Office for Nuclear Regulation

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Boiler spine recovery project

Heysham Reactor 1 - Extended three quadrant operation safety case considering defect in 1D1 boiler spine, EC 354024 002 proposal version 02

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EXECUTIVE SUMMARY

Title

Extended three quadrant operation safety case considering defect in 1D1 boiler spine as presented in engineering change (EC) 354024 002 proposal version 02.

Permission Requested

EDF Energy Nuclear Generation Ltd (NGL), the licensee of Heysham 1 power station, has requested that the Office for Nuclear Regulation (ONR) agree to the implementation of "Heysham reactor 1: Extended three quadrant operation safety case considering defect in 1D1 boiler spine", EC354024 002 proposal version 02.

Background

The reactors at Heysham 1 and Hartlepool power stations are currently operating at reduced power following the discovery of a defect in one of the eight boiler spines at Heysham 1 reactor 1. The defect, located at weld 12.3 was discovered during in-vessel inspections of the boiler spine. Inspections were undertaken during August 2014 following suspect indications revealed during routine guided wave testing of the boiler spine during the 2013 statutory outage.

The boiler design used in the Heysham and Hartlepool reactors consists of eight pod boilers, grouped into four zones, designated A, B, C, and D quadrants. Each of the four quadrants contains two pod boilers identified as pod boiler one and pod boiler two. The identified defect was found on D quadrant, pod boiler one (1D1).

The pod boiler design is based on a central multi-section spine that supports the boiler pipe-work. The material selection for each of the spine sections is determined by temperature profiles along the length of the spine. The spine sections are welded together to form a single rigid component. It was within one of the section welds (weld 12.3) that the defect was identified.

Heysham 1 reactor 1 returned to operation on 9^{h} January 2015 following assessment of a revised low power safety case. Under the safety case, return to service was limited to three quadrant operations, with pod boilers 1D1 and 1D2 isolated, stored dry and filled with nitrogen.

Operation was subject to further power limitations to ensure that the temperature at other weld 12.3 locations on the other spines was reduced by ~40°C, mitigating the risk of further weld failures. The safety case was time limited, and justified operation of Heysham 1 reactor 1 to the planned 2015 refuelling outage.

NGL has prepared an extension to the original safety case proposing to extend operation of Heysham 1 reactor 1 beyond the 2015 refuelling outage. Operating conditions remain unchanged with the reactor operating at reduced load and running on three quadrants. The proposed safety case remains time-bound, justifying a maximum operating period of three years from the current, September 2015 re-fuelling outage to the next statutory outage in spring 2017.

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

The ONR project inspector and ONR specialist inspectors have sampled the safety case along with the arrangements for implementation at Heysham 1 reactor 1.

Assessment has been undertaken by ONR specialist structural integrity and fault studies assessors. Additional support has been provided to these regulatory judgements by input from civil engineering and probabilistic safety assessment specialists.

I have made use of the completed assessments as well as reports and records from the original 2014 three quadrant, low power case safety case to form a regulatory judgement on the proposed activity.

Matters arising from ONR's work

Assessment work has been completed in line with ONR guidance. The conclusions of the specialist assessors are summarised below:

Structural integrity

- Quality of build records presented do not alter the original claim on random boiler spine failure frequency and that a frequency of infrequent failure remains unchanged for the duration of the proposed extended operation period for Heysham 1 reactor 1.
- Guided wave tests (GWT)to demonstrate the integrity of key butt welds of the boiler spines are important to support the proposed activity, and that the proposal recognises the importance of the offline GWT inspections which does not seek to amend the frequency or scope of these inspections.
- Proposed changes to operating conditions are unlikely to affect the judgements made previously by ONR for gas circulator integrity associated with the isolated boilers in D quadrant.

Civil Engineering

- Issues associated with cracked direct contact heater steel-work are being appropriately managed by NGL.

Fault studies

- Extension of the case to multiple three quadrant start-ups and shutdowns and for shutdown periods post three quadrant operation remain acceptable.
- Licensee's judgement that there would be no significant adverse impact of extended three quadrant operation on fuel handling activities is valid.

Probabilistic safety analysis

- Claims made by NGL on probabilistic analysis of boiler tube failure rates are reasonable and remain tolerable.

