Cyfoeth Naturiol Cymru
Natural Resources Wales

Environment Agency

Assessing new nuclear power station designs

Generic design assessment of Hitachi-GE's Advanced Boiling Water Reactor

Assessment report - AR07 Monitoring

12 December 2016

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We can't do this alone. We work with government, local councils, businesses, civil society groups and communities to make our environment a better place for people and wildlife.

Natural Resources Wales is the largest Welsh Government Sponsored Body - employing 1,900 staff across Wales. We were formed in April 2013, largely taking over the functions of the Countryside Council for Wales, Forestry Commission Wales and the Environment Agency in Wales, as well as certain Welsh Government functions.

- Adviser: principal adviser to Welsh Government, and adviser to industry and the wider public and voluntary sector, and communicator about issues relating to the environment and its natural resources
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- Employer: of almost 1,900 staff, as well as supporting other employment through contract work.

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Executive summary

Protective status	This document contains no sensitive nuclear information or commercially confidential information.

Process and Information Document[1]	The following sections of Table 1 in our process and information document (P&ID) are relevant to this assessment: Item 6: A description of the sampling arrangements, techniques and systems for measurement and assessment of discharges and disposals of radioactive waste.

Radioactive Substances Regulation Environmental Principles[2]	The following principles are relevant to this assessment: RSMDP 13 – 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. 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 site. Additionally Hitachi-GE raised the following principles that have some supporting relevance. RSMDP9 – Characterisation: Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal. RSMDP14 – Record keeping: Sufficient records relating to radioactive substances and associated facilities should be made and managed so as: to facilitate the subsequent management of those substances and facilities; to demonstrate whether compliance with requirements and standards has been achieved; and to provide information and continuing assurance about the environmental impact and risks if the operations undertaken, including waste disposal. ENDP4 – Environmental protection function and measures: Environmental protection functions under normal and fault conditions should be identified, and it should be demonstrated that adequate environmental protection measures are in place to deliver these functions.

[1] Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Version 2, Environment Agency, Mar 2013. http://webarchive.nationalarchives.gov.uk/20151009003754/https://www.gov.uk/government/publications/assessment-of-candidate-nuclear-power-plant-designs

[2] Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation – Environmental Principles, Version 2), Environment Agency, April 2010. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296388/geho0709bqsb-e-e.pdf

	ENDP14 Control and instrumentation – Environmental protection systems: Best available techniques should be used to for the control and measurement of plant parameters and releases to the environment, and for assessing the effects of such releases to the environment.

Report author	Jane Rowe

This report covers the assessment of Hitachi-GE's sampling arrangements, techniques and systems proposed for measuring and assessing the discharges and disposals of radioactive waste from the United Kingdom Advanced Boiling Water Reactor (UK ABWR) design as required in Table 1 Item 6 of our process and information document (P&ID) (Environment Agency, 2013). This assessment covers both gaseous and aqueous effluents and solid radioactive waste.

Hitachi-GE has considered the Environment Agency's Regulation Environmental Principles (REPs), the main ones being: RSMDP13 – Monitoring and assessment and ENDP10 Quantification of discharges, both require the use of best available techniques (BAT) for the activities being undertaken.

The process of nuclear new build can be divided into early design, detailed design, procurement, construction and commissioning phases followed by operation and decommissioning.

The information that Hitachi-GE has provided for gaseous (main stack reactor building) and liquid effluents, focusing on techniques, covers all the required areas associated with the design stages. There is also a demonstrated understanding of the issues, and commitments to fulfilling the requirements, that can only be addressed in later phases of the new build process.

The information Hitachi-GE provided on sampling of solid radioactive wastes is only an overview, since the solid waste management system (SWMS) has only been developed to concept level during generic design assessment (GDA). However the 'Radioactive Solid Waste Monitoring Requirements' document (Hitachi-GE, 2016b) provides information on the processes that have been considered with account of the guidance. Also the monitoring systems for the waste handling facilities have only been developed to concept level and so will need to be assessed at a later stage.

