ASSESSMENT REPORT			
Unique Document ID and Revision No:	ONR-OFD-AR-17-009 Revision 0	**TRIM Ref:**	2017/189621
Project:	Torness (TOR) Reactor 1 (R1) 2017 Periodic Shutdown		
Site:	Torness		
Title:	Torness (TOR) Reactor 1 (R1) 2017 Periodic Shutdown – Assessment of the results of the Graphite Core Inspections		
Nuclear Site Licence No:	Sc14		
Licence Condition(s):	30, 28		
ONR Assessment Rating (Mandatory): *(Rating should be based on licensee's original safety case submission)*	Green		
COIN Service Order:			

Step-based Document Review

Step	Description	Role	Name	Date	TRIM Revision[*]
1	Initial Draft, including identification and mark-up of SNI/CCI	Author	[redacted]	24/05/2017	
2	Main editorial review	Author	[redacted]	24/05/2017	
3	Peer Review in accordance with NS-TAST-GD-085 Rev 4	Peer Reviewer	[redacted]	24/05/2017	6
4	Assessor update / sentencing of comments and return to Peer Reviewer	Author	[redacted]	24/05/2017	
5	Final editorial / clean draft review	Author	[redacted]	24/05/2017	
6	Acceptance review in accordance with NS-TAST-GD-084 Rev 8	Professional Lead	[redacted]	31/05/2017	
7	Report Sign-off	Author / Peer Reviewer / Professional Lead	[redacted]	31/05/2017	11

---

[*] *TRIM revision to be identified upon completion of activity and incorporation of any changes to document*

Document Acceptance

Role	Name	Position	Signature	Date
Author	[redacted]	[redacted]	[redacted]	24/05/2017
Peer Review[†]	[redacted]	[redacted]	[redacted]	24/05/2017
Acceptance[‡]	[redacted]	[redacted]	[redacted]	31/05/2017

Revision History

Revision	Date	Author(s)	Reviewed By	Accepted By	Description of Change
0	24/05/2017	[redacted]	[redacted]	[redacted]	First formal issue

Circulation (latest issue)

Organisation	Name
ONR	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]

[†] Where required in accordance with ONR How2 BMS Document NS-TAST-GD-085 Revision 6
[‡] Hard-copy of document signed-off, TRIM version updated with authors / approver / acceptor names and dates and record finalised

Operating Facilities Division

Torness Reactor 1 2017 Periodic Shutdown – Assessment of the results of the Graphite Core Inspections

Assessment Report ONR-OFD-AR-17-009
Revision 0
24 May 2017

EXECUTIVE SUMMARY

The licensee, EDF Energy Nuclear Generation Limited (NGL), of Torness (TOR) power station has shutdown Reactor 1 (R1) under licence condition (LC) 30. During the periodic shutdown of TOR R1 the graphite reactor core has undergone surveys, as required under LC28. An intervention was performed during the outage to determine the adequacy of the inspections. There are no outstanding actions from that intervention, which would prevent consent being granted by Office for Nuclear Regulation (ONR) to the return to service of TOR R1.

NGL has completed its graphite core inspection schedule and will request Consent from ONR to restart TOR R1. Therefore, my assessment of the final graphite core structural integrity inspection results is based on the findings provided by NGL in supporting inspection results documents.

I have assessed the TOR R1 periodic shutdown draft documentation and inspection results relating to the graphite core. I have compared the findings with the current graphite safety case and assessed them against the relevant Safety Assessment Principles. Overall, NGL states that the results of the graphite core inspections at TOR R1 2017 periodic shutdown are acceptable and do not challenge safe operation.

In my opinion the graphite core inspection results are within the bounds of NGL’s safety case and do not present any impediment to return to service of TOR R1. I have no objection to the subsequent project assessment report (PAR) recommending that consent is given to return TOR R1 back to service.

My recommendations are as follows.

Recommendation 1: I recommend the project inspector confirms the Independent Nuclear Safety Assessment (INSA) statement has been made available by NGL.

Recommendation 2: I recommend that the PAR records that NGL is in the process of producing a post-stress reversal safety case for the graphite cores at HYB and TOR. This will need to be produced before the extant safety case expires in 2018.

I have ascribed an ONR Assessment rating of green, no formal action.

LIST OF ABBREVIATIONS

AGR	Advanced Gas-cooled Reactor
BMS	Business Management System
fpy	Full power year
GWd	Giga-Watt day
HOW2	(ONR) Business Management System
TOR	Torness Power Station
IJCO	Interim Justification for Continued Operation
INA	Independent Nuclear Assurance
JCO	Justification for Continued Operation
LC	Licence Condition
MW (th)	Mega-Watt (thermal)
NGL	EDF energy Nuclear Generation Limited
NICIE2	New In-Core Inspection Equipment mark 2
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
PBAP	Peripheral Brick Assessment Panel
R	Reactor
SAP	Safety Assessment Principle(s)
TAG	Technical Assessment Guide(s) (ONR)
HYB	Heysham 2 Power Station

TABLE OF CONTENTS

1 INTRODUCTION

1. The licensee, EDF Energy Nuclear Generation Limited (NGL), of Torness (TOR) power station has shutdown Reactor 1 (R1) under licence condition (LC) 30. During the periodic shutdown of TOR R1 the graphite reactor core has undergone surveys, as required under LC28.

2. NGL has completed its graphite core inspection schedule and will request Consent from ONR to restart TOR R1. Therefore, my assessment of the final graphite core structural integrity inspection results is based on the findings provided by NGL in supporting inspection results documents.

