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Heysham 1 and Hartlepool: Boiler spines recovery

NP/SC 7733 Heysham 1 Power Station Reactor 2 return to service at reduced power with spine cooling modifications installed (EC355558)

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EXECUTIVE SUMMARY

Title

NP/SC 7733 Heysham 1 Power Station Reactor 2 return to service at reduced power with spine cooling modifications installed.

Permission Requested

EDF Energy Nuclear Generation Ltd (NGL), the licensee of Heysham 1 power station, has requested Office for Nuclear Regulation's (ONR's) agreement under arrangements made under Licence Condition 22(1) for Reactor 2 to return to service at reduced power with a boiler spine cooling modification installed.

Background

The Heysham 1 and Hartlepool reactors utilise a pod boiler design. The role of the pod boilers is to remove heat from the core, converting this energy into steam. Each reactor comprises four boiler quadrants, with each boiler containing two pods, eight pods in total. The pods are suspended from individual spines that support the weight of the pod assembly. The spines are welded structures, manufactured from several types of material. Material selection of each section of the boiler spine is based on the thermal and load duty associated with that location of the pod boiler.

The reactors at Heysham 1 and Hartlepool are currently operating at reduced power following the discovery of a defect in the spine of boiler 1D1 at Heysham 1 Reactor 1.

The defect was discovered during in-vessel inspections of the boiler spine undertaken during August 2014 following suspect indications that there may be a defect present, revealed during routine Guided Wave Testing of this particular boiler spine during the 2013 statutory outage.

Heysham 1 Reactor 2 was returned to service under a revised safety case in November 2014 following assessment by ONR, for which the project assessment report is available on the ONR website. The approach taken by NGL was the introduction of a new claim on defect tolerance and forewarning of failure. This provided confidence that, should similar defects be present on other spines, inspection techniques would be capable of detecting them before they reached the point of failure. This claim was primarily supported by a reduction in weld operating temperature with a targeted reduction of 40°C from full power conditions. The reduced temperature was stated to reduce rates of creep damage accumulation and creep crack growth by approximately a factor of 10 in the event that previously undetected defects were present on other boiler spines. The safety case argued that (with the exception of Heysham 1's Reactor 1 Boiler Spine 1D1), sufficient evidence was presented to demonstrate that boiler spine failure remained an infrequent fault (less than 1 spine failure per 1000 years). Additionally, NGL provided justification demonstrating that the safety case remained tolerant against failure of boiler spines in up to two quadrants.

Several commitments were made by NGL to improve the safety case position in the longer term. These included a commitment to develop an implementation plan for a cooling modification to reduce the temperature around the highest risk welds. Inner shroud annulus insulation was identified as the preferred cooling modification and is being implemented on Heysham 1 Reactor 2 during the statutory outage. Justification for implementation of the cooling modification, including full details of the proposed design, has been addressed separately under a modification proposal called an engineering change. The modification involved remote installation of insulation within the gap between the boiler spine and the Re-Heater Inner Shroud, where the highest risk welds are located.

The ultimate aim of the cooling modification is to support a return to full power operation. However, the full programme of work required to underwrite a full power safety case was not available on the timescales of the statutory outage where the modification was to be implemented. Therefore, NGL have sought to justify return to service with the cooling modifications installed but with the same spine temperature reductions as stated within the extant safety case, i.e. return to service without claiming the benefit from the cooling modification.

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; this has included inspections of NGL's readiness to implement the safety case at Heysham 1.

The specialist inspectors 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

Assessment of the NGL case was undertaken against the following topic areas:

Structural integrity:

The structural integrity specialist is satisfied that the proposed cooling modification is unlikely to significantly affect the previous structural integrity judgements. This judgement is time-bound to the validity of the safety case for a period of no longer than a period of three years from restart of Heysham 1 Reactor 2 or until a safety case for operating at revised conditions is implemented following acceptance by ONR.

The ONR structural integrity specialist noted in his assessment that the installation of the cooling modification has a dis-benefit in terms of removing the ability to undertake further visual inspections to support the infrequent seismic claim. This does not, in his judgement, affect the return to service of the reactor at low power operation, but could prove difficult should a long term case for the infrequent seismic case not be possible without further visual inspection, or if cracking was identified on a spine at some stage in the future.

Mechanical engineering:

The ONR mechanical engineering specialist considered the potential impact of the insulation material being released. The assessment looked at the effects of this material entering the primary coolant (gas) circuit, and the potential effects on the associated pressure relief systems, focusing on main vessel pressure relief valves, the down-stream filters and the associated bypass bursting discs. From a mechanical engineering perspective, the specialist is satisfied that the release if material will not adversely affect safe operation of the reactor and he has no objections to the proposed return to service of Heysham 1 Reactor 2 at reduced power.

Fault studies:

The ONR fault studies specialist considers that confidence derived from the validation of the thermal models as presented is limited by the various adjustments to the model that were required to match the rig data and by the need to ignore some thermocouple measurements. The specialist does however accept that the rig tests indicate that the cooling modification is unlikely to result a temperature increase in weld 12.3.

Consequently, it is the view of the ONR fault studies specialist that the absolute values of calculated temperature should be treated with a degree of caution. The ONR faults studies specialist concludes that in his judgement it is highly unlikely that the cooling modification could result in an increase in weld 12.3 temperature relative to the unmodified case.

