Office for Nuclear Regulation

New Reactors Division – Generic Design Assessment

Step 4 Assessment of Decommissioning for the UK HPR1000 Reactor

Assessment Report ONR-NR-AR-21-015
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EXECUTIVE SUMMARY

This report presents the findings of my assessment of the decommissioning aspects of the UK HPR1000 reactor 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 decommissioning 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 decommissioning information contained within the PCSR and supporting documentation.

My assessment focussed on the following aspects of the generic UK HPR1000 safety case:

- Decommissioning source term and waste inventory
- Decommissioning strategy
- OPEX (Operational Experience) for decommissioning
- Decontamination processes and techniques
- Dismantling processes and techniques
- Design for decommissioning
- Management of decommissioning wastes
- Preliminary Decommissioning Plan
- Demonstration that Relevant Risks Have Been Reduced to ALARP
- Consolidated Safety Case.

The conclusions from my assessment are:

- The RP has derived the decommissioning source term using appropriate techniques underpinned by a verified and validated model and/or relevant OPEX. The conservatism applied is appropriate to address uncertainties, meets relevant regulatory expectations and is appropriate to GDA. It provides an appropriate basis for the preliminary assessment of radiological risks and estimating arisings of decommissioning wastes.
- The selected decommissioning strategy of immediate dismantling is adequately underpinned, meets relevant regulatory expectations and is consistent with relevant UK policies. The strategy is integrated with the radioactive waste management strategy, does not foreclose other decommissioning options and is appropriate to the stage of the lifecycle of the generic UK HPR1000 design and GDA.
- The RP has taken due account of international decommissioning OPEX, which meets relevant regulatory expectations.
- The RP has provided information on decontamination techniques and processes which meets relevant regulatory expectations and is appropriate to GDA. The information is adequate to substantiate the sub-claim that the generic UK

HPR1000 design can be decommissioned using current methods and technologies, as they relate to decontamination. I expect the proposed application of Full System Decontamination to be a significant contributor to reducing the risks of decommissioning.

- The RP has provided information on dismantling activities that meets relevant regulatory expectations and is appropriate to GDA. The information is adequate to substantiate the claims and sub-claims that the design and intended operation will facilitate safe decommissioning and can be decommissioned using current methods and technologies, as they relate to dismantling. I expect the dismantling methods proposed, particularly for high activity components and the Steam Generators, to be significant contributors in reducing the risks of decommissioning.
- The RP has provided information on design for decommissioning that meets relevant regulatory expectations, most notably Safety Assessment Principle (SAP) DC.1 and is appropriate to GDA. The information substantiates the claims and sub-claims that the design and intended operation will facilitate safe decommissioning. The measures identified will be significant contributors in reducing the risks of decommissioning.
- The RP has provided information on the management of decommissioning wastes which meets relevant regulatory expectations and is appropriate to GDA. The information substantiates the relevant sub-claim that disposal routes are available (or will be available) for wastes arising during decommissioning.
- The RP has provided information on planning for decommissioning that meets relevant regulatory expectations and is appropriate to GDA. The information is also adequate to substantiate the relevant claims and sub-claims. I consider the RP has not provided adequate information on records for decommissioning to fully meet the relevant SAP and substantiate the relevant sub-claim.
- The RP has provided an adequate demonstration that relevant risks of decommissioning are reduced to As Low As Reasonably Practicable (ALARP). The information provided also substantiates relevant claims and sub-claims.
- The RP has adequately consolidated Regulatory Query (RQ) and Regulatory Observation (RO) responses into the safety case for decommissioning. The updated safety case, including the supporting submissions, is consistent with the safety case I have assessed.
- Overall, I consider the RP has provided adequate evidence to meet the expectations of the relevant SAPs and Technical Assessment Guides and international guidance on decommissioning, appropriate to GDA.

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 information, reviews and analysis of key aspects of the generic safety case undertaken by a Technical Support Contractor.
- Detailed technical interactions with the RP during the GDA process, in addition to assessment of responses to the RQs and ROs 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 five Assessment Findings. I have also identified three minor shortfalls.

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 decommissioning perspective a DAC may be granted.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
BMS	Business Management System
CAE	Claims-Arguments-Evidence
CDM	Construction, Design and Management Regulations 2015
CGN	China General Nuclear Power Corporation Ltd
CRDM	Control Rod Drive Mechanism
DAC	Design Acceptance Confirmation
DF	Decontamination Factor
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
EIMT	Examination, Inspection, Maintenance, and Testing
EPRI	Electric Power Research Institute
ERICP	Eliminate, Reduce, Isolate, Control, Protect
FSD	Full System Decontamination
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GNI	General Nuclear International Ltd.
GNSL	General Nuclear System Ltd.
GSR	General Safety Requirements (IAEA)
HLW	High-Level Waste
HOW2	(ONR) Business Management System
IAEA	International Atomic Energy Agency
iDAC	Interim Design Acceptance Confirmation
ILW	Intermediate Level Waste
ISF	Interim Storage Facility
IWS	Integrated Waste Strategy
LLW	Low Level Waste
LLWR	Low Level Waste Repository
MSQA	Management for Safety and Quality Assurance
NPP	Nuclear Power Plant
NSL	Nuclear Site Licence
OEF	Operational Experience and Feedback
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PCER	Pre-construction Environmental Report
PCSR	Pre-construction Safety Report

PDP	Preliminary Decommissioning Plan
POCO	Post Operational Clean Out
PWR	Pressurised Water Reactor
QA	Quality Assurance
RCP	Reactor Coolant Pump
RGP	Relevant Good Practice
RI	Regulatory Issue
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
RPV	Reactor Pressure Vessel
RQ	Regulatory Query
RVI	Reactor Vessel Internals
RWM	Radioactive Waste Management Limited
SAP(s)	Safety Assessment Principle(s)
SDM	System Design Manual
SFAIRP	So Far As Is Reasonably Practicable
SFIS	Spent Fuel Interim Storage
SFP	Spent Fuel Pool
SFR	Safety Functional Requirement
SG	Steam Generator
SoDA	(Environment Agency's) Statement of Design Acceptability
SQEP	Suitably Qualified and Experienced Personnel
SRL	Safety Reference Levels
SSC	Structures, Systems and Components
SWTC	Standard Waste Transfer Container
TAG	Technical Assessment Guide(s)
TBq	Terabecquerel
TSC	Technical Support Contractor
VLLW	Very Low Level 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 (ONR) Generic Design Assessment (GDA) for the generic UK HPR1000 design within the topic of decommissioning.

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 of GDA which focussed on an examination of the main claims made by the RP for the UK HPR1000. In Step 3 of GDA, 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 of GDA are published on the joint regulators' website. The objective of Step 4 of GDA 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 assessments during Steps 2 and 3 of GDA.
- 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).
- 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 decommissioning 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 RIs and 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 decommissioning 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) 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. 4).

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 (TAG), 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 decommissioning aspects of the generic 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 my assessment plan (Ref. 5).

12. I considered all 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 RO I raised as a result of my ongoing assessment, and the resolution thereof.

2.2 Sampling Strategy

13. In line with ONR's guidance (Ref. 4), I chose a sample of the RP's submissions to undertake my assessment. The main themes considered were:

- Decommissioning source term and waste inventory – I have assessed the RP's source term information for decommissioning wastes to gain assurance that the waste categories and risks are consistent with the methods set out in the Preliminary Decommissioning Plan and other supporting submissions and support the RP's demonstration that the risks of decommissioning are capable of being reduced to ALARP.
- Preliminary Decommissioning Plan, including decommissioning strategy – I have assessed the strategy to gain assurance that it is consistent with relevant UK policies and have assessed the plan and strategy to determine whether they meet the expectations established by the relevant SAPs (DC.2, DC.4), and that the scope of buildings covered by the plans is adequate for the purpose of GDA.
- Decontamination processes and techniques - I have assessed the proposed processes to determine whether they are consistent with operational experience (OPEX) and/or Relevant Good Practice (RGP), are currently available technologies and that they do not present any issues of concern for either safety or the management of the resulting radioactive wastes.
- Dismantling processes and techniques, with focus on the primary circuit, large items and significant structures – I have assessed the methods proposed for dismantling to determine whether they are consistent with RGP and/or OPEX and that the generic UK HPR1000 design can be safely decommissioned using currently available technologies, as part of the demonstration that risks can be reduced to ALARP.
- Design for Decommissioning – I have assessed the arguments and evidence supporting the key claim that the generic UK HPR1000 will be designed and is intended to be operated so it can be safely decommissioned using currently available technologies, to determine whether they meet the expectations established by SAP DC.1, other relevant guidance and as part of the overall demonstration that risks can be reduced to ALARP.
- Management of decommissioning wastes – I have assessed the adequacy of the management of decommissioning wastes (Higher Activity Waste (HAW)), noting that disposal of Low Level Waste (LLW) arising from decommissioning is outside the scope of GDA. I have focused on the safe management of the

higher dose rate components arising from decommissioning (e.g. reactor vessel internals) and on how higher activity concrete will be characterised, segregated and managed safely. This forms part of the overall demonstration that the risks of decommissioning can be reduced to ALARP.
- Demonstration of ALARP for decommissioning – I have assessed whether the RP has provided an adequate demonstration that the risks from decommissioning are capable of being reduced to ALARP and that the demonstration is holistic and adequately substantiated, appropriate to the GDA stage.

14. I have considered consistency with OPEX and/or RGP for all the themes identified in the sampling strategy at the beginning of Step 4.

2.3 Out of Scope Items

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

- Radioactive wastes produced during the operational phase remaining in storage during the decommissioning phase.
- Spent fuel produced during the operational phase remaining in storage during the decommissioning phase.
- The disposal of solid LLW arising from decommissioning, as this is outside the scope of GDA.
- The disposal of liquid and gaseous wastes arising from decommissioning, as this is outside the scope of GDA.
- The proposed workshop for the decontamination and size reduction of decommissioning wastes, as this is outside the scope of GDA.
- Consideration of conventional health and safety hazards associated with decommissioning, as these are addressed by the Conventional Health and Safety topic area, appropriate to the GDA stage.
- The basis of the modelling underpinning the decommissioning source term, including the accuracy of the values calculated for the source term and validity and veracity of the calculation methods used, as this has been addressed by the Radiological Protection and Fuel and Core topic areas.
- Site selection as relevant to design for decommissioning as site-specific issues are outside the scope of GDA.
- Transport routes for waste packages and materials outside buildings, as these are outside the scope of GDA.
- The design and safety case for the facilities to be used to package Intermediate Level Waste (ILW) arising from decommissioning, as these are outside the scope of GDA.
- Decommissioning of the ILW Interim Storage Facility (ILW ISF) and the Spent Fuel Interim Storage Facility.

2.4 Standards and Criteria

16. The relevant standards and criteria adopted within this assessment are principally the SAPs (Ref. 2), relevant TAGs, 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 section. Relevant good practice (RGP), where applicable, is cited within the body of the assessment.

2.4.1 Safety Assessment Principles

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

18. The key SAPs applied within my assessment were SAPs DC.1 – 6 and 9, RW.1 - 7, SC.3 – 5, RP.5, ENM.3 and ECV.1 – 3, 6 and 7.

2.4.2 Technical Assessment Guides

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

- Guidance on Mechanics of Assessment. NS-TAST-GD-096. Revision 0. April 2020. ONR (Ref. 4)
- Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable). NS-TAST-GD-005. Revision 11. November 2020. ONR (Ref. 6)
- The Purpose, Scope and Content of Safety Cases. NS-TAST-GD-051. Revision 7. December 2019. ONR. (Ref. 7)
- Management of Radioactive Material and Radioactive Waste on Nuclear Licensed Sites. NS-TAST-GD-024. Revision 6. September 2019. ONR. (Ref. 8)
- Decommissioning. NS-TAST-GD-026. Revision 5. September 2019. ONR. (Ref. 9).

2.4.3 NS-National and International Standards and Guidance

20. The following national guidance was used as part of this assessment:

- The Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites. Joint Guidance from the Office for Nuclear Regulation, Environment Agency, Scottish Environment Protection Agency and Natural Resources Wales to Nuclear Licensees. July 2021. Revision 2.1 (Ref. 10).

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

- Fundamental Safety Principles. Safety Fundamentals No SF-1. November 2006. IAEA (Ref. 11)
- Safety of Nuclear Power Plants: Design. Specific Safety Requirements No SSR-2/1. Rev. 1. February 2016. IAEA (Ref. 12)
- General Safety Requirements Part 5: Predisposal management of radioactive waste. No. GSR Part 5. IAEA, Vienna. 2009. (Ref. 13)
- General Safety Requirements Part 6: Decommissioning of Facilities. No. GSR Part 6. IAEA. Vienna, 2014. (Ref. 14)
- Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities. SSG-47. IAEA. Vienna. 2018. (Ref. 15)
- Decommissioning Safety Reference Levels, version 2.2, WENRA, 2015 (Ref. 16).

22. ONR has benchmarked the TAGs against relevant international guidance as part of the process of their regular review and update.

2.5 Use of Technical Support Contractors

23. 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.

24. Table 1 below sets out the area in which I used TSCs to support my assessment. I required this support on the assessment of submissions relevant to design for decommissioning, to provide evidence in support of reaching a regulatory judgement on whether the expectations of SAP DC.1 (Facilities should be designed and operated so that they can be safely decommissioned) are met by the generic design for the UK

HPR1000. This work took account of reports on design for decommissioning prepared by the TSC during Step 3 of GDA.

Table 1: Work Packages Undertaken by the TSC

Number	Provision of Support to GDA for the UK HPR1000 on OPEX/OEF relating to design for decommissioning
1	Review of UK HPR1000 Step 4 submissions against good practices and operating experience and feedback in design for decommissioning.

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

2.6 Integration with Other Assessment Topics

26. 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 were:

- Environment Agency inspectors on decommissioning and radioactive waste management, including the demonstration of both ALARP and Best Available Techniques (BAT, regulated by the Environment Agency) for decommissioning and the management of decommissioning wastes including consideration of disposability where relevant to the scope of GDA.
- Radiological Protection on the decommissioning source term.
- Chemistry, which took the lead on the source term topic and the minimisation of radioactivity, which is a key part of the minimisation of radioactive wastes in support of decommissioning.
- Mechanical engineering on the safe dismantling of significant equipment and components.
- Civil engineering on layout issues, design for decommissioning and building dismantling aspects.
- Conventional health and safety on decommissioning.

3 REQUESTING PARTY'S SAFETY CASE

3.1 Introduction to the Generic UK HPR1000 Design

27. The generic UK HPR1000 design is described in detail in the PCSR (Ref. 17). It is a three-loop PWR designed by CGN using the Chinese Hualong technology. The UK generic 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 generic design is claimed to have a lifetime of at least 60 years and has a nominal electric output of 1,180 MW (megawatts).

28. 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 with 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.

29. 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 BRX 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. Finally, the Nuclear Auxiliary Building (BNX) 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.

30. There are or will be a number of buildings which house systems for the processing and/or storage of radioactive wastes, including the radioactive waste treatment building, the interim storage facility for Intermediate Level Waste (ILW) and the waste auxiliary building. There will also be an interim storage facility for the long-term storage of spent fuel.

3.2 The Generic UK HPR1000 Safety Case

31. In this section I provide an overview of the decommissioning 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 sections of my report.

32. The primary submission I have assessed is Chapter 24 of the PCSR on Decommissioning (Ref. 3). This indicates that decommissioning is considered throughout the processes of siting, design, construction and operation even though it is the last stage in the lifecycle of a nuclear facility. Chapter 24 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.

33. This objective is underpinned by a number of high-level claims as set out in Chapter 1 of the PCSR (Ref. 18), of which the one of relevance to decommissioning is:

- Claim 5: The UK HPR1000 will be designed, and is intended to be operated, so that it can be decommissioned safety, using current available technologies, and with minimal impact on the environment and people.

34. PCSR Chapter 24 is intended to support two claims derived from Claim 5, which in turn are supported by a number of sub-claims as shown below:

- Claim 5.1: The design and intended operation will facilitate safe decommissioning using current available technologies.
  - Sub-claim 5.1SC24.1: The UK HPR1000 design features facilitate safe and effective decommissioning.
  - Sub-claim 5.1SC24.2**:** Documents and records required for decommissioning are identified and under preliminary preparation.
  - Sub-claim 5.1SC24.3: Faults and hazards of UK HPR1000 decommissioning are identified and assessed, and risks shown of being capable of being ALARP.
  - Sub-claim 5.1SC24.4: The UK HPR1000 can be decommissioned using current methods and technologies**.**
- Claim 5.2: The decommissioning strategy and plan are prepared and maintained for the generic design, which reflect UK policy.
  - Sub-claim 5.2SC24.5: Proper preliminary decommissioning plans/strategies are prepared.
  - Sub-claim 5.2SC24.6: Disposal routes are available (or will be available) for all waste arising from decommissioning.
  - Sub-claim 5.2SC24.7: The decommissioning plan will be developed to reflect technologies and experiences, to ensure that the timing and methods adopted for decommissioning are safe and protect the environment.

35. The RP has chosen not to use the “Claims-Arguments-Evidence” methodology for decommissioning, instead it has set out a “route map” in PCSR Chapter 24 which provides information on the submissions that have been prepared which supports the claims and sub-claims listed above. The RP has also provided information on the document hierarchy for the submissions which support PCSR Chapter 24, which is set out in the ‘ALARP Demonstration for Decommissioning of the UK HPR1000’ (Ref. 19).

36. The overall document hierarchy which supports PCSR Chapter 24 is based on the following:

- Overarching aspects including general requirements (and requirements of specific relevance to decommissioning), codes and standards, methodologies and processes (e.g. ALARP methodology) and specific waste management aspects (Integrated Waste Strategy (IWS) and disposability).
- Documents which provide information on the three key themes of:
  - Decommissioning strategy
  - Design of facilitating decommissioning
  - Preliminary Decommissioning Plan.

37. The RP has provided a set of submissions which provide the technical underpinning for the claims made in PCSR Chapter 24 and the three key themes listed above. These are summarised briefly below:

- ‘Decommissioning Technical User Source Term Report’ (Ref. 20) –This presents the methods used to determine the decommissioning source term, information on inputs and assumptions and the decommissioning source term values. A key input to this report is the ‘Activated Structures Source Term Supporting Report’ (Ref. 21), as activation is a very significant contributor to the decommissioning source term.
- ‘OPEX on Decommissioning’ (Ref. 22)– this presents information on relevant good practice (RGP) and operational experience (OPEX) of the decommissioning of nuclear power plants and the lessons learnt, with focus on PWRs. This includes information on design measures for facilitating decommissioning, existing techniques that can be used to decommission the generic UK HPR1000 design and key hazards and faults and their mitigation to reduce risks.
- ‘Design Requirements for Facilitating Decommissioning’ (Ref. 23) – this provides design requirements for facilitating decommissioning derived from good practices across the world and the learning from review of decommissioning OPEX.
- ‘Consistency Evaluation for Design of Facilitating Decommissioning’ (Ref. 24) – this presents information on how the generic design of the UK HPR1000 facilitates decommissioning and meets the relevant design requirements.
- ‘Preliminary Decommissioning Plan’ (PDP) (Ref. 25) – this presents and justifies the decommissioning strategy and presents the preliminary decommissioning plan proposed for the generic UK HPR1000 design.
- ‘Decommissioning Waste Management Proposal’ (Ref. 26) – this presents estimates of the wastes arising from the decommissioning of the generic UK HPR1000 design and, for some higher activity radioactive wastes, information on the characteristics of the wastes. The report is intended to demonstrate that the radioactive wastes arising from decommissioning are minimised and can be managed, conditioned, packaged and disposed of in a way that reduces risks to ALARP and minimises impacts on the environment and the public through the use of Best Available Techniques (BAT), commensurate to the scope and stage of GDA.

38. In addition, the RP has produced a number of submissions on specific technical aspects of decommissioning, which describe applicable techniques that are currently available and provide largely generic information on the associated risks and hazards and how they are prevented/mitigated, in support of PCSR Chapter 24. These are:

- ‘Decontamination Processes and Techniques during Decommissioning’ (Ref. 27) – this presents currently available decontamination techniques that could be used and the proposed approach to decontamination for the generic UK HPR1000 design.
- ‘Preliminary Disassembly Programme for the Main Equipment Decommissioning’ (Ref. 28) – this presents the proposal for the dismantling of the main equipment (the primary circuit, SGs and the spent fuel pool), based on existing techniques.
- ‘Dismantling Example Analysis of Steam Generator’ (Ref. 29) – this presents the proposed approach to dismantling of the SGs based on worldwide experience, providing information on the various steps necessary to achieve dismantling and management of the resulting radioactive wastes.
- ‘Decommissioning Building Dismantling Proposal’ (Ref. 30) – this presents information on the methods available for the decommissioning of civil structures, including those applicable to the UK HPR1000.

39. PCSR Chapter 24 also provides information on key assumptions underpinning the safety case, applicable codes and standards, information on safety management,

records and knowledge management and assessment of ALARP. This has been supplemented during Step 4 by the following submission:

- ‘ALARP Demonstration for Decommissioning of the UK HPR1000’ (Ref. 19) – this report is intended to demonstrate the main risks of decommissioning are reduced to ALARP through the consideration of design measures and the application of existing techniques for decommissioning, with focus on the main tasks of Post-Operational Clean-Out (POCO) and decontamination, the dismantling of the main equipment and the dismantling/demolition of buildings.

4 ONR ASSESSMENT

4.1 Structure of Assessment Undertaken

40. Decommissioning is the last stage in the lifecycle of a nuclear facility and has been defined by IAEA in General Safety Requirements (GSR) Part 6 Decommissioning (Ref. 14) as "the administrative and technical actions needed to remove some or all of the regulatory controls from a facility". GSR Part 6 requires that "decommissioning is regulated throughout all stages of a facility's lifetime from initial planning during siting and design to completion of decommissioning actions and removal from regulatory control". The operational life of the generic UK HPR1000 design is 60 years, so decommissioning is not expected to take place until many years in the future. However, ONR recognises the importance of decommissioning throughout all stages of a facility's lifecycle in its guidance. SAP DC.1 (Ref. 2) states that "facilities should be designed and operated so that they can be safely decommissioned".

41. The structure of the assessment I have undertaken is based on the technical areas I identified in my Step 4 Assessment Plan, as listed in section 2.2, which built on the assessment I carried out during Step 2 of GDA (Ref. 31) and Step 3 of GDA (Ref. 32). I have reported my assessment of decommissioning strategy and the PDP in separate sub-sections even though the RP provided the information on both in the PDP. This is because there are two separate SAPs (DC.2 on decommissioning strategies and DC.4 on planning for decommissioning).

42. I have also included a separate sub-section on OPEX for decommissioning because of its importance to the underpinning of the safety case provided by the RP. There is no experience of the decommissioning of civil PWRs in the UK (which currently has one operational civil PWR and one under construction). The UK has experience of the decommissioning of other types of reactors (gas-cooled and research reactors) and many other types of nuclear facilities. No PWRs have been decommissioned to date in China but a number have been decommissioned across the world, so the RP has of necessity considered international OPEX. It is therefore important to consider the RP's approach to the identification of OPEX and how it has informed the development of the design and safety case for decommissioning of the generic UK HPR1000 design.

43. The order of the sub-sections is intended to aid understanding and to reflect the steps I have undertaken in the assessment and is listed below:

- Decommissioning source term and waste inventory
- Decommissioning strategy
- OPEX for decommissioning
- Decontamination processes and techniques
- Dismantling processes and techniques
- Design for Decommissioning
- Management of decommissioning wastes
- Preliminary Decommissioning Plan
- Demonstration that Relevant Risks Have Been Reduced to ALARP
- Consolidated Safety Case.

4.2 Decommissioning Source Term and Waste Inventory

44. This sub-section discusses the decommissioning source term and thus the radioactive waste inventory that is expected to arise as a result of the decommissioning of the generic UK HPR1000 design. This information provides the technical basis for the RP's decisions on design to facilitate decommissioning, and the strategy, methods and plans for decommissioning, and thus of the assessment of hazards and risks. This information underpins the safety case, noting SAP SC.4 states "a safety case should be accurate, objective and demonstrably complete for its intended purpose", including

demonstrating that radioactive waste management and decommissioning have been addressed in an appropriate manner.

4.2.1 Overview of the Decommissioning Source Term

45. 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. 33). Normal operation comprises steady-state conditions, transient conditions, and shutdown conditions. Some of these radionuclides will be present in materials in the facility at the end of operations and can give rise to exposures and radioactive wastes and discharges during decommissioning. They thus form part of the source term for decommissioning.

