Generic design assessment of new nuclear power plants

Sampling and monitoring for the UK HPR1000 design - AR06

Detailed assessment – final report

10 January 2022

Version 1

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Executive summary

This report covers our detailed assessment of the Requesting Party's (RP's) submission on sampling and monitoring for the United Kingdom Hualong Pressurised Water Reactor design (UK HPR1000) as required in Table 1, Item 6 of our Process and Information document (P&ID) (Environment Agency, 2016). This assessment covers both sampling and monitoring of gaseous and liquid effluents, and solid and non-aqueous liquid radioactive wastes.

Our assessment has considered the RP's submission in relation to relevant UK policy, legislation and guidance, including the Environment Agency's Radioactive Substances Regulation (RSR) Environmental Principles (REPs) (Environment Agency, 2010a), the relevant REPs including Radioactive Substance Management Developed Principle 13 (RSMDP13) – Monitoring and Assessment, and Engineering Developed Principle 10 (ENDP10) – Quantification of Discharges. Both principles require best available techniques (BAT) to be used for the activities being carried out.

The information the RP provided for gaseous (main stack on the fuel building) and liquid effluents, focusing on techniques, covers all the required areas associated with the requirements of generic design assessment (GDA). There is also a demonstrated understanding of the issues, and commitments to fulfilling the requirements, that would be addressed in later phases of the new build process if proposals are brought forward.

The information the RP provided on sampling of solid and non-aqueous liquid radioactive wastes is an overview, since the monitoring systems for the waste generation, treatment and conditioning, and storage facilities have only been developed to concept level during GDA. and so will need to be assessed at a later stage. During permitting, more information will be required from a future operator on the specific sampling and monitoring equipment and sampling of solid and non-aqueous liquid radioactive wastes.

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 the site-specific stage.

Our conclusions are that the RP has demonstrated in principle the use of BAT for the UK HPR1000 for both the gaseous and liquid effluent monitoring systems. For the monitoring of solid and non-aqueous liquid radioactive wastes, our conclusion is that the practices being developed appear appropriate for the monitoring of final disposal of these wastes, but a full assessment needs to be carried out when more information has been provided by a future operator.

We have identified 4 Assessment Findings (AFs) that we will expect a future operator to address. These are:

Assessment Finding 33: A future operator shall demonstrate that, before signing the relevant procurement contracts, the selected sampling and monitoring equipment

for determining the discharges are best available techniques, and enable the statutory required levels of detection to be met.

Assessment Finding 34: A future operator shall demonstrate, before reactor commissioning commences, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.

Assessment Finding 35: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.

Assessment Finding 36: A future operator shall address the monitoring post-GDA commitments the Requesting Party identified in the Post-GDA Commitment List, GHX00100084KPGB03GN.

Contents

1. Introduction

This report provides our detailed assessment of the RP's submission in relation to sampling and monitoring in the UK HPR1000 design for GDA purposes. This report is based on the final consolidated set of GDA submissions.

We require the design to use BAT for measuring discharges and for in process measurements to enable any operational UK HPR1000 to:

- compare actual with predicted discharges
- assess whether operation is in accordance with the optimised parameters (BAT envelope)
- assess compliance with permitted limits
- provide good quality data for retrospective dose assessments
- characterise solid waste to enable its disposal by optimal routes
- inform a future operator's actions and decisions

We set out in our P&ID (Environment Agency, 2016) the requirements for a Requesting Party (RP) to provide information to us for assessment. Item 6 of the P&ID requires a description of the sampling arrangements, techniques and systems proposed for measuring and assessing discharges and disposals of radioactive waste. This includes details of the in-process monitoring arrangements, as well as those for final discharges of gaseous and liquid 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 referenced to by the Direction to bring in the recommendation to our regulation: 'The Standardised Reporting of Radioactive Discharges Direction 2018'. The Direction is made under the Environmental Permitting Regulations (EPR) 2016 (as amended) (UK Parliament, 2016) Schedule 23, Part 4, Paragraph 9(3), which brings this recommendation into English law.

This detailed assessment has built on that initial assessment and is based on additional submissions and ongoing technical engagement with the RP . The assessment method, findings and conclusions are presented in the following sections.

