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5.1 ACRONYMS AND ABBREVIATIONS

The standard project glossary of terms, abbreviations, and plant systems is provided in HI-2230643, SMR-300 Plant Breakdown Structure, Acronyms, and Glossary of Terms [1]. The following additional abbreviations are used and shown in Table 1:

Table 1: Acronyms and Abbreviations

Term	Definition
ALARA	As Low As Reasonably Achievable
BAT	Best Available Techniques
CAI	Service Air System
CAR	Commitments, Assumptions, Requirements
CAS	Condenser Vacuum System
CBV	Containment Building Ventilation System
CCW	Component Cooling Water System
CVC	Chemical Volume Control System
Da	Diameter
DRP	Design Reference Point
EA	Environment Agency
ENDP	Engineering Developed Principle
EPRI	Electric Power Research Institute
FPS	Flow Proportional Sampler
G-M	Geiger-Mueller
GDA	Generic Design Assessment
GRW	Gaseous Radwaste System
HEPA	High-Efficiency Particulate Air
HVAC	Heating Ventilation and Air Conditioning
ILW	Intermediate Level Waste
IWS	Integrated Waste Strategy
IX	Ion Exchange
LLW	Low Level Waste
LRW	Liquid Radwaste System
MCERTS	Monitoring Certification Scheme
MSS	Main Steam System
NRV	Non-Radiologically Controlled Area HVAC System
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PER	Preliminary Environmental Report
PSL	Primary Sampling System
PSR	Preliminary Safety Report
PWR	Pressurised Water Reactor
QEDL	Quantification of Effluent Discharges and Limits
RAB	Reactor Auxiliary Building
RCV	Radiologically Controlled Ventilation System
RCS	Reactor Coolant System
RDS	Radioactive Drainage System

Term	Definition
RGP	Relevant Good Practice
RMS	Radiation Monitoring System
RP	Requesting Party
RSMDP	Radioactive Substances Management Developed Principle
RSR	Radioactive Substances Regulation
RWMA	Radioactive Waste Management Arrangements
SDD	System Design Description
SFC	Spent Fuel Pool Cooling System
SMR-300	Small Modular Reactor-300
SRW	Solid Radwaste System
SSC	Structures, Systems and Components
TID	Turbine Island Vent
TBV	Turbine Building HVAC
URD	Utilities Requirements Document
US	United States
VCT	Volume Control Tank
WAC	Waste Acceptance Criteria
WWS	Waste Water System

5.2 INTRODUCTION

5.2.1 Purpose

Preliminary Environmental Report (PER) Chapter 5 presents the sampling and monitoring arrangements for radioactive waste arising from normal operation of generic Small Modular Reactor 300 (SMR-300), which aims to satisfy the information requirements in the Environment Agency's (EA) Generic Design Assessment (GDA) guidance [2] and relevant principles in the Radioactive Substances Regulation (RSR) [3].

This sub-chapter introduces the purpose, structure and scope of this Approach to Sampling and Monitoring chapter in the generic SMR-300 GDA. Interfaces with other chapters for the development of this chapter have also been outlined.

Best Available Techniques (BAT) justification of sampling and monitoring is undertaken commensurate with the GDA scope, as well as the maturity of the Holtec SMR-300 design.

Where gaps at GDA are acknowledged and methodologies to address these gaps are presented, they will be delivered through use of Commitments in line with the Holtec SMR-300 Generic Design Assessment Capturing and Managing Commitments, Assumptions and Requirements [4] process. Further work to be undertaken as part of normal business, where no GDA Commitment is necessary, is recorded within the chapter as Future Evidence and listed Table 19.

5.2.2 Chapter Structure

This chapter is structured to provide information required for a meaningful GDA assessment. The main structure of this chapter consists of:

- Sub-chapter 5.1 provides the abbreviations used within this chapter.
- Sub-chapter 5.2 introduces the purpose, scope and interfaces for PER Chapter 5.
- Sub-chapter 5.3 presents the regulatory context, such as regulatory expectations and requirements, RSR principles and conditions, and codes and standards considered in the Sampling and Monitoring arrangements.
- Sub-chapter 5.4 provides an overview of the radionuclides and groups of radionuclides to be monitored for the generic SMR-300
- Sub-chapter 5.5 provides an overview of relevant radioactive waste processing systems, and signposts to detailed system design descriptions (SDD).
- Sub-chapter 5.6 provides the associated sampling and monitoring arrangements for gaseous radioactive waste in the Holtec SMR-300 design, and associated BAT demonstration.
- Sub-chapter 5.7 provides the sampling and monitoring arrangements for liquid radioactive waste in the Holtec SMR-300 design, and associated BAT demonstration.
- Sub-chapter 5.8 provides the sampling and monitoring arrangements for solid and non-aqueous radioactive waste in the Holtec SMR-300 design, and associated BAT demonstration.
- Sub-chapter 5.9 presents an overview of plant condition monitoring for the generic SMR-300.

- Sub-chapter 5.10 provides a summary of sustainability considerations associated with PER Chapter 5.
- Sub-chapter 5.11 summarises the GDA commitments and planned future evidence for PER Chapter 5.
- Sub-chapter 5.12 summarises the contents of PER Chapter 5.

5.2.3 Scope

Development of PER Chapter 5 is based on the generic SMR-300 concept design. It aims to demonstrate that adequate monitoring and sampling arrangements of the SMR-300 are in place to inform the management of radioactive waste and recording and reporting of discharges. This chapter is consistent with the scope defined in SMR-300 UK Generic Design Assessment GDA Scope [5] and contains the following key elements:

- A description of the sampling and monitoring arrangements, techniques, and systems for measuring and assessing discharges and disposals of radioactive waste, including:
  - Gaseous, aqueous, solid, and non-liquid radioactive waste.
  - In-process monitoring for radioactive waste management, including measuring parameters relevant to waste generation and management and process control.
  - Final discharges of liquid and gaseous effluents to environment and discharge outlets.
- High level provisions for:
  - Independent sampling facilities for the final discharges of liquid and gaseous effluents.
  - Monitoring technology, including consideration of the sensitivity of sampling and representativeness.
- Justification of sampling and monitoring by use of BAT.

For the purposes of this chapter, the term “liquid” wastes will be used to refer to aqueous waste, with non-aqueous liquid wastes such as oils or sludges being considered alongside solid wastes.

Based on above GDA Scope and GDA guidance for Requesting Parties (RP) [2], the following areas are out of scope of this chapter:

- Accident conditions – Monitoring of discharges released during accident scenarios. Note that operational fluctuations, trends and events that are expected to occur over the lifetime of the facility consistent with the application of BAT (referred to as ‘expected events) are in scope.
- Sampling and monitoring of non-radiological wastes – Discussion of conventional waste is covered in PER Chapter 4 Conventional Impact Assessment [6].
- Environmental Monitoring – These arrangements will be site-specific; this will be required to be fully assessed at future environmental permitting stage

- Information on the monitoring instrumentation is not required due to the concept design of generic SMR-300, as well as the advancement of technologies at the site-specific stage.
- Any additional monitoring or sampling provisions that may be required to facilitate decommissioning.

5.2.4 Interface with Other SSEC Chapters

The chapters in the Safety, Security and Environment Case (SSEC) interfaced with this chapter are detailed in Table 2 below.

Table 2: Interfaces with Other Chapters in the SSEC

PER Chapter	Interface
Holtec SMR GDA PER Chapter 1 Radioactive Waste Management Arrangements [7]	This chapter describes the radioactive waste management arrangements and assumptions, which contribute to the development of sampling and monitoring arrangements.
Holtec SMR GDA PER Chapter 2 Quantification of Effluent Discharges and Limits [8]	This chapter describes the significant radionuclides and discharge limits, which are monitored in the radioactive effluent discharges to be discharged.
Holtec SMR GDA PER Chapter 4 Conventional Impact Assessment [6]	This chapter provides details sustainability considerations relevant to PER Chapter 5
Holtec SMR-300 GDA PER Chapter 6 Demonstration of Best Available Techniques [9]	This chapter summaries BAT demonstration of the sampling and monitoring, relevant evidence to substantiate the arguments are presented in this chapter. The formulation of BAT arguments for sampling and monitoring considers the following: • The GDA scope [5] (Sub-chapter 5.2.3). • Maturity of the generic SMR-300 design; evidence has been provided according to the availability of existing design documentation. • Applicable codes and standards (Sub-chapter 5.3.3). • Good practice and monitoring objectives from EA guidance notes. PER Chapter 6 [9] contains the following sampling and monitoring BAT claim: ***Claim 4.7: Sampling and monitoring:*** *The Generic SMR-300 includes appropriate sampling and monitoring arrangements for measuring and assessing discharges, disposals and releases of radioactive waste to demonstrate compliance with the proposed limits and as an indication of plant performance.* The claim and associated arguments/evidence that sit underneath provide an overview of the arguments and evidence presented in this chapter to support the BAT demonstration for the generic SMR-300.
Holtec SMR GDA PSR Part A Chapter 1 Introduction [10]	This chapter provides the information required in the GDA process and the structure of the PER, which PER Chapter 5 should consider.
Holtec SMR GDA PSR Part A Chapter 2 Generic Design and Site Characteristics [11]	This chapter introduces the main Structures, Systems and Components (SSCs) in the generic SMR-300 design, as well as the philosophy followed in the design which are considered in the sampling and monitoring arrangements.
Holtec SMR GDA PSR Part B Chapter 5 Reactor Supporting Facilities [12]	This chapter describes the design of Primary Sampling System (PSL), as well as Heating, Ventilation and Air Conditioning (HVAC) systems, which contribute to development of sampling and monitoring arrangements in this chapter.

PER Chapter	Interface
Holtec SMR GDA PSR Part B Chapter 10 Radiological Protection [13]	This chapter describes the radiological protection engineered features of the PSL and general information relating to the source term which contribute to the sampling and monitoring for radioactive waste.
Holtec SMR GDA PSR Part B Chapter 11 Environmental Protection [14]	This chapter provides a summary of PER chapters and BAT claims, including for PER Chapter 5.
Holtec SMR GDA PSR Part B Chapter 23 Reactor Chemistry [15]	This chapter describes the reactor chemistry regime with focus on how the chemistry has been designed to minimise radioactive waste at source, which are monitored and sampled in this chapter.

5.3 REGULATORY CONTEXT

5.3.1 GDA Requirements

To guide the development of the environment case for a new reactor power plant in the UK, Generic Design Assessment Guidance for Requesting Parties [2] details the information required for the environment case for the GDA process. Information related to sampling and monitoring includes:

> ***Sampling arrangements, techniques and systems for measuring and assessing discharges and disposals of radioactive waste***
>
> *The Requesting Party (RP) must provide details of their arrangements for:*
>
> - *In-process monitoring, including measuring parameters relevant to waste generation and management and process control*
> - *Monitoring final discharges of gaseous and aqueous wastes*
> - *Monitoring disposal of non-liquid and solids wastes*
>
> *The RP must demonstrate that their proposals represent BAT for monitoring and confirm that sensitivity is sufficient to:*
>
> - *Readily demonstrate compliance with the proposed limits*
> - *Meet the levels of detection specified in 2004/2/Euratom, which we consider to be good practice*
>
> *The RP must describe the facilities provided for independent periodic sampling (by the regulator) of final discharges of gaseous and aqueous wastes.* [2]

Table 3 below details where sampling and monitoring GDA information requirements are considered and incorporated in the development of this chapter.

Table 3: Alignment Analysis between GDA Submissions and GDA Requirements relevant to Sampling and Monitoring

GDA requirements for Step 2 assessment	Information as part of GDA
Details of sampling arrangements for: • in-process monitoring, including measuring parameters relevant to waste generation and management and process control.	In-process sampling and monitoring for liquid and gaseous effluents are presented in sub-chapters 5.5 and 5.6, respectively.
Monitoring final discharges of gaseous and aqueous wastes.	Sampling and monitoring for gaseous discharge and aqueous discharges are presented in sub-chapters 5.6 and 5.7.
Monitoring disposals of non-liquid and solid wastes.	Solid and non-liquid sampling and monitoring is presented in sub-chapter 5.8.
The RP must demonstrate that their proposals represent BAT for monitoring.	• The BAT justification of Sampling and Monitoring presented in this chapter is summarised in PER Chapter 6 [9]. • The relevant design information to substantiate the arguments relevant to sampling and monitoring is detailed and summarised in sub-chapters 5.5. 5.6, 5.7 5.8 and 5.9.

GDA requirements for Step 2 assessment	Information as part of GDA
To confirm that the sensitivity is sufficient to: • readily demonstrate compliance with the proposed limits • meet the levels of detection specified in 2004/2/Euratom [16], which is considered to be good practice.	• The EU 2004 levels of detection of key radionuclides in the source term is provided in this chapter, sub-chapter 5.3.3.1. • More information on the 'source term' can be found in PER Chapter 2 Quantification of Emission Discharges and Limits [8] (QEDL).
The RP must describe the facilities provided for independent periodic sampling (by the regulator) of final discharges of gaseous and aqueous wastes.	Operational Experience (OPEX) and Relevant Good Practice (RGP) relating to independent sampling of final gaseous discharges is provided in Sub-chapter 5.5 and final liquid discharges in sub-chapter 5.6.

5.3.2 RSR Principles

Generic developed principles for radioactive substances [3] sets out the that aim to protect people and the environment from the harmful effects of ionising radiation, as well as aiming to protect and enhance the environment.

The key generic developed principles related to sampling and monitoring have been identified and are considered appropriately. Table 4 presents where the generic SMR-300 GDA documents consider the relevant RSR principles: Radioactive Substances Management Developed Principles (RSMDP) and Engineering Developed Principles (ENDP).

Table 4: Alignment Analysis between GDA Submissions and RSR Principles

RSR Principle:	Information as part of GDA:
RSMDP6 – Application of BAT *In all matters relating to radioactive substances, the 'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation.*	BAT is applied to sampling and monitoring and evidence to support BAT claims and arguments is included within this chapter. Claims, arguments and evidence for sampling and monitoring is included in PER Chapter 6 Demonstration of BAT [9] and a summary of claims and arguments is included in Sub-chapter 5.8 of this chapter.
RSMDP4 – Methodology for identifying BAT *The best available techniques should be identified by a methodology that is timely, transparent, inclusive, based on good quality data, and properly documented.*	
RSMDP9 – Characterisation *Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal.*	Radioactive wastes are characterised using the sampling and monitoring arrangements discussed in Sub-chapters 5.5, 5.6, 5.7 and 5.8 to inform and optimise the radioactive waste management.
RSMDP13 – Monitoring and Assessment *The best available techniques, consistent with relevant guidance and standards, should be used to monitor and assess radioactive substances, disposals of radioactive wastes and the environment into which they are disposed.*	Relevant standards and guidance which have been considered within this chapter is presented in sub-chapter 5.3.4. BAT is applied to sampling and monitoring and evidence to support BAT claims and arguments is included in sub-chapters 5.6, 5.7 and 5.8.
ENDP4 – Environmental Protection Functions and Measures *Environment protection functions under normal and fault conditions should be identified, and it should be demonstrated that adequate environment protection measures are in place to deliver these functions.*	In-process and final monitoring and sampling requirements and arrangements were taken into account in the definition of GDA Environmental Protection Functions for the generic SMR-300 [17].
ENDP10 – Quantification of Discharges *Facilities should be designed and equipped so that best available techniques are used to quantify the gaseous and liquid radioactive discharges produced by each major source on a site.*	The sub-chapters 5.5, 5.6 and 5.7 presents the sampling and monitoring arrangements for measuring discharges. PER Chapter 2 QEDL describes the quantification of prospective effluent (aqueous and gaseous) discharges from the generic SMR-300 design.

