Office for Nuclear Regulation

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Sizewell B Dry Fuel Store
Assessment of Dry Fuel Store Post Operational Safety Case, Stage Submission 1 Revision 1
NP/SC 7575, EC 338898-1

Project Assessment Report ONR-OPF-PAR-16-010
Revision 0
October 2016

EXECUTIVE SUMMARY

Title : Dry Fuel Store Operations Safety Case Stage NP/SC 7575, EC 338898-1

Permission Requested

The Office for Nuclear Regulation (ONR) Project Assessment Report (PAR) has been issued to record regulatory views on the adequacy of the EdF Energy Nuclear Generation Limited (NGL) Sizewell B' Dry Fuel Store Post Operational Safety Case NP/SC 7575, Engineering Change (EC) 338898. This work supports permissioning requirements specified by ONR through Nuclear Site Licence Condition (LC) 21 (4): Commissioning requiring NGL to seek ONR's consent prior to commencing active commissioning of dry fuel store processing and storage operation.

Background

NGL has constructed a Dry Fuel Store on Sizewell B Nuclear Licenced Site due to a range of converging issues:

- Limited storage capacity in Sizewell B Station's fuel cooling pond;
- Limited nuclear fuel reprocessing capacity both worldwide and within the UK given the Government's decision to stop nuclear fuel reprocessing at Sellafield and move to underground radiological waste disposal;
- The UK underground radiological waste disposal facility has yet to be constructed.

As this is a major change to activities conducted on site NGL produced a Category 1 Safety Case in compliance with Nuclear Site Licence Condition (LC) 23(1): Operating Rules. This requires the licensee to produce a safety case to show that any operations that may affect safety have been adequately addressed and to identify conditions and limits necessary in the interests of safety.

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

ONR's assessment of the Sizewell B Dry Fuel Store Operations Safety Case involved assessment of 5 areas considered important to safety: fuel and storage container integrity; fault studies; human factors; radiation protection; and radioactive waste management. Three site inspections were undertaken to evaluate the development of arrangements supporting requirements set out in the safety case:

- Structural Integrity and Radiological Protection;
- Fuel Selection and Human Factors; and
- Radioactive Waste Management.

Matters arising from ONR's work

A number of regulatory issues were raised by ONR covering: assessment of fuel integrity for dry storage; design of containment for storage of fuel; threat from aging and degradation; and radiation protection of the public. All of these issues were addressed by NGL developing its safety case to show risk from potential harm has been reduced to So Far As Is Reasonably Practicable.

Conclusions

ONR considers NGL has complied with the requirements of LC 23(1) by producing an adequate safety case for dry fuel store processing and storage operations showing that potential risks from activities involved in placing spent nuclear fuel into dry storage on the Sizewell B Nuclear Licenced Site have been reduced to So Far As Is Reasonably Practicable.

Recommendation

As a result of changes to the required permissioning arrangements for the Sizewell B dry fuel store, there is no longer a requirement for this PAR to support a Licence Instrument. It should be published as a record of the assessment work undertaken and ONR's view that NGL has produced an adequate post operational safety case in compliance with LC23(1) for dry fuel

processing and storage operation and identification appropriate conditions and limits in the interests of safety. This PAR will be used as supporting evidence for the subsequent permissioning of active commissioning of the dry fuel store.

LIST OF ABBREVIATIONS

ASME	American Society of Mechanical Engineers
ALARP	As low as reasonably practicable
BSL	Basic Safety level
BSO	Basic Safety Objectives
CFD	Computational Fluid Dynamics
CTF	Cask Transfer Facility
DFRP	Dry Fuel Repackaging Plant
EC	Engineering Change
FHD	Forced Helium Dehydration
IAEA	International Atomic Energy Agency
INA	Independent Nuclear Assurance
INSA	Independent Nuclear Safety Assessment
LC	Licence Condition (attached to Nuclear Site Licence)
LI	Licence Instrument
MPC	Multi-Purpose Cask
MPCCS	Multi-Purpose Cask Cooling System
NDA	Nuclear Decommissioning Authority
NGL	EDF Energy Nuclear Generation Limited
NSR	Nuclear Safety Requirements
ONR	Office for Nuclear Regulation
OpEx	Operational Experience
OR	Operating Rules
PAR	Project Assessment Report
PFB	Pond Fuel Building
PPB	Pond Preparation Bay
RGP	Relevant Good Practice
RWMD	Radioactive Waste Management Directorate
SFR	Safety Functional Requirements
SCC	Stress Corrosion Cracking
SS	Stainless Steel
SFAIRP	So Far As Is Reasonably Practicable
SS1 Rev 1	Dry Fuel Store Operational Safety Case Stage Submission 1 Revision 1
SQEP	Suitably Qualified and Experienced Persons
TDMS	Temperature Difference Monitoring System
UK	United Kingdom
USNRC	United States Nuclear Regulatory Commission

TABLE OF CONTENTS

1 PERMISSION REQUESTED 8
2 BACKGROUND 8
3 ASSESSMENT AND INSPECTION WORK UNDERTAKEN BY ONR 9
4 MATTERS IDENTIFIED FROM ONR'S EVALUATION 10
4.1 ONR'S Structural Integrity Assessment Findings 11
4.2 ONR's Fuel Integrity Assessment Findings 14
4.3 ONR Fault Studies, Human Factors and Criticality Assessment Findings 18
4.4 ONR Radiological Protection Findings 20
4.5 ONR Radioactive Waste and Decommissioning Assessment Findings 21
4.6 Closure of Outstanding ONR Issues 23
4.7 Communication with other UK Governmental Organisations 23
5 CONCLUSIONS 24
6 RECOMMENDATIONS 24
7 REQUIREMENTS FROM ONR's ASSESSMENTs 24
8 REFERENCES 26
Appendix 1 History of Sizewell B Dry Fuel Store 28
Appendix 2 ONR's Permissioning of Dry Fuel Store Project 29
Appendix 3 Dry Fuel Store Equipment and Process Description 30

1 PERMISSION REQUESTED

1. This Office for Nuclear Regulation (ONR) Project Assessment Report (PAR) has been produced to record regulatory views and judgment on the adequacy of the EdF Energy Nuclear Generation Limited (NGL) Sizewell B power station Post Operational Safety Case for Dry Fuel Processing and Storage NP/SC 7575, Engineering Change (EC) 338898.

2. This report supports regulatory decision-making in granting ONR's consent to allow NGL to commence active commissioning for dry fuel store operations. This requirement is established through ONR specifying under Licence Condition (LC) 21 (4) Commissioning, Sizewell B Licence Instrument (LI) 531 issued December 2012.

2 BACKGROUND

3. Nuclear facilities are licenced through the Nuclear Installations Act 1965. ONR regulates these facilities through Licence Conditions (LC) attached to the Nuclear Site Licence. Nuclear Site Licence Condition (LC) 23 (1): Operating Rules (OR) states:

4. "*The licensee shall, in respect of any operation that may affect safety, produce an adequate safety case to demonstrate the safety of that operation and to identify conditions and limits necessary in the interests of safety. Such conditions and limits shall hereinafter be referred to as operating rules.*"

5. The purpose of the safety case is to describe operations to be carried out and identify hazards, risks and consequences from these activities. It also identifies engineered and management controls established to manage the identified risks and show they have been reduced So Far As Is Reasonably Practicable (SFAIRP). The SFAIRP requirement established through Sections 2 and 3 of the Health and Safety at Work Act 1974.

6. The carrying out of dry fuel storage on the Sizewell B Nuclear Licenced Site is based on a number of converging reasons:

- Limited storage capacity in the Sizewell B station fuel storage pond.
- Limited nuclear fuel reprocessing capacity worldwide and within the UK, given the Government's decision to stop nuclear fuel reprocessing at Sellafield and move to geological disposal.
- The UK's geological disposal facility has not been constructed.

7. The implication of the above is that Sizewell B would have to cease generation much earlier than planned as it will be unable to adequately manage its spent nuclear fuel inventory and demonstrate compliance with requirements set out in its nuclear facility safety case.

8. There is a need to address the situation until the UK's geological disposal facility is available. NGL has proposed to introduce interim spent nuclear fuel storage on the Sizewell B Nuclear Licenced Site. This position has been reached through a series of optioneering studies where dry fuel storage provided the most acceptable solution given safety, security and environmental considerations. Further optioneering assessment by NGL led to Holtec International (Holtec) being selected as the preferred supplier for the dry fuel storage system and provider of operational support in this activity. Factors taken into consideration in coming to this decision were:

- Holtec's technical justification of their dry spent fuel storage system provided a high level of confidence that long-term safe storage requirements could be met;
- The Holtec dry spent fuel storage system has been licenced by the United States (US) nuclear regulatory authority, the Nuclear Regulatory Commission (NRC);
- Holtec has demonstrated consistent high standards in manufacture, delivery and performance in its dry fuel storage systems.

