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**Assessment of the  
Off-load Depressurised Refuelling Safety Case  
(NP/SC 7684, EC 349137, October 2014)  
presented by EdF Energy NGL for Heysham 2**

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## EXECUTIVE SUMMARY

### **Assessment of the Off-load Depressurised Refuelling Safety Case (NP/SC 7684, EC 349137, October 2014) presented by EdF Energy NGL for Heysham 2**

This report presents the conclusions from ONR's assessment of the safety case, presented by Électricité de France Energy Nuclear Generation Limited (NGL) to support the implementation of Off-load Depressurised Refuelling (ODR) at Heysham 2 nuclear power station and the relevant changes of Nuclear Safety Requirements for plant operation – further referred to as “the Safety Case”.

#### **Permission Requested**

NGL, the owner and operator of Heysham 2 (the Licensee), has requested ONR's approval of changes to the station Nuclear Safety Requirements (NSR) under Licence Condition 23(5), to enable refuelling to be carried out while the reactor is off-load and depressurised in a Carbon Dioxide (CO<sub>2</sub>) atmosphere with limited air content.

#### **Background**

ODR implementation would enable additional graphite core inspections that could not be otherwise undertaken within the limited duration of a periodic shutdown (Statutory Outage). ODR includes temporary storage of the Irradiated Fuel Assembly (IFA) in the isolated fuelling machine while the relevant channel is subject to inspection with specially developed equipment that operates in a low pressure carbon dioxide (CO<sub>2</sub>) environment.

The temporary storage of an IFA in the fuelling machine removes the existing limitation on the number of inspected channels that is currently imposed by the number of tubes available for temporary IFA storage at the end of a statutory refuelling outage.

Notably, ODR has already been successfully implemented at Torness nuclear power station, following assessment of a safety case and approval of similar NSR changes by ONR.

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

The Safety Case was subject to assessment by a team of ONR specialist inspectors in the following specialist areas:

- Mechanical Engineering (ME).
- Probabilistic Safety Analysis (PSA).
- Fault Studies (FS).
- Human Factors (HF).
- Structural Integrity (StI).
- Control and Instrumentation (C&I).

An initial meeting was held with NGL to discuss the proposal early in the development of the Safety Case. This was followed by an inspection at Heysham 2 by a number of ONR specialist assessment inspectors to observe the hardware preparations and personnel training arrangements for the ODR implementation.

The Safety Case comprises eight claims supported by arguments and underpinning evidence. Each of these claims, arguments and supporting evidence have been assessed by one or more of the ONR specialist assessment inspectors depending on the relevance to the specific specialism. The conclusions of these assessments are summarised within this Project Assessment Report (PAR).

### **Matters arising from ONR's work**

The judgements of the specialist assessment inspectors are unified in supporting ONR granting approval of the amendment to NSR 9 as proposed by the Licensee. Overall, I am satisfied that the amended NSR, the supporting Safety Case and the other relevant documents, presented by the Licensee, provide an adequate base for safe implementation of the ODR operation mode at Heysham 2.

### **Conclusions**

Based on the specialist assessments, and my own review of both the revised NSR and the Safety Case, I am satisfied that the claims, arguments and evidence laid down within the NGL submission are adequate and support the request for approval of the amended NSR 9 to allow ODR operations at Heysham 2.

I conclude that it is appropriate for ONR to permit the amended NSR 9 , therefore granting an approval under LC 23(5) by the issuing of Licence Instrument (LI) 582.

### **Recommendation**

I recommend that LI 582 be issued to approve the amended Nuclear Safety Requirement 9 such that refuelling operations may be undertaken with the reactor off-load and depressurised in a Carbon Dioxide atmosphere.

