ASME N509–2002
[Revision of ASME N509–1989 (R1997)]

NUCLEAR POWER PLANT AIR-CLEANING UNITS AND COMPONENTS

AN ASME STANDARD

The American Society of Mechanical Engineers

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NUCLEAR POWER PLANT AIR-CLEANING UNITS AND COMPONENTS

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This Standard will be revised when the Society approves the issuance of a new edition. There will be no addenda issued to this edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the ASME Web site under the Committee Pages at http://www.asme.org/codes/ as they are issued.

The American Society of Mechanical Engineers
Three Park Avenue, New York, NY 10016-5990

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FOREWORD

This Standard covers requirements for the design, construction, and testing of units and components which make up high efficiency air and gas cleaning systems used in nuclear power plants. The standard was originally developed by the American National Standards Committee N45 on Reactor Plants.

This Standard specifies acceptance testing, including minimum acceptance requirements, in accordance with the standard prepared by the companion ad hoc working group, "Testing of Nuclear Air Cleaning Systems." It was originally approved on December 7, 1976 by the American National Standards Institute and designated N509-1976.

In 1975, the N45.8 Subcommittee was reorganized into the ASME Committee on Nuclear Air and Gas Treatment and began operating under the accredited ASME Procedures for Nuclear Projects which received accreditation on January 15, 1976. The ASME Committee on Nuclear Air and Gas Treatment was chartered to develop, review, maintain, and coordinate Codes and Standards for design, fabrication, installation, testing, and inspection of equipment for gas treatment for nuclear power plants.

Suggestions for improvement gained in the use of this Standard will be welcomed. They should be sent to the Secretary, Committee on Nuclear Air and Gas Treatment, The American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016.

This Standard was approved by the ASME Committee on Nuclear Air and Gas Treatment and approved as an American National Standard by the American National Standards Institute on November 6, 2002.

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NUCLEAR POWER PLANT AIR-CLEANING UNITS AND COMPONENTS

1 SCOPE

This Standard covers requirements for the design, construction, and qualification and acceptance testing of the air-cleaning units and components which make up Engineered Safety Feature (ESF) and other high efficiency air and gas treatment systems used in nuclear power plants.

1.1 Limitations

The Standard does not cover sizing of a complete nuclear air treatment system, redundancy, or single-failure requirements. It applies only to systems which employ particulate filtration, ambient-temperature adsorption, or both, as the principal functional mechanism. It does not apply to condenser off-gas systems. Also, it does not apply to other applications that employ primarily gas storage or holdup, cryogenic adsorption or fractionation, or solvent absorption as the principal method of gas treatment. Nor does the Standard cover requirements for containment isolation valves, recombiners, comfort heating, air-conditioning, or ventilation to achieve ordinary cooling or industrial hygiene objectives. Field acceptance testing of nuclear air-treatment systems is covered in ASME AG-1, Section TA (the primary reference was to ASME N510-1989).

1.2 Purpose

The Standard identifies and establishes requirements for filters, adsorbers, moisture separators, air heaters, filter housings, dampers, valves, fans, ducts, and other components of nuclear air-treatment systems for a specific application in a nuclear power plant. The Standard also establishes requirements for operability, maintainability, and testability of systems necessary for the maintenance of system reliability for the design conditions. Qualification and acceptance testing provisions are specified to verify the adequacy of the air-cleaning unit and component design, to verify that components have been properly fabricated and installed, and that the system will perform in accordance with specification requirements.

2 APPLICABLE DOCUMENTS

The following documents supplement this Standard and are a part of it to the extent indicated in the text. The issue of the referenced document noted below shall be in effect. If no date is listed, then the issue of the referenced document in effect at the time of the Purchase Order shall apply.

ASME AG-1, Code on Nuclear Air and Gas Treatment[1]

Publisher: The American Society of Mechanical Engineers (ASME International), Three Park Avenue, New York, NY 10016; Order Department: 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300

3 TERMS AND DEFINITIONS

Terms and Definitions are located in ASME AG-1, Article AA-1000 and various specific ASME AG-1 Code sections.

4 FUNCTIONAL DESIGN

4.1 General

Depending on the function of the system and the conditions under which it will operate, air-cleaning units include some or all of the following internal components.

(a) Prefilters are required in air-cleaning units when design inlet particulate concentrations and particle size are such that the HEPA filter may be rendered ineffective prematurely. On other air-cleaning units prefilters are recommended only when it is desired to increase HEPA filter life.

