Office for Nuclear Regulation

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Site:	Heysham 1		
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Role	Name	Position	Signature	Date
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Boiler spine recovery project

Consent to the modification: NP/SC 7728 Heysham 1 Reactor 2 - boiler spine structural integrity safety case & justification for return to full power following implementation of the spine cooling modification, EC No: 355061, Version No: 005

Project assessment report ONR-HYA-PAR-15-017
Revision 0
27th November 2015

EXECUTIVE SUMMARY

Permission Requested

This report presents the justification to issue consent under Licence Condition 22(4) for EdF Energy Nuclear Generation Ltd (NGL) to implement the safety case “NP/SC 7728 Heysham Reactor 2 - boiler spine structural integrity safety case & justification for return to full power following implementation of the spine cooling modification, EC No: 355061, Version No: 005”.

It is noted that, whilst the safety case as presented refers to full power operations, the letter of request specifically states that the licensee will self-impose a restriction of 10°C below the full power operating condition. This restriction is controlled through compliance arrangements associated with the full power safety case “Compliance arrangements for boiler spine weld temperatures (EC256499, version 003)”. As per NGL’s letter of request, any change to the 10°C reduction in weld 12.3 temperature, or to the way that the 10°C is achieved must be agreed by ONR prior to implementation.

Background

The reactors at Heysham 1 and Hartlepool 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 defects were judged by NGL to be affected by the operating temperature. NGL demonstrated that by reducing the temperature of the weld site; the crack growth mechanism could be effectively reduced. This temperature reduction has, to date, been delivered by operating the reactors at reduced power. However, NGL made a commitment to identify longer term solutions to the problem, including development of a cooling modification to reduce weld 12.3 temperatures. The cooling modification was installed on Heysham reactor 2, during the 2015 statutory outage, and the reactor returned to reduced power operation under existing arrangements. No benefit was claimed for the cooling modification at that time.

Thermal modelling work undertaken by NGL to substantiate the effectiveness of the cooling modification has also progressed. This work looks at the ability of the installed cooling modification to act as a surrogate for the reduced operating power and provide necessary temperature reduction to the weld 12.3 site without de-rating the reactor. The thermal modelling work, supported by new analysis and arguments that any defect would become apparent through periodic inspection before reaching a critical size (forewarning of failure arguments) have been presented within a new safety case *NP/SC 7728*.

Due to the complex and novel nature of the arguments made within the case, ONR took the decision to permission the activity utilising a flexible permissioning strategy, which included the use of primary powers. ONR included a specification that NGL shall not proceed with the implementation of the safety case without the consent of ONR.

This Project Assessment Report (PAR) presents a summary of the assessment work undertaken by ONR and presents a recommendation on issuing the consent.

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

The ONR project inspector and ONR specialist inspectors have sampled NGL’s safety case and arrangements.

The specialist inspectors, in selected disciplines, have undertaken assessments and produced reports for each specialism. These reports have been used to underpin the decisions made within this project assessment report.

Matters arising from ONR's work

Structural integrity

Based on the review of the inspection techniques undertaken by NGL, the ONR structural integrity assessor accepts that the likelihood of further spines containing a similar uncontrolled welding technique (buttering), considered by NGL to be the cause of the spine defect, is low. The assessors notes however that the possibility of buttering on other spines cannot be excluded. The assessor is also satisfied that there is sufficient evidence to suggest that, at this point in time, there are no spines on Heysham 1 Reactor 2 in a similar condition to the one with the defect on Heysham 1 Reactor 1.

The forewarning of failure argument for buttered welds presented by NGL requires a temperature reduction of 10°C, local to the lower heat affected zone of weld 12.3 as compared to full power operation. The assessor reviewed the effect of this temperature reduction on the crack growth estimates and accepts that the 10°C reduction is sufficient, providing appropriate margin for forewarning of failure for both as-designed and buttered welds.

Fault studies

The fault studies assessor has consistently challenged the claim in *NP/SC 7728 version 003* that weld 12.3 temperatures can be calculated to within 8°C. NGL has accepted this, providing a revised uncertainty allowance of 15°C. Notwithstanding this, the fault studies assessor remains of the view that evidence from plant thermocouple measurements will be needed in order to support weld 12.3 calculated temperatures.

The original algorithm used to administer the 40°C temperature reduction imposed by the previous safety case has been shown by NGL to be limiting in terms of power. The same algorithm will not be used to operate the reactor with the required 10°C temperature reduction; this is in-line with the assessor's expectations. The assessor also notes that NGL will also use the new absolute temperature algorithm to confirm that weld 12.3 temperature remains below the 530°C limit. The assessor considers this to be a sensible check.

The fault studies assessor considers the level of protection available to mitigate the potential failure of a single boiler spine, both due to random failure and as a result of an infrequent seismic event to be adequate.

Probabilistic safety analysis (PSA)

Overall, the PSA assessor is satisfied that the overall risk to the public from operation of Heysham 1 Reactor 2 is at the level predicted before the defect on Heysham 1 Reactor 1 was identified and that assessment remains sufficiently conservative. The update to the Heysham and Hartlepool PSAs is covered by a separate ONR intervention. Progress will be reviewed as part of routine Level 4 PSA meetings; the next one scheduled for 7th December 2015.

The PSA assessor accepts the arguments made in respect to the remaining risk being as low as reasonably practicable. A review of guidance supporting ALARP decisions has been discussed with the ONR corporate inspector for NGL and a forward plan agreed.

Conclusions

Based on the sampling undertaken, the specialist assessors have identified no significant issues that would prevent the permissioning of the proposed activity, provided the reactor is operated with a 10°C temperature reduction compared to the full power operating conditions.

Based on the interventions carried out, the specialist assessments completed and the project inspector's review of NGL's arrangements, ONR was therefore satisfied that, based on the sampling undertaken, there is an adequate justification for the proposed activity.

Recommendation

Based on the assessment undertaken, it was the recommendation of the author of this project assessment report that the deputy chief inspector should:

- sign this project assessment report, confirming support for the ONR technical and regulatory arguments used to justify issuing Heysham 1 Reactor 2 licence instrument 594; and
- sign Heysham 1 Reactor 2 licence instrument number 594.

LIST OF ABBREVIATIONS

1D1	(Heysham) reactor 1 spine 1 delta quadrant (spine with known defect)
AGR	Advanced Gas-Cooled Reactor
ALARP	As low as reasonably practicable
BSL	Basic Safety Level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
ECT	Eddy-Current Testing (electrically based non-destructive inspection technique)
ESR	External Steel Restraint
GWT	Guided Wave Testing (ultrasound based non-destructive testing technique)
HOW2	(Office for Nuclear Regulation) Business Management System
HYA	Heysham 1 Power Station
HAR	Hartlepool Power Station
INA	Independent Nuclear Assurance
INSA	Independent nuclear safety assessment (process undertaken by INA)
NGL	EdF Energy Nuclear Generation Ltd (site licensee for Heysham and Hartlepool)
ONR	Office for Nuclear Regulation
PSA	Probabilistic Safety Assessment
RGP	Relevant Good Practice
SAP	Safety Assessment Principle(s)
SFAIRP	So far as is reasonably practicable
SQEP	Suitably qualified and experienced person
SSC	Structure, System and Component
TAG	Technical Assessment Guide (ONR)

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1 Permission requested

1. This report presents the justification to issue consent under licence condition 22(4) for NGL to implement the modification: "*NP/SC 7728 Heysham 1 Reactor 2 - boiler spine structural integrity safety case & justification for return to full power following implementation of the spine cooling modification, EC No: 355061, Version No: 005".*

   It is noted that whilst the presented safety case refers to full power operations, the letter of request specifically states that the licensee will self-impose a restriction of 10°C compared to the full power operating condition. This restriction is controlled through compliance arrangements associated with the full power safety case *"Compliance arrangements for boiler spine weld temperatures (EC No: 256499, Version 003)"*. As per NGL's letter of request, any change to the 10°C reduction in weld 12.3 temperature, or to the way that the 10°C is achieved must be agreed by ONR prior to implementation.