Our assessment of the Approach to Sampling and Monitoring submission (GNSL, 2018a) and the supporting submissions generated a number of Regulatory Queries (RQs). A table summarising these RQs and later RQs is provided in the Appendix. Subsequent responses to these RQs and discussions at meetings with the RP have been incorporated into the later revisions of the Approach to Sampling and Monitoring submission (GNSL, 2020a, 2020b and 2021a) and supporting documents. It is recognised that there are still some decisions to be made, for example, the stack height will be determined at the site-specific stage to optimise dispersion based on site-specific parameters, and the actual monitoring equipment will only be specified fully for procurement, so BAT must be demonstrated at that time.

The Environment Agency's initial assessment report (Environment Agency, 2018a) recommended further information on the RP's arrangements, techniques and systems and The RP provided the Approach to Sampling and Monitoring submission (GNSL, 2021a). The items raised for further information at detailed assessment included details of in-process monitoring arrangements and arrangements for monitoring solid waste and non-aqueous waste.

The RP's approach to sampling and monitoring has covered operator monitoring of gaseous and liquid effluent discharges, independent assurance of these, and in-process monitoring. The monitoring systems for the solid 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 provided, with the aim of informing a future operators' decisions so as to minimise radiological impacts on the environment. The sampling arrangements and radiation monitoring systems are designed to achieve the following:

- assess whether the radioactive discharges to the environment are within permitted limits
- provide reliable data to retrospectively assess radiological impacts to the public and the environment
- to inform a future operators' decision so as to minimise radioactive discharges to the environment
- enable a future operator to make informed decisions

We have assessed the supporting arguments the RP provided in its demonstration of BAT.

Operators, when disposing of radioactive waste, need to ensure that the radiological impacts on people are kept as low as reasonably achievable (ALARA), taking into account economic and social factors. This is the 'optimisation requirement'. We expect operators to achieve this by using best available techniques (BAT) in the relation to managing the generation and disposal of radioactive waste (Environment Agency, 2010b).

2. Assessment

2.1. Assessment method

The basis of our assessment was to:

- review the appropriate sections of the Pre-Construction Environmental Report (PCER) and its supporting submissions
- hold technical meetings with the RP to clarify our understanding of the information presented and explain any concerns we had with that information
- raise Regulatory Queries (RQs) to clarify our understanding of the information presented
- raise Regulatory Issues (RIs) or Regulatory Observations (ROs) where we believed the RP did not provide enough information, the details of which are in the Appendix

- assess the techniques the RP proposed for monitoring radioactive disposals against standards and guidance
- decide if there are GDA Issues (GDAIs) at the end of the detailed assessment and Assessment Findings to carry forward from GDA

2.2. Assessment objectives

The assessment considered:

- the sampling arrangements, techniques and systems proposed for measuring and assessing the discharges and disposals of radioactive waste
- the specific nuclides to be monitored and whether systems are adequate to meet required levels of detection
- how monitoring proposals compared to our technical guidance notes (TGNs) M1, LIT 14887 and LIT 55216 (Environment Agency, 2017, 2020a and 2020b, technical guidance available upon request) and relevant international and national standards (for example, BSI, 2010)
- commitment given to our monitoring certification scheme (MCERTS) for current in scope standards (Environment Agency, 2014, 2018b and 2019)
- whether arrangements represented BAT

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

2.3. The Requesting Party's documentation

We referred to the following documents to produce this report, and details of the most recent version of the documents are provided in the References section:

- Pre-Construction Environmental Report Chapter 5 Approach to Sampling and Monitoring (HPR/GDA/PCER/0005).
- Particle Penetration Factor Report for Gaseous Effluent (GH000500001DIYK02GN).
- The CFD Analysis Report for Representative Sampling of Gaseous Effluent (GH000500002DIYK02GN).
- Stack Platform Design Report (GHX06700001DIYK03GN).

2.4. Monitoring gaseous effluents

Monitoring radioactive gaseous disposals is described in the RP's Approach to Sampling and Monitoring submission (GNSL, 2021a), including consideration of BAT. This includes both the approach to in-process and final discharge monitoring. For final discharge monitoring, which is the given scope of GDA, only information on monitoring the main stack of the fuel building has been provided and assessed. Monitoring of other outlets will be assessed at the site-specific stage (for example, waste stores deemed out of GDA scope due to being at conceptual design only).

