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| ONR Project assessment report  Heysham 2 and Torness – Graphite Safety Case  Agreement to NP/SC 7819 - Revised Safety Case for Seal Ring Groove Wall Debris (HYB EC No: 369835 Revision 000 and TOR EC No: 369826 Revision 000) |



ONR Project assessment report

**Project name**:

Heysham 2 and Torness – Graphite Safety Case

**Report title**: Agreement to NP/SC 7819 - Revised Safety Case for Seal Ring Groove Wall Debris (HYB EC No: 369835 Revision 000 and TOR EC No: 369826 Revision 000)

**Dutyholder/Applicant**: EDF Energy Nuclear Generation Limited

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# Executive Summary

**Title**

Agreement to NP/SC 7819 – Heysham 2 and Torness Power Stations, Revised Safety Case for Seal Ring Groove Wall Debris (HYB EC No: 369835 Revision 000 and TOR EC No: 369826 Revision 000).

**Permission Requested**

EDF Energy Nuclear Generation Ltd (EDF), under arrangements made under Licence Condition 22(1) of Schedule 2 attached to Nuclear Site Licences 60 and Sc.14 (for Heysham 2 (HYB) and Torness (TOR), respectively), applied for Review and Consideration from the Office for Nuclear Regulation (ONR) for NP/SC 7819, “EC 369835/369826: Revised Safety Case for Seal Ring Groove Wall Debris”.

ONR subsequently notified EDF, under the same arrangements made under Licence Condition 22(1), that the licensee shall not commence nor thereafter proceed with NP/SC 7819 without the Agreement of ONR, which will be issued via a licence instrument following ONR’s assessment of NP/SC 7819.

**Background**

HYB and TOR power stations each have two advanced gas-cooled reactors (AGRs). The core of each reactor is made up of a large assembly of graphite bricks keyed together to form channels for fuel assemblies and control rods.

It has long been understood that the irradiation of the graphite leads to dimensional and material property changes of the graphite bricks. These changes can eventually lead to the generation of cracking in the fuel channel graphite bricks. An active cracking mechanism that is known to occur late in the reactor life is keyway root cracking (KWRC), which affects the graphite bricks of the fuel channels. Operation with KWRC at HYB/TOR is justified in a separate safety case NP/SC 7810.

At HYB/TOR, the keying system between vertically adjacent graphite bricks of fuel channels in the graphite core consists of seal rings located within annular grooves cut into the brick ends. This differs from the cruciform arrangement of radially oriented end-face keys and keyways in the active regions of all other AGRs. The opening of axially cracked bricks at HYB/TOR late in the reactor life is stipulated to lead to interaction between the brick end face seal rings and groove walls. Such interaction has the potential to generate graphite debris, due to failure of the seal ring groove wall (SRGW).

SRGW debris has the potential to affect the nuclear safety function of the graphite core. This is because it has the potential to affect (a) the free movement of fuel assemblies and control rods and (b) the cooling gas flows.

The HYB/TOR reactors are currently operating under the extant safety case for SRGW debris NP/SC 7808. This case demonstrated that operation is tolerable and that risk is as low as reasonably practicable (ALARP) as long as SRGW debris is not ‘widespread’ in the core. NP/SC 7808 has therefore limited operation to 25 channels with SRGW debris per reactor.

The proposed safety case NP/SC 7819 makes a significant modification to the safety principles of the extant case. NP/SC 7819 proposes two limits to control the risk from SRGW debris during operation and defuelling:

* *Nuclear Safety Limit (NSL)* to control the risk during operation. This limit is set to *a single fuel snag due to SRGW debris*.
* *Defuelling Risk Limit (DRL)* to control the risk and delays to defuelling, due to the accumulation of SRGW fragments. This limit is set to *100 fuel channels containing SRGW fragments*.

In this context, a fragment needs to be formed first and if it moves away from its in-situ position within a parent brick, it becomes debris. No SRGW fragments or debris have been observed to date.

One of the main aspects of the proposed safety case is a new body of experimental testing, referred to as the ‘5-Layer Rig’, to estimate the likelihood and consequences of fuel snagging due to SRGW debris. EDF utilises this new work in its risk estimate using existing and updated probabilistic safety analysis (PSA) to demonstrate that the risk from fuel snagging due to SRGW debris is tolerable during operation and defuelling.

Compliance with the limits on the number of channels with SRGW debris is maintained by regular core inspections. Inspection findings will be reviewed by ONR where necessary to ensure compliance with the limits of the proposed safety case.

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

ONR’s assessment of NP/SC 7819 has focused on whether the risk from SRGW debris predicted to occur in the graphite bricks of the fuel channels that form the reactor core could compromise the key nuclear safety requirements of the HYB and TOR reactor cores. Assessments have been carried out by ONR’s specialist inspectors from:

* Graphite structural integrity specialism;
* Fault studies specialism; and
* Probabilistic safety analysis (PSA) specialism.

In support of their assessments, ONR’s specialist inspectors have engaged with EDF in technical discussions to ensure that key nuclear safety issues have been adequately addressed.

**Matters arising from ONR's work**

Following assessment, all specialist inspectors consider that the issue of ONR’s Agreement to the implementation of the proposed safety case NP/SC 7819 is acceptable.

**Conclusions**

It is concluded that EDF has provided an adequate justification underpinning NP/SC 7819, “Revised Safety Case for Seal Ring Groove Wall Debris” for HYB and TOR reactors, and that a licence instrument should be issued to EDF.

**Recommendation**

ONR should issue Licence instruments 642 and 566 to HYB and TOR Power Stations, respectively, agreeing to the implementation of the proposed safety case NP/SC 7819.

Table 1: List of abbreviations.

|  |  |
| --- | --- |
| Term/Acronym | Description |
| AGR | Advanced Gas-cooled Reactor |
| AGU | Anti-gapping Unit |
| ALARP | As low as reasonably practicable |
| BSL | Basic Safety Level |
| BSO | Basic Safety Objective |
| DB | Dose Band |
| DRL | Defuelling Risk Limit |
| EA | Environment Agency |
| EC | Engineering Change |
| EDF | EDF Energy Nuclear Generation Limited |
| FCA | Fuel Channel Annulus |
| FEHG | Fuel Element Handling Groove |
| FGLT | Fuel Grab Load Trace |
| FM | Fuelling Machine |
| HYB | Heysham 2 Power Station |
| IFA | Irradiated Fuel Assembly |
| INSA | Independent Nuclear Safety Assessment |
| KWRC | Keyway Root Crack, Keyway Root Cracking, Keyway Root Cracked |
| LPR | Lower Power Refuelling |
| LC | Licence Condition |
| NSC | Nuclear Safety Committee |
| NFA | New Fuel Assembly |
| NSL | Nuclear Safety Limit |
| ODR | Off-load Depressurised Refuelling |
| ODRE | Off-load Depressurised Refuelling Exchange |
| ONR | Office for Nuclear Regulation |
| OPR | Off-load Pressurised Refuelling |
| PAR | Project Assessment Report |
| PRY | Per Reactor Year |
| PSA | Probabilistic Safety Analysis |
| PSD | Primary Shutdown System |
| RGP | Relevant Good Practice |
| SAP | Safety Assessment Principle(s) |
| SEPA | Scottish Environment Protection Agency |
| SRGW | Seal Ring Groove Wall |
| SSD | Secondary Shutdown System |
| TOR | Torness Power Station |
| TSD | Tertiary Shutdown System |

