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UK ABWR Generic Design Assessment

Approach to Sampling and Monitoring

Hitachi-GE Nuclear Energy, Ltd.

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1. Acronyms

ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BS	British Standard
C&I	Control and Instrumentation
D/W	Drywell
EPR	Environmental Permitting Regulations
EP-RSR	Environmental Permit - Radioactive Substances Regulation
EU	European Union
GEP	Generic Environmental Permit
GEP-RSR	Generic Environmental Permit - Radioactive Substances Regulation
GDA	Generic Design Assessment
HFE	Human Factors Engineering
HMI	Human Machine Interface
HP	High Pressure
HVAC	Heating Ventilation and Air Conditioning System
IPPC	Integrated Pollution Prevention and Control
LP	Low Pressure
MCERTS	Monitoring Certification Scheme
MCR	Main Control Room
NC	Non-Categorised
NPP	Nuclear Power Plant
OSPAR	Oslo and Paris Convention on Protection of the Marine Environment of the North East Atlantic
P&ID	Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Design
PCSR	Pre-Construction Safety Report
R/B	Reactor Building
REPs	Radioactive Substances Regulation - Environmental Principles
RGP	Relevant Good Practice
RPV	Reactor Pressure Vessel
Rw/B	Radwaste Building
S/B	Service Building
S/C	Suppression Chamber
SGTS	Standby Gas Treatment System
SJAE	Steam Jet Air Ejector
T/B	Turbine Building
TGN	Technical Guidance Notes

2. References

[Ref-1] Process and Information Document for the Generic Assessment of Candidate Nuclear Power Plant Designs, Version 2, Environment Agency, March 2013.

[Ref-2] Other Environmental Regulations, GA91-9901-0027-00001, XE-GD-0098, Rev. D, Hitachi-GE, August 2014.

[Ref-3] Demonstration of BAT, GA91-9901-0023-00001, XE-GD-0097, Rev. D, Hitachi-GE, August 2014.

[Ref-4] The Environmental Permitting Regulations (England and Wales) Regulations 2010 (SI 2010 No.675), The Stationery Office, March 2010.

[Ref-5] Approach to Optimisation, GA91-9901-0021-00001, XE-GD-0096, Rev. D, Hitachi-GE, August 2014.

[Ref-6] Commission verification of facilities in Member States which carry out continuous monitoring of levels of radioactivity in air, water and soil, Euratom, 2006.

[Ref-7] Directives laying down basic safety standards of protection against the dangers arising from exposure to ionising radiation, Euratom, 2013 (2013/59/EURATOM).

[Ref-8] Commission recommendation on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation, Euratom, 2004 (2004/2/Euratom).

[Ref-9] Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities, BS ISO 2889:2010.

[Ref-10] Performance Standard for Organisations Undertaking Radioanalytical Testing of Environmental and Waste Waters, Environment Agency, 2012e.

[Ref-11] General requirements for the competence of testing and calibration laboratories, ISO/IEC 17025:2005.

[Ref-12] Minimum requirements for the Self-Monitoring of Effluent Flow, Environment Agency, February 2013.

[Ref-13] Performance Standards and Test Procedures for Continuous Emissions Monitoring Systems – For gaseous, particulate and flow-rate monitoring systems, Environment Agency, July 2012.

[Ref-14] Regulatory Guidance Series, No RSR 1; Radioactive Substances Regulation – Environmental Principles, Version 2, Environment Agency, April 2010.

[Ref-15] Consideration of and Compliance with the Radioactive Substances Regulation Environmental Principles (REPs), GA91-9901-0028-00001, XE-GD-0099, Rev. D, Hitachi-GE, August 2014.

[Ref-16] Sampling requirements for stack emission monitoring, Technical Guidance Note (Monitoring) M1, Environment Agency, 2010d.

[Ref-17] Monitoring of Radioactive Releases to Atmosphere from Nuclear Facilities, Technical Guidance Note (Monitoring) M11, Environment Agency, 1999a.

[Ref-18] Monitoring of Radioactive Releases to Water from Nuclear Facilities, Technical Guidance Note (Monitoring) M12, Environment Agency, 1999b.

[Ref-19] Quantification of Discharges and Limits, GA91-9901-0025-00001, HE-GD-0004, Rev. D, Hitachi-GE, August 2014.

3. Introduction

3.1 Objective

The Environment Agency's requirements for the provision of information in the Generic Design Assessment (GDA) submission are defined within their Process and Information Document (P&ID) [Ref-1]. This stipulates the necessary GDA information requirements relating to sampling arrangements, as well as techniques and systems for measurement and assessment of discharges and disposals of radioactive waste.