It is noted from Hitachi-GE's 'Radioactive Waste Management Arrangements' (Hitachi-GE, 2016a) that non-aqueous radioactive liquid wastes are excluded from the aqueous liquid treatment and discharge to the environment, and will require export from sites for specialist disposal. Their management has been considered with solid radioactive waste disposal.

An environmental monitoring programme is not included within the scope of GDA, due to the site-specific nature of such monitoring. This will need to be assessed at a later stage.

As the process moves forward into later phases more information will be required from a future operator on the specific sampling and monitoring equipment and sampling of solid radioactive wastes.

We have concluded that BAT has been demonstrated in principle for Hitachi-GE's UK ABWR for both the gaseous effluent and liquid effluent monitoring systems. For the monitoring of solid radioactive wastes our preliminary conclusion is that the practices being developed appear appropriate for the monitoring of final disposal of solid wastes, but a full assessment needs to be undertaken when more information has been provided by a future operator. Similarly for non-aqueous liquid wastes.

We have identified the following Assessment Findings:

Assessment Finding 11: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G, July 2016.

Assessment Finding 12: A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.

Assessment Finding 13: A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.

Assessment Finding 14: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.

Assessment Finding 15: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.

Contents

1. Introduction

This report is based on information received up to and including 8 July 2016. It covers the assessment of the sampling arrangements, techniques and systems proposed for measuring and assessing the discharges and disposals of radioactive waste from the UK ABWR. We require the design to use the BAT for measuring and assessing discharges, to enable any operational UK ABWR to:

- confirm that actual discharges are as predicted by the designer
- assess compliance with limits
- provide good quality data for dose assessments
- characterise solid waste to enable its disposal by optimal routes

We set out in our P&ID the requirements for a requesting party to provide information. Item 6 of the P&ID requires a description of the sampling arrangements, techniques and systems proposed for the measurement and assessment of discharges and the disposals of radioactive waste. This includes details of the in-process monitoring arrangements, as well as those for final discharges of gaseous and aqueous wastes, and the disposals of non-aqueous liquid and solid wastes. A demonstration that the proposals represent BAT for monitoring, and confirmation that the sensitivity is sufficient to demonstrate compliance with the proposed limits and meet the levels of detection specified in EU Commission recommendation 2004/2/Euratom (EU, 2004) are also required.

We set up an agreement with Hitachi-GE to undertake GDA of the UK ABWR design, which came into effect in April 2013. Revision A of the 'Approaches to Sampling and Monitoring' document was submitted in December 2013 (Hitachi-GE, 2016e). In April 2014, 2 Regulatory Queries (RQ) were issued; RQ-ABWR-0106 'Operator monitoring of discharges' and RQ-ABWR-0105 'Independent monitoring'. These laid out in detail our expectations for both operator and independent monitoring of discharges, to enable gaps in the original submission to be addressed.

Subsequent responses to these RQs and discussions at meetings have been incorporated into the later revisions of the generic environmental permit (GEP) document 'Approach to sampling and monitoring'. This has provided enough information to be able to do an assessment. It is recognised there are still some areas that need to be finalised, by an appropriate designer, for example the stack height will be site-specific and the actual monitoring equipment will only be specified at the point of procurement so BAT can be applied at the time. A reference to the potential for particulate material to enter the main stack from the turbine gland steam system (TGS) and mechanical vacuum Pump (MVP) appeared in 'Approach to Sampling and Monitoring' Revision E (Hitachi-GE, 2016f).

A further Regulatory Query (RQ-ABWR-0840 Filtration of TGS and MVP discharges and effect on monitoring efficiency) was issued in April 2016 to investigate this. Hitachi-GE has addressed this with the addition of High Efficiency Particulate Air (HEPA) filtration now described in the generic environmental permit (GEP) document 'Approach to sampling and monitoring' Revision G (Hitachi-GE, 2016d).

Hitachi-GE's approach to sampling and monitoring has covered operator monitoring of gaseous and liquid effluent discharges, provision to enable independent assurance of these, and in-process monitoring. The monitoring systems for the waste handling facilities have only been developed to concept level and so will need to be assessed at a later stage.