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# Permission requested

1. EDF Energy Nuclear Generation Limited (EDF), under arrangements (ref. [1]) made under Licence Condition (LC) 22(1) of Schedule 2 attached to Nuclear Site Licences 60 and Sc.14 (for Heysham 2 (HYA) and Torness (TOR), respectively) to control any modification or experiment carried out on any part of the existing plant or processes, applied for Review and Consideration from the Office for Nuclear Regulation (ONR) for NP/SC 7819, “EC 369835/369826: Revised Safety Case for Seal Ring Groove Wall Debris” (refs. [2] and [3]).
2. The proposed safety case (ref. [3]) is a Category 1 submission.
3. ONR subsequently notified EDF (refs. [4] and [5]), under the same arrangements (ref. [1]) made by the licensee under LC 22(1) of Schedule 2 attached to Nuclear Site Licences 60 and Sc.14 to control any modification or experiment carried out on any part of the existing plant or processes, that the licensee shall not commence nor there after proceed with NP/SC 7819 without the Agreement of the ONR, which will be issued via a licence instrument following ONR’s assessment of NP/SC 7819.
4. In line with ONR's arrangements, ONR has produced this Project Assessment Report (PAR) to document ONR's view on the adequacy of the proposed safety case. ONR will also produce Licence Instruments to communicate ONR's decision to the stations.

# Background

## General description

1. HYB and TOR Power Stations each have two advanced gas-cooled Reactors (AGRs). Each reactor core is made up of a large assembly of graphite bricks keyed together via a keying system as shown in Figure 1 to form channels for fuel assemblies and control rods. Each core contains around 3,000 fuel channel graphite bricks. For brevity these bricks are referred to as fuel bricks.
2. Ceramic uranium oxide fuel is contained within fuel assemblies in channels in the graphite core, see Figure 2. Control rods, containing boron, move within control rod channels in the graphite core to control the nuclear reaction and to shut-down and hold-down the reactor.
3. The control rods are the primary means of controlling the nuclear reaction and shutting down the reactor. They make up the primary shutdown system (PSD). At HYB and TOR, a nitrogen injection system is available as another means of shutting down the reactor in the unlikely event that the primary shutdown fails and is referred to as the secondary shutdown system (SSD). The SSD is supported by a tertiary shutdown system (TSD) of boron bead injection to maintain long term hold-down.

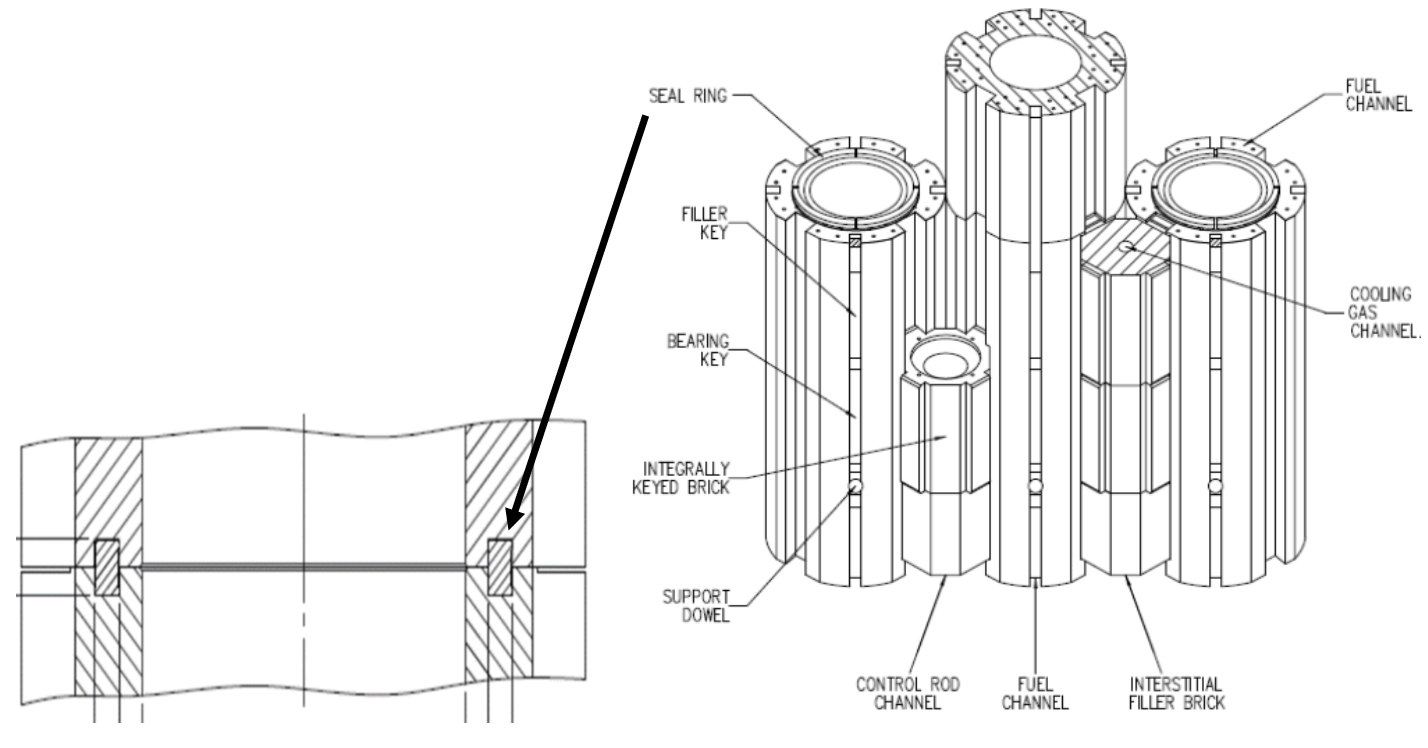


Figure 1: HYB/TOR graphite bricks and seal ring arrangement

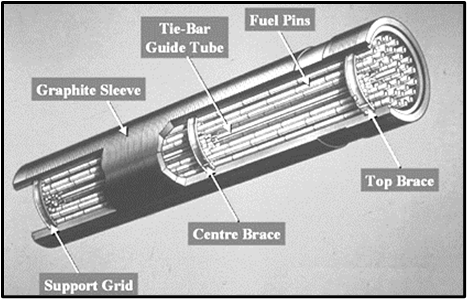
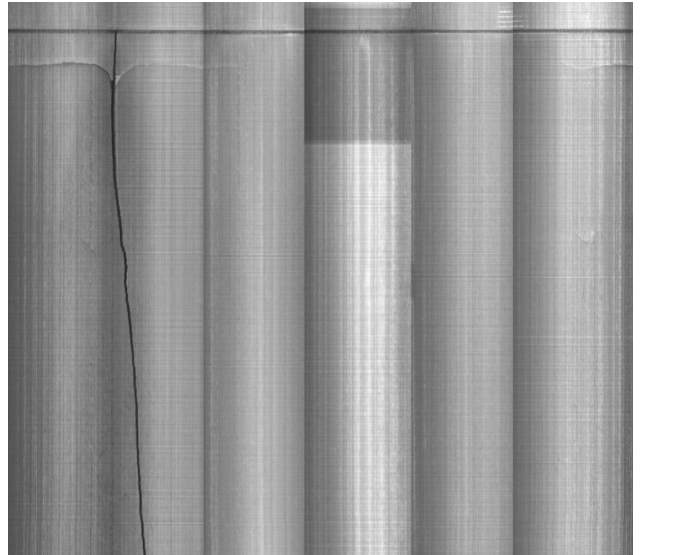


