

Hunterston B / Hinkley B End of Generation

**Agreement to the declassification of the Reactor Pressure Boundary & Associated
Systems for the Post Generation Phase**

Project Assessment Report ONR-OFD-PAR-21-11
Revision 0
December 2021

Report ONR-OFD-PAR-21-011
CM9 Ref: 2021/85297

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Published 02/22

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EXECUTIVE SUMMARY

Agreement to the declassification of the Reactor Pressure Boundary & Associated Systems for the Post Generation Phase

Permission Requested

The Licensee (EDF-NGL) has requested the Office for Nuclear Regulation's (ONR) agreement to the declassification of the reactor pressure boundary and associated systems for the post generation phase at Hunterston B and Hinkley Point B, in accordance with its arrangements made under Licence condition (LC) 22(1): *Modification or experiment on existing plant.*

Background

The Hunterston B (HNB) and Hinkley Point B (HPB) reactors are due to cease generation no later than 7 January 2022 and 15 July 2022 respectively.

Following end of generation, the reactor operating conditions are significantly more benign than when operating such that the nuclear safety risks are substantially reduced. As such, the EDF-NGL has requested ONR's agreement to declassify the existing high safety duty claims of the reactor pressure boundary and associated steam and feed systems to one where failure is tolerable.

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

This modification proposes to remove high duty safety claims for a large number of components which is a significant alteration to the existing safety case claims.

As such, I judged it proportionate to obtain specialist inspector advice to undertake this assessment to gain regulatory confidence in EDF-NGL's claim that following end of generation the likelihood and consequence of pressure boundary failure is extremely low and will not affect Essential Safety Functions. I therefore sought advice from structural integrity, internal hazards and fault studies specialist inspectors.

Matters arising from ONR's work

A number of technical engagements have taken place with EDF-NGL by way of telephone conference and exchange of documents. Based on the evidence sampled, all the specialist inspectors have advised that they have no objections to the proposal. They recommend that ONR issues the Licence Instruments to allow the declassification of the reactor pressure boundary and associated systems for the post generation phase.

In addition, I note that the proposal has been subject to independent internal governance by EDF-NGL's internal regulator who has concluded that they have no objection to the project progressing.

I note that there are several outstanding commitments associated with this proposal. Given many of them are key to supporting the case, I have raised ONR regulatory issues 10476 for HPB and 10477 for HNB to ensure timely completion of each of the commitments before the case is enacted.

Conclusions

Based on the evidence sampled by ONR, I am satisfied with the claims, arguments and evidence within the proposal and supporting documents. I consider that the operating conditions on a defuelling reactor are significantly more benign than when it was generating, such that the nuclear safety risks from the failure of the systems concerned are substantially decreased. I therefore consider the declassification of the reactor pressure boundary and associated systems is acceptable.

Recommendation

I recommend that ONR should issue an Agreement (Licence Instrument 573) to HNB and issue an Agreement to HPB (Licence Instrument 568) for the declassification of the reactor pressure boundary and associated systems for the post generation phase.

I also recommend that ONR should maintain regulatory oversight and routinely monitor progress of the commitments to ensure timely completion, via regulatory issues 10476 for HPB and 10477 for HNB.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BSUV	Boiler Start Up Vessel
CNS	Civil Nuclear Security (ONR)
EDF-NGL	EDF Energy Nuclear Generation Ltd
FGC	Forced Gas Circulation
FS	Fault Studies
HI	High Integrity
HNB	Hunterston B Power Station
HPB	Hinkley Point B Power Station
INSA	Independent Nuclear Safety Assessment
IoF	Incredibility of Failure
IoGF	Incredibility of Guillotine Failure
NC	Natural Circulation
NSC	Nuclear Safety Committee
ONR	Office for Nuclear Regulation
RACW	Reactor Ancillary Cooling Water
SEPA	Scottish Environmental Protection Agency
SFAIRP	So Far As Is Reasonably Practicable
SI	Structural Integrity
SRV	Safety Relief Valves

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1 PERMISSION REQUESTED

1. The Licensee (EDF-NGL) has requested the Office for Nuclear Regulation's (ONR) agreement to the declassification of the reactor pressure boundary and associated systems for the post generation phase at Hunterston B and Hinkley Point B (Ref 1&2), in accordance with its arrangements made under Licence condition (LC) 22(1): *Modification or experiment on existing plant*.