## LIST OF ABBREVIATIONS

AGR	Advanced Gas-cooled Reactor
ALARP	As low as reasonably practicable
BSL	Basic Safety level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
C&I	Control and Instrumentation
CO <sub>2</sub>	Carbon Dioxide
EDF	Électricité de France
FS	Fault Studies
FSCSP	Fuel Size Closure Short Plug
HOW2	(Office for Nuclear Regulation) Business Management System
IAEA	The International Atomic Energy Agency
IFA	Irradiated Fuel Assembly
LC	Licence Condition
LI	Licence Instrument
LPR	Low Power Refuelling
ME	Mechanical Engineering
NDA	Nuclear Decommissioning Authority
NFA	New (non-irradiated) Fuel Assembly
NGL	EDF Energy Nuclear Generation Limited
NSR	Nuclear Safety Requirement
NSP	Nuclear Safety principles (NGL)
O <sub>2</sub>	Oxygen
ODR	Offload Depressurised Refuelling
ONR	Office for Nuclear Regulation
OPR	Off-load Pressurised Refuelling
PAR	Project Assessment Report
PSA	Probabilistic Safety Assessment
RGP	Relevant Good Practice
SAP	(ONR) Safety Assessment Principle(s)
SQEP	Suitably Qualified and Experienced Person
SFAIRP	So far as is reasonably practicable
SSC	System, Structure and Component
StI	Structural Integrity
TAG	(ONR) Technical Assessment Guide
TSOL	Treasury Solicitor's Office

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## 1 PERMISSION REQUESTED

1. Currently Heysham 2 can inspect a maximum of eight reactor channels during a statutory outage – due to the limited availability of vacant tubes in the fuel decay store. In recognition of the need to increase graphite core inspections, the Licensee has developed a safety case for Off-load Depressurised Refuelling (ODR).
2. This operational mode includes charging and discharging of irradiated fuel assemblies (IFAs) while the reactor is depressurised from its normal operation pressure of 40 barg to about 0.5 barg in a carbon dioxide (CO<sub>2</sub>) atmosphere with limited oxygen (O<sub>2</sub>) content. The New In-Channel Inspection Equipment – Mark 2 (NICIE2) is deployed while the IFA is taken out of the inspected channel and stored in the isolated fuelling machine. This eliminates the dependency on the fuel decay store.
3. In order to implement ODR at Heysham 2 the Licensee has requested the Office for Nuclear Regulation (ONR) to grant its approval of the replacement of operating rule - Nuclear Safety Requirement (NSR) 9 Revision 002 with NSR 9 Revision 003 under Licence Condition (LC) 23(5). All other operating rules remain unchanged.

## 2 BACKGROUND

4. The risk of Advanced Gas cooled Reactors (AGR) graphite core cracking and degradation increases with age. EDF NGL's computer models that predict the effects of core ageing must be validated by information from physical inspections of the reactor graphite channels. Additional in-core channel inspections are needed to collect data and identify trends necessary to ensure that the core integrity safety case remains valid.
5. ODR removes the dependence on IFA storage space, allowing for 30 channel inspections by NICIE2 in addition to the eight inspections that are currently possible.
6. The Heysham 2 ODR proposal is based on comprehensive analysis as well as on the successful ODR implementation in Torness, and on the experience with off-load depressurised fuel handling operations at Hinkley Point B and Hunterston B.
7. Heysham 2 plans to carry out 16 in-channel inspections during the 2015 statutory outage of Reactor 7 if the requested LI is issued by ONR in time to allow for ODR.
8. The key nuclear safety considerations are associated with the temporary withdrawal of an IFA from the reactor into the fuelling machine at low pressure (i.e. reduced heat transfer) which creates two potential sources of hazard related to ODR:
  - Insufficient fuel cooling in the event of a fault causing the IFA to stop in a partly withdrawn position could lead to tie bar overheating and failure;
  - Possibility of drop and damage of an IFA with subsequent radioactive release.
9. The proposed NSR changes minimise the possibilities for occurrence of these failures by imposing specific limits and conditions for ODR, as follows:
  - Prevention of tie-bar overheating: low reactor temperature, low fuel decay heat and availability of gas circulators with associated main or decay heat boilers.
  - Mitigation of release in case of IFA drop: low oxygen content in the reactor.
10. This report presents a summary of the assessments undertaken by ONR of the Safety Case (NP/SC 7684, Category 1 Engineering Change 349137, October 2014), which supports NGL's request for approval of the amended NSR under LC23(5).

