Office for Nuclear Regulation

New Reactors Division – Generic Design Assessment

Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor

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EXECUTIVE SUMMARY

This report presents the findings of my assessment of radioactive waste management aspects of the generic UK HPR1000 design undertaken as part of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA). My assessment was carried out using the Pre-Construction Safety Report (PCSR) and supporting documentation submitted by the Requesting Party (RP).

The objective of my assessment was to make a judgement, from a radioactive waste management perspective, on whether the generic UK HPR1000 design could be built and operated in Great Britain, in a way that is acceptably safe and secure (subject to site specific assessment and licensing), as an input into ONR's overall decision on whether to grant a Design Acceptance Confirmation (DAC).

The scope of my GDA assessment was to review the safety aspects of the generic UK HPR1000 design by examining the claims, arguments and supporting evidence in the safety case. My GDA Step 4 assessment built upon the work undertaken in GDA Steps 2 and 3, and enabled a judgement to be made on the adequacy of the radioactive waste management information contained within the PCSR and supporting documentation.

My assessment for the radioactive waste management topic focussed on the following aspects of the generic UK HPR1000 safety case:

- Radioactive waste inventory
- Radioactive waste management strategies
- In-Core Instrument Assemblies (ICIAs) management strategy
- ICIA Winding operations safety case
- Radioactive waste treatment systems
- Interim storage of Intermediate Level Waste (ILW)
- Demonstration that the risks of radioactive waste management systems are reduced to As Low As Reasonably Practicable (ALARP).

The conclusions from my assessment are:

- The radioactive waste inventory appears to be complete and is consistent with operational experience (OPEX) on waste inventories generated from the operation of similar reactor technologies worldwide.
- The radioactive waste management strategies are consistent with UK policy and practices and takes due account of the lifecycle of radioactive wastes from generation to disposal.
- The RP has identified and made effective use of national and international Relevant Good Practice (RGP) and OPEX in radioactive waste management.
- The RP has provided adequate evidence to demonstrate minimisation of the generation and accumulation of radioactive waste.
- The RP's safety case provides adequate evidence that it has considered the full range of options in developing the management strategy for ICIAs and the RP is proposing winding operations to retrieve waste ICIAs. Winding is identified as novel in the UK.
- The RP has presented a conceptual design for the storage of ILW and the ILW Interim Storage Facility (ISF). The design is consistent with RGP and OPEX, with clear assumptions and requirements including aspects relevant to the Structures, Systems and Components (SSCs), to aid the future site-specific detailed design.
- The RP has provided adequate evidence to demonstrate that the risks associated with radioactive waste management are reduced to ALARP, with the exception of a small number of specified sub-systems in the Solid Waste

Management System (TES[SWTS]), for which Assessment Findings have been identified.

These conclusions are based upon the following factors:

- A detailed and in-depth technical assessment, on a sampling basis, of the full scope of safety submissions at all levels of the hierarchy of the generic UK HPR1000 safety case documentation.
- Independent reviews and analysis of key aspects of the generic safety case for the radioactive waste treatment systems undertaken by a Technical Support Contractor (TSC).
- Detailed technical interactions with the RP during the GDA process, in addition to assessment of the responses to the Regulatory Queries (RQs) and Regulatory Observations (ROs) which I raised during my assessment.

A number of matters remain, which I judge are appropriate for a licensee to consider and take forward in its site-specific safety submissions. These matters do not undermine the generic UK HPR1000 design and safety submissions, but are primarily concerned with the provision of site-specific safety case evidence which will become available as the project progresses through the detailed design, construction and commissioning stages. These matters have been captured in eight Assessment Findings.

Overall, based on my assessment undertaken in accordance with ONR's procedures, the claims, arguments and evidence laid down within the PCSR and supporting documentation submitted as part of the GDA process present an adequate safety case for the generic UK HPR1000 design. I recommend that from a radioactive waste management perspective a DAC may be granted.

LIST OF ABBREVIATIONS

AiP	Agreement in Principle
ALARP	As Low As Reasonably Practicable
APG [SGBS]	Steam Generator Blowdown System
BAT	Best Available Techniques
BFX	Fuel Building
BMS	How2 Business Management System
BNX	Nuclear Auxiliary Building
BQA	Nuclear Island Liquid Waste Storage Tank Building
BQS	Waste Auxiliary Building
BRX	Reactor Building
BSL	Basic Safety Level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
BSX	Safeguards Building
BWX	Radioactive Waste Treatment Building
C & S	Concentrates and sludges
CCTV	Close Circuit Television
CGN	China General Nuclear Power Corporation Ltd
DAC	Design Acceptance Confirmation
DAW	Dry Active Waste
DBA	Design Basis Analysis
DBC	Design Basis Condition
DWN [NABVS]	Nuclear Auxiliary Building Ventilation System
EIMT	Examination, Inspection, Maintenance and Testing
EPRI	Electric Power Research Institute
ERICP	Eliminate, Reduce, Isolate, Contain and Protect (risk management hierarchy)
FCG3	Fangchenggang Unit 3
FCRD	Filter Cartridge Replacement Device
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GNI	General Nuclear International Ltd.
GNSL	General Nuclear System Ltd.
HAW	Higher Activity (Radioactive) Waste
HEPA	High Efficiency Particulate (in) Air
HLW	High-Level Waste
HOW2	(ONR) Business Management System
HVAC	Heating, Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency

ICIA	In-Core Instrumentation Assembly
ILW	Intermediate Level Waste
IRWST	In-Containment Refuelling Water Storage Tank
ISF	Interim Storage Facility
IWS	Integrated Waste Strategy
LAW	Lower Activity Waste
LoC	Letter of Compliance
LLW	Low Level Waste
LLWR	Low Level Waste Repository
NC	Non-classified
NEA	Nuclear Energy Agency (within OECD)
NFCC	Non-Fuel Core Component
NLR	Nuclear Liabilities Regulation
NNSA	National Nuclear Safety Administration (China)
NPP	Nuclear Power Plant
OECD	Organisation for Economic Cooperation and Development
OLC	Operating Limit and Condition
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PCER	Pre-construction Environmental Report
PCSR	Pre-construction Safety Report
PIE	Postulated Initiating Event
PSA	Probabilistic Safety Analysis
PSSR	Pressure System Safety Regulations 2000
PTR [FPCTS]	Fuel Pool Cooling and Treatment System
PWR	Pressurised Water Reactor
RCCA	Rod Cluster Control Assembly
RCP	Reactor Coolant Pumps
RCV [CVCS]	Chemical Volume and Control System
REPPIR	The Radiation (Emergency Preparedness and Public Information) Regulations 2019
RGP	Relevant Good Practice
RIS [SIS]	Safety Injection System
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
RPE [VDS]	Nuclear Island Vent and Drain System
RPV	Reactor Pressure Vessel
RQ	Regulatory Query

RWM	Radioactive Waste Management Limited
RWMC	Radioactive Waste Management Case
SAP(s)	Safety Assessment Principle(s)
SCCA	Stationary Core Control Assembly
SDM	System Design Manual
SEL [LWDS(CI)]	Conventional Island Liquid Waste Discharge System
SFA	Spent Fuel Assembly
SFC	Spent Filter Cartridge
SFAIRP	So Far As Is Reasonably Practicable
SFCCM	Spent Filter Cartridge Change Machine
SFIS	Spent Fuel Interim Storage
SFP	Spent Fuel Pool
SFRTD	Spent Filter Replacement and Transfer Device
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SoDA	(Environment Agency's) Statement of Design Acceptability
SRE [SRS]	Sewage Recovery System
SSC	Structures, Systems and Components
TAG	Technical Assessment Guide(s)
TEG [GWTS]	Gaseous Waste Treatment System
TEP [CSTS]	Coolant Storage and Treatment System
TER [NLWDS]	Nuclear Island Liquid Waste Discharge System
TES [SWTS]	Solid Waste Treatment System
TEU [LWTS]	Liquid Waste Treatment System
TSC	Technical Support Contractor
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria
WSW	Wet-solid Waste
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1.1 Background

1. This report presents my assessment conducted as part of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) for the generic UK HPR1000 design within the topic of nuclear liabilities regulation, focusing on radioactive waste management.

2. The UK HPR1000 is a pressurised water reactor (PWR) design proposed for deployment in the UK. General Nuclear System Ltd (GNSL) is a UK-registered company that was established to implement the GDA on the UK HPR1000 design on behalf of three joint requesting parties (RP), i.e. China General Nuclear Power Corporation (CGN), EDF SA and General Nuclear International Ltd (GNI).

3. GDA is a process undertaken jointly by the ONR and the Environment Agency. Information on the GDA process is provided in a series of documents published on the joint regulators' website (www.onr.org.uk/new-reactors/index.htm). The outcome from the GDA process sought by the RP is a Design Acceptance Confirmation (DAC) from ONR and a Statement of Design Acceptability (SoDA) from the Environment Agency.

4. The GDA for the generic UK HPR1000 design followed a step-wise approach in a claims-argument-evidence hierarchy which commenced in 2017. Major technical interactions started in Step 2 which focussed on an examination of the main claims made by the RP for the UK HPR1000. In Step 3, the arguments which underpin those claims were examined. The Step 2 reports for individual technical areas, and the summary reports for Steps 2 and 3 are published on the joint regulators' website. The objective of Step 4 was to complete an in-depth assessment of the evidence presented by the RP to support and form the basis of the safety and security cases.

5. The full range of items that form part of my assessment is provided in 'ONR's GDA Guidance to Requesting Parties' (Ref. 1). These include:

- Consideration of issues identified during the earlier Step 2 and 3 assessments.
- Judging the design against the Safety Assessment Principles (SAPs) (Ref. 2) and whether the proposed design ensures risks are As Low As Reasonably Practicable (ALARP).
- Establishing whether the system performance, safety classification, and reliability requirements are substantiated by a more detailed engineering design.
- Assessing arrangements for ensuring and assuring that safety claims and assumptions will be realised in the final as-built design.
- Resolution of identified nuclear safety issues or identifying paths for resolution.

6. The purpose of this report is therefore to summarise my assessment in the radioactive waste management topic which provides an input to the ONR decision on whether to grant a DAC, or otherwise. This assessment was focused on the submissions made by the RP throughout GDA, including those provided in response to the Regulatory Queries (RQs) and Regulatory Observations (ROs) I raised. Any ROs issued to the RP are published on the GDA's joint regulators' website, together with the corresponding resolution plans.

1.2 Scope of this Report

7. This report presents the findings of my assessment of the radioactive waste management topic of the generic UK HPR1000 design undertaken as part of GDA. I carried out my assessment using the Pre-Construction Safety Report (PCSR) (Ref. 3) (Ref. 4) and supporting documentation submitted by the RP. My assessment was

focussed on considering whether the generic safety case provides an adequate justification for the generic UK HPR1000 design, in line with the objectives for GDA.

1.3 Methodology

8. The methodology for my assessment follows ONR's guidance on the mechanics of assessment, NS-TAST-GD-096 (Ref. 5).

9. My assessment was undertaken in accordance with the requirements of ONR 's How2 Business Management System (BMS). ONR's SAPs (Ref. 2) together with supporting Technical Assessment Guides (TAGs) (Ref. 6, Ref. 7, Ref. 8), were used as the basis for my assessment. Further details are provided in section 2. The outputs from my assessment are consistent with ONR's GDA Guidance to RPs (Ref. 1).

2 ASSESSMENT STRATEGY

10. The strategy for my assessment of the radioactive waste management aspects of the UK HPR1000 design and safety case is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been applied.

2.1 Assessment Scope

11. A detailed description of my approach to this assessment can be found in assessment plan ONR-GDA-UKHPR1000-AP-19-007 Rev 0 (Ref. 9).

12. I considered all of the main submissions within the remit of my assessment scope, to various degrees of breadth and depth. I chose to concentrate my assessment on those aspects that I judged to have the greatest safety significance, or where the hazards appeared least well controlled. My assessment was also influenced by the claims made by the RP, my previous experience of similar systems for reactors and other nuclear facilities, and any identified gaps in the original submissions made by the RP. A particular focus of my assessment has been the RQs and ROs I raised as a result of my on-going assessment, and the resolution thereof.

2.2 Sampling Strategy

13. In considering the sampling strategy for radioactive waste management, I took account of the work carried out in earlier steps of GDA. During Step 2 I identified there were potential gaps and differences between UK and Chinese practices for radioactive waste management that could have an impact of the design of the UK HPR1000. This led to the issue of Regulatory Observation RO-UKHPR1000-0005 (Ref. 10) (see sub-section 4.1) which, amongst other aspects, asked the RP to undertake a gap analysis of radioactive waste management practices. The result of this gap analysis (Ref. 11) indicated there were no significant gaps or differences between UK and Chinese practices for the management of liquid and gaseous radioactive wastes but there were gaps/differences for solid radioactive wastes. On the basis of this I decided to focus my assessment on the management of solid radioactive wastes whilst undertaking a proportionate assessment of systems used to manage liquid and gaseous radioactive wastes.

14. In line with ONR's guidance (Ref. 5), I chose a sample of the RP's submissions to undertake my assessment. This focused on submissions pertinent to the highest hazard nuclear liabilities generated from the operation of the UK HPR1000 or where, due to the mobility of the material, the hazard may be least well controlled. For the scope of my assessment, I considered the highest hazards to be the solid High Level Wastes (HLW) and Intermediate Level Wastes (ILW), which give rise to high dose rates. For aspects where there is the greatest potential for the hazards to be least well controlled, I sampled evidence against the principles of containment and the detection and prevention of leakage and escape from solid, liquid and gaseous radioactive waste systems.

15. The main themes considered for radioactive waste management are consistent with the fundamental expectations in NS-TAST-GD-024 (Ref. 7):

- Radioactive waste inventory - Generation of radioactive waste should be avoided, where radioactive waste is unavoidable, generation should be minimised according to the waste hierarchy.
- Radioactive waste management strategy - Radioactive waste should be managed safely throughout its lifecycle in a manner that is consistent with UK policy and modern standards/practices.

- Radioactive waste treatment systems - Predisposal management of radioactive waste should take account of the anticipated disposal route, and full use should be made of existing routes. My assessment includes two areas of focus:

  - The retrieval and processing of HLW and ILW into a passively safe condition for interim storage on site pending disposal to a UK Geological Disposal Facility (GDF). The operational HLW generated from the UK HPR1000 is limited to a sub-set of the In Core Instrument Assemblies (ICIAs). The ILW generated from the operation of the UK HPR1000 includes waste ICIAs, spent filter cartridges, Dry Active Waste (DAW), ion exchange resins, sludges and concentrates.
  - The substantiation of the design of the radioactive waste management systems in the generic UK HPR1000 design. I have focused on the substantiation of the designs for normal operations as well as the primary means of confinement, provision of further containment barriers and the suitability of the means of detecting leakage and escape from the systems. I have considered the design of the radioactive waste management systems as part of the overall demonstration that risks are reduced to ALARP, including whether the evidence provided is consistent with the RP's claims in the safety case.

- Safe Storage - Where the disposal route is not yet available, radioactive material and radioactive waste should be put into a passively safe state as soon as reasonably practicable for interim storage pending future disposal, or other long-term solution. For ILW safe storage is provided by the ILW Interim Storage Facility (ISF). For HLW safe storage is provided by the Spent Fuel Interim Storage (SFIS) Facility.
- Demonstration of ALARP - The RP's overall demonstration that the risks from radioactive waste management are ALARP. Alongside the consideration of whether the design of the radioactive waste management systems reduce the risks to ALARP, I have also considered whether the RP has adequately considered the principle of minimisation in the generation and accumulation of radioactive wastes.

2.3 Out of Scope Items

16. The following items were outside the scope of my assessment.

- Operations leading to the generation of waste ICIAs, including, but not limited to, the operational safety case associated with their use.
- Due to the relatively low hazard associated with Low Level Waste (LLW), I have not sampled the management strategy and associated facilities required for the safe management of LLW (for example the Waste Auxiliary Building (BQS)). This is also consistent with Appendix A the 'Scope of the UK HPR1000 GDA Project' (Ref. 12) where buildings which form part of the Conventional Island, or other buildings not listed in Appendix A, are out of scope of GDA.
- The RP has placed the detailed design of radioactive waste processing equipment out of scope of GDA (Ref. 12). For this assessment relevant processing equipment includes, but is not limited to, drum monitoring equipment, cementation (grouting) equipment, drying equipment and dewatering equipment.
- The management of spent fuel is assessed in ONR-NR-AR-21-017 'Step 4 Assessment of Spent Fuel Interim Storage for the UK HPR1000 Reactor' (Ref. 13).
- The assessment of the management strategy of waste Rod Cluster Control Assemblies (RCCAs) and Stationary Core Component Assemblies (SCCAs).

This is in the scope of the 'Step 4 Assessment of Spent Fuel Interim Storage for the UK HPR1000 Reactor' (Ref. 13).

- Radioactive wastes generated as a result of decommissioning activities. These are assessed in ONR-NR-AR-21-015 'Step 4 Assessment of Decommissioning for the UK HPR1000 Reactor' (Ref. 14).
- Assessment of internal and external hazards, human factors and conventional health and safety unless explicitly stated.

2.4 Standards and Criteria

17. The relevant standards and criteria adopted within this assessment are principally the SAPs (Ref. 2), TAGs (Ref. 6) (Ref. 7) (Ref. 8), relevant national and international standards, and relevant good practice informed from existing practices adopted on nuclear licensed sites in Great Britain. The key SAPs and any relevant TAGs, national and international standards and guidance are detailed within this sub-section. Relevant Good Practice (RGP), where applicable, is cited within the body of the assessment.

18. Radioactive waste is an example of nuclear matter, and therefore where ONR guidance refers to nuclear matter this is relevant guidance to the topic of this assessment report. Further details on the definition of nuclear matter are provided in the TAG on the control of processes involving nuclear matter (Ref. 15).

2.4.1 Safety Assessment Principles

19. The SAPs (Ref. 2) constitute the regulatory principles against which ONR judges the adequacy of safety cases. The SAPs applicable to radioactive waste management are included within Annex 1 of this report.

20. The key SAPs applied within my assessment were SAPs RW.1-7, ELO.1, 3 and 4, ECV.1 - 7, SC.4 – 6, EMT.1, 2, 5 and 6, ESC.1 and 2, ECM.1, and EKP.1 and 3.

2.4.2 Technical Assessment Guides

21. The following Technical Assessment Guides were used as part of this assessment:

- NS-TAST-GD-005, 'ONR Guidance on the Demonstration of ALARP' (Ref. 6)
- NS-TAST-GD-024, 'Management of Radioactive Material and Radioactive Waste on Nuclear Licensed Sites' (Ref. 7)
- NS-TAST-GD-051, 'The Purpose, Scope and Content of Nuclear Safety Cases' (Ref. 8)

2.4.3 National and International Standards and Guidance

22. The following standards and guidance were used as part of this assessment:

- 'General Safety Requirements Part 5: Predisposal management of radioactive waste', International Atomic Energy Agency (IAEA) (Ref. 16).
- 'Predisposal management of Radioactive Waste from Nuclear Power Plants and Research Reactors', Specific Safety Guide 40, IAEA (Ref. 17).
- 'Storage of Radioactive Waste', Safety Guide WS-G-6.1, IAEA (Ref. 18)
- 'Waste and Spent Fuel Storage Safety Reference Levels', Western European Nuclear Regulators' Association (WENRA) (Ref. 19).
- 'Radioactive Waste Treatment and Conditioning Safety Reference Levels', WENRA (Ref. 20).
- 'The management of higher activity radioactive waste on nuclear licensed sites', Office for Nuclear Regulation, Natural Resources Wales, Scottish Environment Protection Agency and Environment Agency. (Ref. 21) (also

referred to in this report as the joint guidance on management of higher activity waste).
- 'New Nuclear Power Plants: Generic Design Assessment Technical Guidance', ONR (Ref. 22).
- 'Funded Decommissioning Programme Guidance for New Nuclear Power Stations', Department of Energy and Climate Change (Ref. 23).

23. It is noted that the ONR SAPs and TAGs are benchmarked against the IAEA and WENRA guidance available at the time of publication.

2.4.4 Use of Technical Support Contractors

24. It is usual in GDA for ONR to use Technical Support Contractors (TSCs) to provide access to independent advice and experience, analysis techniques and models, and to enable ONR's inspectors to focus on regulatory decision making.

25. Table 1 below sets out the area in which I used TSCs to support my assessment. I required this support to provide independent expert advice in the assessment of the design of a sample of the radioactive waste management systems in the UK HPR1000. The TSC assessed the adequacy of the design and considered whether the evidence provided by the RP substantiated relevant claims and arguments for the selected systems.

26. I have considered the outcomes and findings identified by the TSC to reach my own judgements. I also note that the TSC has of necessity assessed a sample of the RP's submissions at a certain stage of revision, and that there may be other evidence not assessed by the TSC that may be relevant to the overall outcome of my assessment. I make reference where this is the case within this assessment report.

Table 1: Work Packages Undertaken by the TSC

Number	Description
1	Technical Assessment of Selected Radioactive Waste Management Systems for the GDA Reference Design for the UK HPR1000 (Ref. 24). The radioactive waste management systems sample selected by ONR for the TSC included: ■ Nuclear Island Vent and Drain System (RPE [VDS]), excluding F-SC1 containment isolation valves; ■ Liquid Waste Treatment System (TEU [LWTS]); ■ Nuclear Island Liquid Waste Discharge System (TER [NLWDS]); ■ Gaseous Waste Treatment System (TEG [GWTS]), excluding F-SC1 containment isolation valves; ■ Solid Waste Treatment System (TES [SWTS]); and ■ Steam Generator Blowdown System (APG [SGBS]), limited to aspects relevant to radioactive waste management.

27. Whilst the TSC undertook detailed technical reviews, this was done under my direction and close supervision. The regulatory judgment on the adequacy, or otherwise, of the generic UK HPR1000 safety case in this report has been made exclusively by ONR.

2.5 Integration with Other Assessment Topics

28. GDA requires the submission of an adequate, coherent and holistic generic safety case. Regulatory assessment cannot be carried out in isolation as there are often issues that span multiple disciplines. I have therefore worked closely with a number of other ONR inspectors and the Environment Agency to inform my assessment. The key interactions for the radioactive waste management topic were:

- ONR Nuclear Liabilities Regulation (NLR) specialist inspectors led on ONR's assessment of the spent fuel interim storage and decommissioning technical topics. These are covered in separate assessment reports for Step 4 of the UK HPR1000 GDA (Ref. 13, Ref. 14).
- Fault Studies specialist inspectors took the lead on the RP's approach to the categorisation of safety functions and classification of structures, systems and components (SSCs) within the radioactive waste management systems and the assessment of faults. Assessment of radiological risks in fault conditions, including those associated with radioactive waste management, are addressed by the Fault Studies topic area (Ref. 25). However, the outcome of this work is noted in this report where relevant.
- ONR Radiation Protection specialist inspectors took the lead on the adequacy of the RP's safety case for aspects related to shielding requirements for the radioactive waste management systems, environmental monitoring (air, radiation and contamination) outside containment barriers, and occupational radiation doses arising from the normal operation of the radioactive waste management systems and processes (Ref. 26).
- ONR Chemistry specialist inspectors, who took the lead on source term and the minimisation of radioactivity in the generic UK HPR1000 safety case.
- Mechanical Engineering specialist inspectors led on a range of technical topics relevant to radioactive waste management, including containment and ventilation, the design of Heating, Ventilation and Air Conditioning (HVAC) systems, safe isolation of plant and equipment, handling/lifting operations and arrangements for Examination, Inspection Testing and Maintenance (EIMT) (Ref. 27). The assessment of compliance with HSG253 (Ref. 28) has been addressed by the Mechanical Engineering topic area, with support from the Radiological Protection topic area. However, the outcome of this work is noted in this report where relevant.
- Verification and validation of modelling codes used in the RP's submissions, for example the PALM code used for modelling the activity and radioactive decay of ICIAs. The PALM modelling results are associated with the neutron flux/operation of the reactor core. This work is part of the scope of work of the ONR Fuel and Core specialist inspector's assessment (Ref. 29).
- Environment Agency inspectors considered the demonstration of Best Available Techniques (BAT) for radioactive wastes across the lifecycle. The Environment Agency also took the lead regarding the RP's approach to management of LLW where a disposal route is available, the disposability of Higher Activity Wastes (HAW), and the assessment of proposed discharges of gaseous and liquid radioactive effluents during normal operation. This included consideration of the type of filters used to remove particulate material from gaseous discharges. ONR does not regulate the disposal of radioactive waste but maintains oversight of progress with disposability assessment, as this is relevant to minimising the risk that radioactive waste is stored on site indefinitely because it has no disposal route.

2.6 Overseas Regulatory Interface

29. ONR has formal information exchange agreements with a number of international nuclear safety regulators, and collaborates through the work of IAEA and the Organisation for Economic Co-operation and Development Nuclear Energy Agency

(OECD-NEA). This enables us to utilise overseas regulatory assessments of reactor technologies, where they are relevant to the UK. It also enables the sharing of regulatory assessments, which can expedite assessment and helps promote consistency.

2.6.1 Bilateral Collaboration

30. As part of my assessment I took part in a bilateral workshop on radioactive waste management (and environmental assessment) with the Chinese nuclear safety regulator (NNSA) and the Environment Agency in November 2019 (Ref. 30). This provided valuable background knowledge of practices and national infrastructure for radioactive waste management in China and the regulatory framework.

3 REQUESTING PARTY'S SAFETY CASE

3.1 Introduction to the Generic UK HPR1000 Design

31. The generic UK HPR1000 design is described in detail in the PCSR (Ref. 3). It is a three-loop PWR designed by CGN using the Chinese Hualong technology. The generic UK HPR1000 design has evolved from reactors which have been constructed and operated in China since the late 1980s, including the M310 design used at Daya Bay and Ling'ao (Units 1 and 2), the CPR1000, the CPR1000$^+$ and the more recent ACPR1000. The first two units of CGN's HPR1000, Fangchenggang Nuclear Power Plant (NPP) Units 3 and 4, are under construction in China and Unit 3 is the reference plant for the generic UK HPR1000 design. The design is claimed to have a lifetime of at least 60 years and has a nominal electric output of 1,180 MW.

32. The reactor core contains zirconium clad uranium dioxide (UO_2) fuel assemblies and reactivity is controlled by a combination of control rods, soluble boron in the coolant and burnable poisons within the fuel. The core is contained within a steel Reactor Pressure Vessel (RPV) which is connected to the key primary circuit components, including the Reactor Coolant Pumps (RCP), Steam Generators (SG), pressuriser and associated piping, in the three-loop configuration. The design also includes a number of auxiliary systems that allow normal operation of the plant, as well as active and passive safety systems to provide protection in the case of faults, all contained within a number of dedicated buildings.

33. The Reactor Building (BRX) houses the reactor and primary circuit and is based on a double-walled containment with a large free volume. Three separate safeguard buildings surround the reactor building and house key safety systems and the main control room. The Fuel Building (BFX) is also adjacent to the reactor and contains the fuel handling and short-term storage facilities as part of the Spent Fuel Pool (SFP). Finally, the nuclear auxiliary building contains a number of systems that support operation of the reactor. In combination with the diesel, personnel access and equipment access buildings, these constitute the nuclear island for the generic UK HPR1000 design.

3.2 The Generic UK HPR1000 Safety Case for Radioactive Waste Management

34. In this sub-section I provide an overview of the radioactive waste management aspects of the generic UK HPR1000 safety case as provided by the RP during GDA. Details of the technical content of the documentation and my assessment of its adequacy are reported in the subsequent sub-sections of my report.

35. The primary submission I have assessed is Chapter 23 of the PCSR on Radioactive Waste Management (Ref. 4). The RP's purpose for this chapter is to demonstrate that a practicable strategy has been developed for the management of the gaseous, liquid and solid radioactive wastes which will be generated during the operation of the UK HPR1000 reactor. Chapter 23 of the PCSR (Ref. 4) presents qualitative information on how the radioactive wastes will be managed from generation to discharge and/or disposal, taking into account reducing the risks to ALARP and protecting the environment and the public to reflect the application of BAT, which is regulated by the Environment Agency.

36. Chapter 23 of the PSCR (Ref. 4) states the fundamental objective of the UK HPR1000, which is that the generic UK HPR1000 could be constructed, operated and decommissioned in the UK on a site bounded by the generic site envelope in a way that is safe, secure and that protects people and the environment. This objective is underpinned by a number of high level claims as set out in Chapter 1 of the PCSR (Ref. 31), of which the one of relevance to radioactive waste management is:

- "Claim 3: The design and intended construction and operation of the UK HPR1000 will protect the workers and the public by providing multiple levels of defence to fulfil the fundamental safety functions, reducing the nuclear safety risks to a level that is as low as reasonably practicable."

37. Chapter 23 of the PCSR (Ref. 4) identities a number of claims/sub-claims relevant to the radioactive waste topic derived from Claim 3, with Appendix 23A of Chapter 23 providing a route map of the evidence against the radioactive waste management claims:

- "Claim 3.3: The design of the processes and systems has been substantiated and the safety aspects of operations and management have been substantiated."
  - "Claim 3.3.11: The design of radioactive waste management systems has been substantiated."
    - "Sub-claim 3.3.11.SC23.1: The functional requirements have been derived for radioactive waste management systems."
    - "Sub-claim 3.3.11.SC23.2: The systems design satisfied the functional requirements."
    - "Sub-claim 3.3.11.SC23.3: The production and accumulation of radioactive waste from the UK HPR1000 has been minimised."
    - "Sub-claim 3.3.11.SC23.4: Radioactive waste has been put into a passively safe form for interim storage."
    - "Sub-claim 3.3.11.SC23.5: All reasonably practicable measures have been adopted to optimise the design of radioactive waste management systems."
- "Claim 3.4: The safety assessment shows that the nuclear safety risks are ALARP."
  - "Claim 3.4.8: All reasonably practicable options to improve nuclear safety have been adopted, demonstrating that the risk is ALARP."
    - "Sub-claim 3.3.11.SC23.5: All reasonably practicable measures have been adopted to optimise the design of radioactive waste management systems."

38. The supporting submissions are too numerous to list here but are referred to as appropriate in Section 4 of this report for the areas sampled and are referenced in Chapter 23 of the PCSR (Ref. 4).

39. Chapter 23 of the PCSR (Ref. 4) and the Integrated Waste Strategy (IWS) (Ref. 32) provide an overview of the gaseous, liquid and solid radioactive wastes arising from the operation of the UK HPR1000, with more detailed information provided in supporting submissions. The IWS provides an overview of the wastes arising from the operation of the UK HPR1000 reactor (both radioactive and non-radioactive) and describes how the RP has optimised its approach to the management of gaseous, liquid and solid radioactive wastes.

40. Operation of the reactor results in the production of the following types of radioactive species as discussed in the 'Report of Radionuclide Selection during Normal Operation' (Ref. 33):

- Fission products – these are produced in the nuclear fuel. Small amounts are transferred into the primary coolant as a result of small defects in the fuel cladding and from 'tramp uranium' left on the surface of the fuel after manufacturing. Fission products comprise mainly isotopes of iodine and caesium and noble gases such as xenon and krypton.

- Activated corrosion products – These arise from corrosion of the surfaces of metallic SSCs which form part of the reactor primary circuit and are in contact with primary coolant. This results in the release of both soluble and insoluble species into the coolant which are activated due to the neutron flux in the reactor. Activated corrosion products can be deposited on the surfaces of pipes and other components in the primary circuit, which gives rise to radiation doses to workers during maintenance. The amounts and species of activated corrosion products depend on the materials selected for the SSCs in the primary circuit, control of the water chemistry of the primary coolant and changes in solubility of species associated with temperature changes during operation. Activated corrosion products include radioactive isotopes of cobalt, iron, silver, antimony, nickel, chromium and manganese.
- Activation products – These are produced by neutron activation of the SSCs in the RPV, such as Non-Fuel Core Components (NFCCs) and constituents of the primary coolant and gases in the primary circuit and associated systems (which include water, oxygen, nitrogen, chemical additives to control the water chemistry and impurities). Activation products in the primary circuit include tritium (a radioactive isotope of hydrogen), carbon-14, short-lived isotopes of nitrogen, sodium-24, zinc-65 and argon-41.
- Actinide products – these arise as a result of the activation of uranium and are transferred into the primary coolant as a result of fuel defects and tramp uranium. They comprise a range of transuranic elements including isotopes of uranium, neptunium and plutonium. The quantities of actinides produced are predicted to be very small on the basis of Operational Experience (OPEX) on the quality of fuel manufacturing processes and reliability of nuclear fuel integrity during operation.

41. The radionuclides described above that arise as a result of operation of the reactor result in the generation of radioactive wastes by means of processes in a number of systems, as described in Chapter 23 of the PCSR (Ref. 4). A simplified summary of the relevant systems is provided in the following paragraphs.

3.2.1 Liquid Radioactive Waste Management Systems

42. Liquid radioactive wastes arise due to the use of liquid coolant in the reactor primary circuit and associated secondary effluent systems (Ref. 4).

43. The primary circuit coolant is cleaned by removal (letdown) of a proportion from the primary circuit for treatment in the Chemical Volume and Control System (RCV[CVCS]). The RCV[CVCS] ensures the chemical properties and volume of the reactor coolant are controlled. Leakage/drainage from the RCV[CVCS] system is collected in the Nuclear Vent and Drain System (RPE[NVDS]). Sampling and monitoring arrangements are provided to inform decisions on whether effluent (from letdown or leakage/drainage) is “recyclable” after treatment in the Coolant Storage and Treatment System (TEP[CSTS]). If the effluent is unsuitable for reuse and thus “non-recyclable” it is transferred to the appropriate management systems for treatment via process drains. Treated liquid effluent is sampled and monitored to ensure it meets the criteria for discharge. Further details on recyclable and non-recyclable effluents from the primary circuit coolant are provided below:

- The recyclable primary circuit effluent is transferred to the TEP[CSTS] via the RCV[CVCS] where it is treated by a range of processes including evaporation and demineralisation to enable reuse. Treatment by demineralisation results in the generation of ILW spent (ion-exchange) resins. Treatment by evaporation results in the generation of waste concentrates but both enable the recovery of water and boric acid, which are reused where possible in making up the primary coolant.

- Non-recyclable primary circuit coolant effluents are segregated into defined streams based on their source and radiological/chemical characteristics. There are three sources of non-recyclable primary circuit coolant in the RPE[NVDS]:
  - Process drain effluent, used to collect primary coolant from RCV[CVCS] system or equipment leakages. Primary coolant is expected to have low levels of chemical impurities.
  - Chemical drain effluent, for chemically contaminated primary coolant effluent from laboratories.
  - Floor drain effluent, for floor washings which, due to the proximity of the primary circuit equipment, maybe potentially contaminated by primary circuit coolant.

44. Non-recyclable effluents are also generated from washing/decontamination activities and are collected in the Sewage Recovery System (SRE[SRS]). These include:

- Floor washing effluent from inside controlled areas, and therefore may be slightly contaminated, is collected in floor drains.
- Effluent from floor washings outside the controlled area, and therefore the effluent is not expected to be contaminated. This is collected in floor drains.

45. All non-recyclable effluents from both the RPE[NVDS] and SRE[SRS] are transferred to and treated in the Liquid Waste Treatment System (TEU[LWTS]) by a range of methods with the specific treatment method depending on the effluent streams. Effluent from the laundry system is also routed from the laundry drains directly to the TEU[LWTS].

46. The treatment methods used result in the generation of wet-solid radioactive wastes in the form of spent ion-exchange resins (also referred to as spent resins), spent filter cartridges, evaporator concentrates and sludges, all of which contain a range of radionuclides from the primary coolant as well as a range of chemical constituents. Wet-solid radioactive wastes are processed in the Solid Waste Treatment System (TES[SWTS]) into various solid waste forms. There are four categories of treatment defined by the RP for non-recyclable effluents:

- Process drain effluents are treated by demineralisation with pre- and post-filtration.
- Chemical drain effluent is treated by evaporation after pre-filtration.
- Floor drain effluent is treated by filtration.
- Laundry drain effluent is treated by filtration.

47. The treatment of non-recyclable liquid radioactive wastes, as listed above, result in effluents containing low levels of residual radioactivity. The effluents are sampled and monitored, then sent to the Nuclear Island Liquid Waste Discharge System (TER[NLWDS]) for discharge to the environment.

48. Demineralisation and filtration processes are also used in a number of other reactor secondary circuit effluent systems, including the Steam Generator Blowdown System (APG[SGBS]) which can also give rise to arisings of wet-solid radioactive wastes. The APG[SGBS] forms part of the secondary circuit and is not in direct contact with radioactive material. Therefore contamination levels in the effluent are expected to be lower than those in the primary circuit and are as a result of leakage of small amounts from the primary to the secondary circuit.

3.2.2 Gaseous Radioactive Waste Management Systems

49. Gaseous radioactive wastes arise from two main sources in the scope of GDA. The first is primary gaseous effluent arising from degassing and the head spaces of vessels containing primary coolant and primary effluent. The second is gaseous effluent arising from the ventilation of buildings in which radioactivity is present.

50. Primary gaseous effluent is collected and processed by the Gaseous Waste Treatment System (TEG[GWTS]). During steady state operation this system operates continuously to flush vessels and tanks with nitrogen to remove hydrogen and oxygen, which are converted to water using a catalytic recombiner after an initial drying stage.

51. Radioactive gases present in the TEG[GWTS] include fission products such as noble gases (xenon and krypton) and isotopes of iodine which have relatively short half-lives and which decay during the flushing process in steady-state operations. However, excess gas is released to the system from flushing of the RPV gas space and thermal expansion of the reactor coolant during shutdown and start-up transients. This excess gas is directed into charcoal delay beds, which are sized to provide sufficient capacity to enable safe and optimised management of the targeted noble gases (xenon and krypton). This includes a decay unit to delay the discharge of radioactive nuclides for a minimum of 40 hours for krypton and 40 days for xenon to reduce the amount of radioactivity discharged to the environment via the main stack. Gaseous effluent also contains activation products such as carbon-14, tritium and argon-41. After treatment in the TEG[GWTS] the gaseous effluent is routed to the Nuclear Auxiliary Building Ventilation System (DWN[NABVS]), also referred to as the HVAC system, where it is filtered by High Efficiency Particulate (in) Air (HEPA) filters.

52. The design lifetime of the activated charcoal delay beds in the TEG[GWTS] is expected to be 60 years and the charcoal is thus not expected to become waste until the decommissioning phase. It thus does not form part of the operational solid waste inventory and is outside the scope of this assessment.

53. Other gaseous effluents from buildings in which radioactivity is present, such as the SFP, is collected by the building HVAC systems. These are fitted with HEPA filters to remove particulate material and also charcoal iodine adsorbers which are used in the event of the presence of elevated levels of iodine. The treated gaseous effluent is discharged to the environment via the main stack.

54. The treatment methods used for gaseous wastes result in the generation of solid radioactive wastes in the form of HEPA filters and waste charcoal from iodine adsorbers. Solid radioactive wastes arising from the treatment of gaseous radioactive wastes are processed as part of the TES[SWTS] into solid waste forms.

3.2.3 Solid Radioactive Waste Management Systems

55. The concentration and overall content of radionuclides in the solid radioactive wastes vary depending on the system from which they arise. The RP has categorised most solid radioactive waste as either ILW or LLW, based on the expected radioactivity content derived from OPEX of similar PWRs in operation in China and worldwide, including the UK, and theoretical assessment on the basis of numerical modelling. A small proportion of solid radioactive waste (by volume) is initially classified as HLW.

56. A summary of the solid radioactive wastes generated from the operation of the UK HPR1000, including the waste container selected by the RP and the processing technique is presented in Table 2.

Table 2: Radioactive Waste Inventory Summary

Waste Type	Waste Classification	Description	Container Type	Treatment Process
ICIAs	HLW	Metallic waste NFCC wound from the RPV.	500 litre robust shielded drum with steel liner	Winding/bundling operations
ICIAs	ILW	Metallic waste NFCC wound from the RPV	500 litre robust shielded drum with steel liner	Winding/ bundling operations
RCCAs/ SCCAs	HLW	Metallic waste NFCC moved from the RPV with Spent Fuel Assemblies (SFAs)	Co-storage/ disposal with SFAs	Dried with SFAs in the spent fuel canister (see sub-section 4.2)
Spent resins	ILW	Wet-solid waste arising from the TEU [LWTS], TEP [CSTS], Fuel Pool Cooling and Treatment System (PTR [FPCTS]) systems and the RCV [CVCS] demineralisers. The resins comprise small spheres made of a cross-linked polystyrene matrix. The diameters of the resin spheres range mainly from 0.45mm to 1.2mm.	500 litre robust shielded drum	De-watering
Spent resins	LLW	Wet-solid waste arising from APG [SGBS] demineralisers during normal operations. The resins comprise small spheres made of a cross-linked polystyrene matrix. The diameters of the resin spheres range mainly from 0.45mm to 1.2mm.	210 litre drum	De-watering prior to off-site incineration
Concentrates	ILW /LLW boundary wastes	Wet-solid waste arising from TEU [LWTS] evaporators.	210 litre drum	Cement grouting
Spent filter Cartridges	ILW	Wet-solid filters used in water treatment systems which arise from filter changes in the TEU [LWTS], TEP [CSTS], PTR [FPCTS], RCV [CVCS] and RPE [VDS] systems.	3 cubic metre box	Cement grouting

Waste Type	Waste Classification	Description	Container Type	Treatment Process
Spent filter cartridges	LLW	Wet-solid filters used in water treatment systems which arise from filter changes in the TEU [LWTS] and APG [SGBS] systems.	210 litre drum	Supercompaction off-site.
Sludge	ILW/LLW boundary wastes	Wet-solid waste arising from the sumps and tanks in the liquid radioactive waste management systems (for example RPE [VDS] and TEU [LWTS]) systems.	210 litre drum	Cement grouting
Dry Active Wastes	ILW/LLW boundary wastes	Metal maintenance wastes	On-site - 210 litre drum, sent off site in Berglof boxes	Off-site melting
		Combustible wastes	210 litre drum	Off-site incineration
		Un-combustible / compactable waste		Off-site supercompaction
		Un-combustible / un-compactable waste		Cement grouting
Ventilation filter cartridges	LLW	Solid waste arising from the ventilation systems located in the Nuclear Auxiliary Building (BNX), Fuel Building (BFX), Safeguards Building (BSX), Reactor Building (BRX) and Radioactive Waste Treatment Building (BWX).	Bag	Off-site supercompaction
Oil	LLW/VLLW	Non-aqueous liquid waste arising during normal operations, such as maintenance of pumps and hydraulic equipment.	210 litre drum	Off-site incineration
Organic Solvent	LLW/VLLW	Non-aqueous liquid waste arising during normal operations, such as decontamination of RPV bolts.	210 litre drum	Off-site incineration

60. In addition to the generation of wet-solid radioactive wastes from the operation of liquid radioactive waste management systems (spent resins, spent filter cartridges, evaporator concentrates and sludges) and the solid radioactive wastes from the gaseous radioactive waste management systems (HEPA filters and charcoal adsorbers), other solid radioactive wastes generated include:

- NFCCs, these are activated metal components used in the reactor and are thus highly activated due to exposure to high levels of neutron flux. There are three main types, namely RCCAs, SCCAs and ICIAs which become radioactive wastes at the end of their operational lives. These wastes arise throughout operation of the UK HPR1000.
- The structural components of the reactor such as the RPV and the components such as reactor vessel internals are also activated as a result of neutron flux. These components remain in place throughout reactor operation and will only become radioactive waste when the UK HPR1000 ceases operation and is decommissioned. The RP has thus excluded these radioactive wastes from the scope of the inventory of operational radioactive wastes arising from the UK HPR1000. Decommissioning wastes are excluded from the scope of this report but are considered in detail in the assessment report on Decommissioning (Ref. 14).
- Other solid radioactive wastes (referred to as DAW). These arise from the maintenance and/or replacement of components contaminated by radioactivity, as well as secondary wastes such as used personal protective equipment and cleaning materials.
- Non-aqueous liquid wastes such as oils and solvents arise from maintenance and decontamination operations. The solid radioactive waste inventory and that of oils and organic solvents are described in detail in the 'Waste Inventory for Operational Solid Waste' (Ref. 34).