46. The RP has defined a number of source terms for the generic UK HPR1000 design within the overall scope of the normal operation source term. These include those from the primary and secondary coolants, spent fuel assemblies and solid radioactive wastes as well as the decommissioning source term. It has produced a suite of “technical user source term reports”, including the ‘Decommissioning Technical User Source Term Report’ (Ref. 20), which is the main submission I have assessed in relation to the decommissioning source term.

47. The ‘Decommissioning Technical User Source Term Report’ (Ref. 20) identifies user requirements relating to the source term, which primarily relate to radioactive waste management, and summarises the results for decommissioning. The report explicitly recognises its role in supporting the development of the safety case in PCSR Chapter 24 (Ref. 3), as well as development of the waste management strategy for decommissioning and the assessment of the disposability of decommissioning wastes.

48. (Ref. 20) defines the decommissioning source term, which comprises the “activated structure source term” and the “deposit source term”. A number of other source terms relevant to decommissioning have been excluded from the scope of the report, namely gaseous and liquid wastes, solid LLW arising from decommissioning and spent fuel and operational wastes in storage during the decommissioning phase. I consider these exclusions to be appropriate, noting the long term storage of spent fuel is addressed in Chapter 29 of the PCSR (Ref. 34) and supporting submissions.

49. Other aspects such as discharges of gaseous and liquid wastes will be highly dependent on the plant status after the operational phase and the decommissioning techniques used and thus cannot be predicted with confidence at the design phase. I consider the exclusion of solid LLW to be appropriate given there are well-established disposition routes for LLW in the UK and the types of wastes arising during decommissioning are either similar to operational wastes, the management of which is assessed in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35), or are similar in nature to other reactor decommissioning wastes produced in the UK. ONR has assessed the management of spent fuel in the Step 4 Assessment of Spent Fuel Interim Storage for the UK HPR1000 Reactor (Ref. 36).

50. The activated structures source term arises from the neutron activation of nuclides in the structures and components of the reactor when operating at power. The main structures and components that are activated and that will be in place at shutdown are the RPV, RVIs and part of the concrete bioshield surrounding the reactor core. The radionuclides created by activation depend on the composition of the materials but those of significance for decommissioning include cobalt-58 and cobalt-60, of which the latter emits penetrating gamma radiation and thus can present a major hazard to workers. Detailed information on the activated structures source term is provided in the ‘Activated Structures Source Term Supporting Report’ (Ref. 21).

51. The amount of neutron activation for the structures and components and thus the concentrations of radionuclides is calculated using a computer code (PALM, developed by CGN). This uses an initial elemental composition of the structures and components (based on a number of assumptions relating to materials composition), the expected neutron flux for defined regions of the core and reactor structure based on the design, and duration of neutron irradiation (which varies by structure and component) to calculate activity concentrations for a large number of radionuclides over time periods from 4 days after shutdown to 100 years. The code has been used to generate a realistic source term based on average concentrations and a design source term considered to be conservative and bounding using conservative parameters. The outputs of the code are radioactivity concentrations by radionuclide for the various structures and components and by region where defined, at various time periods after shutdown.

52. The deposit source term is based on the deposition of activation and fission product radionuclides on structures and components during power operation, and its derivation is described in detail in the 'Derived Source Term Supporting Report' (Ref. 37) The deposited contamination usually contains activated corrosion products and thus radionuclides such as cobalt-58 and cobalt-60, which are significant in terms of potential radiation doses to workers during decommissioning. Radionuclides produced in the core and primary coolant are transported into connected systems and also can leak out of systems and components and be deposited/adsorbed on to surfaces of SSCs, resulting in contamination. This contamination can be either loose, which is readily removed, or fixed through physical or chemical deposition (e.g. precipitation) and which can only be removed by aggressive techniques such as chemical treatment or physical processes.

53. Deposition is reported to occur in positions where there are large temperature gradients and / or low flow and/or locations with system singularities such as sharp bends and low points. It is reported as mainly occurring in a small number of systems including the Reactor Coolant System, the Chemical Volume and Control System, the Safety Injection System and the Fuel Pool Cooling and Treatment System, based on OPEX. The RP states the deposit source term has been derived on a conservative basis, taking account of concentrations at typical positions where deposition is expected in the various systems based on CGN OPEX and assuming the activity levels are measured 4 days after final shutdown.

54. The RP notes the activated structures source term can comprise thousands and the deposit source term hundreds of terabecquerels (TBq) for PWRs at the end of operation, based on consideration of international OPEX although this OPEX is not specifically referenced. The radioactivity present in SSCs provides the source of the radiation hazard and thus radiological risks during decommissioning. It comprises the radioactivity content of most of the solid radioactive waste and will also contribute to the radioactivity in liquid and gaseous wastes that will be produced during decommissioning.

55. The RP has used the decommissioning source term, in conjunction with OPEX, to estimate the volume of and categorisation of the solid wastes arising from decommissioning into Intermediate Level Waste (ILW) and LLW, based on activity concentrations and assumptions on timescales for decommissioning. This is reported in the 'Decommissioning Waste Management Proposal' (Ref. 26), which is assessed in sub-section 4.8 of this report. This information has been used to support the assessment of disposability of ILW and determine the capacity needed for storage of ILW arising from decommissioning. Large amounts of LLW will also be produced from the decommissioning of SSCs that have been contaminated by contact with radioactive fluids. Disposal of LLW arising from decommissioning is outside the scope of this report.

56. Based on the predicted activated structures source term the RPV and the inner surface layer (~0.5 m depth) of the primary bioshield will be ILW at shutdown. Some of the RVIs are predicted to have a sufficiently high heat output to be classified as High Level Waste at shutdown (HLW, defined as heat output exceeding 2kW/m^3 and activity levels exceeding 12 GBq/tonne for beta/gamma-emitting nuclides), but the heat output is predicted to decrease to below the HLW threshold between 5 and 10 years after shutdown.

57. In addition the RP has identified two bounding cases where the deposit source term is expected to be highest, to assess whether the wastes will be ILW or LLW, namely the SG U-tube and the Cold Leg. The SG U-tube could be classified as ILW but the RP claims this category would be reduced to LLW as a result of decontamination using currently available techniques, based on an assumed Decontamination Factor (DF) of 200. This is discussed further in section 4.5 on Decontamination Techniques and Processes. The activity concentration of the Cold leg decontamination is several orders of magnitude lower than for the SG U-tube and would be classified as LLW prior to decontamination.

4.2.2 Assessment of the decommissioning source term

58. I have assessed the decommissioning source term against the expectations in the relevant SAPs. In this case I have specifically considered SAPs SC.4 and SC.5 (Ref. 2). SAP SC.4 states that “a safety case should be accurate, objective and demonstrably complete for its intended purpose”, while SC.5 states that “safety cases should identify areas of optimism and uncertainty, together with their significance, in addition to strengths and any claimed conservatism”. SAP SC.5 addresses optimism and uncertainty in the basis of the safety case including aspects such as analytical methods and codes and assumptions, with areas of uncertainty expected to be offset by appropriate levels of conservatism. I consider the approach of defining two source terms, namely the activated structures and deposit source term to be appropriate and reasonable on the basis of knowledge of the physical and chemical processes that result in activation and contamination of SSCs in a PWR.

59. The assessment of PALM, the computer code used to calculate the activated structure source term is outside the scope of this report, but I have sought evidence that the code being used is robust and has been appropriately verified and validated. A number of other technical topic areas, including Fuel and Core and Radiological Protection, have undertaken work to establish the adequacy of the PALM code used to generate the activated structures and other source terms.

60. The Radiological Protection topic area prepared an assessment of source term documentation (Ref. 38). This provided a summary of the verification and validation of the PALM code used and indicated the code has been verified and validated by the RP. Independent reviews of the RP’s verification and validation by two of ONR’s technical support contractors identified no significant issues of concern. The review of the code for the purpose of assessment of the source term used to determine radiation shielding indicated the selection of validation cases appeared reasonable, there was a good level of agreement with the experimental data used for verification and that sensitivity studies included the range of burn-ups and enrichments expected for application in the generic UK HPR1000 design. The code is reported to have built upon methods and techniques adopted in other well-established codes used in the UK and elsewhere for similar purposes. On the basis of the assessment of the verification and validation of the PALM code by other topic areas, as summarised in the assessment of source term documentation (Ref. 38), I am satisfied it provides an adequate basis for the activated structures source term and thus the associated waste inventory. It thus meets the relevant expectation of SAP SC.4 in terms of accuracy, objectivity and completeness for its intended purpose in underpinning the safety case.

61. I consider the design source term for activated structures as set out in the 'Activated Structures Source Term Supporting Report' (Ref. 21) to be appropriately conservative, noting the RP has based it on a conservative neutron flux, maximum neutron flux in each region, has not taken outages into account and where concentrations of impurities in materials are considered to be conservative, based on the elemental composition of the specified structural materials for metallic components, including impurities, and a defined elemental composition for concrete. The RP has acknowledged that it will be necessary to review the concrete composition at the site-specific stage.

62. The 'Derived Source Term Supporting Report' (Ref. 37) describes the RP's approach to the derivation of the deposit source term presented in (Ref. 20). The deposit source term has been derived using a combined method of theoretical calculation and OPEX data, which is consistent with the approach taken in the GDA for the UK EPR™. (Ref. 37) indicates where the RP considers a conservative approach has been taken, noting that the deposit source term is one of a number of source terms considered and that the deposit source term is used in other technical topic areas such as radiological protection. Detailed assessment of source terms is presented in the Step 4 Assessment of Radiological Protection for the UK HPR1000 Reactor (Ref. 39).

63. The design values are stated to be conservative, based on maximum values from CGN OPEX data and activity concentrations at 4 days after shutdown. As noted above the RP has identified two bounding cases where high levels of deposition may result in the generation of ILW, where only SG U-tubes have been identified as potential ILW prior to decontamination. I consider this approach to be reasonable.

64. The RP recognises the difficulty in predicting what will happen during the operational lifetime of the generic UK HPR1000 design (60 years), in terms of activation and contamination of SSCs. From the perspective of decommissioning and radioactive waste management, being conservative in estimating the source term provides some confidence that predicted waste categories are also conservative and thus the RP will make adequate provision for the management of ILW, which will be stored on site pending the availability of a disposal route. It also provides confidence that the radiological hazards of decommissioning will not be underestimated, noting the dose rates of RVIs are very high at shutdown and thus present a significant hazard to workers that needs to be adequately controlled. The risks associated with decommissioning of the primary circuit are discussed elsewhere in this report (see sub-section 4.6). The risks of decommissioning after shutdown will be assessed by the licensee, taking account of available data on characterisation of plant radiation and contamination levels and other relevant parameters.

65. I sought clarification of a number of technical issues relevant to the decommissioning source term by means of RQ-UKHPR1000-0719 (Ref. 40), with focus on the basis of the deposit source term and how uncertainties have been taken into account in the overall decommissioning source term such as the SG U-tubes and the typical positions used to derive the bounding cases. I considered the RQ responses to be adequate, with the exception of the clarity of information on OPEX relating to the measurement of some specific radionuclides, which has also been considered in the Step 4 Assessment of Radiological Protection for the UK HPR1000 Reactor (Ref. 39). The RP has incorporated the responses where appropriate into the 'Decommissioning Technical User Source Term Report' (Ref. 20), which is an updated version from that assessed when compiling RQ-UKHPR1000-0719.

66. I consider the approach the RP has taken to the derivation of the deposit source term to be adequate against the expectations of SAP SC.5, as it relates to decommissioning. The deposit source term takes account of CGN and international OPEX in identifying where deposition occurs and the amounts of deposition are based on OPEX from CGN plants as shown in (Ref. 37), which the RP states to be

conservative. I consider the approach of identifying bounding cases to be reasonable. The assumption of activity concentrations at 4 days after shutdown is conservative in that decommissioning is not expected to take place until more than 5 years after shutdown as assumed by the RP in the PDP (Ref. 25). This will result in radioactive decay by at least one half-life of the one of the most radiological significant radionuclides, cobalt-60 (5.3 years), which will reduce dose rates and the activity concentrations of materials during decommissioning.

67. In reality, and as the RP has recognised, the decommissioning source term is inherently uncertain, particularly the deposit source term. It will depend on many factors, including plant history (operations and maintenance including the application of any techniques to minimise and/or remove deposited material prior to shutdown), the timing of decommissioning, uncertainties in models/inputs/assumptions and the techniques that may be used by a future operator, especially for decontamination. These uncertainties are difficult to quantify before operation and thus cannot readily be taken into account at the design stage.

68. The adequacy of the RP's evidence relevant to the activated corrosion products that are significant contributors to the deposit source term is outside the scope of my assessment. The Step 4 Assessment of Chemistry for the UK HPR1000 Reactor (Ref. 41) includes detailed consideration of the RP's evidence on the generation, transport and accumulation of corrosion products. The Chemistry specialist inspector has raised a number of Assessment Findings, including the development of plant-specific corrosion product estimations for future operation (AF-UKHPR1000-0117) and optimisation of the inventory of cobalt and other radionuclides in the generic UK HPR1000 design (AF-UKHPR1000-0112, AF-UKHPR1000-0113 and AF-UKHPR1000-0114).

69. In addition, the Step 4 Assessment of Radiological Protection for the UK HPR1000 (Ref. 39) includes Assessment Finding AF-UKHPR1000-0096 on the application and use of the deposit source term in the safety case, as a result of assessment of a number of submissions on source term, with focus on the RP's use of OPEX. Addressing these Assessment findings in the site-specific stage will strengthen the RP's safety case in terms of demonstrating that the deposit source term present at decommissioning will be minimised.

70. I do not consider it necessary or proportionate to identify Assessment Findings additional to those already identified in the Step 4 assessment reports for Chemistry and Radiological Protection, relating to activated corrosion products and deposit source term. The Chemistry Assessment Findings will be of benefit in addressing uncertainty during the operational phase. From a decommissioning perspective I am satisfied the conservatism applied by the RP in the derivation of both activated structure and deposit source terms meets the expectation of SAP SC.5, with respect to the balance of conservatism against uncertainty and is appropriate to the GDA stage.

71. For the purpose of this technical topic area, I consider the decommissioning source term to provide an adequate basis for the preliminary consideration of the radiological risks associated with decommissioning and the identification of potentially applicable decommissioning strategies and techniques. The RP has used the decommissioning source term appropriately to define waste inventories and waste categories to underpin the decommissioning waste management strategy and assess disposability, with focus on higher activity wastes, which I consider in detail in sub-section 4.8. The licensee will need to characterise the amount and location of radioactivity after shutdown to underpin the decommissioning plan, assess the relevant risks and estimate arisings of radioactive wastes.

4.2.3 Strengths

72. The key strengths/positive aspects of the safety case are summarised below:

- The RP's derivation of the activated structures source term is appropriately underpinned and is consistent with OPEX for the derivation of source terms by numerical modelling.
- The RP's derivation of the deposit source term is based on both CGN and international OPEX.
- The conservatism applied by the RP in the derivation of both activated structure and deposit design source terms meets the expectation of SAP SC.5 with respect to the balance of conservatism against uncertainty from a decommissioning perspective, which I also consider to be appropriate to the GDA stage.

4.2.4 Outcomes

73. I have not identified any Assessment Findings or GDA issues for decommissioning source term, nor any minor shortfalls.

4.2.5 Conclusion

74. Based on the outcome of my assessment of the decommissioning source term, I have concluded it has been derived using appropriate techniques that are underpinned by either a verified and validated model and/or relevant OPEX. I consider the conservatism applied by the RP to the decommissioning source term to be appropriate in the light of uncertainties and thus that it meets the expectations of SAP SC.5. It is also appropriate to the GDA stage.

75. I conclude the decommissioning source term provides an appropriate basis for the preliminary assessment of radiological risks during decommissioning and for underpinning the estimates of arisings of radioactive wastes during decommissioning, identification of waste categories and thus the radioactive waste management strategy. It also underpins the assessment of the disposability of higher activity radioactive wastes (ILW), which is discussed further in sub-section 4.8.

4.3 Decommissioning Strategy

4.3.1 Overview of regulatory and policy expectations for decommissioning strategy

76. IAEA GSR Part 6 on Decommissioning (Ref. 14) requires that licensees select a decommissioning strategy that forms the basis for planning for decommissioning and is consistent with the national policy on management of radioactive waste. The WENRA Safety Reference Levels on Decommissioning (Ref. 16) incorporate this requirement.

77. ONR SAP DC.2 states that "a decommissioning strategy should be prepared and maintained for each site and should be integrated with other relevant strategies". It also states that "the strategy should describe the significant assumptions and project risks associated with its achievement, and how these will be managed. The initial strategy should be produced during the planning stage of a new site or facility". ONR SAP DC.2 also states the strategy should describe or refer to the decommissioning options, the timescales considered and the reasons for selecting the chosen option(s). ONR's TAG on Decommissioning (Ref. 9) incorporates similar information, noting "the strategy should be to a level of detail commensurate with the type and status of the facility, the hazards presented and the stage in the lifecycle".

78. IAEA GSR Part 6 (Ref. 14) identifies two possible decommissioning strategies which are applicable for all facilities:

- Immediate dismantling – decommissioning actions begin shortly after permanent shutdown. Facility equipment and SSCs are removed and/or decontaminated to a level that permits the facility to be released from regulatory control for unrestricted use or released with restrictions on future use.
- Deferred dismantling – for nuclear installations after removal of nuclear fuel all or part of a facility is either processed or placed in a condition that it can be put in safe storage and the facility maintained until subsequently decontaminated and/or dismantled. Deferred dismantling may involve early dismantling of some parts of the facility and early processing and removal of radioactive material in preparation for safe storage of the remaining parts of the facility. The period of deferral is referred to in ONR's SAPs as the period of "care and maintenance".

79. IAEA GSR Part 6 (Ref. 14) requires the selection of the decommissioning strategy to be justified by the licensee. It also requires that the facility is maintained in a safe configuration at all times and will reach the specified end states and that no undue burdens will be imposed on future generations. The strategy of immediate dismantling is preferred but IAEA GSR Part 6 explicitly recognises there may be situations in which immediate dismantling is not practicable, considering all relevant factors.

80. ONR SAP DC.3 on the timing of decommissioning states that if it is proposed to defer the decommissioning of a facility, the safety case should justify the continuing safety of the facility for the period prior to its decommissioning. Decommissioning should be carried out as soon as is reasonably practicable, taking all relevant factors into account. Decommissioning should occur promptly where this is reasonably practicable. The timing of the decommissioning should be rigorously justified.

81. UK government policy relevant to decommissioning is set out in the Funded Decommissioning Programme Guidance for New Nuclear Power Stations (Ref. 42). This includes the definition of a number of strategic assumptions regarding the means by which waste may be managed and disposed of and how decommissioning will be carried out by a new nuclear power station operator. These assumptions define a generic lifecycle plan for new nuclear power stations known as the "Base Case".

82. The Base Case assumes prompt decommissioning of the power station, with operators obliged to provide safe and secure interim storage facilities (where prompt has the same meaning as immediate in IAEA guidance). It assumes there is no care and maintenance period after the station has been shut down and before decommissioning takes place. It is open to operators to propose a care and maintenance period in a future Decommissioning and Waste Management Plan (which is prepared at site-specific stage), but this would need to be justified to regulators and the government.

4.3.2 Overview of the RP's Decommissioning Strategy

83. PCSR Chapter 24 (Ref. 3) makes explicit reference to the international guidance discussed above, providing a list of applicable codes and standards including those defined as relevant to decommissioning, most notably IAEA GSR Part 6 (Ref. 14). The RP has also produced a number of other documents which identify the requirements and/or expectations of national and international guidance, such as the 'Analysis Report of Applicable Codes and Standards' (Ref. 43), 'General Requirements for Decommissioning of Nuclear Power Plants' (Ref. 44) and 'Compliance Analysis of Codes and Standards in Decommissioning' (Ref. 45).

84. The RP made Claim 5.2 and sub-claim 5.2.SC24.5 in PCSR Chapter 24 which relate to the preparation of decommissioning plans and strategies. As noted in section 3.2, PCSR Chapter 24 includes a specific section on decommissioning strategy, which provides general principles for the selection of decommissioning strategy and consideration of the scope of and end state of decommissioning. PCSR Chapter 24 and the PDP include a list of the key assumptions that underpin the safety case which

are relevant to decommissioning and waste management. They also set out applicable codes and standards, including policy and regulatory guidance.

85. PCSR Chapter 24 claims that both immediate and deferred dismantling are technically possible for the generic UK HPR1000 design but does not provide any information to substantiate this claim. PCSR Chapter 24 reports the outcome of an options study for the selected decommissioning strategy, which is recorded in an appendix to the PDP (Ref. 25). The preferred option for the generic UK HPR1000 design is immediate dismantling, which is stated as being consistent with UK policy and guidance and which explicitly refers to the UK government's guidance for new nuclear power stations (Ref. 42).

86. Similar but more detailed information on decommissioning strategy is provided in the PDP (Ref. 25), which notes that non-foreclosure of options is important for decommissioning because it will not take place until at least 60 years in the future and there are thus many uncertainties. However, the PDP does not provide any further information to explain why options are not foreclosed for the generic UK HPR1000 design.

87. The PDP describes the assessment of options for the selection of the preferred decommissioning strategy of immediate dismantling, the methodology for which was stated to be consistent with the RP's optioneering process (Ref. 46). The RP defined a number of options ranging from "do nothing" (i.e. no dismantling), two deferred dismantling options (which differed only because of differences in the timing of managing wastes), entombment (disposal in-situ after removal of fuel and wastes with minimal dismantling) and immediate dismantling. The RP screened out "do nothing" because it does not achieve the end state and would not be consistent with UK policy. Entombment was also screened out because of the residual risks and because IAEA GSR Part 6 (Ref. 14) is clear it is not an option in the case of planned permanent shutdown.

88. The RP assessed the screened options against a range of criteria including safety (both radiological and conventional), technical, environmental, regulatory and socio/economic factors, with reasonings provided for the assignment of relative ranking/scoring. The RP did not apply weightings to the assessment criteria used and did not carry out any sensitivity analyses. Immediate dismantling was clearly identified as the preferred option, but the RP noted that the screened options assessed had advantages and disadvantages. Immediate dismantling was stated as providing clearance of the site at the earliest opportunity to reduce hazard and risk, with lower risk of plant degradation. However, the RP acknowledged the benefits of deferred dismantling in terms of reduced radiation levels, reduced amounts of higher activity radioactive wastes and the opportunity to use simpler methods with less reliance on remote methods. The RP also compared the preferred option with UK policy and international practices for PWR decommissioning.

4.3.3 Assessment of the RP's Decommissioning Strategy

89. I have assessed the RP's decommissioning strategy against the expectations of the relevant SAPs (Ref. 2), most notably SAP DC.2 (and DC.3) and other RGP with focus on IAEA GSR Part 6 (Ref. 14) and SSG-47 on the Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities (Ref. 15).

90. I assessed the decommissioning strategy aspects of both PCSR Chapter 24 and the PDP and sought clarification of a number of aspects relevant to decommissioning strategy by means of RQ-UKHPR1000-1512 (Ref. 40). I asked for evidence to underpin the RP's position that deferred dismantling is technically possible for the generic UK HPR1000 design and that the option is thus not foreclosed. In particular I asked for evidence as to whether there were any life-limiting features that could affect

the viability of deferred decommissioning. The RP's initial response to RQ-UKHPR1000-1512 on this issue was not adequate so I asked a follow-up query in RQ-UKHPR1000-1696 (Ref. 40).

91. In the response to RQ-UKHPR1000-1696 the RP noted the evidence from international OPEX that life extensions and deferred decommissioning have been demonstrated to be feasible for many PWRs. Design life extensions have been permissioned on the basis of evidence that SSCs including buildings, cranes and other equipment important to deferred decommissioning can continue to be safely operated during an extended operational lifetime.

92. The RP also indicated there will be a robust regime for Examination, Inspection, Maintenance and Inspection (EIMT) during the operational lifetime and noted the work undertaken to respond to ONR's Regulatory Observation RO-UKHPR1000-0021 (Ref. 46) on the demonstration of the adequacy of EIMT of SSCs important to safety, which the RP has adequately addressed during Step 4 of GDA. The RP also provided information on the specific example of the polar crane (which is important for dismantling and removal of the primary circuit and SGs, see also section 4.6 on dismantling) and how its planned use during the decommissioning phase has been addressed in the design, taking account of OPEX. The RP also acknowledged that some SSCs would need to be replaced during decommissioning and that some new ones may need to be added. This is consistent with OPEX and my knowledge and experience of decommissioning where there has been a need for new SSCs such as ventilation systems and waste processing equipment. I considered the response to be adequate in supporting the RP's position that the option of deferred decommissioning has not been foreclosed.

