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REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0036
RO Title:	HEPA filter type
Technical Area(s)	Environmental
Revision:	0
Overall RO Closure Date (Planned):	2020-10-31
Linked RQ(s)	RQ 0194/0514
Linked RO(s)	
Related Technical Area(s)	Mechanical Engineering, Radiological Protection, Radwaste, Decommissioning & Spent Fuel Management
Other Related Documentation	GHX08000003DCNT03TR

Scope of Work

Background

The Pre-Construction Environmental Report (PCER) Chapter 3 (Ref. 1) discusses the minimisation of the radioactivity of gaseous radioactive waste discharges by optimising the Heating, Ventilation, and Air Conditioning (HVAC) system including the provision of High Efficiency Particulate Air (HEPA) filters to reduce the concentration of radioactive aerosols.

Interactions with the Requesting Party (RP) concerning HEPA filter type include Regulatory Query (RQ) 0194 'Management of Aerial Filtration Systems' issued by the Environment Agency (Ref. 2) and RQ 0514 'Justification for the use of Rectangular HEPA Filters' issued by the Office for Nuclear Regulation (Ref. 3):

- *RQ 0194 included a query concerning the type of HEPA filters selected for the design;*
- *RQ 0514 contained four queries regarding HEPA filter type. These concerned:*
  - *quantifying the effects on building volume and space layout that would result from a change from rectangular to cylindrical HEPA filters,*
  - *how rectangular HEPA filters are optimised to prevent by-pass leakage,*
  - *quantifying the differences in HEPA filter waste volumes that would be generated over the operating and decommissioning lifetime of a UK HPR1000 reactor, noting that UK RGP is that HEPA filters are replaced after a maximum of 10 years, and;*
  - *requesting examples of the uneven airflow of cylindrical filters and how this causes problems in measuring the differential pressure compared to rectangular filters.*

In response to RQ 0194, the RP stated that rectangular HEPA filters are used. The RQ response indicated knowledge that cylindrical HEPA filters are recommended in the UK and stated that a topic report on

optioneering of the HEPA filter type (rectangular versus cylindrical) would be submitted in July 2019. The submitted Optioneering Report of the HEPA Filters Types (Ref. 4) concluded that, "After the comparison process between cylindrical type and rectangular type, the preferable type of HEPA filters in UK HPR1000 is rectangular HEPA filters". The optioneering report did not assign weighting to the criteria used to indicate their relative importance in the decision making process and the analysis would have benefited from more narrative.

In response to the four queries in RQ 0514, the RP stated that their investigations will be carried out before June 2020 which could result in the Environment Agency having a potential Generic Design Assessment (GDA) issue relating to the use of HEPA filters at Public Consultation (Ref. 5).

In the UK, cylindrical HEPA filters are preferred due to better sealing efficiency compared with rectangular HEPA filters, which reduces bypass leakage and waste volumes and thus are also better for safe change maintenance procedures (Ref. 6). Bypass leakage can result in fugitive discharges and exposure to the worker. Increased sealing efficiency reduces the potential for filter wastage resulting from failed filter tests and five cylindrical HEPA filters fit into a standard 200 litre disposal drum reducing radioactive waste (Ref. 7). The optioneering report (Ref. 4) assumed that the same number of filters will be used and did not take into account filter wastage as a result of failed filter tests.

This Regulatory Observation (RO) has therefore been raised to:

- *Explain the regulator's expectations;*
- *Ensure the RP provides a robust optioneering study and justification for the choice of HEPA filter type;*
- *Obtain confidence that adequate evidence will be provided by the RP to support the claims and arguments made in the PCER;*
- *Demonstrate to the regulators that the minimisation of the radioactivity of gaseous radioactive waste discharges by the optimisation of the HVAC system including the provision of HEPA filters to reduce the concentration of radioactive aerosols is Best Available Techniques (BAT).*

Scope of work

This Resolution Plan describes the current plan to address RO-UKHPR1000-0036. It contains the planned activities and deliverables, milestones and timescales.