At this stage of the GDA process, it is not yet possible to provide precise details on what sampling, measurement and monitoring will be installed in the UK ABWR. Further information will be provided over the course of the GDA process as the design develops and, in some instances where it falls to the responsibility of the future licensee, information will be developed following GDA as part of the site-specific permitting application.

In this submission the high level approach taken to determine the sampling and monitoring design in the UK ABWR is described, with a focus on radioactive effluent sampling and monitoring. Once completed, the systems identified will allow the measuring of performance against what is deemed to be Best Available Technique (BAT), as well as the recording of discharges into the environment.

3.2 Scope

The scope of this document is summarised in Table 3.2-1. Sampling of radioactive gaseous and aqueous wastes is covered in this document; sampling of non-aqueous liquid as well as solid waste will be submitted in Step 3 of the GDA process. Non-radioactive sampling and monitoring arrangements will be described in Hitachi-GE's Other Environmental Regulations report [Ref-2]. Other aspects of the GDA safety case design that will influence the sampling and monitoring arrangements, for example, details of Control and Instrumentation (C&I) such as digital network, plant computer system and Human Machine Interface (HMI) are included within the scope of PCSR Chapter 14 Control and Instrumentation.

An environmental monitoring programme is not included within the GDA submission due to the site-specific nature of the programme that will need to be developed. Environmental monitoring regimes vary from site to site as they are developed to reflect local conditions such as the critical group, local flora and fauna, dispersion and the operating conditions of the site. Hitachi-GE is committed to making sure that the future licensees will have a well-developed and meaningful environmental monitoring programme and will work with potential future licensees to this effect.

Table 3.2-1: Document Scope

Subject		Sampling point	Document
Gaseous waste	Radioactive	Final discharge In-process	This document
	Non-radioactive	Final discharge	[Ref-2]
Aqueous waste	Radioactive	Final discharge In-process	This document
	Non-radioactive	Final discharge	[Ref-2]
Non-aqueous liquid	Radioactive	Disposal	TBD (Step-3)
Solid waste	Radioactive	Disposal	TBD (Step-3)
Demonstration of BAT		--	[Ref-3] and this document
Detail of C&I (Computer system, digital network, etc.)		--	PCSR Chapter 14 Control and Instrumentation
Environmental monitoring		Site specific	Future EP-RSR Permit

4. Regulatory Context

4.1 P&ID

The Environment Agency has identified the information they require to carry out their determination of the GDA process in their P&ID [Ref-1]. The P&ID requirements relating to sampling arrangements, techniques and systems for measurement and assessment of discharges and disposals of radioactive waste are reproduced below:

> *'A description of the sampling arrangements, techniques and systems for measurement and assessment of discharges and disposals of radioactive waste.*
>
> *Include:*
> - *details of in-process monitoring arrangements, as well as those for final discharges of gaseous and aqueous wastes, and disposals of non-aqueous liquid and solid wastes;*
> - *a demonstration that your proposals represent the best available techniques for monitoring;*
> - *confirmation that the sensitivity is sufficient to:*
>   - *readily demonstrate compliance with the proposed limits;*
>   - *meet the levels of detection specified in reference EU, 2004.'*

4.2 Legislation

The main legislative requirements relevant to this section of the P&ID are the Environmental Permitting Regulations 2010 (as amended) (EPR 10) [Ref-4].

A further requirement on nuclear licensed sites in England and Wales is that BAT is used for monitoring discharges. The concept of BAT is defined in the OSPAR convention and in Directive 1996/61/EC on Integrated Pollution Prevention and Control (IPPC). Further information on Hitachi-GE's approach to assessing and demonstrating BAT are provided in the Approach to Optimisation and Demonstration of BAT reports [Ref-5][Ref-3].

Additionally, Article 35 of the Euratom Treaty [Ref-6] requires not only self-monitoring of the levels of radioactivity in nuclear facilities but also the independent verification of the operation and efficiency of that monitoring from proper authorities.

4.3 Standards

The following standards are relevant to the development of the UK ABWR sampling approach and will be considered throughout the GDA process and beyond.

4.3.1 EU 2004

The European Basic Safety Standards [Ref-7] references EU 2004 [Ref-8], which in turn provides recommendations on the standardised information on radioactive gaseous and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operations. Within the recommendations, a number of key nuclides and detection limit requirements are listed for both gaseous and liquid discharges as reproduced in Table 4.3.1-1 and 2 below.