2 BACKGROUND

2. The Hunterston B (HNB) and Hinkley Point B (HPB) reactors are due to cease generation no later than 7 January 2022 and 15 July 2022 respectively.
3. Following end of generation, the reactor operating conditions are significantly more benign than when operating such that the nuclear safety risks from failure of the systems concerned are substantially reduced. As such, EDF-NGL has requested ONR's agreement (Ref 1 & 2) to declassify the existing high safety duty claims (e.g. Incredibility of Failure (IoF), Incredibility of Guillotine Failure (IoGF), and High Integrity (HI)), of the reactor pressure boundary and associated steam and feed systems to one where failure is tolerable on the following:
 - The IoF claims are associated with the reactor primary pressure boundary (reactor penetrations). These arise from the consequence associated with reactor depressurisation and hot gas release. This is primarily due to unacceptable consequences following a breach in the circulator hall which could damage equipment (due to high temperature release from breach) providing forced gas circulation (FGC). FGC is the only line of protection for a reactor depressurisation where the breach is too large for CO₂ pressure support to enable cooling by natural circulation (NC).
 - The IoGF claims on the steam and feed pipework systems. These arise from a postulated guillotine failure which could create a pipewhip that could strike and undermine the nearby IoF reactor penetrations.
 - The HI claims associated with:
 - Control rod standpipe – a rupture of a control rod standpipe could result in the ejection of an irradiated control rod assembly
 - Small welds associated with the standby filling penetrations – a failure could disable forced gas circulation
 - Boiler Start Up Vessel – failure could generate missiles that could undermine safety related structures and systems
4. As a consequence, it will result in a significant reduction of in-service inspections for the affected reactor and associated steam/feed pressure systems.

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5. To support the declassification of the existing high safety duty claims, new operational constraints for the defuelling reactor need to be put in place. This includes:
 - Maintain reactor gas to 75°C and to less than 1 barg at HPB and 2 barg at HNB under all normal operating conditions, including frequent faults.
 - Reactor Safety Relief Valves (SRVs) to be modified so reactor cannot exceed 15 barg to take account of possible fault conditions requiring the reactor to be repressurised to support natural circulation. This is classed as an infrequent fault.
 - Maintain channel decay heat to less than 8kW.
6. It should be noted that defuelling will take place on one reactor at a time at each nuclear site (HNB and HPB). While the second reactor is waiting to be defuelled the conditions may be more arduous than those in the first reactor. As such, this request will not apply to the second reactor until the conditions are reduced and controlled in line with the defuelling operational conditions listed above.

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

7. This modification proposes to remove loF/loGF/HI safety case claims for a large number of components which is a significant alteration to the existing safety case claims.
8. Also, if this modification was ill-conceived or ill-executed it might lead to a significant increase in radiological risk. As such, EDF-NGL has categorised this change in accordance with their procedures as Category A.
9. In accordance with ONR's regulatory permissioning strategy (Ref 3), I judged it proportionate to obtain specialist inspector advice to undertake this assessment (Ref 4). I targeted the assessment on gaining regulatory confidence in EDF-NGL's claim that following end of generation the likelihood and consequence of pressure boundary failure resulting in hot gas/steam release is extremely low and will not affect Essential Safety Functions. I therefore sought advice from the following specialist areas:
 - Structural Integrity – to gain confidence that structural reliability of reactor plant remains assured, and the likelihood of failure is acceptably low, with altered classification;
 - Internal Hazards – to gain confidence that the consequences of failure in the primary pressure boundary and associated systems are acceptable and hence high safety duty claims (IOF, loGF & HI) can be declassified; and
 - Fault Studies – to gain confidence that the nuclear safety risks associated with this proposal is As Low As Reasonably Practicable (ALARP) from a fault studies perspective.

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10. A number of engagements have taken place with EDF-NGL by way of telephone conference and exchange of documents. (Ref 5)
11. Several documents have been sampled as part of this assessment and include:
 - Declassification of the reactor pressure boundary and associated systems for the post-generation phase (Ref 6);
 - HNB post generation, an update of the declassification proposal of the reactor plant pressure boundaries to accommodate a reactor pressure of 2 barg (Ref 7);
 - HPB/HNB Assessment of the consequences of reactor gas pressure boundary failure during defuelling (Ref 8);
 - Nuclear Safety Committee (NSC) advice (Ref 9); and
 - Independent Nuclear Safety Assessment (INSA) approval statement (Ref 10).