61. The TES[SWTS] is used to manage the solid radioactive wastes and non-aqueous liquid wastes arising from operation of the generic UK HPR1000 design. The purpose of the TES[SWTS] is to collect, characterise and segregate, treat, condition, package and store various types of solid radioactive waste and non-aqueous liquid waste in normal operations, as well as to measure and record waste packages for transport and disposal.

62. The TES[SWTS] comprises a number of sub-systems:

- DAW Treatment – The DAW treatment sub-system is not a single engineered system but a set of facilities/arrangements primarily used to manage 'typical' arisings of radioactive wastes from routine operations, maintenance activities and outage periods (refuelling activities). The scope of the sub-system covers the processes associated with the characterisation, segregation, collection, on-site movement, pre-treatment and storage of these notionally dry, solid, radioactive wastes generated during normal operation. DAW is segregated by waste category at source (LLW or ILW). LLW DAW is further segregated and packaged in the Waste Auxiliary Building (BQS), which is at a conceptual stage of design for the GDA stage. The Waste Auxiliary Building is also used for the preparation of spent HEPA filters for subsequent management. ILW DAW is identified as ILW/LLW boundary wastes as the RP's safety case identifies that these wastes will decay to LLW in less than 2 years after arising (Ref. 35). At the point of generation ILW DAW is loaded into 210 litre drums at source and stored in the ILW ISF until it has decayed to LLW. Once decayed to LLW, the DAW can then be segregated further and managed through the Waste Auxiliary Building as LLW. All the UK HPR1000 ILW DAW inventory is expected to decay to LLW.
- Spent Resins Flushing and Storage – with the exception of spent resins from the TEU[LWTS], spent resins from a number of systems are flushed into

storage tanks in the nuclear auxiliary building and then transferred to storage tanks in the Radioactive Waste Treatment Building for storage prior to treatment as part of the Wet-solid Waste (WSW) Receipt and Treatment sub-system. TEU[LWTS] resins are flushed directly into tanks in the Radioactive Waste Treatment Building.

- Spent Filter Cartridge Changing – There are two sets of machines used to change spent filter cartridges depending on location. The Spent Filter Cartridge Changing Machine (SFCCM) is located in the Nuclear Auxiliary Building and is used to change the filters in systems associated with the primary circuit. The Spent Filter Replacement and Transfer Device (SFRTD) in located in the Radioactive Waste Treatment Building and is used to change the filters in the TEU[LWTS]. The dose rates of the spent filter cartridges are monitored when retrieved to segregate them into ILW and LLW filters.
- WSW receipt and treatment – This receives, temporarily stores and then treats/conditions wet solid wastes such as spent resins, spent filter cartridges, concentrates and sludges. The main functions of this sub-system are the receipt and temporary storage of spent resins and ILW spent filter cartridges from the Nuclear Auxiliary Building and Radioactive Waste Treatment Building, the packaging and dewatering (draining/drying) of spent resins in 500 litre robust shielded drums, cementitious grouting of concentrates and sludges in 210 litre drums and the cementitious grouting of ILW spent filter cartridges in 3 cubic metre boxes. ILW packages are then transferred to the ILW ISF pending disposal to a GDF. In the case of 210 litre drums of encapsulated concentrates and sludges they will be stored in the ILW ISF until they have decayed to LLW and can then be disposed of to the Low Level Waste Repository (LLWR).
- Non-Aqueous Liquid Management – Oils and solvents arising from maintenance and decontamination activities are segregated and collected in 210 litre drums depending on their radioactive and chemical properties. They are stored in the Waste Auxiliary Building prior to off-site disposal by means of incineration. Non-aqueous liquid wastes are categorised as LLW or Very Low Level Waste (VLLW, a sub-set of LLW with defined activity limits), see Table 2.
- NFCC Waste Management – RCCAs and SCCAs form an integral part of the spent fuel assemblies and after use are co-stored with spent fuel in the SFP. They are then packaged with the spent fuel in spent fuel canisters for dry storage and transferred to the SFIS Facility. RCCAs/SCCAs are assessed as part of the scope of the SFIS topic (Ref. 13). ICIAs (which are long, slender metal components) are removed from the RPV by means of a winding machine which size reduces them into bundles. The bundles are packaged in 500 litre robust shielded drums and then transferred to the ILW ISF pending disposal to the GDF. Waste ICIAs categorised as HLW upon arising are initially stored in the SFIS Facility for decay storage from HLW to ILW, followed by later transfer to the ILW ISF.

3.2.4 Higher Activity Radioactive Wastes

63. HAW is defined in the UK as HLW, ILW, and such LLW as cannot be disposed of at present (Ref. 21). Where a disposal route is not yet available, radioactive waste should be put into a passively safe state as soon as reasonably practicable for interim storage pending future disposal, or other long-term solution. The UK Base Case for new nuclear power stations (Ref. 23) assumes that HAW from new nuclear power stations is kept in interim storage on the site of the power station until the point at which it is disposed of in a GDF.

64. To ensure consistency with UK Policy (Ref. 23) the RP has included the conceptual design of two radioactive waste storage facilities on site, each of which has a design lifetime of at least 100 years:

- The SFIS Facility, whose primary purpose is to support the safe long term interim storage of spent fuel, which is addressed in the ONR assessment report for the SFIS topic (Ref. 13). However, the SFIS Facility also includes facilities for the decay storage of HLW ICIAs.
- The ILW ISF, which is designed to accommodate all ILW, including ILW/LLW boundary wastes, which are stored until they decay to LLW.

4 ONR ASSESSMENT

4.1 Structure of Assessment Undertaken

65. Consistent with the sampling strategy (sub-section 2.2) the focus of my assessment is on the highest hazard nuclear liabilities generated from the operation of the UK HPR1000. For the radioactive waste management topic this includes solid radioactive wastes categorised as HLW and ILW.

66. The structure of my assessment for radioactive waste is as follows:

- Radioactive Waste Inventory
- Radioactive Waste Management Strategy (liquid, gaseous and solid)
- ICIA Management Strategy
- ICIA Winding Operations Safety Case
- Radioactive Waste Treatment System Safety Cases (liquid, gaseous and solid radioactive waste treatment systems)
- ILW Interim Storage Facility (including accident and incident wastes)
- Demonstration that relevant risks have been reduced to ALARP
- Consolidated Safety Case.

4.1.1 Regulatory Observations and Queries

67. Where ONR identified potential shortfalls between the RP's safety case and regulatory expectations a RO was raised to highlight key regulatory expectations that the RP was expected to address as part of the GDA process. For the radioactive waste management technical topic three ROs were raised (Ref. 10), these are:

- RO-UKHPR1000-0005 'Demonstration that the UK HPR1000 design reduces the risks associated with radioactive waste management, so far as is reasonably practicable (SFAIRP)'. A targeted assessment to support the closure of RO-UKHPR1000-0005 has been undertaken in Step 4 of the GDA (Ref. 10).
- RO-UKHPR1000-0037 'In-Core Instrument Assemblies Radioactive Waste Safety Case'. A targeted assessment supporting the closure of RO-UKHPR1000-0037 has been undertaken in Step 4 of the GDA (Ref. 36).
- RO-UKHPR1000-0040 'Provision of an adequate safety case for the interim storage of Intermediate Level Waste (ILW)'. A targeted assessment supporting the closure of RO-UKHPR1000-0050 has been undertaken in Step 4 of the GDA (Ref. 37).

68. I have based my assessment on the latest versions of the RP's safety case submissions, which incorporate improvements to meet the expectations of all three ROs. Where relevant, the ROs are identified in my assessment, with the key sub-sections for each RO being:

- RO-UKHPR1000-0005 – sub-section 4.8 presents the overall assessment of the adequacy of the RP's generic UK HPR1000 design to reduce the risks associated with radioactive waste management, SFAIRP.
- RO-UKHPR1000-0037 – sub-sections 4.4 and 4.5 present the assessment of the management strategy and safety case for the management of HLW ICIAs.
- RO-UKHPR1000-0040 – sub-section 4.7 presents the assessment of the ILW ISF.

69. My assessment also considers clarifications provided by the RP in response to RQs raised during Step 4 of the UK HPR1000 GDA (Ref. 38). These are referenced throughout my assessment where relevant.

4.2 Radioactive Waste Inventory

4.2.1 The RP's Submissions on Radioactive Waste Inventory

70. As described in Section 3, a range of radionuclides is generated as a result of the operation of the UK HPR1000. The RP has defined the "normal operation source term" as "the types, quantities, and physical and chemical forms of the radionuclides present in a nuclear facility that have the potential to give rise to exposure to radiation, radioactive waste, or discharges" (Ref. 39). Normal operation comprises steady-state conditions, transient conditions and shutdown conditions.

71. The RP has defined a number of source terms for the UK HPR1000, which include those from the primary and secondary coolants, spent fuel assemblies and solid radioactive wastes. It has produced a number of 'technical user source term reports', including the 'Solid Radioactive Waste Management Technical User Source Term Report' (Ref. 40) and other source term reports, of which the 'Activated Structures Supporting Source Term Report' (Ref. 41) is of most relevance to the solid radioactive waste inventory.

72. The 'Solid Radioactive Waste Management Technical User Source Term Report' (Ref. 40) provides evidence on how the RP's radioactive waste inventory has been compiled. The inventory is based on two main sources of information, namely theoretical assessment of materials that potentially become radioactive waste as a result of their operational conditions and characteristics, and OPEX from PWRs (in operation in China and worldwide).

73. The source term considers gamma, beta and alpha-emitting radionuclides that contribute significantly to overall activity and support the analysis of the categories of radioactive waste used in the UK of HLW, ILW and LLW. These categories are based primarily on activity concentrations of alpha and beta/gamma emitting radionuclides and levels of heat generation. The RP selected the radionuclides on the basis of the principles presented in the 'Report of Radionuclide Selection during Normal Operation' (Ref. 33) and consideration of previous GDA processes. The list of radionuclides in the primary coolant was the starting point for the selection of radionuclides in the operational solid radioactive waste source term (including non-aqueous liquid wastes but excluding NFCCs, which are discussed below). The RP also included specific radionuclides listed as relevant to solid radioactive waste management to underpin the analysis of compliance with relevant criteria and the identification of strategies for radioactive waste management. The list also included long-lived radionuclides because of their relevance to the safety of radioactive waste disposal.

74. As noted in Section 3, NFCCs are metal components which become highly activated as a result of their use in the RPV where they are subject to high levels of neutron flux. Radionuclides and their concentrations in NFCCs have been predicted on the basis of theoretical assessment by means of computer modelling using the PALM code (Ref. 41).

75. The RP's approach to the definition of the inventory for solid radioactive wastes (and non-aqueous liquid wastes) first considered the source term information and operation of the UK HPR1000 to identify the radioactive wastes generated (Ref. 40). This included the radiological and other characteristics of each waste type (stream) and the average and maximum concentrations of the main radionuclides selected for each waste type based on OPEX, with the exception of NFCCs.

76. The RP then combined the radionuclide information (Ref. 40) with the computer modelling data (Ref. 41) and OPEX to determine the quantities of each waste type expected to arise from operation. The RP produced an inventory of both annual

arisings (volumes) and total amounts arising over the lifetime of operation of one unit in the 'Waste Inventory for Operational Solid Radioactive Waste' (Ref. 34).

77. The RP's submission identifies each of the waste streams and their raw (unconditioned) waste properties (Ref. 34). It also provides information on radioactive wastes after they have been packaged into forms considered to be suitable for storage and/or disposal.

78. Consistent my sampling strategy I have focused on the solid radioactive wastes which are categorised as HAW, because they present the highest level of radiological hazard. The inventories of HLW and ILW are discussed in more detail in the following paragraphs.

4.2.1.1 High Level Waste

79. The primary difference between HLW and ILW is the need to consider management of the heat component of HLW in the safety case. There are three types of HLW generated from the operation of the UK HPR1000, all of which are sub-groups of NFCCs. The three sub-groups are:

- ICIAs, which are instruments measuring the pressure, temperature, or neutron flux in the reactor core (Ref. 34). The resultant radiological characteristics of this waste stream depend on a number of factors, with the level of activation being dependent upon the physical location within the reactor core, and the neutron flux experienced. The categorisation of the ICIA components and/or part of components ranges from LLW to heat generating HLW.
- RCCAs, assessment of which is presented in the Step 4 assessment report for SFIS (Ref. 13) and not discussed further here.
- SCCAs, assessment of which is presented in the Step 4 assessment report for SFIS (Ref. 13) and not discussed further here.

80. At the beginning of Step 4 of the GDA process I judged there to be potential shortfalls associated with the strategy and safety case for the management of waste ICIAs. I therefore raised RO-UKHPR1000-0037 'In-Core Instrument Assembly Radioactive Waste Safety Case' (Ref. 10). I sought clarity on the physical and radiological characteristics of the ICIAs, in order to underpin the RP's demonstration that the risks associated with the management of waste ICIAs were reduced to ALARP. The information presented here, and my assessment, is based on the RP's updated submissions provided in response to RO-UKHPR1000-0037.

81. As a result of the response to RO-UKHPR1000-0037, the RP's safety case provided greater clarity on the physical characteristics of the ICIAs which enables identification of the different aspects of the ICIAs, including the range of waste categories within what appears to be a single waste stream. In order to understand the HLW ICIA inventory the whole of the waste ICIA is considered. This is to ensure the characteristics of the waste stream are adequately understood to facilitate its subsequent safe and effective management, consistent with the regulatory expectations in ONR SAP RW.4 and assessed in sub-section 4.4. The RP's safety case identifies that the physical and radiological properties of the waste ICIAs depends on the type of ICIA. There are three types of ICIAs in the generic UK HPR1000 design which can be described in two groups:

- Type i&ii ICIAs are of a similar design, measuring approximately 12m in length, and are used in the reactor core for neutron and temperature measurements. More than 90% of the volume of the waste ICIA inventory is Type i or Type ii ICIAs (Ref. 34).

- Type iii ICIAs are approximately 7.5m long, are used for reactor pressure vessel level measurements, and do not extend into the reactor core. The remaining 10% of the volume of the waste ICIA inventory is Type iii (Ref. 34).

82. The following information is taken from 'The Waste Inventory for Operational Solid Radioactive Waste' (Ref. 34) and 'Activated Structures Source Term Supporting Report' (Ref. 41).

83. Each ICIA type has a lower and a higher source term region. The lower source term region of the ICIA components is located above the RPV upper internals during reactor operations and is therefore exposed to a much lower neutron flux (i.e. reducing the activation levels) than the rest of the component. The lower source term region of the ICIA is consistent for all ICIA types, accounts for approximately 50% of the mass, and can be segregated and managed as LLW. The lower source term region of the ICIA is managed as part of the DAW within the RP's radioactive waste inventory and includes aspects described as the ICIA protecting parts. The protecting parts include columns, plates, clamps and nuts used to position and secure the ICIAs in place during operations. I have not assessed the safety case for the management of LLW DAW inventory in detail because of the lower hazard presented by LLW, consistent with my sampling strategy.

84. The radiological properties of the remaining higher source term section of the ICIA is either HLW or ILW depending on the ICIA type.

- Type i&ii: The higher source term regions of Type i&ii ICIAs are HLW at the time of generation. The RP has presented decay heat curves as evidence of the time taken to decay to ILW (Ref. 34). The time taken for Type i&ii ICIAs to decay from HLW to ILW is approximately 14 years, which the RP considers to be short in comparison with the operational period of the UK HPR1000 reactor (60 years).
- Type iii: The higher source term regions of Type iii ICIAs are ILW at the time of generation. The difference in initial waste category is due to Type iii ICIAs being shorter in length and which therefore do not extend into the reactor core when in use.

85. For the higher source term regions of all three ICIA types the safety case (Ref. 34) provides the arguments/evidence that the half-life of the dominant radioactive nuclides (nickel-59 and nickel-63) would require significant time periods (100,000 - 75,000 years) to decay to LLW. Therefore the RP concludes that the appropriate management strategy for ICIAs is based upon the assumption that all waste ICIAs will be categorised as ILW when disposed of. However Type i&ii ICIAs require an initial (approximate) 14 year period of storage to decay from HLW to ILW (Ref. 34). The RP has taken this into account in the management strategy for ICIAs, which is discussed in more detail in sub-section 4.4 on radioactive waste management strategy.

4.2.1.2 Intermediate Level Waste

86. The RP's environment case (Ref. 42) identifies that it is consistent with BAT to minimise the volume of radioactivity of solid radioactive wastes disposed of to a GDF through the use of decay storage. The RP identifies decay storage as being suitable for the part of the ILW inventory where the concentrations of specific radionuclides challenge the waste acceptance criteria (WAC) for existing (or planned) LLW disposal facilities but could be managed as LLW (based on radiochemical and physicochemical properties) through application of decay storage over a reasonable time period. As a result the RP has defined two categories of ILW inventory, ILW and ILW/LLW boundary wastes (identified in Table 2).

87. ILW inventory – This is defined as ILW which requires storage on site until disposal in a GDF. These wastes are processed and packaged into containers suitable for future disposal to a GDF. The ILW inventory defined by the RP is based on the operation of two UK HPR1000 units and includes spent resins, spent filter cartridges and ICIAs. ILW generated as a result of decommissioning activities is assessed in the Step 4 Assessment of Decommissioning for the UK HPR1000 Reactor (Ref. 14).

88. ILW/LLW boundary wastes – These are radioactive wastes which the RP has categorised as ILW upon arising, but the RP's analysis indicates they can be disposed of as LLW after a period of on-site decay storage, based on their radiological properties. ILW/LLW boundary wastes are defined by the RP as having a relatively short decay period in comparison to the anticipated overall operational life of the generic UK HPR1000 design (60 years of electricity generation and 40 years of post-generation waste storage). ILW/LLW boundary wastes include concentrates, sludges, and some DAW.

89. The RP provides evidence on the characteristics of concentrates, sludges and DAW over time to underpin their decision to decay store these wastes as ILW/LLW boundary wastes (Ref. 35). The RP's safety case (Ref. 35) provides information on the main radionuclides in the ILW/LLW boundary wastes, and models the decay of these as a function of time, to show the point at which the gamma/beta levels decay to below the limit for LLW (under 12GBq/t beta/gamma). The three waste streams of concentrates, sludges, and DAW which are expected to decay to LLW in approximately 7.4 years,16.5 years and 1.65 years, respectively.

4.2.1.3 Low Level Waste

90. The RP identifies LLW streams generated during the operation of the UK HPR1000, in **Table 2**, including oils and organic solvents generated from the operation of the UK HPR1000. Consistent with the scope of my assessment I have not sampled the management of operational LLW.

4.2.2 ONR Assessment of the Radioactive Waste Inventory

91. The purpose of this sub-section is to assess the evidence provided by the RP on the inventory of radioactive wastes arising from the operation of the UK HPR1000 against relevant regulatory expectations. A number of ONR's SAPs, augmented by the joint guidance on the management of higher activity wastes (Ref. 21), set a number of expectations in relation to radioactive waste inventory.

92. ONR SAP RW.1 on radioactive waste management strategies indicates the strategy should include consideration of the site's current and future radioactive waste inventory. ONR SAP RW.3 sets an expectation that the total quantity of radioactive waste accumulated on site at any time should be minimised, so far as is reasonably practicable. ONR SAP RW.4 on the segregation and characterisation of radioactive wastes sets an expectation that an inventory identifying all the radioactive waste at the site should be established, kept up to date and reviewed periodically. ONR SAP RW.7 on making and keeping records includes the radionuclide inventory in the records that need to be kept for the current and future safe management of radioactive wastes. In addition ONR SAP SC.4 states that a safety case should be accurate, objective and demonstrably complete.

93. The establishment of a radioactive waste inventory is important in underpinning the strategies for management of radioactive wastes, understanding the risks of managing radioactive wastes across their lifecycle so they can be minimised, and providing the information needed for the safe disposal of radioactive waste (noting ONR does not regulate the disposal of radioactive wastes).

94. With respect to the inventory of radioactive wastes, I have focused my assessment on solid radioactive wastes and have not assessed the inventory of gaseous and (aqueous) liquid wastes. As described in Section 3, gaseous and liquid radioactive wastes are treated to remove radioactivity (which results in the generation of solid radioactive wastes) and then discharged (disposed of) to the environment. The Environment Agency has assessed the discharges of gaseous and (aqueous) liquid wastes from normal operation of the generic UK HPR1000 design in its report (Ref. 43).

95. I have assessed the RP's information on solid radioactive waste inventory against the regulatory expectations listed above. The first matter I have considered is whether the solid radioactive waste source term, and its derivation on the basis of OPEX and theoretical assessment, is adequate in providing an accurate and complete basis for the estimation of the radioactive waste inventory.

96. ONR's assessment of the normal operation source term has been undertaken by means of a multidisciplinary approach involving specialist inspectors in Chemistry, Radiological Protection, NLR and the Environment Agency, with Chemistry taking the lead in the combined assessment (Ref. 44). The Radiological Protection specialism undertook assessment of the source term during Step 4 (Ref. 45), with focus on the choice of radionuclides, the use of OPEX and calculations, and the magnitude of the source term generated.

97. The assessment of PALM, the computer code used to calculate the activated structure source term which includes ICIAs, is outside the scope of this report, but I sought information that the code being used is robust and has been appropriately verified and validated. ONR's assessment concluded that the RP has verified and validated the PALM code used (Ref. 45). On the basis of the assessment of the RP's verification and validation of the PALM code by other topic areas, I am satisfied it provides an adequate basis for the activated structures source term and thus for the inventory of the ICIAs.

98. With respect to the selection of radionuclides on the basis of OPEX, the RP has generated a list of radionuclides that agrees well with the lists found in a comprehensive range of information sources (Ref. 45). The RP also compared the source term for the UK HPR1000 and those of other similar designs, concluding that the radionuclide activity concentrations calculated for the UK HPR1000 source term were reasonable (Ref. 45). The specialist inspector in Chemistry was also content with the approach taken and the radionuclides selected (Ref. 44). From a specific radioactive waste management perspective I note the RP has provided inventory information that has been sufficient to enable the preliminary assessment of the disposability of both HAW and LLW, which is discussed in more detail in sub-section 4.3 on radioactive waste management strategies.

99. Overall, I consider the OPEX and information identified in the RP's submissions provide adequate evidence that the solid radioactive waste inventory derived for the UK HPR1000 is similar to that of other PWRs, including the PWR in operation in the UK (Ref. 34, Ref. 40). I consider the inventory to be complete, objective and accurate, taking into account assumptions and uncertainties which I consider to be appropriate to the GDA stage, and that it meets the relevant expectations of ONR SAP SC.4. My assessment takes into account the conclusions of other specialist assessors on the adequacy of the normal operation source term and theoretical assessment.

100. In my opinion, the level of detail provided on the inventory for each of the waste streams identified is sufficient to enable the RP to demonstrate adequate consideration of the regulatory expectations in ONR SAP RW.4 on the characterisation and segregation of radioactive waste to facilitate its subsequent safe and effective management. The initial definition of the radioactive waste inventory is a key step in

generating the records that will need to be kept for the current and future safe management of radioactive wastes, as expected in ONR SAP RW.7 and discussed in Chapter 23 of the PCSR (Ref. 4).

101. For HLW, I consider the updated 'Waste Inventory for Operational Solid Radioactive Waste' (Ref. 34) and 'Activated Structures Source Term Supporting Report' (Ref. 41) adequately describe the physical, chemical and radiological characteristics of ICIAs. This will enable the licensee to understand the evidence provided by the RP for the justification of the waste categorisation of the lower and higher source term regions of the ICIAs and how the higher source term region decays to ILW over a period of approximately 14 years.

102. Although not explicitly claimed within the safety case, it is my judgement that the decay storage periods for ILW/LLW boundary wastes are sufficiently short that they do not extend the period of storage for radioactive waste on the site, and therefore do not impact upon the design life of the ILW ISF. In addition, no additional facilities are required for the sorting/segregation of DAW once decayed to LLW (after ~1.65 years). Overall, in my opinion the RP's safety case provides adequate evidence that the decay periods of the three ILW/LLW boundary waste streams are reasonable, taking into consideration the radiochemical and physicochemical properties. In addition, in my opinion, the RP's identification of ILW/LLW boundary wastes in the ILW inventory, and the determination of time periods to decay from ILW to LLW, is consistent with the regulatory expectations of ONR SAP RW.3, through effective use of disposal or recycling facilities.

103. To facilitate this, the RP's package selection (210 litre drums) for ILW/LLW boundary waste is based upon the characteristics of the waste when it will be disposed of. In my opinion, the RP's consideration of the compatibility with disposal routes for the container takes into consideration the relevant regulatory expectations in ONR SAP RW.1. However, I have identified a Minor Shortfall for the licensee to ensure the design life of the 210 litre drum is suitable for the on-site storage period of the ILW/LLW boundary wastes, including the safe retrieval of the 210 litre drums once decayed to LLW.

4.2.3 Radioactive Waste Inventory Conclusions

104. In my judgement, the RP has provided adequate evidence that the solid radioactive waste inventory derived for the UK HPR1000 is similar to that of other PWRs identified, including the PWR in operation in the UK. I consider the inventory to be complete, objective and accurate, appropriate to the GDA stage, and thus meets the relevant expectations of ONR SAP SC.4.

105. The inventory for each of the waste streams identified is sufficient to enable the RP to demonstrate adequate consideration of the relevant regulatory expectations in ONR SAP RW.4 on the characterisation and segregation of radioactive waste. The initial definition of the radioactive waste inventory is a key step in generating the records to meet the expectations of ONR SAP RW.7.

106. The RP's consideration of the inventory in assessing the compatibility of radioactive wastes with disposal routes meets the relevant regulatory expectations in ONR SAP RW.1.

107. The RP has identified that a sub-set of the ILW inventory are suitable for decay storage on site, based on the radiochemical and physicochemical properties of HLW ICIAs and ILW/LLW boundary wastes. For ILW/LLW boundary wastes this enables the licensee to dispose of the waste as LLW instead of to a GDF, thereby minimising the total quantity of radioactive waste accumulated on the site which is an expectation of ONR SAP RW.3. I have identified a Minor Shortfall for the licensee to ensure the design life

of the 210 litre drum is suitable for the on-site storage period of the ILW/LLW boundary wastes.

108. Overall I am of the opinion that the evidence provided by the RP on the solid radioactive waste inventory meets relevant regulatory expectations, and I have not raised any Assessment Findings.

4.3 Radioactive Waste Management Strategies

109. This sub-section presents my assessment of the RP's selection of the management strategies for gaseous, liquid and solid radioactive wastes generated from the operation of the UK HPR1000. During Step 2 of GDA I issued RO-UKHPR1000-0005, the objective of which was to address identified shortfalls at the time relating to:

- The requirement to demonstrate that risks relevant to radioactive waste management (and management of spent nuclear fuel) will be reduced to ALARP, and that regulatory expectations in relevant SAPs had been adequately considered.
- The need to take account of gaps/differences in regulation and critical infrastructure in the UK and China relating to radioactive waste management, and to recognise that the design of the HPR1000 (FCG3) may need to be modified to meet UK regulatory expectations.

110. The RP has summarised its overall response in the 'ALARP Demonstration Report for Radioactive Waste Management' (Ref. 46). My overall assessment of the RP's response to RO-UKHPR1000-0005, including minimisation of the generation of radioactive waste, is presented in detail in sub-section 4.8.

4.3.1 The RP's Submissions on the Radioactive Waste Management Strategies

111. The first Regulatory Observation Action (ROA) of RO-UKHPR1000-0005 asked the RP to carry out an evaluation of gaps/differences between UK practices and the HPR1000 (FCG3) design/Chinese practices in radioactive waste management. In resolution of RO-UKHPR1000-0005 ROA1 the RP produced the 'Gap Analysis Report of Radioactive Waste Management' (Ref. 11). This provided an analysis of potential gaps between the practices applied in the design of the UK HPR1000, RGP in terms of relevant codes, standards and guidance and UK OPEX based on practices implemented at the PWRs in operation and under construction in the UK. The conclusions of the RP's gap analysis are presented below.

112. Consistent with the radioactive waste inventory described in sub-section 4.2, my assessment of the RP's radioactive waste management strategy is divided into three sub-groups:

- gaseous and liquid wastes;
- solid ILW; and
- ILW/LLW boundary wastes.

113. The management strategy for waste ICIAs was the subject of RO-UKHPR1000-0037 'In Core Instrument Assembly Radioactive Waste Safety Case' (Ref. 10), and is therefore considered in detail in sub-section 4.4.

4.3.1.1 Gaseous and Liquid Wastes

114. The RP's gap analysis indicated the management arrangements for the UK HPR1000 gaseous wastes were consistent with RGP and therefore did not identify any gaps (Ref. 11). The RP's ALARP demonstration for radioactive waste management (Ref. 46) provides a summary of the main improvements in the development of the generic UK

HPR1000 design in comparison with earlier reactor designs relating to the management of gaseous wastes which are listed below.

- The design of the TEG[GWTS] uses nitrogen gas as the cover gas for vessels and tanks connected to the TEG[GWTS], which reduces the explosion risk associated with hydrogen. This has been assessed by the ONR Chemistry specialist inspectors (Ref. 44). The use of nitrogen results in an increase in the amount of carbon-14 in the radioactive wastes produced, as a result of activation, most notably in discharges of gaseous and liquid effluents to the environment during normal operations. The RP has provided evidence to demonstrate that there are no reasonably practicable techniques to remove carbon-14 from the effluents (Ref. 11, Ref. 42). The RP considered the safety benefits of the reduction in the hydrogen explosion risk to outweigh the impacts of the increased generation of carbon-14, which largely relate to the radiological impacts of discharges to the environment. The Environment Agency has assessed the environmental impacts of predicted discharges of radioactivity from normal operation of the generic UK HPR1000 design (Ref. 43).
- The TEG[GWTS] design incorporates a catalytic recombiner to recombine hydrogen and oxygen in the gas phase to reduce the hydrogen concentration and thus the explosion risk. This process also converts some of the tritium present as a result of activation into liquid form from gaseous form. The RP states that, given the low concentration of tritium, there are no reasonably practicable measures to remove tritium from the wastes (Ref. 42).
- As described in Section 3 of this report, the TEG[GWTS] design incorporates activated charcoal delay beds to reduce discharges of noble gases. Use of delay beds reduces the amount of space required compared to the previous technology of pressurised storage tanks. Delay beds operate passively which reduces radiation doses to workers.
- Although the RP did not identify any gaps against RGP with respect to the use of HEPA filters for the removal of particulate material (Ref. 11), the generic UK HPR1000 design uses rectangular HEPA filters as opposed to the cylindrical filters considered to be RGP in the UK for new facilities (Ref. 42). The Environment Agency issued RO-UKHPR1000-0036 on the HEPA filter type selection (Ref. 10). This asked the RP to provide a robust optioneering study and justification for the choice of HEPA filter type and to demonstrate that minimisation of the radioactivity of gaseous radioactive waste discharges by the optimisation of the HVAC system, including the provision of HEPA filters to reduce the concentration of radioactive aerosols, is BAT. The RP updated the ‘Optioneering Report of the HEPA Filters Types’ (Ref. 47) in response to RO-UKHPR1000-0036, the outcome of which confirmed the RP’s selection of rectangular HEPA filters.

115. Similarly, the gap analysis identified that the management strategies for liquid wastes from the UK HPR1000 were consistent with RGP and no gaps were identified (Ref. 11). The ALARP demonstration for radioactive waste management (Ref. 46) provides a summary of the main elements in the management of liquid wastes, which is consistent with the information in Chapter 23 of the PCSR (Ref. 4) and summarised in Section 3 of this report.

116. In addition the RP produced optioneering studies for both gaseous (Ref. 48) and liquid (Ref. 49) radioactive wastes which, for gaseous wastes, focused on the technique selected for the minimisation of noble gases. The RP has also produced a number of other submissions relating to other radioisotopes present in gaseous wastes including carbon-14, tritium and iodine, which are supporting references to Chapter 3 of the Pre-Construction Environmental Report (PCER) ‘Demonstration of BAT’ (Ref. 42). Information on the processing of all radioactive wastes is summarised in the ‘Integrated

Waste Strategy' (Ref. 32). I consider the IWS and the minimisation of radioactive wastes in sub-section 4.8 on the demonstration of ALARP. The ONR specialist inspector in Chemistry has led the assessment of minimisation of radioactivity at source in RO-UKHPR1000-0026 (Ref. 10), which is discussed in the relevant assessment report for the Chemistry topic (Ref. 44) and in sub-section 4.8 of this report.

4.3.1.2 Solid Intermediate Level Waste

117. The management strategy for the ILW inventory is to process the waste into a passively safe waste form for storage in the ILW ISF, which is assessed in sub-section 4.7. The ILW inventory includes spent filter cartridges, spent resins and waste ICIAs, with the management strategy for waste ICIAs assessed in sub-section 4.4.

118. Given ILW is a sub-category of HAW, there are regulatory expectations in the joint guidance on the management of HAW (Ref. 21) and ONR's technical guidance for GDA for new nuclear power plants (Ref. 22) relating to the need for evidence that the packaging and conditioning of HAW is compatible with the requirements of geological disposal. Ensuring compatibility with appropriate off-site disposal routes is consistent with the regulatory expectations in ONR SAP RW.3 to minimise the accumulation of radioactive waste on site. Therefore, the RP sought advice from Radioactive Waste Management Limited (RWM) on the disposability of the ILW arising from operation and decommissioning of the UK HPR1000. This advice is intended to provide confidence to the regulators that the wastes generated from the operation and decommissioning of the UK HPR1000 are likely to be capable of being disposed of to a GDF.

119. RWM's generic design for a GDF (Ref. 50) considers the potential development of a new build programme for up to a generating capacity of 16GW(e), and therefore includes wastes and spent fuel inventory from the operation of up to 12 nuclear new build reactors in the UK. Although the UK HPR1000 wastes are not explicitly identified in the generic design of a GDF, RWM concludes that, as a PWR, the UK HPR1000 wastes may be interchangeable for wastes and spent fuels already assumed without any need for a major revision of a GDF design (Ref. 51).

120. Spent filter cartridges - Appendix E of the RP's gap analysis (Ref. 11) identified that the FCG3 reference strategy to encapsulate spent filter cartridges in cementitious grout (also referred to as "grouting") was consistent with UK practice, but that the waste container used in China (a 400 litre drum) was not. The RP has undertaken optioneering for the selection of containers for the UK HPR1000 wastes (Ref. 52). Taking into consideration UK OPEX on ILW containers and the spent filter cartridge waste loading, the RP has selected the use of a 3 cubic metre box to package a total of 11 spent filter cartridges per box. RWM's disposability assessment (Ref. 51) concludes that, subject to detailed analysis of the effectiveness of the grout flooding to minimise voidage, the proposed use of the 3 cubic metre box as the waste package is compatible with disposal to a GDF.

121. The RP's identified that the retrieval strategy for spent filter cartridges requires the initial use of a 210 litre drum (with shielded cask) for transfer of each cartridge to the waste packaging plant. Therefore the RP's strategy depends on the facilities in the WSW receipt and treatment sub-system for the safe accumulation of 11 ILW spent filter cartridges prior to loading and grouting into a 3 cubic metre box, which is addressed in sub-section 4.6.4.4. Spent filter cartridges are grouted prior to storage in the ILW ISF. The RP's optioneering study (Ref. 53) identified the need to reduce the dose to workers resulting from the on-site processing activities (cementitious grouting and package loading) as part of the TES[SWTS] design and during on-site storage in the ILW ISF, which I consider in sub-sections 4.6.4 and 4.7, respectively. The safety case identified the requirement to use a shielding cask for movement of the 3 cubic metre box outside the ILW ISF.

122. ILW spent resins - Appendix C of the RP's gap analysis (Ref. 11) identified that the FCG3 strategy for the management of spent resins was inconsistent with UK practice. The FCG3 strategy is based on cementitious grouting, however, due to the potential reaction between spent resins and cementitious grouts, the RP considered this to be inconsistent with the regulatory expectation of passive safety during storage (ONR SAP RW.5).

123. The RP's optioneering studies on the selection of waste containers (Ref. 52) and solid waste processing techniques (Ref. 53) identified OPEX in the UK and internationally on the dewatering) of spent resins to create a passively safe product. The RP has selected dewatering as the strategy for the management of ILW spent resins in the generic UK HPR1000 design. Materials such as cement are not added to the resins in the drying process, so there is no encapsulated (cemented) waste form which can contribute to safety by means of aspects such as containment (through immobilisation of radionuclides) and structural strength. The RP's safety case thus places safety requirements on the integrity of the container as the primary containment barrier for the release of radioactive materials, where primary containment is not provided by the form of the waste in the container. The RP has selected a 500 litre robust shielded drum for the packaging of spent resins (Ref. 52).

124. The processing of spent resins into 500 litre robust shielded drums forms part of the WSW receipt and treatment sub-system in the Radioactive Waste Treatment Building. The strategy also refers to the RWM's disposability assessment (Ref. 51), which concludes that, subject to adequate removal of free water and consideration of voidage within the packages, the UK HPR1000 spent resins, dewatered in a 500 litre robust shielded drum, are compatible with the generic RWM safety case for disposal in a GDF.

4.3.1.3 ILW/LLW Boundary Wastes

125. For ILW inventory identified as ILW/LLW boundary waste, namely concentrates, sludges and DAW, the RP's radioactive waste management strategy is based upon ensuring these wastes are packaged into containers suitable for both on-site management as ILW, and disposal as LLW. The RP has selected a 210 litre unshielded drum (Ref. 54) for the processing and storage of ILW/LLW boundary wastes (Ref. 35). The RP's ALARP demonstration for radioactive waste management (Ref. 46) made claims on the need to use a shielding cask to minimise radiation doses to workers during on-site activities when the waste is categorised as ILW.

126. The RP has sought advice from LLWR on the disposability of the ILW/LLW boundary wastes once decayed to LLW. Following assessment LLWR issued an Agreement in Principle (AiP) (Ref. 55) which stated it is likely the wastes will be acceptable for disposal at the LLWR or via current treatment/disposal providers, based upon the inventory and source term information provided at GDA.

127. Concentrates and Sludges – Appendix D and Appendix H of the RP's gap analysis (Ref. 11) identified that the FCG3 strategy to encapsulate concentrates and sludges using cementitious grout is consistent with UK practice for passivating similar materials. The management strategy was confirmed in the RP's optioneering (Ref. 53). The RP identified that the FCG3 concentrate container (a 400 litre drum) is not currently used in the UK for disposal of LLW and hence the RP selected the 210 litre drum for the generic UK HPR1000 design. The RP's management strategy (Ref. 32) requires grouting prior to on-site decay storage to ensure the waste form is stored in a passively safe form.

128. The RP has identified facilities in the WSW receipt and treatment sub-system for the immobilisation of the concentrates and sludges through in-drum cementitious grouting to create a solid waste form. For concentrates the system includes a concentrate

metering tank. The RP has considered the risk that both concentrates and sludges may not decay to LLW over the operational lifetime of the UK HPR1000 (100 years) and provided evidence that the concentrates and sludges could be packaged and disposed of as ILW to a GDF if required (Ref. 52). If identified as ILW, the wastes would require cement grouting in a 500 litre drum (which is a standard waste package for HAW), rather than the 210 litre drum.

129. DAW – Appendix F of the RP's gap analysis (Ref. 11) identified that the FCG3 strategy for DAW does not align with UK practices as it does not fully apply the waste hierarchy. The RP identified a gap that DAW could be segregated to make use of alternative treatment and disposal routes available in the UK that are not available in China. The RP's management strategy for ILW/LLW boundary waste DAW (Ref. 32) is decay storage in unconditioned form in 210 litre drums in the ILW ISF. Once decayed to LLW the DAW will be retrieved from the 210 litre drums and sorted and segregated into combustible, metal, un-combustible/compactable and un-combustible/un-compactable wastes. LLW DAW will be repackaged to facilitate off-site treatment, for example the transfer of metallic wastes into metallic boxes. LLW repacking activities are within the scope of operations of the Waste Auxiliary Building (Ref. 56), and are out of scope of my assessment.

4.3.2 ONR Assessment of the Management Strategies for Radioactive Wastes

130. I have assessed the RP's submissions on the management strategies for radioactive wastes against the relevant expectations in ONR SAPs RW.1 on radioactive waste management strategies and ONR SAP RW.4 on the characterisation and segregation of radioactive wastes. I have also considered other sources of RGP including the ALARP TAG, NS-TAST-GD-005 (Ref. 6), NS-TAST-GD-024 on the management of radioactive wastes (Ref. 7), IAEA GSR Part 5 on the predisposal management of radioactive waste (Ref. 16) and IAEA SSG-40 on the predisposal management of radioactive waste from nuclear power plants and research reactors (Ref. 17).

