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DESIGN, TESTING, AND MAINTENANCE CRITERIA FOR ENGINEERED-SAFETY-FEATURE ATMOSPHERE CLEANUP SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

A. INTRODUCTION

General Design Criteria 41, 42, and 43 of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," require that containment atmosphere cleanup systems be provided as necessary to reduce the amount of radioactive material released to the environment following a postulated design basis accident (DBA) and that these systems be designed to permit appropriate periodic inspection and testing to ensure their integrity, capability, and operability.

General Design Criterion 61 of Appendix A to Part 50 requires that fuel storage and handling systems, radioactive waste systems, and other systems that may contain radioactivity be designed to ensure adequate safety under normal and postulated accident conditions and that they be designed with appropriate containment, confinement, and filtering systems. General Design Criterion 19 requires that adequate radiation protection be provided to permit access to and occupancy of the control room under accident conditions and for the duration of the accident without personnel radiation exposures in excess of 5 rems to the whole body.

This guide presents methods acceptable to the NRC staff for implementing the Commission's regulations in Appendix A to 10 CFR Part 50 with regard to the design, testing, and maintenance criteria for air filtration and adsorption units of atmosphere cleanup systems in light-water-cooled nuclear power plants. This guide applies only to engineered-safety-feature atmosphere cleanup systems designed to mitigate the consequences of postulated accidents. It addresses the atmosphere cleanup system, including the various components and ductwork, in the postulated DBA environment.

B. DISCUSSION

Atmosphere cleanup systems are included as engineered safety features in the design of light-water-cooled nuclear power plants to mitigate the consequences of postulated accidents by removing from the building or containment atmosphere radioactive material that may be released in the accident. All such cleanup systems should be designed to operate under the environmental conditions resulting from the accident.

In this guide, atmosphere cleanup systems that must operate under postulated DBA conditions inside the primary containment (i.e., recirculating systems) are designated as primary systems. Systems required to operate under conditions that are generally less severe (i.e., recirculating or once-through systems) are designated as secondary systems. Secondary systems typically include the standby gas treatment system and the emergency air cleaning systems for the fuel handling building, control room, and shield building.

The DBA environmental conditions for a given system should be determined for each plant. DBA environmental conditions for typical primary and secondary systems are shown in Table 1. In addition, primary systems should be designed to withstand the radiation dose from water and plateout sources in the containment and the corrosive effects of chemical sprays (if such sprays are included in the plant design).

An atmosphere cleanup system consists of some or all of the following components: demisters, heaters, prefilters, high-efficiency particulate air (HEPA) filters, adsorption units, fans, and associated ductwork, valving, and instrumentation. The purpose of the demister is to remove entrained water droplets from the inlet

stream, thereby protecting prefilters, HEPA filters, and adsorbers from water damage and plugging. Heaters, when used on secondary systems, normally follow the demisters in the cleanup train and are designed to mix and heat the incoming stream to reduce the stream's relative humidity before it reaches the filters and adsorbers.

Prefilters and HEPA filters are installed to remove particulate matter, which may be radioactive. Prefilters remove the larger particles and prevent excessive loading of HEPA filters; to some extent demisters may also perform this function. The HEPA filters remove the fine discrete particulate matter and pass the air stream to the adsorber. The adsorber removes gaseous iodine (elemental iodine and organic iodides) from the air stream. HEPA filters downstream of the adsorption units collect carbon fines. The fan is the final item in an atmosphere cleanup train.

The environmental conditions preceding a postulated DBA may affect the performance of the atmosphere cleanup system. Such factors, for example, as industrial contaminants, pollutants, temperature, and relative humidity contribute to the aging and weathering of filters and adsorbers and reduce their capability to perform their intended functions. Therefore, aging and weathering of the filters and adsorbers, both of which vary from site to site, should be considered during design and operation. Average temperature and relative humidity also vary from site to site, and the potential buildup of moisture in the adsorber should also be given design consideration. The effects of these environmental factors on the atmosphere cleanup system should be determined by scheduled testing during operation.

All components of atmosphere cleanup systems should be designed for reliable performance under accident conditions. Initial testing and proper maintenance are primary factors in ensuring the reliability of the system. Careful attention during the design phase to problems of system maintenance can contribute significantly to the reliability of the system by increasing the ease of such maintenance. Of particular importance in the design is a layout that provides accessibility and sufficient working space so that the required functions can be performed safely. Periodic testing during operation to verify the efficiency of the components is another important means of ensuring reliability. Built-in features that will facilitate convenient in-place testing are important in system design.