(b) HEPA filters are required in all air-cleaning units when filtration of inlet particulate matter requires a minimum efficiency of 99.97% for particles equal to 0.3 micrometer in size.

(c) Adsorbers are required when air-cleaning units are designed for removal of adsorbable compounds.

(d) Moisture separators (demisters) are required when entrained water droplet concentration may be greater than 1 lb (0.45 kg) of water per 1,000 cfm (1,700 m^3/hr) of airflow.

(e) Heaters should be utilized for air-cleaning units with adsorbers when the relative humidity of air to the adsorber exceeds 70% based upon the 1% percentile meteorological conditions (where applicable). For nuclear air-treatment systems which are unaffected by outside air meteorological conditions, heaters should be utilized when an accident would result in an airstream exceeding 70% relative humidity for more than 1 hr.

(f) Postfilters. When adsorbers are used in ESF air-cleaning units, provision shall be made for a postfilter

[1] ASME AG-1 contains Code requirements for nuclear air and gas treatment equipment. See Article AA-2000.

to retain carbon fines. Postfilters should also be considered in non-ESF air-cleaning units discharging into occupied spaces where carbon fine carryover is not acceptable.

4.2 Design Parameters

Values of the following design parameters shall be specified when invoking this Standard and shall be used wherever referenced:

(a) volumetric air flow rate, acfm (m^3/hr);
  (1) minimum flow rate;
  (2) maximum flow rate;
  (3) design flow rate;

(b) design pressures, in. w.g. (Pa);
  (1) maximum operating pressure;
  (2) leak test pressure;
  (3) maximum design pressure;
  (4) structural capability pressure (usually determined by component designer);

(c) pressure-time transient (if applicable), in. w.g./sec (Pa/sec);

(d) maximum and minimum gas temperature, °F (°C) and density, lb/ ft^3 (kg/m^3);

(e) maximum inlet relative humidity, %;

(f) entrained liquid water, (mass flow rate), lb/min (kg/min);

(g) concentrations of specific contaminants in airstream;

(h) required decontamination factors for each contaminant;

(i) component radiation integrated life dose (rad) and maximum dose rate (rad/hr);

(j) maximum dirty filter pressure differential, in. w.g. (Pa);

(k) structural loadings;

(l) duct and housing maximum permissible leak rate, scfin (m^3/hr) and associated operating pressure, in. w.g. (Pa);

(m) environmental design conditions including temperature, pressure, and relative humidity;

(n) expected duration and environmental conditions of storage area;

(o) particle size distribution and quantity of aerosols and contaminants under normal and accident conditions (if known);

(p) safety classification (ESF or non-ESF);

(q) number of adsorber test cannisters per adsorber bank;

(r) heater capacity, watts, voltage, temperature differential, if applicable.

4.3 Size (Installed Capacity) of Air-Cleaning Unit

The installed capacity cfm (m^3/hr) of the air cleaning unit shall be no greater than the limiting installed capacity of any bank of components contained in the air-cleaning unit through which the airflow must pass. The installed capacity of any bank or stage of components should not exceed the number of components in the bank times the rated capacity of the individual components. Test cannisters shall not be included in determining the installed capacity of any bank or stage of adsorbers.

4.4 Environmental Design Condition

All parts and components of the air-cleaning unit shall be selected or designed to operate under the environmental conditions (temperature, relative humidity, pressure, radiation, etc.) specified in para. 4.2. Materials of construction and components shall be selected or treated to limit generation of combustibles and contaminants and to resist corrosion and degradation that would result in loss of function when exposed to the specified environmental conditions for the design life of the component.

Environmental qualification requirements are contained in 10 CFR 50.49, IEEE 323 and ASME AG-1, Section AA and various specific ASME AG-1 Code sections.

4.5 Structural Load Requirements

ESF systems and all of their components shall be shown, either by testing or by a mathematical technique, to remain functional under the structural loading specified in ASME AG-1, Article AA-4000 and various specific ASME AG-I Code sections.

4.6 Air-Cleaning Units and Components That Must Withstand Fan Peak Pressure

The maximum design pressure shall be documented by calculation, including the basis for the condition, and included in procurement specifications for manufacturer's design.

