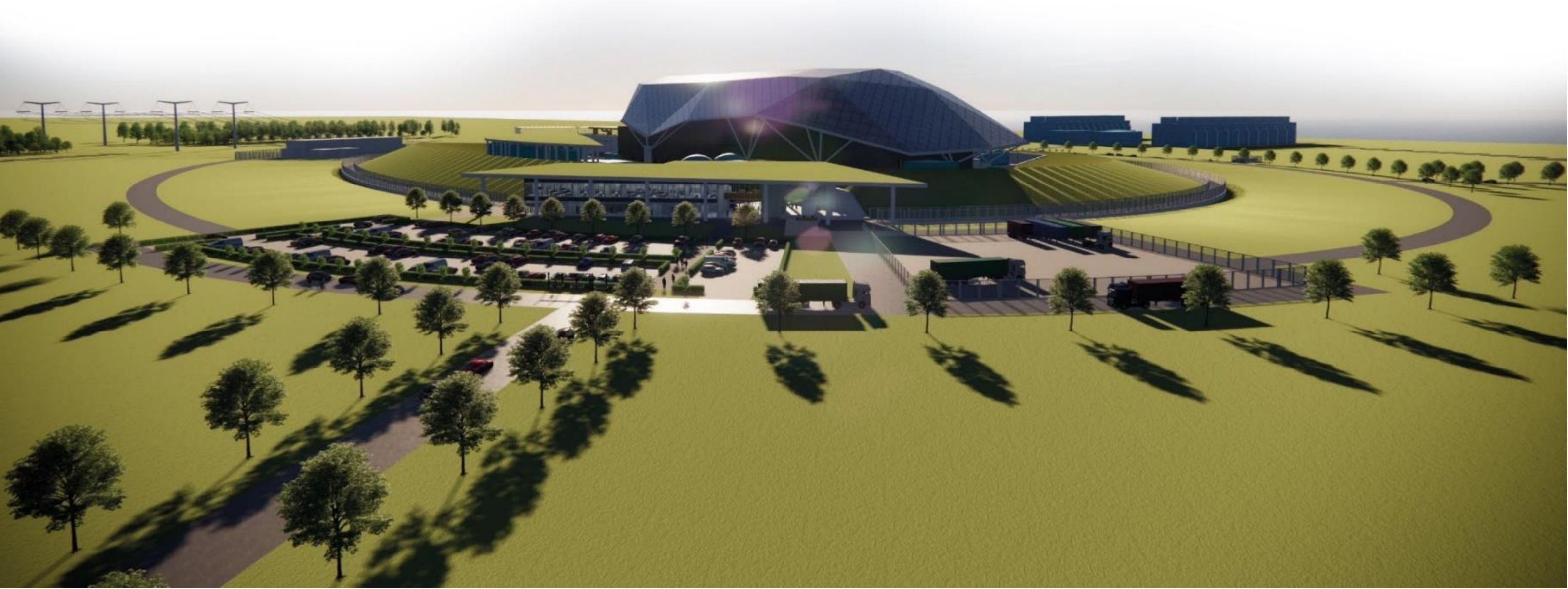
Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 11: Management of Radioactive Wastes



Record of Change

Date	Revision Number	Status	Reason for Change
March 2023	1	Issue	First version of E3S Case
February 2024	2	Issue	Second issue to reflect DRP1
May 2024	3	Issue	Updated to correct revision history status at Issue 2. Chapter changes include: • Amendment to section 11.2.10 • Removal of 'Simplified flow diagram of an HVAC system serving a controlled area' figure in section 11.3.3.2 • Further information added to section 11.4.10 • Addition of a future dutyholder/licensee/permit holder commitment to develop a records' management plan/strategy (section 11.4.15) • Additional detail within conclusions section for how arguments and evidence presented meet the generic E3S Case objective (section 11.5) • Addition of claims, arguments, evidence table in Appendix A (section 11.7) Minor template/editorial updates for overall E3S Case consistency.
June 2025	4	Preview	Updated for Version 3 of the generic E3S Case. Incorporates revisions of the site, plant and environmental information at Design Reference Point 4. Chapter changes include: • Increased clarity on golden thread and use of CAE and E3S requirements (Section 11.0.3). • Updated solid radioactive waste quantities in Section 11.1.2. • Inclusion of Fundamental Environmental Functions in Sections 11.2.2 and 11.4.2.
August 2025	4	Issue	Changes to Section 11.0.3 for consistency across the E3S Case. Information on the Gaseous Radioactive Effluent Treatment System [KPL] included in Section 11.3. Inclusion of simplified waste system schematics. Removal of operating parameter tables. Detail on Component Decontamination System [FKA] and HVAC systems [KL] removed and now in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems.

Executive Summary

Chapter 11 of the Rolls-Royce Small Modular Reactor (RR SMR) Environment, Safety, Security, and Safeguards (E3S) Case presents the overarching summary of the RR SMR liquid, gaseous and solid radioactive waste systems based on Design Reference Point (DRP) 4 and describes the Radioactive Waste Management Arrangements (RWMA) for radioactive waste arisings, with reference made to supporting documents where appropriate.

The chapter summarises the arguments and evidence to underpin the top-level claims that 'Radioactive Waste Structure, System and Component (SSC) design ensures delivery of allocated E3S functions through-life', and 'Radioactive waste systems and arrangements are optimised and demonstrate that the generation of wastes and discharges are minimised for the lifecycle of the RR SMR'.

For each Radioactive Waste SSC in scope, the following aspects are summarised:

- Safety functions delivered by the SSC, and the assigned safety categorised functional requirements and non-functional system requirements.
- Fundamental Environmental Functions that the SSCs contribute to and where applicable, the potential Key Environmental Protection Equipment (KEPE) supporting that contribution.
- Design description, including architecture, layout, and operating modes.
- Key verification activities and evidence to support substantiation of SSCs up to DRP4

The design description for each SSC summarises how the E3S functions and requirements are achieved through the design definition. All SSCs are developed based on Relevant Good Practice (RGP) and Operational Experience (OPEX), and in accordance with the E3S design principles through the integrated E3S and engineering processes. This includes design to codes and standards according to the safety classification. The design has been evaluated and developed against E3S criteria to optimise the design and support risk reduction to As Low As Reasonably Practicable (ALARP) and demonstrating Best Available Techniques (BAT), secure/ safeguards/ sustainability by design. Evidence of Verification & Validation (V&V) is to be presented in future revisions of the chapter.

The RWMA for all forms of radioactive waste arising during commissioning, normal power operations and decommissioning are within the scope of this chapter.

The sources of radioactive waste from the operation and decommissioning of the RR SMR are described in this chapter, alongside the quantities of solid radioactive waste. Quantities of liquid and gaseous radioactive wastes are provided in E3S Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits.

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11.0 Introduction to Chapter

11.0.1 Introduction

This is Chapter 11 of the Rolls-Royce Small Modular Reactor (RR SMR) Environment, Safety, Security, and Safeguards (E3S) Case.

This issue of Chapter 11 presents the overarching summary of the RR SMR liquid, gaseous and solid radioactive waste systems based on Design Reference Point (DRP) 4 and describes the Radioactive Waste Management Arrangements (RWMA) for radioactive waste arisings, with reference made to supporting documents where appropriate.

The objectives of this chapter are to:

- Summarise the sources and predicted arisings of liquid and gaseous radioactive wastes, noting that further detail of these arisings is provided in E3S Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits [1].
- Describe the sources and predicted arisings of solid radioactive wastes and Spent Fuel (SF) over the lifecycle of the RR SMR noting that details on the management of SF is provided in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2].
- Describe the Structures, Systems and Components (SSCs) designed for the management of the anticipated RR SMR radioactive waste streams, noting that Auxiliary systems are described in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2].
- Identify potential Key Environmental Protection Equipment (KEPE) associated with the management of RR SMR radioactive wastes, in accordance with the method set out in Environmental Functions and Environmental Measures [3].
- Describe the proposed arrangements for managing radioactive waste arisings over the lifecycle of the RR SMR, and how these protect people and the environment.
- Summarise how the proposed RWMA have been derived from Relevant Good Practice (RGP) and meet the requirements of applicable legislation within the United Kingdom (UK)[1] and associated regulatory guidance.

11.0.2 Scope and Maturity

This chapter covers the SSCs as set out in Table 11.0-1. For each SSC in scope, the following aspects are summarised:

- Safety functions delivered by the SSC, and the assigned safety categorised functional requirements and non-functional system requirements.
- Fundamental Environmental Functions that the SSCs contribute to and where applicable, the potential KEPE supporting that contribution.
- Design description, including architecture, layout, operating modes, As Low As Reasonably Practicable (ALARP) and Best Available Techniques (BAT) considerations in the design development.

[1] It is considered that RWMA that meet UK regulatory requirements will also be acceptable in an international regulatory context. This is based upon international standards being used to frame UK national policy and legislation.

- Key verification activities and evidence to support substantiation of SSCs up to DRP4.

The RWMA for all forms of radioactive waste arising during commissioning, normal power operations and decommissioning are within the scope of this chapter. It must be noted that the level of information available on waste arisings varies between waste streams and systems, and the different lifecycle phases, reflecting the current maturity in the design of the RR SMR.

The lifecycle of the RR SMR is broken down into five phases as illustrated in Figure 11.0-1, noting that some SF and Higher Activity Waste (HAW) management and disposal will occur alongside commissioning and operation, and reactor decommissioning.

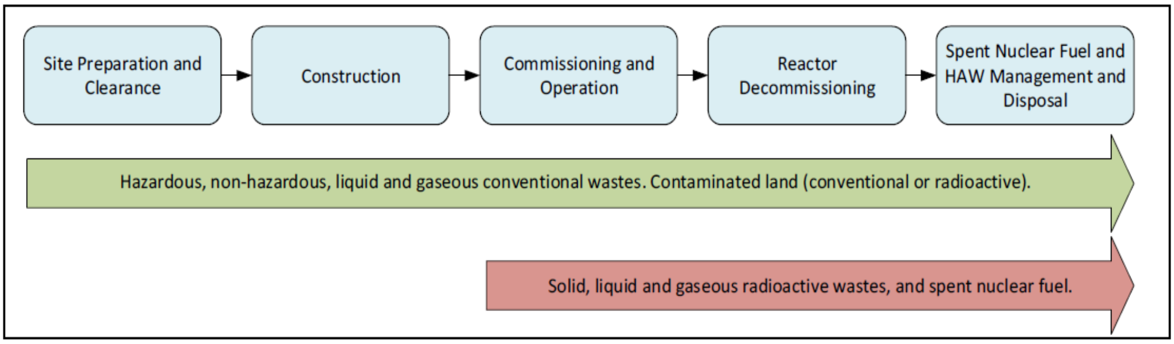

Figure 11.0-1: Overview of the Lifecycle Stages of the RR SMR

As shown in Figure 11.0-1, the types of waste produced over the lifecycle stages of the RR SMR will vary. SF and liquid/gaseous/solid radioactive wastes are expected to be produced only from the start of commissioning, operations and into decommissioning, whilst conventional waste (outside the scope of this chapter) may be expected to be produced throughout the RR SMR lifecycle. Whilst active commissioning may feasibly generate quantities of radioactive waste, any quantities generated would likely be very limited.

It is recognised that there is potential for radioactive waste from historical radioactive land contamination to be produced during the site preparation, clearance and construction phases, but this is a site-specific matter and out of scope of this chapter. The different types of radioactive waste that are expected to be produced are described in Section 11.1.

Further information on the RR SMR lifecycle stages and the relevance to waste arisings can be found in the Integrated Waste Strategy (IWS) Part 1 [4] and Part 2 [5].

The IWS Part 1 [4] and Part 2 [5], along with the Radioactive Waste Management Case (RWMC) [6] identified a number of Forward Actions associated with the management of radioactive wastes and it is not proposed to repeat these in this Chapter.

Process and effluent radiological monitoring and sampling systems are not within the scope of this chapter but are to be covered within E3S Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements [7] and E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2]. The quantification of radioactive liquid and gaseous discharges is covered within E3S Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits [1].

Table 11.0-1 presents the SSCs within the scope of Chapter 11. The following systems, presented in the list below are relevant to elements of the management of radioactive wastes but are not within the full scope of this Chapter:

- The Outfall Pond [UPK20] and Outfall Head [UPK30] are only discussed in relation to the discharge of liquid radioactive effluents to the environment within Section 11.1.3.

- The Reactor Island (RI) Emissions Stack [UKH] is only discussed in relation to the discharge of gaseous radioactive wastes to the environment in Section 11.1.3.
- The RI Heating, Ventilation and Air Conditioning (HVAC) System [KL] is an Auxiliary System and whilst contributes to the management of gaseous radioactive wastes, is primarily discussed in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2], with a brief overview provided in Section 11.3.5.
- The Component Decontamination System is an Auxiliary System and whilst contributes to the management of solid radioactive waste, is primarily discussed in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2], with a brief overview provided in Section 11.4.5.

Table 11.0-1: SSCs within the Scope of Chapter 11

Reference Designation System for Power Plants® (RDS-PP®)	SSCs	Section of Chapter 11
[KNF]	Liquid Radioactive Effluent Treatment System	11.2
[KNF10]	Processing and Treatment System for Primary Liquid Effluent	11.2
[KNF20]	Processing and Treatment System for Spent Liquid Effluent	11.2
[KNF30]	Liquid Effluent Monitoring and Discharge System	11.2
[KTA]	RI Collection and Drainage System	11.2
[KTA10]	Collection and Transfer of Reactor Coolant Drains	11.2
[KTA20]	Collection and Transfer of Process and Floor Drains	11.2
[KTA30]	Collection and Transfer of Chemical Drains	11.2
[KPL]	Gaseous Radioactive Effluent Treatment System	11.3
[KMA]	Solid Radioactive Waste Processing System	11.4
[KMA10]	Processing and Dispatch System for Low Level Waste (LLW)	11.4
[KMA20]	Processing and Treatment System for Intermediate Level Waste (ILW)	11.4
[KME]	Solid Radioactive Waste Storage System	11.4
[KME10]	Temporary storage for LLW	11.4
[KME20]	Temporary storage for wet ILW	11.4

Reference Designation System for Power Plants® (RDS-PP®)	SSCs	Section of Chapter 11
[KME30]	Solid ILW Store	11.4

The RR SMR radioactive waste systems within Table 11.0-1 are formally defined at the DRP4 level of design maturity at time of writing and have all achieved final concept.

The design of civil structures, bunds and liners etc. are not in scope of this Chapter and reference should be made to E3S Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures [8].

11.0.3 Claims, Arguments and Evidence Route Map

The E3S Case employs a Claims, Arguments, Evidence (CAE) framework to provide a structured demonstration that the RR SMR achieves the E3S fundamental objective 'to protect people and the environment from harm' through compliance with the E3S design principles, as described in E3S Case Version 3, Tier 1, Chapter 1: Introduction [9]. The CAE framework is presented in the E3S Case Route Map [10].

The claims decomposition for Chapter 11 is developed from the Chapter 3 claim that 'the fundamental functions are achieved through-life' [11]. Chapter 11 primarily presents information to cover the first level sub-claims [Sub-Claim 11.1] 'Radioactive Waste SSC design definition ensures the delivery of their E3S functions through-life', and [Sub-Claim 11.2] 'Radioactive waste systems and arrangements are optimised and demonstrate that the generation of wastes and discharges are minimised for the lifecycle of the RR SMR', both of which are further decomposed into sub-claims described below.

Given the evolving nature of the generic E3S Case alongside the detailed design, some of the underpinning arguments and detailed evidence remain under development. The conclusions of the chapter therefore provide an evaluation of how the arguments and evidence presented, and their trajectory, provide confidence in the case achieving its objective at this stage.

[Sub-Claim 11.1.1] Radioactive Waste SSC design ensures delivery of allocated E3S functions through-life.

[Sub-Claim 11.1.1.1] E3S requirements are adequately specified for the SSC to achieve its E3S functions through-life.

Arguments and evidence covering the claims is summarised in:

- Section 11.2.2, which summarises the design bases for the systems for the management of liquid radioactive wastes.
- Section 11.3.2, which summarises the design bases for the systems for the management of gaseous radioactive wastes.
- Section 11.4.2, which summarises the design bases for the systems for the management of solid radioactive wastes.

[Sub-Claim 11.1.1.2] SSC design definition ensures the delivery of their E3S functions through-life.

Arguments and evidence covering the claims is summarised in:

- Sections 11.2.3 to 11.2.10, which summarise the optimised design definition to achieve the E3S functions and an evaluation of the performance and safety of the liquid radioactive waste management systems.
- Sections 11.3.3 to 11.3.10, which summarise the optimised design definition to achieve the E3S functions and an evaluation of the performance and safety of the gaseous radioactive waste management systems.
- Sections 11.4.3 to 11.4.10, which summarise the optimised design definition to achieve the E3S functions and an evaluation of the solid radioactive waste management systems.

[Sub-Claim 11.2.1] Radioactive waste management and disposal strategies and plans adopt the waste management hierarchy and apply BAT.

Arguments and evidence covering the claim is summarised in:

- Sections 11.2.3, 11.3.3, and 11.4.3, which provide summary descriptions for the waste management systems for liquid, gaseous, and solid radioactive wastes respectively.

[Sub-Claim 11.2.2] Radioactive wastes (solid, non-aqueous) and SF arisings are quantified, understood and minimised over lifecycle of RR SMR.

Arguments and evidence covering the claims is summarised in:

- Section 11.1.1, which summarises the sources of radioactive wastes within a RR SMR.
- Section 11.1.2, which summarises the quantities of radioactive wastes.
- Section 11.1.3, which summarises the disposal of radioactive wastes.
- Section 11.1.4, which summarises the radioactive waste management strategies and principles.

The proportionate summary of the arguments and evidence draws upon information in Tier 2 and Tier 3 documentation as presented in the E3S Case Route Map [10].

Sub-claim 11.2.1 and the minimisation of radioactive wastes over the lifecycle of RR SMR aspect of sub-claim 11.2.2 are both heavily supported by E3S Case Version 3, Tier 1, Chapter 27: Demonstration of Best Available Techniques [12].

In addition to E3S Case Version 3, Tier 1, Chapter 27: Demonstration of Best Available Techniques [12], aspects of the CAE for Chapter 11 are further evidenced across other E3S Case Version 3 chapters, including:

- Claims that measures are assigned safety functions based on credible Postulated Initiating Events (PIEs) and classified according to the E3S significance of the functions they deliver, are covered in E3S Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [11].
- Claims that the reactor (fuel and core) is conservatively designed and verified to deliver E3S functions through-life are covered in E3S Case Version 3, Tier 1, Chapter 4: Reactor (Fuel and Core) [13].
- Claims on the Control and Instrumentation (C&I) and electrical systems to deliver functions allocated from engineered safety features are covered in E3S Case Version 3, Tier 1, Chapter 7: Control & Instrumentation [14] and E3S Case Version 3, Tier 1, Chapter 8: Electrical Power [15] respectively.
- Claims on civil structures to provide waste system functions are covered in E3S Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures [8].

- Claims that the safety analysis (including deterministic, probabilistic, internal and external hazards) demonstrates that safety functions allocated to measures are achieved for all PIEs and acceptance criteria are met, are covered in E3S Case Version 3, Tier 1, Chapter 15: Safety Analysis [16].
- Claims that safe operational limits and conditions are defined and covered in E3S Case Version 3, Tier 1, Chapter 16: Operational Limits and Conditions [17].
- Claims to justify the allocation of operator actions to deliver measures, and their substantiation, are covered in E3S Case Version 3, Tier 1, Chapter 18: Human Factors Engineering [18].
- Claims on the optimisation of the chemistry regime to minimise degradation of SSCs are covered in E3S Case Version 3, Tier 1, Chapter 20: Chemistry [19].
- Claims to justify the structural integrity of safety classified SSCs are covered in E3S Case Version 3, Tier 1, Chapter 23: Structural Integrity [20].
- Claims that holistically the plant can reduce risks to ALARP, and ensure security and safeguards by design are covered in E3S Case Version 3, Tier 1 Chapters 24 [21], 32 [22], and 33 [23] respectively.

11.0.4 Applicable Regulations, Codes and Standards

Regulations, codes and standards, alongside policies and strategies, are applicable to both the development of RWMA, and the design, of mechanical systems and components.

Publications from international organisations such as the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators' Association (WENRA) are used to frame UK national policy and legislation. It is therefore considered that by meeting UK regulatory requirements, Rolls-Royce SMR Limited's waste management arrangements will be acceptable in an international regulatory context. Reference should be made to the IWS – Part 1 [4] for more detail on those publications which are applicable to the development of RWMA.

The mechanical systems and components summarised in this chapter are designed in accordance with their safety classification, to the codes and standards outlined in Table 11.0-2, as identified in [24].

Table 11.0-2: Summary of RR SMR Codes and Standards

Safety classification	Design basis code
VHR	American Society of Mechanical Engineers (ASME) III (Sub-section NB) and beyond code requirements
HR	ASME III (Sub-section NB) and beyond code requirements
Class 1	ASME III
Class 2	ASME III
Class 3	ASME III or Commercial standards e.g., ASME VIII, British Standard (BS) EN 13445 (with nuclear supplements added depending on potential dose levels)

Safety classification	Design basis code
n/a	Commercial standards e.g., ASME VIII, BS EN 13445

11.1 Sources of Radioactive Waste

11.1.1 Sources of Radioactive Waste Within a RR SMR

11.1.1.1 Sources of Liquid Radioactive Wastes

11.1.1.1.1 Sources of Liquid Radioactive Wastes During Commissioning and Operations

Fuel rods, comprising fuel pellets and rod cladding, are the largest source of fission products in the RR SMR, which are formed as a result of the controlled processes in the generation of electricity in a Nuclear Power Plant (NPP). These fission products can be released into the primary coolant and the supporting purification systems e.g. the Coolant Purification System [KBE], resulting in liquid radioactive effluents (see E3S Case Version 3, Tier 1 Chapter 5: Reactor Coolant Systems and Associated Systems [25]).

Liquid radioactive effluents are categorised and segregated based on their source and expected levels of contamination, noting that this section only covers aqueous wastes. Information on the sources of Non-Aqueous Phase Liquids (NAPLs) is provided in Section 11.1.1.3. Two primary sources of liquid radioactive effluents have been characterised for the RR SMR [26]:

- Primary liquid effluent originating from:
    - The Chemical and Volume Control System (CVCS) [KB] letdown and the drainage of primary coolant to the Reactor Coolant Drain Tank (RCDT) in the Collection and Transfer of Reactor Coolant Drains [KTA10].
    - On start-up, coolant let down volume due to thermal expansion of reactor and pressuriser coolant.
    - On shutdown, reactor coolant let down before Reactor Pressure Vessel (RPV) head removal.
- Spent liquid effluent comprising several effluent streams originating from different sources, collected by the sumps and vessels of the RI Collection and Drainage System [KTA]. Spent liquid effluent comprises the following categories:
    - Process drains – effluent derived from equipment drainage for maintenance, testing, or safety relief etc.
    - Chemical drains – effluent derived from chemical sampling, equipment decontamination and supernatant from resin flushing/sluicing and filter backwashing.
    - Floor drains – effluent derived from leaks and floor washings. Floor drains are segregated into active and non-active (conventional), depending upon layout based upon radiological contamination zoning, and potential failure modes and maintenance activities.
    - Contaminants that could be detrimental to the performance of the effluent treatment process are expected to be identified and captured. This is subject to further development.

11.1.1.1.2 Sources of Liquid Radioactive Wastes During Decommissioning

Liquid radioactive effluents generated during decommissioning cannot be returned to operational systems after they have been removed from service and therefore will require alternative and appropriate treatment, conditioning, or discharge in line with environmental permit conditions. The effluent may arise from decontamination operations, system draining, or components cleaning and may contain particulates, dissolved radionuclides, and chemically active species.

11.1.1.2 Sources of Gaseous Radioactive Waste

11.1.1.2.1 Sources of Gaseous Radioactive Waste During Commissioning and Operations

Active gaseous effluents can be separated into two main categories, which differ in activity levels and filtration techniques deployed:

- Gaseous effluent including hydrogen and volatile fission products derived from the systems handling reactor coolant, primary circuit effluent or make-up water. The key sources of these gases during power operation are the vacuum degasser in the Liquid Radioactive Effluent Treatment System [KNF], routine gas venting from the Level and Volume Control System [KBA] Volume Control Tank (VCT), and gas bleed from the Reactor Coolant Pressurising System [JEF] pressuriser, which first passes through the Collection and Transfer of Reactor Coolant Drains [KTA10] RCDT. Routine venting of the Level and Volume Control System [KBA] VCT refers to the operator driven controlled venting of the VCT ullage via raising of the tank liquid level. These gases may contain radioactive fission and activation products (isotopes of krypton, xenon, argon and iodine), which require abatement before discharge.
- Gaseous effluent from the RI HVAC System [KL] systems that are installed in all Radiologically Controlled Areas (RCAs) (which may be referred to as HVAC air). The HVAC air is expected to contain a low level of activity, including particulates and sometimes iodine, resulting from fuel pin failures, for example.

The [KL] systems relevant to gaseous radioactive effluents, which are outside the scope of this chapter and are primarily covered within E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2], are:

- [KLA] – HVAC systems serving primary containment.
- [KLB] – HVAC systems serving the interspace.
- [KLC] - HVAC systems serving the controlled areas in RI.
- [KLF] – HVAC systems serving the waste processing areas in RI.
- [KLL] – HVAC systems serving the fuel storage and handling areas in RI.

11.1.1.2.2 Sources of Gaseous Radioactive Waste During Decommissioning

Gaseous radioactive waste arises from the disturbance, depressurisation, or dismantling of activated or contaminated systems and structures. These effluents may include tritium, volatile fission products (e.g., iodine, xenon, krypton), activation gases, or particulates mobilised during intrusive operations. Airborne contamination may also be generated through cutting, ventilation flow, or surface disturbance within controlled areas. Such emissions require capture, filtration, monitoring, and control prior to discharge in accordance with regulatory requirements.

11.1.1.3 Sources of Solid Radioactive Waste

11.1.1.3.1 Sources of Solid Radioactive Waste During Commissioning and Operations

The solid radioactive wastes expected to be generated by the RR SMR during normal operations (including Expected Events – See E3S Case Version 3, Tier 1, Chapter 15 – Safety Analysis [16]) have been identified and summarised in Table 11.1-1. Where the term 'boundary' has been used, this is to identify wastes that may arise as one waste category but after a period of decay storage and/or decontamination, could be disposed at a lower waste category (in terms of radioactivity).

Table 11.1-1: Summary of Operational Solid Radioactive Wastes

Main Waste Category	Sub-Category
SF	SF Assemblies
	Failed Fuel or damaged fuel rods/assemblies
Non-Fuel Core Components (NFCCs)	In-Core Monitoring (ICM) Assemblies – Probes
	Control Rod Assemblies (CRAs)
	Thimble Plug Assemblies (TPAs)
	Neutron Sources
	Control Rod Housing Columns (CRHCs)
	RPV Surveillance Capsules (RPVSCs)
Dry Solid ILW	Dry Active Waste (DAW)
Wet Solid ILW	[KBE] Ion Exchange (IX) Resins
	[KBE], [FAL], [KNF] and [LCQ] Suspended Filter Solids
	Sludges[2]
Dry Solid Boundary ILW/LLW	[KBE], [FAL] and [KNF] Removable Cartridge Filters[3]
	Reverse Osmosis (RO) Membranes
	Boundary ILW/LLW DAW[4]
	Miscellaneous operational waste
Wet Solid Boundary ILW/LLW	[KNF20], [FAL] and [LCQ] Spent IX Resins
	Evaporator Concentrates
Dry Solid LLW	Air Filters – High Efficiency Particulate Air (HEPA), coarse filters, fine filters and carbon filters

[2] Note that sludges are not anticipated to arise but have been included in recognition of a risk identified in the IWS
[3] These are backwashable filters that will need replacing at the end of their operating life.
[4] This waste stream is expected to be removed for Version 4 of the Generic E3S Case. DAW will either be referred to ILW or LLW.

Main Waste Category	Sub-Category
	Miscellaneous Operational Contaminated Maintenance Wastes
	LLW DAW
	Pool skimmer filters
	Ultrasonic filters
	[LCQ] Removable Cartridge Filters
NAPLs	Oils and Solvents
Wet Solid LLW	LLW sludges[2]

11.1.1.3.2 Sources of Solid Radioactive Waste During Decommissioning

A summary of decommissioning solid radioactive wastes is provided in Table 11.1-2.

Table 11.1-2: Summary of Decommissioning Solid Radioactive Waste

Main Waste Category	Waste Type / Source
SF	• Irradiated fuel assemblies removed from the reactor core during final offload at end of life, containing high levels of fission products, activation products, and actinides, • Damaged or failed fuel assemblies, if present, requiring specialist handling and potentially distinct storage or conditioning approaches.
NFCCs	• Rod Control Cluster Assemblies (RCCAs), • ICM Assemblies – Probes and Lances, • CRHCs, • RPVSCs.
Dry Solid ILW	• Reactor and primary circuit components (RPV and internal structures), • RPV Shielding.
Dry Solid Boundary ILW/LLW	• Waste Systems Contaminated Dismantling Waste – this waste stream will comprise primarily metallic materials (pipes, tanks, electrical components) in the form of size reduced irregular pieces.
Dry Solid LLW	• Metallic Waste - from the primary circuit or systems handling radioactive substances,

Main Waste Category	Waste Type / Source
	• Concrete waste - comprises wholly or majority concrete in either consolidated or broken up (i.e., rubble) form, • Secondary wastes and miscellaneous materials – comprise materials such as non-ferrous metals, gaseous delay bed charcoal, (instrument panels) electronics, items with internal contamination, composite materials, used Personal Protective Equipment (PPE), cleaning materials, filters, cutting residues, contaminated tools, absorbents and other process related waste generated during decommissioning.