<table>
<tr><th>RSR Principle:</th><th>Information as part of GDA:</th></tr>
<tr><td>ENDP11 – Maintenance, inspection and testing
Structures, systems and components that are, or comprise part of, environment protection measures should receive regular and systematic examination, inspection, maintenance and testing.</td><td>Sampling and monitoring equipment will require maintenance, inspection and testing. Arrangements for access to sampling and monitoring equipment is discussed in sub-chapter 5.6 and 5.7.</td></tr>
<tr><td>ENDP14 – C&I – Environment Protection Systems
Best available techniques should be used for the control and measurement of plant parameters and releases to the environment, and for assessing the effects of such releases in the environment.</td><td rowspan="3">BAT is applied to sampling and monitoring and evidence to support BAT claims and arguments is included and summarised in sub-chapters 5.6, 5.7 and 5.8
The BAT argument for detecting abnormal discharges to minimise release to the environment is provided in sub-chapters 5.6.4.4 and 5.7.4.3 The BAT justification of sampling and monitoring is summarised in PER Chapter 6 Demonstration of BAT [8].</td></tr>
<tr><td>ENDP16 – Ventilation systems
Best available techniques should be used in the design of ventilation systems.</td></tr>
<tr><td>ENDP18 – essential services
Best available techniques should be used to ensure that loss of essential services does not lead to radiological impacts to people or the environment.</td></tr>
</table>

5.3.3 RSR Permit Conditions

Disposals/discharges of radioactive substances to the environment from nuclear licensed sites is controlled under the RSR [18]. RSR Conditions relevant to Sampling and Monitoring are listed in Table 5 which explains which conditions have been considered within the SSEC, and which will be considered at site-specific stage.

Table 5: RSR Conditions relevant to Sampling and Monitoring

No.	RSR Condition:	Stage at which condition have or will be considered
3.2.1	The operator shall: (a) take samples and conduct measurements, tests, surveys, analyses and calculations to determine compliance with the conditions of this permit; (c) use the best available techniques when taking such samples and conducting such measurements, tests, surveys, analyses and calculations, and carrying out such environmental monitoring programmes and retrospective dose assessment, unless particular techniques are specified in schedule 3 of this permit or in writing by the Agency; (d) define and document the techniques being employed to determine the activity of radioactive waste disposals and shall inform the Environment Agency in writing in advance of any modifications to those techniques that have a potential to change the results obtained.	The arrangements and requirements of sampling and monitoring for radioactive waste are detailed in sub-chapter 5.5, 5.6 and 5.7 commensurate with GDA scope and the maturity of generic SMR-300 design, which reflect the consideration of RSR condition 3.2.1 (a) in GDA process. 3.2.1 (c) has been considered in Step 2 (use of BAT) and will be implemented further at the site-specific stage. See sub-chapter 5.9. 3.2.1 (d) has been considered at Step 2.and will be implemented further at the detailed design stage.
3.2.2	The operator shall maintain records of all monitoring required by this permit including records of the taking and analysis of samples, instrument measurements (periodic and continual), calibrations, examinations, tests and surveys and any assessment or evaluation made on the basis of such data.	The management of records management is detailed PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance [19]. At the site-specific stage, an appropriate information management system should be developed to maintain all relevant records, including records relevant to sampling and monitoring.

No.	RSR Condition:	Stage at which condition have or will be considered
3.2.3	Monitoring equipment, techniques, personnel and organisations employed for the monitoring of disposals and the environment required by condition 3.2.1 or 3.2.5 shall have either MCERTS certification or MCERTS accreditation (as appropriate), where available, unless otherwise agreed in writing by the Environment Agency.	Choice of monitoring equipment and personal organisations will be Site Specific. MCERTS certification/accreditation is a UK regulatory requirement which is discussed within Step 2.
3.2.4	Permanent means of access shall be provided to enable sampling and monitoring to be carried out in relation to the disposal outlets specified in schedule 3 unless otherwise agreed in writing by the Environment Agency.	This requirement is considered in Sub-chapters 5.5 and 5.6. This will be implemented in the detailed design stage of SMR-300.
3.2.5	If required by the Environment Agency, the operator shall: (a) take such samples and conduct such measurements, tests, surveys, analyses and calculations, including environmental measurements and assessments, at such times and using such methods and equipment as the Environment Agency specifies (b) keep samples, provide samples, or dispatch samples for tests at a laboratory, as the Environment Agency specifies, and ensure that the samples or residues thereof are collected from the laboratory within three months of receiving written notification that testing and repackaging in accordance with the relevant legislation are complete.	This requirement is considered in Sub-chapters 5.5, 5.6 and 5.7 and will be implemented at site-specific stage.
3.2.6	The operator shall carry out: (a) regular calibration, at an appropriate frequency, of measuring instruments and other systems and equipment provided for: (i) carrying out any monitoring and measurements necessary to determine compliance with the conditions of this permit; (ii) measuring and assessing exposure of members of the public and radioactive contamination of the environment. (b) regular checking, at an appropriate frequency, that such measuring instruments and other systems and equipment are serviceable and correctly used.	This requirement is relevant to Examination, Inspection, Maintenance and Testing for sampling and monitoring instruments are identified and considered in sub-chapters 5.5, 5.6 and 5.7.

5.3.4 Applicable Codes and Standards Relevant to Sampling and Monitoring

5.3.4.1 EU 2004/2/Euratom

The EU Commission Recommendation 2004/2/Euratom [16] provides recommendations on standardised reporting of information on radioactive gaseous and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operations, it also provides nuclide limits of detection for each category of radioactive discharge.

The identification and justification of significant radionuclides to be measured considering the EU 2004 recommendation and EA guidance on limit setting [20], is detailed in PER Chapter 2 QEDL [8]. The key radionuclides identified for monitoring and reporting at PWR's are listed together with requirements for limits of detection in Table 6 and Table 7 below.

Table 6: Key Radionuclides for Discharge to Atmosphere in 2004/2/Euratom

Significant Radionuclides (Gaseous)	Euratom Limits of Detection (Bq/m^3)
Carbon-14	1E+01
Tritium	1E+03
Cobalt-60	1E-02
Krypton-85	1E-04
Xenon-133	1E+04
Iodine-131	2E-02

Significant Radionuclides (Gaseous)	Euratom Limits of Detection (Bq/m^3)
Strontium-90	2E-02
Caesium-137	3E-02

Table 7: Significant Radionuclides for Liquid Discharges in the Generic SMR-300

Significant Radionuclides (Aqueous)	Euratom Limits of Detection (Bq/m^3)
Tritium	1E+05
Cobalt-60	1E+04
Strontium-90	1E+03
Caesium-137	1E+04

5.3.4.2 Applicable Codes, Standards and Guidance

The codes, standards and guidance applied to sampling and monitoring are summarised in Table 8.

Table 8: Applicable Codes and Standards

Codes and Standards	Summary	Application in GDA Process
ISO 10780:1994 Stationary source emissions — Measurement of velocity and volume flowrate of gas streams in ducts [21]	Specifies manual methods for determining the velocity and volume flow rate of gas streams in ducts, stacks and chimneys vented to the atmosphere.	This standard is used for the determination of flow rate and velocity in ducts and vents; this is discussed in sub-chapter 5.5.
ISO 2889:2023 Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities [22]	Sets out performance-based criteria and recommendations for the design and use of systems for sampling of airborne radioactive materials in the effluent air from the ducts and stacks of nuclear facilities.	This standard provides criteria for the use of air-sampling equipment, including probes, transport lines, sample collectors, sample monitoring instruments and gas flow measuring method to obtain representative samples. These requirements are relevant to detailed design of systems at the site-specific stage and are appropriately discussed in sub-chapter 5.5.
EN 60761-1:2004 Equipment for continuous monitoring radioactivity in gaseous effluents - Part 1: General requirements [23]	Lays down mandatory general requirements and gives examples of acceptable methods for equipment for continuous monitoring of radioactivity in gaseous effluents. Specifies general characteristics, general test procedures, radiation, electrical, safety and environmental characteristics and the identification and certification of the equipment.	This requirement has been acknowledged and will be considered at the detailed design stage.
EN 60761-3:2004 Equipment for continuous monitoring radioactivity in gaseous effluents - Part 3: Specific requirements for radioactive noble gas monitors [24]	Lays down specific standard requirements, including technical characteristics and general test conditions, and gives examples of acceptable methods for noble gas effluent monitors.	This standard defines the technical requirements and general test conditions required for noble gas monitoring in effluents. Requirements within this standard will be taken into consideration during detailed design This requirement has been acknowledged and will be considered at the detailed design and site-specific stages.

Codes and Standards	Summary	Application in GDA Process
ISO 5667-1:2023 Water quality — Sampling: Part 1: Guidance on the design of sampling programmes and sampling techniques [25]	Sets out the general principles for, and provides guidance on, the design of sampling programmes and sampling techniques for all aspects of sampling of water (including waste waters, sludges, effluents, suspended solids and sediments).	Fulfilment of the requirements of this standard regarding representative sampling as Future Evidence at detailed design is discussed in sub-chapters 5.6.4 and 5.6.6.
ISO 5667-3:2024 Water quality — Sampling: Part 3: Preservation and handling of water samples [26]	Specifies the general requirements for sampling, preservation, handling, transport and storage of all water samples for physicochemical, chemical, hydrobiological and microbiological analyses and determination of radiochemical analytes and activities.	This requirement has been acknowledged and will be considered at the site-specific stage.
IEC 60861:2006 Equipment for monitoring of radionuclides in liquid effluents and surface waters [27]	Defines technical requirements for equipment for monitoring of alpha-, beta- or gamma-emitting radionuclides in liquid effluents and surface waters, provides general guidance as to the possible detection capability of such equipment and indicates when and where its uses may be practicable.	This requirement has been acknowledged regarding representative sampling and detection of abnormal discharge requirements within sub-chapter 5.6.4 and will be considered in post-GDA timescales.
LIT 14887 Monitoring of radioactive releases to atmosphere from nuclear facilities [28]	This technical guidance applies to all nuclear sites in England where discharges to atmosphere are made and provides good practice for the design of sampling and monitoring systems. The document takes into account and references the following guidance: a) Monitoring stack emissions: measurement locations (EA 2022). b) Method implementation document for EN 15259:2007 (EA 2019). c) Internal guidance on standardised reporting of radioactive discharges from nuclear sites (EA 2020). d) Radiological monitoring technical guidance note 2 on environmental radiological monitoring (EA et al. 2010). e) Radioactive substances management arrangements at nuclear sites (EA 2010a). f) Principles of optimisation in the management and disposal of radioactive waste (EA 2010b). g) Nuclear Operator Monitoring Assessment guidance (EA 2023).	Source of regulatory guidance/good practice as derived from relevant standards, which contribute to a demonstration of BAT. See sub-chapter 5.5.
LIT 55216 [29] Monitoring of radioactive releases to water from nuclear facilities	This technical guidance note applies to all nuclear sites in England where discharges are made to water and provides good practice for the design of sampling and monitoring systems. The document takes into account and references the guidance in c) – g) above.	Source of regulatory guidance/good practice as derived from relevant standards, which contribute to a demonstration of BAT. See sub-chapter 5.6.

Codes and Standards	Summary	Application in GDA Process
Advanced Nuclear Technology: Advanced Light Water Reactor Utility Requirements Document Rev.13 [30]	This report contains the entirety of the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) for Advanced Light Water Reactors. It also documents owner/operator requirements and expectations for small modular light water reactors and the projects to design, construct and operate them based on United Stated (US) good practice.	Where applicable, international good practice contained within the EPRI URD has been utilised.
The management of higher activity radioactive waste on nuclear licensed sites [31]	Provides joint guidance from the Office for Nuclear Regulation (ONR), the EA, the Scottish Environment Protection Agency and Natural Resources Wales to nuclear licensees	Guidance relating to sampling and monitoring record keeping and waste characterisation which is discussed in sub-chapter 5.7.

MCERTS is the EA's Monitoring Certification Scheme for environmental permit holders and is used to approve people, instruments and laboratories [32]. Relevant applicable MCERTS standards for this chapter include:

- **Water and flow monitoring performance standards;** MCERTS for flow monitoring, water monitoring equipment and accreditation of laboratories that analyse water samples.
    - Performance standards and test procedures for continuous water monitoring equipment:
        - Part 1 – Automatic sampling equipment [33]
        - Part 2 – Online monitors [34]
        - Part 3 – Water Flowmeters [35]
    - Radioanalytical testing of environmental and waste waters [36]
    - Minimum requirements for self-monitoring of flow: MCERTS performance standard [37]
- **Stack emissions monitoring;** Technical guidance notes for monitoring stack emissions.
    - Monitoring stack emissions: standards for continuous sampling and monitoring [38]

Flow measurements are required for both gaseous and liquid effluents and flow monitoring shall meet EA MCERTS requirements (which apply ISO/British national standards).

5.4 PARAMETERS TO BE MONITORED

The parameters for monitoring final discharges have been determined based on the radionuclides deemed significant in PER Chapter 2 QEDL [8] and PER Chapter 3 Radiological Impact Assessment [39]. The significant radionuclides were determined using EA guidance [20] and the EU 2004/2/Euratom recommendation discussed in sub-chapter 5.3.4.1.

Where appropriate radionuclides have been grouped together when proposing limits for ease of analysis. The radionuclides/groupings for which prospective RSR permit limits have been proposed are summarised in Table 9 below, and will form the basis for the generic SMR-300 discharge monitoring requirements:

Table 9: Significant Radionuclides for Gaseous and Aqueous Discharges for the Generic SMR-300

Significant Radionuclides (Gaseous)	Significant Radionuclides (Aqueous)	Other Parameters
Tritium	Tritium	Discharge flow rate
Carbon-14	Carbon-14	
Noble Gases	Caesium-137	
Iodine-131	Other beta/gamma emitting radionuclides	
Other beta-emitting Radionuclides associated with particulate matter		

Sub-chapters 5.6 and 5.7 cover the suitable design provisions to ensure that the significant radionuclides shown in Table 9 above, can be monitored for recording and regulatory reporting purposes in line with the limits of detection set out in the EU commission recommendation.

As there are differences between UK and US regulatory standards and practices, the generic SMR-300 concept design does not specifically address carbon-14 monitoring and sampling requirements. Carbon-14 has been highlighted as a significant radionuclide in PER Chapter 2 QEDL [8] and an associated limit for its discharge has been proposed, it will therefore need to be ensured that the design facilitates it's measurement.

Where the design specifies liquid/gaseous grab sampling to be included for sampling and quantification at the discharge as a key radionuclide identified in PER Chapter 2 QEDL [8], these samples should allow for measurement of carbon-14. Therefore it has been determined that the current design does not preclude it's assessment, however a future evidence is to be captured to ensure that as the UK design matures the design is suitably aligned to ensure carbon-14 can be adequately monitored (see sub-chapter Table 19: Future Evidence).