Figure 2: Example of an AGR fuel element

1. It has long been understood that the irradiation of the graphite leads to dimensional and material properties changes of the graphite bricks. These changes could eventually lead to the generation of cracking in the fuel channel graphite bricks. There are two types of cracking:

* one associated with the early reactor life referred to as bore cracking; and
* another associated with the late reactor life referred to as keyway root cracking (KWRC). A KWRC could also bring forward cracking in a neighbouring fuel brick and this is referred to as ‘induced cracking’.

1. Bore cracking is limited in nature, as the tensile stresses at the brick bore reverse into compressive stresses as the reactor core ages, reducing the likelihood of crack initiation from the bore significantly.
2. The KWRC is an active mechanism late in the reactor life that can lead to widespread cracking of the fuel bricks. This is because at high irradiation dose accumulation, i.e., later in the reactor life, tensile stresses are generated at the outer section of the brick wall where keyway features are present by design, see Figure 1. These keyway features at the brick periphery act as stress concentration sites where cracks could initiate from the keyway root and propagate through the brick wall to the bore leading to a keyway root crack.
3. At HYB/TOR, the keying system between vertically adjacent fuel bricks in the graphite core differs from the cruciform arrangement of radially oriented end-face keys and keyways in the active regions of all other AGRs. The HYB/TOR axial keying consists of annular grooves cut into each brick end and seal rings as illustrated in Figure 1. The opening of axially cracked fuel bricks at HYB/TOR can lead to interaction between the seal rings and the groove walls. Such interaction has the potential to generate graphite debris, due to failure of the Seal Ring Groove Wall (SRGW).
4. All AGR reactors are periodically shutdown so that the bricks in some fuel channels can be inspected for cracks, providing a sample of the core condition. Figure 3 shows an example of a keyway root crack and SRGW cracking (no SRGW fragment or debris observed to date) in a graphite brick, as seen from the fuel channel bore, during a core inspection.



SRGW Cracking

Keyway Root Crack

Figure 3: Example of a keyway root crack and SRGW cracking

1. Both keyway root cracking and SRGW cracking have been observed at HYB/TOR, but no fully formed SRGW fragments or debris have been observed to date. A fragment is defined as a piece of SRGW which has fully detached from the parent brick (i.e. no longer physically connected) due to SRGW cracking, but without significantly moving away from its original location in the parent brick (i.e. not mobilised). If a fragment mobilises, it becomes debris.
2. EDF states that the nuclear safety functions that the graphite core supports are:

* Allow movement of control rods and fuel;
* Allow operation of the secondary and tertiary shutdown systems;
* Direct gas flows to ensure cooling of the fuel and core; and
* Provide neutron moderation and thermal inertia.

1. SRGW debris has the potential to affect (a) free movement of fuel and control rods and (b) cooling gas flows for the fuel channels in which it forms.

## Extant SRGW debris safety case NP/SC 7808

1. The HYB/TOR reactors are currently operating under the extant safety case for SRGW debris NP/SC 7808 (ref. [6]). This case was assessed by ONR, see ref. [7]. NP/SC 7808 is the first case that justified operation with a limited amount of SRGW debris present in the core. The case demonstrated that operation is tolerable and ALARP as long as SRGW debris is not ‘widespread’ in the core. NP/SC 7808 defines ‘widespread’ as being greater than 25 channels per reactor.
2. With continued operation and the observations of both keyway root cracking and SRGW cracking, although no SRGW debris has been observed to date, the current limitation of the extant case NP/SC 7808, i.e., SRGW debris in less than 25 channels, could be challenged.
3. Therefore, EDF has developed the proposed safety case NP/SC 7819 to demonstrate tolerance to a higher number of channels with SRGW debris.

## Proposed SRGW debris safety case NP/SC 7819

1. The proposed safety case NP/SC 7819 (ref. [3]) makes a significant modification to the safety principles on which the safety arguments in the extant case NP/SC 7808 were based, i.e. fewer than 25 channels affected by SRGW Debris.
2. NP/SC 7819 proposes two limits to control the risk from SRGW debris during operation and defuelling:

* **Nuclear Safety Limit (NSL)**: The frequency of SRGW snag or ledge faults will be limited to ensure the overall snagging frequency produces a reactor risk which is tolerable and ALARP.

NP/SC 7819 proposes a **NSL of a single snag due to SRGW debris**.

* **Defuelling Risk Limit (DRL)**: The extent of SRGW fragments in the core will be restricted so that the risk from snagging in defuelling is tolerable and ALARP, the risk of significant delay to fuel assembly discharge during defuelling is acceptable, and the likelihood of exceeding the recovery capability of the fuelling machine is acceptably low.

The DRL is expressed in terms of three principles:

* + DRL Principle 1: The number of channels requiring use of alternative intrusive recovery techniques will be limited to a small proportion of the core, judged appropriate to the confidence in recovery methods.
  + DRL Principle 2: Any potential for delay to defuelling will be appropriately managed.
  + DRL Principle 3: The risk from snagging in defuelling will be tolerable and ALARP.

NP/SC 7819 proposes a **DRL of 100 channels containing SRGW fragments** per reactor.

1. In this context, a fragment needs to be formed first and if it moves away from its in-situ position within a parent brick, it becomes debris.
2. The main aspects of the proposed safety case and the sections of this report in which they are discussed are as follows:

* EDF’s claims related to the likelihood of SRGW debris entrainment, likelihood of snagging, and likelihoods of needing different recovery options, this is based on a new set of experimental tests referred to as the ‘5-Layer Rig’; see Section ‎3.1.1.
* Likelihood of significant flow blockages due to SRGW debris; see Section ‎3.1.1.4.
* EDF’s assessment of the nuclear safety risk due to fuel snagging and the consequences of potential flow blockages; see Section ‎3.1.2.
* A Fuel Route PSA update modelling ODR refuelling exchange operations, the only mode of operation currently permitted at HYB/TOR; see Section ‎3.1.3.
* EDF’s ALARP considerations and measures implemented to reduce the risk ALARP, see Sections ‎3.1.1.6 and ‎3.1.2.3.

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

1. In accordance with the regulatory permissioning plan (PR-01358 and PR-01359), ONR has carried out the following specialist assessments:

* a structural integrity (graphite) specialist assessment recorded in an assessment report type ‘major’ (ref. [8]);
* a fault studies specialist assessment recorded in an assessment report type ‘major’ (ref. [9]); and
* a probabilistic safety analysis (PSA) specialist assessment recorded in an assessment report type ‘routine’ (ref. [10]).