No safety significant matters have been raised by any of the specialist inspectors in respect to the proposed activity.

Conclusions

This report presents the findings of assessment of the EDF NGL safety submission "Heysham reactor 1: Extended three quadrant operation safety case considering defect in 1D1 boiler spine, EC 354024 002 version 02".

Assessments undertaken by ONR specialist inspectors have raised no nuclear safety significant issues which would preclude the issuing of a licence instrument agreeing to the proposed activity.

Recommendations

Based on the assessment of the specialist inspectors and on the review of the safety case undertaken within this project assessment report, the following recommendations are made.

The superintending inspector should:

- Sign this project assessment report, confirming support for the ONR technical and regulatory arguments used to justify issuing Heysham 1 reactor 1 licence instrument 593.

- Sign this project assessment report approving its release for publication, after redaction where appropriate.
- Sign Heysham reactor 1 licence instrument number 593.

LIST OF ABBREVIATIONS

1D1	Reactor 1, quadrant D, pod boiler 1 (location of known defect)
ALARP	As low as reasonably practicable
CLA	Component life assessment
DC	Direct contact (type of heating arrangement)
EC	Engineering change
ECT	Eddy current testing
GWT	Guided wave technology
HOW2	(Office for nuclear regulation) Business management system
HRA	Hartlepool power station
HYA	Heysham 1 power station
LARC	Life assessment reference component
LC	Licence condition
LI	Licence instrument
NGL	EdF Energy Nuclear Generation Limited
ONR	Office for nuclear regulation
OSRC	Operational safety review committee
PAR	Project assessment report
PSA	Probabilistic safety assessment
SAP	Safety assessment principle(s)
SFAIRP	So far as is reasonably practicable
SSC	Structure, system and component
TAG	Technical assessment guide (ONR)

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1 PERMISSION REQUESTED

1 EDF Energy Nuclear Generation Ltd (NGL) , the licensee of Heysham 1 (HYA) power station, has requested *(Ref. 1)* that the Office for Nuclear Regulation (ONR) agree to the implementation of "Heysham reactor 1: Extended three quadrant operation safety case considering defect in 1D1 boiler spine", EC354024 002 proposal version 02 *(Ref.2).*

2 The request has been made in accordance with HYA arrangements to comply with Licence Condition (LC) 22(1) "Modifications or experiment on existing plant". This project assessment report (PAR) considers ONR's assessment of NGL's safety case and the readiness of the site to implement it. The purpose of the PAR is to inform the regulatory judgement on whether an 'agreement' should be granted for the proposed activity.

2 BACKGROUND

3 The reactors at HYA and Hartlepool (HRA) are currently operating at reduced power following the discovery of a defect in one of the eight boiler spines at HYA reactor 1. The defect, located at weld 12.3 was discovered during in-vessel inspections of the boiler spine undertaken during August 2014. The inspections were undertaken following suspect indications revealed during routine Guided Wave Testing (GWT) of one of the boiler spines during the 2013 statutory outage.

4 In light of this anomaly, NGL presented a safety case to justify a limited period of reactor operation of HYA reactor 1 (six months) with the D boiler quadrant isolated, with both boiler pods in this quadrant stored dry with a nitrogen atmosphere.

5 Following further non-destructive testing in July 2014, a crack (~475mm long, circa 25% spine circumference) was identified near one of the boiler spine weld locations. NGL took the decision in August 2014 to shut down the operating reactors at HYA and HRA to allow further investigations on all of the boiler spines in each of the four reactors. This decision was supported by ONR.

6 The HYA / HRA boiler design consists of eight pod boilers, grouped into four zones, designated A, B, C, and D quadrants. Each of the four quadrants contains two pod boilers identified as pod boiler one and pod boiler two. The identified defect was found on D quadrant, pod boiler one (1D1).

7 The pod boiler design is based on a central, multi-section spine that supports the boiler pipe-work. Material selection for each of the spine sections is determined by temperature profiles along the length of the spine. The spine sections are welded together to form a single rigid component. It was within one of these section welds (weld 12.3) that the defect was identified on 1D1.