2.4.1. Final discharge monitoring

The RP has properly considered our requirements that we enforce through EPR 2016 (as amended) (UK Parliament, 2016), both for self-monitoring and provision of additional capacity to allow for independent verification of the discharges.

The RP proposes monitoring and sampling systems will be in place to enable activity concentrations to be determined for:

- total noble gases (krypton-85 will not be measured specifically)
- cobalt-60
- strontium-90
- caesium-137
- total alpha (reported instead of individual alpha emitters) in particulate matter
- iodine-131
- tritium
- carbon-14

Except for combining krypton-85 (main nuclide to represent noble gases) in a total noble gas measurement, all the main radionuclides required to meet required levels of detection are being monitored. The RP provided minimum values of historic data from CGN's nuclear power plants (NPPs), as the instrument type and detection method will be determined at later stages and the detection limits will depend on a number of parameters (including flow rate and sampling period).

Final confirmation that the EPR 2016 (as amended) detection limits will be met will be required at the site-specific stage. The RP states that specific instrumentation is not being detailed at the GDA stage and it is appropriate for the operator to define the instrumentation during the site-specific stage. The laboratory and analytical methods will be for a future operator to determine. We expect that these methods will be accredited to International Standards Organisation ISO 17025 (BSI, 2017) and MCERTS (Environment Agency, 2018b) where applicable. Meeting our requirements, the volumetric flow required to determine the activity discharged will be measured continuously using an appropriate MCERTS accredited technique. As final confirmation is required at the site-specific stage, we have raised an Assessment Finding for a future operator:

Assessment Finding 33: A future operator shall demonstrate that, before signing the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques, and enable the statutory required levels of detection to be met.

The RP proposes that for final discharge reporting there will be 2 gaseous sampling points in the main stack, feeding duplicate sampling and monitoring systems (described below). The main stack has inputs from the heating, ventilation, and air conditioning (HVAC), the gaseous waste treatment system and the condenser vacuum system via the nuclear auxiliary building ventilation system.

The Computational Fluid Dynamics (CFD) Analysis Report for Representative Sampling of Gaseous Effluent (GNSL, 2018c) submission provides a demonstration that BAT will be

adopted to obtain representative gaseous sample in UK HPR1000 design. The CFD analysis indicates that mixing tracer gas and tracer aerosol particle becomes uniform at a height of 54.75m, and recommends that the relevant experimental verification should be completed at this position. The stack height would be confirmed at the site-specific permitting stage, including tests to demonstrate a representative sample can be obtained.

The particle penetration factor is an important parameter to demonstrate that a representative gaseous sample can be received by the monitoring equipment and instrumentation. The Particle Penetration Factor Report for Gaseous Effluent (GNSL, 2018b) submission describes the layout of the sampling and monitoring pipeline and system, and provides a calculated result of the penetration factor for 10 micrometres (μm) aerodynamic diameter (AD) aerosol particles, which meets the requirements of BS ISO2889:2010 (BSI, 2010). Using 10μm AD particles to evaluate the penetration factor is a conservative measure as all ventilation systems discharged to the stack are filtered by high efficiency particulate air (HEPA) filters. The RPL proposes using a shrouded single nozzle sampling probe, which is considered good practice for sampling and collection systems to obtain representative samples for effluent streams containing particulate matter (Environment Agency, 2020a).

The total stack volumetric discharge flow will also be measured at the sampling points within the stack. The exact configuration of the system will be determined during the commissioning phase following the appropriate ISO standards (currently: ISO 10780:1994 [ISO, 1994] and BS ISO 2889:2010 [BSI, 2010]). Additional flow measurements will also be taken on the gaseous systems upstream of the main stack. Two calibration ports, located upstream of the flow meter, are proposed for periodic calibrations tests.

The Stack Platform Design Report (GNSL, 2019a) describes a sampling platform designed to comply with our guidance note, M1 (Environment Agency, 2017) and provided to allow workers safe access to inspect and maintain the sampling equipment, including the calibration ports. We issued an RQ concerning the design life of the sampling platform in the corrosive coastal atmosphere (RQ-UKHPR1000-0211), which resulted in an update to the RP’s submission. The final design will depend on the equipment choice and would be made by a future operator.