1.1 Background

3. NGL's intended scope of the graphite inspections during the periodic shutdown of TOR R1 covered inspections and sampling of fuel channels and inspection of the peripheral shield wall. Inspection of fuel channels has been performed routinely by NGL at all of the Advanced Gas-cooled Reactors (AGR) in the fleet. However, inspection of the peripheral shield wall is unique to Heysham 2 (HYB) and TOR stations as this is a design feature of the reactors at these sites. NGL committed to performing inspections of the graphite peripheral shield wall at these reactors as a result of the observation of cracking of peripheral bricks at TOR Reactor 2 (R2) in 2015 [1], where 17 cracked bricks were observed after inspection of 10 of the 16 faces of the peripheral wall. This approximates to 1.5% cracking of the peripheral bricks in TOR R2. Subsequently, in the Heysham 2 (HYB) Reactor 8 (R8) 2016 statutory outage, 22 cracked peripheral bricks were found from an inspection of 9 out of 16 faces, indicating a percentage of cracking of 2.1%.

4. NGL's intended scope of graphite inspections for the TOR R1 2017 outage is summarised below [22, 3]:

- Inspection of a minimum of 16 fuel channels both visually and dimensionally using a New In-Core Inspection Equipment (NICIE2).
- Trepanning of a minimum of 24 graphite specimens to a depth of 65mm with a target of 30.
- Visual Inspection of control rod channel FG40.
- Inspection of a minimum of 13 out of 16 faces of the peripheral shield wall.

2 ASSESSMENT STRATEGY

5. This report presents the findings of the assessment of the graphite core inspections of TOR R1 during the 2017 periodic shutdown and supporting documentation provided by NGL. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide NS-PER-GD-014 [4]. The ONR Safety Assessment Principles (SAP) [5], together with supporting Technical Assessment Guides (TAG) [6], have been used as the basis for this assessment.

6. The findings of the laboratory examinations of the trepanned samples are not expected before the return to service of TOR R1 and are not considered in this assessment report.

2.1 Methodology

7. The methodology for the assessment follows HOW2 guidance on mechanics of assessment within the Office for Nuclear Regulation (ONR) [7].

8. This assessment has been focused primarily on the findings of the graphite core inspections of TOR R1 during the 2017 periodic shutdown and supporting documentation provided by NGL. The assessment will determine whether the findings of the graphite core inspections are consistent with the licensee’s safety case and as such, whether they support consent being given to return TOR R1 back to service.

4 LICENSEE’S SAFETY CASE

9. This assessment compares the available results from the inspections against relevant sections of the TOR graphite core safety case [3, 8, 9, 10], to determine whether they pose any challenge to the return to service of TOR R1 for a further three years of operation. Furthermore, NGL has provided me with a separate document [11] summarising the results of the peripheral brick inspections. The document claims that, despite cracks being observed, they are of low safety consequence and bounded by the safety case [3], therefore, the reactor should be returned to service. As stated, at the time of writing this document was provided in verified form and has not been approved by NGL’s Independent Nuclear Assurance (INA) function. Therefore, my assessment is based on that there are no substantive changes made to this document and that it is approved by INA. The relevant inspection results and operating limits of the graphite core safety case are summarised below.

4.1 Peripheral Shield Wall

10. The most recent revision to the graphite core safety case is JCO 3 [3] that has been developed following finding cracks in the peripheral shield wall at TOR R2 in 2015 and HYB R8 in 2016. JCO 3 gives a comprehensive description of what was found at TOR R2 in 2015 and Heysham 2 (HYB) Reactor 8 (R8) in 2016 and claims it is safe to operate the reactors at HYB and TOR with some cracked peripheral bricks. NGL listed criteria in [17] that defined observations to bound the anticipated extent of the cracking. Any observations outside these bounds would require further work before TOR R1 could be returned to service.

11. NGL has completed inspection of the peripheral shield wall at TOR R1 and provided me with copies of all the peripheral brick inspection reports and PBAP minutes [12]. I have summarised this information in this section.

12. Inspection of 13 out of 16 faces, see Figure 1, of the peripheral shield wall at TOR R1 found 25 cracked bricks which extrapolates to a total of 31 cracked bricks for the entire peripheral shield wall, approximate to 1.6% cracked bricks, if the incidence of cracking is uniformly distributed.

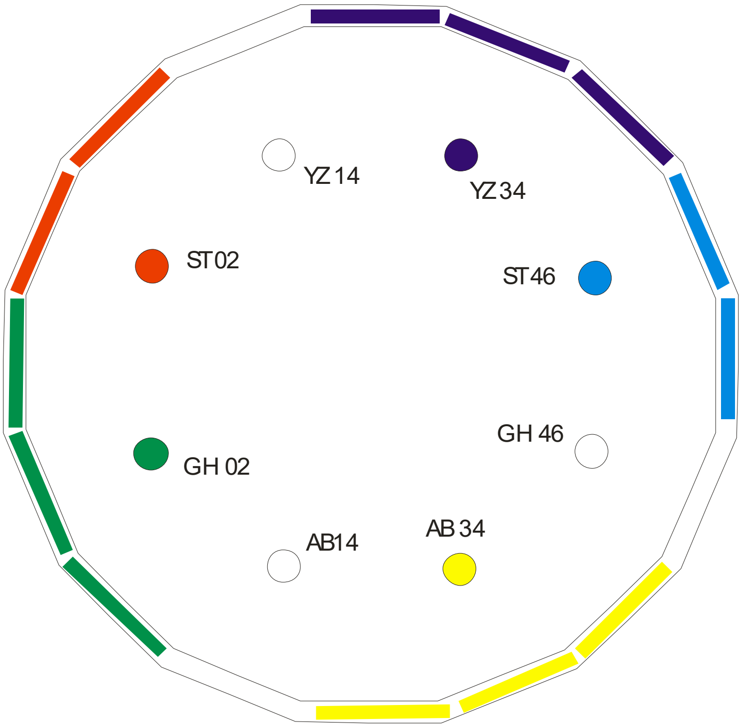

Figure 1: TOR R1 2017 Peripheral Inspection Coverage.

13. Overall, NGL claims that the observed cracking is broadly consistent with that seen in TOR R2 2015 and HYB R8 2016 where approximately 1.5% and 2.1%, respectively, of peripheral shield wall bricks were determined to have cracked. However, when examining closely the morphology of the cracks, it is evident that the TOR R1 findings show more similarity to HYB R8 than to TOR R2.