8 NGL's analyses and investigations identified that the nuclear safety risk for an operational reactor with the boiler spine design is dominated by boiler spine failure which could result in a drop of the boiler, potentially resulting in failure of the boiler tubes. NGL also determined that high temperature is a significant contributing factor to the crack identified on HYA reactor 1 boiler spine 1D1, which has been attributed to creep crack growth damage during operational service.

9 HYA reactor 1 returned to operation on 9th January 2015 following assessment *(Ref. 3)* of a revised low power safety case EC354024 rev 000 *(Ref. 4).* The safety case justified the return to service limited to three quadrant operations, with pod boilers 1D1 and 1D2 isolated, stored dry and filled with nitrogen.

10 Operation was subject to further power limitations to ensure that the temperature at the other weld 12.3 locations on the other spines was reduced by ~40°C, mitigating the risk of further weld failures. The safety case was time limited, and justified operation of reactor 1 to the planned 2015 refuelling outage.

11 Revision 001 of the case was prepared by NGL following a delay to the refuelling outage, allowing for a further two months operation under the conditions set out within the original case (EC354024 rev 000). ONR took the decision not to permission this pre-refuelling extension based on the limited duration of operation beyond that set out in the revision 000 case.

12 NGL has now prepared a revision 002 *(Ref. 2)* of the case proposing to extend operation of Heysham 1 reactor 1 beyond the 2015 refuelling outage. Operating conditions remain unchanged with the reactor operating at reduced load and running on three quadrants. The proposed safety case remains time-bound, justifying a maximum operating period of three years from the current, September 2015 re-fuelling outage to the next statutory outage in spring 2017.

3 SUMMARY OF LICENSEE'S SAFETY CASE

13 EC354024 revision 002 presents NGL's justification for return to service of HYA reactor 1 on reduced power, three quadrant operations, with pod boilers 1D1 and 1D2 isolated and stored dry in nitrogen. The case is time limited to allow operation to the 2017 statutory outage, and cannot exceed three years.

14 The case has not been set out in the traditional claims, argument and evidence format. Instead, NGL has relied upon the original safety case (Rev 000) and presents improved understanding of the boiler spine risk position, justifying the proposed three year operating period.

3.1 STRUCTURAL INTEGRITY

15 From a structural integrity perspective, the case presents the following arguments:

- Quality of build – increased confidence in the parent / weld material and absence of any other 'buttered welds[3]' beyond that discovered in weld 12.3 of spine 1D1.
- Guided wave technology (GWT) – use of the GWT inspection technique provides capability to identify defects in the spine structure once they reach a minimum detection size.
- Pressure boundary structural integrity – further work has been undertaken to justify the infrequent claim of failure of a boiler spine leading to a failure of the gas circulator penetration.

3.2 PREVIOUS COMMITMENTS

16 The safety case provides commentary and an update on progress and completion of the six commitments, raised as part of the original revision 000 of the safety case.

3.3 OPERATING EXPERIENCE

17 An operational safety review committee (OSRC) was completed in June 2015 that considered part power operations at HYA since return to service (7th January). The OSRC reported no significant issues specific to three quadrant operation, but highlighted some minor issues, identifying actions to be completed as part of the routine OSRC process; these issues relate to:

[3] Weld buttering is the process of deliberately building up weld material. In this instance, buttering is a non-specified operation and has potential to significantly affect the micro-structure of the parent metal.

- Boiler stability and performance;
- Cracking of direct contact (DC) heater supports.[4]

3.4 UPDATED TRANSIENT DATA

18 A weakness in the post trip cooling capability following a spine failure was identified in the revision 000 case *(Ref. 4*). NGL undertook a fault studies sensitivity analysis to address this shortfall. The output of the analysis is summarised within the proposal and covers three main areas as follows:

I. *Use of one quadrant emergency boiler feed with pressure support from reserve on-site carbon dioxide supplies, but without forced gas circulation, remains capable of controlling fuel and structural temperatures.*

19 *Reference 2* however notes that emergency boiler feed may no longer be available following an infrequent seismic event and as such is not claimed. Based on this potential shortfall, analysis is also presented based on a single quadrant of high pressure back up cooling:

II. *A single quadrant of high pressure back up cooling system and pressure support without forced gas circulation controls both fuel and structural temperatures with one exception. The core restraint differential temperature limit would be exceeded by 12°C.*