9. The main development of Holtec's system required by NGL was for the storage period to be increased to 100 years. The Holtec system is currently licensed by the US NRC for a period of 20 years with the ability to extend this storage period for a further 20 years providing a suitable safety justification is given that potential degradation of the storage containers will be managed. Details of ONR's engagement with NGL on the selection of dry fuel storage are provided in Appendix 1.

10. NGL has complied with the requirements of LC 23(1) by submitting to ONR the Sizewell B Dry Fuel Store Post Operational Safety Case, Stage Submission 1, Revision 1, NP/SC 7575, EC 338898, **Ref 1** issued under cover letter **Ref 2**. NGL consider Ref 1 provides a suitable and sufficient assessment of the risks and consequences of dry fuel processing and storage operations. This claim is supported by safety arguments and evidence presented in Ref 1 together with identified engineering and management controls. The safety case also identified conditions and limits in the interest of safety for these activities.

11. NGL has categorised Ref 1 as a Category 1 safety case submission on the grounds that it is a major change to current activities undertaken on the Site. As a consequence of this, a high degree of scrutiny has been applied to the case with submission to NGL's Nuclear Safety Committee for review and enforcement.

12. NGL has produced Ref 1 against its own nuclear safety requirements based on UK and International nuclear safety standards and Relevant Good Practice (RGP). The safety case was reviewed by Sizewell B's Nuclear Safety Operational Review Committee on 2 September 2015 (**Ref 3)** and NGL's Nuclear Safety Committee on 8 October 2015 (**Ref 4)**. Both committees concluded that the safety case was suitable and sufficient.

13. NGL also carried out its own Independent Nuclear Safety Assessment (INSA) of Ref 1 through its Independent Nuclear Assurance (INA) department. An interim INSA certificate (**Ref 5)** was issued by INA on the grounds that, although INSA issues had been addressed, supporting documentation had not been verified. NGL considers that these issues do not undermine the safety arguments presented in Ref 1 and have given a commitment to issue a full INSA certificate once the required documentation has been submitted and evaluated by INA. NGL state in their letter (Ref 2) that they will not seek ONR's Consent to commence active commissioning until a full INSA certificate has been issued to ONR.

3 ASSESSMENT AND INSPECTION WORK UNDERTAKEN BY ONR

14. The introduction of dry fuel storage on the Sizewell B Nuclear Licenced Site has required the construction of a dry fuel storage facility together with modification to existing plant and processes. Appendix 2 provides a summary of the main safety justifications made by NGL and considered by ONR in the permissioning of dry fuel store storage.

15. ONR's assessment of Ref 1 builds on previous regulatory work that involved evaluating NGL's Dry Fuel Store Paper of Principle **(Ref 6)**. This document set out optioneering work undertaken by NGL to determine the best way to manage spent nuclear fuel stored within Sizewell B's storage pond. Assessment of a range of storage options was undertaken with dry fuel storage being identified as the most suitable based on safety, security and environmental impact. Ref 6 formed part of NGL's planning application to the Department of Energy and Climate Change (DECC) under Section 36 of the Electricity Act for construction and operation of dry fuel storage facility on the Sizewell B Nuclear Licenced Site.

16. DECC requested that ONR provide a regulatory view on the adequacy of the case being made by NGL **(Ref 7**). This is set out in ONR report **Ref 8** where ONR states that no practical reason could be identified that would prevent DECC giving its consent for planning approval. The main justification behind ONR view being:

- Dry spent fuel storage is recognised internationally as a safe means of managing this type of material with international guidance published on the subject.
- The science and technology underpinning dry fuel storage is mature based with this type of storage in operation for a number of years in countries such as the US, Sweden, Spain, Japan, and China.
- The dry spent fuel storage has been shown to have a good safety record to date based on an operational history of 35 years.

17. The most significant development of the dry fuel storage solution proposed by NGL was the need to store spent fuel for up to 100 years. Although this requirement did not change the fundamentals of the storage system it was a change to Holtec's current design and posed increased risk due to potential degradation of fuel and secondary containment barriers. This issue received a heightened level of scrutiny by ONR in the assessment of NGL safety justification Ref 1. The issue of final disposal of fuel placed into dry storage is not directly addressed within Ref 1 although consideration of radioactive waste management and transfer of this material off the Sizewell B Nuclear Licenced Site is provided. Although ONR has provided a view on the adequacy of proposed radioactive waste management arrangements, it is unable to provide a view on final disposability as the decision on how this material will be disposed of has not been made.

18. ONR reviewed NGL's Pre-Construction Safety Case NP/SC 7575, EC 338898, Stage Submission 1 Revision 0 **(Ref 9)** reported in **Ref 10**. ONR concluded that NGL was making suitable progress in the development of safety arguments to demonstrate that dry fuel storage could be operated for up to 100 years on the Sizewell B Nuclear Licenced Site.

19. ONR's assessment of Ref 1 focused on 5 areas considered the most important: fuel and storage containment integrity for extended storage period; fault studies; human factors; radiation protection and radioactive waste management. The justification behind this is set out in **Ref 11** which builds on previous ONR assessment work (Ref 8 and 10).

20. Seven ONR specialist assessments were undertaken on Ref 1:

- Structural integrity of dry fuel storage secondary containment **(Ref 12);**
- Fuel selection requirements for dry storage of fuel **(Ref 13);**
- Fault studies review of dry fuel store operations **(Ref 14);**
- Human factors review of dry fuel storage operations **(Ref 15);**
- Criticality assessment of dry fuel processing and storage **(Ref 16);**
- Radiological safety dry fuel processing and storage **(Ref 17);**
- Radioactive waste management of dry fuel processing and storage **(Ref 18).**

21. In addition to these assessments, three on-site inspections were undertaken to evaluate the development of arrangements supporting the requirements identified in Ref 1:

- Structural Integrity and Radiological Protection, 6 and 7 July 2015 **(Ref 19)**
- Fuel Selection and Human Factors, 28 and 29 July 2015 **(Ref 20)**
- Radioactive Waste Management, 3 and 4 November 2015 **(Ref 21).**

22. This report provides the findings of these assessments and also addresses unresolved issues identified in the ONR letter to DECC **(Ref 22)** which confirmed that ONR had not identified any practical reason to prevent DECC from giving its consent to NGL's planning approval for construction and operation of dry fuel storage facility on the Sizewell B Nuclear Licenced Site.

4 MATTERS IDENTIFIED FROM ONR'S EVALUATION

23. The purpose of ONR's assessment of Ref 1 s to establish that NGL has discharged its responsibilities in carrying out a suitable and sufficient assessment of hazards and risks

for dry fuel storage operations. It also evaluates the engineered and administrative safety controls implemented to minimise risks SFAIRP.

24. ONR's assessment is based on ensuring RGP has been followed for dry fuel storage using ONR's guidance on the Storage of Spent Nuclear Fuel **(Ref 23)**; ONR's Nuclear Safety Assessment Principles for Nuclear Facilities **(Ref 24)**; International Atomic Energy Agency (IAEA) guidance **(Ref 25 and 26)** and Western European Nuclear Regulators Association (WENRA) guidance **(Ref 27)**.

25. Ref 1 is over 1000 pages and structured around 21 Sections that mirror the Station's Safety Case structure. NGL has presented Ref 1 as an extension of the Station's current Safety Case for spent fuel handling and storage. This approach is considered appropriate by ONR given that a number of existing operations (fuel element identification, movement and inspection) are to be used in dry fuel processing and have already been justified through existing safety arguments.

26. Ref 1 is built on Safety Functional Requirements (SFR) identified from hazard assessment of dry fuel storage activities. The SFRs form the foundations for the main safety claims set out in Ref 1. These claims have been developed and are considered by NGL to demonstrate that risks from dry fuel store operations are SFAIRP:

Claim 1: The design and operation of the dry fuel storage system will comply with appropriate safety assessment principles, national and international guidelines.
Claim 2: The spent nuclear fuel will be maintained in a safe state during its period of dry storage.
Claim 3: The spent nuclear fuel will be retrievable from dry storage.
Claim 4: The dry fuel storage facilities will be commissioned and operated in accordance with design intent.
Claim 5: The dry fuel storage facilities will be safely decommissioned.
Claim 6: The radiological risks to operators and members of the public are ALARP.