A demonstration of BAT has also been put forward, with the aim of minimising radiological impacts on the environment. The sampling arrangements and radiation monitoring systems are designed to achieve the following:

- verify that radioactive discharges to the environment comply with the permit
- provide reliable data to assess radiological impacts to the public and the environment
- minimise radioactive discharges to the environment

We have assessed the supporting arguments.

2. Assessment

2.1. Assessment methodology

The basis of our assessment was to:

- review the appropriate sections of the GEP and its supporting documents
- hold technical meetings with Hitachi-GE to clarify our understanding of the information presented and explain any concerns we had with that information
- raise Regulatory Queries (RQs) where we believed information from Hitachi-GE was insufficient
- assess the techniques Hitachi-GE proposed for monitoring radioactive disposals
- decide on any potential GDA Issues or Assessment Findings to carry forward from GDA

2.2. Assessment objectives

The assessment considered:

- the sampling arrangements, techniques and systems proposed for measurement and assessment of the discharges and disposals of radioactive waste
- the specific nuclides to be monitored and whether systems are adequate to meet the levels of detection specified in the EU Commission recommendation 2004/2/Euratom (EU, 2004)
- how monitoring proposals compared to our technical guidance notes (TGNs) M1, M11 and M12 (Environment Agency, 2010a, 1999a and 1999b) and relevant international and national standards (for example, BSi, 2010)
- commitment given to our MCERTS (monitoring certification) scheme for current in scope standards (Environment Agency, 2011a, 2014 and 2011b) and flexibility to adopt future standards if nuclear facilities are bought into scope
- whether arrangements represented BAT

Radiological protection monitoring was not considered as part of this assessment as this is within the remit of the Office for Nuclear Regulation (ONR).

2.3. Monitoring gaseous disposals

Monitoring radioactive gaseous disposals is described in Hitachi-GE's 'Approach to Sampling and Monitoring' document (Hitachi-GE, 2016d), including considerations of BAT. This includes both the approach to in-process and final discharge monitoring. For final discharge monitoring given the

scope of GDA, only information on monitoring of the main stack on the reactor building has been provided and assessed.

Hitachi-GE has given proper consideration to our requirements that we enforce through EPR 2010, and the Euratom requirements, both for self-monitoring of levels of radioactivity and provision to allow for independent verification of the discharges.

In the early phases of working with Hitachi-GE we issued 2 Regulatory Queries that clarified our requirements for both operator and independent monitoring, including for gaseous discharges. In addition to requirements set out in our assessment objectives above, we reiterated the need to provide facilities for independent monitoring; for continuous flow measurement and samples being demonstrably representative of the final discharge. Following that, Hitachi-GE developed its monitoring approach to show how the requirements would be met.

A reference to the potential for particulate material to enter the main stack from the TGS system and MVP appeared in the 'Approach to Sampling and Monitoring' document Revision E (Hitachi-GE, 2016f). A further Regulatory Query (RQ-ABWR-0840 'Filtration of TGS and MVP discharges and effect on monitoring efficiency') was issued in April 2016 to investigate this and the response is considered below.

Hitachi-GE proposes monitoring and sampling systems will be in place to enable activity concentrations to be determined for total noble gases (krypton-85 and argon-41 will not be measured specifically), cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters) in particulate matter, iodine-131, tritium and carbon-14. With the exception of combining krypton-85 (key nuclide to represent noble gases) in a total noble gas measurement, all the key radionuclides required to fulfil EU commission recommendation 2004/2/Euratom are being monitored. While it is recognised that the detection limits achievable will be dependent on a number of parameters (including flow rate and sampling period) that will only be finalised at later stages, calculations have been performed that indicate that the required EU Commission recommendation 2004/2/Euratom detection limits for key radionuclides can be met using currently available systems. These are summarised in the table below: Hitachi-GE used the EU required detection limit value as the discharge activity concentration and calculated the activity that would be present in a sample using an assumed sampling flow rate (3 m3/h) and sample time (336 h) and compared these to achievable method detection limits. The Hitachi-GE calculations have been confirmed by the Environment Agency.