In addition, flow rate of both the gaseous and liquid discharges is to be continuously and accurately measured to facilitate the reporting of discharges.

5.5 SYSTEM DESCRIPTIONS

The main systems relevant to sampling and monitoring radioactive waste are summarised and signposted in this sub-chapter. Unless otherwise stated, all information provided is consistent with the latest Design Reference Point (DRP) for the SMR-300 GDA [40].

5.5.1 Primary Sampling System (PSL)

The PSL is designed to obtain samples throughout systems containing primary process fluid systems to provide the analytical information necessary to monitor the performance of components and systems, as well as properties of liquid and gaseous effluents. It consists of the following:

- **Primary Sampling Panel** – The Primary Sampling Panel is designed to receive and route samples of primary process fluids from various points within the Reactor Coolant System (RCS) and CVC, with results of the analyses used to:
    - Monitor fuel rod integrity.
    - Evaluate ion exchanger and filter performance.
    - Specify chemical additions to the various systems.
    - Maintain acceptable hydrogen levels in the RCS.
    - Detect leakages of radioactive material.
- **Local Grab Sampling** – For normally accessible locations throughout the plant, local sample connections are provided for manually collecting samples directly from the source, for local analysis.
- **Post-Accident Sampling** – The PSL provides the analytical and confirmatory information necessary to monitor post-accident conditions. Sampling of post-accident conditions is out of scope for this chapter this will not be discussed further here.

The design of the PSL is presented in detail in the Preliminary Safety Report (PSR) Part B Chapter 5 Reactor Supporting Facilities. Specifics of sampling and monitoring within the PSL system is presented in sub-chapter 5.6 and 5.7. Sampling has been broadly categorised into three definitions:

- **Continuous sampling –** Online monitoring that does not require human intervention and can monitor the process stream automatically, typically contained within the RMS system (see sub-chapter 5.5.2).
- **Grab Sampling** – Sample taken in an instantaneous moment in the process stream. Analysis of grab samples to take place in on-site laboratory.
- **Integrated sampling –** Continuous sampling of a process stream which obtains a sample at specified intervals for analysis at a later time. Includes time or flow proportional sampling.

5.5.1.1 PSL Gap Analysis

A gap analysis of the PSL system against UK expectations and best practices [41] was conducted during GDA. The gap analysis focussed on safety aspects and the ONR's expectations for monitoring and sampling in the primary circuit. The report identified potential gaps and made several recommendations to align the PSL to UK best practice.

Of relevance to the BAT demonstration, a recommendation was to consider inclusion of a second penetration to sample the hot and cold legs, accumulators and pressuriser spaces of the RCS. An additional sample line would allow for dedicated gaseous sampling and reduce risks of cross-contamination, but could pose additional risk to the environment from the additional containment penetration to, and potential for generation of additional waste.

The PSL Preliminary Chemistry Engineering Justification [42] report identifies shortfalls in the generic SMR-300 design and establishes forward actions to address. A design development recommendation included adding a second train to the existing PSL line which prioritises the sampling of the accumulators to reduce the risk of cross-contamination.

This solution avoids a new containment penetration and avoids additional generation of wastes as flushings from both sample lines are routed to the Volume Control Tank (VCT) and returned to the primary circuit. The PSL Piping & Instrumentation Diagram [43] has been updated to reflect this change in the latest DRP [40].

5.5.2 Radiation Monitoring System (RMS)

The RMS [44] provides radiation monitoring for the functional classifications listed below. Individual monitoring devices may provide functionality in more than one classification.

- **Process Radiation Monitors** – Process monitors determine concentrations of radioactive material in plant fluid systems (see sub-chapter 5.5.2.1).
- **Airborne Radioactivity Monitors** – Airborne monitors provide operators with information on concentrations of radioactivity at various points in the ventilation system (see sub-chapter 5.5.2.2).
- **Effluent Radiation Monitors** – Monitor radioactivity of liquid and gaseous effluents discharged to the environment (see sub-chapter 5.5.2.3).
- **Area Radiation Monitors** – The area radiation monitoring subsystem provides radiation measurement at fixed internal locations. They continuously monitor and alert operators to changes in dose exposure levels. They have no direct role in monitoring discharges of radioactivity to the environment and not discussed in detail within this chapter.

The following other functions are performed by the Radiation Monitoring System:

- Monitor, indicate, and archive radioactive release levels for effluent paths. Initiate alarms when specific thresholds are reached. Where required, provide signals to perform isolation functions to control releases of radioactivity to the environment. Where required, sampling capability is provided.
- Indicate and archive process radiation levels and initiate alarms for process paths when system-specific thresholds are reached. Where required, provide signals to perform isolation or actuation functions to protect control room environmental conditions, isolate contamination sources, or protect process sample locations. Where required, sampling capability is provided.
- Detect and determine the rate of reactor coolant system leakage into containment, secondary coolant, or Component Cooling Water System (CCW).

Selection of a specific detector type is governed by the required sensitivity, the operating conditions of the process stream and environmental conditions near the point of detection. Three types of detectors can be used in a process radiation monitor:

- **Gas-Filled Detectors** – These detectors are subdivided into three separate technologies: ionization chambers, proportional counters, and Geiger-Mueller (G-M) tubes.
- **Scintillators** – Beta plastic scintillators are normally used for noble gas detection and NaI is used for gammas from radio-isotopes in liquids.
- **Solid State** – Cadmium Telluride (CdTe) semiconductor detector (typically used only for plant vent mid and high range gas detectors).

Further details on the specific functions and locations of these detectors will be provided in sub-chapters 5.6 and 5.7.

5.5.2.1 Process Radiation Monitors

The Process Radiation Monitors are used to provide the below indication to the operator by continually monitoring radioactivity levels in various plant process and effluent streams.

- Provide early warning of a possible plant malfunction
- Warn operating personnel of increasing radiation/radioactivity
- Provide indications of radioactivity/radiation which may help to prevent inadvertent release of radioactivity to the environment.

5.5.2.2 Airborne Radioactivity Monitors

The airborne radiation monitoring equipment are placed in selected areas and ventilation systems to give plant operating personnel continuous information about the airborne radioactivity levels throughout the plant. The majority of the airborne radioactivity within the plant results from equipment leakage.

The monitors operate on the exhaust of active and non-active HVAC systems to detect levels of radiation outside of normal parameters and prompt automated or operator-led actions.

5.5.2.3 Effluent Radiation Monitors

The gaseous effluent monitoring and sampling system monitors the vent stack for the radioactive materials. The liquid effluent radioactive waste monitoring and sampling system measures the concentration of radioactive materials in liquids released to the environment.

Discharge points to the environment are continuously monitored for radioactivity, with appropriate alarms on detection of elevated radioactivity, and automatic isolation of discharge routes to prevent release to the environment if necessary.

5.5.3 Interfacing Systems

The following systems are relevant to radioactive effluents:

- **Gaseous Radioactive Waste System (GRW)** – Designed to process gaseous radioactive waste generated during plant normal operations. The design of the GRW is presented in SDD for GRW [45], and summarised in PER Chapter 1 Radioactive

Waste Management Arrangements [7] (RWMA) and PSR Part B Chapter 13 Radioactive Waste Management [46]

- **Liquid Radioactive waste System (LRW)** – Designed to collect, treat and release or recycle radioactive liquid waste generated during normal plant operations. The design of the LRW is presented in SDD for LRW [47], and summarised in PER Chapter 1 RWMA [7] and PSR Part B Chapter 13 Radioactive Waste Management [46]
- **Solid Radioactive waste System (SRW)** – Designed to separately collect, process, package and store solid radioactive waste from normal plant operations. The design of the SRW is presented and SDD for SRW [48], and summarised in PER Chapter 1 RWMA [7] and PSR Part B Chapter 13 Radioactive Waste Management [46].
- **Radioactive HVAC systems (Containment Building Ventilation (CBV) and Radiologically Controlled Ventilation (RCV))** – Designed to provide fresh air and filter the exhaust air for different plant buildings, to maintain the required ambient conditions for normal operation of relevant equipment and operator access to the facilities. The design of the HVAC is presented in PSR Part B Chapter 5 Reactor Supporting Facilities [12].

In addition to the above, other generic SMR-300 systems are discussed where they include grab sampling provisions or radiation monitors to detect radioactivity leakage into non-active systems. Many of these are conventional island systems such as the non-active HVAC systems and the Waste Water System (WWS). The design maturity of these conventional island systems is currently low and as such they are out of scope of GDA. Information on monitoring provisions for these systems will be discussed as appropriate, with further information on systems to be provided as future evidence as the design matures.

5.6 GASEOUS SAMPLING AND MONITORING

The significant radionuclides in the generic SMR-300 gaseous effluent, which require sampling and monitoring prior to being discharged to the environment, include carbon-14, tritium, noble gases, iodines and beta particulate. The justification and identification of these significant radionuclides is presented in PER Chapter 2 QEDL [8], and summarised in sub-chapter 5.3.4.1.

Figure 1 illustrates the main gaseous radioactive effluents arising from the generic SMR-300 and their associated sampling and monitoring arrangements. The systems responsible for managing gaseous effluent include the GRW, CBV and RCV, which contribute to minimising radiation exposure to the members of the public and the environment to As Low As Reasonably Achievable (ALARA).

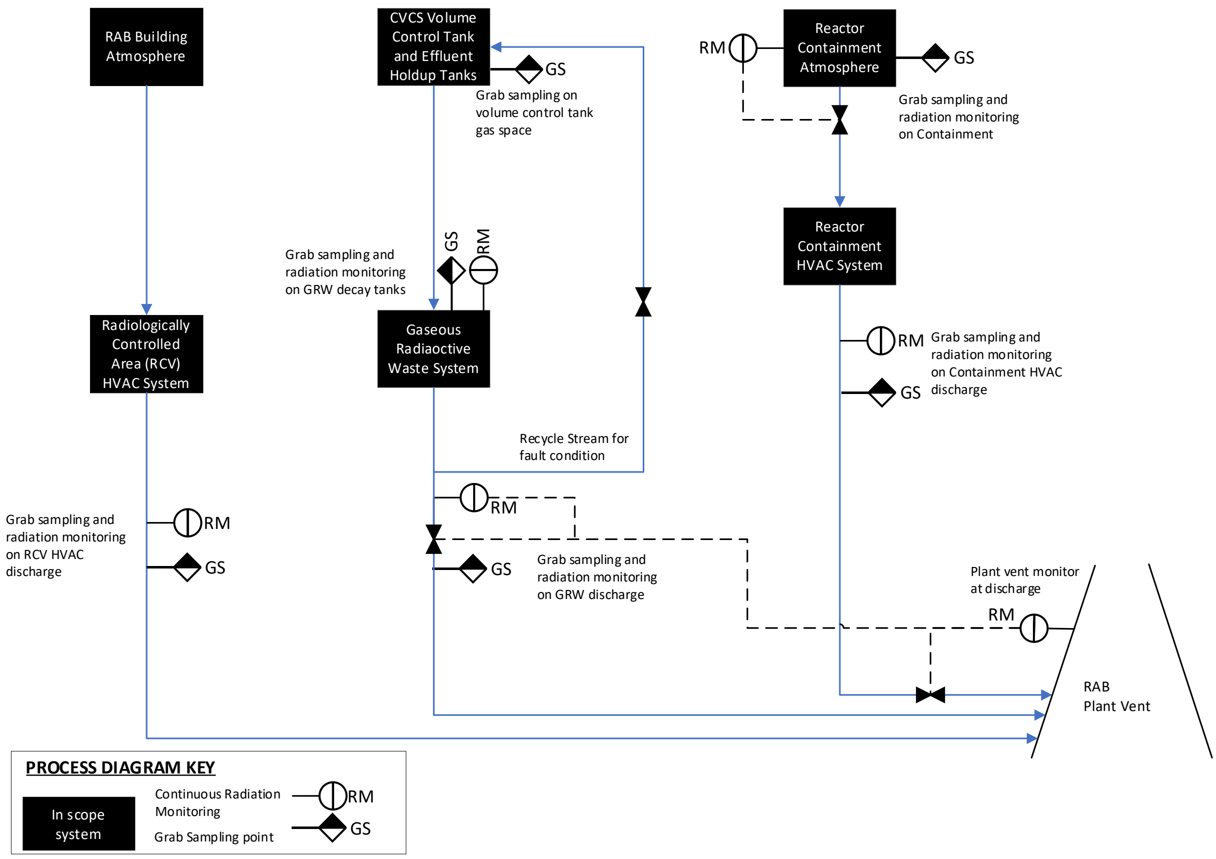

Figure 1: Overview of Sampling and Monitoring Arrangements for Gaseous Radioactive Effluents

The gaseous effluent stream in the generic SMR-300 is radiation monitored and sampled to quantify significant radionuclides and ensure compliance with permitted discharge limits before releasing to the environment via the Reactor Auxiliary Building (RAB) HVAC system and subsequently the plant vent. The generic SMR-300 design is a twin reactor unit plant. Currently the RCV and plant vent stack(s) are at a concept design stage and it has not been concluded to what extent that there will be duplication between units.

5.6.1 In-Process Sampling and Monitoring for Gaseous Effluents

In-process sampling and monitoring provides early warning to the operator of elevated radioactivity in process effluents. It also provides diagnostic capability to identify the source of an increase in radioactivity that has been detected downstream and to understand plant performance.

BAT is applied to minimise discharges and ensure impacts on members of the public and environment for radioactive discharges are ALARA. Radioactive wastes should be sampled and monitored as they are generated, ideally at the point of generation, to determine the subsequent management of the radioactive waste (i.e. segregation, treatment and discharge) as necessary in line with RSMDPs 8 and 9 [49].

Table 10 presents in-process sampling and monitoring arrangements for systems managing radioactive gases in the generic SMR-300. Grouped parameters including noble gases and particulates are identified by radionuclide in Methodology for Calculating Liquid and Gaseous Discharges to Determine Monthly and Annual Limits [50].

Table 10: Gaseous Radioactive In-Process Sampling and Monitoring Arrangements

System	Sample Point	Sample Type	Sampling System	Parameters Monitored	Purpose
Main Steam System (MSS)	Main Steam Line	Gamma Scintillator (Nitrogen-16 (N-16)	RMS	N-16	Provides near real-time indication of leak rate when reactor is at power to supplement other leak detection methods.
GRW	GRW Decay Tank	Grab Sampling	PSL	To be confirmed	Quantification of decay tank activity prior to discharge.
	GRW outlet	Grab Sampling	PSL	Noble Gas activity and release rate	Quantification of GRW discharges and determination of origin of elevated discharges.
	GRW outlet	Integrated Sampling	PSL	Noble Gases, Tritium, Iodine, particulates	Quantification of GRW discharges and determination of origin of elevated discharges.
	GRW outlet	Beta scintillator or G-M tube	RMS	Gross activity	Detection of elevated radioactivity, automatic termination of discharge on exceeding predetermined setpoint.
CBV	CBV location to be confirmed	Grab Sampling	PSL	Noble Gases, Tritium, Iodine, particulates	Quantification of CBV discharges and determination of origin of elevated discharges.
	CBV location to be confirmed	Gamma scintillator	RMS	Gross activity	Continuous monitoring of containment purge exhaust air, automated alarm on exceeding predetermined setpoint.
RCV	RCV exhaust	Beta scintillator	RMS	Gross activity	Continuous monitoring of RCV exhaust air, automated alarm on exceeding predetermined setpoint.
NRV	Non-Rad HVAC exhaust	Beta scintillator	RMS	Gross activity	Continuous monitoring of non-active HVAC exhaust air, automated alarm on exceeding predetermined setpoint.
Annular Reservoir	Annular Reservoir Vent	Beta scintillator	RMS	Gross activity	Continuous monitoring of Annular Reservoir vent air, automated alarm on exceeding predetermined setpoint.
Turbine Building HVAC (TBV)	TBV exhaust	Beta scintillator	RMS	Gross activity	Continuous monitoring of turbine island HVAC exhaust air, automated alarm on exceeding predetermined setpoint.