Table 4.3.1-1: Key nuclides and Requirements for the detection limit in EU 2004 (Discharges to atmosphere)

Key nuclides	Requirements for the detection limit (in Bq/m^3)
Noble gases	
Kr-85	1E+04*
Particulates (excluding iodines)	
Co-60	1E–02
Sr-90	2E–02
Cs-137	3E–02
Pu-239 + Pu-240**	5E–03
Am-241**	5E–03
Total-alpha**	1E–02
Iodines	
I-131	2E–02
H-3	1E+03
C-14	1E+01

* Can normally be obtained by beta-measurement after decay of short-lived isotopes.

**Total-alpha should only be reported if nuclide-specific information on alpha-emitters is not available.

Table 4.3.1-2: Key nuclides and Requirements for the detection limit in EU 2004 (Liquid discharges)

Key nuclides	Requirements for the detection limit (in Bq/m^3)
H-3	1E+05
Other radionuclides (excluding H-3)	
Co-60	1E+04
Sr-90	1E+03
Cs-137	1E+04
Pu-239 + Pu-240*	6E+03
Am-241*	5E+01
Total-alpha*	1E+03

* Total-alpha should only be reported if nuclide-specific information on alpha-emitters is not available.

4.3.2 BS ISO 2889:2010

BS ISO 2889:2010 [Ref-9] is an international standard, which has been adopted as a British Standard. The Standard contains sets of criteria and recommendations for sample extraction, sample system design, sample transport (particulate, vapor and gaseous), performance criteria and quality control. In addition, it contains Appendices which provide some options for collection and analysis of selected analytes. This standard will be used to ensure BAT is being applied to the gaseous sampling and monitoring design of the UK ABWR.

4.3.3 MCERTS

MCERTS is the Environment Agency's Monitoring Certification Scheme. Its purpose is to promote the production of quality monitoring data and provide the key foundation of the operator's self monitoring policy.

At present, for the analysis of radioactive discharges, only the analysis of effluents is currently covered by MCERTS [Ref-10]. This is in addition to the requirement of any analysis being conducted to the ISO 17025 standard [Ref-11]. There is also a requirement for flow measurements (for both gaseous and liquid discharges) to be undertaken to MCERTS standard [Ref-12][Ref-13]. Flow measurements are required to enable accurate accounting of the discharges as they are released to the environment.

4.4 Guidance

The following guidances are relevant to the development of the UK ABWR sampling approach and will be considered throughout the GDA process and beyond.

4.4.1 Consideration of the REPs

The sampling and monitoring arrangements that will be presented in this report will be consistent with industry Relevant Good Practice (RGP) and take into account the relevant Radioactive Substances Regulation – Environmental Principles (REPs) [Ref-14]. Hitachi-GE's Consideration and Compliance with the REPs report [Ref-15] details the approach undertaken by Hitachi-GE to reviewing and showing compliance with each of the relevant REPs within the GDA submission, highlighting the REPs specifically addressed within each report.

Principally, this report addresses RSMDP13, as well as ENDP4, ENDP10 and ENDP14, in presenting a sampling and monitoring system that is consistent with relevant guidance standards and uses BAT to quantify and control gaseous and liquid radioactive discharges.

4.4.2 Technical Guidance Notes

The Environment Agency has produced a number of Technical Guidance Notes (TGN) that are relevant to sampling and monitoring. The main ones pertinent to the sampling and monitoring strategy are M1 [Ref-16], M11 [Ref-17] and M12 [Ref-18]. It is known that M11 is in the process of being reviewed.

5. Parameters to be Measured (Final Discharge)

5.1 Radionuclide

Radionuclides to be measured in UK ABWR are consistent with the regulatory recommendation and proposed discharges. In EU 2004 [Ref-8], the key nuclides are listed up as in Table 4.3.1-1 and 2. In the Quantification of Discharges and Limits report [Ref-19] a list of significant nuclides is provided by Hitachi-GE for both the gaseous and liquid discharges of the UK ABWR. Consequently, proposed nuclides for determination are shown in Table 5.1-1 and 2.

It is proposed to not measure Kr-85 specifically; instead this will be covered within a total noble gas measurement.

Note that the tables show nuclides at present, and detection limits for each nuclide will be provided in GDA Step 3.

Table 5.1-1: Radionuclides to be Measured in UK ABWR (Gas)

UK ABWR Sampling/monitoring	EU 2004 Key nuclide	Significant nuclide (as defined in [Ref-19])
Gamma nuclides		
Noble gas (total-gamma)	Kr-85*	Ar-41, Kr-85/85m/87/88/89 Xe-131m/133/133m/135/135m/137/138
Particulate (spectroscopy) (Cr-51, Mn-54, Fe-59, Co-58/60, Cs-134/137, etc.)	Co-60 Cs-137	Cr-51, Mn-54, Fe-59, Co-58/60 Cs-134/137
I-131/133	I-131	I-131/133
Beta nuclides		
Sr-89/90	Sr-90	Sr-89/90
H-3	H-3	H-3
C-14	C-14	C-14
Total-beta	–	Total-beta
Alpha nuclides		
–	Pu-239/240**	–
–	Am-241**	–
Total-alpha	Total-alpha**	Total-alpha

* Can normally be obtained by beta-measurement after decay of short-lived isotopes.