14. Out of the 25 cracks found in TOR R1, only three are pronounced cracks found in the corner bricks which exhibit certain level of similarity to TOR R2, albeit not as severe, see Figures 2, 3 and 4. Other cracks however, are fairly tight, straight and mostly located in the mid-face of the brick (see Figure 5), which bears close similarity to the HYB R8 2016 findings.

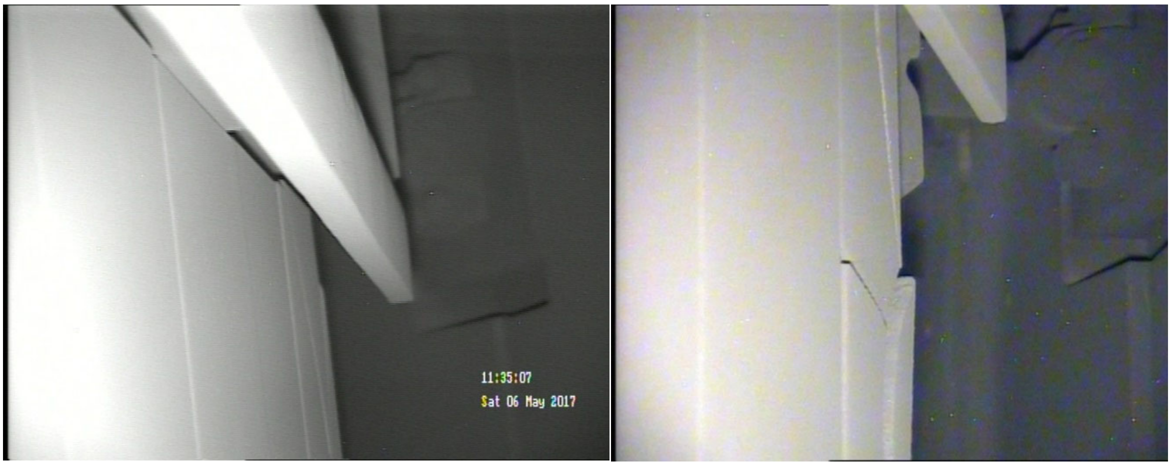

Figure 2: Left: Branched Crack in a Corner Peripheral Brick in **TOR R1**; found via route C50, penetration YZ34. Right: Significant Branched Crack found in a Corner Peripheral Brick in **TOR R2** 2015.

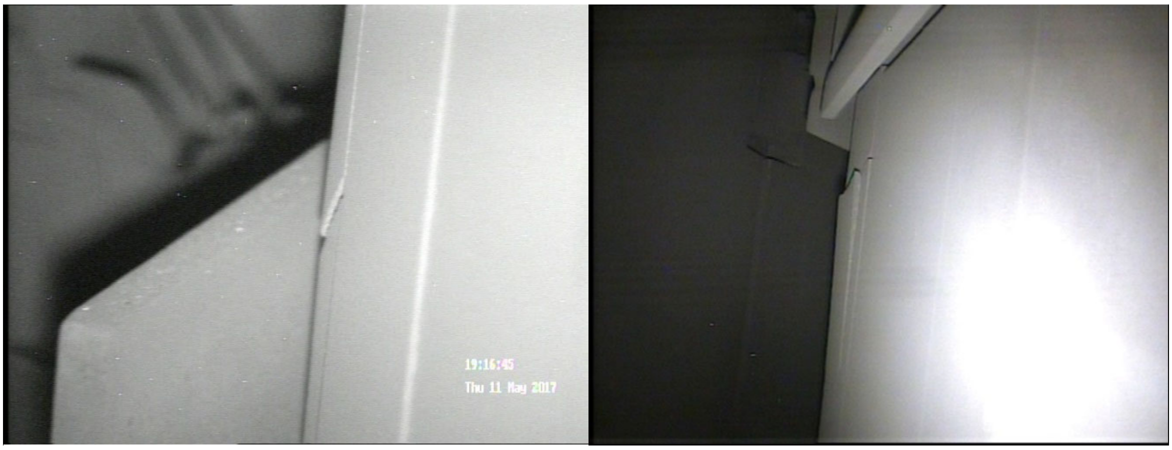

Figure 3: Left: Pronounced Crack in a Corner Peripheral Brick in **TOR R1**; found via route B51, penetration ST02. Right: Significant Branched Crack found in a Corner Peripheral Brick in **TOR R2** 2015

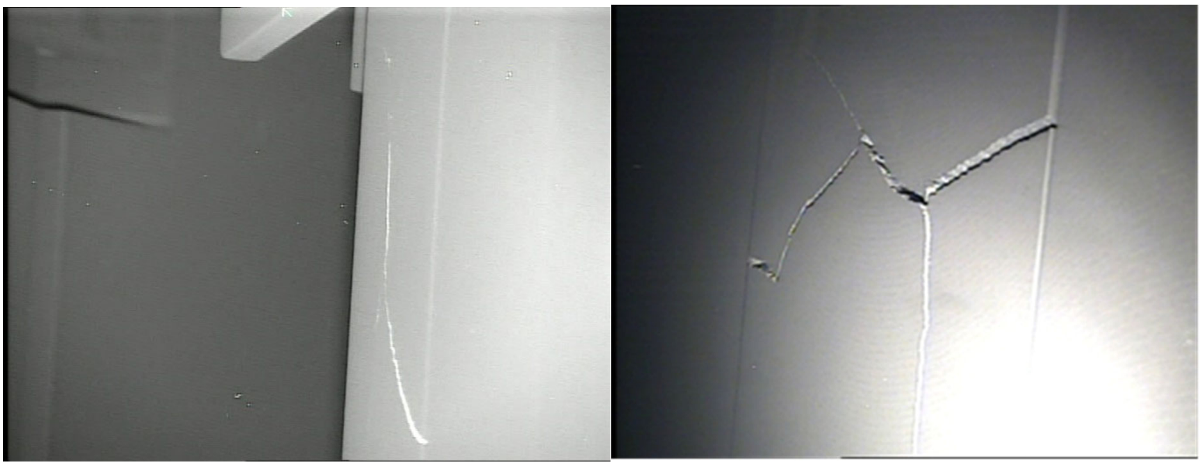

Figure 4: Left: Branched Crack in a Corner Peripheral Brick in **TOR R1**; found via route D55, penetration AB34. Right: Chicken-Wire Crack found in **TOR R2** 2015