Table 1. Hitachi-GE demonstration for achieving detection limits for gaseous discharges as set out in EU, 2004

Category	EU2004 Key nuclides	EU2004 Requirement for detection limit (Bq/m3)	Hitachi-GE estimated sample activity equivalent to detection limit (Bq)	Hitachi-GE (2016d) referenced achievable detection limit (Bq)
Noble gases	Kr-85	1E+04*	No Information	No information
Particulates (excluding iodines)	Co-60	1E-02	10	0.7
	Sr-90	2E-02	20	2
	Cs-137	3E-02	30	0.7
	Pu-239 + Pu-240**	5E-03	Not analysed	Not analysed
	Am-241**	5E-03	Not analysed	Not analysed
	Total-alpha**	1E-02	10	4E-02
Iodines	I-131	2E-02	11.6***	1

Category	EU2004 Key nuclides	EU2004 Requirement for detection limit (Bq/m3)	Hitachi-GE estimated sample activity equivalent to detection limit (Bq)	Hitachi-GE (2016d) referenced achievable detection limit (Bq)
Tritium	H-3	1E+03	2E+08	4E+04
Carbon-14	C-14	1E+01	2E+06	Expected similar to H-3

*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.

*** Half-life also taken into consideration.

Final confirmation, that the EU Commission detection limits will be met, will be required at the site-specific stage. Hitachi-GE states that specific equipment is not being specified at the GDA stage to allow for technological advances. The laboratories and analytical methods chosen will be for future operators, the Environment Agency expects that these will be accredited to ISO 17025 (BSi, 2005) and MCERTS (Environment Agency, 2011a) where applicable. Meeting our requirements, the volumetric flow, required to determine the activity concentrations, will be measured continuously using an appropriate MCERTS accredited technique.

Hitachi-GE proposes that for final discharge reporting there will be one gaseous sampling point in the main stack. This is located over 10 hydraulic diameters downstream of the last input and downstream of the abatement systems. In accordance with guidance, this ensures that the air within the stack is well mixed and that the samples collected are representative of the final discharge. The main stack has inputs from the heating, ventilation and air conditioning (HVAC) and off-gas (OG) systems, the latter including inputs from the TGS system and the MVP.

Hitachi-GE is committed to undertaking isokinetic sampling (to ensure no preferential fractionation of the particles within the sample to the main flow) consistent with BS ISO2889, 2010 (BSi, 2010), with the sampling flow being adjustable to achieve that. Tests will be undertaken during the commissioning phase to determine the particle concentration profile and whether multi-nozzle probes are required. The probe type will be decided based on BAT at that time.

The sampling line will feed the sampling systems (described below) and it is important losses in the sample line are minimised. There needs to be a balance between minimising losses and practicalities of locating the monitoring room and equipment. Hitachi-GE has undertaken modelling, taking into account the likely configuration of the sampling line (that is in relation to bends, length, horizontal runs and temperature control) to determine the particle penetration and ensure that this is within acceptable parameters (BSi, 2010). The particle diameter used in the modelling was 0.3 μm, given that the HVAC and off-gas inputs to the stack have undergone high efficiency particulate air (HEPA) filtration. With these assumptions, the particle penetration exceeds the requirements of BS ISO2889: 2010 (BSi, 2010). A bounding case has also been looked at given pipework could be changed at the detailed design stage and the requirements can still be met.

The modelling of penetration factors has been based on the discharge being HEPA filtered. While this is the case for the OG and HVAC system, information provided indicated that filtration of the TGS system and MVP lines was not intended and, therefore, there was the potential for them to introduce particulates into the main stack and affect the discharge characteristics. We raised a Regulatory Query around this and Hitachi-GE has committed to installing HEPA filtration, appropriate to the conditions, into the TGS and MVP lines in its response.

The total stack volumetric discharge flow will also be measured at the sampling point within the stack. The exact configuration of the system will be determined during the commissioning phase following the appropriate ISO standards (ISO, 1994 and BSi, 2010). To provide back-up gaseous flow measurement a second identical system will be stored outside the stack, ready for prompt

deployment if required. Additional flow measurements are also undertaken on the HVAC and OG systems.

