



PROJECT ASSESSMENT REPORT			
<b>Unique Document ID and Revision No:</b>	ONR-CNRP-PAR-15-005 Revision 1	<b>TRIM Ref:</b>	2015/290168
<b>Project:</b>	EDF Energy Nuclear Generation Ltd (NGL) Heysham 1 (HYA) / Hartlepool (HRA) and Heysham 2 (HYB) / Torness (TOR) Plant Life Extension (PLEX)		
<b>Site:</b>	Heysham, Hartlepool, Torness		
<b>Title:</b>	ONR review of NGL HYA/HRA and HYB/TOR PLEX Technical Overview Reports		
<b>Licence Instrument No:</b> (if applicable)	N/A		
<b>Nuclear Site Licence No:</b>	Hartlepool (59), Heysham (60), Torness (Sc. 14)		
<b>Licence Condition:</b>			

#### Document Acceptance and Approval for Issue / Publication

Role	Name	Position	Signature	Date
Author	[REDACTED]	Inspector	[REDACTED]	17/08/2015
Reviewer	[REDACTED]	Superintending Inspector	[REDACTED]	17/08/2015
Accepted by <sup>1</sup>	[REDACTED]	Superintending Inspector	[REDACTED]	17/08/2015
Approval for publication <sup>2</sup>		Superintending Inspector	[REDACTED]	17/08/2015

#### Revision History

Revision	Date	Author(s)	Reviewed By	Accepted By	Description of Change
A	11/08/2015	[REDACTED]	[REDACTED]	n/a	1 <sup>st</sup> draft for DL review
B	12/08/15	[REDACTED]	[REDACTED]	n/a	2 <sup>nd</sup> draft incorporating DL

<sup>1</sup> Acceptance of the PAR to allow release of LI

<sup>2</sup> Approval is for publication on ONR web-site, after redaction where relevant

					comments
0	17/08/15	[REDACTED]		[REDACTED]	First accepted issue
1	27/01/16	[REDACTED]		[REDACTED]	Minor clarification prior to publication

**Circulation (latest issue)**

Organisation	Name	Date
Office for Nuclear Regulation	[REDACTED]	
Environment Agency		
Licensee	[REDACTED]	

**EDF Energy Nuclear Generation Ltd (NGL) Heysham 1 / Hartlepool and Heysham  
2 / Torness Plant Life Extension (PLEX)**

**ONR review of NGL PLEX Technical Overview Reports**

Project Assessment Report ONR-CNRP-PAR-15-005  
Revision 1  
17 August 2015

© Office for Nuclear Regulation, 2015

If you wish to reuse this information visit [www.onr.org.uk/copyright](http://www.onr.org.uk/copyright) for details.

Published 

*For published documents, the electronic copy on the ONR website remains the most current publicly available version and copying or printing renders this document uncontrolled.*

## EXECUTIVE SUMMARY

### ONR review of NGL Heysham 1/Hartlepool, Heysham 2/TornessPLEX Technical Overview Report

This project assessment report details ONR's assessment of the EDF Energy Nuclear Generation Ltd (NGL) Plant Life Extension (PLEX) Technical Overview Reports and the supporting documentation for Hartlepool, Heysham 1, Heysham 2 and Torness power stations. This is an early engagement exercise which serves three purposes:

1. to provide an early pre-Periodic Safety Review (PSR) consideration of potential issues with two key irreplaceable reactor components (graphite core and boilers).
2. to provide a brief review of the arrangements intended for through life management of components considered to be largely replaceable (fuel route).
3. to give early indication on any potential issues prior to NGL's formal PSR3 submission (the third suite of PSR submissions in the Advanced Gas-cooled Reactor (AGR) lifecycle).

No statement in this document should be interpreted either as a commitment for ONR to accept a safety case that has yet to be submitted, or as an implication that NGL's Lifetime Technical Review restricts the necessary scope of any future safety case or PSR3 submission.

#### Permission requested

This early engagement activity falls outside the requirements for formal permissioning arrangements however; it is directly associated with NGL's next submission of the Heysham 1 / Hartlepool PSR3 in January 2018, and Heysham 2 / Torness PSR3 in January 2019, and therefore, with nuclear site Licence Condition (LC) 15 covering Periodic Review.

ONR was approached as part of NGL's early PSR3 engagement to provide views from a regulatory perspective. This project assessment report and the associated letter to NGL records ONR's position.

#### Background

NGL is managing its UK fleet of AGR reactors through to their end of electrical generation and eventual entry into decommissioning. As part of this, NGL is undertaking studies aimed at optimising the remaining lifetime and generating capacity as part of its lifetime management project. NGL intend to announce the lifetime management study results.

The submission dates for Heysham 1 / Hartlepool and Heysham 2 / Torness PSR3 in 2018 and 2019 respectively, fall after the intended formal announcement by NGL. Therefore, there is a risk for NGL that the future PSR3 submission might reveal a significant issue that could negate its lifetime management project aspirations. To address this, NGL has undertaken a series of reviews which have provided input into its PLEX Technical Overview Report. ONR was asked, as part of NGL's early PSR3 engagement, to provide its regulatory perspective.

Owing to the importance of the future Heysham 1 / Hartlepool and Heysham 2 / Torness PSR3 submissions, ONR agreed to undertake a limited review of the PLEX Technical Overview Report and its supporting documentation.

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

A broad range of specialist inspectors conducted ONR's review which was primarily focused on NGL's PLEX documentation covering the major non-replaceable plant and long term ageing and obsolescence management.

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

ONR's review has established that there are no immediate nuclear safety issues associated with fuel route, the boilers or the graphite core that would preclude adopting NGL's lifetime management project proposals for Heysham 1 / Hartlepool and Heysham 2 / Torness. However, ONR has raised observations for consideration in the future PSR3 programmes.

For Heysham 1 / Hartlepool and Heysham 2 / Torness, the most significant threats in achieving the proposed PLEX are associated with the graphite cores and boilers. The other irreplaceable components are regarded by NGL as a lower threat. ONR considers that the irreplaceable components cannot be ruled out as life-limiting to the reactor, due to the uncertainties in their predicted condition over such a timescale.

Overall ONR supports NGL's view that the proposed life extensions for Heysham 1 / Hartlepool and Heysham 2 / Torness were achievable based on the successful outcome of the proposed further work.

ONR will continue to expect appropriate examination, inspection, maintenance and testing to be conducted throughout the life of the plant, capable of identifying any degradation likely to compromise safe operation of the plant. ONR accepts that currently NGL has adequate arrangements in place to monitor such degradation; however, these arrangements will need to be reviewed. For example, any future inherent uncertainties in the predicted condition may reveal issues which require the need for increasing levels of inspection later in life.

### **Conclusions**

ONR's review of the submitted documentation, which was well presented, has not revealed any significant flaws or omissions with respect to nuclear safety that would preclude adopting NGL's PLEX proposals for Heysham 1 / Hartlepool and Heysham 2 / Torness.

NGL's review of all the potential degradation mechanisms as part of its PLEX review has been judged to be well defined; also, mitigation arrangements are either in place or there are plans to develop such arrangements.

It is important that the limited nature of NGL's submission is taken into account and ONR's comments are taken in context of the potential for other issues emerging from its formal assessment of the PSR3 submissions scheduled for 2018 and 2019.

NGL's PLEX portfolio will require a substantial investment by NGL in both major safety improvements; and a large number of smaller but still significant modifications to improve reliability and/or safety. It is important that safety improvements are made in a timely manner so that risks are maintained as low as reasonably practicable (ALARP). NGL will need to ensure that those commitments that improve nuclear safety over the proposed PLEX are fully funded and resourced in order for them to be delivered at the appropriate time.

Regulation of nuclear power station operation is based on the submission of adequate LC15 PSR submissions, allied to continuing satisfactory performance as judged against inspections of the site and assessment of the safety justification of the plant. This includes the ONR requirement to permission the start-up of reactors after their three yearly periodic shutdowns. Taking this regulatory background into account, any decision regarding the accounting lifetime of the plant and the final cessation of power generation remains a commercial decision solely for the licensee to determine.

## **Recommendations**

I recommend that the Superintending Inspector:

- a. Signs this project assessment report to confirm acceptance of ONR's technical and regulatory arguments supporting issuing a letter of no objection to NGL.
- b. Signs this project assessment report approving its release for publication, after redaction where appropriate.