1. The graphite specialist inspector assessed the likelihood of generating SRGW debris and the likelihood of SRGW debris-related faults, while the fault studies and the PSA specialist inspectors assessed the potential consequences and the overall risk due to SRGW debris within the limits of the proposed safety case.
2. It should be noted that ONR specialist inspectors have engaged with EDF in detailed technical discussions and have raised and resolved a number of technical queries (ref. [11]) throughout their assessments of NP/SC 7819. This report does not attempt to summarise all the questions raised and answers provided. However, they are captured in the relevant specialist assessment reports where necessary.

## Assessment findings

### Graphite structural integrity assessment (ref. [8])

1. The graphite structural integrity specialist inspector has focused their assessment of the proposed safety case on the following areas:

* The appropriateness of EDF’s claims on SRGW debris entrainment, fuel snagging and recovery likelihoods within the proposed limits of the proposed case.
* The confidence in EDF’s claim that a fuel assembly can be placed in a safe position following a snag event.
* The applicability and adequacy of the arguments on SRGW debris migration, fuel sleeve gapping and fuel sleeve disruption previously justified in the extant safety case NP/SC 7808.
* Consideration and implementation of reasonably practicable measures to reduce the risks from SRGW debris ALARP.

#### 5-layer Rig Testing

1. The specialist inspector states that the major development in the understanding of the SRGW debris behaviour and consequences has been through tests completed by EDF on a test set-up known as the 5-layer fuel channel debris rig or simply referred to as the ‘5-layer rig’. This is an experimental set-up which aims to simulate the potential for entrainment of debris and the consequences (i.e. increased loads) when entrained SRGW debris is pulled through the constrictions within a channel.
2. The 5-layer rig is a full-scale rig of sections of the fuel channel, fuel stringer and hoist system. EDF claims that the rig is a reasonable idealisation of sections of the graphite fuel channel which are relevant to the SRGW debris behaviour and interactions during fuel movement.
3. The specialist inspector sought the views of ONR’s independent expert panel, known as the Graphite Technical Advisory Group (GTAC), on the 5-layer rig testing arrangement. Based on GTAC’s advice and the specialist inspector’s consideration of the testing arrangement, the specialist inspector is content that EDF has expended notable efforts to expand the understanding of SRGW debris entrainment.
4. The specialist inspector has therefore focused on other areas where in-reactor response may differ to the testing set-up. The specialist inspector states that EDF has identified that the loads experienced when lifting the dummy fuel in the 5-layer rig are lower than those experienced within the reactors for new and irradiated fuel assemblies (NFA and IFA, respectively). There is also a difference in response between NFA and IFA in the reactor. EDF has considered the basis for these differences and produced factors which would allow the conversion of rig observations into reactor trip limits.
5. The specialist inspector concurs with EDF’s argument that the differences appear to be due to systematic differences between the rig and the reactor and are content that EDF has adopted appropriate conversion factors to account for these differences.

***Scope of Testing***

1. The specialist inspector states that EDF has split the tests conducted on the 5 Layer rig into four categories:

* Two realistic datasets:
  + realistic lift test dataset; and
  + extended realistic lift test consequences dataset.
* Two sensitivity datasets:
  + more onerous debris entrainment sensitivity dataset; and
  + set-down with onerous entrained debris configurations sensitivity data.

1. The different categories inform different aspects of the SRGW debris problem. The specialist inspector is content that EDF has identified the main aspects to investigate. They are also content that EDF has investigated other SRGW debris configurations / scenarios to understand whether there are any cliff edges in the ability to recover fuel.

#### Consideration of potential in-core SRGW debris interactions

1. The specialist inspector states that EDF has assessed, based on the rig work, the potential for the SRGW debris:

* to interact with the fuel stringer through entrainment; or
* if SRGW debris is entrained, to increase the load required to discharge fuel from the reactor.

1. EDF uses this data to estimate the potential risk that is being accumulated if SRGW debris is contained within 100 channels. Therefore, the specialist inspector has considered these aspects to assess whether EDF’s estimation of the risk due to SRGW debris is adequate within the limits of the proposed case.

***Entrainment***

1. The specialist inspector states that, based on the rig data, EDF has used a 15% entrainment likelihood within its baseline calculation of accumulated risk.
2. The specialist inspector notes that EDF has observed that the entrainment likelihood is linked to the size of the SRGW debris. For small, medium and large-sized SRGW debris, the entrainment likelihoods were 18%, 22% and 4%, respectively. The large debris (approximately 100-120mm long) were less likely to entrain, as they would require larger clearances/gaps to move into.
3. Given that SRGW cracking has only been observed in a few bricks, with no fragments or debris being formed to date, there is no information as to how SRGW debris will form within the reactor. Because of this uncertainty, it is the specialist inspector opinion that using 15% is not demonstrably conservative. However, the specialist inspector notes that EDF has completed a sensitivity study using 25% entrainment likelihood, which bounds the highest entrainment likelihood observed for medium sized debris. The specialist inspector has therefore considered the impact on the overall risk inferred from both the baseline and the sensitivity studies to ensure that margins remain adequate.

***Recovery***

1. The specialist inspector has explained that if the hoist protection systems were to be tripped there are a series of recovery options which EDF intends to use within normal trip settings of the fuelling machine. If this is unsuccessful, EDF has the options to increase the trip setting of the protection systems of the fuelling machine to:

* Stage 1: enhanced load
* Stage 2: ultimate load

1. Within each stage there are sub-levels where the permitted load is increased incrementally.
2. EDF has utilised the rig testing to estimate the likelihood for requiring an increased trip settings to recover a fuel stringer following SRGW debris entrainment as follows:

* 60% likelihood of exceeding the normal hoist protection settings.
* 10% likelihood of exceeding the enhanced hoist protection settings.
* 1% likelihood of exceeding the ultimate hoist protection setting and potentially requiring alternative means of recovery.

1. The specialist inspector states that they are content with these baseline likelihoods and notes that there is additional confidence that the station processes (e.g., attempts to reorientate/crush/dislodge the SRGW, staged application of higher hoist loads and fuel grab load trace (FGLT) monitoring) would lower the need for higher trip settings.