93. I consider the assumptions and principles identified by the RP to be appropriate in recognising key aspects of regulatory expectations. I consider the definition and screening of the decommissioning strategy options carried out by the RP to be reasonable and appropriate to the stage of GDA. The RP identified and assessed options for decommissioning and provided reasonings for the option selected. It took account of a range of relevant factors which are broadly consistent with those set out in SAP DC.3 on the timing of decommissioning, although the assessment could have been more explicit on some technical aspects such as the impact of decay of radionuclides such as cobalt-60 on radiological risks. The RP did not explicitly address uncertainties relating to climate change, the precautionary principle and burdens on future generations listed in DC.3 in assessing options, but the selected option of immediate dismantling is the most conservative (precautionary) of those considered with respect to these aspects.

94. The specific information on decommissioning strategy provided in PCSR Chapter 24 and the PDP did not fully address the expectations set out in DC.2 and DC.3. I have thus considered information from other submissions in considering whether the expectations have been adequately addressed in the safety case, commensurate with the stage of the lifecycle of the generic UK HPR1000 design. The RP has considered decommissioning wastes in the IWS(Ref. 48), thereby demonstrating the integration of radioactive waste management and decommissioning strategies. The RP has explicitly addressed the management of decommissioning wastes in the 'Decommissioning Waste Management Proposal' (Ref. 26). Other submissions including the 'ALARP Demonstration for Decommissioning of the UK HPR1000' (Ref. 19) consider the risks and hazards associated with decommissioning. Both of these aspects are discussed elsewhere in this report (sub-sections 4.8 and 4.10 respectively). The discussion of end state in PCSR Chapter 24 is appropriate to the GDA stage, noting the end state will be defined by the licensee.

95. Overall I consider the RP's decommissioning strategy meets the overall expectations of SAP DC.2 and, where relevant, DC.3, and is consistent with the RGP set out in

IAEA GSR Part 6 (Ref. 14) and SSG-47 (Ref. 15), commensurate with the stage of the lifecycle of the generic UK HPR1000 design. It meets the expectation of producing an initial strategy during the planning stage of a new site or facility. The RP has indicated its expectation that the decommissioning strategy should be reviewed by the licensee, noting the safety case will be provided to the licensee. It is not a matter for GDA, but I note ONR assesses decommissioning strategies and plans in the context of compliance with Site Licence Condition 35 for licensed nuclear installations.

96. I consider the RP has provided sufficient evidence to substantiate Claim 5.2 and Sub-Claim 5.2.SC24.5 in relation to the decommissioning strategy and consideration of UK policy.

97. The decommissioning strategy of immediate dismantling is consistent with UK policy as set out in the Base Case for the decommissioning of new nuclear power stations (Ref. 42).

4.3.4 Strengths

98. The key strengths/positive aspects of the safety case as it relates to decommissioning strategy are summarised below:

- The RP has provided adequate evidence to substantiate Claim 5.2 and Sub-Claim 5.2.SC24.5 as they relate to decommissioning strategy.
- The safety case meets the expectations of SAP DC.2 and where relevant, DC.3 on decommissioning strategy and timing of decommissioning, appropriate to the stage of the lifecycle of the generic UK HPR1000 design.
- The safety case is consistent with relevant RGP, including IAEA requirements and guidance on decommissioning, and the RP has shown good awareness of national and international guidance and OPEX on decommissioning in its selection of decommissioning strategy.
- The selected decommissioning strategy of immediate dismantling is consistent with the strategic assumptions in UK policy for new nuclear power stations.

4.3.5 Outcomes

99. I have not identified any Assessment Findings or GDA issues for decommissioning strategy, nor any minor shortfalls.

4.3.6 Conclusion

100. Based on the outcome of my assessment of the evidence the RP has provided on the decommissioning strategy, I have concluded the strategy is adequately underpinned by means of adequate consideration of options and takes due account of RGP and OPEX. The strategy meets the expectations of the relevant SAPs, DC.2 and 3 and other RGP and the information provided substantiates the relevant claims made by the RP. The strategy is appropriately integrated with the radioactive waste management strategy and is appropriate to the stage of the lifecycle of the generic UK HPR1000 design and of GDA.

4.4 OPEX for Decommissioning

4.4.1 The RP’s Submission on OPEX for Decommissioning

101. As noted in section 4.1, there is no experience of the decommissioning of civil PWRs in the UK, no PWRs have been decommissioned to date in China but a number of PWRs and other reactor types have been decommissioned in the UK and across the world. This sub-section is intended to provide a brief overview of the RP’s consideration of international OPEX in decommissioning, which has informed the development of the

generic design and safety case for the UK HPR1000 as it relates to decommissioning and of ONR's work in identifying relevant OPEX to provide an independent review of OPEX and good practices against which to consider the RP's safety case. I provide additional information on the RP's consideration of OPEX for each specific topic area in the other sub-sections, where relevant.

102. PCSR Chapter 24 notes the existence of OPEX for the decommissioning of PWRs and of proven techniques to minimise risks and refers to the submission 'OPEX on Decommissioning' (Ref. 22), which has been used to develop the RP's principles and requirements for facilitating decommissioning, together with government policy, regulations and guidance and relevant codes and standards. Design for decommissioning, which is intended to facilitate decommissioning, is discussed in sub-section 4.7.

103. The RP states the purpose of the submission is to present the main findings of OPEX on decommissioning, and identify those that should be considered for the generic UK HPR1000 design, together with RGP, for developing a design that will facilitate decommissioning, the UK HPR1000 decommissioning strategy and preliminary decommissioning plan, and for demonstrating that UK HPR1000 decommissioning can be achieved using current techniques, in a way that is safe, secure and that will protect the environment and the public. The submission provides information on its role in underpinning the other technical submissions which are summarised in sub-section 3.1 of this report.

104. (Ref. 22) provides brief information on the status of nuclear power plants in decommissioning. Most of the submission focuses on OPEX relating to the following key aspects:

- Consideration of facilitating decommissioning
- Decontamination
- Dismantling, including the RPV, RVIs and large components
- Demolition of concrete structures
- Analysis of decommissioning phases (programmes)
- Knowledge management.

105. It includes information on a number of case studies relevant to specific aspects of the key elements listed above, including lessons learnt. The report is intended to provide a baseline for identifying learning points relevant to the key aspects listed above. The report is effectively self-standing as it does not refer to any of the RP's other decommissioning documents supporting the safety case, nor does it refer to the RP's arrangements for identifying, capturing and justifying the applicability of relevant OPEX, as assessed by ONR and discussed in (Ref. 49). (Ref. 22) is specifically referred to in the majority of the submissions listed in section 3.2.

4.4.2 Regulatory Expectations Relevant to OPEX for Decommissioning

106. Paragraph 5.126 of ONR's Technical Assessment Guide on Decommissioning (Ref. 9) states "The safety case should incorporate learning from experience of operating the facility, as well as learning from relevant decommissioning projects elsewhere, whether in the UK or internationally."

107. Annex 2 of NS-TAST-GD-005 Revision 11 (Ref. 6), ONR's TAG on ALARP, discusses ALARP for proposed new civil reactors, where paragraph A2.4 states "The demonstration should set out how known problem areas (e.g. identified from Operational Experience Feedback (OEF), improved analysis, or improving standards) have been addressed and how and why the particular solution chosen was arrived at."

108. During Step 3 of GDA ONR asked a TSC to undertake a review of the decommissioning of PWRs and other nuclear power plants, with the aim of identifying good practices and Operating Experience and Feedback (OEF) relevant to design for decommissioning of PWRs (Ref. 50). This is discussed further in section 4.7.

4.4.3 Assessment of the RP's Submission on OPEX for Decommissioning

109. I consider the submission on 'OPEX for Decommissioning' (Ref. 22) demonstrates the RP has sought to identify learning from international decommissioning projects, consistent with the expectation in NS-TAST-GD-026, ONR's TAG on Decommissioning (Ref. 9). Most of the submissions supporting PCSR Chapter 24 refer to this submission (Ref. 22) as the source of information on OPEX in support of the "golden thread" from claims to evidence and it is incorporated in the overall structure of submissions underpinning PCSR Chapter 24.

110. I consider the overall content of 'OPEX for Decommissioning' (Ref. 22) to be appropriate to the decommissioning of PWRs and thus of the generic UK HPR1000 design, in terms of identification of technical areas of significance to the decommissioning of PWRs. This appears to have informed the development of the technical submissions underpinning PCSR Chapter 24. I consider OPEX specific to the technical areas in the relevant sections and OPEX more generally in the section on design for decommissioning (section 4.7), including consideration of the RP's submissions against the good practices and OEF identified by ONR's TSC during Step 3 of GDA.

111. However, I have not been able to discern from the evidence I have assessed that 'OPEX for Decommissioning' (Ref. 22) has been prepared in accordance with the RP's arrangements for identifying, capturing and justifying the applicability of relevant OPEX, as discussed in (Ref. 49). Decommissioning is recognised to be an "OPEX-dependent" topic in the RP's arrangements for OPEX. I consider to be a minor shortfall in the light of the evidence of the OPEX considered in (Ref. 22).

4.4.4 Strengths

112. The key strengths/positive aspects of the safety case as it relates to OPEX for decommissioning are:

- The RP has identified and taken account of international OPEX on decommissioning, identifying appropriate technical areas of relevance to the decommissioning of the generic UK HPR1000 design.
- Most of the submissions underpinning PCSR Chapter 24 refer to the submission on 'OPEX for Decommissioning' (Ref. 22), thereby providing evidence of consideration of OPEX in their development.

4.4.5 Outcomes

113. I have identified one minor shortfall.

4.4.6 Conclusion

114. Based on the outcome of my assessment of the evidence the RP has provided on OPEX for decommissioning, I have concluded the RP has taken due account of international OPEX and has identified technical areas relevant to the decommissioning of the generic UK HPR1000 design, which meets relevant regulatory expectations. However, the RP has not provided adequate evidence that the identification of OPEX for decommissioning has been carried out in accordance with appropriate arrangements for identifying, capturing and justifying the applicability of relevant OPEX, which I consider to be a minor shortfall.

4.5 Decontamination Processes and Techniques

4.5.1 The RP's Submission on Decontamination Processes and Techniques during Decommissioning

115. 'Decontamination Processes and Techniques during Decommissioning' (Ref. 27) is one of the submissions supporting PCSR Chapter 24 and the PDP, and the information in it is summarised in PCSR Chapter 24. It makes explicit reference to the relevant claims in PCSR Chapter 24 and is stated as contributing to the demonstration that the generic UK HPR1000 design can be decommissioned safely, with the risks being capable of reduced to ALARP and in a manner that minimises impacts on the public and the environment. It is intended to demonstrate that decontamination, a key activity in the decommissioning of nuclear power plants, can be performed safely with reduction of relevant risks to ALARP, considering existing processes and techniques.

116. The submission makes specific reference to the 'OPEX for Decommissioning' submission (Ref. 22), noting there are many decontamination techniques available that have been used successfully during the decommissioning of nuclear power plants. These are classified into three main types: chemical; electrochemical and mechanical. The RP states it has pre-selected a range of potential techniques but notes the importance of non-foreclosure of options in providing a future operator with sufficient flexibility to select the most appropriate option in the context of uncertainties. These uncertainties include the future radiological status of the plant after 60 years of operation and future OPEX and techniques. Many PWRs will have been decommissioned by the time of shutdown of the UK HPR1000 and thus there will be much more OPEX to consider in the planning of decommissioning at that time.

117. (Ref. 27) encompasses those SSCs that are anticipated to be contaminated at final shutdown, describes existing proven decontamination processes and techniques, and considers the associated risks and impacts and mitigation measures, based on OPEX and current knowledge. It is based on assumptions of an operational period of 60 years, a decommissioning strategy of immediate dismantling and that decontamination is based on techniques and technologies that are available today.

118. The RP noted that decontamination is applied throughout the lifecycle of a plant and it can achieve a number of objectives including:

- Reduction in radiation doses to personnel by reducing occupational doses
- Minimising the radioactivity and / or volume of solid radioactive wastes
- Facilitating dismantling/disassembly activities.

119. The RP has identified criteria to be taken into account in selecting decontamination techniques, recognising that some aspects will depend on information that will only be available during and after operation. The criteria considered include decontamination efficiency (which depends on many parameters such as operational history, the types of surfaces, materials and contaminants, ease of access), availability, costs and complexity, the hazards of the decontamination agents, the management of the resulting wastes and radiation doses. The RP recognises the need to carry out cost/benefit analysis and has identified selection criteria as considered appropriate to the scope and stage of GDA.

120. The RP notes that decontamination is largely carried out in preparation for dismantling during decommissioning. The techniques used during decommissioning tend to be relatively aggressive in comparison with those used during the operational phase, to maximise the decontamination achieved to reduce doses and radiological risks for subsequent steps in decommissioning. The RP separately considers the approaches to the decontamination of systems, components and structures, which are discussed in the following paragraphs.

System Decontamination

121. The decontamination of systems during decommissioning has been carried out successfully for a number of PWRs using a process known as Full System Decontamination (FSD). This involves the application of liquid decontamination reagent(s) to selected intact systems over a number of cycles to remove internal deposition of (mainly) activated corrosion products. This achieves progressive reduction in contamination levels to defined acceptable levels to enable subsequent safe dismantling. The resulting radioactive effluents are treated either by existing treatment systems or temporary treatment systems, with the radioactive components largely retained in solid wastes such as filters and ion exchange resins. The RP expects to use FSD for various systems and integral components including the pressuriser, primary pumps and piping loops in the primary circuit, the SGs and parts of the Chemical and Volume Control System, the Safety Injection System and the Fuel Pool Cooling and Treatment System, based on consideration of the decommissioning source term and international OPEX.

122. The RP considers FSD techniques used worldwide and concludes that relatively aggressive techniques which achieve a high Decontamination Factor (DF, defined as the ratio between the concentration of radioactivity before and after decontamination) are more suitable for decommissioning than less aggressive techniques for FSD that achieve lower DFs that are normally used during the operational phase.

123. The RP has identified two proprietary FSD techniques that achieve a high DF, known as HP CORD D UV (where CORD is Chemical Oxidation Reduction Decontamination) and EPRI DFD/DFDX (where DFD is Decontamination for Decommissioning). (Ref. 27) compares the relative advantages and disadvantages of the two techniques and makes a preliminary selection of CORD D UV for FSD for the generic UK HPR1000 design at the GDA stage of the lifecycle. Further information on the application of this technique to the decontamination of SGs is also provided in the RP's submission 'Dismantling Example Analysis of Steam Generator' (Ref. 29). The RP has selected this technique based on the achievement of a good balance between the DF achieved (assumed to be 200 or above, based on OPEX), minimising the volume of secondary solid radioactive wastes generated and the risks associated with the use of the chemical reagents. The RP considers this technique reduces risks to ALARP (and is also considered to be BAT with respect to meeting the expectations of the Environment Agency). The management of secondary wastes arising from decommissioning is considered in the 'Decommissioning Waste Management Proposal' (Ref. 26).

124. As discussed in section 4.2 on decommissioning source term, the RP notes that the achievement of the assumed DF of 200 would reduce the waste category of the highest deposition source term, namely the SG U-tubes, to LLW from ILW.

Component Decontamination

125. The RP indicates that components which require decontamination (or additional decontamination after system decontamination) will typically be removed from its original location (ex-situ) for decontamination depending on its characteristics, radioactive waste management and radiation protection requirements. Some components, such as tanks, vessels and evaporators may be decontaminated in-situ using connected mobile devices and/or installed nozzles to apply decontamination techniques and/or reagents. The design of systems and components to prevent the accumulation of contamination and/or facilitate decontamination is discussed further in section 4.7 on design for decommissioning.

126. Some large and small components are expected to be transferred to a dedicated "hot" workshop for decontamination and other processes such as size reduction in support

of decommissioning and waste management, taking account of radiation dose levels. The design of this workshop is excluded from the scope of GDA.

Structures Decontamination

127. The RP indicates that decontamination of concrete and steel surfaces is carried out prior to demolition, with the aim of removing all contamination to enable demolition as conventional (non-radioactive) structures. The RP indicates that concrete and steel structures are usually covered with decontaminable paints to facilitate decontamination. The depth of material to be removed will be based on the results of radiation surveys and known plant history.

128. The RP provides information on the range of chemical, electrochemical and mechanical/physical decontamination techniques currently available for components and structures including aspects such as potential applicability, the DFs achieved, the resulting secondary wastes and potential limitations. The RP also provides information on the scope of application of the various techniques, based on review of international OPEX.

129. (Ref. 27) also provides information on the generic risks and impacts, together with relevant mitigation measures associated with decontamination for the design, operational and decommissioning phases, focusing on the risks of worker dose, doses to the public and the spread of contamination. Some specific risks and mitigations are identified for the various decontamination techniques discussed. Some of this information is based on international OPEX.

130. The RP has provided information on mitigation measures implemented in the design of the UK HPR1000, with appropriate references, including selection of materials and the design of equipment, processes, buildings, structures and layout. These aspects are discussed further in sub-section 4.7 on design for decommissioning.

4.5.2 Assessment of the RP’s Submission on Decontamination Processes and Techniques during Decommissioning

131. There are no regulatory expectations relating to the selection of specific decontamination techniques and processes for use in decommissioning. The importance of decontamination and the prevention of accumulation of contamination in reducing radiological risks is recognised in a number of SAPs and is also discussed in sub-section 4.7 on design for decommissioning. It is also important to note that risks are not just radiological, as decontamination techniques may involve the use of chemical reagents which may be hazardous and/or result in conventional safety hazards to workers during their application.

132. ONR-GDA-GD-007, ONR’s Technical Guidance for GDA (Ref. 51) indicates the RP should provide information on the proposed application of decontamination processes and techniques in the decommissioning of the generic design. Consideration of the need or otherwise for decontamination should take account of the overall need to justify the risks as ALARP. This technical guidance also indicates that decommissioning of the generic design should be based on currently available technologies, not on technologies that may become available in the future.

133. I have considered the information in PCSR Chapter 24 and its supporting submission (Ref. 27) against the regulatory expectations of the GDA Technical Guidance (Ref. 51), with focus on the overall need to justify the risks as ALARP. I decided to target my assessment on the proposed use of FSD for the decontamination of key systems as claimed, because of the benefits claimed for its application and because the RP considers its use would reduce risks to ALARP. It thus forms a significant part of supporting the RP’s claims that the faults and hazards are identified and assessed,

and risks shown to be capable of being ALARP, as claimed in Sub-Claim 5.1.SC.24.3 and Claim 5.1.

134. I asked for justification of the assumed DF of 200 for the application of the selected method (HP CORD D UV) in RQ-UKHPR1000-0719 (Ref. 40) and asked why this was considered to be conservative. The RP's response indicated the DF of 200 was based on the average of the DFs reported to have been achieved for decontamination of SGs in three plants where this technique has been applied (i.e. based on OPEX). Much higher DFs than 200 were achieved in one plant but DFs for two of the three plants quoted were lower with the lowest DF value quoted of 147 and the highest DF quoted was just over 1400. Nonetheless the RP considered use of a DF of 200 to be conservative and noted the future operator will reassess in the future based on more accurate information on the radiological characteristics of the SG, the available techniques and associated OPEX and regulation in force at that time.

135. I also sought information on the implication of a DF less than 200 with respect to the waste categorisation of those parts of the plant with the highest deposit source terms (parts of the SG U-tubes) as noted in section 4.2, in terms of the risk of producing ILW instead of LLW. The RP’s response was that achieving a DF of 200 would result in the production of LLW. Whilst I do not consider that the DF of 200 is necessarily conservative on the basis of the information provided by the RP, because some measured values from OPEX were lower than 200, it nonetheless provides a reasonable assumption for the purpose of consideration of waste categories and risks and is based on consideration of relevant OPEX. I also note the RP indicated the DF could be increased if necessary, by means of the application of complementary in-situ or ex-situ techniques, as set out in (Ref. 20). I have already concluded the deposit source term is conservative because it is based on activity levels at 4 days after shutdown.

136. The licensee would need to consider potential options in the event that a DF of 200 was not achieved by application of FSD and the relevant radioactive waste did not meet the criteria for LLW at the time of decommissioning. Given one of the main isotope of concern is cobalt-60, with a half-life of 5.3 years, options such as decay storage or further decontamination might be of benefit in enabling disposal of the relevant waste as LLW. I do not consider these aspects present any significant implications for the generic design of the UK HPR1000.

137. I asked for information on the scope of proposed application of FSD in RQ-UKHPR1000-1312 (Ref. 40), seeking justification of the systems/parts of systems selected for FSD and why this selection was consistent with relevant international OPEX. I also asked for evidence of the incorporation of design features that facilitate decontamination, such as connection points for equipment. The RP’s response indicated the selection was based on consideration of the decommissioning source term, as discussed in Section 4.2, and was consistent with specific international OPEX, where FSD was mainly used for the reactor coolant system, the chemical and volume control system, the residual heat removal system, and purification system. The RP also provided evidence of features that facilitate decontamination. I considered the RP’s response to be adequate.

138. I consider the proposed application of FSD (to achieve a high DF) to selected systems in the generic UK HPR1000 design, where deposition of activated corrosion products is expected to be highest to be consistent with international OPEX for the decommissioning of PWRs and to be a good practice. Undertaking FSD will result in significant reductions in radiological risks during subsequent stages of dismantling through reduction of the dose rates achieved by removal of deposited corrosion products from the system components. It is also expected to reduce the categories of radioactive waste arising from decommissioning (e.g. ILW to LLW, or LLW to out-of-scope), which is consistent with the application of the waste hierarchy and with the

expectation of SAP RW.2 concerning the minimisation of the generation of radioactive waste. As noted above the radioactive material that arises from removal of deposited material during FSD is transferred to ion-exchange resins and filters which form part of the inventory of solid radioactive waste. This is discussed further in section 4.8 on management of decommissioning wastes.

139. The RP has selected HP CORD D UV, a proprietary product, as the preferred technique at the GDA stage. This product is stated as offering safety and environmental benefits including the use of chemical reagents such as oxalic acid which degrade to benign substances (carbon dioxide and water) and thus minimises the amount and hazardous nature of the secondary wastes arising from FSD. This technique is commercially available and has been applied safely in NPPs internationally, on the basis of publicly available information.

140. However, there are other commercially available techniques for FSD during decommissioning which have also been applied safely in NPPs, on the basis of publicly available information, and which could be used safely in the decontamination of the generic UK HPR1000 design. I would expect FSD techniques to continue to develop as more PWRs reach the end of their operational lives over the coming years and decades. It will be for the licensee to review the proposed technique to be used for FSD at the end of the operating lifetime of the UK HPR1000, based on actual plant status and operating data, plant knowledge and experience and taking account of more available OPEX. The licensee can then select the most appropriate technique and extent of application of FSD, as part of the overall justification of reducing the risks of decommissioning to ALARP at the appropriate time.

141. The use of FSD in systems that remain intact (an example of in-situ decontamination) means that the safety protection measures for these systems continue to be available, maintaining the containment of the contamination in liquid effluent in the systems and thereby reducing the risks to workers undertaking the decontamination.

142. Publicly available information indicates the safety (and environmental) benefits of FSD in reducing doses to workers associated with decommissioning of the primary circuit and reducing the amount and/or category of radioactive wastes arising from subsequent dismantling. I consider the RP’s proposal to apply FSD during the decommissioning of the generic UK HPR1000 design to be a significant contributor to substantiating Claim 5.1 that the design and intended operation will facilitate safe decommissioning using current available technologies, which is underpinned by Sub-claim 5.1.SC.24.4. I also consider the proposed use of FSD to be a significant part of the RP’s evidence supporting Claim 5.1.SC24.3 that risks are shown to be capable of being ALARP.

143. I have considered the information provided by the RP on non-FSD aspects of decontamination of structures and components in terms of meeting relevant regulatory expectations. I also consider the aspects of the generic design of the UK HPR1000 that facilitate decontamination and prevent/minimise the accumulation of contamination in sub-section 4.7 on design for decommissioning. The RP has provided information on the range of decontamination techniques that are currently available, including summary information on OPEX and generic information on risks and mitigation measures.