## LIST OF ABBREVIATIONS

ALARP	As low as reasonably practicable
ACAWL	Active core average weight loss
CLA	Component life assessment
HOW2	(Office for Nuclear Regulation) Business Management System
HRA	Hartlepool power station
HYA	Heysham 1 power station
HYB	Heysham 2 power station
IAEA	International Atomic Energy Agency
KWRC	Keyway root cracking
LC	Licence Condition
LMP	Lifetime management project
LSR	Lifetime safety review
LTR	Lifetime technical review
MTR	Material test reactor
NGL	EDF Energy Nuclear Generation Ltd
NSC	Nuclear Safety Committee
ONR	Office for Nuclear Regulation
PAR	Project assessment report
PCPV	Pre-stressed concrete pressure vessel
PLEX	Plant life extension
PSR	Periodic safety review
PVCW	Pressure vessel cooling water
SAP	Safety Assessment Principle(s)
SCHR	Safety Case Health Review
SF	Safety factor
SIAL	Structural integrity assessment limit
SQEP	Suitably qualified experienced person
SSC	Structure, System and Component
TAG	Technical Assessment Guide (ONR)
TOR	Torness power station
VWSG	Vibrating wire strain gauge

## TABLE OF CONTENTS

1	PERMISSION REQUESTED.....	10
2	BACKGROUND.....	10
3	ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST .....	11
3.1	STRATEGY .....	11
3.2	METHODOLOGY .....	11
3.3	NGL ASSESSMENT OF THE HEYSHAM 1 / HARTLEPOOL AND HEYSHAM 2 / TORNESS PLEX .....	12
3.3.1	Lifetime technical review (LTR) .....	12
3.3.2	Lifetime Safety Review (LSR).....	12
3.3.3	Overall Conclusions of NGL's PLEX Submission .....	13
3.4	ONR REVIEW OF THE HEYSHAM 1/ HARTLEPOOL PLEX SUBMISSION.....	14
3.4.1	Lifetime Technical Review .....	14
3.4.2	Lifetime Safety Review .....	15
3.4.3	Conclusion .....	15
3.5	ONR REVIEW OF THE HEYSHAM 2 / TORNESS PLEX SUBMISSION .....	15
3.5.1	Lifetime Technical Review .....	15
3.5.2	Lifetime Safety Review .....	16
3.5.3	Conclusion.....	16
4	CONCLUSIONS .....	16
5	RECOMMENDATIONS .....	17
6	REFERENCES .....	18
	APPENDIX 1: SUMMARIES OF THE ONR SPECIALIST REVIEWS OF THE HEYSHAM 1 / HARTLEPOOL PLEX SUBMISSION.....	26
	Civil engineering .....	26
	Structural integrity .....	26
	Graphite core integrity.....	27
	Mechanical engineering .....	28
	Electrical engineering.....	29
	Control and instrumentation .....	30
	Fault studies.....	31
	APPENDIX 2: SUMMARIES OF THE ONR SPECIALIST REVIEWS OF THE HEYSHAM 2 / TORNESS PLEX SUBMISSION.....	32
	Civil engineering .....	32
	Structural integrity .....	32
	Graphite core integrity.....	33
	Mechanical engineering .....	33
	Electrical engineering.....	34
	Control and instrumentation .....	34
	Fault studies.....	35

### Tables

**Table 1:** Observations from the reviews of the Heysham 1 / Hartlepool PLEX submission

**Table 2:** Observations from the reviews of the Heysham 2 / Torness PLEX submission

## 1 PERMISSION REQUESTED

1. This early engagement activity falls outside the scope of ONR's formal permissioning, however it is associated with the submissions of the Heysham 1 (HYA) / Hartlepool (HRA) and Heysham 2 (HYB) / Torness (TOR) power stations' Periodic Safety Review 3 (PSR 3) which are due in early 2018 and 2019; and therefore it is associated with Licence Condition 15 (LC15) "periodic review".
2. The Office for Nuclear Regulation (ONR) was requested as part of EDF Energy Nuclear Generation Ltd's (NGL's) early PSR3 engagement to provide a regulatory perspective. This project assessment report (PAR) and the associated letter to NGL records ONR's position in response to this request.

## 2 BACKGROUND

3. NGL is managing its UK fleet of AGR reactors through to their end of electrical generation and eventual entry into decommissioning. NGL is undertaking studies aimed at optimising the remaining lifetime and generating capacity as part of its lifetime management project (LMP).
4. As part of the LMP, the licensee for these sites (NGL) is considering a life extension to the current HYA/HRA closure date of 2019 to 2024 and an extension of to the current HYB/TOR closure date of 2023 to 2030. This PAR details ONR's sampled review of the NGL Plant Life Extension (PLEX) Technical Overview Reports for HYA/HRA [1] and HYB/TOR [2], and the supporting documentation.
5. For the NGL Board to make a decision to extend the Current Accounting Life of stations, NGL prepares a suite of life extension assessments to support its decision. These assessments aim to identify the potential risks to safety, technical feasibility, financial viability and political/stakeholder acceptance to fully inform its decision. These assessments include consideration of the significance of the technical issues that could prevent safe, commercial operation throughout the PLEX period (Lifetime Technical Reviews (LTR)), as well as considering the efficiency of the processes that manage nuclear safety (Lifetime Safety Reviews (LSR)).
6. The LSRs follow the same structure as PSR3, which is based on International Atomic Energy Agency (IAEA) guidance [3], and is similarly based on a consideration of the efficacy of NGL's processes that manage nuclear safety. PSR3 will, later, provide a detailed and systematic assessment of the adequacy of the safety cases for the stations against modern standards and a review of the continuing suitability of the plant against likely ageing effects that may render the plant unsafe to operate.
7. NGL has requested that ONR reviews its PLEX Technical Overview Reports in conjunction with supporting documentation to inform NGL's view on the appropriateness of its assessments. A key point to note is that NGL is not asking ONR to agree the conclusions of the PLEX Technical Overview Reports, but is asking ONR for its review to focus on the appropriateness of the general approach that has been taken by NGL.
8. In recognition of the regulatory significance of the PSR3 cycle, ONR agreed to review the HYA/HRA and HYB/TOR PLEX submissions to determine if, on the basis of current knowledge and experience, they provided reasonable evidence in support of NGL's decision to proceed with its intended PLEX campaign.
9. ONR has previously undertaken reviews of PLEX submissions for Hinkley Point B / Hunterston B in 2012 [4] and Dungeness B in 2014 [5]. The reporting approach for HYA/HRA and HYB/TOR has been the same as used for Dungeness B with

consolidated PLEX Technical Overview Reports which reference out to supporting documentation.

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

#### **3.1 STRATEGY**

10. This is an early engagement exercise which serves the following aims:

- Review the content of the HYA/HRA and HYB/TOR PLEX documentation and the appropriateness of the approach taken by NGL, therefore securing some confidence that a future a PSR submission may not adversely impact upon the PLEX aspirations for HYA/HRA and HYB/TOR stations.
- Sample and review the adequacy of the recommendations made by the Licensee as a result of its PLEX aspirations for HYA/HRA and HYB/TOR.
- Identify any additional observations within the PLEX submission that have the potential to impact on future PSR submissions for HYA/HRA and HYB/TOR stations and impact upon PLEX aspirations.
- Form a view on the appropriateness of the NGL PLEX submission and the identified PLEX proposals, possible areas for future consideration or any significant areas of concern that have the potential to impact on future PSR submissions.

11. NGL has provided ONR with the following documentation:-

- PLEX Technical Overview Reports [1,2]
- Lifetime Technical Reviews [6,7]
- Lifetime Safety Review [8,9]

The PLEX documentation was grouped by sister stations, i.e. HYA/HRA and HYB/TOR.

12. Based on the areas which were considered to be important to ongoing lifetime management of the AGRs, the ONR assessments were conducted by the following specialist inspection disciplines:

- Civil engineering [10,11]
- Structural integrity [12,13]
- Graphite core integrity [14]
- Mechanical engineering [15,16]
- Electrical engineering [17]
- Control and instrumentation [18,19]
- Fault studies [20,21]

13. In recognition of the ongoing ONR interventions with respect to the HYA/HRA boiler spines work, the implications of this were not specifically considered during this review; however, clearly this will form a key element of the future lifetime management of these stations since the boilers are irreplaceable items.

#### **3.2 METHODOLOGY**

14. Although, there is no requirement for ONR to permission formally the HYA/HRA and HYB/TOR PLEX submissions, the methodology that has been adopted for this review broadly follows ONR guidance, Purpose and Scope of Permissioning [22].

15. ONR guidance on production of reports [23] has been used in the preparation of this PAR, although there is no requirement for any Licence Instrument to be issued under this PAR. This PAR is instead used to support the content of an ONR letter to be issued to NGL, summarising the outcome of ONR's review.
16. The ONR inspectors sampled the PLEX documentation based on the areas relevant to their disciplines. I considered these areas to represent a proportionate and targeted area of assessment consistent with ONR's enforcement policy statement.

### **3.3 NGL ASSESSMENT OF THE HEYSHAM 1 / HARTLEPOOL AND HEYSHAM 2 / TORNESS PLEX**

17. The PLEX project considers three pertinent criteria that need to be met to extend the life of a power station: Feasibility, Financial Viability and Stakeholder Acceptability. ONR has focused on the feasibility element of the PLEX project and; specifically this report summarises two key reviews supporting the HYA/HRA and HYB/TOR PLEX cases.