** Total-alpha should only be reported if nuclide-specific information on alpha-emitters is not available.

Table 5.1-2 Radionuclides to be Measured in UK ABWR (Liquid)

UK ABWR Sampling/monitoring	EU 2004 Key nuclide	Significant nuclide (as defined in [Ref-19])
Gamma nuclides		
Particulate (spectroscopy) (Cr-51, Mn-54, Fe-59, Co-58/60, I-131, Cs-134/137, etc.)	Co-60 Cs-137	Cr-51, Mn-54, Fe-59, Co-58/60 I-131, Cs-134/137
Beta nuclides		
Sr-89/90	Sr-90	Sr-89/90
H-3	H-3	H-3
Total-beta	–	Total-beta
Alpha nuclides		
–	Pu-239/240*	–
–	Am-241*	–
Total-alpha	Total-alpha*	Total-alpha

* Total-alpha should only be reported if nuclide-specific information on alpha-emitters is not available.

5.2 Flow

To be able to accurately report the discharge of radioactive material from release points, the flow of both gaseous and liquid effluent streams need to be continuously measured using an appropriate MCERTS [Ref-12] and [Ref-13] accredited technique.

6. Demonstration of BAT

6.1 Claim and Argument

The UK ABWR is designed to minimise the radiological impact to the environment and the public through the demonstration of BAT. The details of this assessment are described in [Ref-3]. The sampling and monitoring of radioactive substances provides information to support the demonstration of BAT.

In the UK ABWR, the sampling arrangements and radiation monitoring system are designed to achieve the following three fundamental Claims:

Claim 1 - Verify that radioactive discharge to the environment complies with the Permit[1].

Claim 2 - Provide robust data to assess the radiological impacts to the public and the environment.

Claim 3 - Minimise radioactive discharge to the environment.

Arguments to back up the three Claims are provided in the following sections. Supporting Evidence will be provided in later GDA Steps.

6.1.1 Claim 1 – Compliance with Permit

The UK ABWR is designed to comply with the requirements of the permit and will provide appropriate means to judge compliance. This Claim is based on the following Arguments (supporting Evidence will be provided in later GDA Steps):

Argument 1a: Radioactivity, radionuclide composition, and volume of the substance discharged to the environment are evaluated based on actual measured data.

Argument 1b: All final radioactive discharge points or paths to the environment throughout the NPP are identified and monitored.

Argument 1c: At continuous discharge points or paths, radioactivity levels of effluent streams are continuously monitored during plant operation and maintenance periods to capture temporal fluctuations. Grab sampling provisions are provided for detail analyses to supply nuclide-specific data.

Argument 1d: For batch discharge points, the sample is manually analysed in an onsite laboratory prior to the discharge. The discharge is allowed only once the compliance has been validated.

[1] The "Permit" is the template permit which is currently envisaged for use by a future site operator under the RSR regime.

Argument 1e: Radioactivity measurements will be undertaken using appropriate techniques and instruments to meet the required detection limits.

Argument 1f: Radiation measurements are recorded as part of compliance procedures.

6.1.2 Claim 2 – Disclosure of Radiological Impact

The UK ABWR provides data on the radiation levels discharged to the environment which is essential for the assessment of radiological impacts. The assessment will be completed using site specific environmental monitoring data (monitoring of food, environmental matrices and indicator species will be undertaken to inform impact assessments. These will be site specific and outside the scope of GDA.) This Claim is based on the following Arguments (supporting Evidence will be provided in later GDA steps):

Argument 2a: Radioactivity, radionuclide composition, and volume of the substance discharged to the environment are measured within a public radiological monitoring and assessment report. The data is also a record of the performance of UK ABWR.

Argument 2b: All final radioactive discharge points or paths to the environment throughout the NPP are identified and monitored to obtain complete discharge data.

Argument 2c: Laboratory equipment is used for detailed analyses. Appropriate methods which are both ISO 17025 [Ref-11] and where appropriate MCERTS [Ref-10] accredited will be selected to achieve the required detection levels.

Argument 2d: Radiation measurements are recorded to demonstrate ALARP.