Deliverable Description
The original design and associated arrangements for high efficiency particulate air (HEPA) filters in UK version of the Hua-long Pressurised Reactor (UK HPR1000) take the Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power plant unit 3 (HPR1000 (FCG3)) as a reference. HPR1000, a 3rd generation Pressurised Water Reactor (PWR) technology, is developed from experience and OPEX from

Chinese PWRs taking into account worldwide OPEX and improvements from 2nd generation PWRs. International experiences shows that rectangular HEPA filters have been widely used in China, France, and US PWR ventilation systems. They are also used at Sizewell B (SZB) and are planned to be used at Hinkley Point C (HPC) PWRs.

In the UK, the recommended type of HEPA filter for new plants is cylindrical type filters, as per paragraph 5.43 of TAG-022 (reference [8]). “Cylindrical rather than rectangular high efficiency particulate air (HEPA) filters are generally preferred for new plants to reduce by-passing and waste volumes. These should also be more appropriate for safe change philosophies”.

In this resolution plan, the RP will adopt an appropriate methodology to demonstrate BAT for the choice of HEPA filter and ensure all ways to optimise the design have been considered and implemented as relevant. The strategy to respond to ROA1, ROA2, ROA3 and ROA4 is described below.

Note: Due to the high level of uncertainty associated with the need in terms of HEPA filters during the decommissioning phase and the techniques that will be available by that time, the work carried out as part of this RO will focus on the operational phase.

RO-UKHPR1000-0036.A1 – Comprehensively evaluate the choices of HEPA filter

In response to this Action, the RP should:

- *Provide a comprehensive evaluation of the choices of HEPA filter using a process including consideration of the weighting to criteria to highlight their importance in the decision making process to demonstrate BAT;*
- *Clearly state the assumptions made during optineering including frequency of filter change, expected activity loading, required flow through the filters, reliability, failure rates, etc.*

Resolution Plan for ROA1

In order to undertake a robust assessment of the two options (rectangular vs. cylindrical), it is necessary to define an overall set of criteria, considering both ALARP and BAT principles. The detailed methodology and instruction on ALARP and BAT principles should be complied with, references [10], [11], [12] and [13].

On the basis of experience and good practice presented in reference [14], a set of safety, technical, environmental protection and cost criteria will be identified, which are to be considered to assess performance of the options and identify differences in performance between options.

Criteria have been preliminary identified via plenary discussion with all relevant disciplines, and measures of each criterion determined. These criteria and associated attributes are listed below, these may be subject to change in the final assessment:

Criteria	Attributes
Safety	Nuclear safety
	Operator dose
	Conventional safety
	Fire safety
	Human factor
Technical	Technical maturity
	Compliance with RGP and OPEX
	Ease of implementation
	Ease of operation and maintenance
Environmental protection	Generated solid waste (spent HEPA filters)
	Waste management and disposed volume
	Radioactive discharges and environmental impact
Cost	Modification cost
	Operation and maintenance cost

An appropriate method, e.g. qualitative multi-attribute decision assessment (MADA) methodology or Red, Amber, Green (RAG) assessment methodology will be used to assess the options against the selected set of criteria/attributes to determine the preferred option that represents both BAT and ALARP. The specific methodology used in the optioneering report will be sufficiently justified. The level of detail of the discussion and analysis made in the optioneering report will add appropriate weight to the conclusions made, regardless of the method used to compare the options.

Once the options assessment is finished, a decision-making workshop will be carried out to determine the preferred option for GDA that will then be implemented.

In summary, the plans to resolve this action include:

1) Define criteria and develop the attributes of each criterion;

2) Define the scoring standard for each attribute;

3) Evaluation of the different options;

4) Select the preferable option to recommend and review the recommendation;

5) Select appropriate decision-making body;

6) Present recommendation to the decision-making body;

7) Record the decision;

8) Implement the decided option.

Relevant disciplines' SQEP staff such as BAT, ALARP, waste disposal, HVAC and layout etc. will participate the optioneering process and decision-making workshop.

The entire optioneering process and result described above will be documented clearly in the *Optioneering Report of the HEPA Filters Types*.

The assumptions used in the optioneering process will be presented clearly in the optioneering report. The assumptions will be based on the OPEX, manufacturers' data and public papers where this information is available.