The 2 sampling lines each feed separate sampling systems, both systems will be running at the same time, which allows for redundancy. Having duplicate sampling systems also means we or our representatives can verify them independently. This is because one of the systems, including associated pipework valves, could be protected from interference with tamper evident seals, while particulates, iodine, tritium and carbon-14 are independently sampled. The systems have been designed so that this will not affect the quality of the operator’s own data over that period. We issued 3 RQs (RQ-UKHPR1000-0535, 0539 and 0617) concerning how the requirements for tamper-evident duplicate sampling systems for the gaseous systems are met (Environment Agency, 2020a) and back-up equipment and instrumentation provided. The responses to the RQs provided clarity that one sampling system could be used by the operator and the other for independent verification. The duplicate sampling systems provide a back-up for each

other, and resulted in updates to the Approach to Sampling and Monitoring submission (GNSL, 2021a).

In the RP's design, 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 centimetres of charcoal, therefore, there is only a short delay 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 sampling units are expected to be bubbler systems. The required detection limit of krypton-85 will not be achieved and the measurement of total noble gases will be measured instead of krypton-85. Also, the detection limit can normally be obtained by beta-measurement after decay of short-lived isotopes.

It is considered good practice to return the sample downstream of the sample extraction point to prevent either double counting or dilution of the sample (Environment Agency, 2020a). However, the RP has proposed the sample return line be upstream of the extraction point, which saves 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 has been shown to 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 the RP's demonstration of BAT for the design. As the configuration of the sampling lines and the layout and positioning of the monitoring room are not confirmed during GDA, we have raised an Assessment Finding for a future operator:

Assessment Finding 34: A future operator shall demonstrate, before reactor commissioning commences, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.

2.4.2. In-process monitoring

In-process monitoring and sampling arrangements are provided to detect deviation from normal operation sooner than at the point of final discharge. The UK HPR1000 design has 3 types of in-process sampling and monitoring corresponding to the 3 gaseous effluent streams as mentioned previously:

- HVAC: Monitoring of the gaseous effluents in the ventilation air discharged from buildings which may contain low activity concentrations of radioactive material. If the gaseous activity concentration reaches an alarm threshold, the system line is switched to the iodine filtration train, a light-sound alarm is triggered locally and an alarm is displayed in the main control room.
- Gaseous waste treatment system: Monitoring the operation of carbon delay beds by upstream and downstream detectors. If the gaseous activity concentration reaches

an alarm threshold downstream, a light-sound alarm is triggered locally, an alarm is displayed in the main control room, and the event is investigated by the plant operators. They then take appropriate action, including bypassing the first delay bed without impacting the ability of the system to ensure the expected delay time in all circumstances.

- Condenser vacuum system: Monitoring the steam generator tube integrity to detect any leakage of activity into the secondary circuit. If the gaseous activity concentration reaches an alarm threshold, a light-sound alarm is triggered locally, an alarm is displayed in the main control room, and the event is investigated by the plant operators who take appropriate action. In the case of steam generator tube rupture conditions, the main steam system shall isolate the affected steam generator to confine the contaminated fluid.

In each of the 3 gaseous effluent streams, if the gaseous activity concentration reaches an alarm threshold, a local sound-light alarm is triggered, accompanied by an alarm displayed in the main control room. Investigative and corrective actions on activation of an alarm will be defined by a future operator at the site-specific stage.

We issued 3 RQs concerning the in-process monitoring and associated systems. The RQs concerned the management of the carbon delays beds (RQ-UKHPR1000-0429), confirmation of where alarms relay to (RQ-UKHPR1000-0432) and clarification on the selection of the type or in-process monitor (RQ-UKHPR1000-0433). The responses to the RQs improved the demonstration of BAT by providing additional information for how the in-process monitoring prompts a response to protect the environment, including bypassing the first delay bed without impacting the ability of the system to ensure the expected delay time in all circumstances. The RQ responses resulted in updates to the Approach to Sampling and Monitoring submission (GNSL, 2021a) and some associated supporting submissions.

2.5. Monitoring liquid disposals

Monitoring radioactive liquid disposals is described in the RP's Approach to Sampling and Monitoring submission (GNSL, 2021a), including considering BAT. This includes both the approach to in-process and final discharge monitoring.

The RP has properly considered our requirements that we enforce through EPR 2016 (as amended) (UK Parliament, 2016), both for self-monitoring of levels of radioactivity and provision of additional capacity to allow for independent verification of the discharges.