131. For solid ILW (including ILW/LLW boundary wastes) I have also considered RGP in the joint guidance on the management of HAW (Ref. 21) and the adequacy of the RP's consideration of the regulatory expectations in ONR SAP RW.5 on passive safety during storage and ONR SAP RW.6 on the timescales for processing wastes into a passively safe state.

4.3.2.1 Gaseous and Liquid Wastes

132. I consider the RP's overall management strategies for gaseous and liquid radioactive wastes are consistent with RGP and adequately address the relevant regulatory expectations, on the basis of the evidence provided in Chapter 23 of the PCSR (Ref. 4) and its supporting submissions. I accept the RP's case for the use of nitrogen as a cover gas to minimise the explosion risk presented by hydrogen, noting the impact of increased generation of carbon-14 in gaseous and liquid wastes. I accept the RP's case that there are no reasonably practicable techniques available to remove carbon-14 and tritium from liquid and gaseous wastes prior to discharge to the environment, which drew on international OPEX. As noted above the minimisation of radioactive wastes, including carbon-14 and tritium, is considered in sub-section 4.8. I also consider the RP has provided adequate evidence for the selection of rectangular HEPA filters for the UK HPR1000 (Ref. 47), as opposed to cylindrical filters, which are considered to be RGP for new plant in the UK from a radioactive waste management perspective for aspects such as management of the filters to enable disposal and minimisation of leakage during operation.

4.3.2.2 Solid Intermediate Level Waste

133. In my opinion, the RP's management strategies for solid ILW are consistent with RGP, as demonstrated through adequate consideration of OPEX in the solid waste optioneering study (Ref. 53).

134. The RP has also provided adequate evidence that the selected containers and processing of the ILW spent resins and filter cartridges are consistent with the regulatory expectation of ONR SAP RW.5 on passive safe storage.

- The RP's solid waste inventory (Ref. 34) identifies 19 spent filter cartridges are generated every 12 months. The RP's strategy for spent filter cartridges is interim storage in mortuary holes in the WSW receipt and treatment system followed by loading into 3 cubic metre boxes. The cartridges require cementitious grouting in the boxes to produce a passively safe waste form, with 11 being loaded into each box, prior to transfer for storage in the ILW ISF. The WSW receipt and treatment system is required to support the safe accumulation of spent filter cartridges for loading operations. In my opinion the RP has adequately considered the expectations of ONR SAP RW.6 in ensuring the wastes are processed into a passive safe state as soon as is reasonably practicable. There are safety claims on the mortuary holes in the WSW receipt and treatment system for interim storage, which are considered in sub-section 4.6.4.4.
- For spent resins the RP has adequately considered the UK expectations on passive safety during storage against the FCG3 base case and has identified a gap against UK expectations. The RP has conducted adequate optioneering, consistent with the expectations in ONR SAP RW.1, to determine a management strategy which is consistent with regulatory expectations on ONR SAP RW.5 on passive safety. In my opinion, the RP's decision to implement dewatering of the resins in 500 litre drums is consistent with OPEX in the UK and internationally, and implementation prior to storage in the ILW ISF is consistent with the regulatory expectations of ONR SAP RW.6.

135. It is also my judgement that there is adequate evidence in the RP's safety case that the solid ILW inventory is processed into a passively safe form for interim storage to meet the RP's sub-claim 3.3.11.SC23.4.

136. The RP has engaged with RWM on the disposability of the solid ILW packages (Ref. 51). While RWM raised a number of findings for the licensee to address at the site-specific phase, overall RWM concluded that the proposed packages are compatible with a GDF. The RP has produced a response to the findings from RWM's disposability assessment (Ref. 57). In my opinion, the RP's response to RWM's disposability assessment is consistent with the expectations of the Letter of Compliance (LoC) process (Ref. 21) and I did not consider it necessary raise any specific Minor Shortfalls or Assessment Findings. Overall, in my opinion RWM's assessment provides evidence that the UK HPR1000 does not generate radioactive waste of a type or form that is incompatible with disposal to a GDF. Therefore, in my opinion the solid ILW management strategies are consistent with ONR SAP RW.1, including ensuring consistency with Government policy on the long term management of ILW on site prior to disposal to the future GDF (Ref. 23).

137. The TES[SWTS] is designed to collect, characterise, segregate, treat, condition and package solid radioactive wastes generated in normal operation of the UK HPR1000. I assess the safety case for the processing of ILW in TES[SWTS] in sub-section 4.6.4 and the adequacy of the RP's safety case for the storage of ILW (ILW inventory and ILW/LLW boundary wastes) in sub-section 4.7.

4.3.2.3 ILW / LLW Boundary Wastes

138. As assessed in sub-section 4.2, in my opinion, the RP's identification of ILW/LLW boundary wastes, and the selected management strategy to decay store these wastes to enable disposal as LLW is consistent with RGP (Ref. 18) and the regulatory expectation of ONR SAP RW.3 to minimise the accumulation of radioactive waste on the site. Although I have not sampled the management of LLW in my assessment, I take assurance from the fact that the RP's management strategy does not result in the production of radioactive waste which is incompatible with the currently available disposal routes, based on the evidence of the AiP from LLWR (Ref. 55), which meets the expectation of ONR SAP RW.1.

139. The RP has selected a container and processing technique to form passively safe waste forms based upon the final radiological and physicochemical properties of the wastes, to ensure they are compatible with the relevant disposal facilities. This meets the relevant regulatory expectation in ONR SAP RW.1. In my opinion, the RP's strategy to process these wastes into passively safe waste forms suitable for disposal as LLW as soon as is reasonably practicable, and prior to decay storage in the ILW ISF, is consistent with the expectations of ONR SAP RW.6 on passive safety timescales and ONR SAP RW.5 on passive safe storage.

140. The RP's ALARP demonstration report for radioactive waste management (Ref. 46) identifies the use of a shielded cask with the 210 litre drums as a means of protecting workers from radiation doses, which reduces the risks to operators to ALARP. The RP's decision to use a shielded cask with the 210 litre drums during on-site handling, retrieval and transport of the wastes recognises the increased radiological risks associated with the waste packages prior to decay storage, when they are categorised as ILW. In my opinion, the identification of the need to use a shielded cask with the 210 litre drum during on-site activities ensures consistency with the regulatory expectations in ONR SAP RW.5 on ensuring the design of the waste packages is compatible with the handling, retrieval and transport requirements, as well as a means of reducing the radiological risks to workers. The adequacy of the safety case for decay storage of wastes in the 210 litre drum is considered in sub-section 4.7.

141. I also sought clarity on the number of shielded casks the RP considered are needed for the safe on-site management of ILW/LLW boundary wastes by means of RQ-UKHPR1000-1460 (Ref. 38). The RP has indicatively identified the need for nine shielded casks for 210 litre drums; two for ILW/LLW boundary DAW and seven for ILW/LLW boundary waste concentrates and sludges. The RP's safety case does not provide evidence to support this indicative number of shielded casks, which in my opinion is proportionate to the level of detail required at GDA. However, I have raised a Minor Shortfall for the licensee to consider whether the proposed number of shielded casks for 210 litre drums is adequate to support UK HPR1000 operation. This includes consideration of whether the number of shielded casks for DAW is adequate to ensure the safe management of ILW/LLW boundary DAW at peak times, such as during outages, and whether the number of 210 litre drum shielded casks is adequate to support the on-site management of ILW spent filter cartridges. I also note the 210 litre drum shielded cask was not included in the list of SSCs affected by the modifications to address gaps between UK and Chinese practices (Ref. 58), which is assessed in sub-section 4.8 of this report.

142. It is also my judgement that there is adequate evidence in the RP's safety case that the ILW/LLW boundary waste inventory is processed into a passively safe form for interim storage to meet the RP's sub-claim 3.3.11.SC23.4.

143. In my opinion, the RP's consideration of the risk that concentrates and sludges may not decay to LLW is consistent with the expectation in ONR SAP RW.4 paragraph 806, which is to make provision for the management of radioactive wastes that do not meet

the existing process specifications or disposal criteria. However, during my assessment for the closure of RO-UKHPR1000-0040 (Ref. 37) I identified a residual matter due to a lack of clarity in the RP's evidence on when the decision needed to be made on whether the sludges and/or concentrates would be packaged into a 210 or 500 litre drum, for disposal as LLW or ILW respectively. I raised RQ-UKHPR1000-1460 (Ref. 38) seeking clarity on this. In response the RP identified that the cement encapsulation facilities in the TES[SWTS] would require modification to accommodate the 500 litre drum and identified the following mitigation factors:

- The RP's submission (Ref. 59) indicated the sampling / characterisation of the concentrates and sludges is completed prior to cementitious grouting, reducing the risk that ILW concentrates or sludges with an activity level above that which is expected to decay to LLW will be unknowingly grouted into 210 litre drums.
- The RP identified the risk that these materials may not be manageable as LLW and has identified an alternative package (500 litre drum) and disposal route (in a future GDF) for the wastes as ILW at the GDA stage (Ref. 51).
- The RP considered the risk of having to dispose of ILW/LLW boundary wastes as ILW as low, supported by evidence in the form of the AiP from LLWR (Ref. 55), which states the decay of the radionuclides in the concentrates and sludges means the wastes are likely to be suitable for disposal as LLW. LLWR's conclusions are based upon their own independent analysis of the inventory and source term information provided during GDA.

144. Overall, in my opinion the RP has provided adequate evidence that the risk of generating ILW sludges and concentrates that do not decay to LLW is low, and there is thus a low risk of unknowingly grouting ILW for disposal as LLW. This conclusion is supported by independent disposability assessments from LLWR, based on the GDA waste source term information (Ref. 55).

145. Consistent with the good practice identified in the joint guidance for HAW (Ref. 21) the RP has produced a Radioactive Waste Management Case (RWMC) for ILW (Ref. 60). I have sampled the ILW RWMC and, in my opinion, it adequately considers the lifecycle of the UK HPR1000 ILW inventory, and makes adequate reference to both Chapter 23 of the PCSR (Ref. 4) and the IWS (Ref. 32).

4.3.3 Conclusions on the Assessment of Radioactive Waste Management Strategies

146. I consider that the RP's overall management strategies for gaseous, liquid and solid radioactive wastes are consistent with RGP and practices adopted in the UK. The RP has provided adequate evidence of compatibility of the waste management processes with disposal routes, reducing the likelihood of the generic UK HPR1000 design generating radioactive wastes that are non-compliant with disposal routes (Ref. 51, Ref. 55). For the solid ILW and ILW/LLW boundary waste inventory, I consider the RP has provided adequate evidence to meet the safety case sub-claim 3.3.11.SC23.4 that radioactive waste is placed into a passively safe form for interim storage. I have identified no Assessment Findings relevant to the RP's radioactive waste management strategies and a single Minor Shortfall for the licensee to consider whether the number of shielded casks for 210 litre drums is adequate to support UK HPR1000 operation.

4.4 ICIA Management Strategy

147. At the start of Step 4 of the UK HPR1000 GDA I identified shortfalls associated with the strategy and safety case for the management of waste ICIAs and raised RO-UKHPR1000-0037 'In-Core Instrument Assembly Radioactive Waste Safety Case' (Ref. 32). The RO expected the RP to provide adequate evidence on the optioneering undertaken to underpin the selected management strategy for waste ICIAs (winding operations). The purpose of this sub-section is to assess the RP's evidence in addressing the shortfall identified relating to the management strategy for waste ICIAs.

As noted above, approximately 90% of the inventory is categorised as HLW at the time of arising and it thus presents a significant radiological hazard to workers. As a result of RO-UKHPR1000-0037 the RP updated the ‘Management Proposal of Waste Non-Fuel Core Components’ (Ref. 61). My assessment here considers the adequacy of the evidence in the updated safety case submission, and not of previous versions.

4.4.1 The RP’s Submissions on the ICIA Management Strategy

148. The RP’s selected waste management strategy (Ref. 61) is consistent for all waste ICIAs (Type i, ii & iii), with further details on the ICIA types already provided in sub-section 4.2. The RP’s strategy (Ref. 61) is to size reduce the waste ICIAs prior to packaging in a 500 litre robust shielded drum for storage. Size reduction is achieved after removal of the lower source term region. This is achieved through the use of a shielded winding machine to extract and bundle (coil) the higher source term regions (both HLW and ILW) of the waste ICIAs as they are removed from the RPV upper internals, as shown in Figure 1. The RP’s safety case uses the characteristics of the waste HLW ICIAs (Ref. 41) to define the waste package for all waste ICIAs. The RP decided to use a 500 litre robust shielded drum (with steel liner) for the storage of eight ICIAs. 500 litre robust shielded drums are used for ICIAs which are both HLW and ILW at the time of retrieval. The RP’s waste loading of eight waste ICIAs per 500 litre robust shielded drum (with steel liner) is based upon preliminary shielding calculations (Ref. 34).

149. The UK HPR1000 ICIA winding operations are consistent with the baseline strategy for management of waste ICIAs for FCG3. The RP has provided evidence that there is limited OPEX relevant to the winding machine from the wider Chinese fleet (Ref. 61). There is no OPEX in the UK for the use of the ICIA winding machine.

150. The RP provided information on the ten key steps of the winding operations, of which the first eight are presented in schematic diagrams in Figure 1:

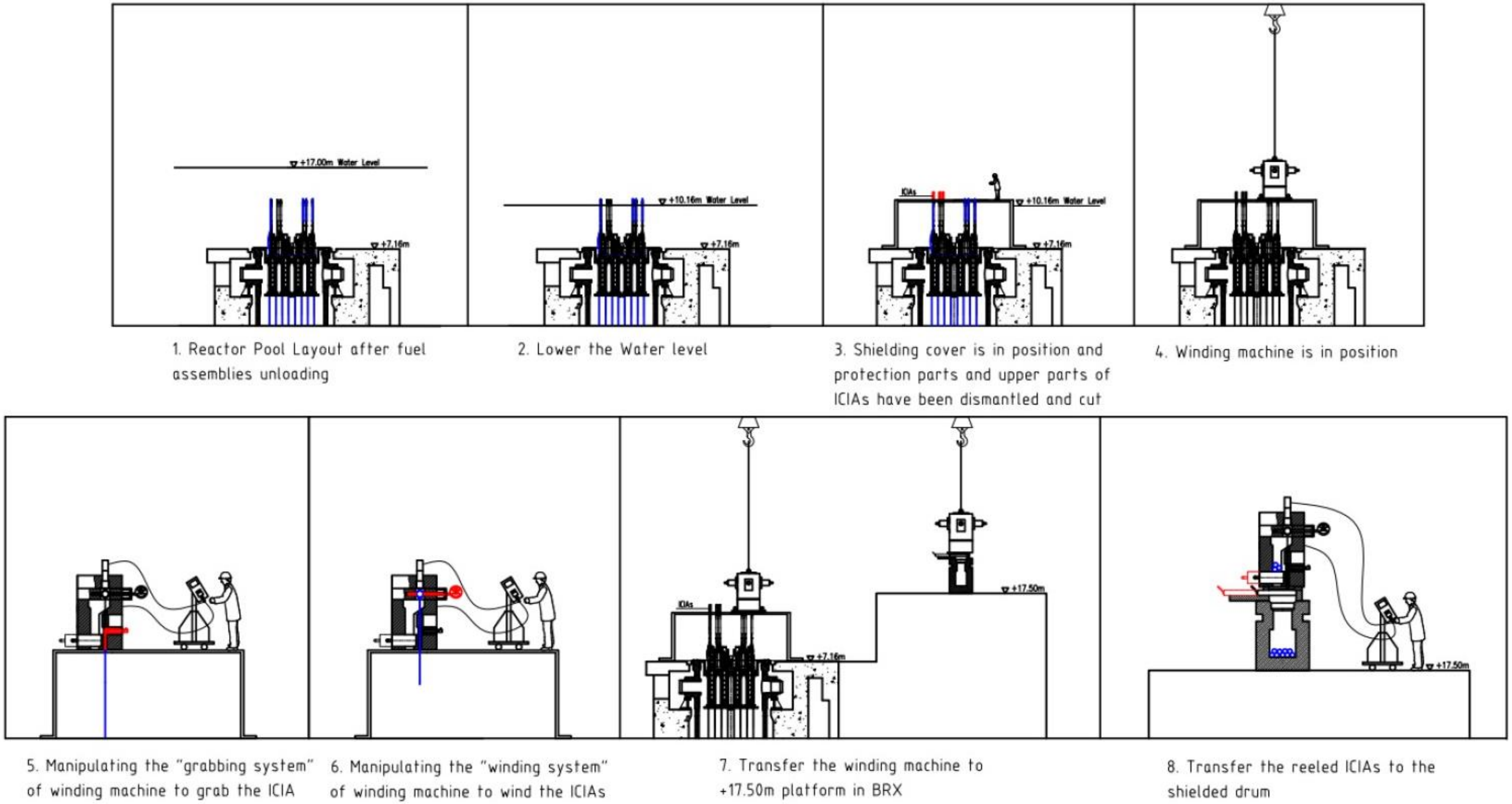
- Step 1: Fuel assemblies are unloaded and the upper internals (with ICIAs) returned to the RPV. The reactor pool water level is at +17.00m.
- Step 2: The water level is lowered to +10.16m.
- Step 3: A shielding cover is lifted on to the top of the RPV, sitting on the mating surface of the RPV. The shielding cover is guided/positioned by three guiding columns temporarily installed on the RPV.
- Step 4: The protecting parts of ICIAs are manually removed and are managed as part of the LLW DAW stream.
- Step 5: After the protecting parts have been removed the upper part of the ICIA, with the lower source term region, is segregated from the higher source term region by cutting. The upper part is categorised as LLW and is managed as part of the DAW stream. The RP’s management strategy identified the cutting process and position as being determined during the detailed design stage beyond GDA.
- Step 6: After removal of the protecting parts and upper part, the winding machine is placed on the top of the shielding cover. The winding machine will automatically grab the ICIA, extract and wind the remaining part of the ICIA into a bundle inside the machine.
- Step 7: After winding 3~4 ICIAs into the winding machine body, the winding machine is transferred to the +17.5m platform.
- Step 8: A 500 litre robust shielded drum with steel liner is positioned on the +17.5m platform with a drum adaptor to enable the winding machine to mate to the drum and be emptied.
- Step 9: Once the 500 litre robust shielded drum is fully loaded the drum is lidded using the crane, with the lid lowering through the drum adaptor.

- Step 10: The waste packages are transferred from the Reactor Building to the relevant store. HLW packages (Type i&ii ICIAs) are transferred to the SFIS Facility, ILW packages (Type iii ICIAs) to the ILW ISF.

151. Step 5 of the process includes the segregation of the lower source term region from the higher source term region. The RP's management strategy for the HLW and ILW parts of the waste ICIAs assumes segregation from the lower source term region. The management of the lower source term region as LLW, once segregated, is outside the scope of this assessment.

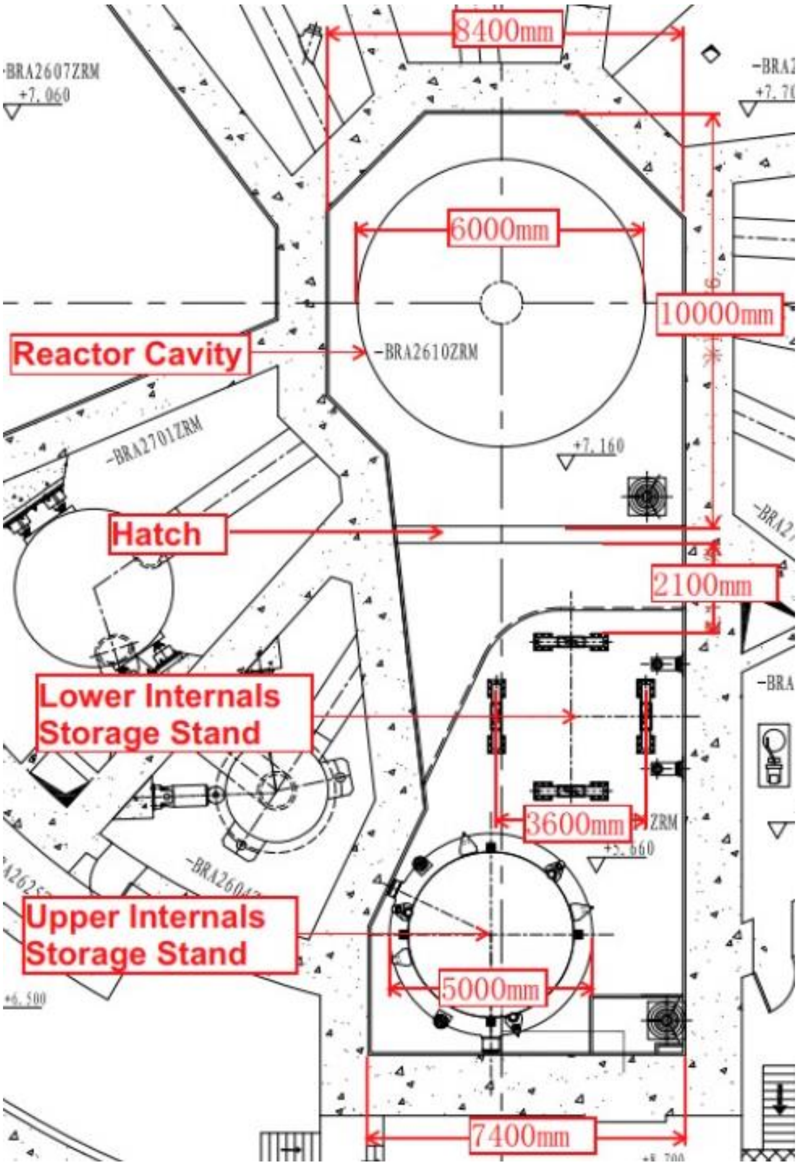
152. The RP's safety case (Ref. 61) states that the lower source term region of the ICIAs is physically identifiable by operators as this region is above the upper internals when the shielding cover is installed. The 'Management Proposal for Waste NFCCs' (Ref. 61) provides further information on how the cutting position can be determined by the licensee during the detailed design of the operations.

Figure 1: ICIA Winding Process Summary from *(Ref. 61)*



153. The RP's management strategy (Ref. 61) includes several diagrams of the SSCs required for the ICIA winding operations and photographic images of similar equipment used outside the UK. The RP also provides further information on operations such as removal and storage of the RPV upper internals during defuelling activities (prior to step 1 on paragraph 150). This requires the use of the upper internals stand in the Reactor Building, accessed via a hatch, shown in Figure 2 which is discussed in sub-section 4.4.2 below.

Figure 2: UK HPR1000 Reactor Building Showing the Upper Internals Storage Stand Relative to the Reactor Cavity



4.4.2 ICIA Management Strategy Assessment

154. ONR's guidance on the demonstration of ALARP, NS-TAST-GD-005 (Ref. 6), includes a specific annex (Annex 2) on ALARP proposals for new civil nuclear reactors. Annex 2 identifies the requirement for ONR to consider the facility's design as a whole, to make a judgement on whether the reactor design represents an ALARP outcome. This is an important aspect of my assessment of the management strategy for ICIAs because of the nature of the management of ICIAs as an integral part of reactor operations.

155. Given the lack of OPEX available worldwide for the use of the ICIA winding machine, none of which is available in the UK, I considered the use of the winding machine and

associated operations to be novel in the UK context and did not align with practices adopted by UK licensees for management of ICIAs.

156. ONR SAP RW.1 paragraph 793 (h) and (i), identifies the regulatory expectations for the RP to consider a full range of options during the development of the management strategy, and to justify the chosen option in the safety case.

157. The RP's optioneering (Ref. 61) considered and discounted the following options:

- Using the SFP for storage of intact ICIAs. The RP provided evidence that the transfer of intact ICIAs is not compatible with the transfer facilities between the Reactor Building and the SFP due to size constraints. The transfer facilities are designed to accommodate SFAs up to 4.3m long, whereas the ICIAs are up to 12m long. In addition, the water level in the reactor pool, which occupies the space above the reactor cavity, is insufficient to provide adequate shielding of the higher source term region of ICIAs during extraction of intact Type i&ii ICIAs.
- Cutting waste ICIAs as they are extracted from the upper internals into lengths that are compatible with the transfer facilities. This option would enable waste ICIAs to be loaded into a container for transfer from the Reactor Building to the SFP for storage. ICIAs could later be retrieved and packaged as ILW for dry storage in the ILW ISF.
  The cutting of waste ICIAs would need to occur in the reactor cavity, which is shown in Figure 2. Cutting operations would be completed under water, to maintain shielding. The RP identified no OPEX relevant to underwater cutting in the reactor cavity during the operational phase of a reactor, with OPEX limited to application during decommissioning. In addition, the RP's optioneering considered the increased risk of cutting debris entering the primary circuit as a result of the increase in the number of cuts and the increase in secondary waste arising from the use of containers for in-pond storage as well as storage in the ILW ISF.
- Installing a separate instrument pool within the Reactor Building for decay storage of waste ICIAs. This was discounted as this could not be accommodated within the current Reactor Building design without significant modification.
- Completing the winding operations when the upper internals, with ICIAs, are stored in the upper internals stand (situated in the Reactor Building but away from the RPV, as shown in Figure 2. This was not considered to be feasible as the strategy would still require a shielded cover over the top of the upper internals when on the stand. In this position the shielded cover would need to be approximately 8m long, however the inner diameter of the Reactor Building equipment hatch is only 8.3m. Therefore, the cover could not easily be lifted to the upper internals stand without significant modification (Ref. 61). Figure 2 shows the positioning of the upper internals stand relative to the reactor cavity, and the location of the hatch which limits the ability to implement winding operations on the upper internal stand. This provided evidence to support the RP's arguments why the options discussed could not be reasonably implemented into the generic UK HPR1000 design, such as the limited space within the area and access hatch size constraints.

158. In my opinion, the improvements in the optioneering made by the RP to the safety case as a result of RO-UKHPR1000-0037 are consistent with the regulatory expectations in ONR SAP RW.1, to consider the full range of options when developing the radioactive waste management strategy, and to refer to the other options considered when justifying the chosen option. The options presented by the RP are consistent with my understanding of relevant practices for management of ICIAs in the UK. In my opinion, the optioneering provides adequate arguments and evidence to underpin the selection

of the winding machine for the retrieval of waste ICIAs in the generic UK HPR1000 design.

159. Overall, I consider the evidence provided in the RP's optioneering identifies that the generic UK HPR1000 design forecloses options for the management of waste ICIAs, with the RP demonstrating that the winding operations are the only reasonably practicable means of managing waste ICIAs. I consider this further in my assessment of the ICIA winding operations safety case in sub-section 4.5.

160. I raised RQ-UKHPR1000-1282 (Ref. 38) to seek further information on the handling and management of the SSCs required for the ICIA waste management strategy, with the support of the ONR Mechanical Engineering and Radiological Protection specialist inspectors. This information is now included within the RP's safety case (Ref. 61) and is considered in my assessment where relevant. The RP's response to RQ-UKHPR1000-1282 provided:

- Information on the decontamination and storage of the shielded cover, winding machine, and drum adaptor, when not in use.
- Specific information on the size of the winding machine and shielded cover, and how the generic UK HPR1000 design enables these to be safely handled/moved inside and outside the Reactor Building.
- Details on how the shielded cover is positioned over the RPV, including the need to use the RPV head guiding columns.
- Further information on the holes in the shielded cover to allow the ICIA upper parts to penetrate, required for both cutting and winding operations.
- Details of the use of seals/covers and guardrails on the shielded cover and holes to reduce the likelihood of any cutting debris (if generated) from entering the defuelled RPV and for conventional health and safety purposes.

161. In my opinion, the RP's safety case provides adequate evidence that the winding machine is the only reasonably practicable management strategy for the retrieval of waste ICIAs, considering RGP, OPEX and the constraints within the UK HPR1000 design. In my opinion, the winding equipment is novel and therefore is not consistent with RGP in the UK. However, the evidence provided by the RP is consistent with regulatory expectations to articulate why there are no further reasonably practicable improvements that could be implemented within the generic UK HPR1000 design without significant modification to the Reactor Building. Therefore, in my opinion, the strategy for the management of ICIAs represents the ALARP outcome for the generic UK HPR1000 reactor design.

162. The RP's selected strategy for the storage of waste ICIAs in both the SFIS Facility and ILW ISF includes consideration of the decay storage period (approximately 14 years) of HLW ICIAs in the SFIS Facility and the timing of transfers to the ILW ISF. In my opinion the submission is consistent with the regulatory expectations of ONR SAP RW.1 paragraph 793 including, but not limited to, item (g) to encompass the anticipated timescales for the management of radioactive waste, including intermediate steps in the radioactive waste management strategy.

163. Consistent with the good practice identified in the joint guidance for HAW (Ref. 21) the RP has produced a Radioactive Waste Management Case (RWMC) for HLW (Ref. 62). The HLW RWMC considers spent fuel, and NFCCs, including ICIAs. To remove the risk of inconsistencies, the RP has decided to use the HLW RWMC for both ICIAs categorised as ILW and HLW upon arising. In my opinion this is appropriate given the only difference in the strategies is a period of decay storage in the SFIS Facility for HLW ICIAs. I have sampled the HLW RWMC and, in my opinion, it adequately considers the lifecycle of the UK HPR1000 HLW inventory, and makes adequate reference to Chapters 23 and 29 of the PCSR (Ref. 4, Ref. 63), the management proposal of waste NFCCs (Ref. 61) and the IWS (Ref. 32).

4.4.3 ICIA Management Strategy Conclusions

164. Overall, in my opinion the RP has provided adequate evidence that it has considered the full range of options in developing the ICIA management strategy, including the decision to implement the ICIA winding operations for the retrieval of waste ICIAs, consistent with the regulatory expectations of ONR SAP RW.1. Consistent with Annex 2 of ONR ALARP TAG, NS-TAST-GD-005 (Ref. 6), it is my judgement that, even though the use of the winding equipment is novel and therefore is not consistent with RGP in the UK, the RP has provided adequate evidence to articulate why there are no further reasonably practicable improvements that could be implemented within the generic UK HPR1000 design. The management strategy selected also takes account of nature of the management of ICIAs as an integral part of reactor operations. Therefore, in my opinion, the strategy for the management of ICIAs represents the ALARP outcome for the generic UK HPR1000 reactor design.

4.5 ICIA Winding Operations Safety Case

165. As noted in sub-section 4.4. at the start of Step 4 of the UK HPR1000 GDA I identified shortfalls associated with the strategy and safety case for the management of waste ICIAs and raised RO-UKHPR1000-0037 ‘In-Core Instrument Assembly Radioactive Waste Safety Case’ (Ref. 10). Prior to RO-UKHPR1000-0037 the RP’s safety case provided little to no evidence of consideration of the hazards associated with the management of waste ICIAs during retrieval, packaging, handling, and storage operations. As a result of this RO the RP provided two new submissions relevant to the safety case for the management of waste ICIAs, aimed at addressing the shortfalls, these are:

- ‘Process Risk / Hazards Analysis for ICIAs Retrieval and Processing Operations’ (Ref. 64)
- ‘Process Risk / Hazards Analysis for ICIAs Packaging, Handling and Storage Operations’ (Ref. 65)

166. My assessment of the waste ICIA safety case is split into two sub-sections aligned with these new submissions, namely ‘Retrieval and Processing’, and ‘Packaging, Handling and Storage Operations’.

4.5.1 The RP’s Submissions on the ICIA Winding Operations Safety Case

4.5.1.1 Retrieval and Processing

167. The scope of the waste ICIA retrieval and processing operations are summarised in Steps 1-10 listed in sub-section 4.4 and illustrated for Steps 1 – 8 in Figure 1. These represent the operations undertaken within the Reactor Building.

168. Step 1 - The safety case (Ref. 64) provides evidence on how the generic UK HPR1000 design enables the RPV to be fully defuelled prior to retrieval of waste ICIAs. This is achieved using a separate reactor cavity to store the RPV upper internals (including ICIAs) during defuelling operations, as shown in Figure 2. The upper internals are returned to the RPV once the reactor is defuelled to enable waste ICIA retrieval (winding) operations.

169. Steps 2-3 and 6-9 – Section 4 of the safety case (Ref. 64) describes the RP’s consideration of the hazards and risks for normal operation and fault conditions associated with the decision to implement the winding machine strategy for ICIAs in the Reactor Building. The RP’s risk assessment considers radiological hazards, conventional safety hazards, and both internal and external hazards. Several SSCs are identified in the RP’s safety case as being key to the demonstration that the risks from normal operations are reduced to ALARP, and that the faults associated with the

management of the ICIAs have been prevented and/or mitigated. The SSCs identified include:

- the winding machine and associated systems;
- the shielding cover for the top of the RPV;
- the robust shielded 500 litre drum for the storage of waste ICIAs (with steel liner);
- the drum adaptor, which interfaces between the winding machine and robust shielded drum (and maintains shielding); and
- relevant handling equipment.

170. The RP's qualitative risk assessment identifies the consequences of radiation exposure to personnel in faults as "Major, 4" (where a scale of 1-5 is used by the RP for qualitative risk assessment). The 'Management Proposal for Waste NFCCs' (Ref. 61) identifies a collective dose limit of 10 mSv for the group undertaking the entire ICIAs winding activities during normal operation, taking account of the claims made on the SSCs for reducing the radiological risk SFAIRP. The 'Waste Inventory for Operational Solid Radioactive Waste' (Ref. 34) identifies the surface dose rate of an unshielded package (unmitigated dose) of between 1.02-1.40 $x10^5$ mSv/hr (102-140 Sv/hr). The package consists of up to eight HLW ICIAs and therefore represents the bounding dose associated with a fault during the winding operations.

171. The RP's safety case (Ref. 64) identifies the need to determine the Operating Limits and Conditions (OLCs) in the interest of safety during the retrieval and processing of waste ICIAs within the Reactor Building. This will be addressed during the detailed design of the SSCs beyond the GDA stage. The SSCs are currently only at concept design so the generic UK HPR1000 safety case identifies two qualitative OLCs linked to demonstrating the radiation doses from the operations are reduced to ALARP, these are:

- OLC1, associated with the water level in the Reactor Building reactor pool due to the shielding function provided by the water.
- OLC2, associated with monitoring and controlling the radiation dose within the working areas during operations.

172. Steps 4-5 - As discussed in sub-section 4.4, the RP's safety case is clear that the lower source term region on the waste ICIA is physically above the upper internals of the RPV and the higher source term region is below the shielded cover (once in place) and is inaccessible without winding. The safety case (Ref. 61) indicates the cut to remove the lower source term region will occur after the removal of the protecting parts of the ICIAs as they protrude through the shielded cover and above the upper internals of the RPV. The RP's safety case identifies the requirement to implement a manual process (long torque pliers or hydraulic scissors) to cut the lower source term region. The exact cutting position and cutting tool is to be defined as part of the detailed design and is therefore beyond the scope of GDA.

4.5.1.2 Packaging, Handling and Storage Operations

173. The scope of the waste ICIA packaging, handling and storage operations are summarised in Step 10 in sub-section 4.4. The safety case (Ref. 65) for Step 10 focuses on the risks/hazards associated with the handling and storage of fully loaded ICIA waste packages, including movement within the Reactor Building and between/in the stores. The key activities for which the RP has considered the hazards and risks, in both normal operations and fault conditions, are summarised in **Table 3** (Ref. 65).

174. Step 10 operations are wide ranging and the RP's safety case addressed a range of matters including the suitability of the 500 litre robust shielded drum for the safe

storage of waste ICIAs, the safety case for handling and lifting of the 500 litre robust shielded drum, and the safety case for the storage of the waste packages.

Table 3: Summary of ICIA Waste Package Handling Operations

	Activities	Building/Location
1	Mounting of bolts of waste package	Reactor Building
2	Lifting and handling the waste package by crane or dolly (dolly with rail)	Reactor Building / Safeguard Building
3	Lifting, handling, and stacking the waste package by forklift truck or crane	SFIS Facility / ILW ISF
4	Monitoring, inspection, and maintenance of waste packages	SFIS Facility / ILW ISF
5	Storage of waste packages	SFIS Facility / ILW ISF

175. The RP's risk assessment for the ICIA package, handling, and storage operations makes clear safety claims on several SSCs in normal operations and for the prevention, protection, and mitigation of faults which may impact on the passive safe storage of HLW ICIAs. The key SSCs and claims are:

- 500 litre robust shielded drum: The integrity of the waste package is claimed to passively maintain adequate containment, shielding and heat management throughout the package lifecycle;
- Handling equipment: The reliability of the handling equipment is claimed to reduce the likelihood of a dropped load fault both in the Reactor Building and in the two storage facilities. This includes the use of the Reactor Building 200t polar crane and 90t transport dolly, and a forklift truck in the storage facilities;
- Storage facilities: sub-section 6.1.3 of the RP's safety case (Ref. 65) provided evidence of the RP's consideration of the storage options for waste ICIAs. The RP's safety case identifies the requirement to store HLW ICIA packages (Type i&ii ICIAs) in the SFIS Facility for approximately 14 years, during which time they are expected to decay to ILW. Once ILW they are transferred to the ILW ISF for storage until ultimate disposal to a GDF. ILW ICIA packages (Type iii ICIAs) are stored in the ILW ISF from the point of generation until ultimate disposal to a GDF. Claims are made on the supporting arrangements for lifting, handling, storage, monitoring and inspection of the packages in the stores.

176. For storage of waste ICIAs two facilities are identified, the SFIS Facility and ILW ISF. The SFIS Facility and ILW ISF are at the stage of concept design for GDA.

- ILW ISF: The adequacy of the RP's safety case for the safe storage for ILW packages, including robust shielded 500 litre drums within the ILW ISF, is considered in sub-section 4.7 of this report. This includes the ILW ISF construction strategy, storage capacity, design and stacking arrangements, hazards and risks during storage in the ILW ISF, OLCs and EIMT requirements.
- SFIS Facility: The safety case (Ref. 65) identifies requirements for the specific ICIA store within the SFIS Facility which is integrated into the SFIS Facility design (Ref. 66). My assessment of the SFIS Facility design, construction strategy and layout is presented in the SFIS assessment report (Ref. 13). My assessment here considers the adequacy of the RP's safety case for the safe storage of HLW ICIAs in the SFIS Facility against the regulatory expectations in

ONR SAP RW.5 on passive safety during storage, and ONR SAP ENM.2 on ensuring designated storage facilities are identified with adequate capacity.

177. The number of 500 litre robust shielded drums required for HLW ICIAs generated is based upon the inventory from 60 years of operations of a single UK HPR1000 reactor unit. The RP's safety case conservatively assumes 15 years of decay storage in the SFIS Facility prior to transfer to the ILW ISF (evidence indicates 14 years of decay storage is required) and indicates the HLW ICIA store needs to be able to safely accommodate 50 HLW 500 litre robust shielded drums. The number of HLW ICIAs has been calculated through consideration of the ICIA service life and the number of ICIAs in the reactor core (Ref. 34).

178. The RP's safety case (Ref. 65) also identifies qualitative parameters that will need to be considered as OLCs as the detailed design progresses beyond the GDA stage. There are seven OLCs captured in Table T-5-1 in the RP's submission (Ref. 65). The OLCs are based upon four key requirements (Ref. 65), which are:

- Protection of workers from radiation exposure. This includes consideration of the waste loading and shielding properties of the 500 litre robust shielded drum, as well as control of the surface dose rate and contamination levels.
- Control of lifting and handling. This includes consideration of the lifting height and control of movement speeds to prevent packages from dropping or being damaged if dropped.
- Passive safety of the package during storage. This includes waste package integrity and consideration of environmental conditions within the store(s) to minimise corrosion of the waste package.
- Safe stacking height. The stack heights should be determined based upon the accident performance of the waste package.

4.5.2 Assessment of the ICIA Safety Case

4.5.2.1 Retrieval and Processing

179. Step 1 – Establishing the status of the RPV as fuelled or defuelled is key in understanding the nuclear safety risk associated with the implementation of the waste ICIA management strategy in the Reactor Building. I raised RQ-UKHPR1000-1281 (Ref. 38), which sought information on the movement and management of the upper internals of the RPV which takes place prior to implementation of the winding operation to remove ICIAs. As a result of the RQ, the RP modified the safety case to provide additional clarity, including the addition of Figure 2.

180. The RP has included the RPV upper internals stand in the generic UK HPR1000 design. This component enables removal and storage of the upper internals and ICIAs from the reactor core during defuelling, thereby eliminating the need to retrieve and process the waste ICIAs over a fully loaded reactor core. In my opinion, and through discussions with the ONR Mechanical Engineers and Fuel and Core specialist inspectors, this design feature provides clarity that the risk of damaging fuel assemblies from implementation of the winding operations is eliminated. This is consistent with the regulatory expectations of ONR SAP EKP.1 for the facility to be inherently safe by design.

181. Steps 2-3 and 6-9 - In my opinion the RP has provided a clear and logical description of the hazards and risks associated with the retrieval and processing of waste ICIAs, including faults associated with the activities undertaken within the Reactor Building (Ref. 64). The safety case makes clear claims on the SSCs to reduce the risks to ALARP. Sub-section 4.4 addressed my assessment of the ICIA management strategy, and I have concluded that the RP's optioneering demonstrates that the generic UK HPR1000 design forecloses options for the management of waste ICIAs, with the

winding operations being the only reasonably practicable means of managing waste ICIAs. Given the unmitigated doses associated with the operations, the novel application in the UK, the foreclosure of options and the claims on the SSCs to reduce the risks to ALARP, in my opinion it is proportionate to identify an Assessment Finding on the detailed design of the SSCs. This is consistent with the residual matter identified in my closure of RO-UKHPR1000-0037 (Ref. 36). I am thus raising an Assessment Finding to ensure regulatory oversight is maintained at the site specific phase of the licensee's detailed design of the SSCs for the ICIA winding operations, where the generic UK HPR1000 safety case makes clear claims on reducing the risks to ALARP.

AF-UKHPR1000-0177 - The licensee shall, as part of the detailed design, demonstrate that the key structures, systems and components associated with waste in-core instrument assembly winding operations reduce risks so far as is reasonably practicable. This includes, but is not limited to the:

- winding machine and associated systems;
- shielding cover;
- robust shielded 500 litre drum (with steel liner);
- drum adaptor; and
- relevant handling equipment.