11.1.2 Quantities of Waste

Reference should be made to E3S Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits [1] for details on the quantities of liquid and gaseous radioactive wastes. Summaries of the anticipated volumes of operational and decommissioning solid waste arisings are provided in Table 11.1-3 and Table 11.1-4 respectively. Waste volumes are predominantly taken from the latest operational waste inventory [27] and the decommissioning waste inventory [28]. Other volumes are taken from documents that have been produced in between updates of the operational and decommissioning waste inventories, including a supplementary technical information report [29] which removes the volumes for boundary ILW/LLW DAW and reduces the volume for expected miscellaneous operational waste arisings, and a report to support a Regulatory Query response clarifying SF arisings [30].

It should be noted that the volumes for resins arising from the Fuel Pool Purification System [FAL] are currently undergoing review pending feedback from suppliers that is taking into account the volume of resins within the IX columns and the likely replacement frequency. Further information on Fuel Pool Purification System [FAL] resins will be provided in Version 4 of the Generic E3S Case.

Table 11.1-3: Anticipated Quantities of Operational Solid Radioactive Waste

Main Waste Category	Sub-Category	Waste Volume
SF	SF Assemblies	Approximately 30 per year 1889 (lifetime arisings)[5]
	Failed Fuel or damaged fuel rods/assemblies	<1 assembly (lifetime arisings)
NFCCs	ICM Assemblies – Probes	3 (per cycle) 136 (lifetime arisings)

[5] Note that figures for SF are based on Spent Fuel Arisings to Support RQ-01074, SMR0022674 Issue 1, June 2025 [83].

Main Waste Category	Sub-Category	Waste Volume
	CRAs	13 (per cycle) 534 (lifetime arisings)
	TPAs	0.9 (per cycle) 37 (lifetime arisings)
	Neutron Sources	0.1 (per cycle) 4 (lifetime arisings)
	CRHCs	Upper Column: 3 (per cycle) 134 (lifetime arisings) Lower Column: 2 (per cycle) 94 (lifetime arisings)
	RPVSCs	0.2 (per cycle) 8 (lifetime arisings)
Dry Solid ILW	DAW	0.1 m^3 (per cycle) 4 m^3 (lifetime arising)
Wet Solid ILW	[KBE] IX Resins	1.6 m^3 (per cycle) 64 m^3 (lifetime arisings)
	[KBE] Suspended Filter Solids	0.02 m^3 (per cycle) 0.8 m^3 (lifetime arisings)
	[FAL] Suspended Filter Solids	0.02 m^3 (per cycle) 0.8 m^3 (lifetime arisings)
	[KNF] Suspended Filter Solids	0.24 m^3 (per cycle) 9.6 m^3 (lifetime arisings)
	[LCQ] Suspended Filter Solids	0.02 m^3 (per expected event)
	Sludges[6]	< 0.1 - 1.62 m^3 (per cycle) < 4 - 64.8 m^3 (lifetime arisings)

[6] Note that sludges are not anticipated to arise but have been included in recognition of a risk identified in the IWS.

Main Waste Category	Sub-Category	Waste Volume
Dry Solid Boundary ILW/LLW	[KBE], [FAL] and [KNF] Removable Cartridge Filters	42 filters (operational lifetime arisings) Note that 12 filters will arise as part of the decommissioning phase.
	RO Membranes	9.6 m^3 / 48 waste membranes (operational lifetime arisings) Note that 16 RO membranes will arise as part of the decommissioning phase.
	Boundary ILW/LLW DAW	0 m^3 (see footnote 4)
	Miscellaneous operational waste	0.98 m^3 (per cycle) 39.2 m^3 (lifetime arisings)
Wet Solid Boundary ILW/LLW	[KNF20], [FAL] and [LCQ] Spent IX Resins	[KNF20]: 0.7 m^3 (per cycle) 28 m^3 (lifetime arisings) [FAL]: To be Confirmed (TBC) by supplier [LCQ]: 0.7 m^3 (per event)
	Evaporator Concentrates	7.57 m^3 (per cycle) 302.8 m^3 (lifetime arisings)
Dry Solid LLW	Air Filters – HEPA, coarse filters, fine filters and carbon filters	3.24 – 21.2 m^3 (per cycle) 129.6 - 848 m^3 (lifetime arisings)
	Miscellaneous Operational Contaminated Maintenance Wastes	4.5 m^3 (per cycle) 180 m^3 (lifetime arisings)
	LLW DAW	0.6 m^3 (per cycle) 24 m^3 (lifetime arisings)
	Pool skimmer filters	TBC
	Ultrasonic filters	TBC
	[LCQ] Removable Cartridge Filters	2 (per event)

Main Waste Category	Sub-Category	Waste Volume
LLW NAPLs	Oils and Solvents	0.03 - 1.7 m^3 (per cycle) 1.2 – 68 m^3 (lifetime arisings)
Wet Solid LLW	LLW sludges[2]	< 0.1 - 1.62 m^3 (per cycle) < 4 - 64.8 m^3 (lifetime arisings)

Table 11.1-4: Anticipated Quantities of Decommissioning Solid Radioactive Waste

Main Waste Category	Sub-Category	Decommissioning Waste Volume
Dry Solid ILW	Activated primary circuit dismantling waste	241.51 m^3
	RPV Shielding	17.86 m^3
Dry Solid Boundary ILW/LLW	Waste systems contaminated dismantling waste – this waste stream will comprise primarily metallic materials (pipes, tanks, electrical components) in the form of size reduced irregular pieces	915.12 m^3 (expected to be disposed as LLW) 16.59 m^3 (expected to be disposed as ILW)
Dry Solid LLW	Metallic Waste	6828.03 m^3
	Concrete Waste	7776.49 m^3
	Secondary wastes and miscellaneous materials	1310.23 m^3

11.1.3 Disposal of Waste

11.1.3.1 Disposal of Liquid Radioactive Waste

The RR SMR is designed on the principle of minimal liquid discharges, with radioactive effluents being treated in the Liquid Radioactive Effluent Treatment System [KNF] to allow their re-use as demineralised water or primary coolant. Liquid radioactive effluent is only expected to be discharged to the environment in cases where high tritium has accumulated following activation of the reactor coolant over time or following events such as fuel failure/leakage.

The Liquid Effluent Monitoring and Discharge System [KNF30] is required for collection, recycle or discharge of treated liquid radioactive effluents. For liquid radioactive effluents requiring discharge, after suitability for discharge is confirmed in [KNF30] via a grab sample, the effluent is pumped via a discharge line to the Outfall Pond [UPK20] in the Cooling Water Island (CWI). The Outfall Pond [UPK20] is a concrete structure that receives effluents from across the RR SMR. The Outfall Pond [UPK20] then passively discharges these effluents to the environment, via the Outfall Head [UPK30], which act as a diffuser promoting the required level of dispersion and mixing of liquid effluents with ambient seawater. The final design of this system is dependent upon site-specific conditions to ensure suitable mixing with ambient seawater.

The radioactive effluents for discharge will mix with cooling water and other effluents from across the RR SMR prior to release to the environment. Reference should be made to E3S Case Version 3, Tier 1, Chapter 31 [31] for details of the conventional liquid effluents discharged via the Outfall Pond [UPK20] and Outfall Head [UPK30].

Reference should be made to E3S Case Version 3, Tier 1, Chapter 28 – Sampling and Monitoring Arrangements [7] on the monitoring and sampling arrangements and E3S Case Version 3, Tier 1, Chapter 27: Demonstration of Best Available Techniques [12] on how BAT has been applied to minimise the detrimental environmental impact of liquid radioactive discharges.

11.1.3.2 Disposal of Gaseous Radioactive Wastes

The RI Emissions Stack [UKH], discussed in E3S Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures [8], is a system required to vent gaseous emissions from the RI HVAC system at a safe height above ground level, providing optimal dispersion into the atmosphere, minimising the risk to personnel and limiting the environmental impact of such releases.

The RI Emissions Stack [UKH] has been designed to have a physical stack height of 65 m which was influenced by atmospheric dispersion modelling. The proposed stack height will need to be reevaluated at site permitting stage, to take account of local site conditions and circumstances including meteorology, topography, proximity to dwellings and the presence of sensitive habitats/ species. Reference should be made to E3S Case Version 3, Tier 1, Chapter 30 – Prospective Radiological Assessment [32] for more information.

11.1.3.3 Solid Waste Disposal

All solid radioactive wastes have a proposed disposal route identified. Engagement with Nuclear Waste Services (NWS) is ongoing to help ensure that upon arising, solid radioactive waste can be managed in such a way to allow for optimised disposal. Where it is BAT and ALARP to do so, wastes will be disposed of based upon the lowest waste category achievable and, for LLW arisings, diverted from disposal at the LLW Repository (LLWR) where possible. For waste that has arisen, on-site techniques to facilitate optimised waste management include:

- Segregation.
- Decay storage.
- Decontamination.
- On-site size reduction of wet solids in [KNF20] evaporator and dry solids in [KMA10] compactor.
- Consolidation and co-disposal.

All operational solid radioactive wastes requiring disposal will be transferred off-site to other premises and will not be disposed on a RR SMR site.

It is noted that some wastes may be transferred to other premises for further management to allow for re-use or recycling, or to receive further treatment or conditioning prior to their disposal. Once transferred off-site, it is not anticipated that these wastes will be returned to a RR SMR site.

For dry solid wastes arising as LLW that cannot be decontaminated on a RR SMR site, these wastes are transferred off site for further management or disposal.

For solid wastes arising as ILW that are not amenable to decay storage or decontamination to a lower classification, these wastes are safely and securely stored on the RR SMR site pending disposal to a future UK Geological Disposal Facility (GDF). Wet solid ILW is conditioned on a campaign basis during operations and interim stored in a conditioned state, whereas dry solid ILW is stored so as to be managed alongside decommissioning wastes to allow disposal to a future UK GDF.

Where feasible, ILW that is suitable for decay storage is stored within the Solid Radioactive Waste Storage System [KME] for the required period to allow its disposal as LLW at the earliest opportunity.

Reference should be made to E3S Case Version 3, Tier 1, Chapter 27: Demonstration of Best Available Techniques [12] on how BAT has been applied to minimise the detrimental environmental impact of solid radioactive disposals.

11.1.4 Radioactive Waste Management Strategy and Principles

11.1.4.1 Radioactive Waste Management Strategy and Principles Overview

Rolls-Royce SMR Limited has developed an IWS [4] underpinned by international and UK policies, legislation and guidance. The Rolls-Royce SMR Limited waste management strategy seeks to prevent, and where not possible, minimise the production of waste, and manage unavoidable waste to achieve optimal protection of people and the environment now and in the future. Rolls-Royce SMR Limited has adopted a waste-oriented design decision-making methodology, to ensure that key waste management principles such as the waste hierarchy have been prioritised.

The key components of the waste management strategy have been summarised into a strategic ‘planning and preparation’ and a ‘design for implementation’ framework that applies across waste categories where possible.

As shown in Figure 11.1-1, relevant international and UK legislation, regulations, policies etc. flow down into Rolls-Royce SMR Limited design documentation.

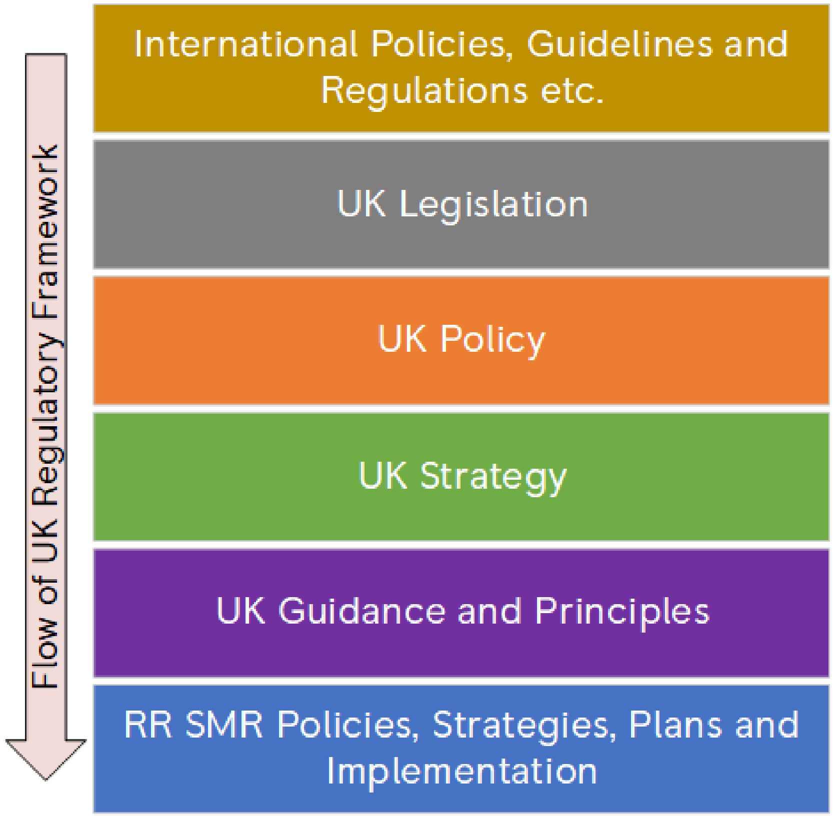

Figure 11.1-1: Flow of UK Regulatory Framework

Reference should be made to the Rolls-Royce SMR Limited IWS [4] for further information, with the IWS covering the topics outlined below.

11.1.4.2 Build Certainty and Approach to Modularisation

Build certainty and the approach to modularisation are fundamental to the development of the RR SMR. There are two key requirements of the Build Certainty Philosophy that drive the need for modularisation, 'maximising the use of the off-site factory', and 'minimising interfaces on site'. These two requirements will have a direct impact on waste generation and subsequent management throughout the lifecycle of the RR SMR, but notably during the construction and decommissioning phases.

11.1.4.3 Minimal Liquid Discharge

A key aspect of the design criteria for the RR SMR is the intent for the overall plant to achieve 'minimal liquid discharge'. This is a design and operational approach/philosophy that is being applied to the RR SMR that describes the intent to use plant features and configurations that will maximise the reuse of fluids and effluents and minimise total discharges to the environment. This will be underpinned by BAT decisions during design and operation – see E3S Case Version 3, Tier 1 Chapter 27: Demonstration of Best Available Techniques [12] for further information on BAT.

11.1.4.4 E3S Design Principles

The E3S design principles present a distillation of established and endorsed international practices for plant and site design and provide a framework against which the design is evaluated and developed [33], and are fundamental in the Planning and Preparation phase. In relation to waste management, the principles include implementation of the waste hierarchy and the prioritisation of the prevention of waste generation, demonstrating compliance with the Waste (England and Wales) Regulations 2011 [34]. The principles collectively present the intent to lead a waste-informed design process and cover the lifecycle of the RR SMR. The principles state that the design shall permit construction, commissioning, operation, maintenance and decommissioning with acceptable doses and risks that are reduced ALARP and should minimise the volume and activity of waste created and disposed, and hence exposure to public and environment to As Low As Reasonably Achievable (ALARA) using BAT. E3S Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [11] should be referred to for further information on the principles setting the design basis of the RR SMR.

11.2 Systems and Arrangements for the Management of Liquid Radioactive Wastes

11.2.1 Systems and Equipment Functions

11.2.1.1 RI Collection and Drainage System [KTA]

The primary function of the RI Collection and Drainage System [KTA] is to collect effluents from across the RI and transfer the effluents to the appropriate system for treatment. The system selectively collects the different categories of effluent to enable optimised treatment of each type of effluent.

The baseline architecture for the RI Collection and Drainage System [KTA] consists of:

- [KTA10]: collection and transfer of reactor coolant drains.
- [KTA20]: collection and transfer of active process & floor drains.
- [KTA20]: with [KPL]: collection and transfer of active process drains with cover gas.
- [KTA30]: collection and transfer of active chemical drains.
- [KTA40]: collection and transfer of non-active drains.

The RI Collection and Drainage System [KTA] contributes to the Fundamental Safety Functions (FSFv of Confinement of Radioactive Material (CoRM) and Control of Radiation Exposure (CoRE), providing duty and preventive safety functions (plant states DBC-1 and DBC-2).

11.2.1.2 Liquid Radioactive Effluent Treatment System [KNF]

The primary function of the Liquid Radioactive Effluent Treatment System [KNF] is to collect and treat radioactive liquid effluents to be suitable for recycle or discharge.

The [KNF] system consists of:

- [KNF10]: Processing and treatment system for primary liquid effluent.
- [KNF20]: Processing and treatment system for spent liquid effluent.
- [KNF30]: Liquid effluent monitoring and discharge system.

The Liquid Radioactive Effluent Treatment System [KNF] contributes to the FSFs of CoRM and CoRE providing duty and preventive functions (plant states DBC-1 and DBC-2).

11.2.2 Design Bases

11.2.2.1 RI Collection and Drainage System [KTA]

The RI Collection and Drainage System [KTA] provides safety functions to confine radioactive effluents and minimise operator exposures, as a duty/preventive measure for specific PIEs listed in the Fault Schedule [35]. The PIEs against which the RI Collection and Drainage System [KTA] is allocated safety functions are:

- NFM.2.1.04: Inadvertent Operator Exposure to R5 Area.
- NFM.1.4.01: Release from High-Activity Liquid Effluent System.
- NFM.1.4.02: Overfill of Non-Vented High-Activity Liquid Effluent System.

- NFM.1.4.04: Overfill of [KTA20] Tank.

Safety categorised functional requirements are derived from the safety functions and allocated to the SSCs that comprise RI Collection and Drainage System [KTA], presented in the Requirements Specification [36].

The integrity of mechanical components and functions for inventory management are assigned safety category C, with the components and C&I that deliver them assigned a safety class 3.

Instrumented trips on the waste systems provide a preventive function against overfill of RI Collection and Drainage System [KTA]. The radiological bunds provide a protective safety function to confine radioactive material following overfill. These measures are expected to be safety class 3, which will be confirmed following more detailed radiological consequence assessments, along with allocation of safety requirements on the supporting HVAC systems as required.

As described in E3S Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [11], fundamental environmental functions are intrinsically linked to the BAT claims. Where a system has been identified in supporting a BAT claim, that system is regarded as contributing towards a Fundamental Environmental Function.

Following Rolls-Royce SMR Limited guidance [3], the RI Collection and Drainage System [KTA] contributes to the following Fundamental Environmental Function:

- Minimisation of the volume and/or activity of radioactive wastes discharged to the environment or transferred to other premises.

Potential KEPE within the RI Collection and Drainage System [KTA] to support delivery of this Fundamental Environmental Function is summarised in Table 11.2-1. Further details on identified KEPE are to be captured in the Environmental Schedule[7].

Table 11.2-1: Potential KEPE for the RI Collection and Drainage System [KTA]

System RDS-PP®	SSC
[KTA10]	RCDT heat exchanger
[KTA10]	RCDT heat transfer pumps
[KTA20]	[KTA20] tanks, and pipework
[KTA20]	Transfer pumps / recirculation line
[KTA20]	TBC: A solution to remove oil contamination in [KTA20]
[KTA30]	[KTA30] tanks, and pipework
[KTA30]	Transfer pumps / recirculation line

No security or safeguards functional requirements are assigned.

[7] The first iteration of the Environmental Schedule is currently being developed and will be issued late 2025 with reference SMR0024354.

11.2.2.2 Liquid Radioactive Effluent Treatment System [KNF]

The Liquid Radioactive Effluent Treatment System [KNF] provides safety functions to confine radioactive effluents and minimise operator exposures, as a duty/preventive measure during specific PIEs listed in the Fault Schedule. The PIEs against which the Liquid Radioactive Effluent Treatment System [KNF] is allocated safety functions are:

- NFM.1.1.04: Release from Liquid Retentate System.
- NFM.1.4.01: Release from High-Activity Liquid Effluent System.
- NFM.1.4.02: Overfill of Non-Vented High-Activity Liquid Effluent System.
- NFM.1.4.03: Overfill of [KNF10] Tank.
- NFM.1.4.05: Overfill of [KNF] Retentate Tank.
- NFM.2.1.03: Inadvertent Operator Exposure to R5 Area.

Safety categorised functional requirements are derived from the safety functions and allocated to the SSCs that comprise Liquid Radioactive Effluent Treatment System [KNF], presented in the Requirements Specification [37].

The following safety categorisations and classifications are assigned for the Liquid Radioactive Effluent Treatment System [KNF] SSCs:

- Liquid effluent tanks perform a safety category C preventive function and are safety class 3, with safety class 3 normal level control.
- Pipework performs a safety category C preventive function and is safety class 3, with class 3 high temperature and pressure trips on tank inlets.
- Pumps perform a safety category C preventive function and are safety class 3, with safety class 3 high pressure trip on the outlets.
- Tanks, pumps and pipework are in a safety class 1 civil bund (civil bund and bund liner – both out of scope of this Chapter). The high-level trips and high-level alarms on the radiological bund perform a safety category C function and are assigned safety class 3.
- A radiation dose alarm monitoring system performs a safety category B protective function to support operator evacuation, which is assigned safety class 2.

The Liquid Radioactive Effluent Treatment System [KNF] contributes to the following Fundamental Environmental Functions:

- Minimisation of the volume and/or activity of radioactive wastes discharged to the environment or transferred to other premises.
- Minimisation of the impacts on the environment and/or members of the public of radioactive wastes discharged to the environment or transferred to other premises.

Potential KEPE within Liquid Radioactive Effluent Treatment System [KNF] to support delivery of these Fundamental Environmental Functions is summarised in Table 11.2-2. Further details on identified KEPE are to be captured in the Environmental Schedule[7].

Table 11.2-2: Potential KEPE for the Liquid Radioactive Effluent Treatment System [KNF]

System RDS-PP®	SSC
[KNF10]	Primary liquid effluent transfer pump and suction line
[KNF10]	Vacuum degasser column
[KNF20]	Process and Floor drain tanks
[KNF20]	Chemical drain tanks
[KNF20]	Pre-filters
[KNF20]	RO system
[KNF20]	IX resin beds
[KNF20]	Post-filters
[KNF20]	Waste evaporator column
[KNF20]	[KNF20] tanks recirculation line
[KNF20]	Pump suction line
[KNF30]	[KNF30] tanks recirculation line
[KNF30]	Pump suction line

No security or safeguards functional requirements are assigned.

11.2.2.3 Non-Functional System Requirements

The RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] are designed in accordance with the E3S design principles for safety class 3 measures (see E3S Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [11] as follows:

- Design to deliver functions following design basis internal hazards.
- Protection against design basis external hazards.
- Design of mechanical SSCs to codes and standards in accordance with Table 11.0-2.
- Optimised Human Machine Interfaces (HMIs) for reliable human performance.
- Equipment Qualification (EQ), including environmental and seismic qualification.
- Design of the layout to facilitate Examination, Maintenance, Inspection and Testing (EMIT).
- Design for installation, commissioning, and decommissioning in accordance with respective strategies.
- Design of SSCs to reduce activation of materials to facilitate decommissioning.

11.2.3 Description

11.2.3.1 RI Collection and Drainage System [KTA]

System Overview

The primary function of the system is to collect effluents from across the RI and transfer the effluents to the appropriate system for treatment. The system selectively collects the different categories of effluent to enable optimised treatment of each type of effluent.

The RI Collection and Drainage [KTA] system is located throughout all areas of RI. The RI Collection and Drainage System [KTA] system will consist of pipework from process equipment and floor drain receivers to intermediary RI Collection and Drainage System [KTA] tanks located at low points, with flow driven by gravity. The fluid can then be pumped from the [KTA] tanks to either Liquid Radioactive Effluent Treatment System [KNF] or the Central Drains System [GMA] for treatment.

The System Design Description (SDD) for the RI Collection and Drainage System [KTA] should be consulted for further, more detailed information on the system [38]. A simplified schematic of the RI Collection and Drainage System [KTA], amended from that in the SDD [38] is provided in Figure 11.2-1.

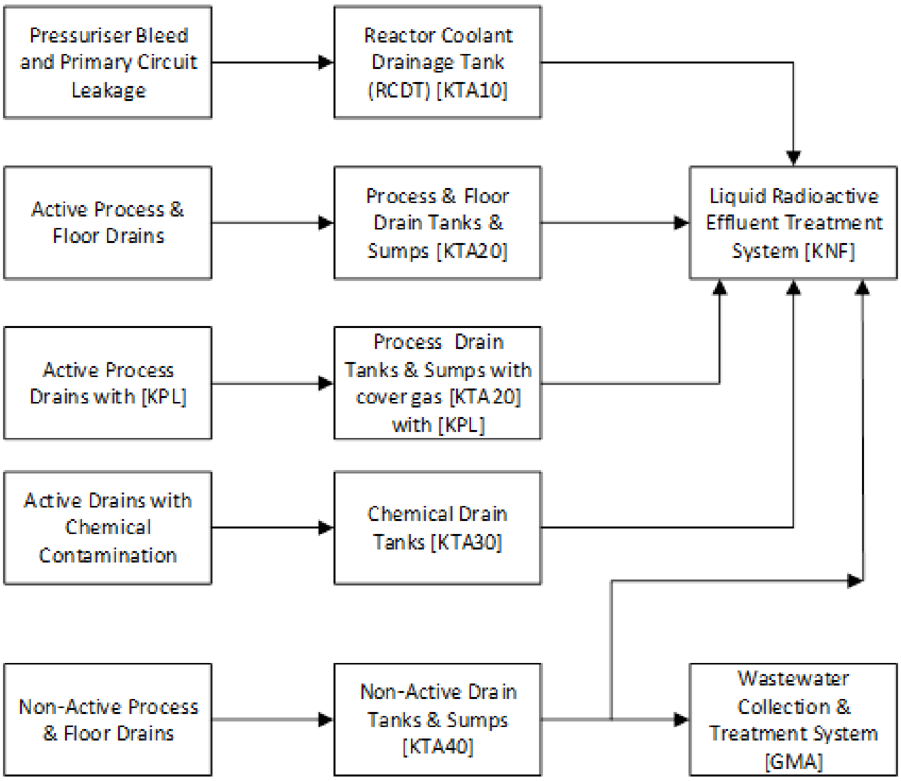

Figure 11.2-1: Simplified Schematic of the RI Collection and Drainage System [KTA]

Collection and Transfer of Reactor Coolant Drains [KTA10]

The Collection and Transfer of Reactor Coolant Drains [KTA10] collects primary liquid effluent in the RCDT and cools and discharges the effluent to the Primary Effluent Storage Tanks in the Processing and Treatment System for Primary Liquid Effluent [KNF10] for storage. Stored primary liquid effluent can either be recycled directly as primary coolant via direct reuse in the CVCS [KB], or if required, be processed for reuse elsewhere on site.

The Collection and Transfer of Reactor Coolant Drains [KTA10] comprises the RCDT, a heat exchanger to cool the effluent and a duty/standby pump set to recirculate for cooling as well as discharge to the Processing and Treatment System for Primary Liquid Effluent [KNF10]. All are located within containment in the steam generator sump. The system also contains isolation valves either side of the containment boundary.

The purpose of the RCDT is to collect and sparge the pressuriser bleed and primary coolant leakages. The tank is maintained at near atmospheric pressure by the Gaseous Radioactive Effluent Treatment System [KPL]. The non-condensable gases; containing hydrogen and radiological fission gases; are removed by the Gaseous Radioactive Effluent Treatment System [KPL] and treated appropriately.

The contents of RCDT are cooled by sparging through the existing body of effluent and by recirculation through the RCDT heat exchanger if necessary.

Collection and Transfer of Process and Floor Drains [KTA20]

The Collection and Transfer of Process and Floor Drains [KTA20] collects active process and floor drains into intermediary storage tanks located across RI and discharges the effluent to the Processing and Treatment System for Spent Liquid Effluent [KNF20] for storage and processing. The active process and floor drains have been combined to minimise complexity. The streams are expected to have similar effluent characteristics (dilute effluent with relatively low activity & contamination) and use the same processing in the Processing and Treatment System for Spent Liquid Effluent [KNF20] [39].

The process and floor drain tanks will be standardised where possible and incorporated as part of a drainage module. They are to be at atmospheric pressure, to allow drainage via gravity. It is expected that the tanks will be open to atmosphere, with controlled overflow to a bund. Process and floor drain tank key design parameters can be found in the SDD for the RI Collection and Drainage System [KTA] [38].

Each Collection and Transfer of Process and Floor Drains [KTA20] tank will include the capability to take a sample via an interface with the Auxiliary Sampling System [KUB]. Duty/standby pumps on the tank outlet are used to transfer effluent to treatment in the Processing and Treatment System for Spent Liquid Effluent [KNF20] or to homogenise it through recirculation for the purposes of obtaining a sample. Information on the Auxiliary Sampling System [KUB] is provided within E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2].

A solution to remove oil contamination in Collection and Transfer of Process and Floor Drains [KTA20] may be included or due to the restricted space within the drainage modules, oil separation may not be feasible within the Collection and Transfer of Process and Floor Drains [KTA20] design and instead be included within the downstream Processing and Treatment System for Spent Liquid Effluent [KNF20] system.