2 Background

2. The reactors at Heysham 1 (HYA) and Hartlepool (HAR) are currently operating at reduced power following the discovery of a defect in one of the eight boiler spines at HYA reactor 1 (R1). 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) inspection of this particular boiler spine during the 2013 statutory outage.

3. Analyses and investigations undertaken by NGL identified that the nuclear safety risk for an operational advanced gas-cooled reactor of the design of Heysham 1 and Hartlepool is dominated by boiler spine failure. This could result in a drop of the boiler, potentially resulting in failure of the boiler tubes. The resulting entrant steam into the reactor has potential to release significant amounts of radioactive material.

4. NGL's analysis and investigations have also determined that high temperature is a significant contributing factor to the crack identified on HYA R1, which has been attributed to creep crack growth damage during operational service.

5. The HYA / HAR boiler design *(figure 1)* consists of eight pod boilers, grouped into 4 zones, designated A, B, C, and D quadrants. Each of the four quadrants contains two pod boilers identified as pod boiler 1 and pod boiler 2. The identified defect was found on D quadrant of pod boiler 1 at Heysham 1 Reactor 1 (1D1).

6. 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 based on the temperature characteristics which vary along the full 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.

7. Through a combination of destructive and non-destructive testing (NDT) techniques, NGL identified significant defects extending just over one quarter of the circumference of the 1D1 spine (~450mm). The defects are local to the heat affected zone (HAZ) of buttering[3], just below weld 12.3 in boiler spine 1D1. The defects were judged by NGL to be thermally sensitive, and adequately demonstrated that by reducing the temperature of the weld site by 40°C, the growth mechanism could be effectively reduced. This temperature reduction was achieved through operating the reactors at reduced power in line with a compliance algorithm that included damage accrual rates

[3] Weld buttering is the deliberate build-up of weld material as opposed to the fusing of two materials. In respect to weld 12.3 and use within this PAR, the term buttering refers to a non-proceduralised operation, this can significantly affect the micro-structure, and therefore the mechanical properties of the metal.

derived from periods where the calculated weld temperature exceeded the required 40°C.

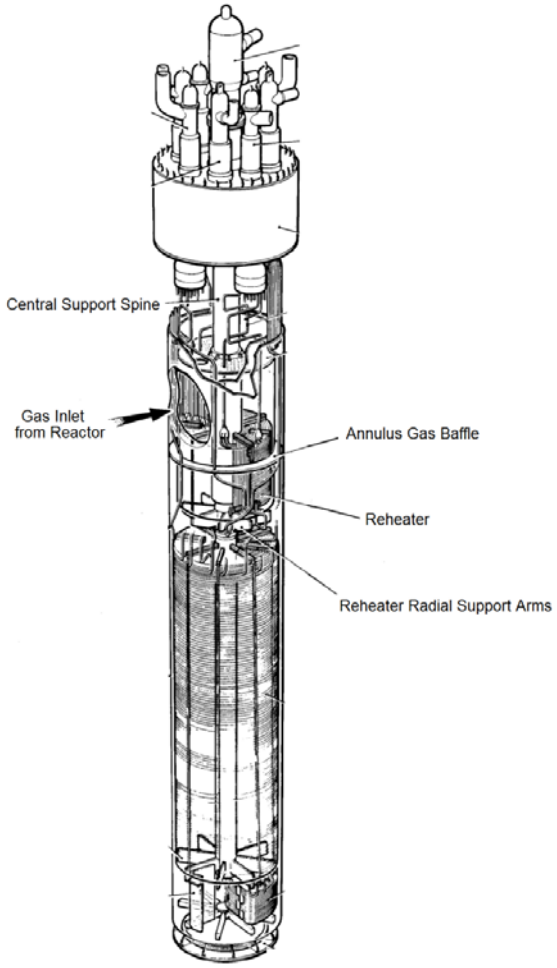

Figure 1 – Heysham / Hartlepool pod boiler design.

8. NGL produced a safety case *[NP/SC 7717 (Ref. 1)]* for the return to service of three of the four reactors (HYA R2, and HAR R1 and R2) at reduced power. The purpose of operating at reduced power was to lower the operating temperature of weld 12.3 and reduce the rate of any future crack propagation to an acceptable level. The reactors at HYA[4] and HRA were returned to service following ONR's assessment *(Ref.2)* of this case in late 2014 and early 2015.

9. *NP/SC 7717* made a commitment to develop an implementation plan for a cooling modification to reduce weld 12.3 temperatures. Inner shroud annulus insulation was identified by NGL as the preferred cooling modification. This approach involved remote installation of blanking plugs to block the bleed holes and grub screw holes at the bottom of the Re-Heater Inner Shroud (RHIS), and installation of insulation within the annulus between the boiler spine and the RHIS, where weld 12.3 is located. The function of the cooling modification was to minimise the flow of hot gas down the RHIS annulus *(figure 2)*, significantly reducing energy transfer between the gas and the weld 12.3 metal and thereby reduce the weld 12.3 operating temperature.

[4] Heysham 1 reactor 1 was returned under a separate safety case which justified isolation of the D-quadrant and operation on three out of four boiler quadrants.

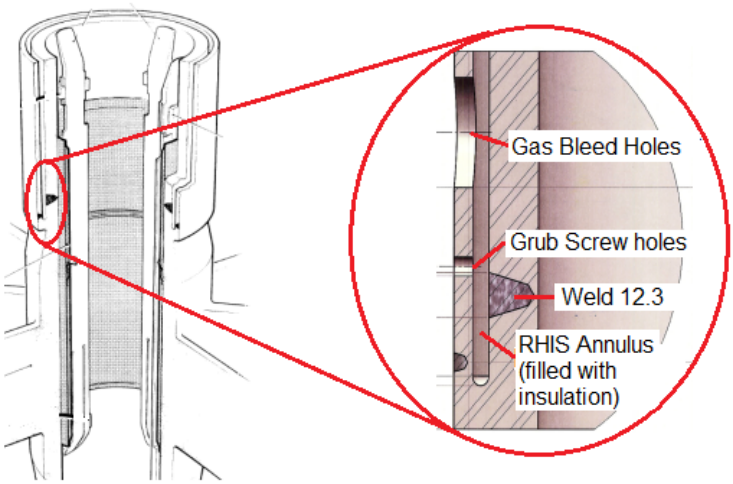

Figure 2 – Re-heater inner shroud cooling modification location with plug and insulation locations

10. The expected cooling benefit to be delivered by the modification was calculated using NGL's thermal model. NGL expected the modification to provide sufficient cooling local to weld 12.3 to act as a surrogate for the temperature reduction delivered by the reduced power operations under NP/SC 7717.