182. Steps 4-5 – ONR SAP RW.4 identifies the regulatory expectation to provide suitable and sufficient design features, locations, equipment and arrangements to support characterisation and segregation. In my opinion, the safety case adequately describes how the future operator is able to distinguish between the lower source term and higher source term region of the waste ICIAs, consistent with the expectations of ONR SAP RW.4. The requirement to extract/wind the ICIA to enable access to the higher source term region, in my opinion, reduces the likelihood of the operator being exposed to the high source term region during manual cutting operations. My conclusions do not negate the requirement for the licensee to define the cutting location during the detailed design but consider this will be defined as part of the normal development of the design at the site specific phase. Aspects such as additional monitoring during the cutting/segregation activities, form part of the scope of the assessment by ONR Radiological Protection specialist inspectors (Ref. 26).

4.5.2.2 Packaging, Handling and Storage Operations

183. Step 10 **–** In my opinion, the RP's identification of the 500 litre robust shielded drum as the primary means of maintaining containment is consistent with the regulatory expectations of ONR SAP ECV.3. ICIAs are activated metal components, and the radioactive component is fixed in the waste item, with minimal surface contamination expected. The risk of surface contamination arises from effluent carry over from the primary coolant. However the surface area of the ICIAs is small, and therefore carry over is expected to be minimal and to largely remain within the ICIA winding machine (Ref. 64). The RP's safety case includes the provision to decontaminate the winding machine, if required (Ref. 64). The RP's safety case (Ref. 65) states that contamination swabs of the outside of the packages (drums) will be taken to demonstrate the containment is maintained and to reduce the risk of spreading contamination. No additional containment barriers are claimed in the safety case, although the stores/buildings themselves also provide some means of confining radioactive material in a fault where the primarily containment barrier has been compromised. In my opinion it would be disproportionate to define a secondary containment barrier beyond the buildings due to the expected absence of radiological

contamination of the waste ICIAs. I consider the RP's safety case is consistent with the expectations of ONR SAP ECV.4.

184. The RP's strategy for the safe storage of ICIAs identifies the requirement for separate storage facilities in the SFIS Facility for the decay storage of HLW ICIAs, prior to transfer to the ILW ISF once decayed to ILW. The basis for two separate storage facilities is consistent with ONR SAP RW.4, on ensuring suitable and sufficient locations to support segregation of radioactive waste, and to facilitate its subsequent safe and effective management. The RP's decision to store HLW ICIAs in the SFIS Facility is consistent with strategies proposed in previous GDAs, as identified by the RP in the SFIS Facility design (Ref. 66). In my opinion maintaining the segregation of 500 litre robust shielded drums with HLW and ILW ICIAs, by means of removal of drums from the SFIS Facility once the ICIAs have decayed to ILW, ensures the expectations on segregation in ONR SAP RW.4 are maintained throughout the period of on-site storage.

185. There are two aspects which could challenge the integrity of the 500 litre robust shielded drum; the heat generated by the HLW ICIAs and a dropped load fault which I consider in the following paragraphs.

186. Heat Management: In my opinion the RP's safety case (Ref. 65) places appropriate emphasis on ensuring passive means of heat removal are implemented, so far as is reasonably practicable. I consider this to be consistent with the regulatory expectations in ONR SAP RW.5 relating to storage in a condition of passive safety. The demonstration of passive means of heat removal in the RP's safety case is based on the claims on the suitability of the 500 litre robust shielded drum to passively withstand the heat loading of waste ICIAs during storage without the need for active cooling. Thus, jointly with the ONR Mechanical Engineering specialist inspectors, I sought clarification of the RP's evidence that the 500 litre robust shielded drum is suitable for the safe storage of HLW with the thermal properties of the ICIAs, by means of RQ-UKHPR1000-1188 (Ref. 38).

187. In response the RP's safety case (Ref. 61) now refers to the datasheet for an example supplier of 500 litre robust shielded drums. The datasheet clarifies that the thermal limit for activated components is 300W, where ICIAs are a sub-group of activated NFCCs. The RP's waste inventory (Ref. 34) provides an average and maximum package heat output of 31.7W and 43.7W respectively for eight HLW (type i&ii) ICIAs in a single drum. In my opinion, the RP has provided adequate evidence there are suppliers of existing 500 litre robust shielded drums with steel liners which are capable of passively storing the ICIAs with the thermal characteristics of those arising from operation of the UK HPR1000.

188. Dropped Load Faults: The RP's safety case (Ref. 65) makes several claims for the reliability of the handling equipment and the withstand of the 500 litre robust shielded drum in dropped load faults:

- Within the Reactor Building the operations require the use of the 200t polar crane and 90t transport dolly on a rail. The ICIA handling safety case (Ref. 65) makes claims on the reliability of such equipment. In discussions with the ONR Mechanical Engineering specialist inspector we concluded that the ICIA operations do not present the bounding aspect of the RP's safety case assessment (i.e. the ICIA package does not represent the bounding mass or most complex lift). For example, the loaded robust shielded container with HLW ICIAs weighs ~ 8.6t, the crane can lift up to 200t and the transport dolly 90t (Ref. 65). However, the reliability also depends upon the components which interface with the polar crane, which enable the lifting/movement of the ICIA specific equipment. This aspect is not just limited to the 500 litre robust shielded drum, but is also relevant to aspects such as lifting/movement of the shielded cover, winding machine and drum adaptor in the Reactor Building. The lifting components will form part of the detailed design of winding operation SSCs and is captured in Assessment Finding AF-UKHPR1000-0177.

- Within the SFIS Facility and ILW ISF, claims are made on the shielding provided by the 500 litre robust shielded drum to enable the use of forklift trucks for package emplacement activities. Based upon my experience, the use of forklift trucks for the movement of shielded waste packages is not novel in the UK. The adequacy of the 500 litre robust shielded drum and the provision of shielding for both HLW and ILW ICIAs will form part of the RP's detailed design of the SSCs. The waste loading per 500 litre robust shielded drum (with steel liner) has been determined by the RP on the basis of ensuring the package maintains adequate shielding. Shielding is dependent upon the detailed design of the package and therefore has not been assessed further during GDA by me or by the ONR Radiological Protection specialist inspectors (Ref. 26). Assessment Finding AF-UKHPR1000-0177 includes the requirement for the licensee to demonstrate that the detailed design of the 500 litre robust shielded drum (with steel liner) reduces the relevant radiological risks to ALARP.
  The ONR Radiological Protection assessment report (Ref. 26) considers the adequacy of the RP's safety case of the ICIA operations for aspects such as occupational exposures. I consider the RP has adequately identified the requirement to define limits and conditions in the interests of safety relevant to protection of workers from radiation exposure during ICIA operations, which will be addressed in the detailed design of the SSCs beyond the GDA stage. I consider this position is consistent with the expectations of ONR SAP SC.6 on operating limits and conditions, appropriate to the GDA stage.
- The safety case (Ref. 65) refers to OPEX in the UK for a similar container (a robust shielded container without a steel liner) to demonstrate the container can be fabricated to withstand the drop heights specified in the generic UK HPR1000 design. Withstanding the drop height means that containment is maintained during dropped load faults. RQ-UKHPR1000-1421 (Ref. 38) was raised jointly by the ONR NLR, Mechanical Engineering and Radiological Protection specialist inspectors to seek clarification of the two risk/hazard analysis submissions (Ref. 64) and (Ref. 65). In response the RP provided clarity on the maximum lifting height and lifting path of the 500 litre robust shielded drum in the safety case and on the relevance of the OPEX referenced. The OPEX showed that the maximum withstand of the 500 litre robust shielded drum without a steel liner is based on a lifting height of 4.5m (equivalent to a 3 high stack). The maximum lift height is 2m for the robust shielded drum throughout the operations, with a stack height of 2 assumed during storage in both the ILW ISF and SFIS Facility. This provides confidence that the OPEX provided on the robust shielded container without a steel liner is appropriate for the UK HPR1000 design. In my opinion, the delivery of the requirements on the integrity of the robust shielded drum with steel liner during handling (lifting) operations forms part of the development of the detailed design beyond GDA and is captured in Assessment Finding AF-UKHPR1000-0177.

189. As noted, ONR SAP SC.6 identifies the regulatory expectation that the safety case should identify important aspects required to maintain safety, including operating limits and conditions. In my opinion, the RP's safety case (Ref. 65) adequately acknowledges the requirement to define limits and conditions in the interests of safety for the control of lifting and handling of waste ICIA packages, taking into account discussions with the ONR Mechanical Engineering specialist inspectors. This includes claims on limiting the lifting height in the generic UK HPR1000 design to prevent and mitigate against the consequences should the package be dropped. The safety case identifies the requirement to consider defining these quantitatively during the detailed design of the SSCs for the winding operation. In my opinion the information provided is

proportionate to the level of detail available at GDA and is consistent with the regulatory expectations in ONR SAP SC.6.

190. Passive Safe Storage: ONR SAP RW.5 identifies regulatory expectations for the RP's safety case to demonstrate the continued safe storage of radioactive waste for the planned storage period, including demonstrating that the radioactive waste is stored in a passively safe condition. RGP in NS-TAST-GD-024 (Ref. 7) identifies that the radioactivity in activated uncontaminated metals is considered immobile by virtue of the nature of the material. This is consistent with the RP's assumption for the waste ICIAs. I concur with the RPs assessment that the risk of surface contamination from primary coolant carrier over is low due to the limited surface area of the ICIAs and controls in place for the management of contaminants in the primary coolant.

191. Passively safe interim storage is one of the RP's case key sub-claims in Chapter 23 of the PCSR (Ref. 4). Consistent with the expectations in SAP RW.5 on storage of radioactive waste, the RP's safety case identifies good engineering principles for the storage of the selected waste packages (ONR SAP paragraph 812 sets out good engineering practices for the storage of radioactive wastes). The RP's safety case includes ensuring the waste form and its container are physically and chemically stable and the need for active safety systems is minimised. As ICIAs are immobile by virtue of the nature of the material, there is no addition of encapsulant or other materials to the waste ICIAs in the drum. Therefore the RP's safety case places all claims for containment and structural strength on the 500 litre robust shielded drum. The RP has selected a single container type (500 litre robust shielded drum) for the storage of both heat generating (HLW) and non-heat generating (ILW) waste ICIAs.

192. The RP's safety case makes no claims on the SFIS Facility storage area or the ILW ISF itself for the passively safe storage of ICIAs, placing all claims on the 500 litre robust shielded drum. My assessment of the adequacy of the ILW ISF storage areas is presented in sub-section 4.7. The RP's safety case for the SFIS Facility (Ref. 66) identifies the need to determine an appropriate EIMT regime for the ICIA waste packages to ensure the containers remain stable in the HLW storage area. This will be developed during detailed design at the site-specific stage.

193. In my opinion, the RP's safety case adequately identifies aspects required to maintain safety during the storage of the packages, including limits and conditions in the interests of safety and EIMT requirements. This is, in my opinion, consistent with the regulatory expectations of ONR SAP SC.6 and proportionate to the level of design detail available at GDA. I also consider the RP's safety case for storage of waste ICIAs provides adequate evidence to substantiate the RP's sub-claim 3.3.11.SC23.4, that radioactive waste has been put into a passively safe form for interim storage.

194. Storage Capacity: ONR SAP ENM.2 identifies the regulatory expectation related to ensuring designated storage facilities are identified with adequate capacity, including spare and buffer capacity. The RP's safety case defined a period of 15 years of decay storage of HLW ICIAs in the SFIS Facility prior to transfer to the ILW ISF, which the RP considered to be conservative. Based on the evidence of the RP's inventory (Ref. 34), the storage capacity of 50 HLW 500 litre robust shielded drums in the SFIS Facility ensures adequate capacity to store HLW ICIAs for a period of 36 years of operation. Given the strategy to move the packages to the ILW ISF once they have decayed to ILW, conservatively defined as 15 years, in my opinion the RP has identified designated storage facilities for the storage of HLW ICIAs with adequate capacity, including spare and buffer capacity.

195. In addition, the RP's construction strategy for the SFIS Facility is based upon two phases of construction, with the second phase expected to be ~15-20 years after the start of operations. The RP claims the licensee will be able to review operational data on the ICIAs, including rates of arising and the decay storage period, to ensure

adequate storage capacity in the SFIS Facility is maintained (Ref. 66). In my opinion the RP's safety case for the storage of HLW ICIAs in the SFIS Facility is consistent with regulatory expectations in ONR SAP RW.1 paragraph 793 (q) to ensure that the storage capacity remains adequate through regular reviews and RW.2 paragraph 798 to consider trends in radioactive waste generation during operation.

4.5.3 ICIA Safety Case Conclusions

196. Overall, in my opinion, through improvements to the safety case to address RO-UKHPR1000-0037 (Ref. 10) the RP has provided adequate evidence that:

- The generic UK HPR1000 design eliminates the risk of needing to conduct the winding operations over a fully fuelled RPV.
- The conceptual design of the winding machine makes adequate claims on several SSCs to reduce the risks from the implementation of the ICIA winding operations to ALARP. The evidence that the SSCs are able to deliver these form part of the licensee's detailed design and I have raised AF-UKHPR1000-0177 to maintain regulatory oversight on the development of the detailed design.
- The safety case adequately describes how the future operator is able to distinguish between the lower source term and higher source term region of the waste ICIAs, consistent with the expectations of ONR SAP RW.4.
- The design of the 500 litre robust shielded drum will maintain containment, provide adequate shielding and provide passive means of managing the heat during the decay storage of HLW ICIAs.
- The RP has adequately considered the regulatory expectations of ONR SAP SC.6 on limits and conditions in the interests of safety and EIMT for the ICIA winding operations and storage.
- The RP has presented sufficient evidence to underpin the decisions taken relevant to the storage capacity in the conceptual design for the ILW ISF.

197. Overall, in my opinion the RP's safety case for waste ICIAs provides adequate evidence to substantiate sub-claim 3.3.11.SC23.4, that waste ICIAs have been put into a passively safe form for interim storage.

4.6 Radioactive Waste Treatment Systems

198. In this sub-section I consider the adequacy of the design of a selected sample of systems used for the processing of gaseous, liquid and solid radioactive wastes in the generic UK HPR1000 design, with the aims of:

- Judging whether the RP's claims and arguments are adequate (complete) and whether the RP has provided sufficient evidence to substantiate them, where the relevant claims are primarily sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5 listed in Section 3 of this report;
- Determining whether the RP has provided adequate evidence for the selected sample of the radioactive waste management systems for the generic UK HPR1000 design.

199. To achieve this objective I have drawn on the independent specialist advice and experience of a TSC, with the aim of identifying and substantiating the adequacy of the design of a sample of radioactive waste management systems in normal operations (the assessment of faults was undertaken by ONR specialist inspectors in Fault Studies, as referred to in sub-section 4.8).

200. I asked the TSC to assess the RP's submissions with focus on the following key aspects:

- The substantiation of design and system functional requirements (sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5);
- The substantiation of the categorisation and classification of the systems and main system components for normal operations, as expected by ONR SAPs ECS.1 and ECS.2 on safety categorisation and standards;
- The prevention and minimisation of releases of radioactive wastes within and from the systems in normal operation, including the means of confinement of radioactive wastes, the provision of further containment (confinement barriers) and the suitability of monitoring devices, alarms and leakage monitoring, which are addressed by ONR SAPs on containment and ventilation (ECV.1 – 7);
- The adequacy of the approaches to commissioning and EIMT, commensurate with the stage of development of the design, as addressed by ONR SAPs ECS.1 (safety categorisation), EMT.1, 2, 5 and 6 on maintenance, inspection and testing and ECM.1 on commissioning.

201. In addition to the SAPs listed above the TSC also considered a wide range of sources of RGP including other SAPs (for example on layout) and IAEA guidance.

202. I asked the TSC to assess the following sample of systems used for the management of gaseous and liquid wastes:

- Nuclear Island Vent and Drain System (RPE[VDS])
- Liquid Waste Treatment System (TEU[LWTS])
- Nuclear Island Liquid Waste Discharge System (TER[NLWDS])
- Gaseous Waste Treatment System (TEG[GWTS])
- Solid Waste Management System (TES[SWTS])
- Steam Generator Blowdown System (APG[SGBS]).

203. I selected the first five systems listed because their primary purpose is the management of gaseous, liquid and solid radioactive wastes. The APG[SGBS] is an auxiliary system for the reactor and its primary purpose is not management of radioactive wastes. I selected this system because it has a broader function than radioactive waste management but produces liquid effluent and solid wastes associated with operation of the secondary circuit. The scope of the TSC work excluded consideration of the F-SC1 containment isolation valves on the TEG[GWTS] and the RPE[VDS] systems as these are of particular relevance to fault conditions.

204. The outcome of the work of the TSC (Ref. 24) is summarised in the following sub-sections. The TSC initially reviewed a sample of the RP's more general submissions (for example Chapter 23 of the PCSR (Ref. 4)) to gain an understanding of the generic UK HPR1000 design and safety case and of the sample of radioactive waste management systems. The TSC also reviewed the RP's 'Methodology on Safety Categorisation and Classification' (Ref. 67) and other general safety requirements.

205. The TSC focused its assessment on Chapter 23 of the PCSR (Ref. 4), as well as Chapter 11 of the PCSR on the Steam and Power Conversion System (which includes the APG[SGBS]) (Ref. 68) and the System Design Manuals (SDMs). The SDMs cover a range of standard subjects for each system, including system functions and bases, system and component design, layout requirements, system operation and maintenance and flow diagrams). The TSC also assessed system sizing reports and various topic reports relevant to the assessment such as commissioning and periodic testing.

206. The TSC assessed the selected sample of systems against the key aspects described above and also noted observations arising from comparison with the system against both RGP and the TSC's relevant experience and expectations. The TSC has documented the outcomes from its assessment (Ref. 24), some of which relate to all or several of the systems sampled and others which relate to specific systems for

managing radioactive wastes and the Steam Generator Blowdown System (APG[SGBS]).

207. The TSC identified a number of findings where it considered that either an aspect of the design may not satisfy RGP and that the associated risks are not reduced to ALARP, or where there are aspects of the design where further justification may be required. I present my consideration of the findings of the TSC in the following sub-sections. A number of the submissions sampled by the TSC have since been updated by the RP, therefore some aspects of the assessment here reflect my judgement on the adequacy of the updated submissions against the TSC's original findings. I have also followed up aspects of the TSC's findings by means of RQs as appropriate.

208. The TSC raised RQs to seek clarification of information in the RP's submissions and/or where it was not clear that the RP's approach was consistent with RGP. Table 4 provides a list of the RQs (Ref. 38) raised by the TSC and ONR considered relevant to the assessment in this sub-section.

Table 4: Summary of RQs Relevant to Assessment of the Radioactive Waste Management Systems.

Regulatory Query Number	Title	Summary of RQ response
RQ-UKHPR1000-0799	Processing of ILW Resins	Clarification of a range of matters relating to sampling and monitoring, characterisation, resin transfer, including the use of sight glasses, and measures to minimise radiation doses to workers associated with resin processing.
RQ-UKHPR1000-1105	Substantiation of Sizing of TEU components	Evidence to underpin assumptions and calculations for the sizing of tanks in the TEU[LWTS].
RQ-UKHPR1000-1106	TEU Effluent Compositions	Information on the chemical and radionuclide composition of liquid effluent streams for average, worst case and peak production scenarios.
RQ-UKHPR1000-1107	Substantiation of Drains Tank Capacity	Information on the operation of process and floor drain tanks to maintain capacity and avoid overfilling in the event of downstream system failures.
RQ-UKHPR1000-1108	Further Detail on the Management of Concentrates	Information on a range of matters relating to chemical and radionuclide composition, sampling and monitoring and the strategy for storage including for decay from ILW to LLW.
RQ-UKHPR1000-1361	Retrieval of sludges from Tanks and Sumps in RPE and TEU Systems	Information on the retrieval and packaging of sludges and the prevention of the spread of contamination.
RQ-UKHPR1000-1362	Collection and on-site transfer of dry active waste	Clarification of the arrangements for DAW accumulations at source, and the risk of free liquid.
RQ-UKHPR1000-1363	Use of Submersible Pumps for Pumping of Radioactive Material	Information justifying the selection of submersible pumps and how the risks associated with their use are minimised.

Regulatory Query Number	Title	Summary of RQ response
RQ-UKHPR1000-1364	Substantiation of Classification of TEU and Sub-systems	Evidence substantiating classification in accordance with the RP's methodology and provision of references to the submissions where the information is presented.
RQ-UKHPR1000-1365	Details of TES spent resin tanks	The RP provided details on the spent resin tank designs for the reference plant (FCG3) and stated that the detailed design of the tanks is completed at the site specific phase.
RQ-UKHPR1000-1366	TES resin agitation systems	The RP provided further details on the resin agitation systems (nitrogen and air injection systems) but noted the design of these systems are out of scope of GDA.
RQ-UKHPR1000-1369	Removal and packaging of spent filter cartridges	The RP provided more details on the SFCCM and SFRTD, which it subsequently included in the update to safety case (Ref. 69).
RQ-UKHPR1000-1371	Use of Sight Glasses	Information clarifying and justifying the use of sight glasses to monitor resin transfers in preference to other techniques such as flow metres or level monitoring.
RQ-UKHPR1000-1372	Substantiation of categorisation and classification of the solid waste treatment system (TES) and subsystems	The RP provided details on, and reference to the 'Methodology of Safety Categorisation and Classification of Safety Functions' (Ref. 67).
RQ-UKHPR1000-1374	Use of Floor Drains in Radioactive Waste Management Systems	Information to justify the use of floor drains to remove effluent and the consideration of alternative options. Information on how the design prevents inadvertent or deliberate discharges of effluents incompatible with downstream treatment processes and prevents the accumulation of radioactive waste.
RQ-UKHPR1000-1389	Use of Flexible Hoses in RPE System	Clarification and justification of the use of flexible hoses in the RPE[VDS] system to collect leakage from valves.
RQ-UKHPR1000-1392	Design and Operation of the Wet-solid Waste Receipt and Treatment Subsystem in BWX	Clarification of the functions for the different areas in the Radioactive Waste Treatment Building (BWX) which are used as part of the WSW receipt and treatment sub-system.
RQ-UKHPR1000-1393	Substantiation of Sizing of TEU components – Follow-up	Clarification of responses to RQ-UKHPR1000-1105, with focus on OPEX.
RQ-UKHPR1000-1394	Functions and operation of drum detection device 9TES4310Z in BWX	The RP provided clarity on use of, and access arrangements to the drum monitoring stations in the Radioactive Waste treatment Building.
RQ-UKHPR1000-1553	Dry active waste characterisation and drying	The RP provided clarity on the ILW DAW inventory including ILW DAW with free water generated from

Regulatory Query Number	Title	Summary of RQ response
		maintenance of effluent systems and drying operations in the Waste Auxiliary Building.
RQ-UKHPR1000-1560	Retrieval of spent filter cartridges	The RP provided clarity on technical details of the SFCCM and SFTRD and the radiological risks associated with the operations.
RQ-UKHPR1000-1615	TES resin agitation systems – follow up	The RP provided clarity on the functions of the agitation systems on the UK HPR1000 resin tanks.
RQ-UKHPR1000-1683	Follow up on design and operation of the Solid Waste Treatment System (TES) in BWX	The RP provided clarity on Postulated Initiating Events (PIEs) relevant to the TES[SWTS] and on various aspects of the design in relation to layout and actions to be taken in the event of plant failure.
RQ-UKHPR1000-1772	Clarification of information on radioactive waste management systems	The RP provided clarity that where the RP's safety case refers to 'gaseous wastes' this includes airborne activity (particulates, mists and dusts). The RP provided information on the detection of leakage and escape of radioactive material/wastes from containment boundaries.
RQ-UKHPR1000-1774	Systems used for the management of liquid radioactive wastes	The RP provided clarity on the capacity of secondary containment for the RPE[VDS] tanks and the measures to achieve defined operational functions including confinement (containment) for the TER[NLWDS].

4.6.1 Assessment of all Relevant Radioactive Waste Management Systems

209. This sub-section considers issues arising from the assessment of radioactive waste management systems that were broadly generic to all the systems sampled.

210. The TSC concluded that the SDM chapters did not provide references to supporting evidence documents and that the "golden thread" from the relevant claims to evidence was thus not complete, for the sample of systems assessed. However, the TSC was able to gain an adequate understanding of the design by means of review of a broader range of submissions and seeking clarification by means of RQs. I consider the lack of completeness of the evidence in the SDMs reviewed to be a Minor Shortfall, given that other evidence was available in the safety case to gain an adequate understanding of the design. I also note the licensee has the opportunity to improve the basis of evidence in the SDMs as the design and associated substantiation progresses beyond the GDA stage.

211. Commissioning requirements: The TSC considered the adequacy of the evidence in the RP's safety case for the radioactive waste treatment systems sampled against the regulatory expectations of ONR SAP ECM.1, which is to define commissioning tests in the safety case for any facility or process that may affect safety. In addition to the various system SDMs, the TSC also sampled the RP's methodology for the identification of commissioning requirements as presented in the 'Topic Report on the Commissioning Requirements of Radioactive Waste Management Systems' (Ref. 70). The TSC concluded that this did not consider how commissioning will demonstrate the systems and components will behave as assumed in the safety case, including the delivery of safety functions. In the TSC's experience there should be a clear distinction

between tests required to demonstrate that the plant will work, and those required to assure safety. In addition the TSC identified that commissioning tests for all safety classified components were not specified in the submissions reviewed. For example, it was not clear from the SDMs and (Ref. 70) whether the testing arrangements between the radioactive waste treatment systems and relevant interfacing systems were specified. The TSC was unable to confirm from the sample that the expectations of SAP ECM.1 have been met.

212. It is my judgement that it is proportionate to raise a Minor Shortall for the licensee to ensure the radioactive waste treatment system SDMs adequately reference the evidence to demonstrate that the commissioning tests are appropriately identified and implemented. My judgement that a minor shortfall is proportionate is based on the commissioning tests are largely procedural (arrangements) to demonstrate that the systems installed will behave as expected during active operations.

213. In-service testing: The TSC considered the adequacy of the evidence in the RP’s safety case for the radioactive waste treatment systems sampled against the regulatory expectations of ONR SAP EMT.1, identification of in-service testing, inspection and other maintenance procedures in the safety case. The TSC concluded that the submissions reviewed did not provide an adequate demonstration that in-service testing has been identified for the SSCs to ensure they continue to deliver their defined safety functions in normal operations, for the radioactive waste management systems sampled. I would expect these arrangements to be developed at the site specific phase during the detailed design and therefore I have not raised any Minor Shortfalls or Assessment Findings on this topic.

214. Prevention and minimisation of releases: The TSC sought evidence in the RP’s submissions relating to the prevention and minimisation of releases of radioactive wastes within and from the systems in normal operation, in relation to the regulatory expectations in ONR SAPs ECV.1 and ECV.2. The TSC identified claims on the connection of a number of liquid radioactive waste storage tanks to the relevant building ventilation systems, as a confinement (containment) measure. As part of my assessment of the TES[SWTS] I raised RQ-UKHPR1000-1772 to seek clarification in relation to the claims (Ref. 38). In response to the RQ the RP referred to the evidence in the safety case on how the generic UK HPR1000 design of the tanks for the spent resins flushing and storage and wet-solid waste treatment systems are connected to the relevant building ventilation systems. I used this information to gain a better understanding of the SDM flow diagrams for the RPE[VDS], TEU[LWTS] and TER[NLWDS], to identify evidence of how the claim is implemented in the relevant radioactive waste treatment systems, which I considered to be adequate.

215. In my opinion, the RP’s evidence on how the RPE[VDS], TEU[LWTS], TER[NLWDS] and TES[SWTS] are connected to the relevant building ventilation systems, and the links to the functional requirement of confinement (containment) is adequate to substantiate sub-claim 3.3.11.SC23.2 “the system design satisfied the functional requirements”.

216. Sampling and Monitoring Systems: The TSC considered the RP’s safety case for the sample of radioactive waste treatment systems against the regulatory expectations of ONR SAP ECV.6, to detect changes in the materials and substances held within the containment and ONR SAP ECV.7, to ensure appropriate sampling and monitoring systems are provided outside the containment to detect, locate, quantify and monitor for leakages or escapes of radioactive material from the containment boundaries. The TSC was unable to identify the relevant evidence, therefore I raised RQ-UKHPR1000-1772 (Ref. 38) to seek clarity on how leakages and escapes from the sampled radioactive waste treatment systems are detected. In response to RQ-UKHPR1000-1772 (Ref. 38) the RP clarified that the relevant SDMs provided the following information:

- For the RPE[VDS] and TEU[LWTS] level monitors are included in the tanks and relevant sumps, there are pressure monitors to indicate a change in the airtightness of the systems. Flowrates are monitored where changes would indicate a leak.
- For the TER[NLWDS], which only processes treated effluents, the RP indicated level measuring equipment is installed in the tanks and the relevant building (the Nuclear Liquid Waste Storage Tank Building) sumps.
- Part of the TEG[GWTS] is kept under negative pressure during normal operation to prevent leakage and escape in normal operation. The conditions in the TEG[GWTS] are thus monitored to indicate a loss of containment. The concentration of oxygen in the system is measured, with an increase indicating leakage into the negative pressure section of the TEG[GWTS]. Alarms are included in the design to notify operators of a loss of containment. Flowrate monitors are installed on the outlets with an increase in the volume of gas indicating leakage into the TEG[GWTS]. An alarm is included on the outlet flow rate meter to notify operators of changes. Pressure sensors are included in the positive pressure section of the TEG[GWTS] to indicate leakage and escape prior to entry into the system if the pressure drops. Alarms are included to notify operators. Operator actions as a result of the alarms are to be defined at the site specific phase.

217. In my opinion, on the basis of the information provided in response to RQ-UKHPR1000-1772, as captured in the relevant SDMs of the RP's safety case, provides adequate evidence for the monitoring of the material and substances held within the containment, to meet the expectations of ONR SAP ECV.6.

218. The RP's safety case provides evidence on monitoring equipment for radioactive material beyond the primary containment, but within the secondary containment, to meet the expectations of ONR SAP ECV.7. However, there is limited evidence in the documents sampled on monitoring outside the secondary containments in the wider facilities. ONR SAP ECV.7 indicates the use of environmental surveys (such as radiation and contamination surveys) in the vicinity of the facility to provide confidence that leakage and escape from the containment has not occurred (including from secondary containment). After discussion with the ONR Radiological Protection specialist inspector, I note the adequacy of the radiation and contamination monitoring in the wider facilities has been considered as part of the scope of the Radiological Protection assessment (Ref. 26), and is therefore not considered further in this report.

219. For the TEU[LWTS] concentrate tanks and TES[SWTS] spent resin tanks the RP's ALARP demonstration for radioactive waste management (Ref. 46) and the response to RQ-UKHPR1000-1772 indicated that, while the tanks themselves have level monitoring equipment, the generic UK HPR1000 design does not include monitoring equipment outside the tanks, for example in the secondary containment. I was unable to determine whether the expectations of SAP ECV.7 have been met for the concentrate and spent resin tanks from the submissions assessed, which is consistent with the TSC's findings. I have thus raised the following Assessment Finding:

AF-UKHPR1000-0178 – The licensee shall, as part of the detailed design, justify the leak detection capabilities outside the primary containment boundary of the Liquid Waste Treatment System concentrate tanks and Solid Waste Treatment System resin tanks.

220. Containment Barriers: The TSC considered the RP had not provided adequate justification of the number and types of containment barriers in the sample of systems assessed, in relation to the radiological hazard and risk presented by the radioactive wastes. The TSC considered this to be a potential shortfall against the expectations of NS-TAST-GD-021 (Ref. 71) on containment for chemical plants (which ONR defines as

non-reactor facilities). However, the TSC largely concluded that the design of the systems aligned with RGP. In my opinion, given the alignment with RGP it is proportionate to raise a Minor Shortfall for the licensee to consider improving the information in the SDMs to ensure they refer to evidence for the justification of the number and type of the containment barriers as the detailed design progresses at the site specific phase.

221. The TSC indicated that some aspects of the systems sampled did not align with RGP, but the assessment was based on a limited number of submissions. I have therefore sampled to make a judgement on whether or not, the totality of the safety case assessed provided adequate evidence that the design of the systems and processes described are consistent with RGP. Where I consider there is evidence that the systems do not meet RGP I have, if appropriate, raised an Assessment Finding.

222. The TSC concluded that the RP had documented good practices for confinement of radioactively contaminated fluids in its ‘Piping Layout Guide’ (Ref. 72) and that these would be potentially applicable to components other than pipework in the systems sampled. The scope of this guide could be expanded to non-pipe components in the future, providing more confidence in the measures applied to confine radioactive wastes during normal operations. I consider this to be a Minor Shortfall for the licensee to consider at the site specific phase. Aspects relevant to the ‘Piping Layout Guide’ on accumulation of contamination in the design of the SSCs containing contaminated fluids are considered in the Step 4 Assessment of Decommissioning for the UK HPR1000 Reactor (Ref. 14).

223. Categorisation and Classification of SSCs: The scope of work of the TSC on categorisation and classification of systems, sub-systems and components related only to normal operations and excluded assessment of fault conditions. The TSC considered the RP did not adequately substantiate the safety categorisation and classification in the submissions reviewed. I consider the adequacy of the application of the methodology for categorisation and classification in the sub-sections below.

4.6.2 Assessment of Gaseous Radioactive Waste Management Systems

224. The TSC assessed (Ref. 24) a number of the RP’s submissions to determine whether the design of the TEG[GWTS] met the defined operational functions, which were:

- To flush the pipes and tanks which contain reactor coolant with nitrogen to avoid hydrogen accumulation in the gas space and limit the hydrogen and oxygen concentrations in the TEG[GWTS] and connected components to below flammability limits;
- Prevent escape of radioactive gases from the connected components into the building atmosphere by maintaining the flushing section in slight negative pressure;
- Collect and treat the excess gas from the connected components during plant start-up, shutdown or flushing components, etc.; and
- Delay the radioactive noble gases and iodine isotopes in the gas stream to reach an acceptable radiation level before discharge to the environment.

225. The TSC assessed a number of submissions including Chapter 3 of the PCER (Ref. 42) and the ‘Sizing Report of the Activated Charcoal Delay Beds’ (Ref. 73), and concluded that the design of the TEG[GWTS] met the defined operational functions. The TSC did not assess submissions concerning the design and sizing of the catalytic recombiner. ONR’s specialist inspector in Chemistry assessed the relevant submission on the recombiner and the charcoal delay bed sizing (Ref. 73), concluding the RP has provided an adequate safety case to justify the chemistry-related functions of the radioactive waste management systems (Ref. 44). I conclude the design operational

functions have been met, on the basis of assessment of the RP's evidence by the TSC and ONR's specialist inspector in Chemistry.

226. The TSC assessed the RP's submissions to determine whether the design safety functions have been met. The TEG[GWTS] is claimed as providing a confinement function in normal operations, which is achieved by sealing of mechanical boundaries, maintenance of the flushing section under negative pressure and measurement devices on the flushing sections to detect leakage. The TSC considered the RP had correctly identified the safety functions for the TEG[GWTS], and that the TEG[GWTS] design measures identified broadly aligned with RGP. However, the TSC identified shortfalls in the RP's evidence in the SDM related to the justification of the number and type of containment barriers which is relevant to the confinement safety function and addressed by the generic Minor Shortfall in sub-section 4.6.1.

227. The TSC assessed the safety categorisation and classification of the TEG[GWTS] components in normal operations. The RP did not provide information in the SDM to explain how these had been derived but the TSC was able to determine that the process for categorisation and classification had been adequately applied and that the outcomes for the system and components were consistent with the TSC's expectations, on the basis of experience. I accept the TSC's conclusions in relation to safety classification and categorisation of the TEG[SWTS].

228. Overall, noting the assessment of generic aspects in sub-section 4.6.1, I accept the TSC's conclusion (Ref. 24) that the design of the TEG[GWTS] is consistent with RGP. The design is based on the application of proven techniques for the management of gaseous wastes in PWRs and takes account of Chinese and international OPEX. Through application of RGP it is my opinion that the RP provided adequate evidence that the TEG[GWTS] is consistent with the RP's safety case sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems. Taking into consideration the TSC's conclusions that RP's safety case for the TEG[GWTS] correctly identifies the safety functions, and that the system design broadly aligns with RGP, then in my opinion the RP's safety case provides adequate evidence to meet sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2, appropriate to the GDA stage.

4.6.3 Assessment of Liquid Radioactive Waste Management Systems

229. Aspects of the generic assessment in sub-section 4.6.1 which are applicable to the systems for the management of liquid wastes are not repeated here. The following sub-sections summarise the TSC's other findings for the RPE[VDS], the TEU[LWTS], the TER[NLWDS] and the APG[SGBS] (where this relates to the management of radioactive wastes).

4.6.3.1 Nuclear Island Vent and Drain System (RPE[VDS])

230. The RPE is a complex system of tanks, drains and pipes arranged across a number of buildings in the nuclear island. The TSC assessed a number of the RP's submissions to determine whether the operational functions of the RPE[VDS], which have been defined by the RP as "serving to collect, store temporarily and transfer radioactive effluents from the nuclear island" have been met (Ref. 24). Chapter 23 of the PCSR (Ref. 4) specified the following operational requirements for the RPE[VDS]:

- Segregation of recyclable effluent at source and sending it to the TEP[CSTS] (Coolant and Storage Treatment System);
- Segregation of non-radioactive liquid waste and sending for discharge after sampling (which is outside ONR's scope of work as ONR does not regulate the management of non-radioactive wastes)

- Facilitation of selection of optimal processing routes through the segregation of liquid effluents as different types based on physical, chemical and radioactive characteristics; and
- Routing the primary gaseous waste collected to the TEG[GWTS] and other gaseous wastes to the ventilation systems of each building.

231. The TSC raised RQ-UKHPR1000-1374 (Ref. 38) which sought information to justify the RP's use of floor drains in directing effluents to the storage vessels in the RPE[VDS], and on how effluents not compatible with downstream processes can be prevented from entering the floor drains. The RP's response indicated there were a number of measures to prevent "undesirable materials" from entering the floor drains such as sump covers. The TSC concluded that the RP had provided sufficient evidence to demonstrate the design of the RPE[VDS] adequately met its operational functions. Adequate evidence was subsequently provided to demonstrate that the RPE[VDS] tanks are connected to building ventilation systems in the RP's response to RQ-UKHPR1000-1772. I consider the RP's evidence that the design of the RPE[VDS] meets the operational functions to be adequate, based on the TSC's assessment and consideration of the response to RQ-UKHPR1000-1772.

232. The RPE[VDS] provides a confinement safety function in normal operations. The TSC concluded that the RP had correctly identified the safety functions of the RPE[VDS]. This confinement is achieved by means of sealing of mechanical boundaries, the lining of sumps with stainless steel, connection of tanks to either the TEG[GWTS] or building ventilation systems to prevent leaks of gaseous wastes and by the use of monitoring systems on tanks and sumps to detect and locate leakage and escape of radioactive material. The TSC considered the information provided by the RP on the safety function of the RPE[VDS] to be generally adequate.

233. The TSC assessed the RP's substantiation of the sizing of RPE[VDS] components in terms of accommodating the expected volume of effluents in all foreseeable scenarios. The 'Sizing Report of Main Equipment in the Liquid Waste Management System' (Ref. 74) provided limited information on vessels and sumps in the RPE[VDS] but this was considered to be sufficient for the current stage of design. The TSC noted the benefit of using a mass balance model in supporting substantiation of the sizes of tanks and sump as the design is further developed, which was not addressed in the submissions reviewed by the TSC. However, I note the derived source term of radioactivity in fluids, accumulated in wastes and deposited on components is based on a mass balance model (Ref. 75), which the TSC did not assess.

234. The TSC noted the submissions reviewed did not provide evidence of the provision of secondary containment for the tanks containing radioactive effluent in the RPE[VDS], which is not consistent with the secondary containment provided for tanks in the TEU[LWTS]. I subsequently sought evidence from the RP on the secondary containment of tanks in the RPE[VDS] by means of RQ-UKHPR1000-1774 (Ref. 38). I considered the RP's response on the provision and volume of secondary containment for tanks to be adequate, although I was not clear where the information provided in the response is presented in the safety case. However, I do not consider it proportionate to raise a Minor Shortfall because the RQ response indicated the capacity of the secondary containment for the RPE [VDS] tanks will be reviewed and refined at the site-specific stage to ensure it meets UK requirements in terms of secondary containment.

235. The TSC assessed the safety categorisation and classification of the RPE[VDS] components in normal operations. The RP did not provide information in the SDM to explain how these had been derived. The TSC was able to determine that the process for categorisation and classification had been adequately applied for the RPE[VDS] and that the outcomes for the system and components were consistent with the TSC's expectations, on the basis of experience. The TSC identified one exception, namely

one of the components stated as collecting “potentially contaminated effluents” from floor drain 3. The TSC indicated that evidence had not been provided to substantiate the absence of categorisation and classification, which I consider to be a Minor Shortfall because floor drains are not used for the management of effluents containing high concentrations of radioactivity. Overall I accept the TSC’s conclusions in relation to safety classification and categorisation.

236. The TSC identified a small number of other issues for consideration relating to the design of the RPE[VDS], based on its experience of effluent management systems. The first was the extensive use of flexible hoses, as opposed to hard piping, as shown in the flow diagrams. The TSC raised RQ-UKHPR1000-1389 (Ref. 38) to understand the reasoning for their use. The RP’s response indicated they are used for the collection of leakage from valve stems. Other options had been considered but flexible hoses had been identified as the most appropriate method because the lines normally have no flow. The TSC considered the RP had provided an adequate justification for their use for the stage of development of the design, with which I concur.

237. As noted above, the TSC sought justification for the extensive use of floor drains in the RPE[VDS] in RQ-UKHPR1000-1374 (Ref. 38), noting that an inadequate design could result in the accumulation of radioactive material. The RP’s response indicated that potential alternatives to the use of floor drains had not been considered but that the approach was based on many years of OPEX. The detailed design of the floor drains will not take place until the site-specific stage. The TSC recommended that further consideration be given to the optimisation of the design and use of floor drains, including whether alternative approaches to the activities that give rise to the effluents routed to the floor drains could reduce the volume of liquid wastes discharged to the drains, for example by the use of closed loops for floor washing. Recognising submersible pumps are used on similar systems in the UK, I consider this to be a Minor Shortfall.