Collection and Transfer of Process Drains [KTA20] with [KPL]

Where process drainage of primary coolant is required; not including leaks from the RCS and venting from the pressuriser which are handled separately; the primary coolant will be drained to the Collection and Transfer of Process and Floor Drains [KTA20] with nitrogen cover gas from the Gaseous Radioactive Waste Treatment System [KPL]. This provides an inert atmosphere and sweeps away any hydrogen and radioactive gases in the tank head space. This system is called [KTA20] with [KPL] cover gas, which collects active process drains into intermediary storage tanks located across RI and discharges the effluent to the Process and Floor Drain Tank for storage and subsequent processing in the Processing and Treatment System for Spent Liquid Effluent [KNF20].

To allow gravity drainage into [KTA20] with [KPL] tanks, the source of effluent should also be from process vessels swept with Gaseous Radioactive Effluent Treatment System [KPL]. The [KTA20] with

[KPL] tanks will not receive floor drainage or drainage/leaks from equipment such as pumps and heat exchangers, therefore differs from [KTA20] tanks in this respect.

Given the use of a Gaseous Radioactive Effluent Treatment System [KPL] nitrogen blanket, connections from central compressed air [QFB] and nitrogen [QJB] and a connection to HVAC [KL] are also required to make the tank safe for maintenance.

The [KTA20] with [KPL] tank key attributes are described in the SDD for the RI Collection and Drainage System [KTA] [38].

The [KTA20] with [KPL] tanks will feature a duty/standby pump arrangement identical to that used for the Collection and Transfer of Process and Floor Drains [KTA20].

Collection and Transfer of Chemical Drains [KTA30]

The Collection and Transfer of Chemical Drains [KTA30] system collects chemical drains into local intermediary storage tanks located across RI and discharges the effluent to [KNF20] chemical drains storage tanks for processing. The Collection and Transfer of Chemical Drains [KTA30] modular drainage design is standardised with the Collection and Transfer of Process and Floor Drains [KTA20], where possible.

The Collection and Transfer of Chemical Drains [KTA30] chemical drain tanks are proposed to be identical to the Collection and Transfer of Process and Floor Drains [KTA20] tanks and standardised across RI. The Collection and Transfer of Chemical Drains [KTA30] tanks will be open to atmosphere to enable gravity drainage to the tank, with overflow directed to a bund. Use of HVAC [KL] to limit airborne contamination is not generally expected to be required due to limited and non-persistent collected effluent volume, this will be confirmed at a future design stage (Further Work Item KTA-A-38). The tank key attributes are as per the Collection and Transfer of Process and Floor Drains [KTA20].

Each Collection and Transfer of Chemical Drains [KTA30] tank will include the capability to take a physical grab sample via an interface with the Auxiliary Sampling System [KUB]. They will also feature the same recirculation line design as the Collection and Transfer of Process and Floor Drains [KTA20] tanks to enable homogenisation of the effluent to ensure a representative sample can be taken.

A solution to remove oil contamination may be included in the Collection and Transfer of Chemical Drains [KTA30] tanks as per the Collection and Transfer of Process and Floor Drains [KTA20].

The Chemical Drainage tanks will feature a duty/standby pump arrangement identical to that used for the Collection and Transfer of Process and Floor Drains [KTA20].

[KTA40]: Non-Active Drains

Whilst predominantly out of scope of this Chapter, if radioactivity is detected within the non-active drains [KTA40], then a routing to [KNF] can be used.

RI Collection and Drainage System [KTA] Layout

The layout of the RI Collection and Drainage System [KTA] is designed in accordance with the E3S design principles to enable delivery of its safety functions. Key aspects of the RI Collection and Drainage System [KTA] layout design to ensure delivery of safety functions are summarised below.

The RI Collection and Drainage system [KTA] is located throughout all areas of RI and is to be updated as interfacing systems and layout matures further. The layout in this Chapter is based on the DRP3 layout and the incorporation of the RI Collection and Drainage System [KTA] tanks in the latest DRP4 layout, will be included in Version 4 of the Generic E3S Case.

The RI Collection and Drainage System [KTA] will consist of pipework from process equipment and floor drain receivers to intermediary RI Collection and Drainage System [KTA] tanks located at low points, with flow driven by gravity. The fluid can then be pumped from the [KTA] tanks to either the Liquid Radioactive Effluent Treatment System [KNF] or the Central Drains System [GMA] for treatment.

A modular philosophy has been adopted whereby standard RI Collection and Drainage System [KTA] and standard [KTA] with [KPL] drainage tank designs are repeated throughout the RR SMR, with minimal differences where possible.

Adequate space for sample points is to be provided in the building layout – see E3S Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements [7] for further information on radioactive liquid effluent sampling and monitoring.

11.2.3.2 Liquid Radioactive Effluent Treatment System [KNF]

System Overview

The Liquid Radioactive Effluent Treatment System [KNF] collects liquid radioactive effluents arising from across the RI in tanks and treats them with a combination of separation methods for the removal of radionuclides and chemical contaminants. This treatment enables the effluent to be recycled in the RR SMR, or if required, allows the effluent to be safely discharged to the environment. The system manages both primary and spent liquid effluent and treats them based on their characterisation (expected levels of radiological and chemical contamination).

The SDD for the Liquid Effluent Treatment System [KNF] should be consulted for further, more detailed information on the system [26]. A simplified schematic of the Liquid Radioactive Effluent Treatment System [KNF], taken from the SDD [26] is provided in Figure 11.2-2.

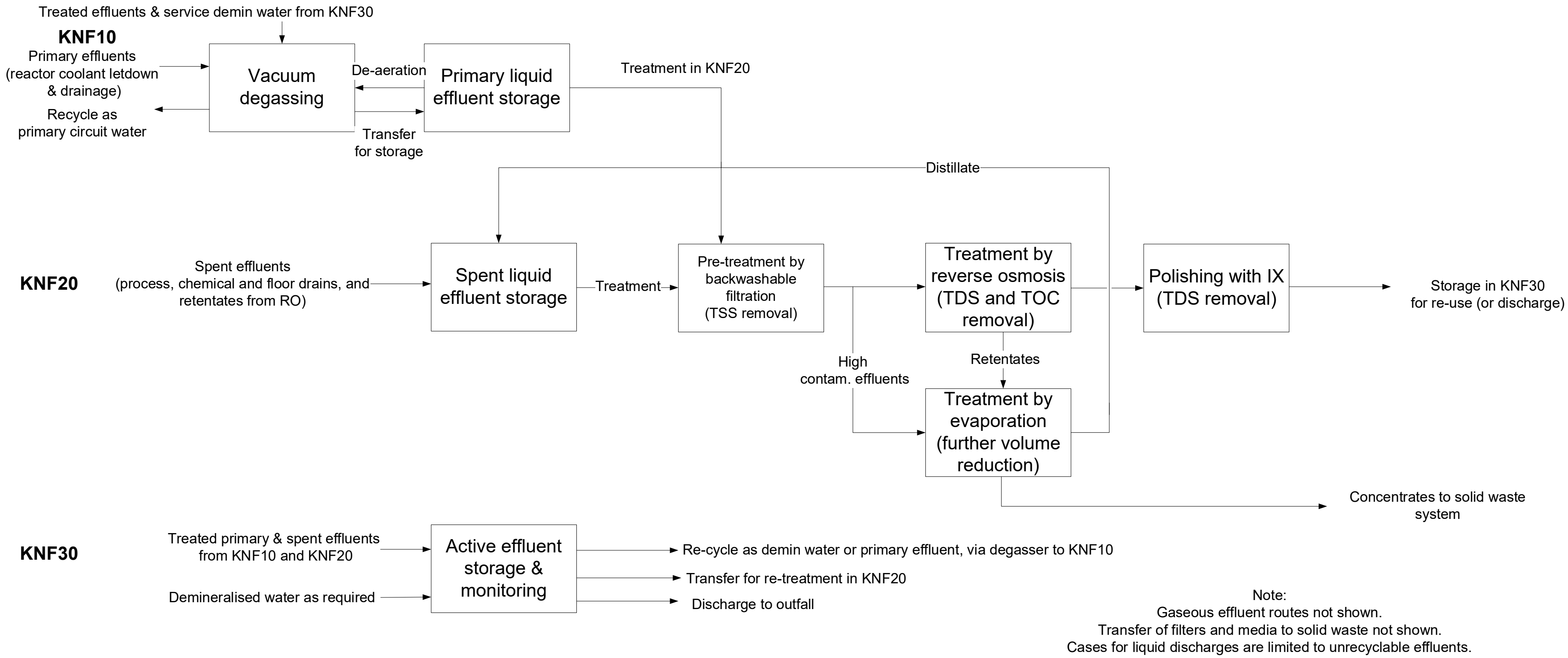

Figure 11.2-2: Simplified Schematic of the Liquid Radioactive Effluent Treatment System [KNF]

Processing and Treatment System for Primary Liquid Effluent [KNF10]

Processing and Treatment System for Primary Liquid Effluent [KNF10] Overview

The Processing and Treatment System for Primary Liquid Effluent [KNF10] collects primary liquid effluent in storage tanks with these effluents expected to be 'reactor grade' and therefore normally low in contaminants. Should sampling results indicate that the effluent does not meet coolant specification, primary effluents will be sent to the Processing and Treatment System for Spent Liquid Effluent [KNF20] for treatment by the same abatement processes as spent effluents.

The Processing and Treatment System for Primary Liquid Effluent [KNF10] contains:

- Storage tanks for primary liquid effluent, with transfer pumps and connection to sampling systems and [KNF20] treatment systems.
- A vacuum degasser for removal of dissolved gases from effluent and make-up water.

Primary Liquid Effluent Storage Tanks

Two effluent storage tanks with a combined volume of 148 m^3 are proposed in a simultaneous configuration to allow simultaneous collection and make-up without affecting primary circuit operation. The tank header space will be swept by nitrogen cover gas from the Gaseous Radioactive Effluent Treatment System [KPL] to maintain positive pressure and sweep any hydrogen and radioactive gases remaining in the tank header.

To allow for sampling for effluent characterisation, connections are proposed downstream of the transfer pumps for connection to a sample manifold. A sampling connection is downstream of the pump in turbulent flow regime to ensure a representative sample, allow a single sampling connection for the primary liquid effluent storage tanks and to provide motive force to deliver effluent for sampling.

Tanks are in a vertical orientation with dished bottoms where particulate material can collect. Any accumulated particulate will be transferred via the suction line, therefore reducing accumulation of tank particulate and sludges.

Connections to service nitrogen gas [QJB20], compressed air [QFB] and the HVAC [KLF] systems are available for purging and venting the tanks for maintenance and inspection.

A summary of the key Processing and Treatment System for Primary Liquid Effluent [KNF10] design attributes can be found in the SDD [26].

Transfer Pumps

One transfer pump per primary effluent storage tank is proposed for ensuring availability of processing effluent or providing coolant make-up, considering the significant time required for either degassing or demineralising in a recirculation loop. A bypass between pump suction lines can be used if one is out of service. Each pump can transfer effluent to the different trains of equipment.

Vacuum Degasser Column

The degasser performs the following functions:

- Removal of dissolved radioactive gases (xenon, krypton) and hydrogen from the reactor coolant. The gaseous effluent is sent to the Gaseous Radioactive Effluent Treatment System [KPL] for gaseous waste treatment and discharge. The degassed coolant is either directly returned to the CVCS, sent to the Processing and Treatment System for Spent Liquid Effluent [KNF20] for treatment, or stored in a Processing and Treatment System for Primary Liquid Effluent [KNF10] tank for later use as make-up.

- Removal of dissolved oxygen from the reactor coolant before the start-up transient. The gaseous effluent is sent to the RI HVAC System [KL] for discharge. The de-aerated water is directly returned to the CVCS.
- Removal of dissolved oxygen from liquid effluent / demineralised water for primary circuit make-up. This will be performed on demand during operation. The gaseous effluent is sent to the RI HVAC System [KL] for discharge. The de-aerated water is then stored in a Processing and Treatment System for Primary Liquid Effluent [KNF10] tank prior to use.

The degassing process will be supplied as a package with the final design being confirmed by the package supplier.

Processing and Treatment System for Spent Liquid Effluent [KNF20]

Processing and Treatment System for Spent Liquid Effluent [KNF20] Overview

The Processing and Treatment System for Spent Liquid Effluent [KNF20] collects spent liquid effluent in storage tanks. The categories of spent liquid effluent are defined in Section 11.1.1.1.1 and are:

- Process drains.
- Chemical drains.
- Floor drains.
- Contaminants that could be detrimental to the performance of the effluent treatment process.

These effluents are treated by a combination of separation techniques to allow them to be re-used in the RI as demineralised water (dependent on allowable tritium levels as tritium is not removed by the Liquid Radioactive Effluent Treatment System [KNF] unit operations).

Effluents will be managed by batch operations. Upon filling a Processing and Treatment System for Spent Liquid Effluent [KNF20] storage tank, the effluents are mixed and sampled. After characterisation, the effluent is transferred to the abatement train, which consists of:

- Pre-treatment: Total Suspended Solids (TSS) removal through filtration.
- Bulk separation: Total Dissolved Solids (TDS) removal through RO system, creating a retentate batch.
- Polishing: Further TDS removal with IX using two mixed resin beds in series (TBC by suppliers).
- Post-treatment: Solids removal through filtration e.g. resin fines.

The retentates removed by the RO system are collected in the RO process feed tank.

A waste evaporator performs further volume reduction of these retentates. It also provides flexibility for treatment of highly contaminated drains e.g. bypass of the RO system for high solute contamination in chemical drains.

Spent Liquid Effluent Storage Tanks

Process drains and floor drains will be stored in the same tanks, due to similar characteristics and treatment.

Connections to the Auxiliary Sampling System [KUB] are proposed downstream of the transfer pumps for connection to a sample manifold. Sampling connection is downstream of the pump in turbulent flow regime to ensure representative sample, allow a single sampling connection for the pairs of spent liquid effluent storge tanks and to provide motive force to deliver effluent for sampling.

A recirculation line allows for mixing of tank contents to ensure a representative sample is taken; jet mixing ejectors in the tanks are proposed to minimise moving parts. Jet mixer suppliers will provide operating information, including managing risk of foaming, and required operating times.

Tanks are in a vertical orientation with dished bottoms where particulate material can collect. Any accumulated particulate will be transferred via the suction line, therefore reducing accumulation of tank particulate and sludges. Each tank is connected to the HVAC system, via a breather valve connection. Service demineralised water connections are available for rinsing tanks.

The key design parameters for the Spent Liquid Effluent Storage Tanks are found in the Liquid Radioactive Effluent Treatment System [KNF] SDD [26].

Transfer Pumps

One transfer pump per two storage tanks is proposed, as only one tank is required to process effluent while the other is available in stand-by configuration. Each pump can process effluent from each type of drain tank. Each pump can transfer effluent to either the RO abatement train, the evaporator, or back to the tank via the recirculation line.

Abatement Train – Filtration, Reverse Osmosis and Ion Exchange

The spent liquid effluent abatement train includes a combination of separation techniques for removal of TDS, TSS and Total Organic Carbon (TOC).

The abatement train is expected to be a modular equipment package, with pre-treatment, RO, IX polishing and post-filtration included. Control modules for online monitoring of chemical contaminants are also expected.

The RO system operates on a batch basis. Liquid effluents are filtered with backwashable filters before entering the process feed tank, where they are then treated by the RO system. The retentate stream is recycled back to the process feed tank, mixing with more effluent feedwater and therefore accumulating solutes over time for a batch. The permeates are further polished by IX followed by a resin trap.

After a batch is processed, the resulting retentate is accumulated in the process feed tank. When the tank is filled with retentates they are then processed by the evaporator for further volume reduction and recovery of distillate. This processing may be via a separate retentate tank to decouple the RO and evaporator trains.

Online measurement for TOC and TDS is proposed upstream and downstream of each RO system for monitoring performance and feedwater quality. It is anticipated that this will be performed as part of the supplier package.

The IX bed will have provisions for resin fluidising, transfer and replacement. The interface for collection in the Temporary Storage for wet ILW [KME20] system can be found in the [KME] SDD [40].

Provisions are made for utilising either stored liquid effluent (a bypass from the transfer pumps) or service demineralised water (connection to [GHC] system) for fluidising resin, backwashing spent filters or membranes, or for general maintenance requirements.

Pre- and post-filtration may be carried out using backwashable filters. Backwashing retained solids from filters reduces the activity of the filter media, such that a filter change machine is not required. Backwashed filter solids will be transferred to Temporary Storage for wet ILW [KME20] for processing. Filter design will be determined by discussion with suppliers.

The method for spent filter changeout is still being developed.

Waste Evaporator Column

The waste evaporator treats spent liquid effluent of relatively high chemical contamination (e.g. sodium or chloride ions), including the retentates from the RO system. Evaporation achieves a high purity distillate stream that is then recycled following re-treatment by the [KNF20] abatement train.

A vacuum evaporator is proposed to reduce the operating temperature and decrease corrosion risk. It is expected the vacuum evaporator will use a liquid ring pump and ejector. It is expected the evaporator and associated components will be provided as a modular system designed and supplied as a package.

Online TDS measurement is proposed on the reflux line to monitor the distillate specification. Online TDS measurement is also proposed on the concentrates recirculation line; limits on certain dissolved species are required to minimise material corrosion. Evaporator distillates are recycled back to the start of the abatement train (for further polishing) via a Processing and Treatment System for Spent Liquid Effluent [KNF20] process and floor drain tank.

At the end of the batch, the concentrates are extracted and transferred to storage in the Temporary Storage for wet ILW [KME20] concentrates tank. A compressed air supply [QE] is also required when draining the sump at the end of a batch. There is a service demineralised water connection to provide flushing after concentrate transfer.

Liquid Effluent Monitoring and Discharge System [KNF30]

Liquid Effluent Monitoring and Discharge System [KNF30] Overview

On-specification effluent is collected in the Liquid Effluent Monitoring and Discharge System [KNF30] and recycled for use in RI. Off-specification effluents that are unsuitable for re-use are returned to the Processing and Treatment System for Spent Liquid Effluent [KNF20] for reprocessing.

Where effluent is not suitable for re-use on the plant even with reprocessing, this is discharged to the environment after characterisation. As the Liquid Radioactive Effluent Processing System [KNF] is required to treat active liquid effluent to enable recycle, liquid effluent is only expected to be discharged in some cases (predominantly due to high tritium accumulation following activation in the reactor coolant over time, or events such as fuel failure/leakage).

If off-specification effluents containing activity are detected in the non-active drains [KTA40], these are transferred to the Liquid Effluent Monitoring and Discharge System [KNF30] and characterised. This will be treated in the same manner as effluent that has entered into the Liquid Effluent Monitoring and Discharge System [KNF30] via other routes and will follow the same processes.

Effluent Storage and Monitoring

The Liquid Effluent Monitoring and Discharge System [KNF30] contains monitoring tanks for treated radioactive effluent. The active effluent tanks (6 x 74 m^3 nominal volume) perform the following:

- Monitor and sample radioactive effluents to determine if they are suitable for recycle or else discharge to the environment.
- Provide excess storage capacity for recyclable effluents. The stored effluent can be recycled as make-up coolant or (tritiated) demineralised water in RI on demand, e.g. as make-up water to the SF Pool.
- Discharge active effluents that are unrecyclable (e.g. due to accumulation of high tritium content) to the environment.

One transfer pump per set of six tanks is required for recirculation of tank effluents and transfer of effluents for recycle or discharge. A second pump may be added pending conclusions drawn regarding reliability. A control valve is used for throttling discharge flow rate.

To allow for sampling for effluent characterisation, a connection to the Auxiliary Sampling System [KUB] is proposed downstream of the pump in turbulent flow regime to ensure representative sample, allow a single sampling connection for the Liquid Effluent Monitoring and Discharge System [KNF30] tanks and to provide motive force to deliver effluent for sampling.

A recirculation line allows for mixing of tank contents to ensure a representative sample is taken; jet mixing ejectors in the tanks are proposed to minimise moving parts. If determined by sampling, effluent can be transferred to the Processing and Treatment System for Spent Liquid Effluent [KNF20] for re-treatment.

Tanks will be in a vertical orientation with a dished bottom. Any accumulated particulate will be transferred via the suction line, therefore reducing accumulation of tank particulate and sludges.

Each tank is open to atmosphere via a gooseneck vent.

The key design parameters for the Liquid Effluent Monitoring and Discharge System [KNF30] effluent storage tanks can be found in the SDD [26]

Effluent Discharge

The active effluent transfer pump can transfer treated effluent to the Processing and Treatment System for Primary Liquid Effluent [KNF10] storage tanks via the degasser, the Processing and Treatment System for Spent Liquid Effluent [KNF20] abatement train or to the CWI outfall pond for discharge to the environment, to the SF Pool, or to other plant users. A control valve downstream of the pump transfers and controls the flow rate.

Liquid Radioactive Effluent Treatment System [KNF] Layout

The layout of the Liquid Radioactive Effluent Treatment System [KNF] is designed in accordance with the E3S design principles to enable delivery of its safety functions. Key aspects of the Liquid Radioactive Effluent Treatment System [KNF] layout design to ensure delivery of safety functions are summarised below.

The Processing and Treatment System for Primary Liquid Effluent [KNF10] and Processing and Treatment System for Spent Liquid Effluent [KNF20] are part of the RI and sit in a RCA outside of containment in the Auxiliary Block [UKA10], outside the hazard shield. The RO systems, filtration and IX train and evaporator in the Processing and Treatment System for Spent Liquid Effluent [KNF20] are located above the Solid Waste Storage System [KME20] collection tanks for transfer of concentrates and spent media for processing.

The Liquid Effluent Monitoring and Discharge System [KNF30] system is also in a RCA and part of RI but is separated from the main sector and located at the south region of the Balance of Plant (BoP)The Liquid Effluent Monitoring and Discharge System [KNF30] system will need frequent access for sampling and as such the cleaner inventory held in the system is segregated from the more hazardous areas of RI to reduce operator dose.

The Processing and Treatment System for Primary Liquid Effluent [KNF10] primary liquid effluent tanks are co-located together, separated from the Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks.

The Processing and Treatment System for Spent Liquid Effluent [KNF20] process and floor drain tanks and chemical drain tanks will be split in a duty-standby configuration. There is civil shielding between the duty and standby tank sets. Each tank set contains one process and floor drain tank and one chemical drain tank.

It is proposed that each pair of tanks will share a bund equipped with localised leak detection for individual waste streams.

The [UKA20] civil structure containing the Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks and process equipment will serve as secondary containment in case of inventory loss providing a Category A safety function [41]. The design of the proposed secondary containment is currently in development.

The Processing and Treatment System for Spent Liquid Effluent [KNF10] and Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks will be segregated from other equipment to enhance operator safety and minimise radiation exposure.

11.2.4 Materials

Materials are selected to minimise risks associated with operator and maintenance dose, corrosion, and decommissioning.

The materials for the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] components are selected in accordance with their safety class using RGP and Operational Experience (OPEX), to ensure their through-life integrity and qualification for relevant environmental conditions. Stainless steel has been selected for the design of components in contact with radioactive liquid effluent with highly corrosion-resistant stainless steel selected for the [KNF] evaporator to ensure integrity throughout the design life.

The approach to materials selection and ageing management for Safety Class 1 SSCs along with the description and justification of materials used for Classified SSCs is provided in E3S Case Version 3, Tier 1, Chapter 23: Structural Integrity [20].

11.2.5 Interfaces with Other Equipment or Systems

The RI Collection and Drainage System [KTA] collects effluents from across the RI as described in Section 11.1.1.1.1 and discharges the liquid radioactive effluents to downstream systems within the Liquid Radioactive Effluent Treatment System [KNF]. The Liquid Radioactive Effluent Treatment System [KNF] returns treated effluent to users around RI, or discharges to the Outfall Pond [UPK20]. Connections to the Auxiliary Sampling System [KUB] (see E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2] and E3S Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements [7]) are required for effluent characterisation in both the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] systems.

The RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] also interface with systems for the supply of various services, e.g. the supply of nitrogen cover gas from the Gaseous Radioactive Effluent Treatment System [KPL], compressed air from [QFB], and demineralised water from [GHC].

Both the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] have interfaces with the HVAC systems [KL] and Gaseous Radioactive Effluent Treatment System [KPL] for the management of radioactive gases (see E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2]).

C&I is provided to both the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] via Radioactive Waste Management System C&I [KY] (see E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14]).

11.2.6 Systems and Equipment Operation

11.2.6.1 Power Station Operating Philosophy

The power station operating philosophy [42] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode. This is summarised in E3S Case Version 3, Tier 1, Chapter 13: Conduct of Operations [43].

11.2.6.2 RI Collection and Drainage System [KTA]

RI Collection and Drainage System [KTA] Overview

The RI Collection and Drainage System [KTA] is designed to function during all modes of operation. This is except for the Collection and Transfer of Reactor Coolant Drains [KTA10] which will not be required during Mode 6 Refuelling and will therefore be available for maintenance.

Collection of Effluent

The Reactor Coolant Drain Tank [KTA10] collects leaks from RPV inner and outer seals, valve packing and the condensation of pressuriser steam bleed.

Cooling of RCDT [KTA10]

The RCDT transfer pumps are used to both recirculate primary coolant through the RCDT heat exchanger for cooling and to transfer effluent to the Processing and Treatment System for Primary Liquid Effluent [KNF10] when the tank is full. The cooling function is to be automated.

When the bulk temperature in the RCDT reaches above 50 °C, the RCDT discharge valves will be aligned to allow for the recirculation of the primary effluent and the RCDT duty pump started. This will recirculate effluent through the RCDT cooler back into the tank until the bulk temperature is reduced to 45 °C. At this point, the pump will be stopped, and the valves will be aligned to their standby configuration. This will be a fully automated function.

Recirculation of Tank Contents in Collection and Transfer of Process and Floor Drains [KTA20] and Collection and Transfer of Chemical Drains [KTA30]

The contents of these tanks can be discharged and recirculated back to the tank via an operator-initiated function. The valves will align to recirculate the effluent, and the duty discharge pump started. Once initiated, recirculation will occur for a fixed time. This will allow the effluent to homogenise. While in recirculation mode, the operator will be able to take a grab sample via an interface with the Auxiliary Sampling System [KUB]. All valves on the sampling line are to be manually operated. Once the time has expired, the pump will be stopped, and the valves will be aligned to their standby configuration.

Transfer of Effluent to Liquid Radioactive Effluent Treatment System [KNF]

The transfer function for all RI Collection and Drainage System [KTA] sub-systems is to be both automated and initiated on operator command. Automatic transfer will occur once the tanks reach high liquid level and provided there is sufficient storage capacity in the downstream treatment system. Operator initiated transfer prior to high-level is expected as part of effective inventory management. Transfer will stop on the tank reaching low level.

The approach to sampling and monitoring is discussed in E3S Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements [7].

Degraded Modes

All RI Collection and Drainage System [KTA] tanks feature a duty/standby discharge pump arrangement. This allows effluent to be discharged even if one pump fails.

In the event of tank overflow, effluent would be directed to bunding around the tank, or another RI Collection and Drainage System [KTA] tank. This is subject to further layout maturity and detailed overflow strategy design. A method of removing effluent from a tank bund requires development, with manual retrieval or usage of the existing pump being potential options.

In the event of RI Collection and Drainage System [KTA] tank failure, it is expected that the effluent would be directed to another nearby RI Collection and Drainage System [KTA] tank. This allows maintenance to be performed on the failed tank.

11.2.6.3 Liquid Radioactive Effluent Treatment System [KNF]

Liquid Radioactive Effluent Treatment System [KNF] Overview

Most of the Liquid Radioactive Effluent Treatment System [KNF] operations are manually actuated from the main control room and there is a dependency on routine sampling to determine the appropriate operations for effluents on demand.

During Mode 1: Power Operation, the Liquid Radioactive Effluent Treatment System [KNF] will be aligned through manual selection of system configurations (grouped commands for aligning the system isolation valves and actuators).

Most of the Liquid Radioactive Effluent Treatment System [KNF] operations are batch-based and therefore require operator selection to initiate them (e.g. operation of the vacuum degasser). Process controls for equipment mostly result in fail-safe trips without alarms to minimise operator burden. This is to be reviewed in a future design phase.

All Liquid Radioactive Effluent Treatment System [KNF] operations are expected during normal operation; even if liquid effluents are generated from faulted operations, transfer to the Liquid Radioactive Effluent Treatment System [KNF] is only required during normal operations.

Coolant Letdown

The Processing and Treatment System for Primary Liquid Effluent [KNF10] effluent tanks will receive effluent from CVCS letdown on demand; this is expected for the reactor start-up transients resulting in thermal expansion, and shut-down Reactor Cooling System (RCS) draining.

If a high level of tritium has accumulated in the primary circuit (e.g. following design basis fuel failure or from activation throughout multiple fuel cycles) then bleeding the reactor coolant to the Processing and Treatment System for Primary Liquid Effluent [KNF10] for treatment and discharge via the Liquid Effluent Monitoring and Discharge System [KNF30] is possible.

If a high level of xenon and krypton activity is detected in the primary circuit sampling (e.g. following design basis fuel failure) then circulation through the vacuum degasser can be performed on demand.

Primary Circuit Make-up

Supply of frequent but small volumes of deaerated make-up water to the CVCS is required. Both the frequency and volume are to be defined by the operating principles of the VCT in the Level and Volume Control System [KBA].