System	Sample Point	Sample Type	Sampling System	Parameters Monitored	Purpose
	Turbine Island Vent	Gamma Scintillator	RMS	Gross activity	Continuous monitoring of turbine island vent for early indication between the primary and secondary side of the steam generators. Automated alarm on exceeding predetermined setpoint.

In-process monitoring and sampling for gaseous effluents is intended for the following purposes:

5.6.1.1 GRW Effluent Monitoring

Grab sampling can be performed on the decay tanks in the GRW to determine compliance of batches before discharge [45]. The radiation monitoring devices on the discharge line will be designed to continuously monitor and record all gaseous radioactivity released from the GRW to the atmosphere through normal release pathways. If out-of-threshold radiation levels are detected, this discharge path will automatically be isolated, preventing further release to the environment.

Since issue of the SDD for PSL [51], development of the concept GRW design has made significant amendments, notably the provision of decay tanks for abatement of gaseous radioactive wastes [45]. As such the description of GRW monitoring and sampling described within the PSL SDD will be aligned with the SDD for GRW [45] post-GDA.

The SDD for GRW [45] notes that the gas analysers provide the capability to analyse levels of hydrogen and oxygen composition in the waste gas, also provides the capability to take a grab sample for further analysis. Operator action is required to initiate controlled discharge from a decay tank to the environment. The radiation monitoring devices on the discharge line will be designed to continuously monitor and record all gaseous radioactivity released from the GRW to the atmosphere through normal release pathways. If out-of-threshold radiation levels are detected, this discharge path will automatically be isolated, preventing further release to the environment. A future evidence (see M&S_01, Table 19) will be identified to confirm that the PSL and RMS incorporate sufficient provisions within the GRW.

5.6.1.2 HVAC Systems Exhaust Monitoring

Radiation monitoring is incorporated into the discharge line of active HVAC systems and typically non-active HVAC systems with risk of contamination, in order to provide early indicator to the operator of abnormally elevated activity, and for diagnostic purposes.

The GRW discharges into the RCV HVAC system, gaseous effluent then flows through air filtration units including HEPA filters and charcoal adsorbers to remove the radioactive particulate and iodine. A radiation monitor is present in the RCV exhaust (post-filtration), prior to mixing with other gaseous effluents in the plant vent.

The CBV HVAC system includes radiation monitoring within reactor containment to trip and isolate the discharge path if high radiation is detected, preventing release of radioactive material into the plant vent. The CBV discharge is also radiation monitored upstream of the plant vent, enabling detection of high radiation at source. A grab sample point is provided at the same location to allow profiling of radionuclides within containment.

Other typically non-active HVAC systems with risk of contamination have online continuous monitoring to detect elevated discharges with alarms at pre-set threshold to alert the operator.

5.6.1.3 Primary-Secondary Leakage Monitoring

A N-16 monitor is located within the main steam line which in near real-time monitors levels of N-16 on the secondary side to detect pinhole leaks between the primary and secondary circuit. Given the very short half-life of N-16 this monitor is only effective when the reactor is at power, and is used in conjunction within other measures to detect secondary side leakage. This includes the Turbine Island Vent (TID) monitor which works similarly to the other HVAC monitors, detecting elevated discharges with alarms at pre-set threshold to alert the operator.

As described in the Integrated Waste Strategy (IWS) [52], the sources of radioactive gaseous effluents in the SMR-300 include primary gaseous effluent, gaseous effluent from HVAC systems and secondary gaseous effluent from the Condenser Vacuum System (CAS) system. The management of secondary gaseous effluent is out of GDA scope and therefore not assessed in detail.

As a result of minor leaks or expected events consistent with the implementation of BAT, radioactively contaminated wastes may arise within non-active systems, for example, via a steam generator leakage pathway between the primary and secondary circuits. It is good practice to have design provisions for radiation monitors in the secondary circuit to provide early indication to the operator of leaks.

In summary, radioactive gaseous discharges from the generic SMR-300 are monitored for radioactivity and sampled upstream of the plant vent and downstream of abatement systems. The design features listed above are intended to provide safety, redundancy and flexibility in the process which contributes to overall process performance and minimisation of release risks ALARA. In-process sampling and monitoring arrangements will be developed further as the design matures and to ensure the above options are non-foreclosing.

5.6.2 Final Sampling and Monitoring for Gaseous Discharges

The generic SMR-300 design provides sampling and monitoring at the point of discharge to the environment (i.e. the plant vent), to quantify the radionuclides in gaseous discharges to the environment for demonstration of compliance with proposed limits. Confirmed provisions within the generic SMR-300 design for this are presented in Table 11.

Table 11: Gaseous Radioactive Final Sampling and Monitoring Arrangements

System	Sample Point	Sample Type	Sampling System	Parameters Monitored	Purpose
RCV	Plant vent radiation monitor	G-M tube	RMS	Gross Activity	Detection of elevated radioactivity, automatic termination of discharge on exceeding predetermined setpoint.

The current design of the generic SMR-300 RCV and plant vent stack has not reached a level of maturity for final sampling and monitoring for gaseous discharges to be confirmed and as such a commitment is to be raised to ensure adequate provisions in the design of the RCV and plant vent to enable quantification of discharges of all identified significant radionuclides:

Commitment C_Moni_119: Further information on the SMR-300 arrangements for the recording & reporting of gaseous discharges is required to ensure that they represent BAT.

A Commitment is raised to undertake a BAT assessment to confirm that suitable arrangements are in place to quantify discharges of all significant radionuclides/groupings and demonstrate compliance with proposed permit limits. The BAT assessment will also describe the facilities within the generic SMR-300 provided for independent periodic sampling of final discharges of gaseous wastes.

Plant vents are designed to discharge at an optimum height to minimise radiological impacts on the public and the environment. It is standard practice to specify the height, dimensions and quantity of the discharge stacks at the site-specific stage. Sizing and design of the stack and number of discharge points will be confirmed at the site-specific stage in line with performance-based criteria and recommendations within ISO 2889:2023 [22], this is captured via future evidence M&S_03 (see Table 19: Future Evidence).

5.6.2.1 Flow Monitoring

It is best practice to provide continuous flow monitoring at the plant vent [53], [54], [55]. This arrangement facilitates quantification of discharges and contaminants released to the environment. ISO 2889:2023 states that the airflow of sampled emission streams should be continuously measured if the flow rate is anticipated to vary by more than 20% per year. Effluent and sample flow rate should be measured within +/- 10%

Use of MCERTS approved equipment, where available, is required by EA and RSR permit conditions [28] (see Table 5). There are multiple equipment options available for use in stack flow monitoring. A selected option must facilitate manual calibration of gas flowmeters on the stack, for example, through installation of measurement hatches, as this is a requirement of the MCERTS standard for continuous emissions monitoring to the environment (BS EN 14181:2004).

The generic SMR-300 design specifies the use of flow monitoring on gaseous discharges to determine radioactivity release rates [45]. To ensure representative sampling, flow rate is continuously monitored on sample lines at discharge points and in-process. Provisions are made in the generic SMR-300 design to ensure continuous and constant flow is maintained to online monitors, reducing overall maintenance and startup operations required [51]. However, determination of sampling and monitoring locations to enable representative sampling are subject to flow modelling during detailed design in post-GDA timescales.

The EA requirement for MCERTS equipment extends to automatic sampling equipment, where these are commercially available. EA guidance specifies design-based performance criteria relating to flow control performance, availability and measurement accuracy for automatic samplers [56]. The applicability of MCERTS certified automatic samplers is site-specific and will be assessed at the detailed design stage (M&S_04, see Table 19: Future Evidence).

5.6.3 Gaseous Sampling and Analysis Methods

Grab/Integrated sampling locations for in-process gaseous effluent are currently being developed. Specific methods for sampling and analysis are to be determined at the site-specific stage when the design of these systems is more mature. The development of specific methods for sample collection, and definition of analytical methods will be captured as future evidence for the site-specific stage.

In order to obtain measurements for low energy beta emitters tritium and carbon-14, specialised sampling equipment (for example bubblers) is required at the plant vent and in-process monitoring locations [53]. These samplers capture and isolate tritium vapour and gaseous tritium for analysis at the on-site laboratory. Variants of bubblers can also be used to isolate samples of Carbon-14 and tritium for analysis using liquid scintillation counting at the on-site lab. Similarly, separate or combined particulate/iodine samplers are commonly employed which use filters to capture aerosols, and iodine cartridges with activated carbon to capture iodine samples. These can be analysed at the on-site laboratory using high-resolution gamma spectroscopy (HRGS).

A future evidence will be captured (M&S_05, Table 19) to review in-process grab sampling locations at the detailed design stage and ensure appropriate equipment is selected where Tritium/Carbon-14/Iodine/particulates sampling would represent BAT and ensure appropriate equipment is incorporated into the generic SMR-300.

Table 12 provides an overview of analytical techniques consistent with other GDA's and extant PWR's in the UK, to be able to achieve the limits of detection requirements set out in EU/2004/Euratom for a 2-Step GDA. It is not possible to demonstrate that the specific detection limits can be achieved; however, future evidence has been identified (M&S_06) to confirm the analytical methods to be employed and demonstrate that the detection limits are achievable via that method.

Table 12: Typical Analytical Methods for Gaseous Radioactivity

Significant Radionuclides (Gaseous)	Analytical Method
Tritium	Liquid Scintillation Counting
Carbon-14	
Noble Gases	High Resolution Gamma Spectroscopy (HRGS)
Iodine-131	
Other beta-emitting Radionuclides associated with particulate matter	

Full specification of the on-site laboratory will take place as the project develops, however a future evidence will be captured to ensure that the laboratory uses methods in accordance with the ISO 17025 standard for lab accreditation, consistent with EA guidance and industry best practice (see M&S_07, Table 19: Future Evidence).

5.6.4 Demonstration of BAT

5.6.4.1 Representative Sampling and Monitoring for Gases

The ISO 2889:2023 standard [22] informs the design of sampling systems for airborne contaminants in ducts, stacks and vents to achieve representative sampling conditions. This includes setting performance-based criteria for the use of air-sampling equipment, probes, transport lines, sample collectors, sample monitoring instruments and gas flow measuring methods. The standard also outlines the requirement for thorough mixing in the airstream to enable even distribution of contaminants and representative measurement of their concentration.

Sampling and monitoring equipment associated with the discharges from the CBV, RCV and GRW are located downstream of any treatment processes, and upstream of mixing at the RAB plant vent, in line with EA guidance [28]. This approach enables representative sampling and monitoring of gaseous discharges before mixing in the RAB plant vent occurs.

ISO 2889:2023 requirements are to be met during the design phase to achieve representative sampling. It is recognised that collecting representative samples is specific to the location of the sample point and requires the following key design requirements to be considered:

- Position sample points at locations where a high degree of mixing is achieved to minimise particulate dropout and increase representativity of samples.
- Sizing of sample lines to enable turbulent flow.
- Where multi-phase flow exists, ensuring iso-kinetic conditions through specification of iso-kinetic nozzles.
- Providing suitable clearance distances between bends and take-off points in ductwork.
- Design of sample points and equipment to enable cleaning and maintenance, and to avoid deposition of samples within sampling lines.
- Performance acceptance testing for sampling equipment to demonstrate representative sampling in operation.
- Fluctuations in process temperature, flow and composition over time and the impact on representative conditions.
- Frequency and timing of sampling.

The design requirements listed above will need to be addressed during detailed design. A future evidence (see M&S_08, Table 19) has been defined to ensure the requirements of ISO2889:2023 are implemented for the generic SMR-300 during detailed design. Key requirements to be demonstrated against at detailed design will be captured below.

5.6.4.1.1 Sampling location requirements

Table 13 presents ISO 2889:2023 recommended characteristics for sampling locations that ensure the sampling stream is well-mixed.

Once the design of the plant vent stack is available suitable modelling will need to be undertaken to ensure the design is compliant with the above and will ensure representative sampling, this has been captured as a future evidence (M&S_03, Table 19).

Table 13: Characteristics for Gaseous Radioactive Waste Sampling Locations

Characteristic	Methodology	Recommendations
Measurement to determine if flow in a duct is cyclonic	ISO 10780	The average resultant angle should be less than 20°.
Velocity Profile	Selection of points across a section based on the guidance in ISO 10780 for the centre 2/3 of the area of the stack or duct. Additional points or area may be added to adequately cover the region.	The coefficient of variation (C_V) should not exceed 20 % over the centre region of the stack or duct that encompasses at least 2/3 of the stack or duct cross-sectional area.

Characteristic	Methodology	Recommendations
Tracer gas concentration profiles	Selection of points across a section based on the guidance in ISO 10780 for the centre 2/3 of the area of the stack or duct. Additional points or area may be added to adequately cover the region.	C_V should not exceed 20 % over the centre region of the stack or duct that encompasses at least 2/3 of the stack or duct cross-sectional area.
Maximum tracer gas concentration deviations	Selection of points across a section based on the guidance in ISO 10780 for the entire cross-sectional area. Additional points or area may be added to adequately cover the region.	At no point on the measurement grid should the tracer gas concentration differ from the mean value by more than 30 %.
Aerosol particle concentration profile	Selection of points across a section based on the guidance in ISO 10780. Additional points or area may be added to adequately cover the region.	C_V should not exceed 20 % over the centre region of the stack or duct that encompasses at least 2/3 of the stack or duct cross-sectional area.

5.6.4.1.2 Sampling and Collection System Requirements

Sampling systems can be designed to ensure isokinetic sampling takes place in order to facilitate a representative sample. Isokinetic sampling is achieved when the particulate matter enters the sampling nozzle at the same velocity and direction as stack flow. If the flow is anisokinetic, the distribution of particulate size will be skewed, meaning that larger particulate matter will either be under- or over-estimated [28], see Figure 2 below.

In the nuclear industry, most emission streams pass through high efficiency particulate air (HEPA) filters meaning streams have low particulate loadings of very small particle size. Such emissions tend to behave like a gas and consequently errors from this effect are likely to be relatively small; however, considerations should be given to the use of isokinetic sampling nozzles when sampling aerosols. There are various ways to ensure samples taken are representative of effluent streams including use of shrouded probes.

