Errata
to
ASME N510–1989
Testing of Nuclear
Air Treatment Systems

The errata corrections listed below apply to ASME N510–1989.

Page	*Location*	*Change*
3	Terms and Definitions	For *refrigerant-112*, delete "1,1,2,2"
6	5.5.1.1(w)	The word "adeuate" should read "adequate"
	5.5.1.5(d)	The word "tighted" should read "tighten"
7	6.2.1	In seventh line, the word "unacceptabe" should read "unacceptable"
10	8.5.1	In Note, "para. 8.5.1" should read "paras. 8.5.1.3, 8.5.1.4, 8.5.1.5"
11	8.6.1	(1) Revise last sentence to read: "For systems with carbon adsorbers, the residence time in the carbon beds shall be greater than or equal to the values specified in the Owners Project Specification." (2) Add note after paragraph to read: "NOTE: For calculations of average residence time in the carbon beds, reference ASME AG-1, Section FD, Appendix FD-I (for Type II adsorbers), and Section FE, Appendix FE-I (for Type III adsorbers)"
	8.6.2	Delete last sentence
12	10.4.4	In first line, the word "from" should read "for"
13	10.5.9	Delete Note
	11.5.1	In third line, delete "through the adsorber bank"

JANUARY 1991

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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Page	*Location*	*Change*
14	12.5.2	In first line, "decay leak" should read "decay leak test"
15	13.5.6	Delete Note
	14.2	"Summay" should read "Summary"
16	15.3.1	"Note (3)" should read "Note (7)"
17	Appendix A	(1) In Nomenclature, "Δ_t" should read "Δt", and "elaped" should read "elapsed" (2) In Nomenclature, "m" should read "$\overline{m}$" (3) In Note following Nomenclature, "5.204 lb/ft" should read "5.204 lb/ft^2"
18	Equation (4)	"$\Delta\overline{m} = M/\Delta t$" should read "$\overline{m} = \Delta M/\Delta t$"
19	Nonmandatory Appendix B	Revise Statement to read: "This Appendix is not a part of ASME N510-1989, and is included for information purposes only."

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ASME N510–1989

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FOR CURRENT COMMITTEE PERSONNEL
PLEASE SEE ASME MANUAL AS-11

TESTING OF NUCLEAR AIR TREATMENT SYSTEMS

AN AMERICAN NATIONAL STANDARD



The American Society of
Mechanical Engineers

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AN AMERICAN NATIONAL STANDARD

TESTING OF NUCLEAR AIR TREATMENT SYSTEMS

ASME N510–1989

(REVISION OF ANSI/ASME N510-1980)

The American Society of Mechanical Engineers

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Date of Issuance: December 15, 1989

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FOREWORD

(This Foreword is not part of ASME N510-1989.)

This Standard covers requirements for the field testing of ESF (Engineered Safety Feature) and other high efficiency air-cleaning systems for nuclear power plants and other nuclear applications. The Standard was originally developed by the American National Standards Committee N45 on Reactor Plants.

This Standard provides a basis for the development of test programs and detailed acceptance and surveillance test procedures, and specifies minimum requirements for the reporting of test results.

Following approval by the N45 Standards Committee, the first edition of the Standard was approved on June 19, 1975 by the American National Standards Institute, and designated ANSI N510-1975.

In 1975, the N45.8 Subcommittee was reorganized into the ASME Committee on Nuclear Air and Gas Treatment (CONAGT) and began operating under the ASME Procedures for Nuclear Projects which received accreditation on January 15, 1976. CONAGT 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.

The second edition of the Standard was approved by CONAGT and the ASME Nuclear Codes and Standards Committee and was subsequently approved by the American National Standards Institute on March 20, 1980.

This is the third edition of this Standard. The purpose of this revision is to update the Standard to incorporate technical inquiries, corrections, and state-of-the-art improvements as part of the ANSI-required 5 year review.

In order to gain input for this revision CONAGT held workshops in February and April of 1985. These workshops were attended by representatives from utilities, consulting engineers, testing contractors, manufacturers, and regulators. The format of the workshop provided an open forum for obtaining comments on where improvements and/or clarifications were needed. These discussions provided the basis for this revision and a revision to N510's companion standard ASME N509.

Requests for clarifications or technical inquiries should be submitted in written form to the ASME Secretary. Technical inquiries should reference the specific paragraph in question and be phrased such that a yes/no response can be made. Unclear inquiries will be returned unanswered to the inquirer. This edition of the Standard was approved by CONAGT and the ASME Board on Nuclear Codes and Standards and was subsequently approved by the American National Standards Institute on October 3, 1989.

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TESTING OF NUCLEAR AIR TREATMENT SYSTEMS

1 SCOPE

This Standard covers field testing of ASME N509-1989 high efficiency air treatment systems for nuclear power plants.

1.1 Use of This Standard

This Standard provides a basis for the development of test programs and does not include acceptance criteria except where the results of one test influence the performance of other tests. Acceptance criteria shall be developed by the owner based on the system design/function in accordance with ASME N509.

This Standard is arranged so that the user may select those portions (tests) which are relevant to each application. Tests should be performed in the sequence listed in Table 1. Laboratory samples should be obtained prior to performance of the adsorber bank in-place leak test. Tests included in this Standard, together with the recommended minimum frequency of testing, are listed in Table 1. The user must specify which tests shall be employed, and the acceptance criteria for those tests, in the test program or project specifications. The Nonmandatory Appendices provide additional discussion and guidance.

1.2 Limitations of This Standard

This Standard covers post-delivery testing of installed air treatment systems. Pre-delivery testing of individual components is covered by ASME N509. This Standard shall be applied in its entirety to systems designed and built to ASME N509 specifications. Sections of this Standard may be used for technical guidance for testing air treatment systems designed according to other criteria.