Probabilistic Safety Analysis (PSA):

The ONR PSA specialist considered that whilst there remain limitations in the ALARP case, he does not consider these to undermine NGL's claim that the risk associated with the return to service of Heysham 1 Reactor 2 at reduced power is ALARP. These limitations will be more important in any safety case to increase the reactor power or for implementing the cooling modifications on Heysham 1 Reactor 1 or the Hartlepool reactors.

Overall the ONR PSA specialist considers the ALARP position is more clearly presented, compared with the previous return to service, and a number of areas have been progressed.

Conclusions

ONR undertook assessment of NP/SC 7733 Heysham 1 Power Station Reactor 2 return to service at reduced power with spine cooling modifications installed following NGLs request under Licence Condition 22(1).

ONR specialist inspectors have engaged with NGL and sampled the presented safety case. Overall the assessment has found that the safety case adequately demonstrates that continued low power operation of the reactor will not be adversely affected by installation of the cooling modification (i.e. a 'no detriment' case). On this basis, the specialists have identified no objections to the proposed activity.

Based on the interventions carried out, the specialist assessments completed and the project inspector's review of NGL's arrangements, ONR was satisfied that NGL's safety case for return to service of Heysham 1 Reactor 2 was ready to be implemented; consequently, agreement to implement the safety case at Heysham 1 Reactor 2 was granted.

Recommendation

It was recommended that the Superintending Inspector:

- Signs this project assessment report to confirm support for the ONR technical and regulatory arguments that justify issuing Heysham 1 Reactor 2 Licence Instrument 589.
- Signs this project assessment report approving its release for publication, after redaction where appropriate.
- Signs Heysham 1 Reactor 2 Licence Instrument 589.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
CNRP	Civil Nuclear Reactor Programme
BSL	Basic Safety Level
EA	Environment Agency
EC	Engineering Change
ECT	Eddy Current Testing
fpd	Failure per demand
GWT	Guided Wave Testing
HRA	Hartlepool
HYA	Heysham 1
HOW2	(Office for Nuclear Regulation) Business Management System
INA	Independent Nuclear Assurance
INSA	Independent Nuclear Safety Assessment
IR	Intervention Report
LC	Licence Condition
LI	Licence Instrument
RP RTS	Reduced Power Return to Service (target reduction of operating temperature by 40°C)
NGL	(EDF Energy) Nuclear Generation Ltd
NSC	Nuclear Safety Committee
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
pry	Per year
PSA	Probabilistic Safety Assessment
PSRG	Project Safety Review Group
QFT	Quadrant Feed Trip
R1	Reactor 1
R2	Reactor 2
RHIS	Re-Heater Inner Shroud
SAPs	ONR Safety Assessment Principles for Nuclear Facilities
T&CP	Testing and Commissioning Panel
VOPE	Vessel Overpressure Protection Equipment

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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) Agrees to the implementation of its reduced temperature operation safety case for the return to service of HYA Reactor 2 (R2) under revised safety case NP/SC7733 (*Ref. 2)*.

2 The requests have been made in accordance with HYA arrangements to comply with Clause 1 of Licence Condition (LC) 22 “Modifications or experiment on existing plant”. This Project Assessment Report (PAR) considers ONR’s assessment and inspection of NGL’s safety case and the readiness of the site to implement it and makes recommendations on whether an Agreement should be granted to enable return to service at low power.

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 8 boiler spines (1D1) 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 following suspect indications revealed during routine Guided Wave Testing (GWT) of this particular boiler spine during the 2013 statutory outage.

4 Following a programme of work, HYA R2 was returned to service under NP/SC 7717 *(Ref. 3)*. The return to service was permissioned in November 2014 under Licence Instruments (LI) 549 and 550 for the Hartlepool reactors and LI 584 for Heysham 1 R2. The approach taken in NP/SC 7717 was the introduction of a new claim on defect tolerance and forewarning of failure. This claim was primarily supported by a reduction in weld operating temperature (target reduction of 40°C from full power conditions) to reduce rates of creep damage accumulation and creep crack growth by approximately a factor of 10 in the event that undetected defects were present on other boiler spines. NP/SC 7717 argued that, with the exception of HYA 1D1, sufficient evidence was available to demonstrate that boiler spine failure remained an infrequent fault, albeit at a higher random failure frequency of 10^{-3} pry compared to the previous 10^{-4} pry claim. Additionally, failure of boiler spines in up to 2 quadrants was conceded for a bounding seismic fault.

5 NP/SC 7717 made several commitments to improve the safety case position in the longer term, including 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 *(Ref. 4)* and is being implemented on HYA R2 during the 2015 statutory outage. Justification for implementation of the cooling modification, including full details of the proposed design, has been addressed separately by EC354803 which is considered by this PAR as a supporting reference for the Reduced Power Return to Service (RP RTS) case. The modification involves 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 design life for the cooling modification is 15 years from installation.

6 The ultimate aim of the cooling modification is to support an increase in reactor operating power. However, the full programme of work required to underwrite an increased power safety case was not available on the timescales of the 2015 statutory outage. Therefore, NGL proposed a justification to return to service with the cooling modifications installed but with the same spine temperature reductions as NP/SC 7717, i.e. return to service without claiming the benefit from the cooling modification.

7 This safety case is intended to remain valid until the 2018 statutory outage on HYA R2, or until a safety case for increasing reactor power is produced and approved.

