RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**251-8320**
SRP Section:	**06.05.01 - ESF Atmosphere Cleanup Systems**
Application Section:	
Date of RAI Issue:	**10/16/2015**

Question No. 06.05.01-1

Other than DCD Tier 2, Section 6.5.1 committing to meet the guidance in Regulatory Guide (RG) 1.52, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," the staff determined that there was insufficient detailed information in the DCD regarding the carbon adsorbers to demonstrate conformance to the provisions of RG 1.52. Please provide in DCD Section 6.5.1 the following information on design or testing:

1. The maximum charcoal loading for the adsorbent trains.
2. Design consideration of iodine desorption and adsorbent auto-ignition.
3. Carbon laboratory test method - If it is ASTM D-3803-1989, please state that in the DCD.
4. Total activated carbon bed depth.
5. The Methyl Iodine Penetration Acceptance Criterion while performing laboratory test for carbon adsorbers.

Also, the staff determined that there was insufficient detailed design information to verify how the specific RG 1.52 guidance is met for the HEPA filters to have sufficient design margin to accommodate fission product loading during an accident without restricting the flow rate. The increase in pressure drop between the clean and dirty conditions for the any of the ESF adsorber units should be within the normal expected pressure increase for a typical filtered exhaust fan design.

Response

1. The carbon adsorber is designed for a maximum loading of 2.5 milligrams of total iodine (radioactive plus stable) per gram of activated carbon. No more than 5 percent of the impregnant (50 milligrams of impregnant per gram of carbon) is used. DCD Tier 2, Subsection 6.5.1.2.2.e will be revised to include the maximum loading of the carbon adsorber.

2. The temperature of carbon adsorbent shall not exceed the design limiting temperature of 300 °F due to radioactivity-induced heat in the adsorbent to prevent iodine desorption in accordance with Section 4.10 of ASME N509. Also, the temperature of the carbon adsorbent shall not exceed the ignition temperature of the carbon adsorber, 626 °F in accordance with Section FF of ASME AG-1.

   The greatest amount of iodine is captured in the carbon adsorber of the control room emergency makeup air cleaning unit (ACU) and the auxiliary building controlled area emergency exhaust ACU under loss of coolant accident (LOCA) conditions. Based on an analysis of the capture of radioactive iodine (elemental iodine and organic iodine) during 720 hours, the maximum radioactivity-induced heat in the adsorbent in the engineered safety feature (ESF) ACUs is as follows:

   - Control room emergency makeup ACU : 0.14 watts
   - Auxiliary building controlled area emergency exhaust ACU : 16.3 watts

   This maximum radioactivity-induced heat is produced in the auxiliary building controlled area emergency exhaust ACU under LOCA conditions. The maximum amount of radioactivity-induced heat within 720 hours is 16.3 watts. The maximum local temperature inside the carbon adsorber is around 220°F with the ACU fan shut down and the isolation dampers of the inlet and outlet closed. This temperature is well below the design limiting temperature to prevent iodine desorption, 300°F and the ignition temperature of the carbon adsorber, 626 °F.

   DCD Tier 2, Subsection 6.5.1.2.2.e will be revised to include the ignition temperature and the design limiting temperature to prevent iodine desorption.

3. The laboratory tests for carbon adsorbers are performed in accordance with NRC RG 1.52. Testing is conducted in accordance with ASTM 3803-1991(R2009). DCD Tier 2, Subsection 6.5.1.4.2 will be revised to include the carbon laboratory test method. Also, DCD Tier 2, Subsection 6.5.7 will be revised to include ASTM 3803-1991.

4. Each carbon adsorber of the ESF filter systems contains a four inch bed depth. DCD Tier 2, Subsection 6.5.1.2.2.e will be revised to include the activated carbon bed depth of the ESF filter systems.

5. As described in DCD Tier 2, Subsection 6.5.1.4.2, testing and inspection of ESF filter systems are performed periodically under the ventilation filter testing program (VFTP) described in Subsection 5.5.11 of Chapter 16, Technical Specifications. The Methyl

Iodine Penetration Acceptance Criterion while performing laboratory test for carbon adsorbers is described in Subsection 5.5.11.c of Chapter 16.

A typical single HEPA filter with a size of 24x24x11½ inches, and a minimum rated airflow of 1,500 scfm and has a dust holding capacity of approximately 1,200 grams. The pressure drop of a HEPA filter while clean is less than 1.3 inch water gage and the HEPA filter in a dirty condition with the dust holding capacity of approximately 1,200 grams has a differential pressure across the HEPA filter of 2.6 in. water gage.

In the event of a design basis accident (DBA), the most severe circumstance with regards to the auxiliary building controlled area HVAC system are LOCA conditions. However, the amount of aerosol in the HEPA filter is zero because, in the case of the accident in which the fission products in the leaked liquid can be carried through the auxiliary building controlled area HVAC system to the atmosphere, all the radioactive materials, with exception of iodines, are assumed to be retained in the liquid and only elemental and organic iodines are assumed to be suspended in the atmosphere.