#### Potential impact of seismic loading on SRGW debris generation and consequences for control rod entry

1. The specialist inspector states that EDF claims that during normal operation the only mechanism for generating SRGW debris arises through the gradual opening of axially cracked bricks. Intact SRGW have sufficient strength to resist failure from all foreseeable loads. However, EDF concedes that it is possible for a seismic event to accelerate the formation of SRGW debris, and especially for those bricks where SRGW cracking has already initiated.
2. Therefore, at the burn-up where 100 channels are predicted to have SRGW fragments, it is expected that a larger population of channels could have SRGW cracking. If a seismic event were to occur, it would be credible that at the end of the event all of these channels could contain SRGW debris and could pose a risk to future fuel movements.
3. EDF acknowledges this possibility and argues that SRGW debris would not degrade the ability to shut down and hold down the reactor. EDF argues that this is because even if SRGW debris were pinned between the fuel and the channel wall allowing a direct load path to move the graphite bricks, the potential movement would be insufficient to challenge control rod entry. For fuel movement, EDF states that the increase in the number of channels with SRGW debris would not alter the planned recovery strategy but could potentially lead to delay to defuelling. EDF argues this will be dwarfed by the post-seismic-event recovery activities.
4. The specialist inspector is content that SRGW debris would not impinge on control rod entry, but questioned which faults and hazards could accelerate SRGW debris formation. EDF states that future testing would reveal the remnant strength of the cracked SRGW and this would be used to evaluate the consequences of certain faults. Therefore, the specialist inspector has raised the following recommendation:

*Recommendation: The licensee should provide the remnant strength of a cracked SRGW and identify which faults and hazards would induce further SRGW cracking or fragmentation.*

1. This recommendation will be recorded and monitored through regulatory issue RI-11708 to ensure it has been adequately resolved in a timely manner by EDF.
2. The specialist inspector advises they are content that this recommendation does not prejudice the agreement to NP/SC 7819 as it concerns the occurrence of faults or hazards and that there is a conservative element to the forecasting of SRGW debris accumulation.

#### Impact of SRGW debris on fuel cooling

1. The specialist inspector states that the main risks to fuel cooling come from:

* The migration of SRGW debris into the annulus space between the fuel assembly and the fuel channel leading to a blockage of the annulus.
* The migration down the fuel channel, into the anti-gapping unit (AGU) and up into the fuel stringer to the element 1 grid and causing a blockage.
* SRGW debris could enter the annulus space and cause the fuel to articulate to such a degree that gaps occur between fuel sleeves allowing flow bypass.
* SRGW debris that is entrained on the fuel sleeve can impart a significant radial load in the event of snagging and hence pose a risk to the integrity of the fuel sleeve itself. Similar to the risk from fuel sleeve gapping, a breach of the fuel sleeve can lead to flow bypass.

1. The likelihood of these potential issues are assessed by the graphite inspector while the consequences of these issues are assessed by the fault studies specialist inspector as will be discussed in Section ‎3.1.2.
2. The graphite specialist inspector notes that the key aspects from a graphite perspective have been read across from the extant safety case NP/SC 7808. Therefore, the specialist inspector has looked at the arguments presented not with the intent to re-assess previous judgements, but rather confirm they are still valid based on new understanding and evidence noting the increased limit on SRGW debris.

***Fuel stringer element 1 flow blockage***

1. EDF judges in the extant case NP/SC 7808 that the likelihood of a safety significant blockage whilst the fuel was in-situ was an infrequent event. This was primarily due to the geometric constraints in the channel which limits SRGW debris migration. EDF argues that despite the higher number of SRGW debris permitted in the proposed safety case NP/SC 7819, a blockage of element 1 remains an infrequent event. A description of the element 1 blockage fault is provided in the fault studies assessment, see Section ‎3.1.2.2 below.
2. The specialist inspector is content that safety significant element 1 blockage remains an infrequent event.

***Fuel channel annulus blockage***

1. The specialist inspector states that considering the potential increased number of fragments in a single channel, it is possible that sufficient debris could exist within a single channel to create a blockage greater than 80%. However, for a safety significant blockage to occur, the debris has to be arranged such that it forms a contiguous blockage. EDF has not identified a mechanism which would drive the SRGW debris around the channel and form a contiguous blockage. The physical constraints in the channel would not be conducive to forming such a blockage.
2. The specialist inspector notes that despite NP/SC 7819 is permitting a higher number of channels with SRGW debris, the majority of channels will not possess sufficient SRGW to create an 80% blockage.
3. The specialist inspector agrees with EDF’s argument and is content that the risk of a safety significant blockage in a single or multiple channels is acceptable, due to the physical constraints in the channels that makes such blockages unlikely.

***Fuel sleeve gapping***

1. The specialist inspector states that within the extant case EDF postulated that SRGW debris displaced into the fuel channel could cause the fuel to articulate creating gaps between fuel sleeves. EDF took a simplistic view and estimated the maximum potential articulation, and hence gap, within the channel due to available space.
2. EDF further simplistically combined the maximum SRGW debris-induced sleeve gap to the sleeve gapping estimated from core distortion.
3. The specialist inspector states that although the sleeve gapping calculation is relatively simplistic, they are content it is appropriate to provide confidence in the fuel gapping calculations, the acceptability of which was considered by the fault studies specialist inspection in Section ‎3.1.2.2.

***Fuel sleeve disruption***

1. The specialist inspector states that whilst it is EDF’s clear expectation that a SRGW debris will not entrain on the fuel sleeve or if it does it will be detected prior to entering the fuel channel restrictions, EDF has considered the consequences. The increased axial load required to pull fuel with trapped SRGW debris past the constrictions can impart a radial load. If the SRGW is entrained on the fuel sleeve, most likely at the fuel element handling groove (FEHG), then the loads could exceed the strength of the fuel sleeve graphite.
2. Although EDF has conceded that fuel sleeve cracking could occur under normal fuelling machine trip settings, they consider it unlikely as any loads sufficient to crack the sleeve under normal trip settings would induce movement or breakage of the SRGW debris.
3. The specialist inspector notes that in the 5-Layer rig tests, EDF tried and failed to entrain SRGW debris on the fuel sleeve. Whilst this doesn’t confirm it is not possible, it gives the specialist inspector confidence that it is not a likely event. Furthermore, if the event were to occur, the specialist inspector had confidence that the load fluctuation caused by entrainment on the fuel sleeve would be detectable on the fuel grab load trace (FGLT) and appropriate action to prevent specific lifting scenarios could be taken.

#### SRGW debris forecasting methodology

1. The specialist inspector states that the proposed safety case NP/SC 7819 limits operation to the burn-up at which 100 channels are expected to contain SRGW fragments. EDF uses the CrackSim methodology to forecast the accumulation of axially cracked bricks and SRGW fragments/debris.
2. ONR has previously reviewed (ref. [12]) the SRGW fragments/debris forecasting methodology and is content that whilst it relied heavily on limited data and judgements, the forecasts used to set operation were conservative.

#### ALARP considerations

1. The specialist inspector states that the main aspects of the ALARP claim from a graphite perspective are the inspection strategy, SRGW debris detection capability and potential modifications to the graphite bricks.

***Inspection strategy***

1. EDF states that following the observation of keyway root cracked bricks, they have enhanced the inspection regime to ‘find and follow’ bricks with KWRC. The purpose of this is to gain more information on the evolution of KWRC and SRGW failure which could lead to SRGW debris. The licensee has considered conducting more frequent inspections or more inspections during each inspection campaign.
2. Whilst the licensee acknowledges that more inspections would provide more information, the relative benefit is not linear. EDF argues that their current inspection plan provides the right balance between benefit and disbenefit.
3. The specialist inspector states that they consider the current inspection strategy of ‘find and follow’ to be reasonable and that any deviation in cracking behaviour will be realised in a timely manner.