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

11. The following ONR team of specialist assessment inspectors has carried out assessment of the proposed NSR amendment and the supporting Safety Case:
  - Mechanical Engineering (ME).
  - Probabilistic Safety Analysis (PSA).
  - Fault Studies (FS).
  - Human Factors (HF).
  - Structural Integrity (StI).
  - Control and Instrumentation (C&I).
12. An initial meeting was held with NGL to discuss the proposal early in the development of the Safety Case. This was followed by an inspection at Heysham 2 by a number of ONR specialist assessment inspectors to observe the hardware preparations and personnel training arrangements for the ODR implementation (Ref.14).
13. The specialist assessment inspectors have also considered the ONR assessment (Ref. 15) of the ODR proposal that has been successfully implemented in Torness.
14. The safe performance of ODR is supported in the Safety Case by eight claims, presented together with their base arguments and underpinning evidence:
  - I. *Compliance with the specified ODR limits ensures operation within the generic safety case envelope [FS, ME].*
  - II. *Dropped fuel damage is restricted to the dropped assembly or stringer, without threatening the adjacent channels, and an appropriate set of bounding radiological consequences has been assessed to allow the PSA and deterministic arguments to be supported [FS].*
  - III. *The pressure boundary and containment integrity are sufficient for ODR operations and there is no significant increased risk to subsequent pressurised operations [StI].*
  - IV. *Lifting Integrity and Tie Bar Reliability has been assessed and shown to be acceptable with an increased Grab Load Monitoring trip setting for normal and fault conditions [ME].*
  - V. *The design of the ODR projection reconfiguration, including an increased trip setting has been assessed and is acceptable [C&I].*
  - VI. *The presence of failed fuel within the reactor will not significantly affect ODR operations [FS].*
  - VII. *The risks associated with new fuel in air loading are acceptably low [C&I, HF].*
  - VIII. *The ODR safety case meets the requirements of the Nuclear Safety Provisions and the estimated risk is as low as reasonably practicable (ALARP) [FS, PSA, HF].*
15. The credibility of each of these claims has been assessed by one or more specialist assessment inspectors. The conclusions are presented in detail within the respective assessment reports (Refs 8 – 13) and are summarised below in section 4.
16. The assessment method used in this PAR follows the ONR Assessment Process (Ref. 1). The ONR Safety Assessment Principles (SAPs – Ref. 2) have been adopted by each of the specialist assessment inspectors and are listed in their respective assessment reports (Refs. 8 – 13). The specialist assessment inspectors have sampled the safety case supporting the change to NSR 9 and have provided judgment on if they find the claims, arguments and evidence acceptable. The outcome of these assessments have been summarised in this PAR to inform ONR's decision regarding approval of the Licensee's request.

## **4 ONR'S ASSESSMENT**

### **4.1 NOVEL ASPECTS INTRODUCED AS PART OF THE MODIFICATION**

17. The document changes, following from the requested approval to replace the actual Revision 002 of NSR 9 with the proposed Revision 003 are mainly related to the introduction of the new Technical Specification 9.3.1 (Ref. 4) that implements the requirements of the ODR Safety Case.
18. Considering the relevant INSA statement (Ref. 6-b) and my review of the Table 9.3.1 – as presented in the Safety Case (Ref. 5), I conclude that the new Technical Specification 9.3.1 represents appropriately the base conditions for ODR performance.

### **4.2 MECHANICAL ENGINEERING ASSESSMENT**

19. A mechanical engineering specialist inspector undertook an assessment of relevant sections of the Safety Case (Ref 5), claims 1 & 4. The results are reported in (Ref.8).
20. The inspector is satisfied that the Licensee's proposed methods for the control of purging operations for the fuelling machine and make-up shield are adequate and provide suitable control of pressure protection and oxygen concentration.
21. The inspector found that Licensee's proposed increases to overload trip settings during ODR IFA handling at the reactor are appropriate and suitably substantiated. The minimisation of spurious trips and challenges to safety equipment are found to be in-line with the safety assessment principles. The proposed changes are judged to align with the existing limits used at both Torness and Heysham 2 for Low Power and Off-load Pressurised Refuelling operations.
22. The introduction of oxygen monitoring, in addition to procedural controls at Heysham 2 for a number of channel inspections, meets inspector's expectations and is judged to represent relevant good practice.
23. The inspector agrees that the gas service trolley spindle failures observed at Torness have been adequately addressed and suitable controls have been put in place to prevent a similar event from re-occurring at either Heysham 2 or Torness during future ODR operations.
24. From a mechanical engineering perspective, the inspector supports the issuing of a LI for approval under LC23(5) to the proposed NSR amendment.