144. I consider the information the RP has provided on currently available non-FSD decontamination techniques to be appropriate to the GDA stage of development of the generic design. The licensee will select the technique to be used and consider whether decontamination should be carried out prior to or after dismantling of the relevant SSC (referred to as in-situ or ex-situ decontamination respectively). The licensee will need to assess the options for and risks of decontamination on the basis of the circumstances at the time of decommissioning and to select techniques that

reduce risks to ALARP, taking account of both radiological and conventional safety risks. It is not necessary or proportionate to expect the RP to pre-select the decontamination techniques to be applied, other than to identify FSD as the preferred approach for key primary circuit systems because of its benefit in PWRs, as shown by international OPEX.

145. The RP provided a list of currently available decontamination techniques with information on their range of applications, associated risks and generic information on risk mitigation, which is adequate for the GDA stage. It will be for the licensee to keep decontamination techniques under review as part of the ongoing review of the PDP, noting they will continue to develop and further OPEX will become available before decommissioning takes place. I also note that good operational and maintenance practices, which are of benefit in reducing the levels of contamination to reduce risks to workers and maintain safe and efficient operations, also contribute to reducing risks during decommissioning.

4.5.3 Strengths

146. The key strengths/positive aspects of the safety case as it relates to decontamination techniques and processes during decommissioning are:

- The RP has identified and taken account of international OPEX for decontamination techniques and processes.
- The RP has identified a range of currently available techniques for the decontamination of systems, structures and components in the UK HPR1000, which is consistent with regulatory expectations at the GDA stage.
- The RP has selected FSD to decontaminate key systems of the generic UK HPR1000 design, which is consistent with international OPEX and which I consider to be a good practice.

4.5.4 Outcomes

147. I have not identified any Assessment Findings or GDA issues for decontamination techniques and processes, nor any minor shortfalls.

4.5.5 Conclusion

148. I conclude the information provided by the RP in PCSR Chapter 24 and its supporting submission on decontamination techniques and processes meets relevant regulatory expectations and is appropriate to the GDA stage. The information is adequate to substantiate Sub-Claim 5.1SC.24.4 that the generic UK HPR1000 design can be decommissioned using current methods and technologies, as it relates to decontamination, and thus supports Claim 5.1, when considered in conjunction with the information on design for decommissioning in section 4.7. I also consider the information on the risks of decontamination and their mitigation to be appropriate to the GDA stage in supporting Sub-Claim 5.1SC24.3 and that the application of FSD will be a significant contributor to reducing the risks of decommissioning of the generic UK HPR1000 design to ALARP.

4.6 Dismantling Activities

149. This sub-section addresses the RP's submissions on dismantling activities. PCSR Chapter 24 includes a section on dismantling, which covers:

- Dismantling of systems and components – this refers to the supporting submission 'Preliminary Disassembly Program for the Main Equipment Decommissioning' (Ref. 28) and to the 'Decommissioning Waste Management Proposal' (Ref. 26).

- Dismantling of concrete and steel structures – this refers to the ‘Decommissioning Building Dismantling Proposal’ (Ref. 30).

In addition the RP produced another submission on dismantling at the end of Step 3 of GDA, namely the ‘Dismantling Example Analysis of Steam Generator’ (Ref. 29), which is considered with other systems and components but is not specifically referred to in PCSR Chapter 24, noting I raised RQ-UKHPR1000-0047 (Ref. 40) seeking information on the decommissioning of large items such as the SGs during Step 2 of GDA.

4.6.1 The RP’s Submissions on the Dismantling of Systems and Components

150. PCSR Chapter 24 states the RP has taken account of OPEX, including the submission ‘OPEX on Decommissioning’ (Ref. 22), in developing the dismantling plan and that there are current techniques, skills and knowledge available to dismantle the generic UK HPR1000 design. The RP has defined criteria to determine the dismantling processes to be applied which include the risks to workers, the public and the environment, the state of the facility at the time of decommissioning, scheduling and nature of the dismantling tasks, the radioactive and non-radioactive wastes that will arise from dismantling, maintenance during dismantling and consideration of emergency arrangements.

151. The RP has defined the following elements in the approach to the dismantling of the generic UK HPR1000 design in PCSR Chapter 24:

- Remote dismantling of highly and moderately activated components under water, e.g. RVIs.
- Dismantling of contaminated and slightly activated components in air, e.g. reactor coolant piping.
- Maximising use of existing facilities for containment and shielding during dismantling.
- The design of access routes to BRX to allow import and export of large components and dismantling equipment.
- Refurbishment of auxiliary buildings to support dismantling and management of decommissioning wastes.
- Removal of components such as coolant piping and pumps to workshops for size reduction and packaging.
- Removal of the SGs as complete units for waste processing outside the BRX.
- The design of handling and transportation features to allow the reverse of installation to achieve removal, including of other large components.
- The design of the polar crane in the BRX to handle heavy equipment and reactor components during decommissioning.
- Consideration of the needs for shielding during dismantling and transportation.

152. The RP has defined the process of dismantling of the primary circuit in PCSR Chapter 24:

- Preparation (drainage and decontamination) and dismantling of auxiliary pipes;
- Removal of the SGs from the BRX;
- Removal and dismantling of the reactor coolant pumps;
- Removal and dismantling of the reactor coolant piping;
- Removal and dismantling of the pressuriser;
- Preparation and dismantling of reactor vessel internals in the reactor pool under water;
- Dismantling of the RPV; and
- Dismantling of the reactor vessel head.

153. PCSR Chapter 24 (Version 1) (Ref. 3) was issued at the beginning of Step 4 and referred to earlier versions of supporting submissions produced during Step 3 of GDA,

including the ‘Preliminary Disassembly Program for the Main Equipment Decommissioning’ (Ref. 52) and the PDP (Ref. 53). The scope of dismantling in these submissions did not include the Spent Fuel Pool (SFP), which I considered to be a significant omission on the basis of UK experience. I noted the gap in a presentation to the RP, which was discussed at a technical meeting in April 2020 (Ref. 54). Subsequently the RP included information on the dismantling of the SFP in the updated submissions (Ref. 28) and (Ref. 25).

154. The ‘Preliminary Disassembly Program for the Main Equipment Decommissioning’ (Ref. 28) provides more detail on the dismantling activities, noting the sequence of dismantling is described in the PDP (See section 4.9). (Ref. 28) makes specific reference to relevant claims and sub-claims, most notably that the generic UK HPR1000 design can be decommissioned using current methods and technologies. It also refers to the submission on ‘OPEX for Decommissioning’ (Ref. 22).

155. (Ref. 28) includes information on the preparatory activities necessary for dismantling, including radiological surveys and decontamination (see section 4.5), consideration of the availability and safety assessment of the SSCs needed for or which could facilitate dismantling, the pre-selected dismantling techniques, access and laydown areas and where necessary operational platforms, emergency arrangements and verification of working conditions, including safety aspects such as space and shielding. Aspects identified as important to safety during dismantling include the stability and capability of plant structures, the containment (confinement) capability of existing plant such as tanks and piping, the adequacy and integrity of plant infrastructure and support systems (e.g. alarms, radiation and contamination detection and lighting/ventilation) and the adequacy and availability of lifting systems and equipment to remove dismantled items.

156. (Ref. 28) provides information on the proposed dismantling processes for the primary circuit equipment (as defined above) and of the main equipment and metal structures in the SFP. A brief summary is provided below:

- RPV – The RPV is categorised as ILW because of high levels of activation of the metal structure. The RP has selected the approach of “disintegrated segmentation” where the two main parts, the vessel and the head, are cut into pieces (as opposed to “integrated segmentation” where the RPV is removed as a single component). The RP has selected this approach because of the need to size reduce the RPV to fit into standard containers for ILW for storage and eventual disposal to the Geological Disposal Facility (GDF). The RP has not selected a specific cutting technique but has identified those available as plasma arc, abrasive water jet, and electrode and laser cutting. This approach necessitates the removal of the Control Rod Drive Mechanisms (CRDMs) and other instrumentation from the RPV head (see below).
- RVIs – The RVIs are highly activated and are categorised as ILW at the time of decommissioning (but are HLW immediately after shutdown, as noted in sub-section 4.2 on decommissioning source term). The RVIs will be disassembled, cut into sections and packaged using remotely operated equipment under deionised water in the defuelling cavity. Available cutting methods are listed by the RP as plasma arc, abrasive water jet, mechanical methods, electrical discharge and machining, with the technique to be selected at the time of dismantling.
- CRDMs – These are mounted on the RPV head and will be removed by a combination of disassembly and cutting of the circular (canopy) weld to remove the pressure housing assembly. These are expected to be categorised as LLW and are expected to be transferred to an on-site facility for further management (e.g. decontamination and further segmentation) and packaging.
- RCP – These are dismantled and overhauled every 10 years as part of operational maintenance, with the exception of the pump casing which is

welded to the Main Coolant Line. Dismantling during decommissioning is thus expected to be broadly similar to that undertaken during operations, with the addition of cutting of weld joints to remove the pump casing. The pumps are expected to be LLW and are expected to be processed and packaged in an on-site facility.

- Pressuriser – This pressure vessel is expected to be removed in one piece, consistent with OPEX, using thermal cutting techniques and installing temporary closure plates to seal nozzles after cutting. It is expected to be LLW and will be transferred to an on-site facility for management and packaging.
- Reactor Coolant Piping – This consists of the Main Coolant Lines and Surge Lines, both of which are expected to be LLW. These will be cut into pieces and where necessary closure plates will be installed to seal in contamination in the cut segments. Temporary supports will be used as necessary to support the piping as it is dismantled. The piping is expected to be LLW and will be transferred to an on-site facility for management and packaging.
- SGs – (Ref. 28) provides limited information on this and SG dismantling is discussed in detail in (Ref. 29) (see below).
- SFP – This is a concrete structure which is lined with the Spent Fuel Pool Liner which comprises welded metal liner plates, an anchor framework and equipment plate, the two latter of which are embedded in the concrete structure. The SFP contains underwater fuel storage racks which are used to store fresh and irradiated fuel, including any fuel which may have failed (where a fault in the fuel cladding may result in leakage of fuel and fission products). It is assumed that all fuel will be removed from the SFP before decommissioning and that the SFP will have been decontaminated prior to the start of dismantling. The storage racks are not attached to the SFP structure and are readily lifted out using a crane and lifting rig to transfer into packages for removal from the Fuel Building for further processing elsewhere. The RP notes the successful experience in China of replacing fuel storage racks during the operational phase of a PWR. The SFP liner comprises plates which will be cut and packaged for transfer for processing elsewhere, while the embedded steel components will be addressed as part of SFP building dismantling.

157. As noted, (Ref. 28) included information on the preliminary identification of major hazards and risks, and information on how these are minimised or mitigated for the design, operational and decommissioning phases. This information is mostly generic in nature and made relatively little reference to specific measures for the UK HPR1000. The RP identified the need for the layout design to consider the one-piece removal of large components to reduce the risks of fire/explosion and of contaminated wounds and to consideration of remote operations, referring to the 'Consistency Evaluation for Design of Facilitating Decommissioning' submission (Ref. 24), which is discussed in sub-section 4.7 on design for decommissioning. It also refers to the need to consider the reliability, lifetime and capability of lifting equipment, especially for heavy components such as the SGs.

158. For the decommissioning phase the RP referred to the use of underwater cutting, especially for RVIs, and to consideration of water filtration for such operations. Decontamination prior to dismantling is noted as a risk mitigation measure during the decommissioning phase. The use of liners is noted as facilitating decommissioning, although this is not explicitly linked to the SFP.

159. The RP's submission 'Dismantling Analysis of Steam Generator' (Ref. 29) provides more detailed analysis of the specific example of the SGs than (Ref. 28). The RP noted that SGs have been replaced during the operational phases of PWRs and the submission discusses international OPEX on both SG replacement and dismantling to support development of the design and approach for the generic UK HPR1000

design. It forms part of the RP's evidence in support of the claim that risks associated with SG replacement and dismantling are reduced to ALARP.

160. (Ref. 29) provides detailed information on decontamination of the SGs by means of FSD using HP CORD UV as discussed in sub-section 4.5 of this report, which cross-refers to (Ref. 27). (Ref. 29) supplements the information in the submission' Decontamination Processes and Techniques during Decommissioning' (Ref. 27), including describing potentially applicable techniques for additional decontamination of SGs, should further measures be necessary following FSD to meet acceptable contamination levels to enable management of the resulting wastes. Decontamination reduces radiation risks during dismantling but the RP notes that use of temporary shielding may be necessary if there are localised areas of high dose rates, on the basis of international OPEX.

161. (Ref. 29) describes the tasks that will be undertaken to dismantle the SGs, including pipe cutting and installation of temporary closure plates for cut pipes and nozzle connections. (Ref. 29) provides detailed information on cutting techniques for pipes for the SGs, which are either thermal (e.g. plasma arc) or mechanical (e.g. saws, shears and cutters of various types). The RP noted that machining cutting is now widely applied and results in lower worker doses and volumes of secondary wastes than other techniques such as plasma arc, on the basis of OPEX. The RP identified the preferred method of machining cutting for the primary inlet/outlet pipes. For the main steam and feedwater pipes it identified either machining or plasma arc cutting and plasma arc for cutting of thinner secondary pipes.

162. The RP has considered two options for lifting and removal on the basis of OPEX, either cutting connecting lines and removing the intact SG in one piece from the reactor containment, or cutting of the SG into two segments, based on OPEX where it has not been possible to remove the SG in one piece. The generic UK HPR1000 design enables the removal of the SGs in one piece because of the following measures:

- The loading capability of the polar crane of 550 t is well in excess of the weight of each SG (471 t).
- The lifetime of the polar crane is stated to be 60 years and thus it is expected to be available during SG dismantling.
- The equipment hatch is larger (8.3 m) than the maximum size of the SG shell (4.87 m).
- The BRX is large enough to handle, lift and allow a change in the orientation of the SG from vertical to horizontal to allow its removal in one piece.

163. The proposed method is to attach the polar crane to the SG to enable the SG supports to be removed and then to lift the SG and place on a transport vehicle in the horizontal orientation in the BRX for removal via the existing equipment access hatch. The RP assumes that the SGs are moved to an on-site facility where they can be stored and/or decontaminated and segmented for packaging. It identified two main options for management of the SG as waste, either removal of the whole SG to an off-site facility for disposal or processing on site into segments for future disposal. The RP notes a future operator will decide at the appropriate time, considering the need to address BAT and ALARP principles.

4.6.2 Assessment of the RP's Submissions on Dismantling Activities for Systems and Components

164. As with decontamination techniques, there are no regulatory expectations with respect to the selection of specific dismantling approaches and techniques, other than the technique is regarded as good practice for the task or otherwise that the risks can be demonstrated to be reduced to ALARP. ONR's Generic Design

Assessment Technical Guidance for New Nuclear Power Plants, ONR-GDA-GD-007 (Ref. 51), expects a demonstration that the generic design enables the risks of decommissioning to be minimised, so far as is reasonably practicable (design for decommissioning), based on currently available technologies for dismantling and decommissioning, not on technologies that may become available in the future. Dismantling can also present significant conventional safety risks, such as dropped loads (components such as the SGs weigh hundreds of tonnes) and injuries to workers undertaking dismantling tasks such as cutting.

165. Paragraph 18 of the SAPs (Ref. 2) states "The application of the ALARP process should be carried out comprehensively and consider all applicable principles, with all relevant risks considered as a combined set. When judging whether risks have been reduced ALARP, it may be necessary to take account of conventional risks in addition to nuclear risks and justify that an appropriate balance has been achieved." Paragraph 871 under SAP DC.9 states "Where decisions on managing radiological risks are affected by conventional risks (e.g. from cutting, dismantling and demolition), the safety case should justify how overall risks are reduced so far as is reasonably practicable".

166. Para 5.32 of NS-TAST-GD-026, ONR's TAG on Decommissioning (Ref. 9), states that "in the case of new facilities, inspectors should check that the licensee's arrangements and processes recognise the need to challenge the design in order to reduce the risks of future decommissioning to as low as reasonably practicable (ALARP)". It also provides a list of practical examples including the incorporation of design features to aid the decommissioning sequence, for example egress routes for removal of large heavy items and provision of cranes with sufficient lifting capacity to deal with the largest expected loads from decommissioning.

167. I have considered the information in PCSR Chapter 24, (Ref. 28) and (Ref. 29) against the regulatory expectations of the GDA Technical Guidance (Ref. 51) and relevant guidance in the SAPs (Ref. 2) and NS-TAST-GD-026 (Ref. 9), with focus on the overall need to justify the risks as ALARP. I thus decided to target my assessment on the dismantling of the primary circuit equipment and SGs, the former because of their significance with respect to radiological risks (high dose rates) and the latter because of the risks to workers associated with the decommissioning of large items and available international OPEX on SG replacement and dismantling.

168. I sought clarification of a number of issues arising from assessment of (Ref. 28), by means of RQ-UKHPR1000-1015 (Ref. 40). (Ref. 28) and PCSR Chapter 24 and were clear that the dismantling of RVIs would be carried out underwater but the reasoning for this was not clear, nor was it clear whether the RP considered it necessary to dismantle other key components underwater or otherwise remotely. I sought information on the dose rates of the RVIs, on the basis of the high activity levels noted in the 'Decommissioning Waste Management Proposal' (Ref. 26) and also asked which dismantling tasks for the primary equipment would need to be carried out remotely and which operations were planned to be carried out underwater.

169. The response received to the RQ was clear that the RP will carry out dismantling and packaging of the RPV and RVIs underwater using remotely operated cutting tools with the provision of underwater filtration. The dose rates of the most activated RVIs (activity levels of which vary substantially with core position) can be very high (up to 100s of Sv/h at a distance of 1m) and so dismantling underwater is thus necessary, even at 15 years after shutdown.

170. The RP plans to place the RVIs as ILW in unshielded 3 m^3 boxes and to immobilise the contents with grout prior to transfer to the on-site ILW Interim Storage Facility for storage pending transfer to the GDF for disposal. I considered the RP's submission

(Ref. 28) did not provide sufficiently clear information on the packaging of RVIs and asked for more information on the dose rates for unshielded boxes containing RVIs. The maximum dose rate at a distance of 1 m is just under 60 Sv/h so use of a shielded transport container is necessary. Dose rates are based on the activated structure source term (as discussed in sub-section 4.2), and verification of activity levels will be limited to measurement of lower dose rate RVIs, where practicable. The RP plans to fill the boxes inside the shielded transport containers underwater in the refuelling cavity and to use the polar crane to transfer them to/from the cavity to a vehicle for transfer to a waste treatment facility (either new or existing) and thence for storage.

171. I sought and received adequate evidence that the design of the BRX provides adequate space, lifting capacity and access/egress of sufficient dimensions to allow safe use of the 3 m^3 box and the shielded transport container. The BRX has an "Equipment Hatch" which allows the import and export of large items of equipment for both construction and decommissioning. I consider the RP's approach to RVI dismantling underwater to be consistent with relevant international OPEX. However, I note the shielded transport container for 3 m^3 boxes has not yet been built, although a specification for such a container has been issued by Radioactive Waste Management Limited (Ref. 55). The licensee will need to review the shielded transport containers available for use during decommissioning during detailed planning at the appropriate time. The RP has provided a preliminary qualitative risk assessment of RVI dismantling in (Ref. 19), which addresses aspects such as impacts and dropped loads as well as radiation exposure (radiation and contamination). The licensee will need to assess the risks associated with dismantling and waste packaging at the appropriate time. These matters will be part of normal business.

172. I asked for evidence that the generic design of the UK HPR1000 minimised the risks associated with the dismantling and packaging of the RPV and its head prior to removal from the BRX, as the components presenting the highest radiological risks after the RVIs, based on the decommissioning source term. The 'Decommissioning Waste Management Proposal' (Ref. 26) indicates the dismantled sections of the RPV will be packaged in shielded 4 m boxes (Ref. 56). The evidence provided by the RP on lifting and transfer was adequate and indicates that worker doses and contamination risks are minimised by cutting the RPV and vessel head underwater and using a water filtration system to remove cutting debris from the water in the defuelling cavity.

173. As noted the RP has produced a preliminary risk assessment in (Ref. 19), which I consider to be appropriate to the GDA stage. However, I note the RP did not consider conventional health and safety risks in detail in (Ref. 19), other than impacts and dropped loads, as these are addressed in other submissions on conventional health and safety.

174. (Ref. 19) does not consider the risks associated with production of hydrogen during decommissioning, as a result of radiolysis of water by high dose rate components. The risks of hydrogen are minimised effectively by the Gaseous Waste Treatment System (TEG[GWTS]) and building HVAC systems during the operational phase. The risks associated with hydrogen include explosion. The Step 4 Assessment of Conventional Health and Safety for the UK HPR1000 Reactor (Ref. 57) has considered the RP's evidence on its approach to meeting the requirements of the Dangerous Substances and Explosive Atmospheres Regulations 2000 (DSEAR) (Ref. 58). The RP provided evidence on the approach to management of hydrogen risks, including during decommissioning. (Ref. 57) concluded the evidence on the RP's approach to DSEAR in the generic design was adequate.

175. The RP noted there may be a need for additional shielding to protect workers during dismantling in (Ref. 28). I thus sought evidence on how the design will allow the installation of additional shielding in RQ-UKHPR1000-1015 (Ref. 40), should this be necessary. The RP provided an adequate response which took account of Chinese OPEX and providing evidence that there is sufficient space in the layout to install temporary shielding. The RP also provided information indicating that the load bearing capacity of the floor in the BRX would be sufficient to support additional shielding. This would be evaluated during decommissioning and if necessary temporary support would be provided. I considered the response to be adequate.

176. I consider the RP's proposed approach of underwater dismantling and packaging for the RVIs and RPV minimises the risks to ALARP, taking into account the proposed use of the polar crane, the availability of sufficient space to allow the safe movement of equipment and waste packages and use of temporary shielding (if necessary) and use of the Equipment Hatch to allow safe export of waste packages. The proposed approach is consistent with international OPEX and can be carried out using technologies that are available today, with the possible exception of the shielded transport container. However, as noted, shielded containers (typically referred to in the UK as "flasks") are available today and the licensee would need to review the shielded transport containers available for use during decommissioning for the proposed waste packages, as part of normal business.

177. The selected decommissioning strategy of immediate dismantling, already discussed in sub-section 4.3, could be considered as potentially foreclosing options for the dismantling of highly activated components, with underwater remote dismantling as the only practicable option because of the high dose rates of some components after shutdown, especially the RVIs. Deferral of decommissioning could potentially allow other dismantling options for some components in the future, such as dismantling in air, because of the relatively short half-life of cobalt-60 (5.3 years) as a significant contributor to radiological risk. In the context of the decommissioning strategy of prompt dismantling the use of water for shielding is very effective in minimising doses and will achieve a significant reduction in radiological hazard, which is a key objective of decommissioning. I thus consider the proposed approach to reduce risks to ALARP consistent with the selected decommissioning strategy of immediate dismantling and is appropriate to the GDA stage. It will be for the licensee to review the decommissioning strategy, including consideration of the risks of dismantling of the primary circuit, in the light of circumstances after the operational period.

178. I consider the information the RP has provided on currently available dismantling techniques to be appropriate to the GDA stage of development of the design and meets the relevant expectations of ONR-GDA-GD-007, ONR's GDA Technical Guidance (Ref. 51). The selection of the specific cutting technique to be used is not necessary at the design stage. It is for the licensee to assess the options for and risks of dismantling on the basis of the circumstances at the time of decommissioning and to select techniques that reduce risks to ALARP, taking account of both radiological and conventional safety risks.

179. The RP provided information on currently available dismantling techniques with their range of applications, associated risks and generic information on risk mitigation in (Ref. 28), which is adequate for the GDA stage, and for some components has identified a preferred technique. It will be for the licensee to keep dismantling techniques under review as part of the ongoing review of the PDP (Ref. 25), noting they will continue to develop and further OPEX will become available before decommissioning.

180. I assessed the submission on the dismantling of the SGs (Ref. 29) . I sought clarification of a number of matters by means of RQ-UKHPR1000-0996 (Ref. 40), working with Mechanical Engineering specialist inspectors. I asked for and received

an adequate response on the removal of the SG supports in preparation for dismantling and how the risks of the operation are minimised. I also asked for and received an adequate response on the exit route for the SGs from the BRX, which clearly indicates there is sufficient space in the design to safely remove each SG in one piece using the polar crane and place on a transport vehicle for exit through the Equipment Hatch. Additional equipment is needed to enable SG removal (or replacement during operation) and I sought information on future requirements or assumptions relating to procurement. The equipment was identified in the response, including the overturning device and lifting trunnion that will enable the transfer of the SG from the vertical to horizontal position to allow removal through the Equipment Hatch, noting the detailed requirements for the equipment will be provided at the site-specific stage. The transfer route for the SG once outside the BRX is outside the scope of GDA.