***SRGW debris detection capability***

1. The specialist inspector states that EDF has already, as part of previous justifications, implemented a Layer 10 Hoist Stop for all fuel movements to review the fuel grab load trace (FGLT) before the fuel is discharged from the core. EDF states that although this will not prevent a snag from happening, it will minimise the potential for an unexpected snag. EDF claims that it will also allow other potential actions to be taken (e.g. attempts to break-up or reorientate SRGW debris) to maximise the chance of recovery under normal trip settings. The licensee has also stated that they have produced additional guidance on how to interpret the FGLT to identify the location and implication of FGLT anomalies.
2. The specialist inspector is content that EDF has taken reasonable steps to improve the SRGW debris entrainment detection capability and that the measures in place should provide an indication of SRGW debris interaction even if entrainment does not occur.

***Potential modifications to the graphite bricks***

1. The specialist inspector states that EDF has reviewed the physical modifications that could be made to the channel or core to minimise or eliminate the risk of SRGW debris and deemed them not appropriate for implementation within the scope of the proposed safety case NP/SC 7819. However, EDF has stated that it has initiated a review of potential modifications, including equipment to relocate SRGW debris, for potential implementation in future safety cases.
2. The specialist inspector agrees with EDF position and notes that ONR will engage with EDF on the new review through regular interactions.
3. Overall, the specialist inspector is content that EDF has either taken reasonable action or justified why no action is appropriate in the areas relevant to graphite structural integrity to reduce the risk from SRGW debris to ALARP.

#### Graphite Structural Integrity Conclusion

1. To conclude, the graphite structural integrity specialist inspector is content that EDF’s proposed safety case NP/SC 7819 is adequate. It is judged that the proposal is sufficient, from a graphite structural integrity perspective, to justify the issue of a Licence Instrument for ONR’s Agreement, under arrangements made under Licence Condition 22(1), to the implementation of NP/SC 7819 by Heysham 2 and Torness Power Stations.

### Fault studies assessment (ref. [9])

1. The fault studies specialist inspector has focused their assessment of the proposed safety case on determining whether EDF has identified and analysed the potential fault sequences and nuclear safety consequences arising from SRGW debris to demonstrate that the risks have been reduced to ALARP. Hence, they have considered the potential impact of SRGW debris on the key nuclear safety issues of:

* freedom of control rod and fuel movement; and
* fuel and core cooling.

1. Therefore, the specialist inspector has targeted the following aspects of the proposed safety case:

* The nuclear safety risk associated with fuel snagging on SRGW debris during operations and defuelling.
* The consequence analysis for SRGW debris snagging on the fuel element handling groove (FEHG).
* The impact of increased amount of SRGW debris on core distortion, assessing any potential effect on the free movement of control rods.
* The impact of increased amount of SRGW debris on fuel sleeve gapping and its effect on fuel cooling.
* The impact of increased amount of SRGW debris on fuel stringer blockage at element 1 and its effect on fuel cooling.
* The likelihood and potential for fuel channel annulus blockage, with particular consideration to the potential for multiple channels to be affected simultaneously.
* Consideration of reasonably practicable measures that could be introduced to reduce the risk from SGRW debris.

#### Impact of SRGW debris on free movement of control rods and fuel

***Impact on Fuel Movement***

1. SRGW debris could be mobilised during withdrawal of a fuel stringer from the reactor during refuelling or inspection activities and lodge between the fuel assembly and the fuel channel, which has the potential to impede the free movement of the assembly (an event referred to as ‘snagging’). This has the potential to increase the load on the fuelling machine (FM) and the tie-bar that supports the weight of the fuel elements, which together form the ‘load path’. If the fuel were to become stuck, and the FM overload protection failed, there is potential for part of the load path to fail, resulting in part, or all, of the fuel stringer being dropped. This may lead to mechanical fuel damage and a release of radioactive isotopes into the primary circuit.
2. The specialist inspector has considered EDF’s demonstration that the potential impact of SRGW debris impeding fuel stringer movement has been identified, analysed and the consequences considered in line with the expectations of the relevant ONR Safety Assessment Principles (SAP). The specialist inspector has also considered the identification of the relevant safety measures providing protection against overload and underload on the fuelling machine, which are designed to prevent a dropped load being realised following snagging or ledging faults, as per the expectations of the relevant SAP.
3. The specialist inspector notes that in addition to the normal overload and underload protection measures of the fuelling machine, EDF has introduced modifications to the fuelling machines hoist speed profile and introduced a layer 10 hoist stop to check the fuel grab load trace for any potential anomalies to reduce the risks associated with SRGW debris during fuel handling.
4. The specialist inspector states that in the event of a snag, EDF will try to recover the fuel within the normal fuelling machine trip setting. If this fails to free the snag, EDF has justified progressively increasing the load limits under separate safety cases referred to as the Enhanced and the Ultimate Pull Safety Cases (refs. [13] and [14]). ONR has considered the Enhanced and Ultimate Pull cases in refs. [15] and [16].
5. To estimate the number of snags that could occur in a 100 channels with SRGW debris (i.e., the DRL), EDF has developed and carried out rig testing referred to as the “5-layer rig”, which has been discussed in Section ‎3.1.1. EDF estimates that, for 100 channels with SRGW debris, a total of 9 snags are predicted. This is referred to as the baseline case. EDF states that for a conservative case, this total would increase to 15 snags. EDF further conservatively assumes that these would occur within a single year. These values are compared with the PSA sensitivity studies to demonstrate that the potential risk during defuelling will remain tolerable. The appropriateness of the PSA has been considered by a PSA specialist inspector as discussed in Section ‎3.1.3.
6. The specialist inspectors states that the cumulative fault frequencies resulting from increased snag probabilities remain between the basic safety objective (BSO) and the basic safety level (BSL) of ONR’s numerical target 8 for all dose bands. Therefore, the specialist inspector considers that this demonstrates tolerance to snagging faults in line with the expectations of the relevant ONR SAP.
7. The specialist inspector is content that EDF has provided an adequate demonstration that the potential impact of SRGW debris impeding fuel stringer movement has been identified, analysed and the consequences considered in line with the expectations of the relevant ONR SAP. The specialist inspector is also content that EDF has identified and implemented relevant safety measures providing protection against overload and underload on the fuelling machine, which are designed to prevent a dropped load being realised following snagging or ledging faults, as per the expectations of the relevant ONR SAP.

***Impact on Control Rod Movement***

1. The specialist inspector is content that EDF has provided an adequate justification that the likelihood of control rod movement being impeded by SRGW debris is negligible. This is because there is no credible route for SRGW debris created or mobilised from a parent fuel channel brick to enter the control rod channels in normal operation and during a seismic event.

#### Consequences of SRGW debris on fuel and core cooling

1. SRGW debris can potentially impact fuel and core cooling through inter-element ‘fuel sleeve gapping’ and flow blockages of the fuel channel annulus or the element 1 grid.