20 *Reference 2* goes on to state that, if a more realistic limit of 182°C is applied, then a margin of 10°C is expected. Results of a further study are presented within the safety case, considering whether at reduced temperatures, the gas circulator pony motors would be sufficient to cool the reactor post trip. The study concluded that:

III. *Cooling capability of gas circulators operated on pony motors (low speed), with no pressure support beyond that provided by the carbon dioxide purge into two quadrants was considered.*

21 The conclusion was that at reduced temperatures, this mode of operation could control fuel and structural temperatures provided the pony motors were initiated within three hours, and the carbon dioxide purge within 30 minutes.

3.5 FAULT STUDIES

22 Other aspects of the safety case presented as evidence for extended three quadrant operation break down into the areas of fault studies and probabilistic safety analysis (PSA). These points are summarised below:

- Assessed boiler tube failure rate limits – Quadrant D is currently isolated and left dry, with a nitrogen purge. Post trip cooling capacity is therefore only available from the three operating quadrants (six pod boilers). The case presents evidence that the derivation of more restrictive limits is sound, and the limits will not be breached within the proposed three year operating period.
- Impact of extended three quadrant operation on fuel handling activities. As a result of operation at reduced power, dwell time of fuel stringers to reach their target discharge irradiation level will increase. Dwell times could be extended significantly beyond the typical duration of five years.
- Review of the ‘as low as reasonably practicable’ (ALARP) position statement – Revision 000 of the safety case based the ALARP position on a period of 8 months operation. A qualitative and quantitative review of the ALARP position in support of extended three quadrant operations has been presented for the three year period. NGL considers the increase to be ALARP when balanced against the benefits accrued from generation

[4] It is NGL’s view that the cracking of the DC heater supports is due to vibrational stress associated with three quadrants, low power operations

23 The ONR fault studies assessment and findings are summarised in *section 5.2* below.

3.6 GENERIC 3 QUADRANT CASE

24 A generic three quadrant operating safety case has also been produced by NGL. The updated HYA specific case (Revision 002) references the generic case throughout. ONR has taken the decision to assess these cases separately due to the wider reaching implications that the generic case may present.

25 ONR has not at this time assessed the NGL generic three quadrant case *(Ref. 5)*. Assessment of the HYA specific case has therefore been undertaken with little reference to the generic case.

26 Although ONR has not fully assessed he generic case, the HYA case relies on the following elements:

- The generic case sets out a justification for safe operation of the HYA and HRA reactors running on three quadrants for periods up to 30 days..
- Beyond the 30 day operating period, the generic case presents three extension issues. The issues outline the proposed claims, arguments and evidence structure that should be adopted to demonstrate safe operation of HYA and HRA reactors running on three quadrants for durations in excess of 30 days.

27 These extension issues are used within the HYA reactor 1 specific case and are discussed in more detail within *sections 5.1.1 & 5.2.4* below.

4 ASSESSMENT WORK CARRIED OUT IN CONSIDERATION OF THIS REQUEST

28 In order to form a view on the adequacy of the safety case presented in support of the safety case, ONR has undertaken assessment, led by the following specialisms:

- Structural Integrity *(section 5.1)*
- Fault Studies *(section 5.2)*

29 These assessments have been supported by additional assessment provided by the following specialisms:

- Civil Engineering *(section 5.1.3)*
- Probabilistic Safety Analysis *(section 5.2.4)*

5 ONR ASSESSMENT OF THE PROPOSED ACTIVITY

5.1 STRUCTURAL INTEGRITY

5.1.1 EXTENSION ISSUES

30 As discussed in *section 3.6* above, the generic three quadrant case set out three ‘extension issues’ that should be addressed prior to operation of any of the reactor at Heysham 1 or Hartlepool for periods in excess of 30 days.

31 **Extension issue 1** recommends that a review should be undertaken to consider the life assessment reference component set temperature assessment for any previous periods of three quadrant operation. This should ensure continued compliance against the assumptions of the case.