2 REFERENCE 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/ANSI AG-1 contains code requirements for nuclear air and gas treatment equipment. These code requirements may be substituted for the requirements listed herein.

2.1 Project Specifications

The project specifications for the facility.

2.2 American Conference of Government Industrial Hygienists (ACGIH)

Industrial Ventilation: A Manual of Recommended Practice (20th edition)

2.3 American Society for Testing and Materials (ASTM)

ASTM D 3803-1979	Standard Method for Radioiodine Testing of Nuclear-Grade Gas-Phase Adsorbents

NOTE: Refer to Nonmandatory Appendix B.

2.4 American Nuclear Society (ANS)

ANS 3.1-1987	Selection Qualification and Training of Nuclear Power Plant Personnel

2.5 Air Movement and Control Association Inc. (AMCA)

AMCA-500 1983	Test Methods for Louvers, Dampers, and Shutters

2.6 American Society of Mechanical Engineers (ASME)

ASME/ANSI AG-1–1988	Code on Nuclear Air and Gas Treatment

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ASME N509-1989	Nuclear Power Plant Air-Cleaning Units and Components
ANSI/ASME NQA-1-1986	Quality Assurance Program Requirements for Nuclear Facilities

2.7 National Environmental Balancing Bureau (NEBB)

Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, 1983

2.8 Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

HVAC Systems Testing, Adjusting, and Balancing, 1982-2

2.9 Associated Air Balance Council (AABC)

National Standard of Total System Balance, 1982

2.10 NRC/INEL Activated Carbon Testing Program

Report No. EGG-CS-7653 (April 1987)

2.11 American National Standards Institute (ANSI)

ANSI/ASHRAE 34-1978	Number Designation of Refrigerants

2.12 U.S. Department of Energy (DOE)

DOE Proceedings, 16th DOE Nuclear Air Cleaning Conference, page 125, "Size Distributions of Aerosols Produced from Substitute Material by the Laskin Cold DOP Aerosol Generator," by W. Hinds, J. Macher, M. First (February 1981 NITS Springfield, VA).

3 TERMS AND DEFINITIONS

activated carbon — an adsorbent of porous structure manufactured by carbonization of organic material and treated by controlled oxidation to increase its microporosity, consisting mainly of the element carbon in a porous structure

adsorbent — any solid having the ability to concentrate significant quantities of other substances on its surface

adsorber — a device or vessel containing adsorbent

adsorber bank or filter bank — one or more filter or adsorber cells secured in a single mounting frame, or one or more side-by-side panels containing poured or packed air treatment media, confined within the perimeter of a duct, plenum, or vault cross section; sometimes referred to as a *stage*

adsorber cell or cell — a modular container for an adsorbent, with provision for sealing to a mounting frame, which can be used singly or in multiples to build up a system of any airflow capacity

aerosol — a stable suspension of particles, solid or liquid, in air (particle size less than 100 μm)

aerosol detection instrument — an instrument capable of measuring DOP aerosol concentration with a linear range of at least 10^5

average ($\overline{C}$) —

$$\overline{C} = \frac{\sum_1^n C_i}{n}$$

where

Σ = summation of reading from *1* through *n*
C_i = individual readings
n = number of readings

cell or adsorber cell — a modular container for an adsorbent, with provision for sealing to a mounting frame, which can be used singly or in multiples to build up a system of any airflow capacity

challenge — to expose a filter, adsorber, or other air-cleaning device to an aerosol or gas of known characteristics, under specified conditions, for the purpose of testing

DOP aerosol — a challenge aerosol (dioctyl phthalate) for testing HEPA filter banks. The DOP aerosol used for in-place testing of installed HEPA filter systems in accordance with this Standard is a polydisperse liquid aerosol having an approximate light-scattering mean droplet size distribution as follows:

99% less than 3.0 μm
50% less than 0.7 μm
10% less than 0.4 μm

The polydispersed DOP aerosol used for in-place leak testing of systems should not be confused with the 0.3 μm monodisperse DOP aerosol used for efficiency testing of individual HEPA filters by manufacturers. For allowable substitutes to DOP, see para. 2.12.

DOP aerosol generator — a device to create an aerosol from liquid DOP in the required particle size and distribution

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duct — an enclosed passage through which air is transferred from point to point; typically will not include air-cleaning components such as HEPA filters or adsorber air-cleaning units

filter — a device that removes matter from a fluid which passes through it

filter bank or adsorber bank — one or more filter or adsorber cells secured in a single mounting frame, or one or more side-by-side panels containing poured or packed air treatment media, confined within the perimeter of a duct, plenum, or vault cross section; sometimes referred to as a *stage*

frame, mounting — a structure designed to support filters or adsorbers and which provides a uniform surface for the seating of filter or adsorber gaskets

halide gas detection instrument — an instrument capable of distinguishing halide challenge gas from background and detecting halide gas with a linear range of at least 10^5

halide gas generator — a device for producing halide challenge gas for testing

HEPA filter — a high efficiency particulate air filter is a throwaway, extended-media dry-type filter with a rigid casing enclosing the full depth of the pleats. The filter shall exhibit a minimum efficiency of 99.97% when tested with an aerosol of essentially monodispersed 0.3 μm particles.

housing — a duct section that contains one or more components, each of which may be used for moving, cleaning, heating, cooling, humidifying, or dehumidifying the air or gas stream

leakage — the passage of air through the pressure boundary

leakage, bypass — a path through which contaminated air can escape treatment around the installed HEPA and/or adsorber banks

nuclear air treatment system — a system designed to remove radioactive gaseous and particulate contaminants from a near-atmospheric pressure gas stream without significantly altering the physical properties of the inert carrier gases. Such a system contains one or both of the high efficiency gas cleaning components referred to as HEPA filters and nuclear-grade carbon or inorganic silver-containing adsorbers. These items are usually accompanied by one or more auxiliary air treatment components such as prefilters, afterfilters, heaters, coils, and moisture separators. Accessories such as dampers, ducts, plennums, and fans are included when they are within or are a part of a defined pressure boundary.