181. (Ref. 28) and (Ref. 29) address dismantling activities which depend on the continued availability of the polar crane during decommissioning (or an alternative if not available). In consultation with the Mechanical Engineering specialist inspector, I sought evidence in RQ-UKHPR1000-1015 and RQ-UKHPR1000-0996 (Ref. 40) on the justification of continued use of the polar crane during decommissioning, noting the design life is stated to be 60 years (the same as the operational period) but decommissioning will take place beyond 60 years after the start of operations. I specifically asked whether any aspects of the design would potentially foreclose the option of deferred decommissioning, which is relevant to decommissioning strategy (see also section 4.3).

182. The responses discussed aspects including the strength and stability for equipment handling during construction, operation and decommissioning, the ease of replacement and accessibility of systems that need to be replaced over the lifecycle (e.g. control system), the requirement for periodic test and maintenance during the operational phase and the need for detailed assessment to verify performance, safety and maximum loading capability for structural components during the decommissioning phase, based on information from the 'Technical Specification for Polar Crane' (Ref. 56). The RP considered the design did not foreclose the option of deferred decommissioning because of the measures listed above but acknowledged there may be a need to overhaul or replace the crane or use other equipment and approaches if it could not fulfil decommissioning requirements.

183. Taking account of the advice provided to me by the Mechanical Engineering specialist inspector on the RQ responses where they were outside the scope of the NLR topic area, I considered the responses to both RQs to be adequate for the polar crane (Ref. 60). This advice indicated the operational life of the lifting capability of the key structural components of the crane is dependent on actual use rather than years of operation, in terms of the number of lifts and masses lifted. The number of lifts during refuelling operations is considered to be low and the masses lifted are low, relative to the maximum lifting capacity, and are much lower than those of the SGs. These factors will be of benefit in maintaining the availability of the polar crane during the decommissioning phase.

184. I have considered 'Dismantling Example Analysis of Steam Generator' (Ref. 29) against the expectations of ONR-GDA-GD-007 the GDA Technical Guidance (Ref. 51), the relevant SAPs and NS-TAST-GD-026, ONR's TAG on Decommissioning (Ref. 9), as well as considering the adequacy of evidence to substantiate the RP's claims on decommissioning in the safety case as it relates to SG decommissioning. I consider the submission has described and made effective use of international OPEX on the dismantling and replacement of SGs in justifying the approach proposed of initial decontamination and removal in one piece using the polar crane. The design clearly takes benefit of consideration of OPEX in terms of application of FSD (see sub-section 4.5), the size of the Equipment Hatch, the space to enable SG

reorientation in the BRX and the lifting capability and lifetime of the polar crane. It describes the planned approach to dismantling clearly and provides good information on learning from international OPEX in mitigating the principal risks identified (e.g. dropped load and radiological risks).

185. I consider the submission 'Dismantling Example Analysis of Steam Generator' (Ref. 29) meets the relevant expectations of ONR's GDA Technical Guidance (Ref. 51) in demonstrating the SGs can be safely removed using currently available techniques. I also consider it meets the expectations of the relevant SAPs (Ref. 2) in demonstrating that the risks of SG removal are reduced to ALARP, commensurate with the GDA stage, taking account of both radiological and conventional safety risks.

186. The submissions on preliminary disassembly of the main equipment and dismantling of SGs, (Ref. 28) and (Ref. 29), provide adequate evidence to substantiate Sub-claims 5.1.SC.24.1, 24.3 and 24.4 and thus Claim 5.1 of PCSR Chapter 24 that the design and intended operation will facilitate safe decommissioning for the SSCs in the scope of the submissions.

187. I also consider the proposed approach of SG removal in one piece is of benefit in not foreclosing options for management of the resulting radioactive waste. There has been experience in the UK of the removal and transfer of intact SGs for processing by means of metal smelting, removing the need for on-site processing. Removal of SGs in one piece will maximise the options available for future management, noting the licensee will need to decide what option is ALARP (and BAT) at the time of decommissioning.

4.6.3 The RP's Submissions on Dismantling of Concrete and Steel Structures

188. PCSR Chapter 24 (Ref. 3) includes a section on the dismantling of concrete and steel structures, listing the concrete structures included in the generic design of the UK HPR1000 within the scope of GDA. Most buildings in the generic UK HPR1000 design are normal reinforced concrete structures, except for the internal containment of the BRX which is pre-stressed. PCSR Chapter 24 presents preliminary information on the proposed sequence of dismantling of structures after completion of spent fuel removal and the decontamination, dismantling and removal of systems/components. This is based on dismantling of the Fuel Building, the BNX after clean-up of the nuclear island buildings and demolition of the BRX from external to internal containment.

189. PCSR Chapter 24 defines the scope of decommissioning of structures in the nuclear island, which will be demolished after removal of equipment and components. The RP will decontaminate surfaces in radioactive areas prior to dismantling, using surface cleaning or scabbling techniques (mechanical removal of the surface of the concrete) to remove surface contamination.

190. The RP provides information on existing proven techniques for dismantling/ demolishing concrete structures, namely cutting techniques (flame, plasma arc, laser, mechanical and hydraulic) and explosive demolition. The RP indicates all these methods could be used to dismantle the structures in the generic UK HPR1000 design.

191. More information on building dismantling is provided in the 'Decommissioning Building Dismantling Proposal' (Ref. 30). (Ref. 30) does not make any specific reference to any of the relevant claims in PCSR Chapter 24 but does refer to the 'OPEX in Decommissioning' submission (Ref. 22), unlike a number of the other submissions supporting PCSR Chapter 24. However, it includes information on existing proven techniques for dismantling buildings cleared of contamination, the identification of techniques applicable to the generic UK HPR1000 design and those

considered when designing the plant as part of design requirements for facilitating decommissioning (see sub-section 4.7 on design for decommissioning). It identified risks/impacts and mitigation measures based on current knowledge and OPEX and provides a summary of design features to facilitate building dismantling relating to the risk mitigation measures.

192. (Ref. 30) includes information on a range of issues in response to RQs and other feedback provided by ONR (see section 4.6.4 below). These include the decontamination of concrete and segregation of concrete into ILW, LLW and VLLW / out of scope waste (see sub-section 4.8 on management of decommissioning wastes). (Ref. 30) provides specific information on the segregation of the expected layer of ILW concrete arising from activation of the inner part of the primary bioshield (as noted in sub-section 4.2 on the decommissioning source term). The RP has identified diamond wire sawing as an appropriate technique taking account of OPEX. (Ref. 30) also discusses the characterisation to enable segregation of ILW concrete.

193. (Ref. 30) includes information on the demolition of prestressed concrete structures such as the internal containment in the Reactor Building, including consideration of relevant OPEX. This internal containment is the only prestressed structure in the generic design of the UK HPR1000.

194. Examples of the mitigation measures against the identified hazards/risks implemented in the generic design of the UK HPR1000 include removable plates, barrier shields and access openings to facilitate access for decommissioning, with a specific example of the SG room which includes bolted shield walls that can be readily moved. Other measures include removable structural members and the installation of holes in the BRX floor to allow ingress, dismantling and removal of equipment such as pumps. The RP presents a number of examples with specific references to evidence including drawings.

4.6.4 Assessment of the RP’s Submissions on Dismantling of Concrete and Steel Structures

195. As for the dismantling of systems and components, ONR-GDA-GD-007 the GDA Technical Guidance on use of currently available techniques is relevant (Ref. 51), and SAPs paragraphs 18 and 871 (Ref. 2) are relevant regulatory expectations for the dismantling of structures, as discussed above. SAP DC.1, namely that” facilities should be designed and operated so that they can be safely decommissioned” is also relevant and is discussed in detail in sub-section 4.7.

196. SAP RW.4, namely that radioactive waste should be characterised and segregated to facilitate its safe and effective management, is relevant to the dismantling of structures because part of the primary bioshield is predicted to be ILW. The ILW needs to be segregated from other concrete waste to enable its safe management and subsequent disposal. I thus targeted my assessment on this aspect of dismantling of structures. I discuss the management of decommissioning wastes in sub-section 4.8.

197. I initially assessed an earlier version of the ‘Decommissioning Building Dismantling Proposal’ (Ref. 61) and considered that the submission did not present sufficient information on some aspects of the scope to make a judgement against the relevant regulatory expectations. Some of the evidence provided was also not adequately supported by references. I therefore issued RQ-UKHPR1000-1417 (Ref. 40) to seek clarification of a range of aspects including: methods considered for the removal of the steel liner of the prestressed internal containment; concrete contamination; clarification of the RP’s position on the applicability of diamond wire sawing/cutting as a dismantling technique for the generic UK HPR1000 design; methods for characterisation and segregation of ILW concrete and consideration of the sequence

of demolition of buildings on the common raft foundation (a number of buildings on the nuclear island are built on one raft rather than all on separate rafts, which is primarily a matter for the Civil Engineering topic area). I asked for information on relevant OPEX.

198. The RP's response to RQ-UKHPR1000-1417 provided valuable clarifications. Overall I considered the RQ response was adequate, and it has been incorporated into (Ref. 30). The RP added more evidence and improved the presentation of relevant OPEX. The addition of information on the segregation of ILW concrete is important in underpinning the information presented in the 'Decommissioning Waste Management Proposal' (Ref. 26) by indicating it is technically feasible to segregate the ILW (see sub-section 4.8).

199. The Civil Engineering topic area subsequently issued RQ-UKHPR1000-1629 (Ref. 40) which followed up on certain aspects of RQ-UKHPR1000-1417 on the decommissioning sequence and method, with focus on the internal containment structure in the BRX. The response was considered to be adequate and has also been incorporated into (Ref. 30). The Civil Engineering topic area discusses decommissioning in the context of relevant SAPs in the assessment report for the topic area (Ref. 62).

200. I have considered the evidence in PCSR Chapter 24 and the 'Decommissioning Building Dismantling Proposal' (Ref. 30) on the dismantling of concrete and steel structures and consider they meet the relevant expectations of ONR-GDA-GD-007, ONR's GDA Technical Guidance (Ref. 51) in demonstrating there are currently available techniques for the dismantling of the structures of the UK HPR1000 and for segregating ILW concrete, consistent with the expectation of SAP RW.4. I also consider they meet the expectations of the relevant SAPs in demonstrating that the risks of dismantling of structures can be reduced to ALARP, commensurate with the GDA stage. The design incorporates features to reduce the risks of dismantling. The licensee will decide on which technique(s) to apply to the various aspects of dismantling of the structures, with focus on the structures in the nuclear island. This will be part of normal business.

201. The proposed approach of decontamination of structures by segregation and removal of radioactive material, so far as practicable, to enable demolition as non-radioactive or conventional structures through the application of clearance processes is consistent with good practice for nuclear decommissioning and facilitates application of the waste management hierarchy.

202. I consider the 'Decommissioning Building Dismantling Proposal' (Ref. 30) provides adequate evidence to substantiate Sub-claims 5.1.SC.24.1, 24.3 and 24.4 and thus Claim 5.1 of PCSR Chapter 24 that the design and intended operation will facilitate safe decommissioning for the SSCs in the scope of the submissions.

4.6.5 Strengths

203. The key strengths/positive aspects of the safety case as it relates to dismantling techniques are:

- The RP has identified and taken account of international OPEX in the dismantling of components, systems and structures in the generic design of the UK HPR1000.
- The RP has identified a range of currently available techniques for the dismantling of systems, structures and components in the generic UK HPR1000 design, which is consistent with relevant regulatory expectations at the GDA stage.

- The RP has selected underwater remote dismantling of RPV and RVIs to minimise risks during dismantling of these highly activated components.
- The RP will remove decontaminated SGs from the BRX in one piece using the existing polar crane to minimise the risks of dismantling and maximise options for the management of the resulting radioactive wastes.
- The RP has identified diamond wire cutting as a potentially suitable method for the segregation of ILW concrete arising from the primary bioshield to underpin the waste estimate in the 'Decommissioning Waste Management Proposal' (Ref. 26).
- The RP expects to decontaminate structures to enable demolition as non-radioactive structures and thus facilitate application of the waste management hierarchy.

4.6.6 Outcomes

204. I have not identified any Assessment Findings, GDA issues or minor shortfalls for dismantling activities.

4.6.7 Conclusion

205. I conclude the information provided by the RP in PCSR Chapter 24 and its supporting submission on dismantling activities meets relevant regulatory expectations and is appropriate to the GDA stage. The information is adequate to substantiate Sub-claims 5.1.SC.24.1 and 24.4 that the design and intended operation will facilitate safe decommissioning and can be decommissioned using current methods and technologies, as they relate to dismantling, and thus supports Claim 5.1. I also consider the evidence on the risks of dismantling to be appropriate to the GDA stage in substantiating Sub-Claim 5.1SC24.3. I consider that the dismantling methods proposed are significant contributors in reducing the risks of decommissioning the generic UK HPR1000 design to ALARP.

4.7 Design for Decommissioning

4.7.1 Overview of Regulatory Expectations for Design for Decommissioning

206. Paragraph 7.1 under Requirement 10 of IAEA GSR Part 6 (Ref. 14) on the Decommissioning of Facilities states "the regulatory body shall ensure that the licensee takes decommissioning into account in the siting, design, construction, commissioning and operation of the facility, by means which include features to facilitate decommissioning……and consideration of physical and procedural methods to limits contamination and/or activation". Paragraph 7.3 states that "for a new facility planning for decommissioning shall begin early in the design phase….". WENRA's SRLs for Decommissioning (Ref. 16) are consistent with the relevant requirements of IAEA GSR Part 6.

207. SAP DC.1 states: "Facilities should be designed and operated so that they can be safely decommissioned". Decommissioning and waste retrieval should be taken into account during the planning, design, construction and operational stages of a new facility or modifications of an existing facility, including measures to minimise activation and contamination, physical and procedural controls to prevent the spread of contamination, control of activation, design features to facilitate decommissioning and reduce doses in decommissioning workers and minimise the generation of radioactive waste.

208. A number of other SAPs are relevant to design for decommissioning, including paragraph 472 under the Control of Nuclear Matter SAP ENM.3 which states that "Plant components such as vessels, pipework, ducting and secondary containment

structures should be designed to avoid unintended accumulation of nuclear matter and to facilitate decontamination". The Radiation Protection SAP RP.5 on decontamination states: "Suitable and sufficient arrangements for decontaminating people, the facility, its plant and equipment should be provided". SAPs ECV.1 and 2 address the prevention of leakage and minimisation of releases. Civil engineering SAP ECE.26 states: "Special consideration should be given at the design stage to the incorporation of features to facilitate radioactive waste management and the future decommissioning and dismantling of the facility", which is addressed in the Step 4 Assessment of Civil Engineering (Ref. 62) and is outside the scope of this report.

209. Paragraph 5.28 of NS-TAST-GD-026, ONR's TAG on Decommissioning (Ref. 9) states "Throughout the steps of design, construction, commissioning, maintenance and operation, the evaluation of options should consider the potential impacts on future decommissioning – licensees should take the opportunity to reduce the challenges and risks of future decommissioning wherever it is reasonably practicable to do so." Para 5.32 states that "in the case of new facilities, inspectors should check that the licensee's arrangements and processes recognise the need to challenge the design in order to reduce the risks of future decommissioning to as low as reasonably practicable (ALARP)", providing a list of practical examples as noted in section 4.6.

4.7.2 The RP's Submissions on Design for Decommissioning

210. PCSR Chapter 24 includes a section entitled "Design Considerations of Facilitating Decommissioning", which is based on principles and requirements for facilitating decommissioning, which take account of governmental policies and strategies, regulation, relevant codes, standards and guidance and decommissioning OPEX as set out in 'OPEX for Decommissioning' (Ref. 22). The RP produced the supporting submission 'Consistency Evaluation for Design of Facilitating Decommissioning' (Ref. 24), the objective of which is to assess whether the design of the UK HPR1000 fulfils the principles and requirements for facilitating decommissioning, commensurate with the phase and scope of GDA.

211. PCSR Chapter 24 lists the main areas considered in relation to design to decommissioning, which essentially summarises the information presented in (Ref. 24):

- Site selection (which is outside the scope of this assessment)
- General layout
- Selection of materials
- Equipment Design
- Process Design
- Building and structure design
- Layout design
- Waste management
- Radiological protection.

212. (Ref. 24) is stated to be focused on the approach applied at the GDA stage to ensure decommissioning of the generic UK HPR1000 design is facilitated, the main measures implemented or being considered to facilitate decommissioning and reduce risks/impacts to ALARP and the justification for the selection of the measures selected. (Ref. 24) refers to all relevant decommissioning submissions except the 'Dismantling Example Analysis of Steam Generator' (Ref. 29).

213. (Ref. 24) provides more detailed information on the main areas listed above. The submission states clearly its purpose in supporting Claim 5.1 (the design and intended operation will facilitate safe decommissioning using currently available technologies) and sub-claims 5.1.SC24.1 (design features that facilitate safe and effective decommissioning) and 24.3 (faults and hazards of decommissioning,

identified, assessed and risks shown to be capable of being ALARP). It sets out principles and design requirements for decommissioning for the subjects listed above, derived from ‘Design Requirements for Facilitating Decommissioning’ (Ref. 23).

214. (Ref. 24) provides information on the methodology adopted to ensure requirements for facilitating decommissioning have been considered and implemented in the generic design, noting decommissioning is integrated with other factors and its facilitation should not be in conflict with the primary objective of designing a facility that is safe and reliable to operate and maintain. If the design is not consistent with the relevant requirements for facilitating decommissioning, then potential enhancements would be identified and options assessed to identify a preferred option, which would be in accordance with the RP’s methodology on ALARP (Ref. 60).

215. (Ref. 24) provides summary information on the evolution of the design from the CPR1000 fleet to Fangchenggang NPP Unit 3 (HPR1000) to the generic UK HPR1000 design, with focus on the main improvements relevant to facilitating decommissioning. These include the control of chemical elements susceptible to activation in the RPV and primary circuit (for example, cobalt and nickel), optimisation of pH control and application of zinc injection in the primary circuit to minimise the generation of corrosion products and the optimisation of shielding in various systems to reduce worker doses. These aspects are also considered in the Step 4 assessment reports for Radiological Protection (Ref. 39) and Chemistry (Ref. 41).

216. This is followed by information intended to provide evidence of application of the principles and requirements in the generic design of the UK HPR1000, including a number of specific examples, providing evidence in the form of summary information with references and/or diagrams. Some of the pictorial information on the examples is taken from the 3D model of the detailed design for, Fangchenggang NPP Unit 3, and is stated to be for illustrative purposes only.

4.7.3 Assessment of the RP’s Submissions on Design for Decommissioning

217. I decided to focus my assessment on design for decommissioning from an early stage of the GDA process for the generic UK HPR1000 design, because the design stage provides the earliest opportunity to incorporate measures to reduce the risks of decommissioning and take account of OPEX and good practices and the regulatory expectations set out in section 4.7.1. Experience in the UK has illustrated the importance of consideration of decommissioning at the design stage to reduce risks to workers, noting decommissioning of some older nuclear facilities can be very challenging and presents significant risks to workers.

218. I raised RQs on design for decommissioning during Step 2 of GDA (RQ-UKHPR1000-0047 and 0105) (Ref. 40). I followed these up during Step 3 of GDA by first commissioning an independent review of good practices and operating experience and feedback (OEF) on design for decommissioning relevant to pressurised water reactors from a TSC (Ref. 50). I did this in order to have a robust basis of evidence of OPEX and good practices against which to assess the RP’s submissions, in the context of the absence of experience of PWR decommissioning in the UK and China. The TSC then undertook a review of selected GDA Step 3 submissions against this review of good practices and OEF (Ref. 64), which was completed early in Step 4. The submissions reviewed by the TSC included earlier revisions of PCSR Chapter 24, ‘OPEX for Decommissioning’ (Ref. 65) and the ‘Consistency Evaluation for Design of Facilitating Decommissioning’ (Ref. 66).

219. The TSC reported that the RP’s GDA Step 3 submissions showed a reasonable understanding of design for decommissioning and that good practices had been

adopted. However, the TSC considered insufficient information had been provided on how good practices have been addressed in the generic design and that insufficient evidence had been presented of their application.

220. The RP had described the approach to ensuring design for decommissioning is adequately considered and for making optimised design decisions that balance decommissioning benefits against other competing factors, such as structural integrity (i.e. the methodology described in (Ref. 24)). However, while the described approach appeared to be adequate, the TSC considered the submissions reviewed did not adequately demonstrate that the approach has been implemented. I agreed with the conclusions of the TSC on the basis of the evidence presented in the review and my assessment of the submissions.

221. Review of the RP's submissions during Step 3 of GDA indicated the design had been developed in line with many of the good practices identified in the TSC review, but the TSC identified two omissions, firstly leak detection or monitoring capabilities and/or systems and secondly ensuring that roads used as transfer routes for components and waste packages have adequate structural strength. Transfer routes outside buildings have been defined by the RP as being outside the scope of GDA (Ref. 67) and this matter has thus not been considered further in this report.

222. Overall I considered the RP had not provided sufficient evidence in the submissions during Step 3 of GDA to substantiate the relevant claims and meet the relevant regulatory expectations including SAP DC.1. Early in Step 4 of GDA I provided summary feedback to the RP on the outcome of the TSC's review (Ref. 54), with the intent of ensuring the RP understood the shortfalls identified. The RP had already decided to update the 'Consistency Evaluation for Design of Facilitating Decommissioning' submission during Step 4.

223. On the basis of the outcome of the TSC's review of the RP's submissions during Step 3 of GDA, I commissioned further work from the TSC with the following objectives:

- A review of the key submissions relevant to design for decommissioning supplied in Step 4 of GDA and an agreed sample of their supporting references, to verify the RP's approach to design for decommissioning and the evidence provided of incorporation of good practice in the generic design of the UK HPR1000 to substantiate the key claims relating to design for decommissioning.
- An assessment of the adequacy of the claims, arguments and evidence provided by the RP in relation to the expectations of SAP DC.1 and other relevant standards and guidance.

224. A key focus of the TSC work during Step 4 was to seek evidence that would substantiate the RP's claims and thus address the shortfall of lack of supporting evidence identified in the submissions during Step 3 of GDA. The TSC therefore assessed the submissions and sought detailed information by means of RQs (Ref. 40).

225. The TSC's assessment is presented in (Ref. 65) and the list of RQs (Ref. 40) raised and discussed in the report is provided below, which focused on a number of the key areas identified in the RP's submission. The TSC also requested a number of supporting submissions referenced in the submissions or RQ responses to verify the evidence provided.

- RQ-UKHPR1000-1016 Recording decommissioning features inherent in the design
- RQ-UKHPR1000-1017 Application of methodology for design for decommissioning

- RQ-UKHPR1000-1018 Consideration of decommissioning in layout design
- RQ-UKHPR1000-1251 Consideration of decommissioning in equipment and process design
- RQ-UKHPR1000-1253 Decommissioning – control of concrete composition
- RQ-UKHPR1000-1254 Coating or lining of buildings, structures and components to facilitate decommissioning
- RQ-UKHPR1000-1255 Provision of leak detection and monitoring capabilities to facilitate decommissioning.

226. (Ref. 68) indicates the RP has demonstrated a good understanding of design for decommissioning and has taken appropriate steps to demonstrate the generic design of the UK HPR1000 facilitates decommissioning at a level appropriate to GDA, a view with which I concur. The TSC considered the information in the Step 4 submission on ‘OPEX on Decommissioning’ (Ref. 22) had been used to develop the set of design requirements for facilitating decommissioning documented in (Ref. 24), which the TSC considered to be adequate. However, the TSC considered the RP had provided only limited information on how the information on OPEX had been identified and why it was considered to be relevant to design for decommissioning of the UK HPR1000. This finding is consistent with and is addressed by the minor shortfall in sub-section 4.4 on OPEX for decommissioning.

227. The RP’s design principles and requirements for facilitating decommissioning presented in (Ref. 24) were developed from ‘Design Requirements for Facilitating Decommissioning’ (Ref. 23), which are based on selected codes and standards and the review of OPEX presented in ‘OPEX on Decommissioning’ (Ref. 22) as noted. The TSC considered the selection of codes and standards to be appropriate and that identified learning from OPEX had been adequately considered in the design requirements for facilitating decommissioning. It also considered that the requirements set out in (Ref. 24) aligned well with the good practices identified by the TSC in Step 3 (Ref. 50) and provided a good basis for demonstrating the generic UK HPR1000 design facilitates decommissioning.

