Office for Nuclear Regulation

Assessment of NP/SC 7750: Dungeness B Fuel Storage Pond Decay Heat Limit Increase from 160 kW to 275 kW

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EXECUTIVE SUMMARY

This report presents the findings of ONR's assessment of Dungeness B NP/SC 7750: "Justification for Increasing the Fuel Storage Pond Decay Heat Limit from 160 kW to 275 kW".

Permission Requested

Licence Condition 22 (1) requires the licensee to make and implement adequate arrangements to control any modification (or experiment) carried out on any part of the existing plant or processes which may affect safety. In accordance with its arrangements made under Licence Condition 22(1), EDF Nuclear Generation Limited (EDF NGL) has requested that ONR issue an Agreement or Acknowledgement to NP/SC 7750. ONR has chosen to assess the safety case for agreement due to the potential safety significance of the limit which EDF NGL seeks to modify.

Background

Spent nuclear fuel elements are retained in the fuel storage pond for several months to allow their decay heat to decline sufficiently, such that they can then be loaded into a transport flask and taken off-site. The pond water cools the fuel elements and provides shielding from nuclear radiation to workers. The pond water is dosed with boron to reduce the risk of a criticality incident.

The total decay heat from all the elements in the pond is calculated based on records of each elements time in the reactor, buffer store and pond. The total decay heat input to the pond water is limited to ensure that there would be sufficient time to address potential pond faults, such as a pond leak or breakdown in the pond water cooling system, before elements are exposed to air or the degree of shielding reduces unacceptably.

EDF NGL has submitted an Engineering Change (EC356180) proposal to increase the spent fuel pond decay heat inventory from 160 kW to 275 kW. The current pond decay heat limit is resulting in a tendency towards prolonged storage of irradiated fuel within the buffer stores, whereas a higher decay heat limit would encourage a shorter delay before transfer to the cooling pond. A comparison of the risk associated with buffer store loss of cooling faults against fuel pond loss of cooling faults has identified that the risk associated with the buffer store is significantly higher. This is primarily due to the shorter timescales which are available for fault recovery at the buffer store. EDF NGL has concluded that storage of irradiated fuel within the cooling pond offers an overall risk reduction compared with storing the same fuel in the buffer stores. On this basis, EDF NGL no longer considers it to be ALARP to maintain the existing pond decay heat limit of 160 kW. The proposed increase to 275 kW is considered by EDF NGL to offer an overall risk reduction whilst ensuring that the timescales for post-fault recovery actions remain adequate.

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

ONR has carried out a programme of work to produce assessments under the topics of Fault Studies and Civil Engineering. The leading discipline for the assessment was Fault Studies. The Fault Studies assessment focused on the increased challenge a higher decay heat limit would pose by increasing the rate at which temperatures would rise after any pond cooling fault, thereby shortening the time available for post-fault mitigatory actions.

During construction concrete tends to harden quicker than it cools and this may result in thermal contraction cracks. This phenomenon is normal and the level of cracking is controlled by the build process to maintain acceptable limits. Whilst these cracks do not usually have a significant effect on structural integrity, a reinforced concrete structure cannot be expected to be 100% water-tight. Thermal transients change the cracks throughout the lifetime of the structure, and this affects the rate of seepage through the concrete. The Fault Studies

Inspector requested a Civil Engineering assessment for two specific issues, the estimation of leak rates from cracks and a confirmatory check on the overall pond integrity.

Matters arising from ONR's work

The Civil Engineering assessment highlights that the predicted flow rates through cracks should not be considered to be precise, but concludes that the uncertainties would not undermine the conclusion on the acceptability of the grace times for site personnel to react to mitigate the effects of a failure in the pond water cooling plant. So far as the on-going integrity of the pond structure is concerned, the Civil Engineering Inspector has judged that provided the pH of the boronated water is maintained within the prescribed limits, the important material properties of concrete will not degrade, and unless high flow rates persist for an extended period through any cracks, corrosion of the reinforcing steel is not likely to be significant. Given the current condition of the structure, the Civil Engineering Inspector has judged the monitoring being adopted by the Licensee for pond integrity to be adequate.