Hitachi-GE has committed to providing a sample port on the main stack for independent flow measurement. The access port will be consistent with the requirements of M1 (Environment Agency, 2010a) and with the provision of 3 standard waterproof sockets of single phase 110 V.

A sampling platform designed to comply with M1 (Environment Agency, 2010a) will be provided to allow workers safe access for inspection and maintenance of the sampling equipment, including to the independent port. This could be a full circumference or one-sided platform. The final design will depend on the equipment choice and be will made by the future operator.

The sampling line will feed 2 duplicate sampling systems, both systems will be running at the same time, with a sample change off-set, which allows for redundancy. Having duplicate sampling systems also allows for independent verification by the regulator or our representatives. There will be provision to enable one of the systems, including associated pipework valves, to be isolated with tamper evident seals while the independent sampling of particulates, iodine, tritium and carbon-14 is undertaken. The systems have been designed so that this will not affect the quality of the operator's own data over that period.

The required nuclides are collected in a sequence that ensures the best sample, for each, is obtained. Particulates (for cobalt-60, strontium-90, caesium-137 and total alpha analysis) are collected first to minimise losses through plating out. Once particulates have been removed the sample is passed through an appropriate iodine adsorber. Typically, these samples only contain several tens of mm of charcoal, therefore, there is only a short delay through them before the sample is passed into the gas chamber for the analysis of noble gases. This arrangement complies with BS EN 60761-3 (BSi, 2004). Tritium and carbon-14 are collected on a different line and the order will be determined by the specific instrument purchased by the future operator.

Continuous monitoring will be undertaken for noble gases in the gaseous discharge stream from the main stack, using a gamma detector. The choice of detector will be determined by the future operator. Krypton-85 will not be measured specifically in the final discharge, but as noble gas gamma content. A grab sample of the post treated OG can provide data on krypton-85 (only route containing it) as activity concentrations are not diluted at this point and, therefore, levels will be discernable. These values could be used to calculate the final discharge.

It is best practice to return the sample downstream of the sample extraction point to prevent either double counting or dilution of the sample. However, Hitachi-GE has proposed the sample return line be upstream of the extraction point to save pipework and the amount of potentially contaminated material that needs to be disposed of at the end of the plant life. Given this saving and the fact that the impact of the returning gas would be negligible due to the very small sample volume being diluted by the large stack flow rate (and any double counting being conservative), we have accepted this approach as BAT for the design.

In-process monitoring and sampling arrangements are provided to detect deviation from the normal state sooner than in the final discharge. A major cause of increased radiation level in the OG is fuel failure. The main gaseous radioactive waste is contained in the OG and this is treated in the OG system where noble gases are held up on charcoal adsorbers. The inlet and outlet of the OG charcoal adsorber are both monitored for gross radiation levels. Levels are indicated and recorded in the main control room (MCR). If the system detects a high radiation level it activates an alarm in the MCR and there is provision for a grab sample to be taken for analysis to determine the radionuclide composition. Similarly, a radiation detector continuously monitors the gross radiation levels of the TGS and MVP exhaust. Again, if the system detects a high radiation level it activates an alarm in the MCR and there is provision for a grab sample to be taken. Flow rate measurement also takes place on these systems. No radiation level monitoring takes place on the HVAC system. However, as the HVAC system discharge is monitored for compliance via the main stack, should any elevated levels be seen there that are not correspondingly being signalled by the OG system and TGS, MVP exhaust monitoring these could be attributed to the HVAC system. In addition,

there are area monitors located within the controlled areas, which would indicate if there is an issue with elevated activity in those areas.

2.4. Monitoring liquid disposals

Monitoring radioactive liquid disposals are described in the 'Approach to Sampling and Monitoring' (Hitachi-GE, 2016d) document, including consideration of BAT. This includes both the approach to in-process and final discharge monitoring.

Hitachi-GE has given proper consideration to our requirements that we enforce through EPR, 2010 and the Euratom requirements both for self-monitoring of levels of radioactivity and provision to allow for independent verification of the discharges.