6.1.3 Claim 3 – Minimisation of Radioactive Discharge

Unnecessary radioactive discharge can be prevented due to adequate radiation monitoring. The UK ABWR monitors plant performance as well as radioactive discharge. When an anomaly is detected, measures will be taken to prevent unnecessary radioactive discharge. This Claim is based on the following Arguments (supporting Evidence will be provided in later GDA Steps):

Argument 3a: At continuous discharge points or paths, radioactivity levels of effluent streams are continuously monitored during plant operation and maintenance periods so as to detect and mitigate anomalies at the earliest opportunity.

Argument 3b: In-process monitoring and sampling arrangements are provided to detect unexpected anomalies earlier than those at final discharge points.

Argument 3c: Locations of in-process monitoring and sampling are selected as they can identify position of unexpected operation.

Argument 3d: Radiation measurements are conducted sequentially from simple (coarse) to precise (fine) measurements.

Gross gamma radiation measurement is a primary course measurement, and therefore is continuously monitored. Specific analyses such as those for particulates, iodine, tritium and so on, are carried out in the laboratory when appropriate.

Argument 3e: For batch discharge points, a continuous monitor is also provided to prevent human error.

Note that the discharge is allowed only after the compliance has been validated.

Argument 3f: Automatic interlocks are designed based on Human Factors Engineering (HFE).

An unexpected radioactive release sequence will occur faster than human operators can realistically respond to. If such a release is deemed to be significant then the discharge is automatically stopped.

7. Safety Categorisation and Classification

UK ABWR safety categorisation and classification is defined in PCSR Chapter 5.4 Categorisation and Classification of Systems, Structures, and Components. The continuous monitoring system can provide timely information on radiological risk and support plant operation to ensure it is ALARP. Therefore it is categorised and classified as C3. Any other grab sampling systems provide detail data for accurate assessment of the radiological impacts and therefore are not safety-categorised.

8. Description of Equipment Design

8.1 GDA Submission Scope

At this stage of the process it is not deemed appropriate to provide detail of the sampling and monitoring equipment, as technology progresses at pace and Hitachi-GE would not be applying BAT at the time of procurement if the ones to be used are stated at this stage. However, current methods and techniques are described below that are suitable to achieve the appropriate detection limit for each nuclides listed in Table 4.3.1-1 and 2.

8.2 Sampling and Monitoring Location

A basic layout of the sampling and monitoring point in the UK ABWR design is provided in Figure 8.2-1. The grab sample is analysed at the onsite laboratory in the Service Building (S/B). Sufficient space to install laboratory equipments will be considered in the design. Continuous monitoring data is centralised in the Main Control Room (MCR) for display and record. Note that Figure 8.2-1 illustrates the sampling and monitoring points important to assessment of impact to the environment during normal plant operation. In the UK ABWR, further points are provided for detection and monitoring of the design base accident. These are described in PCSR Chapter 14 Control and Instrumentation in Step 3. For example, the Standby Gas Treatment System (SGTS) is operated only under accident conditions, and therefore the sampling and monitoring on the SGTS line is out of scope of the GEP application and submitted in PCSR.