228. The TSC had identified leak detection or monitoring capabilities and/or systems as an omission in the RP’s submissions during Step 3 of GDA against the good practices identified. RQ-UKHPR1000-1255 (Ref. 40) sought information and evidence on these aspects. The TSC considered that the RP’s response had demonstrated understanding of the requirement for leakage detection and monitoring capabilities that suitable and sufficient evidence had been provided on the adoption of good practices for the primary coolant boundary and the SFP. However, leakage and monitoring capabilities remain omissions in the design requirements for facilitating decommissioning. The TSC has not seen any evidence for implementation of leakage detection and monitoring for other systems carrying or storing radioactive fluids, which is an expectation of SAPs ECV.6 and 7, in the context of design requirements for decommissioning. I have therefore raised the following Assessment Finding:

AF-UKHPR1000-0172 – The licensee shall, as part of detailed design, demonstrate that leakage detection and monitoring capabilities are included in the design requirements for facilitating decommissioning. This should include all relevant structures, systems and components in contact with radioactive fluids.

229. The TSC considered the RP has developed and implemented an appropriate approach for ensuring design for decommissioning is adequately considered and for making optimised design decisions that balance decommissioning against other factors, such as safety and reliability, radiological protection, cost and ease of manufacture. I concur with the view of the TSC.

230. The RP’s response to RQ-UKHPR1000-1017 (Ref. 40) provided two detailed examples of the application of the RP’s methodology for design for decommissioning, one on the

selection of the material for the Main Feedwater Line and the other on the process design of the Liquid Radioactive Waste Treatment System (TEU[LWTS]) with focus on valve isolations (which are considered in more detail in the Step 4 Assessment of Mechanical Engineering for the UK HPR1000 Reactor (Ref. 69)).

231. The example on material selection provided evidence of the application of the RP's methodology (Ref. 70), which reflects the balance of a number of related technical topic areas including structural integrity, radiological protection, decommissioning and radioactive waste management. The methodology takes account of the lifecycle of SSCs, including decommissioning. The example provided evidence that decommissioning was one of the factors considered in the material selection decision for the Main Feedwater Line and that appropriate personnel with experience of decommissioning had been involved in consideration of options.

232. The TSC considered the response to RQ-UKHPR1000-1017 (Ref. 40) demonstrated application of the methodology and concluded that appropriate evidence had been provided, thus addressing the shortfall previously identified in the assessment of the submissions during Step 3 of GDA. The TSC also noted the RP's approach for design for decommissioning formed part of the overall design process, which aligned with good practice identified by the TSC in Step 3 of GDA (Ref. 50). I concur with the view of the TSC.

233. The TSC noted the RP had been asked for (by means of RQ-UKHPR1000-1016 (Ref. 40)) but had not provided evidence that inherent design features that benefit decommissioning, such as the selection of materials to minimise activation and thus worker radiation doses, have been comprehensively identified and recorded, which the TSC identified as a good practice. I consider this to be a minor shortfall. The TSC also considered that the RP had not provided evidence of a systematic review of the extent to which the design for Fangchenggang NPP Unit 3 facilitates decommissioning, which it considered to be a missed opportunity to provide increased confidence that the generic design of the UK HPR1000 will facilitate decommissioning. Whilst this would have been helpful, I do not consider it proportionate to raise this matter as an Assessment Finding or minor shortfall.

234. In its assessment of relevant submissions during Step 3 of GDA the TSC had identified that the RP's requirement for the layout design was not consistent with the good practices identified: "The arrangement should be as compact as possible and reduces the number of radioactive areas." The TSC had noted a compact design will minimise the waste generated but this needed to be balanced against other competing factors, particularly space and access for decommissioning. This requirement has been amended to: "The arrangement should be as compact as possible to reduce the size of radioactive areas, and adequate space for equipment should be taken into account during design stage" in (Ref. 24). This has resolved the shortfall of the RP's requirement against good practice identified by the TSC in the submissions assessed in Step 3 of GDA.

235. I have considered decontamination techniques in sub-section 4.5, but to reduce the risks associated with contamination to ALARP it is also important to consider how the generic design of the UK HPR1000 prevents or minimises the accumulation of contamination in / on SSCs and facilitates decontamination. Both of these aspects have been considered in the submissions relevant to design for decommissioning. (Ref. 24) provides a number of relevant principles and requirements and provides evidence of their application. Examples include the lining and/or coating of structures to prevent contamination (e.g. lining of the SFP to prevent contamination of the concrete structure), the selection of materials that minimise contamination, the design of piping and vessels to facilitate drainage though drainage nozzles at lowest points, the design of surfaces and shapes to minimise accumulation of contamination (e.g. the heater support plate for the pressuriser in the primary circuit is smooth with holes to

facilitate drainage) and incorporation of nozzles for connection of decontamination equipment.

236. The TSC sought clarification of the information on these aspects by means of RQ-UKHPR1000-1251 (Ref. 40) on consideration of decommissioning in equipment and process design. The TSC considered the response provided good evidence of the balance of decommissioning considerations against other competing requirements and how the accumulation of contamination is prevented and/or decontamination achieved. However, the TSC noted the RP had cited the 'Piping Layout Guides' (Ref. 71) as ensuring appropriate design measures are applied to equipment to prevent the accumulation (hold-up) of contamination and promote drainage. The scope of (Ref. 71) is limited to pipework, so it is not clear whether it is intended to be applicable to other SSCs containing contaminated fluids such as tanks and sumps. The TSC noted this as an area for improvement within the GDA safety case. I have therefore raised the following Assessment Finding:

> AF-UKHPR1000-0173 – The licensee shall, as part of detailed design, implement controls to minimise the accumulation of contamination as part of the design of structures, systems and components other than piping. This should ensure proportionate design measures to prevent contamination are applied to all relevant structures, systems and components in contact with radioactive fluids.

237. The TSC considered the evidence provided in the RP's submission (Ref. 24) and RQ responses relevant to building and structure design to be suitable and sufficient to demonstrate the RP's design requirements for facilitating decommissioning have been met, appropriate to the GDA stage. One of these requirements was the "use of easily removable modular plant, which may benefit both decommissioning". The RP provided limited evidence on structural features such as removable plates and shield walls. (Ref. 24) also states that "construction methods for the UK HPR1000 are site specific and will be specified at site specific stage". The TSC noted the submissions reviewed did not provide information on how the design is being developed to avoid foreclosing the use of construction techniques that may benefit decommissioning such as installation of modular components. I have therefore raised the following Assessment Finding:

> AF-UKHPR1000-0174 – The licensee shall, as part of detailed design, demonstrate the use of construction techniques that reduce risks to as low as reasonably practicable during decommissioning.

238. The TSC noted the RP had made use of design information from the reference plant (Fangchenggang NPP Unit 3) to demonstrate the generic UK HPR1000 design can be developed to facilitate decommissioning in (Ref. 24). The TSC noted the submissions reviewed did not provide information on the arrangements for transfer of the design requirements for facilitating decommissioning from the GDA stage to the licensee. It was thus not possible to confirm whether the arrangements were sufficiently robust to ensure the design requirements in the generic safety case would be identified and implemented during detailed design and the site-specific stage to meet regulatory expectations. I have therefore raised the following Assessment Finding:

> AF-UKHPR1000-0175 – The licensee shall ensure that the design requirements for facilitating decommissioning in the generic safety case are fully identified and implemented in the detailed design and site-specific aspects and are included in the safety case.

239. On the basis of its assessment of the sample of submissions and RQ responses, the TSC advised me that it considered the RP to have provided an adequate demonstration, supported by suitable and sufficient evidence, that the generic design

of the UK HPR1000 at GDA stage facilitates decommissioning and meets the expectations of SAP DC.1 on design for decommissioning. In reaching my judgement against the regulatory expectations on design for decommissioning set out in section 4.7.1 I have considered the evidence in the RP's submissions on design for decommissioning, the advice of the TSC in its report (Ref. 65) and other evidence relevant to design for decommissioning, particularly that discussed in sub-sections 4.2, 4.5 and 4.6 on decommissioning source term and decontamination/dismantling techniques.

240. The need to reduce the risks of decommissioning to ALARP has to be balanced against many other considerations such as the reduction of doses to workers during operation, the need to ensure the safety in fault conditions and accidents and operational and maintenance requirements. I consider the RP's inclusion of decommissioning in the overall design process to be a good practice in that decommissioning is considered against other relevant factors in a proportionate manner. The RP has provided suitable and sufficient evidence on how this has been achieved for the generic design of the UK HPR1000.

241. Minimisation of the decommissioning source term and thus of the radioactivity in decommissioning wastes is achieved through design measures such as material selection to minimise activation and corrosion, as discussed in (Ref. 24). I have also assessed the RP's submission "Minimisation of Radioactivity Route Map Report (Ref. 72), which was prepared in fulfilment of RO-UKHPR1000-0026 issued by the Chemistry topic area (Ref. 47) but is also of relevance to the Radioactive Waste Management and Decommissioning topic areas. I consider the evidence in this submission also contributes to meeting the expectations of SAP DC.1 and supporting Claim 5 and its sub-claims, for aspects such as material selection, even though this has not been explicitly recognised by the RP in the submission.

242. I consider the design measures described in other submissions, such as (Ref. 28) and (Ref. 29), for example those enabling removal of the SGs in one piece and the capacity and lifetime of the polar crane, also contribute to the RP's evidence of design for decommissioning.

243. The RP has significantly improved the evidence it has provided on design for decommissioning during Step 4, notably improving the referencing of the evidence provided in (Ref. 24) and other submissions. It has also improved the linkage between the relevant claims in PCSR Chapter 24 and the information in the supporting submissions. Overall I consider the RP's submissions provide adequate evidence to meet the regulatory expectations set out in section 4.7.1, most notably SAP DC.1, and the expectations of the RGP set out in IAEA GSR Part 6 (Ref. 14) and the WENRA Decommissioning SRLs (Ref. 16), appropriate to the GDA stage.

244. I also consider the RP has provided suitable and sufficient evidence to substantiate Claim 5.1 and Sub-Claims 5.1.SC24.1 and that the submissions on design for decommissioning are significant contributors in reducing the risks of decommissioning the generic UK HPR1000 design to ALARP and thus Sub-Claim 5.1.SC.24.3.

4.7.4 Strengths

245. The key strengths/positive aspects of the safety case as it relates to design for facilitating decommissioning are:

- The RP has identified and taken account of international OPEX and relevant codes and standards in the identification of principles and requirements for design for facilitating decommissioning.

- The measures identified by the RP for design for facilitating decommissioning are largely consistent with the good practices independently identified by the TSC during Step 3 of GDA.
- The RP has developed and implemented an appropriate approach for ensuring design for decommissioning is adequately considered and for making optimised design decisions that balance decommissioning against other competing factors, as part of the overall design process, which aligns with good practice.
- The RP has provided specific examples of aspects of the generic design of the UK HPR1000 to demonstrate the principles and requirements for design for facilitating decommissioning have been met.

4.7.5 Outcomes

246. I have identified four Assessment Findings and one minor shortfall relating to design for decommissioning.

4.7.6 Conclusion

247. I conclude the information provided by the RP in PCSR Chapter 24 and its supporting submissions on design for decommissioning meets relevant regulatory expectations and is appropriate to the GDA stage. The information is also adequate to substantiate Sub-claim 5.1.SC24.1 that the design and intended operation will facilitate safe decommissioning and thus supports Claim 5.1. I also consider the evidence on design for facilitating decommissioning to be appropriate to the GDA stage in substantiating Sub-Claim 5.1SC24.3 and that the measures identified are significant contributors in reducing the risks of decommissioning the UK HPR1000 to ALARP.

4.8 Management of Decommissioning Wastes

4.8.1 Regulatory Expectations Relating to the Management of Decommissioning Wastes

248. ONR regulates the accumulation and storage of radioactive wastes on nuclear sites whilst the Environment Agencies regulate the disposal of both radioactive and non-radioactive wastes from nuclear sites. The availability of disposal routes for radioactive wastes is relevant to the ONR's regulation of nuclear sites because if disposal routes are not available or planned to be available radioactive wastes will be accumulated for an indeterminate period, noting the expectation that accumulation is minimised in accordance with the expectation of SAP RW.3, so far as is reasonably practicable.

249. The regulatory expectations for the management of decommissioning wastes across the lifecycle from generation to disposal are the same as for other radioactive wastes and are discussed in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35). In addition to the Radioactive Waste Management SAPs RW.1 – RW.7, ONR and the Environment Agencies have issued the 'Joint Guidance on the management of higher activity radioactive waste on nuclear licensed sites' (Ref. 10), which provides additional information on regulatory expectations relevant to the management of HAW. ONR's TAGs, NS-TAST-GD-024 on Management of Radioactive Material and Radioactive Waste on Nuclear Licensed Sites (Ref. 8) and NS-TAST-GD-026 on Decommissioning (Ref. 9), note the importance of integration of the strategies for decommissioning and radioactive waste management, as does SAP DC.2 on decommissioning strategies. ONR's guidance is benchmarked against relevant international guidance on radioactive waste management such as IAEA GSR Part 5 on the predisposal management of

radioactive waste (Ref. 13) and WENRA's SRLs on waste treatment and conditioning (Ref. 73).

4.8.2 The RP's Submissions on Management of Decommissioning Waste and Other Relevant Documents

250. PCSR Chapter 24 provides information on the management of the wastes arising from the decommissioning of the generic UK HPR1000 design and refers to the more detailed information provided in the supporting submission 'Decommissioning Waste Management Proposal (Ref. 26). (Ref. 26) provides more details on the decommissioning solid waste inventory. The inventory excludes radioactive wastes and spent fuel that have been generated during operation but will not have been disposed of during the decommissioning phase. It also excludes wastes arising from decommissioning of the ILW Interim Storage Facility and Spent Fuel Interim Storage Facility (which are expected to be non-radioactive).

251. PCSR Chapter 24 and the supporting submission (Ref. 26) refer to the information the RP has provided for the purpose of assessment of the disposability of HAW which will arise from decommissioning (see below and also section 4.2 on decommissioning source term), which is presented in the 'UK HPR1000 HAW Disposability Assessment' (Ref. 74) . Radioactive Waste Management Ltd (RWM, the organisation to be responsible for the design, construction and operation of the GDF) has since undertaken a pre-conceptual assessment of the disposability of all HAW expected to arise from operation and decommissioning of the UK HPR1000, which is reported in (Ref. 75). The RP has produced a response to RWM's assessment, which is presented in (Ref. 76). The submissions (Ref. 74), (Ref. 75) and (Ref. 76) were issued after the issue of PCSR Chapter 24 at the beginning of Step 4 of GDA.

252. PCSR Chapter 24 indicates ALARP (and BAT) has been considered in the management of decommissioning wastes, noting the importance of non-foreclosure of options and the expectation that the licensee will review the waste management strategy. The RP indicates the waste management hierarchy will be applied to the management of all wastes arising from construction, operation and decommissioning to achieve waste minimisation.

253. The RP provides summary information on the sources of gaseous, liquid and solid wastes which arise from various decommissioning processes such as decontamination and dismantling. Gaseous and liquid wastes will be treated by either existing systems used during the operational phase or temporary systems installed during the decommissioning phase, with the decision as to which being made by the licensee.

254. Solid radioactive wastes are expected to be the most significant arisings during decommissioning, comprising mainly activated and contaminated materials arising from the dismantling of SSCs. Other solid wastes also arise as a result of the treatment of gaseous and liquid wastes such as ion exchange resins from effluent treatment, charcoal from delay beds in the Gaseous Waste Treatment System and miscellaneous secondary wastes such as liquid effluents arising from decontamination processes, cleaning materials and reagents and used personal protective equipment.

255. PCSR Chapter 24 provides an overview of the hierarchy of waste processing and disposal routes and notes the licensee will adopt suitable facilities for waste characterisation and segregation. LLW will be packaged for either off-site treatment processes (e.g. incineration, metal melting and supercompaction) or disposal to LLWR but its disposal is outside the scope of GDA.

256. As discussed in sub-section 4.2 some decommissioning wastes are expected to be categorised as ILW. Spent ion-exchange resins arising from treatment of liquids during decommissioning will be managed in the same way as resins generated during the operational phase, which is discussed in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35).

257. Three types of decommissioning waste are expected to be categorised as ILW, namely the RPV, the RVIs and a layer of activated concrete from the bioshield closest to the RPV, as identified in sub-section 4.2. The packaging strategy for the RPV and the ILW concrete is to immobilise (grout) the wastes in concrete in standard RWM 4 metre boxes (which contain some internal shielding). The RVIs will be immobilised in standard RWM 3 m^3 boxes (which are unshielded and therefore need additional shielding and are expected to be transported using an overpack designed for RWM known as the Shielded Waste Transfer Container). The resulting waste packages are expected to be transferred to the ILW Interim Storage Facility for storage pending the availability of the GDF.

258. The 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 77) includes information on the planned storage capacity for all expected arisings of ILW, including decommissioning wastes. There is no information on the facilities in which the grouting will take place, which will be determined in the site-specific phase. The capacity of the ILW Interim Storage Facility is assessed in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35).

259. The 'Decommissioning Waste Management Proposal' (Ref. 26) refers to the relevant claims in PCSR Chapter 24 including Claims 5, 5.1 and 5.2, and Sub-Claims 5.1.SC24.3, which relates to faults and hazards and that risks are capable of being ALARP, and 5.2.SC24.6 that disposal routes are available (or will be available) for all wastes arising during decommissioning. It refers to most of the other supporting submissions (although not to 'OPEX on Decommissioning (Ref. 22)). It indicates its specific role in supporting the PDP (Ref. 25) and also states it has been developed based on the IWS (Ref. 48), which sets out waste management principles for the lifecycle of the generic UK HPR1000 design.

260. (Ref. 26) discusses the assumptions used and steps taken in calculating the inventory of radioactive wastes (volume and category), based on the decommissioning source term and international OPEX. The RP has based the activity of the radioactive wastes in the inventory on a time period of 15 years after shutdown of the reactor, taking account of the expected duration of decommissioning (see also sub-section 4.9).

261. The submission (Ref. 26) presents the expected waste arisings as ILW, LLW and Very Low Level Waste (VLLW is a sub-category of LLW which is now obsolete but is still referred to in some policy and guidance documents and the RP has chosen to use it). The RP presents the total inventory by component type (e.g. SGs, pumps, pipes) and category rather than by the building from which it arises, but also presents inventories for the main nuclear island buildings and the SFP. The predicted volume of unconditioned (i.e. unpackaged) ILW arising from decommissioning is 259.5 m^3 compared to the volume of unconditioned LLW/VLLW of 12021 m^3, so ILW is approximately 2% of the total volume of radioactive waste, while the IWS (Ref. 48) indicates ILW is approximately 3% by volume of conditioned radioactive waste (i.e. conditioned and packaged).

262. (Ref. 26) provides more detailed information than PCSR Chapter 24 on the treatment, conditioning and packaging of ILW, noting some spent resins may be defined as ILW/LLW boundary waste and may be immobilised in cement grout (also referred to as "grouted") in LLW drums and stored to allow decay followed by disposal as LLW. It discusses the generation, treatment and packaging of radioactive wastes including

processes such as characterisation, decontamination, decay storage and size reduction. It provides information on the proposed packaging of the ILW streams of the RPV, RVIs and ILW concrete including preliminary selection and properties of the waste packages. It also presents information on the average and maximum activity values for radionuclides in the RPV, RVIs and ILW concrete. ILW packages will be stored in the ILW Interim Storage Facility, with boundary wastes being stored until they decay to LLW while wastes that do not decay to LLW will be disposed of to the GDF when available. Decommissioning LLW will be stored temporarily in dedicated areas pending disposal or off-site treatment.

263. The RP submitted information to support RWM's pre-conceptual assessment of the disposability of the higher activity wastes and spent fuel arising from the operation and decommissioning of the generic UK HPR1000 design in (Ref. 74). RWM's assessment of disposability is presented in (Ref. 75). Whilst not one of the RP's submissions I consider the content of the report here because of its relevance to the decommissioning claims, particularly sub-claim 5.2.SC24.6, and also to the relevant SAPs.

264. RWM concluded that "sufficient information has been provided by GNSL to produce valid and justifiable conclusions under the GDA Disposability Assessment. The proposals for the packaging of the UK HPR1000 wastes are based on the use of UK standard waste containers consistent with RWM standards and specifications. The issues identified from the GDA Disposability Assessment for the UK HPR1000 could all be resolved through appropriate development of the proposals. 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" (Ref. 75).

265. RWM identified a number of issues relating to ILW, many of which are relevant to decommissioning wastes, for which the information will need to be developed during the disposability assessment beyond the GDA stage. The following issues were raised, together with RWM's consideration of how the issues could be addressed:

- RWM's assessment conservatively assumed that the decommissioning wastes would be disposed of to the GDF 15 years after shutdown of the reactor. Based on this assumption the packages containing the RPV and RVIs (referred to by RWM as RPVIs) would not meet the transport dose rate limits. This could be addressed by a period of decay storage on site and, in the case of the RPV packages, by adding more shielding to the package.
- The heat output of the RVI packages would not meet the limit for the post-closure phase but this could be addressed by a period of decay storage on site.
- The RVI packages would not meet the containment limit for tritium for a fire during transport. This could be addressed by decay storage on site.
- RVI packages would need to be purged of flammable gases prior to transport.
- In common with similar wastes from other reactor systems the RVI packages have high specific activity levels of carbon-14, which is an issue of concern to RWM with respect to potential long-term releases from a GDF. RWM indicated this could be addressed by reviewing carbon-14 levels and release rates from the steel components at a later stage.
- RWM indicated the packaging efficiency for RVIs may not be achievable and could be addressed by packaging in a larger number of containers.
- The high dose rates of the RVIs could affect the long-term integrity of the grouted waste form. RWM indicated this could be addressed by cooling and/or development of the grout formulation.

- The proposed use of the 4 metre box for the RPV and ILW concrete, which is an IP-2 transport package, may not meet the “no loss or dispersal” criterion if the boxes have to be vented during transport. This issue is not unique to these wastes and RWM will consider this matter in the future, but alternatives would be to consider other packaging and transport options.
- Other issues identified included the need to demonstrate adequate infiltration of grout into the wastes, to consider the impact of steel reinforcement on gas generation rates for ILW concrete packages and the need to ensure particulates generated from cutting of the wastes during dismantling are managed during packaging to prevent release in accident scenarios.

266. The RP reviewed RWM’s assessment report and produced ‘Response to RWM Assessment Report for UK HPR1000 HAW and spent fuel disposability’ (Ref. 76), which sets out how the RP would expect to address the issues raised by RWM and whether there are any concerns that could affect the overall assessment that the wastes will be disposable to a GDF. The RP concluded that it expected the licensee to be able to resolve all the issues raised by RWM and that it had no concerns that the wastes would not be disposable in the future.

267. The RP indicated the ILW can be stored safely on site to allow decay storage and that the planned capacity and lifetime of the ILW Interim Storage Facility will be adequate, noting there will be a two-phase approach to ILW storage (two facilities constructed at different times, with the second store sized to account for decommissioning wastes) as set out in the ‘Conceptual Proposal of ILW Interim Storage Facility’(Ref. 77).

268. The RP also noted the conservatisms used in defining the source terms during GDA and that further information will become available at later stages of the lifecycle on aspects such as material composition, neutron flux, OPEX and radiological characterisation to assess the source term more accurately and thus understand the impacts on the assessment of disposability.

4.8.3 Assessment of the RP’s Submissions on the Management of Decommissioning Wastes

269. I have assessed PCSR Chapter 24 and the submissions (Ref. 26), (Ref. 74) and (Ref. 76) against the relevant regulatory expectations set out in section 4.8.1. In doing so I have also taken account of my assessment of other submissions relevant to radioactive waste management, as reported in the Assessment Note for RO-UKHPR1000-0005 (Ref. 78) and which is discussed in the Step 4 Assessment of Radioactive Waste Management of the UK HPR1000 Reactor (Ref. 35). I have also taken account of the ‘Conceptual Proposal of ILW Interim Storage Facility’ (Ref. 77), which the RP produced in response to RO-UKHPR1000-0040’ (Ref. 47) and which ONR assessed in (Ref. 79), which addresses the storage of decommissioning ILW.