27. Ref 1 identifies two operating limits for dry fuel storage activities:

1. No fuel determined as non-retrievable will be loaded into a Multi-Purpose Cask (MPC) or evaluated to have failed will be moved out of the Fuel Building;

2. The assessed decay heat emitted by fuel assemblies within an MPC shall not exceed 26 kW.

[redacted]

The following sections summarise the main views and regulatory opinion reached from ONR's assessment of Ref 1.

4.1 ONR'S Structural Integrity Assessment Findings

29. ONR's Structural Integrity Inspector's assessment (Ref 12) focused on Section 5 of Ref 1, Spent Fuel Storage Casks:

- The adequacy of Holtec design, manufacture and quality standards for dry fuel storage components;
- The adequacy of NGL's design optioneering of the Holtec dry fuel storage system given identified hazards and risks (eg. increased storage duration);
- Adequacy of Structural integrity claims for MPCs based on fault conditions;
- In service monitoring and inspection of MPCs placed into storage.

This assessment's primary aim was the adequacy of Claim 1: The design and operation of the dry fuel storage system will comply with appropriate safety assessment principles, national and international guidelines.

30. The Structural Integrity Assessment Inspector visited the US Holtec manufacturing facility **(Ref 28)** and evaluated design standards and manufacturing techniques used in

the fabrication of the MPC (fuel storage container), HI-TRAC (MPC transfer flask) and HI-STORM (MPC shielded storage container). The Inspector considered an appropriate design standard had been applied to the design and manufacture of dry storage components (American Society of Mechanical Engineers (ASME), Section III Rules for Construction of Nuclear Facilities and Components). This view was based on ASME Section III being developed for the design and manufacture of equipment for use in nuclear applications. It is considered to be conservatively based with appropriate safety margins and a proven track record.

31. The Inspector visited the Sizewell B site (Ref 19) and reviewed quality documentation supplied by Holtec for the manufacture of MPCs to confirm compliance with design and quality standards. A number of non-conformities raised by Holtec were reviewed. The Inspector considered these were minor in nature and had no impact on MPC structural integrity. Welder qualification for the lid to shell weld was evaluated with NGL explaining that US approval had been considered acceptable to confirm welders were Suitably Qualified and Experienced Persons (SQEP). Evidence was provided by Holtec through the ASME certificates process of Welder Performance Qualification records which were considered acceptable.

32. The ONR Inspector considers that NGL undertook an adequate review of Holtec's dry fuel cask design to minimise potential hazards and risks. This view was supported by the following evidence:

- [redacted]
- [redacted]
- NGL require shock absorbers (deformable metal tubes) to be installed in the base of the HI-STORM and Cask Transfer Facility (CTF) to minimise damage to MPC during transfer process from a potential drop-load event.
- NGL are developing ultrasonic inspection equipment to confirm the integrity of the lid to shell weld. The Holtec process only uses the ASME code requirement of die penetrant inspection.
- NGL are developing Eddy Current inspection equipment to identify surface anomalies during storage of MPCs which could indicate the start of SCC. This approach is also supported by a full size MPC corrosion monitoring rig being internally heated to simulate thermal conditions of fuel contained with MPCs. The MPC corrosion monitor rig will provide early warning of the onset of SCC or similar damage mechanisms.

33. NGL commissioned Frazer-Nash to carry out an independent review of structural integrity analysis of MPC, HI-TRAC and HI-STORM **(Ref 29)** based on data provided by Holtec and R3 impact assessment and R6 fracture assessment techniques. This concluded that in the case of the two most onerous events, a [redacted] drop and topple event (fall from transport frame) onto an unyielding surface, the outer shell of the MPC would be plastically deformed but the inner shell would remain intact. Part of the impact energy is absorbed by HI-TRAC it was contained within. In the case of the [redacted] drop (transfer of MPC between HI-TRAC to HI-STORM at CTF) the MPC integrity would remain intact given shock absorbers positioned within HI-STORM and CTF base. NGL conceded that in both cases fuel integrity within MPC could not be justified given that

fuel gravitational acceleration load limits would be exceeded. Fuel pin displacement due to a drop-load event would not challenge criticality geometry limits due to the MPC fuel segregation basket providing sufficient containment.

34. NGL has determined fault frequencies for a drop-load event as $1.2x10^{-4}$ per year and $3x10^{-5}$ per year for a drop and topple event. These figures are justified on the grounds that MPC will not be lifted higher than 300 mm given the design of limiting equipment, other than when transferring the MPC within the HI-TRAC on to its transport frame and transfer of MPC from HI-TRAC into HI-STORM at CTF. All lifting equipment, including fuel building crane, has been classified as high integrity based on design and protection provided as well as managerial controls required during all lifting operations.

35. Based on safety arguments presented in Ref 1 and supporting references, ONR's Structural Integrity Assessment Inspector considered NGL had carried out a suitable and sufficient assessment of MPC, HI-TRAC and HI-STROR integrity. This view was justified by the adequacy of engineering assessment and protection provided for the fault conditions identified. In consideration of the fault frequencies claimed, the ONR Fault Studies Inspector considered these were reasonable based on the lifting operations to be carried out and the claimed integrity of equipment.

36. ONR's structural Integrity Inspector considers NGL has taken additional steps to minimise risk, given improvements in the Holtec dry storage system design with use of high grade corrosion material and the development of ultrasonic and Eddy Current inspection equipment. The ultrasonic inspection of the lid to shell weld provides additional confidence in weld integrity given this weld forms part of load lifting path during transfer of MPC between HI-TRAC into HI-STORM at CTF. Eddy Current inspection of MPC surfaces provides early forewarning of the onset of SCC initiation in combination with a full size corrosion monitoring rig.

37. Given that NGL had not completed its INSA on Ref 1 when submitted to ONR, the ONR Structural Integrity Assessment Inspector made the following recommendations before active commissioning commences:

1	That the ONR Sizewell B Dry Fuel Store (SZB DFS) Project Inspector obtain assurance from NGL that any issues relating to the use of imperial components are identified and managed. This will include Structural Integrity, control of welding consumables, control of fittings and attention to through-life monitoring.
2	That the ONR SZB DFS Project Inspector obtains confirmation from NGL that all INA comments from Section 5 Ref 1 have been satisfactorily closed out.
3	That the ONR SZB DFS Project Inspector ensures that a complete and suitable non-conformance and concession report is obtained for all nuclear safety significant equipment.
4	That the ONR SZB DFS Project Inspector ensures that Operational Commitment (OC) 1643.10-04 (adequate technical justification is provided for the MPC LTS Weld UT Inspection System) is complete.

38. These recommendations do not detract from the conclusion reached but allow identified issues to be closed out. Evidence supporting closure of recommendations will be presented in the ONR's PAR justifying the issuing of its consent to allow NGL to commence active commissioning of Sizewell B's dry fuel storage operations.

4.2 ONR's Fuel Integrity Assessment Findings

39. ONR's Fuel Inspector's assessment (Ref 13) focused on Section 4 of Ref 1: Fuel and Core Components. The assessment looked to establish that NGL had taken reasonable steps for:

- Identification of hazards and risks posed in placing Sizewell B's spent fuel into dry storage.
- The method of selecting and inspecting spent fuel for dry storage provided a level of assurance that fuel clad would remain intact during period of storage.
- No detrimental impact on fuel clad integrity would result from storage of core components with fuel loaded into MPCs.
- Adequacy of predictive condition monitoring of fuel integrity inside MPC.

40. This assessment was supported by a site visit to Sizewell B (Ref 20) to evaluate arrangements developed by NGL in determining fuel element integrity and thermal output.

41. Although this assessment was primarily focused on assessment of spent fuel element integrity, consideration was given to the impact of storing core components (Primary and Secondary Source Assemblies, Rod Cluster Control Assemblies, Thimble Plug Assemblies) within fuel assemblies loaded into the MPC. The concern here was that these components contain a range of materials which, if released into the MPC hot helium storage environment, could result in fuel clad degradation. The reason why core components are to be stored with spent fuel assemblies is that Sizewell B does not have a radioactive waste disposal route for these items. The issue of disposability of core components is addressed in Section 4.5 of this report, ONR Radioactive Waste and Decommissioning Assessment Findings.

42. In determining whether NGL had taken reasonable steps in identifying hazards and risks in placing Sizewell B's spent fuel into dry storage, the ONR Fuel Inspector concluded that an adequate assessment had been undertaken. This view was based on NGL's case identifying challenges to fuel integrity based on hazard assessment with the underpinning SFRs being:

- Fuel clad will function as a radiological containment barrier; and
- Fuel element assemblies will be retrievable when placed into an MPC

43. These SFRs support safety case claims 2 and 3:

Claim 2: The spent nuclear fuel will be maintained in a safe state during its period of dry storage.

Claim 3: The spent nuclear fuel will be retrievable from dry storage.