4 MATTERS ARISING FROM ONR'S WORK

12. The proposal (Ref 6 & 7) makes three claims, each supported by a series of arguments. The claims are as follows:
 - Claim 1 – The consequences of failure of the primary pressure boundary are reduced such that loF, loGF or HI claims are no longer required;
 - Claim 2 – The structural reliability of reactor plant remains assured and the likelihood of failure is acceptably low; and
 - Claim 3 – The nuclear safety risk is ALARP.
13. The matters arising from the work carried out by each of the ONR specialists are summarised below.

Internal Hazards Assessment

14. The author of this PAR also carried out the internal hazards assessment, so the assessment has been included in this PAR. The assessment was also subject to ONR technical review. (Ref 11)
15. I undertook the Internal Hazards assessment and concentrated my assessment on Claim 1 of the safety case. This was to gain confidence that the consequences of failure of the reactor pressure boundary and associated systems are acceptable to support the proposal to declassify high safety duty claims (loF, loGF & HI) under the new operational constraints (75°C and to less than 2 barg under all normal operating conditions). These claims are discussed in turn below:

loF Claims associated with the reactor pressure boundary

Hot Gas Release

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16. I sampled the evidence supporting the claims (Ref 6 & 7) that the consequences of a hot gas release from a breach in the currently classed loF pressure boundary components is acceptable. EDF-NGL states that the reactor gas temperatures will be constrained to 75°C (but is expected to be operated at much lower than 75°C). Following a hot gas release in the Circulator Hall, I accept EDF-NGL's has conservatively judged that the ambient air would be cooler than 70°C, due to mixing with the cold ambient air. At such temperatures, the forced gas circulation equipment is not expected to be undermined as it has a withstand capability of 70°C.

Missile Impacts

17. EDF-NGL has considered the threats of missile impacts following failure of the reactor pressure boundary on the Essential Safety Functions (e.g. Forced Gas Circulation (FGC) equipment and boiler feed pipework). It should be noted that the Reactor Ancillary Cooling Water system (RACW) (which forms part of the FGC system) is deemed most vulnerable to missiles/dropped loads due to poor separation and segregation. The other elements of the RACW system and boiler feed system are considered more resilient to missile/dropped loads due to segregation in separate quadrants.
18. EDF-NGL considers that a number of the reactor penetrations will not be able to fully eject and generate a missile due to a combination of tubes internal to the reactor which tether them to the reactor and the external pipework which offers additional restraint. In addition, EDF-NGL considers by constraining reactor pressure to 2 barg, any missile ejected will have a short trajectory and represent more of a dropped load hazard than a missile.
19. I have sampled the evidence provided (Ref 8) and consider that EDF-NGL has identified credible targets and assessed the potential consequences. I also accept the EDF-NGL's judgement that the potential to generate a missile is limited (due to tethering) but that any missile that is ejected will have limited trajectory due to low reactor pressures. Overall, I accept the EDF-NGL's judgement that a missile/dropped load could not undermine both lines of RACW simultaneously (due to the RACW circuits spaced a short distance apart) and therefore the RACW function will be maintained. I also accept the judgement that missiles/dropped load hazards generated in one quadrant will not affect other quadrants.

20. Jet / Blast Impacts

21. EDF-NGL has also considered the impacts of a gas jet or blast from a hot gas release on the FGC equipment (Ref 8). EDF-NGL considers that the impacts from jets/blasts will be insignificant given the constraints on operating pressure to 2 barg for HNB and 1 barg for HPB. I accept the EDF-NGL's judgement that the threats to the FGC equipment from jet/blasts would be insignificant at these low pressures and would be bounded by the missile impacts discussed above.