11. The cooling modifications were installed on HYA R2 during the 2015 statutory outage and the reactor returned to power under the existing reduced power safety case *(NP/SC 7717).* No benefit was claimed for the cooling modification at that time; as such ONR's assessment *(Ref. 10)* of the safety case which allowed return to service of HYA R2 with the cooling modification installed *(NP/SC 7733, Ref.9)* was carried out on a 'no detriment' basis, i.e. the cooling modification had no detrimental effects on reactor operation. This assessment provided regulatory confidence that the modification did not represent an increase in risk.

12. Further inspections of HYA 1D1 were carried out during the autumn 2015 refuelling outage using techniques specifically developed by NGL for boiler spine inspections. The inspection focused on two circumferential regions: one close to the cracking (referred to as the 180° position) and one diametrically opposite (at the 0° position). The inspection indicated the presence of buttering at the 180° position, as expected. However, no indication of buttering was observed at the 0° position. The inspection also indicated differences in the height of weld 12.3 at the two circumferential positions. This discovery was contrary to NGL's expectation that the buttering was fully circumferential and appeared to indicate the buttering to be localised in nature.

13. Thermal modelling work undertaken by NGL to substantiate the effectiveness of the cooling modification has also progressed. This work looks at the ability of the installed cooling modification to act as a surrogate for the reduced operating power and provide necessary temperature reduction to the weld 12.3 site without de-rating the reactor.

14. The thermal modelling work, supported by new analysis and arguments that any defect would become apparent through periodic inspection before reaching a critical size (a forewarning of failure argument) have been presented within a new safety case *(NP/SC 7728 version 005 (Ref. 4))*, seeking to justify the return to full power operation of HYA R2. This case is the focus of the assessment work undertaken and summarised in this PAR.

3 SUMMARY OF THE LICENSEE'S SAFETY CASE

15. NGL are seeking permission to return HYA R2 back to full power operation. As discussed in the section above, the reactors at HYA and HRA have been operating at reduced power following discovery of a defect on boiler spine 1D1 at HYA.

16. NGL have undertaken significant work in order to support the case. They consider that they have:

- Gained an understanding of the mechanism *(re-heat cracking)* that caused the defect *(section 5.1.1)*;
- Demonstrated that the existence of uncontrolled buttering on other spines is unlikely*(section 5.1.1);*
- Demonstrated through detailed visual and other NDT inspections that there are no spines in a similar condition to 1D1 *(un-controlled use of a non proceduralised buttering technique) (section 5.1.1)*;
- Designed and installed a plant modification *(cooling modifications),* to reduce the temperature in the vicinity of spine weld 12.3 *(section 5.1.2)*;
- Demonstrated that the risk associated with increasing power remains as low as reasonably practicable *(section 5.1.3)*.

17. Based on the multi-legged approach discussed below, NGL argues that random failure of a single boiler spine can be regarded as an infrequent event. These legs are summarised in the sections below, with the claims and arguments set out within *section 3.2* below.

3.1.1 PLANT CONDITION:

18. NGL claims that there is now sufficient confidence that no other defects are present on any of the eight HYA R2 spines. This confidence is based on the following:

- a detailed review of original build records;
- successful completion of full 360° visual inspections of all the HYA R2 spines, showing no defects;
- Completion of GWT of each of the HYA R2 spines with no defects detected; and
- ECT on at least one circumferential location of each of the eight HYA R2 spines with no anomalies detected (i.e. buttering or abnormal weld location).

19. The discovery of a non-fully circumferential buttered weld on HYA 1D1 spine has led NGL to acknowledge the potential for buttering to be present on other spines. NGL caveat this concession on the basis that they consider there is only a very low probability of uncontrolled buttering being present on other welds, capable of challenging structural integrity. Accounting for the potential presence of buttering, NGL concede that, for an infrequent seismic event, a single spine failure remains credible.

3.1.2 FOREWARNING OF FAILURE:

20. One of the legs supporting the infrequent failure claim *(paragraph 56)* for the spine is a forewarning of failure argument. The forewarning of failure demonstration uses creep crack growth calculations to show that a crack at the limit of detectability[5] of the cold GWT would not exceed the limiting defect size[6] within the 7 month period between GWT testing.

21. The creep crack growth rates depend on the temperature of the weld. *NP/SC 7728 Version 005* is predicated on the basis that the reactor will be operated such that the temperature in the lower heat affected zone in weld 12.3 does not exceed an absolute temperature limit of 530°C. The case references new compliance arrangements *(Ref. 7)* to ensure that 530°C is achieved and is not exceeded for any significant period of time. The reduction equates to a weld 12.3 temperature drop of 10°C, as opposed to the current reduction of 40°C.

3.1.3 COOLING MODIFICATION EFFECTIVENESS:

22. Cooling modifications were successfully installed on HYA R2 during the 2015 statutory outage. NGL claim the cooling modification (installed under *NP/SC 7733 (Ref.9))* is capable of delivering sufficient cooling to weld 12.3 to support the forewarning of failure capability, as provided by GWT. This position is based on the new compliance algorithm which assesses the thermal benefit delivered from the cooling modification. The compliance arrangements set out within *EC356499 version 003* (*Ref. 7)* are controlled through NGL's Nuclear Safety Group (NSG) and the Boiler Assessment Working Group (BAWG). NGL therefore argue that no further reactor power restriction is required.

23. Through on-going discussion with NGL, ONR raised concerns over the confidence levels associated with the new thermal model and associated compliance arrangements. This position was further reinforced following thermocouple results taken from HRA R2 showing an off-set of approximately 40°C that was not predicted by the model. NGL took the decision to modify the compliance arrangements to utilise both the new and old temperature algorithms, working to the most pessimistic value.

24. This revised compliance EC, whilst acknowledging the benefit delivered by the cooling modification does not rely on it. EC256499 requires that the temperature reduction of 10°C necessary to support the forewarning of failure argument is delivered by operating the reactor at reduced power.

25. It is specifically stated in NGL's letter of request (*Ref. 3)* that any change to the 10°C temperature reduction, or the means by which it is achieved shall be agreed with ONR prior to implementation.

3.2 CLAIMS, ARGUMENTS AND EVIDENCE

26. The justification for the return of HYA R2 back to full power operations is set out within *NP/SC 7728 version 005* and is supported by the following claims:

Claim 1: The integrity of key butt welds is acceptable for infrequent failure tolerability

Claim 2: In the event of boiler spine failure, the consequences remain tolerable;

Claim 3: The radiological risk arising from boiler spine failure at Heysham 1 Reactor 2 is as low as reasonably practicable such that the cost of remaining de-rated is grossly disproportionate to the safety benefit.

[5] Limit of detectability is the smallest defect that cold GWT could be reasonably expected to detect,
[6] Limiting defect size is the smallest defect likely to cause failure of the spine.