* Standards for the design and testing of atmosphere cleanup systems include draft standard ANSI N509, "Nuclear Power Plant Air Cleaning Units and Components" (Ref. 1), and ANSI N510-1975, "Testing of Nuclear Air Cleaning Systems" (Ref. 2).

Other standards are available for the construction and testing of certain components of systems. Where such standards are acceptable to the NRC staff, they are referenced in this guide. Where no suitable standard exists, acceptable approaches are presented in this guide. ORNL-NSIC-65, "Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Application" (Ref. 3), provides a comprehensive review of air filtration systems. It is not a standard but a guide that discusses a number of acceptable design alternatives.

C. REGULATORY POSITION

1. Environmental Design Criteria

a. The design of an engineered-safety-feature atmosphere cleanup system should be based on the maximum pressure differential, radiation dose rate, relative humidity, maximum and minimum temperature, and other conditions resulting from the postulated DBA and on the duration of such conditions.

b. The design of each system should be based on the radiation dose to essential services in the vicinity of the adsorber section integrated over the 30-day period following the postulated DBA. The radiation source term should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 4), 1.4 (Ref. 5), and 1.25 (Ref. 6). Other engineered safety features, including pertinent components of essential services such as power, air, and control cables, should be adequately shielded from the atmosphere cleanup systems.

c. The design of each adsorber should be based on the concentration and relative abundance of the iodine species (elemental, particulate, and organic), which should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 4), 1.4 (Ref. 5), and 1.25 (Ref. 6).

d. The operation of any atmosphere cleanup system should not deleteriously affect the operation of other engineered safety features such as a containment spray system, nor should the operation of other engineered safety features such as a containment spray system deleteriously affect the operation of any atmosphere cleanup system.

e. Components of systems connected to compartments that are unheated during a postulated accident should be designed for postaccident effects of both the lowest and highest outdoor temperatures used in the plant design.

*Lines indicate substantive changes from previously published regulatory guide.

2. System Design Criteria

a. Atmosphere cleanup systems designed and installed for the purpose of mitigating accident doses should be redundant. The systems should consist of the following sequential components: (1) demisters, (2) prefilters (demisters may serve this function), (3) HEPA filters before the adsorbers, (4) iodine adsorbers (impregnated activated carbon or equivalent adsorbent such as metal zeolites), (5) HEPA filters after the adsorbers, (6) ducts and valves, (7) fans, and (8) related instrumentation. Heaters or cooling coils should be used when the humidity is to be controlled before filtration.

b. The redundant atmosphere cleanup systems should be physically separated so that damage to one system does not also cause damage to the second system. The generation of missiles from high-pressure equipment rupture, rotating machinery failure, or natural phenomena should be considered in the design for separation and protection.

c. All components of an engineered-safety-feature atmosphere cleanup system should be designated as Seismic Category I (see Regulatory Guide 1.29 (Ref. 7)) if failure of a component would lead to the release of significant quantities of fission products to the working or outdoor environments.

d. If the atmosphere cleanup system is subject to pressure surges resulting from the postulated accident, the system should be protected from such surges. Each component should be protected with such devices as pressure relief valves so that the overall system will perform its intended function during and after the passage of the pressure surge.

e. In the mechanical design of the system, the high radiation levels that may be associated with buildup of radioactive materials on the system components should be given particular consideration. System construction materials should effectively perform their intended function under the postulated radiation levels. The effects of radiation should be considered not only for the demisters, heaters, HEPA filters, adsorbers, and fans, but also for any electrical insulation, controls, joining compounds, dampers, gaskets, and other organic-containing materials that are necessary for operation during a postulated DBA.

f. The volumetric air flow rate of a single cleanup train should be limited to approximately 30,000 cfm. If a total system air flow in excess of this rate is required, multiple trains should be used. For ease of maintenance, a filter layout three HEPA filters high and ten wide is preferred.

g. The atmosphere cleanup system should be instrumented to signal, alarm, and record pertinent pressure drops and flow rates at the control room.

h. The power supply and electrical distribution system for the atmosphere cleanup system described in Section C.2.a above should be designed in accordance with Regulatory Guide 1.32 (Ref. 8). All instrumentation and equipment controls should be designed to IEEE Standard 279 (Ref. 9). The system should be qualified and tested under Regulatory Guide 1.89 (Ref. 10). To the extent applicable, Regulatory Guide 1.30 (Ref. 11) and IEEE Standards 334 (Ref. 12), 338 (Ref. 13), and 344 (Ref. 14) should be considered in the design.