operating cycle — a period of time, defined by the owner, not to exceed 18 months

penetration — leakage of challenge gas or aerosol past the components between the upstream and downstream sample ports

$$P = 100\left(\frac{C_d}{C_u}\right)$$

where

P = % penetration
C_d = downstream concentration of a gas or aerosol
C_u = upstream concentration of a gas or aerosol

pressure, maximum operating — the maximum static pressure the air-cleaning units and components will be subjected to and still be required to continue to perform their air-cleaning function. Static pressure resulting from off-normal operating conditions which do not render the system inoperable (e.g., closure of branch dampers or registers) shall be considered as maximum operating pressure.

pressure, operating — the static pressure that corresponds to the normal design operating mode of the air-cleaning unit, component, or system. This pressure is less than or equal to the maximum operating pressure, but may not exceed it.

pressure, test — the static pressure used for establishing leakage rates (pressure decay method only). This pressure is 1.25 times the maximum operating pressure of the item being tested, but shall not exceed structural capability pressure.

pressure, structural capability — the static pressure to which the designer specifies the component or equipment can be safely loaded without permanent distortion. This pressure may exceed the maximum operating pressure due to inclusion of a margin of safety.

pressure drop, maximum housing component — the maximum design differential pressure across all housing components in an air treatment system as established by the designer

project specifications — the facility specifications that define specific technical operating limits and conditions imposed upon the facility's operation (e.g., final safety analysis report, technical specifications, regulatory commitments)

refrigerant-11 — trichloromonofluoromethane (R-11) in accordance with ANSI/ASHRAE 34

refrigerant-112 — challenge gas 1,1,2,2 tetrachlorodifluoroethane (R-112 or R-112A) in accordance with ANSI/ASHRAE 34

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scanning — a method for locating leaks in which the probe nozzle of a detection instrument is moved back and forth across the entire area being tested

standard air — dry air at 70°F and 29.92 in. mercury barometric pressure. This corresponds to an air density of 0.075 lb/ft^3.

test, acceptance — a test made upon completion of on-site fabrication, installation, repair, or modification of a system to verify that it meets specified requirements

test, leak, in-place — a test to measure bypass leakage around or through a specified test boundary

test, surveillance — a series of tests periodically performed to monitor system condition and its ability to perform its intended function

test boundary — the physical limit component, system, or device being subjected to a leakage test as defined in specific test procedures

test canister — a specially designed sample holder containing sufficient adsorbent for specific laboratory tests that can be removed from an adsorber bank to provide samples for laboratory testing. A full-sized Type II adsorber cell may be substituted for the test canister for the purposes of providing material for specific laboratory tests.

test program — a schedule which specifies tests and the sequence of tests to be made for the evaluation of a total air or gas cleaning system

4 GENERAL

The tests covered by this Standard are of two types:

(a) acceptance tests which verify that the systems have been correctly installed and meet the requirements of project specifications;

(b) surveillance tests which monitor the condition of the systems.

This classification of tests as acceptance or surveillance, and the recommended minimum frequency of tests are shown in Table 1.

4.1 Test Procedure

Procedures shall be prepared for each required test, based upon the requirements of this Standard.

4.2 Personnel

Tests shall be performed only by persons who have demonstrated the competence to satisfactorily perform the specific tests in question as evidenced by experience and training. Personnel shall be certified in accordance with ANSI/ASME NQA-1 or ANS 3.1 and in accordance with the facility project specifications and quality assurance program.

4.3 Instrumentation — Permanent

The permanent instrumentation used on the installed systems shall have an established routine calibration program in accordance with the facility project specifications and quality assurance program.

4.4 Instrumentation — Portable

Portable instrumentation used in the performance of the tests specified in this standard shall meet the accuracy requirements of this standard and shall be calibrated in accordance with the facility project specifications and quality assurance program.

5 VISUAL INSPECTION

5.1 Purpose

A visual inspection of the air treatment system, as specified by the test program, shall be made in conjunction with each test series to identify visual deficiencies in the system prior to commencing the tests. In addition, this inspection may be used to verify that system design and construction are in accordance with ASME N509.

5.2 Summary of Method

Visual inspection shall be made under a combination of background light plus supplementary light that provides adequate illumination of the surface to be inspected.

5.3 Prerequisites

Construction, modification, and/or repairs shall be completed to the extent of supporting the test series.

5.4 Apparatus

Supplementary light as required to provide adequate illumination of the surface to be inspected.

5.5 Procedure

As a minimum, the lists of items in para. 5.5.1 should be checked. When performed as part of the

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TABLE 1 TESTS AND INSPECTIONS WITH RECOMMENDED FREQUENCIES

Test	Section of Standard	Recommended Frequency [Note (1)]
Visual inspection	5	Before each test series [Note (2)]
Duct leak test	6	Acceptance [Note (3)]
Structural capability test	6	Acceptance [Note (3)]
Housing leak test	6	Acceptance and at least once each 10 years [Note (3)]
Mounting frame pressure leak test	7	Optional [Note (4)]
Airflow capacity and distribution	8	Acceptance [Note (3)] Surveillance [Note (5)]
Air–aerosol mixing uniformity test	9	Acceptance [Note (3)]
In-place leak test, HEPA filters	10	Acceptance, after each HEPA filter replacement and at least once each operating cycle [Notes (3), (6)]
In-place leak test, adsorbers	11	Acceptance, after each adsorber replacement and at least once each operating cycle [Notes (3), (6)]
Duct damper bypass test	12	Acceptance and at least once each operating cycle [Notes (3), (6)]
System bypass test	13	Acceptance and at least once each operating cycle [Notes (3), (6)]
Air heater performance test	14	Acceptance and at least once each operating cycle [Note (3)]
Laboratory tests of adsorbent	15	Acceptance, before each adsorber replacement, and at least once each operating cycle [Notes (3), (7), (8)]