RO-UKHPR1000-0036.A2 – Demonstrate the selection of HEPA filter has considered the prevention of fugitive discharges by optimisation of the sealing efficiency

In response to this Action, the RP should:

- *Provide adequate supporting evidence comparing how rectangular and circular HEPA filters are optimised to prevent by-pass leakage.*

Resolution Plan for ROA2

The HEPA filters are normally installed on the exhaust duct of the ventilation systems of the nuclear power plant controlled areas to filter the (radioactive) aerosol in the air and limit the discharge of radioactive materials to environment.

The actual efficiency of the HEPA filter is related to the filtration performance of the equipment itself and the by-pass leakage related to sealing performance. As the service time of the HEPA filter in the ventilation system increases, the actual efficiency of the HEPA filter will inevitably decrease. In UK HPR1000, in order to ensure an optimal efficiency of HEPA filters and notably minimise the by-pass leakage, the actual efficiency of the HEPA filter is periodically checked through periodic tests. OPEX-based operation management procedures are also considered.

For this action, the following work will be carried out:

First, gather the inputs for the assessment of rectangular and cylindrical HEPA filters against defined criteria/attributes, including:

1) The airflow of each ventilation system in the UK HPR1000 ventilation system;

2) Minimum requirements for HEPA filter efficiency;

Then, carry out comparison on the following aspects:

1) Assess and compare the filtration performance of the two types of HEPA filters, using information from codes & standards, equipment procurement requirements, publicly available publications and actual supplier data, as relevant and available;

2) Assess and compare the sealing types and failure mechanisms leading to by-pass leakage for the two types of HEPA filters,

3) Assess and compare the operation management measures to be adopted for the two types of HEPA filters to prevent by-pass leakage;

Noting that the information needed to perform the above work may be limited for cylindrical HEPA filters as rectangular HEPA filters are used in PWRs in China, France and the UK and cylindrical HEPA filters are used in the UK at some non-PWR plants. Where necessary, relevant, reasonable assumptions will be made, with due consideration of the limitations and uncertainties introduced by the limited data and / or assumptions.

The above work and the outcomes will be documented clearly in the *Optioneering Report of the HEPA Filters Types*.

RO-UKHPR1000-0036.A3 – Assess what impact the choice of HEPA filter has on the volume and disposability of the radioactive waste over the operational lifetime of a UK HPR1000 reactor

In response to this Action, the RP should:

- *Provide an appropriate degree of robust supporting evidence to compare the volume and disposability of radioactive waste from the rectangular and cylindrical HEPA filters, to include where appropriate the use of international OPEX and noting that UK RGP is that HEPA filters are replaced after a maximum of 10 years.*

Resolution Plan for ROA3

To ensure good efficiency of HEPA filters, the HEPA filters installed in the ventilation system will be replaced when they meet the operating change criteria. The spent HEPA filters, classified as low level radioactive waste (LLW), are to be managed and disposed of to appropriate UK facilities.

To resolve this action, the work plan includes:

1) Collect information on the configuration of the HEPA filters in the UK HPR1000 ventilation systems, including the airflow of each ventilation system and the number of installed HEPA filters, etc.
2) Identify the change criteria of HEPA filters in the UK HPR1000 ventilation systems;
3) Collect the characteristics of HEPA filters, such as rated airflow, dimension, initial pressure drop and filter media characteristics. Where this information is not readily available, reasonable assumptions will be made.
4) Identify the factors that affect the frequency of HEPA filters replacement;
5) Assess and compare, based on above information, the waste generation (replaced HEPA filters) for the two types of HEPA filters to provide the robust evidence to support the optioneering process. Where OPEX is not readily available, reasonable assumptions will be made and UK RGP in filter replacement will be considered.
6) Collect waste route information on HEPA filter in UK;

7) Assess and compare the waste management strategy and final volume of waste to be disposed for the two types of HEPA filters based on relevant input or assumptions.

Noting that cylindrical HEPA filters are not used in UK, US, China and France PWRs ventilation systems, see references [9], [15], [16] and [17], the comparison will be conducted based on current available OPEX and reasonable assumptions.

The above work and the outcomes will be documented clearly in the *Optioneering Report of the HEPA Filters Types*.