(a) Positive Pressure. Air-cleaning units and components including ducts located on the discharge side of fan(s) which can be isolated by closure of a downstream damper, or potentially plugged components, shall be designed to withstand a positive internal pressure equal to or greater than the peak pressure of the fan(s). If provision is made to deenergize fan(s) on high differential pressure or low flow, the components shall be designed to withstand the trip point design pressure plus a margin to include the rate of pressure rise between reaching the pressure setpoint and the time for the instrumentation response, or 10%, whichever is greater.

(b) Negative Pressure. Air-cleaning units and components located on the inlet side of fan(s) which can be isolated by closure of an upstream damper, or potentially plugged components shall be designed to withstand a negative internal pressure equal to or more negative than the peak pressure of the fan(s). If provision is made to deenergize fan(s) on high differential pressure or low flow, the components shall be designed to withstand the trip point design pressure plus a margin to

include the rate of pressure rise between reaching the pressure setpoint and the time for the instrumentation response, or 10%, whichever is greater.

4.7 Nuclear Air-Treatment System Configuration and Location

Physical location and arrangement of the components of a nuclear air-treatment system influence the requirements for leak tightness for the various parts of the pressure boundary. Air flow should be from potentially less contaminated areas to potentially more contaminated areas. Whenever possible, routing of contaminated air through clean spaces or interspaces should be avoided. If this can not be done, the general guidance in this Section should be followed.

Figures B-1410-1, B-1410-2, and B-1410-3 of ASME AG-1, Section SA schematically depict examples of possible combinations and location of fan and air-cleaning unit to minimize impact of system contaminated outleakage on surrounding clean spaces and interspaces as well as contaminated inleakage into a cleaner system component.

4.7.1 Effluent Nuclear Air-Treatment System (Once-Through)

(a) Maintain ducts conveying contaminated air through clean spaces or clean interspaces at a negative pressure with respect to the surrounding areas.

(b) With air-cleaning unit located in a clean interspace, locate exhaust fan downstream of air-cleaning unit in order to keep air-cleaning unit under negative pressure. Any leakage through fan shaft will be from clean interspace.

(c) When air-cleaning units are located in contaminated spaces or interspaces, the fan shall be located upstream of the air-cleaning unit in order to keep air-cleaning unit under positive pressure and to prevent infiltration of contaminated air through fan shaft, or into the filter housing downstream of filters, thereby bypassing filters.

(d) The length of positive pressure discharge ducts from the air-cleaning unit routed through clean spaces or interspaces should be kept as short as practical to minimize outleakage from ductwork from impacting in-plant personnel exposure.

4.7.2 Habitability Systems

(a) Outside air ducts routed through clean spaces or interspaces that may convey radioactive air following a release shall be under a negative pressure relative to the spaces.

(b) Negative pressure recirculating air ducts that pass outside the habitable space should be avoided or additional filtration provided.

(c) The makeup air fan shall be located:

(1) upstream of air-cleaning unit if air-cleaning unit is in a contaminated space;

(2) downstream of air-cleaning unit if air-cleaning unit is in a clean space.

(d) The length of positive pressure ducts outside of the habitable boundary should be kept as short as practical to reduce effect of duct leakage on ability to pressurize habitable boundary.

(e) Recirculating system housings should be kept at a positive pressure if located outside habitable boundary in a contaminated space or interspace.

4.7.3 Recirculating Nuclear Air-Treatment Systems

(a) If an air-cleaning unit is located in a clean space or interspace outside of the space served, the fan should be located downstream of the air-cleaning unit.

(b) Fans may be either upstream or downstream of air-cleaning units if located totally within the space served.

(c) The length of ductwork outside the space served should be kept as short as practical.

4.8 Maintainability Criteria

4.8.1 Access for Service, Testing, and Inspection. The air-cleaning unit shall be designed to keep radiation exposures during maintenance, testing, and inspection as low as reasonably achievable (ALARA). Some design features which contribute to keeping these exposures ALARA are the following.

(a) Man-entry air-cleaning units should be located at floor level or should be equipped with a permanent service gallery at least 4 ft (1.23 m) wide with permanent stairs or fixed ladders.

(b) Smaller air-cleaning units should be located at a height above the floor or work gallery level convenient for access, based on human factors and the design of the housing.

(c) The area in which the air-cleaning unit is located shall be served by a clear aisle wide enough to accommodate servicing of internal components and equipment.