238. The TSC noted the submissions reviewed indicated the extensive use of submersible pumps in the tanks and sumps of the RPE[VDS] (and TER[NLWDS]) and raised RQ-UKHPR1000-1363 (Ref. 38) to seek information on their use and the basis of their selection in preference to other pumping technologies. The RP’s response indicated they were selected because of the location of the sumps and tanks at the lowest levels of the buildings and because their use is common practice in China. Detailed design of the pumps will not take place until the site-specific stage. Assessment of the mechanical requirements placed on equipment, such as submersible pumps, and the evidence that this can be met forms part of the ONR Mechanical Engineering inspector’s assessment (Ref. 27). The TSC recommended the consideration of alternative technologies to submersible pumps (for example eductors), which may be beneficial in limiting the number of components in contact with radioactive effluent and simplifying maintenance. Such alternatives may also potentially reduce the amount of radioactive waste components arising from pumping operations. I consider this to be a Minor Shortfall.

239. Overall I conclude the design of the RPE[VDS] is consistent with RGP, noting the generic and specific Minor Shortfalls identified. Through application of RGP it is my opinion that the RP provided adequate evidence that the RPE[VDS] is consistent with the RP’s safety case sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems. Taking into consideration the TSC’s conclusions that the RP’s safety case for the RPE[VDS] correctly identifies the safety functions, and that the system design broadly aligns with RGP in my opinion the RP’s safety case provides adequate evidence for GDA to meet sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2.

4.6.3.2 Liquid Waste Treatment System (TEU[LWTS])

240. The TEU[LWTS] is a radioactive waste management system for liquid effluents located in the Radioactive Waste Treatment Building. It is designed to monitor, collect, store and treat radioactive liquid wastes produced in the nuclear island during normal operation, separating soluble and insoluble radionuclides from liquid wastes to meet discharge management objectives which form part of the environmental permit issued by the Environment Agency. The TSC has provided a summary description of the system (Ref. 24). Chapter 23 of the PCSR (Ref. 4) specified the following operational functions for the TEU[LWTS]:

- Sampling liquid wastes in the storage tanks and transferring liquid wastes to the appropriate treatment routes;
- Treating the liquid waste to reduce the concentration of radioactivity to the level acceptable for discharge into the environment; and
- Transferring the treated liquid waste to the TER[NLWDS] for discharge after monitoring.

241. The TSC concluded the RP had provided adequate evidence to demonstrate the operational functions of the TEU[LWTS] were met, appropriate to the GDA stage. I accept the TSC's conclusion.

242. The TEU[LWTS] provides a confinement safety function in normal operations. This confinement is achieved by means of sealing of mechanical boundaries, location of tanks in retention pits (which ONR typically refers to as secondary containment), containment provided by the civil engineering structure of the building, the connection of tanks to the ventilation system to prevent leaks of gaseous wastes and by use of monitoring systems on tanks to detect and locate leakage. In the TSC's assessment they concluded that the design measures identified broadly align with RGP.

243. The TSC sought evidence, by means of RQ-UKHPR1000-1105, 1107 and 1393 (Ref. 38), that the system components were adequately sized to accommodate the volume of effluent expected in all foreseeable scenarios and thus minimise the risk of release through overflow. The TSC considered the RQ responses provided sufficient evidence that the tanks were adequately sized, and also that the throughput capacity of the treatment units in the TEU[LWTS] was adequate, on the basis of the information in the sizing report for the liquid waste systems (Ref. 74). I accept the TSC's conclusions (Ref. 24). The TSC noted that one of the assumptions underpinning the adequacy of tanks capacity, namely the assumed time of one hour for analysis of effluents in the tanks may be optimistic, but that this could be substantiated during detailed design. I consider this to be a Minor Shortfall.

244. The TSC concluded the RP had correctly defined the confinement safety function of the TEU[LWTS], consistent with sub-claim 3.3.11.SC23.1. I concur with this conclusion and consider the RP has, overall, provided adequate evidence to demonstrate the design meets this safety function, relevant to sub-claim 3.3.11.SC23.2, noting the Minor Shortfalls identified.

245. The TSC assessed the safety categorisation and classification of the TEU[LWTS] components in normal operations. The RP did not provide information in the SDM to explain how these had been derived so the TSC raised RQ-UKHPR1000-1364 (Ref. 38). The response explained how the categorisation and classification had been undertaken in accordance with the RP's methodology (Ref. 67). The TSC considered the RQ response demonstrated the RP had adequately applied the methodology to the TEU[LWTS] and its sub-systems, and that the outcomes in terms of the categorisation and classification aligned with their expectations and experience. I accept the TSC's conclusions.

246. The TSC noted there were some components that fall within the scope of the 'Pressure System Safety Regulations 2000 (PSSR)' (Ref. 76), which the TSC considered to be relevant to the delivery of the confinement safety function. The submissions reviewed did not refer to PSSR or written schemes of examination, but I note the RP addresses conventional health and safety regulatory requirements in submissions which the TSC did not assess. Following discussions with specialist inspectors in Conventional Health and Safety and Mechanical Engineering, I do not consider it necessary to consider the requirements of PSSR for the TEU[LWTS] further in this report as they will be addressed during detailed design at the site-specific stage.

247. The TSC indicated two potential improvements to the design and operation of the TEU[LWTS], the first relating to remote monitoring of differential pressure across the filters in the TEU[LWTS] as an alternative to local operator monitoring, and the second to consider use of treated liquid effluent instead of demineralised water to flush equipment to decrease the demand on the treatment system and volume discharged. These matters are not of high safety significance and I consider them to be Minor Shortfalls for future consideration by a licensee as the design is developed.

248. On the basis of my consideration of the TSC's assessment (Ref. 24) I conclude the design of the TEU[LWTS] is consistent with RGP, noting the generic and specific Minor Shortfalls identified and that the RP's safety case provides adequate evidence for GDA to meet sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2. Through application of RGP it is my opinion that the RP provided adequate evidence that the TEU[LWTS] is consistent with the RP's safety case sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems.

4.6.3.3 The Nuclear Island Liquid Waste Discharge System (TER[NLWDS])

249. The TER[NLWDS] is a radioactive waste management system for liquid effluents with its main components located in the Nuclear Island Liquid Waste Storage Tank Building (BQA). It is designed to receive treated liquid waste from the TEU[LWTS], TEP[CSTS] and the Fuel Pool Cooling and Treatment System (PTR[FPCTS]) which is discharged to the environment after blending, monitoring, sampling and analysis of the effluent, which contains only very low levels of radionuclides and non-radioactive substances. The discharge line is fitted with a radiation monitor. In the event that effluent does not meet the discharge limits it can be returned to the TEU[LWTS] for further processing.

250. The SDM chapter on system functions and design bases for the TER[NLWDS] (Ref. 77) defines the following operational requirements:

- to collect liquid waste from the TEU[LWTS] and TEP[CSTS] and mix, sample, analyse and monitor before discharge;
- to collect liquid waste from the Conventional Island Liquid Waste Discharge System [SEL[LWDS(CI)] when storage capacity is insufficient, storage tank rupture occurs or its radioactivity level is abnormal and to mix, sample, monitor and analyse before discharge;
- under special conditions to collect liquid waste from the In-Containment Refuelling Water Storage Tank (IRWST) of the Safety Injection System (RIS[SIS]) via piping from the PTR[FPCTS];
- to return liquid waste to the TEU[LWTS] for treatment if the radioactivity level of the liquid waste exceeds the discharge management objective after sampling, analysis or monitoring; and
- to monitor and record the activity level, flow rate and volume of the liquid waste discharged.

251. The TSC was able to identify evidence that the operational requirements are met for three of the five requirements listed above but not for those relating to collection of

liquid waste from the Conventional Island or from the IRWST. I sought further evidence from the RP on these two requirements by means of RQ-UKHPR1000-1774 (Ref. 38), the response to which I considered to be adequate.

252. The TER[NLWDS] provides a confinement safety function in normal operations. This is achieved by the sealing of the equipment and pipes, location of tanks in retention pits and the presence of monitoring systems on tanks and sumps to detect and locate leakage. The TSC reviewed the number and sizing of the TER storage tanks as presented by the RP's submission (Ref. 74) and concluded the number and tanks provided adequate storage capacity, noting that normal operations require two tanks to accommodate effluent from the TEU[LWTS] and TEP[CSTS] while a third tank, normally spare, is available which could accommodate effluent from either the IRWST or the SEL[LWDS(CI)]. The TSC noted that the submissions reviewed did not provide evidence concerning the sealing of equipment and pipes in relation to the confinement of radioactive wastes. Again I sought additional evidence from the RP concerning the sealing of equipment and pipes by means of RQ-UKHPR1000-1774 (Ref. 38), the response to which I considered to be adequate in substantiating the confinement safety function.

253. The TSC concluded the RP had correctly defined the confinement safety function of the TER[NLWDS], and that the containment barriers identified broadly align with RGP. I concur with this conclusion.

254. The TSC assessed the safety categorisation and classification of the TER[NLWDS] system and components in normal operations, based on comparison of information on the TEU[LWTS] with the RP's response to RQ-UKHPR-1000-1364 (Ref. 38) on the categorisation and classification of the TEU[LWTS]. The TSC concluded the RP had adequately applied the methodology to the TER[NLWDS] and that the outcomes in terms of the categorisation and classification of the system and components aligned with their expectations and experience. I accept the TSC's conclusions.

255. On the basis of my consideration of the TSC's assessment (Ref. 24) I conclude the design of the TER[NLWDS] is consistent with RGP, noting the generic Minor Shortfalls identified. Through application of RGP it is my opinion that the RP provided adequate evidence that the TER[NLWDS] is consistent with the RP's safety case sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems. I consider the RP has provided adequate evidence to demonstrate the design meets this safety function, consistent with sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2.

4.6.3.4 The Steam Generator Blowdown System (APG[SGBS])

256. The APG[SGBS] is part of the Steam and Power Conversion System of the generic UK HPR1000 design and radioactive waste management is only one of a number of its functions. The TSC focused on the aspects of the system relevant to radioactive waste management. The Nuclear Sampling System continuously monitors the condition of the water in the secondary circuit.

257. The APG[SGBS] maintains the chemical condition of the water in the secondary circuit by continuous blowdown (removal) of water from the SGs in the Reactor Coolant System which is collected and treated. After cooling and depressurisation the removed water is treated by means of demineralisation using ion exchange resins and the system also includes filters.

258. The secondary circuit is not expected to contain radioactive material but the RP notes that in normal operations there may be slight leakage from the primary circuit through the SG tubes. This results in the accumulation of corrosion products and other radioactivity in wastes from the demineralisers and filters, which the RP has classified

as LLW. Steam Generator Tube Rupture (SGTR) is a known possible fault which would lead to significant contamination of the resins and filters. The spent resins are routed to the Spent Resins Flushing and Storage sub-system (which is assessed in sub-section 4.6.4), noting the design allows transfer of SGBS resins to the ILW spent resin tanks in the TES[SWTS] in the event of a SGTR.

259. The SDM chapter on system functions and design bases for the APG[SGBS] (Ref. 78) defines the following operational requirements:

- Continuous blowdown of SG at a certain flow to maintain the chemical condition of the SG secondary water within the required limits.
- Cooling and depressurisation of the SG blowdown water.
- Treatment and purification of the SG blowdown water by the filters and demineralisers.
- Total or partial drain of the SG secondary side during Maintenance Cold Shutdown.
- Connection of nitrogen injection to mix chemical reagents at the SG secondary side by nitrogen bubbling during Maintenance Cold Shutdown.
- Recovery and treatment of the water sample taken from the SG secondary side.
- discharge of treated blowdown water to the condenser for recycling, or to the SEL[LWDS(CI)] in exceptional cases.
- Continuous sampling to monitor the chemical characteristics of the SG secondary water.

260. The TSC reviewed the relevant SDM and was able to confirm it contained information on how these operational functions are met by the APG[SGBS].

261. As noted, the APG[SGBS] has many functions other than those relating to radioactive waste management. The TSC's review indicated that a number of the safety functions are applicable to accident as opposed to normal operations and thus were outside the scope of its work. However, the TSC noted the difference between this system and the radioactive waste management systems assessed in that a confinement safety function has not been defined for the APG[SGBS] in normal operation. The TSC considered this to be appropriate, provided there is no radioactive contamination in the secondary circuit. This matter is considered further below.

262. The TSC considered the safety categorisation and classification of the components of the APG[SGBS] relevant to radioactive waste management, which it defined as the regenerative heat exchanger, filter, demineralisers and resin trap filter. All of these are not categorised or classified because the secondary circuit is not expected to contain radioactive material. However, the RP has noted that during normal operations there may be slight leakage of radioactivity through the SG tubes from the primary circuit in the SDM for layout requirements and environment condition (Ref. 79). The demineralisers and filters of the APG[SGBS] are abatement techniques and will reduce the risks to the systems posed by the presence of both activated and non-activated corrosion products during normal and fault operations, for example SGTR.

263. The TSC considered the RP had not provided an adequate substantiation of the non-categorisation and non-classification of these components in accordance with the RP's methodology (Ref. 67) in the submissions reviewed. I have thus raised the following Assessment Finding:

AF-UKHPR1000-0179 – The licensee shall, as part of detailed design, justify the safety classification of the filters and demineralisers in the Steam Generator Blowdown System.

264. On the basis of my consideration of the TSC's assessment (Ref. 24) I conclude the design of the APG[SGBS] relevant to management of radioactive wastes is consistent with RGP, noting the Assessment Finding and the generic Minor Shortfalls identified. Through application of RGP it is my opinion that the RP provided adequate evidence that the APG[SGBS] is consistent with the RP's safety case sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems. Taking into consideration that the APG[SGBS] system is not expected to contain radioactive material, the RP has not defined functional requirements for normal operations. Therefore, noting the scope of this assessment excludes faults and accident conditions, then, I consider it appropriate that the RP's safety case sampled for the APG[SGBS] does not include evidence against sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2.

4.6.4 Assessment of the Solid Waste Treatment System (TES[SWTS])

265. The RP's safety case (Ref. 80) identifies several sub-systems which make up the TES[SWTS] system for the management of solid radioactive waste, as described in Section 3. Consistent with the assessment strategy presented in Section 2, I have focused on the highest hazards. For the TES[SWTS] system I consider this to be the ILW inventory which is processed in the:

- DAW Treatment sub-system
- Spent Resins Flushing and Storage sub-system
- Spent Filter Cartridge Changing sub-system
- WSW receipt and treatment sub-system.

266. As identified in sub-section 2.4.4, I have used a TSC to support my assessment of the TES sub-systems (Ref. 24).

267. The TSC identified that the only functional requirement on the TES[SWTS] in the RP's safety case (Ref. 81) relates to confinement (containment). The RP identifies this is achieved through:

a) The prevention of gas and liquid generated during processing the radioactive solid waste from releasing into the environment directly.
b) The production of passively safe waste packages and reduction of the volumes of radioactive waste for disposal.
c) Limiting radiation exposures to workers and the public through shielding measures and remote control for operation of high risk tasks.

268. Based upon the TSC's assessment of Chapter 23 of the PCSR (Ref. 4), a number of aspects of the design relevant to the confinement function of the TES[SWTS] system were identified:

- sealing of the mechanical boundaries
- production of passively safe waste packages
- location of spent resins tanks in retention pits with stainless steel liners
- the civil engineering structure of the building in providing containment
- connection of tanks to the ventilation system to prevent leaks of gaseous species
- monitoring systems on the tanks to detect leakage.

269. The TSC concluded that the measures identified were consistent with their expectations, but that the submissions reviewed did not provide adequate evidence that the containment barriers are suitable and sufficient to protect against the hazard and risk present. This has been taken into consideration in a generic Minor Shortfall. I have considered the hazard and risk for each of the sub-systems, the TSC's conclusions on the containment barriers, and ONR guidance on the 'Identification of

Assessment Findings and Minor Shortfalls for the GDA of the UK HPR1000' (Ref. 82) to make a judgement on whether any Assessment Finding(s) are required for any of the sub-systems of the TES[SWTS].

270. The TSC identified that the TES[SWTS] SSCs are categorised/classified as category/class 3 (FC3/F-SC3), respectively, depending on whether they are in direct contact with radioactive material, and therefore contribute to the confinement safety function. If the SSC is not in direct contact with the radioactive material then it is non-categorised/non-classified (NC). The TSC sampled the RP's methodology of safety categorisation and classification (Ref. 67), but was unable to identify how the RP had derived the TES[SWTS] categorisation and classification and therefore raised RQ-UKHPR1000-1372 (Ref. 38). The TSC considered the response to the RQ did not provide additional clarity and therefore raised a finding in their assessment that the approach adopted by the RP to limit classification of components of the TES[SWTS] to those in direct contact with radioactive material may lead to the incorrect classification of some components. I consider the TSC's finding on the categorisation and classification of the TES[SWTS] SSCs for each of the sampled sub-systems.

4.6.4.1 Dry Active Waste Treatment Sub-System

271. The TSC considered the adequacy of the DAW treatment sub-system for arisings categorised as both ILW and LLW DAW in its report (Ref. 24). However, consistent with my sampling strategy, I have focused on ILW DAW, which accounts for approximately 13% of the total anticipated DAW inventory volume (Ref. 34). The RP's management strategy is to decay store ILW DAW to LLW and so is also referred to as ILW/LLW boundary wastes by the RP, as noted in sub-section 4.3. For ease of reference, in this sub-section ILW/LLW boundary DAW is referred to as ILW DAW. The DAW system identifies the use of plastic bags for the collection of LLW DAW and 210 litre drums for ILW DAW.

272. The TSC concluded that the collection of ILW DAW at source in 210 litre drums is consistent with its experience for the management of similar wastes. In my opinion the DAW treatment sub-system for the generic UK HPR1000 design aligns with RGP, consistent with the TSC's conclusion.

273. The TSC's assessment identified that some DAW is anticipated to contain free liquids, for example wastes generated during maintenance activities on liquid systems. On the basis of the TSC's assessment I raised RQ-UKHPR1000-1553 (Ref. 38), to further understand the ILW DAW inventory, including whether there is the potential for the generic UK HPR1000 design to generate ILW DAW with free water. The RP clarified that the DAW arising from maintenance activities includes SSCs in contact with liquid radioactive effluents, which is initially categorised as ILW. Therefore the DAW treatment system is designed to manage the drying of both ILW and LLW DAW containing free water. The RP clarified that the conceptual design of the Waste Auxiliary Building includes a single facility to dry both LLW and ILW DAW in a 210 litre drums, therefore ILW DAW is dried prior to decay storage in the ILW ISF.

274. The safety case for the drying of ILW DAW depends on the detailed design of the drying equipment, which the RP considers to be mobile equipment and therefore out of scope of GDA (Ref. 12). The safety case for the Waste Auxiliary Building is out of scope of my sample, as described in sub-section 2.3. The RP's safety case does not provide information on the drying operations for ILW DAW in 210 litre drums, including how the risks to operators are reduced to ALARP, due to the absence of detail on the design available at the GDA stage. There is a lack of evidence of the RP's consideration of the safety function of containment during drying to meet the regulatory expectations of ONR SAPs ECV.3 and ECV.4, and on how the design of the drying system for ILW addresses the regulatory expectations of ONR SAP ECV.2 on minimisation of radioactive released from systems during normal operations. There is

no information on fault and accident conditions; nor an adequate justification of the timing for drying ILW DAW (for example whether it is ALARP to dry before or after decay storage in the ILW ISF given the relatively short decay period (1.65 years for DAW).

275. In my judgement the RP has not demonstrated a good understanding of the risks associated with the drying of ILW DAW because of the lack of design information available at the GDA stage. The RP is thus unable to demonstrate that the risks from drying of ILW DAW have been reduced to ALARP. I have therefore raised the following Assessment Finding:

AF-UKHPR1000-0180 - The licensee shall demonstrate that the management strategy for dry active Intermediate Level Waste containing free water, and the detailed design of the drying system, reduces risks so far as is reasonably practicable.

276. On the basis of my consideration of the TSC's assessment (Ref. 24) I conclude that the design of the DAW treatment sub-system (collection in 210 litre drums and drying to remove free water) is consistent with RGP. However, on the basis of the scope of GDA, which excludes the design of mobile engineered systems, such as the drying equipment in the Waste Auxiliary Building, in my opinion it is appropriate that the RP's safety case for the DAW treatment sub-system at GDA does not include evidence against sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2. Without aspects such as the detailed design of the drying equipment it cannot be determined whether the RP's safety case has optimised the design so far as is reasonably practicable, as claimed in sub-claim 3.3.11.SC23.5. However, it is my expectation that at the site specific phase the licensee will provide adequate evidence that the risks from drying ILW DAW are reduced to ALARP, and therefore I have raised AF-UKHPR1000-0180 to ensure the licensee provides adequate evidence against sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.

4.6.4.2 Spent Resins Flushing and Storage Sub-System

277. Consistent with my sampling strategy, I have only considered the adequacy of SSCs for the management of ILW resins. However, the TSC considered all resins, including lower activity resins, in its assessment of the spent resin flushing and storage system (Ref. 24).

278. ILW resins are accumulated in tanks in two UK HPR1000 buildings; in the Nuclear Auxiliary Building as part of the Spent Resin Flushing and Storage sub-system, and in the Radioactive Waste Treatment Building as part of the WSW receipt and treatment sub-system. Due to similarities in the design, functional requirements and usage of the resin tanks in both systems, the TSC's assessment considered the accumulation of resin in the tanks for both sub-systems, including transfers in and out of the tanks. Both systems include:

- The capability to segregate spent resins into the ILW and lower activity resins;
- Two stainless steel storage tanks, sized for 5 years of accumulations, placed in shielded and lined cells;
- Resin tanks with inlet and outlet nozzles, level measuring nozzle, overflow nozzle, and manholes to facilitate maintenance;
- Sight glasses installed on the resin inlet and outlet lines, to observe spent resin transfers;
- A nitrogen (Nuclear Auxiliary Building) or air (Radioactive Waste Treatment Building) system designed with three purposes; to ensure resins do not settle or harden, to homogenise the resins using recirculation lines, and to facilitate resin transfers out of the tanks.

279. Resins are flushed on a batch basis, with all ILW resins transferred to the tanks in the Radioactive Waste Treatment Building to enable processing (drying in 500 litre shielded drums).

280. The TSC concluded that the 'Sizing Report of Main Equipment in Solid Waste Treatment System' (Ref. 83) provided adequate evidence to substantiate the sizing of the spent resin tanks in both the Radioactive Waste Treatment Building and the Nuclear Auxiliary Building. However, the TSC was unable to identify why there are two systems in two buildings of the generic UK HPR1000 design for the accumulation of ILW spent resins, given all ILW spent resins must be transferred to the Radioactive Waste Treatment Building for processing. The TSC identified the opportunity to optimise the design through co-location of the four resin tanks. I concur with the TSC's observation that there may be an opportunity to optimise the resin tank locations.

281. The resin tank sizing report is based upon resins arising from one UK HPR1000 unit. At the site specific phase it is anticipated that two UK HPR1000 units will be constructed. Therefore, consistent with nuclear power stations under construction in the UK, the licensee will need to review the adequacy of the radioactive waste treatment systems for two units to ensure the risks remain ALARP, including the spent resin storage and processing facilities. As this is part of the normal site-specific process, and no shortfalls have been identified by the TSC in the sizing of the tanks across the two facilities in the generic UK HPR1000 design, I have identified a Minor Shortfall for the licensee to consider the location of the spent resin storage tanks at the site specific phase.

282. The TSC identified that the RP's safety case considered the confinement (containment) functional requirement and has identified aspects such as the tanks, pipes and pumps as primary means of containing radioactive material, and has appropriately categorised and classified these, consistent with the RP's methodology (Ref. 67).

283. The TSC identified that the RP's safety case adequately considered the tanks and pipes as the primary and passive means of confinement of radioactive material, consistent with the regulatory expectations of ONR SAP ECV.3. However the TSC was unable to identify whether the safety case adequately considered the use of seals on manholes in the tanks. The TSC was also unable to identify whether an appropriate programme of EIMT was defined for the seals to ensure the primary containment function of the tank was not compromised. In my opinion manhole access to tanks to enable tank maintenance tasks is not novel, neither is the use of seals on penetrations to ensure primary containment barriers are maintained during operations. Therefore, in my opinion, it is proportionate to identify a Minor Shortfall related to the TSC's finding. The Minor Shortfall is for the licensee to ensure appropriate seals are included in the detailed design of the resin tanks, and that the EIMT requirements on the seals are appropriately defined.

284. The TSC identified that the tank rooms in both the Radioactive Waste Treatment Building and Nuclear Auxiliary Building include stainless steel liners with adequate capacity to retain resin from a full tank, in the event of loss of the primary containment of a tank. In my opinion secondary containment for mobile material, such as that in the resin tank room, should be designed to be consistent with RGP in the non-nuclear high hazard industry (Ref. 84) and sized to retain 110% of the volume of the largest tank. It is unclear from the TSC's assessment (Ref. 24) and from the RP's safety case (Ref. 85) whether the liner is for the whole room, and therefore has a volume which equates to two full tanks (200% of a single tank), or if it is for the full volume of a single tank (100%). In the response to RQ-UKHPR1000-1774 (Ref. 38) the RP provided clarity on the secondary containment sizing for the RPE[VDS] tanks, quoting the RGP from non-nuclear high hazard industry (Ref. 84). Therefore I am raising a Minor Shortfall for the

licensee to ensure the resin tank room liners are sized to ensure consistency with RGP for secondary containment, as applied to the RPE[VDS] (Ref. 84).

285. The TSC identified that the generic UK HPR1000 design included the use of sight glasses on spent resin transfer lines, with Close Circuit Television (CCTV) installed to enable remote readings. In response to RQ-UKHPR1000-0799 and RQ-UKHPR1000-1371 (Ref. 38), the TSC noted that the RP provided evidence that the use of sight glasses and CCTV is consistent with Chinese OPEX for PWRs. The TSC was unable to identify any evidence that the RP had considered alternative technologies, such as flow meters, on the resin transfer pipework. In the TSC's experience sight glasses provided limited benefits in detection of leakage and escape from pipework during resin transfer activities, compared with other available technologies which could provide additional opportunities to detect leakage and escape of resin from pipework during transfer activities. I have identified this as a Minor Shortfall for the licensee to consider alternative technologies to sight glasses during detailed design of the system at the site specific phase.

286. On the basis of my consideration of both the TSC's (Ref. 24) and my assessment I conclude the design of the spent resins flushing and storage system, and resin tanks of the WSW receipt and treatment sub-system is consistent with RGP, noting the generic Assessment Finding AF-UKHPR1000-0178 and generic and specific Minor Shortfalls identified. Taking into consideration the conclusions that RP's safety case for the systems correctly identifies the safety function of confinement (containment), and that the system design broadly aligns with RGP, then in my opinion the RP's safety case provides adequate evidence for GDA to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.

4.6.4.3 Spent Filter Cartridge Changing Sub-System

287. The RP's radioactive waste inventory source term (Ref. 40) identifies that approximately 80% of the waste spent filter cartridges generated from the operation of the UK HPR1000 effluent systems are categorised at ILW, with the remaining 20% categorised as LLW.

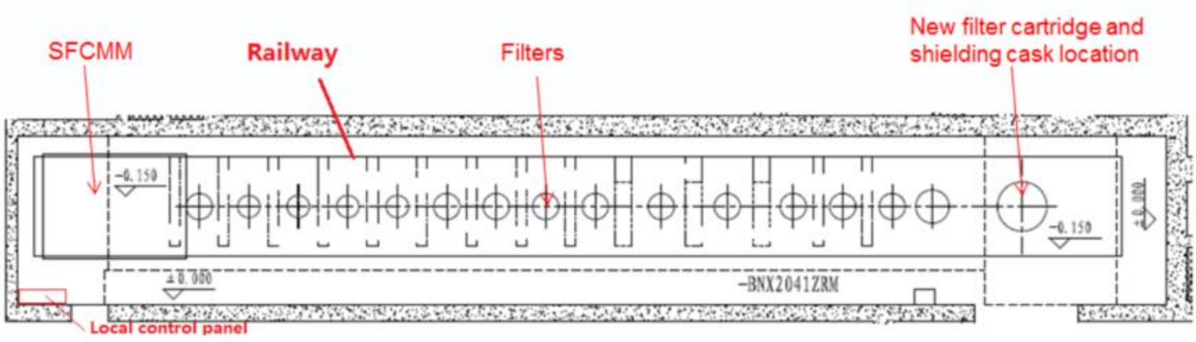
288. The TEP[CSTS], PTR[FPCTS], RCV[CVCS] and RPE[VDS] spent filter cartridges are changed using the SFCCM. The TEU[LWTS] spent filter cartridges are changed using the SFRTD. After retrieval, spent filter cartridges are processed as part of the WSW receipt and treatment sub-system, which is assessed in sub-section 4.6.4.4.

289. The TSC identified that the RP's safety case considered spent filter cartridges with surface dose rates (unmitigated) of up to 10 Sv/hr, with claims on the SSCs for shielding to reduce worker doses to ALARP. ONR's assessment of occupational exposures to workers from operations is led by the ONR Radiological Protection specialist inspectors (Ref. 26), therefore the assessment of the spent filter cartridge changing sub-system presented in this report has been completed with support from ONR Radiological Protection specialist inspectors.

Spent Filter Cartridge Changing Machine (SFCCM) system description

290. The filter housings of the TEP[CSTS], PTR[FPCTS], RCV[CVCS] and RPE[VDS] systems are configured in a linear array within shielded cells in the Nuclear Auxiliary Building, with the SFCCM located on a rail and positioned over the filter housing. Control of the process is semi-automated, with operators utilising a local control panel, as presented in **Figure 3** taken from (Ref. 86).

Figure 3: Spent Filter Cartridge Change Machine Shielded Cell, Nuclear Auxiliary Building



291. Individual filters are isolated, drained to the RPE[VDS] and depressurised. Once isolated, depressurised and drained the filter housing lid is manually unbolted. The operator is afforded radiological shielding by an integral shielding plate on top of the filter itself and shielding within the filter housing. The SFCCM is then moved along the rails and positioned over the filter housing. The SFCCM then undertakes the following automated sequence of activities:

- removal of the shielding plate;
- removal of spent filter cartridge;
- replacement of the spent cartridge with a new filter; and
- replacement of the shielding plate.

292. A dose rate measurement of the spent filter is carried out by inserting two instruments into the SFCCM once in position and prior to removal of the shielding plate. The dose rate measurement is used to categorise the spent filters within the SFCCM as either ILW or LLW, prior to loading into the 210 litre drum (with a shielding cask if ILW). The SFCCM is also used to remove and replace the shielding cover on the cask for spent filter cartridge loading operations in the 210 litre drum.

Spent Filter Replacement and Transfer Device (SFRTD) system description

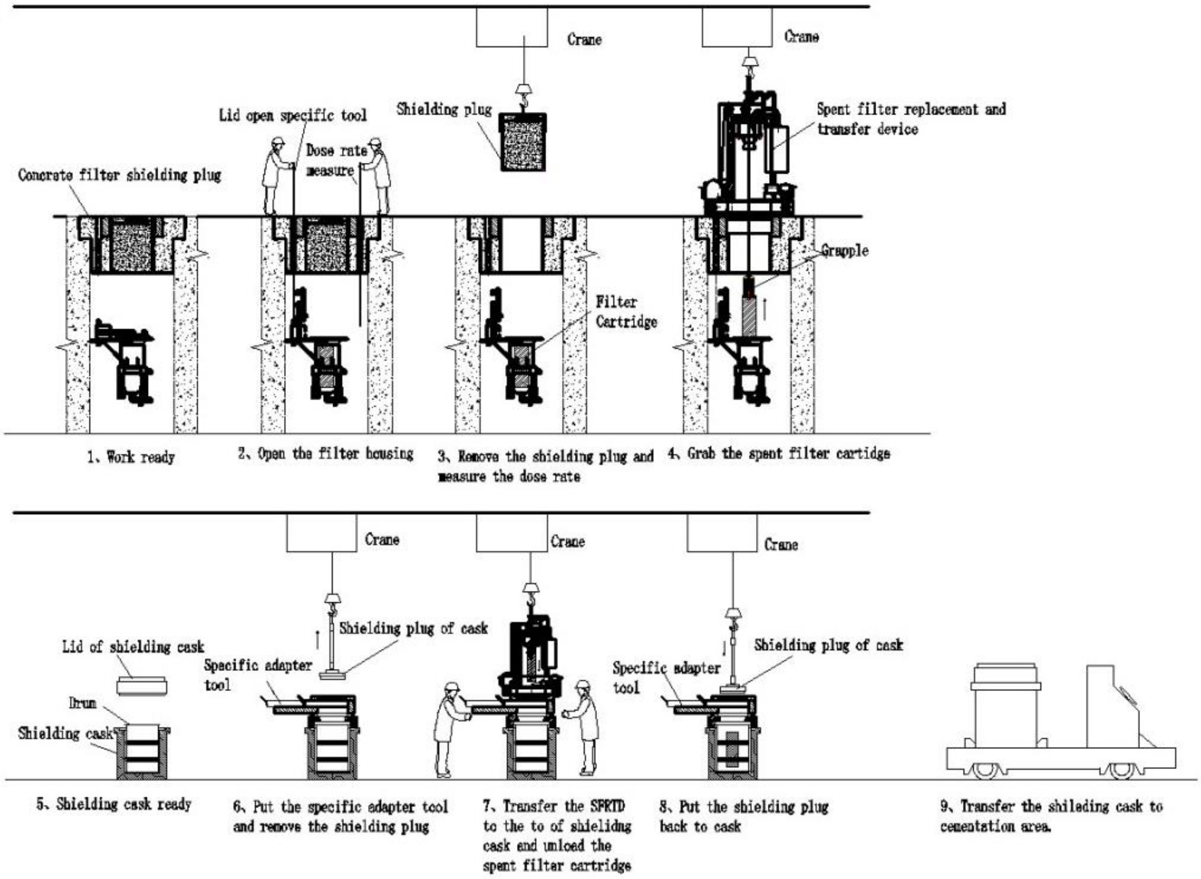
293. The SFRTD is only used in the TEU[LWTS], where 65% of the spent filter cartridges are categorised as ILW (Ref. 40). Figure 4 includes sketches with details of the process steps for the retrieval and packaging of spent filters using the SFRTD, taken from (Ref. 86):

- Step 1: Shutdown, drainage, venting of the filter to be replaced. Effluents are drained to the Sewage Recovery System (SRE [SRS]).
- Step 2: Unscrewing of the cover bolts and, through the concrete filter shielded plug, opening the cover of the filter using special tools. Measurements of the dose rate of the filter are taken using the long pole with a dose rate measurement instrument through the concrete filter shielding plug.
- Step 3: Removal of the concrete filter shielding plug using the crane.
- Step 4: Moving the SFRTD into position using the crane and retrieving the spent cartridge into the SFRTD using the SFRTD control panel.
- Step 5: Preparing the drum and shielding cask.
- Step 6: Installing the drum adaptor and removing the shielding plug of the shielding cask (ILW spent filter cartridges only).
- Step 7: Transferring the SFRTD with spent filter cartridge to the top of the shielding cask using the crane (operated remotely from the local control panel). Opening the drum adaptor manually and releasing the spent cartridge into the drum with shielding cask, followed by closure of the drum adaptor.
- Step 8: Placing the shielding plug on the shielding cask through the drum adaptor.

- Step 9: Lifting the shielding cask with the drum loaded with the spent cartridge on to the electric vehicle by crane and then transferring it to the Radioactive Waste Treatment Building.

294. A new filter is installed using the crane, not the SFTRD.

Figure 4: Spent Filter Replacement and Transfer Device (SFRTD) in the Radioactive Waste Treatment Building.



295. As the SFCCM and SFRTD are different in their design, my assessment is split into three sub-sections:

- generic assessment of the spent filter cartridge changing sub-system;
- assessment of the SFCCM and;
- assessment of the SFRTD.

Generic assessment of the spent filter cartridge changing sub-system

296. The TSC's assessment identified that the RP's safety case did not categorise or classify any of the components of the spent filter cartridge changing sub-system. The TSC identified that the non-categorisation and classification of the SFCCM and SFRTD is inconsistent with the RP's arrangements (Ref. 67), as the changing machines are in direct contact with radioactive material. This is also inconsistent with the RP's safety case where several components have been identified in both the SFCCM and SFRTD design with implicit claims on providing adequate confinement (containment) of radioactive material for operators. Consistent with the TSC's conclusions (Ref. 24), I have been unable to identify how the RP has considered the initiating events associated with the operation of the spent filter cartridge changing machines which could challenge the containment safety function. In my opinion, given the hazard posed by the spent filter cartridges, the lack of categorisation of the containment

function of the SFCCM and SFRTD is inconsistent with the regulatory expectation of ONR SAP ECS.1, as well as the RP's own arrangements.

297. I also considered the absence of arguments and evidence to justify why the confinement (containment) function is not categorised for the SFCCM and SFRTD to be inconsistent with the RP's safety case sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2.

298. With support from the ONR Radiological Protection specialist inspector, I raised RQ-UKHPR1000-1560 (Ref. 38), to seek clarification of the gaps identified by the TSC. As a result of RQ-UKHPR1000-1560, the RP made improvements to the TES[SWTS] SDM chapters on the system and component design (Ref. 85), and the system operation and maintenance (Ref. 69). My assessment considers the improvements made to the RP's safety case relevant to the containment safety function, and contamination controls, for each of the filter changing machines. My assessment considers the regulatory expectations of ONR SAPs ECV.1, ECV.2 and ECV.3 for the containment design of systems to prevent leakage, minimise releases and provide a primarily passive means of confining radioactive material, respectively.

Assessment of the SFCCM

299. The TES[SWTS] SDM on the system and component design (Ref. 85) now includes outline sketches of the SFCCM and descriptions of design features of SSCs relevant to confinement and contamination controls, including:

- The SFCCM includes three grabs, one for the new filter cartridge, one for the spent filter cartridge, and one for the shielding cover of the filter house or shielding cask. The RP states that the purpose of the three grabs is to avoid cross contamination.
- The inner base of the SFCCM is designed with an incline to create a low point for any residual effluent in the spent filter cartridge and draw the contamination away from the SFCCM bottom opening. This is to ensure contamination is not spread outside the SFCCM. A drainage pipe and hand valve is included at the bottom of the SFCCM design to allow residual water to be drained.
- A sealing ring and sealing pad on the bottom of the SFCCM are designed to ensure contiguous containment between the SFCCM and the rails/filter housing.
- The SFCCM is connected to the Nuclear Auxiliary Building ventilation system to create a negative pressure and prevent leakage and escape of airborne contamination.
- Two dose rate measurement plugs are arranged on the top of the SFCCM to allow dose rate measurement devices to be installed on opposite sides of the spent filter cartridge. The dose rate measurement devices are installed prior to spent filter cartridge retrieval, fixed in place and shielding/containment re-instated on the plug hole prior to retrieval operations. This allows measurement of the spent filter cartridge without breaching containment when the hazard (the spent filter cartridge) is present in the SFCCM.
- Access is included on the top of the SFCCM design to enable decontamination (if required). The drainage pipe and hand valve at the bottom can also be used to remove effluent arising from decontamination.

300. The RP's safety case (Ref. 86) identifies OPEX to provide evidence that the SSCs of the SFCCM are able to deliver the required containment function and support minimisation of the spread of contamination, even though the safety case does not make this claim. In my opinion the OPEX available is limited, because the SFCCM is an improvement first implemented by CGN for the FCG3 power station (currently under

construction) and a second nuclear power station, Nuclear Power Plant T, in China* (currently in operation) (Ref. 86).

301. In my opinion, the improvements made to the RP's safety case include design features for the SFCCM SSCs which are consistent with the regulatory expectations of ONR SAPs ECV.1, ECV.2 and ECV.3 for normal operations. However, the SFCCM has not been categorised/classified. It therefore remains unclear whether the RP has adequately considered the initiating events which could give rise to fault conditions and challenge the confinement function of the SFCCM during filter change operations, which may then lead to the spread of contamination.

302. I consider it proportionate to raise an Assessment Finding, given the unmitigated doses associated with the spent filter cartridges, the limited evidence available through OPEX and the fact that the generic UK HPR1000 design does not categorises / classify the SFCCM. I have also taken account of discussions with the ONR Radiological Protection specialist inspector. The Assessment Finding will ensure regulatory oversight of the detailed design of the SFCCM, to ensure the hazards posed by the spent filter cartridges and the faults which could give rise to operator dose are adequately considered, and that the risks during retrieval are reduced to ALARP.

AF-UKHPR1000-0181 - The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Cartridge Changing Machine reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.

Assessment of the SFRTD

303. The TES[SWTS] SDM on the system and component design (Ref. 85) now includes outline sketches of the SFRTD and descriptions of design features of SSCs relevant to confinement and contamination, including:

- The two moveable plates on the bottom of the SFRTD are designed to create a seal on the bottom of the SFRTD and minimise the risk of spreading contamination during movement. Each plate includes a drip pan to collect any residual effluent. The RP has identified OPEX from Nuclear Power Plant T, where absorbent paper is placed in the drip trays due to the low volumes of residual effluent.
- The bottom of the SFRTD is designed to be compatible with the filter housing to ensure there is no gap, and therefore no risk of airborne contamination, into the wider room/facility as the spent filter cartridge is retrieved into the SFRTD.
- A specific adaptor tool is required to interface between the SFRTD and the shielded drum to enable the spent filter cartridge to transfer into the 210 litre drum (in the shielding cask) while maintaining contiguous containment.
- The SFTRD is designed to maintain its integrity in the event of a dropped load fault.
- In response to RQ-UKHPR1000-1772 (Ref. 38) the RP clarified that the SFRTD is connected to the relevant building ventilation system, however this has not been identified in the RP's safety case submissions sampled.

304. The UK HPR1000 SFRTD is based on a similar Filter Cartridge Replacement Device (FCRD) from the CPR1000 reactor design, where the CPR1000 is the reference plant for FCG3. The RP has used OPEX from the FCRD to make improvements to the

* *Nuclear Power Plant T cannot be directly identified in the RP's safety case due to the protection of proprietary information. I have adopted the same principle in my assessment report.*

design of the SFRTD, including improvements to minimise the risk of release/spreading of contamination.

305. In my opinion, the improvements made to the RP's safety case include design features of the SFRTD SSCs which are consistent with the regulatory expectations of ONR SAPs ECV.1, ECV.2 and ECV.3 in normal operations. However, these have not been categorised/classified and it is unclear whether the RP has adequately considered the initiating events which could give rise to fault conditions. However, the safety case (Ref. 86) makes claims on the integrity of the SFRTD to maintain containment in a dropped load fault.