i. To maintain radiation exposures to operating personnel as low as is reasonably achievable during plant maintenance, atmosphere cleanup systems should be designed to facilitate maintenance in accordance with the guidelines of Regulatory Guide 8.8 (Ref. 15). The atmosphere cleanup train should be totally enclosed. Each train should be designed and installed in a manner that permits replacement of the train as an intact unit or as a minimum number of segmented sections without removal of individual components.

j. Outdoor air intake openings should be equipped with louvers, grills, screens, or similar protective devices to minimize the effects of high winds, rain, snow, ice, trash, and other contaminants on the operation of the system. If the atmosphere surrounding the plant could contain significant environmental contaminants, such as dusts and residues from smoke cleanup systems from adjacent coal burning power plants or industry, the design of the system should consider these contaminants and prevent them from affecting the operation of any atmosphere cleanup system.

k. Atmosphere cleanup system housings and ductwork should be designed to exhibit on test a maximum total leakage rate as defined in Section 4.12 of draft standard ANSI N509 (Ref. 1). Duct and housing leak tests should be performed in accordance with the recommendations of Section 6 of ANSI N510-1975 (Ref. 2).

3. Component Design Criteria and Qualification Testing

a. The demisters installed in engineered-safety-feature atmosphere cleanup systems should meet qualification requirements similar to those found in MSAR 71-45, "Entrained Moisture Separators for Fine Particle Water-Air-Steam Service, Their Performance, Development and Status" (Ref. 16). Demisters should meet Underwriters' Laboratories (UL) Class 1 (Ref. 17) requirements.

b. Adsorption units function efficiently at a relative humidity of 70%. If heaters are used on secondary systems, the heating section should reduce the relative humidity of the incoming atmosphere from 100% to 70% during postulated DBA conditions. A prototype heating element should be qualified under postulated DBA conditions. Consideration should be given in system design to minimizing heater control malfunction. The heater should not be a potential ignition adsorbent source.

c. Materials used in the prefilters should withstand the radiation levels and environmental conditions prevalent during the postulated DBA. Prefilters should meet UL Class 1 (Ref. 17) requirements and should be listed in the current UL Building Materials List (Ref. 18). The prefilters should have not less than a 40% atmospheric dust spot efficiency rating (see Section 9 of the ASHRAE Standard 52, "Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter" (Ref. 19)).

d. The HEPA filters should be steel cased and designed to military specifications MIL-F-51068D (Ref. 20) and MIL-F-51079B (Ref. 21). The HEPA filters should satisfy the requirements of UL-586 (Ref. 22). The HEPA filter separators should be capable of withstanding iodine removal sprays if the atmosphere cleanup system will be exposed to such sprays following a DBA. HEPA filters should be tested individually by the appropriate Filter Test Facility listed in the current Energy Research and Development Administration (formerly USAEC) Health and Safety Bulletin for the Filter Unit Inspection and Testing Service (Ref. 23). The Filter Test Facility should test each filter for penetration of dioctyl phthalate (DOP) in accordance with the recommendations of MIL-F-51068D (Ref. 20) and MIL-STD-282 (Ref. 24).

e. Filter and adsorber mounting frames should be constructed and designed in accordance with the recommendations of Section 4.3 of ORNL-NSIC-65 (Ref. 3).

f. Filter and adsorber banks should be arranged in accordance with the recommendations of Section 4.4 of ORNL-NSIC-65 (Ref. 3).

g. System filter housings, including floors and doors, should be constructed and designed in accordance with the recommendations of Sections 4.5.2, 4.5.5, 4.5.7, and 4.5.9 of ORNL-NSIC-65 (Ref. 3).

h. Water drains should be designed in accordance with the recommendations of Section 4.5.6 of ORNL-NSIC-65 (Ref. 3).

i. The adsorber section of the atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency. Since impregnated activated carbon is commonly used, only this adsorbent is discussed in this guide. Each original or replacement batch of impregnated activated carbon used in the adsorber section should meet the qualification and batch test results summarized in Table 2 of this guide. If an adsorbent other than impregnated activated carbon is proposed or if the mesh size distribution is different from the specifications in Table 2, the proposed adsorbent should have demonstrated the capability to perform as well as or better than activated carbon in satisfying the specifications in Table 2.