NOTES:
(1) Field test of motors, valve and damper actuators, and fire protective systems are not covered by this Standard.
(2) Frequency of verifying loop seals and traps shall be evaluated by the owner to assure integrity at all times.
(3) Acceptance tests to be made after completion of initial construction and after any major system modification or repair.
(4) The mounting frame leak test is a recommended, but optional test which serves to identify mounting frame leakage which would be included as a part of total bank leakage during HEPA filter bank and adsorber bank in-place leak tests. In many cases, a thorough visual inspection of the mounting frame ensures the mounting frame leakage component of total bank leakage will be minimal. It is left up to the owner to determine whether a mounting frame leak test is warranted based upon the visual examination.
(5) Airflow capacity for surveillance purposes is performed prior to any in-place leak test per para. 8.5.1.2.
(6) Periodic in-place leak tests of systems located within reactor containments and used only for 100% recirculation are not necessary.
(7) Adsorbents must be tested before installation or replacement to establish efficiency. Samples for laboratory testing should be taken before the routine in-place testing of the installed system to verify the condition of the adsorbent.
(8) Adsorbent is sampled and laboratory tests shall be made to confirm performance at intervals not exceeding 720 hr of system operation or for any system immediately following inadvertent exposure to solvent, paints, or other organic fumes or vapors which could degrade the performance of the adsorbent. The 720 hr requirement may be modified based on laboratory test history.

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acceptance test, the visual inspection should be started prior to filter media installation and completed after completion of media installation. Those items indicated by an asterisk (*) usually need only be inspected during acceptance testing and/or after any system modification or repair. Whenever "unacceptable" is used, it is intended to mean any damage or condition that would impair the ability of the item to perform its function (reference ASME N509).

5.5.1 Guidance for Visual Inspection

5.5.1.1 Housing and Ducts

(a) Adequate access to housing.

(b) Adequate space for personnel and equipment for maintenance and testing.*

(c) Doors of rigid construction to resist unacceptable flexure under operating conditions.*

(d) Adequate seal between door and casing.

(e) Gasket joints are dovetail type with a seating surface suitable for accomodating a knife edge sealing device.

(f) Provision for opening doors from inside and outside of housing.*

(g) Adequate number and acceptable condition of operable latches on access doors to achieve uniform seating.

(h) Provision for locking doors.*

(i) Adequate structural rigidity of housing to resist unacceptable flexure during operating conditions.*

(j) Access to upper tiers, (above the 7 ft level), provided with permanent ladders and platforms.*

(k) At least 3 ft clearance between banks of components for maintenance and testing.*

(l) Door provided on each side, (upstream and downstream), of each component bank.*

(m) No back-to-back installation of components.*

(n) Sample ports located and labeled upstream and downstream of each HEPA filter and adsorber bank.

(o) Challenge injection ports located and labelled.

(p) Sample and injection ports equipped with leak-tight caps or plugged.

(q) Housekeeping in and around housing adequate for maintenance, testing, and operation.

(r) Adequate guards provided on fans for personnel safety.

(s) Condition of flexible connection between housing and fan located external to housing adequate to prevent leakage of untreated air.

(t) Fan-shaft seals installed where required.

(u) Airtight seals for conduits, electrical connections, plumbing, drains, or other conditions that could result in bypassing of the housing or any component therein.

(v) No sealant or caulking of any type on/in housings or component frames. Caulking on/in ducts may be permissible depending on project specifications.

(w) Loop seals have adeuate water level.

(x) Satisfactory condition of fire protection components (if provided).

5.5.1.2 Local Instrumentation

(a) No unacceptable damage to instrumentation (e.g., gages, manometers, thermometers, etc.).

(b) All connections complete.

5.5.1.3 Lighting, Housing

(a) Adequate lighting provided for visual inspection of housing and components.

(b) Flush mounted fixtures serviceable from outside the housing.*

5.5.1.4 Mounting Frames for Filters and Moisture Separators

(a) Continuous seal weld between members of all frames and between frame and housing.*

(b) Adequate structural rigidity for supporting internal components during operating conditions without flexure.*

(c) No unacceptable damage to the frames that may interfere with proper seating of components.

(d) Sample canisters installed and unused connections capped or plugged leak-tight.

(e) No penetrations of the mounting frame except for test canisters.

(f) No sealant or caulking of any type.

5.5.1.5 Filter Clamping Devices

(a) Sufficient number of devices of adequate size to assure specified gasket compression.

(b) Individual clamping of filters and adsorbers.*

(c) All clamping hardware complete and in good condition.

(d) Adequate clearances provided between filter and adsorber units in same bank to tighted clamping devices.*

5.5.1.6 Moisture Separators

(a) No unacceptable damage to media, frame, or gaskets.

(b) No dirt or debris loading which creates a higher than the specified pressure drop across the bank of components at the design airflow rate.

(c) Proper installation of moisture separators.

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5.5.1.7 Air Heating Coils — Inside Housing

(a) No unacceptable damage to coils which may affect operability of the heaters.

(b) No unacceptable dirt or debris on or between coils.

5.5.1.8 Prefilters

(a) No damage to media, frame, or gaskets which may affect operability of prefilters.

(b) No dirt or debris loading which creates higher than the specified pressure drop across the filter bank at the design flow rate.

(c) Proper installation of prefilters.

5.5.1.9 HEPA Filters

(a) No unacceptable damage to filter media.

(b) Acceptable condition and seating of gaskets with at least 50% compression.

(c) No dirt of debris loading which creates higher than the specified pressure drop across the filter bank at the design flow rate.