Additional make-up is required for thermal contraction of the primary circuit during shutdown transients.

Spent Liquid Collection

Effluents from collected process, chemical and floor drains are transferred to the Processing and Treatment System for Spent Liquid Effluent [KNF20] effluent tanks on demand when the upstream sumps/vessels in the RI Collection and Drainage System [KTA] system are filled. Most of the drainage volumes are expected to be from maintenance operations requiring bleeding of equipment and floor drains.

Sampling

All Liquid Radioactive Effluent Treatment System [KNF] storage tanks require effluent characterisation before processing / transfer and have provisions for sampling. The contents of these tanks can be discharged and recirculated back to the tank via an operator-initiated function. The valves will align to recirculate the effluent, and the duty discharge pump started. Once initiated, recirculation will occur for a fixed time to be determined during detailed design. This will allow the effluent to homogenise. While in recirculation mode, the operator will be able to take a grab sample via an interface with the Auxiliary Sampling System [KUB]. All valves on the sampling line are to be manually operated. Once the time has expired, the pump will be stopped, and the valves will be aligned to their standby configuration.

Effluent Discharge

Authorisation from the Main Control Room (MCR) is required for effluent discharge to the environment. This includes confirmation of the discharge flow rate set-point to be throttled by the discharge control valve.

Degraded Modes

The Liquid Radioactive Effluent Processing System [KNF] may be expected to operate in certain degraded or abnormal operating modes. These include:

- Liquid Radioactive Effluent Treatment System [KNF] transfer pump failure. There is duty/standby configuration enabled on transfer pumps hence a pump failure does not inhibit Liquid Radioactive Effluent Treatment System [KNF] operation.
- Bypass of Processing and Treatment System for Primary Liquid Effluent [KNF10] vacuum degasser. If the vacuum degasser was taken out of commission for unplanned maintenance, then bypass of the degasser can take place, with storage of coolant in the Processing and Treatment System for Primary Liquid Effluent [KNF10] tank. Shielding of/occupancy around the Processing and Treatment System for Primary Liquid Effluent [KNF10] tanks will be cognisant of these tanks managing non-degassed coolant. Shielding requirements in this scenario are TBC.
- Bypass of the Processing and Treatment System for Spent Liquid Effluent [KNF20] RO skid. For particularly contaminated batches of effluent into the Processing and Treatment System for Spent Liquid Effluent [KNF20], the RO unit may require bypassing and processing by the evaporator may be required. This is a rare but expected scenario and will be better understood during future design work and feedback from suppliers.

11.2.7 Instrumentation and Control

11.2.7.1 Instrumentation and Control Overview

To support the safe operation and control of the system, the Waste Management System C&I [KY] is required to monitor a range of key system parameters and provide indication of these to the operator in the control room and, during emergencies, the emergency control centre.

Equipment packages such as the RO skid, the vacuum evaporator and the vacuum degasser are supplier provided packages, and the supplier will be requested to provide the necessary monitoring and indication as part of the equipment package.

Reference should be made to E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14] for further information.

11.2.7.2 Alarms and Warnings

The difference between an alarm and a warning has been defined in the RR SMR HMI Style Guide [44]. A warning is a signal indicating the imminent onset of a dangerous situation requiring appropriate measures for the elimination or control of the danger. An alarm is a signal indicating the beginning or the actual occurrence of a dangerous situation requiring immediate action.

To support the safe operation and control of both the RI Collection and Drainage System [KTA] and the Liquid Radioactive Effluent Treatment System [KNF], the Reactor C&I System [KY] will be required to provide alarms and warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. Details of the alarms and warnings associated with the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] are contained within the [KTA] and [KNF] SDDs respectively [38] [26].

11.2.7.3 Control Logic

Reference should be made to E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14] for further information on control logic.

Control logic for the RI Collection and Drainage system [KTA] is under development by the Radioactive Waste Management System C&I [KY].

Control logic for the Liquid Radioactive Effluent Treatment System [KNF] has been progressed as summarised below, and is now also managed by the Radioactive Waste Management System C&I [KY].

The control of the Processing and Treatment System for Primary Liquid Effluent [KNF10], Processing and Treatment System for Spent Liquid Effluent [KNF20], and Liquid Effluent Monitoring and Discharge System [KNF30] is based on a series of group commands initiated by the operator, with some automatic safety trips. The Liquid Radioactive Effluent Treatment System [KNF] SDD details these group commands [26].

11.2.8 Examination, Maintenance, Inspection and Testing

11.2.8.1 Through Life Activities Module

Both the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] have a Through Life Activities (TLA) module in the RR SMR requirements management system populated with all known maintenance tasks (in line with design maturity), specific to the system environment and the operating context.

The maintenance activities considered in the TLA include:

- Safety derived tasks (Industrial Safety Instructions (ISI)).
- Design derived tasks (Supplier provided).
- Reliability derived tasks (Reliability-Centred Maintenance (RCM)/Preventative Maintenance).

- Industry best Practice/OPEX (Electric Power Research Institute (EPRI) Preventive Maintenance Database).
- Non-Product Breakdown Structure (PBS) (Module, Site Facility).

11.2.8.2 RI Collection and Drainage System [KTA]

All RI Collection and Drainage System [KTA] drainage modules have 800 mm x 800 mm x 2200 mm of space within the module, which facilitates space for an operator to enter the space and perform EMIT activities [38].

Furthermore, it is assumed that the tank and pumps can be removed for repair/replacement with appropriate mechanical handling equipment if required. The integration and architecture of the RI Collection and Drainage System [KTA] is currently under development as to enable standardisation, modularisation, optimisation of operability and facilitation of EMIT activities within the module frames.

11.2.8.3 Liquid Radioactive Effluent Treatment System [KNF]

Parts of the Liquid Radioactive Effluent Treatment System [KNF] system can be isolated and taken out of service for maintenance where required. Current system configuration includes duty / standby components (for example, the Liquid Radioactive Effluent Treatment System [KNF] transfer pumps) to facilitate maintenance operations and enhance availability.

Equipment handling primary liquid effluent (e.g. the Processing and Treatment System for Primary Liquid Effluent [KNF10] tanks, vacuum degasser) requires a nitrogen purge to [KPL] prior to drainage followed by purging with compressed air to HVAC to allow manual access for maintenance and inspection. This is due to hazards associated with hydrogen and airborne activity arising in vessel headers. Oxygen depletion monitoring and procedural controls will be used to ensure the vessels are sufficiently purged with air prior to access. To prevent erroneous transfer of air into the Gaseous Radioactive Effluent Treatment System [KPL] cover gas stream, automated valves have been included in the design so that grouped commands will appropriately route waste gases to the correct location based on the operation being performed, minimising the scope for human error. Manual isolation valves are provided to enable maintenance with the downstream [KPL] system isolated.

The RO membranes are subject to biofouling when on standby. To minimise the risk of biofouling, a connection to demineralised water supply is proposed for rinsing the RO systems on demand or continuously. The permeate can be recycled to the process feed tank, allowing the system to recirculate the water. RO membrane operation will be optimised to minimise rinsing and disposal requirements with advice from suppliers being sought on the requirements for frequency of rinsing and the use of cleaning solutions, such as acid washing.

The evaporator and its associated equipment are considered high risk for corrosion and likely to worsen over plant life, therefore provisions will be made for removal and replacement during plant life. Maintenance of the evaporator is key in order to minimise and potentially avoid the need for replacement of the column. Periodic dilute chemical washing is proposed for cleaning and decontamination of the evaporator column. Chemicals will be provided on demand and injected via a connection from the central supply system [QC].

The Processing and Treatment System for Primary Liquid Effluent [KNF10] is designed to operate frequently during normal operation, performing activities such as collecting, degassing and returning primary coolant to the primary coolant loop. During planned outages, the Processing and Treatment System for Primary Liquid Effluent [KNF10] will degas and collect all the coolant letdown from the primary coolant loop prior to treatment. The treated coolant is stored in the Liquid Effluent Monitoring and Discharge System [KNF30]. It is assumed that the [KNF10] system will therefore be emptied during the first part of the outage window, allowing for maintenance activities on all the Processing and Treatment System for Primary Liquid Effluent [KNF10] equipment.

The Processing and Treatment System for Spent Liquid Effluent [KNF20] will be busiest during the outage window, collecting and treating effluents that arise from maintenance activities throughout the RI systems. It is therefore assumed that the Processing and Treatment System for Spent Liquid Effluent [KNF20] equipment will undergo maintenance at some point during normal operation. At this stage, it is assumed this window falls just before the outage window, where maintenance can occur prior to its busiest period. The treatment and evaporator train will undergo maintenance whilst the Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks collect effluent.

The Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks will undergo maintenance prior to the treatment train, to ensure the Processing and Treatment System for Spent Liquid Effluent [KNF20] can store spent effluent whilst the treatment train is offline. It is expected that the duty-standby configuration of the Processing and Treatment System for Spent Liquid Effluent [KNF20] tanks can ensure continual operation during maintenance. When this occurs is not yet detailed, but again is assumed just before the outage window.

The hot water loop operates concurrently with the evaporator and degasser by providing hot water to these components. Consequently, maintenance of the equipment within the hot water loop is necessary when the evaporator and degasser are not in use. Currently, it is assumed this occurs during the outage window, coinciding with the maintenance of the Processing and Treatment System for Primary Liquid Effluent [KNF10]. The degasser will not be needed after the first part of the outage window. The evaporator will be used, but there will be downtime due to its batch operation and there is expected to be sufficient time to undertake maintenance of the hot water loop. The available maintenance window is subject to further development.

The Liquid Effluent Monitoring and Discharge System [KNF30] collects treated effluent during both normal operation and the outage period. Due to the Liquid Effluent Monitoring and Discharge System [KNF30] tanks having duty-standby configurations, there are fewer restrictions on when maintenance can occur. Currently, it is assumed that the Liquid Effluent Monitoring and Discharge System [KNF30] undergoes maintenance at the same time as the Processing and Treatment System for Spent Liquid Effluent [KNF20], just before the outage window, ensuring that it won't receive treated effluent while the Processing and Treatment System for Spent Liquid Effluent [KNF20] is offline.

To avoid potential pipe blockages due to high particle loading during resin transfer, the pipes are flushed with demineralised water after transfer. A Safe Isolation Assessment has been carried out on the system, consistent with HSG253 [45]. Note this is not directly related to the safety-related maintenance related to EMIT (rather conventional maintenance).

11.2.9 Radiological Aspects

11.2.9.1 Radiological Aspects - Overview

Analysis of radiological consequences following operation of the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] during design basis fault conditions are presented in E3S Case Version 3, Tier 1, Chapter 15: Safety Analysis [16].

The hierarchy of controls has been applied to reduce the risk of radiation exposure to the operator. This is summarised below:

- Elimination: Complete drainage of the equipment eliminates the major source of radiation within the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] equipment prior to operator access for EMIT. Where possible, EMIT activities will be performed online e.g. calibration of sensors. Furthermore, the waste hierarchy ensures that, where possible, the amount of equipment is minimised. These design considerations minimise the time operators will spend in RCAs performing EMIT.

- Substitution: If inspections are required offline, non-destructive examination methods are preferably deployed to prevent 'opening' up the equipment and reducing the risk of internal exposure, whilst also reducing the time spent performing EMIT.
- Engineering Controls: Exposure to operators is limited by suitable shielding arrangements. Furthermore, to minimise internal exposure to operators, suitable HVAC systems will be used to reduce the risk posed by airborne radionuclides.
- Administrative Controls: Exposure to operators during EMIT is mitigated by flushing the tanks, pipework and pumps with demineralised water prior to operator access, minimising the contamination within the system which reduces the risk of both internal and external exposure to operators. Furthermore, it is expected that access to RCAs is controlled, whilst appropriate training, signage and operator procedures are in place. These controls are outside the scope of the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] design and will be developed plant system-wide.
- PPE: This is a mitigative dose control element that should only be considered when all other elements (engineering and procedural control) have been fully explored. The design of PPE is not within the scope of the RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] design.

The RI Collection and Drainage System [KTA] contains radiologically active effluent and so requires the subsequent dose from gamma rays to be managed to ALARP levels. A bulk system shielding assessment has been carried out for the waste systems [46] to determine the required thickness of steel or concrete shielding required for each component to reduce dose rates within the bounds for designated areas as illustrated in Table 11.2-3.

Table 11.2-3: Designated Areas and Radiation Classifications

Designation	Radiation Classification	Dose Rate Range (μSv/h)
Undesignated	R0	<0.5
Supervised Area	R1	<7.5
Controlled Area	R2	7.5 - 25
	R3	25 - 100
	R4	100 - 500
	R5	>500

11.2.9.2 RI Collection and Drainage System [KTA]

The Collection and Transfer of Reactor Coolant Drains [KTA10], Collection and Transfer of Process and Floor Drains [KTA20], and Collection and Transfer of Chemical Drains [KTA30] tanks are to be located in RCAs, requiring shielding to reduce dose below 25 μSv/h. The shielding solution currently proposed is civil walls, due to the large thicknesses of steel that would be required for Modular Kit of Parts (MKoP) shielding. This will be reviewed and developed as the design progresses and may vary depending on the RI Collection and Drainage System [KTA] tanks' locations. RI Collection and Drainage System [KTA] pipework is unlikely to require shielding in RCAs.

Further to shielding, dose rates from the RI Collection and Drainage System [KTA] are controlled through minimal operator interactions in normal operation, e.g. effluent transfer is generally automatic and remote, reducing occupancy to walkdowns and maintenance. The RI Collection and Drainage System [KTA] tanks are to be drained from the bottom of the tank to reduce any accumulated solids.

11.2.9.3 Liquid Radioactive Effluent Treatment System [KNF]

A shielding assessment has been performed for the Liquid Radioactive Effluent Treatment System [KNF] [47]. In this assessment, dose rate calculations using the primary source term have been performed to determine the required thickness of steel or concrete shielding for each of the vessels and tanks, and the process area, within the [KNF] system to reduce dose rates below the upper bounds for an undesignated area (R0), supervised area (R1), and the first two dose rate bands of the controlled area (R2, R3) respectively.

Occupational dose risk will be managed and sought to be reduced as the design of the system matures and a better understanding of plant layout and occupancy is understood.

The [KNF] tank rooms radiological designation is assumed to be R5 during normal operation, and R3 when drained to allow access for EMIT. The R5 designation is based on the shielding calculations, the R3 is an assumption at this stage, allowing for contributions from shine through the shield walls from adjacent tank areas, and residual activity in the tanks after draining and flushing.

11.2.10 Performance and Safety Evaluation

The RI Collection and Drainage System [KTA] and Liquid Radioactive Effluent Treatment System [KNF] are designed to deliver their CoRM and CoRE safety functions.

Vessels and tanks are designed to appropriate codes and standards in accordance with their safety classification to ensure their integrity, including following internal and external hazards. There is redundancy of key instrumentation such as level measurement, however, segregation of these instruments is not required for internal hazard protection. For external hazards, the majority of the active RI Collection and Drainage System [KTA] is also located within the hazard shield and on the aseismic bearing. The Liquid Radioactive Effluent Treatment System [KNF] is located in the Auxiliary Block [UKA10], which is also on the aseismic bearing.

Appropriate shielding is incorporated into the design to minimise operator exposure, and the systems are located within RCAs. Further defence in depth is provided through radiation alarms to alert operators to evacuate.

The design of the layout facilitates CoRE and sufficient space is afforded for EMIT.

The layout of SSC enables assembly and installation within modules in accordance with the RR SMR modularisation approach [48], also enabling some commissioning activities to be undertaken at the module factory in accordance with the RR SMR commissioning strategy [49]. It is expected that individual RI Collection and Drainage System [KTA] drainage tanks and associated fittings, pumps etc. will come as individual, pre-built drainage modules, which can be assembled in the Module Mechanical, Electrical and Plumbing (MEP) Factory.

SSCs are designed to facilitate safe decommissioning in accordance with the RR SMR decommissioning strategy [50], such as use of stainless steel materials that minimise potential for contamination, and the design of pipework with long radius bends to reduce potential buildup of contamination during operation. Further information can be found in E3S Case Version 3, Tier 1 Chapter 21: Decommissioning and End of Life Aspects [51].

In summary, the arguments and evidence presented at DRP4 provide confidence that the RI Collection and Drainage System [KTA] and the Liquid Radioactive Effluent Treatment System [KNF] will be capable of achieving the claim that the design ensures fundamental functions are achieved through-life. Evidence will continue to be generated for the E3S Case as the verification programme progresses, including continued iteration of the safety analysis, EQ of SSC including environmental and seismic qualification, and validation through commissioning.

11.3 Systems and Arrangements for the Management of Gaseous Radioactive Wastes

11.3.1 Systems and Equipment Functions

11.3.1.1 Gaseous Radioactive Effluent Treatment System [KPL]

The primary function of the Gaseous Radioactive Effluent Treatment System [KPL] is to process gaseous effluent from the primary circuit and liquid waste systems, containing hydrogen and volatile fission products.

The baseline architecture of the Gaseous Radioactive Effluent Treatment System [KPL] provides a cover gas to various systems in the RI to maintain a positive pressure and collects the contaminated cover gas using compressors to be discharged to the RI Emissions Stack [UKH], via delay beds. The delay beds provide abatement of fission products by extended hold-up and decay.

The Gaseous Radioactive Effluent Treatment System [KPL] supports the FSF of CoRM, providing duty and preventive safety functions (plant states DBC-1 and DBC-2).

As previously noted, the RI HVAC System [KL] is primarily covered within E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2], with key elements related to the management of gaseous radioactive wastes summarised in Section 11.3.5.

11.3.2 Design Bases

11.3.2.1 Safety Categorised Functional Requirements

The Gaseous Radioactive Effluent Treatment System [KPL] provides safety functions to confine radioactive effluents, as a duty/preventive measure for specific PIEs listed in the Fault Schedule [35]. The PIE against which the Gaseous Radioactive Effluent Treatment System is allocated safety functions is:

- NFM.1.2.01: Release from Gaseous Waste System.

The PIE NFM.2.1.03: Inadvertent Operator Exposure to R5 Area is also relevant to the Gaseous Radioactive Effluent Treatment System [KPL] due to the high potential dose rates during certain operating periods but this is a RR SMR wider fault and not specific to the Radioactive Effluent Treatment System [KPL].

Safety categorised functional requirements are derived from the safety functions and are to be allocated to the SSCs that comprise the Gaseous Radioactive Effluent Treatment System [KPL], and subsequently presented in the Requirements Specification [52].

Safety classification has not yet been assigned on a component level within the Gaseous Radioactive Effluent Treatment System [KPL]; however, can be inferred from the categorisation of their relevant safety function. Following the latest issue of the [KPL] Categorisation and Classification assessment [53], the [KPL] cover gas network has now been assigned up to a category B safety function.

Components within the Gaseous Radioactive Effluent Treatment System [KPL] plant and delay bed rooms are to be safety class 3, with the dose alarms assigned safety class 2.

A conservative preliminary dose modelling assessment [53] suggested hazards associated with the Gaseous Radioactive Effluent Treatment System [KPL] were sufficient to demand class 1 safeguards. However, class 2 has been assigned as the most stringent safeguards, with the categorisation and classification to be revisited. This has driven to a more stringent categorisation and classification than the Gaseous Radioactive Effluent Treatment System [KPL] plant room, despite the equivalent source terms, due to the pipe routing through currently unrestricted or unventilated areas. The findings of this assessment will be used to inform future refinements in the design with the aim to enhance radiological safety.

Components contributing to safety functions stopping backflow from interfacing tanks are assigned safety class 3 for the Processing and Treatment System for Primary Liquid Effluent [KNF10], the Collection and Transfer of Process and Floor Drains [KTA20], and the Collection and Transfer of Reactor Coolant Drains [KTA10].

Following Rolls-Royce SMR Limited guidance [3], the Gaseous Radioactive Effluent Treatment System [KPL] contributes to the following Fundamental Environmental Functions:

- Elimination or reduction in the generation of radioactive waste.
- Minimisation of the volume and/or activity of radioactive wastes discharged to the environment or transferred to other premises.
- Minimisation of the impacts on the environment and/or members of the public of radioactive wastes discharged to the environment or transferred to other premises.
- Measurement and assessment of radioactive wastes discharged to the environment or transferred to other premises.

Potential KEPE within the Gaseous Radioactive Effluent Treatment System [KPL] to support delivery of this Fundamental Environmental Function is summarised in Table 11.3-1. Further details on identified KEPE are to be captured in the Environmental Schedule[7].

Table 11.3-1: Potential KEPE for the Gaseous Radioactive Effluent Treatment System [KPL]

System RDS-PP®	SSC
[KPL]	Delay beds
[KPL]	Delay bed dryer
[KPL]	Delay bed guard beds
[KPL]	Delay bed control valve

No security or safeguards functional requirements are assigned.

11.3.3 Description

Gaseous Radioactive Effluent Treatment System [KPL] Overview

The Gaseous Radioactive Effluent Treatment System [KPL] uses nitrogen cover gas to blanket interfacing systems handling reactor coolant, primary circuit effluent or make-up water. The Level and Volume Control System [KBA] VCT is an exception to this and provides its own hydrogen blanket for chemistry control; see E3S Case Version 3, Tier 1, Chapter 20: Chemistry [19] for further information on the chemistry regime of the RR SMR.

Hydrogen and volatile fission products (primarily xenon and krypton) off-gas from solution into the cover gas blanket in the tank ullages and are collected as gaseous effluent. These interfacing tanks are pressure controlled, and the contaminated cover gas is displaced into the Gaseous Radioactive

Effluent Treatment System [KPL] when further liquid or gas is introduced to the tank. The Gaseous Radioactive Effluent Treatment System [KPL] also receives gases removed directly from reactor coolant, primary circuit effluent or make-up water by the Treatment System for Primary Liquid Effluent [KNF10] degasser.

The cover gas is not recycled and is discharged directly to the RI Emissions Stack [UKH] once it has been processed by the Gaseous Radioactive Effluent Treatment System [KPL] delay beds. Cover gas is distributed from clean upstream systems to the interfacing tanks by [KPL]. The upstream systems which supply the clean cover gas to the Gaseous Radioactive Effluent Treatment System [KPL] distribution network are not within the Gaseous Radioactive Effluent Treatment System [KPL] scope and reference should be made to E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2] for further information on air and gas systems.

Hydrogen and oxygen content in the gas stream are constantly measured through a gas analyser.

Gas is dried upstream of the delay beds to sufficiently reduce moisture content and ensure the optimum delay bed performance.

The Gaseous Radioactive Effluent Treatment System [KPL] consists of:

- Control valves for controlling pressure within interfacing system tanks by either adding nitrogen or releasing cover gas.
- Pipework to route cover gas from the interfacing tanks to the compressor packages.
- Gas analysers for detecting the hydrogen and oxygen content.
- Gas compressors with liquid seal systems.
- A series of delay beds with an exhaust to the RI Emissions Stack [UKH]. A dryer package and guard bed upstream protect the delay beds from excessive moisture that affect their performance. A control valve downstream of the delay beds maintains delay line pressure.

A simplified schematic of the Gaseous Radioactive Effluent Treatment System [KPL] is presented in Figure 11.3-1.

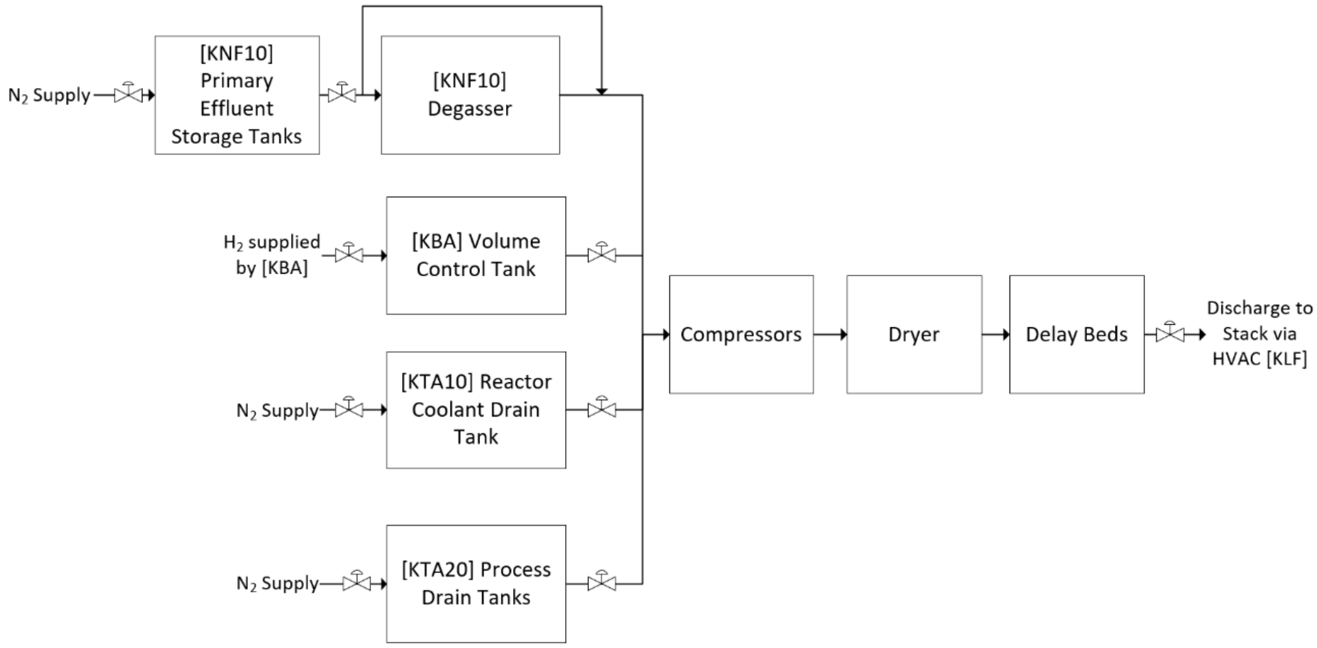

Figure 11.3-1: Simplified Schematic of the Gaseous Radioactive Effluent Treatment System [KPL]

Compressors

Gas compressors are proposed.

A surge gas line is proposed for recirculating flow when low compressor suction pressure is detected, to avoid spurious trips.

The compressors are fixed speed devices. Pressure downstream of the compressors, in the delay line, is controlled by a backpressure controller on the outlet of Gaseous Radioactive Effluent System [KPL]. A relief line on the outlet of the compressor is provided in the case of overpressure, which relieves back to the cover gas manifold.

Dryer

A dryer equipment package is proposed for removing moisture to maximise performance of the delay beds. This is anticipated to be either condenser or desiccant based, or a combination of the two, to be confirmed upon further supply chain engagement. The dryer package shall also be developed with input from the delay bed supplier due to the interlinked nature of the performance requirements.

Delay Beds

The activated charcoal beds provide hold-up and decay of xenon and krypton, prior to release to the RI Emissions Stack [UKH] via the HVAC Servicing Radioactive Waste Systems [KLF].

A guard bed of activated charcoal acts as a sacrificial bed to protect the delay beds against fouling from contaminants or moisture carryover.

A control valve downstream of the beds maintains the upstream pressure >0.5 MPa(a), to maintain the dynamic adsorption coefficient for the fission gases. The discharge flow rate is monitored but not controlled due to the significantly larger flow rate downstream in the HVAC Servicing Radioactive Waste Systems [KLF] ventilation air. Provisions for sampling are available downstream of the delay beds – see E3S Case Version 3, Tier 1 Chapter 28: Sampling and Monitoring Arrangements [7].

The size and operating conditions of the delay beds are to be confirmed by a supplier and will be determined by adsorption coefficients at the chosen conditions.

The two delay beds may be broken down into trains of small beds, pending supplier design input, as is provisioned for in the layout allocation. The sizing case proposed requires one delay bed/train to have sufficient hold-up during normal operation. This allows one bed to be bypassed for maintenance and inspection during operation.

The key factor in sizing of delay beds is total volumetric flow rate. Whether a design basis fuel failure may require both delay beds/trains to be used for sufficient hold-up shall be investigated with supplier input. Early supplier engagement suggests the total volume of fission gases in PWR fuel failures is too low to have a significant impact on delay bed hold-up time. This will be confirmed through continued supplier engagement.

Key operating parameters that influence delay bed performance can be found in the Gaseous Radioactive Effluent Treatment System [KPL] SDD [54].

Gaseous Radioactive Effluent Treatment System [KPL] Layout

The key Gaseous Radioactive Effluent Treatment System [KPL] equipment is located in the Auxiliary Block (UKA10), outside the hazard shield. The cover gas lines interface with systems in the reactor containment, fuelling and auxiliary buildings. The effluent discharge connects to the RI Emissions Stack [UKH], discussed in E3S Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures [8].

The current Gaseous Radioactive Effluent Treatment System [KPL] layout includes two delay bed rooms and a process hub space. There is a requirement to shield the operator from the delay beds to reduce dose and as such constraints have been placed on the layout to segregate the delay beds from each other and other equipment requiring access. Each delay bed room can be accessed without passing through the other.

As noted earlier, the two delay beds may be broken down into trains of small beds, pending supplier design input. The current Gaseous Radioactive Effluent Treatment System [KPL] layout includes more than two delay beds and a conservative space allocation has been provided to minimise risk of layout rework.

11.3.4 Materials

Materials are selected to minimise risks associated with operator and maintenance dose, corrosion, and decommissioning.