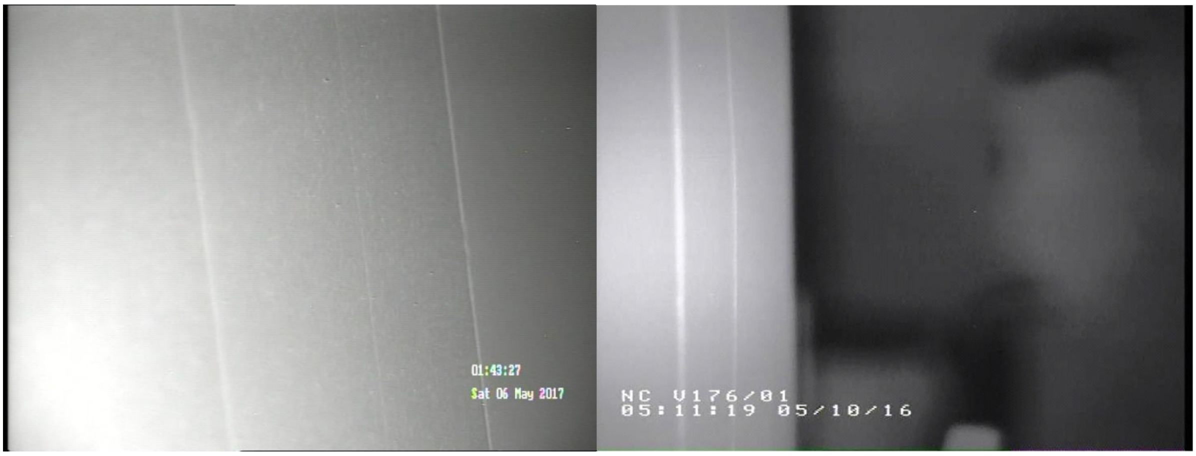

Figure 5: Left: Linear Crack Observed in **TOR R1**; Right: Linear Crack Observed in **HYB R8 2016**.

15. The distributions of the cracks are found to be fairly random in all layers, showing no obvious trends or patterns.

16. NGL also conducted inspection on the core restraint components adjacent to the 13 peripheral faces of the core.

17. The core restraint arrangement is shown in Figure 6. Steel restraint rods pass through the peripheral shielding bricks at each interlayer position. Short steel cylinders, or inserts, are mounted on the ends of the restraint rods and locate in selected graphite outer reflector bricks. The restraint rods attach to restraint beams forming a sixteen-sided polygon around the core at each interlayer. The beams are loosely connected at their ends by pin joints, as a secondary restraint feature, and their weight is supported through pads which rest on cut-outs in the peripheral shielding bricks. Radial loads from the core are transferred to the restraint tank by two ball-ended restraint links – Warwick links. These constrain the core boundary to move radially with the steelwork, whilst at the same time allowing for differential thermal expansion of the graphite core structure and the steel restraint tank in the vertical direction.

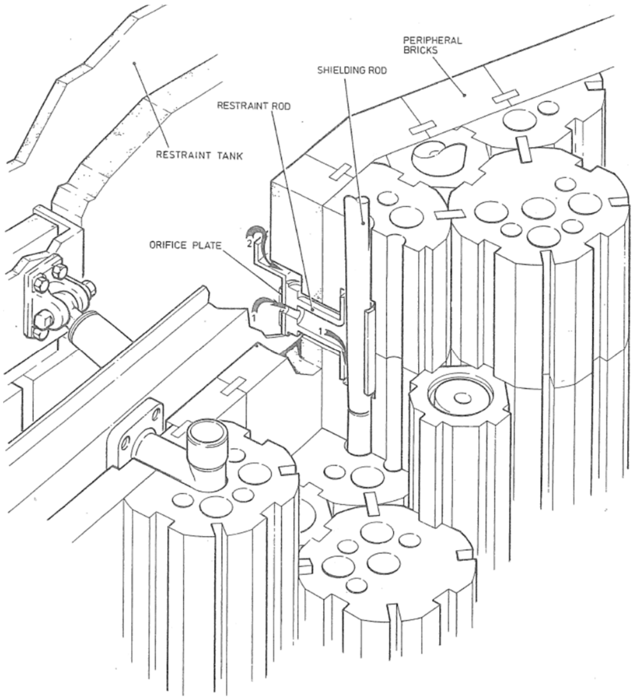

Figure 6: Restraint Structure showing Peripheral shielding bricks and Gas Coolant Flow

18. NGL’s core restraint inspection was conducted at the same time as the peripheral brick inspection, as the camera was inserted in the annulus between the restraint tank and the peripheral shield wall. During the television inspection, views were obtained of the peripheral shielding graphite bricks, horizontal restraint beams, Warwick links and the joints connecting the restraint beams and the restraint tank wall. NGL reported that no significant degradation or deformation was observed in the core restraint components.

19. Overall, NGL has provided me with a comprehensive summary of the inspections of the peripheral shield wall [12]. Broadly, NGL states in its document [11] that the findings are similar to those at TOR R2 and HYB R8 and more specifically that they are within the bounds of the safety case [3]. Therefore, NGL claims in [11] that based on the results of the inspection of the peripheral shield wall and core restraint that it is safe to return TOR R1 back to service.