(d) Sufficiently wide clear area adjacent to the housing door or hatch shall be provided to allow servicing the air-cleaning unit; a space of at least 4 ft wide x 7 ft (1.23 m wide x 2.15 m) high is recommended. The clear work space may also serve as aisle space as long as it can be used while servicing the air-cleaning unit, or it may serve as the clear space for an adjacent air-cleaning unit.

(e) Clearance of 18 in. (0.46 m) is recommended above the housing for installation and inspection.

(f) Elevated work galleries shall be designed in accordance with Occupational Safety and Health Act (OSHA) requirements.

(g) Ducts that are cleaned out periodically shall be equipped with low leakage access hatches at strategic points

4.8.2 Internal Space for Maintainance. For ease of maintenance, air-cleaning unit design should provide for a minimum of 3 ft (0.92 m) from mounting frame to mounting frame between banks of components. If components are to be replaced between mounting frames, the bank-to-bank dimension should be the maximum deflated length of component plus a minimum of 3 ft (0.92 m). The designer should consider susceptibility of permanently installed testing manifolds to damage in determination of maintenance space. An extra 3 ft (0.92 m) bank-to-bank spacing should be considered for testing manifold clearance when manifolds are permanently installed.

4.9 Monitoring of Operational Variables

Instruments and Controls shall meet the requirements of ASME AG-1, Section IA.

4.10 Adsorbent Cooling

Where heat of radioactive decay or heat of oxidation or both may be significant, means shall be provided to remove this heat from the adsorbent beds to limit temperatures to values below 300°F (149°C) to prevent significant iodine desorption.

For this purpose, a minimum circulatory air flow shall be available for all operational modes of the air-cleaning unit and shall be based on the maximum possible radioactivity loading on the adsorbent beds. Water deluge systems are not acceptable for this purpose.

4.11 Fire Protection

4.11.1 General. Nuclear air-treatment systems shall be designed, fabricated, and installed so as to minimize the use of combustibles.

Filter media, sealants, gaskets, and insulation shall meet the requirements in ASME AG-1.

4.11.2 Fire Detection. When adsorbers are provided, a fire detection system shall be installed downstream of each carbon adsorber bank to detect either abnormally elevated temperature or products of combustion. The fire detection system shall be designed to be responsive to the unique features of the installation and application (e.g., low air velocity, stratification). A two-stage alarm shall be provided. The fire detection system shall operate an alarm (first stage) upon detection of temperature above a prearranged setpoint and automatically trip fan(s) and isolate the air-cleaning unit. The second stage shall operate an alarm when a fire is detected. Documentation shall be provided to the owner which shows that the fire detection system is designed to be responsive to a fire within the carbon adsorber bed.

4.11.3 Fire Hazard Procedures. Plant fire protection procedures should include requirements that upon first-stage, high-temperature alarm, the plant fire brigade is dispatched to the area to take appropriate action.

4.11.4 Fire Hazard Analysis. A fire hazard analysis shall be performed for all air-cleaning units and components in accordance with 10 CFR 50 Appendix R and NFPA 803, except that for adsorbers consideration shall be given to the type of carbon (or other media) utilized in adsorbers and the potential for fire.

4.11.5 Fire Protection Systems. Fire protection systems, when provided, may use water deluge, inert gases (e.g., halon, CO_2) or other extinguishing agents as appropriate for the hazard and designed in accordance with all applicable NFPA standards.

4.11.6 Water Deluge Systems. Deluge nozzles should be permanently mounted within the housing and located to ensure that both deep-seated or surface fires can be extinguished. Nozzles shall be piped to an accessible location outside the housing and provided with redundant leak-tight isolation valves and a connection suitable for manual attachment to the plant's fire protection system. Permanently connected fire protection systems are not recommended, but may be used in lieu of manual hose connections.

4.11.7 Actuation of Fire Protection Systems. If the result of the fire hazard analysis requires that a fire protection system be provided for an air-cleaning unit, the fire protection system should be manually actuated. Automatic actuating water deluge systems are not recommended because spurious actuation of detection/automatic protection systems will significantly degrade adsorber capability and damage the adsorber.

4.11.8 Permanently Connected Fire Protection System. If permanently connected fire protection systems are installed, provision shall be made to activate an alarm upon initiation of flow of extinguishing agent (e.g., water, halon, CO_2).