32 The specialist structural integrity assessor has previously reviewed the component life assessment (CLA) process and use of life assessment reference component (LARC)

sets for other AGR structural integrity safety cases, which they judged to be adequate for managing the structural integrity of key reactor internal components. The specialist structural integrity assessor is satisfied that the CLA process and the LARC set selected for HYA reactor 1 is sufficient, from a structural integrity perspective, to support the proposed activity.

33 **Extension issue 2** states that, where extended three quadrant operation is required, a review of the current accrued damage and proposed operational period should be reviewed. The safety case identifies that, during reduced power operations, the risk of oxidation of the feed restrictor tubes on the isolated boiler is increased. A review of the oxidation predictions of the feed restrictor tubes, states that isolation of 1D quadrant for 3.75 years is acceptable.

34 The specialist structural integrity assessor accepts the licensee's arguments for a 3.75 year safe operating period. This period of time bounds the proposed extended period of three quadrant operation at low power. Additional work to support this extension issue has also been completed by the licensee in accordance with Commitment 1 of *Reference 3.*

35 **Extension issue 3** is not relevant to structural integrity and is discussed further in *section 5.2.4* below.

5.1.2 STRUCTURAL INTEGRITY SPECIFIC ARGUMENTS

36 **Quality of build:** It is the judgement of the ONR structural integrity assessor that information provided in respect the quality of build records is for information purposes only. It does not provide substantive evidence to strengthen the claims already presented in *Reference 3*.

37 Whilst uncontrolled buttering as seen on 1D1 weld 12.3 is unlikely to be widespread, it cannot be fully discounted. Updated review of the quality of build records presented in *Reference 2* do not, in the ONR structural integrity assessors view, alter the original claim on random boiler spine failure frequency.

38 **Guided wave testing:** The ONR structural integrity assessor is satisfied that the proposed activity does not seek to amend the frequency or scope of guided wave testing. It remains the expectation of the ONR structural integrity assessor that GWT will be completed on all boiler spines at HYA R1 during all shutdown periods as discussed in *Reference 2*.

39 The structural integrity assessor recommended that the ONR boiler spine project inspector confirm that the licensee did not identify any anomalous GWT readings on the spine population of HYA reactor 1, with the exception of 1D1. I have received confirmation *(Ref. 10)* that the licensee has completed the required inspections with no anomalous results detected. I have discussed the results with the ONR structural integrity assessor who is satisfied that the recommendation is therefore complete.

40 **Pressure boundary:** The ONR structural integrity assessor judged that the proposed changes to operating conditions presented in *Reference 2*, will not affect the judgements made previously by ONR for gas circulator integrity associated with the isolated boilers in D quad. Therefore, the assessor is satisfied that the arguments presented in *Reference 4* remain valid for the period of extended operation proposed.

5.1.3 REVIEW OF PREVIOUS COMMITMENTS

41 The original three quadrant case (*EC 354024 000*) identified six commitments. These were necessary to improve the licensee's understanding of the defect discovered on 1D1 boiler spine and support the continued ALARP case for the three quadrant operation at HYA reactor 1.

42 The ONR structural integrity assessor judged that that adequate progress has been made by the licensee in managing these commitments. The assessor is further satisfied that the work completed has been in accordance with the original scope.

43 Following confirmation from NGL, the assessor is satisfied that all six of the commitments are now complete.

5.1.4 DIRECT CONTACT HEATERS

44 The direct contact (DC) heaters do not perform a direct nuclear safety function. The consequential effects following a failure, however, have the potential to affect systems that are required for nuclear safety, specifically the emergency boiler feed system. As a result of failure of the DC heater steel-work, the pipe-work associated with the de-aerator make-up route supplies to the reserve feed tanks can be affected. The reserve feed tanks supply is required by the three quadrant safety case as a second line of protection against infrequent (seismic) faults.

45 Earlier in 2015, cracks were identified on steel-work supporting DC heater stage 2. The specialist structural integrity assessor consulted with an ONR civil engineering assessor on the repairs and modifications carried out by NGL to address the issue.

46 Repair work associated with the secondary beam of reactor 1 - DC Heater Stage 2 has removed loading from the beam, transferring load back to the primary beam. The repair work has been designed assuming a vibration load that will need to be confirmed when the reactor is back on power.