4.2 Fuel Channel Inspections

20. The current estimate of the earliest stress reversal in graphite bricks at TOR is 24.6 full power years (fpy), which is predicted to be reached in March 2019 [23]. A post stress reversal safety case (NP/SC 7663) is due to be produced in 2017 which will replace the current safety case [8, 9, 10]. NGL shared that NP/SC 7663 will extend the period of validity of the current cracking safety case and cover operation beyond the time of stress reversal at the keyway root at power to the time of onset of keyway root cracking. At the time of the writing, NGL informed ONR that NP/SC 7663 was currently undergoing review by NGL’s Internal Nuclear Assurance (INA) [21].

21. Currently the most limiting core weight loss limit is the average core weight loss and is 17.5% mean weight loss over a peak irradiated brick [10]. It is presently predicted that this limit will not be reached until at a core burn-up of 16500 GWd in 2022.

22. It should be noted that the average core weight loss core burn-up limit for TOR is derived in an Interim Justification for Continued Operation (IJCO) [10]. NGL informed ONR that weight loss limits will be formally introduced into HYB and TOR graphite core safety case in NP/SC 7663 [21].

23. In addition to the limits within the graphite core safety case, NGL states their expectations of the inspection results for the number of cracks [13] prior to the TOR R1 2017 outage. NGL's statistical analysis predicted that up to 3 singly axially cracked bricks, 1 doubly axially cracked brick and up to 2 fully-circumferentially cracked bricks would be within expectations based on previous inspection data.

24. During the shutdown, 15 of the initially proposed [2] 16 fuel channels and 1 control rod channel were successfully inspected. Channel H09 was planned for inspection but could not be inspected during the outage due to a stuck fuel assembly. NGL subsequently replaced it with inspection of an adjacent channel G11 [18].

4.2.1 Stuck Fuel in Channel H09

25. On Sunday 23rd April NGL made an attempt to vacate the fuel from Channel H09 for inspection, but after taking the weight of the plug unit the hoist tripped on overload. NGL made a second attempt to raise the fuel assembly but to no avail. NGL then re-seated the fuel assembly successfully into the channel. NGL later confirmed that no faults were found in the fuelling machine load protection systems.

26. NGL shared with ONR that H09 was refuelled in 2013 when small unusual load increases (approx. 100-150kg) were noted on discharge. NGL however advised that there had been some similar observations to this previously at Torness and Heysham 2; and there had been no instances of a systematic trend towards potential 'snagging' of fuel [18].

27. NGL confirmed that Channel H09 was inspected in 2014 and no cracked bricks and no significant channel bow / tilt were reported. The fuel movement had not shown any indication of abnormalities in the fuel grab load trace. NGL believed this channel was typical of any other channel at Torness (and Heysham 2) and there was no reason to suspect that the brick shrinkage and weight loss would be significantly different from other similar channels. NGL understands that the overall level of bore cracking is very low at Torness and therefore it is unlikely that Channel H09 has a number of bore cracks [18].

28. Subsequent inspection of the adjacent channel G11, see Figure 7, revealed no cracking in any of the bricks; the channel bow and tilt were 1 mm and 5 mm, respectively, but were all within the acceptance limits and did not suggest significant distortion.

29. NGL later also confirmed that inspection of the peripheral bricks near Channel H09 had not found any cracks [24].

30. NGL therefore argue that the stuck fuel in Channel H09 is unlikely to be caused by distortion of the fuel channel or cracking in the peripheral bricks.