3 SUMMARY OF LICENSEE's SAFETY CASE

8 NGL proposes to return HYA R2 to operation at reduced power following the 2015 R2 outage with cooling modifications installed. The claims, arguments and evidence for this case are presented in NP/SC 7733 *(Ref. 2)*. The power level achieved will be as per the arrangements set out within the extant safety case NS/PC 7717 *(Ref. 3)*. No claim is made under NP/SC 7733 to claim benefit from the installed cooling modification. Return to service of HYA R2 is being undertaken on a 'no nuclear safety detriment' case i.e. that installation of the cooling modifications has not adversely affected operation of HYA R2 at reduced power.

9 *Reference 2* presents arguments to demonstrate that the likelihood of a boiler spine failure is unaffected by the installation of the cooling modification. Further evidence is provided through presentation of inspection results (visual, eddy current testing (ECT) and guided wave testing (GWT)) demonstrating confidence that defects are not present in any of the other reactor boiler spines. In the unlikely event that such defects arise and remain undetected and lead to boiler spine failure, NGL demonstrate that the consequences are acceptable and the nuclear safety risk is As Low As Reasonably Practicable (ALARP).

10 The cooling modifications were installed on HYA R2 under EC354803 *(Ref. 5)*. The spine cooling modification involves filling the RHIS annulus with loose-fill insulation material to a depth sufficient to cover weld 12.3. In order to retain the insulation material within the RHIS annulus it is necessary to plug the 8 bleed holes and 4 grub screw holes which are present at the bottom of the RHIS *(Fig 1)*. The principle purpose of the modification is to limit the flow of hot 'coolant' gas down the annulus, it is this gas flow that represents the dominant heat transfer. The gas bleed holes and grub screw holes are covered using specially designed plugs which will be held in place by springs. The blanking plugs are remotely deployed from the top of the Boiler Closure Units via the TV and instrument penetrations. Given the variability in the annulus geometry and the differing access afforded by the TV and instrument penetrations, two types of plug were justified for installation at each type of hole. Specially developed deployment equipment was used to insert the blanking plugs into the RHIS annulus.