***Fuel Sleeve Gapping***

1. The specialist inspector states that SRGW debris in the fuel channel annulus could potentially exert force on the fuel stringer, resulting in articulation and consequent inter-element fuel sleeve gapping. The entry of coolant gas into the fuel stringer through the gap potentially has thermal implications for the fuel pins and other fuel components. Notably, the elements below the gap will see reduced re-entrant coolant gas flow and are predicted to rise in temperature, and the elements above the gap are predicted to reduce in temperature. The same is true for the tie-bar at the centre of the fuel stringer.
2. The risks associated with fuel sleeve gapping were previously assessed by the specialist inspector (ref. [17]) as part of the assessment of the extant case NP/SC 7808. Therefore, the specialist inspector has focussed on the impact of two key developments, occurring since the prior safety case was submitted:

* Debris may be present in a larger number of channels and a larger amount of debris may be present in a single channel.
* The largest sleeve gap arising from core distortion may have increased due to ongoing irradiation damage to the graphite.

1. The specialist inspector states that EDF has used bounding analyses and sensitivity studies to demonstrate that the combined impact from SRGW debris and core distortion induced fuel sleeve gapping on temperature rises is very limited (i.e., less than 30°C). The specialist inspector is therefore satisfied that EDF has provided an adequate justification that the consequences from SRGW debris on fuel sleeve gapping have been demonstrated to be tolerable.

***Fuel stringer element 1 flow blockage***

1. EDF recognises that SRGW debris could migrate into the fuel stringer gas inlet during fuel handling. SRGW debris could also migrate during operations, but EDF considers this to be less likely due to the limited clearances between the fuel and the fuel channel annulus. It is possible that this debris could be levitated into the fuel stringer by the gas flows during at-power operation and then pass through the anti-gapping unit (AGU) before being held by the gas flow against the element 1 grid. Depending upon the level of gas flow blockage, localised overheating of the fuel in element 1 could occur, potentially resulting in radiological consequences.
2. The justification for the tolerability of the potential consequences relies on evidence presented in the extant safety case NP/SC 7808 (ref. [6]), which was previously assessed by the fault studies specialist inspector and found to be adequate (ref. [17]).
3. As there is an increase in the permitted amount of debris in the proposed safety case NP/SC 7819, the specialist inspector has considered the potential increase in the fault frequency of element 1 blockage and the impact on the wider whole-core if multiple channels are affected.
4. EDF claims that the formation of safety significant blockage at the element 1 grid due to SRGW debris would remain an infrequent fault. This claim is supported by the graphite specialist inspector, see Section ‎3.1.1.4. The fault studies specialist inspector states that this aligns with their previous assessment (ref. [17]). Therefore, the specialist inspector consider the risk on a single channel basis remains broadly acceptable.
5. From a wider whole-core perspective, there is also the potential for unrevealed increases in clad temperature during normal operation (due to element 1 blockages if they were to occur), which would reduce margins to clad melt in a subsequent fault.
6. The specialist inspector states that EDF argues that there is typically a large margin to clad melt in Element 1, as peak fuel temperatures in reactivity faults occur higher up the fuel stack, even for bottom-peaked rating shapes. In addition, EDF argues that due to the low likelihood of debris migration and levitation, the number of channels that could be simultaneously affected is likely to remain very low.
7. Consequently, the specialist inspector is content that the risk from fuel stringer blockage faults due to SRGW debris remains within the broadly acceptable region, despite the increased debris burden permitted under the proposed safety case NP/SC 7819.

***Fuel channel annulus blockage***

1. SRGW debris could form a blockage in the fuel channel annulus (FCA), disrupting the re-entrant gas flows. The gas flows in the core consists of direct and re-entrant gas flows. The fuel channel annulus refers to the space between a fuel assembly and the fuel channel wall. This is the space into which SRGW fragments may mobilise from a parent brick.
2. The specialist inspector states that EDF has analysed the effect of high levels of annulus blockage of a single channel, where EDF considered 80% flow area blockage with sensitivity studies up to 98%. This analysis has shown that there is no significant impact on temperatures of fuel and core components as the gas flows redistribute through other routes.
3. From a ‘whole-core’ perspective, EDF has undertaken further analysis considering a scenario with every fuel channel in the core containing a 50% FCA blockage. EDF claims that there is a negligible effect on stringer gas flow and temperature.
4. The specialist inspector is content that the analyses and results presented by EDF indicate that the risk from a single and widespread FCA blockages is not significant.
5. The specialist inspector notes that any pressure drop across the gas baffle would be detected, as it is routinely monitored by operators, ensuring that it does not deviate from the allowable range. This monitoring ensures there would be no ‘cliff edge’ effect if significant annulus blockage became widespread.

#### Justification that the risks from SRGW debris have been reduced to ALARP

1. The specialist inspector states that EDF claims to have conducted a systematic optioneering process to identify all reasonably practicable measures to minimise the risk posed by SRGW debris. EDF has produced a dedicated analysis note that records the options considered throughout the ongoing process of managing the risks associated with SRGW debris, and documents the decision-making process behind which options have been implemented to reduce those risks.
2. The specialist inspector has reviewed EDF’s analysis and considers that all reasonably practicable measures identified have been taken forward, and the justifications provided for discounted options are reasonable. Therefore, the specialist inspector is content that EDF has demonstrated adequate optioneering, meeting the expectations set out in the relevant ONR guidance (ref. [18]).
3. However, the specialist inspector notes two exceptions to the above:

* the option to develop a recovery solution for a ‘hard bi-directional snag’, which is identified as ‘not being further developed’; and
* options associated with the risk insights provided by the new off-load depressurised refuelling exchange (ODRE) PSA, which have not yet been incorporated into the ALARP optioneering. The ODRE PSA is discussed in Section ‎3.1.3 below.

1. Hence, the specialist inspector makes the following recommendations:

*Recommendation 1: EDF should reflect on the ODRE PSA insights, review the impact on the risk associated with a hard bi-directional snag on SRGW debris, and develop reasonably practicable mitigation and recovery options, as appropriate.*

*Recommendation 2: EDF should carry out a systematic review of the dominant sequences in the ODRE PSA (for both generation and defuelling) to identify risk insights and any reasonably practicable safety measures to reduce risks.*

1. The specialist inspector has raised Regulatory Issue RI-11710 to record and monitor these recommendations to ensure they are adequately resolved in a timely manner by EDF.
2. The specialist inspector, however, recognises that further reasonably practicable risk reduction measures may be of limited benefit during generation whilst the proposed safety case validity is restricted to a single snag on SRGW debris. Therefore, they consider that it would not be proportionate to withhold permission until these recommendations have been addressed. The insights may however be significant in reducing risk when multiple snags may be realised (i.e. during defuelling or if EDF develops a safety case permitting multiple snags).
3. The specialist inspector concludes that they are content that EDF has provided adequate demonstration of reduction of risks to ALARP over the validity limits of the proposed case.

#### Fault Studies Conclusion

1. To conclude, the fault studies specialist inspector is content that EDF’s proposed safety case NP/SC 7819 is adequate. It is judged that the proposal is sufficient, from a fault studies perspective, to justify the issue of a Licence Instrument for ONR’s Agreement, under arrangements made under Licence Condition 22(1), to the implementation of NP/SC 7819 by Heysham 2 and Torness Power Stations.

### Probabilistic safety analysis assessment (ref. [10])

1. The probabilistic safety analysis (PSA) specialist inspector has focussed their assessment (ref. [10]) of NP/SC 7819 on determining whether EDF’s use of the PSA to support the proposed safety case is appropriate. This included ensuring that:

* A suitable and sufficient PSA has been used to support the safety case, and the PSA results provided as evidence in the safety case have been correctly interpreted.
* Whether risk insights from the PSA have been used to identify measures to reduce the risks ALARP.