If impregnated activated carbon is used as the adsorbent, the adsorber system should be designed for an average atmosphere residence time of 0.25 sec per two inches of adsorbent bed. The adsorber should have the capacity of loading 2.5 mg of total iodine (radioactive plus stable) per gram of activated carbon. No more than 5% of impregnant (50 mg of impregnant per gram of carbon) should be used. The radiation stability of the type of carbon specified should be demonstrated and certified (see Section C.1.b of this guide for the design source term).

j. If tray or pleated-bed adsorbent canisters are used in the adsorbent section, they should be designed in accordance with the recommendations of CS-8T, "Tentative Standard for High-Efficiency Gas-Phase Adsorber Cells" (Ref. 25). The activated carbon should be totally restrained in the adsorber. A qualification test on a prototype adsorber should be performed in accordance with paragraph 7.4.1 of CS-8T (Ref. 25), except that the safe shutdown earthquake parameters particular to the site should be used. The adsorber should be tested both before and after the qualification test and should show no significant increased penetration when challenged with a gaseous halogenated hydrocarbon refrigerant in accordance with USAEC Report DP-1082 (Ref. 26).

To ensure that the adsorber section will contain carbon of uniform packing density, written procedures for filling the adsorber beds should be prepared and followed in accordance with the recommendations of Section 7.4.2 of CS-8T (Ref. 25).

k. The design of the adsorber section should consider possible iodine desorption and adsorbent autoignition that may result from radioactivity-induced heat in the adsorbent and concomitant temperature rise. Acceptable designs include a low-flow air bleed system, cooling coils, water sprays for the adsorber section, or other cooling mechanisms. Any cooling mechanism should satisfy the single-failure criterion. A low-flow air bleed system should satisfy the single-failure criterion for providing low-humidity (less than 70% relative humidity) cooling air flow.

l. The system fan, its mounting, and the ductwork connections should be designed and constructed in

accordance with the recommendations of Section 2.7 of ORNL-NSIC-65 (Ref. 3).

m. The fan or blower used on the cleanup system should be capable of operating under the environmental conditions postulated, including radiation.

n. Ductwork should be designed in accordance with the recommendations of Section 2.8 of ORNL-NSIC-65 (Ref. 3).

o. Ducts and housings should be laid out with a minimum of ledges, protrusions, and crevices that could collect dust and moisture and that could impede personnel or create a hazard to them in the performance of their work. Straightening vanes should be installed to ensure representative air flow measurement and uniform flow distribution through cleanup components.

4. Maintenance

a. To keep radiation exposures to operating personnel as low as is reasonably achievable, the atmosphere cleanup system should be designed to control leakage and permit maintenance in accordance with the guidelines of Regulatory Guide 8.8 (Ref. 15).

b. Accessibility of components and maintenance should be considered in the design of atmosphere cleanup systems in accordance with the recommendations of Sections 2.5.2, 2.5.3, and 2.5.4 of ORNL-NSIC-65 (Ref. 3).

c. For ease of maintenance, the system design should provide for a minimum of three linear feet from mounting frame to mounting frame between banks of components. If components are to be replaced, the dimension to be provided should be the maximum length of the component plus a minimum of three feet.

d. The system design should provide for permanent test probes with external connections. Preferably, the test probes should be manifolded at a single convenient location, with due consideration given to balancing of line lengths and diameter to produce reliable test results for refrigerant gas, resistance, flow rate, and DOP testing.

e. Each atmosphere cleanup train should be operated at least 10 hours per month, with the heaters on (if so equipped), in order to reduce the buildup of moisture on the adsorbers and HEPA filters.

f. The cleanup components (i.e., HEPA filters, prefilters, and adsorbers) should not be installed while active construction is still in progress.