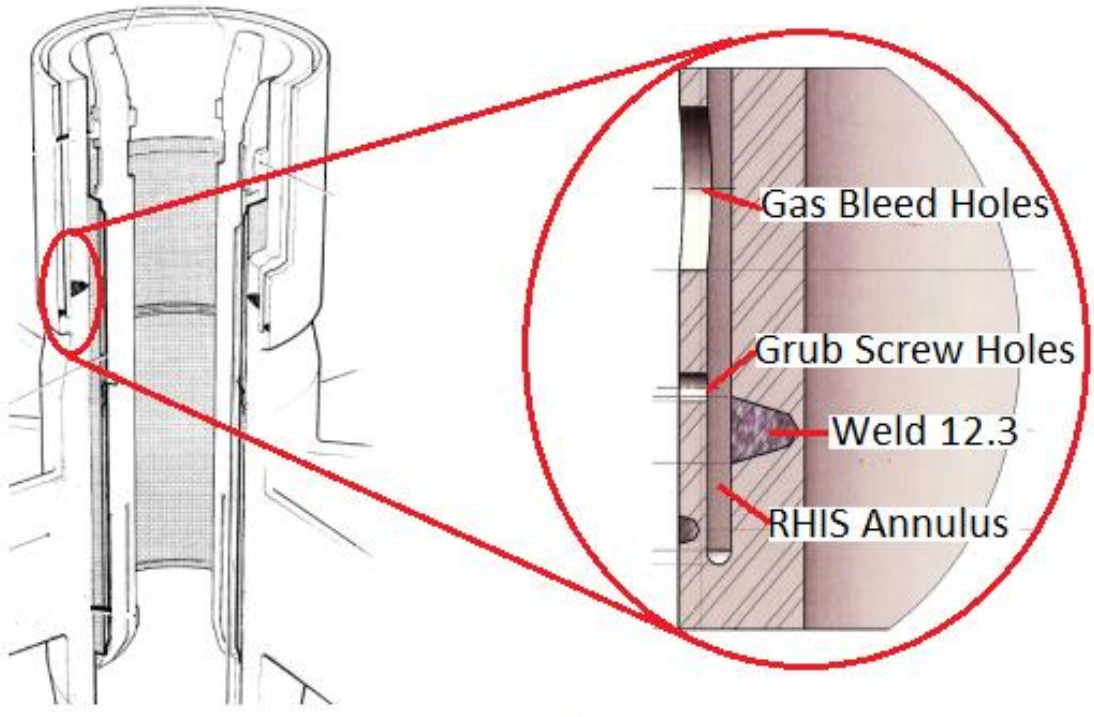

Fig 1 - Boiler Spine RHIS Annulus

3.1 Claims, Arguments and Evidence:

11 NGL's safety case is based on the following Claims and Arguments:

- **Claim 1: Random failure of the boiler spines remains infrequent.**
  - Argument 1.1: The effect of the cooling modification on spine weld temperatures has been assessed.
  - Argument 1.2: The temperature changes at weld 12.3 do not significantly affect the limiting defect size.
  - Argument 1.3: Forewarning of failure margins are not significantly degraded following cooling modification installation.
  - Argument 1.4: Temperature changes over the remainder of the spine do not significantly adversely affect structural integrity.
- **Claim 2: In the event of boiler spine failure, the consequences remain tolerable.**
  - Argument 2.1: The reduction in spine length due to the cooling modification can be predicted.
  - Argument 2.2: Pressure boundary integrity is not sensitive to the increase in drop distance.
- **Claim 3: Boiler tube failure rates are not significantly increased by the cooling modification.**
  - Argument 3.1: Local increases in temperature due to the cooling modification are not significant for tube integrity.
  - Argument 3.2: Reduction in spine expansion and the corresponding increase in tailpipe loads does not lead to a significant increase in the risk of tailpipe failure.
- **Claim 4: The modification will not adversely affect reactor internals even if materials are released into the circuit.**
- **Claim 5: The risk associated with return to service of HYA R2 at reduced power is ALARP.**
  - Argument 5.1: Installation of the spine cooling modification is a desirable risk reduction measure that provides a significant safety benefit.
  - Argument 5.2: All other reasonably practicable risk reduction measures are being progressed.

4 ONR's ASSESSMENT AND INSPECTION SCOPE

12 The scope of this assessment is limited to the return to service of HYA R2 at reduced power, as set out within the extant safety case NS/PC 7717 *(Ref. 3)* following installation of cooling modifications to the boiler spines. The assessment has been undertaken on a 'No Detriment' basis to ensure work undertaken by NGL to install cooling modifications to the boiler spines at HYA R2 has not adversely affected the safe operation of the reactor once it returns to power under the extant operating conditions.

13 Installation of the cooling modifications was carried out under EC354803 *(Ref. 5)*. Whilst this case has not been formally called in for permissioning by ONR, the EC has been included within the scope of this assessment to ensure adequacy of the no detriment case.

14 ONR has assessed NGL's safety case, supported by several level 4 interventions to determine NGL's readiness to implement the safety case. The scope of these aspects of ONR's work is considered below.

4.1 Assessment Scope

15 Reference 6 is the ONR Task Sheet for this work. The task sheet outlines the scope of ONR's assessment and identifies the following specialists assigned to assess NGL's safety case:

- Structural integrity *(Ref.7)*;

- Fault studies *(Ref. 8)*;
- Mechanical Engineering *(Ref. 10)*;
- Probabilistic Safety Analysis (PSA) *(Ref. 11)*.

16 These specialists have sampled NGL's safety case *(Ref. 2)* focusing their attention on the following Claims:

- Structural Integrity – Claim1, Claim 2 and Claim 3;
- Fault Studies – Claim 3;
- Mechanical Engineering – Claim 4;
- Probabilistic Safety Assessment – Claim 5.

5 ONR ASSESSMENT UNDERTAKEN TO PERMISSION THE PROPOSED ACTIVITY

5.1 Structural Integrity

17 The ONR Structural Integrity assessment *(Ref. 7)* comprised the significant portion of the ONR scope. This was due to the significance and relevance of the safety case claims to the Structural integrity specialism. The findings of this assessment are summarised below:

5.1.1 Claim 1 - Random failure of the boiler spines remains infrequent.

18 The ONR Structural Integrity specialist noted that that ONR's previous assessment of the existing HYA safety case (*Ref. 3)* did not accept that the random failure frequency should be considered as infrequent. ONR accepted, on a judgement basis, that the evidence supported a random failure frequency for the boiler spine of the order to 10^{-3} pry, but that due to the difficulties in quantifying this number, a cautious approach should be taken and the failure frequency should be considered to be on the frequent side of the frequent/infrequent boundary of 10^{-3}.

19 The ONR Structural Integrity specialist was satisfied that the cooling modification does not adversely affect the structural integrity of the spine nor the forewarning of failure margins compared with the existing safety case *(Ref. 3) n*or the validity period of the case. The specialist therefore considers that the cooling modification does not adversely affect ONR's previous conclusion.

20 This conclusion is conditional on the licensee's claim that the temperatures in the weld 12.3 region following the modification cannot be higher than in the unmodified state and as such, the Structural Integrity specialist recommends that the project inspector confirms with the ONR fault studies specialist that there can be no increase in temperature of the spine in the Weld 12.3 region as a result of the cooling modification [*See section 5.2 below*].

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

21 The ONR Structural Integrity specialist highlighted in their assessment report that one of the potential consequences associated with a failure of the boiler spine is for the boiler to drop and impact on the gas circulator housing, resulting in an impact on the associated pressure vessel penetrations. The gas circulator housing and associated penetration fixings have been assessed and qualified as a highest reliability component for a variety of operational and fault conditions.

22 The cooling modification will reduce the amount of thermal expansion that the spine extends under normal operating conditions by circa 10mm. This reduction will increase the potential boiler drop height following spine failure under operational conditions. The ONR Structural Integrity specialist is satisfied that the thermal boundary conditions used by NGL represent a maximum cooling assumption from the modification, The

specialist is therefore satisfied that the case is conservative in terms of maximising the potential drop height.

23 The licensee judges that the consequences of the increase in boiler drop height as a result of the cooling modification are inconsequential and that the claim on the gas circulator liner/penetration integrity remains acceptable against the ASME III service level D conditions for an infrequent failure component.

24 The ONR Structural Integrity specialist sampled the supporting assessment work conducted by the licensee and is satisfied that the assessment is suitably conservative and adequate to support the claim that the installation of the cooling modification and the subsequent reduction in potential boiler drop height will not affect the claim on the gas circulator liner/penetration integrity.