The RP proposes that monitoring and sampling systems will be in place to enable activity concentrations to be determined for tritium, carbon-14, cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters). All the main radionuclides required to meet statutory requirements will be 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 would be finalised at site-specific stages, the RP has provided reference values indicating required detection limits can be met using currently available systems.

Final confirmation that the required detection limits will be met would be required at the site-specific stage. The RP states that specific instrumentation is not detailed at the GDA stage and it is appropriate for the operator to define the instrumentation during the site-specific stage. The laboratory and analytical methods chosen will be for future operators, and we expect that these will be accredited to ISO 17025 (BSI, 2017) and MCERTS (Environment Agency, 2018b) where applicable. Meeting our requirements, the volumetric flow, required to determine the activity discharged, will be measured continuously using an appropriate MCERTS accredited technique. As final confirmation is required at the site-specific stage, we have raised an Assessment Finding for a future operator:

Assessment Finding 33: A future operator shall demonstrate that, before signing the relevant procurement contracts, the selected sampling and monitoring equipment for determining the discharges are best available techniques, and enables the statutory required levels of detection to be met.

The final discharge line receives liquid disposals from 2 sampling locations downstream of the liquid waste treatment sub-systems. The 2 sampling locations are in the nuclear island liquid waste discharge system and conventional island liquid waste discharge system and each of these systems contains 3 storage tanks. The nuclear island liquid waste discharge system mainly receives liquid waste from the liquid waste treatment system, which contains tanks for process, chemical, floor and laundry drains, and treatment systems, including demineralisers, evaporators, and filters. The conventional island liquid waste discharge system receives liquid waste from the steam generator blowdown system and the waste fluid collection system for the conventional island.

When a storage tank is full it is manually isolated and locked to prevent additional input. We issued an RQ concerning the controls and interlocks on storage tanks (RQ-UKHPR1000-0633). The RQ response provided clarity on the environmental protection function that the controls and interlocks provided, and resulted in an update to the Approach to Sampling and Monitoring submission (GNSL, 2021a). A sample is collected once the storage tank is mixed and the sample is analysed to confirm it is below the permitted activity concentration, before being discharged. The discharge valve is interlocked with the inlet isolation valves of the tank to prevent liquid waste being discharged without being sampled and confirmed appropriate for discharge. The system is designed to prevent uncharacterised liquid waste being discharged into the environment. In-process sampling and monitoring arrangements are also provided for the liquid effluents in the discharge upstream systems, including the liquid waste treatment system, the coolant storage and treatment system and the steam generator blowdown system.

As we require, the RP has committed to the final accountancy samples being taken via flow proportional sampling systems on the final discharge line. This gives an accurate record of the volume and activity discharged. The RP 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. The discharge flow is also measured at this point using an appropriate MCERTS accredited technique.

We issued 3 RQs (RQ-UKHPR1000-0535, 0539 and 0617) concerning the provision of independent sampling facilities (Environment Agency, 2020b) and back-up provision for equipment and instrumentation. The responses to the RQs detailed how the flow proportional samplers and flow measurement apparatus will be provided for both the nuclear island liquid waste discharge system and conventional island liquid waste discharge system systems. These will allow us or our representatives to independently verify them, as we require. Each discharge system will have a single sampler and flow measurement apparatus with sufficient capacity for both the operator's sample and the independent sample. Operational experience from Sizewell B and Hinkley Point C shows that providing duplicates will be technically difficult to incorporate into the design, adding an additional maintenance and testing burden to the operator. The 3 storage tanks for each of the nuclear island liquid and conventional island liquid waste discharge systems will have the necessary storage capacity if the sampler and flow measurement are unavailable. The capacity has been calculated considering a period of unavailability of the processing or discharge and the maximum volume generated by the 'most constraining event' (maximum volume generated over the shortest period) (GNSL, 2020c).

In addition to sample collection, a continuous radiation monitor is provided in the liquid discharge line. If the system detects an elevated radiation level, it activates an alarm and closes an isolation valve to stop discharge to the environment. A manual valve is also fitted to enable the operator to stop the discharge if required.