4.11.9 Returning Air-Cleaning Unit to Service. If carbon does become wet, the wet carbon shall be removed from the adsorber as soon as practical to prevent structural damage to the adsorber due to chemical interaction. Before placing the air-cleaning unit back in service, the adsorber shall be thoroughly dried, visually inspected for corrosion damage, dried carbon shall be laboratory tested per ASME AG-1, Section FF and adsorber leak testing shall be performed per ASME AG-1, Section TA.

4.12 Insulation

Acoustic linings, thermal insulation, and similar materials shall not be applied to the inside of ducts and housings. Materials applied to the outside of ducts and housings shall not prevent access to any bolted construction joint, door, access hatch, or instrument in the housing or ducting, or result in penetrations through the pressure boundary which would result in exceeding allowable leakage rates in accordance with para. 4.14.

4.13 Testability

(a) To ensure that the testing requirements of this Standard can be met, sufficient permanently installed halide and DOP injection and sampling ports shall be

provided to permit accurate testing in accordance with ASME AG-1, Section TA.

Where required for proper challenge agent mixing and/or sampling, multiple inlet or outlet distribution manifolds shall be provided to allow injection and sampling per ASME AG-1, Section TA.

(b) Sufficient test cannisters or other means of obtaining samples (see Mandatory Appendix I) of used adsorbent shall be installed in the adsorber system to provide a representative determination of the response of the adsorbent to the service environment over the predicted life of the adsorbent. Test cannisters shall be installed in a location where they will be exposed to the same airflow conditions as the adsorbent in the system, shall have the same adsorbent bed-depth as the adsorbent in the system, and shall be filled with representative adsorbent from the same batch of adsorbent as that of the system.

The quantity of test cannisters to be provided shall be based on the expected frequency of operation. For continuously operating systems, where laboratory testing of carbon is required every 720 hr of operation, a minimum of 18 test cannisters is recommended. For those systems where laboratory carbon testing is required once every 18 months, a minimum of 6 test cannisters is recommended. If the adsorber operation may vary from part time to continuous then classifying the adsorber as continuous is recommended.

The type of test cannister design (including connection to adsorber bank) shall be qualified by the manufacturer. Any change in the cannister design or mounting to bank shall require a retest. The qualification test shall measure air velocity at the test cannister. Measured velocity shall be ±10% of adsorber bank design velocity. Tests on each production air-cleaning unit are not required.

(c) Access shall be provided between banks of components in the housing to permit physical inspection of both sides of each bank; components shall not be installed back-to-back on the same or opposite sides of the same mounting frame, or on adjacent mounting frames which are so close as to not permit adequate access space between banks.

4.14 Pressure Boundary Leakage

4.14.1 Maximum Allowable Leakage. Maximum allowable leakage across the pressure boundary of any portion of a nuclear air-treatment system shall be based on health physics requirements. Leakage into or out of nuclear air treatment systems may affect:

(a) control room habitability;

(b) plant personnel exposure during normal plant operation due to contaminated outleakage in clean spaces or clean interspaces;

(c) plant personnel exposure due to excessive system inleakage which prevents the nuclear air-treatment system from performing its design function in contaminated spaces or contaminated interspaces during plant normal, upset, or accident conditions;

(d) offsite exposure during plant normal, upset, or accident conditions.

4.14.2 Calculation of Allowable Leakage. The system designer (Engineer) shall determine leakage criteria and allowable leakage to meet governing Codes, Standards, regulations, and plant-specific requirements for required portions of the nuclear air-treatment system pressure boundary (ducts, housing, dampers, fans, etc.). The basis for determining the leak rate, and coincident operating (static) pressure shall be documented and provided to the owner.

Additional leakage criteria may be applied to the pressure boundary as determined by the owner to meet plant-specific ALARA programs and/or regulatory requirements.

Additional leakage criteria can be found in nonmandatory Appendix SA-B of ASME AG-1, including examples of determining allowable leakage for typical installations.

4.14.3 Leak Test Parameters. Components shall be designed, fabricated, and installed to not exceed allowable leakage at specified operating pressure. See nonmandatory Appendix SA-B of ASME AG-1.

5 COMPONENTS

5.1 HEPA Filters

HEPA filters shall meet the requirements of ASME AG-1, Section FC.

5.2 Tray-Type Bed and Deep Bed Adsorber Cells

Tray-type and deep bed adsorber cells shall meet the requirements for Type II or Type III cells, respectively, of ASME AG-1, Sections FD, Type II Adsorbers, and FE, Type III Adsorbers; and shall be filled with an adsorbent which meets the requirements of ASME AG-1, Section FF.