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Pipewhip

22. EDF-NGL has considered the potential for pipewhip to be generated from failure of reactor penetrations to impact the nearby RACW pipework (Ref 8). EDF-NGL considers that the potential for pipewhip to challenge the integrity of the RACW pipework to be unlikely due to the low reactor pressures. I accept the EDF-NGL's judgement that the propensity for pipewhip to be low and that even if impacted are unlikely to challenge the integrity of the RACW pipework. As such, at least one circuit of RACW would survive and maintain cooling.
23. Based on my sample, I consider EDF-NGL has considered the direct and indirect (missile/flooding) consequences of failure of primary pressure boundary (reactor penetrations). These consequences are shown to be acceptable, I therefore consider loF claims are not required post generation.

loGF Pipework Claim associated with the steam and feed systems

Pipewhip

24. The existing safety case identifies numerous pipework locations in the steam and feed systems as loGF. This is due to the potential for a failure in the steam and feed pipework to generate a pipewhip and strike and fail a nearby reactor penetration, which leads to unacceptable consequences. I accept the EDF-NGL's judgement that removing the loF claim on the reactor penetrations means a pipewhip of the steam and feed pipework becomes tolerable, due to the more benign reactor conditions. As such, the loGF claim is no longer required.
25. In addition, EDF-NGL has identified that the feed and decay heat pipework run close to RACW system. EDF-NGL has not ruled out the potential for pipewhip to be generated following a failure in the feed and decay heat pipework and strike and disable part of the RACW system. However, it is noted that in the unlikely event that both circuits of the RACW system are disabled, the layout of plant is such that a pipewhip is unable to fail a reactor penetration at the same time and thus natural circulation (NC) remains viable. I consider EDF-NGL has undertaken a conservative assessment and accept the judgement that the consequence of failure from previously loGF pipework in the steam and feed systems are acceptable, hence loGF claims are not required post generation.

High Integrity (HI) Claims

26. It is noted that there is a HI claim associated with the boiler start-up vessel (BSUV) due to consequence of gross rupture and potential impact on lines of protection. EDF-NGL has confirmed that if the BSUV continues to operate during defuelling the HI claims will remain. However, if the BSUV is taken out of service during defuelling, the risk is removed and hence, the HI claim can be removed. I note that EDF-NGL is committed to determine the status of the

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BSUV prior to this case being adopted. I confirm that I am content EDF-NGL's approach.

27. There is also a HI claim on some of the smaller welds on the standby filling penetrations. Given the consequences of failure of the larger IoF welds on these same penetrations are acceptable as an infrequent fault, I accept EDF-NGL's view that the larger IoF welds bound the consequences of these smaller welds. As such, I support the declassification of these components.
28. ONR's fault studies specialist has reviewed the HI claim associated with the control rod standpipes (Ref 11). At power, a HI claim is made for the control rod standpipes because a rupture could result in the ejection of an irradiated control rod assembly which could potentially land off-site and result in a radiological release. Under defuelling conditions, EDF-NGL has shown ample margin to the full ejection of a control rod assembly. The fault studies inspector concurs that the reasoning behind the HI requirement on the control rod standpipes does not apply post generation.
29. Based on my sample, I consider EDF-NGL has adequately considered the direct and indirect consequences of failure and incorporated appropriate conservatisms. In addition, ONR's structural integrity specialist inspector has sampled the consequence analysis assessment undertaken (Ref 8) and considers it appropriate. I also consider the operating conditions on a defuelling reactor are significantly more benign than when it was generating. As such, the nuclear safety risks from failure of the systems concerned are significantly reduced. From an internal hazards perspective, I recommend ONR's agreement to the proposal to declassify the reactor pressure boundary and associated systems for post generation operations.

Fault Studies Assessment

30. The Fault Studies (FS) specialist assessed the claims in the proposal in order to consider whether risks have been reduced as low as reasonably practicable (ALARP) from a fault studies perspective (Ref 12). In general, they concurred with EDF-NGL's assertion that the reactor operating conditions are more benign during defuelling than when generating in terms of power, pressure and temperature. However, to support the proposal, they concentrated their assessment on the impact of the modification on the FGC and NC core cooling as cooling is still required for a defuelling reactor.
31. The FS specialist assessed the impact on FGC, which is the only line of protection following a large breach of the reactor pressure boundary (e.g. breach of reactor penetration). They noted that post generation, the maximum reactor gas temperature is constrained to 75°C. As the FGC is qualified to withstand such temperatures, this line of protection is shown to survive a breach of the reactor pressure boundary and remain effective. The FS specialist judged that EDF-NGL has justified the adequacy of FGC as the