270. I targeted my assessment on the decommissioning ILW that will arise from dismantling, because this presents the highest radiological risk. The RVIs are amongst the highest dose rate components that will need to be safely managed during the lifecycle of the generic UK HPR1000 design. Other ILW arising during decommissioning includes filter cartridges and spent ion exchange resins. These wastes will have essentially similar characteristics to the wastes generated during the operational phase and will be managed in a similar manner. I have also not assessed the radioactive wastes that will arise as a result of POCO after shutdown, when there will be a process of cleaning and removal of accumulated wastes for treatment using operational processes such as filtration and ion-exchange and the wastes are thus similar to operational wastes.

271. I sought and received clarification of a number of issues relating to the 'Decommissioning Waste Management Proposal' (Ref. 26) by means of RQ-UKHPR1000-1310 (Ref. 40). These included consideration of decontamination in relation to the categories of some decommissioning wastes, secondary wastes arising during decommissioning, measures to segregate and characterise decommissioning wastes in the generic design of the UK HPR1000, ILW/LLW boundary waste resins and the packaging efficiency for the RPV, which was lower than for some of the other packages proposed for other ILW.

272. With respect to meeting the expectations of the SAPs on radioactive waste management and decommissioning strategies, I consider the RP has taken good account of decommissioning wastes in the development of the IWS (Ref. 48). I considered the IWS met the regulatory expectations of SAP RW.1 on radioactive waste management strategies in (Ref. 78). I also concluded in sub-section 4.3 of this report that the RP has demonstrated the decommissioning and radioactive waste management strategies are integrated.

273. (Ref. 26) discusses the application of the waste management hierarchy including the minimisation of radioactive waste as expected in SAP RW.2. This largely refers to other submissions discussed elsewhere in this report. The RP has provided adequate information on the minimisation of decommissioning wastes through measures such as material selection and design of components to prevent the accumulation of contamination, chemistry control during the operational phase and the application of decontamination techniques such as FSD in other submissions and (Ref. 26). I consider the RP has provided adequate evidence with respect to meeting the expectations of SAP RW.2 for decommissioning wastes.

274. SAP RW.3 states the total quantity of radioactive waste accumulated on site at any time should be minimised so far as is reasonably practicable. The production of decommissioning wastes will be unavoidable in achieving the objective of reaching the agreed end state and the generation will be minimised as already considered. Accumulation will be minimised by ensuring disposal routes are or will be available.

275. Whilst the disposal of LLW arising from decommissioning is outside the scope of GDA I have no concerns that the types of LLW expected to arise from decommissioning of the generic UK HPR1000 design, as described in (Ref. 26), will not be disposable or otherwise capable of being treated using the existing disposition routes in the UK, based on my knowledge and experience of the management of decommissioning wastes. The management of out-of-scope wastes (where out of scope means below the activity concentrations which define wastes as radioactive) is also outside the scope of GDA but I note the application of robust clearance processes by the licensee would enable removal of much of the waste arising from decommissioning the generic UK HPR1000 design as out of scope, enabling application of the waste management hierarchy through measures such as metals recycling and recycling of demolition wastes.

276. In (Ref. 76) I consider the RP has provided adequate evidence on the disposability of decommissioning ILW means of its consideration of the outcome of RWM's assessment (Ref. 75). I consider the evidence is appropriate to the GDA stage, meets the expectation of RW.3 and also substantiates subclaim 5.2.SC24.6.

277. I consider the RP has identified appropriate measures to address the issues identified by RWM in its assessment and has provided adequate evidence that sufficient storage capacity would be available to enable decay storage as appropriate. I note the conservatism of the RWM assessment in terms of the assumed timing of consignment of decommissioning wastes to the GDF 15 years after shutdown and that of the RP's assessment of the decommissioning source term, as assessed in sub-section 4.2.

278. The licensee may decide to review the strategy for the proposed packaging of the RVIs and RPV in the light of their high dose rates and other characteristics relevant to disposability. An alternative option would be to review the timing of decommissioning as deferral would reduce dose rates because of radioactive decay (mainly cobalt-60), as acknowledged by the RP in relation to decommissioning strategy. However, this would not be consistent with the strategic assumptions in the Government's Base Case (Ref. 42). This would be a decision for the licensee.

279. SAP RW.4 expects radioactive waste to be characterised and segregated to facilitate its subsequent safe and effective management. At the GDA stage I consider the decommissioning source term discussed in sub-section 4.2 to be adequate for the purpose of initial characterisation to enable the RP to define the management of decommissioning wastes as separate waste streams.

280. (Ref. 26) indicates a future operator will define the measures for characterisation and segregation of wastes during decommissioning. In RQ-UKHPR1000-1310 (Ref. 40) I asked whether there were any aspects of the design that facilitated the characterisation and segregation of decommissioning wastes, noting this was not discussed in the 'Consistency Evaluation for Design of Facilitating Decommissioning' (Ref. 24) . The RP's response was that provisions cannot be accurately defined at the GDA stage. Whilst I agree that many aspects cannot be accurately defined, I consider the RP has not provided evidence of consideration of potential design measures for characterisation and segregation such as those noted in the TSC's review of good practice in design for decommissioning in Step 3 of GDA (Ref. 50). Examples include the use of "test coupons" to measure the behaviour of materials, measures to enable samples of materials to be taken and the provision of sufficient space to allow characterisation during decommissioning. I consider this to be a minor shortfall.

281. As noted in section 4.6, I sought evidence by means of RQ-UKHPR1000-1417 (Ref. 40) concerning the technique to be used for segregation of ILW concrete to substantiate the estimate made for the volume. I was content with the response received, which indicated that the RP had identified diamond wire cutting as an appropriate technique that would enable segregation of ILW concrete. I considered the response met the relevant expectations of SAP RW.4. Diamond wire cutting has been successfully applied in the decommissioning of a number of facilities and can be used to segregate material of different radioactivity levels, based on adequate characterisation.

282. SAP RW.5 expects radioactive waste to be stored in accordance with good engineering practice and in a passively safe condition. The decommissioning ILW will be stored with other ILW arising from the operational phase in the ILW Interim Storage Facility. This is currently at a conceptual stage of design and is presented in the 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 77). I have confirmed this submission contains information that indicates the planned capacity of the store takes account of ILW arising from decommissioning. The RP plans to take a two phase approach (two separate stores) to the provision of ILW storage capacity, addressing decommissioning wastes in the second phase. The design life of the store is defined as 100 years which is consistent with assumptions for other ILW stores in the UK pending the availability of the GDF. ONR's assessment of 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 77) is presented in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35).

283. I note the RP has selected standard RWM waste containers which will be suitable for long-term storage as well as disposal to the GDF. Unlike operational wastes the RP has not undertaken detailed assessment of options for the management of decommissioning ILW as discussed in (Ref. 78). The Environment Agency asked for

and received justification of the selection of the waste containers in RQ-UKHPR1000-0648 (Ref. 40) and this information has been included in (Ref. 26). I consider the information provided to be adequate and takes account of information on the selection of waste containers for other ILW and from other GDA processes. As discussed above RWM has raised some issues about the selection of containers but these can be addressed by the licensee.

284. SAP RW.6 expects that waste should be processed into a passive safe state as soon as is reasonably practicable. The placement of the ILW in the boxes and the grouting of the contents will produce waste packages that are considered to be in a passive safe state. The information in (Ref. 26) and the 'Conceptual Proposal of ILW Interim Storage Facility' (Ref. 77) indicates the decommissioning ILW is packaged (which includes the grouting of the contents) soon after the waste is produced. There is no period in which the wastes are planned to be stored in unconditioned form after the dismantling process. I thus consider the RP's proposal for decommissioning ILW meets the relevant expectation in RW.6.

285. The location, design and safety case for the facilities that will be used to package decommissioning wastes to meet regulatory expectations on disposability and waste storage are not in the scope of GDA and will be defined by the licensee. Experience in the UK indicates it is sometimes necessary to construct new facilities to process wastes arising from decommissioning into a passively safe form. The high radiological hazard of the decommissioning ILW, particularly RVIs, will mean that these matters should be given careful consideration to enable the dismantling to proceed on the planned timescales as set out in the PDP (Ref. 25) (see sub-section 4.9).

286. SAP RW.7 states information that might be needed for the current and future safe management of radioactive waste should be recorded and preserved. (Ref. 26) does not include any information on records, but they are considered in other submissions on radioactive waste management and in the PDP (Ref. 25). ONR has also considered waste records in the Step 4 Assessment of Radioactive Waste Management for the UK HPR1000 Reactor (Ref. 35).

4.8.4 Strengths

287. The key strengths/positive aspects of the safety case as it relates to management of decommissioning wastes are:

- The RP has obtained adequate evidence of the disposability of decommissioning ILW by means of RWM's pre-conceptual assessment.
- The RP has provided adequate evidence to meet the key regulatory expectations of radioactive waste management for decommissioning wastes.
- The RP has ensured that decommissioning ILW has been taken into account in the planning for and capacity of storage for radioactive wastes.
- The RP has ensured decommissioning has been integrated into the radioactive waste management strategy.

4.8.5 Outcomes

288. I have identified one minor shortfall.

4.8.6 Conclusion

289. I conclude the information provided by the RP in PCSR Chapter 24 and its supporting submissions on management of decommissioning wastes meets relevant regulatory expectations and is appropriate to the GDA stage. The information is also adequate to

substantiate Sub-claim 5.1.SC24.6 that disposal routes are available (or will be available) for waste arising during decommissioning and thus supports Claim 5.1.

4.9 Preliminary Decommissioning Plan

4.9.1 Regulatory Expectations for Decommissioning Plans

290. IAEA GSR Part 6 on Decommissioning (Ref. 14) requires that licensees prepare a decommissioning plan and maintain it throughout the lifetime of a facility, in order to show that decommissioning can be accomplished safely to meet the defined end state. Paragraph 7.3 states that" planning for decommissioning shall begin early in the design stage and continue through to termination of the authorisation for decommissioning" (which in the UK would be at the stage of delicensing). The WENRA SRLs on Decommissioning (Ref. 16) incorporate this requirement.

291. IAEA GSR Part 6 expects the preparation of an initial decommissioning plan which identifies decommissioning options, demonstrates the feasibility of decommissioning, and identifies and estimates the quantities of waste that will be generated. A final decommissioning plan is expected to be prepared close to the expected time of final shutdown of a facility.

292. ONR SAP DC.4 states "A decommissioning plan should be prepared for each facility that sets out how the facility will be safely decommissioned," which should form part of the demonstration that the facility can be safely decommissioned. Some of the supporting guidance is not relevant to the design phase. However, the type of information and level of detail should be commensurate with the type and status of the facility, radiological hazard, decommissioning timescales and practicability of obtaining information. The plan should identify the type and quantity of wastes to be managed (solid, liquid and gaseous), timescales over which wastes will arise and be consistent with the waste management strategy. Information and knowledge should be generated and maintained throughout its life to inform later detailed planning and during decommissioning, including design, modifications and operating history/knowledge. Paragraphs 5.66 and 5.67 of NS-TAST-GD-026, ONR's TAG on Decommissioning (Ref. 9), incorporate information from the relevant WENRA SRLs, including guidance on the expectation of the content of strategies and plans.

293. ONR SAP DC.6 states "Documents and records that may be required for decommissioning purposes should be identified, prepared, updated, retained and owned so that they will be available when needed". The process of making and preserving these documents and records should start at the planning and design stage and continue throughout the whole lifecycle of the facility.

4.9.2 The RP's Submissions on Decommissioning Planning

294. PCSR Chapter 24 (Ref. 3) presents summary information on the PDP, including information on assumptions, strategy, project management, the main decommissioning activities, waste and safety management and records and knowledge management. The PDP aims to show that safe decommissioning is feasible using current technologies and within current policies, the regulatory context and the waste management framework.

295. The relevant sub-chapter of PCSR Chapter 24 provides information on the timing of decommissioning and stages of decommissioning, which are defined as:

- Stage 1 – preparatory work performed before final shutdown, including strategy and plan update, development of decommissioning design and technology, review of organisational structure and programme for transition from operation to decommissioning, evaluation of the availability of facilities and systems, preliminary characterisation and construction or modification of facilities at an appropriate time to support decommissioning. This stage is expected to take approximately five years.

- Stage 2 – activities carried out shortly after final shutdown, including removal of spent fuel from the reactor to the SFP, radiological characterisation, POCO, decontamination of the primary circuit, auxiliary facilities and process building. This stage is expected to take approximately two years.
- Stage 3 – activities depend on the outcome of Stage 2 but will include transfer of spent fuel from the SFP to the Spent Fuel Interim Storage Facility for dry storage (which is discussed in PCSR Chapter 29 (Ref. 34) and its supporting submissions), dismantling of non-essential systems, dismantling of radioactive equipment and buildings including the primary circuit, SGs and auxiliary systems and buildings, the management of radioactive wastes, removal of the RPV and activated concrete and removal of the pre-stressed inner containment. This stage is expected to take approximately eight years.
- Stage 4 – activities carried out after dismantling, including maintenance of the stores for spent fuel and ILW, transfer of spent fuel and ILW to the GDF when available, dismantling of the stores and site restoration prior to delicensing to demonstrate the agreed end state has been reached. The duration of this stage depends on GDF availability, but the activities are expected to take three years.

296. PCSR Chapter 24 provides information on the radiological characterisation that will be carried out to determine the composition and distribution of radionuclides/ contamination to support the identification of risks and hazards for decommissioning and underpin the decommissioning plan. By definition this is not carried out until shutdown. It refers to the ‘Decommissioning Technical User Source Term Report’ (Ref. 20) as the basis for characterisation at the GDA stage (which is assessed in sub-section 4.2 of this report). Other parts of the sub-chapter cover decontamination, dismantling and waste management activities, which are assessed in sub-sections 4.4, 4.5 and 4.8 of this report.

297. PCSR Chapter 24 provides summary information on safety management, which recognises the need to reduce risks to ALARP. It recognises that the systems and devices used in the operational phase may not be appropriate for decommissioning, and the need for ongoing assessment of safety measures during decommissioning. It also clearly recognises the importance of conventional safety risks during decommissioning, which are outside the scope of this report but is nonetheless welcome. It provides a summary of the risks and hazards identified for the various decommissioning tasks and of protection and mitigation measures, drawing on the information in the various supporting submissions. It also briefly discusses organisation for decommissioning, recognising the need for changes from operation to decommissioning and the importance of learning from experience of decommissioning projects. These aspects are beyond the scope of GDA.

298. PCSR Chapter 24 presents information on records and knowledge management, providing information on the definition of knowledge management and techniques for their application, and refers to PCSR Chapter 20 on MSQA and Safety Case Management (Ref. 80) for information management systems and quality assurance. It identifies generic records produced during the design, construction and commissioning phases which are needed for decommissioning, which include design documents and specifications, drawings and charts. It acknowledges the need for baseline surveys and for the collection of material samples as baselines for understanding the levels of corrosion, activation and contamination of materials following operation.

299. The relevant supporting submission is the PDP (Ref. 25), the objective of which is to present the decommissioning strategy and plan for the UK HPR1000. I summarised and assessed the strategy elements of the PDP in sub-section 4.3 of this report. The

PDP is intended to support the demonstration of ALARP by setting out how the facility will be safely decommissioned. It largely presents more detail on the main areas presented in PCSR Chapter 24 and much of the information presented is summarised from the other supporting submissions, which I assessed in other sections of this report.

300. The PDP (Ref. 25) is intended to provide evidence to support Claim 5.1 (design and operation to facilitate safe decommissioning), Sub-claim 5.1SC24.2 (documents and records required for decommissioning are identified and under preliminary preparation) and Claim 5.2 (decommissioning strategy and plan are prepared and maintained for the generic design, and which reflect UK policy). It also supports Sub-claims 5.2.SC24.5 (proper preliminary decommissioning plans/strategies are prepared) and 5.2.SC24.7 (development of the decommissioning plans to reflect developments in technologies and experiences to ensure the timing and methods adopted for decommissioning are safe and protect the environment).

301. The PDP provides a little more detail on document and records than PCSR Chapter 24, identifying generic information needed for decommissioning and recognising the need to ensure the future integrity and traceability of records. It provides more information on radiological characterisation, including the scope and type of characterisation and identification of the main radionuclides arising from light water reactors. As with PCSR Chapter 24 the information presented on safety management includes the preliminary identification of radiological and non-radiological hazards and mitigation measures, based on defined OPEX (IAEA safety guides and reports) but does not include information on any specific mitigation measures in the generic design of the UK HPR1000.

4.9.3 Assessment of the RP’s submissions on decommissioning planning

302. I have assessed PCSR Chapter 24 (Ref. 3) and the PDP (Ref. 25) against the regulatory expectations set out in section 4.9.1. I initially sought clarification of a number of aspects of the PDP in RQ-UKHPR1000-1512 (Ref. 40), a number of which related to the absence of information and cross-referencing to information in other relevant submissions which support the PDP and thus show the overall golden thread from claims to evidence. The most significant queries related to the schedule of decommissioning of the SFP, which may need to be on a different timescale to other parts of the generic UK HPR1000 design in the event of the need to store any failed fuel for a prolonged period, and the absence of information on the application of the Construction (Design and Management) Regulations 2015 (CDM) (Ref. 81) to decommissioning in the PDP.

303. In its response on the SFP the RP indicated that it has identified options for the packaging of failed fuel that will enable its removal from the SFP and so should not have any impact on the timescales for SFP decommissioning, which are discussed in a submission in the Spent Fuel Interim Storage topic area (ONR’s assessment is presented in (Ref. 36)). The RP indicated this issue would be addressed as necessary at the site-specific stage. I considered the response to be adequate.

304. Although strictly outside the scope of this report I liaised with the Conventional Health and Safety specialist inspector in deciding to seek information about the application of CDM to decommissioning. Experience in the UK indicates that conventional health and safety risks during decommissioning can be significant and need to be controlled effectively. The PDP sets out key information on the plans for decommissioning and the associated risks, including those relating to conventional (non-radiological) safety. I therefore sought assurance there was appropriate recognition of the linkage of the information in the PDP and other documentation prepared in fulfilment of pre-construction information requirements under CDM. This will enable the licensee to understand the significance of the PDP in providing information on decommissioning to

support the management of conventional health and safety risks. I was content with the response, which referred to the relevant GDA procedure for Design Risk Management (Ref. 82). ONR's consideration of the RP's safety case for Conventional Health and Safety is reported in the relevant Step 4 assessment report (Ref. 57).

305. I consider that the RP's submissions on planning for decommissioning, supported by information in the supporting submissions referred to therein, meet the expectations on planning for decommissioning in SAP DC.4, IAEA GSR Part 6 (Ref. 14) and the relevant expectations of NS-TAST-GD-026, ONR's Decommissioning TAG (Ref. 9) as summarised in section 4.9.1. I consider the information provided to be commensurate to the stage of the design and to GDA and that the RP has made good use of OPEX. I also consider the evidence provided by the RP is adequate to substantiate Claim 5.2 and Sub-claim 5.2.SC24.5 as it relates to preparation of the decommissioning plan, and that the plan reflects UK policy. It will be for the licensee to maintain the plan and strategy. As noted, ONR assesses decommissioning plans and strategies for licensed installations as part of compliance arrangements made under Site Licence Condition 35.

306. I also consider the RP has provided adequate evidence, commensurate with the stage of development of the generic UK HPR1000 design, to substantiate Sub-claim 5.2SC24.7 on development of the decommissioning plan to reflect developments in technologies and experiences. The RP has done so based on existing OPEX and technologies available today, but it will be for the licensee to continue the development of the plan in the site-specific phase. I note IAEA GSR Part 6 (Ref. 14) expects decommissioning plans to be updated by a licensee and reviewed by the regulatory body periodically (typically every five years), so it would be a good practice for the licensee to consider defining and implementing arrangements for periodic review of the PDP to take account of OPEX and the development of technologies, to provide confidence that it can continue to substantiate Claim 5.2 and relevant Sub-Claims in the future.

307. I have also assessed the RP's submissions against the expectations of SAP DC.6 on records for decommissioning. The information provided in PCSR Chapter 24 and the PDP on records is largely generic in nature and did not provide any indication of how records for decommissioning are being identified and managed for the generic UK HPR1000 design, nor did it refer to other parts of the safety case where records management is addressed. I thus raised RQ-UKHPR1000-1252 (Ref. 40) which sought information on how and where documents and records that may be required for decommissioning purposes are identified, prepared, updated, retained and owned at the design phase, and which if any documents and records have been identified as being potentially required for decommissioning purposes.

308. The RP's response indicated documents are identified, prepared and updated by the designers and retained and owned under the internal design management and procedure management system, as described in PCSR Chapter 20 on MSQA and Safety Case Management (Ref. 80). The RP indicated its expectation that in the GDA design phase only a few documents would be expected to be fit for purpose for decommissioning purposes and that documents will be updated at the site-specific stage to reflect site specific aspects and detailed design. The licensee will be responsible for defining arrangements to ensure records needed for decommissioning are adequately identified, produced, updated, managed, owned and kept. The RP will define processes and procedures to transfer the safety case to the licensee.

309. In considering my assessment of the RP's response to RQ-UKHPR1000-1252 (Ref. 40) against the expectations of SAP DC.6 I recognise there are limitations at the GDA stage in enabling the identification of records for decommissioning purposes and accept the RP's position that the licensee will be responsible for defining arrangements at the site-specific stage. However, I have reviewed PCSR Chapter 20 (Ref. 80) and it

does not appear to explicitly address the identification of records required for decommissioning purposes. I thus have not found adequate evidence relating to the identification of documents for decommissioning purposes to meet the expectation in SAP DC.6, although I am satisfied that the RP's management systems for design and procedure management should ensure that other aspects of SAP DC.6 are addressed, based on the evidence in PCSR Chapter 20. I consider the RP has not provided sufficient evidence to adequately substantiate Sub-claim 5.2.SC24.2. I am therefore raising the following Assessment Finding:

AF-UKHPR1000-0176 – The licensee shall ensure that documents and records required for decommissioning purposes are included in site-specific operating documentation, which should address site-specific aspects and detailed design. As a minimum, the arrangements should address the shortfall identified during GDA.

310. I consider it would have been helpful if the PDP had referred to the relevant information in PCSR Chapter 20 on MSQA (Ref. 80) as this would increase confidence that the licensee will understand the importance of processes for managing documents and records for decommissioning purposes in the future.

4.9.4 Strengths

311. The key strengths/positive aspects of the safety case as it relates to planning of decommissioning are:

- The RP has provided adequate evidence that it meets the expectation of SAP DC.4 and relevant international guidance in the preparation of the Preliminary Decommissioning Plan, which takes good account of OPEX.

4.9.5 Outcomes

312. I have identified one Assessment Finding relating to identification of records for decommissioning.

4.9.6 Conclusion

313. I conclude the information provided by the RP in PCSR Chapter 24 and its supporting submissions on planning for decommissioning meets relevant regulatory expectations and is appropriate to the GDA stage. The information is also adequate to substantiate Claim 5.2 and Sub-claims 5.2.SC24.5 and 24.7. I consider that the RP has not adequately substantiated Sub-claim 5.1.SC.24.2 and I have identified an Assessment Finding relating to the shortfall identified.

4.10 Demonstration that Relevant Risks Have Been Reduced to ALARP

4.10.1 Regulatory Expectations on ALARP of Particular Relevance to Decommissioning

314. NS-TAST-GD-005, ONR's TAG on ALARP (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 NS-TAST-GD-026, the Decommissioning TAG (Ref. 9). Paragraphs 6.46 – 6.48 of NS-TAST-GD-005 (Ref. 6) 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 and decommissioning. 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. Decommissioning will take place in the future (the operational life is assumed to be 60 years) so the risks of decommissioning will be to future generations. The inclusion of decommissioning as a technical topic in GDA can be seen as reflecting the expectations concerning long-term projects set out in NS-TAST-GD-005 (Ref. 6), as well as meeting the expectations of international guidance.

315. 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. SAP SC.3 states that for each lifecycle stage, control of the hazard should be demonstrated by a valid safety case that takes into account the implications from previous stages and for future stages.

316. Section 4.6 of ONR-GDA-GD-007, ONR's GDA Technical Guidance, (Ref. 51) expects a demonstration that the generic design enables the risks of decommissioning to be minimised, so far as is reasonably practicable (design for decommissioning), based on currently available technologies, not on technologies that may become available in the future. This can be seen as consistent with the expectation in NS-TAST-GD-005 (Ref. 6) that the risks to future generations should be consistent with those to present generations because of the use of currently available techniques, which can be seen as precautionary. This does not preclude the future development and application of new and/or improved techniques that could reduce the risks of decommissioning to future generations, but the case for their use would need to be made by the licensee.