(d) No sealant or caulking of any type.

(e) Filters are properly installed with pleats vertical.

5.5.1.10 Adsorbers

(a) No unacceptable damage to adsorbers or adsorbent beds.

(b) Acceptable condition and seating of gaskets with at least 50% compression.

(c) No through bolts on Type II adsorbers or other structure that could cause bypass in an adsorber bank.

(d) No sealant or caulking of any type.

5.5.1.11 Dampers — Housing and Associated Bypass Duct

(a) No unacceptable damage to or distortion of frame or blades.

(b) No missing seats or blade edging.

(c) No unacceptable damage to shaft, pivot pins, operator linkages, operators, or packing.

(d) Linkage connected and free from obstruction.

(e) No unacceptable damage to gaskets.

5.5.1.12 Manifolds

(a) No unacceptable damage to test manifolds.

(b) Adequate clearance between permanent manifolds and filters.

5.6 Acceptance Criteria

The acceptance criteria shall be in accordance with test program or project specifications.

5.7 Report

The test procedure shall document the results of the test and conform to the owner's test program. Items identified as unacceptable should be further documented in the comment section of the test report to assist the owner in preparation of corrective action.

6 DUCT AND HOUSING LEAK AND STRUCTURAL CAPABILITY TESTS

6.1 Purpose

These tests are to verify the leak tightness and structural integrity of housings and ducts.

6.2 Summary of Method

6.2.1 Structural Capability Test. Ducts and housings of once-through and recirculation air treatment systems which could be subjected to structural capability pressure due to closure of dampers on suction or discharge of fans shall be pressure tested to the structural capability pressure and verified that there is no unacceptabe distortion or breach of integrity.

6.2.2 Duct and Housing Leak Tests. Ducts and housings shall be pressurized to determine leak tightness. If the measured leakage is in excess of the acceptance criteria, the leaks should be located by one of the methods listed in paras. 6.5.4 or 6.5.5. After leaks are repaired, the housing or duct shall be retested.

6.3 Prerequisites

Construction, modifications, and repairs affecting the test boundary shall be complete and the inlet and discharge openings of the duct or housing sealed before the test is started. All electrical, piping, and instrument connections shall be complete and all permanent seals installed before the test is started.

6.4 Apparatus

6.4.1 Structural Capability Test

6.4.1.1 Test fan with flow control.

6.4.1.2 Covers to seal test boundaries.

6.4.1.3 Clock or timer accurate to ±1.0 sec.

6.4.1.4 Pressure indicating device accurate to ±0.1 in. w.g.

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6.4.2 Duct and Housing Leak Rate Test

6.4.2.1 Fan with flow control.

6.4.2.2 Flowmeter or totalizing gas volume meter accurate to ±5% of reading.

6.4.2.3 Temperature indicating device accurate to ±0.5°F.

6.4.2.4 Pressure indicating device accurate to ±0.1 in. w.g.

6.4.2.5 Covers to seal test boundaries.

6.4.2.6 Clock or timer accurate to ±1.0 sec.

6.4.3 Bubble Method

6.4.3.1 Bubble solution in a plastic squeeze-type laboratory wash bottle (a commercial test solution or a solution consisting of equal parts liquid detergent, glycerine, and water).

6.4.4 Audible Leak Method

6.4.4.1 Suitable electronic sound detection equipment (optional).

6.5 Procedure

6.5.1 Structural Capability Test

6.5.1.1 Connect the test fan with flow control to the housing and/or ducting.

6.5.1.2 Install a pressure indicating device so that it will indicate the pressure inside the duct and/or housing being tested.

6.5.1.3 Seal test boundaries and close access openings in the normal manner.

6.5.1.4 Start the fan and operate until the structural capability pressure is achieved. Maintain pressure for the duration of the inspection.

6.5.1.5 Inspect the pressure boundary for distortion or breach of integrity.

6.5.1.6 Release pressure and inspect for permanent distortion.

6.5.2 Duct and Housing Leak Rate Test (Constant Pressure Method)

6.5.2.1 Connect the test fan with flow control to duct/housing. Connect the flowmeter or totalizing gas volume meter between the fan and the housing (downstream of the throttling valve, if used).

6.5.2.2 Install temperature and pressure devices to indicate representative temperature and pressure inside the duct/housing being tested.

6.5.2.3 Seal test boundaries and close access openings in the normal manner. Do not use temporary sealants, duct tape, or similar temporary materials except for sealing temporary blankoffs.

6.5.2.4 Start the fan and operate until the maximum operating pressure is achieved. Maintain pressure constant with a flow control device until the temperature remains constant within ±0.5°F for a minimum of 10 min.

6.5.2.5 Measure the flow rate of the air being added to or removed from the duct/housing while maintaining the maximum operating pressure within ±0.1 in. w.g. The flow rate should be measured by one of the following methods.

(a) For a flowmeter: record flow readings once a minute for a 10 min continuous period and average the readings to calculate the measured leakage flow rate.

(b) For a totalizing gas volume meter: measure the total volume of air for a 10 min continuous period and divide the measured volume by time (10 min) to calculate the measured leakage flow rate.

6.5.2.6 If the calculated leak rate exceeds the acceptance value, report to the owner and locate the leaks in accordance with para. 6.5.4 and/or para. 6.5.5. Repair and retest as required.

6.5.3 Duct and Housing Leak Rate Test (Pressure Decay Method)

NOTE: This paragraph is phrased as if the operating pressure were positive, but would be identical for negative pressure systems with correct signs used in the data collection and calculations.

6.5.3.1 Connect test fan with shutoff valve to duct/housing.

6.5.3.2 Install temperature and pressure devices to indicate representative temperatures and pressures inside the duct/housing being tested.