5.3 Prefilters and Postfilters

Medium efficiency prefilters and postfilters shall meet the requirements of ASME AG-1, Section FB.

5.4 Moisture Separators

Moisture separators shall meet the requirements of ASME AG-1, Section FA.

5.5 Air Heaters

Heaters shall meet the requirements of ASME AG-1, Section CA.

5.5.1 Heater Stage. The heater stage shall be sized on the basis of heat transfer calculations showing a capability of reducing the maximum expected relative humidity of the entering airstream mixture to approximately 70% in the housing space between the moisture separator or housing inlet (whichever is applicable) and the refilter stage, at the system design flow rate. The sensible heat produced by the heater stage shall not result in increasing air temperatures to more than 225°F. An overtemperature cutoff switch set at this value shall be provided. Manually reset overtemperature cutoff switches are not recommended for ESF air-cleaning units located in areas not accessible following a DBA.

5.5.2 Heaters for ESF Systems. Heaters in ESF air-cleaning units shall be qualified to meet the requirements of IEEE 323, IEEE 344, and ASME AG-1, Section CA.

5.6 Filter Housing

Housing shall meet the requirements of ASME AG-1, Section HA.

5.7 Fans

Fans shall meet the requirements of ASME AG-1, Section BA.

Fans shall be selected on the basis of detailed system pressure loss calculations, and shall be capable of producing the specified design flow rates. The system designer shall, in accordance with AMCA 201, prepare a system characteristic curve for design and limiting conditions under which the fans will be required to operate.

All resistances in the system, including clean and dirty component pressure drops (as well as test pressure differential), full-open and intermediate control damper positions, duct inlet losses, and losses in ducts, housing inlets and outlets, and fan inlets and outlets shall be considered in the estimate of the system characteristics. A set of constant speed fan performance curves, showing the static or total pressure, corresponding efficiency, capacity, and brake horsepower shall be obtained from the fan manufacturer for each fan configuration. Fan inlet and discharge configurations, or other system characteristics, that would adversely alter the published fan performance shall be avoided. Fan size shall be chosen after performing an analysis of the system characteristic and fan performance curves, considering all system factors including temperature, pressure, required airflow and, particularly for fans operating in post-accident primary containment atmospheres, density and viscosity of the air or air-steam-entrained water mixture.

Fan selection shall also allow for test conditions in accordance with ASME AG-1, Section TA. The system designer shall identify the maximum allowable differential pressure for each filter bank plus a margin to accommodate filter loading which may occur prior to the next surveillance (typically 25% of the coincident dirty filter differential pressure). The fan and system characteristic curves shall be included in the system documentation. The fan shall be selected to operate on the stable portion of its pressure curve under all operating conditions. Provision shall be made in the design to maintain stable operation under the design flows and varying pressure range. Inlet vanes, inlet/outlet damper modulation, variable speed fan control are acceptable alternatives.

5.8 Fan Drives

Fan drives shall meet the requirements of ASME AG-1, Section BA.

5.8.1 Integral Horsepower Motors — General. Motors shall comply with and be tested and rated in accordance with applicable requirements of NEMA MG-1, and IEEE 112A. Performance shall be verified by either test or certification as specified for each requirement. Rated service factor shall be a minimum of 1.0 unless specified otherwise.

Motors shall be sized to supply maximum mechanical load demand without exceeding the rated horsepower under all identified operating conditions and to produce the required torque and acceleration as required by the driven equipment under the most adverse voltage, frequency and conditions specified, and shall be designed for the starting sequence specified by the Engineer.

5.8.2 Drives for ESF Systems. Drives in ESF systems shall comply with IEEE 323. In addition, drives of ESF systems located inside containment shall be qualified in accordance with IEEE 334.

ESF fan drives shall be qualified in accordance with IEEE 344. Motor supports and hangers shall be designed to withstand all seismic and operating loads with the motor in its normal operating orientation without impairment of operating characteristics.

5.9 Dampers

Dampers shall meet the requirements of ASME AG-1, Section DA.

5.10 Ducts

Ducts shall meet the requirement of ASME AG-1, Section SA.