#### **3.3.1 Lifetime technical review (LTR)**

18. AGR lifetimes are generally determined by the technical considerations of the irreplaceable nuclear island plant. The LTRs assessed the major technical issues that were considered life limiting and safety case issues that necessitate being addressed for continued operation. The LTRs concentrated on the four main areas of nuclear island plant (graphite core, boilers, reactor internals, and the pre-stressed concrete pressure vessel (PCPV)), in addition the fuel route, radioactive waste vault capacities and data processing and control system were also included.
19. For HYA/HRA and HYB/TOR the most significant threats to achieving a lifetime of 2024 and 2030 were associated with the graphite cores and boilers. The other irreplaceable components were regarded as a lower threat, but the inherent uncertainties in the predicted condition of all of the irreplaceable plant over such a timescale cannot totally rule out any of these components as life limiting.
20. For HYA/HRA it was noted that the threats to achieving extended lifetime as discussed in the LTR assume that the reactors will operate at full load until the end of life. If any plant issues lead to the down-rating of the reactors at the sites (e.g. implications of boiler spines defect, high temperature behaviour of austenitic stainless steel and hot box dome temperature compliance for both stations and the impact of gas side CO<sub>2</sub> oxidation of the 9%Cr primary superheater tubes at HRA), then the operation of the reactors at lower loads could improve the confidence of achieving extended life.
21. Further work was identified and would be required to support life extension to 2024 (HYA/HRA) and 2030 (HYB/TOR). Overall, the current best estimate lifetime judgement was that 2024 and 2030 should be achievable.
22. Independent Peer Reviews of the LTRs [24,25] by AMEC Nuclear were carried out to support the formal decision on PLEX. It was noted that overall AMEC Nuclear supported the proposals within the LTR, albeit with a number of additional issues identified. The reviewers considered it would be possible to demonstrate that the proposed confidence levels put forward in the LTR could be substantiated.

#### **3.3.2 Lifetime Safety Review (LSR)**

23. The LSR determines whether there are any obvious process shortfalls, which might leave significant safety issues undetected or unaddressed, should a review be carried out after the life extension decision. The PSR3 would follow later and build upon this

- by providing a more detailed and systematic assessment of the adequacy of the same Safety Factors.
24. The LSR investigated the effectiveness of NGL's management systems using its PSR3 review structure. This PSR3 structure is based on the fourteen safety factor (SF) approach as specified in the IAEA guidance [26], and is similarly based on a consideration of the efficacy of NGL's processes that manage nuclear safety. Two additional Safety Factors have been added to the IAEA list to meet NGL's requirements; radiological protection and decommissioning.
25. NGL's LSR documents [8,9] cover each of the 16 SFs. These SFs have been reviewed in order to identify the appropriate management systems that support the management of nuclear safety risks which could arise or could significantly increase as a consequence of PLEX if they were not managed. Conclusions from the LSRs provide confidence to NGL and its stakeholders that HYA/HRA and HYB/TOR have adequate processes to manage safety risks throughout the proposed PLEX period.
26. The safety factors were grouped into six topics:
- Plant – SF1-4
  - Safety analysis – SF5-7
  - Performance and feedback of experience – SF8-9
  - Management – SF10-13
  - Radiological hazard – SF14-15
  - Decommissioning – SF16
27. Both LSRs identified one key issue and a number of minor issues. The common key issue related to the Safety Case Health Review (SCHR) process which was set to provide periodic and systematic health reviews of safety cases to identify previously unmitigated threats to safety case integrity. The development on an SCHR process represented a positive action by NGL but it was recognised; however, that it had not yet matured and its implementation at HYA/HRA and HYB/TOR was still at early stages.
28. Although it was considered that this did not jeopardise NGL's PLEX intentions, limited progress in performing SCHR's would represent a potential threat to PSR3 submissions. A recommendation was made that PSR3 further reviews the application and findings of this process.
29. The remaining less significant issues were not considered to represent threats to HYA/HRA or HYB/TOR achieving their life extension ambitions or to PSR3.

### **3.3.3 Overall Conclusions of NGL's PLEX Submission**

30. The Lifetime Technical Review and Lifetime Safety Review indicated that safety, technical and process risks to the HRA/HYA and HYB/TOR PLEX proposals to 2024 and 2030 were known and had been mitigated or mitigation arrangements were in place or will be developed.
31. Collectively, the reviews concluded that the proposal to extend the life of HRA/HYA to 2024 and HYB/TOR to 2030 is feasible. Confidence was built on the basis that technical and safety threats to irreplaceable plant were known and programmes to mitigate these have been set. Further to that, NGL has an established management system that can assure identification and management of safety risks which could arise. The management system processes were reviewed against 16 safety areas.

32. Based on findings from the technical, safety, process and business case reviews; the proposal to extend the operational life of HRA/HYA to 2024 and HYB/TOR to 2030 was judged to be achievable.
33. The PLEX submissions were considered by the Nuclear Safety Committee (NSC) [27] and the significant threats discussed. The NSC recognised that although the plants may be similar, the operating histories required each to be considered individually to ensure the appropriate threats to PLEX were addressed.

### 3.4 ONR REVIEW OF THE HEYSHAM 1/ HARTLEPOOL PLEX SUBMISSION

34. The reviews of the Heysham 1 / Hartlepool PLEX submission by the ONR inspectors are summarised in Appendix 1.

#### 3.4.1 Lifetime Technical Review

35. The inspectors reviewed the potential significance of a number of key plant items in achieving the PLEX proposals for HYA/HRA identified in the LTR[6]:

- Graphite core
  - Graphite weight loss
  - Graphite brick shrinkage and brick cracking
- Boilers
  - Boiler spine
  - Boiler pressure drop
  - Boiler tube restrictions and failure
  - Uncertainty in plant condition
  - Oxidation of tubes with 9% Cr
  - Carbon deposition
  - Chemistry control
  - High temperature behaviour of austenitic stainless steel
  - Component life assessment (CLA)
- Reactor internals
  - Hot box dome
  - High temperature behaviour of austenitic stainless steel
  - CLA
- Pre-stressed concrete pressure vessel
- Fuel route
- Radioactive waste facilities
- Data processing and control system
- Time limited safety cases

and considered them to be a reasonable assessment of the likely degradation mechanisms.

36. The inspectors judged that the proposed further work to deliver the PLEX proposals was generally appropriate but noted that operation at lower power may be required to address some of the shortfalls should the future work not deliver the required benefits.
37. It was however noted that the condition of material on plant and the management of the corrosion in components such as buried, trenched and lagged pipework and tanks was not considered as part of the PLEX submission, but the inspectors judged that this aspect required significant investment in order to support NGL's PLEX aspirations.

38. The inspectors raised a number of observations which were considered pertinent to the future PSR3 submission for the ongoing justification for continued plant operations, see Table 1.

### 3.4.2 Lifetime Safety Review

39. The inspectors sampled the safety factors they considered appropriate to their disciplines and considered that the LSR[8] provided sufficient commentary on how safety would be demonstrated for stations operating beyond their existing design life and the IAEA safety factors had been appropriately used and provided a clear structure for the case.

### 3.4.3 Conclusion

40. ONR has reviewed the Heysham 1 / Hartlepool PLEX submission and, in general, considers the Licensee's approach to the life time extension of HYA and HRA to be appropriate and the reviewed documents fit for the purpose of describing the general framework of the PLEX project and identifying the significant safety issues.
41. The further work required and issues identified in the LTR and LSR were considered to be adequate and appropriate to address the PLEX aspirations for HYA/HRA.
42. During their reviews, the inspectors raised a number of observations which should be considered as part of the future PSR3 submissions, see Table 1.

## 3.5 ONR REVIEW OF THE HEYSHAM 2 / TORNESS PLEX SUBMISSION

43. The reviews of the Heysham 2 / Torness PLEX submission by the ONR inspectors are summarised in Appendix 2.

### 3.5.1 Lifetime Technical Review

44. The inspectors reviewed the potential significance of a number of key plant items in achieving the PLEX proposals for HYB/TOR identified in the LTR[7]:
- Graphite core
    - Graphite weight loss
    - Graphite brick shrinkage and brick cracking
  - Boilers
    - High temperature behaviour of austenitic stainless steel
    - Superheater & reheater carbon deposition
    - Elevated boiler gas inlet temperature
    - Breakaway oxidation (9 %Cr evaporator sections)
    - Reheater tube leaks (TOR only)
    - Boiler structural integrity issues
  - Reactor internals
  - Pre-stressed concrete pressure vessel
  - Fuel route
  - Radioactive waste facilities
  - Data processing and control system
  - Time limited safety cases

and considered them to be a reasonable assessment of the likely degradation mechanisms.

45. The inspectors judged that the proposed further work to deliver the PLEX proposals was generally appropriate but raised a number of observations which were considered

pertinent to the future PSR3 submission for the ongoing justification for continued plant operations, see Table 2.

### 3.5.2 Lifetime Safety Review

46. The inspectors sampled the safety factors they considered appropriate to their disciplines and considered that the LSR[9] provided sufficient commentary on how safety would be demonstrated for stations operating beyond their existing design life and the IAEA safety factors had been appropriately used and provided a clear structure for the case.