6.5.3.3 Seal test boundaries and close access openings in the normal manner.

6.5.3.4 Start fan and operate until the test pressure is achieved. Maintain test pressure constant with a flow control device until the temperature remains constant within ±0.5°F for a minimum of 10 min. Close shutoff valve.

6.5.3.5 Record initial time, pressure, and temperature.

6.5.3.6 Record barometric pressure.

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6.5.3.7 Record pressure readings once a minute until pressure decays to 75% of the test pressure, or for a maximum of 15 min.

6.5.3.8 Record final time, pressure, and temperature.

6.5.3.9 Calculate leakage from the equation:

$$\overline{Q} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right) \frac{V}{R\Delta t(0.075)}$$

where

$\overline{Q}$ = average leakage rate, scfm
V = volume within test boundary, ft^3
P_i = initial pressure within test boundary, lb/ft^2 ABS
P_f = final pressure within test boundary, lb/ft^2 ABS
T_i = absolute temperature at start of test, °R
T_f = absolute temperature at end of test, °R
$\Delta t = t_f - t_i$
t_i = time at start of test, min
t_f = time at end of test, min
R = gas constant for air

$$53.35 \left(\frac{\text{ft lb}}{\text{lb °R}}\right)$$

6.5.3.10 If calculated leak rate exceeds the acceptance value, report to owner. Locate leaks in accordance with paras. 6.5.4 or 6.5.5. Repair and retest as required.

6.5.4 Bubble Leak Location Method

6.5.4.1 Pressurize the test boundary to a pressure adequate to locate leaks (not to exceed structural capability pressure).

6.5.4.2 With test boundary under continuous pressure, apply bubble solution to areas to be tested. Identify places where bubbles are found.

6.5.4.3 After repair of leaks, retest as required.

6.5.5 Audible Leak Location Method

6.5.5.1 Pressurize the test boundary to a pressure adequate to detect leaks (not to exceed structural capability pressure).

6.5.5.2 With the test boundary continuously pressurized, locate audible leaks (electronic sound detection equipment optional). Identify places where leaks are found.

6.5.5.3 After repair of leaks, retest as required.

6.6 Acceptance Criteria

6.6.1 Structural Capability Test. Meets the requirements of ASME N509, test program and project specifications.

6.6.2 Duct and Housing Leak Test. Meets the requirements of ASME N509, test program and project specifications.

6.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program.

7 MOUNTING FRAME PRESSURE LEAK TEST (OPTIONAL)

7.1 Purpose

This optional test is used to verify the absence of leaks through seal welds of the HEPA filter and/or adsorber frames, and between the frames and housing.

NOTE: Presence of these leaks will be evident when performing Sections 10 and 11 of this Standard. A good visual verification per Section 5 is usually adequate. This test method is provided for use when leakage needs to be located or quantified.

7.2 Summary of Method

Openings of the test boundary and mounting frame shall be sealed with blank-off plates. The leak tightness of the mounting frames meets requirements of para. 6.6.2 when tested by the pressure decay method (para. 6.5.3) or the constant pressure method (para. 6.5.2).

7.3 Prerequisites

7.3.1 Construction, modications, and repairs of the test boundary shall be completed.

7.3.2 Mounting frame blank-off plates installed.

7.3.3 Test boundary sealed and all doors and access panels closed in the normal manner.

7.4 Apparatus

The same as para. 6.4.

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7.5 Procedure

The same as paras. 6.5.2 or 6.5.3.

7.6 Acceptance Criteria

Meets the requirements of ASME N509, the test program and project specifications.

7.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program or project specifications.

8 AIRFLOW CAPACITY AND DISTRIBUTION TESTS

8.1 Purpose

These tests shall be used:

(a) to verify that the design airflow can be achieved with the fan as furnished, under actual field conditions at maximum and minimum filter pressure drop;

(b) to verify that airflow distribution across each HEPA filter bank or adsorber bank is uniform at the design flow rates.

8.2 Summary of Method

8.2.1 Airflow Capacity Test. Total airflow is measured to verify capacity at clean and dirty filter conditions when the system is operated at normal or simulated minimum and maximum design conditions.

8.2.2 Airflow Distribution Test. Velocity profiles of the filter bank(s) shall be made to evaluate uniform airflow distribution. The presence of uniform airflow distribution for the upstream HEPA filter bank shall be adequate to verify uniform distribution for the downstream adsorber and/or HEPA filter banks if the banks have relatively uniform geometry and cross-sectional area, and are not interrupted by turns or bends.

8.3 Prerequisites

8.3.1 Airflow Capacity Test. System airflow balancing required for the performance of these tests shall be completed. The extent of the system balancing requirement shall be documented in the test program. All housing components, or equal artificial resistance devices shall be installed.

8.3.2 Airflow Distribution Test. Airflow capacity test is complete and all components shall be installed.

NOTE: Filters should be in the clean condition to prevent variations in flow due to unequal loading.

8.4 Apparatus

8.4.1 Standard pitot tube (length as required).

8.4.2 Pressure indicating device accurate to ±5.0% of reading.

8.4.3 Rotating vane, heated wire or heated thermocouple anemometer or other suitable measuring device accurate to ±5.0% of reading.

8.5 Procedure

8.5.1 Airflow Capacity Test

NOTE: The tests described in para. 8.5.1 need be performed only as acceptance tests and after major system modification or repair.

8.5.1.1 Start system fan and verify stable (no surging) fan operation for 15 min.

8.5.1.2 Measure system airflow in accordance with para 2.2 or equivalent.

8.5.1.3 Clean System Airflow. With new housing components installed, or simulated, operate at the clean differential pressure and compare measured flow rate (using methods of para. 8.5.1.2) with the value specified by the test program or project specifications. If the specified value cannot be achieved, report to owner.

NOTE: This may indicate excessive system in leakage, improper fan design, improper housing design, or inadequate air balance.