44. The ONR Inspector considered NGL's approach (shown in Table 1) in showing how SFRs were underpinned through Design Requirements (DRs) and Design Criteria (DCswas effective. The approach allows known requirements to be used to determine limits and conditions that had to be met during spent fuel processing and storage.

Table 1 Relationship between FRs, DRs and DCs for DFS Operations

		DFS FR1 **The fuel clad shall function as a radiological containment barrier.**		
DR - Fuel pellets must not melt.	DR - Fuel clad must not melt.	DR - Damage or deformation of the fuel clad that could jeopardise its integrity must not occur.	DR - Deterioration of the fuel clad that could jeopardise its integrity must not occur.	DR - Deformation or failure of fuel assembly components that could jeopardise the integrity of the fuel clad must not occur.
DC308 - fuel pellet melt DC324 - fuel pellet Gd content	DC307 - fuel clad melt	DC302 - fuel clad strain DC303 - fuel clad strain ratcheting DC309 - fuel peak pellet burnup DC311 - fuel rod end cap weld DC312 - fuel clad scratch DC322 - TN-rod-BN simultaneous contact DC323 - fuel plenum spring clad contact DC329 - thermal shock DC330 - fuel clad generalised stress	DC300 - fuel clad hydride re-orientation DC301 - fuel clad hydrogen transport DC304 - fuel clad fatigue DC305 - fuel clad corrosion DC306 - fuel clad hydrogen content DC 325 - biological fouling DC327 - stress corrosion cracking DC328 - liquid film corrosion DC331 - ductile-brittle transition DC332 - delayed hydride cracking DC333 - fuel pellet fragmentation DC 335 - axial hydrogen distribution	DC313 - spacer grid dimensional stability DC314 - GT/IT dimensional stability DC315 - joints and connections dimensional stability DC318 - TN and holddown spring dimensional stability DC319 - BN dimensional stability

	DFS FR2 **Fuel and core components shall retain their structural integrity so as to be retrievable.**	
DR - Damage or deformation of the fuel assembly components that could jeopardise the removal of the fuel must not occur.	DR - Deterioration of the fuel assembly components that could jeopardise the removal of the fuel must not occur.	DR - Core components must not suffer any damage, deformation or deterioration that could jeopardise their removal.
DC313 - spacer grid dimensional stability DC314 - GT/IT dimensional stability DC315 - joints and connections dimensional stability DC316 - holddown spring screw integrity DC317 - holddown spring clamp screw integrity (BNFL) DC318 - TN and TN holddown springs stability DC319 - BN dimensional stability DC329 - thermal shock DC330 - fuel clad generalised stress	DC 325 - biological fouling DC 327 - stress corrosion cracking DC328 - liquid film corrosion DC334 - stainless steel sensitisation	DC310 - core component melt DC320 - core component spider, holddown assembly, joints and connections DC321 - core component rod integrity

45. In evaluating the range of DRs and DCs, the ONR Inspector considered NGL's approach to group these factors under 4 **D**ry fuel store **I**nterface **P**arameters (DIP) was reasonable given the inter-relationship between these factors. This allowed dominant risks to be identified and show how they would be managed. The 4 DIPs were identified as;

DIP1 Limit on Fuel Peak Clad Temperature (PCT) during processing and storage
DIP2 Limit on hydride re-orientation
DIP3 Chemical impurity limits for internal MPC storage environment
DIP4 Fuel lateral and axial gravitational acceleration load limits

46. DIP 1 set the fuel PCT temperature limit at 375°C for processing and storage. NGL consider that, providing this limit is not exceeded, clad hoop stress will not exceed 90 MPa and strain within the fuel clad should remain below 1%. These values are justified against known material fuel performance data and codes.

47. DIP 2 set a maximum PCT of 490°C. If exceeded this would challenge fuel clad integrity due to hydride re-orientation within the fuel clad. Hydride formation occurs due to diffusion of hydrogen from the water side of the fuel into fuel clad forming brittle compound and reducing ductility and toughness.

48. DIP 3 sets chemical impurity limits to minimise the presence of corrosive species within the MPC's hot helium storage environment. Impurities are introduced through the loading process from pond cooling, failure of core components stored within fuel element structure and impurities in helium used to back fill MPC. This requirement highlights the need for cleanliness during the MPC loading process.

49. DIP 4 sets a gravitational acceleration load limit of [redacted]. NGL considers fuel clad integrity would be compromised if this was exceeded based on materials data. This recommendation also supports safety analysis of mechanical handling and transport operations.

50. ONR's peer review challenged NGL's safety argument justifying the temperature limit for hydride re-orientation on the grounds that it was not considered conservative. This challenge was based on the experimental data used by NGL which ONR considered to

be limited. NGL's response (Ref 30) clarified the safety margins and conservatisms in NGL's approach. ONR File Note **(Ref 31)** records how this issue was resolved based on additional information presented by NGL. ONR has requested that NGL clearly identify these limits in Section 4 of the Operational Dry Fuel Store Safety Case, Stage Submission 2. In addition ONR has raised an Operational Issue 4673 to monitor NGL's evaluation of fuel clad integrity given collaborative research programmes with US Electric Power Research Institute (EPRI) and the Holtec User Group (HUG). These requirements were communicated to NGL in Ref 31.

51. The ONR Inspector concluded that NGL had carried out a suitable and sufficient assessment of hazards and risks posed by placing Sizewell B's spent fuel into dry storage and that suitable controls and measures were in place through the 2 ORs established:

OR 1 No fuel determined as non-retrievable will be loaded into an MPC and any fuel in an MPC evaluated to have failed will not be moved out of the Fuel Building;

OR 2 The assessed decay heat emitted by fuel elements contents within an MPC shall not exceed 26 kW.

52. To comply with OR 1 NGL has developed a 4 step inspection process to provide the assurance to confirm that only intact and retrievable fuel will be placed into dry storage. Each step provides additional confidence of the integrity of fuel pin cladding and the elements structure. The ONR Fuel Inspector considered the inspection process to be methodical and logical in approach, involving:

- **Review of fuel performance records:** This covers fuel manufacturing history (concessions raised against fuel elements) and fuel performance whilst within the core (clad temperature history, core reloads inspection results in-core sipping, ultrasonic examination of fuel elements and visual inspection). This approach highlights any anomalies that could be potential weaknesses in the fuel element.
- **Visual inspection of fuel clad before loading into MPC:** This step is physically confirming the condition of each fuel element to be loaded: that it is complete and there are no signs of corrosion / degradation that could challenge the decision to load the fuel element into the MPC.
- **Sampling of Caesium-137 (Cs-137) levels from MPC and Cooling Pond Water**: Cs-137 isotope levels from a water sample taken from the MPC and fuel cooling pond water will be measured and compared. If a higher Cs-137 level is detected in the water taken from the MPC this could indicate fuel clad failure requiring further analysis.
- **Inline Helium gas sampling for Krypton-85 (Kr-85):** Analysis for Kr-85 isotope in Helium gas used to dry fuel elements will be carried out. If Kr-85 is detected fuel clad integrity could not be confirmed and the MPC would need to be opened for further analysis. This step has been developed by NGL and is an addition to the Holtec process.

53. In determining the adequacy of control to ensure OR 2 is met, the ONR Fuel Inspector considers NGL has developed suitable and sufficient arrangements. This view is based on the use of 2 independent methods to calculate fuel element thermal output. Each approach is based on different computer codes that have proven track records in nuclear applications. This methodology allows a level of independent checking to be established given the same source data (the Station's fuel element database) is used in both cases.

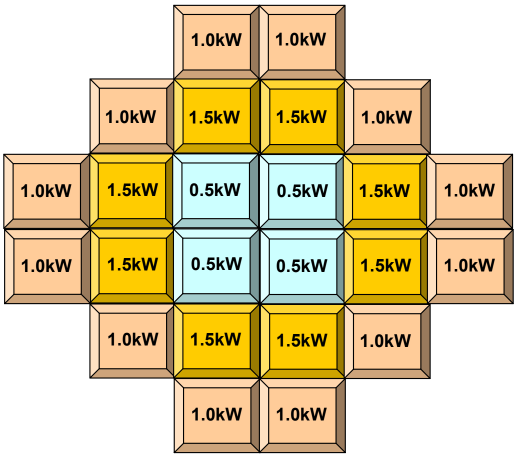
54. The first method uses Westinghouse propriety CASKWORKS software. This code is a US nuclear industry standard that complies with US NRC requirements. The software calculates the thermal output of individual fuel elements using information held on the Station's fuel element database. It then generates an MPC fuel element loading plan as

shown in Figure 1 by optimising all available fuel element combinations from assemblies stored in the station's cooling pond.