In the early phases of working with Hitachi-GE we issued 2 Regulatory Queries that clarified our requirements for both operator and independent monitoring including for liquid discharges. In addition to requirements set out in our assessment objectives, we reiterated the need to provide facilities for independent monitoring; for flow measurement on the final discharge line and sampling of liquid discharges to be on the final discharge line using a flow proportional sampler, in addition to proposed monitoring of final tanks. Following that, Hitachi-GE developed its monitoring approach to show how the requirements would be met.

Hitachi-GE proposes that monitoring and sampling systems will be in place to enable activity concentrations to be determined for tritium, cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters). All the key radionuclides required to meet EU Commission recommendation 2004/2/Euratom are being monitored. While it is recognised that the detection limits achievable will depend on a number of parameters (including sample volume, measurement instrument and count time) that will only be finalised at later stages, Hitachi-GE has provided reference values indicating Euratom detection limits can be met using currently available systems. An exception to this is for alpha emitters and Hitachi-GE indicates the detection limit could be achieved using longer count times. These will be required of future operators if this is the best way to achieve the required detection limit. These are summarised in the table below. We recognise that these values are achievable from experience of laboratory capabilities.

Table 2. Hitachi-GE demonstration for achieving detection limits for aqueous discharges as set out in EU, 2004.

Category	EU2004 Key nuclides	EU2004 requirement for detection limit (Bq/m3)	Hitachi-GE referenced achievable detection limit (Bq/m3) (Hitachi-GE, 2016d)
Tritium	H-3	1E+05	4E+04
Other radionuclides (excluding H-3)	Co-60	1E+04	1E+04
	Sr-90	1E+03	7E+02
	Cs-137	1E+04	1E+04
	Pu-239 + Pu-240*	6E+03	Not analysed
	Am-241*	5E+01	Not analysed
	Total-alpha*	1E+03	4E+03

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

Final confirmation that the EU Commission detection limit will be met will be required at the site-specific stage. Particular equipment is not being specified at GDA to allow for technological advances. Future operators will need to choose the laboratories and analytical methods. The Environment Agency and Natural Resources Wales expect that these will be accredited to ISO 17025 (BSi, 2005) and MCERTS (Environment Agency, 2011a), where applicable. Meeting our requirements, the volumetric flow required to determine the activity concentrations will be measured continuously using an appropriate MCERTS accredited technique.

For final discharge reporting there will be one sampling location on the final discharge line downstream of the aqueous waste treatment sub-systems. There are 4 sub-systems but only 3 of these feed into the discharge line. These are high chemical waste system (HCW), laundry drain system (LD) and controlled area drain system (CAD). Each of these sub-systems has 2 storage tanks.

When a storage tank is full it is sealed from additional input and a sample collected once the re-circulation line has agitated that tank. This sample is analysed prior to being discharged to confirm the activity is less than the permitted activity. This forms the in-process monitoring. If the levels are above the permitted activity, the tank contents are sent for retreatment and not released until they meet the discharge requirements. Interlocks are in place to prevent simultaneous discharge and filling of the tank. The inlet valve cannot be opened if the pump for the recirculation line or the discharge line is operational. Meeting our requirements, the system is designed to prevent uncharacterised liquid waste being discharged into the environment.

As we require, Hitachi-GE has committed to the final accountancy samples being taken via a flow proportional sampling system on the final discharge line. This gives an accurate record of what is actually discharged. Hitachi-GE is committed to using MCERTS accredited systems where available. At present pressurised systems are not covered, but are likely to be brought into scope in future. The samples will then be analysed by an accredited laboratory, including MCERTS, where applicable. The discharge flow is also measured at this point using an appropriate MCERTS accredited technique.

To provide contingency in the event of equipment failure, duplicates of both the flow proportional samplers and flow measurement apparatus will be provided. Providing these duplicate systems also allows for independent verification by the regulator or our representatives, as we require. When verification is required, the additional sampler and flow measurement apparatus will be able to be operated with tamper evident seals for the full sampling period to ensure a representative sample can be taken for independent analysis. The systems have been designed so that this will not affect the quality of the operator's own sampling during that period. Only one sampler and flow measurement apparatus will be in use during normal operation, but both will be kept maintained and calibrated, as we require.