306. Overall, I consider it proportionate to raise an Assessment Finding, given that 65% of the spent filter cartridges retrieved by the SFRTD are categorised as ILW, and the fact that the generic UK HPR1000 design does not categorise/classify the SFRTD. I have also taken account of discussions with the ONR Radiological Protection specialist inspector and the findings of the assessment (Ref. 26),. The Assessment Finding will ensure regulatory oversight of the detailed design of the SFRTD, to ensure the hazard posed by the spent filter cartridges and the faults which could give rise to operator dose and spread of contamination are adequately considered and that the risks during the retrieval are reduced to ALARP.

AF-UKHPR1000-0182 - The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Retrieval and Transfer Device reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.

307. Overall, taking into consideration the TSC's and my assessment, I consider the lack of functional requirements of the SFCCM and SFRTD does not align with RGP, or with ONR's expectations, in the context of the relatively high hazards associated with the spent filter cartridges. I have raised Assessment Findings AF-UKHPR1000-0181 and AF-UKHPR1000-0182 to address the shortfalls identified and ensure the licensee provides adequate evidence against sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5 for the two filter cartridge change machines.

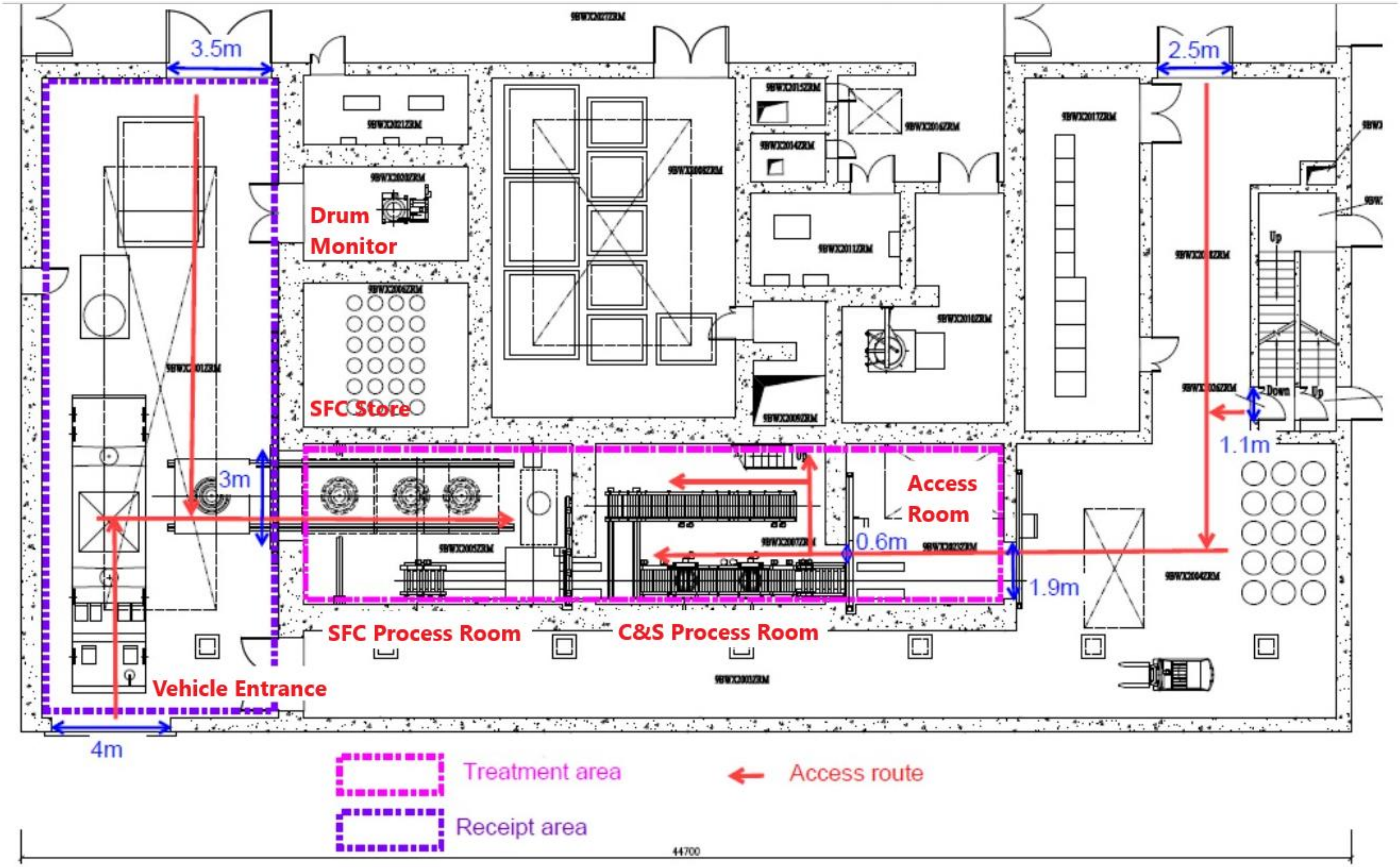
4.6.4.4 Wet-Solid Waste (WSW) Receipt and Treatment Sub-System

308. The WSW receipt and treatment sub-system is located in the Radioactive Waste Treatment Building of the generic UK HPR1000 design. This sub-system provides the capability for packaging and conditioning of a range of radioactive wastes arising from normal operation. Sub-section 4.3 addresses how the RP has addressed differences between Chinese and UK practices for radioactive waste management. As a result of the differences this facility has been modified specifically for the generic UK HPR1000 design to support implementation of the identified waste management strategies. Wastes processed as part of the WSW receipt and treatment sub-system include:

- spent filter cartridges
- spent resins
- evaporator concentrates
- sludges.

309. The WSW receipt and treatment sub-system comprises a suite of shielded cells located on the Floor 0.0m of the Radioactive Waste Treatment Building, with further plant, equipment and waste storage above the cells on Floor +5.5m. To facilitate the processing operations the Radioactive Waste Treatment Building includes several rooms, as shown in Figure 5.

Figure 5: Radioactive Waste Treatment Building (+0.00m) WSW Receipt and Treatment Facilities (Ref. 46)



310. From the TSC's assessment of the TES[SWTS] SDM chapters (Ref. 69, Ref. 80, Ref. 81, Ref. 85) the following is a summary of the processes/ rooms relevant to this assessment for each of the wastes:

- Spent filter cartridge (SFC) processing room. Facilities support both the receipt of 210 litre drums with spent filter cartridges, and the 3 cubic metre box for loading/grouting operations.
- Concentrates and sludges (C & S) processing room. This enables in-drum mixing of the wastes with cementitious additives. Operations are completed remotely, with drums moved on conveyors.
- Access area.
- SFC storage area. This is designed to enable the safe accumulation of at least 11 spent filter cartridges, and is best described as an area with 24 mortuary holes each designed to house a single spent filter cartridge and provide sufficient shielding.
- 210 litre drum measuring station, accessed via crane over the top of the spent filter cartridge processing room and storage area.

311. Consistent with the TSC's findings, I have identified several aspects of the layout of the Radioactive Waste Treatment Building relevant to WSW receipt and treatment sub-system rooms which, in my opinion, do not align with RGP. This is divided into six groups:

- management of contamination during processing operations;
- access and movement around the WSW receipt and treatment areas;
- three metre cubic box shielding cask;
- characterisation and dewatering of spent resin;
- management of concentrates; and
- management of sludges.

Management of contamination during processing operations

312. The purpose of the WSW receipt and treatment sub-system is to receive unconditioned wastes and process these into a passively safe state, which ensures the wastes are managed in accordance with the regulatory expectations of ONR SAP RW.5. During these operations (retrieval, loading, drying and grouting) there is a risk of spreading contamination. This risk is not unique to the UK HPR1000, but the RP needs to provide evidence that the design of the SSCs provide adequate confinement (containment) of the radioactive material and adequately minimise the risk of the spread of contamination during normal operation, fault and accident conditions, as captured in ONR SAPs ECV.1 and ECV.2.

313. The following points are relevant to management of the contamination risk for the WSW receipt and treatment sub-systems in the Radioactive Waste Treatment Building:

- The TSC identified that the RP's safety case places all claims for containment on the shielding cells of the Radioactive Waste Treatment Building, which are kept under negative pressure and connected to the relevant building ventilation system. The TSC was unable to find evidence relevant to the effectiveness of the ventilation system in maintaining a negative pressure when the shielding cell doors are open. Some of the shielding doors are sized to enable a 3 cubic metre box with a shielding cask to pass through, and are therefore considered to be large openings.
- The spent filter cartridges are received into the spent filter cartridge processing room and are retrieved using the travelling overhead crane and transferred into the adjacent spent filter cartridge storage room. There is a lack of evidence in the RP's safety case on the management of residual moisture during the operations. In my opinion, as these wastes are generated from systems used

for the management of liquids, there is a risk of liquid remaining in the spent filter cartridges during operations in the Radioactive Waste Treatment Building. The safety case does not adequately consider the accumulation of residual moisture in:

- the bottom of the 210 litre storage drums
- the spent filter cartridge mortuary holes
- around the processing cell during lifting operations
- the interspace between the 3 cubic metre box and its shielding cask during loading operations.

The last of these may result in the spread of contamination to the ILW ISF as the 3 cubic metre box is removed from the shielding cask for storage. It is also unclear whether the spent filter cartridge is lifted to the store in the 210 litre drum or is placed directly into the mortuary hole.

314. I concur with the TSC's finding that the RP's safety case provided inadequate evidence to justify how the design of the WSW receipt and treatment sub-system is designed to meet the regulatory expectations in ONR SAPs ECV.1 and ECV.2, and how the design provides for adequate containment to reduce the risk of the spread of contamination to ALARP. I will consider this, together with my assessment of the access and movement around the WSW receipt and treatment areas, in considering the sub-system as a whole.

Access and movement around the WSW receipt and treatment areas

315. I raised RQ-UKHPR1000-1683 and RQ-UKHPR1000-1772 (Ref. 38) to seek clarity on aspects of the WSW receipt and treatment areas layout. The following points are relevant to the layout of the WSW receipt and treatment sub-systems for the movement of waste packages and access for personnel and equipment to undertake EIMT in the Radioactive Waste Treatment Building.

- The spent filter cartridge processing room, the concentrate and sludges processing room, and the access areas are in a linear arrangement, segregated/accessed using shielded doors, as shown in **Figure 5**.
- Layout drawings which highlight access routes are captured in the latest update to the ALARP demonstration for radioactive waste management (Ref. 46). Taking the example in **Figure 5**, the operator access between facilities in the WSW receipt and treatment areas can be through openings as small as 0.6m (60cm). No evidence is provided in the RP's safety case to demonstrate that 60cm is adequate to enable personnel/equipment access for EIMT activities, and therefore it is unclear if the expectations of ONR SAP ELO.1 have been met.
- Concentrate and sludge drums are moved on the conveyor into the spent filter cartridge processing room for lifting. The drum measuring station is used for measuring 210 litre drums containing processed concentrates and sludges. To access the drum measuring station the overhead travelling crane is used to lift the 210 litre drums from the spent filter cartridge processing room, over the top of the spent filter cartridge storage area, and finally into the drum measuring station. The TSC was unable to identify evidence that the RP has adequately considered the risks from the lifting operations, for example the risk of a dropped load on to the spent filter cartridge storage area.

316. Taking account of the assessment conducted by the TSC, it is my judgement that the RP's safety case provides inadequate evidence that the regulatory expectations on layout have been met for the WSW receipt and treatment facilities in the Radioactive Waste Treatment Building, specifically ELO.1 on access arrangements, ELO.3 on

minimising the movement of nuclear matter and ELO.4 on minimising the effects of incidents.

317. Overall, in my opinion the RP's safety case provides inadequate evidence that the design of the WSW receipt and treatment sub-system takes into consideration the RGP in ONR SAPs ELO.1, ELO.3, ELO.4, ECV.1 and ECV.2, based on the information on layout, containment barriers, management of contamination and the movement of wastes and waste packages around the Radioactive Waste Treatment Building. Until adequate evidence is provided on how the design of the WSW receipt and treatment sub-system meets these regulatory expectations I am unable to conclude that the risks from the movement of wastes in Radioactive Waste Treatment Building are reduced to ALARP. Therefore I have raised the following Assessment Finding:

> AF-UKHPR1000-0183 - The licensee shall, as part of the detailed design, demonstrate that the wet-solid waste receipt and treatment sub-system in the Radioactive Waste Treatment Building reduces risks so far as is reasonably practicable, in normal operations and fault conditions. This should include, but is not limited to:
>
> - access for personnel and equipment to undertake examination, inspection, maintenance and testing activities;
> - the risks from the movement of wastes in and around the facilities prior to, during and after processing activities; and
> - the risk of spreading contamination and containment to minimise releases.

318. Taking into consideration AF-UKHPR100-0183, I consider there is inadequate evidence in the RP's safety case to determine whether the WSW receipt and treatment sub-system meets sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5. In my opinion, the licensee should provide adequate evidence to substantiate the sub-claims in addressing AF-UKHPR1000-0183. I consider this finding is consistent with the residual matter identified during the closure of RO-UKHPR1000-0005 (Ref. 87).

Three cubic metre box shielding cask

319. In addition to the above findings on the layout and the interface with the management of spent filter cartridges, the TSC identified that the generic safety case assumes the use of the SWTC-285 cask as the shielding cask for the 3 cubic metre box containing spent filter cartridges. The SWTC-285 is designed as an overpack for off-site transport of 3 cubic metre boxes to the GDF and weighs up to 65,000kg. The TSC considered the handling and operations of the SWTC-285 (including remote fitting and securing of the cask lid in the UK HPR1000 design) to be more onerous for the licensee than is needed for the on-site movement of the waste packages. The SWTC-285 shielding cask enables movement of 3 cubic metre boxes between the Radioactive Waste Treatment Building and the ILW ISF. I have therefore identified a Minor Shortfall for the licensee to ensure the detailed design of the shielding cask for the 3 cubic metre box is appropriate for UK HPR1000 operations, including those in the Radioactive Waste Treatment Building and ILW ISF.

Characterisation and dewatering of spent resin

320. ONR raised RQ-UKHPR1000-0407 (Ref. 38) to seek clarity on how the design of the resin system facilitated the characterisation of resins. The RP clarified that once a spent resin tank is full, it is isolated (valves upstream of the tank are closed) and any incoming resins are routed to the alternative tank. The recirculation line on the system is equipped with a sampling line connected to a resin sampler, which enables the

operator to take samples into a shielded bottle for laboratory analysis of the resins. In my opinion the generic UK HPR1000 design includes adequate design features to enable a representative sample of the resin to be taken for characterisation, consistent with the expectations of ONR SAP RW.4. The laboratory used for sample analysis is amongst the conventional island buildings and other buildings excluded from the scope of the UK HPR1000 GDA (Ref. 12). In my experience the use of a laboratory for characterisation of radioactive wastes such as resins is consistent with practices adopted on nuclear licensed sites in the UK, and the generic UK HPR1000 design would not foreclose options for such a facility.

321. The safety case for the dewatering of ILW spent resins is limited to the consideration of transfer of resins from the storage tanks, to the metering tank and into the 500 litre robust shielded drum for dewatering. The RP considers the detailed design of the dewatering equipment as mobile equipment and therefore out of scope of GDA (Ref. 12). In my experience, and consistent with the RP's consideration of OPEX (Ref. 46), dewatering of ILW resins in 500 litre robust shielded drums using mobile equipment is not novel and therefore in my opinion should be progressed as normal business at the site specific phase. The safety case is not clear on where dewatering of the resins in the 500 litre robust shielded drum will occur within the WSW receipt and treatment area, but these operations take place remotely within the shielded cells (Ref. 69). The safety case identifies that dewatering will occur in two steps; the first is removal of the bulk water, and then the second occurs after at least one hour of settling (Ref. 69). I have identified a Minor Shortfall for the licensee to ensure the design of the WSW receipt and treatment area includes adequate space for mobile equipment, such as the dewatering equipment for spent resins, when addressing Assessment Finding AF-UKHPR1000-0183.

322. Consistent with my conclusions in sub-section 4.6.4.2 and taking into consideration that the system design broadly aligns with RGP then, in my opinion, the RP's safety case for spent resins provides adequate evidence to meet sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5 at the GDA stage.

Management of concentrates

323. The RP has decided to implement design modification M73 'Modification to add a concentrate tank in TEU[LWTS]' (Ref. 88) into the generic design of the Radioactive Waste Treatment Building. The modification introduced a third concentrate tank, which is a second tank for ILW concentrates. This enables the decay storage of ILW concentrates prior to metering into 210 litre drums for solidification using cementitious grouting. The additional tank for ILW concentrates is part of the RP's demonstration that risks for the processing of concentrates have been reduced to ALARP in the WSW receipt and treatment sub-system. Due to the interface of this modification with the ALARP demonstration for radioactive waste management, I have also considered it in my overall assessment of the RP's demonstration that relevant risks have been reduced to ALARP in sub-section 4.8.

324. For cement grouting of concentrates, the unlidded 210 litre drum enters the WSW receipt and treatment area and is moved around the different cement encapsulation facility stations on the conveyor. Concentrates are loaded in one drum batches from the storage tanks via the metering tank at the waste filling station. Additives for concentrate grouting are weighed and loaded into mobile tanks outside the Radioactive Waste Treatment Building. The additives are added into the 210 litre drum (with shielded cask for boundary wastes) with concentrates via the dry agent screw (Ref. 69). The drum with concentrate and additives is moved to the mixing station for in-drum mixing with sacrificial paddle, and is lifted to create a seal. The contents are then mixed to produce a homogeneous waste form. The sacrificial paddle is disconnected, and the waste container sealed under pneumatic covers for initial curing. The drum lid is closed manually prior to transport to storage.

325. In my opinion the cementitious grouting process for concentrates described by the RP in the generic UK HPR1000 design is consistent with practices adopted in the UK. Notwithstanding Assessment Finding AF-UKHPR1000-0183 on the WSW receipt and treatment facility, I consider the development of the detailed design of the processes to be part of the normal process at the site specific phase. I consider the management strategy is consistent with RGP, as assessed in sub-section 4.3. I have therefore not identified any additional Assessment Findings or Minor Shortfalls.

Management of sludges

326. The TSC's assessment identified that the RP's safety case does not define how sludges, which maybe be characterised as ILW, are retrieved. The TSC was unable to identify evidence on how the retrieval processes reduces the risks to ALARP, including minimisation of the risk of any spread of contamination. Through the response to RQ-UKHPR1000-1361 (Ref. 38) the RP clarified that 210 litre drums of sludges are imported into the access room. For LLW sludges the 210 litre drum lid is manually removed and for ILW sludges the 210 litre shielded cask lid is manually removed, prior to lifting on to the processing room conveyor using a forklift truck. I have been unable to identify how the risks from the manual operations have been reduced to ALARP in the RP's ALARP demonstration for radioactive waste management (Ref. 46), or identify information on how the 210 litre drum shielding cask lid will be lifted. In addition, the 210 litre drum shielding cask was missing from the list of SSCs for the optimal options (Ref. 58) (see sub-section 4.8), therefore the size/weight of the shielded cask and lid is unclear. I consider there to be a gap in the evidence in the RP's safety case for the sludge retrieval operations against Claim 3.1.1 "the design of radioactive waste management has been substantiated", taking into account the TSC's conclusions on the retrieval of sludges, and the lack of detail on the operations in the access room of the WSW receipt and treatment sub-system,. I have therefore raised the following Assessment Finding:

AF-UKHPR1000-0184 - The licensee shall justify that the risks from management of sludges arising from operations are reduced so far as is reasonably practicable. This should include, but is not limited to:

- retrieval of sludges;
- receipt of sludges into the Radioactive Waste Treatment Building; and
- the potential spread of contamination.

327. The RP's safety case (Ref. 69) identifies that the grouting of sludges is undertaken in the cement encapsulation facility, similar to the process for cement grouting of concentrates, using the same facilities in the WSW receipt and treatment area, with the main difference being that sludges are imported into the area already loaded into the 210 litre drum.

328. In my opinion, notwithstanding Assessment Findings AF-UKHPR1000-0183 on the WSW receipt and treatment area and AF-UKHPR1000-0184 on the retrieval and receipt of sludges, the cementitious grouting process described by the RP in the generic UK HPR1000 design is consistent with practices adopted in the UK. I have therefore identified no additional Assessment Findings or Minor Shortfalls for sludges.

4.6.5 Radioactive Waste Treatment Systems Conclusions

329. As a result of my assessment of the adequacy of the design of a selected sample of systems used for the processing of gaseous, liquid and solid radioactive wastes in the UK HPR1000 I have identified a number of generic Minor Shortfalls for the licensee to

consider at the site specific phase as the detailed design is developed. Overall I have concluded that:

- The design of the TEG[GWTS] is consistent with RGP. No Assessment Findings have been identified. The RP's safety case provides adequate evidence at GDA for the TEG[GWTS] to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The design of the RPE[VDS] is consistent with RGP. No Assessment Findings have been identified. The RP's safety case provides adequate evidence at GDA for the RPE[VDS] to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The design of the TEU[LWTS] is consistent with RGP. However I have raised the Assessment Finding AF-UKHPR1000-0178 for the licensee to provide adequate evidence that the design of the TEU[LWTS] concentrate tanks (and associated SSCs) includes adequate capability for detecting leakage of radioactive waste outside the primary containment boundary. Overall it is my judgement that the RP's safety case provides adequate evidence to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The design of the TER[NLWDS] is consistent with RGP. No Assessment Findings have been identified. The RP's safety case provides adequate evidence at GDA for the TER[NLWDS] to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The design of the APG[SGBS] relevant to management of radioactive wastes is consistent with RGP and therefore the RP's safety case provides adequate evidence at GDA for the APG[SGBS] to substantiate sub-claim 3.3.11.SC23.5. I have raised one Assessment Finding, AF-UKHPR1000-0179 relating to the justification of the classification of the filters and demineralisers in the APG[SGBS]. Considering the scope of this assessment excludes faults and accident conditions, then, in my opinion it is proportionate that the RP's safety case for the APG[SGBS] does not include evidence to substantiate sub-claims 3.3.11.SC23.1 and 3.3.11.SC23.2.
- The DAW treatment sub-system of the TES[SWTS] aligns with RGP. I raised an Assessment Finding, AF-UKHPR1000-0180, for the licensee to consider the RP's management strategy for ILW DAW with free water and provide the evidence that the detailed design of the drying system reduces the risks so far as is reasonably practicable. On the basis of the scope of GDA, which excludes the design of mobile engineered systems such as the drying equipment, in my opinion it is appropriate that the RP's safety case for the DAW treatment sub-system at GDA does not include evidence to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The design of the spent resins flushing and storage system, and resin tanks of the WSW receipt and treatment sub-system, part of the TES[SWTS], is consistent with RGP. However, I have raised Assessment Finding AF-UKHPR1000-0178 for the licensee to provide adequate evidence that the design of the resin tanks (and associated SSCs) includes adequate capability for detecting leakage of radioactive waste outside the primary containment boundary. The RP's safety case provides adequate evidence at GDA to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5 for the design of the spent resins flushing and storage system and the resin tanks of the WSW receipt and treatment sub-system.
- For the SFCCM, part of the TES[SWTS] spent filter cartridge changing sub-system, there was limited evidence available to demonstrate that the design reduced the risks to ALARP, including gaps in the safety case relevant to the categorisation/classification of the SSCs in contact with radioactive material. Given the unmitigated doses (up to 10Sv/hr), I have raised Assessment Finding AF-UKHPR1000-0181 for the licensee to provide adequate evidence that the detailed design of the SFCCM, relevant to containment and contamination

controls, reduces the risks so far as is reasonably practicable, for both normal operations and in fault conditions. I consider the lack of arguments and evidence in the safety case, to justify why the confinement (containment) function of the SFCCM is not categorised and therefore the SFCCM equipment not classified, is inconsistent with the RP's safety case sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.

- For the SFRTD, I have raised a similar Assessment Finding to that for the SFCCM, AF-UKHPR1000-0182, for the licensee to provide evidence that the detailed design of the SFRTD, relevant to containment and contamination controls, reduces the risks so far as is reasonably practicable, for both normal operations and fault conditions. I consider the lack of arguments and evidence in the safety case, to justify why the confinement (containment) function of the SFRTD is not categorised and the SFTRD equipment not classified, is inconsistent with the RP's safety case sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- Several aspects relevant to the layout of the WSW receipt and treatment sub-system were identified to be inconsistent with RGP. I have thus raised Assessment Finding AF-UKHPR1000-0183 for the licensee to demonstrate that the design of the WSW receipt and treatment sub-system in the Radioactive Waste Treatment Building ensures the risks (including the risk of spreading contamination) from the movement of wastes around the facilities are reduced, so far as is reasonably practicable. There is inadequate evidence in the safety case to determine whether the WSW receipt and treatment sub-system meets sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5.
- The processing (dewatering) of ILW spent resins in 500 litre robust shielded drums is consistent with RGP. The RP's safety case for the resin dewatering operations provides adequate evidence to substantiate sub-claims 3.3.11.SC23.1, 3.3.11.SC23.2 and 3.3.11.SC23.5, appropriate to the GDA stage.
- For the management of sludges in the WSW receipt and treatment sub-system, there was a lack of detail in the RP's safety case on how the shielded cask lid of a 210 litre drum (containing ILW sludge) would be removed and how the sludges would be retrieved.. I have raised Assessment Finding AF-UKHPR1000-0184 for the licensee to provide adequate evidence that risks from the retrieval of sludges are reduced so far as is reasonably practicable. This includes, but is not limited to minimising the likelihood of spread of contamination. Due to the lack of detail I consider there to be a gap in the evidence for the RP's safety case for the sludge retrieval operations against Claim 3.1.1 "the design of radioactive waste management has been substantiated".
- I have raised Assessment Findings for the TES[SWTS] that reflect the intent of the residual matter identified during the closure of RO-UKHPR1000-0005 (Ref. 87).

4.7 ILW Interim Storage Facility

330. Consistent with the technical guidance on GDA (Ref. 22) the RP is expected to demonstrate HAW is stored safely on site pending availability of a GDF. In Step 4 of the UK HPR1000 GDA shortfalls were identified in the RP's safety case for the conceptual design of the ILW ISF against regulatory expectations, which resulted in the raising of RO-UKHPR1000-0040 'Provision of an adequate safety case for the interim storage of Intermediate Level Waste (ILW)' (Ref. 10). Further details of my assessment of the RP's evidence to support the closure of RO-UKHPR1000-0040 can be found in the relevant closure note (Ref. 37) and are discussed in this assessment. As a result of RO-UKHPR1000-0040 the RP provided a substantial update to the 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 35). My assessment is based on the

latest versions of the RP's safety case documentation, including (Ref. 35), which incorporated improvements to meet the expectations of RO-UKHPR1000-0040.

331. Taking into consideration the expectations noted above this sub-section includes assessment of:

- ILW ISF construction strategy and storage capacity
- The ILW ISF design and stacking arrangements
- Storage of ILW arising from reasonably foreseeable incidents
- ILW ISF hazards and risks
- Operating limits and conditions and EIMT requirements.

4.7.1 ILW ISF Construction Strategy and Storage Capacity

332. In the 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 35) the RP has considered OPEX from several nuclear power plants from around the world, including OPEX for the construction of ILW storage facilities. The RP considered two broad options for construction of storage facilities for the ILW inventories:

- A one-off construction plan. A single store is built to accommodate all ILW arisings from operation and decommissioning.
- A two phase construction plan. This is where either two independent stores are built at different times, or an extension is made to an initial store to enable further ILW arisings to be stored safely.

333. The RP has determined through a decision-making workshop that it will adopt a two phase construction plan for the ILW ISF. Phase 1 is designed to accommodate the ILW packages generated during the first 30 years of operations of two UK HPR1000 units. Phase 2 will be designed to accommodate the final 30 years of operational ILW from two units, and ILW arisings from decommissioning. In addition, the RP claims that the storage capacity of the second phase ILW ISF can be adjusted during its development. This will be based upon actual ILW arisings from the initial operating period of the UK HPR1000, and the updated decommissioning ILW inventory, to provide sufficient storage capacity. I sought clarity on the two phase construction plan in RQ-UKHRP1000-1311 (Ref. 38). The RP clarified that these are two independent ILW storage facilities.

334. The storage capacity requirements of the ILW ISF has been calculated by the RP through consideration of two distinct groups of ILW inventory for the UK HPR1000:

- ILW inventory which is stored on site until disposal in a GDF. This includes ILW generated from the operation and decommissioning of two UK HPR1000 units.
- ILW/LLW boundary wastes including concentrates, sludges, and DAW, which are stored in the ILW ISF to allow the radionuclides in the wastes to decay from ILW to LLW.

335. The RP's conceptual design of the ILW ISF is clear on the conservative use of these decay periods in determining the capacity of the store. For example, for decay storage of concentrates (which requires approximately 7.4 years) a conservative storage period of 10 years has been defined when determining the storage capacity of the ILW ISF.

336. The sizing of the two construction phases of the ILW ISF has been calculated by the RP based upon the assumptions for decay storage to predict when wastes can be transferred off the site for disposal. This information is presented by the RP in Tables T-7.1-6 ("Expected amount of store waste packages of the first phase facility") and T-7.1-7 ("Expected amount of stored waste packages of the second phase facility") (Ref. 35). From the waste inventory data in Tables T-7.1-6 and T-7.1-7 it can be seen that

the RP has considered the inventory for each phase to understand the impact upon the sizing of each facility individually.

337. The 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 35) concludes that the inventory for the operational arisings, and therefore the storage capacity of the ILW ISF, is conservative as it includes conservativism in the ILW/LLW boundary waste decay period and also includes a 10% margin. The 10% margin is based upon the RP's consideration of OPEX from the operation of similar pressurised water reactors (Ref. 35).

4.7.1.1 Assessment of the ILW ISF Construction Strategy and Storage Capacity

338. Regulatory expectations for the construction strategy and storage capacity of the ILW ISF focus on ONR SAP ENM. 2 and the expectation that the design should ensure adequate storage facilities are identified to enable the safe management of radioactive waste for the entire planned storage period. My assessment focuses on the RP's decision to implement a two phase approach to the construction of the ILW ISF, and the assumptions in the decay storage period of the ILW/LLW boundary wastes, to ensure sufficient storage capacity is defined in the generic UK HPR1000 design.

339. In my opinion, the RP has presented adequate evidence within the submission to underpin the decision to adopt a two phase construction plan, supported by relevant OPEX. In my opinion the two phase construction strategy does not impact on the RP's ability to demonstrate that adequate storage facilities for ILW are available for the entire planned storage period. In addition, in my opinion the decision to implement a two phase construction strategy and the review of the inventory to inform the second phase is consistent with the regulatory expectations in ONR SAP RW.1 paragraph 793 (q), to ensure that the storage capacity remains adequate through regular reviews, and RW.2 paragraph 798 to consider trends in radioactive waste generation during operation.

340. I have verified that the storage capacity defined for ILW in each of the phases of the conceptual design of the ILW ISF is consistent with the radioactive waste inventory defined (Ref. 34), as assessed in sub-section 4.2, and the ILW decommissioning inventory (Ref. 89), as assessed in the 'Step 4 Assessment of Decommissioning for the UK HPR1000 Reactor' (Ref. 14).

341. In my opinion, the conservative storage periods defined for the ILW/LLW boundary wastes, together with the 10% margin within the concept design, are consistent with the expectations of ONR SAP ENM.2, principally paragraph 471 item (d), for the RP to designate storage facilities of appropriate capacity, including spare and buffer capacity where necessary.

342. Overall, in my opinion, the RP has presented sufficient evidence to underpin the decisions taken relevant to the construction strategy and storage capacity in the conceptual design for the ILW ISF. The safety case presents an appropriate level of conservativism on the aspects of the decay periods of ILW/LLW boundary wastes and is also, in my opinion, consistent with ONR SAP SC.5.

4.7.2 The ILW ISF Design and Stacking Arrangements

343. The RP's conceptual design of the ILW ISF has several design assumptions, including an assumed design lifetime of at least 100 years (Ref. 35).

344. The ILW ISF conceptual design (Ref. 35) includes three dedicated storage areas, each designed for the storage of different waste package types: 500 litre robust shielded drums, 210 litre drums and 3 cubic metre boxes. The RP's optioneering considered the

type of storage areas which could be implemented within the design. Two options were identified by the RP:

- Ground level whole spaces termed vaults, which are typically adopted in the UK for the storage of similar radioactive waste types as for the UK HPR1000; or
- Isolated shielded shafts, as implemented in China.

The conclusions of the RP's optioneering assessment (Ref. 35) identified that, even though there are radiological safety advantages to selecting isolated shielded shafts, there are several advantages for the vault design including aspects relevant to conventional health and safety, operability, maintainability, flexibility and decommissioning.

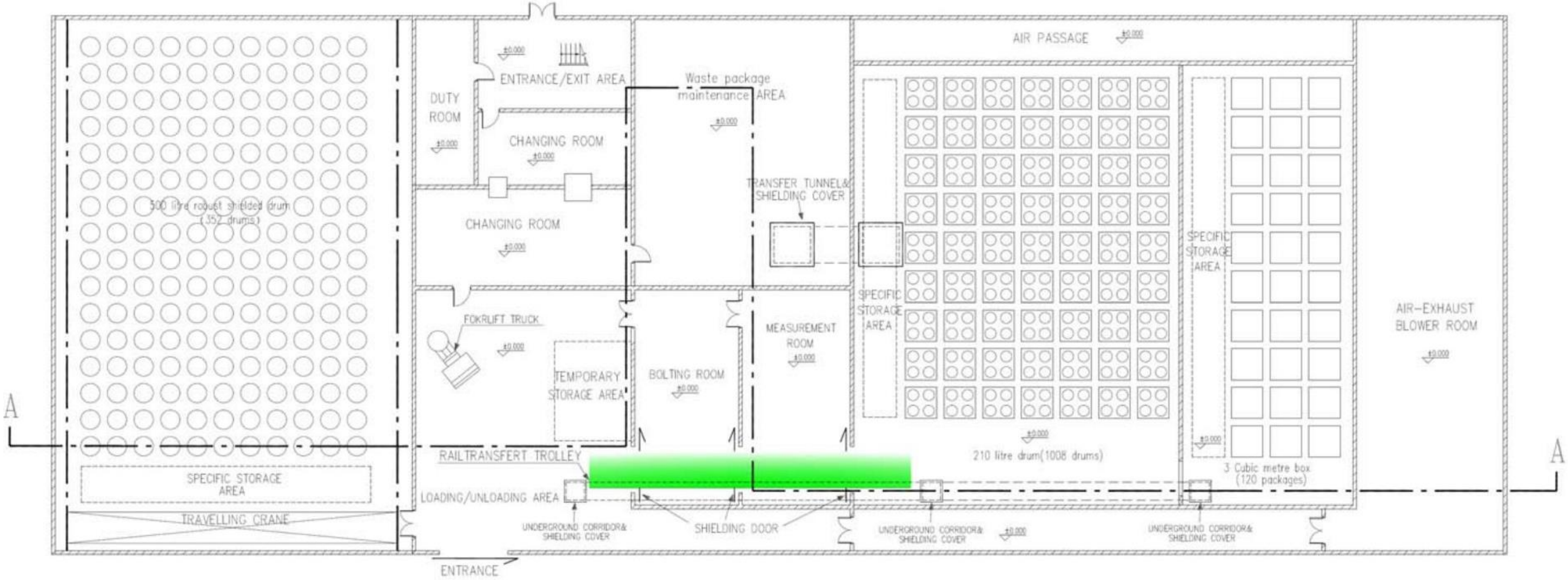
345. The RP's submission (Ref. 35) identified that, by storing each waste package type in its own vault, each vault can be tailored to meet the legal requirement to reduce the risks to ALARP. Measures include the use of shielding to reduce the radiation levels outside the vault and identification of SSCs required to support operations within the vaults. For the three package types:

- The 500 litre robust shielded drums (ILW ICIAs and spent resins) incorporate appropriate shielding in their design; therefore surface dose rates are low. The RP identified that, in addition to a travelling crane, a forklift can be used for package emplacement operations for this package type. The 500 litre robust shielded drums are stacked in two layers in the conceptual design of the ILW ISF (Ref. 35). The RP has identified OPEX that the maximum safe stacking height for the containers is three layers, which the RP has determined is feasible in the ILW ISF concept design, if required (Ref. 35).
- The 210 litre drums are used for decay storage of ILW to LLW (sludges, concentrates and DAW) and have no shielding. 210 litre drums containing ILW are moved around site in the shielding cask. The ILW ISF design identifies the need for a transfer trolley/rail system and a remotely operated crane to support removal of the 210 litre drum from the shielding cask and for package emplacement operations. The 210 litre drums are loaded into four-drum stillages to enable stacking within the vault. The RP's submission (Ref. 35) indicates the structure of the vault will be designed to provide sufficient shielding to reduce the external radiation dose rate to the public and workers in the other areas of the facility. The RP notes that the thickness of the shielding is to be optimised at the site-specific phase during detailed design of the ILW ISF. The RP's safety case for the conceptual design of the ILW ISF defines a stacking height of four layers for 210 litre drums (in stillages) (Ref. 35). The RP has identified OPEX to support a maximum safe stacking height of 210 litre drums in a stillage of up to 20 layers, but notes the ILW ISF conceptual design can only accommodate up to six layers (Ref. 35).
- 3 cubic metre boxes are used for the storage of ILW spent filter cartridges and ILW arising from decommissioning activities. The 3 cubic metre boxes are transported in shielding casks and undergo an import process requiring the use of a rail/transfer trolley and remotely operated crane for removal from the shielding cask and package emplacement. As before, the RP notes that the shielding requirements of the vault are also defined as part of the ILW ISF detailed design. The RP's safety case for stacking of 3 cubic metre boxes identifies four layers are to be used in the conceptual design of the ILW ISF, with OPEX available to support the stacking of 3 cubic metre boxes up to 13 layers high (Ref. 35). The limit for stacking in the ILW ISF conceptual design for 3 cubic metre boxes is six layers (Ref. 35).

346. The schematic drawings of the ILW ISF concept design are provided in the RP's submission (Ref. 35), with the Ground Floor layout included in Figure 6. The 210 litre drums and 3 cubic metre boxes are unshielded packages and are located on one side of a central operational area. The central operational area is defined in the RP's concept design as providing access, container preparation operations, service supplies, container measurements and ILW ISF equipment maintenance. The 500 litre robust shielded drums are stored on the other side of the central area.

347. The RP has considered the SSCs required to enable safe operations within the ILW ISF design. For example, the concept design identifies the requirement for a single remotely operated crane and a rail/transfer trolley which can access the unshielded storage area, which includes both the 210 litre drum and 3 cubic metre box storage vaults. Taking into consideration the need to routinely retrieve 210 litre drums, the RP has positioned the 210 litre drums closest to the measurement room/export route to minimise the 210 litre drums lift path and eliminate the risk of dropping a 210 litre drum into the 3 cubic metre box storage vault.

Figure 6: ILW Interim Storage Facility Conceptual Design (Ground Floor)



4.7.2.1 Assessment of the ILW ISF Design and Stacking Arrangements

348. In my opinion the RP's safety case provides adequate evidence to underpin the optioneering undertaken and the decision to use whole space vaults is consistent with ONR SAP RW.1. In addition, the RP's safety case refers to relevant UK OPEX for the storage of similar waste packages in vault type storage facilities.

349. ONR SAP RW.5 identifies the regulatory expectation for the safety case to demonstrate that radioactive waste is managed in accordance with relevant good practice and good engineering principles, and to justify the continued safe storage of waste for the entire planned storage period. Due to the operational period of the UK HPR1000 reactor design (60 years), the expectations of the UK Base Case for new nuclear power stations (Ref. 23), and the estimated disposal date for nuclear new build radioactive wastes to a GDF (2100-2140), the RP's conceptual design of the ILW ISF has an assumed design lifetime of at least 100 years (Ref. 35). This is consistent with existing industry guidance for similar storage facilities in the UK (Ref. 90). In my opinion, defining the need to build the ILW ISF with a design life of 100 years ensures the radioactive waste is stored in accordance with relevant good practice and that the storage of the waste is justified for the entire planned storage period, consistent with ONR SAP RW.5.

350. ONR SAP RW.4 identifies the expectation for the radioactive waste to be segregated to facilitate its subsequent safe and effective management. In my opinion, the RP's identification of three dedicated storage areas in the ILW ISF concept design based on the waste package type is consistent with the regulatory expectations of ONR SAP RW.4. During my assessment for the closure of RO-UKHPR1000-0040 I identified a residual matter relating to clarification of the point during package import at which and where the 210 litre drums are removed from shielded transfer casks and loaded into four-drum stillages, to enable stacking within the vault. Stacking is required to reduce the overall footprint of the ILW ISF. In my opinion the generic UK HPR1000 design does not foreclose options related to this operation, and therefore it is proportionate to identify this as a Minor Shortfall for the licensee to clarify during the detailed development of the ILW ISF design and operations.

351. As part of my assessment for the closure of RO-UKHPR1000-0040 (Ref. 37) I considered the adequacy of the RP's conceptual design of the ILW ISF against the regulatory expectations of ONR SAP ELO.1, which identifies the regulatory expectation of the design and layout to facilitate access for necessary activities. The RP's safety case focuses on using the layout of the ILW ISF to facilitate access for necessary activities. I sought evidence, by means of RQ-UKHPR1000-1311 (Ref. 38) on the RP's consideration of ONR SAP ELO.1 paragraph 224 item (c) to "ensure that radiation doses to workers carrying out operation, maintenance, inspection and testing activities are ALARP". In the response the RP clarified that within the ILW ISF concept design:

- The design of the operational areas ensures the lower dose rate areas are accessible without passing through higher dose rate areas.
- The positioning of routinely accessed areas (duty/change room) is away from the storage area for unshielded packages.
- The layout design will be optimised, and the relevant ALARP requirements justified, during detailed design at the site specific stage.

352. In my opinion, due to the central location of the operational areas, there is a need for the licensee to consider the layout of the ILW ISF during detailed design, to meet the regulatory expectations of ONR SAP ELO.1. This should provide adequate evidence to support the safety case position that the radiological risks are reduced to ALARP by the ILW ISF detailed design. This was captured as a residual matter in my closure of RO-UKHPR1000-0040 (Ref. 37) and is captured as a Minor Shortfall here for the

licensee to consider if there are opportunities to isolate aspects of the operational areas from the main storage facility, and therefore reduce the radiological risks further.