2.6. Monitoring solid and non-aqueous liquid waste disposals

Monitoring radioactive solid and non-aqueous liquid waste disposals is described in the RP's Approach to Sampling and Monitoring submission (GNSL, 2021a), including considering BAT. This includes a description of the sampling and monitoring arrangements for solid and non-aqueous liquid waste carried out at different stages in the complete waste cycle for the UK HPR10000 design, including proposed techniques. The stages include at or close to the point of production, before processing, after processing (before and during storage), and before transfer to retrieval/repackaging or disposal or off-site treatment facilities.

The arrangements for monitoring solid and non-aqueous liquid waste have only been developed to a concept level during GDA as the design scope of solid and non-aqueous waste storage facilities is limited to concept design for GDA (GNSL, 2019b). Information on the solid and non-aqueous sampling and monitoring processes has taken account of relevant guidance, including guidance from the International Atomic Energy Agency (IAEA) (IAEA 2009a and 2009b). This gives reassurance that the practices being developed are expected to be appropriate. As the arrangements for monitoring solid and non-aqueous liquid waste have only been developed at a concept level during GDA, we have raised an Assessment Finding for a future operator:

Assessment Finding 35: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.

We issued an RQ (RQ-UKHPR1000-0633) concerning the sampling and monitoring of waste packages to demonstrate decay and whether the waste packages meet the requirements for disposal. The response to the RQ described the process to determine the waste characteristics and confirm the waste category, calculate the expected decay time, apply appropriate conditioning and packaging, storage in the relevant area, monitoring and inspection, recording of information and retrieval for disposal or further storage once the package has decayed to a lower category. The response to the RQ also resulted in an update to the Approach to Sampling and Monitoring submission (GNSL, 2021a).

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.

2.7. Monitoring matters for future operator

The following list of forward action plans (FAPs) is adapted from the Approach to Sampling and Monitoring (GNSL, 2021a) submission and shows the areas that a future operator will need to address at the site-specific stage.

- The representative sampling of gaseous effluent will be reviewed according to the specific height of stack at the site-specific stage.
- Calculation of the total transmission efficiency of the sampling lines for UK HPR1000 will be performed at the site-specific stage when detailed design information will be available.
- Commitment to use MCERTs accredited flow proportional sampler for pressurised system if such equipment is available.
- Use of appropriate measurement equipment and measurement methods to meet the requirement of detection limits.

The forward action plans the RP identifies related to activities carried out during the site-specific stage. For example, the stack height will be decided at the site-specific stage to optimise dispersion based on site-specific parameters, and the monitoring equipment will only be specified fully for procurement, so BAT must be demonstrated then. The list of FAPs is included in the Post-GDA Commitment List (GNSL, 2021b) submission along with other BAT relevant commitments from sources, including RQs and technical meetings. We have raised an Assessment Finding to capture the identified BAT commitments in the Post-GDA Commitment List:

Assessment Finding 36: A future operator shall address the monitoring post-GDA commitments the Requesting Party identified in the Post-GDA Commitment List, GHX00100084KPGB03GN.

3. Compliance with Environment Agency requirements

The requirements set out in our P&ID and REPs (Environment Agency, 2016a and 2010) are shown below:

- P&ID Item 6: Sampling arrangements and techniques for assessment of discharges and disposal of solid waste. The RP provided details of gaseous and liquid in-process and discharge monitoring. Also, an overview of proposed solid waste and non-aqueous liquid monitoring and a demonstration of BAT. The RP has provided reference values, indicating the required detection limits can be met using currently available systems. Final confirmation that the required detection limits will be met will be required at the site-specific stage. In meeting statutory requirements, the RP has indicated that compliance with the proposed limits is achievable.
- RSMDP9 – Characterisation (Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal). The characterisation of waste is discussed at a high level in the RP's documentation and will need to be developed by a future operator and demonstrated to be BAT.
- 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 have been considered and provision has been made to allow for independent regulatory check monitoring of discharges. An environmental monitoring programme is, inherently, site-specific and is not included in the scope of GDA.
- ENDP4 – Environmental protection function 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 carry out these functions). Details of the monitoring systems designed to detect radiation levels during normal and fault conditions are provided. Interlocks are in place to protect the environment.
- 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 main gaseous discharge route and only liquid discharge route have been designed to allow for BAT for quantifying discharges. A future operator will need to specify the exact monitoring equipment (to take account of technological advances between GDA and construction). Identifying any other gaseous discharge routes requiring monitoring has also been left to a future operator. Early warning systems are in place for abnormal radiation levels.
- ENDP14 – Control and instrumentation – environmental 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). There is in-process monitoring that allows for an understanding of the state of the facility and enables decision-making. The provision of an environmental monitoring programme is not a requirement of GDA.