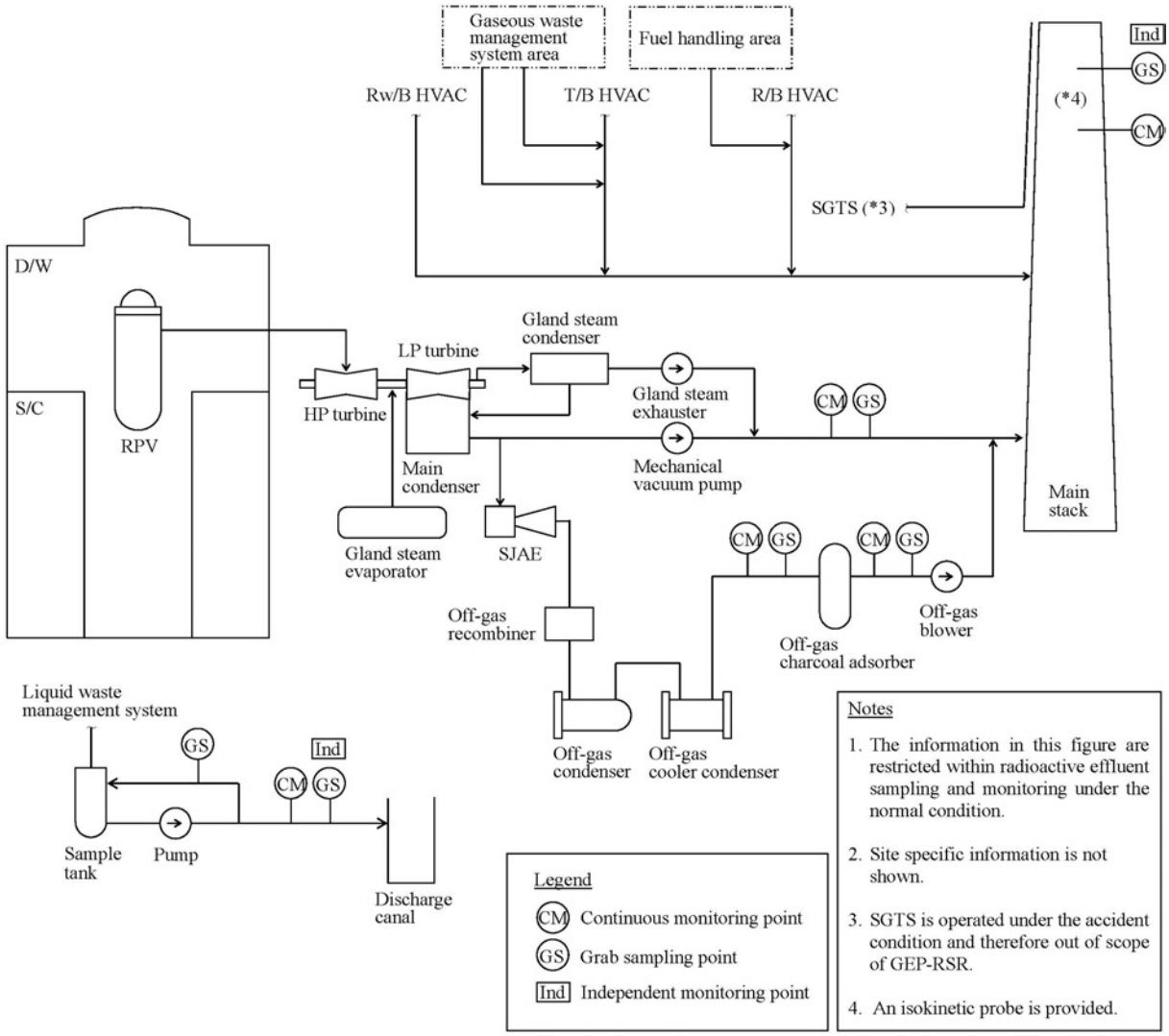

Figure 8.2-1: Sampling and Monitoring Point in UK ABWR

8.3 Gaseous Discharge

This subsystem monitors the main stack discharge for gross radiation level during normal plant operation and collects particulate, iodine, tritium and carbon samples for laboratory analyses. The discharge includes off-gas, turbine gland seal off-gas, Heating Ventilation and Air Conditioning System (HVAC) exhausts from the controlled areas. A representative sample is continuously extracted from the main stack through an isokinetic probe, passed through the sample panels for monitoring and sampling, and returned to the main stack. The sampling plane is 10D downstream of all abatement, where D is the diameter of the stack. Studies during the commissioning phase will be undertaken to determine the ideal location for the sampling port(s) depending on the flow characteristics of the stack.

A schematic diagram of the sampling and monitoring system for the gaseous discharge point is shown in Figure 8.3-1. The system has built in redundancy to avoid lack of measurement under maintenance or single failure. One of the pair can be used for independent sampling as described in section 8 of this document. This equipment will be located in specific rooms where sufficient space and accessibility is provided for service and maintenance.

Note that, in the standard design, the gas is returned upstream of the sample collection point as shown in solid line. Since the sampling flow rate is a several orders smaller than the stack flow, this design does not affect measurement quality; the reported values will be slightly conservative. Options of returning the gas to a downstream location relative to the collection point is indicated by the dotted line in Figure 8.3-1 and are to be explored later in the GDA process.

