical Engineering Assessment of Hunterston B & Hinkley Point B Fuel Handling & Shutdown Reactor Safety Cases - 02 March 2022, CM9 2021/89430.

19. ONR-OFD-AR-21-080, Control and Instrumentation Assessment of EDF NGLs Nuclear Safety Justification for implementing the Defueling Essential Shutdown Reactor Safety Case (EC 364023 (HNB) and EC 363701 (HPB)), and the Defueling Fuel Handling Essential Safety Case (EC 363991 (HNB) and EC 363993 (HPB)) at HNB and HPB Power Stations - 17 March 2022, CM9 2022/11991.

20. ONR-OFD-AR-21-079, Hinkley Point B and Hunterston B Defuelling - Probabilistic Safety Analysis Specialist Assessment - 31 January 2022, CM9 2021/91456.

21. ONR-OFD-AN-21-64, Hinkley Point B and Hunterston B Power Stations Defuelling Essential Shutdown Reactor Safety Case – NP/SC 7781 Revision 0 version 6 – Electrical Engineering Assessment Note – 13 January 2022, CM9 2022/2286.

22. ONR-OFD-AN-21-65, Hinkley Point B and Hunterston B Power Stations Defuelling Fuel Handling Essential Safety Case – NP/SC 7786 Revision 0 version 8 – Electrical Engineering Assessment Note - 13 January 2022, CM9 2022/2677.

23. ONR-OFD-AR-21-078, Human Factors Assessment of Hunterston B (HNB) and Hinkley Point B (HPB) Shutdown Reactor and Fuel Handling Defuelling Safety Cases – 24 January 2022, CM9 2021/89802.

24. ONR-OFD-AR-21-054, Chemistry assessment of the Hinkley Point B / Hunterston B End of Generation combined shutdown and defueling safety cases - 15 March 2022, CM9 2022/86511.

25. HPB/HNB Defuelling Fuel Handling Essential Safety Case NP/SC 7786 - Commitment to update the basis of NP/SC 7786, e-mail - 7 March 2022, CM9 2022/15290.

26. E'mail from SEPA & EA – Shutdown of the Reactors and Commencement of Defuelling - Confirmation of SEPA No Objection - 1 March 2022, CM9 2022/13865 & Shutdown of the Reactors and Commencement of Defuelling - Confirmation of EA No Objection - 1 March 2022, CM9 2022/13869