### 3.5.3 Conclusion

47. ONR has reviewed the Heysham 2 / Torness PLEX submission and generally considers the Licensee's approach to the life time extension of HYB and TOR to be appropriate and the reviewed documents fit for the purpose of describing the general framework of the PLEX project and identifying the significant safety issues.
48. The further work required and issues identified in the LTR and LSR were considered to be adequate and appropriate to address the PLEX aspirations for HYB/TOR.
49. During their reviews, the inspectors raised a number of observations which should be considered as part of the future PSR3 submissions, see Table 2.

## 4 CONCLUSIONS

50. This report presents the findings of the review of the Heysham 1 / Hartlepool and Heysham 2 / Torness PLEX submissions to provide a view on the appropriateness of the NGL PLEX submission and the identified PLEX proposals, possible areas for future consideration or any significant areas of concern that have the potential to impact on future PSR submissions.
51. For both HYA/HRA and HYB/TOR the most significant threats in achieving the proposed PLEX are associated with the graphite cores and boilers. The other irreplaceable components are regarded by NGL as a lower threat, but the inherent uncertainties in the predicted condition of all of the irreplaceable plant over such a timescale cannot totally rule out any of these components becoming life-limiting.
52. In general terms, I consider the submitted PLEX documentation to be well presented and ONR's review of the submitted documentation has not revealed any significant flaws or omissions with respect to nuclear safety that would preclude adopting NGL's PLEX proposals for HYA/HRA and HYB/TOR. NGL's review of all the potential degradation mechanisms as part of its review of PLEX appears to be well defined and degradation has been mitigated or mitigation arrangements are in place or will be developed.
53. Overall I support NGL's view that the proposed life extensions for Heysham 1 / Hartlepool and Heysham 2 / Torness were achievable based on the successful outcome of the proposed further work.
54. It is important that the limited nature of NGL's submission is taken into account and ONR's comments are taken in context of the potential for other issues emerging from its formal assessment of the PSR3 submissions scheduled for 2018 and 2019.
55. It should remain clear that the regulation of nuclear power station operation is based on the submission of adequate LC15 PSR submissions, allied to continuing satisfactory performance as judged against inspections of the site and assessment of the safety justification of the plant (this includes the ONR requirement to permission

the start-up of the reactors after their three yearly periodic shutdowns). Provided that these are maintained, any decision regarding the accounting lifetime of the plant and the cessation of power generation remains a commercial decision solely for the Licensee to determine.

56. NGL should note that no statement in this document should be interpreted either as a commitment to accept a safety case that has yet to be submitted to ONR, or as an implication that NGL's Lifetime Technical Review restricts the necessary scope of any subsequent safety case modification or future PSR3 submission.

## **5 RECOMMENDATIONS**

57. I recommend that the Superintending Inspector:
  58. a. Signs this Project Assessment Report to confirm acceptance of ONR technical and regulatory arguments supporting issuing a letter of no objection to NGL.
  59. b. Signs this Project Assessment Report approving its release for publication, after redaction where appropriate.

## 6 REFERENCES

- 1 *DAO\_REP\_JIEF\_063\_AGR\_15 - HYA-HRA PLEX Technical Overview Report*, February 2015. TRIM 2015/91415
- 2 *DAO\_REP\_JIEF\_064\_AGR\_15 - HYB/TOR PLEX Technical Overview Report*, February 2015. TRIM 2015/91420
- 3 *Periodic Safety Review for Nuclear Power Plants Specific Safety Guide*, SSG-25, 10 April 2013. International Atomic Energy Agency (IAEA). Vienna. [www.iaea.org](http://www.iaea.org).
- 4 *PAR 12-046 - Assessment Of EDF-NGL Hinkley Point B/Hunterston B (HPB/HNB) Lifetime Safety Review*, November 2012. TRIM 2012/476636
- 5 *NGL - Dungeness B - Project Assessment Report (PAR) - 14-008 - Plant Life Extension (PLEX)*, August 2014. TRIM 2014/321878
- 6 *DAO\_REP\_JIEF\_054\_AGR\_14 – HYA/HRA Lifetime Technical Review*, December 2014. TRIM 2015/91413
- 7 *DAO\_REP\_JIEF\_056\_AGR\_14 - HYB/TOR Lifetime Technical Review*, February 2015. TRIM 2015/91419
- 8 *DAO\_REP\_JIEF\_055\_AGR\_14 - HYA/HRA Lifetime Safety Review*, December 2014. TRIM 2015/96224
- 9 *DAO\_REP\_JIEF\_062\_AGR\_14 - HYB/TOR Lifetime Safety Review*, December 2014. TRIM 2015/96225
- 10 *NGL - HRA/HYA – Assessment Report – 15-022 - Civil Engineering Review of Hartlepool / Heysham 1 Plant Life Extension Case*. 31 July 2015. TRIM 2015/224823
- 11 *NGL - TOR/HYB – Assessment Report – 15-021 - Civil Engineering Review of Torness / Heysham 2 Plant Life Extension Case*, 31 July 2015. TRIM 2015/251139
- 12 *ONR - CNRP - AR - 15-028 - PLEX HRA-HYA - Structural Integrity Review of Hartlepool/Heysham1 Plant Lifetime Extension*, 5 August 2015. TRIM 2015/236557
- 13 *ONR - CNRP - AR - 15-038 - PLEX-HYB/TOR - Structural Integrity Review of Heysham 2/Torness Plant Life Extension*, 5 August 2015. TRIM 2015/261114
- 14 *ONR - CNRP - AR - 15-031 - Graphite Assessment of HYA HRA Plant Life Extension (PLEX)*, 27 July 2015. TRIM 2015/258870
- 15 *ONR - CNRP - AR - 15-010 - PLEX HRA-HYA - Mechanical Engineering Review of Hartlepool and Heysham 1 Plant Lifetime Extension Case*, 24 June 2015. TRIM 2015/155345
- 16 *ONR - CNRP - AR - 15-003 - PLEX HYB-TOR - Mechanical Engineering Review of the Torness / Heysham 2 Plant Life Extension case*, 29 June 2015. TRIM 2015/130092
- 17 *HYB/TOR HRA/HYA PLEX - Electrical Engineering aspects*, 31 July 2015. TRIM 2015/288761
- 18 *ONR - CNRP - AR - 15-033 - Control and Instrumentation review of Heysham 1/ Hartlepool plant life-time extension case*, 7 August 2015. TRIM 2015/261131

- 19 *ONR – CNRP – AR - 15-042 - Control and Instrumentation review of Heysham 2 & Torness plant life-time extension case*, 10 August 2015. TRIM 2015/296544
- 20 *ONR - CNRP - AR - 14-116 - PLEX HRA-HYA - Fault Studies Assessment of Hartlepool and Heysham 1 Plant Lifetime Extension case*, 17 April 2015. TRIM 2015/102943
- 21 *ONR - CNRP - AR - 15-023 - PLEX TOR-HYB - Fault Studies Assessment of Torness / Heysham 2 Plant Lifetime Extension case*, 18 June 2015. TRIM 2015/215176
- 22 *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>
- 23 *NS-TAST-GD-084 – ONR Guidance on production of reports – Rev 9*, July 2015. TRIM 2015/239133
- 24 *HYA & HRA - Lifetime Technical Review (Independent Peer Review) - Issue 01*, 28 April 2015. TRIM 2015/164984
- 25 *HYB & TOR - Lifetime Technical Review (Independent Peer Review) - Issue 01*, 28 April 2015. TRIM 2015/164990
- 26 *Periodic Safety Review of Nuclear Power Plants, International Atomic Energy Agency (IAEA), Specific Safety Guide No. SSG-25*. IAEA. Vienna, 2013
- 27 *HYA-HRA and HYB-TOR PLEX - NSC Minutes*, 25 June 2015. TRIM 2015/298737

**Table 1:** Observations from the reviews of the Heysham 1 / Hartlepool PLEX submission

Reference Number	Discipline	Comment
1.1	Civil	NGL should review the condition of the VWSGs, establish a minimum level of coverage and invest on the recovery of these gauges.
1.2	Civil	NGL should implement the TGN/027 on management of thermocouples and provide similar guidance for the management of VWSGs
1.3	Civil	NGL should inspect the PCPV inner wall bearings to confirm their condition for the extended life of the Stations
1.4	Civil	The PSR3 submission should present evidence that the commitments made on the PCPV safety case (NP/SC 7676) can be achieved before the end of 2019.
1.5	Civil	The PSR3 submission should confirm the integrity of the concrete foundations, especially under thaumasite attack.
1.6	Civil	NGL should review fuel pond integrity, repair strategy and inspection regime.
1.7	Civil	NGL should review the ageing and degradation mechanism on ponds, tanks and other nuclear significant civil engineering structures
1.8	Civil	NGL should carry out a comprehensive review of the Categorisation and Class of the structures that are peripheral to safety, such as the cooling water structures.
1.9	Civil	NGL should consider the condition and capacity of the fuel storage facilities
1.10	Civil	NGL should consider reviewing the site processes and personnel training for identifying and reporting excessive vibration on equipment and pipework.
1.11	Structural Integrity	Noting the management strategy for breakaway oxidation, NGL should aim to utilise the results of the Boiler Lifetime Management programme in order to gain understating of the status of the plant as part of their PSR3 submission.
1.12	Structural Integrity	The reactors at HRA are more sensitive to breakaway oxidation of the 9% Chrome sections due to the fins situated at the top of the super-heater tubes. Although the LTR notes this briefly, its full implications have not been considered as part of the PLEX submission. It is suggested that this is addressed as part of NGL's PSR 3 submission.
1.13	Structural Integrity	There is a further significant uncertainty associated with the boilers, which is the reheat cracking observed in the boiler spines. The LTR presents several mitigation techniques currently under consideration, however, the success criteria for these techniques is unknown and the possible impact of the changes to the plant is not considered in the LTR. Therefore it is suggested that NGL considers this as part of their PSR 3 submission.
1.14	Structural Integrity	Due to the uncertainties associated with re-heat cracking and breakaway oxidation, ONR has reservations that the 2024 PLEX aspirations at full power may not be achievable and encourages NGL to consider low power operation as part of their PSR 3 submissions.