The Fault Studies assessment identified a number of potentially non-conservative assumptions, but concluded that that grace times would not be reduced unacceptably by the increased decay heat limit. The Fault Studies Inspector initially challenged the adequacy of the severe accident guidance for pond faults. However, following the production of new severe accident guidance by EDF NGL regarding the response to a fuel uncovering event, the Fault Studies Inspector concluded that the Licensee has done all that is reasonably practicable.

Conclusions

With respect to NP/SC 7750, ONR considers that EDF NGL has provided sufficient evidence to adequately demonstrate that the risks have been reduced So Far As Is Reasonably Practicable (SFAIRP).

Recommendation

It is recommended that a Licence Instrument is issued to EDF Nuclear Generation Limited for Agreement to the implementation of the Dungeness B Fuel Storage Pond Decay Heat Limit Increase from 160 kW to 275 kW as presented in NP/SC 7750.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
CAE	Claims Arguments Evidence
DNB	Dungeness B
EC	Engineering Change
EDF NGL	Électricité De France Nuclear Generation Limited
LC	Licence Condition
ONR	Office for Nuclear Regulation
OPEX	Operating Experience
PAR	Project Assessment Report
RGP	Relevant Good Practice
SAPs	Safety Assessment Principles
SFAIRP	So Far As Is Reasonably Practicable

TABLE OF CONTENTS

1 PERMISSION REQUESTED

1. NP/SC 7750 (Ref. 1) has been submitted as a category 1 modification under the Licensee's arrangements for LC 22(4). The safety case covers changes at Dungeness B power station and EDF Nuclear Generation Limited (EDF NGL) has requested agreement or acknowledgment to the changes under their LC 22(1) arrangements (Refs. 2). ONR has chosen to assess the safety case for agreement due to the potential safety significance of the limit which EDF NGL seek to modify.

2 BACKGROUND

2. Spent nuclear fuel elements are retained in the fuel storage pond for several months to allow their decay heat to decline sufficiently, such that they can then be loaded into a transport flask and taken off-site. The pond water cools the fuel elements and provides shielding from nuclear radiation to workers. The pond water is dosed with boron to reduce the risk of a criticality incident.

3. The total decay heat from all the elements in the pond is calculated based on records of each elements time in the reactor, buffer store and pond. The total decay heat input to the pond water is limited to ensure that there would be sufficient time to address potential pond faults, such as a pond leak or breakdown in the pond water cooling system, before elements are exposed to air or the degree of shielding reduces unacceptably.

4. EDF NGL has submitted an Engineering Change (EC356180) proposal to increase the spent fuel pond decay heat inventory from 160 kW to 275 kW. The current pond decay heat limit is resulting in a tendency towards prolonged storage of irradiated fuel within the buffer stores, whereas a higher decay heat limit would encourage a shorter delay before transfer to the cooling pond. A comparison of the risk associated with buffer store loss of cooling faults against fuel pond loss of cooling faults has identified that the risk associated with the buffer store is significantly higher. This is primarily due to the shorter timescales which are available for fault recovery at the buffer store. EDF NGL has concluded that storage of irradiated fuel within the cooling pond offers an overall risk reduction compared with storing the same fuel in the buffer stores. On this basis, EDF NGL no longer considers it to be ALARP to maintain the existing pond decay heat limit of 160 kW. The proposed increase to 275 kW is considered by EDF NGL to offer an overall risk reduction whilst ensuring that the timescales for post-fault recovery actions remain adequate.

2.1 LICENSEE'S SAFETY CASE

5. The proposed new case is in claims, arguments and evidence (CAE) format.

6. **Claim 1**: Increasing the pond decay heat limit from 160 kW to 275 kW does not result in any significant increase in the risk of an on-site or off-site radiological release.

7. Claim 1 is based on the effect of loss of cooling faults being understood and assessment of the effect of the greater pond decay heat on the post-fault pond thermal transient and pond cracking. The analysis is said to show that post-fault recovery timescales remain very long (several days for all acceptance criteria) and hence the assessed risk of a radioactive release from pond cooling faults remains acceptably low.

8. **Claim 2**: The risk associated with pond loss of cooling faults remains acceptably low and ALARP following the proposed increase in the pond decay heat limit.

9. Claim 2 is based on the fact that as low as reasonably practicable (ALARP) optioneering studies have been carried out; that risk is reduced overall due to a

reduction in time that the fuel is stored in the buffer store; and the implementation of reasonably practicable options before the decay heat limit is increased. The reasonably practicable options identified for implementation include replacement of pond water circulating pumps, heat exchangers and associated pipework; and new pond water temperature and level indications.