4 PERMISSIONING STRATEGY

4.1 EARLY ENGAGEMENT

27. ONR has pro-actively engaged with NGL regarding the cooling modification and full power case since February 2015. In July 2015, NGL presented an overview of the proposed full power case to the ONR assessment team *(Ref. 12 & 14)*. Following this meeting, ONR wrote *(Ref. 15)* to NGL identifying a number of points raised by the assessment team for discussion during subsequent working-level meetings.

28. *NP/SC 7728* was first presented to ONR at *version 003 (Ref. 29)* following completion of NGL's due process. Several meetings were undertaken prior to and post receipt of *NP/SC 7728 version 003* to discuss the claims, arguments and evidence presented within the case.

29. It was ONR's view that the safety case, as initially presented, had a significant shortfall in that it did not adequately address the potential for buttered welds to be present on spines other than 1D1. This was an important omission in that the cracking in boiler spine 1D1 is attributed to a "non-routine" buttering process which increased the susceptibility of this spine to reheat cracking. Rather than addressing the potential implications of a buttered weld being present, *NP/SC 7728 version 003* argued that there was only a remote possibility of buttering being present on any of the HYA R2 Esshete[7] welds. ONR did not share the view that there was sufficient confidence to exclude the need to address the implications of a buttered weld being present.

30. ONR's concerns, combined with the more recent ECT results from 1D1, led NGL to revise their safety case to include a forewarning of failure argument for buttered welds. *NP/SC 7728 version 005* took account of results from inspections carried out during the HYA R1 September 2015 refuelling outage. These included the discovery that the 1D1 buttering was not fully circumferential.

31. Whilst ONR has taken cognisance of the earlier version of the case, the permissioning decision is based on assessment of the updated case *(NP/SC 7728 version 005* (*Ref. 4))*.

32. It should be noted that within NP/SC 7728, NGL consider that they have delivered a safety case which, justifies returning to full power operations. ONR considers that there is sufficient evidence within the case to support the forewarning of failure claims, based on a 10°C reduction in temperature. The evidence provided at this time does not provide ONR with the confidence required that this 10°C temperature reduction can be delivered by the installed cooling modification.

33. In light of this position, NGL have therefore adopted a two stage approach to return to full power, with the 10°C temperature reduction being the first step. Only once further evidence is presented and accepted by ONR regarding the performance of the cooling modification, will compliance arrangements be revised enabling full power operations. This requirement is captured within the letter of request received from the licensee.

4.2 USE OF PRIMARY POWERS

34. The boiler spine recovery project has been a long-term permissioning activity and has included assessment of several safety cases, with further safety cases for the other reactors to follow. In order to effectively manage the permissioning approach, ONR developed a permissioning strategy *(Ref. 17)*. This document set out the approach to be taken by ONR in permissioning each of the activities outlined within the NGL Paper of Principle for the cooling modification project *(Ref. 16).*

7 Esshete is an austenitic steel with high creep strength and is well established as a super-heater boiler tube material in UK power stations

35. The permissioning strategy identified that the return of HYA R2 to full power operation constituted a significant departure from the current operating conditions. Recognising that many of the arguments and some of the evidence used within the safety case were novel and complex, ONR considered it appropriate to permission the activity under primary powers[8]. The permissioning strategy and the decision to use primary powers were agreed at the operating reactors sub-programme board *(Ref.13)*.

36. ONR wrote to NGL setting out the details of the permissioning regime *(Ref.17),* specifically outlining the decision to use primary powers to permission the full power case.

37. ONR issued licence instrument 592 (*Ref. 18)* on 1st September 2015, specifying that NGL shall not proceed with the implementation of the safety case *NP/SC 7728* without the consent of ONR.

5 MATTERS ARISING FROM ONR'S WORK

5.1 ASSESSMENT UNDERTAKEN

38. In order to form a view on the adequacy of the claims, arguments and evidence presented, ONR assessed the safety case. The selection of specialist disciplines to assess the case was risk-based, focusing on the higher consequence fault sequences.

- Structural Integrity *(Section 5.1.1)*
- Fault Studies *(Section 5.1.2)*
- Probabilistic Safety Analysis *(Section 5.1.3)*

39. Summaries of the specialist assessments are provided below:

5.1.1 STRUCTURAL INTEGRITY ASSESSMENT

40. An ONR structural integrity assessor undertook assessment of the safety case. This work was supported by input from an ONR specialist civil engineering assessor and an ONR non-destructive testing specialist. The findings of the assessment are presented in a combined report *(Ref. 20).*

Condition of the spines is understood

41. Claim 1, argument 1 of NGL's case seeks to demonstrate that the condition of the key boiler spine butt welds on HYA R2 is established. This is based on an inspection undertaken by NGL and a thorough review of build records. ONR's assessment of these points is summarised below:

Visual inspection

42. The ONR structural integrity assessor sampled NGL's arrangements for the assessment, verification and sentencing of visual inspections undertaken on the boiler spines. It is the considered opinion of the structural integrity assessor that NGL's process for sentencing visual inspections is adequate, and he accepts that the visual inspections provide assurance that defects, developed to the same extent as that identified on 1D1 are not present on other spines.

43. With respect to the detection of significant defects, the assessor is satisfied with the evidence provided that visual inspection could identify fully penetrating defects greater

[8] "Primary powers" refer to legally binding provisions imposed by the licence conditions attached to the nuclear site licence. These are distinct from derived powers, which are created through the licensee's own arrangements.

than 150mm (circumferential) length. The specialist inspector does not accept however that this capability can confirm the absence of buttering on the inspected spine welds. Additional inspection techniques are therefore required to support the case.

Eddy current testing (ECT)

44. ECT results presented by NGL indicate that buttering does not exist on any of the pods, with two results giving less confidence than the others. 2D1 was measured with a weld width between 12-17 mm higher than a normal weld. NGL stated that this was due to large weld repairs (50%). Whilst 2A2 was measured as approximately 12 mm larger than the design weld width, NGL did not consider this to demonstrate buttering as the abnormal result was only measured by one of the inspections, with other results showing a normal weld profile.

45. ECT inspection carried out on 1D1 during the recent HYA R1 refuelling outage has shown a positive detection of buttering. This was however only detected on the 180° side (that known to contain the surface-breaking defect), with the 0° side showing a normal weld width.

46. The structural integrity assessor reviewed the results from 1D1, discussing them with a suitably qualified and experienced person (SQEP) from NGL. The assessor concluded that the explanations provided by NGL with respect to the abnormal weld results of 2D1 and 2A2 are plausible. The assessor also accepted that results from 1D1 added to confidence in the capability of the ECT technique to detect buttering. He noted however that uncertainties associated with the technique mean that buttering cannot be discounted. This position is further re-enforced in the opinion of the assessor that there is the potential for non-full circumferential buttering similar to that found on 1D1 to be present, and the fact that ECT is only performed at two discrete locations around the circumference.

Guided wave testing (GWT)

47. GWT technology has been used to test all eight spines on HYA R2 with no anomalous indications or trends recorded. The structural integrity assessor is satisfied that the evidence provides confidence that there are no anomalous indications or trends associated with the presence of a defect above the limit of detectability. The assessor notes however that the results cannot demonstrate the absence of buttering. Therefore, the current condition of the spines is only known to be 'without a gross defect'.