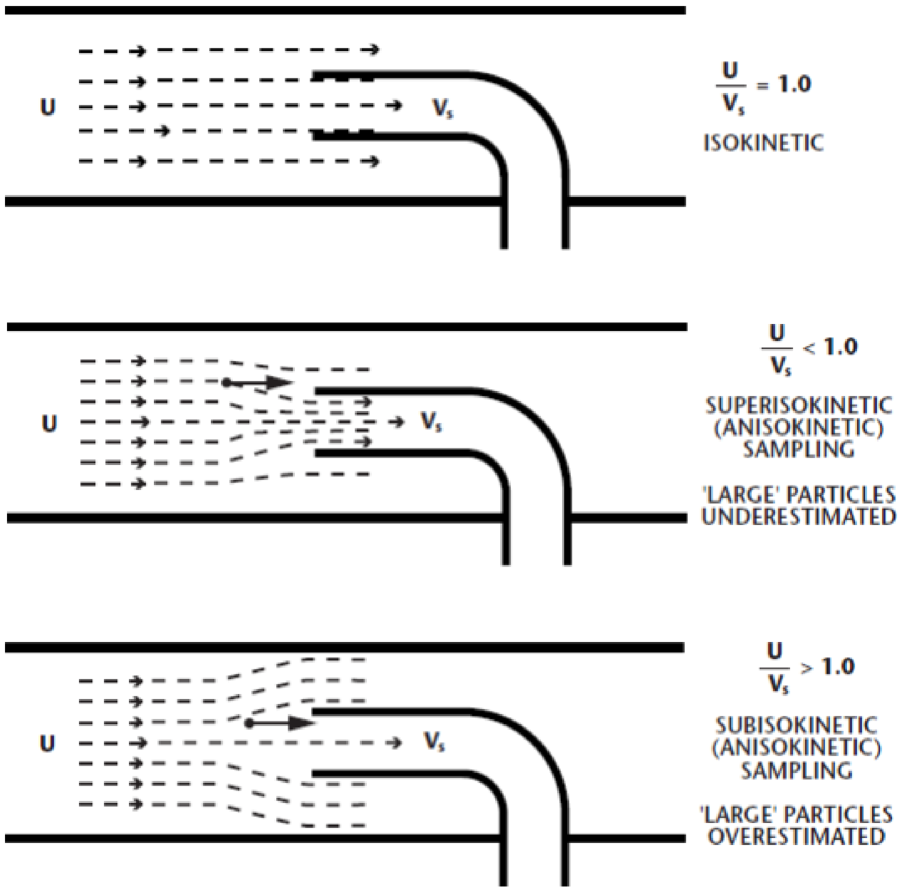

Figure 2: Isokinetic and Anisokinetic Sampling of Particulates [28].

ISO 2889:2023 does not specify an exact type of sampling nozzle to be used only that that the nozzle should have a transmission ratio ≥80% and ≤130 % for particles with a diameter (Da) of 10µm.

5.6.4.1.3 Minimisation of Depositional Losses

Additional requirements are specified within ISO 2889:2023 for minimisation of depositional losses within sampling lines. It is noted that some losses of aerosol particles are inevitable and any design will contain compromises, all recommendations should be carefully chosen to enhance the overall utility of the system.

The deposition of particles inside the transport lines from the extraction point to the filter should be determined experimentally using test aerosol particles or by the use of documented computer codes or documented and referenced hand calculations. This will be captured as a future evidence (M&S_09 in Table 19) to be tested against the following criteria:

The performance of the sampling system is considered sufficient under normal, off-normal and anticipated accidental conditions, if a test with near monodisperse particles of 8 µm to 12 µm aerodynamic particle diameter (Da) yields a penetration value above 50 %.

A Da of 10 µm is mentioned when no information on aerosol size distribution is available. In cases where additional data about the relevant size distribution (e.g. activity size distribution) are available, the test aerosol particle size can be selected accordingly.

Particles with a Da smaller than 10 µm have a higher penetration due to lower deposition rates. Particles with a Da larger than 10 µm can be expected to have smaller penetrations. On the other hand, for dry particles, the penetration can increase with particle size due to resuspension. Therefore, penetration measurements with test aerosol particles having a Da of 10 µm can be considered to address the penetration minimum.

During the design stage the above criteria can be tested computationally using documented computer codes based on verified experimental data in order to assist design work. A number of additional recommendations are provided for minimising depositional losses relevant to the generic SMR-300:

- Straight sections of sampling lines particularly horizontal sections should be kept as short as possible.
- Number of bends should be minimised.
- There should be no inward-facing steps at the tubing connections that cause more than a 1 % reduction in line diameter.
- Line pipework ends should be free of burrs and crimping.
- Pipe bends should have a curvature ratio of at least 3.
- Flattening, which is defined as the ratio of the minimum pipe diameter to the original tube diameter, should not be less than 0.85.
- The internal walls of the transport system should be constructed of materials that are minimally reactive to inadvertently deposited aerosol particles or to reactive vapour compounds that can be present in the sample – Stainless steel recommended to nuclear applications.
- To minimize aerosol-particle depositional losses and to facilitate decontamination, the internal surfaces of transport lines should be as close to hydraulically smooth as practical.
- Sample transport lines, collectors and analysers should be designed to avoid condensation of vapour, thermal insulation of trace heating can be utilised if necessary to prevent condensation.
- Consideration of equipment for cleaning of sampling lines to remove deposition.

5.6.4.2 Sample Return Requirements

In line with EA guidance [28] it is expected that sampled gases will be returned to the duct or stack at a location downstream of the sampling position, in a manner that minimises the volume of radioactive waste generated in the sampling and monitoring process.

Where it may not be possible to meet the guidance of samples being returned downstream of the sampling point, it will be ensured that samples are returned far enough upstream, and are small enough in volume compared to the total volume of the effluent stream so as to not unduly impact the representativeness of the sampling point.

A potential example of this is on the plant vent stack, where samples return downstream would introduce an additional penetration into the stack which would disturb and potentially impact sample representativeness. It is likely in the plant vent that the flow rate and dilution will be sufficient to ensure upstream return of the sample will have negligible impact on representativeness.

In cases where samples of relatively small volume are returned to a comparably large inventory, the impact on the representativity of future samples may be insignificant. Sample disposal routes must be revisited during detailed design of the sampling and monitoring system to ensure demonstration of BAT. An item of future evidence (see M&S_10, Table 19) has been identified confirm return locations for gaseous samples won't impact representativeness at the sampling point.

5.6.4.3 Safe and Suitable Access

Provisions are made to permit periodic inspection, maintenance and calibration of sampling and monitoring equipment in the generic SMR-300 design. Sufficient space will be provided for personnel, inspection equipment, removal space, and temporary storage, handling machinery, and repairs or replacement [51], and suitable environmental conditions.

The technical guidance note on monitoring stack emissions: measurement locations [57] requires:

- The sample location must be safely accessible at all times required during the monitoring process.
- Permanent platforms should be used wherever possible platforms which comply with relevant standards, including minimum weight requirements, safety rails etc.
- Measurement ports must be suitably sized to install and remove the equipment used and reach the measurement points, and facilitate periodic manual monitoring of key parameters for testing and calibration purposes.

The sampling system components should be protected against unauthorised tampering. This is usually achieved by housing the equipment in a locked cabinet, with authorised access provided only to those with responsibilities for the system [28]. Areas required for the maintenance of sampling or monitoring equipment should be designed to be accessible and safe for the operator. For example, ensuring that maintenance personnel have enough space to operate and manoeuvre equipment without injuring themselves or others around them. They should also be protected from heat, dust, radiation, radioactivity or significant temperature fluctuations. Essential services should be provided for monitoring systems. Electrically-powered sampling and monitoring equipment should be connected to an emergency supply system.

For gaseous discharge monitoring provision of safe and suitable access to equipment is a consideration of the proposed future evidence to consider BAT for the design of the plant vent stack (M&S_03, Table 19: Future Evidence). The location of sampling lines will likely be a compromise between competing requirements; the necessity of providing safe and suitable access to the equipment for operators and the recommendation to shorten sampling lines as far as is practicable to minimise depositional losses and reduce material use in construction.

The generic SMR-300 will arrange sampling and monitoring equipment to facilitate safe access without interrupting continuous monitoring or sampling of discharges. Maintenance arrangements will be detailed further and implemented in line with ISO 2889:2023 at detailed design. This will include design of platforms and walkways to enable sufficient access for periodic maintenance, inspections and repairs/replacements as required. These requirements are to be considered at detailed design (see M&S_03, Table 19: Future Evidence).

5.6.4.4 Detecting Abnormal Discharges for Gases

EA guidance [28] specifies that equipment failures and process alarms shall be acoustically enunciated and visually displayed in the control room. Alarms on radiation monitors and sampling systems are to be provided for effluent flow and radioactivity at high and low thresholds [28]. It is considered best practice to provide facilities that allow checking of alarm functionality that are secure and tamper-free.

The full specification of alarms for gaseous discharges is subject to finalisation of the RMS system [58]. However, the following key alarms for radioactive gases are identified in the generic SMR-300 design:

- Alarms are sounded if high oxygen levels are detected in the GRW, which isolates the inlet stream and sounds in the control room [44], [45].
- An alarm setpoint is instated for radioactivity on the GRW discharge, to alert the operator of high radioactivity and facilitate automatic isolation of the discharge if required [44], [45].
- High radioactivity detected in the RCV and CBV HVAC exhaust streams will trigger an alarm in the main control room [44] , [58].
- Alarms are also tied to RMS monitors on non-active HVAC systems to alert the operator to activity within those systems and prompt operator action [44].
- The plant vent radiation monitor will identify the concentration of radioactive contaminants released to the environment, and facilitate automatic termination of the discharge on exceeding the pre-determined setpoint. [44]

At the site-specific stage it will be confirmed that set points for alarms and associated automatic and manual operator actions are appropriate and consistent with ensuring that BAT is applied. This will be captured as a future evidence (M&S_11 in Table 19).

5.6.4.5 Independent Sampling and Monitoring Arrangements for Gases

The provision of secure and safe independent sampling facilities for final discharges of gaseous effluents is a UK-specific regulatory requirement [28]. This would typically be addressed via a redundant (or "backup") sampling and monitoring train should be positioned on the plant vent stack with measures in place to facilitate independent sampling and monitoring (witnessed by the regulator if required).

Appropriate provisions (according to regulatory guidance and good practice above [28]) for previous UK GDAs, such as HPR1000 [59], [60] have been considered to allow for independent regulatory verification of gaseous monitoring and discharge reporting. These facilities duplicate operator sampling facilities as much as possible, ensuring representative conditions are maintained.

Given the maturity of the RCV and plant vent stack design these requirements are yet to be embedded within the design however they will be covered by the scope of Commitment ***C_Moni_119*** (See 5.6.2).

5.7 LIQUID SAMPLING AND MONITORING

Significant radionuclides in the generic SMR-300 liquid effluent which require sampling and monitoring prior to being discharged to the environment include carbon-14, tritium and other fission and activation products. The justification and identification of these significant radionuclides is presented in PER Chapter 2 [8], and summarised in sub-chapter 5.3.4.1.

Figure 3 illustrates the sampling and monitoring arrangements for radioactive liquid effluent arising from the generic SMR-300. Effluents from the Chemical Volume Control System (CVC) and residual water from spent resin and containment, radioactive and miscellaneous drains are treated in the LRW to minimise impacts on the environment. The LRW system is described further in Sub-chapter 5.4 and the IWS [52].

Liquid effluent in the generic SMR-300 is radiation monitored and sampled to quantify significant radionuclides and ensure compliance with permitted discharge limits before releasing to the environment via the plant outfall. The source of liquid effluents is presented in PER Chapter 1 RWMA [7]. The in-process and discharge sampling and monitoring arrangements for liquid effluents which contribute to minimising impacts on the public and environment ALARA are discussed further in sub-chapters 5.7.1 and 5.7.2 respectively. Sampling and monitoring arrangements presented in this chapter are subject to development as the design matures and are therefore considered non-foreclosing at GDA.

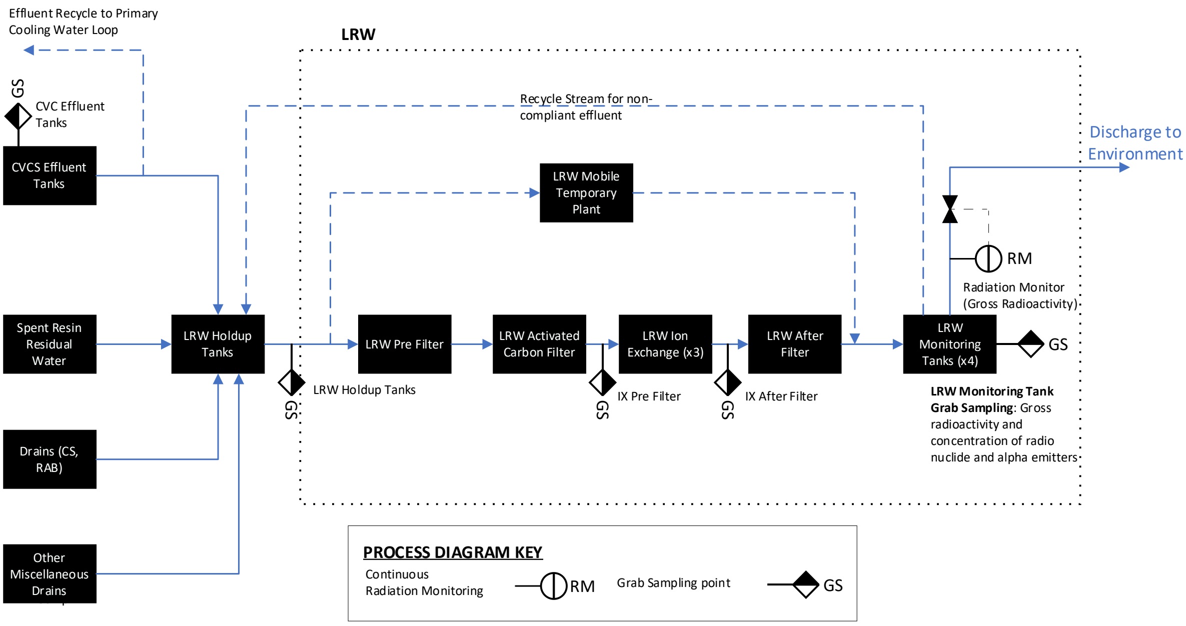

Figure 3: Simplified Diagram of Sampling and Monitoring for Liquid Radioactive Waste

5.7.1 In-Process Sampling and Monitoring for Liquid Effluents

As discussed in Sub-chapter 5.6.1, it is considered best practice to provide in-process sampling and monitoring that facilitates early warning of failures in the discharge and includes diagnostic capability to identify sources of elevated levels of radioactivity. BAT must be applied to minimise discharges and impacts on members of the public and environment ALARA in line with UK context. Liquid radioactive wastes are to be sampled and monitored as they arise, ideally at the point of generation, to identify effective management approaches as necessary in line with RSMDP8 and RSMDP9 [49].

For normally accessible locations throughout the plant, PSL local sample connections are provided for manually collecting samples directly from the source. These local sample system connections reduce sample line tubing, provides shielding, minimises radiation exposure to operators and reduces volume inputs to LRW [47].