The materials for the Gaseous Radioactive Effluent Treatment System [KPL] components are selected in accordance with their safety class using RGP and OPEX, to ensure their through-life integrity and qualification for relevant environmental conditions. The Gaseous Radioactive Effluent Treatment System [KPL] is expected to be constructed primarily from stainless steel which is conventionally recyclable. No unusual materials are expected

The approach to materials selection and ageing management for Safety Class 1 SSCs along with the description and justification of materials used for Classified SSCs is provided in E3S Case Version 3, Tier 1, Chapter 23: Structural Integrity [20].

11.3.5 Interfaces with Other Equipment or Systems

The following systems interface with the Gaseous Radioactive Effluent Treatment System [KPL] cover gas:

- Treatment System for Primary Liquid Effluent [KNF10] Degasser – Cover gas collects hydrogen and fission product during reactor coolant degassing (except during non-active de-aeration functions). The cover gas provides vessel blanket when in standby mode.
- Treatment System for Primary Liquid Effluent [KNF10] Primary Effluent Storage Tanks – Cover gas collects residual hydrogen, oxygen, fission product gases from collected primary effluents. Blanket is provided to minimise air ingress to primary circuit make-up water.
- [KTA10] Collection and Transfer of Reactor Coolant Drains RCDT – Cover gas collects hydrogen and fission product from effluents during reactor operation and shutdown transient.
- Collection and Transfer of Process and Floor Drains [KTA20] Process Drain Tanks / Vessels – Cover gas collects hydrogen and fission product from process drain effluents.
- Level and Volume Control System [KBA] VCT – Cover gas collects hydrogen and fission product from effluents during reactor operation and shutdown transient.

Gaseous Radioactive Effluent from the Gaseous Radioactive Effluent Treatment System [KPL] is discharged to the RI Emissions Stack [UKH] via the HVAC Servicing Radioactive Waste Systems [KLF]. See E3S Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures [8] and E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2] respectively for further information on those systems.

The Gaseous Radioactive Effluent Treatment System [KPL] features interfaces with the Auxiliary Sampling System [KUB] and Process and Emissions Radiation Monitoring System [KUK] for the purposes of sampling and monitoring. Sampling and monitoring are discussed in E3S Case Version 3, Tier 1 Chapter 28: Sampling and Monitoring Arrangements [7].

11.3.6 Systems and Equipment Operation

Overview

The Gaseous Radioactive Effluent Treatment System [KPL] is aligned through manual selection of system configurations (grouped commands for aligning the system isolation valves and actuators). Current system configurations include switchover of duty / standby compressor packages and switchover of duty / standby control valves.

The Gaseous Radioactive Effluent Treatment System [KPL] will be operating continuously during power operation.

Most of the Gaseous Radioactive Effluent Treatment System [KPL] operations are regulated automatically, this includes a combination of pressure and flow rate measurements for maintaining operating conditions within the required operating ranges. Deviations from these operating conditions will result in alarms and warnings to the operator.

Degraded Modes

The Gaseous Radioactive Effluent Treatment system [KPL] may be expected to operate in certain degraded or abnormal operating modes. These include:

- The Gaseous Radioactive Effluent Treatment System [KPL] liquid ring pump failure or taken out of commission for maintenance. There is a duty/standby configuration enabled on the

Gaseous Radioactive Effluent Treatment System [KPL] liquid ring pumps hence a pump failure does not inhibit the Gaseous Radioactive Effluent Treatment System [KPL] operation.

- The Gaseous Radioactive Effluent Treatment System [KPL] outlet control valve station failure or taken out of commission for maintenance. There is a duty/standby configuration enabled on the control valve station, hence, control valve failure does not inhibit the Gaseous Radioactive Effluent Treatment System [KPL] operation.
- The Gaseous Radioactive Effluent Treatment System [KPL] measuring gas cabinet failure or taken out of commission for maintenance. Connections to the Auxiliary Sampling System [KUB] are provided for grab-sampling during these periods, to avoid shutdown of the Gaseous Radioactive Effluent Treatment System [KPL] system entirely.
- Loss of nitrogen supply. This will result in failure of the Gaseous Radioactive Effluent Treatment System [KPL] to maintain pressure in interfacing tanks. Very low pressure in these tanks is interlocked against emptying of the tank. It has been identified that tanks and vessels should be rated for full vacuum to provide inherent safety in low pressure fault scenarios.
- Isolations of discharge in the event of low HVAC Servicing Radioactive Waste Systems [KLF] flow, or high activity measurements in the Process and Emissions Radiation Monitoring System [KUK] or the RI Emissions Stack [UKH].
- Bypass of the delay line dryer. If the Gaseous Radioactive Effluent Treatment System [KPL] delay line dryer is taken out of commission for maintenance, the inlet to the delay line can be isolated if excessive moisture is measured in-line. Upon this isolation, coolant movement on interfacing systems is interlocked to prevent shutdown of the Gaseous Radioactive Effluent Treatment System [KPL]. The delay line dryer is expected to be supplied in the same package as the delay beds, and vendor input will be sought to consider a duty-standby arrangement for the dryer.
- Bypass of one Gaseous Radioactive Effluent Treatment System [KPL] delay bed train. While both are online in normal operation, the Gaseous Radioactive Effluent Treatment System [KPL] delay beds are sized for 100 % redundancy. Hence, if a delay bed is taken out of service for maintenance, it is not required to shut down the Gaseous Radioactive Effluent Treatment System [KPL] since sufficient capacity is provided by the remaining delay bed train.

The Gaseous Radioactive Effluent Treatment System [KPL] is required to operate for plant availability reasons, and not nuclear safety, so there is no diversity or segregation requirement for any of these functions.

11.3.7 Instrumentation and Control

11.3.7.1 Instrumentation and Control Overview

To support the safe operation and control of the system, the Waste Management System C&I [KY] is required to monitor a range of key system parameters and provide indication of these to the operator in the control room and, during emergencies, the emergency control centre. Noting that dedicated control cubicles are expected for the following equipment:

- The gas compressors are expected to be packaged equipment, including trips for compressor suction temperature, pressure, flow and sealing liquid drum level managed by dedicated control.
- The hydrogen and oxygen analyser is expected to be package equipment, including equipment for gas compression, distribution, cooling, drying, etc. requiring dedicated control.

11.3.7.2 Alarms and Warnings

To support the safe operation and control of the Gaseous Radioactive Effluent Treatment System [KPL], the Reactor C&I System [KY] will be required to provide alarms and warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. Details of the alarms and warnings associated with the Gaseous Radioactive Effluent Treatment System [KPL] are contained within its SDD [54].

11.3.7.3 Control Logic

Control logic for the Gaseous Radioactive Effluent Treatment System [KPL] is under development by the Radioactive Waste Management System C&I [KY] – see E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14].

The [KPL] system can be described as four sub-sections that perform control functions to enable the [KPL] system as a whole to be controlled, namely – blanketed tanks, gas analysis, compression, and delay beds. The Gaseous Radioactive Effluent Treatment System [KPL] SDD summarises these control functions [54].

11.3.8 Examination, Maintenance, Inspection and Testing

The Gaseous Radioactive Effluent Treatment System [KPL] has a TLA module in the RR SMR requirements management system populated with all known maintenance tasks (in line with design maturity), specific to the system environment and the operating context.

The maintenance activities considered in the TLA include:

- Safety derived tasks (ISI).
- Design derived tasks (Supplier provided).
- Reliability derived tasks (RCM/Preventative Maintenance).
- Industry best Practice/OPEX (EPRI Preventive Maintenance Database).
- Non-PBS (Module, Site Facility).

As the Gaseous Radioactive Effluent Treatment System [KPL] is required to be operational in all plant states, key equipment is redundant with the appropriate valves and pressure sensors to prove the isolation, as well as connections for flushing the equipment with gas to the HVAC system. This allows maintenance while the system is online.

The delay bed trains are housed in separate rooms, meaning safe maintenance can be carried out on the standby delay beds whilst the Gaseous Radioactive Effluent Treatment System [KPL] continues to operate.

11.3.9 Radiological Aspects

The Gaseous Radioactive Effluent Treatment System [KPL] delay bed rooms will consistently be very high dose during shutdown degassing. The delay bed rooms regularly receive vented gas from the Reactor Coolant Pressurising System [JEF] pressuriser and Level and Volume Control System [KBA] VCT and likely remain at high dose rates throughout the cycle. This finding supports the approach of splitting the delay bed trains into two separate shielded rooms to allow maintenance of one delay bed train at a time, whilst isolated from the system.

Results for the Gaseous Radioactive Effluent Treatment System [KPL] plant room radiation classification vary heavily depending on the source term used. With the best estimate source term, the highest radiation dose present in the room will be during Level and Volume Control System [KBA] VCT routine venting, bringing the room to R2. Otherwise, the room is an R0, reaching R1 only during shutdown. This would allow online maintenance at almost all times during the cycle.

However, when the design basis source term is applied, the Gaseous Radioactive Effluent Treatment System [KPL] plant room reaches R5 at all times. The current layout does not segregate the duty/standby compressors, meaning online maintenance during the cycle would not be possible during design basis. An investigation to seek improvements to the design and operating philosophy has been initiated as described in the Gaseous Radioactive Effluent Treatment System [KPL] SDD [54].

Occupational dose risk will be managed and sought to be reduced as the design of the system matures and a better understanding of plant layout and occupancy is understood. This shall enable development of an argument that the design and operational solution is ALARP, with respect to the level of shielding.

11.3.10 Performance and Safety Evaluation

The Gaseous Radioactive Waste Treatment System [KPL] is designed to deliver its CoRM safety function.

SSCs are designed to appropriate codes and standards in accordance with their safety classification to ensure their integrity, including following internal and external hazards. As the Gaseous Radioactive Effluent Treatment System [KPL] is required to be operational in all plant states, key equipment is redundant with the appropriate valves and pressure sensors to prove the isolation, as well as connections for flushing the equipment with gas to the HVAC system. For external hazards, the Gaseous Radioactive Effluent Treatment System [KPL] is located outside the hazard shield, which raises the need to respond to address external hazards. This will be developed to support Revision 4 of the E3S Case.

Appropriate shielding is incorporated into the design to minimise operator exposure, and the systems are located within RCAs. Further defence in depth is provided through radiation alarms to alert operators to evacuate.

The design of the layout facilitates CoRE and sufficient space is afforded for EMIT, noting that there is an investigation to determine the impact of the design basis source term on the Gaseous Radioactive Effluent Treatment System [KPL] plant room and their duty/standby compressors. This is subject to further development as the design progresses.

The layout of SSC enables assembly and installation within modules in accordance with the RR SMR modularisation approach [48], also enabling some commissioning activities to be undertaken at the module factory in accordance with the RR SMR commissioning strategy [49]. Modular solutions including the compressor packages, the dryer package, the delay beds and the gas analyser are considered to reduce installation time, with most pipework and cabling already installed. Specific control modules and panels for these equipment packages, such as flow or pressure regulation are to be integrated also.

SSCs are designed to facilitate safe decommissioning in accordance with the RR SMR decommissioning strategy [50], such as use of stainless steel materials that minimise potential for contamination, and the design of ductwork with long radius bends to reduce potential buildup of contamination during operation. Further information can be found in E3S Case Version 3, Tier 1 Chapter 21: Decommissioning and End of Life Aspects [51].

In summary, the arguments and evidence presented at DRP4 provide confidence that the Gaseous Radioactive Effluent System [KPL] will be capable of achieving the claim that the design ensures fundamental functions are achieved through-life. Evidence will continue to be generated for the E3S

Case as the verification programme progresses, including continued iteration of the safety analysis, EQ of SSC including environmental and seismic qualification, and validation through commissioning.

11.4 Systems and Arrangements for the Management of Solid Radioactive Wastes

11.4.1 Systems and Equipment Functions

11.4.1.1 Solid Radioactive Waste Storage System [KME]

The Solid Radioactive Waste Storage System [KME] collects and stores LLW and ILW. Waste can be divided into two main categories:

- Wet solid radioactive waste including evaporator concentrates, resins and backwashed filter solids, arising from the Coolant Purification System [KBE], SF Pool Purification and Cooling System [FAL], Liquid Radioactive Effluent Treatment System [KNF] and Steam Generator Purification System [LCQ} in the event of a Steam Generator Team Leak (SGTL). Miscellaneous waste such as NAPLs may also arise from the plant.
- Dry solid radioactive waste from the RI and the rest of the plant, e.g. filter casings and waste produced during maintenance.

The Solid Radioactive Waste Storage System [KME] consists of:

- Temporary Storage Area for LLW [KME10].
- Temporary Storage System for ILW [KME20].
- Solid Intermediate Level Waste Store [KME30] [40].

The Solid Radioactive Waste Storage System [KME] contributes to the FSF of CoRM and CoRE, providing duty and preventive safety functions (plant states DBC-1 and DBC-2).

11.4.1.2 Processing and Treatment System for Solid Radioactive Waste [KMA]

The Processing and Treatment System for Solid Radioactive Waste [KMA] receives solid wastes from the Solid Radioactive Waste Storage System [KME] and produces waste packages to be dispatched off-site or to the Interim Storage Facility for packaged ILW [KME30].

The Processing and Treatment System for Solid Radioactive Waste [KMA] consists of:

- Processing and Dispatch System for LLW [KMA10]. This system is divided into two distinct processes as the Processing and Treatment System for Solid Radioactive Waste [KMA] receives both dry and wet-solid LLW. For the purposes of this chapter, these will be referred to as the Processing and Dispatch System for Dry LLW [KMA10] and the Processing and Dispatch System for Wet LLW [KMA10] respectively, though it should be noted that the small volume of 'miscellaneous non-aqueous phase liquids' are processed within the Processing and Dispatch System for Dry LLW [KMA10].
- Processing and Dispatch System for ILW [KMA20] [55].

The Processing and Treatment System for Solid Radioactive Waste [KMA] contributes to the FSF of CoRM and CoRE, providing duty and preventive safety functions (plant states DBC-1 and DBC-2).

11.4.2 Design Bases

11.4.2.1 Solid Radioactive Waste Storage System [KME]

The Solid Radioactive Waste Storage System [KME] provides safety functions to confine radioactive wet and solid wastes during storage and prior to dispatch, as a duty/preventive measure for specific PIEs listed in the Fault Schedule [35]. The PIEs against which the Solid Radioactive Waste Storage System [KME] is allocated safety functions are:

- NFM.1.3.01: Release from Solid waste Storage.
- NFM.1.3.02: Release from Solid waste Processing Systems.
- NFM.1.3.03: Overfill of Solid waste Storage.
- NFM.2.1.04: Inadvertent Operator Exposure to R5 Bunker Area.
- NFM.2.1.03: Inadvertent Operator Exposure to R5 Area.

Safety categorised functional requirements are derived from the safety functions and allocated to the SSCs that comprise the Solid Radioactive Waste Storage System [KME], presented in the Requirements Specification [56].

The following safety categorisations and classifications are assigned for the Solid Radioactive Waste Storage System [KME] SSCs:

- Tanks perform a safety category C preventive function and are safety class 3, with safety class 3 normal level control.
- Pipework performs a safety category C preventive function and is safety class 3.
- Pumps perform a safety category C preventive function and are safety class 3, with safety class 3 low flow trip on the outlets.
- Tanks, pumps and pipework are in a safety class 1 civil bund (civil bund and bund liner – both out of scope of this Chapter). The high-level trips and high-level alarms on the radiological bund perform a safety category C function and are assigned safety class 3.
- The civil structure performs a safety category A shielding function and is assigned safety class 1.
- Unauthorised access to the process or tank room requires a safety category A duty function. There are safety class 1 physical locks on the tank area shield plug, and a safety class 1 physical lock on the pump room door for access control.
- A radiation dose alarm monitoring system performs a safety category B protective function to support operator evacuation, which is assigned safety class 2.

The Solid Radioactive Waste Storage System [KME] contributes to the following Fundamental Environmental Function:

- Minimisation of the volume and/or activity of radioactive wastes discharged to the environment or transferred to other premises.

Potential KEPE within the Solid Radioactive Waste Storage System [KME] to support delivery of this Fundamental Environmental Function is summarised in Table 11.4-1. Additional KEPE associated with the ILW store [KME30] will be established as the design matures. Further details on identified KEPE are to be captured in the Environmental Schedule[7].

Table 11.4-1: Potential KEPE for the Solid Radioactive Waste Storage System [KME]

System RDS-PP®	SSC
[KME10]	Waste storage cages
[KME10]	NAPLs storage bund
[KME20]	Evaporator Concentrate tanks
[KME20]	Filter solid tanks
[KME20]	Resins tanks
[KME20]	Evaporator Concentrate tanks recirculation line
[KME20]	Evaporator Concentrate tanks draw-off sump
[KME20]	Resin tanks recirculation line
[KME20]	Resin tanks draw-off sump
[KME20]	Pipework flushing supply points
[KME30]	ILW Store

No security or safeguards functional requirements are assigned.

11.4.2.2 Processing and Treatment System for Solid Radioactive Waste [KMA]

The Processing and Treatment System for Solid Radioactive Waste [KMA] provides safety functions to confine radioactive wet-solid LLW, wet-solid ILW and dry-solid LLW during treatment and packaging, as a duty/preventive measure for specific PIEs listed in the Fault Schedule [35]. The PIEs against which the Processing and Treatment System for Solid Radioactive Waste [KMA] is allocated safety functions are:

- (NFM.1.3.01) Leak or rupture of Batch Preparation Tank Module (BPTM) causing high dose to local operators.
- (NFM.1.3.02) Leak or rupture of waste slurry transfer pipes / valves / pumps causing high dose to local operators.
- (NFM.1.3.03) Overfill BPTMs causing unplanned return of waste to [KME20].
- (NFM.1.3.04) Operator enters BPTM enclosure during operation.

PIEs for dry-solid ILW are not yet identified. Safety categorised functional requirements are derived from the safety functions and allocated to the SSCs that comprise the Processing and Treatment System for Solid Radioactive Waste [KMA], presented in the Requirements Specification [57].

The following safety categorisations and classifications are assigned for the Processing and Treatment System for Solid Radioactive Waste [KMA] SSCs:

- Batch preparation tanks perform a safety category C preventive function and are safety class 3, with safety class 3 normal level control.

- Pipework performs a safety category C preventive function and is safety class 3, with class 3 high temperature and pressure trips on inlets.
- Pumps perform a safety category C preventive function and are safety class 3, with safety class 3 high pressure trip on the outlets.
- Batch preparation tanks civil bund performs a safety category A function and is assigned safety class 1, with a safety class 2 bund liner. Pumps and pipework are in a safety class 1 civil bund. The high-level trips and high-level alarms on the radiological bunds perform a safety category C function and are assigned safety class 3.
- The civil structure performs a safety category A shielding function and is assigned safety class 1.
- Unauthorised access to the process BPTM enclosure requires a safety category A duty function. There are safety class 1 physical locks on the tank area and shield area.
- A radiation dose alarm monitoring system performs a safety category B protective function to support operator evacuation, which is assigned safety class 2.

The Processing and Treatment System for Solid Radioactive Waste [KMA] has been assessed as contributing to the following Fundamental Environmental Function:

- Minimisation of the volume and/or activity of radioactive wastes discharged to the environment or transferred to other premises.

Potential KEPE within the Processing and Treatment System for Solid Radioactive Waste [KMA] to support delivery of this Fundamental Environmental Function is summarised in Table 11.4-2. Further details on identified KEPE are to be captured in the Environmental Schedule[7] .

Table 11.4-2: Potential KEPE for the Processing and Treatment System for Solid Radioactive Waste [KMA]

System RDS-PP®	SSC
[KMA10]	Sorting Table
[KMA10]	Metal Detector
[KMA10]	Fume Cupboard with Size Reduction Capability
[KMA10]	Small & Large Article Monitors
[KMA10]	In-Drum Low-Force Compactor
[KMA10]	Weighing Station
[KMA20]	BPTM Decant Pumps
[KMA20]	BPTM Hydro-Cyclones
[KMA20]	Sodium Hydroxide Preparation and Dosing System
[KMA20]	Waste Delivery Pumps

System RDS-PP®	SSC
[KMA20]	Grout Preparation Plant and Mini Grout Preparation Plant (for [KMA10] and [KMA20] respectively)
[KMA20]	Grout Delivery Dumps
[KMA20]	Cement Powder Delivery System
[KMA20]	Flexible Waste Transfer Hoses and Associated Secondary Containment
[KMA20]	TC03 Third Height ISO (THISO) Filling Area Bund
[KMA20]	MEU and Process Vent Extraction Systems
[KMA20]	BPTM Bund High-Level Alarm
[KMA20]	TC03 THISO Filling Area Bund High-Level Alarm

No security or safeguards functional requirements are assigned.

11.4.2.3 Non-Functional System Requirements

The Solid Radioactive Waste Storage System [KME] and the Processing and Treatment System for Solid Radioactive Waste [KMA] are designed in accordance with the E3S design principles for safety class 3 measures (see E3S Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [11]) as follows:

- Design to deliver functions following design basis internal hazards.
- Protection against design basis external hazards.
- Design of mechanical SSCs to codes and standards in accordance with Table 11.0-2.
- Optimised HMIs for reliable human performance.
- EQ, including environmental and seismic qualification.
- Design of the layout to facilitate EMIT.
- Design for installation, commissioning, and decommissioning in accordance with respective strategies.
- Design of SSCs to reduce activation of materials to facilitate decommissioning.

11.4.3 Description

11.4.3.1 Solid Radioactive Waste Management System [KM] Overview

A simplified schematic of the Solid Radioactive Waste Management System [KM], taken from the Processing and Treatment System for Solid Radioactive Waste [KMA] SDD [55] is provided in Figure 11.4-1. Note that whilst it is not currently expected that dry ILW would be transferred to the Component Decontamination System [FKA], it is included in Figure 11.4-1 on the basis that a future operator may be able to make an ALARP case for specific waste items.

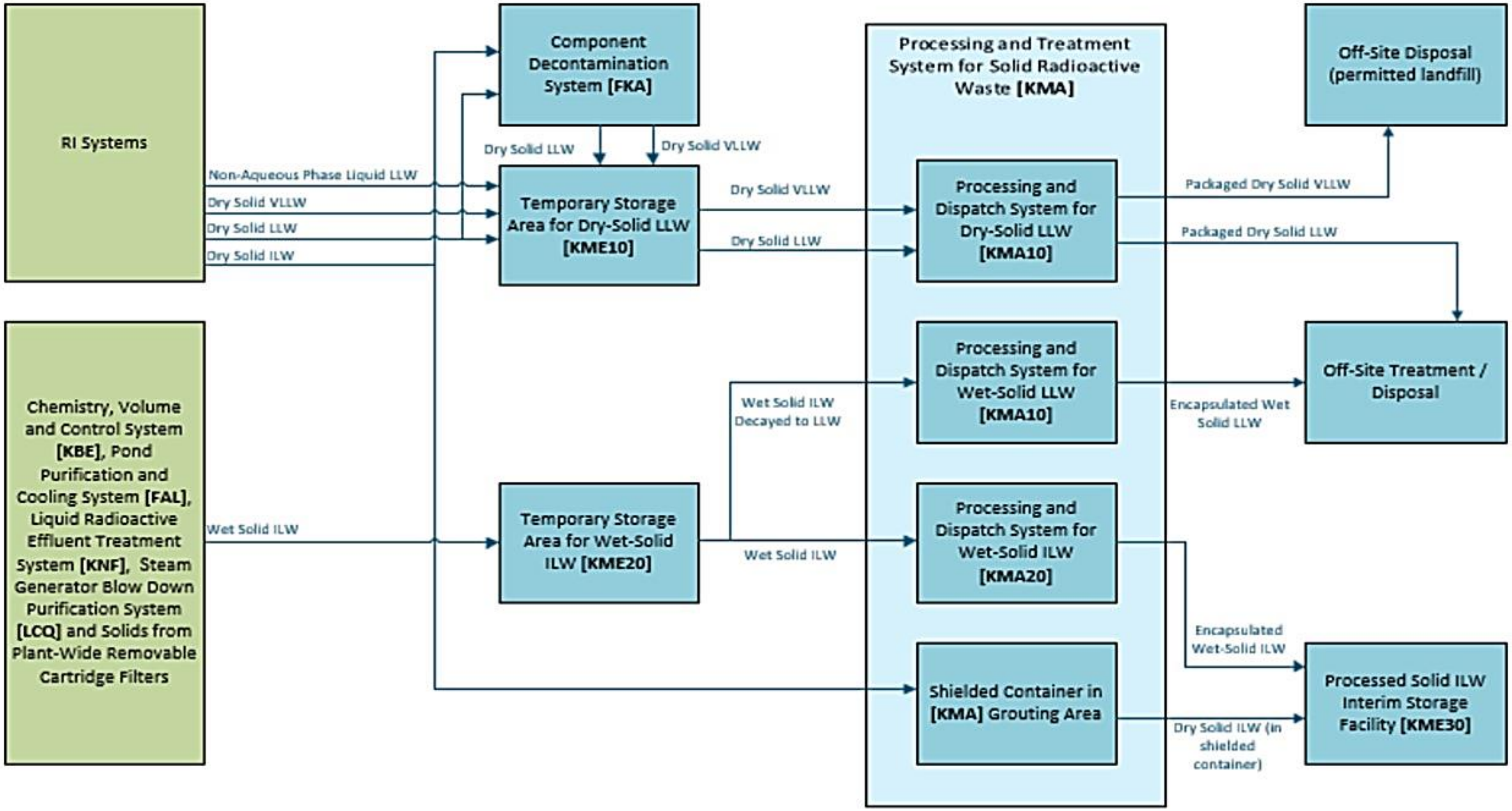

Figure 11.4-1: Simplified Schematic of the Solid Radioactive Waste Management System [KM]

11.4.3.2 Solid Radioactive Waste Storage System [KME]

Temporary Storage for LLW [KME10]

The Temporary Storage for LLW [KME10] is an area for the collection and storage of dry LLW and miscellaneous NAPLs before transfer to the Processing and Dispatch System for dry LLW [KMA10]. Dry LLW includes HEPA filters from the Nuclear HVAC System [KL], RO membranes from the Liquid Radioactive Effluent Treatment System [KNF], backwashed filters from the Coolant Purification System [KBE], Liquid Radioactive Effluent Treatment System [KNF], SF Pool Purification and Cooling System [FAL], and Steam Generator Purification System [LCQ] in the event of a SGTL, and dry active wastes arising from routine maintenance operations during outages.

The Temporary Storage for LLW [KME10] shall consist of cages for storing different waste types: metal melt, combustible and compactible. These waste categories are set to meet the LLWR Waste Acceptance Criteria (WAC). Very Low Level Waste (VLLW) is stored in a separate cage for disposal to permitted landfill.

The Temporary Storage for LLW [KME10] bays can be designed with clip-in partitions to vary the size of cages for different Processing and Dispatch System for dry LLW [KMA10] campaigns, to accommodate varying waste volumes and types whilst maintaining segregation [40].

Layout

The Temporary Storage for LLW [KME10] cages for separating and storing dry unprocessed waste are in the waste block [UKA20]. There is a bunded area adjacent to cages for storing miscellaneous oils and solvents in leak tight containers. There is an area reserved for storing one shielded container of dry ILW as it decays, with additional area reserved in the ILW Store [KME30] [40].

Temporary Storage for ILW [KME20] – Dry ILW

Suitable shielded containers will be provided for miscellaneous ILW dry waste. Suitable container types include 500 L drum, 3 m^3 box and Ductile Cast Iron Containers (DCIC). Options on waste container selection are not foreclosed in the design, given size, type and source term of dry solid ILW is not fully evaluated for the RR SMR. Storage area sizing is based off an assumption that only one shielded container of dry ILW shall be stored at any time. A temporary laydown area has been reserved in L0 Waste Block (Processing and Treatment System for Solid Radioactive Waste [KMA] area) for one shielded container of dry ILW [40].

Storage for ILW [KME20] – Wet ILW

Overview

Wet solids are received and transferred via a shielded pipe run to the south of the tank areas, which connects to a pump and valve room in an adjacent room of the Auxiliary block. It is conservatively predicted that most wet solid waste will be ILW upon arising. However, it has been calculated that some wet solid waste will decay to below ILW levels after two cycles.

This boundary ILW/LLW waste will be stored in duty-standby tanks and allowed to decay store in the Temporary Storage for Wet ILW [KME20] before treatment and disposal as LLW.

The Temporary Storage for Wet ILW [KME20] contains three distinct storage tank groupings: concentrates (2x), filter solids (2x) and resins storage tanks (3x – two ILW/LLW boundary and one ILW). The concentrates and filter solids tanks share a bund. The three resin tanks share a separate bund. The bunds collect any leakage from the system.

There is an interface between all [KME20] tanks to the Auxiliary Sampling System [KUB] sampling system for waste characterisation – See E3S Case Version 3, Tier 1 Chapter 28: Sampling and Monitoring Arrangements [7].

Table 11.4-3 provides an overview of the waste types stored within each of the Temporary Storage for Wet ILW [KME20] storage tanks.