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- single line of protection for an infrequent failure, post generation reactor pressure boundary breach.
32. The FS specialist also assessed the impact on NC, which is the line of protection following loss of FGC, which is an infrequent fault. In order for NC to be effective, the reactor pressure needs to be increased to 10 barg. However, re-pressurisation may be prevented if there is a breach of the pressure boundary which is too large for CO₂ pressure support to enable cooling by NC. The FS specialist concurs with EDF-NGL that a gross breach of the reactor pressure boundary can only occur as an uncorrelated (random) event. Therefore, they considered the likelihood of being under NC (which requires pressure to be increased to 10 bar) and random gross breach is so low, it can be discounted as it is beyond design basis.
 33. The FS specialist reviewed the modification to the reactor SRVs to lift at a lower pressure. They noted that the new lift setting (15 barg) will enable pressure to be increased to support NC without SRVs lifting in the event of a loss of reactor cooling fault. Based on the optioneering conducted by EDF-NGL, and the benefit of the safety improvement, they judged that risks have been reduced ALARP.
 34. The FS specialist notes that this proposal discounts the potential for the nitrogen injection system to result in an overpressure fault on the basis that the nitrogen system will be taken out of service. However, the safety justification to remove the nitrogen system is not currently in place. ONR is currently reviewing the justification for the removal of the nitrogen system as part of its assessment of the end of generation case (Ref 13) for HNB/HPB. EDF-NGL has therefore placed an 'approved hold milestone' within their asset management system to ensure ONR agreement is received prior to taking the nitrogen system out of service (Ref 5). The FS specialist is content with this approach and has therefore discounted the potential for the nitrogen injection system to result in a pressurisation fault for this assessment. However, if the nitrogen injection system is kept in service post generation, EDF-NGL accepts that it would need to consider the potential for the nitrogen injection system to result in an over pressurisation fault for this proposal.
 35. In conclusion, the FS specialist considers that adequate protection is provided by FGC for an infrequent failure claim on the reactor pressure boundary during post generation operations. In addition, based on the optioneering conducted by EDF-NGL, and the benefit provided by the SRV modification, they judged that risks have been reduced ALARP. As such, the FS specialist recommends ONR agreement to the proposal to declassify the reactor pressure boundary and associated systems for post generation operations.

Structural Integrity Assessment

36. The Structural Integrity (SI) specialist concentrated their assessment on Claim 2 of the safety case. Claim 2 states that the structural reliability of reactor

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plant remains assured, and the likelihood of failure is acceptably low, with altered classification. The SI specialist concentrated on the risk of degradation in the defuelling phase and the justification of the significant reduction in the scope of inspections that is proposed.

37. The SI specialist notes (Ref 14) that the proposed reduction to the scope of the inspection programme is substantial, but judges it to be proportionate in light of the reduced risk that lower temperatures and pressures confer. Their conclusions are based on the following:
- The SI specialist is satisfied that the guidance which will define future inspections is adequate. He considers that it correctly targets degradation mechanisms for which there will be continued risk and justifiably takes credit for those which will diminish or be eliminated in the defuelling phase.
 - The SI specialist is content that the arrangements to fulfil this guidance are satisfactory and allow for an appropriate degree of specialist oversight.
 - The SI specialist accepts that the scope of inspections is adequate. They consider it is broadly consistent with components that have long held infrequent failure classification across the reactor fleet and considers it would be disproportionate for an inspection regime that originates from highest reliability classification to continue where reduced classification has been justified. They also note that those inspections required by the Pressure Systems Safety Regulations written schemes of examination will continue.
38. Overall, the SI specialist concludes that the proposal is satisfactory from a structural integrity perspective and satisfies EDF-NGL's legal duty to reduce risk so far as is reasonably practicable (SFAIRP). However, the SI specialist states that these conclusions are only valid if the altered classification is judged acceptable as an outcome of the ONR internal hazards assessment. As discussed above, the internal hazards assessment supports the declassification.