Remote possibility of buttering

48. The structural integrity assessor acknowledges the effort that NGL expended to remove the restrictions from the boiler spines, facilitating visual inspections on the eight octants of all eight spines. Similarly, GWT testing undertaken on the spines has been thoroughly reviewed with no anomalies identified. The structural integrity assessor considers that the work provides reasonable assurance that, at present, there are no other spines on HYA R2 in a similar condition to 1D1. It does not however exclude the possibility of uncontrolled buttering being present.

49. The assessor accepts that ECT inspections have been shown to be capable of detecting uncontrolled buttering. This in the assessor's view adds support to the argument that there is no widespread use of buttering on the spines, but that it cannot conclusively exclude the possibility. Difficulties in applying the ECT and analysing the data, combined with the finding that the buttering does not extend around the full circumference on 1D1 detract from confidence in the argument that there is no buttering present.

50. The assessor accepts that the possibility of further spines containing uncontrolled buttering is remote, noting that the possibility cannot be excluded. The assessor is also satisfied that there is sufficient evidence to suggest that, at this point in time, there are no spines on HYA R2 in a similar condition to 1D1.

Forewarning of failure for as-designed, non-buttered welds

51. The forewarning of failure argument presented is based on the potential for defect growth in weld 12.3. This approach is accepted by the structural integrity assessor, who recognises this as the bounding case, other spine welds being less susceptible to reheat crack propagation. The forewarning of failure capability for as-designed, non-buttered welds is based on three parameters:

- The initial defect size (taken as the limit of GWT detectability);
- The component limiting defect size;
- The rate of crack growth for a specified operating temperature.

52. The structural integrity assessors reviewed the evidence associated with the detection capability of the GWT technique. Based on the evidence provided, it is accepted that the capability for detection of defects greater than 374 mm in length, located in the lower heat affected zone of weld 12.3, appears to be reasonable.

53. The approach taken to calculate limiting defect sizes and crack growth rates used in the determination of safe life values is in-line with the structural integrity assessor's expectations. The work has been undertaken using a well-established, internationally recognised methodology. The limiting defect sizes and crack growth rates are based on an un-cooled state and take no benefit for local temperature reduction delivered by the installed cooling modification.

54. The structural integrity assessor accepts that the safe life values presented demonstrate that an as-designed weld 12.3 meets the requirements of infrequent failure tolerability in an uncooled state. The assessor points out however that this work is not relevant to support an instance where buttering may be present. On the basis that other buttered welds cannot be discounted, a specific forewarning of failure capability is required for buttered welds.

Forewarning of failure for buttered welds

55. Uncertainties associated with the materials properties of a buttered weld 12.3 undermine the conventional methods of creep crack growth rate predictions to establish safe life margins and so provide a forewarning of failure argument. In order to deliver a forewarning of failure argument for buttered welds, NGL required a crack growth rate associated with un-controlled buttering. This has been estimated using the information gathered from the defect detected on 1D1 with respect to the defect characteristics (size, type, location) and period of time. The structural integrity specialist has reviewed the approach taken by NGL to estimate a crack growth rate for a buttered weld 12.3 in the lower heat affected zone and accepts that the method used is a reasonable approach. The estimate includes reasonable conservatisms and takes account of uncertainties.

56. To provide a forewarning of failure argument, a tolerable amount of crack growth has been determined between the GWT detection capability (374mm) and the limiting defect size for all cases (normal operation, frequent seismic and infrequent seismic) for the 7 month period between offline GWT inspections. Providing the estimated defect

growth does not exceed the tolerable defect size then a forewarning of failure claim is considered acceptable.

57. The forewarning of failure argument for buttered welds can only be made for the lower heat affected zone of weld 12.3 if the operating temperature is reduced from full power operating temperatures by at least 10°C. The assessor reviewed the effect of temperature reduction on the crack growth estimates and accepts that the 10°C reduction is sufficient to provide an appropriate forewarning of failure margin.

Structural integrity conclusion

58. Based on the assessment undertaken by the structural integrity assessor, he has no objection to the proposed activity provided a 10°C temperature reduction from the full power operating condition is delivered.

5.1.2 FAULT STUDIES ASSESSMENT

59. A specialist fault studies assessor, with specific knowledge associated with thermal modelling, undertook assessment *(Ref. 21)* of the case. A summary of the findings is presented below:

Thermal modelling

60. The ONR fault studies assessor is satisfied that, based on the thermal analysis presented in Reference *NP/SC 7728 version 005*, it is very unlikely that the cooling modification has increased the temperature at weld 12.3. However he notes that it is not possible without further evidence to quantify the magnitude of the temperature reduction delivered by the cooling modification to an appropriate level of confidence. Consequently, on the basis of the evidence provided, the fault studies assessor does not accept that there is sufficient confidence in the claim that the cooling modification will provide at least 10ºC worth of cooling at weld 12.3.

61. In order to be able to establish sufficient confidence in the temperature reduction that can be claimed for the cooling modification, the fault studies assessor considers it necessary to address the discrepancy between measured and calculated temperatures from the existing HRA R2 thermocouple measurements. Noting that the HRA R2 thermocouple is not actually that close to weld 12.3, the assessor considers it will also be important to have measurements from the thermocouple recently installed on HYA R1. If these measurements compare well with predictions, this might be sufficient to support full power operation. However, it may be necessary to wait until measurements are available from the thermocouples planned to be installed in HRA R1 during the November 2015 re-fuelling outage.

Through Life Performance of the Cooling Modification

62. NGL proposes to carry out a visual inspection of the top of the insulation within the annulus at the next HYA R2 statutory outage on one boiler pod. Whilst the fault studies assessor judged this to be sufficient in terms of monitoring insulation degradation, he challenged the adequacy in terms of gaining confidence in the robustness of the plugs and the insulation remaining within the RHIS annulus. NGL accepted that it is reasonably practical to plan for additional visual checks on the boiler spine cooling insulation for up to four spines in the next statutory outages planned at each Station in 2016 and 2017.

63. NGL confirmed *(Ref. 23)* additional visual inspections will be taken forward into the outage intentions document as part of boiler inspection work scope. This point has also been reflected in *NP/SC 7728 version 005*, which states that the maintenance

schedule for HYA will be updated to reflect this position. The fault studies assessor considered this to be an appropriate response to the issue.

64. The fault studies assessor commented on the promising development of the GWT 'time of flight'[9] technique, due for completion by end of November 2015. If the outcome is successful, the assessor judges this could provide an alternative technique for detecting any significant spine temperature change associated with the presence of (or loss of) insulation and be applicable across a wider population of spines. Depending on the capability and reliability of the technique, this may subsequently change the benefit of and thus the requirement for additional visual inspections on spines during statutory outages. Clearly this will depend upon the outcome of the GWT work.

Revised Temperature Compliance Arrangements

65. The fault studies assessor has consistently challenged the claim in *NP/SC 7728 version 005* that, based on available evidence, weld 12.3 temperatures can be calculated to within 8°C. In response to this challenge, NGL presented a revised uncertainty allowance of 15°C *(Ref. 23)*. Notwithstanding this, the fault studies assessor remains of the view that evidence from plant thermocouple measurements will be needed in order to support weld 12.3 calculated temperatures.