5. In-Place Testing Criteria

a. The atmosphere cleanup system should be tested in place (1) initially, (2) at least once per operating cycle thereafter for systems maintained in a standby status or after 720 hours of system operation, and (3) following painting, fire, or chemical release in any ventilation zone communicating with the system. A visual inspection of the system and all associated components should be made before each test in accordance with the recommendations of Section 5 of ANSI N510-1975 (Ref. 2).

b. The air flow distribution to the HEPA filters and iodine adsorbers should be tested in place initially and at least once per operating cycle thereafter for uniformity. The distribution should be within ±20% of the average flow per unit. The testing should be conducted in accordance with the recommendations of Section 9 of "Industrial Ventilation" (Ref. 27) and Section 8 of ANSI N510-1975 (Ref. 2).

c. The in-place DOP test for HEPA filters should conform to Section 10 of ANSI N510-1975 (Ref. 2). HEPA filter sections should be tested in place (1) initially, (2) at least once per operating cycle thereafter for systems maintained in a standby status or after 720 hours of system operation, and (3) following painting, fire, or chemical release in any ventilation zone communicating with the system to confirm a penetration of less than 0.05% at rated flow. An engineered-safety-feature air filtration system satisfying this condition can be considered to warrant a 99% removal efficiency for particulates in accident dose evaluations. HEPA filters that fail to satisfy this condition should be replaced with filters qualified pursuant to regulatory position C.3.d of this guide. If the HEPA filter bank is entirely or only partially replaced, an in-place DOP test should be conducted.

If any welding repairs are necessary on, within, or adjacent to the ducts, housing, or mounting frames, the filters and adsorbers should be removed from the housing during such repairs. The repairs should be completed prior to periodic testing, filter inspection, and in-place testing. The use of silicone sealants or any other temporary patching material on filters, housing, mounting frames, or ducts should not be allowed.

d. The activated carbon adsorber section should be leak tested with a gaseous halogenated hydrocarbon refrigerant in accordance with Section 12 of ANSI N510-1975 (Ref. 2) to ensure that bypass leakage through the adsorber section is less than 0.05%. During the test the upstream concentration of refrigerant gas should be no greater than 20 ppm. After the test is completed, air flow through the unit should be main-

tained until the residual refrigerant gas in the effluent is less than 0.01 ppm. Adsorber leak testing should be conducted whenever DOP testing is done.

6. Laboratory Testing Criteria for Activated Carbon

a. The activated carbon adsorber section of the atmosphere cleanup system should be assigned the decontamination efficiencies given in Table 3 for elemental iodine and organic iodides if the following conditions are met:

(1) The adsorber section meets the conditions given in regulatory position C.5.d of this guide,

(2) New activated carbon meets the physical property specifications given in Table 2, and

(3) Representative samples of used activated carbon pass the laboratory tests given in Table 3.

If the activated carbon fails to meet any of the above conditions, it should not be used in engineered-safety-feature adsorbers.

b. The efficiency of the activated carbon adsorber section should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the adsorber section. Each representative sample should be not less than two inches in both length and diameter, and each sample should have the same qualification and batch test characteristics as the system adsorbent. There should be a sufficient number of representative samples located in parallel with the adsorber section for estimating the amount of penetration of the system adsorbent throughout its service life. The design of the samplers should be in accordance with the recommendations of Appendix A of draft standard ANSI N509 (Ref. 1). Where the system activated carbon is greater than two inches deep, each representative sampling station should consist of enough two-inch samples in series to equal the thickness of the system adsorbent. Once representative samples are removed for laboratory test, their positions in the sampling array should be blocked off.

Laboratory tests of representative samples should be conducted, as indicated in Table 3 of this guide, with the test gas flow in the same direction as the flow during service conditions. Similar laboratory tests should be performed on an adsorbent sample before loading into the adsorbers to establish an initial point for comparison of future test results. The activated carbon adsorber section should be replaced with new unused activated carbon meeting the physical property specifications of Table 2 after the last representative sample has been removed and tested or if any preceding representative sample has failed to pass the tests in Table 3.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant or licensee proposes an acceptable alternative method, the staff will use the method described herein in evaluating an applicant's or licensee's capability for and performance in complying with specified portions of the Commission's regulations until this guide is revised as a result of suggestions from the public or additional staff review.

REFERENCES

1. Draft Standard ANSI N509 (Draft 9 – November 1975), "Nuclear Power Plant Air Cleaning Units and Components," American National Standards Institute.

2. ANSI N510-1975, "Testing of Nuclear Air Cleaning Systems," American National Standards Institute.

3. ORNL-NSIC-65, "Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application," Oak Ridge National Laboratory, C.A. Burchsted and A.B. Fuller, January 1970.

4. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," Office of Standards Development, U.S. Nuclear Regulatory Commission (USNRC).

5. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors," Office of Standards Development, USNRC.

6. Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors," Office of Standards Development, USNRC.