5.1.3 Claim 3 - Boiler tube failure rates are not significantly increased by the cooling modification.

25 The concern for this claim originates from changes in operational conditions local to the cooling modification, such as localised increases in temperature and stressing of the boiler tubes.

26 In the unmodified state, the boiler spine and boiler tubes will expand and contract proportionately. The consequences of cooling Weld 12.3 of the boiler spine will reduce the amount of thermal expansion that occurs under on load conditions. This will induce a loading on the boiler tube tailpipes, constraining the expansion that normally occurs.

27 The licensee has reviewed the implications of the cooling modification on the increase in tailpipe compression for normal operation conditions at reduced or increased power conditions until 2019. The licensee has used this information to support a judgement that the cooling modification will have minimal impact on the tailpipe failure frequency as a result of differential thermal expansion between the tailpipe and the spines until 2019 which is in excess of the current proposed validity date of 2018 presented in NP/SC 7733 *(Ref. 2)*.

28 The ONR Structural Integrity specialist sampled the scope of environmental and mechanical input parameters used by the licensee within the submission and concluded that these are appropriate to support NGL's judgement. The licensee has also provided a list of conservatisms applied in making this judgement, which the specialist considers to be adequate. These included assuming the maximum predicted cooling margin for a full power reactor which will impose the highest magnitude of compression to the boiler tube tailpipes.

29 The ONR structural integrity inspector conducted a high level review of the engineering advice note that is referenced by the licensee in support of Claim 3. The judgement was that the licensee's approach and methodology to demonstrate that the cooling modification does not significantly increase the frequency of tube failure rates is considered appropriate. However, this is noted to be a reactor-specific judgement, and that the same argument cannot necessarily be applied for other reactors where the number of restricted boiler tubes and chemical cleaning cycles will vary.

5.1.4 Overall Structural Integrity Conclusion

30 Overall the ONR Structural Integrity specialist is satisfied that, based on the sampling undertaken, the proposed cooling modification is unlikely to significantly affect the structural integrity judgements made previously regarding the likelihood of boiler spine failure for operation at reduced power conditions. This judgement is time-bound to the validity of the safety case for a period of no longer than a period of three years from restart of HYA R2 or until a safety case for operating at revised conditions is implemented following acceptance by ONR.

31 The ONR Structural Integrity specialist noted in his assessment that the installation of the cooling modification has a dis-benefit in terms of removing the ability to undertake further visual inspections to support the infrequent seismic claim. This does not affect the return to service of HYA R2 at low power operation, but could prove difficult should a long term case for the infrequent seismic case not be possible without further visual inspection or if cracking was identified on a spine at some stage in the future. ONR wrote to NGL on 13th June 2015 *(Ref. 8)* setting out its concerns in respect to this matter. The licensee accepts this limitation and believes that the further analysis work that is being undertaken to support the revised operation case for increasing power will show that there will be no requirement for further visual examination to support the infrequent seismic case. ONR has not yet seen this further work, and has informed the licensee that they are proceeding at their own commercial risk, pending a suitable demonstration.

32 The licensee has also provided an update with regards to the progress that is on-going to support the commitments made in the previous safety case. A recommendation made by the previous ONR structural integrity assessment was to review the structural integrity commitments. The ONR Structural Integrity specialists reviewed the updates provided by the licensee on this matter and is satisfied that the licensee is making adequate progress with the commitments. It is the opinion of the ONR Structural Integrity specialist that progress to date has identified no structural integrity issues that are likely to affect the safe return to service of R2 for another operating period.

33 The following recommendations were raised within the Structural Integrity assessment:

- **Structural Recommendation 1:** The project inspector should confirm that the outcome of the fault studies assessment is aligned with the Structural Integrity specialist's understanding that installation of a cooling modification will not increase temperatures in the Weld 12.3 region of the boiler spines within HYA R2.
- **Structural Recommendation 2:** The project inspector confirms that the report on the as-installed condition of the pods is reviewed as part of the project assessment report to confirm that there are no adverse findings from the visual inspections.

Based on the sampling undertaken, the ONR Structural Integrity specialist had no objection to the proposed activity.

5.2 Fault studies

34 The ONR Fault Studies specialist focused their assessment *(Ref. 8)* on Claim 3 of the safety case; specifically the claim that the cooling modification is not detrimental.

35 The thermal modelling of weld 12.3 temperature is complex and is supported by experimental validation. It is the view of the ONR Fault Studies specialist that the confidence derived from the validation of the thermal models as presented is limited by the various adjustments to the model that were required to match the rig data and by the need to ignore some thermocouple measurements. Whilst the explanations provided for this are plausible, they could mask other modelling deficiencies. Given this and other limitations of the rig tests, the specialist does not accept the claim in *Reference 1* that the results of the test rig are considered to provide validation of the thermal model when extrapolated to reactor conditions. The specialist does however accept that the rig tests indicate that the cooling modification is unlikely to result a temperature increase in weld 12.3.

36 Consequently, it is the view of the ONR Fault Studies specialist that the absolute values of calculated temperature should be treated with a degree of caution. Notwithstanding this, the specialist notes that even on a "worst case" basis the cooling modification results in a small reduction in weld 12.3 temperature. They also note that that the thermal conductivity of the insulation, a key factor in determining the effect of the cooling modification, would have to be significantly higher than the measured thermal conductivity for weld 12.3 temperature to increase. Taking these factors into

account, the ONR Fault Studies specialist judges that it is very unlikely that the cooling modification could result in an increase in weld 12.3 temperature relative to the unmodified case.