66. The weld 12.3 temperature limit upon which *NP/SC 7728 version 005* is based is 530°C. The fault studies assessor notes that, based on the evidence presented, compliance with the 530°C limit may result in the maximum operating limit falling short of full power. It is the opinion of the fault studies assessor that this adds additional weight to the need for confidence in the thermal analysis.

Impact of Thermal Analysis Assessment on Compliance Arrangements

67. The fault studies assessor notes that, based on the evidence provided, he cannot currently accept NGL's claim that the 10ºC reduction in weld 12.3 temperature can be delivered by the cooling modification.

68. Discussions with NGL *(Ref. 22)* have resulted in an alternative approach. It has been agreed that NGL will implement a temperature reduction of 10ºC on the plant in a similar manner to the reduction of 40ºC currently in place (i.e. via reducing reactor power from the full power operating condition to deliver this temperature reduction). This will enable an increase in power from the current level.

69. This has been implemented through an update to the compliance arrangements discussed above which have been re-issued *(Ref. 7)*. The re-issued compliance arrangements make it clear that the original compliance algorithm used to achieve a 40ºC reduction will be used such that a 10ºC reduction in temperature will be achieved. The assessor considers this to be an appropriate means of ensuring a 10ºC reduction in weld 12.3 temperature relative to full power operation. It is also noted in the letter of request that, in order to remove the 10ºC reduction in temperature, a revision to the compliance arrangements will be needed and this must be agreed by ONR prior to implementation.

70. Whilst the original algorithm with a 10ºC reduction in temperature has been shown by NGL to be limiting in terms of power, the assessor notes that NGL will also use the revised algorithm to confirm that weld 12.3 temperature remains below the 530°C limit. The assessor considers this to be a sensible check and demonstrates good practice.

[9] NGL propose that the GWT signal could be used to demonstrate the cooling modification remains in place by analysing the time of flight of the test signal. This is dependent on the temperature of the material the signal passes through, and the increase in spine length caused by thermal expansion. At the time of writing, this work was not complete.

This change in arrangements were captured within the compliance engineering change *(Ref. 7)* with NGL's Boiler Assessment Working Group (BAWG) paper *(Ref.8)* modified to reflect this position.

Lines of protection

71. The ONR fault studies specialist reviewed the arguments and evidence presented within *NP/SC 7728 version 005* in respect to the lines of protection claimed.

72. The assessor accepts NGL's argument that, for random failure of a single boiler spine, the emergency boiler feed pumps and the high pressure back-up cooling system remain available. These provide the two lines of protection necessary to support the safety case claim.

73. In terms of infrequent seismic events[10], a single line of protection is stated as being required for failure of a boiler spine. The fault studies assessor accepts the justification, demonstrating that the high pressure back-up cooling system would, under these conditions, remain capable of delivering its safety function post-event.

Fault studies conclusion

74. In conclusion, the fault studies assessor considers the level of protection available to mitigate the potential failure of a single boiler spine, both due to random failure and as a result of an infrequent seismic event to be adequate.

75. The fault studies specialist does not currently accept that the 10ºC temperature reduction can be delivered with sufficient confidence by relying on the cooling modification. However, based on the assessment undertaken, and accepting the changes to the compliance arrangements presented by NGL which deliver the temperature reduction through a reduction from the full power condition, the fault studies assessor has no objection to the proposed activity.

5.1.3 PROBABILISTIC SAFETY ANALYSIS (PSA)

76. An ONR specialist PSA assessor carried out an assessment *(Ref.25)* of the case. The assessment reviewed the PSA arguments and evidence covered within claim 3 of the case. The assessment also considers evidence provided to demonstrate the risk from full power operation is reduced as low as reasonably practicable (ALARP). The findings of the assessment are summarised below:

Review of PSA arguments

77. *NP/SC 7728 version 005* argues that there is sufficient evidence to concede the likelihood of one buttered weld in a population 31 boiler spines (eight boilers per reactor, four reactors with HYA R1 1D1 already declared failed). For the purpose of the risk assessment, it is assumed that there is one buttered 12.3 weld in one quadrant on each reactor; therefore a probability of 0.25 is assigned. The consequential failure of a spine following an infrequent seismic event is assigned a frequency of 2.5 failures every 100,000 years.

78. The likelihood of a subsequent water ingress and failure of the lines of protection is assigned a frequency of one failure per 100 demands. On this basis, the overall frequency of an accident that could lead to an off-site release, with dose consequence greater than 1 Sievert to the public *[target 8 of the ONR Safety Assessment Principles (SAPs, Ref.32)]* is predicted to be low (2.5 events per 10,000,000 years).

[10] An infrequent seismic event refers to a 1 in a 1000 year seismic event challenging to the station

79. Random spine failure resulting in water ingress from multiple tubes is assessed on a best estimate basis, and the risk to the public is also predicted to be low (2 events per 10,000,000 years). This has decreased from the reduced power case *(Ref. 1)* based on an improved understanding of the structural integrity case. NGL confirmed that the PSA model had not yet been fully updated for the random spine failure to recognise the second line of protection available following the transient analysis assessments reported in *Reference 1*.

80. It is however recognised in *NP/SC 7728 version 005* that the initial model developed was conservative with respect to the claims on operator actions, which could result in an uncontrolled release. In advance of updating the model as part of the general PSA update, *NP/SC 7728 version 005* has taken a simplified bounding assumption that the second line of protection is only provided with a probability of failure on demand of one in ten. The PSA assessor accepts the use of such a low failure on demand value and considers it to be suitably conservative.

81. Following discussion with the ONR structural integrity assessor and fault studies assessor, the PSA assessor is satisfied that the initiating event frequencies and lines of protection reliability claims are reasonable.

82. The PSA assessor is satisfied that the overall risk to the public from operation of HYA R2 is at the level predicted before the defect on HYA R1 was identified and that the assessment remains sufficiently conservative. The update to the HYA / HRA PSAs is covered by a separate ONR Intervention and progress will be reviewed as part of routine Level 4 PSA meetings.

Review of ALARP arguments

83. The ONR PSA assessor considered the ALARP position as part of her assessment, challenging the wording used by NGL in presenting claim 3. The assessor did not consider it appropriate or in-line with technical assessment guidance *(Ref. 31)* to base the ALARP argument on the premise that it was grossly disproportionate to remain de-rated. The ONR PSA assessor states that her assessment is based on the demonstration that risks associated with the return to full power are adequately assessed, tolerable and ALARP. This approach ensures that all reasonably practicable measures have been implanted to the point where the sacrifice (in terms of time, trouble and money would be grossly disproportionate to the further risk reduction that would be achieved.

84. Argument 3.2 of *NP/SC 7728 version 005* considers the robustness of the ALARP case, providing evidence which concludes no further cooling modifications or plant improvements are reasonably practicable to implement.

85. Argument 3.3 presents evidence which concludes that a number of ALARP recommendations for further work identified in the ALARP head document *(Ref. 26)* can be progressed as part of routine Design Authority reviews of dominant risks. This approach is taken to ensure appropriate consideration against other wider plant modifications, rather than focusing solely on the boiler spines faults.

86. The PSA assessor accepts this position but notes that the work should be monitored by ONR as part of routine regulatory business. A review of guidance supporting ALARP decisions has been discussed with the ONR corporate inspector for NGL and a forward plan agreed. The PSA assessor is also satisfied that commitments 13 and 14 made within *NP/SC 7717 (Ref. 1)* are closed.