55. The second method was developed by NGL and uses PANTHER and FISPIN fuel performance computer codes. Tables of thermal output values for all fuel types in the Sizewell B fuel storage pond have been generated. Using fuel identities initially selected by CASKWORKS, their thermal output values are re-checked using NGL tabulated values. A trial was conducted to check the accuracy and repeatability of the process. The outcome was that both methods calculated similar thermal output values.

56. By optimising the fuel loading pattern, the thermal heat profiles across the MPC can be optimised [redacted] This allows steady state thermal convection within the MPC to be established. The heat is dissipated from the MPC by conduction through its metal structure and radiation to the external environment.

Figure 1 showing MPC fuel element thermal loading pattern with individual fuel element limits. Ensuring 26kW maximum limit is not exceeded



[redacted]

57. NGL target an MPC upper thermal load range of between 24 to 26kW with a lower limit of 17kW given the need to ensure the MPC is maintained with a surface temperature of around 80°C for as long as possible over the 100 year storage period. This is intended to protect the MPC from potential SCC by preventing chlorine salts condensing on the surface due to the dry air environment achieved around the PMC given elevated temperature. The temperature of air leaving the HI-STORM monitored through thermocouples mounted in its top vents.

58. The ONR Fuel Inspector concluded that NGL had developed suitable arrangements to confirm ORs and provide the assurance that identified requirements could be met.

59. In considering the impact of storing core components with fuel assemblies placed into MPCs and the effect on fuel pin cladding integrity, the ONR inspector considers NGL has carried out a suitable analysis of the risks. The main concern is potential inability to recover trapped pond cooling water within failed core components, thereby providing a source of oxygen which could result in oxidation. NGL's main justification is based on the risk of this being very small supported by good visual records of core components to confirm their integrity and only undamaged core components would be loaded into fuel elements to be placed into the MPC.

60. The ONR Fuel Inspector reviewed the indicative condition monitoring system developed by NGL to detect failure of MPC pressure boundary, the MPC Temperature Difference Monitoring System (TDMS). This showed both resourcefulness and attention to detail in driving down risk. The system monitors the temperature difference between the Top

(T_1) and bottom (T_2) of the MPC through cassette mounted thermocouples loaded through the wall of the HI-STORM.

61. NGL's Computational Fluid Dynamics (CFD) modelling of MPC internal conditions based on lead fuel elements having a surface temperature around 375°C, with the MPC's internal pressurised helium environment providing thermal convection and the MPC surface allowing heat to be dissipated. This showed that a temperature difference between T_1 and T_2 of about 15°C should be created providing the helium environment remains intact. Loss of the helium pressure due to breach in MPC pressure boundary would result in loss of internal convection and an increase in temperature difference between T_1 and T_2.

62. In a situation where a change in T_1 and T_2 values occurred, health physics monitoring of HI-STORM top vent ports would be carried out to detect the presence of radiological species. If the radiological risk is considered low, the MPC would be inspected using Eddy Current inspection equipment to detect breakthrough of the sacrificial layer.

63. The ONR Fuel Inspector considered that NGL had carried out suitable and sufficient assessment of hazards and risks posed by placing Sizewell B's spent fuel in dry storage. Adequate selection and inspection arrangements have been developed to provide a level of assurance that fuel clad would remain intact during the processing and period of storage. The Inspector's view was that there was no impact on fuel clad integrity given NGL's requirement to store core components with fuel assemblies loaded into MPCs and that NGL had taken reasonable steps to develop a method of monitoring fuel conditions within the MPC with the TDMS. The Inspector concluded that NGL had developed a suitable safety case for justifying fuel assemblies to be placed into dry storage.

4.3 ONR Fault Studies, Human Factors and Criticality Assessment Findings

64. ONR's assessment of Ref 1 against fault studies, human factors and criticality was undertaken to establish that NGL had taken reasonable steps to identify potential hazards and risks from dry fuel store activities and implement appropriate engineered and management control measures to show risks had been minimised SFAIRP.

This assessment looked to confirm the adequacy of claim 1: The design and operation of the dry fuel storage system will comply with appropriate safety assessment principles, national and international guidelines, and involved:

- ONR's Fault Studies assessment (Ref 14) focused on Sections 3 and 14 of Ref 1, General Design Aspects and Fault & Hazard Analysis Summary respectively. The assessment took an overview of fault analysis carried out by NGL then focussed on safety margins for thermal cooling faults.
- ONR's Human Factors assessment (Ref 15) focused on Sections 13 and 16 of Ref 1, Human Factors and Operational Management respectively. This assessment looked at the risks where man machine interfaces existed such as moving fuel from the fuel storage pond into the MPC using the pond fuel handling machine. This assessment was supported by a site visit to Sizewell B (Ref 20) to confirm the scope and approach of human factors assessment undertaken by NGL.
- ONR's assessment of criticality (Ref 16) considered whether appropriate safety measures and mitigation had been implemented to protect against potential criticality.

65. The ONR Fault Studies Inspector's view of NGL's approach in developing its fault schedule for dry fuel store operations was that a methodical and structured approach had been adopted. NGL introduced 2 lines of protection to provide for all frequent events and one line for infrequent events. This approach is shown in the evaluation of an MPC drop-load event, which NGL considers is an infrequent event. Fuel pin

cladding, normally claimed as providing one line of protection, has been discounted by NGL on the grounds that fuel gravitational acceleration load limits would be exceeded. The MPC pressure boundary is claimed as providing the required single line of protection for an infrequent event by containing any potential radioactive material release. The justification for this claim is based on Frazer-Nash's assessment of MPC integrity (Ref 29). As well as engineered safety measures using solid lifting strops when moving MPC to limit the height to which the MPC can be lifted off the ground to 300mm, there is increased administrative control through a Banksman in the management of lifting operations to provide warning of snagging and ledging hazards. The ONR Fault Studies Inspector considered the methodology and approach adopted by NGL complied with RGP and showed compliance with appropriate safety assessment principles.

66. The Inspector considered NGL's use of CFD modelling to develop a better understanding of thermal behaviour of MPCs containing fuel during normal and fault conditions demonstrated good practice. The approach draws on limits and conditions NGL established in their fuel assessment work and identification of DIP.

67. NGL has used Holtec's bespoke MPC CFD model which is a US nuclear industry standard and approved by the US NRC to justify thermal faults. The Holtec CFD model is based on a 3D mesh and has been developed over several years. The main drawback in using this model is that it does not replicate the Sizewell B MPC design exactly given the changes made by NGL such as dual-walled, fuel basket design, etc.

68. NGL has developed its own MPC CFD model using CONCORD computer code. The model is based on a 2D mesh to accelerate calculation time. The results from this model have been compared with Holtec's and found to show good agreement for steady state conditions to within 1°C, although variations were identified for some fault conditions with the Holtec model predicting higher temperatures. [redacted]

69. NGL has carried out further assessment of its CONCORD code and identified anomalies have been corrected resulting in closer correlation of values to the Holtec CFD model. NGL is still carrying out work in this area to better understand why differences exist between the two models and improve accuracy of their model. ONR's Fault Studies Inspector did not carry out a review of modified code. Based on initial assessment of NGL's MPC CFD modelling, the Inspector considered the approach taken demonstrated good practice.

70. The CFD models have also been used to predict when MPC surface temperatures would start to fall below 60°C, resulting in an increased risk of SCC given the 100 year storage period. The NGL CONCORD model has shown that by controlling air flow through HI-STORM the MPC surface temperatures can be maintained at a higher temperature for a longer duration which will extend the period before there is a potential risk of SCC starting.

71. The ONR Fault Studies Inspector's evaluation of NGL's assessment of loss of the MPC Cooling System (MPCCS) during the lid to shell welding operation found that the NGL calculated period of over [redacted] before water within the MPC would start to boil was reasonable. This view was based on a level of conservatism built into the prediction with the MPC containing a thermal load of 26kW and the temperature of the pond water within the MPC set at 60°C.

72. In a case of failure of MPCCS and helium drying system due to loss of electrical power supply, NGL has argued that PCT limits of 490°C would not be exceeded within the MPC and would remain around 375°C providing sufficient helium gas pressure was present within the MPC. NGL have stated that an MPC can be filled with helium without electrical supplies being available and that a mission time of [redacted] has been identified

for this task. Again, the ONR Fault Studies Inspector considered NGL has adopted a reasonable approach based on conservatisms in thermal analysis and time needed to re-establish MPCCS or re-flood MPC.

73. The ONR Fault Studies Inspector raised the following requirement prior to active commissioning:

5	That the ONR SZB DFS Project Inspector should monitor commissioning of TDMS and confirm values recorded to those predicted by NGL's MPC CFD model.