RO-UKHPR1000-0036.A4 – A demonstration of BAT for the choice of HEPA filter

In response to this Action, the RP should:

- *Provide a demonstration of BAT for the choice of HEPA filter to protect people and the environment*

Resolution Plan for ROA4

The whole optioneering process will be a process to demonstrate that the choice of HEPA filter type is ALARP and BAT. In addition, the entire process of the choice of HEPA filter will be documented clearly in the optioneering report. This optioneering will be summarised in the PCER Chapter 3 and PCSR Chapter 10.

The optioneering report will be updated and submitted before 30/06/2020.

Impact on the GDA Submissions

The information will be incorporated into Optioneering Report and summarised in PCER Chapter 3 and PCSR Chapter 10. The documents impacted by this resolution plan are as follows:

GDA Submission Document	Related ROAs	Planned schedule for submission
Optioneering Report of the HEPA Filters Types (Revision C)	ROA1, ROA2, ROA3, ROA4	June 30th 2020
PCER Chapter 3 V1.1	ROA1, ROA2, ROA3, ROA4	Oct. 07th 2020
PCSR V1 Amendment Report for EA Public Consultation	ROA1, ROA2, ROA3, ROA4	Oct 07th 2020

Timetable and Milestone Programme Leading to the Deliverables

See attached Gantt Chart in APPENDIX A.

Reference

References

[1] CGN, UK HPR1000, Pre-Construction Environmental Report Chapter 3 - Demonstration of BAT GHX00510003KPGB02GN, Revision 001, January 2020

[2] UK HPR1000, RQ 0194 Management of Aerial Filtration Systems, March 2019

[3] UK HPR1000, RQ 0514 Justification for the use of Rectangular HEPA Filters, November 2019

[4] UK HPR1000, Optioneering Report of the HEPA Filters Types, GHX08000003DCNT03TR, Revision A, July 2019

[5] Environment Agency Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, v3 October 2016.

[6] National Nuclear Ventilation Forum (NNVF), ES_0_1738_Issue 1, Ventilation Systems for Radiological Facilities, Design Guide, Issue 1, December 2018

[7] Nuclear ventilation High Efficiency Particulate Air (HEPA) - Lessons learned, DOE, USA, 1998

[8] Office for Nuclear Regulations, Nuclear Safety Technical Assessment Guide, NS-TAST-GD-022, Revision 5, April 2017

[9] [redacted] Circular HEPA Filters for use in Nuclear Containment and Ventilation Systems, Proceedings of the 25th DOE/NRC Nuclear Air Cleaning and Treatment Conference, Minnesota, August 3-6, 1998

[10] CGN, ALARP Methodology, GHX00100051DOZJ03GN, rev C, 2020

[11] CGN, ALARP Demonstration Instruction, GHX00100119DOZJ03GN, rev A, 2019

[12] CGN, BAT Methodology, GHX00100055DOHB03GN, rev C, 2018

[13] CGN, BAT Application Work Instruction for GDA Project, GH-30E-010, rev A, 2019

[14] Nuclear Industry Safety Directors Forum, Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Wastes, Issue 1, December 2010

[15] [redacted] ASME AG-1 Section FK Radial Flow HEPA Filters; Requirements and Considerations, 34th-NACC, June 5-7, 2016, San Antonio, TX

[16] CGN, BSY27200001DCNT44DS, Technical specification of HEPA filters for FCG3 (the reference plant for UK HPR1000, rectangular HEPA filters used), Rev. D, 2017

[17] FRAMATOME, PL227230A10FNEU44DD, Casing for 1 HEPA Filter Horizontal Axis Reference:2 DVC 002 FA (LingAo plant document, the 2nd generation plant, rectangular HEPA filters used, same with the CPY, France technology), Rev. A, 1998

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APPENDIX A RO-UKHPR1000-0036 Gantt Chart

Task and Schedule		2020								
		Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
RO Action 1, Action 2, Action 3 and Action 4										
1	Development of deliverable-[Optioneering Report of the HEPA Filters Types (Rev.C)]									
2	Submission of deliverable-[Optioneering Report of the HEPA Filters Types (Rev.C)]			▲						
Assessment										
3	Regulatory Assessment									
4	Target RO Closure Date							▲		