PSA conclusion

87. In conclusion, the PSA assessor has identified no significant issues associated with the safety case and as such has no objection to the proposed activity.

5.1.4 REVIEW OF PREVIOUS COMMITMENTS

88. The original safety case justifying the return to service of the reactors at HYA and HRA following discovery of the 1D1 defect *(NP/SC 7717 (Ref. 1))* made a number of commitments. As part of the assessment of *NP/SC 7728 version 005* the ONR assessment team considered the progress made against the *NP/SC 7717* commitments.

89. The ONR assessment team agreed that based on level 4 engagements, progress appears to have been made against the commitments. There are no outstanding issues preventing HYA implementing *NP/SC 7728*. No issues were identified that would preclude ONR permissioning the requested activity.

5.2 LICENCEE'S ARRANGEMENTS

5.2.1 VERIFICATION STATEMENT

90. NP/SC 7728 underwent NGL internal verification at version 003 and version 005. The case was accepted on both occasions with minor comments.

91. The ONR fault studies assessor identified that aspects of the thermal case were validated (at both version 003 and version 005) by members of the team responsible for delivering the work. Despite re-assurance from NGL that this approach is accepted within NGL arrangements, the ONR assessor remained uncomfortable with the practice.

5.2.2 INDEPENDENT NUCLEAR SAFETY ASSESSMENT

92. INA was represented at the majority of the level 4 meetings held to discuss the full power case, and previous interventions associated with installation of cooling modifications. INA was also copied into all communications between ONR and NGL.

93. INA accepted *NP/SC 7728 version 003 (Ref. 27)* on 2nd September 2015 with no significant points raised.

94. Following initial assessment of the case, ONR noted the following points as areas that would have benefitted from additional INA focus:

- Challenge of evidence used by NGL in demonstrating re-establishment of boiler spine design intent, or the remaining potential for buttering to be present on other spines. These led INA to accept the absence of a forewarning of failure argument for buttered welds.

- Independent specialist assessment of the techniques used by NGL in determination of the extant of condition of the spines, specifically ECT. INA accepted NGL's view that ECT is a well-established testing technique. Whilst this point is accepted by ONR, it should be recognised that the application in which the ECT was applied is bespoke, and thus should not be considered standard.

- Independent specialist assessment of the techniques and assumptions used in NGL's development and verification of the thermal model.

95. *NP/SC 7728 version 005* completed INSA on 19th November 2015 *(Ref. 6)*.

96. ONR notes the inclusion of specific areas, beyond those discussed in the previous INSA, namely:

- Techniques and assumptions used within the thermal model, including its potential limitations and use of other data sources (thermocouples).
- Capability of the NDT techniques used by NGL in assessing the state of the boiler spines. This included ECT results, including in respect to discovering non-fully circumferential buttering on 1D1. INA also considered the appropriateness of the forewarning of failure argument as applied to potentially buttered welds
- Compliance arrangements used to monitor and control weld 12.3 temperature.

97. INA has worked closely with NGL in production of the case and it is possible that this cooperation has led to a degree of 'group think'. This potentially reduces the ability of INA to deliver truly independent challenge. It is also recognised that through early involvement in the development of the case, INA and ONR may have started their assessment journeys from a different places, resulting in different lines of enquiry being followed by each.

98. ONR also accepts that, whilst INA endeavours to be independent, ultimately they can be subject to the same business drivers imposed on NGL. These constraints may have been factors in the INSA of NP/SC 7728.

5.2.3 NUCLEAR SAFETY COMMITTEE

99. NP/SC 7728 was presented at the NSC at version 003 and version 005 *(Ref. 28 & 5).* The case was accepted on both occasions with no significant points raised.

5.3 ONR PROCESS

100. To support this permissioning I have:

- Utilised the services of the ONR specialist inspectors assigned to this project by the ONR CNRP management team, taking cognisance of their conclusions and recommendations.
- Considered NGL's safety case verification statement
- Considered the resolution of NGL INSA comments and the issuing of the NGL INSA statement
- Considered NSC comments and its overall support for the return to service of HYA R2

101. I have drawn upon the ONR specialist inspector's considerations and recommendations in the areas of structural integrity, fault studies and PSA.

102. Each discipline has produced a report presenting their assessment findings, opinions, judgments and recommendations. All assessments were undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide *Purpose and Scope of Permissioning (NS-PER-GD-014, Rev 4 (Ref. 31)).*

103. All of the specialist inspectors' assessment reports have undergone independent peer review and formal approval via the respective professional leads in accordance with ONR How2 Business Management System (BMS) guide Peer Review for Technical

Assurance (*NS-TAST-GD-085, Rev 4 (Ref. 31)*) which supports the approach taken, conclusions raised and recommendations made by the specialist inspectors.

104. All of the ONR specialist assessment reports contain either a statement supporting the proposed activity, or note that there is no reason to withhold permission for the proposed activity.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

105. Through the work carried out by NGL on visual and non-destructive testing and inspection techniques, I am satisfied that there is sufficient confidence in the as-built state of HYA R2 spines that further random failures can be considered infrequent. Additionally, sufficient lines of protection have been justified to mitigate the risk, so far as is reasonably practicable, should a failure occur.

106. Based on the structural integrity assessment, I am satisfied that a suitable forewarning of failure argument has been demonstrated for both as-designed and buttered welds. The method appears to provide an effective means to detect defects prior to failure. This acceptance is however based on a 10°C reduction in temperature as compared to un-cooled full power conditions.

107. Based on the fault studies assessment, I do not currently have sufficient confidence in the ability of the thermal model to accurately predict the benefit gained from the installed cooling modification. On this basis, I do not at this time accept the argument that the 10°C temperature reduction can be delivered by the installed cooling modification.

108. However, the fault studies assessor considers that NGL do have sufficient understanding of the thermal model to adequately predict weld 12.3 temperature with reasonable accuracy. On this basis, I am satisfied that the revised compliance arrangements proposed to restrict reactor power are sufficient to deliver the required 10°C cooling needed to support the forewarning of failure argument.

109. I specifically note that the proposed compliance arrangements *(Ref. 7)* impose a restriction on operating power. This restriction delivers the 10°C temperature reduction to weld 12.3, required to support the forewarning of failure argument. As per NGL's letter of request, any change to the 10°C reduction in weld 12.3 temperature, or to the way that the 10°C is achieved must be agreed by ONR prior to implementation.

110. In summary, whilst significant issues have been raised as a result of the assessment of *NP/SC 7728 version 005*, specifically in respect to the justification of the cooling modification benefit, I consider that appropriate controls have been put in place to minimise the risk of future spine failures. Additionally, based on the PSA assessment, I judge sufficient lines of protection have been identified to mitigate the risk of any spine failure that may occur.

111. The self-imposed restriction on operating power, set out within the letter of request, requires ONR's agreement prior to any change in the 10°C temperature reduction, or the means by which it is achieved. This, in my considered opinion, provides adequate regulatory control over any proposed increases in reactor power.