74. In looking at other fault scenarios, including potential miss-loading of MPC with higher thermal output fuel, the ONR Human Factors Inspector concluded that NGL had carried out an adequate assessment of hazards and risks due to man-machine interfaces. The Inspector did challenge NGL on the use of lower than expected initiating fault frequencies in this assessment. However, based on NGL's arguments that activities to be carried out were already standard practice and that NGL was able to show that appropriate reliability values could be demonstrated, the Inspector was broadly satisfied with the safety claims presented by NGL. The Inspector suggested introducing additional engineered controls may have strengthen the case being made by NGL, but supported NGL's view that this was not ALARP as increased complexity was being introduced.

75. The ONR Human Factors Inspector raised the following requirement prior to active commissioning:

6	That the ONR SZB DFS Project Inspector monitor NGL's Human Factors Implementation Plan to ensure adequate closure of Human Factors Operational Commitments for SS1 Rev 1 and SS5. OC 1643.13-1 Ensure the assumptions underpinning the DFS Human Reliability Assessments are validated during commissioning activities to substantiate the Human Error Probabilities that have been derived. OC 1643.13-3 To enable the DFS Human Factors assessments to remain valid, ensure the items outlined in Table 13.4 of EC338898 are incorporated within the operational regime of the Dry Fuel Store prior to commencement of Active System Commissioning.

76. ONR's review of NGL's criticality assessment (Ref 13) concluded this was suitable in covering dry fuel store operations including fault scenarios where fuel configuration could occur due to drop-load and/or topple events. NGL evaluation was found to be thorough and robust with adequate criticality safety margins. The ONR Criticality Inspector noted that NGL had specified increased neutron and gamma shielding materials be installed for Sizewell B MPC and HI-TRAC compared to that normally installed by Holtec in their standard MPC and HI-TRAC design.

4.4 ONR Radiological Protection Findings

77. The ONR's Radiological Protection Inspector's assessment (Ref 17) focused on Section 12 of Ref 1 Radiological Protection, focusing on establishing:

- Public dose limit from normal operation shall not exceed <20 microSv/yr;
- Engineering controls provide adequate protection to workers and are ALARP;
- Radiological consequences of dry storage events meet targets and are ALARP.

This assessment addressed claim 6: the radiological risks to operators and members of the public are ALARP.

78. The ONR Radiological Protection Inspector visited the Sizewell B site (Ref 19) to review NGL's evaluation of dose assessments of target groups as well as radiological work procedures for activities undertaken during dry fuel processing and storage.

79. In the case of radiological exposure to the public at the site boundary, NGL have identified the target group as office workers located 20m away from the Dry Fuel Store building on the Sizewell A Nuclear Licenced Site. The ONR Radiological Protection Inspector considered that NGL's approach in evaluating radiological exposure is balanced in that it is conservative based in assuming all 160 MPC storage locations are filled. As well as taking into account increased shielding requirements specified by NGL for HI-STORM's, NGL has raised Operational Commitments OC 1643.12-1 and 1643.12-2 to monitor radiological exposure during the dry fuel store processing campaign and when material is placed into store. This ensures actual radiological exposure values are no greater than those calculated. The ONR Inspector considered the public dose limit of 20 microSv/yr can be met. NGL have indicated that additional shielding can be added if the dose limit is challenged by monitoring results.

80. The ONR Inspector evaluated engineering controls for the protection to workers during the dry fuel store processing campaign, covering: MPC lid to shell welding; transport of MPC from Fuel Building to Dry Fuel Storage; and handling operations within Dry Fuel Store. The inspector has recommended that an inspection be carried out during active commissioning to confirm adequate implementation of engineering controls given that this is a new process and the benefit of increased vigilance.

81. Evaluation of radiological consequences from events from dry fuel store operations are considered to meet Basic Safety Objectives (BSO) targets 6, 7 and 8 for the facility and Basic Safety Limit (BSL) for overall Site risks targets 4, 5 and 6 based on evaluation of Ref 1 Section 14: Fault Studies & Hazard Analysis Summary.

82. The ONR Radiological Protection Inspector raised the following requirement:

7	ONR should carry out a radiological protection compliance inspection during active commissioning of dry fuel store processing and storage to monitor the effectiveness of engineered radiological protection measures and procedures.

4.5 ONR Radioactive Waste and Decommissioning Assessment Findings

83. The ONR Radioactive Waste and Decommissioning Inspector's assessment (Ref 18) focused on Section 11 and 19 of Ref 1, Radiological Waste Considerations and Decommissioning . The assessment looked to establish that NGL had taken reasonable steps to:

- Minimise Radioactive Waste arising during dry fuel store processing, storage and its management in final disposal;
- Put adequate arrangements in place for management of radioactive waste during the lifetime of the dry fuel store and final disposal.

84. All intact spent fuel from Sizewell B will be placed into dry store. This fuel will not be classified as waste given that it has an economic value if reprocessed, with the possibility to reuse most of the uranium. All reactor core components to be stored with the fuel placed in dry storage are classified as waste based on the fact that the core components have delivered their operational commitment and are unable to be reused so have no economic value.

85. This ONR assessment addressed the adequacy of

- Claim 5: The dry fuel storage facilities will be safely decommissioned.

86. Based on assessment of arguments presented by NGL in Ref 1 and evidence collected from the joint ONR and Environment Agency (EA) site visit to Sizewell B (Ref 21), the Inspector came to the following opinions.

87. It is considered that the approach NGL has adopted in placing spent nuclear fuel from Sizewell B into MPC does not comply with current guidance issued by the Radioactive Waste Management Limited (RWM). RWM is part of the Nuclear Decommissioning Authority (NDA) and will be responsible for managing the UK underground radiological repository. The Inspector's view is based on the fact that fuel placed in MPC cannot be directly disposed of as an MPC is not considered suitable as transport or final disposal container. NGL has stated that a further facility will be constructed at Sizewell prior to decommissioning of Sizewell B, the Dry Fuel Repackaging Plant (DFRP), to allow fuel to be placed into suitable transport containers for despatch from Sizewell for either final disposal or reprocessing whichever the UK Government considers appropriate at the time of construction.

88. In considering this position the Inspector was of the view that NGL had adopted the most ALARP solution given the range of factors NGL faces with Sizewell B having to stop generating if fuel was not removed from its storage pond. MPC storage provides a safe interim radioactive waste management solution allowing time for the UK Radiological Disposal Facility to be constructed and start operation. It will also allow RWM guidance on spent fuel packaging to be developed for underground disposal.

89. NGL has suitable radioactive waste management arrangements in place for the processing and storage of fuel to be placed in dry storage. This view is based on the fact that little radioactive waste would be generated during these activities. NGL had developed a suitable document management system to record information on fuel and core components placed in dry storage for subsequent repackaging and disposal. The Inspector confirmed that RWM was aware of NGL's decision to place core components with fuel into dry storage (**Ref 33)** and that NGL was of the view that both fuel and core components could be disposed of together. NGL consider the increase in volume of radioactive waste from core components to be small. This issue arises due to RWM only issuing a pre-conceptual Letter of Compliance (LoC) in 2011 and the Inspector being of the opinion that limited discussion between NGL and RWM had taken place on this subject.

90. The Inspector considered whether further regulatory monitoring of NGL's management of core component was appropriate. At the Sizewell B Core Components Stakeholder workshop (**Ref 34)** Option 1a: storage of core components with irradiated fuel elements was identified as the most ALARP solution. NGL confirm that it would update Section 11 Radioactive Waste of Ref 1 setting out their ALARP case for this decision. Based on this outcome it was considered that no further regulatory monitoring was necessary as this matter is being addressed through routine business in ONR's compliance inspection programme for radioactive waste.

91. In the case of NGL's ability to demonstrate adequate management of radioactive waste during the lifetime of the dry fuel store and final disposal / decommissioning, the Inspector took the view that NGL had produced an adequate Higher Activity Waste (HAW) Management Case. This was based on advice provided by EA's Nuclear Waste Assessment Team who assessed the case. The purpose of the HAW Management Case was to provide a transparent and informative commentary of how the duty-holder complies with regulatory requirements given national and international radioactive waste management policy and standards. This coordinates the inter-dependency of how radioactive waste is generated, conditioned, stored, managed and finally disposed of to minimise the need for re-work which could impact on safety, health and environment.

92. The Inspector challenged the level of detail NGL presented in the HAW Management Case on the qualities of material to be classified as intermediate and low level waste through disposal of MPCs and shielding components such as HI-STORMs. NGL

responded that values were based on work Holtec had undertaken and that these values would be refined through collaborative work programmes between NGL and Holtec.