47 With respect to the information presented regarding the event recovery of the DC heater steel-work, the ONR civil engineering assessor is satisfied that modifications made to the DC heaters stage 2 will seismically qualify them for a frequent seismic event.

48 This judgement is based on the satisfactory completion of the following commitments made by NGL:

- NGL to confirm vibration levels on the steelwork of DC Heaters Stage 1 & 2 and amend the calculations appropriately if the level of vibration is found to be higher than the level assumed.
- NGL to continue to monitor the performance of the DC Heater modifications to ensure that fatigue cracks are not developed. To this end, NGL should carry out routine inspections of the DC Heater steelwork.

49 Both these commitments refer to post re-start operation to measure and monitor the steel-work associated with the DC heaters. These recommendations will be tracked and updated as part of existing ONR *issues 3657* and *issue 3375* via the structural integrity and civil engineering assessors. Progress on the close out of these items will also be monitored by the nominated site inspector and boiler spine project engineer as part of on-going boiler spine recovery work.

5.2 FAULT STUDIES

50 A fault studies specialist assessment *(Ref. 8)* findings are summarised below:

5.2.1 UPDATED TRANSIENT ANALYSIS

51 The updated transient analysis presented in the case discusses a mitigation argument to address the potential vulnerability of the claimed line of protection, i.e. post trip cooling via forced gas circulation and high pressure back up cooling system feeds.

52 The specialist fault studies assessor obtained clarification that the high pressure back up cooling system is qualified to withstand the infrequent seismic event. The potential vulnerability to single failure is therefore in the gas circulator systems that provide forced gas circulation.

53 The transient analysis of natural circulation utilises well-established code for primary circuit modelling. The analysis route results appear credible in terms of numbers of fuel

pin failures and hence off-site radioactive release as in-service pin pressures would be lower for any given fault than for full power reactor operation.

54 The specialist fault studies assessor judged the updated transient analysis to be adequate to support the mitigation argument against vulnerability to single failure in the claimed line of protection, i.e. in forced gas circulation.

5.2.2 ADEQUACY OF ASSESSED BOILER TUBE FAILURE RATE LIMITS

55 This element of the case relies on two underpinning assumptions. Firstly the derivation of more restrictive limits, and secondly the demonstration that the more restrictive limits will not be breached within three years are soundly based. The derivation of more restrictive limits was assessed by a PSA Specialist Assessor *(section 5.2.4)*.

56 The assessment identified several points made in the statement that were judged by the assessor to provide confidence that the boiler tube failure rate would be low compared with the new, more restrictive boiler tube failure limits:-

- nine of the ten restricted tubes on HYA reactor 1 are located within quadrant D, and as such are isolated, and thus incapable of contributing to future boiler tube failure rates.
- review of operating experience showed no significant issues for HYA reactor 1
- the 2014 stress corrosion cracking[5] risk increase will be minimal and any increase due to additional wet tubes under three quadrant operations is insignificant.

57 Based on the above, the assessor accepts the claim that the new more restrictive boiler tube failure rate limits will not be breached in the three year period of three quadrant operation sought. The specialist fault studies assessor noted that the next triennial assessment of boiler tube failure rate due in early 2016 will take account of boiler conditions achieved during low power three quadrant operation and would give forewarning of any breach of limits.

5.2.3 EXTENDED THREE QUADRANT OPERATION ON FUEL HANDLING

58 The specialist fault studies assessor found that, whilst there is consideration of the impact of longer dwell times on fuel components in the generic three quadrant case, this consideration is limited to the dwell period itself. It excludes any impact on fuel discharge movements and passage through the fuel route.

59 The Licensee recognises that the dwell period would increase but judges that this would not lead to a significant change in risk. Failure would be revealed through normal operational monitoring and be addressed by an early discharge of the affected stringer.

60 It was also noted that other plug unit functions such as provision of a lifting load path are not affected by dwell period since loads on the plug unit are reduced whilst in the reactor; also the adoption of off-load depressurised refuelling means the plug units do not experience significant thermal transients during fuel handling.

61 The specialist fault studies assessor accepts the arguments put forward within the case and concludes that there would be no significant increase in fuel handling risks from adoption of a longer period of three quadrant operation.