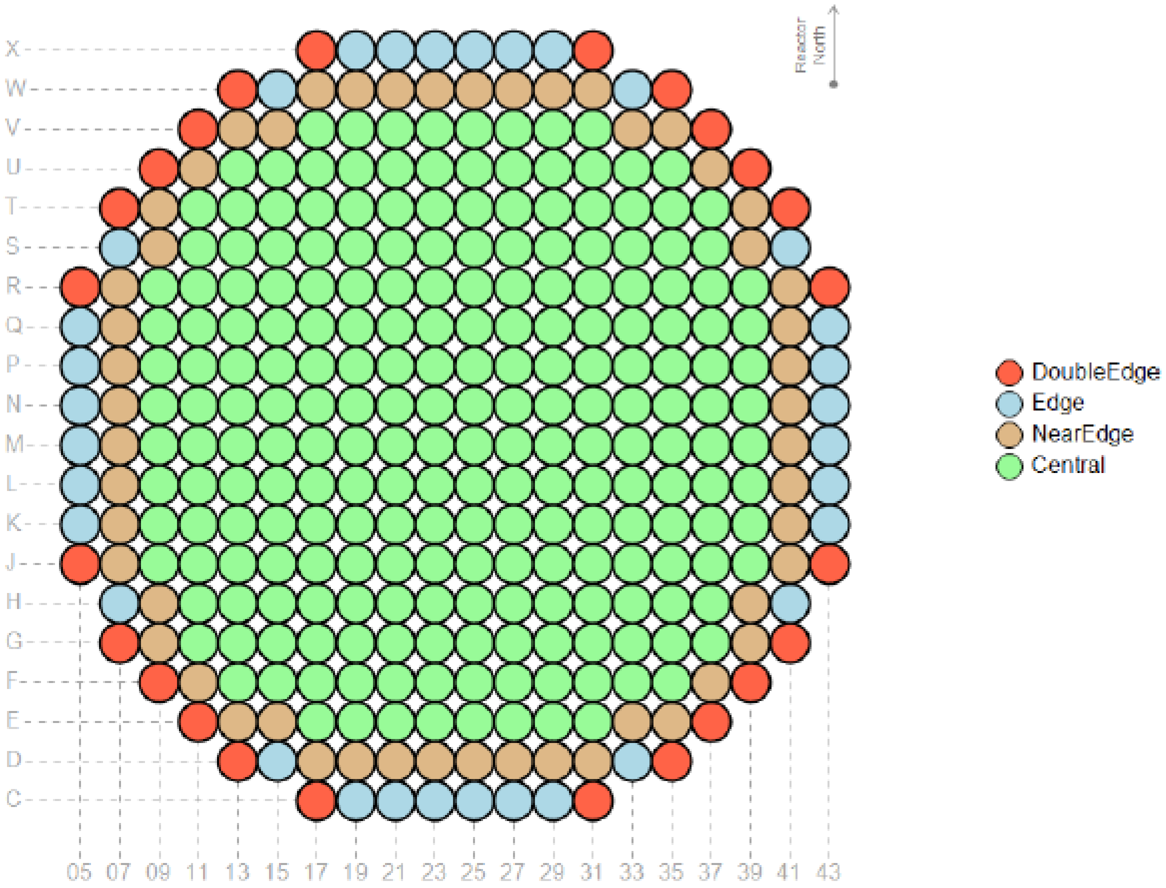

Figure 7: TOR R1 core map

4.2.2 Fuel Channel Inspection Findings

31. NGL reported that one fully circumferential crack (Type IIIC) was observed in Layer 8 of Channel N41 (Figure 8), which had not been previously inspected. One partial circumferential crack in Layer 5 of Channel C31 had grown to a fully circumferential crack between 2010 and 2017 (Figure 9). All bore shrinkages and channel distortions were however small and within expectations set by NGL [14].

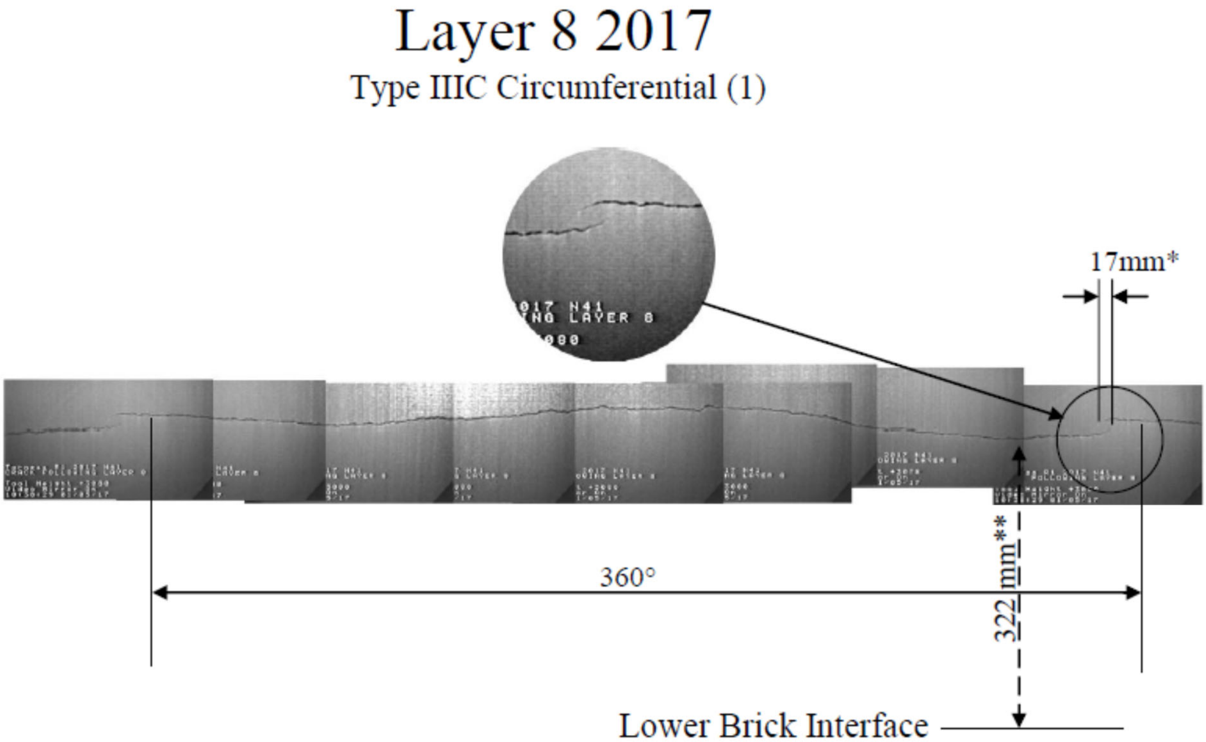

Figure 8: Fully circumferential crack found in a layer 8 brick of fuel channel N41 in TOR R1