### **4.3 PROBABILISTIC SAFETY ASSESSMENT**

25. The assessment of claim 8 of the submitted Safety Case - carried out by the PSA specialist assessor is presented in (Ref. 9).
26. The inspector has judged that the methodology used for the analysis is acceptable and the level of risk associated with ODR operations has been adequately quantified, leaving sufficient margin to the Base Safety Limit, defined in ONR SAPs.
27. The inspector has found that sensitivity studies are provided to show the absence of cliff-edge effects and the claim that following ODR implementation the Heysham 2 level of risk will remain ALARP is appropriately supported.
28. The inspector has agreed that the slight increase of fuel route risk is balanced by the significant reduction in overall station risk resulting from the increase of reactor

channel inspections that the ODR shall facilitate. On this basis the ODR proposal is judged to represent an ALARP position.

29. Based on the PSA assessment, and notwithstanding some areas for improvement noted in his report, the inspector has concluded that it would be disproportionate not to permission the change to NGL's NSR 9 that will allow ODR operations and has recommended that ONR should issue an LI for approval under LC23(5) to the proposed NSR amendment.

#### **4.4 FAULT STUDIES ASSESSMENT**

30. A specialist Fault Studies assessor carried out an assessment which covered claims 1, 2, 6 & 8 of the submitted Safety Case (Ref. 10). Correspondence was established with the Licensee to clarify the validation status of the applied computer models and the reasoning behind some of the fault studies assumptions.
31. The results from the fault studies assessment of the ODR project for Torness (TRIM 2013/236197) were taken into account and the differences between the ODR projects for Torness and for Heysham 2 were considered in the Safety Case assessment.
32. The assessment concluded that there were no outstanding concerns from a fault studies perspective regarding permissioning the ODR for Heysham 2. Hence the inspector recommended the issuing of an LI for approval under LC23(5) to the proposed NSR amendment.

#### **4.5 HUMAN FACTORS ASSESSMENT**

33. The human factor assessment (Ref. 13) of the Safety Case concluded that the inspector was broadly satisfied with the claims, arguments and evidence laid down within the Safety Case and the additional evidence gathered during my assessment.
34. Whilst the inspector has identified some Human Factors shortfalls associated primarily with the presentation of the case, he is satisfied that these are being addressed by the Licensee and are not considered to be of sufficient safety significance to delay the issue of an LI for approval of the proposed NSR amendment,.
35. The inspector supports the issuing of a LI to signify ONR approval under LC23 (5) to the identified amendments to the Nuclear Safety Requirements text.

#### **4.6 CONTROL AND INSTRUMENTATION ASSESSMENT**

36. A C&I specialist assessor undertook a review (Ref. 11) of Claims 5 and 7 of the ODR Safety Case (Ref. 5) and supporting documents and judged that the proposed C&I modifications to the fuel handling equipment to implement ODR have been suitably conceived and analysed.
37. The inspector considers that the risk control provided by the C&I systems following the modifications will not be significantly different to that provided by the current systems.
38. The sampling of the Safety Case has not revealed any outstanding concerns. Hence, from a C&I perspective, the proposal is judged to be adequate to justify issue of an LI for approval under LC23(5) to the proposed NSR amendment.

#### **4.7 STRUCTURAL INTEGRITY ASSESSMENT**

39. The Structural Integrity (StI) specialist assessor carried out an assessment (Ref 12) of the evidence associated with Claim 3. The assessment scope has covered the following aspects:
- Fuelling Machine pressure boundary and containment boundary integrity
  - Tie bar integrity
40. The inspector has compared the arguments presented in the Heysham 2 safety case against the safety case presented for Torness power station and has considered the ONR structural integrity assessment of the case presented for Torness. No significant changes were observed between the two cases. Following the sampling of the claims, arguments and evidence laid down within the Safety Case, the inspector has no concerns from a structural integrity perspective regarding the off-load depressurised refuelling.
41. The inspector recommends that the proposed change to NSR 9 is judged to be adequately addressed by the Safety Case (Ref. 5) and serves to justify the issue of an LI for approval under LC23(5) to the proposed NSR amendment.