5.2.4 REVIEW OF THE ALARP POSITION

62 In addition to the above fault studies work, additional assessment *(Ref. 9)* was provided by a specialist probabilistic safety analysis (PSA) assessor. This work is captured in assessing extension issue 3 as summarised below.

[5] Stress corrosion cracking is the growth of cracks formed in a corrosive environment. It can lead to unexpected and sudden failure of metals subjected to a tensile stress, especially at elevated temperatures.

63 **Extension Issue 3** states that, for periods of long term three quadrant operation the need for a more restrictive boiler tube leak frequency limit is recognised and any extension beyond normal maintenance must account for this revised limit in order to demonstrate risk is being maintained to ALARP.

64 As discussed in *section 5.2.2* above, the 2013 analysis assumed 30 restrictions, ten of which were current (nine were in the isolated D quadrant). HYA reactor 1 currently has only three restrictions and therefore the extant predictions were conservative and a review is scheduled for early 2016 to underpin this claim. NGL confirmed that good boiler performance had been maintained whilst operating on three quadrants at reduced power. NGL has confidence therefore that if the analysis were re-run, failure rates would not change significantly. Tube damage is predicted to reduce by a factor of 0.75 and on this basis, NGL have confidence that the revised safety case limit would be met.

65 The ONR PSA assessor is content that, for three quadrant operation of HYA reactor 1, the revised boiler tube safety case limits of 0.08 tube failures per year (pry) and 0.04 pry reflect suitable best estimate initiating event frequencies. On this basis, the contribution to the frequency of a Dose Band 5[6] event would remain at the level justified in the original safety case *(Ref. 4*).

66 The contribution to risk from boiler tube leaks whilst operating on three quadrants is assessed to be slightly higher than that predicted in the original safety case. This is due to changes in initiating event frequencies and the inclusion of random tube failure followed by post-trip failure in two of the three quadrants. This fault sequence places reliance on only one quadrant for post-trip cooling. Assuming the increase from other plant faults such as reactor trip frequency as a result of three quadrant operations remain the same, then the ONR PSA assessor judges the overall increase remains tolerable, SFAIRP.

6 ONR PROJECT INSPECTOR'S REVIEW OF LICENSEES SAFETY CASE

67 On 28th October 2015, the Station Director of HYA wrote to ONR *(Ref.1)* under HYA's LC22 (1) arrangements requesting Agreement to the return to service of HYA reactor 1 at reduced power and operating on three out of the four boiler quadrants for a period of three years to the next statutory outage in 2017.

68 The ONR process for delivering a permissioning project requires preparation of a PAR to facilitate a permissioning decision by the superintending inspector with the appropriate delegated authority. The PAR is prepared in accordance with ONR guidance document: *Guidance on the Production of Reports - NS-TAST-GD-084, Rev 8 (Ref. 13)* and is informed by the assessment findings of specialist inspectors assigned to the project.

69 To enable ONR to undertake its assessment process in parallel with NGL's own internal processes, ONR has maintained open dialogue via regular telephone conferences and meetings between ONR and NGL throughout the project.

70 I have considered NGL's request for ONR to Agree to the implementation of NGL's Safety case submission *(Ref. 2)*, as part of my role as ONR project inspector assigned to this case. I have followed ONR procedures for delivering a permissioning project, as detailed in *ONR's Business Management System (HOW2) (Ref. 11)*.

6.1 INDEPENDENT NUCLEAR SAFETY ASSESSMENT

71 NGL's internal regulator, Independent Nuclear Assurance (INA) undertook an independent nuclear safety assessment (INSA) of the case and found no significant

[6] Dose band 5 relates to the frequency of an accident that could lead to an off-site release, with dose consequence greater than 1Sv to the public [see Target 8 of the SAPs *(Ref 15*)].

issues, issuing an INSA certificate on 11 September 2015. Key points raised as part of INA's assessment are as follows:

- The case builds on the previous revisions of EC354024, addressing spine integrity aspects and demonstrated tolerance to single & multiple spine failure.
- The lessons learnt from the previous period of three quadrant operation on HYA reactor 1 were captured or were in the process of being addressed.
- Where further work was identified in previous revisions or related safety cases to remove uncertainties and/or reduce station risk, this has either been completed or is progressing as quickly as is reasonably practicable.
- The increased risks associated with operating HYA reactor 1 on three quadrants for a maximum period of three years (or up to the next statutory outage whichever is the sooner) are judged to be ALARP.