4. Public comments

4.1. General Nuclear System Limited's public comments process

General Nuclear System Limited (GNSL) received no public comments up to 17 September 2021 concerned directly with sampling and monitoring.

4.2. Environment Agency public consultation

We held a public consultation on our preliminary GDA Assessment Findings (Environment Agency, 2021 a and b), which ran for 12 weeks, from 11 January to 4 April 2021. We received several consultation responses, all of which have been published (https://consult.environment-agency.gov.uk/nuclear/assessing-new-nuclear-power-station-ukhpr1000). Our replies to each point raised are presented within our decision document (Environment Agency, 2022).

We received a response (UK HPR1000-017) from a Bradwell resident concerning the inclusion of an environmental monitoring programme during GDA. An environmental monitoring programme is not included within the scope of GDA due to the site-specific nature of such monitoring. The requirements for an environmental monitoring programme would be addressed at site specific permitting.

We received a response (UK HPR1000-043) concerning the management of the liquid waste treatment system within the discharge limits, and operator monitoring and independent sampling. The RP has provided reference values indicating statutory detection limits can be met using currently available systems. In meeting statutory requirements, the RP has indicated that compliance with the proposed limits is achievable. Also, in addition to sample collection, a continuous radiation monitor is provided in the liquid discharge line. If the system detects an elevated radiation level, it activates an alarm and closes an isolation valve to stop discharge to the environment. A manual valve is also fitted to enable the operator to stop the discharge if required. In response to the operator monitoring and independent sampling question, the RP has properly considered our requirements that we enforce through EPR 2016 (as amended) (UK Parliament, 2016), both for self-monitoring of levels of radioactivity and provision of additional capacity to allow for independent verification of the discharges.

We received a response (UK HPR1000-047) concerning the lack of clarity of BAT and the provision of publicly available guidance, operational procedures for isolation valves and inclusion of an environmental monitoring programme during GDA. The principles of optimisation guidance (Environment Agency, 2010b) provides guidance to our regulators and to operators on optimising the management of generating and disposing of radioactive waste. Internal Environment Agency guidance on monitoring of radioactive discharges to

atmosphere and water (Environment Agency, 2020a and 2020b respectively) can be made available to anyone on request. The RP has been clear where the design has deviated from the guidance for the gaseous sample return line and demonstrated the impact is negligible, but with a beneficial reduction in solid waste at decommissioning. Operational aspects are addressed at the planning and permitting stage following the GDA stage.

Following careful consideration of the comments received there are no changes to the conclusions we set out in our consultation assessment report.

5. Conclusion

For the UK HPR1000 gaseous effluent monitoring system we have concluded that:

- BAT has been demonstrated in principle for monitoring systems at a level acceptable for GDA
- 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 carried out
- 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 HPR1000 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 carried out
- appropriate analysis will be carried out
- appropriate provision will be made to allow for independent regulatory verification of the liquid monitoring and discharge reporting

For the UK HPR1000 monitoring of solid and non-aqueous liquid waste, our conclusion is that the practices being developed appear appropriate for monitoring final disposal of wastes, but a full assessment would need to be carried out at a site specific stage. More information will be required on the specific sampling and monitoring equipment and sampling of solid and non-aqueous liquid waste, as a detailed design progressed.

We have identified 4 Assessment Findings:

Assessment Finding 33: A future operator shall demonstrate that, before signing the relevant procurement contracts, the selected sampling and monitoring equipment

for determining the discharges are best available techniques, and enable the statutory required levels of detection to be met.

Assessment Finding 34: A future operator shall demonstrate, before reactor commissioning commences, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to comply with ISO2889 and the use of best available techniques.

Assessment Finding 35: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid and non-aqueous liquid waste are best available techniques.

Assessment Finding 36: A future operator shall address the monitoring post-GDA commitments the Requesting Party identified in the Post-GDA Commitment List, GHX00100084KPGB03GN.