In addition to sample collection, a continuous radiation monitor is provided in the liquid discharge line. If the system detects a high radiation level, it activates an alarm and closes an isolation valve to stop discharge to the environment.

2.5. Monitoring solid waste disposals

The solid waste management system (SWMS) has only been developed at a concept level during GDA, so only an overview of the sampling of solid radioactive wastes has been provided. Hitachi-GE states that solid radioactive waste will be sampled and analysed at each stage to maintain traceability and assure SWMS performance. Prior to being dispatched for final disposal, the sample is analysed in order to ensure compliance with the regulatory permit.

The 'Radioactive Solid Waste Monitoring Requirements' document (Hitachi-GE, 2016b) looks at the complete waste cycle for the UK ABWR design, through operation to consignment for disposal, and provides information on the processes that have been considered taking account of relevant guidance from the IAEA and industry (IAEA, 2007, IAEA, 2009 and NICoP, 2012). This gives reassurance that the practices being developed should be appropriate. Examples of typical

instruments and equipment have been cited to show proposals are based on current and achievable techniques. Hitachi-GE raises the issue that the UK analytical supply chain may have little experience with the mix of radionuclides in the ABWR waste types and, therefore, method development may be required. Also it is recognised that future operators will need to work with the UK supply chain to identify where experienced characterisation capability exists or a development programme may be required.

As the monitoring systems for the waste handling facilities have only been developed to concept level these will need to be assessed at a later stage.

2.6. Non-aqueous liquid waste

Hitachi-GE states that non-aqueous liquid wastes will be sampled as close to the point of generation as possible, with a sample sent to an appropriate laboratory for characterisation. Once it is recognised as radioactive, sampling and monitoring will be carried out prior to treatment and/or disposal by a specialist contractor.

2.7. Monitoring matters for future operator

Table 3 adapted from the 'Approach to Sampling and Monitoring' (Hitachi-GE, 2016d) document shows the areas that the future operator will need to follow up either during site-specific design or during commissioning and operations.

Table 3. Follow up actions identified by Hitachi-GE

Follow-up actions identified by Hitachi-GE
Identification of any additional gaseous discharge routes for monitoring (such as the service building and waste processing and storage facilities). Only main stack of reactor building considered in GDA.
Review of the main stack sampling design for a site-specific main stack design.
Determination of the main stack platform design.
Recording and reporting of the measurements. Including a recording system for sample collection time.
Ensuring all sampling and monitoring techniques achieve EU2004 detection limits.
Ensuring appropriately accredited laboratories are selected for analysing samples, including MCERTS accreditation where applicable.
Selection of the specific sampling and monitoring equipment for the determination of the discharges. Including consideration of sampling flow rates. Allowing for technological advances.
For gaseous sampling the sampling period for each sample collector and the order of sampling will need to be confirmed.
Flow velocity distribution test in the main stack. Determination of locations of the flow measurement and sampling point in the sampling plane.
Selection of the type of isokinetic probe for the main stack sampling, for example shrouded or unshrouded.

Follow-up actions identified by Hitachi-GE
Define appropriate performance and leak checks to be undertaken after the maintenance and inspection of sampling probes to ensure the correct operation of the probe(s).
Determine the volume of the liquid sample required per unit of volume of discharge to enable analytical requirements to be met.

3. Compliance with Environment Agency requirements

Table 4. Compliance with Environment Agency requirements

P&ID Table 1 Section or REP	Compliance comments
P&ID Item 6 (Sampling arrangements and techniques for assessment of discharges and disposal of solid waste)	Details of in-process monitoring provided. Details of gaseous discharge monitoring provided. Details of aqueous discharge monitoring provided. Overview of proposed solid waste monitoring provided. Some information on monitoring of non-aqueous liquid waste provided. A demonstration in regards to BAT has been provided. Sensitivity can meet the levels of detection specified in reference EU, 2004 (for alpha emitters in liquids this has not been demonstrated, but assumed achievable with longer counting times) – final compliance reliant on future operator. In meeting EU, 2004 requirements will be capable of compliance with proposed limits.
RSMDP 13 – Monitoring and assessment	Relevant standards and guidance have been considered. Provision has been made to allow for independent regulatory check monitoring of discharges. An environmental monitoring programme is, inherently, site-specific and is not covered by GDA.
ENDP10 – Quantification of discharges	The main gaseous discharge route and only liquid discharge route have been designed to allow for BAT for quantification of discharges. The future operator will need to specify the exact monitoring equipment (to take account of technological advances between GDA and construction). Identification of any other gaseous discharge routes requiring monitoring has also been left to the future operator. Early warning systems are in place for abnormal radiation levels.