112. Based on the above, I consider that there are no issues that prevent ONR issuing the requested consent.

6.2 RECOMMENDATIONS

113. Based on the assessment undertaken, it is the recommendation of this PAR that the deputy chief inspector should:

- sign this project assessment report, confirming support for the ONR technical and regulatory arguments used to justify issuing Heysham 1 reactor 2 licence instrument 594; and
- sign Heysham 1 reactor 2 licence instrument number 594.

7 REFERENCES

1. *NGL Safety Case NP/SC 7717 Rev 6, Safety case for return to service of Heysham 1 reactor 2, Hartlepool reactor 1 and reactor 2 at reduced temperature operation following the discovery of a defect on Heysham 1 reactor 1 boiler spine 1D1, (TRIM 2014/425760)*

2. *ONR Project Assessment Report - ONR-CNRP-PAR-14-015 Revision 0 - Hartlepool and Heysham 1 Boiler Spines Return to Service - A safety case for return to service of Heysham 1 Reactor 2, Hartlepool Reactor 1 and Reactor 2 at reduced temperature operation following the discovery of a defect on Heysham 1 Reactor 1 boiler spine 1D1 (TRIM 2014/399532)*

3. *EDF NGL Letter: NSL/HYA/50781 dated 19 November 2015, Nuclear Installations Act 1965 (as amended), EDF Energy Generation Ltd, Heysham 1 Power Station, Nuclear Site Licence 60: NP/SC 7728 Reactor 2 Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification (EC 355061) covering: (TRIM: 2015/442778)*

4. *NP/SC 7728 Heysham 1 Reactor 2 – Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification, EC No 355061, Revision 000, Proposal Version No: 05. (TRIM:2015/444170)*

5. *NSC minutes considering NP/SC 7728 version 005, dated 12th November 2015 (TRIM:2015/442798)*

6. *Full INSA Approval Statement : NP/SC 7728 Heysham 1 Reactor 2 – Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification, EC No 355061, Revision 000, Proposal Version No: 05. (TRIM:2015/442785)*

7. *Compliance arrangements for boiler spine weld temperatures (EC256499, version 003) (TRIM:2015/442800)*

8. *Temperature compliance strategy to support increase power operation following installation of cooling modifications at Heysham 1 and Hartlepool (BAWG/P(15)2 – issue 003) (TRIM:2015/442820)*

9. *NGL Safety Case NP/SC 7733 – Heysham 1 Reactor 2: Return to Service at Reduced Power with Spine Cooling Modifications Installed, EC 355558, Rev 000, Ver 4 (TRIM: 2015/221673)*

10. *ONR Project Assessment Report - ONR-CNRP-PAR-15-004 Revision 0 - Heysham Reactor 2: Return to Service at Reduced Power with Spine Cooling Modifications Installed (TRIM: 2015/177118)*

11. *Letter from* [redacted] *to* [redacted] *dated 13th may 2015. Progression of installation of cooling modifications at Heysham 1 reactor 2 are done so at NGL's own commercial risk (TRIM 2015/292289)*

12. *NGL presentation to ONR: HYA R2 – Progress on Return to Service and Proposal for Revised Operating Conditions, 2st July 2015 (TRIM: 2015/272855)*

13. *Minutes from the Operating reactor sub-programme board, 28th July 2015 (TRIM: 2015/284488)*

14. *Contact Record* - ONR-CNRP-CR-15-117 - *Boiler Spine Recovery Project - Revised Operating Condition meeting for HYA and HRA (TRIM: 2015/272734)*

15. *E-mail between* [redacted] *and* [redacted]*, dated 28th August 2015, ONR comments on the full power overarching boiler spines case presentation (TRIM: 2015/281147)*

16. *NGL Paper of Principle – Installation of Insulation in Boiler Spine Annulus and Subsequent Reactor Operation – NP/SC 7734 – EC 355834 (HAR) & EC356010 (HYA) (TRIM 2015/249641)*

17. *Letter from [redacted] to [redacted] dated 28th August 2015, Permissioning strategy for boiler spine recovery project (TRIM 2015/317311).*

18. *LI592 – Specification of Heysham 1 reactor 2 boiler spine structural integrity safety case & justification for return to full power following implementation of the spine cooling modification, NP/SC 7728, EC35506. (TRIM: 2015/325592)*

19. *ONR Project Assessment Report - ONR-CNRP-PAR-15-012 Revision 0* - Specification of Heysham 1 reactor 2 boiler spine structural integrity safety case & justification for return to full power following implementation of the spine cooling modification, NP/SC 7728, EC35506 *(TRIM 2015/308268)*

20. *Structural integrity assessment report – ONR-HYA-AR-15-044 (TRIM: 2015/386994)*

21. *Fault studies assessment report – ONR-HYA-AR-15-055 (TRIM: 2015/425723)*

22. *ONR Contact Report: ONR-HYA-CR-15-235 Revision 0 Teleconference to discuss permissioning approach for HYA R2 NP/SC 7728 (TRIM 2015/423388).*

23. *EDF NGL Email: HYA - Full Power Case Post BSCM - Actions from ONR L4 6th Oct - Updated Response (TRIM 2015/376916).*

24. *EDF NGL Email: EDF NGL - Boiler Spines NP/SC 7728: Final Response to Thermal Assessment Questions (1 -10) (TRIM 2015/397784).*

25. *Probabilistic safety assessment (PSA) assessment report – ONR-HYA-AR-15-065 (TRIM: 2015/438172)*

26. *EDF NGL Report, Hartlepool and Heysham 1: ALARP Head Document for the Long Term Operation of the HYA and HAR Reactors following Defect Identification in HYA 1D1 Boiler Spine. FCP/REP/BSR/008/AGR/15 - Revision 000, May 2015. (TRIM Ref: 2015/191480*

27. *INSA certificate for NP/SC 7728 version 003, dated 2nd September 2015 (TRIM: 2015/327254)*

28. *Minutes of NP/SC 2278 version 003, presented to NSC on 26th August 2015 TRIM: 2015/331393)*

29. ******SUPERSEDED***** *EDF NGL Letter: NSL/HYA/50776 (Y) dated 4 September 2015, Nuclear Installations Act 1965 (as amended), EDF Energy Generation Ltd, Heysham 1 Power Station, Nuclear Site Licence 60: NP/SC 7728 Reactor 2 Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification (EC 355061) covering:*

    ******SUPERSEDED***** *NP/SC 7728 Heysham 1 Reactor 2 – Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification, EC No 355061, Revision 000, Proposal Version No: 03.*

    ******SUPERSEDED***** *Full INSA Approval Statement : NP/SC 7728 Heysham 1 Reactor 2 – Boiler Spine Structural Integrity Safety Case & Justification for Return to Full Power Following Implementation of the Spine Cooling Modification, EC No 355061, Revision 000, Proposal Version No: 03. (TRIM 2015/359430).*

30. *ONR Integrated intervention strategy (IIS) rating guide table (TRIM 2014/12522).*

31. *ONR HOW2 Business management System*

http://www.onr.org.uk/operational/assessment/index.htm

Purpose and Scope of Permissioning - NS-PER-GD-014 Rev 4

Guidance on the production of Reports - NS-TAST-GD-084, Rev 8

Peer Review for Technical Assurance NS-TAST-GD-085, Rev 4

32. Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014.

http://www.onr.org.uk/saps/saps2014.pdf