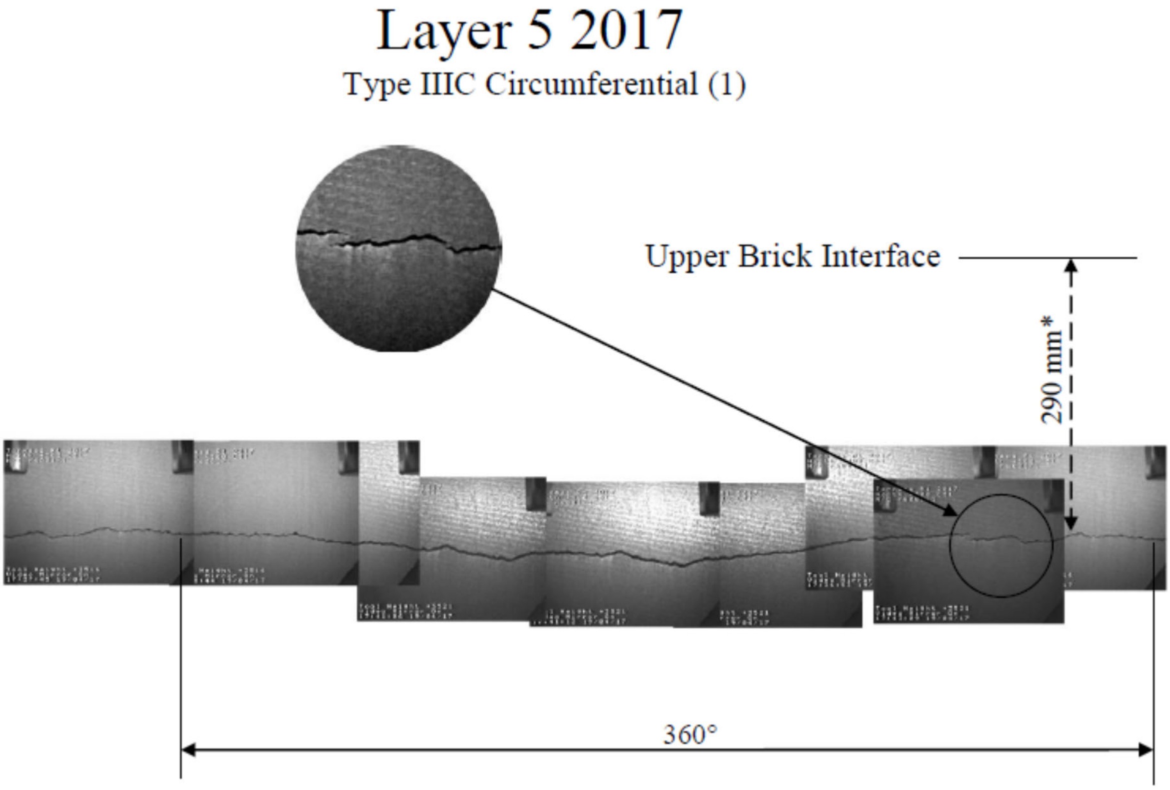

Figure 9: Partial circumferential crack found in layer 5 brick of fuel channel C31 grown to a fully circumferential crack between 2010 and 2017

32. It should be noted that two edge fuel channels were also inspected. These channels are the nearest fuel channels to the peripheral shield wall and any gross distortion of these channels would possibly be indicative of a problem with the core restraints. The channel bow and tilt from these edge channels was within expectations identified by NGL before the inspections [14]. Combined with the inspection of the core restraint NGL state that there is no evidence to suggest any gross failure of the core restraint which support the arguments in its safety case [3].

33. 35 trepanned specimens of 65 mm in length were removed from 5 fuel channels during the shutdown; it was a significant achievement and in excess of the target of 30 specimens.

34. Overall, NGL has provided me with a statement [15] that the results of the graphite fuel channel inspections are within allowable bounds of the safety case and no additional inspections are required to support the return to service of R1. However, NGL's return to service justification with INA approval, which will summarise the graphite fuel channel inspections, has not yet been provided to me. My assessment is therefore based on the assumption that this position does not change and is approved by INA.

4.3 Outcome of graphite core inspection

35. Overall, NGL's inspection of the graphite core of TOR R1 has been completed for this periodic shutdown. NGL has considered the results of those inspections and are of the opinion that they do not prevent return to service of TOR R1.

5 ONR ASSESSMENT

5.1 Peripheral Brick Inspections

36. I have considered the inspection results and draft documentation provided by NGL [11] which claims that the results of the inspections are within the bounds of the safety case [3].

37. I have observed that the cracks found in TOR R1 bear close similarity to those in HYB R8, and some, although not as severe, exhibit resemblance to the branched cracks in TOR R2. However, most importantly, I consider that the percentage of cracking of 1.6% demonstrate consistency with the 1.5% cracked bricks found in TOR R2 2015 and 2.1% in HYB R8 2016.

38. ONR's fault studies inspector has confirmed that NGL's thermal hydraulic consequence analysis suggest tolerability of this level of cracking in the peripheral bricks [20].

39. I note that the level of cracking in the peripheral bricks is still small (1.6%). Taking into account the random / uniform nature of the distribution of the cracks, I consider that the inspection findings so far suggest peripheral brick cracking is less likely to be caused by a systematic mechanism.

40. Furthermore, inspection of the core restraints and the measurement of the bow and tilt of edge channels has provided some reassurance that the cause of the peripheral brick cracking is not the gross failure of the core restraints.

41. I therefore consider that the level of cracking found in TOR R1 are within the bounds of the safety case [3] which supports TOR R1 return to service.

42. I consider NGL, having inspected 13 out of 16 faces of the peripheral wall, has now characterised the condition of the peripheral bricks in TOR R1 with sufficient confidence. I consider it provides a well-established baseline for future inspections on TOR R1, which would enable NGL to gain a much clearer understanding of the damage progression at TOR R1.

5.2 Fuel Channel Inspections

43. Inspection of 16 fuel channels in TOR R1 found one fully circumferentially cracked fuel brick (Figure 4) and one partial circumferentially cracked brick in the channels not previously inspected, and a fully circumferentially crack developed from a partially circumferential crack between 2010 and 2017 (Figure 5). These numbers are well below any level that would challenge the safety case and are within NGL's statistical prediction [13]. The core distortion measurements were within expectation and in my opinion consistent with the expected slow progression of irradiation induced dimensional change.

44. I have examined the monitoring data for the stuck fuel Channel H09 [19] in conjunction with the inspection findings of the adjacent channel G11. I consider that all the evidence so far suggests that NGL's argument is plausible that the stuck fuel is unlikely to be caused by the fuel channel distortion. However, until the fuel stringer is successfully vacated and an inspection is conducted on Channel H09, the condition of the channel remains uncertain. This assessment is based on the understanding that the stuck fuel in Channel H09 is not concerned with distortion of the graphite bricks in that channel.

45. The retrieval of 35 trepanned specimens from 5 channels is an excellent achievement for the inspection team and will provide significant extra data to support graphite weight loss predictions. The weight loss and materials properties data derived from

the trepanned specimens will not be available for several months. Therefore, the current prediction is that the most pressing graphite weight loss limit will not be reached until at a core burn-up of 16500 GWd [10] in 2022.

5.3 Completion of the outage related documentation

46. I have assessed the TOR R1 periodic shutdown draft documentation and inspection results relating to the graphite core [11, 12, 14]. I have compared the findings with the current graphite safety case [3, 8, 9] and assessed them against the relevant SAPs [5]. Overall, NGL argues that the results of the graphite core inspections at TOR R1 2017 periodic shutdown are acceptable and do not challenge safe operation. If the results considered in this assessment report are not subject to change and are approved by INA then I judge that this claim has been adequately demonstrated. Furthermore, I confirm that the graphite inspection requirements of the safety case have been met.