Other Matters Considered

39. I note that the proposal contains several commitments, many of which are key to supporting the case. EDF-NGL has confirmed (Ref 5) that each of the commitments are being tracked internally by their action tracking system and has confirmed that the commitments are scheduled to be addressed during the pre-defuelling outage at both stations and targeted for completion by 7/1/2022 for HNB and 15/07/2022 for HPB. Given the number of commitments and the prolonged timescales for delivery for HPB, I have raised ONR regulatory issues 10477 for HNB and 10476 for HPB to maintain regulatory oversight to ensure the commitments are adequately progressed in a timely manner, before the case is enacted.
40. I have gained regulatory confidence from the fact that EDF-NGL's proposal and supporting documents have been subject to EDF-NGL's due process, including consideration by the NSC (Reference 9) and was subjected to INSA

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(Reference 10). I gain further confidence that the internal regulator has added an additional hold point on the implementation of changes to the maintenance schedule from the declassification of the high safety duty components.

41. In accordance with the ONR/the Environment Agency/Scottish Environmental Protection Agency (SEPA) Memorandum of Understanding, I have consulted with the Environment Agency and SEPA inspectors whether they had any objections on environmental grounds to ONR agreeing to implementation of the activities requested. The Environment Agency and SEPA inspectors have confirmed that the Environment Agency/SEPA have no objections (Ref 15). Similarly, ONR's Civil Nuclear Security inspector has indicated that they have no objection (Ref 16).

5 CONCLUSIONS

42. Based on the work carried out by ONR, I am satisfied with the claims, arguments and evidence laid down within the proposal and supporting documents. I consider that the operating conditions on a defuelling reactor are significantly more benign than when it was generating, such that the nuclear safety risks from the failure of the systems concerned are substantially decreased. I therefore consider the declassification of the reactor pressure boundary and associated systems is acceptable.
43. There are several outstanding commitments associated with this proposal. Given many of them are key to supporting the case, I have raised ONR regulatory issues to ensure timely completion of each of the commitments before the case is enacted.

6 RECOMMENDATIONS

44. I recommend that ONR should issue an Agreement (Licence Instrument 573) to HNB (Ref 17) and issue an Agreement to HPB (Licence Instrument 568) (Ref 18) for the declassification of the reactor pressure boundary and associated systems for the post generation phase.
45. I also recommend that ONR should maintain regulatory oversight and routinely monitor progress of the commitments to ensure timely completion, via regulatory issues 10476 for HPB and 10477 for HNB.

7 REFERENCES

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2. Hinkley Point B (HPB): Request for Agreement under Arrangements made under Licence Condition LC22(1), dated 18 August 2021. CM9: 2021/65733
3. *ONR Guide – The Purpose and Use of Permissioning - NS-PER-GD-001 Revision 5*. May 2021.
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5. ONR Contact Records – Level 4 meetings on Declassification of the reactor pressure boundary and associated systems for the post generation phase CM9: 2020/319593, 2021/14838, 2021/17584 & 2021/84102
6. HNB and HPB – Declassification of the reactor pressure boundary and associated systems for the post generation phase, NP/SC 7811, dated July 2021. CM9: 2021/62182
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8. HPB and HNB – Assessment of the Consequences of Reactor Gas Pressure Boundary Failure During Defuelling, Issue 02, dated August 2021. CM9:2021/85290
9. EDF-NGL Nuclear Safety Committees Minutes of the Meeting (07/21), held on 22nd July 2021. CM9: 2021/65733
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11. E’mail from ONR – confirmation of no objection to Internal Hazards Assessment – D Lisboa, dated 24/11/2021. CM9: 2021/87392
12. ONR Fault Studies Assessment – HNB / HPB Declassification of the Reactor Pressure Boundary - J Downing, dated 22nd November 2021. CM9: 2021/79881
13. NP/SC 7781 - Defuelling Essential Shutdown Reactor Safety Case - Modification Submission, Version 6 – 22 September 2021, CM9 2021/79005.
14. ONR Structural Integrity Assessment Report – Declassification of the reactor pressure boundary and other systems post-generation - A Toft, dated 22/10/2021 CM9: 2021/74213

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15. E'mail from SEPA & EA – confirmation of no objection from SEPA, 25/11/2021 & confirmation of no objection from EA, dated 26/11/2021. CM9: 2021/85300 & 2021/85279
16. E'mail from ONR Nuclear Security – confirmation of no objection dated 24/11/2021. CM9: 2021/85280
17. HNB Licence Instrument 573, dated December 2021. CM9: 2021/85283
18. HPB Licence Instrument 568, dated December 2021. CM9: 2021/85284