8.5.1.4 Maximum Housing Component Pressure Drop Airflow. After successful completion of para. 8.5.1.3, increase housing component resistance (artificially by blanking off portions of the filter bank or by adjusting throttling dampers) until the maximum housing component pressure drop for the system (as specified in the test program or project specifications) is achieved. Measure flow rate per para. 8.5.1.2. If the maximum housing component pressure drop airflow cannot be achieved, report to owner.

8.5.1.5 Return system to "clean" condition.

8.5.2 Airflow Distribution Test

NOTE: Airflow distribution tests are not required for a filter bank containing a single HEPA filter.

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8.5.2.1 Airflow Distribution Through HEPA Filter Banks. The minimum number of velocity measurements shall be one in the center of each filter. All measurements should be made an equal distance away from the filters. Velocity measurements should be made downstream of the filters to take advantage of the airflow distribution dampening effects of the HEPA filters.

8.5.2.2 Airflow Distribution Through Adsorber Banks. For banks containing Type I adsorbers, the air distribution test shall follow the same procedures specified for HEPA filter banks in para. 8.5.2.1. For banks containing Type II modular trays, the air distribution test shall follow the same procedure specified for filter banks in para. 8.5.2.1, except that all velocity measurements shall be made in the plane of the face of the air channels, in the center of every open channel and an equal distance away from the adsorbers. For type III adsorbers, velocity measurements shall be made in the plane of the face of the air channels. These measurements shall be made in centers of equal area that cover the entire open face, not in excess of 12 in. between points on a channel, and an equal distance away from the adsorber.

8.5.2.3 Calculate the average of the velocity readings (Section 3).

8.5.2.4 Note the highest and lowest velocity readings and calculate the percentage they vary from the average found in para. 8.5.2.3. If acceptance criteria are exceeded, notify owner.

8.6 Acceptance Criteria

8.6.1 Airflow Capacity Test. Airflow shall be within ±10% of the value specified in the test program or project specifications. Maximum housing component pressure drop airflows shall be ±10% of the value specified in the test program or project specifications with the pressure drop greater than or equal to the maximum housing component pressure drop. For systems with carbon adsorbers, the maximum velocity of air through the carbon beds shall be limited to that value specified in the laboratory test (Section 15).

8.6.2 Airflow Distribution Test. No velocity readings shall exceed ±20% of the calculated average. For systems with carbon adsorbers, maximum velocity of air through the carbon beds shall be limited to that value specified in the laboratory test (Section 15).

8.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program.

9 AIR–AEROSOL MIXING UNIFORMITY TEST

9.1 Purpose

This test is a prerequisite for conducting the tests in Sections 10 and 11, in-place leak tests of HEPA filter and adsorber banks, respectively. The purpose of the test is to verify that the challenge gas is introduced so as to provide uniform mixing in the airstream approaching the HEPA filter bank or adsorber stage to be tested. When acceptable uniformity is achieved, an upstream sample taken in the same position that the uniformity data were obtained is defined as an acceptable single point upstream sample.

This test is performed upon completion of initial system installation and after modification or major repair. It is not required each time an in-place leak test of the filters or adsorbers is performed. If the location of the injection and/or upstream sample ports is changed, the air–aerosol mixing uniformity shall be recertified.

NOTE: The air–aerosol mixing uniformity test is not necessary for a single HEPA filter in a bank. If the housing has more than one HEPA filter bank (which is required to be leak tested) or more than one adsorber stage in series, a separate challenge-injection port is required for each bank. Therefore, a separate air–aerosol mixing test is required for each injection port and filter bank. If air–aerosol mixing is adequate for the first bank of HEPA filters, it can be assumed to be adequate for the first adsorber bank downstream of the first HEPA bank. If the system contains a second bank of HEPA filters requiring leak testing, DOP must be injected at a point between the two HEPA filter banks in order to introduce sufficient aerosol to the second bank for a valid test. Refer to ASME N509, Appendix C, for a discussion of manifold design guidelines, and Appendix D for manifold qualification test requirements.

9.2 Summary of Method

DOP aerosol is introduced into the airstream at a previously selected injection point. Aerosol concentration readings shall be taken across a plane parallel to, and a short distance upstream of, the HEPA filter bank or adsorber stage. The uniformity of the readings establishes the acceptability of the injection port location. DOP aerosol is used to establish uniform challenge/air mixing upstream of both HEPA filter and adsorber banks.

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9.3 Prerequisites

The airflow capacity and distribution tests of Section 8 have been satisfactorily performed. If permanent manifolds are installed, the injection and sample manifold qualification testing has been completed in accordance with Appendix D of ASME N509.

9.4 Apparatus

9.4.1 Aerosol generator.

9.4.2 Aerosol detection instrument.

9.4.3 System fan or auxiliary fan (for systems normally without fans) capable of producing the airflow specified in the test program.

9.5 Procedure

9.5.1 Connect an aerosol generator to the injection port.

9.5.2 Start system fan (or auxiliary fan). Establish airflow as specified by the test program and project specifications.

9.5.3 Connect aerosol detection instrument to an upstream sample port.

9.5.4 Start DOP injection.

9.5.5 Take a concentration reading approximately 1 ft upstream and at the center of each filter. Allow adequate time at each location to ensure representative readings.

9.5.6 Calculate average concentration (Section 3).

9.5.7 Calculate the percent difference of each reading with respect to the average.

9.5.8 If the maximum and minimum readings do not meet the acceptance criteria, notify owner.

NOTE: Relocation of the injection port or provision for additional mixing between the injection port and the sample point may be required. Following relocation of the injection port or system modifications, retest is required.

9.6 Acceptance Criteria

No readings shall exceed ±20% of the calculated average reading.

9.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program.

10 HEPA FILTER BANK IN-PLACE TEST

10.1 Purpose

This test is used for both acceptance and surveillance leak testing of the installed HEPA filter bank.