Table 14 details the in-process sampling and monitoring arrangements for systems managing liquid effluents in the generic SMR-300. A detailed list of radionuclides is provided in Methodology for Calculating Liquid and Gaseous Discharges to Determine Monthly and Annual Limits [50].

Table 14: Liquid Radioactive In-Process Sampling and Monitoring Arrangements

System	Sample Point	Sample Type	Sampling System	Parameters Monitored	Purpose
RCS	RCS Hot Leg	Grab sampling	PSL	Laboratory analysis	Determination of activity levels in the RCS. Results can inform operator decision making on reuse of RCS or consignment to the LRW.
CVC	CVC letdown (before demineraliser)	Grab sampling	PSL	Laboratory analysis	For monitoring upstream and downstream of the CVC demineralisers to determine their effectiveness and to inform resin changes
	CVC letdown (after demineraliser)	Grab sampling	PSL	Laboratory analysis	
	CVC VCT	Grab sampling	PSL	Laboratory analysis	Determination of activity in VCT, can be used for diagnostics
RHR	RHR Heat Exchangers	Grab sampling	PSL	Laboratory analysis	Determination of leakage of radioactivity into primary circuit heat exchangers
LRW	LRW Containment Sump	Grab sampling	PSL	Laboratory analysis	Sampling of elevated activity in the containment sump indicating an RCS leak
	LRW Effluent Holdup Tanks	Grab sampling	PSL	Laboratory analysis	Determination of activity in LRW waste holdup tanks prior to treatment, can be used to infer effectiveness of LW treatment.
SFC	SFC upstream of demineralisers	Grab sampling	PSL	Laboratory analysis	Determine effectiveness of spent fuel pool demineralisers and inform resin changes
	SFC downstream of demineralisers	Grab sampling	PSL	Laboratory analysis	
SGB	SGB Radiation Monitor	Gamma scintillator	RMS	Gross activity	Detection of elevated radioactivity, automatic alarm and isolation of the system on exceeding predetermined setpoint
CCW	CCW Radiation Monitor	Gamma scintillator	RMS	Gross activity	Continuous monitoring of the CCW system to detect leaks from the RCS, the Spent Fuel Pool Cooling System (SFC) Heat Exchanger, the CVC the RHR, Service Air (CAI) or PSL Systems into the CCW system, automated alarm on exceeding predetermined setpoint
SWS	Service water Blowdown Radiation Monitor	Beta scintillator or G-M tube	RMS	Gross activity	Continuous monitoring of blowdown flow from the CCW for determination of primary-secondary leakage from the RCS, automated alarm on exceeding predetermined setpoint

System	Sample Point	Sample Type	Sampling System	Parameters Monitored	Purpose
RDS	Equipment Floor and Drainage System Radiation Monitor	Gamma scintillator	RMS	Gross activity	Detection of elevated radioactivity in floor drainage, automated alarm on exceeding predetermined setpoint

The sampling and monitoring arrangements described in Table 14 are provided to monitor sources of liquid radioactive waste arising from the primary coolant loop. Liquid waste arising from these sources is subsequently treated in the LRW. Equipment facilitating the removal of radioactive species from the reactor circuit are provided in the CVC and Spent Fuel Pool Cooling System (SFC) and sampling and monitoring is provided here to measure their performance.

The Component Cooling Water System (CCW) continuously monitors the component cooling water system for activity which would be indicative of a leak from reactor coolant from the Reactor Coolant System (RCS), the SFC Heat Exchanger, the Chemical Volume Control System, the Residual Heat (RHR) Exchangers, Service Air (CAI)/Primary Sampling (PSL) Systems, into the CCW system. Various other systems above have online monitoring or grab sampling to detect leakage from the RCS into secondary systems.

The key sampling points enabling characterisation of liquid radioactive waste are shown in Figure 3. The main functions of the in-process sampling and monitoring system for liquid radioactive waste are as follows [47], [51]:

- Radioactive properties are monitored on various systems to detect fuel leaks and egress of radioactive material from the reactor.
- The CVC VCT is sampled to determine characterisation for effluent recycling or transfer to waste holdup tanks in the LRW. The CVC effluent storage tanks also feature drains for sampling if required.
- LRW waste holdup tanks (upstream of treatment) and LRW treatment equipment, such as demineralisers and filters, are sampled upstream and downstream, to determine performance of these components.
- LRW effluent monitoring tanks are sampled to ensure compliance with radionuclide levels before release.

In addition to the above, the condition of the primary circuit is controlled through measurement of non-radioactive parameters, including pH, boron and other chemical properties to minimise the generation of radioactive waste and corrosion products. These arrangements facilitate performance monitoring of equipment and minimise the risk of releases that have harmful impact to the public and the environment ALARA.

During normal operations, as a result of unplanned but not unexpected events, it is foreseeable that radioactively contaminated wastes may arise from non-radioactive source systems and provisions must be provided to characterise, segregate and manage contaminated wastes arising from these systems. For example, monitoring radioactivity in the secondary side of the steam generator in the Steam Generator Blowdown (SGB) system to indicate a primary to secondary system leak.

Given the current design maturity of certain key systems in-process sampling and monitoring arrangements are non-foreclosing at GDA, and will be reviewed during detailed design. This is particularly relevant for the Radioactive Drainage System (RDS) which is out of scope of

GDA, and the RCV which currently has low design maturity. A future evidence (see M&S_02, Table 19) has been captured to undertake this BAT review for both liquid and gaseous systems.

5.7.2 Final Sampling and Monitoring for Aqueous Discharges

Sampling and monitoring parameters for liquid radioactive wastes from source systems in the generic SMR-300 are summarised in Table 15. The locations of these sampling and monitoring points are shown in Figure 3.

Table 15: Discharge Radioactive Liquids Sampling and Monitoring Parameters

Discharge Route	Monitoring Type	System	Parameters Monitored	Purpose
LRW Monitoring Tanks	Grab sampling	PSL	Laboratory analysis	Determination of radioactivity within discharged liquid effluent for the purposes of reporting and recording, and confirmation of compliance for discharge.
LRW discharge	Continuous	RMS	Gross activity	Detection of elevated radioactivity within LRW discharge line, automatic termination of discharge on exceeding predetermined setpoint
WWS discharge	Continuous	RMS	Gross activity	Detection of radioactivity within WWS, automatic termination of discharge, (or automatic rerouting of discharges to the LRW) on exceeding predetermined setpoint

In the conceptual design for the generic SMR-300, effluent is processed and discharged through the LRW in batches. Determination of activity in discharges LRW effluent monitoring tanks is done by manual tank sampling of the LRW monitoring tanks prior to discharge. Treated radioactive effluent from the LRW is sampled with each effluent monitoring tank employs recirculation mixing to enable representative sampling. In line with best practice, appropriate valve interlocks will be defined to prevent inadvertent discharges of tank contents whilst sampling is taking place, and to prevent discharge occurring as the tank is being filled.

Analysis of the sample will take place in the on site-lab to determine activity for the significant radionuclides listed in Table 15 and PER Chapter 2 [8]. On determination that the batch is suitable for discharge, the tank is discharged to the outfall and subsequently to the environment. Positive operator action is required to initiate batch discharges from LRW monitoring tanks to the outfall [47].

Continuous radiation monitoring is provided on the discharge path from the LRW to the outfall [51]. This is situated downstream of LRW monitoring tanks (and LRW treatment) and upstream of the outfall, prior to mixing with effluents from the non-radioactive WWS occurs and is therefore compliant with Environment Agency guidance [29]. Detection of high radioactivity in the discharge stream automatically isolates flow, and operator action is required to re-establish discharge.

In the event of termination of a discharge, the tank contents will be recirculated to the LRW holdup tank for reprocessing [47]. In the generic SMR-300, the processed effluent from the LRW once monitored, sampled and sentenced to discharge will be mixed with effluent from non-radioactive sources at the outfall.

It is recognised that this arrangement for determining discharge activity falls short of EA guidance and expectations for independent sampling, and doesn't employ an MCERTS method for sampling. As such a commitment (***Commitment C_Moni_099*** is to be drafted to address this, see sub-chapter 5.7.4.5.

The non-radioactive WWS collects waste water from the condenser overflow area sump and condenser overboard pump [44]. The WWS discharge radiation monitor initiates transfer of discharges to the LRW upon detection of radioactive contamination at the sump pump discharge piping [61]. In addition, the channel continuously monitors all Waste Water liquid releases from the plant and automatically isolates the effluent path to prevent further release after a high radiation level is indicated and alarmed. The WWS is out of scope of GDA and current design information is limited.

5.7.2.1 Flow Monitoring

It is best practice to provide continuous flow monitoring of liquid radioactive discharges [53], [54], [55]. This facilitates quantification of key radionuclides released to the environment. Sourcing of MCERTS approved equipment is a regulatory requirement and a requirement according to RSR permit conditions [29]. The MCERTS standard requires that liquid flowmeters can be calibrated to suitable standards to enable continuous monitoring of releases to the environment [62].

The generic SMR-300 design specifies the use of flow rate monitoring on the liquid discharge before the liquid effluent stream is mixed with other non-active waste streams at the point of discharge [47]. Flow is continuously monitored on the LRW discharge line as a tank is being discharged. Provisions are made in the generic SMR-300 design to ensure continuous and constant flow is maintained to online monitors, reducing overall maintenance and startup operations required [51].

Specific determination of sampling and monitoring locations to enable representative sampling are subject to flow modelling during the detailed design stage. Future evidence (see M&S_12, Table 19) has been defined to determine the exact location of this equipment to ensure representative sampling, and to confirm that the equipment can meet MCERTS.

5.7.3 Liquid Sample Analysis Methods

The liquid sampling techniques set out in 5.7.1 and 5.7.2 result in a sample of liquid effluent which can be analysed in the on-site laboratory. Laboratory methods such as scintillation detection can then be employed on the sample to measure the radioactivity of samples.

Table 16 provides an overview of analytical techniques consistent with other GDA's and extant PWR's in the UK, to be able to achieve the limits of detection requirements set out in EU/2004/Euratom.

Table 16: Typical Analytical Methods for Liquid Radioactivity

Significant Radionuclides (Aqueous)	Analytical Method
Tritium	Liquid scintillation detection
Carbon-14	
Caesium-137	High Resolution Gamma Spectroscopy (HRGS)
Other radionuclides	

Additionally, sampling of spent filter media can determine the presence of alpha emitters, and other radionuclides that may be of interest for individual analysis can be quantified via the methods listed above (such as Co-60 (HRGS) or Sr-90 (Liquid scintillation)). Laboratory techniques are not foreclosed at GDA and will be specified in detail at the site-specific stage to ensure they can achieve the detection limits set out in EU 2004/2/Euratom.

As set out in sub-chapter 5.6.3, full specification of the on-site laboratory will take place as the project develops, and is covered by an identified future evidence.

5.7.4 Demonstration of BAT

5.7.4.1 Representative Sampling and Monitoring for Liquids

The international standard ISO 5667:2023 provides cross-industry guidance on the design of sampling programmes and sampling techniques for all aspects of sampling of water (including waste waters, sludges, effluents, suspended solids and sediments). This standard informs the design of UK plants and is extensively referenced in Environment Agency guidance [29].

For process stream samples, sample points for the generic SMR-300 are located in turbulent flow zones to ensure that representative samples are collected. Sample flow rate capabilities are to be selected based on sample point location, line size, and fluid temperature to assure that sample flow is turbulent. A constant flow rate is maintained for continuous samples to prevent sample line deposits [51].

Samples taken on an intermittent time basis are circulated for a predetermined volume to provide a valid sample at the PSL central panel. For tank sampling, tank contents circulated for a predetermined volume to provide a valid sample at the central panel. Liquid tank contents are recirculated to ensure the system is well mixed prior to sampling. Sampling is performed following recirculation of tank contents. Sample containers, such as sample pressure vessels, are cleaned and flushed to ensure a representative sample is obtained [51].

When sampling for a mixed phase sample (gas-liquid, liquid-solid), iso-kinetic flow may be required in order to obtain a representative sample. Locations such as RCS hot leg and Chemical and Volume Control system (CVC) demineralizer inlet where primary side corrosion products will be sampled require particulates be in motion at the same velocity as the fluid media. Use of iso-kinetic nozzles ensure velocity of all components of the sample stream are the same. Sample nozzles are provided for iso-kinetic sampling where required [51].

Before PSL samples are drawn, sample lines are purged by opening the appropriate recirculation/purge line isolation valve for sufficient volume to ensure that a representative sample may be obtained from the process line or vessel. To reduce overall activity levels and volume of radwaste, sample purge is returned to their point of origin, as practical.

For sampling of the LRW effluent prior to discharge, the processed waste is collected in a LRW monitoring tank. If a high level in the tank is reached, the system automatically realigns to direct the processed water to a standby. When processing is complete and the tank is ready for discharge, the tank contents are recirculated to ensure the contents are sufficiently well mixed, and sampled for analysis in the on-site laboratory. Based on analytical results, the contents of the tank can be released to the environment or sent to the holdup tanks for reprocessing.

In the generic SMR-300, recirculation mixing is adopted on LRW effluent tanks to enable representative conditions for sampling [47]. Some OPEX plants adopt jet eductor mixers on effluent monitoring tanks to enable non-powered tank mixing [53]. This optimises mixing efficiency without the need to replace moving parts, ensuring the representativity of samples [30]. Other techniques such as air sparging may also be employed depending on detailed design requirements. It will be confirmed during detail design via a future evidence (M&S_13 in Table 19) whether any additional measures are required aid mixing and ensure a representative sample.

Additional future evidence has been outlined (M&S_14 in Table 19) to ensure that liquid sampling points are consistent with design requirements set out in ISO 5667:2023 as these requirements are closely linked to detailed design.

5.7.4.2 Sample Return Requirements

In the generic SMR-300, provisions are in place to ensure that samples and purges are returned to their system of origin, as practicable, to reduce generation of additional radioactive waste [51]. Most PSL sample lines of primary effluent are re-routed to the VCT in the CVC letdown stream in order to be returned to their point of origin once processed in the PSL [63]. This provides the benefit of recycling effluents where possible and minimising radioactive waste generation. As sampling isn't continuous, rerouting samples to the VCT should have no impact on sample representativeness.

An exception to this for reactor-grade water is samples from the accumulators which go via the active drains to the LRW, given the higher boron concentration in the accumulators (and therefore activity delta) compared to the primary circuit.

All other liquid samples are purged directly to the RDS or to the sample sink for disposition via the RDS to the or to the sample sink for disposition via the RDS to the LRW system [51].

5.7.4.3 Safe and Suitable Access

EA guidance [29] (and ISO 5667-1: 2023) recommend the following

- Location to provide easy and safe access.
- Adequate workspace for safe and comfortable operation.
- Protect sampling personnel in the working area from heat, dust, radiation, radioactive contamination, asphyxiation, chemical vapours or conventional issues (e.g. working at height, trips slips or falls) that might pose a hazard.
- The measuring and sample extraction equipment shall be installed and located such that testing, maintenance and repair can easily be performed

For the PSL [51], samples are transported to the appropriate sample panels or local sample points for collection using stainless-steel tubing. All sample lines are equipped with an isolation valve located immediately downstream of the sample point. Lines that are normally inaccessible within containment are equipped with remote SOVs to isolate and route sample fluids.