Table 11.4-3: Temporary Storage for Wet ILW [KME20] Storage Tanks and Waste Types

Waste Source	Waste Type	Storage Tank	Volume (m^3/cycle)
[KBE] IX Column	Resin	ILW Resin Storage Tank	1.60
[FAL] IX Column	Resin	Boundary Resin Storage Tank	TBC by supplier
[KNF] IX Column	Resin	Boundary Resin Storage Tank	0.70
[KBE] Filters	Filter Solids	Filter Solids Tank	0.02
[FAL] Filters	Filter Solids	Filter Solids Tank	0.02
[KNF] Filters	Filter Solids	Filter Solids Tank	0.24
[KNF] Evaporator	Evaporator Concentrates	Evaporator Concentrates Tank	7.57
Waste Source	**Waste Type**	**Storage Tank**	**Volume (m^3/Expected Event)**
[LCQ] IX Column	Resin	Boundary Resin Storage Tank	0.70
[LCQ] Filter Solids	Filter Solids	Filter Solids Tank	0.02

Evaporator Concentrates Storage Tanks

The Concentrates Storage Tanks (2x) collect batches of concentrates that are drained from the Liquid Radioactive Effluent Treatment System [KNF] evaporator. The evaporator shall be operated in small batches, following complete treatment of a Liquid Radioactive Effluent Treatment System [KNF] drain tank in the RO unit. The frequency of concentrates transfer depends on the total volume and composition of the effluent that is treated in the Liquid Radioactive Effluent Treatment System [KNF].

Tanks are in a duty-standby configuration to allow decay storage, with each treatment campaign occurring after two cycles or three years. For the first treatment cycle, this occurs after four cycles to allow waste to accumulate.

Concentrates are transferred from the evaporator to the Concentrates Storage Tanks by gravity flow. Flushing of the associated piping will be performed after every transfer for corrosion prevention and to minimise residual radiation and contamination. Flushing effluent is diverted through a drain line on each section of pipework, to prevent dilution of evaporator concentrates in the tank.

Tanks include a recirculation line with jet mixing ejectors for fluidisation and sampling. Tanks also have air sparging nozzles for a back-up fluidisation method.

The bottom of each tank is fitted with a draw-off sump, with the tank floor sloping to a low point where particulate material can collect. Any accumulated particulate is transferred via the suction line to downstream treatment, therefore reducing accumulation of tank particulates and sludges over repeated storage-treatment campaigns.

Concentrate Storage Tanks are connected to the HVAC system to remove aerosol radionuclides and any hydrogen hazards arising due to radiolytic breakdown of water. Tanks have an open overflow at the top of the tank to prevent over pressurisation of tanks and overflow into HVAC connections which would require high-dose clean-up operations. The overflow directs to the local tank bund, which can be recovered to a secondary tank [40].

Resin Storage Tanks

The Resins Storage Tanks collect IX bed resins from the Liquid Radioactive Effluent Treatment System [KNF], Coolant Purification System [KBE] and Fuel Pool Purification and Cooling System [FAL] systems.

Coolant Purification System [KBE] resins are collected in the designated ILW Resins Tank (1x), while Liquid Radioactive Effluent Treatment System [KNF] and Fuel Pool Purification and Cooling System [FAL] resins are preferentially collected in the designated Boundary Resins Tanks (2x).

All tanks are identically sized with a usable tank volume of 16 m^3 to allow for decay storage of the resins. The first treatment campaign is slightly longer given resins may take several cycles to become exhausted for the first time. Boundary Resin Tanks are in a duty-standby configuration to allow decay storage.

Resins are transferred to the Temporary Storage for Wet ILW [KME20] by demineralised water, with each resin transfer accompanied by a volume of water, used for flushing the resin transfer pipes after transfer to avoid resin settling in pipes. Tanks include a recirculation line with jet mixing ejectors for fluidisation and sampling. Tanks also have air sparging nozzles for a back-up fluidisation method.

As noted in Section 11.1.2, the volume and frequency of resins arising from the Fuel Pool Purification System [FAL] are subject to confirmation from suppliers. A review of the proposed strategy for managing these resins will be undertaken and presented in Version 4 of the Generic E3S Case.

The Resin Storage Tanks are connected to the HVAC system to remove aerosol radionuclides and any hydrogen hazards arising due to radiolytic breakdown of water. Tanks have an open overflow at the top of the tank to prevent over pressurisation of tanks and overflow into HVAC connections which would require high-dose clean-up operations. The overflow directs to the local tank bund, which can be recovered to a secondary tank [40].

Filter Solid Storage Tanks

Filters in the Coolant Purification System [KBE] (1x), Fuel Pool Purification and Cooling System [FAL] (1x), and Liquid Radioactive Effluent Treatment System [KNF] (3x) are backwashed to release retained solids, reducing their activity from ILW to LLW. The resulting slurry, a dilute suspension of filter solids, is expected to remain ILW for the plant's lifecycle and will be processed as wet ILW in [KMA20].

Filter Solids Tanks (2x) operate in a duty-standby configuration, each tank sized to store two cycles' worth of retained filter solids and should have capacity for one filter's worth of backwashing slurry. Treatment campaign is expected every two cycles or three years.

The backwash will be sluiced to the Filter Solids Tanks using pressurised water, with optional compressed air as specified by the supplier. After each transfer, associated piping will be flushed to remove solids and minimise residual radiation. Flushing effluent is routed via drain lines on each pipe section to the Collection and Transfer of Chemical Drains [KTA30] to avoid diluting the tank contents.

After each filter backwash transfer, solids shall gravity settle to 5–10 % content. Excess water will be drained via an upper nozzle to the Collection and Transfer of Chemical Drains [KTA30] to reach the target concentration. Once concentrated, the tank's design incorporates pumped recirculation, air sparging and a sloped base to prevent further settling and solidification.

The Filter Solids Tanks are connected to the HVAC system to remove aerosol radionuclides and any hydrogen hazards arising due to radiolytic breakdown of water. Tanks have an open overflow at the top of the tank to prevent over pressurisation of tanks and overflow into HVAC connections which would require high-dose clean-up operations. The overflow directs to the local tank bund, which can be recovered to a secondary tank [40].

Layout

The Temporary Storage for Wet ILW [KME20] storage tanks are located from Basement Level (BL) 02 to Ground Level of Auxiliary Block [UKA10]. As stated above, the concentrates tanks and filter solids tanks are co-located. The resin tanks are co-located. Each co-located set of tanks is in an individual shielded and bunded no-access area. There is a RI Collection and Drainage System [KTA] drainage tank outside of the tank area. Any equipment that requires maintenance e.g. instrumentation and valves, is located outside of the high dose tank area. There are access ports for remote maintenance and inspection from above the tanks, with an operator access point for entry following faulted scenarios [40].

Solid ILW Store [KME30]

The ILW Store [KME30] is a shielded storage facility designed to maintain the condition of the packaged ILW in a manner that protects workers, the public and the environment from hazards associated with interim storage until the waste can be transported to a future UK GDF. To fulfil the primary function of interim storage and to enable the transportation of the waste offsite, the facility will optimise the waste package life and maintain the disposability of the packages. Sufficient shielding of the store will be implemented to ensure containment of the waste and the protection of operators from radiation exposure. The store will also include remote monitoring and inspection capability of both the packages and the store life-limiting components which will inform the maintenance of the store components and the remedial action of any degraded packages. Moreover, to optimise the package life and maintain key parameters such as temperature, relative humidity and moisture levels, the store shall include an HVAC system.

The ILW store will contain immobilised wet solid wastes (IX resins and suspended filter solids) which are processed and packaged onsite within 500 L drums. In addition to the storage vault which will be enclosed by a shield wall, the ILW store [KME30] will include an import/export area, monitoring and maintenance facilities, plant and control rooms, a package inspection cell and a package transfer area.

The formal sizing of the facility will be carried out once the waste characteristics and anticipated volumes are refined as the design develops further. Currently, additional waste arisings beyond the presently anticipated waste volumes have been accounted for by the inclusion of contingency storage. The ability to alter the configuration of the packages in the vault and to remove and inspect individual packages will not impact the capacity of the ILW Store.

Access to the building will be determined as part of the detailed store design. The package transfer arrangements from the Processing and Treatment System for ILW [KMA20] to the ILW store [KME30] have yet to be defined however the current assumption is that the 500 L drums will be moved from the Processing and Treatment System for ILW [KMA20] to the ILW store [KME30] in a shielded overpack [40].

Layout

The ILW Store [KME30] is located outside of the RI however the specific location in the plant layout is currently undefined due to the site-specific constraints and requirements that must be considered. It is assumed that the ILW store [KME30] will be in the vicinity of the SF store. Stored waste dose rates and distance to the property boundary will need to be considered as a key aspect of the function of the ILW store is to ensure that the dose to workers, the public and the environment are ALARP/ALARA.

The dose risk and therefore the measures to reduce the dose risk are highly dependent on the characteristics of the waste packages and the site. The location of the ILW store will be informed by the topology, access points, and various other site-specific constraints. The topology of the chosen site is a crucial factor in the store location choice as criteria such as direction of rainwater flow and flood risk will inform the decision. Consequently, at the current design stage the level of detail that can be provided regarding the store location is limited. The ILW store [KME30] will be located outside of the berm and ideally near an access point for efficiency of transfer of waste offsite. The store location will be decided once the plant design maturity has progressed further, and an operator and site have been chosen.

The preliminary store layout assumes a stillage stack height of three, which is well below the maximum stillage stack height of seven. From a local community and new infrastructure perspective, the chosen stillage stack height ensures that the RR SMR will minimise disruption to the skyline. The mechanical handling capability is expected to consist of an overhead crane to emplace packages in the vault and in transport overpacks and to retrieve packages for analysis and export. Therefore, a maintenance area is required to ensure that the handling equipment can be appropriately serviced when necessary. The control room shall maintain the remote handling of the packages and the plant room shall control the environmental conditions and key parameters. The inspection cell will allow for packages to be assessed for signs of degradation and to confirm disposability upon export [40].

11.4.3.3 Processing and Treatment System Solid Radioactive Waste [KMA]

Dry-Solid LLW Processing System [KMA10]

The purpose of the [KMA10] dry-solid LLW system is to process, package and dispatch the dry LLW and NAPLs stored within [KME10]. The waste packages are exported for disposal or further processing depending on the waste type, with NWS providing the waste services for all dry-solid LLW waste types.

The waste that is processed by [KMA10] dry is segregated at source and then stored within the [KME10] cages that are co-located with [KMA10] dry. The waste types accepted by [KMA10] dry are as follows:

- Combustible dry-solid LLW.
- Dry-solid LLW suitable for compaction.
- Dry-solid metals suitable for metal melt.
- Generic dry-solid LLW for disposal at the LLWR.
- Dry-solid VLLW.
- NAPLs - Miscellaneous oils and solvents.

Dry-solid waste arrives in [KME10] double bagged in polythene bags to contain any contamination on the objects.

The Processing and Dispatch System for Dry LLW [KMA10] is operated on a demand basis, with the highest periods of demand being outage periods as a result of the increased maintenance activity on-site during this time.

Key equipment within the Processing and Dispatch System for Dry LLW [KMA10] include:

- **Sorting table** - A sorting table is required to verify that the waste has been correctly segregated at source. This table is non-metallic as it is necessary to pass a metal detector over the waste during this process.
- **Fume cupboard with size reduction capability** - A fume cupboard provides operators protection from airborne contamination when opening the bags of waste. This may be necessary if non-compliant items need to be removed following assay or should items require size reduction. The fume cupboard is equipped with a size reduction capability, the nature of which will be determined at detailed design but will likely be a table saw or angle grinder.
- **Mechanical aides and transport trolleys** - Dry-solid waste items arrive at the facility on metal transport trolleys with similar trolleys being used to move items around the [KMA10] dry-solid waste processing facility. Other mechanical aides are also used; these include drum lifters, sack trucks with drum cradles and lift tables etc, facilitating movement and lifting of waste items and packages around the facility and for drums to be stacked, swabbed, palletised and checked safely. The use of such mechanical aides minimises the direct manual handling of waste by operators as well as increasing conventional safety when handling heavy items.
- **Lifting crane** - Some wastes will be exported within TC01 Half Height ISO (HHISO) containers, with these containers requiring lifting onto the back of articulated lorries. This will need to be performed by a crane, though the nature of this crane is unknown at this stage of design.
- **Article monitors** - Small and large article monitors will assay waste items according to their geometry, and based on the origin of the waste, assign a waste fingerprint. This will determine whether the waste items meet the WAC.
- **In-drum low-force compactor** - Wastes suitable for compaction such as PPE and cleaning wipes etc. are compacted into drums to increase the waste loading within each container
- **Weighing station** - A weighing station is used to determine the mass of each item to ensure that the packages are not overloaded and in the case of loading a TC01 HHISO, this facilitates the development of a loading plan to ensure even weight distribution across the container.

The Plant and Equipment (P&E) that facilitate the Processing and Dispatch System for Dry LLW [KMA10] processing capabilities are discrete and Commercial Off The Shelf (COTS) items, meaning they can be easily repaired or removed and swapped with functional P&E in the event of malfunction. OPEX indicates a lifetime of 10 – 15 years for items of this type [55].

Layout

The Processing and Dispatch System for Dry LLW [KMA10] P&E is located on the ground floor of the [UKA20] building to the North of the circulation corridor. The system is co-located with the Temporary Storage System for LLW [KME10] storage cages and bunded NAPLs storage area. The Temporary Storage System for LLW [KMA10] portion of the facility consists of receipt, processing and export areas, as well as an enclosed space containing both small and large article monitors. The export area in the northwest corner of [UKA20] features vehicular access for import and export of TC01 HHISO containers and 200 L drums [55].

Processing and Dispatch System for Wet LLW [KMA10]

The purpose of the Processing and Dispatch System for Wet LLW [KMA10] is to receive batches of wet-solid LLW via the BPTMs and encapsulate them in a thoroughly mixed cementitious matrix in

TC03 THISOs with a radiologically 'clean' capping grout layer. In order to achieve this, the prepared waste slurry batch and a grout slurry are pumped through separate hoses into a TC03 THISO container. The design of these hoses includes secondary containment. A homogenous mixing of the two slurries is achieved by a connection of the two hoses to a manifold which is in turn connected to a sacrificial in-line static mixer assembly that is fabricated and fitted to the TC03 THISO before it is brought to site.

This container has a grout filling port at one end of its lid, and a ventilation port at the centre line of the short length wall at the opposite end of the container from the grout filling port. Owing to the presence of these ports, this container is appropriate for use in this application.

An essential part of the transfer of the waste from the Solid Radioactive Waste Storage System [KME] system to the BPTMs is the removal of excess water from the incoming waste so that radioactivity content of the waste form is optimised in the disposal containers (either TC03 THISO or 500 L drum). This water will be added by the Solid Radioactive Waste Storage System [KME] / Liquid Radioactive Effluent Treatment System [KNF] to fluidise the wet-solid wastes for transfer and this water will be removed by the BPTMs and re-used or recycled as appropriate.

The concept design of the BPTMs includes for two means of separating solids from the aqueous phase. The first is water separation from wet-solid slurries containing coarser particles (>50 μm particle particle) using hydro-cyclone technology where the separated water is discharged from the overflow back to the Liquid Radioactive Effluent Treatment System [KNF] for recycling / reuse. The second is based on settling of finer particles over time either with or without the use of an inorganic flocculating agent which will be pumped into the BPTM as a thick slurry from a small flocculant preparation tank and dosing pump. The flocculant recommended at this stage of design is bentonite clay slip [54]. After a period of flocculant-accelerated settling, the clarified supernatant layer of water to the top of the tank in the BPTM will be removed by a decant pump and returned to the [KNF] system for recycling / reuse.

Organic IX resins swell under alkaline conditions such as being added to highly caustic cement materials. As such, the resins will be pre-swelled to their saturation point in the batch preparation tank prior to encapsulation using a concentrated sodium hydroxide solution. This solution is added to the dewatered waste batch to ensure that the resins do not swell within the waste-grout matrix and compromise the structural integrity of the final wasteform [55].

The proposed cement formulation for encapsulating the waste streams is a mix of Blast Furnace Slag (BFS) and Ordinary Portland Cement (OPC) in a ratio of 3:1 respectively.

The cement powder will be delivered in 1 tonne Rigid Intermediate Bulk Containers (RIBCs) pre-mixed and blended by the supplier. The RIBCs will be designed specifically for the storage and transportation of dry particulate material. These will be lifted onto a bin discharge feeder unit with an integrated screw conveyor that will be connected via a second discharge feeder into the mini grout plant.

The RIBCs will not be exposed directly to the waste stream or contaminated with waste, meaning they will be returned to the supplier for re-use following a check to ensure they are clean.

11.4.3.4 Layout

During a Processing and Dispatch System for Wet LLW [KMA10] processing campaign, the northern end of the western bay becomes the TC03 THISO filling and curing area. This consists of a frame within which modular shielding blocks are placed, a Mobile Extraction Unit (MEU) and a surplus grout and wash-out skip. The centre portion of the western bay becomes the temporary shielded lid set-down area, and the southern end is used as an export area within which the articulated lorries may enter. The portion of the eastern bay to the south of the BPTM cave contains the grout preparation plant alongside the flocculant and sodium hydroxide preparation and dosing systems.

The Processing and Dispatch System for Wet LLW [KMA10] and Processing and Treatment System for ILW [KMA20] have a shared civil structure. The proposed shared civil structure will support key radiological control functions, building services and provide lifting equipment that can be used for sequential use of both the wet-solid waste encapsulation systems. The benefits of this shared structure being:

- A civil structural footprint that is minimised (reducing construction costs, resource use and subsequent decommissioning wastes).
- An asset count that is minimised (reducing maintenance, C&I updates and repair costs).
- Plant utilisation is maximised (minimising degradation through under-utilisation of equipment and assisting in retention of knowledge by operators in the use of the equipment) [55].

Processing and Treatment System for ILW [KMA20]

The purpose of the Processing and Treatment System for ILW [KMA20] is to receive batches of wet-solid ILW via the BPTMs and encapsulate them in a cementitious matrix in 500 L drums. The incoming prepared wet-solid LLW shall comprise spent resins and filter solid wastes in slurry form. The encapsulated wasteform demonstrates compliance with the WAC for the ILW store [KME30] interim storage, with these criteria being defined by the design of ILW store [KME30] and the associated safety case. WAC for later consignment to a future UK GDF have not been defined given the early stages of the programme, however, NWS defines the parameters required for the disposability assessment / Letter of Compliance (LoC) process within [58]. The document states that properties of the wasteform shall comply with requirements for containment within the geological disposal concept, as defined by the future UK GDF safety case.

It is important for the waste to be thoroughly mixed with the cement powders to ensure a homogenous, safe and compliant waste form. To achieve this, it is necessary to mix the waste with the cement powders by stirring the mixture with a sacrificial paddle in the 500 L drum, and mixing for sufficient time to ensure all the wet waste is thoroughly mixed with cement.

By the nature of the homogeneous mixing, there will be waste at, or near to, the surface of the encapsulated wasteform. This presents a challenge of ensuring secure encapsulation of the waste and controlling contamination levels which makes the drum lidding process more hazardous. Therefore, once the waste / cement mixture has been given sufficient time to initially cure and harden, a further layer of cementitious grout is poured onto the waste / cement mixture to cap and seal the top surface with a solid layer. This is radiologically inert and provides a level of protection to the operators exposed to the surface during lidding.

The proposed cement formulation for encapsulating the waste streams is a mix of BFS and OPC in a ratio of 3:1 respectively.

It is assumed that the waste slurry contains all the water needed for cement hydration and no additional water is required. The same cement powder formulation will be mixed with water for preparation of the capping grout slurry.

The cement powder will be delivered in 1 tonne RIBCs pre-mixed and blended by the supplier. The RIBCs will be designed specifically for the storage and transportation of dry particulate material. These will be lifted onto a bin discharge feeder unit with an integrated screw conveyor that will be connected to the mixer head to feed powders into the 500 L drums.

The RIBCs will not be exposed directly to the waste stream or contaminated with waste, meaning they will be returned to the supplier for re-use following a check to ensure they are clean.

The 500 L drums will be supplied with the sacrificial mixing paddles pre-installed, with quality assurance checks taking place in the import buffer storage area to test functionality prior to use within the [KMA20] system.

Following these checks, the drum lids are removed, and the drums are placed in a standard 4 drum stillage using a drum lifting grapple attached to either an overhead crane or lifting being fitted to a Forklift Truck. The stillage is then lifted into a shielded overpack mounted on a Self-Propelled Modular Transporter (SPMT) using an overpack lid and stillage lifting frame, with these overpacks being loaded onto the SPMT in the ILW store [KME30]. The SPMT can carry two overpacks which will then be imported into the wet-solid waste processing facility after which the overpack lids will be removed and set aside. The drums will be lifted out of the overpacks using a drum lifting grapple attached to the overhead crane and set aside ready for use.

The drum lids will be imported into the wet-solid waste processing facility separately and will be re-fitted to the drums during the lidding process.

The 500 L drums will be stored on site in the ILW store [KME30] until their eventual transfer to a future UK GDF. However, the high dose rate emitted from the drums means that their transfer to the ILW store [KME30] requires the use of shielded overpacks [55].

Layout

During a processing campaign the western processing bay is occupied by a modular shielded tunnel which is separated from the export area by temporary shielding blocks. An SPMT is parked within this export area, with this area also serving as temporary storage for the shielded overpack lids. As with the Processing and Dispatch System for Wet LLW [KMA10], the eastern bay is occupied by the flocculant and sodium hydroxide dosing systems, but also the Processing and Treatment System for ILW [KMA20] mini grout plant, cement hopper and relevant delivery systems [55].

11.4.4 Materials

The materials for the Solid Radioactive Waste Storage System [KME] and Solid Radioactive Waste Processing System [KMA] components are selected in accordance with their safety class using RGP and OPEX, to ensure their through-life integrity and qualification for relevant environmental conditions. Stainless steel is used for the majority of the components.

The approach to materials selection and ageing management for safety class 1 SSCs is described in E3S Case Version 3, Tier 1, Chapter 23: Structural Integrity [20].

11.4.5 Interfaces with Supporting Systems

Solid Radioactive Waste Storage System [KME]

To support the safe operation and control of the Radioactive Waste Management System [KM], the Radioactive Waste Management System [KY] is required to monitor a range of key system parameters and provide indication of these to the operator in the MCR and Waste Control Room (WCR). Duplication of monitoring and indication is included for safety claimed instruments and instruments interfacing with other systems control. The Radioactive Waste Management System [KY] is discussed in E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14].

There is an interface between all Temporary Storage for Wet ILW [KME20] tanks to the Auxiliary Sampling System [KUB] for waste characterisation (see E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2] and E3S Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements [7]).

Temporary Storage for Wet ILW [KME20] pipework drains to the Collection and Transfer of Chemical Drains [KTA30] where it is pumped to the Liquid Radioactive Effluent Treatment System [KNF], the radioactive liquid effluent treatment system.

There is active HVAC ventilation connected directly to all the Temporary Storage for Wet ILW [KME20] tanks for dilution of radiolytic gases and hydrogen generated by resin degradation and radiolysis of water [40].

Processing and Treatment System for Solid Radioactive Waste [KMA]

The most significant interface of the Processing and Dispatch System for LLW [KMA10] and Treatment System for ILW [KMA20] wet-solid waste processing systems is with the Temporary Storage for Wet ILW [KME20] wet-solid waste storage tanks. A transfer route needs to be established from the Temporary Storage for Wet ILW [KME20] system discharge pumps which are located on level B2 (-5.6m) in the RI to the BPTMs in the Solid Radioactive Waste Processing System [KMA] (Waste Processing Block [UKA20] building).

HVAC extraction occurs from the Processing and Dispatch System for LLW [KMA10] in two places. The first is linked with the removal of displaced air from the TC03 THISO during filling. The second is associated with the removal of displaced air from the BPTM during filling and discharge.

HVAC extraction occurs from the Processing and Treatment System for ILW [KMA20] in three places The first is linked with the removal of displaced air from the initial curing module of the Processing and Treatment System for ILW [KMA20] process tunnel. The second is associated with the removal of displaced air from the grout cap curing module of the Processing and Treatment System for ILW [KMA20] process tunnel. The third is associated with the removal of displaced air from the BPTM during filling and discharge [55].

To reduce the volume of dry solid LLW requiring management via [KMA10] Dry-Solid LLW Processing and eventual disposal, the Component Decontamination System [FKA] is utilised to remove surface contamination from small to medium size metallic components from RI. Decontamination is performed to reduce the waste classification, reduce operator dose, or to enable wider downstream treatment and disposal options. Further information on the Component Decontamination System [FKA] is provided in E3S Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems [2].

11.4.6 Systems and Equipment Operation

11.4.6.1 Solid Radioactive Waste Storage System [KME]

Temporary Storage for LLW [KME10]

Operator procedures for collection of waste are not yet developed, but it is assumed that operators will locally collect dry LLW. Waste must pass through a health physics assessment, which shall identify the total gamma activity and separate waste by activity, contamination type and material. Waste will be double bagged in clear plastic, appropriately marked with a trefoil marking and the outside will be swabbed. Bagged waste will then be moved to Temporary Storage for LLW [KME10] for buffer storage between Solid Radioactive Waste Processing System [KMA] treatment campaigns [40].

Storage Tanks for Wet ILW [KME20]

All Temporary Storage for Wet ILW [KME20] system operations are batch-based and therefore require operator selection to initiate them. The Temporary Storage for Wet ILW [KME20] system will be aligned through manual selection of system configurations (grouped commands for aligning the system isolation valves and actuators). Operators shall select system configurations based off procedural action sheets [40].

Tank Configuration

Evaporator Concentrates and Boundary Resin Tanks are in a duty-standby configuration to allow decay storage. The proposed operating philosophy for these tanks is:

- One tank will be aligned for receiving effluent at the end of each batch, while the second tank is on standby.
- When the first tank is full, it will be left to decay for three years (two cycles) while the second tank is being filled.
- Treatment campaigns are expected to occur every six years for ILW and boundary resins and every three years for filter solids and evaporator concentrates.
- If waste is produced at a faster rate than expected, the contents of Tank 1 can be processed before the complete two cycles decay time. Processed waste is then temporarily stored on site in a container to complete the decay to LLW, freeing up a tank for additional filling.

There is only one ILW Resin Tank, which collects resins for the complete period between treatment campaigns.

There are duty-standby filter solids tanks to allow flexibility in collected waste volumes. Waste shall be collected in the first tank until it is full and then switched over to the standby tank, independent of treatment campaigns [40].

Wet Solid Waste Collection

Wet solid waste transfer from upstream systems is managed by the upstream system control logic, which has yet to be developed. The Temporary Storage for Wet ILW [KME20] system must display availability status for each tank and passively receive waste into an available tank.

It is suggested that upstream demineralisers and filters are isolated for one week prior to transfer of solid contents to the Temporary Storage for Wet ILW [KME20]. This allows short lived radionuclides to decay in-situ, reducing the risk of high dose rate from the Temporary Storage for Wet ILW [KME20] pipework and tanks.

Solid collections are recorded procedurally to manage waste generation on site and track levels in tanks. Tanks shall also include continuous level detection to support management of collected waste volumes.

Concentrates are gravity drained from the Liquid Radioactive Effluent Treatment System [KNF] evaporator into the Concentrates Tanks.

Resins are fluidised in upstream beds by pressurised water connections, which are isolated prior to transfer to the Temporary Storage for Wet ILW [KME20]. A water connection at the resin transfer manifold allows the fluidisation of resins to be maintained while being transferred from the resin beds into the Resin Tanks. The injection ensures that the header is full of water during the transfer. Excess transfer water will overflow from a weir with a strainer on the tank and will be transferred to the RI Collection and Drainage System [KTA].

Engagement with suppliers suggests that filters are backwashed using pressurised water whilst the connection to the Temporary Storage for Wet ILW [KME20] is closed, with the backwash slurry being driven to the Temporary Storage for Wet ILW [KME20] similarly to suspended resins. Compressed air may be used to drive the backwash slurry to the Temporary Storage for Wet ILW [KME20], depending on filter design [40].

Sampling

All the Temporary Storage for Wet ILW [KME20] tanks have provisions for sampling on tanks for waste characterisation. Waste is expected to be characterised prior to waste treatment campaigns.

Boundary resin tanks shall be characterised once full, to inform required decay periods [40]. See E3S Case Version 3, Tier 1 Chapter 28: Sampling and Monitoring Arrangements for further details [7].

Fluidisation

Tanks must be periodically fluidised to prevent resins settling at the base of the tank. Weekly fluidisation is assumed, but this must be confirmed following discussion with resin suppliers. The primary method of fluidisation is pumped recirculation through a recirculation line with jet mixing ejectors. This fluidisation method minimises additional moving parts and does not produce secondary waste.

Air sparging is also included for tanks as a secondary fluidisation method, though this produces contaminated air for HVAC treatment. Air spargers must also be periodically deployed to prevent blockages of nozzles.

Fluidisation shall be performed based off a group command configuration, initiated by an operator selecting a push button in the waste control room [40].

Wet Waste Transfer

The first treatment campaign will occur after nine years for boundary resins and six years for ILW resins, filter solids and evaporator concentrates to allow time for the first batch of waste to accumulate.

Treatment campaigns shall align with a full duty tank where possible to minimise operator burden on commissioning and decommissioning treatment equipment. Treatment campaigns for different waste types shall also be performed consecutively where possible i.e. processing evaporator concentrates followed by filter solids.

It is anticipated that during a campaign, Processing and Dispatch System for LLW [KMA10] and Processing and Treatment System for ILW [KMA20] batching tanks shall be filled weekly with sufficient waste for uninterrupted processing during the week, however, the details of the processing throughput will be subject to the supply chain's proposed system design configuration. Processing volumes shall account for shift patterns of trained operators, which are to be defined by plant operators.

Wet waste transfer shall be initiated by operators managing treatment equipment, with an interface between COTS equipment and the Temporary Storage for Wet ILW [KME20] control logic [40].