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List of abbreviations

AD	Aerodynamic diameter
AF	Assessment Finding
BAT	Best available techniques
CFD	Computational fluid dynamics
CGN	China General Nuclear Power Group
ENDP	Engineering Developed Principle
EPR	Environmental Permitting Regulations
GDA	Generic design assessment
GDAI	GDA Issue
GNSL	General Nuclear System Limited
HEPA	High efficiency particulate air
HPR	Hualong Pressurised Reactor
HVAC	Heating, ventilation and air-conditioning
IAEA	International Atomic Energy Agency
ISO	International Standards Organisation
JPO	Joint Programme Office
MCERTS	Monitoring certification scheme
NPP	Nuclear power plants
ONR	Office for Nuclear Regulation
P&ID	Process and Information Document
PCER	Pre-Construction Environmental Report
REP	RSR Environmental Principles
RI	Regulatory Issue
RO	Regulatory Observation
RP	Requesting Party

RQ	Regulatory Query
RSMDP	Radioactive Substance Management Developed Principle
RSR	Radioactive Substances Regulation

Glossary

BAT envelope

The set of limits and conditions within which the station must be operated to ensure conformance with the BAT demonstration, upon which the design was assessed and which can be monitored by or on behalf of the operator.

Appendix: Summary of Regulatory Queries relating to monitoring

The following list summarises the RQs that are most relevant to monitoring for the UK HPR1000. There are no Regulatory Observations (ROs) or Regulatory Issues (RIs) relevant to monitoring.

Revision 2 of the Approach to Sampling and Monitoring submission (GNSL, 2021a) and supporting submissions is intended to address the results of addressing any RQs at that time.

Note that ROs and RIs are published on the ONR website, along with resolution plans. RQ information is not published, but all RQs relevant to monitoring are summarised below. Progress against each has been discussed at technical level meetings with the RP.

- RQ-UKHPR1000-0211 (13 February 2019): Lifetime of the stack platform design. We requested further information on the design life of the stack platform and whether the material selection has factored in the potential corrosive coastal atmosphere.
- RQ-UKHPR1000-0432 (13 August 2019): Discharge monitor alarms. We requested further information on:
    - which gaseous and liquid discharge alarms are relayed to the control room and which alarm locally
    - clarification on the use of 'permitted limit' in terms of internal limit or future site permit limit
    - why some discharge valves are automatic and some are manual, and whether the environmental protection function of the valve has been considered in the valve selection process
- RQ-UKHPR1000-0433 (13 August 2019): Discharge monitor selection during design. We requested further information on:
    - substantiating the selection of the type of in-process monitor with respect to the anticipated radionuclides
    - evidence for considering the expected non-radiological species in the system for the design life of the sampling and monitoring system
- RQ-UKHPR1000-0535 (13 November 2019): Equipment availability. We requested further information on the back-up provision for equipment and instrumentation, on the gaseous and liquid discharge routes, which provide an environmental protection function as a result of maintenance activities or from normal operations.
- RQ-UKHPR1000-0539 (13 November 2019): Independent sampling. We requested further information on how the UK HPR1000 design will meet the requirements for tamper-evident duplicate sampling systems for the gaseous and liquid systems.
- RQ-UKHPR1000-0617 (27 January 2020): Duplicate independent sampling. We requested further information on:
    - how the duplicate final discharge liquid samples will be collected when required for both the operator and regulator

    - confirmation that the UK HPR1000 design's sampling systems can provide sufficient gaseous and liquid samples to determine all discharges and disposals from the facility at the required levels of detection, including when the gaseous and liquid samples are divided for the operator and regulator
- RQ-UKHPR1000-0633 (12 February 2020): Sampling and monitoring - general queries. We requested further information on:
    - the solid waste and non-aqueous liquid waste sampling and monitoring arrangements' codes and standards that the design is based on and demonstration that they apply to UK requirements
    - how decay storage of waste will be demonstrated via sampling and monitoring of packages
    - the arrangements for monitoring and sampling before disposal and to assess whether the waste packages meet the requirements for disposal
    - progress of demonstrating representative sampling of gaseous effluent
    - the controls and interlocks in place to stop a storage tank receiving more liquid once it has reached a predetermined value and the liquid in the storage tank is recirculating before sampling and discharge
    - feasibility of long count times for discharge sample analysis
    - capture of commitments as forward actions plans

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