In the control room emergency makeup ACU and the auxiliary controlled area emergency exhaust ACU HEPA filters, the maximum mass loading amounts are as follows:

- Control room emergency makeup ACU : 3.72 mg (=3.72E-6 kg)
- Auxiliary controlled area emergency exhaust ACU : 0 mg

The maximum mass loading of HEPA filters in the ESF ACUs is much smaller than the dust holding capacity of the HEPA filter. Therefore, the HEPA filters of the ESF ACUs are designed to have sufficient margin to accommodate fission product loading during an accident. Also, the rated airflow capacity of the HEPA filter has 20% minimum margin of air flowrate at the design condition.

The pressure drop across the ESF filter system, which is needed to size the fan in the ACU, is calculated based on the dirty condition of each filter in the ACU. Therefore, the increase in pressure drop caused by the dirty condition of the filter of ESF ACUs does not degrade the performance of the fan.

Impact on DCD

DCD Tier 2, Subsections 6.5.1.2.2, 6.5.1.4.2, and 6.5.7 will be revised as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

The maximum temperature of the carbon adsorber due to radioactivity-induced heat in the adsorber does not exceed the design limiting temperature to prevent iodine desorption, 300°F (149°C) . The ignition temperature of the carbon is 626°F (330°C) or higher.

a. The moisture separator is designed to remove any entrained water droplets and moisture to minimize water loading of the filters. The moisture separator is located upstream of the electric heating coil and the prefilter. The moisture removal efficiency for 10 micron particles is not less than 99 percent.

b. The electric heating coil is installed and sized to reduce the humidity of the air stream to at least 70 percent relative humidity for the worst inlet conditions to provide a reasonable assurance of a high iodine removal capability of the carbon adsorber.

c. The prefilter is located upstream of the HEPA filter to protect the HEPA filter by removing large particles. The prefilter exhibits 90 to 95 percent efficiency based on America Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 52.2 (Reference 5).

d. The HEPA filter is located upstream of the carbon adsorber to protect the carbon adsorber from particulate loading. The HEPA filter is capable of a minimum removal efficiency of 99 percent of particulates that are 0.3 μm and larger in size. HEPA filters are designed, constructed, qualified, and factory tested in accordance with ASME AG-1 (Reference 6).

e. The carbon adsorber is provided to remove airborne radioactivity. The carbon adsorber is a rechargeable Type III adsorber cell and ~~the quantity of the carbon adsorber is based on a retention of 2.5 mg iodine/g carbon.~~ The bed dimensions are designed so that the air has at least a 0.25 seconds residence time in charcoal per 50.8 mm (2 in) of bed.

f. The postfilter is located downstream of the carbon adsorber to trap charcoal fines that may be entrained by the airstream. The postfilter is a medium-efficiency filter of minimum efficiency reporting value 15.

g. The fan is provided to draw and exhaust air from the corresponding area. The fan total pressure is based on the worst pressure condition when the filters are operating at design pressure drop for dirty filter conditions.

the carbon adsorber is designed for a maximum loading of 2.5 miligrams of total iodine (radioactive plus stable) per gram of activated carbon. No more than 5 percent of the impregnant (50 milligrams of impregnant per gram of carbon) is used. Each carbon adsorber in the ESF filter system contains a four inch bed depth.

b. The HEPA filter in-place leak test is performed in accordance with Section 5 of N511.

c. The carbon adsorbers in-place leak test is performed in accordance with Section 5 of N511.

d. The laboratory test for carbon adsorbers are performed in accordance with NRC RG 1.52. Test canisters are used to sample and analyze the activated carbon adsorber material. Testing is conducted in accordance with ASTM D3803 (Reference 16).

6.5.1.5 Instrumentation Requirements

ESF actuation signals such as SIAS, CREVAS, and FHEVAS, as well as the high radiation signal from the radiation monitor in the common discharge duct of the fuel handling area exhaust ACUs actuate emergency ACUs. ESFAS signals are described in Subsection 7.3.1. Flow rate, pressure drop, and status indication of the ACUs are provided based on ASME AG-1 and Table 1 of NRC RG 1.52. The relevant readout or alarms are monitored in the MCR and RSR.

6.5.1.5.1 Radiation Monitors

The radiation monitors for the airborne radioactivity detection and alarm of the ESF filter systems are described in Subsection 11.5.3.

6.5.1.5.2 Flow Rate

Each volumetric air flow rate of emergency ACUs in the ESF filter systems is indicated in the MCR and RSR. The airflow rate high and low alarms are provided in the MCR and RSR.

6.5.1.5.3 Pressure

Differential pressure across the filters in the ACU is indicated locally and alarmed in the MCR and RSR.

9. Regulatory Guide 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” U.S. Nuclear Regulatory Commission.

10. NUREG-0800, Standard Review Plan, Section 6.5.2, “Containment Spray as a Fission Product Cleanup System,” Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

11. NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, 1992.

12. NUREG/CR-6189, “A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments,” U.S. Nuclear Regulatory Commission, July 1996.

13. NUREG/CR-6604,“RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation,” U.S. Nuclear Regulatory Commission , June 1997.

14. ASME Boiler and Pressure Vessel Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

15. ASME OM Code, “Code for Operation and Maintenance of Nuclear Power Plants,” The American Society of Mechanical Engineers.

16.ASTM D3803-1991, "Standard Test Methods for Nuclear-Grade Activated Carbon," American Society for Testing and Meterials, 1991, Reapproved 2009.