47. In my opinion the graphite core inspection results are within the bounds of NGL's safety case and do not present any impediment to return to service of TOR R1. I expect NGL to analyse further the graphite core inspection results from this periodic shutdown, particularly of the peripheral bricks, and use this data to further strengthen their safety case. I therefore support the further work which NGL has committed to in their draft peripheral brick return to service document [11].

5.4 ONR Assessment Rating

48. Based on the reasoning presented in the previous section I ascribe an ONR Assessment rating of green, no formal action.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

49. I have assessed the graphite core inspection results from the TOR R1 2017 periodic shutdown and found them to be within the bounds and arguments of NGL's safety case.

50. To conclude, I have no objection to the subsequent project assessment report (PAR) recommending that consent is given to return Torness Reactor 1 back to service.

6.2 Recommendations

51. My recommendations are as follows.

52. Recommendation 1: I recommend the project inspector confirms the Independent Nuclear Safety Assessment (INSA) statement has been made available by NGL.

53. Recommendation 2: I recommend that the PAR records that NGL is in the process of producing a post-stress reversal safety case NP/SC 7663 for the graphite cores at HYB and TOR. This will need to be produced before the extant safety case expires in 2018.

Where the assessment identifies a shortfall in regulatory compliance, one or more issues should be raised to address the gap, and brought to the attention of the duty holder/licensee. In general, these will rate Amber on the ONR Inspection Rating Guide. These issues should be recorded on the ONR Issues Database and subsequently tracked and managed. More significant issues should be categorised higher and progressed in the usual manner. Please refer to the Regulatory Issues Management process.

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No	SAP Title	Description
EGR. 1	**Engineering principles:** **graphite components and structures: safety case**	The safety case should demonstrate that either: a) graphite reactor core is free of defects that could impair its safety functions; or b) the safety functions of the graphite reactor core are tolerant of those defects that might be present.
EGR. 2	**Engineering principles:** **graphite reactor cores: design: monitoring**	The design should demonstrate tolerance of graphite reactor core safety functions to: a) ageing processes; b) the schedule of design loadings (including combinations of loadings); and c) potential mechanisms of formation of, and defects caused by, design specification loadings.
EGR. 10	**Engineering principles:** **graphite reactor cores: defect tolerance assessment**	An assessment of the effects of defects in graphite reactor cores should be undertaken to establish the tolerance of their safety functions during normal operation, faults and accidents. The assessment should include plant transients and tests, together with internal and external hazards.
EGR. 15	**Engineering principles:** **graphite components and structures: examination, inspection, surveillance, sampling and testing:** **Extent and frequency**	In-service examination, inspection, surveillance, and sampling should be of sufficient extent and frequency to give sufficient confidence that degradation of graphite components and structures will be detected well in advance of any defects affecting safety function.

7 REFERENCES

---

1 NGL - Torness – Assessment Report – 15-047 - Torness – 2015 Reactor 2 Statutory Outage– 08 September 2015 (TRIM 2015/327473)

2 TOR R1 2017 GAP #2 Minutes (TRIM 2017/188038)

3 Justification for Continued Operation in Light of The Discovery of Cracked Peripheral Bricks during the 2015 Torness R2 and 2016 Heysham R8 Outage inspections EC356536 003 (TRIM 2017/159591)

4 ONR HOW2 Guide NS-PER-GD-014 Revision 4 - Purpose and Scope of Permissioning. July 2014. http://www.onr.org.uk/operational/assessment/index.htm

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

6 Graphite Core NS-TAST-GD-029 Revision 3. ONR. July 2014 (TRIM 2014/10849) http://www.onr.org.uk/operational/tech_asst_guides/index.htm

7 Guidance on Mechanics of Assessment within the Office for Nuclear Regulation (ONR) – (TRIM 2013/204124)

8 NPSC 7359 Issue 1 Further Substantiation of the Safety Case for Bore Cracking of Graphite Core Bricks HAR HYA HYB DNB TOR, [redacted], Feb 2004, (TRIM 2013/404659)

9 EC 337677 337678 337679 337680 337681 rev000 Topic Proposal Version 02 Verified 28 July10 Hartlepool, Heysham 1, Heysham 2, Torness & Dungeness B: Redefinition of the Time of Stress Reversal in the Graphite Core Safety Case (TRIM 2013/404697)

10 HYB-TOR JCO: Safety Case for At-Power, In-reactor Faults with increased Levels of Graphite Weight Loss at HYB/TOR (TRIM 2014/130260)

11 EC 360769 RTS EC For TOR R1 From the 2017 Statutory Outage In Light Of the Discovery Of Cracked Peripheral Bricks (TRIM 2017/201501)

12 TOR R1 2017 Peripheral brick PBAP minutes and NCRs (TRIM 2017/193424)

13 QRS-3007M-5 Version 1.0 Application of Statistical Models for Brick Cracking to Torness R1 Inspections in April 2017 (TRIM 2017/185234)

14 TOR R1 2017 Fuel channel inspections GAP Sheets (TRIM 2017/192272)

15 Statement for graphite fuel channel inspections to be included in the EAN support TOR R1 RTS (TRIM 2017/206662)

17 Assessment criteria for TOR R1 2017 inspection findings (TRIM 2017/159598)

18 Emergent issue GAP minute (TRIM 2017/188046)

19 TOR 1H09 Graphite Inspection and Monitoring Information (TRIM 2017/200790)

20 Email: TOR R1 return to service peripheral brick cracking consequence assessment (TRIM 2017/201078)

21 Contact report for the Level 4 meeting on HYB/TOR post stress reversal safety case NP/SC 7663 (TRIM 2017/150114)

22 TOR R1 2017 outage intentions document (TRIM 2017/203699)

23 TOR R1 revised date for the current graphite safety case (TRIM 2017/205721)

---

24 TOR R1 inspection finding – no cracking in the peripheral bricks near Channel H09 (TRIM 2017/210456)