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

10. ONR has carried out a programme of work to produce assessments under the topics of fault studies and civil engineering.

11. The leading discipline for the assessment was fault studies. The fault studies assessment (Ref. 3) focused on the increased challenge a higher decay heat limit would pose by increasing the rate at which temperatures would rise after any pond cooling fault, thereby shortening the time available for post-fault mitigatory actions. The Fault Studies Inspector requested a civil engineering assessment (Ref. 4) for two specific issues, the overall pond integrity and the estimation of leak rates from cracks.

12. For this assessment, ONR's assessment effort has been concentrated on:

- Confirming that grace times for post-fault mitigatory actions remain adequate.
- Confirming on-going integrity of the pond structure.
- Confirming that the uncertainties pertaining to the predicted flow rates through cracks do not undermine the safety case.

3.1 CIVIL ENGINEERING ASSESSMENT

13. ONR's Civil Engineering assessment sampled evidence in the following areas (Ref. 4):

- The adequacy of EDF NGL's management arrangements for pond structural integrity.
- The adequacy of EDF NGL's predicted flow rates through cracks.

14. During construction, concrete sees an increase in temperature once water is added to the dry mix, as the hydration of cement is an exothermic reaction. The concrete usually hardens before it cools and this can cause thermal contraction cracks within the concrete. Further shrinkage cracking occurs over time as the concrete dries out. These are normal processes and are controlled to within acceptable limits by concrete mix design, provision of reinforcing steel, pouring sequence, and temperature and humidity control during concrete curing. Whilst these cracks do not usually have a significant effect on structural capacity, a reinforced concrete structure cannot be expected to be 100% water-tight. In 1986 an overcooling event occurred at Dungeness B that resulted in the cracking of the structure and leakage from the pond. On recovery to normal operating temperatures, the cracks closed and the leakage reduced to the relatively low levels of seepage that exist today.

15. Based on operating experience (OPEX) and relevant good practice (RGP) it was identified that provided the pH of the boronated water is maintained within the prescribed limits, it will not degrade the important material properties of concrete, and unless high flow rates persist for an extended period through any cracks, corrosion of the reinforcing steel is not likely to be significant. Thus, so far as the on-going integrity of the pond structure is concerned, the monitoring being adopted by the Licensee is judged to be adequate.

16. Accurately predicting concrete crack widths is not an exact science, nor is determining the likely water flow rates through them. Whilst the Licensee has employed conservatisms within its methodology to account for uncertainties and obtain

overestimates of potential water flow rates, the flow rates quoted should not be seen as being precise. However, the safety case presented by the licensee (Ref. 1) is sufficiently detailed and exhaustive to judge that whatever the actual flow rates, they are unlikely to change the overall conclusion on the acceptability of the grace times for site personnel to react to mitigate the effects of a failure in the pond water cooling plant.

17. The Civil Engineering assessment does not raise an objection to the implementation of the proposed engineering change (Ref. 1).

3.2 FAULT STUDIES ASSESSMENT

18. ONR's Fault Studies Assessment Report (Ref. 3) sampled evidence in the following areas:

- The adequacy of grace times for post-fault mitigating actions given the increased rate at which temperatures would rise due to the higher decay heat limit.
- The adequacy of EDF NGL's accident management arrangements should the pond drain and not be refilled.

19. The assessment has evaluated the evidence that the increase in pond decay heat inventory does not adversely affect the ability to perform post-fault recovery actions. Recovery action times are estimated by the licensee to be 15 hours to restore water supplies and 25 hours to restore cooling (Ref. 1). The Licensee has estimated the grace times to a number of criteria including boiling; dose rates at which operations are hindered; fuel uncovering; and the water level at which the pond cooling system pumps trip (restart inhibited to limit the leak rate should there be a loss of integrity in the cooling loop). The higher pond decay heat limit of 275 kW reduces the time to boil by about two thirds; however from nominal initial water depth the grace time to boiling is still over 17 days (419 hours). The minimum grace time estimated by the licensee with 275 kW decay heat is 3.8 days (90 hours). This minimum grace time relates to the time at which the dose rate in the pond hall is assumed to hinder post-fault recovery actions (10 mSv/hr at the pond surface). Even though this minimum grace time is calculated conservatively, there is ample margin to the required recovery action times (90 hours available, 25 hours required). Although the reductions in grace time are significant, the grace times in all cases remain long enough to arrange a suitable response. The grace times to respond are therefore not reduced unacceptably by the proposed increase in decay heat limit.