93. The Inspector also challenged NGL's strategy for maintaining an available cooling pond facility to manage inspection / leaking MPC's based on Sizewell B Power Station entering decommissioning circa 2035 with the Dry Fuel Store facility remaining operational until 2116. NGL indicated that the cooling pond facility could be decommissioned providing an adequate safety case could be made. The DFRP would contain a pond facility and would be available before the Station's cooling pond was taken out of service. The construction and permissioning of the DFRP is identified in the Station's long-term plans which are reviewed by ONR.

4.6 Closure of Outstanding ONR Issues

94. Following NGL's planning application to DECC for construction and operation of Dry Fuel Store facility, DECC requested that ONR provide a regulatory view on the adequacy of the case presented by NGL (Ref 7). ONR's letter **(Ref 35**) confirmed that ONR had not identified any issues preventing DECC giving its consent to NGL's planning application, but drew DECC's attention to the following outstanding issues:

a) ONR considered NGL should provide evidence that radiation dose to personnel on the adjacent Sizewell A Site has been assessed and demonstrated as ALARP.

   This matter was addressed in section 4.4 of this report and is considered closed.

b) ONR considered NGL should continue to work with the relevant government agencies in the development of a final disposal strategy.

   This matter is considered closed in that NGL is in dialogue with RWM, EA and ONR on a range of issues dealing with final disposal covering fuel and decommissioning of its nuclear reactor power stations fleet.

c) [redacted]

   [redacted]

4.7 Communication within ONR and other UK Governmental Organisations

95. Internal discussions have also taken place within ONR on the assessment of Ref 1 in respect to security **(Ref 37)** and safeguards **(Ref 38)**. This report has been shared with the responsible Inspectors with no issues raised to challenge it being issued.

96. Throughout ONR's assessment of Ref 1, interactions with other UK Governmental organisations have taken place. This has been with the EA and with RWM. A final draft copy of this report was shared with EA Sizewell B Site Inspector for comments. EA's Response **(Ref 39)** confirmed they did not have any comments to raise against this report and was content for it to be issued.

5 CONCLUSIONS

97. Based on views presented by Inspectors from their assessment reports of Ref 1 together with my own evaluation of Ref 1 I consider that NGL has produced an adequate Safety Case for post operational dry fuel storage activities. This view takes into account that NGL has undertaken a suitable and sufficient review of Holtec's spent fuel storage system design and process. The outcome of this was the identification of improvements to reduce nuclear risks and improve system reliability. This was demonstrated in NGL requesting higher grade stainless steel for manufacture of Sizewell B MPC compared to that normally used to protect against SCC, design improvements to the actual MPC in dual-walled construction and development of an MPC cooling system to provide the time needed to carry out lid to shell welding.

98. In addition, I consider that NGL has increased confidence in weld integrity by the development of ultrasonic inspection equipment for the lid to shell weld. Furthermore, the Eddy Current surface examination equipment to identify defects in MPC walls improves the indication of presence of SCC. Other improvements are TDMS to establish pseudo fuel operating temperatures and loss of containment from MPCs.

99. The ONR assessment team considers an adequate assessment of hazards and risks from dry fuel store operations has been undertaken. A number of issues were raised with NGL over claims and arguments presented in Ref 1. Most of these issues have been addressed although a small number are still outstanding and have been captured as requirements. These will be progressed by the ONR Sizewell Dry Fuel Store Project Inspector and closed out as part of regulatory activities in supporting issuing ONR's consent to allow Sizewell B to move into active commissioning for dry fuel store processing and storage.

100. As stated in paragraph 13 of this report NGL INA department has only issued an interim INSA certificate (Ref 5) for Ref 1. This was on the grounds that, although INSA comments raised had been addressed in principle, the evidence to allow these findings to be closed had not been provided. As such, NGL intend to resubmit Ref 1 to ONR at version 5 with modified text. ONR has monitored the closure of INSA comments through Level 4 project meetings. The ONR Project Inspector will carry out a review of Ref 1 version 5 to confirm that ONR is content that INSA comments and ONR requirements have been addressed. This will be reported in the PAR supporting ONR consent to allow Sizewell B to move into active commissioning of dry fuel store processing and storage.

6 RECOMMENDATIONS

101. It is As a result of changes to the required permissioning arrangements for the Sizewell B dry fuel store, there is no longer a requirement for this PAR to support a Licence Instrument. It should be published as a record of the assessment work undertaken and ONR's view that NGL has produced an adequate post operational safety case in compliance with LC23(1) for dry fuel processing and storage operation and identification appropriate conditions and limits in the interests of safety. This PAR will be used as supporting evidence for the subsequent permissioning of active commissioning of the dry fuel store.

7 REQUIREMENTS FROM ONR'S ASSESSMENTS

102. The following actions and requirements have been identified from ONR's assessment of Ref 1. Evidence to demonstrate that these requirements have been addressed will be presented in ONR's PAR justifying consent to allow Sizewell B to move into active commissioning of dry fuel processing and storage

- NGL to submit to ONR the Sizewell B Dry Fuel Store Post Operational Safety Case, NP/SC 7575, EC 338898, Stage Submission 1, Revision 1 Version 5.

- NGL to submit to ONR the full INSA certificate for the Sizewell B Dry Fuel Store Post Operational Safety Case, NP/SC 7575, EC 338898, Stage Submission 1, Revision 1 Version 5.

1	That the ONR Sizewell B Dry Fuel Store (SZB DFS) Project Inspector obtains assurance from NGL that any issues relating to the use of imperial components are identified and managed. This will include, from Structural Integrity, control of welding consumables, control of fittings and attention to through-life monitoring.
2	That the ONR SZB DFS Project Inspector obtains confirmation from NGL that all INA comments from Section 5 Ref 1 have been satisfactorily closed out before active commissioning commences.
3	That the ONR SZB DFS Project Inspector ensures that a complete and suitable non-conformance and concession report is obtained for all nuclear safety significant equipment before active commissioning commences.
4	That the ONR SZB DFS Project Inspector ensures that Operational Commitment (OC) 1643.10-04 (adequate technical justification is provided for the MPC LTS Weld UT Inspection System) is complete before active commissioning commences.
5	That the ONR SZB DFS Project Inspector monitors commissioning of TDMS to confirm values recorded to those predicted by NGL's MPC CFD model.
6	That the ONR SZB DFS Project Inspector monitor NGL's Human Factors Implementation Plan to ensure adequate closure of Human Factors Operational Commitments for SS1 Rev 1 and SS5. OC 1643.13-1 Ensure the assumptions underpinning the DFS Human Reliability Assessments are validated during commissioning activities to substantiate the Human Error Probabilities that have been derived. OC 1643.13-3 To enable the DFS Human Factors assessments to remain valid, ensure the items outlined in Table 13.4 of EC338898 are incorporated within the operational regime of the Dry Fuel Store prior to commencement of Active System Commissioning.
7	ONR to carry out radiological protection compliance inspection during active commissioning of dry fuel store processing and storage to monitor effectiveness of engineered radiological protection measures and procedures.

8 REFERENCES

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2. Sizewell B Power Station letter Unique Number NSL SZB 50834N dates 30 September 2016, ONR TRIM Ref 2016/382496.
3. Sizewell B's Nuclear Safety Operational Review Committee minutes from meeting 582 held 2 September 2015, ONR TRIM Ref 2015/388707
4. NGL's Nuclear Safety Committee minutes from meeting 10/15 held 8 October 2015, ONR TRIM Ref 2015/394234
5. NGL Independent Nuclear Safety Assessment interim certificate, ONR TRIM Ref 2015/89495
6. NGL Dry Fuel Storage Paper of Principle NP/SC 7575, Engineering Change 334648 December 2009 ONR TRIM Ref 2010/749
7. Letter from Department of Energy and Climate Change dated 5 March 2010 requesting ONR's views on Planning Application under Section 36 of the Electricity Act for construction and operation dry fuel store TRIM Ref 2010/134566.
8. ONR Project Assessment Report, ND Division 1 Report No 2010/29 ONR TRIM Ref 2010/197487
9. Sizewell B Dry Fuel Store Pre Construction Safety Case NP/SC 7575 EC 338898 Stage Submission 1 Revision 0 ONR TRIM Ref 2012/496728
10. ONR Project Assessment Report, ONR-SZB-PAR-13-020 ONR TRIM Ref 2013/238321
11. ONR Assessment strategy for evaluation of safety arguments presented in Post Operational Safety Case NP/SC 7575 EC 338898 Stage Submission 1 Revision 1 TRIM Ref 2015/59515
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19. ONR Intervention Record ONR-SZB-IR-15-047 ONR TRIM Ref 2015/248210
20. ONR Intervention Record ONR-SZB-IR-15-054 ONR TRIM Ref 2015/275820
21. ONR Intervention Record ONR-SZB-IR-15-112 ONR TRIM Ref 2015/418260
22. ONR Letter dated 13 May 2010 providing regulatory views on Planning Application under Section 36 of the Electricity Act for construction and operation dry fuel store ONR TRIM Ref 2010/202537
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26. International Atomic Energy Agency Optimization Strategies for Cask Design and Container Loading in Long Term Spent Fuel Storage TECDOC-1523