Reference Number	Discipline	Comment
1.15	Structural Integrity	For the reactor internals, ONR is encouraged to see that NGL has a plan for achieving the safety case margins, however, these modifications have not yet proven in-service that they can perform the duties required. Therefore, from a reactor internals view point; ONR encourages NGL to consider the implications of their modifications together with operation at reduced power as part of their PSR 3 submission.
1.16	Structural Integrity	ONR has considered the condition of material on plant and the management of the corrosion in components such as buried, trenched and lagged pipework and tanks. ONR judges that this aspect requires significant investment in order to support NGL's PLEX aspirations. It was noted that this aspect was not considered as part of the PLEX submission; ONR encourages NGL to provide their management plans as part of the PSR 3 submission
1.17	Structural Integrity	NGL's approach to the management of stress corrosion cracking (SCC) during periods of off-load operation appears satisfactory. However, this is caveated with the lack of information regarding proposed control criteria during long-term outage intervals, where the plant is at an increased risk of SCC degradation. ONR suggests that NGL should consider this as part of their PSR 3 submissions
1.18	Graphite	Plant improvements need to be developed and implemented to provide effective boiler tube leak protection to reduce water ingress into the reactor core following tube leaks.
1.19	Graphite	The material test reactor experiments need to produce results that are translatable to the AGR operational environment, and demonstrate that the structural integrity assessment limit can be increased to 50%.
1.20	Graphite	The whole core modelling methodology used for the new 20% cracking safety case needs to be well justified and validated, and the safety margins predicted for normal, fault and extreme conditions shown to be reasonable considering the uncertainties.
1.21	Graphite	Improvements need to be made on the secondary or tertiary shutdown systems to provide shutdown and hold down for both reactors simultaneously during a 10-4 seismic event.
1.22	Graphite	The inspection strategy after onset of KRC should be statistically substantiated to provide sufficient confidence that degradation of the graphite core will be detected well in advance of cracking affecting its safety function.
1.23	Mechanical Engineering	Consider including in the PSR3 case the means by which NGL confirm confidence in deployment of their SF2 and SF4 supporting processes and the effectiveness of such processes in determining the actual condition of SSCs important to safety.
1.24	Mechanical Engineering	Consider including in the PSR3 case the means by which SF2 supporting process outcomes, which have wider consequences between AGR stations, are shared and acted upon.
1.25	Mechanical Engineering	For both SF2 and SF4, consider how process performance is demonstrated in order to underpin confidence they achieve the outcomes expected, including where appropriate areas for improvement or developments to show a continuous improvement ethos.
1.26	Mechanical Engineering	NGL should confirm that internal, external or independent review processes undertaken in order to provide confidence performance claims in support of SF4 are being achieved.

Reference Number	Discipline	Comment
1.27	Mechanical Engineering	Ensure there is an NGL process for SSCs important to safety which considers the design life extension implications based on review of the original design basis and confirms the validity of the EIMT arrangements.
1.28	Mechanical Engineering	Confirm the adequacy of the level of technical support allocated through the PLEX period in addressing the risk of increasing rates of SSC failures, both predicted and unpredictable, due to ageing effects, both known and potentially unknown.
1.29	Control and Instrumentation	NGL should consider a programme for establishing the operational status (following TGNs 027 and 118) of thermocouples at Heysham 1 and Hartlepool prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case. This programme should ensure that thermocouples integral to the delivery of safety functions are adequately assessed.
1.30	Control and Instrumentation	NGL may wish to consider a programme for replacing the original polyethylene cabling with irradiation resistant PEEK type cable prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case.
1.31	Control and Instrumentation	NGL should consider a programme for establishing the operational and safety case status of the reactor PCPV VSWGs at Heysham 1 and Hartlepool prior to submission of PSR3 to correctly inform the optioneering of alternative methods of concrete strain measurement.
1.32	Control and Instrumentation	NGL should consider whether the frequency of condition monitoring and maintenance of critical components important to safety is appropriate as those components operate beyond their design life.
1.33	Control and Instrumentation	NGL should consider how SSCs important to safety are to be assessed to demonstrate their ability to operate beyond their original design specified life. This should be considered in terms of satisfying safety functions, failure modes and maintenance requirements.
1.34	Control and Instrumentation	Maintaining a sufficient depth of technical understanding is essential within the contracting organisations supporting what are often obsolete, ageing systems. NGL should consider reviewing current equipment support contracts with a focus on external SQEP retention/development.
1.35	Control and Instrumentation	NGL should consider completion of the Heysham 1 and Hartlepool specific aspects of the fleet-wide EMI/RFI safety case at prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case.
1.36	Control and Instrumentation	NGL is funding ongoing solar storm research to further their knowledge of the magnitude and frequency of the hazard. NGL should consider including a solar storm hazard discussion within the submission of PSR3.
1.37	Fault Studies	NGL should consider including a reference to the existing standardised cross-fleet technology for AGR boiler tubes plugging.
1.38	Fault Studies	NGL should consider developing or referencing plans for updating, verification and validation of the applicable computer codes and models regarding the plant ageing effects identified by specific research and by analysis of the operational experience.

**Table 2:** Observations from the reviews of the Heysham 2 / Torness PLEX submission

Reference Number	Discipline	Comment
2.1	Civil Engineering	NGL should review the condition of the vibrating wire strain gauges (VWSG), establish a minimum level of coverage and invest on the recovery of these gauges.
2.2	Civil Engineering	NGL should implement the NGL Technical Guidance Note on management of thermocouples and provide similar guidance for the management of vibrating wire strain gauges (VWSG)
2.3	Civil Engineering	NGL should conduct inspections of the PCPV wall bearings to confirm their condition for the extended life of the Stations
2.4	Civil Engineering	NGL should establish the condition of the unlined monitoring ducts (UMD) at HYB and unblock the UMDs if necessary. If the UMDs are not unblocked, then an air flow monitoring regime should be established. Carry out the UMDs inspection at TOR
2.5	Civil Engineering	NGL should provide further evidence that the concrete voids (concrete leaching) are not caused by the big PVCS leaks at HYB – A test programme should be considered.
2.6	Civil Engineering	NGL should implement grease sampling at both Stations every 3 years
2.7	Civil Engineering	NGL should review the fuel pond integrity and the inspection regime taking into account the ageing and degradation mechanisms.
2.8	Civil Engineering	NGL should review the ageing and degradation mechanism on ponds, tanks and other nuclear significant civil engineering structures.
2.9	Civil Engineering	NGL should carry out a comprehensive review of the Categorisation and Class of the structures that are peripheral to safety, such as the cooling water structures.
2.10	Civil Engineering	NGL should implement frequent inspections and load testing of the rock anchors.
2.11	Civil Engineering	Heysham B should reduce the groundwater ingress in the reactor building basement and assess the degradation caused by it on the concrete and steelwork.
2.12	Structural Integrity	The management strategy for breakaway oxidation highlighted NGL's reassessment of the boiler failure probabilities only until 2023, the assessments for breakaway oxidation of 9% Cr sections remain unclear beyond 2023. NGL should consider this issue further as part of their PSR 3 submission.
2.13	Structural Integrity	ONR found that it was encouraging that NGL demonstrated a clear route for the management of carbon deposition, however, both modified oxygen injection and increase in COS concentration have not been demonstrated on plant and their actual effectiveness remains unclear. NGL should consider these aspects as part of their PSR 3 submission.