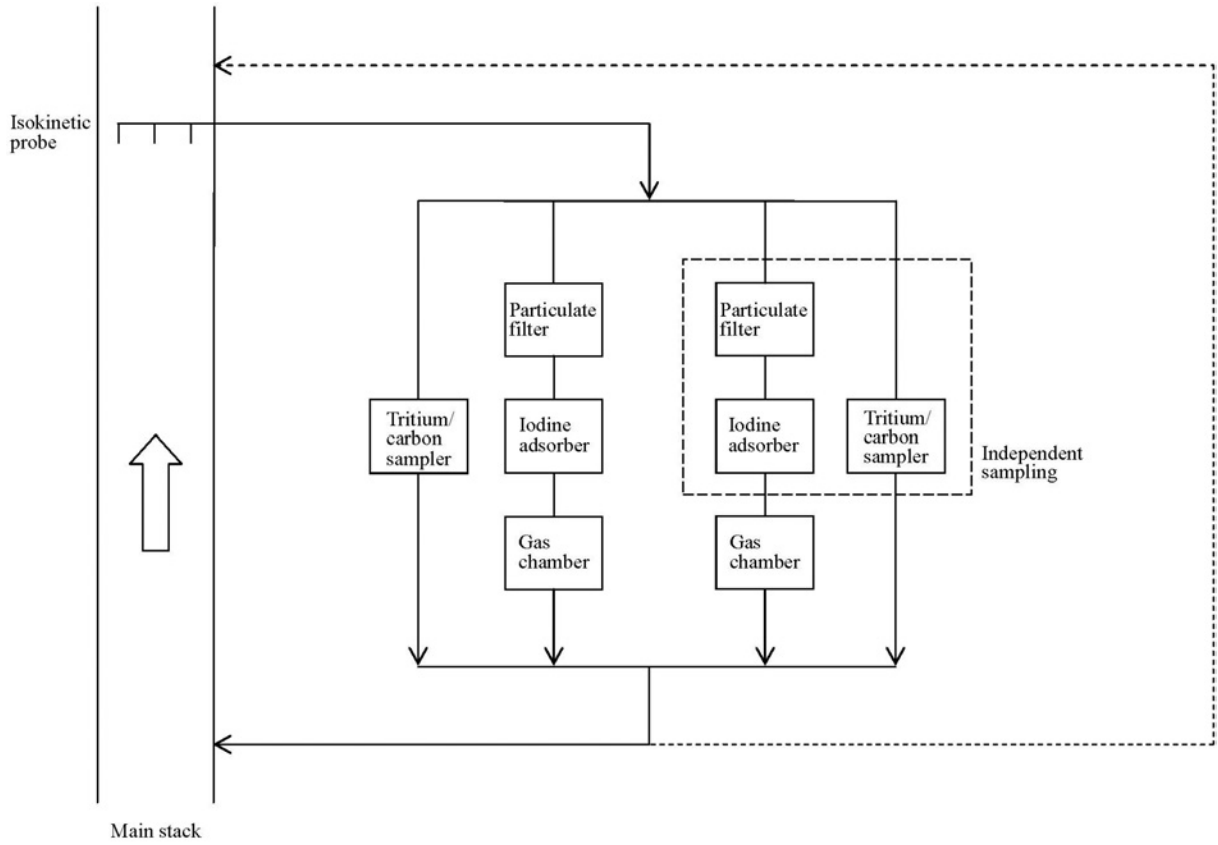

Figure 8.3-1: Diagram of Sampling and Monitoring System for Gaseous Discharge in UK ABWR

8.3.1 Particulate

Particulate material will be collected on appropriate filter media for laboratory analysis. The probe to collect the sample will be designed to ensure that isokinetic sampling takes place. A sampling pipe is designed to be as short as practicable, and the number of bends is minimised within the geometrical constraints of the application.

8.3.2 Iodine

In addition to any particulate iodine, other chemical forms of iodine will be collected using an appropriate solid adsorbent material.

8.3.3 Noble Gases

Gases will be continuously monitored by the use of a fixed volume calibrated chamber and appropriate detector system(s). The gases will be collected and analysed after the removal of any potential particulate material has been collected for separate analysis.

The radiation detector assembly will consist of a shielded gas chamber that houses a detector. A checking source is contained as necessary. A radiation monitor in the MCR analyses and visually displays the measured radiation level. If the system detects an anomaly, it activates an alarm in the main control room to warn operating personnel.

The gas chamber is purged with ambient air when background level is measured.

8.3.4 Tritium and Carbon

It is proposed to use a series of bubblers to collect samples for analysis by an appropriate analytical technique for the determination of tritium and carbon-14.

8.4 Liquid Discharge

The liquid effluent is sampled from the discharge tank through the use of a recirculation line and the subsequent sample is analysed in a laboratory. Furthermore, the samples are collected from the final discharge line exiting the discharge tank using a proportional sampler to give an accurate record of what is finally discharged. Sufficient space and accessibility is provided for service and maintenance.

In addition to the sample collection, a radiation monitor is provided in the liquid discharge line as a countermeasure to human error. If the system detects an anomaly, it activates an alarm and closes an isolation valve to stop the discharge to the environment.

8.5 In-process Sampling and Monitoring

8.5.1 Sampling and Monitoring Location

The off-gas and turbine gland seal off-gas are continuously monitored before they feed to the main stack as shown in Figure 8.2-1. For the sake of nuclide analyses, grab sampling provisions are considered.