20. Increasing the decay heat limit may adversely affect the consequences of a loss of cooling fault by making any potential release both earlier and larger. The greater number of fuel elements in the pond increases the maximum potential release magnitude. The greater heat input into the water results in a faster temperature rise and a shorter grace time to fuel uncovering. However, EDF NGL have provided severe accident guidance that identifies how to respond to a fuel uncovering event. ALARP optioneering has been carried out and no additional severe accident mitigatory measures have been identified as reasonably practicable. Given this and the fact that the pond has been shown to be a safer location to hold spent fuel elements than the buffer storage tubes, the proposal is judged to have reduced risks ALARP.

21. The Fault Studies Assessment Report has been the subject of a peer review and an acceptance review, in compliance with the due process requirements for ONR Assessment as defined in ONR's How2 Business Management System.

4 MATTERS ARISING FROM ONR'S WORK

22. The civil engineering assessment highlights that the predicted flow rates through cracks should not be considered to be precise, but concludes that the uncertainties would not undermine the conclusion on the acceptability of the grace times for site personnel to react to mitigate the effects of a failure in the pond water cooling plant. So far as the on-going integrity of the pond structure is concerned, the Civil Engineering Inspector has judged that, provided the pH of the boronated water is maintained within the prescribed limits, the important material properties of concrete will not degrade. In addition, unless high flow rates persist for an extended period through any cracks, corrosion of the reinforcing steel is not likely to be significant. Given the current condition of the structure, the Civil Engineering Inspector has judged the monitoring being adopted by the licensee for pond integrity to be adequate.

23. The fault studies assessment identified a number of potentially non-conservative assumptions, but concluded that that grace times would not be reduced unacceptably by the increased decay heat limit. The Fault Studies Inspector initially challenged the adequacy of the severe accident guidance for pond faults. However, following the production of new severe accident guidance by EDF NGL regarding the response to a fuel uncovering event, the Fault Studies Inspector concluded that the Licensee has done all that is reasonably practicable.

5 CONCLUSIONS

24. This report presents the findings of ONR's assessment of Dungeness B NP/SC 7750: "Justification for Increasing the Fuel Storage Pond Decay Heat Limit from 160 kW to 275 kW".

25. To conclude, ONR is satisfied with the claims, arguments and evidence laid down within the safety case. The civil engineering assessment concluded that adequate arrangement were in place to maintain the pond structural integrity. The fault studies assessment report concluded that adequate grace times were available for post-fault recovery actions.

26. ONR considers that EDF NGL have provided sufficient evidence to adequately demonstrate that risks associated with the fuel storage pond decay heat limit at Dungeness B power station have been reduced so far as is reasonably practicable (SFAIRP).

6 RECOMMENDATIONS

27. It is recommended that a Licence Instrument is issued to EDF Nuclear Generation Limited for Agreement to the implementation of the Dungeness B fuel storage pond decay heat limit increase from 160 kW to 275 kW as presented in NP/SC 7750.

7 REFERENCES

1. CM 2016/463401, Nuclear Safety Committee, Dungeness B Power Station Justification for Increasing the Fuel Storage Pond Decay Heat Limit from 160 kW to 275 kW, NP/SC 7750 (EC 356180), July 2016.

2. CM 2016/461650, Formal request for agreement or acknowledgement from EDF NGL under LC22(1) arrangements, Received 23rd November 2016.

3. CM 2016/475174, ONR-OFP-AR-17-007, Revision 0, ONR Assessment Report: Dungeness B Power Station - Fuel Storage Pond Decay Heat Limit Increase - Fault Studies Assessment of Proposal to Increase Decay Heat Limit from 160 kW to 275 kW, March 2020.

4. CM 2017/311744, ONR-OFP-AR-17-018, Revision 0, Fuel Storage Ponds - Justification for increasing the fuel storage decay heat limit from 160 kW to 275 kW, Assessment of the civil engineering aspects pertinent to the reinforced concrete pond structure, August 2017.

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