Reference Number	Discipline	Comment
2.14	Structural Integrity	Based the impact of pitting corrosion on the decay heat boilers at Heysham 2 and Torness, NGL has a well-developed theoretical analysis for determining the life of the decay heat boilers. Based on the mitigation techniques using operational and chemistry control, ONR believes the operation until 2030 may be feasible. However, ONR encourages NGL to determine the actual status of the plant in order to support their PSR 3 submission.
2.15	Structural Integrity	NGL has highlighted the safety case implications of high temperature creep degradation, and has found that at Heysham 2 and Torness there are a number of components which have been deemed as Red under their RAG review. Although these issues were highlighted as part of NGL's PLEX submission, their implications for plant were not discussed. ONR was content with NGL's approach and encourage the development of the HTBASS programme but also encourages NGL to consider its implications as part of their PSR 3 submission.
2.16	Structural Integrity	ONR notes that the design codes against which PSR 2 comparisons of the diagrid was conducted (PD 5500:2006) has now been superseded by PD 5500:2009. ONR recommends that NGL conducts a review to assess the changes to the design codes and the potential impact on plant as part of their PSR 3 submission.
2.17	Structural Integrity	NGL has a reactor ISI and material monitoring strategy up to 2023. ONR recommends that NGL should consider reviewing this strategy to complement their PLEX aspirations as part of their PSR 3 submissions.
2.18	Structural Integrity	The condition of material on plant and the management of the corrosion in components; such as buried, trenched and lagged pipework and tanks, was not considered as part of the PLEX submission. ONR judges that this aspect requires significant investment in order to support NGL's PLEX aspirations.
2.19	Structural Integrity	NGL should consider the management of degradation of High Density Polyethylene (HDPE) pipework as part of their PSR 3 submissions.
2.20	Mechanical Engineering	NGL may wish to consider putting in place measures to ensure analyses (in support of TGN/097) of higher risk equipment are completed prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case.
2.21	Mechanical Engineering	ONR would expect to see significant enhancements put in place to condition monitor the inner seal to provide confidence the fuelling machine pressure boundary remains robust. These arrangements would form part of any safety case developed for single seal operation of the fuelling machine.
2.22	Mechanical Engineering	NGL should consider how SSCs (specifically those classified as critical components) are to be assessed to demonstrate their ability to operate beyond their original design life. This should be considered in terms of satisfying safety functions, failure modes and maintenance requirements).
2.23	Control and Instrumentation	NGL should consider a programme for completing the work required for compliance with TGN 027 and TGN 118 prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case. This programme should ensure that thermocouples integral to the delivery of safety functions are adequately assessed.

Reference Number	Discipline	Comment
2.24	Control and Instrumentation	NGL should confirm that the phased reinforcement for Heysham 2 and Torness DPCS is in line with the expectations for the end of life of the existing systems when considering the potential length of time required to implement this reinforcement.
2.25	Control and Instrumentation	NGL should note that although Fuel Route may not be critical to PLEX it can have a significant impact on station operations and therefore applying appropriate priority to Fuel Route could bring longer term benefit.
2.26	Control and Instrumentation	NGL should consider bringing the system safety review process at Torness into line with the rest of the AGR fleet.
2.27	Control and Instrumentation	NGL should consider how SSCs important to safety are to be assessed to demonstrate their ability to operate beyond their originally specified design life. This should be considered in terms of satisfying safety functions, failure modes and maintenance requirements.
2.28	Control and Instrumentation	NGL should consider reviewing current equipment support contracts with a focus on external SQEP retention/development.
2.29	Control and Instrumentation	NGL should consider completion of the Heysham 2 and Torness specific aspects of the fleet-wide EMI/RFI safety case at prior to submission of PSR3 to mitigate the risk of safety significant gaps in the safety case.
2.30	Control and Instrumentation	NGL should consider addressing solar storm hazard within the submission of PSR3.
2.31	Fault Studies	NGL should consider developing or referencing plans for updating, verification and validation of the applicable computer codes and models regarding the plant ageing effects identified by specific research and by analysis of the operational experience.

## APPENDIX 1: SUMMARIES OF THE ONR SPECIALIST REVIEWS OF THE HEYSHAM 1 / HARTLEPOOL PLEX SUBMISSION

### CIVIL ENGINEERING

1. Reference 10 presents the ONR civil engineering review of the HYA/HRA PLEX submission. The review primarily focussed on:
  - Pre-stressed Concrete Pressure Vessel (PCPV)
  - Ageing and degradation of civil structures
  - Ponds
  - Fuel storage facilities
  - Previous Periodic Safety Review (PSR2) outstanding issues
2. The inspector judged that the LTR had identified some of the significant issues facing the PCPV at Hartlepool and Heysham 1, such as the Pressure Vessel Cooling Water (PVCW) and CO<sub>2</sub> leaks. The PVCW leaks are the most significant threat to the Pressure Vessel due to the frequency of these leaks and the degradation effects on the tendons, if combined with CO<sub>2</sub> leaks. The PVCW leak monitoring and sealing have substantially improved as well as the tendon inspection and strand withdrawal, which are targeted and the number of inspections have increased. These improvements should be carried out during the proposed life extension.
3. However, other areas reported in the LTR, such as the embedded instrumentation needed further consideration. The LTR made specific safety claims on the vibrating wire strain gauges (VWSGs) but currently the level of working gauges is low with some areas with no coverage. Therefore, a recovery and maintenance plan that includes the identification of the minimum required number of working gauges should be put in place.
4. The inspector considered that processes such as the Safety Case Health Review were beneficial but they were threatened by emergent issues and the lack of resources.
5. The inspector considered that there were examples where the processes in place had failed due to lack of understanding of the fault conditions and their consequences. NGL should improve the plant walkdowns and train the plant personnel to understand and report plant conditions such as excessive vibrations and their effect on the plant.
6. Based on the information provided, the inspector judged that the Licensee's approach to the life extension of Hartlepool and Heysham 1 power stations was appropriate although there are a number of items affecting the safety case claims that should be addressed during the PSR3, see Table 1

### STRUCTURAL INTEGRITY

7. Reference 12 presents the ONR structural integrity review of the HYA/HRA PLEX submission. The inspector focused on the structural integrity of the components or systems providing significant safety duty, mainly focussing on the non-replaceable items. This included:
  - Boilers and their supports
  - Reactor internals
  - Other components supporting the main safety functions.

The inspector excluded the civil structures, the graphite core and the boiler spines issue.

8. The inspector judged that the LTR identified some significant issues at Heysham 1 and HRA which required consideration as part of the PSR3 submission. The issues identified included:
  - Breakaway oxidation of the 9% chrome boiler tube sections on the HRA boilers due to finned tube sections.
  - Boiler tube failure, dominated by the risk arising from internally restricted boiler tubes.
  - Hot box dome maximum temperature increasing due to progressive degradation of insulation.
  - Time limited safety cases related to the structural integrity of boiler and reactor internal components.
9. The inspector noted that there were several life limiting features on the non-replaceable components that do not yet support operation through to 2024 based on the current analysis work. The inspector was satisfied that NGL has plans in place to address these shortfalls but noted NGL's current judgement of a medium-low confidence of achieving a 2024 justification. The inspector noted that operation at lower power may be a way to address some of the shortfalls should the future work not deliver the required benefits.
10. The inspector considered the condition of material on plant and the management of the corrosion in components such as buried, trenched and lagged pipework and tanks. The inspector noted that this aspect was not considered as part of the PLEX submission, but judged that this aspect requires significant investment in order to support NGL's PLEX aspirations.
11. Overall, the structural integrity inspector was broadly satisfied with NGL's approach to assessing the feasibility of plant life extension at Heysham 1 and Hartlepool power stations. The documents had not highlighted anything which caused any current safety concern and the inspector has noted a number of technical areas that ONR should seek to continue to engage with NGL, see Table 1.

## **GRAPHITE CORE INTEGRITY**

12. Reference 14 presents the ONR graphite core integrity review of the HYA/HRA PLEX submission. The two main degradation mechanisms of the graphite core identified by NGL were; graphite weight loss due to radiolytic oxidation, and graphite dimensional change and material property change with irradiation. The inspector focussed their review on the following areas:
  - Graphite weight loss
  - Brick cracking
  - Seismic qualification of secondary or tertiary shutdown systems
  - Graphite core inspection and sampling
  - Primary coolant chemistry
13. The inspector considered that it would be possible for the active core average weight loss (ACAWL) limit to be increased so long as the amount of the water ingress from the boiler tube failure can be controlled to an adequate extent. NGL is currently identifying various plant improvements to limit water ingress, aiming to increase the ACAWL to 23% for both stations. The inspector considered that provided that effective boiler tube leak protection is developed and implemented to reduce water ingress to the reactor core, it is foreseeable that a safety case can be made to justify operation of HYA/HRA beyond 2018 (HYA) and 2019 (HRA), without exceeding the revised ACAWL limit.