4.10.2 The RP's Submissions Relevant to the Demonstration that Relevant Risks have been Reduced to ALARP

317. PCSR Chapter 24 (Ref. 3) includes a section on ALARP assessment. The RP recognises that, although decommissioning will take place a long time in the future, it is necessary to consider both ALARP and BAT in the context of decommissioning by the licensee. The RP states it has identified RGP in its analysis of applicable codes and standards from consideration of worldwide OPEX in the decommissioning of PWRs in (Ref. 43).

318. The RP indicates that OPEX on decommissioning, design for facilitating decommissioning and the PDP contribute to demonstrating that the risks of decommissioning are capable of being demonstrated as ALARP/BAT, referring to other parts of PCSR Chapter 24 and supporting submissions already assessed in earlier sections of this report. The RP states it has carried out an initial identification of major risks and mitigation measures for decommissioning, based on OPEX, which are presented in the supporting submissions. It also presents a small number of specific examples, such as SG dismantling and minimisation of the use of elements susceptible to activation, in PCSR Chapter 24.

319. PCSR Chapter 24 stated the RP did not plan to produce a detailed BAT/ALARP demonstration for decommissioning because of inherent uncertainties in planning for a phase at least 60 years after GDA. It also indicated that options for the licensee had not been foreclosed. Subsequent to the issue of PCSR Chapter 24 the RP produced a new submission, 'ALARP Demonstration for Decommissioning of the UK HPR1000' (Ref. 19), which I discuss in sub-section 4.10.3 because it was produced in response to ONR's assessment of the generic safety case for the UK HPR1000.

4.10.3 Assessment of the RP's Submissions Relevant to the Demonstration that Relevant Risks have been Reduced to ALARP

320. I assessed the information on ALARP assessment in PCSR Chapter 24 (Ref. 3) early in Step 4, in conjunction with the supporting submissions, which at that stage were earlier versions than those assessed in this report. My initial conclusions were that the information in PCSR Chapter 24 did not provide an adequate basis for the statement

that the risks of decommissioning can be demonstrated to be ALARP and that it was not adequately supported by referenced evidence. Much of the information on risks and their mitigation presented in the versions of the supporting submissions assessed with PCSR Chapter 24 was essentially general in nature (i.e. was not related to the design), did not discuss the relative magnitude of risks, and provided little evidence on why the generic design of the UK HPR1000 minimised risks during decommissioning.

321. I also had some reservations regarding the RP's planned scope of work during Step 4 of GDA, with respect to the absence of a plan to produce a detailed ALARP demonstration for decommissioning because of the inherent uncertainties associated with decommissioning of the generic UK HPR1000 design, with the RP planning to leave this to the licensee. I considered the RP's position to be inconsistent with the expectation in NS-TAST-GD-005 (Ref. 6) that there should be a stringent demonstration of ALARP in applying a precautionary approach to protect future generations for long-term projects.

322. Overall I considered the RP had not provided sufficient information to enable me to reach a judgement on whether relevant risks associated with decommissioning will be reduced to ALARP. I thus issued Regulatory Observation RO-UKHPR1000-0042 (Ref. 47) to seek to remedy the shortfall identified. I asked the RP to produce a suitable and sufficient justification that the relevant risks associated with the decommissioning of the generic design of the UK HPR1000 are reduced to ALARP, which should be holistic and address all aspects relevant to the risks. I asked for the overall justification to balance health, safety and environmental aspects, in an optimised manner, which is an expectation of NS-TAST-GD-005 (Ref. 6). I also emphasised the expectations of NS-TAST-GD-005 (Ref. 6) with respect to the long term aspects of decommissioning in the RO.

323. In response the RP produced the 'ALARP Demonstration for Decommissioning of the UK HPR1000' (Ref. 19). The objectives of this submission are to demonstrate that decommissioning of the generic UK HPR1000 design can be undertaken safely with the associated risks reduced to ALARP and provide the basis of evidence underpinning Claim 5, 5.1 and 5.2 and sub-claims 5.1SC.24.1, 24.3 and 24.4 in PCSR Chapter 24. As noted in Section 3 the focus is on the main tasks of POCO and decontamination, dismantling of the main equipment and the dismantling/demolition of buildings.

324. (Ref. 19) refers to the supporting submissions assessed in sub-sections 4.2 – 4.9 of this report. It also provides information on key assumptions and an overview of the ALARP methodology. It provides a holistic review of design for decommissioning, including the evolution of the generic design of the UK HPR1000 from earlier designs of Chinese PWRs and an overview of the main improvements relevant to decommissioning. It provides a summary of key design measures to facilitate decommissioning, which I have assessed in sub-section 4.7 of this report.

325. In (Ref. 19) the most significant element is the preliminary decommissioning risk assessment, based on the main decommissioning tasks defined by the RP. The RP has applied a qualitative risk assessment methodology based on OPEX to identify the main hazards and assign qualitative consequences and likelihood for the various decommissioning tasks. The RP has assessed the "inherent" risk, defined as the level of risk in the absence of controls/mitigating measures and the "residual" risk after design measures or application of other measures, based on the well-established risk control principles of Elimination, Reduction, Isolation, Control and Protection (ERICP). The RP notes the ERICP approach cannot be fully applied at the GDA stage because there is insufficient information relating to operator dependent tasks. I accept the RP's stated position with respect to the scope of application of ERICP to decommissioning tasks for the GDA stage.

326. The RP has provided a preliminary definition of the decommissioning activities and tasks for decontamination and the dismantling of the main equipment and buildings. It has

used these to assess the inherent risks and identify the design and other control/mitigation measures to assess residual risks. The main risks identified are direct and indirect radiation exposure (where indirect exposure means arising from contamination) and conventional industrial risks, with separate consideration of impacts and dropped loads. The RP also presents control measures by the lifecycle stage at which they are applied, i.e. design, operation and decommissioning. The risk assessment is set out in detail in appendices which draw on the relevant supporting submissions. The RP has also considered key experience and lessons from decommissioning OPEX. I consider the main risks identified to be appropriate for decommissioning.

327. The RP has summarised the outcome of the risk assessment for the three main activities (decontamination and equipment and building dismantling) and has concluded that the residual risks are moderate and that all reasonably practicable steps have been taken to reduce the risks to ALARP, commensurate to GDA stage and scope. It also concluded that the design incorporates suitable and sufficient features that facilitate decommissioning to enable the generic UK HPR1000 design to be decommissioned safely.

328. I assessed the 'ALARP Demonstration for Decommissioning of the UK HPR1000 '(Ref. 19) and sought clarification of a small number of matters by means of RQ-UKHPR1000-1696 (Ref. 40). I asked for evidence supporting the RP's position in the submission that appropriate steps have been taken at the design stage to prevent the foreclosure of decommissioning options. In its response the RP referred to (Ref. 24) to provide evidence that the design of components such as cranes do not require specific decommissioning techniques, and other information that the techniques identified in the supporting submissions provide a large set of options for future decommissioning, a position with which I concur.

329. I also asked for specific information on which operations would need to be carried out remotely based on an assumed strategy of prompt dismantling. The RP identified that prompt dismantling forecloses non-remote options for the dismantling of equipment with high levels of radioactivity (e.g. RPV, RVI and CDRMs and decontamination of the primary circuit) but notes that deferring decommissioning would allow a future operator to consider options other than remote dismantling, a position with which I also concur. I asked a small number of questions seeking a sample of evidence relating to the design of structures and components relevant to decommissioning. I considered the responses to RQ-UKHPR1000-1696 to be adequate.

330. In reaching an overall judgement on whether relevant risks of decommissioning have been reduced to ALARP and thus whether RO-UKHPR1000-0042 can be closed, I have carefully considered the totality of the evidence in (Ref. 19) and the other submissions supporting PCSR Chapter 24, which I have assessed in sub-sections 4.2 – 4.9 of this report, with focus on design for decommissioning (sub-section 4.7).

331. While the submission (Ref. 19) would have benefitted from improved cross-referencing to the other supporting submissions in terms of the evidence cited and more focus on the most significant contributors to risk reduction (e.g. FSD and underwater dismantling), I consider it has adequately addressed the intent of the RO, when taken in conjunction with the other submissions. The submission provides a more holistic consideration of decommissioning than hitherto and the preliminary risk assessment is fit for purpose in terms of qualitatively assessing risks and identifying control and mitigation measures.

332. The RP has explicitly identified elements of ERICP, such as reduction of the decommissioning source term, for the various control and mitigation measures, thereby demonstrating its understanding of how the measures reduce risks. It has made good use of OPEX, although the linkage from lessons learned to the measures in the generic UK HPR1000 design would have benefitted from being more explicit. The submission

has provided improved referencing to detailed documents such as the System Design Manuals and Technical Specifications, which improves the demonstration of the “golden thread” from PCSR Chapter 24 to supporting submissions.

333. I consider the RP’s assessment of risks is adequate for the stage of the development of the generic UK HPR1000 design and as noted elsewhere in this report, future operation and maintenance will have a material impact on the risks that will be encountered after the end of operation. I consider the RP’s qualitative approach to the identification of risks and control/mitigation for decommissioning to be proportionate and appropriate and will provide useful information to the licensee planning the decommissioning of the UK HPR1000. I also consider the RP’s approach to be consistent with the guidance in NS-TAST-GD-005, ONR’s TAG on ALARP, in that it focuses on good practice (as evidenced by consideration of OPEX) and the hierarchy of risk controls. Whilst it is not possible to provide a quantitative risk assessment, I consider the RP has satisfied the expectation in SAP SC.3 relating to control of the hazard, that takes into account the implications from previous stages and for future stages in its assessment of risks for decommissioning in (Ref. 19) and the other supporting submissions to PCSR Chapter 24.

334. I have noted elsewhere in this report where I consider the design and proposed decommissioning techniques to be significant contributors to reducing risks to ALARP, such as FSD, removal of SGs in one piece and underwater dismantling. In addition, as supported by the independent judgement of my TSC (Ref. 68), the overall generic safety case for the UK HPR1000 satisfies the expectations of ONR SAP DC.1 on design for decommissioning, which is a key consideration for the GDA stage. I consider the RP’s approach to producing the safety case for decommissioning of the generic UK HPR1000 design compares favourably to that for existing nuclear facilities in the UK, noting the stage of its development.

335. I consider the ‘ALARP Demonstration for Decommissioning of the UK HPR1000’ (Ref. 19) and the information in the other supporting submissions provide an adequate demonstration that relevant risks of decommissioning are reduced to ALARP, commensurate to the GDA stage. I have therefore closed RO-UKHPR1000-0042 as documented in (Ref. 83). I also consider the RP has provided adequate evidence to substantiate the relevant claims and sub-claims.

4.10.4 Strengths

336. The key strengths/positive aspects of the safety case as it relates to the demonstration that relevant risks of decommissioning of the generic UK HPR1000 design have been reduced to ALARP are:

- The RP has provided a qualitative risk assessment for decommissioning based on identification of activities and tasks that is appropriate and proportionate to the stage and scope of GDA.
- The RP has made good use of international OPEX in identifying risks and control/mitigation measures for the decommissioning of the generic UK HPR1000 design.

4.10.5 Outcomes

337. I have not identified any Assessment Findings or minor shortfalls.

4.10.6 Conclusion

338. I concluded the information provided by the RP in PCSR Chapter 24 did not initially meet relevant regulatory expectations with respect to demonstrating that relevant risks have been reduced to ALARP. However, I consider the information provided in the

'ALARP Demonstration for Decommissioning of the UK HPR1000' (Ref. 19) produced in response to RO-UKHPR1000-0042 and updated supporting submissions now provides an adequate demonstration. The information is also adequate to substantiate the relevant claims and sub-claims.

4.11 Consolidated Safety Case

4.11.1 Assessment

339. I assessed the version of PCSR Chapter 24 issued at the beginning of Step 4 (Ref. 3), which included a Forward Action Plan, and referred to its supporting submissions. I raised a number of RQs and one RO, as discussed in sub-sections 4.2 – 4.10 in this report. In its responses the RP committed to incorporation of some or all of the information into the safety case, mostly by means of updates of supporting submissions and in the case of the RO, issue of a new submission (Ref. 19). The purpose of this section is to document my consideration of the RP's consolidation of the RQ and RO responses into the generic safety case for decommissioning.

340. The RP has maintained a 'Commitment Capture Log' which identifies the work planned to address matters such as RQ responses and other interactions with the regulators and tracks progression to completion, which the RP has submitted monthly to ONR. I have used the most up-to-date issue of this log (Ref. 84) to identify the work identified by the RP for the majority of RQs I have issued. I then reviewed the relevant submissions to check whether the information has been incorporated as planned. I have also noted in earlier sub-sections examples where I consider the RQ responses have been adequately incorporated.

341. In addition the TSC providing support to me on design for decommissioning reviewed the adequacy of the incorporation of relevant RQ responses into the updated submission 'Consistency Evaluation for Design of Facilitating Decommissioning' (Ref. 24), which is documented in its report (Ref. 68).

342. The RP identified some RQ responses where they would expect the necessary work to be carried out during the site specific phase, examples of which include RQ-UKHPR1000-1252 (Ref. 40) on records and some aspects of the response to RQ-UKHPR1000-0996 (Ref. 40) on the dismantling of SGs. These have been documented in the Commitment Capture Log (Ref. 84), which I understand is planned to be passed on to the licensee. In its RQ responses the RP was clear about the information it did not intend to incorporate into updated submissions which was either clarification or addressed in other RQ responses or other submissions.

343. On the basis of the evidence of my review I consider the RP has adequately incorporated the RQ responses into the updated submissions, with the exception of one aspect of the response to RQ-UKHPR1000-1696 (Ref. 40) relating to the risk of emptying of the refuelling cavity. The response indicated the information on this risk is available elsewhere in the safety case, so I consider further work to be unnecessary.

344. The TSC considered the RP had adequately incorporated the responses to the RQs issued on design for decommissioning, except in two cases. The first related to RQ-UKHPR1000-1255 (Ref. 40) on leak detection and monitoring capabilities. I assessed this matter in sub-section 4.7 and raised an Assessment Finding. The second related to the absence of incorporation of part of the response to RQ-UKHPR1000-1018 (Ref. 40) relating to minimum dimensions of the site layout to accommodate large equipment transportation (based on Fangchenggang NPP Unit 3). Transport outside buildings is outside the scope of GDA but the RP noted in the RQ response that the plant layout will be refined during the site-specific phase. I do not consider it necessary to raise a minor shortfall because it is outside the scope of GDA. Overall, I consider the RP's

consolidation of RQ responses into the updated submissions adequate in fulfilling the intended purpose.

345. With respect to the incorporation of the response to RO-UKHPR1000-0042 (Ref. 47) into the safety case, the RP produced the ‘ALARP Demonstration for Decommissioning of the UK HPR1000’ (Ref. 19) during Step 4, which I assessed in sub-section 4.10. This is an important part of the underpinning of the safety case and thus should be referenced in PCSR Chapter 24 as part of the demonstration of the golden thread from claims to evidence.

346. The RP issued an updated version of PCSR Chapter 24 close to the end of the GDA process. I have reviewed PCSR Chapter 24 (Version 002) (Ref. 85), to identify whether it incorporates the response to RO-UKHPR1000-0042 (Ref. 47) and RQ responses where relevant (most notably RQ-UKHPR1000-1512 and 1696, (Ref. 40)) and reviewed progress against the Forward Action Plan. I have also checked whether the safety case as it exists at the end of GDA is consistent with the submissions and RQ/RO responses I have assessed and on which I have based my judgements.

347. On the basis of my review I consider the RP has adequately consolidated the response to RO-UKHPR1000-0042 (Ref. 47). The RP has revised the section on ALARP assessment to provide a summary of the ‘ALARP Demonstration for Decommissioning of the UK HPR1000’ (Ref. 19), which is now a reference to PCSR Chapter 24. Elements relating to decommissioning strategy have also been improved to reflect the information in the responses to RQ-UKHPR1000-1512 and 1696 (Ref. 40).

348. The version of PCSR Chapter 24 issued at the beginning of Step 4 (Ref. 3) included a “Route Map of Decommissioning” which listed the various sections of PCSR Chapter 24 and supporting submissions addressing the claims and sub-claims. The RP has substantially revised this table in the updated PCSR Chapter 24 (Version 002) (Ref. 85) to define specific evidence against the claims and sub-claims against which the sub-chapters, supporting submissions and other references are listed. This includes a significantly increased list of references from the overall safety case supporting Claim 5.1 and Sub-claim 5.1.SC24.1 (the design features facilitate safe and effective decommissioning). The Route Map now includes references on broader aspects such as material selection, reactor chemistry and various aspects of the System Design Manuals. This provides an improved demonstration of the golden thread from claims to evidence on design for decommissioning. I also note the RP has revised the supporting submissions to include specific references to the relevant claims and sub-claims. The RP has completed all Forward Action Plan items.

349. In conclusion I consider the RP has adequately consolidated RQ and RO responses into the safety case for decommissioning and that the updated safety case, including the supporting submissions, is consistent with the safety case I have assessed.

4.11.2 Strengths

350. The key strengths/positive aspects relating to consolidation of the safety case are:

- The RP has adequately consolidated RQ and RO responses into the safety case.
- The RP has improved the presentation of the golden thread from claims to evidence and its demonstration that risks have been reduced to ALARP in the updated version of PCSR Chapter 24 and its supporting submissions.

4.11.3 Outcomes

351. I have not identified any Assessment Findings or minor shortfalls.

4.11.4 Conclusion

352. I consider the RP has adequately consolidated RQ and RO responses into the safety case for decommissioning and that the updated safety case, including the supporting submissions, is consistent with the safety case I have assessed.

4.12 Comparison with Standards, Guidance and Relevant Good Practice

353. I have compared the information in the RP’s safety case for decommissioning against standards, guidance and relevant good practice in sub-sections 4.2 – 4.10. The full list used is provided in section 2.4.3. I have mainly used the SAPs (Ref. 2) with focus on decommissioning and radioactive waste management, IAEA GSR Part 6 (Ref. 14) and NS-TAST-GD-026 and NS-TAST-GD-005, ONR’s TAGs on Decommissioning (Ref. 9) and ALARP (Ref. 6) respectively, noting these take account of international guidance such as the WENRA SRLs. The SAPs used are presented in Annex 1.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

354. This report presents the findings of my Decommissioning assessment of the generic UK HPR1000 design as part of the GDA process.

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

- The RP has derived the decommissioning source term using appropriate techniques underpinned by a verified and validated model and/or relevant OPEX. The conservatism applied is appropriate to address uncertainties, meets relevant regulatory expectations and is appropriate to GDA. It provides an appropriate basis for the preliminary assessment of radiological risks and estimating arisings of decommissioning wastes.
- The selected decommissioning strategy of immediate dismantling is adequately underpinned, meets relevant regulatory expectations and is consistent with relevant UK policies. The strategy is integrated with the radioactive waste management strategy, does not foreclose other decommissioning options and is appropriate to the stage of the lifecycle of the generic UK HPR1000 design and GDA.
- The RP has taken due account of international decommissioning OPEX, which meets relevant regulatory expectations.
- The RP has provided information on decontamination techniques and processes which meets relevant regulatory expectations and is appropriate to GDA. The information is adequate to substantiate the sub-claim that the generic UK HPR1000 design can be decommissioned using current methods and technologies, as they relate to decontamination. I expect the proposed application of Full System Decontamination to be a significant contributor to reducing the risks of decommissioning.
- The RP has provided information on dismantling activities that meets relevant regulatory expectations and is appropriate to GDA. The information is adequate to substantiate the claims and sub-claims that the design and intended operation will facilitate safe decommissioning and can be decommissioned using current methods and technologies, as they relate to dismantling. I expect the dismantling methods proposed, particularly for high activity components and the SGs, to be significant contributors in reducing the risks of decommissioning.
- The RP has provided information on design for decommissioning that meets relevant regulatory expectations, most notably SAP DC.1, and is appropriate to GDA. The information substantiates the claims and sub-claims that the design and intended operation will facilitate safe decommissioning. The measures identified will be significant contributors in reducing the risks of decommissioning.
- The RP has provided information on the management of decommissioning wastes which meets relevant regulatory expectations and is appropriate to GDA. The information substantiates the relevant sub-claim that disposal routes are available (or will be available) for waste arising during decommissioning.
- The RP has provided information on planning for decommissioning that meets relevant regulatory expectations and is appropriate to GDA. The information is also adequate to substantiate the relevant claims and sub-claims. I consider the RP has not provided adequate information on records for decommissioning to fully meet the relevant SAP and substantiate the relevant sub-claim.
- The RP has provided an adequate demonstration that relevant risks of decommissioning are reduced to ALARP. The information provided also substantiates relevant claims and sub-claims.
- The RP has adequately consolidated RQ and RO responses into the generic safety case for decommissioning and the updated safety case, including the supporting submissions, is consistent with the safety case I have assessed.

- Overall, I consider the RP has provided adequate evidence to meet the expectations of the relevant SAPs and TAGs and international guidance on decommissioning, appropriate to GDA.
- I have identified five Assessment Findings and three minor shortfalls.

356. 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 Decommissioning perspective.

5.2 Recommendations

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

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

- **Recommendation 2**: The five Assessment Findings identified in this report should be resolved by the licensee for a site-specific application of the generic UK HPR1000 design.

6 REFERENCES

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Annex 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
DC.1	Design and operation	Facilities should be designed and operated so that they can be safely decommissioned.
DC.2	Decommissioning strategies	A decommissioning strategy should be prepared and maintained for each site and should be integrated with other relevant strategies.
DC.3	Timing of decommissioning	The safety case should justify the continuing safety of the facility prior to its decommissioning. Where adequate levels of safety cannot be demonstrated, prompt decommissioning should be carried out and, where necessary prompt remedial and operational measures should be implemented to reduce the risk.
DC.4	Planning for decommissioning	A decommissioning plan should be prepared for each facility that sets out how the facility will be safely decommissioned.
DC.5	Passive safety	Facilities should be made passively safe before entering a care and maintenance phase.
DC.6	Planning for decommissioning	Documents and records that may be required for decommissioning purposes should be identified, prepared, updated, retained and owned so that they will be available when needed.
DC.9	Decommissioning safety case	A safety case should be provided to demonstrate the safety of the decommissioning plan and its associated decommissioning activities and then kept up to date as the work progresses.
RW.1	Radioactive Waste Management 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 prevent 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 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 passive 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.
SC.3	Lifecycle aspects	For each lifecycle stage, control of the hazard should be demonstrated by a valid safety case that takes into account the implications from previous stages and for future stages.
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.
RP.5	Decontamination	Suitable and sufficient arrangements for decontaminating people, the facility, its plant and equipment should be provided.
ENM.3	Transfers and accumulation of nuclear matter	Unnecessary or unintended generation, transfer or accumulation of nuclear matter should be avoided.
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.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.
ECV.7	Leakage monitoring	Appropriate sampling and monitoring systems should be provided outside the containment to detect, locate, quantify and monitor for leakages and escape of radioactive material from the containment boundaries.

Annex 2

Assessment Findings

Note: These Assessment Findings must be read in the context of the sections of the report listed in this table, where further detail is provided regarding the matters that led to the findings being raised.

Number	Assessment Finding	Report Section
AF-UKHPR1000-0172	The licensee shall, as part of detailed design, demonstrate that leakage detection and monitoring capabilities are included in the design requirements for facilitating decommissioning. This should include all relevant structures, systems and components in contact with radioactive fluids.	4.7.3
AF-UKHPR1000-0173	The licensee shall, as part of detailed design, implement controls to minimise the accumulation of contamination as part of the design of structures, systems and components other than piping. This should ensure proportionate design measures to prevent contamination are applied to all relevant structures, systems and components in contact with radioactive fluids.	4.7.3
AF-UKHPR1000-0174	The licensee shall, as part of detailed design, demonstrate the use of construction techniques that reduce risks to as low as reasonably practicable during decommissioning.	4.7.3
AF-UKHPR1000-0175	The licensee shall ensure that the design requirements for facilitating decommissioning in the generic safety case are fully identified and implemented in the detailed design and site-specific aspects and are included in the safety case.	4.7.3
AF-UKHPR1000-0176	The licensee shall ensure that documents and records required for decommissioning purposes are included in site-specific operating documentation, which should address site-specific aspects and detailed design. As a minimum, the arrangements should address the shortfall identified during GDA.	4.9.3