353. In my opinion, the RP's decision to position the 210 litre drums closest to the measurement room/export route, to minimise the lift path and eliminate the risk of dropping a 210 litre drum into the 3 cubic metre box storage, is a positive example of how the RP's ILW ISF conceptual design takes into consideration the regulatory expectations in ONR SAPs, including engineering principle ONR SAP ELO.3 to minimise the movement of nuclear matter.

354. Overall, the RP has provided adequate arguments and evidence that the ILW ISF design takes into consideration the requirements of the packages and, notwithstanding the Minor Shortfalls identified, is consistent with the key engineering principles captured within the relevant ONR SAPs. In addition, the RP has clearly identified relevant OPEX used to inform the decision-making process for these aspects of the ILW ISF design.

4.7.3 Storage of ILW Arising from Reasonably Foreseeable Incidents

355. Regulatory expectations for the consideration of radioactive waste arisings from reasonably foreseeable incidents are set out in ONR SAP paragraph 817 and aspects of The Radiation (Emergency Preparedness and Public Information) Regulations 2019 (REPPIR) (Ref. 91). Within the scope of GDA, there is no regulatory expectation for the RP to demonstrate how a licensee would comply with the requirements of REPPIR. For GDA there is a regulatory expectation (Ref. 22) that the generic safety case clearly identifies provisions which could be claimed for the safe management of radioactive waste generated in accident conditions. Considering the scope of my assessment I chose to sample the provisions for the management of ILW, given their accumulation on the nuclear licensed site until availability of a GDF. The licensee will be required to develop and underpin these provisions as adequate in developing its emergency arrangements.

356. The RP's safety case for the management of ILW generated in accident conditions indicates the inclusion of an additional 10% storage capacity in the ILW ISF to ensure safe storage of ILW until a GDF is available.

4.7.3.1 Assessment of Storage of ILW Arising from Reasonably Foreseeable Incidents

357. By means of RQ-UKHRP1000-1311 (Ref. 38) I sought clarity on the basis of the RP's conclusion in submission (Ref. 35) that inclusion of an additional 10% storage capacity in the ILW ISF for all waste containers (210 litre drums, 500 litre robust shielded drums and 3 cubic metre boxes) is adequate for the storage of ILW arising from reasonably foreseeable incidents. The RP clarified other aspects of the generic UK HPR1000 design that could support the safe storage of ILW from reasonably foreseeable incidents (Ref. 35). These are listed below:

- The licensee will be able to determine the available storage capacity within the ILW ISF and the SFIS facility. The SFIS also includes storage facilities for HLW packages, which could be used for safe storage of ILW arising from reasonably foreseeable incidents.
- The stacking height of waste packages stored within the ILW ISF could be increased from the planned height to the maximum available in the conceptual design of the ILW ISF, subject to the provision of an adequate safety justification (see sub-section 4.7.2). This would offer flexibility to the licensee for the management of ILW from reasonably foreseeable incidents.
- Phase 2 of the ILW ISF (when constructed) includes storage capacity for decommissioning wastes. This could be used for the storage of wastes arising from reasonably foreseeable incidents ahead of building a new storage facility.

- The option to build a third ILW store is not foreclosed in the generic UK HPR1000 design.

358. In my opinion the RP has presented adequate evidence, which is proportionate to the detail available at the GDA stage and meets the expectation of ONR SAP paragraph 817 by means of identification of provisions which could be claimed for the safe management of radioactive waste generated from incidents in the conceptual design of the ILW ISF.

4.7.4 ILW ISF Hazards and Risks (Normal Operations and Faults)

359. Two regulatory expectations were captured for the ILW ISF design in RO-UKHPR1000-0040 'Provision of an adequate safety case for the interim storage of Intermediate Level Waste (ILW)' (Ref. 10), which were that the RP should:

- Provide suitable and sufficient identification and assessment of the relevant hazards and risks to workers, members of the public and to the safety of the reactor (including any risks associated with a phased approach to construction of interim storage capacity, where applicable). ONR SAP FP.4 sets the regulatory expectation to demonstrate an effective understanding and control of the hazards posed by a facility through a comprehensive and systematic process of safety assessment.
- Identify any provisions in the ILW ISF design required for protection against identified faults. Consistent with regulatory expectations in ONR SAP EKP.3, this could be identification of preventative or mitigative features which are claimed to reduce the probability or consequences of the fault.

360. As a result of RO-UKHPR1000-0040 the RP identified hazards relevant to the ILW ISF and undertook a qualitative risk assessment (Ref. 35). The RP's preliminary safety assessment for the ILW ISF for normal operations and fault conditions described application of the hierarchy of hazard control, termed ERICP (Elimination, Reduction, Isolation, Control and Protect), to each of the identified hazards, such as radiation exposure. This included design features within the ILW ISF for the prevention, mitigation and protection against identified faults.

361. Wastes are processed into a passively safe form prior to receipt into the ILW ISF, which is discussed in sub-section 4.3 on the radioactive waste management strategies. The RP's safety case (Ref. 35) is clear that there are no criticality risks from the radioactive wastes to be stored in the ILW ISF. In addition, the ILW ISF is limited to the storage of waste packages categorised as ILW upon arising, and therefore by definition none of the wastes identified for storage in the ILW ISF are heat generating to the extent that they require active heat removal systems. The safety case (Ref. 35) also states that packages are to be lifted/stacked to a substantiated height, so that in a fault where a package in dropped, the package is able to withstand the impact of the drop without breaching.

4.7.4.1 Assessment of ILW ISF Hazards and Risks

362. In my opinion, the RP has provided evidence to demonstrate an adequate understanding of the hazards presented by the operations within the ILW ISF; and of the RP has identified preventative measures to control the hazard through a comprehensive and systematic process, which is consistent with the regulatory expectations in ONR SAP FP.4. The RP's identification of design features within the ILW ISF for the prevention, mitigation and protection against identified faults aligns with the regulatory expectations of ONR SAP EKP.3.

363. The RP's safety case for the ILW ISF (Ref. 35) assumes no fissile material in the ILW inventory generated from normal operations. This is consistent with my experience for

similar facilities in the UK and, in my opinion, removes the requirement for the RP to consider the criticality risk in the ILW ISF safety case. For these reasons I considered it disproportionate to seek advice and guidance from an ONR Fault Studies specialist inspector on the storage of ILW in the ILW ISF. The ONR Radiological Protection specialist inspector has considered the ILW ISF in the assessment of the doses to the public by means of RO-UKHPR1000-0028 (Ref. 10), the response to which ONR has assessed to be adequate. (Ref. 26) provides further details on the ONR Radiological Protection assessment. Therefore I did not consider it necessary to seek additional advice from the ONR Radiological Protection specialist inspector on the RP's assessment of the hazards and risks of the conceptual design of the ILW ISF for GDA.

364. Overall, in my opinion, the qualitative risk assessment, which links to the design features of the ILW ISF, is proportionate to the level of detail available at the GDA stage. During the detailed design of the ILW ISF the licensee will need to consider all regulatory expectations, including those within the relevant ONR SAPs, to demonstrate that the design and operations within the ILW ISF will reduce relevant risks to ALARP.

4.7.5 Operating Limits and Conditions and EIMT Requirements

365. The RP's ILW ISF concept design (Ref. 35) identifies operational limits and conditions necessary in the interests of safety and EIMT for the ILW ISF concept design. These are qualitative due to the level of design detail available for the ILW ISF at the GDA stage, with the safety case identifying the requirement for the future detailed design to quantitatively define the parameter values. The parameters include:

- Temperature and humidity controls to control the internal environment and reduce the risk of corrosion of the external surface of the packages, with the inclusion of a ventilation system in the ILW ISF conceptual design to deliver this function.
- Waste package heat output limits, given the ILW ISF and associated systems are not designed to store heat generating wastes.
- A monitoring and inspection regime for the facility SSCs and the waste packages, to verify the integrity of the waste packages is being maintained.

4.7.5.1 Assessment of Operating Limits and Conditions and EIMT Requirements

366. Prior to raising RO-UKHPR1000-0040 (Ref. 10) ONR had identified shortfalls in relation to regulatory expectations concerning identification of the operating limits and conditions necessary in the interests of safety and EIMT aspects for the ILW ISF. My assessment here is of the safety case submissions updated as a result of the RP's response to RO-UKHPR1000-0040.

367. In my opinion, the RP's ILW ISF concept design (Ref. 35) identifies operational limits and conditions necessary in the interests of safety and EIMT for the ILW ISF, listed above, which are consistent with the regulatory expectations in ONR SAP RW.5 and the joint guidance on HAW (Ref. 21). The RP's use of qualitative parameters, and the requirement for the future detailed design to quantitatively define the parameter values is, in my opinion, adequate given the level of design information available for the ILW ISF at the GDA stage.

4.7.6 ILW Interim Storage Facility Conclusions

368. In my opinion, the RP has provided adequate evidence on the following aspects of the ILW ISF:

- The construction of two independent ILW ISFs enables the RP to demonstrate that the generic UK HPR1000 design includes adequate storage facilities with sufficient storage capacity for radioactive wastes for the entire planned storage period. This is consistent with expectations in ONR SAP ENM.2 on ensuring adequate storage provisions of appropriate capacity and ONR SAP RW.5 paragraph 812 (g) on good engineering practices for the entire planned storage period.

- The conceptual design of the ILW ISF, Figure 6, is consistent with regulatory expectations in ONR SAPs RW.4 and ELO.3 to segregate the radioactive waste packages by type, and thus facilitate subsequent safe management through minimisation of movement. I have identified two Minor Shortfalls, the first related to the sequencing of the import operations and the removal of the 210 litre drum from the shielded cask into the four-drum stillage, and the second for the detailed design to consider the central location of the operation areas to ensure they are consistent with the regulatory expectations in ONR SAP ELO.1.
- There are adequate provisions which could be claimed for the safe management of radioactive waste generated from incidents in the conceptual design of the ILW ISF to meet the expectation of ONR SAP paragraph 817.
- The RP has demonstrated an adequate understanding of the hazards presented by the operations within the ILW ISF and has identified relevant measures to control the hazard consistent with the regulatory expectations in ONR SAP FP.4.
- The conceptual design for the ILW ISF identifies relevant operating limits and conditions necessary in the interests of safety and EIMT, consistent with the regulatory expectations in ONR SAP RW.5 and proportionate to the level of detail available during the GDA stage.

369. Overall, in my opinion the RP has presented adequate evidence that the ILW ISF provides adequate facilities for the safe storage of ILW on the site, pending availability of a GDF.

4.8 Demonstration that Relevant Risks have been Reduced to ALARP

4.8.1 Regulatory Expectations on the Management of Radioactive Waste and ALARP

370. ONR's TAG on ALARP, NS-TAST-GD-005 (Ref. 6), provides detailed guidance on the regulatory expectations relating to the demonstration that risks have been reduced to ALARP, which is supplemented by information in the TAG on radioactive waste management, NS-TAST-GD-024 (Ref. 7).

371. The requirement for risks to be ALARP is fundamental and is essentially a requirement to take all measures to reduce risk where doing so is reasonable. In most cases this is by applying established RGP and standards. In cases where standards and RGP are less evident or not fully applicable, the onus is on implementation of measures to the point where the costs of any additional measures would be grossly disproportionate to the further risk reduction that would be achieved.

372. Paragraphs 6.46 - 6.48 of NS-TAST-GD-005 discuss the management of risks over the long term, noting that future generations of workers and the public will be affected for some projects, particularly those associated with radioactive waste management such as long term storage of radioactive waste. ONR expects that for such cases the risks should be assessed in a holistic manner and not restricted to part of the overall time period or part of a process.

373. NS-TAST-GD-005 (Ref. 6) states we should seek to protect future generations at least as well as the present one, and that uncertainty argues for a precautionary approach and a particularly stringent demonstration that risks are ALARP. ONR therefore expects to see particular efforts made to demonstrate that risks to future generations are at least consistent with the levels of risk that would be accepted as adequate protection for the present generation. Given the uncertainties in estimating long-term

future risks, good practice and the application of the engineering key principles hierarchy, with the emphasis on control of hazard, are likely to be much more important than numerical risk estimates and cost benefit analysis.

374. The purpose of this sub-section is to assess whether the RP has provided adequate evidence to demonstrate that the risks associated with radioactive waste management in the generic UK HPR1000 design have been reduced to ALARP, in the context of the scope and stage of GDA.

375. The overall assessment of ALARP for radioactive waste management brings together a number of aspects including:

- Consideration of RGP and OPEX
- Gap analysis and assessment of options
- Radioactive waste management strategy
- Minimisation of radioactive wastes (generation and accumulation)
- Assessment of hazards and risks, including fault analysis and potential improvements to safety.

376. Some of these aspects have been assessed in detail elsewhere in this report, with summaries of their contribution to the demonstration of ALARP provided in the following sub-sections. The specific aspects of radioactive waste management considered in GDA are based on the sampling strategy described in sub-section 2.2. Firstly I present an overview of the RP's overall response to RO-UKHPR1000-0005 (Ref. 10) which, as noted in sub-section 2.2, I raised during Step 2 of GDA to address:

- The requirement to demonstrate that risks relevant to radioactive waste management are reduced to ALARP, and that relevant regulatory expectations in the ONR SAPs had been adequately considered.
- The need to take account of gaps/differences in regulation and critical infrastructure in the UK and China relating to radioactive waste management, and to recognise that the design of the HPR1000 (FCG3) may need to be modified to meet UK regulatory expectations and/or UK Government policy.

4.8.1.1 Overview of RO-UKHPR1000-0005 and Relevant RP Submissions

377. RO-UKHPR1000-0005 asked for a largely stepwise approach to the resolution of the shortfalls identified, which was intended to be broadly consistent with the expectations of the ALARP TAG, NS-TAST-GD-005 (Ref. 4), in terms of consideration of options and assessment of risks. The RO also asked for the production of a radioactive waste management strategy to underpin the development of options to meet the expectations of ONR SAP RW.1. The RO included the following actions:

- RO-UKHPR1000-0005.A1 - Evaluation of gaps/differences between UK practices and the HPR1000 (FCG3) design/Chinese practices in radioactive waste management.
- RO-UKHPR1000-0005.A2 - Evaluation and identification of options to address gaps/differences between UK practices and the HPR1000 (FCG3) design/Chinese practices in radioactive waste management.
- RO-UKHPR1000-0005.A3 - Production of a radioactive waste management strategy.
- RO-UKHPR1000-0005.A4 - List of UK HPR1000 Structures, Systems and Components (SSCs) modified and/or affected by addressing gaps/differences between UK practices and the HPR1000 (FCG3) generic design/Chinese practices in radioactive waste management.
- RO-UKHPR1000-0005.A5 - ALARP justification for radioactive waste management for the UK HPR1000.

378. My assessment of the RP's response to RO-UKHRP1000-0005 is presented in the relevant closure note (Ref. 37) and the outcomes are summarised in this sub-section. The aspects of radioactive waste management addressed by RO-UKHPR1000-0037 'In-Core Instrument Assemblies Radioactive Waste Safety Case)' (Ref. 36) and 'RO-UKHPR1000-0040 (Provision of an adequate safety case for the interim storage of Intermediate Level Waste (ILW))' (Ref. 37) were originally intended to be within the scope of RO-UKHPR1000-0005 when it was issued during Step 2 of GDA. Assessment of the more detailed submissions that became available during Step 3 and Step 4 of GDA indicated it was necessary to issue separate ROs for the management of ICIAs and interim storage of ILW to enable more targeted and detailed assessment of the shortfalls identified for these specific aspects, taking account of the sampling strategy which is focused on the highest hazards. I present the assessment of the RP's submissions prepared in response to these two ROs in sub-sections 4.4, 4.5 and 4.7 of this report with only summary information on the outcomes presented in this sub-section.

379. In response to RO-UKHPR1000-0005 the RP produced the following submissions:

- 'Gap Analysis Report for Radioactive Waste Management' (Ref. 11) - This comprised the response to RO-UKHPR1000-0005.A1 and is considered in my assessment of the RP's radioactive waste management strategies, presented in sub-section 4.3.The submission indicated there were no gaps/differences for the management of liquid (aqueous) and gaseous radioactive wastes, but the RP identified a number of gaps/differences relating to the management of a number of solid waste streams and non-aqueous liquid wastes and the reasonings, which are presented in Table 5.
- The report provided information on the work planned to address the gaps/differences identified.
- 'Optimal Options Study for Identified Gaps in Radioactive Waste Management' (Ref. 92) - This comprised the response to RO-UKHPR1000-0005.A2 and was based on the response to RO-UKHPR1000-0005.A1. The submission presented the optioneering process used and sources of RGP or OPEX for each identified gap/difference (Ref. 11) (as listed in Table 5).
- . It listed and evaluated the options that suitably addressed the identified gaps/differences in the scope of GDA, in accordance with the RP's optioneering process, to identify the preferred options to form the baseline for the design of radioactive waste management systems for the UK HPR1000. This included identification of any modifications to SSCs needed to implement the preferred options identified. The RP prepared optioneering studies for gaseous (Ref. 48), liquid (Ref. 49) and solid radioactive wastes (Ref. 53) which have been assessed in sub-sections 4.3-4.6 as relevant.
- 'Integrated Waste Strategy' (Ref. 32) - This comprised the response to RO-UKHPR1000-0005.A3, documenting the radioactive waste management strategy developed to take account of UK government policy and regulatory framework, including the expectations of SAP RW.1 on radioactive waste strategies. It integrated the outcomes from the responses to actions RO-UKHPR1000-0005.A1 and RO-UKHPR1000-0005.A2. The assessment of the adequacy of the RP's radioactive waste management strategies for liquid, gaseous and solid wastes is presented in sub-section 4.3 and 4.4.
- 'The List of SSCs Affected by the Optimal Options' (Ref. 58) - This comprised the response to RO-UKHPR1000-0005.A4 and took account of the outcome of RO-UKHPR1000-0005.A2. The submission summarised the SSCs potentially affected (commensurate to GDA scope and stage) by the holistic review and evaluation of the impact of the radioactive waste management related design changes on the overall plant. It identified and explained the SSCs which did and did not need to be modified in the generic UK HPR1000 design during

GDA and presented strategies, plans and timescales to deal with any necessary modifications to SSCs.

- ‘ALARP Demonstration Report for Radioactive Waste Management’ (Ref. 46) - This comprised the response to RO-UKHPR1000-0005.A5 and took account of the responses to RO-UKHPR1000-0005.A1, RO-UKHPR1000-0005.A2 and RO-UKHPR1000-0005.A4. The RP progressively developed this submission during Step 4 of the GDA to take account of feedback from ONR as well as the broader development of ALARP assessments for other technical disciplines. The submission summarised the gaps first identified by the systematic review of UK HPR1000 Design Reference 1.0 against UK RGP or OPEX and the outcome of optioneering of identified gaps and how this has been implemented in Design Reference 2.2. It also presented information on the design evolution of radioactive waste management systems and potential improvements arising from risk assessment. The submission provided an overview of measures to prevent and minimise the generation and accumulation of radioactive waste and summarised design features relevant to radiation protection in radioactive waste management systems (Ref. 46). It also addressed the outcomes of the Probabilistic Safety Analysis (PSA) and assessment of faults including the identification of PIEs and cross referenced to number of relevant submissions from a range of technical disciplines.

Table 5: Gaps Against RGP/OPEX Identified by the RP for Radioactive Waste Management for Design Reference 1.0 of the Generic UK HPR1000 Design

Gap ID	Gap identified by RP	Reasoning	Relevant optioneering submission where the gap is addressed
1	Treatment process for ILW spent resins	Cementitious grouting not demonstrated to produce long term stable waste form.	'Optioneering Report for Operational Solid Waste Processing' (Ref. 53)
2	Segregation and treatment process for DAW	There are different disposal routes in China and the UK.	'Optioneering Report for Operational Solid Waste Processing' (Ref. 53)
3	Treatment process for non-aqueous liquid wastes	There are different disposal routes in China and the UK.	'Optioneering Report for Operational Solid Waste Processing' (Ref. 53)
4	Management process for low active spent resins and ventilation filters	Decay storage of HVAC filters and low active resins was not identified as RGP, so the proposed process needed to either be demonstrated as ALARP (and BAT) or modified.	'Optioneering Report for Operational Solid Waste Processing' (Ref. 53)
5	In-Core Instrument Assembly (ICIA), RCCA and SCCA management process	The proposed management processes for the UK HPR1000 were not identified as RGP, so the proposed processes needed to either be demonstrated as ALARP (and BAT) or modified.	'Management Proposal of Waste Non-Fuel Core Components' (Ref. 61)
6	ILW container and shielding container for ICIA	The containers proposed for the UK HPR1000 were not standard containers and not yet accepted for disposal of ILW/HAW in the UK.	'Selection of waste containers for disposal of ILW' (Ref. 52)
7	ILW Interim Storage Facility	There are different disposal routes and different on-site storage requirements in China and the UK. The design criteria for on-site interim storage for design reference 1.0 were not compatible with the UK context.	'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 35)

380. I present my assessment of the RP's submissions relevant to the demonstration of ALARP in the following sub-sections.

4.8.2 Consideration of RGP and OPEX in Radioactive Waste Management

381. Annex 2 of the ALARP TAG, NS-TAST-GD-005 (Ref. 6) states that RGP is the basic requirement for demonstrating that designs meet the law, and that the RP must set out the standards and codes used and justify them to the extent that they can be deemed RGP when viewed against our SAPs. This justification is also expected to include a comparison with other international/national standards. The RP needs to show it has met the standards and codes it has adopted.

382. The purpose of this sub-section is two-fold, firstly to assess the RP's evidence in relation to meeting the expectations of Annex 2 of the ALARP TAG, NS-TAST-GD-005, as it relates to RGP and the second to assess the RP's demonstration of the identification, analysis and use of relevant OPEX.

4.8.2.1 The RP s Submissions on RGP and OPEX

383. The 'ALARP Demonstration Report for Radioactive Waste Management' (Ref. 46) explicitly stated that compliance with RGP/OPEX was considered to be the start point for the demonstration of ALARP. The RP carried out an analysis of RGP compliance for radioactive waste management, as reported in 'Analysis Report of Applicable Codes and Standards' (Ref. 93), with the RP identifying standards and guidance for radioactive waste management from a number of sources including the UK, WENRA, IAEA and OPEX from previous GDA processes. The RP screened those identified against a range of criteria including whether they were RGP in the UK or internationally, application in engineering practice, familiarity to the designer and whether there are mature companion standards. The RP thus identified RGP for radioactive waste management (Ref. 93).

384. The RP also undertook a process of identifying and analysing OPEX to ensure it used relevant OPEX appropriately, which is described in 'Methodology for Use of OPEX in UK HPR1000' (Ref. 94), which the RP produced in response to RO-UKHPR1000-0044 (Ref. 10) on the identification and use of OPEX in the generic UK HPR1000 design and safety case, which was closed by ONR in Step 4 of the GDA (Ref. 95). The RP applied this process and produced the 'OPEX Analysis Report for Radioactive Waste Management' (Ref. 96), which identified OPEX-related themes relevant to radioactive waste management and considered the intended use of the OPEX identified. This is also integrated into the radioactive waste management ALARP submission (Ref. 46). The RP considered a range of OPEX including:

- OPEX on waste generation and treatment efficiency from the CGN fleet of PWRs.
- Radioactive waste management arrangements for the Chinese fleet of PWRs.
- Lessons learnt from previous GDA processes including ONR's and EA's assessments
- OPEX from UK organisations such as RWM on aspects such as waste packaging practices.
- Information on worldwide practices, OPEX and research from international organisations including IAEA, OECD and Electric Power Research Institute (EPRI).
- Publications in waste management practices in a range of countries.
- Operational information/lessons learnt from workshops with EDF and other NPP operators.

385. The RP classified the OPEX collected into three types for consideration in developing the generic UK HPR1000 design and safety case:

- OPEX from PWRs was used in the identification and quantification of radioactive waste generation and disposals;
- OPEX relevant to proposals for radioactive waste management was used in optioneering/justification of optimisation of radioactive waste management; and
- Lessons learnt from previous GDAs.

4.8.2.2 Assessment of the RP's Submissions on RGP and OPEX

386. On the basis of the evidence summarised in the ALARP demonstration for radioactive waste management (Ref. 46) and its supporting references, including on applicable codes and standards (Ref. 93), I consider the RP has set out the appropriate codes

and standards for radioactive waste management and has provided adequate justification for their use as RGP when viewed against ONR's SAPs. I thus consider the RP has met the expectation of Annex 2 of the ALARP TAG, NS-TAST-GD-005, with respect to justification of the codes and standards identified as RGP.

387. With respect to OPEX I concluded that the RP's OPEX arrangements had been adequately implemented in relation to radioactive waste management, with adequate identification and use of OPEX found.

388. I note that for the radioactive waste management strategy for the retrieval of waste ICIAs the generic UK HPR1000 design includes the use of a winding machine, which was assessed in sub-sections 4.4 and 4.5. The winding machine is novel in the UK and is therefore not consistent with RGP in the UK. However the winding machine forms part of the baseline design and is therefore included in the design of FCG3 (currently under construction) and Nuclear Power Plant T, in China† (currently in operation). My assessment in sub-section 4.4 concluded that, consistent with Annex 2 of ONR ALARP TAG, NS-TAST-GD-005 (Ref. 6) the strategy for the management of ICIAs represents the ALARP outcome for the generic UK HPR1000 design.

389. Overall I consider the RP has identified and made effective use of national and international OPEX from an early stage of the GDA process, where it was important in identifying gaps between UK and Chinese practices in radioactive waste management. Further details of my assessment on the RP's use of OPEX in the safety case are presented in sub-sections 4.2 - 4.7, where relevant.

4.8.3 Assessment of the RP's Submissions on Gap Analysis and Selection of Options for Radioactive Waste Management

390. I assessed the 'Gap Analysis Report for Radioactive Waste Management' (Ref. 11) which constituted the RP's response to RO-UKHPR1000-0005.A1. I concluded that the RP's gap analysis met our expectations with respect to relevant aspects of ONR SAP RW.1 for aspects of radioactive waste management strategies, including consideration of a range of options and taking account of relevant factors. The gaps identified in Table 5.

391. were consistent with my expectations, based on my knowledge of UK radioactive waste management practices. I concurred with the RP's view that there were no gaps against RGP/OPEX for the management of gaseous and liquid radioactive wastes, as discussed in sub-section 4.3 of this report.

392. I considered the submission provided sufficient information on the practices undertaken at FCG3 and their evaluation against applicable UK codes and standards as well as OPEX and international guidance. I considered that the gap analysis presented was suitable and sufficient for the purposes of identifying where further design development and justification was required and where this would be presented in other reports. The gap analysis (Ref. 11) was also appropriately summarised and reported in the RP's overall ALARP demonstration report for radioactive waste management (Ref. 46), thereby providing part of the safety case golden thread in relation to the evidence needed to demonstrate the overall intent of the RO has been met.

393. My assessment of the optioneering studies for gaseous (Ref. 48), liquid (Ref. 49) and solid radioactive wastes (Ref. 53) and (Ref. 61), as identified in Table 5, is primarily presented in sub-sections 4.3, 4.4 and 4.6 of this report. The selected options are consistent with the information presented in Table 2 on the operational radioactive waste inventory. I have not assessed the submission 'Selection of Waste Containers

† Nuclear Power Plant T cannot be directly identified in the RP's safety case due to the protection of proprietary information. I have adopted the same principle in my assessment report.

for Disposal of ILW' (Ref. 52) in detail but note I have considered the disposability of HAW in sub-section 4.3 on radioactive waste management strategies, to which the selection of waste containers is largely applicable.

394. The RP's optimal options study (Ref. 92) also included two additional potential improvements not identified in the gap analysis against Design Reference 1.0 (Ref. 11), namely zinc injection in the primary circuit to reduce corrosion and the type of HEPA filters used for treatment of gaseous wastes in HVAC systems. ONR's specialist inspector in Chemistry has assessed zinc injection in detail, including consideration of possible impacts on the production of radioactive wastes (Ref. 44). I thus do not consider it necessary to address zinc injection further in this report. I considered the selection of the type of HEPA filters in the HVAC systems in sub-section 4.3 on radioactive waste management strategies, concluding the RP had provided an adequate case for the selection of HEPA filters from a radioactive waste management perspective, based on the RP's optioneering carried out in response to RO-UKHPR1000-0036 'HEPA Filter Type', issued by the Environment Agency (Ref. 10).

395. I raised RQ-UKHPR1000-0837 (Ref. 38) to seek clarification of a number of matters in the RP's optimal options study (Ref. 92). These matters included the scope of one of the gaps relating to the management of ILW, the optioneering process applied, evidence of workshops for design modifications, and whether there were any other gaps relating to waste minimisation. I concluded that overall the RP provided adequate information on the options chosen to address identified gaps/differences in radioactive waste management practices to meet the intent of RO-UKHPR1000-0005.A2 consistent with the regulatory expectations in aspects of ONR SAP RW.1 and ONR's ALARP TAG, NS-TAST-GD-005 (Ref. 6), in relation to the consideration of options.

396. I considered that the RP's optimal options study (Ref. 92) and its supporting references was also appropriately summarised and reported in the overall ALARP demonstration report (Ref. 46), and thus reflected in the overall "golden thread" from the claims in Chapter 23 of the PCSR (Ref. 4) to the supporting submissions where the evidence was presented.

397. Notwithstanding the Assessment Finding raised in sub-section 4.6, overall I consider the RP has adequately substantiated the relevant evidence for sub-claim 3.3.11.SC23.5 that all reasonably practicable measures have been adopted to optimise the design of radioactive waste management systems through implementation of design changes against the identified gaps.

4.8.4 Assessment of the RP's Integrated Waste Strategy (IWS)

398. The joint guidance on HAW (Ref. 21) sets out the regulatory expectations for an IWS. The regulators (ONR and the Environment Agencies) consider production of an IWS to be a good practice and that the specification and guidance produced by the Nuclear Decommissioning Authority (Ref. 97) is appropriate for the content and format of an IWS. The RP used this specification to produce the IWS for the generic UK HPR1000 design (Ref. 32).

399. I consider the IWS produced by the RP met the regulatory expectations for radioactive waste management strategies set out in ONR SAP RW.1 and the joint guidance on HAW (Ref. 21), appropriate to the stage of GDA.

400. In addition to consideration of the IWS, I have considered more detailed aspects of the radioactive waste management strategies for a number of specific waste streams in sub-section 4.3 and 4.4 of this report, with focus on solid HAW which gives rise to the most significant hazards. Overall I consider the strategy set out in the IWS and its supporting submissions provided an adequate basis for the development of the generic design and safety case for the UK HPR1000 for radioactive waste management, and

thus contributed to the overall demonstration that relevant risks associated with radioactive waste management are reduced to ALARP.

401. Overall, I consider the RP has provided adequate evidence that a radioactive waste management strategy has been produced and maintained for all radioactive waste generated from the operation of the generic UK HPR1000 design. The evidence in the IWS has been taken into consideration to ensure the scope of sub-claim 3.3.11.SC23.2, that the system design satisfies the functional requirements, is clearly defined.

4.8.5 Assessment of the RP's Submission on the SSCs Affected by the Optimal Options for Radioactive Waste Management

402. The RP's submission (Ref. 58) indicated the implementation of the options that address the gaps listed in Table 5.

403. has had impacts on a number of SSCs across a number of buildings. The RP also provided clear information on what SSCs were not affected by implementation of the options for radioactive waste management, as requested by RO-UKHPR1000-0005.A4.

4.8.5.1 Radioactive Waste Treatment Building

404. The design of the Radioactive Waste Treatment Building was modified in the generic UK HPR1000 design to accommodate changes in the design of the TES[SWTS] to enable the treatment of spent resins, spent filter cartridges, concentrates, sludges and the dewatering of ILW resins.

405. Examples of the range of changes to structures in the Radioactive Waste Treatment Building included modifications to rooms, increases in the thickness of walls and shield doors with associated impacts on floor loading, and changes in fire zoning. The systems affected by the changes were not limited to the TES[SWTS] but also included support systems such as ventilation, air distribution, power, control and fire extinguishing systems. A number of existing components in the Radioactive Waste Treatment Building were impacted by the changes, for example an increase in the loading capacity of the crane in the vehicle entrance area and changes to transfer trolleys to accommodate larger waste packages in the generic UK HPR1000 design for the management of ILW in shielding casks.

406. Sub-section 4.6.4 presents my assessment of a sample of the sub-systems which form part of the TES[SWTS]. As a result of my assessment I have raised five Assessment Findings relevant to the design of TES[SWTS] SSCs, some of which result from the modifications to address the gaps between Chinese and UK practices and infrastructure. Of particular note is the Wet-Solid Waste Receipt and Treatment System in the Radioactive Waste Treatment Building, where the radioactive wastes are managed in a very different way in the UK compared to Chinese practices for these wastes. This system is a new design for the generic UK HPR1000 design and incorporates a number of new and modified SSCs. Further work will be needed to justify the risks are reduced to ALARP, as defined in Assessment Finding AF-UKHPR1000-0183.

4.8.5.2 Radioactive Waste Treatment Systems

407. The RP also included information on modifications to SSCs in radioactive waste management systems resulting from consideration of improvements arising from consideration of other technical disciplines (Ref. 58). This included Fire Safety, Mechanical Engineering and Radiological Protection. Examples of the changes included fire-fighting lifts, changes to pumps and valves in the RPE[VDS], TEU[LWTS]

and TEG[GWTS] following analysis of compliance with HSG253 on safe isolation of plant and equipment, installation of flow proportional samplers in the TER[NLWDS] and installation of an additional concentrate tank in the TEU[LWTS] (Ref. 88), as discussed in sub-section 4.6. Whilst assessment of these aspects is largely outside the scope of this report, I consider the modifications further below in the context of the overall demonstration of ALARP to meet the expectations of RO-UKHPR1000-0005, in particular the modification to add a new concentrate tank in the TEU[LWTS].

408. I sought further clarification by means of RQ-UKHPR1000-0987 (Ref. 38) on the scope of the list of SSCs and the impacts of additional shielding as a result of the modifications. The RQ addressed aspects such as floor loading, fire zoning and the safety categorisation and classification of the ventilation system. Whilst the responses were adequate, I decided to issue RQ-UKHPR1000-1136 (Ref. 38) to seek information on the status of the various modifications to SSCs with respect to their inclusion (or otherwise) in Design Reference 2.1 and the stage of lifecycle of the design at which the modification would be undertaken. The response was adequate and has been incorporated into a number of the RP's submissions. However, there appeared to be an omission in the list of SSCs affected by the optimal options as it does not include the 210 litre drum shielded casks (Ref. 58), as noted in sub-section 4.3. Given the RP's ALARP demonstration for radioactive waste management (Ref. 46) makes claims on the need to use a shielding cask to minimise radiation doses to workers during on-site activities when the ILW/LLW boundary wastes are categorised as ILW I have raised a Minor Shortfall for the licensee to ensure the list is complete, although it is clear the RP has taken account of this component in the design of the TES[SWTS].

4.8.5.3 Storage on Site

409. Implementation of the options to meet UK Government Policy for on-site storage of HAW and spent fuel resulted in the removal of some waste storage buildings from the design and the inclusion of the ILW ISF and SFIS Facility, which are assessed in detail in sub-section 4.7 of this report and the assessment report for SFIS (Ref. 13), respectively.

4.8.5.4 Overall Judgement on the RP's SSCs Affected by the Optimal Options for Radioactive Waste Management Submission

410. The objective of action RO-UKHPR1000-0005.A4 was to ensure the RP identified those SSCs affected by modifications to address the gaps/differences in radioactive waste management, and thus be in a position to assess the risks posed by the modifications, as part of the overall assessment that relevant risks have been reduced to ALARP. I note the design already incorporated measures to reduce the risks associated with the modifications, for example increased thicknesses of shield walls, the impact of this on floor loading and changes to fire zoning. I consider the RP has met this objective, appropriate to the stage of GDA, noting that further work will be needed to assess the risks associated with the modifications and demonstrate they are reduced to ALARP as the design is developed in more detail.

411. Overall I consider the RP's identification of the SSCs affected by the options selected for management of radioactive wastes to address gaps against RGP/OPEX in fulfilment of RO-UKHPR1000-0005.A4 met my expectations, noting the Minor Shortfall raised related to the shielded cask for 210 litre drums. The RP's analysis (Ref. 58) contributing to the overall demonstration of ALARP by identifying those elements where safety assessment needs to be carried out as a result of modifications. The RP has already carried out some of this assessment, but I recognise that further work will be needed as the design progresses. I have identified Assessment Findings to address identified shortfalls in relation to the detailed design of the SSCs affected by the selected options in my assessment of the radioactive waste treatment systems, as presented in sub-section 4.6.

412. I welcome the holistic approach the RP has taken in documenting a broader range of modifications to meet the intent of RO-UKHPR1000-0005.A4 and identifying the reasoning for the modifications in achieving safety improvements. I also note the work on the 'SSCs Affected by the Optimal Options for Radioactive Waste Management Submission' (Ref. 58) is appropriately summarised and referenced in the RP's overall ALARP demonstration report (Ref. 46).

413. My assessment of whether the RP has adequately substantiated the relevant evidence for sub-claim 3.3.11.SC23.5, namely that all reasonably practicable measures have been adopted to optimise the design of the radioactive waste management systems, is presented in sub-section 4.6 for each of the systems/sub-systems sampled.

4.8.6 Minimisation of the Generation and Accumulation of Radioactive Waste

414. SAP RW.2 states that the generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms of quantity and activity, while SAP RW.3 states that the total quantity of radioactive waste accumulated on site at any time should be minimised, so far as is reasonably practicable (Ref. 2). It is therefore necessary to consider both these aspects in the context of demonstrating that the risks associated with radioactive waste management have been reduced, so far as is reasonably practicable, which was the key expectation of RO-UKHPR1000-0005 (Ref. 10). This sub-section assesses the safety case with respect to meeting the expectations relevant to ONR SAPs RW.2 and RW.3.

4.8.6.1 Minimisation of the Generation of Radioactive Waste

415. The minimisation of the generation of radioactive waste is one part of the broader consideration of the minimisation of radioactivity arising from the operation of the UK HPR1000. The prevention/minimisation of radioactivity at source, in the primary circuit, is the most fundamental aspect of reducing the amount of radioactive waste generated from the operation of the reactor, and has been an area of focus for the assessment of the generic design of the UK HPR1000.

416. The compositions of the primary circuit component materials and coolant have a direct impact on the inventory of radioactivity in the primary coolant, especially in relation to corrosion products. Optimisation of the chemistry and radiochemistry in the generic UK HPR1000 design reduces the primary circuit radioactive inventory, which in turn minimises the activity of corrosion products which contribute to radioactive waste arisings including, but not limited to, spent filter cartridges, spent resins and sludges.

417. The minimisation of radioactivity arising from operation of the generic UK HPR1000 design has been considered in detail as part of the Chemistry technical topic (Ref. 44). The specialist inspector in Chemistry raised RO-UKHPR1000-0026 (Ref. 10), which asked the RP to provide an adequate demonstration of how radioactivity is generated and transported in the UK HPR1000, information on the nature and quantity of all radiochemical species, and to demonstrate that radioactivity has been reduced, so far as is reasonably practicable. I worked with the specialist inspector on Chemistry and inspectors from other relevant technical disciplines, including colleagues from the Environment Agency, to assess submissions prepared by the RP to address the expectations of RO-UKHPR1000-0026 from a radioactive waste management perspective.

418. The RP's response to RO-UKHPR1000-0026 was to produce the 'Minimisation of Radioactivity Route Map Report' (Ref. 98). This was a "document map" (list of documents) that provided the detailed demonstration that the radioactivity sources and levels in the generic UK HPR1000 design have been minimised, so far as is reasonably practicable. The document map covered multiple technical areas/disciplines, including radioactive waste management, spent fuel management

and decommissioning, and covered the lifecycle of radioactivity from generation to disposal. The ‘Minimisation of Radioactivity Route Map Report’ (Ref. 98) also provided an accompanying narrative focusing on the most significant measures contributing to minimisation of radioactivity, with respect to both safety and environmental protection. It also provided the explanation of how a balance has been achieved to reach an ALARP/BAT position, where relevant.

419. The RP provided summary information on the minimisation of radioactive waste at source (defined as from the reactor and primary circuit) in Chapter 23 of the PCSR (Ref. 4) including:

- The minimisation of fission products in the primary coolant by means of the design and manufacture of fuel (by minimising the likelihood of fuel failure and minimising fissionable material on the surface of the fuel (known as tramp uranium)).
- Minimising activated corrosion products through material selection (for example avoidance/minimisation of elements which are easily activated and use of materials with good corrosion resistance and surface finish).
- Minimising the radioactivity in waste by optimising water chemistry in the primary coolant (by minimising the generation of activation and corrosion products and the use of additives that may adversely affect the management of radioactive waste).
- Minimising leaks of radioactive process fluids from containment systems to prevent the spread of contamination and thus minimise the generation of radioactive waste.

420. The RP also produced the submission ‘Topic Report on Radioactive Waste Management in Mechanical Engineering’ (Ref. 99). This presented the approach applied to ensure waste prevention/minimisation is given due consideration at all stages of the plant lifecycle. It presented measures being implemented or considered to prevent/minimise radioactive waste in the area of mechanical engineering. It described design principles and considerations for aspects including purification at source by filters and demineralisers, containment and leak tightness of systems, optimisation of maintenance and the containment of gaseous discharges by HVAC systems. It presented information on how these aspects have been addressed in the generic design provisions of the UK HPR1000. Assessment of these aspects is largely outside the scope of this report, but the RP produced the specific topic report on radioactive waste minimisation for mechanical engineering (Ref. 99) in support of sub-claim 3.3.11.SC23.3 “The production and accumulation of radioactive waste from UK HPR1000 operation has been minimised”.

421. The RP provided a summary of the information on minimisation of the generation of radioactive waste in the ‘ALARP Demonstration Report for Radioactive Waste Management’ (Ref. 46). This provided a holistic review of radioactive waste management, with an overview of the evolution of the design of the HPR1000 at FCG3 (the reference design for the UK HPR1000) and of those improvements relevant to the minimisation of radioactive waste. These were:

- The application of advanced fuel assemblies that minimise the release of fission products.
- The application of an extended fuel cycle length that reduces the amount of radioactive waste (and spent fuel) generated.
- The control of elements susceptible to activation in the materials of components in the primary circuit (for example cobalt and nickel) to reduce the activation of corrosion products in the primary circuit and the activity levels of activated structures.
- Optimisation of the pH control value in the primary circuit to minimise the generation and deposition of corrosion products.