14. NGL considered that the graphite material testing in the material test reactor (MTR) suggested that the structural integrity assessment limit (SIAL) could be increased to 50% for HYA/HRA. The inspector considered that provided that the MTR experiments produce results that are translatable to the AGR operational environment, the SIAL limit could be increased to 50%.
15. The graphite cracking safety case put great emphasis on the damage tolerance assessment, which was based on the whole core modelling. The inspector considered that provided that the whole core modelling methodology was well justified and validated, and the safety margins for normal, fault and extreme conditions were reasonable considering the uncertainties, it was likely that for the graphite core of HYA/HRA, operation beyond 2019 could be justified.
16. The inspector considered that, as identified in the LTR, NGL should make improvements to the secondary or tertiary shutdown systems to ensure either system can provide shutdown and hold down for both reactors simultaneously during a  $10^{-4}$  seismic event.
17. NGL considered that keyway root cracking (KWRC) was potentially a life limiting feature of the core because its effects can lead to excessive distortion of channel shapes, which could eventually impede control rod insertion. The inspector found that there was insufficient evidence to demonstrate that the NGL proposed increase in the number of core inspections after the onset of KWRC would adequately identify the state of the deterioration of the core. The inspector considered it may be reasonably practicable to sample statistically significant sample sizes from targeted locations, at a statistically substantiated increased frequency.
18. The inspector considered adequate control of the gas chemistry was an important aspect of controlling graphite core weight loss and therefore supported the LTR findings that improvements should be made to the gas bypass plant to ensure tight control on the coolant gas chemistry.
19. The inspector is broadly satisfied that NGL has conducted a thorough review of the state of the graphite core and has identified a set of reasonably practicable improvements, which could support future safe operation of HYA/HRA beyond 2019. A number of areas were considered important to support the PLEX proposals and are shown in Table 1.

## **MECHANICAL ENGINEERING**

20. Reference 15 presents the ONR mechanical engineering review of the HYA/HRA PLEX submission. The inspector established that the PLEX submission made limited reference to mechanical engineering related structures, systems and components (SSCs) important to safety. Accordingly the assessment report did not present an assessment of the NGL case, but a review of the case to confirm the validity of the assumptions and appropriateness of the case as a basis for PSR3.
21. The inspector confirmed that the key and minor issues identified in the LSR were not directly mechanical engineering related but may impact matters which do relate to mechanical SSC important to safety.
22. To gain confidence that LSR was adequately substantiated; the inspector sampled two of the 16 safety factors (SF), SF2 – Actual condition of SSCs important to safety, and SF4 – Ageing and Lifetime Management. The two safety factors were selected for review as the inspector judged them to most likely identify significant threats to SSCs important to safety for mechanical components which may impact continuing safe operations or pose safety-significant risks in addressing vulnerabilities or known life limiting deterioration in condition.

23. The SF2 case was positively presented with each supporting process described on the basis of being effective in achieving NGL's expectations. There was limited reference to process maturity and no recognition or comment on areas NGL recognise may be further improved consistent with a continuous improvement ethos. The inspector therefore judged that the SF2 case presented a non-critical review of NGL's processes and accordingly may have overstated performance to that being achieved in reality. In part this judgement was also informed through inspection findings during the inspector's normal regulatory activities.
24. The SF4 case presented many of the elements associated with NGL's Ageing Management Process which were consistent with the inspector's expectations. But, similar to SF2, it provided limited reference to process maturity, basis of confidence in consistency of deployment, identified process improvements and review processes to confirm performance, which the inspector judged necessary in meeting the expectations of ONR's Technical Assessment Guides and Safety Assessment Principles.
25. The LTR was dominated by review of structural integrity related challenges on the boilers and graphite cores which were judged not mechanical engineering related. Therefore the inspector's review did not consider further the impact on the LTR case supporting HRA/HYA PLEX for such matters.
26. The LTR recognised that there were some fuel route items, particularly those associated with the fuelling machine, fuel ponds and irradiated fuel dismantling cell, which could only be replaced with difficulty and whose failure could have nuclear safety consequences. The LTR however made limited reference to mechanical engineering related challenges for each item but the inspector judged that the claims and arguments appeared well founded and consistent with his expectations.
27. From a mechanical perspective, the inspector judged the LTR adequately identified the safety significant technical issues facing Hartlepool and Heysham 1. The inspector was satisfied that sufficient work had been undertaken to address the identified risks as the stations move beyond their original design life.
28. The inspector was satisfied that the Lifetime Safety Review provided sufficient commentary on how safety will be demonstrated for stations operating beyond their existing design life. Use of the IAEA safety factors had been appropriately used and provided a clear structure for the case. The inspector accepted the Licensee's position that the majority of mechanical equipment was not life limiting, and that due to its replaceable nature, it represented a commercial rather than a nuclear safety risk.
29. Based on the sampling of the documentation, the inspector judged the Licensee's approach to the life time extension of Hartlepool and Heysham 1 power stations to be appropriate. The inspector found the reviewed documents fit for the purpose in describing the general framework of the PLEX project and identifying the significant safety issues.
30. Through this review, the inspector identified items which NGL may wish to consider during production of the third PSR, see Table 1

## **ELECTRICAL ENGINEERING**

31. Reference 17 presents the ONR electrical engineering review of the HYA/HRA PLEX submission. The inspector noted that the proposed plant life extension reviews for HRA/HYA focussed on the irreplaceable components, mainly graphite cores and boilers and consequently electrical engineering components had not been extensively considered as part of the PLEX process.

32. The electrical engineering components were considered to be replaceable and, therefore, are covered by other NGL lifetime management strategies for example, Maintain Design Intent and system safety reviews; the outcomes of these are used to inform the plant safety reviews.
33. In carrying out the PLEX submission review the inspector did not review any of the reports relating to the other NGL lifetime management strategies. However, the inspector has over the past several years inspected the electrical systems, and sampled the application of NGL lifetime management strategies for electrical engineering components, at the sites. The inspector was content with NGL's lifetime management strategies for electrical engineering components.
34. The inspector's assessment of the PLEX reports for HYA/ HRA did not identify any electrical engineering issues that had not already been identified by NGL from the application of its existing lifetime management strategies for electrical engineering components.

## **CONTROL AND INSTRUMENTATION**

35. Reference 18 presents the ONR control and instrumentation review of the HYA/HRA PLEX submission. Throughout the review, the inspector considered the ability of the proposed arrangements and plans to ensure safe on-going operations, beyond original design life of safety systems important to safety.
36. To a large extent, the control and instrumentation systems were claimed by NGL to be replaceable and therefore not considered to present a direct threat to achieving extended lifetimes. Maintaining reliable operation will however require significant resource and investment. The main ageing and degradation issues were associated with obsolescence, cost and potential increased dose burden on maintenance staff, rather than the technical feasibility of repair/replacement.
37. The inspector reviewed the LTR areas with relevance to control and instrumentation:
  - Thermocouples
  - Neutron Flux Detectors
  - Vibrating Wire Strain Gauges
  - Data Processing and Control System
38. Within the LSR the inspector identified and reviewed the following safety factors which were considered to be of greatest relevance to control and instrumentation:
  - SF2 - Actual Condition of Systems, Structures, Components Important to Safety
  - SF3 - Equipment Qualification
  - SF4 - Ageing and Lifetime Management
  - SF7 - Hazard Analysis
39. Based on sampling of the documentation, the inspector judged the Licensee's approach to the life time extension of HYA and HRA to be appropriate and found the reviewed documents fit for the purpose of describing the general framework of the PLEX project and identifying the significant safety issues.
40. However, the inspector judged significant benefit could be realised (in terms of nuclear safety and commercial risk reduction) by re-assessing equipment important to safety against the revised design life, re-enforcing suitably qualified experienced person (SQEP) capability and demonstrating a continued understanding of the type,

magnitude and frequency of the current and predicted hazards facing HYA and HRA, see Table 1.

## **FAULT STUDIES**

41. Reference 20 presents the ONR fault studies review of the HYA/HRA PLEX submission. The inspector reviewed the three PLEX reports; technical overview report, LTR and LSR, and also made use of a number of supporting safety cases and ONR assessments.
42. The inspector found that the overview report presented the fundamental structure of the HRA/HYA PLEX project and brief descriptions of key documents, main issues and planned work. The inspector considered that the document provided a systematic high-level description of the project and concluded that it broadly satisfied the applicable SAPs and presented a realistic picture of the numerous factors that affect HRA/HYA PLEX viability.
43. The LSR presented a review of the way NGL company processes were implemented at HRA/HYA regarding the goals of PLEX and PSR-3 and the inspector concluded that it provided useful support to the achievement of safety case objectives and compliance with modern standards.
44. The inspector's review of the LTR identified specific observations regarding the impact of plant ageing; boilers and graphite core, on the HYA/HRA fault studies that would need to be completed for PLEX substantiation. The inspector noted NGL's various research activities to address these issues, but the LTR did not identify a plan for updating the applicable computer codes and models.
45. Overall the inspector judged that the Licensee's approach to the potential life time extension of HYA/HRA power stations was broadly appropriate. He found the reviewed documents fit for purpose; describing the general framework of the PLEX project, identifying the significant safety issues and identifying the related work that needs to be carried out.
46. The inspector identified two areas where further information could have been provided, see Table 1.