#### **4.8 REVIEW OF NGL INTERNAL APPROVAL PROCESS**

42. The ODR Safety Case and amended NSR have both completed NGLs internal due process (Refs. 6 & 7).
43. The report (Ref. 6-a) presents a rigorous process of internal safety assessment (INSA) of the ODR Safety Case (Ref. 5) that has resulted in a positive conclusion.
44. The report (Ref. 6-b) presents the final positive result from the INSA of the proposed changes to Heysham 2 NSR 9 and relevant station documents. The report concludes that the main change is related to the introduction of Table 9.3.1, which defines the ODR-related reactor parameters in compliance with the Safety Case (Ref. 5).
45. I reviewed the minutes from the Nuclear Safety Committee (Ref. 7) which reflect the discussions held relating to the submission of the ODR safety case. The minutes provided me with confidence that the case was given due consideration at the meeting and no points of significant concern were raised.
46. Based on the above, I am satisfied that the ODR safety case and the changes to NSR 9 were subject to an appropriate internal review process.

### **5 CONCLUSIONS**

47. Based on my own assessment of the submitted safety case, and on the review of the assessments undertaken by the specialist assessment inspectors summarised above, I am satisfied that the claims, arguments and evidence laid down within the NGL submission supporting the request for issue of an LI for approval of the amended NSR 9 to allow ODR operations to be undertaken at Heysham 2 are adequate.
48. The LI is one of the standard documents covered by ONR Management System Guidance and, therefore, it has been prepared to satisfy the standard pro-forma and does not require review by Treasury Solicitor's Office (TSOL).

49. I conclude that it is appropriate for ONR to permission the amended NSR 9 granting approval under LC23(5).

## **6 RECOMMENDATIONS**

50. I recommend that the Superintending Inspector:
- Signs this Project Assessment Report to confirm support for Licence Instrument No. 582 to be issued under LC23(5).
  - Signs this Project Assessment Report approving its release for publication.
51. Finally, I recommend that an ONR Deputy Chief Inspector should sign Licence Instrument No. 582 granting approval of the amended NSR 9 to allow ODR operations to be undertaken at Heysham2 and LI 582 be issued accordingly.

## 7 REFERENCES

1. ONR HOW2 Guide - Purpose and Scope of Permissioning - NS-PER-GD-014 Revision 4. July 2014. <http://www.onr.org.uk/operational/assessment/index.htm>
2. Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014 <http://www.onr.org.uk/saps/saps2014.pdf>.
3. NSL HYB/51006R EdF Energy. Request for approval under Licence Condition 23(5) Amendment to Nuclear Safety Requirements, 30/10/2014, TRIM:2014/366330
4. EDF E/REP/BREB/0068/HYB/14 Revision 000, Engineering Report, Heysham 2 Power Station, Off Load Depressurised Refuelling – Changes to Nuclear Safety Requirements and Technical Specifications, October 2014, TRIM: 2014/366330
5. NP/SC 7648, Heysham 2 Power Station, Off load Depressurised Refuelling Safety Case, EC No. 349137, Revision 000, October 2014, TRIM: 2014/404205
6. INSA approval statement for NP/SC 7648, Heysham 2 Power Station, Off load Depressurised Refuelling: a) Safety Case, 10/10/2014, TRIM: 2014/366330 & b) Associated Tech Spec Changes, TRIM: 2015/15583
7. NSC approval statement for NP/SC 7648, Heysham 2 Power Station. Off load Depressurised Refuelling Safety Case, 09/10/2014, TRIM: 2014/395005.
8. Mechanical Assessment Report - ONR-HYB-AR-14-097 Feb 2015, TRIM: 2015/5703
9. Probabilistic Safety Analysis Assessment Report ONR-HYB-AR-14-104, Jan 2015, TRIM: 2015/18884
10. Fault Studies Assessment Report ONR-HYB-AR-14-89, Jan 2015, TRIM: 2015/45574
11. Control and Instrumentation Assessment Report ONR-HYB-AR-14-102, Jan 2015, TRIM: 2015/31583
12. Structural Integrity Assessment Report ONR-HYB-AR-14-100, Jan 2015, TRIM: 2015/18006
13. Human Factors Assessment Report ONR-HYB-AR-14-103, Jan 2015, TRIM: 2015/17508

### Other applicable documents

14. ONR-HYB-CR-14-274 Contact Report – Site visit to support ODR Safety Case assessment, 01/12/2014, TRIM: 2014/441323
15. Project Assessment Report ONR-TOR-PAR-13-029 Request for Approval to change NSR 9.3 of Technical Specification NSR 9: Handling of Fuel, In-Core Components and Nuclear Matter at Torness Power Station TRIM: 2013/278156