Before collection samples are conditioned for area habitability, operator safety and instrument compatibility. To keep radioactive exposure ALARA, a delay coil is provided on the RCS Hot Leg sample lines within the CS boundary to allow for the decay of short-lived radioisotopes. The coil provides sufficient tube length to delay reactor coolant to allow for the decay of very short-lived isotopes prior to leaving the CS boundary.

Pressure and temperature-reducing equipment is provided within the primary sample panel to condition samples, as necessary. Local temperature and pressure indicators are provided within the sampling room as well as on the sampling panel lines which enable the operator to determine sample conditions and evaluate equipment performance.

Samples are reduced to pressures compatible with online instrumentation and atmospheric pressure for grab sampling. A sample heat exchanger is provided to reduce fluid temperatures to sufficient levels for handling

Provisions are made to permit periodic inspection, maintenance and calibration of sampling and monitoring equipment in the generic SMR-300 design. Sufficient space will be provided for personnel, inspection equipment, removal space, and temporary storage, handling machinery, and repairs or replacement [51]. It is recognised that provisions for calibration, maintenance and sufficient access to equipment should be considered and implemented in the design. Where available, automatic sampling methods such as flow or time-proportional sampling are employed to automatically retrieve samples. This requirement is discussed further in Sub-chapter 5.7.4.5. Independent sampling equipment is made secure using tamper-free seals or similar methods and must provide safe access to third parties as well as operators [28].

5.7.4.4 Detecting Abnormal Discharges for Liquids

Alarms are intended to provide early warning of failure and abnormal conditions in the process, instructing further operator actions (e.g. maintenance, inspection or otherwise), as required, to minimise the impact of system failures on discharges.

Environment Agency guidance [29] specifies that equipment failures and process alarms shall be acoustically enunciated and visually displayed in the control room. Alarms on monitors and samplers should be provided for high and low sample flow and high and low activity thresholds [29]. Alarms are to be active for the duration of the deviation conditions.

To reduce risk of instrumentation failure, IEC 60861:2006 [27] provides guidance for radionuclide monitoring equipment in liquid effluents and describes features to enable self-diagnostic capability. Alarm functionality on discharges is intended to provide the operator with sufficient information to identify faults and further actions as necessary to minimise the risk of radioactive releases.

Alarm functionality for aqueous and gaseous online monitoring in the generic SMR-300 shall adhere as far as is practicable to BS EN 60861 to facilitate fault identification capability and inform further action by operators to minimise risk of radioactive releases (see M&S_15, Table 19: Future Evidence).

One of the identified functions of the RMS system is to indicate and archive process radiation levels and initiate alarms for process paths when system-specific thresholds are reached. Where required, provide signals to perform isolation or actuation functions to protect control room environmental conditions, isolate contamination sources, or protect process sample locations [58]. The following alarms for radioactive liquids on the generic SMR-300 have been identified:

- An alarm alerts the operator when waste holdup tanks at the start of the LRW are ready for processing.
- An alarm setpoint is instated for radiation monitoring on the LRW discharge, to alert the operator of high radiation and automatic isolation of the discharge.
- Alarms will be provided to alert operators of the need for manual overrides on specific equipment and systems requiring manual intervention or initiation.

- Online RMS monitoring on the SGB, CCW, SWS and RDS systems have associated alarms to alert the operator to activity detection above a predetermined setpoint on non-active systems. The alarm on the SGB system automatically isolates the system to provide any further ingress of activity.

In some UK OPEX designs, a manual valve is installed on the discharge to enable isolation in case of failure of the automatic isolation system [53]. This provides an alternative means for operators to prevent releases to the environment if other systems fail and is considered good practice for consideration for the generic SMR-300 at detailed design (see M&S_16, Table 19: Future Evidence).

5.7.4.5 Independent Sampling and Monitoring Arrangements for Liquids

The provision of secure and safe independent sampling for final discharges of aqueous effluents is a UK regulatory requirement [29]. UK OPEX, including those discussed in Sub-chapter 5.6.4.5, are applicable to both liquids and gases for independent sampling. This includes ensuring secure and safe access to obtain independent samples, providing means to calibrate equipment, employing automatic sampling methods and duplicating operator sampling, monitoring facilities and conditions.

Appropriate provisions (according to regulatory guidance and good practice above [28]) within previous UK GDAs, such as HPR1000 [59], [60] and UK ABWR [64] have been considered to allow for independent regulatory verification of liquid effluent monitoring and discharge reporting. For liquid discharges, use of automatic sampling methods on the discharge line such as flow proportional sampling, combined with a radiation monitor and isolatable discharge path is recognised as standard UK practice [54], [53].

Methods for achieving independent sampling are not currently detailed or illustrated in system requirements. The application of automatic sampling methods such as flow proportional sampling is not specified. Given the importance of flow proportional sampling as UK best practice, a Design Challenge has been raised [65] via the RP's design challenge process [66] and endorsed via the design acceptance committee. As a result an associated GDA Commitment (C_Moni_099) has been identified to ensure this design challenge is progressed and incorporated into the design:

Commitment C_Moni_099: Design Challenge Paper 'Provision of Sampling & Monitoring Arrangements for the generic SMR-300' (HI-2250824) associated with PER Claim 4 Argument 4.7-A2: 'Final Discharge Monitoring and Sampling' is with the Design Authority for Design Decision.

This Design Challenge relates to the requirement that any UK version of the generic SMR-300 design will meet UK Best Practice and EA requirements to ensure sufficient provisions for Independent Sampling and represent BAT. Specifically, the implementation of a flow-proportional sampler into the UK SMR-300 design to meet the requirements for independent sampling and ensure the final discharge monitoring & sampling arrangements will be compliant with MCERTS requirements.

A Commitment is raised to progress this Design Challenge through the Design Management process (HPP-3295-0017-R1.0) to completion.

Design options for independent sampling and monitoring are not foreclosed within the GDA process and are subject to further assessment with consideration of BAT at the site-specific stage. Automatic samplers and flow monitoring equipment on liquid discharges must be certified as complying with the requirements of the MCERTS standard, subject to availability [67].

5.8 SOLID AND NON-AQUEOUS LIQUID WASTE SAMPLING AND MONITORING

The baseline management strategies for solid and non-liquid radioactive wastes in the generic SMR-300 are illustrated in a simplified flow diagram in the Integrated Waste Strategy (IWS) [52]. The IWS explains how radioactivity and volume of waste streams arising from the Solid Radioactive waste System (SRW) will be minimised through characterisation, segregation and further processing before disposal, ensuring BAT is applied.

5.8.1 Demonstration of BAT

The design of the SRW in the generic SMR-300 is presented in PSR Part B Chapter 13 Radioactive Waste Management [46] and HI-2240582, System Design Description for Solid Radioactive Waste System [48]. The SRW SDD [48] details the sampling and monitoring arrangements for principal solid waste streams in the generic SMR-300. These are summarised in Table 17. Detailed breakdown of solid radioactive waste streams is provided within the IWS [52].

Table 17: Solid and Non-aqueous Liquid Waste Sampling and Monitoring Parameters

Waste Type	Waste Description	Sampling and Monitoring Arrangements
Non-fuel waste (NFW)	NFW consists of redundant activated components associated with the fuel assemblies and other in-core components.	Rod Cluster Control Assemblies (RCCAs), also called control rod assemblies, are managed separately onsite alongside the spent fuel. Other NFW that has the potential to be boundary HLW/ILW at the time of removal from the core is surveyed for packaging in non-fuel waste canister (NWFC) and dry stored alongside spent fuel. Due to the difficulty and safety considerations in taking samples of spent fuel and NFW after removal from the reactor, modelling methods are likely to be used to predict activity levels.
Wet Solid Waste	Wet wastes typically include spent ion exchange resin (bead or powdered), filter bed media, filter cartridges, and sludges from the bottom of tanks and sumps.	Parameters sampled and monitored including pressure, flow, level and radiation are monitored during the resin transfers and dewatering operations.
Dry Solid Waste	Dry waste consists of any solid, dry material that becomes contaminated with radioactive material and is discarded as waste during operation of equipment, such as Heating Ventilation and Air Conditioning (HVAC) filters, Personal Protective Equipment (PPE), paper, cloth, wood, plastic, rubber, glass, and metal waste.	Filter cartridges are analysed before being dewatered and solidified. Contaminated dry solid wastes are monitored for contact dose rates for further processing and subsequent offsite shipment.
Miscellaneous Waste	Miscellaneous waste includes liquid or solid contaminated wastes that are not considered wet or dry solid wastes, including chemical wastes, oily wastes, or mixed wastes (i.e. a waste that is both radioactive and hazardous).	Miscellaneous wastes, including contaminated oily or mixed wastes, are directly packaged and stored for offsite shipment.

Principally, solid & non-aqueous liquid waste generated by the generic SMR-300 is to be monitored throughout the management process dependent on waste stream:

- **At point of generation –** Radioactive properties of the waste are identified to ensure appropriate segregation and treatment. Filter cartridges are analysed before being dewatered and solidified. Samples of ion exchange resins, sludges/oils are sampled as close to the point of generation as is practicable.
- **Before waste processing –** Prior to packaging waste is characterised in order ensure it complies with waste stream criteria and will meet relevant waste acceptance criteria for disposal off-site.
- **During storage –** Once waste has been packaged it is stored on-site until being transferred off-site for further treatment or disposal. Depending on the length of the storage (which varies for LLW compared to ILW/Spent fuel) the storage period will vary. Waste in storage will be monitored to confirm the radiological inventory prior to transfer, to maintain an adequate inventory of all wastes on site and to ensure integrity of waste packages in storage.
- **Before off-site transfer -** Once the off-site treatment or disposal facility is available, the waste package will undergo monitoring to confirm adherence to waste acceptance criteria and integrity of the package. Measurements taken at this stage are incorporated into records submitted to the waste facility receiving the transfer.

In accordance with RSR regulations (see Sub-chapter 5.3.2), and ONR guidance [31] the generic SMR-300 must minimise, characterise and segregate different types of solid waste before treatment and disposal. The application of BAT is required to minimise the activity and quantity of waste arisings. To contribute to the effective application of the waste hierarchy, and therefore waste management, waste characterisation information is required through sampling and monitoring.

A strategy for waste characterisation, covering the stages from raw waste generation through to disposal, should be developed by the waste producer at the site-specific stage. The characterisation programme should be supported, where practicable, by a suitable waste sampling plan that is designed to provide a statistically robust data set. Where comprehensive sampling and characterisation is not practicable, for example due to dose considerations, this should be explained, and arguments should be presented as to why an alternative approach is considered appropriate. In the UK context, the waste characterisation strategy encompasses the following possible measurements [31].

- **Radioactivity** – The radioactivity content of the waste should be known with sufficient accuracy and precision to meet key radionuclide limits and Waste Acceptance Criteria (WAC). This includes those specified by facilities to which the waste will be directed, in so far as these are known.
- **Dose rate** – Package external dose rates should be known so that compliance with the limits for facilities and equipment in which they will be handled, stored and transported can be demonstrated. Where shielding has been identified as a means of restricting dose, it should be effective under all operating conditions.
- **Surface contamination** – For conditioned wastes, the amount and extent of any non-fixed surface contamination should be known. Suitable and sufficient decontamination provisions should be provided to meet the relevant safety case requirements. Transferable radioactive contamination on the exterior of the waste packages should be maintained within limits established for the storage, transportation, and packaging facilities where these wastes are to be handled.

- **Fissile content** – For wastes containing fissile matter, the nature and quantity of the fissile materials, and any other waste components that may influence the neutron reactivity of the system (e.g. neutron moderating or absorbing material), should be known in sufficient detail to enable assessment of the criticality hazard and to facilitate safe management, safeguards and disposal arrangements.
- **Physical and chemical composition** – The bulk composition and chemical properties of the waste should be understood to the extent that any chemical hazards or challenges posed by the waste can be assessed.

In accordance with UK OPEX, it is expected that the following waste monitoring conditions will apply, however this doesn't foreclose other options as appropriate to meet the principles of BAT [53]:

- Surface dose measurements and gamma spectrum measurements apply to heterogeneous wastes (spent filter cartridges (from HVAC and liquid systems) and dry active wastes).
- Grab sampling applies for homogeneous solid and non-liquid wastes (spent resins, concentrates, sludges, oils and organic solvents).

A Design Challenge, HI-2241553, Design Challenge - ILW and LLW Facilities [68] for ILW and LLW management facilities has been raised via a Design Challenge Paper to highlight gaps between US and UK disposal routes for ILW and LLW. Due to the maturity of generic SMR-300 design and the identified design challenge relevant to solid radioactive waste management proposed, radioactive waste management design will be subject to further development at the site-specific stage and as such, options for the design of ILW and LLW management facilities are subject to further assessment; this is discussed in further detail in PER Chapter 1 RWMA [7]. The outcomes of the design challenge will have a direct impact on the solid waste sampling and monitoring design in the generic SMR-300.

Given the current state of design maturity, specific of the monitoring arrangements for solid and non-aqueous liquid wastes are yet to be specified in detail. A future evidence (M&S_17 in Table 19) has been captured to ensure that all relevant aspects are considered at the detailed design stage.

5.9 PLANT CONDITION MONITORING

In addition to in-process monitoring of radioactivity associated with liquid and gaseous effluents, the generic SMR-300 includes provisions for monitoring of various other plant parameters that have a direct or indirect impact on the generation/treatment of radioactive waste. This type of monitoring is referred to collectively as ‘plant condition monitoring’ and plays a key role in providing information to operators to enable them to ensure that BAT continues to be applied and demonstrated.

These features optimise plant performance, availability and maintenance without directly sampling or monitoring radioactive products.

- Control of reactor coolant chemistry (including pH, boron and lithium concentration) minimises the formation of waste products at source and ensures gaseous wastes from the primary circuit are effectively managed and treated via the GRW as discussed in PSR Part B Chapter 23 Reactor Chemistry [15].
- HEPA filters in the CBV are pressure monitored up-stream and down-stream, to determine maintenance requirements and filter changes for optimum performance.
- Oxygen and hydrogen levels are sampled and monitored in the CVC to detect leaks and prevent flammable conditions, initiating isolation of the GRW and activating the nitrogen purge system as required. Hydrogen is also sampled in the GRW decay tanks.

An exhaustive list of plant condition monitoring which serves a role in the demonstration of BAT will be developed during detailed design (see M&S_18, Table 19: Future Evidence).

5.10 SUSTAINABILITY

A sustainability strategy for the generic SMR-300 [69] has been produced to substantiate the contribution of the generic SMR-300 design towards sustainable development. In line with this strategy, the approach to sampling and monitoring contributes to sustainability through implementation of the following design concepts.

- In-process sampling and monitoring facilitates effluent recycling and minimisation of unnecessary waste streams at source and subsequently informs effective radioactive waste management. Equipment performance monitoring enables maintenance and calibration of instruments and equipment, thereby prolonging the lifetime of plant equipment, reducing end-of-life waste.
- Discharge sampling and monitoring minimises and quantifies the release of radioactive effluents to the environment, thereby protecting the environment and public and contributing to sustainability principles.
- Implementation of BAT principles throughout the design process enables relevant OPEX to be considered in the design of sampling and monitoring systems. This in turn minimises radiological risk to members of the public and the environment.