## APPENDIX 2: SUMMARIES OF THE ONR SPECIALIST REVIEWS OF THE HEYSHAM 2 / TORNESS PLEX SUBMISSION

### CIVIL ENGINEERING

1. Reference 11 presents the ONR civil engineering review of the HYB/TOR PLEX submission. The inspector focused on the civil engineering structures covered in the PLEX submission; the PCPV, ponds and fuel storage buildings and also reviewed the ageing and degradation issues.
2. There were a number of the issues raised within the LTR which the inspector considered needed further work to address the PLEX aspirations:
  - Tendon grease sampling
  - Vibrating wire strain gauges
  - Unlined monitoring ducts
  - Rock anchor inspections
  - Groundwater ingress
  - PCPV wall bearings
3. The inspector reviewed the following Safety Factors (SF) within the LSR:
  - SF 1 – Plant Design
  - SF 2 – Actual Condition of Systems, Structures and Components Important to Safety
  - SF 4 – Ageing and Lifetime Management
  - SF 16 - Decommissioning
4. The inspector considered that processes to ensure nuclear safety, such as the Safety Case Health Review, were beneficial but they were threatened by emergent issues and the lack of resources.
5. Overall, the inspector judged that NGL's approach to the life extension of Torness and Heysham 2 power stations was appropriate although there are a number of items that should be addressed during the PSR3, see Table 2.

### STRUCTURAL INTEGRITY

6. Reference 13 presents the ONR structural engineering review of the HYB/TOR PLEX submission. The inspector concentrated on the non-replaceable structural steel components which were important to nuclear safety and also considered plant systems that were subject to significant ageing and degradation which affect nuclear safety. Structural integrity aspects concerning graphite or civil engineering structures were excluded. The inspector utilised the three references supplied by NGL and information gained during routine inspection and assessment activities.
7. The inspector considered a number of areas required additional work to meet the PLEX aspirations through the future PSR3 submissions. These included:
  - Breakaway oxidation of the 9% chrome boiler tube sections.
  - Carbon deposition.
  - Pitting corrosion on the decay heat boilers
  - High temperature creep.
  - High temperature behaviour of austenitic stainless steel assessment programme

8. The inspector noted that the condition of material on plant and the management of the corrosion in components such as buried, trenched and lagged pipework and tanks was not considered as part of the PLEX submission, but judged that this aspect required significant investment in order to support NGL's PLEX aspirations.
9. Overall, the inspector was broadly satisfied with NGL's approach to assessing the feasibility of plant life extension at Heysham 2 and Torness power stations. The documents did not highlight anything which caused any current safety concern. The inspector noted a number of technical areas that ONR should seek to continue to engage with NGL, see Table 2.

#### **GRAPHITE CORE INTEGRITY**

10. Owing to higher priority graphite assessment work, the review of the HYB/TOR PLEX submission has yet to be completed. Any observations will be passed on to NGL when this is done.

#### **MECHANICAL ENGINEERING**

11. Reference 16 presents the ONR mechanical engineering review of the HYB/TOR PLEX submission. The inspector established that the PLEX submission made limited reference to mechanical engineering-related SSCs important to safety. Accordingly the assessment report did not present an assessment of the NGL case, but a review of the case to confirm the validity of the assumptions and appropriateness of the case as a basis for PSR3.
12. The inspector reviewed the ability of the proposed arrangements and plans to ensure safe on-going operations, beyond original design life of safety significant systems such as:
  - Fuel route equipment (fuelling machine)
  - Cooling systems (gas circulators)
  - Emergency generation equipment
13. The inspector considered that, from a mechanical perspective, the main issues facing Heysham 2 / Torness were obsolescence and spares, failure and ageing of plant equipment, and carbon deposition. There were two ongoing ONR interventions underway at the time, fuel route and carbon deposition, which will continue to monitor the progress and effectiveness of work undertaken.
14. The inspector reviewed the following safety factors in the LSR from a mechanical engineering perspective:
  - SF2 - Actual condition of systems, structures, components important to safety
  - SF3 - Equipment qualification
  - SF4 - ageing and lifetime management

and found that there was sufficient commentary on how safety would be demonstrated for stations operating beyond their existing design life and considered the use of the IAEA safety factors appropriate and provided a clear structure for the case. The inspector accepted the Licensee's position that the majority of mechanical equipment was not life limiting, and that due to its replaceable nature, it represented a commercial rather than a nuclear safety risk.
15. The inspector judged the LTR adequately identified the safety significant technical issues facing Heysham 2 and Torness and was satisfied that sufficient work was been

undertaken to address the identified risks as the stations move beyond their original design life.

16. Based on sampling of the documentation, the inspector judged the Licensee's approach to the life time extension of Heysham 2 and Torness power stations to be appropriate and found the reviewed documents fit for purpose in describing the general framework of the PLEX project and identifying the significant safety issues. A number of items were identified during the review which NGL should consider during the production of PSR3, see Table 2.

## **ELECTRICAL ENGINEERING**

17. Reference 17 presents the ONR electrical engineering review of the HYB/TOR PLEX submission. The inspector noted that the proposed plant life extension reviews for HRB/TOR focussed on the irreplaceable components, mainly graphite cores and boilers and consequently electrical engineering components had not been extensively considered as part of the PLEX process.
18. The electrical engineering components were considered to be replaceable and, therefore, are covered by other NGL lifetime management strategies for example, Maintain Design Intent and system safety reviews; the outcomes of these are used to inform the plant safety reviews.
19. In carrying out the PLEX submission review the inspector did not review any of the reports relating to the other NGL lifetime management strategies. However, the inspector has over the past several years inspected the electrical systems, and sampled the application of NGL lifetime management strategies for electrical engineering components, at the sites. The inspector was content with NGL's lifetime management strategies for electrical engineering components.
20. The inspector's assessment of the PLEX reports for HYB/TOR did not identify any electrical engineering issues that had not already been identified by NGL from the application of its existing lifetime management strategies for electrical engineering components.

## **CONTROL AND INSTRUMENTATION**

21. Reference 19 presents the ONR control and instrumentation review of the HYB/TOR PLEX submission. Throughout the review, the inspector considered the ability of the proposed arrangements and plans to ensure safe on-going operations, beyond original design life of safety systems important to safety.
22. To a large extent, the control and instrumentation systems were claimed by NGL to be replaceable and therefore not considered by NGL to present a direct threat to achieving extended lifetimes. Maintaining reliable operation will however require significant resource and investment. The main ageing and degradation issues were associated with obsolescence, cost and potential increased dose burden on maintenance staff, rather than the technical feasibility of repair/replacement.
23. The inspector reviewed the LTR areas with relevance to control and instrumentation:
  - Thermocouples
  - Neutron Flux Detectors
  - Vibrating Wire Strain Gauges
  - Data Processing and Control System

24. The inspector also identified the fuel route as an area which may prove challenging to keep operational due to a substantial number of items that have the potential to cause a threat due to the extreme difficulty in their repair or replacement and whose failure could have nuclear and radiological safety consequences if incorrectly managed. Dealing with these hazards and maintaining reliable operation will require significant resource and investment as fuel route plant will be required to operate for up to eight years following final shutdown while fuel is removed from the reactors and subsequently processed.
25. Within the LSR the inspector identified and reviewed the following safety factors which were considered to be of greatest relevance to control and instrumentation:
  - SF2 - Actual Condition of Systems, Structures, Components Important to Safety
  - SF3 - Equipment Qualification
  - SF4 - Ageing and Lifetime Management
  - SF7 - Hazard Analysis
26. The inspector was satisfied that the LSR provided sufficient commentary on how safety will be demonstrated for stations operating beyond their existing design life. Use of the IAEA safety factors had been appropriately used and provided a clear structure for the case. The inspector also accepted the Licensee's position that the majority of control and instrumentation equipment was not life limiting, and that due to its replicable nature, it represents a commercial rather than a nuclear safety risk.
27. Based on sampling of the documentation, the inspector judged the Licensee's approach to the life time extension of Heysham 2 and Torness power stations to be appropriate and found the reviewed documents fit for the purpose of describing the general framework of the PLEX project and identifying the significant safety issues. A number of items were identified during the review which NGL should consider during the production of PSR3, see Table 2.

## **FAULT STUDIES**

28. Reference 21 presents the ONR fault studies review of the HYB/TOR PLEX submission where the inspector reviewed the three PLEX reports; technical overview report, lifetime technical review and lifetime safety review.
29. The inspector found that the overview report presented the fundamental structure of the HYB/TOR PLEX project and brief descriptions of key documents, main issues and planned work. The inspector considered that the document provided a systematic high-level description of the project and concluded that it broadly satisfied the applicable SAPs and presented a realistic picture of the numerous factors that affect HYB/TOR PLEX viability.
30. The inspector considered that none of the issues identified in the LSR directly related to the faults studies area, however, noted that the recommended work on the issues identified under safety factor 1 (Plant Design) could eventually lead to modification of the HYB/TOR fault schedule and performance of additional fault studies to be presented within PSR3. The inspector concluded that the LSR provided useful support to the achievement of safety case objectives and compliance with modern standards.
31. The inspector's review of the LTR identified specific observations regarding the impact of plant ageing; boilers and graphite core, on the HYB/TOR fault studies that would need to be completed for PLEX substantiation. The inspector noted NGL's various research activities to address these issues, but the LTR did not identify a plan for updating the applicable computer codes and models.

32. Overall the inspector judged that the Licensee's approach to the potential lifetime extension of HYB/TOR power stations was broadly appropriate. He found the reviewed documents fit for purpose; describing the general framework of the PLEX project and identifying the significant safety issues.
33. The inspector identified an area where further information could have been provided, see Table 2.