1. The PSA establishes the overall station risk during generation. The proposed safety case presents the current position as established in the extant safety case NP/SC 7808 (ref. [6]). NP/SC 7808 was supported by several sensitivity studies on the baseline HYB/TOR fuel route PSA available at the time. This PSA modelled low power refuelling (LPR), off-load pressurised refuelling (OPR) and off-load depressurised refuelling (ODR) modes.
2. These sensitivity studies assessed the impact on the risk for different snagging frequencies due to SRGW debris, assuming 0.15, 1.5 and 15 snags per reactor year (pry). The results for all sensitivities were in EDF’s tolerable-if-ALARP region, except for 15 snags pry for dose band 1 (DB1) which was in EDF’s intolerable region. EDF notes that this DB1 result is dominated by OPR (93.5% contribution) operations.
3. Both HYB and TOR have adopted ODR as the only mode for refuelling and graphite core inspections. EDF has therefore been developing a new PSA for ODR mode only; this is referred to as off-load depressurised refuelling exchange (ODRE) PSA. EDF claims that in this PSA, the full impact of snagging is evaluated and is confirmed not to significantly increase the risk. EDF also claims that a separate safety case will be produced to formally present the ODRE PSA results. Following this, a review will be done to consider if the proposed NSL of a single snag due to SRGW debris is still appropriate, and whether the risk from a larger number of snags can be demonstrated as ALARP. Any such change to the limit will be justified in a separate safety case.
4. The specialist inspector carried out a comparison of the results and sensitivities studies of both the extant LPR/OPR PSA and the new ODRE PSA. The specialist inspector has found that the ODRE PSA results show that the overall fuel route risk is higher in some dose bands than the equivalent LPR/OPR PSA.
5. Furthermore, LPR/OPR modes are no longer applicable to HYB/TOR, hence it could be argued that the LPR/OPR PSA does not reflect the current design and operation of the facility, although EDF considers ODR operations to be inherently at a lower risk than LPR/OPR operations.
6. Consequently, the specialist inspector does not consider the extant LPR/OPR PSA, referred to in NP/SC 7819, a suitable and sufficient PSA to be a pessimistic and bounding assessment of snagging risk/sensitivity during generation and defuelling.
7. The specialist inspector states that the new ODRE PSA has removed all LPR/OPR operations that are irrelevant to ODR, the only refuelling mode permitted for HYB/TOR. In addition, EDF has included consideration of snag recovery fault and a number of faults not included in the LPR/OPR PSA.
8. The specialist inspector considers the new ODRE PSA to be a constructive development of the PSA, leading to a more representative PSA overall and in line with the relevant ONR SAP.
9. The specialist inspector states that the overall fuel route risk presented in the ODRE PSA for HYB and TOR are in EDF’s tolerable-if-ALARP region.
10. EDF has also conducted sensitivity studies in the ODRE PSA to investigate the impact of 2, 5, 10, 15, 20 and 50 snags due to SRGW debris on the PSA results. For all the cases the risk remains in EDF’s tolerable-if-ALARP region for all dose bands.
11. The specialist inspector is content that the results of the ODRE PSA and the sensitivity studies support EDF’s claim that the risk will remain tolerable during generation and defuelling and that there are no cliff-edge effects within the limits of the proposed safety case.
12. Therefore, the specialist inspector considers the proposed NSL of 1 snag pry due to SRGW debris is acceptable.
13. The specialist inspector notes that the ODRE PSA is undergoing an update following which it will be formally introduced to the safety case. As EDF has made a formal commitment in the proposed safety case NP/SC 7819 to review the judgments following this update, the specialist inspector is satisfied with the judgments made in the NP/SC 7819 and that they will be reviewed against the results of the updated ODRE PSA.
14. It is the specialist inspector’s expectation according to relevant ONR SAP that the PSA should be used to inform the design process and help ensure the safe operation of the site and its facilities. Appropriate use of the PSA includes, among others, supporting the demonstration that risks are tolerable and ALARP.
15. Whilst the safety case makes satisfactory use of the PSA to demonstrate that risks are below the basic safety limit (BSL), there is inadequate evidence to indicate that the PSA has been used to reduce risks ALARP.
16. Therefore, the specialist inspector has recommended that EDF carry out a systematic review of the dominant sequences in the ODRE PSA (for both the generation base case and defuelling base case) to identify risk insights and measures to reduce risks ALARP.
17. This recommendation will be captured as part of a regulatory issue related to the ALARP claim in the fault studies assessment, as noted in Section ‎3.1.2.3.

#### Probabilistic Safety Analysis Conclusion

1. To conclude, the PSA specialist inspector is content that EDF’s proposed safety case NP/SC 7819 is adequate. It is judged that the proposal is sufficient, from a PSA perspective, to justify the issue of a Licence Instrument for ONR’s Agreement, under arrangements made under Licence Condition 22(1), to the implementation of NP/SC 7819 by Heysham 2 and Torness Power Stations.

# Matters arising from ONR’s work

1. All ONR specialist inspectors agree that the proposed safety case modification of NP/SC 7819 (ref. [3]) is acceptable. On that basis, I have prepared licence instruments 642 and 566 for Agreement to NP/SC 7819: Heysham 2 and Torness Revised Safety Case for Seal Ring Groove Wall Debris EC 369835 (HYB) and 369826 (TOR). These have been written according to ONR guidance for derived power arrangements (ref. [19]).
2. Some Recommendations were raised by the specialist inspectors which are discussed in this report. None of the recommendations prevent Agreement to NP/SC 7819.
3. I have liaised with the Environment Agency (EA) and the Scottish Environment Protection Agency (SEPA) and they have confirmed that they have no objections to the operation of Heysham 2 and Torness reactors under the proposed safety case (refs. [20] and [21]).
4. I have confirmed that EDF has followed its own due process. An Independent Nuclear Safety Assessment (INSA) statement for NP/SC 7819 has been submitted (ref. [3]) and the Nuclear Safety Committee (NSC) meeting minutes have been submitted in support of the case (ref. [22]).

# Conclusions

1. Based on the work carried out by ONR, I am satisfied that the proposed safety case NP/SC 7819 has been adequately justified by EDF and that licence instruments should be issued to HYB and TOR agreeing to the implementation of NP/SC 7819.

# Recommendations

1. ONR should issue Licence Instruments 642 and 566 to HYB and TOR Power Stations, respectively, to agree to the implementation of NP/SC 7819.
2. ONR should maintain regulatory oversight and routinely monitor progress against the assessment recommendations identified by the specialist inspectors, which are recorded in:

* Regulatory Issue raised by the graphite structural integrity specialist inspector (see para. ‎46): RI-11708, title: “SRGW Debris Snag Recovery Process”.
* Regulatory Issue raised by the fault studies specialist inspector (see para. ‎104): RI-11710, title: “SRGW Debris - Review of ODRE PSA risk insights and identification of reasonably practicable safety improvements”.

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