37 The judgement is subject to the cooling modification being implemented as per the requirements of the safety case. Noting that information (summary sheets for each boiler pod) confirming the status of the cooling modification and the outcome of the PSRG will be provided to ONR prior to the issue of the requested Licence Instrument, the ONR Fault Studies specialist makes the following recommendation:

- **Fault Studies Recommendation 1:** The project inspector should review the information provided by NGL relating to installation of the cooling modification, and satisfy himself that:
    - The RHIS to boiler spine annular gap for each boiler pod is not significantly less than the 11mm assumed in the safety case.
    - That the depth of insulation in each boiler pod is at least 500mm.
    - There are no boiler pods where the modification has only been partially implemented.

38 The ONR Fault Studies specialist notes that information (summary sheets for each boiler pod) confirming the status of the cooling modification and the outcome of the Project Safety Review Group (PSRG) will be provided to ONR prior to the issue of the requested Licence Instrument.

39 In terms of the potential benefit of the cooling modification, it is currently unclear to the ONR Fault Studies specialist whether it will be possible to justify an increase in power on the basis of the cooling modification. This position should become clearer in the near future when EDF NGL outlines its proposal for increased operating power. In the context of Heysham 1 Reactor 2 given that the cooling modification is nearly complete, the lack of clarity over the benefit that may be claimed was noted to be less than ideal. The specialist therefore recommended that before the cooling modification is implemented on the Hartlepool reactors and Heysham 1 Reactor 1, ONR will need an appropriate level of confidence that there is an overall benefit from the modification.

40 Based on this position, the specialist makes the following recommendation:

- **Fault Studies Recommendation 1:** The ONR boiler spine assessment team should consider whether, in light of the reduced benefit of the cooling modification, it is appropriate for EDF NGL to progress with implementation of the cooling modification on the Hartlepool reactors and Heysham 1 Reactor 1.

41 NGL has since been confirmed that the ALARP demonstration for installation of the cooling modification at other reactors will be included as part of the engineering change used to implement the modification *(Ref. 12*). These will be done on a reactor by reactor basis rather than a generic case.

42 Fault Studies 1 recommendation has since been closed, see *section 5.5* below.

5.3 Mechanical Engineering:

43 The ONR Mechanical Engineering specialist based his assessment *(Ref. 10)* on the potential impact of molecular sieve 4A bead insulating material being released. The assessment looked at the effects of this material entering the primary coolant (gas) circuit, and the potential effects on the associated pressure relief systems, focusing on main vessel pressure relief valves, the down-stream filters and the associated bypass bursting discs.

44 The ONR Mechanical Engineering specialist reviewed the Carbon deposition and Graphite debris report since NGL argue that release of insulation is bounded by the extant case for these other types of debris. The specialist noted a significant variance

in mass, particle size and strength between the carbon deposition and the molecular sieve material. The specialist concluded however that due to the conservative assumptions made within the carbon deposition report, the case remained suitably bounding for the cooling modification insulating material.

45 The specialist considered that insulation material could enter the gas circulation circuit and hence the Safety Relief Valve (SRV), thus preventing the SRV from functioning correctly by reducing the flow rate through the valve. The specialist considered the strength of the insulating material to resist the closing force of the SRV as being the most relevant factor concluding that the SRV has sufficient force to crush the insulating material. The ONR Mechanical Engineering Specialist considered the impact of the insulation material causing a blockage to the valve, preventing reseat. The ONR Mechanical Engineering specialist is satisfied that sufficient defence in depth is present in the safety system design to mitigate the potential fault.

46 The mechanical assessment considered the impact of a release of insulating material on the main pressure relief valve filters and associated bursting discs. The specialist is satisfied that the insulating material installed as part of the cooling modification does not pose any increased risk to the safe operation of the reactor at reduced load and is adequately bounded by the extant safety case.

47 From a mechanical engineering perspective, the specialist has no objections to the proposed return to service of Heysham 1 Reactor 2 at the currently-justified reduced power.

5.4 PSA

48 The ONR PSA specialist sampled the case to determine whether the recommendation made relating to ALARP (ONR issue 2714, Action 6) had been adequately addressed *(Ref. 11)*. Regarding NGL's claim on ALARP, the specialist considered whether the ALARP case supports return to service, and the approach taken in the identification of options for improvement.

49 The ONR PSA specialist considered that, whilst there remain limitations in the ALARP case, he does not consider these to undermine NGL's claim that the risk associated with the return to service of Heysham 1 Reactor 2 at reduced power is ALARP. These limitations will be more important in any safety case to increase the reactor power or for implementing the cooling modifications on Heysham 1 Reactor 1 or the Hartlepool reactors.

50 Overall the ONR PSA specialist considers the ALARP position is more clearly presented, compared with the previous return to service, and a number of areas have been progressed. This therefore addresses the recommendation captured in action 6 of ONR issue 2714 which can now be closed.

- NGL's original expectation was for the cooling modification to deliver a new cooling to Weld 12.3 in excess of 40°C. Subsequent refinement to the thermal modelling has revised down to a conservative estimate of circa 27°C. The specialist concluded that, whilst he had no objection to the proposed activity, he made the following recommendation:

- **PSA Recommendation 1:** NGL should provide a robust ALARP demonstration to show that the alternative cooling modifications remain not reasonably practicable due to the reduced benefit compared to originally envisaged. This is required prior to NGL implementing the boiler spine re-heater inner shroud annulus insulation modification on Heysham 1 Reactor 1 or the Hartlepool reactors.