P&ID Table 1 Section or REP	Compliance comments
RSMDP9 – Characterisation	Hitachi-GE raised this REP recognising that sampling and monitoring has a role in characterising the physical, chemical, radiological and biological properties of wastes.
RSMDP14 – Record keeping	Hitachi-GE raised this REP recognising that there are numerous records that need to be kept in support of the monitoring programme for discharges and disposal.
ENDP4 – Environmental protection function and measures	Hitachi-GE raised this REP, whereas it is not directly relevant to sampling and monitoring of final discharges, it has provided descriptions of the monitoring systems designed to detect radiation levels during normal and fault conditions.
ENDP14 Control and instrumentation – environmental protection systems	There is in-process monitoring that allows for an understanding of the state of the facility. The provision of an environmental monitoring programme is not a requirement of GDA.

4. Public comments

No comments from the public were received up to 8 July 2016 concerning sampling and monitoring.

5. Conclusion

For the UK ABWR gaseous effluent monitoring system we have concluded that:

- BAT has been demonstrated in principle for monitoring systems
- appropriate consideration has been given to the sampling line to ensure requirements for sampling can be met (through modelling penetration factors). Final confirmation of the acceptability of the sampling line will be needed once the position of the monitoring room has been finalised
- representative samples will be taken
- appropriate measurement and analysis will be undertaken
- having the return of the sample to the discharge stack upstream of the sample extraction point will have a negligible effect on the discharge monitoring and is acceptable given the saving in pipework
- appropriate provision will be made to allow for independent regulatory verification of the gaseous monitoring and discharge reporting

For the UK ABWR liquid effluent monitoring system we have concluded that:

- BAT has been demonstrated in principle for the monitoring systems
- representative samples will be taken of the final discharge
- appropriate flow measurement will be undertaken
- appropriate analysis will be undertaken

- appropriate provision will be made to allow for independent regulatory verification of the liquid monitoring and discharge reporting

For the UK ABWR monitoring of solid wastes our preliminary conclusion is that the practices being developed appear appropriate for monitoring final disposal of solid wastes, but a full assessment needs to be undertaken when more information has been provided. This is also the case for non-aqueous liquid wastes.

More information will be required on the specific sampling and monitoring equipment and sampling of solid radioactive wastes and non-aqueous liquid wastes, as the detailed design progresses.

We have identified 5 Assessment Findings:

Assessment Finding 11: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G, July 2016.

Assessment Finding 12: A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.

Assessment Finding 13: A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.

Assessment Finding 14: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.

Assessment Finding 15: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.

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List of abbreviations

Abbreviation	Details
ABWR	Advanced Boiling Water Reactor
BAT	Best available techniques
BSi	British Standards Institute
CAD	Controlled area drain
EPR	Environmental Permitting Regulations
EU	European Union
GDA	Generic design assessment
GEP	Generic environmental permit
HCW	High chemical impurity waste
HEPA	High efficiency particulate air
HVAC	Heating, ventilation and air conditioning
IAEA	International Atomic Energy Authority
ISO	International Standards Organisation
LCW	Low chemical impurity waste
LD	Laundry drain
MCERTS	Monitoring certification
MCR	Main control room
MVP	Mechanical vacuum pump
OG	Off-gas
ONR	Office for Nuclear Regulation
P&ID	Process and information document

Abbreviation	Details
REP	Regulation environmental principle
RQ	Regulatory Query
SWMS	Solid waste management system
TNG	Technical guidance note
TGS	Turbine gland steam system
UK	United Kingdom

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