Flushing

The Temporary Storage for Wet ILW [KME20] pipework must be flushed after transfer operations to reduce the operator dose from pipework and prevent solids settling out in dead legs/cavities.

Flushing effluent shall preferentially be provided by the Liquid Effluent Monitoring and Discharge System [KNF30], to reduce contamination of demineralised water. However, a Demineralised Water Supply System [GHC] connection is also included as a backup.

Flushing shall be performed based off a group command configuration, initiated by an operator selecting a push button in the waste control room. Flushing is not an automatic operation included in transfer operations but shall be outlined on operator actions sheets following BAT assessments [40].

Drainage

The Temporary Storage for Wet ILW [KME20] pipework drains to the Collection and Transfer of Chemical Drains [KTA30], where it is pumped to the Liquid Radioactive Effluent Treatment System [KNF].

To avoid large amounts of radioactive solid waste being distributed around site, a line between the Temporary Storage for Wet ILW [KME20] recirculation pumps and tank bund is included so that in the event of a leak, the Solid Radioactive Waste Storage System [KME] contents can be recovered to a secondary tank with available capacity.

Solid ILW Waste Store [KME30]

Import

The operating procedures for the transfer of the packaged waste from the Processing and Treatment System for ILW [KMA20] to the ILW store [KME30] have yet to be defined. It is currently assumed that the package will be placed in shielded overpacks to be transferred via a lorry that will be reversed into the import/export area of the storage facility. The unloading of the packages into the import area is expected to be carried out by the store's mechanical handling capability. The overhead crane will require operator input from the store control room. The operator will similarly control the remote handling of the packages for removal of the packages from the shielded overpacks, emplacement of packages in the vault, retrieval of packages for inspection and for emplacement in a Standard Waste Transport Container (SWTC) for final export to a future UK GDF.

Upon import, all packages will be appropriately checked to ensure that contamination levels are consistent with the store's environmental control approach and WAC. Before being emplaced in the vault, waste packages will be monitored and inspected to establish a baseline. The baseline will enable the assessment of any change in the container performance over the storage period and will include package performance criteria such as the container corrosion, waste-form expansion, lifting feature degradation and loss of mechanical strength. The operator will be charged with recording and maintaining this baseline. The initial baseline is also required to confirm the absence of any surface contamination that could initiate or accelerate corrosion of the package. The operator will be required to remediate any surface contamination that is found [40].

Interim Storage

In order to interim store the packages until disposal at a future UK GDF, the packages shall be optimised and protected. The suitable environmental conditions and controls shall be put in place to maintain and maximise the life of the stored packages to prevent degradation and ensure the disposability of the packages is maintained. The disposability of the waste packages shall be demonstrated through the Disposability Case (DC). The DC will form part of the assessment process and will establish an appropriate package quality management system and store monitoring programme. These programmes will include the establishment of the baseline conditions of the store life-limiting features and components, the store environment, and the waste packages.

Additionally, a robust set of Environmental Operational Limits and Conditions (OLCs) for the key parameters with which to maintain the storage system in a safe state and provide homogeneous environmental conditions spatially shall be established. Examples of key parameters include temperature, relative humidity, moisture and contamination. The store shall maintain the predetermined optimal environmental conditions without operator input however deviations from the optimal conditions must be handled appropriately. The deviations of store conditions will be managed according to the store monitoring programme.

Export

To ensure that the packages will be accepted at the future UK GDF, the transportability and disposability of the packages must be proven. As mentioned, the DC will demonstrate these key capabilities of the waste upon packaging. The containers will thus be disposable and transportable (within SWTCs) once the waste has been processed and packaged in the Processing and Treatment System for ILW [KMA20]. Throughout the interim storage period, data on critical parameters (identified by the Disposability Assessment) of the packages will be recorded to provide confirmation that degradation, damage or failures have not resulted in the packages no longer meeting the guidance and specification for geological disposal. The data must be retained to provide evidence that the packages remain in the ideal and tolerable package performance range [40].

Degraded Modes

Degraded modes are addressed for the Temporary Storage for Wet ILW [KME20] system only. There are no expected degraded modes for the Temporary Storage for LLW [KME10]. Degraded modes for the ILW store [KME30] shall be developed at a later design stage, with support from operations and waste processing suppliers.

The key degraded condition for the Temporary Storage for Wet ILW [KME20] system is a tank, pipe or pump rupture or leak. Operations are isolated on detection of a leak in the tank bund or pump bund. Any remaining media in the damaged tank can then be moved to the non-damaged tank designated for the leaked media (with ILW resins sent to boundary resin tanks), which are located in a separately shielded tank room [40].

If maintenance is required in the sealed cell, all tanks in the bunker must be emptied to the Processing and Dispatch System for LLW [KMA10]/ Processing and Treatment System for ILW [KMA20] and flushed prior to operator entry for inspection and maintenance. The bund must be emptied and remotely washed down to remove accumulated solids, prior to operator entry for maintenance. Recovery of bunded fluids across RI is to be assessed.

11.4.6.2 Processing and Treatment System for Solid Radioactive Waste [KMA]

[KMA10] Dry-Solid LLW Processing

The wastes are segregated at source and arrive double bagged in polythene bags. If the item meets the WAC, it is weighed and then loaded or poured into the relevant waste container. Once a container is filled with waste it is lidded or otherwise closed and exported. Wastes suitable for compaction are compacted into the drum using the low-force compactor prior to lidding of the drum.

Should an item not meet the WAC for its relevant disposal or downstream treatment destination, it is moved to the fume cupboard where remediation activities can be performed.

The fume cupboard also houses the size reduction capability, with this area being used to safely reduce the size of particularly large or heavy items or to remove uncontaminated portions of the item. Surface contamination along cut lines will be removed to reduce the risk of generating airborne contamination.

The waste packages used will depend on the throughput at the time, with OPEX indicating that TC01 HHISOs will be used particularly during outages and Type IP-2 200L drums at other times. When loading TC01 HHISOs, a loading plan must be produced to ensure an even weight distribution across the container. The 200 L drums will be banded into pallets of four drums for export [55].

[KMA10] Wet-Solid LLW Processing

Once the Processing and Dispatch System for Wet LLW [KMA10] is installed and commissioned and a BPTM contains a waste batch (of approximately 3 m^3) of settled and prepared waste, grouting operations begin [55].

TC03 THISO Import

The TC03 THISO will be brought to the site on a just in time basis from an off-site TC03 THISO preparation and buffer storage facility. Only one TC03 THISO can be present in the [KMA10] system at a time. All components of the TC03 THISO container being used at the time will be retained in the western N-S oriented bay / canyon area.

The TC03 THISO is prepared by removing the grout filling port and ventilation port lids being removed and retained along with their bolts. A temporary shielded lid is placed on the TC03 THISO.

Grouting

The wet-solid LLW waste feed hose and grout feed hose are connected to the grout port manifold along with the MEU (with HEPA filters) which is then switched on. The grout port manifold is connected to the in-line static mixer pipe connections visible through the TC03 THISO grout filling port. A limit switch is used to detect that a positive connection is made between the in-line static mixer assembly in the TC03 THISO at the grout filling port and the grout port manifold; this connection being the completion of the primary containment needed to fill the TC03 THISO.

MEU operation is mandatory through the TC03 THISO filling sequence. If it fails, then filling will be paused until a standby MEU is connected to the TC03 THISO and switched on.

Separate feeds of the prepared LLW slurry in conjunction with the cementitious grout slurry will be fed together into the sacrificial in-line static mixer inside the lidded TC03 THISO via the grout filling port in the TC03 THISO lid. A small fixed volume of grout will be fed into the TC03 THISO prior to the start-up of the waste delivery pumps, after which the sacrificial in-line static mixer homogenises the two slurries.

Once the wet-solid LLW volume has been added to the TC03 THISO to make up the radioactive waste form, the waste addition feed will cease, and a waste feed hose flush sequence commence using a fixed volume of radiologically clean water.

After the flush sequence ends the grout slurry feed continues until the high-level detector in the TC03 THISO is reached as which point the grout slurry feed is stopped. This final phase of grout addition will create an inactive grout cap to the content of the TC03 THISO.

Curing for Transport

Once the TC03 THISO is filled, it is kept in the shielded and bunded TC03 THISO filling enclosure with the shielded lid in place until the waste form has cured to achieve approximately 70 % of its strength, i.e. to a point where it is suitable for transport; this is expected to be 48 hours.

The Grout Port Manifold is removed from the TC03 THISO grout filling port and a temporary shielding plug installed in the shielded lid to the TC03 THISO grout filling port.

It is yet to be determined if this activity will be a manual or remote activity. Considering this from a site basis, there are four operations in a six-year cycle, therefore manual operation may be tolerable. Though it must be taken into consideration that the teams may be specialists who move from site to site depending on mobile vs transportable decisions and as such could be involved in two campaigns a year. This corresponds to eight operations a year so a remote automated operation may be required. Specific fleet-based dose models would need to be developed and assumptions made around how the capabilities will be staffed before an answer can be determined.

The grout feed system hose can be disconnected from the grout port manifold and connected to the waste grout skip and the grout mixer and feed system flushed clean.

Temporary Shielded Lid Removal

The top of the TC03 THISO is swabbed for external contamination (particularly around the grout filling port) using the grout port for access. If proven to be within acceptable limits of external contamination, the shielded lid is removed and laid down.

Export

The TC03 THISO filling enclosure and bund is swabbed for external contamination and remediated if needed. The TC03 THISO grout filling port lid and ventilation port lids are fitted manually in accordance with the NWS TC03 package operating instructions.

If the TC03 THISO is found to be within acceptable limits of external contamination then it is transported back into the clean TC03 THISO filling enclosure and bund, transport equipment is brought into the wet-solid waste processing facility vehicle bay and the TC03 THISO put onto the vehicle for moving out of the Waste Processing Block [UKA20] Building to a hard-standing in a radiologically sterile area (or as so far as it is reasonably practical to find one). The externally clean and cured TC03 THISO is then subjected to radiological assay and dose monitoring to ensure that the container compiles with the IAEA transport regulations [59].

The shield doors and roller shutter doors are opened and the articulated lorry reverses into the road bay. It should be noted the shield doors will only be opened once the following are satisfied:

- The TC03 THISO is shown to be within acceptable limits of external contamination and curing has occurred for a minimum of 48 hours duration after filling and capping has been completed.
- The grout filling port and ventilation port lids have been secured in accordance with TC03 THISO operating instructions.
- The external dose from the TC03 THISO is within acceptable limits for both on-site and off-site transport.

The TC03 THISO is then loaded onto lorry for export.

[KMA20] Wet-Solid ILW Processing

Once the Processing and Treatment System for ILW [KMA20] system is installed and commissioned and a BPTM contains a waste batch (approximately 1.8 m^3) of settled and prepared waste, grouting operations begin. An overpack containing a drum stillage and empty 500 L drums will be loaded onto an SPMT in the [KME30] interim ILW store and will travel across site and enter the vehicle bay in the wet-solid waste processing facility [55]. The process steps are as follows:

Preparation

Four drums will be imported from the import buffer storage area into the stillage with one drum imported onto the conveyor at a time and transferred to the mixing module. Only once the previous drum has been conveyed to the furthest available location within the initial curing module (see *Curing* heading below), will the next drum be imported onto the conveyor.

Grouting

The Sacrificial mixing paddle is engaged. The section of the conveyor within the mixing module is raised, pressing the drum to a temporary lid which prevents the spread of contamination. This action also engages the mixing paddle drive motor and begins to turn the paddle as a final functional check before waste is delivered into the drum.

The ILW slurry is delivered into the drum until level 1 (L1) is reached, where L1 is the pre-defined recorded level within the drum which is to be filled with waste slurry alone.

The cement powders are delivered into the drum until level 2 (L2) is reached, where L2 is the pre-defined recorded level to which the uncapped and uncured wasteform is formed. The grout matrix achieves a pre-defined degree of curing to allow movement along the conveyor, after which the conveyor is then lowered, and the mixing paddle drive disengages.

Curing

The drum is transferred to the initial curing module and conveyed to the furthest available location within the initial curing module with the remaining drums transferred in the same manner.

The mixture is allowed to cure sufficiently such that it can support the pouring of capping grout on top with no adverse effects. Consideration of the method of verification that sufficient curing has occurred was an action to emerge from the Hazard and Operability study (HAZOP) and will be closed out at the detailed design stage.

The water content in the waste stream is absorbed by the cement powders in the chemical process of curing and setting of the cement / waste mixture, this ensures that there is no free water that could be released from the waste package in the event of the drum being tipped over or drum envelope being punctured etc. Not only does the cement absorb the free water and solidify the waste form, but the cement also provides an element of shielding.

Capping

The drum is transferred to the mixing module where a capping grout slurry is delivered into the drum. The capping grout is applied until level 3 (L3) is reached, where L3 is the pre-defined recorded level within the drum to which the final wasteform reaches (i.e. waste / cement matrix + capping grout). The drum is subsequently transferred to the cap curing module to allow the cap to cure and the process is repeated for the remaining three drums.

Lidding

On completion of the drum processing activities and when the capping grout has cured to the point where the drum can be lifted, the drum grapple will be attached to the overhead crane and used to lift the cured drums from the discharge conveyor and placed in a four-sided steel shielded lidding enclosure.

The drum lids will be secured to the underside of a shielded lid cradle. This will be lifted into position on top of the processed drum. Alignment features on the base of the drum and positioning dowels on the underside of the lid allow the lid to be positioned on the drum correctly. The shielded lid cradle has a series of holes through the shielding aligning with the lid securing bolt locations that will allow an operator to manually place the bolt into the drum (to minimise the potential for cross threading) and secure the lid using a long reach tooling.

The shielding of the lidding enclosure and that of the lid cradle will allow an operator to approach the drum for the short duration necessary for this task. The exact dose uptake for an operator performing this task has yet to be determined as well as the lidding enclosure shielding thickness. This will need to be done following a human factors task assessment to ensure that reasonable durations for each of the operations in the disconnection process are determined before the dose update calculations are performed.

Export

The lidding station is fitted with access ports that allow the external surfaces to be swabbed, also using long reach tooling. A shielded overpack containing a four drum stillage is loaded onto the SPMT prior to the drum lidding operation. Four lidded drums are then loaded into each overpacks and the overpack lid is secured. Each filled overpack will be exported individually to [KME30], however this would be subject to the [KMA20] safety case and the SPMT transfer of filled overpacks safety case and it may be that multiple overpacks are transported to [KME30] together [55].

Degraded Modes

No degraded modes have been identified for the Processing and Treatment System for Solid Radioactive Waste [KMA].

Changes in the Processing and Treatment System for Solid Radioactive Waste [KMA] waste feedstock due to degraded modes of operation of the reactor will have no material impact on the performance and operation of the system as it is designed using the design basis inventory and sampling / assay of waste is performed upstream in the Temporary Storage for Wet ILW [KME20] or at source for the wet-solid and dry-solid systems respectively [55].

11.4.7 Instrument and Control

Solid Radioactive Waste Storage System [KME]

The only system considered in this section for the Solid Radioactive Waste Storage System [KME] is the Temporary Storage for Wet ILW [KME20]. The Temporary Storage for LLW [KME10] is not expected to require C&I, given it is a storage area and conditions shall be managed by the HVAC [KL] system. The ILW store [KME30] is expected to require C&I to support operation as a permanent storage area, which shall be defined for the site-specific version of the E3S Case.

The scope split between the MCR and WCR for the Solid Radioactive Waste Management System [KM] operations has been reviewed by Human Factors but may be subject to change. It is expected that the WCR will control recovery operations and transfers from the Temporary Storage for Wet ILW [KME20] tanks to sampling and Processing and Dispatch System for LLW/ILW [KMA10]/[KMA20]. Transfer of resins/concentrates/filter solids into the Temporary Storage for Wet ILW [KME20] tanks will be controlled by upstream system logic from the MCR. Regular functions such as recirculation and air sparging shall be controlled by the MCR and WCR, to allow flexibility in operation between/during treatment campaigns. If control can be performed from both control rooms, an interlock is foreseen to prevent dual conflicting control.

To support the safe operation and control of the system, the Radioactive Waste Management System C&I [KY] (see E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14]) is required to monitor a range of key system parameters and provide indication of these to the operator in the MCR and WCR. Duplication of monitoring and indication is included for safety claimed instruments and instruments interfacing with other systems control [40].

Reference should be made to E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14] for further information.

Processing and Treatment System for Solid Radioactive Waste [KMA]

The control of the Processing and Dispatch System for Wet LLW [KMA10] and Processing and Treatment System for ILW [KMA20] is via simple control panels that will consist of hard-wired controls with simple relay logic where necessary, process parameter indications and where applicable, visual indication of the position status of various items i.e. Closed-Circuit Television (CCTV) feedback.

A largely hard-wired control system has been selected owing to its ease of inspection and repair by a trained electrical engineer with normal tools. Programmable logic controllers with supervisory control and data acquisition (SCADA) style interfaces have not been proposed due to long-term reliability issues that would be accentuated by cyclic assembling, commissioning, use, shut down, disassembling and storage.

It should be noted that general building access and control will be provided as part of the Solid Radioactive Waste Processing System [KMA] / Waste Processing Block [UKA20] access arrangements [55].

Reference should be made to E3S Case Version 3, Tier 1, Chapter 7: Instrumentation and Control [14] for further information.

11.4.8 Examination, Maintenance, Inspection and Testing

11.4.8.1 Solid Radioactive Waste Storage System [KME]

This section discusses the Temporary Storage for Wet ILW [KME20] system and the packages within the ILW store [KME30]. Temporary Storage for LLW [KME10] maintenance shall be determined by the Operational Team at a later stage. Maintenance activities for the ILW store [KME30] system itself shall be developed.

Temporary Storage for Wet ILW [KME20] availability is driven by the presence of waste within the tanks. If the tanks are not empty, to be able to conduct maintenance on the system there must be proven double isolation between the tank and the component as detailed in the Waste Systems Safe Isolation philosophy [60]. Valves have been added to this purpose for commonly maintainable components such as pumps, however, components that are not isolatable from the tanks must only be maintained when the tank is empty.

The maintenance philosophy is that all components and structures comprising the Temporary Storage for Wet ILW [KME20] will be designed to be maintainable unless the system equipment is in a walled-in-cell (i.e. Solid Radioactive Waste Storage System [KME] tanks). Therefore, Temporary Storage for Wet ILW [KME20] shielded pipe run must have removable walls/access panels to allow maintenance of pipework. Routine inspection and testing and preventative maintenance shall be performed on accessible [KME20] equipment to improve reliability. Inaccessible equipment shall not undergo regular maintenance, and reliability shall be demonstrated by regularly remote inspection.

Local operations shall be performed once the system has been emptied and flushed with clean water, preferably. A confirmation of the lack of activity should be sought prior to start of work. Additional efforts, such as cleaning or provision of temporary shielding, may be performed on areas of known waste accumulation.

Tanks shall be remotely inspected using cameras lowered down through a port in the shielded cell ceiling.

Pipes shall be visually inspected by operators during plant walk-downs but are not expected to be proof tested after initial commissioning is complete.

Valves shall be manually inspected and periodically tested, to reduce probability of failure on demand.

Pumps shall undergo preventative maintenance, with particular focus on regular membrane replacement if diaphragm pumps are selected to prevent rupture during operation and loss of containment. Pumps are in duty-standby configuration, so shall be maintained individually to allow continued system operation. Pump maintenance activities shall be educated by the supplier, as they depend on pump design and material choice [40].

For packages in the ILW store [KME30], inherent in the objective to optimise and protect the package is the maintenance of the package safety functions. There are several key safety functions, including containment under normal operating conditions and certain accident conditions and the container lifting features. The safety functions determine the performance of the package through the assignment of one of three performance zones depending on the function’s measurable indicator. The store environmental conditions and the remote monitoring and inspection regimes must maintain the packages in the ideal and tolerable performance zones. The package safety functions are key in maintaining the store safety case and the transportability and disposability of the packages.

In addition to the baseline of package conditions, the package quality management system will describe the inspection and monitoring programmes. The remote monitoring and inspection equipment will not require continuous operator input however operator actions will be defined in the package monitoring programme. The waste package monitoring programme will identify evolutionary processes that may affect the performance of the package safety functions and measurable indicators of these processes. The operator must regularly review the maintenance, periodic testing and inspection programmes. Periodic surveillance and inspection shall be facilitated by deployment of at least one full scale representative dummy package on top of which an optimum number of dummy packages will be decided. An optimum number of coupons shall also be deployed. The operator will routinely inspect and test the dummy package and selected coupons to assess the container performance (e.g. signs of degradation or corrosion, loss of mechanical strength etc.) and the store conditions against the baseline [40].

Maintaining OLCs, alongside a robust package quality management system, minimises the chance of waste package rework. A comprehensive rework plan should be in place to restore the safety functions of the waste packages if the package performance has declined.

11.4.8.2 Processing and Treatment System for Solid Radioactive Waste [KMA]

[KMA10] Dry-Solid LLW Processing System

EMIT activities for the Processing and Dispatch System for LLW [KMA10] dry are still to be developed.

[KMA] Wet-Solid Waste Processing Systems

Whilst an EMIT schedule has not been produced for the wet-solid waste processing systems at this stage of design maturity, the maintenance, repair and obsolescence strategy for the different types of P&E within the system can be summarised [55].

The types of P&E considered are:

- Fixed Assets:
  - Structures: EMIT of civil structural components, building weather envelope and cladding.
  - Fixed P&E: Whether the P&E item is COTS or bespoke, if it is in a fixed location, maintenance is assumed to occur based on the results of asset performance monitoring and preventative maintenance at scheduled plant outages designed to facilitate the maintenance, repair or component replacement around scheduled use of the asset. To deal with obsolescence of key components, time bound planned replacement will be arranged within the overall design life of the item.
- Mobile Assets (turn-key contract):
  - Mobile asset EMIT will be the responsibility of the supply chain through a turn-key contract, however the strategies employed are:
    - Bespoke P&E:
      - If the mobile asset is a bespoke item, then it should, with adequate logistical planning, be able to be rotated out of services for maintenance, repair or change of obsolescent parts on a planned basis. Condition / performance monitoring of the asset will enable reactive asset maintenance rather than resorting to planned maintenance which may yield productivity / asset life benefits.
    - COTS P&E:
      - If the mobile asset is COTS, then the maintenance, repair and obsolescence strategy will be based on performance monitoring /

inspection and exchange when the fitness of the mobile asset is deemed insufficient for function.

11.4.9 Radiological Aspects

11.4.9.1 Solid Radioactive Waste Storage System [KME]

Dose risk to operators shall be reduced for the Temporary Storage for LLW [KME10] and Temporary Storage for Wet ILW [KME20] systems by the following measures:

- Shielding around tanks and pipework.
- Routing of Temporary Storage for Wet ILW [KME20] pipework away from high occupancy areas.
- Access controls for pump and valve room and pipework corridors during Temporary Storage for Wet ILW [KME20] transfer operations.
- No-access to tank cells during plant operation.
- Containment of Temporary Storage for Wet ILW [KME20] equipment, including leak tight bunding of tanks and pumps, double containment of pipework and direct HVAC extraction on tanks.
- Flushing after transfers to remove accumulated solids.
- Remote inspection of tanks.
- Regular waste processing for dry LLW to reduce accumulated activity in Temporary Storage for LLW [KME10] storage area.
- Delayed transfer of resins and filter solids to Temporary Storage for Wet ILW [KME20], to allow for in situ decay of short-lived radionuclides.
- Waste treatment campaigns to be performed by trained, Suitably Qualified and Experienced Person (SQEP) operators with a dedicated waste control room.

Temporary Storage for LLW [KME10] is expected to require shielding, given accumulated activity from stored components (despite individual components being low activity and stored in limited volumes). Shielding requirements shall be assessed once waste catalogue is better understood.

Temporary Storage for Wet ILW [KME20] storage tanks require shielding due to the high activity of solid waste. Waste transfer pipework must also be shielded to protect operators in surrounding areas during transfers. The pump and valve areas shall be isolated from operator entry during use, so will not require additional shielding.

Operational dose assessments shall be performed for Temporary Storage for LLW [KME10] and Temporary Storage for Wet ILW [KME20] systems once operational procedures are confirmed in later design. There shall be area radiation monitors in waste handling and storage areas, with local alarms.

For the ILW store [KME30], the reduction of dose risk to operators shall be achieved by the shielded storage vault and the use of remote monitoring and inspection. Alongside the remote monitoring and inspection of the packages, the deployment of at least one full scale dummy package and coupons to support the assessment of package performance and store conditions will reduce operator dose. Further procedural practices that can be implemented by the operator such as the use of shield plates on the uppermost packages and positioning of lowest dose packages at the top of the stack may be considered later in the design stage [40].

11.4.9.2 Processing and Treatment System for Solid Radioactive Waste [KMA]

No shielding is likely to be required within the Processing and Dispatch System for Dry LLW [KMA10], as such, this section details the radiological zoning and shielding analysis performed for the Processing and Dispatch System for Wet LLW [KMA10] and Processing and Treatment System for ILW [KMA20].

The wet waste processing block is situated outside of the containment boundary but spacing for expected shielding is included in the current design of the layout. The batching tanks are situated in isolated rooms with localised shielding and doors with access control are included in the design to control access to the wet processing area at the main bay doors (controlling access to outside) and within the waste block itself to control operator movements. The system is run in batch process campaigns with the risk of dose to operators only being present during campaigns (and afterwards during clean-up). The shielding requirements may change as a comprehensive shielding analysis including the Processing and Treatment System for ILW [KMA20] inventory is included.

The BPTM shielded enclosure will represent a radiation source hazard from the start of operations (owing to the presence of at least one BPTM at any time during operations). The eastern bay in the building will be maintained at R1C1[8] during normal operations and at R2C2 during installation of a mobile BPTM (should a mobile BPTM be used). As such, the BPTM enclosure area will also be designated R2C2 between grouting campaigns after the removal of the steel modular shielding following Post Operational Clean Out (POCO) activities. The radiation level within this area will increase to R4 during operation, with personnel access being prohibited (no access route provided).

The eastern bay in the building will be maintained at R1C1 during normal operations and at R2C2 during installation of the mobile BPTM.

For the western bay in the building when empty this space will be maintained as a supervised area with R1C1 designation. During operation of the Processing and Dispatch System for Wet LLW [KMA10] and Processing and Treatment System for ILW [KMA20] the bay will be a controlled area. The vehicle loading bay will be managed as a C1 area so far as reasonably practical in all [KMA] wet-solid processing operations.

During operation of the Processing and Dispatch System for Wet LLW [KMA10], designation of the area around the TC03 THISO Filling Area and the TC03 THISO shielded lid lay-down area will be maintained as R2C2. Any maintenance of the waste delivery hose or hose to in-line static mixer assembly connection manifold will need to be undertaken as a R3C3 operation.

During operation of the Processing and Treatment System for ILW [KMA20] the area around the Processing and Treatment System for ILW [KMA20] process tunnel will be R2C2, around the 500 L drum lidding enclosure is likely to be designated R3C2 owing to the need for operators to lid the drum using long reach tools through apertures in the shielded enclosure.

Should maintenance of components inside the Processing and Treatment System for ILW [KMA20] process tunnel be needed, the tunnel will be cleared of 500 L drums and they will be moved to a safe location (preferably into a shielded overpack). At this point repair / maintenance will be undertaken under R2C2 conditions. Components contaminated to C3 or above could mandate removal of the module under fault recovery with the installation of a replacement module. The contaminated module would be remediated elsewhere in this instance [55].

[8] This is reference to the Radiation and Contamination Zoning Scheme. The Radiation Scheme is summarised in Section 11.2.9.2. For contamination, C0 is an undesignated area, C1 is supervised area, and C2, C3 and C4 are all Contamination Controlled Areas.

11.4.10 Performance and Safety Evaluation

The Solid Radioactive Waste Storage System [KME] and the Processing and Treatment System for Solid Radioactive Waste [KMA] are designed to deliver their CoRM and CoRE safety functions.

Within the Solid Radioactive Waste Storage System [KME] and the Processing and Treatment System for Solid Radioactive Waste [KMA], vessels and tanks are designed to appropriate codes and standards in accordance with their safety classification to ensure their integrity, including following internal and external hazards. There is redundancy of key instrumentation such as level measurement and discharge pumps, however segregation of these instruments is not required for internal hazard protection. The Solid Radioactive Waste Storage System [KME] system has been designed to minimise sources of internal hazards.

For external hazards, the Temporary Storage for LLW [KME10] and the Processing and Treatment System for Solid Radioactive Waste [KMA] are located in the Waste Processing Block [UKA20], which is Seismic Performance Class 1. The Temporary Storage for Wet ILW [KME20] is located in the Auxiliary Block [UKA10] which is on the aseismic bearing.

Appropriate shielding is incorporated into the design to minimise operator exposure, noting that temporary shielding will be utilised within the Processing and Treatment System for Solid Radioactive Waste [KMA]. The Solid Radioactive Waste Storage System [KME] is located within RCAs, with the Processing and Treatment System for Solid Radioactive Waste [KMA] having areas maintained as supervised areas unless operations are taking place, in which instance, they will be managed as controlled areas. Further defence in depth is provided through radiation alarms to alert operators to evacuate.

The design of the layout facilitates CoRE and sufficient space is afforded for EMIT.