51 As discussed within the Fault Studies assessment above *(paragraph 41),* NGL has since confirmed an ALARP demonstration will be provided on a station by station basis for installation of the cooling modification.

52 Fault Studies 1 recommendation has since been closed, see *section 5.5* below.

5.5 ALARP Position on Future Cooling Modifications

53 An internal meeting was held on 3rd August 2015 (*Ref. 13)* to discuss the ALARP position of installing the cooling modification on other stations considering the reduced benefit. The meeting concluded that, based on the longer term benefit expected to be delivered by the modification in terms or return to an increased power, the modifications remain ALARP. This is expected to be further reinforced by the reactor-specific ALARP justifications contained within the individual Engineering changes.

54 The Project Inspector will continue to monitor this process as part of normal business for boiler spine recovery work, seeking specialist input and assessment as required.

55 The PSA and Fault Studies specialists have confirmed they are satisfied to close their recommendations based on this.

6 ONR PROJECT INSPECTOR'S REVIEW OF LICENSEE'S PROCESS

56 On 23rd July 2015, the Station Director for HYA wrote to ONR *(Ref. 1)* under HYA's LC22 (1) arrangements requesting Agreement to the return to service of HYA R2.

57 NGL's approach to the HYA R2 boiler spine cooling modification was considered by ONR to be unusual. NGL did not follow its normal arrangements for managing a project with such wide reaching implications. No Nuclear Safety Requirements Specification or Paper of Principle was produced for the HYA R2 case, with work being proposed through a series of standalone ECs. ONR also considered the potential for commercial pressure to be applied to the project to complete it within the statutory outage time-scales. ONR took cognisance of these factors, concluding that enhanced regulatory focus on NGLs procedures was appropriate and proportionate to ensure the proposed activities were not ill-conceived or poorly implemented.

58 ONR is satisfied that HYA have made appropriate requests under their current LC22 (1) arrangements. For a Category 1 safety case, HYA LC22 arrangements require Verification. This is followed by Independent Nuclear Safety Assessment (INSA) clearance by NGL's internal regulator, Independent Nuclear Assurance (INA). The arrangements also require consideration and advice by the relevant Nuclear Safety Committee (NSC). Following, Verification, INSA clearance and review by the NSC, Agreement from ONR is requested prior to implementation.

59 The Verification statement within *reference 2* indicates that a detailed and thorough verification process has taken place. The verifiers have challenged the impact of the safety case. They have concluded that no major safety issues had been overlooked and that the submission is fit for purpose.

60 INA has issued INSA approval statements *(Ref. 16)*. The overall INSA conclusions were that the installation of the cooling modification has not adversely affected the ability of the station to operate safely at reduced power. Whilst some of the detailed comments raised by INSA have not been fully addressed, INA are satisfied that these apply to the increased power case and do not affect the decision to return HYA R2 to operation at reduced power. INA are further satisfied that the risk of boiler spine failure remains ALARP.

61 The final revision of the safety case *(Ref. 2)* was taken at the NSC held on 25th June 2015 *(Ref. 17)*. The overall conclusions were that they supported the return to service of HYA R2. INA are satisfied there are no issues remaining to prevent start up and subsequent operation at reduced power.

62 Governance of the project has been managed through the Project Safety Review Group (PSRG) and the Testing and Commissioning Panel (T&CP). I have considered the terms of reference *(Ref. 18)* for both the PSRG and the T&PC that sits beneath it and have found them to be in line with ONR's expectations. I have sampled minutes from the PSRG *(Ref. 19)* and am satisfied that they have provided adequate control to the project in terms of considering release of internal hold points and sentencing of inspection results. I requested that NGL submit the pod-by-pod completion report (*Ref. 20)* as part of the letter of request package. The report was accepted by the PSRG on 28th July 2015 *(Ref. 1).* As recommended by the ONR Structural Integrity Assessment (Structural Recommendation 1), I have reviewed the report and associated PSRG minutes and am satisfied that due process has been completed in line with NGL's arrangements.

63 I conclude that NGL's due process for Category 1 safety cases has been completed and that the NGL internal regulator has performed due diligence on the case.

7 ONR PROJECT INSPECTOR REVIEW OF LICENSEE'S SAFETY CASE

64 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. 21)*.

65 The ONR process for delivering a permissioning project requires preparation of a PAR to facilitate a permissioning decision by the 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. 21)* and is informed by the assessment findings of specialist inspectors assigned to the project.

66 To enable ONR to undertake its assessment process in parallel with NGL's own internal processes, ONR has maintained open dialogue via telephone conferences on a weekly basis and meetings between ONR and NGL throughout the project. *Reference 6* provides a full record of these dialogues.

67 To support this permissioning activity I have:

- Utilised the services of the ONR specialist inspectors assigned to this project by the ONR CNRP management team.
- Considered NGL's safety case Verification statement *(Ref. 2)*
- Considered the resolution of NGL INSA comments *(Ref. 15)* and the issuing of the NGL INSA statement *(Ref. 16)*.
- Considered NSC comments and its overall support for the return to service of HYA R2 *(Ref. 17)*.
- I have considered the overall safety case as presented.
- I have drawn upon the ONR specialist inspector's considerations and recommendations in the areas of structural integrity, fault studies, mechanical engineering and PSA. I have drawn together their findings and conclusions in this PAR to inform my overall judgement on NGL's submitted safety case.