6 PACKAGING, SHIPPING, RECEIVING, STORAGE, AND HANDLING OF COMPONENTS

Packaging, shipping, receiving, storage, and handling shall meet the requirements of ASME NQA-1; ASME AG-1, Article AA-7000, and various specific ASME AG-1 Code section.

7 INSTALLATION AND ERECTION

7.1 Drawings

Complete system layout drawings showing the location of housings, ducts, fans, dampers, and the other external components in each of three mutually perpendicular planes shall be prepared prior to the start of erection. Drawings, shall show all connections, hangers, and anchors, the location and joint details for all welds, and the procedure specification for each weld. The layout drawings shall reference dimension and shop drawings of components, as applicable. Layout shall be checked for interferences with other items to be installed in the area, and conflicts shall be resolved before installation.

7.2 Erection

All ducts, housings, fans, dampers, hangers, anchors, and services (electrical, steam, drains, etc.) shall be installed in strict conformance with the layout drawings; deviations of more than the design tolerance from the location in any plane from the position shown in the drawings shall be approved by the system designer or other responsible Engineer, and shall be documented by "as-built drawings." Prefabricated duct subassemblies should be made as large as practicable to minimize field joints and field welding. Housings shall not be used to support other equipment of the facility for which it was not designed; field runs of pipe, duct, or conduit or other systems of the facility shall not be permitted to penetrate the housing. Internal components (filters, adsorbers, etc.) shall not be installed until immediately before the system is presented for testing, and shall not be removed from their cartons or crates until they are ready to be installed. The recommendations for handling and installation of HEPA filters given in ASME AG-1, Section FC shall be complied with.

7.3 Welding

Welding procedures, welders, and welding operators shall be qualified in accordance with ASME AG-1.

7.4 Installation of HEPA Filters and Adsorbers

Installation personnel shall be instructed in the proper handling of the HEPA filters and carbon cell adsorbers prior to the installation and clamping of the filters.

Components should not be removed from protective cartons, crates, pallets, or skids until immediately before they are to be installed. Each item should be checked for physical damage, or evidence of abuse. Replace or repair damaged items before use. The position and alignment of foundations, anchors, hangers, ducts, housings, dampers, fans, motors, and other components shall be checked and their locations shall be within tolerance as shown on the drawings. Pleats of HEPA filters shall be vertical, gaskets of HEPA filters and adsorbers shall be securely affixed so that they are not displaced during installation. Clamping devices shall be in place and completely tightened to produce the required gasket compression.

After filters and adsorbers are unpacked and opened to the atmosphere, extreme care is required to ensure that degradation does not occur either from exposure before loading or by system operation during testing, construction, repair, or plant modification. Prefilters and HEPAs are particularly vulnerable to degradation due to construction dust. If additional welding is required on the filter housing after HEPA filters or adsorbent is installed, the HEPA filters and adsorbent must be removed before starting this work. HEPA filters are very susceptible to pinholes from welding sparks. Carbon adsorbent is aged or poisoned by trace concentrations of vapors such as solvents, paint off-gassing, engine exhaust and welding fumes, or by moisture condensation.

8 QUALITY ASSURANCE

The design organization, manufacturers of components, and constructors (including subcontractors) shall each establish and comply with a comprehensive quality assurance program and plan which meets the requirements of ASME NQA-1.

9 ACCEPTANCE TESTING

Acceptance testing shall be in accordance with ASME AG-1, Section TA and operational testing shall be in accordance with ASME N510. It is recommended that prefilters be installed before fan is first turned on to protect filters and fans from construction debris, and the system fan(s) should be operated for at least 25 hr before installation of HEPA filters and adsorbers to clean up the worst of construction dirt (artificial resistance may have to be added during this operation to prevent overloading of the fan motor). Prefilters may have to be replaced after this evolution. For personnel protection, personnel should not enter housing until fan has operated for a sufficient period of time to remove air entrainable debris. After installing the HEPA filters and adsorbers, the system heaters should be operated, where provided, to reduce, if necessary, the relative humidity of the air prior to making tests on the adsorbers.

All dampers, valves, and controls shall be exercised through their full operating range and shown to be in good operating condition before the start of testing. After completion of acceptance testing, the system shall be sealed and the fan controls locked out to protect the components during the remainder of construction operations at the site.

MANDATORY APPENDIX I
SAMPLING OF INSTALLED ADSORBENTS FOR SURVEILLANCE TESTING

I1 SCOPE

Provision shall be made to periodically remove a representative sample of adsorbent from an installed system for Surveillance Tests.