7. Regulatory Guide 1.29, "Seismic Design Classification," Office of Standards Development, USNRC.

8. Regulatory Guide 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants," Office of Standards Development, USNRC.

9. IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

10. Regulatory Guide 1.89, "Qualification of Class IE Equipment for Nuclear Power Plants," Office of Standards Development, USNRC.

11. Regulatory Guide 1.30, "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment," Office of Standards Development, USNRC.

12. IEEE Std 334-1974, "IEEE Standard for Type Tests of Continuous-Duty Class IE Motors for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

13. IEEE Std 338-1971, "Trial-Use Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems," Institute of Electrical and Electronics Engineers.

14. IEEE Std 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

15. Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposure As Low As Is Reasonably Achievable (Nuclear Power Reactors)," Office of Standards Development, USNRC.

16. MSAR 71-45, "Entrained Moisture Separators for Fine Particle Water-Air-Steam Service, Their Performance, Development and Status," Mine Safety Appliance Research Corporation, March 1971.

17. Standard UL-900, "Air Filter Units," Underwriters' Laboratories (also designated ANSI B124.1-1971).

18. Underwriters' Laboratories Building Materials List.

19. ASHRAE Standard 52-68, "Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter, Section 9," American Society of Heating, Refrigerating and Air Conditioning Engineers.

20. MIL-F-51068D, "Filter, Particulate, High-Efficiency, Fire-Resistant," Military Specification, 4 April 1974.

21. MIL-F-51079B, "Filter Medium, Fire-Resistant, High-Efficiency," Military Specification, 29 March 1974.

22. Standard UL-586, "High Efficiency, Particulate, Air Filter Units," Underwriters' Laboratories (also designated ANSI B132.1-1971).

23. USERDA (formally USAEC) Health and Safety Bulletin, "Filter Unit Inspection and Testing Service," U.S. Energy Research and Development Administration.

24. MIL-STD-282, "Filter Units, Protective Clothing Gas-Mask Components and Related Products: Performance-Test Methods," Military Standard, 28 May 1956.

25. AACC CS-8T, "Tentative Standard for High-Efficiency Gas-Phase Adsorber Cells," American Association for Contamination Control, July 1972.

26. USAEC Report DP-1082, "Standardized Nondestructive Test of Carbon Beds for Reactor Confinement Application," D.R. Muhlbaier, Savannah River Laboratory, July 1967.

27. American Conference of Governmental Industrial Hygienists, "Industrial Ventilation," 13th Edition, 1974.

28. ASTM D2862-70, "Test for Particle Size Distribution of Granulated Activated Carbon," American Society for Testing and Materials.

29. ASTM E11-70, "Specifications for Wire Cloth Sieves for Testing Purposes," American Society for Testing and Materials.

30. RTD Standard M16-1T, "Gas-Phase Adsorbents for Trapping Radioactive Iodine and Iodine Compounds," USAEC Division of Reactor Development and Technology, October 1973.

31. A.G. Evans, "Effect of Intense Gamma Radiation on Radioiodine Retention by Activated Carbon," CONF-720823, Proceedings of the Twelfth AEC Air Cleaning Conference, 28-31 August 1972.

32. ASTM D2854-70, "Test for Apparent Density of Activated Carbon," American Society for Testing and Materials.

TABLE 1

TYPICAL ACCIDENT CONDITIONS FOR ATMOSPHERE CLEANUP SYSTEM

Environmental Condition	Atmosphere Cleanup System: Primary	Atmosphere Cleanup System: Secondary
Pressure surge	Result of initial blowdown	Generally less than primary
Maximum pressure	60 psi	~ 1 atm
Maximum temperature of influent	280° F	180° F
Relative humidity of influent	100% plus condensing moisture	100%
Average radiation level		
For airborne radioactive materials	10^6 rads/hr[a]	10^5 rads/hr[a]
For iodine buildup on adsorber	10^9 rads[a]	10^9 rads[a]
Average airborne iodine concentration		
For elemental iodine	100 mg/m^3	10 mg/m^3
For methyl iodide and particulate iodine	10 mg/m^3	1 mg/m^3

[a]This value is based on the source term specified in Regulatory Guide 1.3 (Ref. 4) or 1.4 (Ref. 5), as applicable.