68 Each discipline has produced a report that presents the assessment findings, inspector's 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. 21).*

All of the specialist inspectors' assessment reports have undergone independent peer review in accordance *with ONR How2 Business Management System (BMS)* guide *Peer Review for Technical Assurance NS-TAST-GD-085, Rev 4 (Ref. 21)* which

supports the approach taken, conclusions raised and recommendations made by the specialist inspectors.

69 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.

70 A number of questions arose from the inspectors' work, these have adequately been closed out to the satisfaction of the specialist inspectors concerned *(Ref. 13).*

71 I am content that the safety case has been adequately challenged by Verification, INSA and the NSC.

72 I am satisfied that NGL's submitted safety case *(Ref. 2)* has been adequately challenged by the assessment undertaken by ONR's specialist inspectors (within the identified bounds of their sampled assessment).

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

73 ONR undertook assessment of NP/SC 7733 Reactor 2 Return to Service at Reduced Power with Spine Cooling Modifications Installed (EC355558) following NGL's request under Licence Condition 22(1) in relation to HYA R2.

74 ONR specialist inspectors have engaged with NGL and sampled the presented safety case. Overall the assessment has found that the presented safety case adequately demonstrates a 'no detriment' case. The specialists have identified no objections to the proposed activity.

75 Based on the specialist assessments completed and my own review of NGL's arrangements, I am satisfied that NGL's safety case for return to service of Heysham 1 Reactor 2 is ready to implement the safety case; consequently, Agreement (*Ref. 23)* to implement the safety case at Heysham 1 Reactor 2 can be granted.

8.2 Recommendations

52 I recommend that the Superintending Inspector:

- Signs this Project Assessment Report to confirm support for the ONR technical and regulatory arguments that justify issuing Heysham 1 Reactor 2 Licence Instrument 589.
- Signs this Project Assessment Report approving its release for publication, after redaction where appropriate.
- Signs Heysham 1 Reactor 2 Licence Instrument 589.

3.1.4 REFERENCES

1 *NGL Letter of request for NP/SC 7733 Heysham 1 Power Station Reactor 2 Return to Service at Reduced Power with Spine Cooling modifications Installed (EC355558) – Dated: 3rd August 2015 – (TRIM: 2015/292488).*

2 *Reactor 2 Return to Service at Reduced Power with Spine Cooling Modifications Installed – NP/SC 7733 - EC355558, Revision 000, Version 04 Dated 06/2015(TRIM: 2015/221673)*

3 *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- NP/SC 7717 v6 [HRA R1 - EC354020, HRA R2 EC354021, HYA R2 EC354025] (TRIM: 2014/420713).*

4 *ALARP Review in Support of the Interim Return to Service of HYA R2 and HRA Reactors Following Detection of a Defect in the Spine of HYA 1D1- FCP/REP/BSR/002/AGR/14 (TRIM:2015/178329).*

5 *Heysham 1 Reactor 2 - Installation of Insulation in Boiler Spine Annulus – EC354803 (TRIM: 2015/170530)*

6 *ONR Task Sheet* - Heysham 1 and Hartlepool: Boiler Spines Recovery - *TS338 (TRIM: 2014/434077)*

7 *Structural integrity Assessment Report – ONR-HYA-AR-15-014 (TRIM: 2015/259094)*

8 *Email from ONR to NGL regarding installation of cooling modifications on Heysham 1 Reactor 2 (TRIM: 2015/292289)*

9 *Fault studies Assessment Report – ONR-HYA-AR-15-019 (TRIM: 2015/266829)*

10 *Mechanical Engineering Assessment Report – ONR-HYA-AR-15-037 (TRIM: 2015/267753)*

11 *Probabilistic Safety Analysis Assessment Note (TRIM: 2015/ 2015/269735)*

12 *Contact Record of Revised Operating Condition Overarching presentation – CR-15-117 - 21st July 2015 (TRIM: 2015/272734)*

13 *E-mail - ONR discussion on ALARP position of installation of cooling modifications on other stations considering reduced cooling benefit (TRIM: 2015/290750)*

14 *Boiler Spine Cooling modification – ONR Document Tracking Spread-sheet (TRIM: 2015/191819)*

15 *INSA Comments and Responses to EC355558 and NSC Brief (TRIM: 2015/236916)*

16 *NGL INA INSA Statement for NP/SC 7733, EC355558 (TRIM:2015/244713)*

17 *NSC Minutes for EC355558 – 25th June 2015 (TRIM: 2015/267936)*

18 *NSC Comments on EC355558 (TRIM:2015/166129)*

19 *Sample of PSRG Minutes from 19th May, 8th, 11th and 23rd (TRIM: 2015/258988)*

20 *Pod by Pod Report – FCP/REP/BSR/009/AGR/15 (TRIM: 2015/285063)*

21 *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

22 *Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014.* http://www.onr.org.uk/saps/saps2014.pdf.

23 LI589 – Agreement to Reactor 2 Return to Service at Reduced Power with Spine Cooling Modifications Installed – NP/SC 7733 - EC355558 (TRIM: 2015/51281)