The HVAC exhaust is not continuously monitored before the junction to the main stack (because the radiation level of the HVAC exhaust is extremely low) but monitored at the main stack in total. The required monitoring is significant, not because of the discharge to the environment, but rather the potential for internal exposure to operating personnel. The relevant assessments are described in PCSR Chapter 20 Radiation Protection. If an increase of the radiation level in the HVAC exhaust is detected by the main stack radiation monitor, then operating personnel can identify the appropriate stream by eliminating the other two tributaries: off-gas and turbine gland seal off-gas. Operating personnel can then undertake surveys in the buildings using portable equipment to identify the failure.

8.5.2 Off-gas

Under normal operation of the power plant, the major radioactive gaseous waste is from the off-gas system. Its main components are the fission-produced noble gases released from fuel cladding tubes under routine conditions. The off-gas is treated in the gaseous waste management system where noble gases are held up on charcoal adsorbers for a certain time. Short lived radionuclides decay within the calculated hold-up time and so the amount of radioactive waste gas discharged to the environment is decreased. In the UK ABWR, the inlet and outlet of the gaseous waste management system are monitored.

At the inlet of the gaseous waste management system, a radiation detector is provided. This continuously measures gross radiation level of the pre-treated off-gas which corresponds to the amount of the noble gas transported from the reactor. A radiation monitor in the MCR analyses and visually displays the measured radiation level. If the system detects an anomaly, it activates an alarm in the MCR. A grab sampling provision is also provided for an advanced analysis to obtain the radionuclide composition.

At the outlet of the system there is similar equipment as provided at the system inlet. A radiation detector continuously measures the gross radiation level of the post-treated off-gas which is fed to the main stack to be discharged to the environment. A radiation monitor in the MCR analyses and visually displays the measured radiation level. If the system detects an anomaly, it activates an alarm in the MCR to warn operating personnel to isolate the discharge line. A grab sampling provision is also provided for an advanced analysis to obtain the radionuclide composition.

The results of the nuclide analysis is an essential input for the evaluation of the total radionuclide composition to be discharged to the environment.

8.5.3 Turbine Gland Seal Off-gas and Vacuum Pump Exhaust

Turbine gland seal off-gas is continuously discharged to the environment through the main stack during normal operation. Radiation level of the turbine gland seal off-gas corresponds to the level of the amount of main steam that has escaped from the seal locations. During start up operation, vacuum pump exhaust is also continuously discharged to the environment through the main stack. At the downstream of junction of these two lines, a radiation detector is provided. This detector continuously measures the gross radiation level of the mixture of the turbine gland seal off-gas and vacuum pump exhaust. A radiation monitor in the MCR analyses and visually displays the measured radiation level. If the system detects an anomaly, it activates an alarm in the MCR. A grab sampling provision is also provided for an advanced analysis to obtain the radionuclide composition.

9. Independent Sampling

The Environment Agency requires the ability to undertake independent sampling. This is only required for the final discharge point and for analytes that will be collected for analysis. No resource will be provided for the independent continuous monitoring system. However, all data and quality control information will be available for audit purposes. The use of the redundant system by the regulators will not interrupt the continuous record or the quality of that measurement.

9.1 Gaseous Sampling

The UK ABWR design has a contingency system built into the gaseous discharge monitoring system to allow the system to function in the event of a failure and during maintenance as shown in Figure 8.3-1.

It is proposed that appropriate measures are put in place for the Environment Agency to secure the use of one of the systems during the period when the Environment Agency may wish to conduct independent sampling. This would be in the form of sealing off the system with tamperproof seals so filters, cartridges etc. cannot be accessed by the future licensee unless in an emergency and with prior consent from the Environment Agency.

It is proposed that only one sample line will be present that will feed both monitoring and sampling systems. The gas is returned upstream of the sample collection point. Both systems would be maintained and calibrated by the future licensee.

9.2 Liquid Sampling

As with the gaseous set up, contingency will be built into liquid effluent sampling by having two independent proportional samplers in the final discharge line. Sufficient space will be considered in the design. One of these would be made available to the Environment Agency (or their representatives) to undertake independent sampling.

10. Conclusions

This document describes, at a high level, the design principles for the sampling, measurement and monitoring regime that will be included in the UK ABWR design. Information about the types of analytes to be determined is included along with the required detection limits.

10.1 Forward Action Plan

In Step 3 of GDA, the fundamental design of the UK ABWR will be described in connection with the design principles outlined here. Further information to be provided will include:

- Details of the sampling and monitoring design and the further clarification as to how the systems will comply with appropriate standards and guidance;
- Evidence to back up the claims and arguments for the BAT assessment.