5.11 GDA COMMITMENTS & FUTURE EVIDENCE

Beyond GDA timescale, the sampling and monitoring practices for the generic SMR-300 will continue to develop in line with the evolving maturity of the design, as well as the requirements of environment permits and consents.

Commitments for future stages of regulatory engagement are captured and recorded in the Commitments, Assumptions, Requirements (CAR) Register [4].

Table 18: GDA Commitments

Sub-chapter	Reference	Description of Commitment	Target for Resolution
5.6.2	C_Moni_119	Further information on the SMR-300 arrangements for the recording & reporting of gaseous discharges is required to ensure that they represent BAT. A Commitment is raised to undertake a BAT assessment to confirm that suitable arrangements are in place to quantify discharges of all significant radionuclides/groupings and demonstrate compliance with proposed permit limits. The BAT assessment will also describe the facilities within the generic SMR-300 provided for independent periodic sampling of final discharges of gaseous wastes.	Issue of UK Pre-Construction SSEC
5.7.4.5	C_Moni_099	Design Challenge Paper 'Provision of Sampling & Monitoring Arrangements for the generic SMR-300' (HI-2250824) associated with PER Claim 4 Argument 4.7-A2: 'Final Discharge Monitoring and Sampling' is with the Design Authority for Design Decision. This Design Challenge relates to the requirement that any UK version of the generic SMR-300 design will meet UK Best Practice and EA requirements to ensure sufficient provisions for Independent Sampling and represent BAT. Specifically, the implementation of a flow-proportional sampler into the UK SMR-300 design to meet the requirements for independent sampling and ensure the final discharge monitoring & sampling arrangements will be compliant with MCERTS requirements. A Commitment is raised to progress this Design Challenge through the Design Management process (HPP-3295-0017-R1.0) to completion.	Issue of Pre-Construction SSEC.

Further work to be undertaken as part of 'normal business' where no GDA commitment is required, is incorporated into an indicative list of future work to be undertaken as 'Future Evidence' provided in Table 19 below.

Table 19: Future Evidence

[REDACTED]

5.12 SUMMARY

This chapter has presented the approach to sampling and monitoring of gaseous, liquid and solid radioactive waste in the generic SMR-300 design with due consideration of the appropriate RSR principles, GDA guidance and scope, applicable codes and standards, relevant good practice and OPEX to meet regulatory expectations and requirements commensurate with the GDA scope.

Monitoring and sampling locations for key gaseous and liquid radioactive waste streams, including the LRW, GRW, CBV and RCV HVAC systems, are in line with industry expectations. The parameters and location of the gaseous discharge sampling and monitoring point (i.e. the plant vent) are subject to further assessment in line with BAT principles through to detailed design.

Carbon-14 and tritium have been identified as significant radionuclides requiring quantification for both liquid and gaseous discharges to environment. Sampling techniques at discharge points are to be determined as the design develops and must enable representative sampling. UK specific requirements such as compliance of discharge monitoring equipment with the MCERTS scheme have been identified and designated to later design stages.

Independent sampling facilities have been identified as a UK specific requirement for both gaseous and liquid discharges. This includes the application of continuous sampling techniques such as flow-proportional sampling; this has been captured as a Commitment (C_Moni_099).

The strategy for the characterisation of solid waste is subject to further development through design. This should consider the UK-specific requirements and OPEX summarised in this chapter, including implementation from waste generation through disposal and adherence to regulatory guidance on sampling and monitoring characterisation methods.

5.13 REFERENCES

[1] Holtec Britain, "HI-2230643, SMR-300 Plant Breakdown Structure, Acronyms, and Glossary of Terms," Revision 0, 2024.

[2] Environment Agency, "New nuclear power plants: Generic Design Assessment guidance for Requesting Parties," October 2023. [Online]. Available: https://www.gov.uk/government/publications/new-nuclear-power-plants-generic-design-assessment-guidance-for-requesting-parties/new-nuclear-power-plants-generic-design-assessment-guidance-for-requesting-parties#step-2-fundamental-assessment-1.

[3] Environment Agency, "RSR generic developed principles: regulatory assessment," 1 December 2021. [Online]. Available: https://www.gov.uk/government/publications/rsr-generic-developed-principles-regulatory-assessment.

[4] Holtec Britain, "HPP-3295-0013, Holtec SMR-300 Generic Design Assessment Capturing and Managing Commitments, Assumptions and requirements," Revision 0, January 2025.

[5] Holtec Britain, HI-2240121, SMR-300 UK Generic Design Assessment GDA Scope, Revision 0, 2024.

[6] Holtec Britain, HI-2240363, Holtec SMR GDA PER Chapter 4 Conventional Impact Assessment, Revision 1, 2025.

[7] Holtec Britain, HI-2240360, Holtec SMR GDA PER Chapter 1 Radioactive Waste Management Arrangements, Revision 1, 2025.

[8] Holtec Britain, "HI-2240361, Holtec SMR GDA PER Chapter 2 Quantification of Effluent Discharges and Limits," Revision 1, 2025.

[9] Holtec Britain, "HI-2241253, Holtec SMR-300 GDA PER Chapter 6 Demonstration of Best Available Techniques," Revision 0, 2025.

[10] Holtec Britain, "HI-2240332, Holtec SMR GDA PSR Part A Chapter 1 Introduction," Revision 1, 2025.

[11] Holtec Britain, "HI-2240333, Holtec SMR GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics," Revision 1, 2025.

[12] Holtec Britain, "HI-2240777, Holtec SMR GDA PSR Part B Chapter 5 Reactor Supporting Facilities," Revision 1, 2025.

[13] Holtec Britain, "HI-2240341, Holtec SMR GDA PSR Part Chapter 10 Radiological Protection," Revision 0, August 2024.

[14] Holtec Britain, "HI-2240342, Holtec SMR GDA PSR Part B Chapter 11 Environmental Protection," Revision 1, 2025.

[15] Holtec Britain, "HI-2240352, Holtec SMR GDA PSR Part B Chapter 23 Reactor Chemistry," Revision 1, 2025.

[16] European Union, "2004/2/Euratom," 06 01 2004. [Online]. Available: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:002:0036:0046:EN:PDF.

[17] Holtec Britain, "Holtec SMR-300 GDA Environmental Protection Functions Report," Revision 0, May 2025.

[18] Environment Agency, "RSR permits for nuclear licensed sites: how to comply," February 2020. [Online]. Available: https://www.gov.uk/government/publications/rsr-permits-for-nuclear-licensed-sites-how-to-comply/rsr-permits-for-nuclear-licensed-sites-how-to-comply.

[19] Holtec Britain, "HI-2240335, Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance," Revision 1, 2025.

[20] Environment Agency, Developing guidance for setting limits on radioactive discharges to the environment from nuclear licensed sites, 2005.

[21] International Standards Organisation, "ISO 10780:1994 Stationary source emissions - Measurement of velocity and volume flowrate of gas streams in ducts," Edition 1, 1994.

[22] International Standards Organisation, ISO 2889:2023 Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities, Edition 4, 2023.

[23] British Standards Institution, BS EN 60761-1:2004 Equipment for continuous monitoring radioactivity in gaseous effluents. General requirements., 2004.

[24] British Standards Institution, BS EN 60761-3:2004 Equipment for continuous monitoring of radioactivity in gaseous. Specific requirements for radioactive noble gas monitors., 2004.

[25] International Standards Organisation, "ISO 5667-1:2023 Water quality-Sampling-Part 1: Guidance on the design of sampling programmes and sampling techniques," March 1, 2023.

[26] International Standards Organisation, "ISO 5667-3:2024, Water quality - Sampling - Part 3: Preservation and handling of water samples," April 10, 2024.

[27] I. E. Commission, “IEC 60861:2006 Equipment for monitoring of radionuclides in liquid effluents and surface waters”.

[28] Environment Agency, “LIT 14887, Monitoring of radioactive discharges to atmosphere from nuclear facilities,” 24 June 2024.

[29] Environment Agency, “LIT 55216, Monitoring of radioactive discharges to water from nuclear facilities,” 24 June 2024.

[30] Electric Power Research Institute, “Advanced Nuclear Technology: Advanced Light Water Reactor Utility Requirements Document,” Revision 13, 2014.

[31] Office for Nuclear Regulation, Environment Agency, Natural Resources Wales, Scottish Environmental Protection Agency, “The management of higher activity radioactive waste on nuclear licensed sites,” July 2021. [Online]. Available: https://www.onr.org.uk/media/by2nkmad/waste-management-joint-guidance.pdf.

[32] Environment Agency, “Monitoring emissions to air, land and water (MCERTS),” October 2024. [Online]. Available: https://www.gov.uk/government/collections/monitoring-emissions-to-air-land-and-water-mcerts.

[33] Environment Agency, “MCERTS: performance standards and test procedures for continuous water monitoring equipment - part 1 automatic sampling equipment,” May 2017. [Online]. Available: https://www.gov.uk/government/publications/mcerts-performance-standards-and-test-procedures-for-continuous-water-monitoring-equipment-part-1.

[34] Environment Agency, “MCERTS: performance standards and test procedures for continuous water monitoring equipment - part 2 on-line monitors,” April 2024. [Online]. Available: https://www.gov.uk/government/publications/mcerts-performance-standards-and-test-procedures-for-continuous-water-monitoring-equipment-part-2.

[35] Environment Agency, “MCERTS: performance standards and test procedures for continuous water monitoring equipment - part 3 water flowmeters,” March 2020. [Online]. Available: https://www.gov.uk/government/publications/mcerts-performance-standards-and-test-procedures-for-continuous-water-monitoring-equipment-part-3.

[36] Environment Agency, “MCERTS: radioanalytical testing of environmental and waste waters,” May 2024. [Online]. Available: https://www.gov.uk/government/publications/mcerts-radioanalytical-testing-of-environmental-and-waste-waters.

[37] UK Government, “Minimum requirements for self-monitoring of flow: MCERTS performance standard",,” February 2022. [Online]. Available: https://www.gov.uk/government/publications/minimum-requirements-for-self-monitoring-of-flow-mcerts-performance-standard.

[38] Environment Agency, “Monitoring stack emissions: standards for continuous monitoring and sampling,” March 2024. [Online]. Available: https://www.gov.uk/guidance/monitoring-stack-emissions-standards-for-continuous-monitoring-and-sampling.

[39] Holtec Britain, HI-2240362 - Holtec SMR GDA PER Chapter 3 Radiological Impact Assessment, Revision 1, 2025.

[40] Holtec Britain, “HI-2240648, GDA Design Reference Point,” Revision 2, 2025.

[41] Holtec Britain, “HI-2241190, UK Context - Gap Analysis of SMR-300 Primary Sampling and Monitoring Arrangements, Rev 0,” October 2024.

[42] Holtec Britain, “HI-2241595-R0.0, PSL - Preliminary Chemistry Engineering Justification,” Revision 0, February 2025.

[43] Holtec International, “DWG-15217, Primary Sampling System Piping & Instrumentation Diagram, Revision 2.0,” 2025.

[44] Holtec Britain, HI-2240619 SMR-300 Radiation Monitoring System Detector Specification (DRAFT), Revision 0, 2025.

[45] Holtec International, “HI-2240581, System Design Description for Gaseous Radwaste System,” Revision 0, January 2025.

[46] Holtec Britain, “HI-2240344, Holtec SMR GDA PSR Part B Chapter 13 Radioactive Waste Management,” Revision 1, 2025.

[47] Holtec Britain, “HI-2240497-R0, System Design Description for Liquid Radwaste System,” 2024.

[48] Holtec Britain, “HI-2240582, System Design Description for Solid Radwaste System,” Revision 0, August 2024.

[49] Environment Agency, “Radioactive substances management: generic developed principles,” 2024. [Online]. Available: https://www.gov.uk/government/publications/rsr-generic-developed-principles-regulatory-assessment/radioactive-substances-management-generic-developed-principles.

[50] Holtec Britain, “HI-2241435, Methodology for Calculating Liquid and Gaseous Discharges to Determine Monthly and Annual Limits,” Revision 0, 2025.

[51] Holtec Britain, “HI-2240168-R0.0 System Design Description for Primary Sampling System,” 2024.

[52] Holtec Britain, “HI-2241151, Integrated Waste Strategy,” Revision 0, January 2025.

[53] CGN, EDF, General Nuclear System, “Pre-Construction Environmental Report - Chapter 5 Approach to Sampling and Monitoring,” 2021. [Online]. Available: https://ukhpr1000.co.uk/wp-content/uploads/2022/02/Pre-Construction-Environmental-Report-Chapter-5-Approach-to-Sampling-Monitoring.pdf.

[54] Rolls Royce SMR Ltd, “Environment, Safety, Security and Safeguards Case Version 2 Tier 1, Chapter 28: Sampling and Monitoring Arrangements,” 2024. [Online]. Available: https://gda.rolls-royce-smr.com/assets/documents/documents/rr-smr-e3s-case-chapter-31---conventional-environmental-impact-v2-public-issue-clean.pdf.

[55] EDF Energy Ltd, “Sizewell C Project RSR Permit Application Support Document C1 - Plant Monitoring Revision 1”.

[56] Environment Agency, “Performance Standards and Test Procedures for Automatic Isokinetic Samplers, Version 3,” 2016.

[57] Environment Agency, “Monitoring stack emissions: measurement locations,” 2022.

[58] Holtec International, HI-2240619 SMR-300 Radiation Monitoring System Detector Specification, Revision 0, 2025.

[59] General Nuclear System Ltd, “HPR/GDA/PCER/0005, UK HPR1000 GDA Project, Pre-Construction Environmental Report Chapter 5 Approach to Sampling & Monitoring,” Revision 001-1, October 2020.

[60] Environment Agency, “Generic design assessment of new nuclear power plants, Sampling and monitoring for the UK HPR1000 design - AR06,” January 2022.

[61] Holtec International, “HI-2230740, Control System Description - Waste water drainage & Transfer,” 2024.

[62] Environment Agency, “Competency Standard for MCERTS Inspectors & Assistant Inspectors – Flow Monitoring,” 2018.

[63] Holtec International, “DWG-15217, Primary Sampling System Piping & Instrumentation Diagram,” Revision 1, 2024.

[64] Hitachi-GE Nuclear Energy, Ltd., “3E-GD-K002 UK ABWR Generic Design Assessment, Approach to Sampling and Monitoring,” Revision H, 2017.

[65] Holtec Britain, “HI-2250824, UK GDA [DC32] Design Challenge - Environmental Monitoring and Sampling,” Revision 0, 2025.

[66] Holtec Britain, "HPP-3295-0017, Design Management, Revision 1," Revision 1, December 2024.

[67] Environment Agency, "MCERTS Performance Standards and Test Procedures for Continuous Water Monitoring Equipment. Version 4. Part 1 - Performance standards and test procedures for automatic wastewater sampling equipment," 2017.

[68] Holtec Britain, "HI-2241553, Holtec SMR-300 GDA Design Challenge – ILW and LLW Facilities," Revision 0, January 2025.

[69] Holtec Britain, "HI-2250028, SMR-300 GDA Sustainability Strategy," Revision 0, 2025.