The layout of SSC enables assembly and installation within modules in accordance with the RR SMR modularisation approach [48], also enabling some commissioning activities to be undertaken at the module factory in accordance with the RR SMR commissioning strategy [49]. While the Temporary Storage for Wet ILW [KME20] tanks are freestanding within the civil space, It is expected that the auxiliary items such as pumps, valves and pipe runs will be assembled into modules in the Module MEP factory. For the Processing and Treatment System for Solid Radioactive Waste [KMA], the P&E are expected to be provided by a supplier or are COTS.

SSCs are designed to facilitate safe decommissioning in accordance with the RR SMR decommissioning strategy [50], such as use of stainless steel materials that minimise potential for contamination, and the design of pipework with long radius bends to reduce potential buildup of contamination during operation. Further information can be found in E3S Case Version 3, Tier 1 Chapter 21: Decommissioning and End of Life Aspects [51].

In summary, the arguments and evidence presented at DRP4 provide confidence that the Solid Radioactive Waste Storage System [KME] and the Processing and Treatment System for Solid Radioactive Waste [KMA] will be capable of achieving the claim that the design ensures fundamental functions are achieved through-life. Evidence will continue to be generated for the E3S Case as the verification programme progresses, including continued iteration of the safety analysis, EQ of SSC including environmental and seismic qualification, and validation through commissioning.

11.4.11 Disposability Assessment

The term 'disposability assessment' can refer to two separate (but related) processes that are undertaken in different contexts, defined as follows:

Generic design assessment (GDA) disposability assessment – This refers to a preliminary judgement as to the potential acceptability for proposed generic waste packaging approaches. This process is led by the Requesting Party (RP) undertaking GDA through issue of a report outlining the proposed waste packaging approaches (along with underpinning information) that is assessed by regulators and NWS.

'NWS disposability assessment' refers to the process led and managed by the Waste Management Directorate of NWS, which is initiated when a waste producer approaches NWS with a specific packaging proposal (i.e. for particular containers and waste stream or streams). The proposal is formally assessed using a detailed procedure that considers multiple technical aspects of the waste, containers and associated information records, and leads to acceptance and endorsement (or rejection) through issue of a LoC (a process which is staged to conceptual, interim and final LoCs as the level of detail and confidence is developed).

The term 'disposability case' has been informally established between NWS and Rolls-Royce SMR Limited to minimise the potential for confusion over which assessment is being referred to.

The first issue of the DC Report was issued in September 2023 for the purposes of obtaining an Expert View from NWS so as to inform the ongoing development of the waste management strategy and design of the RR SMR. The overall conclusions of the Expert View [61] were that the anticipated HAW streams from the RR SMR, including SF, were not significantly different to those which NWS already has familiarity with i.e., from other Pressurised Water Reactors (PWRs) operating in the UK, which provided confidence that an overall disposability case can be made for RR SMR HAW. However, a number of risks and uncertainties relating to specific features of the RR SMR were highlighted in the Expert View.

Rolls-Royce SMR Limited issued a response to the Expert View with Forward Actions to address the risks and uncertainties raised by NWS, and in March 2025 submitted a second issue of the DC providing further information and clarification on the waste streams expected to arise during the operation and decommissioning of the RR SMR [62] [63] [64] [65] [66] [67]. Additional information and clarification on the Wet Solid ILW [68] and Wet Solid Boundary ILW/LLW [69] were provided to NWS in updates to the DC in August 2025. It is anticipated that NWS will provide a response to the Disposability Case submission in 2026 with ongoing engagement between Rolls-Royce SMR Limited and NWS taking place throughout this period.

11.4.12 Waste Package/Management Arrangements

Records will need to be made so as to meet the requirements set out in the Office for Nuclear Regulation (ONR) Licence Conditions 25 and 32 [70], the Environment Agency (EA) Radioactive Substances Management: Generic Developed Principle (RSMDP) 14 [71] and those required for the disposal of wastes.

As set out in Licence Condition 25 [70], operational records include those associated with the operation, inspection and maintenance of any plant which may affect safety and shall include records of the amount and location of all radioactive material, including nuclear fuel and radioactive waste, used, processed, stored or accumulated upon the site at any time.

RSMDP14 [71] states that sufficient records relating to radioactive substances and associated facilities should be made and managed so as: to facilitate the subsequent management of those substances and facilities; to demonstrate whether compliance with requirements and standards has been achieved; and to provide information and continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal.

In all instances where waste is generated, stored, discharged, disposed or transferred to other premises, records will be made and kept in accordance with relevant regulatory requirements and RGP. Examples of relevant requirements and guidance include those found in:

- Joint guidance on the management of higher activity radioactive waste on nuclear licensed sites [72].
- Guidance: Radioactive Substances Regulation (RSR) Permits for nuclear licensed sites: how to comply [73].
- Waste Package Specification and Guidance Documentation (WPSGD) Geological Disposal: Waste Package Data and Information Recording Requirements [74].
- WPSGD Geological Disposal: Long-term Management of Information and Records: Explanatory Material and Guidance [75].
- Industry Guidance: Interim Storage of Higher Activity Waste Packages [76].
- Guidance on Hazardous Waste [77].

The key requirements on the operator of any facility that produces radioactive waste that may require disposal to a future UK GDF are as follows:

- The waste packager is responsible for the development of a data and information recording system that would establish the means of capturing information in order to create the disposability record for each waste package.
- The range of information that would need to be recorded for each distinct waste package will be unique and the development of a tailored system may be required for each waste type and packaging campaign.
- Information would be created over the entire lifetime of the waste package, from conception of the packaging process, through process development, waste package production, storage, transport and ultimately disposal.
- Although much relevant information would arise during the development of the packaging process, information acquisition will continue into the waste package production stage and beyond. The information acquired after production would generally focus on storage conditions, interim movements, and package evolution.
- The assessment of packaging proposals, as part of the disposability assessment process leading to potential endorsement, will assist in the development of the data and information recording system through discussion and agreement of the particular disposability record requirements.

It will need to be demonstrated to NWS that suitable data gathering arrangements (in line with the requirements described above) will be in place in the RR SMR waste management systems prior to system commissioning.

Three broad categories of data are expected to form a disposability record, as follows:

- Class A – Underpinning and justification: information that applies to the waste type as a whole, in particular the documents that define the origin of the waste, the packaging process, the results of a development programme, waste container manufacturing specifications, the anticipated properties of the waste package and the waste package disposability record.
- Class B – Specification: a concise statement of the precise requirements to produce a waste package that would be compliant with the obligations for storage, transport and disposal.

- Class C – Compliance: information collected about the as-manufactured waste packages, primarily required to demonstrate compliance with the specifications.

For the long-term management of waste package records, NWS outlines different recording media and also states that transfer of records to a long-term archive facility does not absolve a waste producer of a responsibility to manage and preserve data into the long term.

It is accepted at this stage that waste package records will need to be 'born digital' i.e. to be recorded directly through embedded sensors and systems into digital format at the time of packaging, with no intermediary paper or other record, which have been the cause of the of records data. Therefore, digital data collection systems will need to be incorporated into the design of waste management and packaging systems from conceptual stage onwards.

It is proposed that a future dutyholder/licensee/permit holder develops a records' management plan/strategy based upon the digital data systems incorporated into the design of waste management and packaging systems to account for technology and software developments and the general management and retention of records.

Where records are being generated about expected waste arisings during the design of the RR SMR, these are being managed in accordance with Rolls-Royce SMR Limited Integrated Management System Standard (IMS) for the Management of Documented Information (Records) [78].

A consolidation plan, covering arrangements for the handover of records and information from Rolls-Royce SMR Limited to a future licensee/permit holder has been identified as a future work item within the Generic E3S Case Scope and Deliverable Document [79]. Where assumptions and commitments are made that require a future licensee/permit holder to act upon, these are recorded in accordance with a Project Operating Instruction [80].

It is noted that it is the responsibility of a future licensee/permit holder to develop the management system documenting the management arrangements for radioactive waste management. This includes the requirement to produce a Waste Management Plan and Site-Wide Environmental Safety Case; documents that will be key in managing waste throughout the lifecycle of a nuclear power station and required under RSR Permit condition 1.1.3 [73].

11.5 Conclusions

11.5.1 Conclusions and Forward Look

The generic E3S Case at Version 3 is 'to provide confidence that the RR SMR design will be capable of delivering the E3S fundamental objective as it develops from a concept design into a detailed design' [9]. This confidence is built through development and underpinning of top-level claims across each chapter of the E3S Case, through supporting arguments and evidence. This chapter has summarised the arguments and evidence to underpin the top-level claims that 'Radioactive Waste SSC design ensures delivery of allocated E3S functions through-life', and 'Radioactive waste systems and arrangements are optimised and demonstrate that the generation of wastes and discharges are minimised for the lifecycle of the RR SMR'. The arguments and evidence presented to meet the generic E3S Case objective at Version 3 are described below.

The Radioactive Waste systems' SSC design is developed and evaluated in accordance with the E3S design principles [33] through the integrated E3S and engineering processes [81], including design optioneering using RGP, to drive risk reduction to ALARP, and to demonstrate BAT, secure by design and safeguards by design. The design decision process has resulted in Radioactive Waste systems that have been inherently designed to comprise appropriate levels of defence in depth to support safety measures in the delivery of the FSFs during faults and accidents, and that adequately contribute to fundamental environmental functions.

The Radioactive Waste systems design bases include applicable codes and standards, design rules and philosophies, which encapsulate over-arching non-functional system requirements derived from the E3S design principles [33], RGP, and OPEX. It is noted that the traceability of allocated requirements from the E3S design principles, and other sources of RGP specific to Radioactive Waste Systems, is not complete at DRP4 and further focus will be given to ultimately demonstrate all relevant E3S requirements are allocated and delivered by the design.

Radioactive Waste systems are classified in accordance with the E3S categorisation and classification method [82].

This chapter of the E3S Case has provided a summary of the sources of radioactive wastes arising from the operation and decommissioning of a RR SMR. Quantities of solid radioactive wastes, including NAPLs, have been provided, with E3S Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits [1] providing information on the quantification of liquid and gaseous radioactive arisings. Identified wastes requiring disposal at a future UK GDF are currently undergoing assessment by NWS to form a more developed opinion on their disposability.

Further arguments and evidence will be developed and reported in future revisions of the generic E3S Case, which will further build confidence that the RR SMR can deliver its fundamental E3S objective. This broadly includes:

- Develop a complete set of E3S requirements for the Radioactive Waste systems, sub-systems, and components.
- Further detailed design development of all Radioactive Waste SSCs.
- Conduct relevant safety, environmental, reliability and human factors assessment of the design.
- Continue the development of the installations, commissioning, maintenance, and decommissioning philosophies of the Radioactive Waste systems.

- Continue to development of the layout of Radioactive Waste SSCs within the RR SMR plant including full development of the modularisation in line with build certainty guidelines – see E3S Case Version 3, Tier 1 Chapter 14: Plant Construction and Commissioning [48].
- Continue to develop the EMIT requirements and procedures for all equipment within the Radioactive Waste systems.
- Implement the verification strategies.
- Continue to define quantities, characteristics and disposal routes of radioactive waste arisings.

Commitments have been placed on the future Dutyholder / Licensee / Permit Holder to help ensure that radioactive wastes are managed as intended. These are described in Section 11.5.2.

11.5.2 Assumptions and Commitments on Future Dutyholder / Licensee / Permit Holder

Any assumptions and commitments on the future Dutyholder / Licensee / Permit Holder identified throughout this chapter have been captured in Table 11.5-1.

Table 11.5-1: Assumptions and Commitments on Future Dutyholder/Licensee/Permit Holder

Assumption/Commitment	ID	Description
Commitment	C11.1	Application of the waste management hierarchy principles will be incorporated into operating procedures. For example, operating instructions will prevent bringing materials into radioactive areas unless necessary.
Commitment	C11.2	EMIT of SSCs will be undertaken as required by the engineering design. SSCs must be appropriately maintained to perform their required function and help ensure waste is managed in accordance with BAT.
Commitment	C11.3	Accumulation of radioactive waste on-site will be minimised SFAIRP. Licence Condition 32 states that the licensee shall make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated.
Commitment	C11.4	Where feasible, new technologies will be utilised where it is BAT to do so to further optimise waste management. For example, advances in waste characterisation or treatment should be utilised where the design allows for their use.
Commitment	C11.5	During interim storage of solid radioactive waste, the operator must regularly review the maintenance, periodic testing and inspection programmes. This will help maintain the integrity of solid waste during interim

Assumption/Commitment	ID	Description
		storage and prevent the need for re-work of waste packages.
Commitment	C11.6	The operator will routinely inspect and test the dummy package and selected coupons to assess the container performance (e.g. signs of degradation or corrosion, loss of mechanical strength etc.) and the store conditions against the baseline. This will help maintain the integrity of solid waste during interim storage and prevent the need for re-work of waste packages.
Commitment	C11.7	A records' management plan/strategy should be developed based upon the digital data systems to be incorporated into the design of waste management and packaging systems.
Commitment	C11.8	A management system documenting the management arrangements for radioactive waste management will be developed. This includes the requirement to produce a Waste Management Plan and Site-Wide Environmental Safety Case.
Commitment	C11.9	Authorisation from the MCR is required for effluent discharge to the environment. This includes confirmation of the discharge flow rate set-point to be throttled by the discharge control valve.
Commitment	C11.10	A comprehensive rework plan is to be put in place to restore the safety functions of waste packages if the package performance has declined.

11.6 References

[1] Rolls-Royce SMR Limited, SMR0004486 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 29: Quantification of Radioactive Effluent Discharges and Proposed Limits," August 2025.

[2] Rolls-Royce SMR Limited, SMR0003863 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 9A: Auxiliary Systems," August 2025.

[3] Rolls-Royce SMR Limited, SMR0005548 Issue 3, "Identification of Environmental Functions and Environmental Measures," July 2025.

[4] Rolls-Royce SMR Limited, SMR0002131 Issue 4, "Rolls-Royce Small Modular Reactor Integrated Waste Strategy - Part 1," May 2025.

[5] Rolls-Royce SMR Limited, SMR0020441 Issue 1, "Rolls-Royce Small Modular Reactor Integrated Waste Strategy - Part 2," May 2025.

[6] Rolls-Royce SMR Limited, SMR0013560 - Interim 1, "Rolls-Royce Small Modular Reactor: Radioactive Waste Management Case," September 2024.

[7] Rolls-Royce SMR Limited, SMR0010323 Issue 3, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 28: Sampling and Monitoring Arrangements," August 2025.

[8] Rolls-Royce SMR Limited, SMR0003778 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 9B: Civil Engineering Works and Structures," August 2025.

[9] Rolls-Royce SMR Limited, SMR0004294 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 1: Introduction," August 2025.

[10] Rolls-Royce SMR Limited, SMR0002155 Issue 4, E3S Case Route Map, August 2025.

[11] Rolls-Royce SMR Limited, SMR0004589 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs," August 2025.

[12] Rolls-Royce SMR Limited, SMR0008113 Issue 3, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 27: Demonstration of Best Available Techniques," August 2025.

[13] Rolls-Royce SMR Limited, SMR0004210 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 4: Reactor (Fuel and Core)," August 2025.

[14] Rolls-Royce SMR Limited, SMR0003929 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 7: Instrumentation and Control," August 2025.

[15] Rolls-Royce SMR Limited, SMR0004010 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 8: Electrical Power," August 2025.

[16] Rolls-Royce SMR Limited, SMR0003977 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 15: Safety Analysis," August 2025.

[17] Rolls-Royce SMR Limited, SMR0004555 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 16: Operational Limits and Controls," August 2025.

[18] Rolls-Royce SMR Limited, SMR0004520 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 18: Human Factors Engineering," August 2025.

[19] Rolls-Royce SMR Limited, SMR0004982 Issue 4, "Environment, Safety. Security and Safeguards Case Version 3, Tier 1, Chapter 20: Chemistry," August 2025.

[20] Rolls-Royce SMR Limited, SMR0004363 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 23: Structural Integrity," August 2025.

[21] Rolls-Royce SMR Limited, SMR0004487 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 24: ALARP Summary," August 2025.

[22] Rolls-Royce SMR Limited, SMR0004682 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 32: Generic Security Report," August 2025.

[23] Rolls-Royce SMR Limited, SMR0004293 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 33: Safeguards," August 2025.

[24] Rolls-Royce SMR Limited, SMR0003023 Issue 1, "Rolls-Royce Small Modular Reactor Codes and Standards," October 2022.

[25] Rolls-Royce SMR Limited, SMR0003984 Issue 5, "Environment, Safety, Security and Saferguards Case Version 3, Tier 1, Chapter 5: Reactor Coolant Systems and Associated Systems," August 2025.

[26] Rolls-Royce SMR Limited, SMR0000631 Issue 4, "SMR System Design Description for Liquid Radioactive Effluent Treatment System [KNF]," March 2025.

[27] Rolls-Royce SMR Limited, SMR0020949 Issue 1, "Rolls-Royce Small Modular Reactor Waste Inventory Database," May 2025.

[28] Rolls-Royce SMR Limited, SMR0023496 Issue 1, "Decommissioning Waste Inventory," May 2025.

[29] Rolls-Royce SMR Limited, SMR0023885 Issue 1, "Supplementary Technical Information to support the RR SMR Disposability Assessment being undertaken by NWS," July 2025.

[30] Rolls-Royce SMR Limited. SMR0022673 Issue 1, "Spent fuel arisings to support RQ-01074," June 2025.

[31] Rolls-Royce SMR Limited, SMR0004514 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 31: Conventional Environmental Impact and Other Environmental Regulations," August 2025.

[32] Rolls-Royce SMR Limited, SMR0004490 Issue 5, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 30: Prospective Radiological Assessment," August 2025.

[33] Rolls-Royce SMR Limited, SMR0001603 Issue 2, "Rolls-Royce SMR Environment, Safety, Security and Safeguards (E3S) Design Principles," July 2024.

[34] United Kingdom Government, "The Waste (England and Wales) Regulations 2011 (S.I. No. 988 of 2011)," March 2011.

[35] Rolls-Royce SMR Limited, SMR0004916 Issue 3, "FS (Fault Schedule), SM (Safety Measures) and Plant States DOORS Module Extracts," February 2025.

[36] Rolls-Royce SMR Limited, SMR0000849 Issue 3, "Requirements Specification for KTA (Reactor Island Collection and Drainage System)," March 2025.

[37] Rolls-Royce SMR Limited, SMR0000844 Issue 3, "Requirements Specification for the KN_KNF (Radioactive Liquid Effluent Treatment System)," June 2024.

[38] Rolls-Royce SMR Limited, SMR0000632 Issue 4, "SMR System Design Description Reactor Island Drainage and Collection System [KTA]," March 2025.

[39] Atkins, EDNS01000966413 Issue 1, "RI-157 (Part 1) Liquid Effluent Treatment System Design Definition," April 2021.

[40] Rolls-Royce SMR Limited, SMR0001123 Issue 5, "System Design Description for the Solid Radioactive Waste Storage System [KME]," June 2025.

[41] Rolls-Royce SMR Limited, SMR0017668 Issue 1, "[SMR-114] - (Cat B Decision KNF Tanks Fault Scenario)," April 2025.

[42] Rolls-Royce SMR Limited, SMR0005213 Issue 1, "Power Station Operating Philosophy," July 2023.

[43] Rolls-Royce SMR Limited, SMR0004247 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 13: Conduct of Operations," August 2025.

[44] Rolls-Royce SMR Limited, SMR0003911 Issue 1, "RR SMR HMI Style Guide," December 2022.

[45] Health and Safety Executive, HSG253, "The safe isolation of plant and equipment," 2006.

[46] Rolls-Royce SMR Limited, SMR0004769 Issue 2, "Active Waste Systems Bulk Shielding Assessment," July 2023.

[47] Rolls-Royce SMR Limited, SMR0016351 Issue 1, "Direct Shine Dose Calculations for KNF Faults," November 2024.

[48] Rolls-Royce SMR Limited, SMR0004289 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 14: Plant Construction and Commissioning," August 2025.

[49] Rolls-Royce SMR Limited, SMR0009519 Issue 1, "Rolls-Royce SMR Commissioning Strategy," July 2024.

[50] Rolls-Royce SMR Limited. SMR0004048 Issue 3, "SMR Decommissioning Strategy," April 2025.

[51] Rolls-Royce SMR Limited, SMR0004599 Issue 4, "Environment, Safety, Security and Safeguards Case Version 3, Tier 1, Chapter 21: Decommissioning and End of Life Aspects," August 2025.

[52] Rolls-Royce SMR Limited, SMR0000839 Issue 3, "Processing & Treatment System for Gaseous Radioactive Effluent - Requirements Specifiction," July 2024.

[53] Rolls-Royce SMR Limited, SMR0012618 Issue 2, "Categorisation and Classification for Gaseous Radioactive Effluent Treatment System [KPL] Safety Functions," July 2025.

[54] Rolls Royce SMR Limited, SMR0000746 Issue 4, "System Design Description for the Gaseous Radioactive Effluent Treatment System [KPL]," June 2025.

[55] Rolls-Royce SMR Limited, SMR0017375 Issue 2, "System Design Description for the Processing and Treatment System for Solid Radioactive Waste [KMA]," July 2025.

[56] Rolls-Royce SMR Limited, SMR0006458 Issue 3, "Allocated Requirements Specification from KME (Solid Radioactive Waste Storage System)," March 2025.

[57] Rolls-Royce SMR Limited, SMR0001527 Issue 1, "Solid Radioactive Waste Processing System [KMA] = Requirements Specification," July 2022.

[58] Nuclear Waste Services, WPS/300/05, "Specification for Waste Packages Containing Low Heat Generating Waste Part D - Container Specific Requirements," November 2022.

[59] International Atomic Energy Agency, "IAEA Safety Standards Series No. SSR-6, Regulations for the Safe Transport of Radioactive Material," 2018.

[60] Rolls-Royce SMR Limited, SMR0005329 Issue 2, "Safe Isolation Assessment for Reactor Island Waste Systems," March 2024.

[61] Nuclear Waste Services, RRSMR-REG-0124N, WMIDA-386104532-1686, *GDA Step 2 Expert View on the Disposability of Wastes and Spent Fuel arising from the Rolls-Royce Small Modular Reactor,* March 2024.

[62] Rolls-Royce SMR Limited, SMR0014965 Issue 1, "Disposability Case - Master Index Record," February 2025.

[63] Rolls-Royce SMR Limited, SMR0018085 Issue 1, “Disposability Case - Spent Fuel and Non-Fuel Core Components,” March 2025.

[64] Rolls-Royce SMR Limited, SMR0017865 Issue 1, “Disposability Case - Dry Solid ILW,” March 2025.

[65] Rolls-Royce SMR Limited, SMR0020100 Issue 2, “Disposability Case - Wet Solid ILW,” March 2025.

[66] Rolls-Royce SMR Limited, SMR0017943 Issue 1, “Disposability Case - Dry Solid Boundary ILW/LLW,” March 2025.

[67] Rolls-Royce SMR Limited, SMR0017682 Issue 2, “Disposability Case - Wet Solid Boundary ILW/LLW,” March 2025.

[68] Rolls-Royce SMR Limited, SMR0020100 Issue 3, “Disposability Case - Wet Solid ILW,” August 2025.

[69] Rolls-Royce SMR Limited, SMR0017682 Issue 3, “Disposability Case - Wet Solid Boundary ILW/LLW,” August 2025.

[70] Office for Nuclear Regulation, “Licence Condition Handbook,” February 2017.

[71] Environment Agency, “Radioactive substances management: generic developed principles,” May 2024.

[72] Office for Nuclear Regulation, Environment Agency, the Scottish Environment Protection Agency and Natural Resources Wales, “The management of higher activity radioactive waste on nulcear licensed sites, Revision 2.1,” July 2021.

[73] Environment Agency, “Guidance - RSR permits for nuclear licensed sites: how to comply,” February 2022. [Online]. Available: https://www.gov.uk/government/publications/ rsr-permits-for-nuclear-licensed-sites-how-to-comply. [Accessed May 2025].

[74] Radioactive Waste Management, WPS/850/03, “Geological Disposal: Waste Package Data and Information Recording Requirements: Explanatory Material and Guidance,” December 2015.

[75] Radioactive Waste Management, WPS/870/03, “Geological Disposal: Long-term Management of Information and Records: Explanatory Material and Guidance,” September 2016.

[76] Nuclear Decommissioning Authority, Issue 4, “Interim Storage of Higher Activity Waste Packages - Integrated Approach,” December 2021.

[77] United Kingdom Government, “Hazardous Waste,” [Online]. Available: https://www.gov.uk/dispose-hazardous-waste. [Accessed 28 May 2025].

[78] Rolls-Royce SMR Limited, “Management of Documented Information (Records) Standard, SMR-STD-004,” 2023.

[79] Rolls-Royce SMR Limited, SMR0011087 Issue 2, “Generic E3S Case Scope and Deliverable Document - E3S Case,” February 2025.

[80] Rolls-Royce SMR Limited, SMR0002119 Issue 1, “Project Operating Instruction: Identifying, recording, and tracking GDA and Licensing Assumptions and Commitments,” October 2022.

[81] Rolls-Royce SMR Limited, SMR0000520 Issue 4, “Engineering Management Manual for Rolls-Royce SMR,” July 2024.

[82] Rolls-Royce SMR Limited, SMR0006518 Issue 2, “Rolls-Royce SMR Environment, Safety, Security and Safeguards Categorisation and Classification Method,” October 2024.

[83] Rolls-Royce SMR Limited, SMR0022673 Issue 1, “Spent fuel arisings to support RQ-01074,” June 2025.

11.7 Abbreviations

ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
ASME	American Society of Mechanical Engineers
BAT	Best Available Techniques
BFS	Blast Furnace Slag
BoP	Balance of Plant
BL	Basement Level
BPTM	Batch Preparation Tank Module
BS	British Standard
C&I	Control and Instrumentation
CAE	Claims, Arguments, Evidence
CCTV	Closed-Circuit Television
CoRE	Control of Radiation Exposure
CoRM	Confinement of Radioactive Material
COTS	Commercial Off The Shelf
CRA	Control Rod Assemblies
CRHC	Control Rod Housing Column
CVCS	Chemical and Volume Control System
CWI	Cooling Water Island
DAW	Dry Active Waste
DC	Disposability Case
DCIC	Ductile Cast Iron Container
DRP	Design Reference Point
E3S	Environment, Safety, Security, and Safeguards
EA	Environment Agency
EMIT	Examination, Maintenance, Inspection and Testing
EPRI	Electric Power Research Institute

EQ	Equipment Qualification
FSF	Fundamental Safety Function
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
HAW	Higher Activity Waste
HAZOP	Hazard and Operability (study)
HEPA	High Efficiency Particulate Air
HHISO	Half Height International Organization for Standardization
HLSF	High-Level Safety Function
HMI	Human-Machine Interface
HVAC	Heating, Ventilation and Air-Conditioning
IAEA	International Atomic Energy Agency
ICM	In-Core Monitoring
ILW	Intermediate Level Waste
IMS	Integrated Management System
ISI	Industrial Safety Instructions
IWS	Integrated Waste Strategy
IX	Ion Exchange
KEPE	Key Environmental Protection Equipment
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LoC	Letter of Compliance
MCR	Main Control Room
MEP	Mechanical, Electrical and Plumbing
MEU	Mobile Extraction Unit
MKoP	Modular Kit of Parts

n/a	Not Applicable
NAPL	Non-Aqueous Phase Liquid
NFCC	Non-Fuel Core Component
NPP	Nuclear Power Plant
NWS	Nuclear Waste Services
OLCs	Operational Limits and Conditions
ONR	Office for Nuclear Regulation
OPC	Ordinary Portland Cement
OPEX	Operational Experience
P&E	Plant and Equipment
PBS	Product Breakdown Structure
PIE	Postulated Initiating Event
POCO	Post Operational Clean Out
PPE	Personal Protective Equipment
PWR	Pressurised Water Reactor
RCA	Radiologically Controlled Area
RCCA	Rod Control Cluster Assembly
RCDT	Reactor Coolant Drain Tank
RCM	Reliability-Centred Maintenance
RCS	Reactor Cooling System
RDS-PP©	Reference Designation System for Power Plants©
RGP	Relevant Good Practice
RI	Reactor Island
RIBC	Rigid Intermediate Bulk Container
RO	Reverse Osmosis
RP	Requesting Party
RPV	Reactor Pressure Vessel
RPVSC	Reactor Pressure Vessel Surveillance Capsule
RR SMR	Rolls-Royce Small Modular Reactor

RSMDP	Radioactive Substances Management: Generic Developed Principle
RSR	Radioactive Substances Regulation
RWMA	Radioactive Waste Management Arrangements
RWMC	Radioactive Waste Management Case
SCADA	Supervisory Control and Data Acquisition
SDD	System Design Description
SF	Spent Fuel
SGTL	Steam Generator Tube Leak
SPMT	Self-Propelled Modular Transporter
SQEP	Suitably Qualified and Experienced Person
SSC	Structure. System, and Component
SWTC	Standard Waste Transport Container
TBC	To Be Confirmed
TDS	Total Dissolved Solids
THISO	Third Height International Organization for Standardization
TLA	Through Life Activities
TOC	Total Organic Carbon
TPA	Thimble Plug Assemblies
TSS	Total Suspended Solids
UK	United Kingdom
V&V	Verification and Validation
VCT	Volume Control Tank
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria
WCR	Waste Control Room
WENRA	Western European Nuclear Regulators' Association
WPSGD	Waste Package Specification and Guidance Documentation