- Modification of the Steam Generator Blowdown System (APG[SGBS]) by removing the non-regenerative heat exchanger to reduce the risk of transfer of radioactivity to the secondary circuit as a result of leakage.
- Use of enriched boric acid to reduce the amount used to control reactivity, thereby reducing the amount of lithium hydroxide needed which will reduce discharges of tritium and lithium to the environment as well as enabling better pH control, which reduces the generation and deposition of corrosion products.

422. The RP provided further information on the minimisation of radioactive waste (Ref. 46), including:

- Application of the waste management hierarchy.
- Minimisation of spent fuel and NFCCs.
- The application of segregation and characterisation to avoid mixing and ensure treatment and disposal routes can be applied efficiently.
- Sufficient capacity for treatment and storage of radioactive waste to enable efficient management.
- Optimisation of waste treatment/processing techniques.
- Application of decay storage where appropriate to reduce arisings of HAW which need to be disposed of to a GDF.

423. Appendix A of the ALARP demonstration for radioactive waste management (Ref. 46) and the supporting reference ‘Minimisation of Radioactivity Route Map Report’ (Ref. 98) also provide very useful summaries of the RP’s approach to the minimisation of radioactive waste. This takes account of the lifecycle from generation to disposal and provides the references to where supporting information is provided. Appendix A includes reference to the ‘Topic Report on Radioactive Waste Management in Mechanical Engineering’ (Ref. 99). Appendix A also makes a number of references to information in the PCER where detailed evidence on aspects of waste minimisation is presented.

424. I have assessed the information in the RP’s safety case (Ref. 4, Ref. 46, Ref. 98) against the regulatory expectations of SAP RW.2, insofar as they relate to the stage and scope of GDA. Overall I consider the RP has provided adequate information to meet the relevant expectations of SAP RW.2, in relation to aspects such as process and material selection (for example selection of materials to minimise corrosion and activation), proposed operating practices (for example optimise water chemistry/ pH control to prevent corrosion) and the recycling of boric acid from the primary circuit.

425. I consider the RP has provided a good overview of the minimisation of the generation of radioactive waste at source across all relevant technical areas, which demonstrates good awareness of management of radioactive wastes across the lifecycle from generation to disposal. The RP has provided adequate information on waste minimisation to provide the safety case golden thread. The RP has significantly improved the safety case relating to waste minimisation during Step 4 of GDA, noting that during earlier stages the safety case was largely focused on the systems for the management of radioactive wastes, with less emphasis on minimisation at source and lifecycle considerations. In my opinion, the information provided in (Ref. 98) has been very useful in substantiating the minimisation of generation of radioactive waste at source.

426. I consider the RP has provided adequate evidence to substantiate the relevant claims and sub-claims in Chapter 23 of the PCSR (Ref. 4), namely sub-claim 3.3.11.SC23.3 as it relates to the minimisation of the production of radioactive waste.

4.8.6.2 Minimisation of the Accumulation of Radioactive Waste

427. SAP RW.3 expects the safety case to demonstrate that the accumulation of radioactive waste on the site has been minimised. Accumulation (amassing) of radioactive waste increases as a result of its generation/production and reduces as a result of its disposal/removal. SAP RW.3 also indicates that volume reduction should be considered during all stages of a facility's lifecycle. I assessed the minimisation of generation of radioactive waste in sub-section 4.8.6.1 and concluded it has been minimised for the generic UK HPR1000 design, commensurate with the stage and scope of GDA. The objective of this sub-section is to consider the RP's evidence that disposal routes are available for the radioactive wastes arising from operation of the UK HPR1000, which therefore demonstrates overall that the accumulation of radioactive waste has been minimised.

428. Chapter 23 of the PCSR (Ref. 4) recognises the benefits of appropriate disposal routes for different categories of radioactive waste, and the minimisation of accumulation is stated as being an important element of the radioactive waste management strategy.

- Gaseous wastes arising from the operation of the generic UK HPR1000 design are accumulated in storage tanks, with technologies such as charcoal delay beds to allow decay of noble gases in some circumstances, as described in Section 3, and otherwise are disposed of as they arise following treatment in either the TEG[GWTS] and/or building ventilation systems.
- Liquid wastes are typically accumulated in storage tanks for relatively short periods, before and after treatment, and are disposed of once they have been sampled and monitored to demonstrate they meet the criteria of the Environmental Permit for disposal to the environment.
- Solid Lower Activity Wastes (LAW), including out-of-scope solid wastes, solid LLW and non-aqueous liquid radioactive wastes are disposed of using existing routes available in the UK (Ref. 54). It is noted that some wastes may be recycled after treatment in off-site facilities, in accordance with the UK's policy for the management of LLW (Ref. 100) and the waste management hierarchy.
- As discussed elsewhere in this report, there is currently no disposal route for HAW, which for the UK HPR1000 comprises spent fuel, HLW and ILW. These wastes are therefore stored on site pending the availability of a GDF, which is consistent with the assumptions in the Base Case in the Funded Decommissioning Programme Guidance for New Nuclear Power Stations (Ref. 23).
- In order to minimise the accumulation of solid HAW on the site the RP has identified ILW / LLW boundary wastes which are suitable for management / disposal as LLW after a period of decay storage on site, as presented in sub-sections 4.2 and 4.3.

429. Chapter 23 of the PCSR (Ref. 4) indicated that the minimisation of the accumulation of radioactive waste is based on the following considerations:

- Provision of sufficient storage capacity, facilitating appropriate treatment;
- Providing appropriate space to segregate solid LLW to enable volume reduction and to store conditioned waste packages;
- Establishment of an AiP with LLWR to ensure LLW can be accepted by off-site facilities (Ref. 55); and
- Assessment of disposability by RWM to ensure HAW is compatible with a future GDF (Ref. 51).

430. The 'ALARP Demonstration Report for Radioactive Waste Management' (Ref. 46) also notes that no "orphan wastes" (which are those wastes for which no disposal route is available or expected to be available in the future, which are now more typically

referred to as "problematic wastes") should be generated in order to minimise the accumulation of radioactive waste.

431. The adequacy of storage capacity for radioactive wastes in the scope of this report has been assessed in sub-section 4.6 in relation to liquid and gaseous wastes and to solid ILW in sub-section 4.7 of this report, and considered to be adequate. The storage of LLW is outside the scope of this report in accordance with the sampling strategy described in sub-section 2.2.

432. Segregation of solid radioactive waste will largely take place in the Waste Auxiliary Building used for the processing of LLW, including volume reduction, and is thus outside the scope of this report. The adequacy of storage of conditioned waste packages of HAW is addressed in sub-section 4.7 of this report on storage of ILW and sub-section 4.4 on the management strategy for waste ICIAs, where I concluded that the conceptual storage facility designs (ILW ISF and SFIS Facility) include adequate storage capacity for the HAW arising from the operation (and decommissioning) of the generic UK HPR1000 design.

433. During GDA the RP has obtained the necessary AiP from LLWR (Ref. 55). RWM has completed its assessment of disposability of HAW (Ref. 51) and concluded "There are no issues that would fundamentally challenge the disposability of the wastes and spent fuel expected to be generated from operation and decommissioning of the UK HPR1000. Given a disposal site with suitable characteristics, the wastes and spent fuel from the UK HPR1000 are expected to be disposable".

434. I agree with the RP's position that none of the radioactive wastes in the operational wastes inventory presented in **Table 2** and discussed in the IWS (Ref. 32) are orphan/problematic wastes.

435. On the basis of the evidence presented, most notably on the disposability of radioactive wastes, I consider the RP has provided adequate evidence to meet the regulatory expectation in RW.3 that the accumulation of radioactive waste has been minimised, appropriate to the stage of GDA.

436. I consider the RP has provided adequate evidence to substantiate Claim 3.3.11.SC23.3 that the accumulation of radioactive waste from operation of the generic UK HPR1000 design has been minimised.

4.8.7 Assessment of Risks and Hazards

437. The purpose of this sub-section is to identify where ONR has assessed the RP's evidence to demonstrate that the relevant risks associated with radioactive waste management in the generic UK HPR1000 design have been reduced to ALARP. As noted in sub-section 4.8.1, the 'ALARP Demonstration Report for Radioactive Waste Management' (Ref. 46) addresses a range of technical topics in relation to the risks associated with radioactive waste management, which is consistent with the expectation of a holistic approach in NS-TAST-GD-005, the ALARP TAG, (Ref. 6).

438. The assessment of risks/hazards relating to radioactive waste management has been carried out across a range of technical disciplines in ONR and reported as appropriate in the relevant assessment reports, depending on the sampling strategy selected for each technical discipline. The key assessments related to the radioactive waste treatment systems and the overall demonstration of ALARP include:

- ONR's assessment of radiation doses to workers during normal operations, as presented in the assessment report for Radiological Protection for the generic UK HPR1000 design (Ref. 26).

- ONR’s assessment of non-reactor fault conditions, including the radioactive waste management systems, is presented in the assessment report for Fault Studies for the generic UK HPR1000 design (Ref. 25).
- ONR's assessment of the adequacy of EIMT for the generic UK HPR1000 design have been assessed by the ONR Mechanical Engineering specialist inspector (Ref. 27) and the Fault Studies specialist inspector (Ref. 25).

439. This sub-section contains two further sub-sections, the first relating to the RP’s evidence and ONR’s assessment of the risks and hazards associated with normal operations, the second relating to the RP’s evidence and ONR’s assessment of risks associated with fault conditions.

4.8.7.1 Risks and Hazards for Radioactive Waste Management during Normal Operations

440. There are many regulatory expectations relating to risk assessment in the ONR SAPs and other guidance. I have focused here on the expectations for risk assessment in Annex 2 of NS-TAST-GD-005, the ALARP TAG, (Ref. 6), which provides specific guidance on demonstration of ALARP for proposed new civil nuclear reactors. This indicates that ONR expects to see risk assessments being used to identify potential engineering and/or operational improvements as well as confirming numerical levels of safety. The Basic Safety Objectives (BSOs) represent broadly acceptable level of risk, below which ONR considers the validity of the arguments that the BSOs have been met as it would be disproportionate to seek further improvements to reduce the risk further. NS-TAST-GD-005, states that well-supported numerical risk figures that show BSOs to be met can be an important element of support to the overall ALARP demonstration.

441. The ‘ALARP Demonstration Report for Radioactive Waste Management’ (Ref. 46) provides summary information on the radiological risks arising from radioactive waste management during normal operations, namely the generation, collection, characterisation/monitoring/sampling, processing, transfer and storage of gaseous, liquid and solid radioactive wastes.

442. The RP has assessed radiation doses to members of the public from the operation of the generic UK HPR1000 design. For children and infants this is defined as being well below the BSO, and for adults between the BSO and Basic Safety Level (BSL). Carbon-14 is identified as the most significant contributor to doses from gaseous and liquid discharges.

443. The ALARP demonstration for radioactive waste management (Ref. 46) summarises key engineering measures which contribute to the demonstration of ALARP for normal operations for the management of gaseous, liquid and solid radioactive waste. Examples of the measures identified by the RP are presented below for each system:

- The gaseous radioactive waste management system (TEG[GWTS]) includes automatic/remote operation of the TEG[GWTS] to minimise manual valve operations in high radiation areas, with manual tasks limited to sampling undertaken in relatively low radioactivity areas (classification zones).
- Liquid radioactive waste management systems are constructed of components using corrosion-resistant materials with long service lifetimes. This protects against leakage and escape and minimises the frequency of operator access for EIMT.
- The solid radioactive waste management system (TES[SWTS]) includes remote operation of the cement encapsulation facility and remote handling of unshielded waste packages in the ILW ISF. The RP identified that radiation doses to workers could be reduced during manual closure of the lids of 210 litre drums of ILW/LLW boundary concentrates after cement encapsulation.

Following completion of optioneering, the RP decided to include an additional storage tank for concentrates in the generic design. This allowed for more time to decay store concentrates prior to packaging in 210 litre drums, which reduces radiation doses by a factor of 2, while maintaining adequate tank capacity for operations. The RP implemented this change as a modification in Design Reference 2.2 (Ref. 88), as discussed in sub-section 4.6.

444. Assessment of the design of the radioactive waste treatment systems is presented in sub-section 4.6. ONR’s assessment of radiation doses to workers during normal operations for the radioactive waste treatment systems, including assessment against ONR SAP Target 1 is presented in the generic UK HPR1000 design assessment report for Radiological Protection (Ref. 26).

445. A key regulatory expectation of ONR SAP EKP.3 of defence in depth is maintaining systems to ensure they operate in accordance with appropriate safety margins, which is achieved through identification of an appropriate EIMT schedule. These are essential for safe operation and thus contribute to the overall demonstration that risks have been reduced to ALARP. ONR's specialist inspectors in Mechanical Engineering have assessed the adequacy of EIMT arrangements for the generic UK HPR1000 design (Ref. 27).

446. The ALARP demonstration for radioactive waste management (Ref. 46) provides brief information on EIMT requirements, as part of the risk assessment for normal operations. I have sampled evidence on EIMT in relation to specific aspects of radioactive waste management in other sub-sections of this report, most notably sub-section 4.5 on waste ICIAs, sub-section 4.6 on radioactive waste management systems and sub-section 4.7 on the storage of ILW.

447. As part of the Mechanical Engineering assessment report (Ref. 27) ONR assessed the RP's demonstration of compliance with the UK regulatory guidance in HSG253 on the safe isolation of plant and equipment. This was completed with the support of specialist inspectors in Radiological Protection and informed the closure of RO-UKHPR1000-0035 ‘Optimisation of Collective Occupational Radiation Exposure for the UK HPR1000’ (Ref. 101). The RP produced a specific submission on ‘Design Considerations to Minimise the Worker Dose for Valve Inspection and Maintenance’ (Ref. 102). The RP has implemented a number of design improvements to address HSG253 in Design Reference 2.2 which impacted upon the design of the radioactive waste treatment systems. For example there is an increase in the number of valves in the TEU[LWTS], the TEG[GWTS] and the RPE[VDS] systems to facilitate EIMT and reduce doses to workers as part of the overall demonstration of ALARP.

448. The specialist inspector for Radiological Protection also assessed the RP's submission on ‘Layout Design Considerations to Minimise the Worker Dose’ (Ref. 103) which is also part of the RP's demonstration that radiological risks in normal operation (including EIMT activities) are reduced to ALARP. ONR’s assessment of normal occupational radiation exposure is presented in the assessment report for Radiation Protection (Ref. 26).

449. Overall, notwithstanding the Assessment Findings raised in sub-section 4.6 of this report, I consider the evidence in the ALARP demonstration for radioactive waste management (Ref. 46) adequately demonstrates the RP has undertaken risk assessments to identify potential engineering and/or operational improvements for normal operations. These Assessment Findings primarily relate to the TES[SWTS] and are consistent with the residual matter identified in the closure of RO-UKHPR1000-0005 (Ref. 10). I consider the RP’s consideration of improvements to reduce worker occupational exposures meets the relevant expectation in, NS-TAST-GD-005 (Ref. 6).

4.8.7.2 Risks and Hazards for Radioactive Waste Management for Fault Conditions

450. A summary of the RP's analysis of faults for radioactive waste management systems is presented in the ALARP demonstration for radioactive waste management (Ref. 46). The RP applied its methodology for Failure Modes and Effects Analysis (FMEA) to identify PIEs for radioactive waste management systems, as documented in 'PIE Grouping and Bounding Analysis for the PIE of Internal Event (Radioactive Waste Management Related)' (Ref. 104). This grouped the PIEs and undertook a bounding analysis against defined criteria in terms of on and off-site radiological consequences. All the PIEs except three listed related to leakage of liquid or gaseous radioactive wastes in the various systems (Ref. 104).

451. The ALARP demonstration for radioactive waste management (Ref. 46) provides a comprehensive summary of the outcome of the RP's evaluation of the frequencies and consequences (both on and off-site) of the identified PIEs for radioactive waste management systems. The RP has compared these to the Numerical Targets set out in the ONR SAPs that inspectors use when considering whether radiological hazards are being adequately controlled and risks reduced to ALARP. None met the criteria for a Design Basis Condition (DBC) (i.e. lower than the BSL in Numerical Target 4 of the SAPs) and thus have none have been included in the Fault Schedule.

452. Although the fault analysis indicated the consequences of faults in radioactive waste management systems were lower than the BSL, the RP provided qualitative information on the safety measures that are implemented in the design to prevent faults occurring and to mitigate the consequences (Ref. 46). Detailed design of the measures specified will be carried out at the site-specific stage. Some of these measures are already considered in sub-section 4.8.6.1, as they minimise risks during normal operations but an example for the gaseous, liquid and waste management systems of particular relevance to fault conditions are listed below:

- The gaseous radioactive waste management system (TEG[GWTS]) containment isolation valves are identified in the system to isolate the components of the TEG[GWTS]. These are closed either manually or automatically upon receipt of relevant safety signals.
- Liquid radioactive waste management systems include provisions such as monitoring, alarms and interlocks. For example in the TER[NLWDS] the discharge valve is interlocked with the inlet isolation valves, so effluent cannot be discharged when the inlet valves are open. I raised RQ-UKHPR1000-1616 (Ref. 38), to seek evidence on the minimisation of risks during operation of the liquid waste management systems, including selection of the location and types of valves, the prevention of leakage and escape and measures to prevent fault conditions. The response provided more information on design features and operations that contribute to radiation protection and thus to the demonstration of ALARP for both normal operations and fault conditions. The RP's response was adequately incorporated into the latest version of the ALARP demonstration for radioactive waste management (Ref. 46).
- The solid radioactive waste management system (TES[SWTS]) includes provisions such as manual drives on shield doors in the event of motor failure, and redundant motors and position sensors to roller conveyors used to move waste packages during waste processing in the Radioactive Waste Treatment Building shielded cell. This allows operations to be made safe in the event of equipment failure.

453. The ALARP demonstration for radioactive waste management (Ref. 46) also provides summaries of information on other aspects of risk assessment, including internal and external hazards, human factors and conventional health and safety. These are outside the scope of this report.

454. The RP also assessed the risks associated with radioactive waste management on the basis of PSA (Ref. 46). The highest dose to a member of the public from a PIE in a radioactive waste management system was 4.2 mSv, based on failure of the delay beds in the TEG[GWTS], but the frequency was low at just below 3 $x10^{-4}$ and the overall off-site radiological risk was considered to be low. The highest bounding worker dose arising from a PIE in a radioactive waste management system was 62 mSv, based on breach of pipework in the TEG[GWTS] during shutdown. The overall annual risk of fatality for a generic worker due to exposure to radiation from waste route PIEs was assessed as 2.3×10^{-8}, which is two orders of magnitude lower than the BSO of 10^{-6} per annum and represented approximately 5% of the overall risk to a worker (Ref. 105).

455. ONR's specialist inspectors in Fault Studies have assessed the RP's submissions on fault analysis, including consideration of non-reactor faults (Ref. 25). The Fault Studies specialist inspector assessed a number of the RP's submissions relevant to fault analysis including 'PIE Grouping and Bounding Analysis for the PIE of Internal Event (Radioactive Waste Management Related)' (Ref. 104), with the objective of gaining confidence that none of the faults in radioactive waste management systems met ONR's expectations for Design Basis Analysis (DBA). The specialist inspector selected the TEG[GWTS] as the sample system for the assessment because, as noted above, its failure would give rise to higher consequences, in terms of radiation doses to workers and the public, than faults in other radioactive waste management systems (Ref. 104).

456. The Faults Studies specialist inspector was satisfied the RP had undertaken identification of PIEs and DBCs in a systematic and auditable manner and was satisfied with the RP's methods for deriving the PIE frequency and consequence. The inspector concluded the RP had provided suitable and sufficient evidence to substantiate the claim that none of the identified PIEs for radioactive waste management met the criteria to be a design basis fault.

457. Based on the conclusion of the specialist inspector in Fault Studies that the RP's methods for deriving the frequency and consequences of PIEs were satisfactory, I consider it reasonable to conclude that the derivation of the overall risk to a worker from PIEs in radioactive waste management systems is soundly based. The level of numerical risk to a worker in radioactive waste management systems has been calculated to be two orders of magnitude below the BSO and the level of off-site radiological risk due to a fault is also low, on the basis of both frequency and consequence. I consider the RP has met the relevant regulatory expectation in the ALARP TAG, NS-TAST-GD-005 (Ref. 6) by providing well-supported numerical risk figures that show the BSO to be met as part of support to the overall ALARP demonstration.

4.8.8 Overall Conclusions on the RP's Demonstration that the Risks of Radioactive Waste Management are Reduced to ALARP

458. The purpose of this sub-section is to provide an overall summary of my assessment of the RP's evidence on the demonstration of ALARP, with particular focus on the expectations of Annex 2 of the ALARP TAG, NS-TAST-GD-005, on proposed new civil reactors.

459. Annex 2 expects a clear conclusion that there are no further reasonably practicable improvements that could be implemented, and therefore the risk has been reduced to ALARP. The RP has provided adequate evidence that it has considered whether improvements could be implemented and provided evidence of the implementation of an improvement in a radioactive waste management system to reduce risk (the addition of a concentrate tank in the TEU[LWTS]). The RP has also implemented modifications in radioactive waste management systems to improve the safe isolation

of equipment which will reduce occupational exposures, as assessed by the ONR Mechanical Engineering specialist inspector (Ref. 27) and to reduce the risk to operators during the retrieval of spent filter cartridges, as assessed in the ONR Radiological Protection assessment report (Ref. 26).

460. As presented in sub-section 4.5, I assessed the RP's safety case for the use of the winding machine for the packaging of ICIAs, which is a novel technique in the UK for management of these highly radioactive components and is not consistent with RGP. I considered the RP had provided adequate evidence that there were no reasonably practicable improvements that could be implemented, and that the winding machine represented the ALARP solution for the generic UK HPR1000 design. Overall I consider the RP has provided adequate evidence for its conclusions that there are no further reasonably practicable measures for radioactive waste management.

461. On RGP I consider the RP has met the expectation of Annex 2 with respect to justification of the codes and standards identified as RGP for radioactive waste management. I also consider the RP has provided adequate evidence to demonstrate that RGP has been met, with the exception of those matters identified as Assessment Findings and Minor Shortfalls.

462. With respect to options, I consider the RP has provided adequate evidence on the evolution of the generic design of the UK HPR1000 and how it has improved safety with respect to radioactive waste management, this is summarised in the ALARP demonstration for radioactive waste management (Ref. 46). I consider the RP's approach to the identification of gaps between UK and Chinese practices and its systematic evaluation of options for the management of radioactive waste, which takes account of RGP and OPEX, meets the expectations of Annex 2 on consideration of options.

463. The RP has implemented measures in the design to reduce occupational exposure in radioactive waste management systems on the basis of consideration of OPEX, for example the design of spent filter cartridge change machines. The RP's methodology for assessment of options takes appropriate account of safety and other relevant factors in supporting decision-making (Ref. 46). The RP has also taken a systematic approach to the identification of SSCs affected by the options selected which has been of benefit in defining the modifications necessary for their implementation.

464. On risk assessment I consider the RP's evidence on the assessment of risks, which comprises both numerical assessment and information on the engineering design measures that prevent and mitigate risks, to be adequate in meeting the expectations of Annex 2, taking account of the conclusions of the Fault Studies specialist inspector. However, there are specific aspects of the design of the TES[SWTS] where I consider the RP has not provided adequate evidence that risks have been reduced to ALARP, for which I have raised Assessment Findings.

465. I consider the RP has provided adequate evidence to demonstrate that the generation and accumulation of radioactive waste has been minimised and that the radioactive waste management strategy provides an adequate foundation for the assessment of ALARP for radioactive waste management.

466. I consider the RP has met the regulatory expectations of RO-UKHPR1000-0005 that the demonstration of ALARP for radioactive waste management address a range of technical topics. This is based on the evidence in the ALARP demonstration for radioactive waste management (Ref. 46), which shows that account has been taken of aspects such as radiological protection, mechanical engineering, chemistry, fault studies, PSA, and environmental protection. Throughout GDA I have worked closely with colleagues from the Environment Agency and consider the RP has optimised the design on the basis of both safety and environmental protection. The RP has also

recognised the long-term aspects of radioactive waste management, as expected in the ALARP TAG, NS-TAST-GD-005, based on evidence such as the design life and environmental conditions aspects of the ILW ISF.

467. In conclusion I consider the RP has provided adequate evidence that the risks of radioactive waste management in the generic UK HPR1000 design have been reduced to ALARP, with the exception of specific aspects of the TES[SWTS] where I have already raised Assessment Findings. These address the residual matter identified during the closure of RO-UKHPR1000-0005 (Ref. 87).

468. I also consider the RP has provided adequate evidence to substantiate Claims 3.3.11 and Claim 3.4.8, including sub-claim 3.3.11.SC23.5 in relation to the demonstration that the risks of radioactive waste management have been reduced to ALARP.

4.9 Consolidated Safety Case

469. My assessment in sub-sections 4.2 – 4.8 is based upon the RP's updated submissions as a result of RO-UKHPR1000-0005, RO-UKHPR1000-0037 and RO-UKHPR1000-0040, as discussed in sub-section 4.1.1, and responses to RQs raised throughout Step 4. **Table 4** provides a summary of the RQs raised by ONR and the TSC in Step 4 of the UK HPR1000 GDA relevant to the radioactive waste management systems. Further RQs were raised to support ONR's assessment, where relevant these are referenced in the body of this assessment (Ref. 38).

470. On the basis of the evidence I have assessed in sub-sections 4.2 – 4.8, I consider that the RP has adequately incorporated the RQ responses and made adequate improvements to the safety case to address the shortfalls identified in the three relevant ROs. This includes in the update to Chapter 23 of the PCSR 'Radioactive Waste Management (Ref. 106).

4.10 Strengths

471. From my assessment of the radioactive waste management topic in sub-sections 4.2 – 4.8 the key strengths of the safety case are:

- The radioactive waste inventory defined appears to be complete and is consistent with OPEX available from other PWRs.
- The waste management strategies for gaseous, liquid and solid radioactive wastes are consistent with RGP and practices adopted in the UK, which take into account UK Government Policy and the lifecycle of radioactive wastes from generation to disposal.
- The RP has identified and made effective use of national and international RGP and OPEX from an early stage of the GDA process.
- The RP has provided good evidence to demonstrate minimisation of the generation and accumulation of radioactive waste.
- For the ICIA winding operations, identified as novel in the UK, the RP's safety case provides adequate evidence that they have considered the full range of options in developing the ICIA management strategy.
- The designs of the gaseous and liquid waste treatment systems are consistent with RGP.
- The RP has presented a conceptual design for the ILW ISF, for the safe on-site storage of ILW. The design is consistent with RGP and OPEX and includes clear assumptions and requirements. The design takes account of aspects relevant to the SSCs, to aid the future site-specific detailed design.
- The RP has appropriately considered engineering measures to minimise risks during normal operations and fault conditions in the management of radioactive wastes and thus its demonstration of ALARP.

4.11 Outcomes

472. Based upon my assessment of the radioactive waste management topic presented in Section 4, I have identified the following Assessment Findings:

- AF-UKHPR1000-0177 - The licensee shall, as part of the detailed design, demonstrate that the key structures, systems and components associated with waste in-core instrument assembly winding operations reduce risks so far as is reasonably practicable. This includes, but is not limited to the:

  - winding machine and associated systems;
  - shielding cover;
  - robust shielded 500 litre drum (with steel liner);
  - drum adaptor; and
  - relevant handling equipment.

- AF-UKHPR1000-0178 – The licensee shall, as part of the detailed design, justify the leak detection capabilities outside the primary containment boundary of the Liquid Waste Treatment System concentrate tanks and Solid Waste Treatment System resin tanks.
- AF-UKHPR1000-0179 – The licensee shall, as part of detailed design, justify the safety classification of the filters and demineralisers in the Steam Generator Blowdown System.
- AF-UKHPR1000-0180 - The licensee shall demonstrate that the management strategy for dry active Intermediate Level Waste containing free water, and the detailed design of the drying system, reduces risks so far as is reasonably practicable.
- AF-UKHPR1000-0181 - The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Cartridge Changing Machine reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.
- AF-UKHPR1000-0182 - The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Retrieval and Transfer Device reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.
- AF-UKHPR1000-0183 - The licensee shall, as part of the detailed design, demonstrate that the wet-solid waste receipt and treatment sub-system in the Radioactive Waste Treatment Building reduces risks so far as is reasonably practicable, in normal operations and fault conditions. This should include, but is not limited to:

  - access for personnel and equipment to undertake examination, inspection, maintenance and testing activities;
  - the risks from the movement of wastes in and around the facilities prior to, during and after processing activities; and
  - the risk of spreading contamination and containment to minimise releases.

- AF-UKHPR1000-0184 - The licensee shall justify that the risks from management of sludges arising from operations are reduced so far as is reasonably practicable. This should include, but is not limited to:

- retrieval of sludges;
- receipt of sludges into the Radioactive Waste Treatment Building; and
- the potential spread of contamination.

473. In my assessment I have identified 19 Minor Shortfalls:

- For the licensee to ensure the design life of the 210 litre drum is suitable for the on-site storage period of the ILW/LLW boundary wastes, as discussed in sub-section 4.2.2.
- For the licensee to consider whether the number of shielded casks for 210 litre drums is adequate to support UK HPR1000 operation, as discussed in sub-section 4.3.2.3.
- The SDM chapters did not provide references to supporting evidence documents and that the golden thread from the relevant claims to evidence was thus not complete, for the sample of systems assessed. However, an adequate understanding of the design was possible by means of review of a broader range of submissions and seeking clarification by means of RQs, as discussed in sub-section 4.6.1.
- For the licensee to ensure the radioactive waste treatment system SDMs adequately reference the evidence to demonstrate that the commissioning tests are appropriately identified and implemented, as discussed in sub-section 4.6.1.
- For the licensee to consider improving the SDMs to ensure they refer to evidence for the justification on the number and type of the containment barriers as the detailed design progresses at the site specific phase, as discussed in sub-section 4.6.1.
- For the licensee to consider application of the ‘Piping Layout Guide’ (Ref. 72) to non-pipe components in the future, providing more confidence in the measures applied to confine radioactive wastes, as discussed in sub-section 4.6.1.
- For the licensee to substantiate the absence of categorisation and classification for the low activity floor drains in the RPE[VDS], as discussed in sub-section 4.6.3.1.
- For the licensee to consider optimisation of the design of the RPE[VDS] and use of floor drains, including whether alternative approaches to the activities that give rise to the effluents routed to the floor drains could reduce the volume of liquid wastes discharged to the drains, for example by the use of closed loops for floor washing, as discussed in sub-section 4.6.3.1.
- For the licensee to consider alternative solutions to submersible pumps (for example eductors) in the RPE[VDS], which may be beneficial in limiting the number of components in contact with radioactive effluent and simplifying maintenance, as discussed in sub-section 4.6.3.1.
- For the licensee to ensure the assumption on the time for analysis of effluents does not undermine the sizing of the tanks during detailed design of the TEU[LWTS] tanks, as discussed in sub-section 4.6.3.2.
- For the licensee to consider two potential improvements to the design and operation of the TEU[LWTS], the first relating to remote monitoring of differential pressure across the filters in the TEU as an alternative to local operator monitoring, and the second to consider use of treated liquid effluent instead of demineralised water to flush equipment to decrease the demand on the treatment system and volume discharged, as discussed in sub-section 4.6.3.2.
- For the licensee to consider the location of the spent resin storage tanks in the TES[SWTS] at the site-specific phase, as discussed in sub-section 4.6.4.2.
- For the licensee to ensure appropriate seals are included in the detailed design of the resin tanks, and that the EIMT requirements on the seals are appropriately considered, as discussed in sub-section 4.6.4.2.

- For the licensee to ensure the resin tank room liners are sized to ensure consistency with RGP for secondary containment (110%), as applied to the RPE[VDS], as discussed in sub-section 4.6.4.2.
- For the licensee to consider alternative technologies to sight glasses on the spent resin transfer lines during detailed design of the system at the site-specific phase, as discussed in sub-section 4.6.4.2.
- For the licensee to ensure the detailed design of the shielding cask for the 3 cubic metre box is appropriate for the UK HPR1000 operations, including those in the Radioactive Waste Treatment Building and ILW ISF, as discussed in sub-section 4.6.4.4.
- For the licensee to clarify the point at which and where, in the ILW ISF package import, the 210 litre drums are removed from shielded transfer casks and loaded into four-drum stillages to enable stacking within the vault, as discussed in sub-section 4.7.2.1.
- For the licensee to consider if there are opportunities to isolate aspects of the operational areas from the main storage facility, and therefore reduce the radiological risks further, as discussed in sub-section 4.7.2.1.
- For the licensee to address the apparent omission in the list of SSCs for the 210 litre drum shielded casks, as discussed in sub-section 4.8.5.

4.12 Comparison with Standards, Guidance and Relevant Good Practice

474. I have compared the information in the RP's safety case for radioactive waste management against standards, guidance and relevant good practice throughout my assessment in Section 4. The full list used is provided in sub-sections 2.4.1- 2.4.3. I have mainly used the ONR SAPs for radioactive waste management, IAEA SSG-40 and the ONR TAGs on ALARP, NS-TAST-GD-005, and on the management of radioactive material and radioactive waste on the nuclear licensed sites, NS-TAST-GD-024, noting these take account of international guidance. The list of the relevant ONR SAPs considered during my assessment is presented in Annex 1.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

475. This report presents the findings of my radioactive waste management assessment of the generic UK HPR1000 design as part of the GDA process.

476. Based on my assessment, undertaken on a sampling basis, I have concluded the following:

- The radioactive waste inventory defined appears to be complete and is consistent with OPEX available from similar reactor technologies worldwide.
- The radioactive waste management strategies are consistent with UK policy and practices and take due account of the lifecycle of radioactive wastes from generation to disposal.
- The RP has identified and made effective use of national and international RGP and OPEX in radioactive waste management.
- The RP has provided adequate evidence to demonstrate minimisation of the generation and accumulation of radioactive waste.
- The RP's safety case provides adequate evidence that it has considered the full range of options in developing the management strategy for ICIAs and is proposing winding operations to retrieve waste ICIAs. Winding is identified as novel in the UK.
- The RP has presented a conceptual design for the storage of ILW and the ILW ISF. The design is consistent with RGP and OPEX with clear assumptions and requirements, including aspects relevant to the SSCs, to aid the future site-specific detailed design.
- The RP has provided adequate evidence to demonstrate that the risks associated with radioactive waste management are reduced to ALARP, with the exception of a small number of specified sub-systems in the TES[SWTS], for which Assessment Findings have been identified.

477. Overall, based on my sample assessment of the safety case for the generic UK HPR1000 design undertaken in accordance with ONR's procedures, I am satisfied that the case presented within the PCSR and supporting documentation is adequate. On this basis, I am content that a DAC should be granted for the generic UK HPR1000 design from a radioactive waste management perspective.

5.2 Recommendations

478. Based upon my assessment detailed in this report, I recommend that:

- **Recommendation 1**: From a radioactive waste management perspective, ONR should grant a DAC for the generic UK HPR1000 design.

- **Recommendation 2**: The eight Assessment Findings identified in this report relevant to the radioactive waste management topic should be resolved by the licensee for a site-specific application of the generic UK HPR1000 design.

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Annex 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No	SAP Title	Description
SC.4	Safety case characteristics	A safety case should be accurate, objective and demonstrably complete for its intended purpose.
SC.5	Optimism, uncertainty and conservatism	Safety cases should identify areas of optimism and uncertainty, together with their significance, in addition to strengths and any claimed conservatism.
SC.6	Safety case content and implementation	The safety case for a facility or site should identify the important aspects of operation and management required for maintaining safety and how these will be implemented.
FP.4	Safety assessment	Dutyholders must demonstrate effective understanding and control of the hazards posed by a site or facility through a comprehensive and systematic process of safety assessment.
ECS.1	Safety categorisation	The safety functions to be delivered within the facility, both during normal operation and in the event of a fault or accident, should be identified and then categorised based on their significance with regard to safety.
ECS.2	Safety classification of structures, systems and components	Structures, systems and components that have to deliver safety functions should be identified and classified on the basis of those functions and their significance to safety.
EMT.1	Identification of requirements	Safety requirements for in-service testing, inspection and other maintenance procedures and frequencies should be identified in the safety case.
EMT.2	Frequency	Structures, systems and components should receive regular and systematic examination, inspection, maintenance and testing as defined in the safety case.
EMT.5	Procedures	Commissioning and in-service inspection and test procedures should be adopted that ensure initial and continuing quality and reliability.
EMT.6	Reliability claims	Provision should be made for testing, maintaining, monitoring and inspecting structures, systems and components (including portable equipment) in service or at intervals throughout their life, commensurate with the reliability required of each item.
ECM.1	Commission testing	Before operating any facility or process that may affect safety it should be subject to commissioning tests defined in the safety case.

SAP No	SAP Title	Description
EKP.1	Inherent safety	The underpinning safety aim for any nuclear facility should be an inherently safe design, consistent with the operational purposes of the facility.
EKP.3	Defence in depth	Nuclear facilities should be designed and operated so that defence in depth against potentially significant faults or failures is achieved by the provision of multiple independent barriers to fault progression
ELO.1	Access	The design and layout should facilitate access for necessary activities and minimise adverse interactions while not compromising security aspects.
ELO.3	Movement of nuclear matter	Site and facility layouts should minimise the need for movement of nuclear matter.
ELO.4	Minimisation of the effects of incidents	The design and layout of the site, its facilities (including enclosed plant), support facilities and services should be such that the effects of faults and accidents are minimised.
ECV.1	Prevention of leakage	Radioactive material should be contained and the generation of radioactive waste through the spread of contamination by leakage should be prevented.
ECV.2	Minimisation of releases	Containment and associated systems should be designed to minimise radioactive releases to the environment in normal operation, fault and accident conditions.
ECV.3	Means of Confinement	The primary means of confining radioactive materials should be through the provision of passive sealed containment systems and intrinsic safety features, in preference to the use of active dynamic systems and components
ECV.4	Provision of further containment barriers	Where the radiological challenge dictates, waste storage vessels, process vessels, piping, ducting and drains (including those that may serve as routes for escape or leakage from containment) and other plant items that act as containment for radioactive material, should be provided with further containment barrier(s) that have sufficient capacity to deal safely with the leakage resulting from any design basis fault.
ECV.5	Minimisation of personnel access	The need for access by personnel to the containment should be minimised.
ECV.6	Monitoring devices	Suitable and sufficient monitoring devices with alarms should be provided to detect and assess changes in the materials and substances held within the containment.

SAP No	SAP Title	Description
ECV.7	Leakage monitoring	Appropriate sampling and monitoring systems should be provided outside the containment to detect, locate, quantify and monitor for leakages or escapes of radioactive material from the containment boundaries.
ENM.2	Provisions for nuclear matter brought onto, or generated on, the site	Nuclear matter should not be generated on the site, or brought onto the site, unless sufficient and suitable arrangements are available for its safe management on the site.
RW.1	Strategies for radioactive waste	A strategy should be produced and implemented for the management of radioactive waste on a site.
RW.2	Generation of radioactive waste	The generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms of quantity and activity.
RW.3	Accumulation of radioactive waste	The total quantity of radioactive waste accumulated on site at any time should be minimised so far as is reasonably practicable.
RW.4	Characterisation and segregation	Radioactive waste should be characterised and segregated to facilitate its subsequent safe and effective management.
RW.5	Storage of radioactive waste and passive safety	Radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition.
RW.6	Passive safety timescales	Radiological hazards should be reduced systematically and progressively. The waste should be processed into a passively safe state as soon as is reasonably practicable.
RW.7	Making and keeping records	Information that might be needed for the current and future safe management of radioactive waste should be recorded and preserved.

Annex 2

Assessment Findings

Number	Assessment Finding	Report Section
AF-UKHPR1000-0177	The licensee shall, as part of the detailed design, demonstrate that the key structures, systems and components associated with waste in-core instrument assembly winding operations reduce risks so far as is reasonably practicable. This includes, but is not limited to the: ■ winding machine and associated systems; ■ shielding cover; ■ robust shielded 500 litre drum (with steel liner); ■ drum adaptor; and ■ relevant handling equipment.	4.5.1
AF-UKHPR1000-0178	The licensee shall, as part of the detailed design, justify the leak detection capabilities outside the primary containment boundary of the Liquid Waste Treatment System concentrate tanks and Solid Waste Treatment System resin tanks.	4.6.1
AF-UKHPR1000-0179	The licensee shall, as part of detailed design, justify the safety classification of the filters and demineralisers in the Steam Generator Blowdown System.	4.6.3.4
AF-UKHPR1000-0180	The licensee shall demonstrate that the management strategy for dry active Intermediate Level Waste containing free water, and the detailed design of the drying system, reduces risks so far as is reasonably practicable.	4.6.4.1
AF-UKHPR1000-0181	The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Cartridge Changing Machine reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.	4.6.4.3

Number	Assessment Finding	Report Section
AF-UKHPR1000-0182	The licensee shall, as part of the detailed design, demonstrate that the containment and contamination controls of the Spent Filter Retrieval and Transfer Device reduce risks so far as is reasonably practicable. This should be demonstrated for both normal operations and fault conditions, be consistent with the categorisation of the safety functions, and justify the classification of the equipment.	4.6.4.3
AF-UKHPR1000-0183	The licensee shall, as part of the detailed design, demonstrate that the wet-solid waste receipt and treatment sub-system in the Radioactive Waste Treatment Building reduces risks so far as is reasonably practicable, in normal operations and fault conditions. This should include, but is not limited to: ■ access for personnel and equipment to undertake examination, inspection, maintenance and testing activities; ■ the risks from the movement of wastes in and around the facilities prior to, during and after processing activities; and ■ the risk of spreading contamination and containment to minimise releases.	4.6.4.4
AF-UKHPR1000-0184	The licensee shall justify that the risks from management of sludges arising from operations are reduced so far as is reasonably practicable. This should include, but is not limited to: ■ retrieval of sludges; ■ receipt of sludges into the Radioactive Waste Treatment Building; and ■ the potential spread of contamination.	4.6.4.4