TABLE 2

PHYSICAL PROPERTIES OF NEW ACTIVATED CARBON BATCH TESTS[a] TO BE PERFORMED ON FINISHED ADSORBENT

TEST	ACCEPTABLE TEST METHOD	ACCEPTABLE RESULTS	
1. Particle size distribution	ASTM D2862 (Ref. 28)	Retained on #6 ASTM E11[b] Sieve:	0.0%
		Retained on #8 ASTM E11[b] Sieve:	5.0% max.
		Through #8, retained on #12 Sieve:	40% to 60%
		Through #12, retained on #16 Sieve:	40% to 60%
		Through #16 ASTM E11[b] Sieve:	5.0% max.
		Through #18 ASTM E11[b] Sieve:	1.0% max.
2. Hardness number	RDT M16-1T, Appendix C (Ref. 30)	95 minimum	
3. Ignition temperature	RDT M16-1T, Appendix C (Ref. 30)	330°C minimum at 100 fpm	
4. Activity[c]	CCl_4 Activity, RDT M16-1T. Appendix C (Ref. 30)	60 minimum	
5. Radioiodine removal efficiency			
a. Methyl iodide, 25°C and 95% relative humidity[d]	RDT M16-1T (Ref. 30), para. 4.5.3, except 95% relative humidity air is required	99%	
b. Methyl iodide, 80°C and 95% relative humidity	RDT M16-1T (Ref. 30), para. 4.5.3, except 80°C and 95% relative humidity air is required for test (pre- and post-loading sweep medium is 25°C)	99%	
c. Methyl iodide, in containment[e]	RDT M16-IT (Ref. 30), para. 4.5.4, except duration is 2 hours at 3.7 atm. pressure	98%	
d. Elemental iodine retention	Savannah River Laboratory (Ref. 31)	99.9% loading 99% loading plus elution	
6. Bulk density	ASTM D2854 (Ref. 32)	0.38 g/ml minimum	
7. Impregnant content	State procedure	State type (not to exceed 5% by weight)	

[a]A "batch test" is a test made on a production batch of a product to establish suitability for a specific application. A "batch of activated carbon" is a quantity of material of the same grade, type, and series that has been homogenized to exhibit, within reasonable tolerance, the same performance and physical characteristics and for which the manufacturer can demonstrate by acceptable tests and quality control practices such uniformity. All material in the same batch should be activated, impregnated, and otherwise treated under the same process conditions and procedures in the same process equipment and should be produced under the same manufacturing release and instructions. Material produced in the same charge of batch equipment constitutes a batch; material produced in different charges of the same batch equipment should be included in the same batch only if it can be homogenized as above. The maximum batch size should be 350 ft^3 of activated carbon.

[b]See Reference 29.

[c]This test should be performed on base material.

[d]This test should be performed for qualification purposes. A "qualification test" is a test that establishes the suitability of a product for a general application, normally a one-time test reflecting historical typical performance of material.

[e]This test should be performed for qualification purposes on carbon to be installed in primary containment (recirculating) atmosphere cleanup systems.

TABLE 3

LABORATORY TESTS FOR ACTIVATED CARBON

ACTIVATED CARBON[a] BED DEPTH[b]	ASSIGNED ACTIVATED CARBON DECONTAMINATION EFFICIENCIES	LABORATORY TESTS FOR A REPRESENTATIVE SAMPLE[c]
2 inches. Air filtration system designed to operate inside primary containment.	Elemental iodine 90% Organic iodide 30%	Per Test 5.c in Table 2 for a methyl iodide penetration of less than 10%.
2 inches. Air filtration system designed to operate outside the primary containment and relative humidity is controlled to 70%.	Elemental iodine 95% Organic iodide 95%	Per Test 5.b in Table 2 at a relative humidity of 70% for a methyl iodide penetration of less than 1%.
4 inches or greater. Air filtration system designed to operate outside the primary containment and relative humidity is controlled to 70%.	Elemental iodine 99% Organic iodide 99%	Per Test 5.b in Table 2 at a relative humidity of 70% for a methyl iodide penetration of less than 0.175%.

[a]The activated carbon, when new, should meet the specifications of regulatory position C.3.i of this guide.
[b]Multiple beds, e.g., two 2-inch beds in series, should be treated as a single bed of aggregate depth.
[c]See regulatory position C.6.b. for definition of representative sample. Testing should be performed (1) initially, (2) at least once per operating cycle thereafter for systems maintained in a standby status or after 720 hours of system operation, and (3) following painting, fire, or chemical release in any ventilation zone communicating with the system.