27. WENRA, Working Group on Waste and Decommissioning (WGWD), WENRA Waste and Spent Fuel Storage Safety Reference Levels report, version 2.1, February 2011, www.wenra.org/dynamaster/file_archive/110222/ba5ff4eafa671dc6cbf738482fb4bfe5/WGWD_V2-1Waste-and-spent-fuel-storage-safety-reference-levels.pdf

28. ONR Structural Integrity File Note visit Holtec International US Manufacturing Facility Trim Ref 2016/50572

29. Frazer-Nash Consultancy Ltd, Dry-Store Structural Integrity Analysis Summary for the MPC, HI-TRAC & HI-STORM Report Ref FNC 43488-001/40105R Issue 3 December 2015, ONR TRIM Ref 2016/166202

30. NGL Engineering Advice Note Sizewell B Dry Fuel Store: Summary Note Justifying the Hoop Stress Limit for DC 300, Document Ref E/EAN/BCBB/0057/SZB/16 issued February 2016, ONR TRIM Ref 2016/0092019.

31. ONR File Note Sizewell B Dry Fuel Storage Safety Case M5 Clad Fuel Performance Given Impact of Hydride Re-Orientation, ONR TRIM Ref 2016/107618.

32. Not Used (Information withdrawn)

33. Email 24/07/2015 from M Cairns RWM to H Milburn ONR, RWM response to NGL dry store – ONR TRIM Ref. 2015/278559

34. ONR Contact Record CNRP-CR-15-268, issued 10 December 2015, ONR TRIM Ref 2015/468987

35. ONR letter to Department of Energy and Climate Change Titled Electricity Act 1989, Section 36 Application for Consent to Construct and Operate Dry Fuel Store at Sizewell B dated 13 May 2010, ONR TRIM Ref 2010,202537.

[redacted]

37. ONR email from Security Inspector confirming no objection to ONR's assessment of Assessment of Sizewell B Dry Fuel Store Post Operational Safety Case, Stage Submission 1 Revision 1, NP/SC 7575, EC 338898-1 TRIM Ref 2016/315421

38. ONR email from Safeguards Inspector confirming no objection to ONR's assessment of Assessment of Sizewell B Dry Fuel Store Post Operational Safety Case, Stage Submission 1 Revision 1, NP/SC 7575, EC 338898-1 TRIM Ref 2016/315638

39. Environment Agency (EA) email confirming no objection to ONR issuing Project Assessment Report form assessment of Sizewell B Dry Fuel Store Post Operational Safety Case, Stage Submission 1 Revision 1, NP/SC 7575, EC 338898-1 TRIM Ref 2016/342816

APPENDIX 1 History of Sizewell B Dry Fuel Store

1. ONR has monitored Sizewell B's management of spent fuel inventory from Station's commencement of power generation 1995. This has involved re-racking of fuel elements within its cooling pond to increase fuel element packing density and the number of locations able to be filled with fuel assemblies.

2. Given the developing situation of reducing fuel element storage capacity in the cooling pond NGL presented its strategy for management of spent fuel over the station lifetime in 2007 Nuclear Safety Committee Paper NP/SC 7514 (TRIM Ref 2008/2296). The paper was shared with ONR and EA with consideration of the following factors:

   - Limited oxide fuel reprocessing capability both within the UK and worldwide;
   - Technical challenges with extending existing wet storage facility;
   - The establishment of a UK underground radiological waste repository;
   - Alternative fuel storage systems.

3. Optioneering studies (TRIM Refs 2010/130132 and 2010/1155) focused on identifying the most suitable solution based on Best Practicable Environmental Options (BPEO) and As Low As Reasonable Practicable (ALARP) principles. Options considered were:

   - Reprocessing of fuel in the UK, France or elsewhere in the world;
   - Extending existing wet fuel Storage (new pond at Sizewell B or elsewhere);
   - Dry fuel storage in containers on the Sizewell B site;
   - Dry fuel storage in modular vault on the Sizewell B site.

4. NGL identified container dry fuel storage on the Sizewell B site as the safest and most environmentally acceptable solution. Further optioneering (TRIM Refs 2010/586595) was undertaken on commercially available dry fuel storage systems with 4 vendor designs evaluated. This led to Holtec International system being identified as the preferred supplier. Holtec International is an American company with extensive knowledge and experience in wet and dry fuel storage. Their dry fuel storage is licensed by the United States Nuclear Regulatory Commission (USNRC) and is operated in the US by several nuclear power operators as well as internationally with operations in Sweden, Belgium and China.

5. NGL applied for permission from the Secretary of State for the Department of Energy and Climate Change (DECC) under Section 36 of the Electricity Act 1989 for the construction and operation of a Dry Fuel Store (TRIM Ref 2010/115027).

6. ONR is a consultee under this process. DECC requested comments from ONR on NGL's planning application (TRIM Ref 2010/134566). ONR Project Assessment Report (TRIM Ref 2010/197487) sets out regulatory view on NGL's optioneering and justification. ONR concluded that there were no substantive reasons why DECC could not grant planning approval to NGL for construction and operation of dry fuel storage facility on the Sizewell B Nuclear Licenced Site ONR letter dated 13 May 2010 (TRIM Ref 2010/202537). This letter identified three areas requiring further assessment:

   - The development of adequate safety case(s) covering dry fuel store construction, operations and decommissioning.
   - Provision of evidence to show radiation doses to personnel on the adjacent Sizewell A site have been assessed and demonstrated to be As Low As Reasonably Practicable (ALARP).
   - [redacted]

APPENDIX 2 ONR'S Permissioning of Dry Fuel Store Project

1. NGL development of dry fuel processing and storage on the Sizewell B Nuclear Licenced Site has resulted in the production of a new safety case NP/SC 7575 for dry fuel processing and storage as well as modification of existing plant and equipment. The main activities ONR has permissioned in support of dry fuel processing and storage activities are detailed in Table 1 below with those still outstanding shown in RED TEXT.

A2 Table 1 Main ONR Sizewell B Dry Fuel Store Permissioning Activities

Dry Fuel Store Operational Safety Case	Supporting Safety Cases	ONR Permissioning
NP/SC 7575 Stage Submission (SS) 1 Rev 0 Pre-Construction Safety Case EC 338898 TRIM Ref 2012/496728 Category 1 Safety Case		No Licence Instrument issued ONR formal assessed undertaken TRIM Ref 2013/238321
	Stage Submission 2 Construction of Dry Fuel Store Building EC 338897 Rev 0 TRIM Ref 2014/60562 Category 2 Safety Case	**Licence Instrument 533** Agreement to commence construction of Fuel Building Issued against LC19(1) ONR PAR TRIM Ref 2014/188731
	Stage Submission 3 Modification of Fuel Building Crane EC 340194 rev 001 TRIM Ref 2014/216548 Category 2 Safety Case	**Licence Instrument 542** Agreement to modify Fuel Building Crane Issued against LC22(1) ONR PAR TRIM Ref 2014/112914
	Stage Submission 4 Inactive Testing and Commissioning EC 338509 TRIM Ref 2014/472146 Category 2 Safety Case	No Licence Instrument issued ONR reviewed case but did not permission it
NP/SC 7575 SS 1 Rev 1 Pre Operational Safety EC 338898 TRIM Folder 4.4.2.16691. Category 1 Safety Case		No Licence Instrument ONR modified its approach in regulating new and amended Operating Rules removing the need to Approve. ONR assessed case to confirm compliance with LC23(1) and issued PAR TRIM Ref 2016/294694
	Stage Submission 5 Inactive Testing and Commissioning safety report EC 353982 TRIM Ref 2016/XXXXXX Category 1 Safety Case	**ONR Specified under LC21(4) issuing LI 531 requiring NGL to seek ONR's Consent before commencing active commissioning** Specification Issued against LC21(4) ONR PAR TRIM Ref 2012/363755 Licence Instrument XXX Consent to commence Active Commissioning Issued against LC21(4) ONR PAR TRIM Ref 2015/XXXXXX
NP/SC 7575 SS 1 Rev 2 Operational Safety EC 338898 TRIM Folder X.X.X.XXXX. Category 1 Safety Case		Licence Instrument XXX Agreement of Dry Fuel Store Safety Case Issued against LC23(1) ONR PAR TRIM Ref 2015/XXXXXX

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