A representative sample is defined as one that has experienced flow within ±20% of the average flow of the system (as confirmed by testing per ASME AG-1, Section TA). The detailed means to achieve this is left to the designer of each system, but detailed supporting data (either theoretical or empirical) shall be presented to substantiate that the flow is representative and the sample is, therefore, representative of the entire adsorber bank.

I2 DESIGN BASIS FOR SAMPLERS

For the sample to be representative, it shall have experienced the same exposure to all contaminants as the entire bed it represents. To accomplish this, it shall have experienced the same flow (±20%) during the same period. This criterion can be met only when the bed depth and pressure drop through a sampler section are the same as through the main adsorber bank. All flow restrictions must be taken into account when designing a sampler. Pipe stubs, valves, unions, fittings, elbows, nozzle effects, and similar items or effects add pressure drop to the flow path and tend to make a sampler nonrepresentative. This Standard does not restrict any specific approach or hardware but stresses that the flow criterion for equal bed thickness must be met.

I3 GENERAL TYPES OF SAMPLES (SAMPLERS)

I3.1 Individual Samplers

A special adsorbent sample holder should be designed to hold adsorbent for testing. It shall be the same depth as the main bed, a minimum of 2 in. (5.08 cm) in diameter and in the same orientation as the main bed. If there is a guard bed it shall be duplicated for the sampler.

The sampler shall be filled with adsorbent from the same lot and batch as the main bed.

Each sampler shall have at least the following data attached:

(a) serial number
(b) adsorbent lot and batch number
(c) adsorbent manufacturer and type
(d) installation date
(e) system where installed

The details of sampler design shall include a method to ensure that no bypass will occur, that the sampler(s) will be halide leak tested along with the main bank per Section TA of ASME AG-1 as part of an integrated filter bank leak test, and that the flow path shall be sealed leaktight after the sampler is removed. Consideration should be given in the design to allow insertion of the sampler into a laboratory test apparatus for determination of methyl iodide penetration without disturbing any of the adsorbent.

I3.2 Test Tray Assemblies

A *test tray assembly* is an adsorber cell modified to provide for removal of a portion of the adsorbent (usually one-eighth) in a section without disturbing the remainder of the adsorbent. Its use is acceptable as an alternative to individual samplers described in Section I3.1 of this Appendix for obtaining representative samples.

When a test tray assembly is removed, an entire section is emptied into a clean plastic container or bag, mixed to ensure uniformity, a sample taken, and the section refilled with such makeup adsorbent as required. This makeup carbon shall meet the same requirements as the original adsorbent.

The section sampled shall be marked to indicate when a sample was taken and the section number and position noted both in the field test report and permanent plant records to ensure that this section is not used again.

Each cover plate shall be permanently marked with a unique identification symbol.

Each test tray assembly shall have at least the following data attached:

(a) serial number
(b) adsorbent lot and batch number
(c) adsorbent manufacturer and type
(d) installation date
(e) system

I3.3 Sampling by Adsorber Cell Removal

As a further alternative, an entire adsorber cell or bed may be removed to obtain a sample. It shall be emptied into a clean plastic container or bag, the adsorbent mixed to ensure uniformity, a sample taken, the cell refilled or replaced. If the adsorber cell is refilled it shall be marked as having been refilled and shall not be used for future samples as they are not representative of the adsorbent in the rest of the bank.

I3.4 Slotted-Tube Sampling

For Type III adsorbers, where the adsorbent bed is refilled in-place, a sample may be taken with a slotted-tube sampler if sufficient test cannisters are not available. ASTM E 300 contains slotted-tube sampler details and background. For systems where the adsorbent bed thickness is 2 in. (5.08 cm) deep, insert the slotted-tube sampler into the bed far enough to ensure that the sample will be taken from an area where flow is experienced by the adsorbent. For systems where the adsorbent bed thickness is greater than 2 in. (5.08 cm), the position where the slotted-tube sampler is inserted into the bed is important. When a single sample representative of the entire bed is desired, the slotted-tube sampler should be inserted at an angle to pick up carbon from both the inlet and outlet faces of the bed. No carbon should be taken from areas of less than full flow. When separate samples form inlet and outlet faces are desired, sample positions should be noted and the separate samples should not be mixed. When separate samples are taken, it may be required to calculate a composite efficiency for the bed.

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