72 As part of the assessment process, the ONR specialist assessors have reviewed the INSA certificate and associated commentary *(Ref. 2).* Based on the specialist's assessment of the INSA certificate and commentaries, and my own review of the documents, I am satisfied that NGL has followed its arrangements and the internal, independent assessment is adequate.

6.2 NUCLEAR SAFETY COMMITTEE

73 I have reviewed the arguments set out within the case for categorisation of the EC. I am satisfied that NGL's categorisation of the engineering change is appropriate. As the case was presented at category 2, EC354024 000, version 02 was not presented at nuclear safety committee.

74 I conclude that NGL's due process for the presented safety cases has been completed to an adequate standard. Integrated intervention strategy ratings of 3 – Adequate have been awarded by the specialist inspectors in terms of the quality of the safety case submission which I concur with.

7 CONCLUSIONS

75 This report presents the findings of assessment of the NGL safety submission "Heysham reactor 1 - Extended three quadrant operation safety case considering defect in 1D1 boiler spine, EC 354024 002 version 02".

76 Assessments undertaken by ONR specialist inspectors have raised no nuclear safety significant issues which would preclude the issuing of a licence instrument agreeing to the requested activity.

8 RECOMMENDATIONS

77 Based on the assessment of the specialist inspectors, and on the review of the safety case undertaken within this PAR, three recommendations have been raised. Recommendation 1 has been closed out within this document, with recommendations 2 & 3 requiring longer term resolution, beyond this PAR. These will be monitored appropriately as discussed in *section 5.1.4*.

78 The recommendations are captured in Table 1.

79 On the basis that all matters have been addressed, it is the recommendation of this PAR that the superintending inspector should:

- sign this project assessment report, confirming support for the ONR technical and regulatory arguments used to justify issuing Heysham 1 reactor 1 licence instrument 593;
- sign this project assessment report approving its release for publication, after redaction where appropriate;
- sign Heysham 1 reactor 1 licence instrument number 593.

9 REFERENCES

1. *NGL letter of request: Heysham reactor 1: Heysham reactor 1: Extended three quadrant operation safety case considering defect in 1D1 Boiler spine - EC354024 002 - dated 21st October 2015 – NSL/HYA/50780 (TRIM:* 2015/411462*)*
2. *NGL Engineering Change proposal No EC 354024 002 version 02 (TRIM: 2015/362920)*

   a) Heysham 1 reactor 1: Extended three quadrant operation safety case considering defect in 1D1 Boiler spine

   b) associated INSA certificate
3. *ONR project assessment report for assessment of EC354024 000 – ONR-HYA-PAR-15-025 (TRIM: 2015/1490)*
4. *NGL engineering change proposal No EC 354024, rev 000, version 03 – Interim safety case for return to service on 3 quadrants following discovery of a defect in 1D1 boiler spine. (TRIM: 2014/470581).*
5. *NGL engineering change proposal No EC 353161 (HYA) & 353142 (HRA) – Safety case for operation of the reactors at Heysham 1 and Hartlepool power stations with 3 quadrants of boilers operating (TRIM: 2015/362920)*
6. *ONR structural integrity assessment report – ONR-HYA-AR-15-049 (TRIM: 2015/394224*
7. *ONR civil engineering assessment note (TRIM: 2015/393382)*
8. *ONR fault studies Assessment Report – ONR-HYA-AR-15-057 (TRIM: 2015/363507)*
9. *ONR probabilistic safety analysis assessment note (TRIM: 2015/399071)*
10. *NGL Guided wave testing results and SQEP interpretation (TRIM: 2015/405762)*
11. *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
12. *Purpose and Scope of Permissioning - NS-PER-GD-014 Rev 4*
13. *Guidance on the production of Reports - NS-TAST-GD-084, Rev 8*
14. *Peer Review for Technical Assurance NS-TAST-GD-085, Rev 4*
15. *Safety Assessment Principles for Nuclear Facilities*. 2014 Edition Revision 0. November 2014. http://www.onr.org.uk/saps/saps2014.pdf.