NOTE: DOP leak testing of other non-HEPA filter banks (prefilters) is not required.

10.2 Summary of Method

A DOP challenge is injected into the airstream upstream of the HEPA filter bank. Concentrations shall be determined upstream and downstream of the filter bank. Percent penetration is determined from the ratio of the downstream to upstream concentrations (Section 3).

10.3 Prerequisites

The upstream sample and injection points to be used are those qualified per Section 9. Single point downstream sample points shall be downstream of a fan, or downstream sample manifolds shall be qualified per ASME N509.

10.4 Apparatus

10.4.1 DOP aerosol (or suitable alternate).

10.4.2 DOP aerosol generator.

10.4.3 DOP aerosol detection instrument.

10.4.4 System fan or auxiliary fan from systems normally without fans capable of producing the airflow specified in the test program.

NOTE: Sample line length should be minimized to reduce sample response time and the lengths to upstream and downstream sampling points should be approximately equal to eliminate time delay errors.

10.5 Procedure

10.5.1 Establish airflow through the HEPA filter bank at the flow rate specified by the test program or project specifications.

10.5.2 Measure and record the pressure drop across the bank, using system or temporary test instrumentation.

10.5.3 Connect aerosol detection instrument sample lines to the upstream and downstream sample ports.

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10.5.4 Check the background particulate concentration upstream and downstream of the HEPA filter bank. The preinjection background levels shall be stable to ensure proper instrument response. The levels shall not interfere with the detector's ability to detect penetration smaller than the maximum penetration allowed by the test program or project specifications.

10.5.5 Connect DOP aerosol generator to injection port and start injection.

10.5.6 Record upstream concentration reading.

10.5.7 Record downstream concentration reading.

10.5.8 Repeat steps from paras. 10.5.6 and 10.5.7 until readings are repeatable within ±5% of respective previous readings. Use final set of readings to calculate penetration.

10.5.9 Calculate penetration (Section 3). If calculated penetration exceeds the acceptance criteria, notify the owner.

NOTE: Calculated penetration shall be adjusted for any background readings.

10.5.10 When the housing contains more than one bank of HEPA filters in series which are required to be leak tested, repeat the procedure for each bank.

10.6 Acceptance Criteria

Allowable penetration shall be as stated in the test program or project specifications.

10.7 Report

The test procedure shall include documentation of the results of the tests and conform to the owner's test program or project specifications.

11 ADSORBER BANK IN-PLACE LEAK TEST

11.1 Purpose

This test shall be used for both acceptance and surveillance leak testing of the installed adsorber bank. If samples of adsorbent are to be taken for labroatory testing (Section 15), remove such samples prior to this test, and restore bank to operating condition.

11.2 Summary of Method

A halide challenge gas is injected into the airstream upstream of the adsorber bank. Concentrations shall be determined upstream and downstream of the bank. Percent penetration is determined from the ratio of downstream to upstream concentration (Section 3).

11.3 Prerequisites

The upstream sample and injection points to be used shall be those qualified per Section 9. Downstream sample points shall be downstream of a fan, or downstream sample manifolds shall be qualified per ASME N509.

11.4 Apparatus

11.4.1 Halide gas R-11 is preferred; R-112 (or R-112A) is an acceptable alternate.

11.4.2 Halide gas detection instrument.

11.4.3 Halide gas generator.

11.4.4 System fan or auxiliary fan (for systems normally without fans) capable of producing the flow rate specified in the test program or project specifications.

NOTES:
(1) Sample line lengths should be minimized to reduce sample response time and of approximately equal lengths to eliminate time delay errors.
(2) It may be necessary to operate the system for a period to purge all residual challenge gas remaining from a prior test to reduce background concentrations to acceptable values.

11.5 Procedure

11.5.1 Establish airflow through the adsorber bank at the flow rate specified by test program or project specifications through the adsorber bank.

11.5.2 Connect sample lines to upstream and downstream sample ports.

11.5.3 Measure upstream and downstream background halide concentrations. The concentrations shall not interfere with the halide detection instruments capability to detect leaks smaller than the maximum leak allowed by the test program or project specifications.

11.5.4 Connect the generator to the injection port.

11.5.5 Start injection. After generator stabilization, maintain upstream challenge concentration ±20% of average concentration during the injection period.

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11.5.6 Take upstream and downstream halide concentration readings as rapidly as instrument response permits. Record the time and concentration for each reading.

11.5.7 Calculate penetration. If the calculated penetration exceeds the acceptance criteria, notify the owner.

NOTE: Calculated penetration shall be adjusted for any background readings.

11.5.8 When the housing contains more than one bank of adsorbers in series, repeat the procedure for each bank utilizing the injection and sample ports qualified in Section 9.

11.6 Acceptance Criteria

Allowable penetration shall be as stated in the test program or project specifications.

11.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program or project specifications.

12 DUCT DAMPER BYPASS TEST

12.1 Purpose

To measure the leakage through closed dampers or valves intended to eliminate flow through a bypass duct.

12.2 Summary of Method

There are two equally appropriate methods depending on the type of damper or valve to be leak tested. For low leakage valves, a pressure decay test is usually the method of choice. For higher leakage devices (a few tenths or a percent of rated flow or greater) a DOP aerosol or halide leak test may be more convenient. If a DOP aerosol or halide leak test is specified, only one damper at a time is to be tested. The method shall be defined in the test program or project specifications.

NOTE: If the duct leakage acceptance criterion allows a higher leak rate for the duct than the damper criterion, the pressure decay method may not be adequate to identify bypass leakage. When the DOP aerosol test is used, the duct size and expected leakage range must be considered for the purpose of estimating aerosol transit time from the damper boundary to the downstream test port location.

12.3 Prerequisites

12.3.1 A duct leak test shall have been performed prior to this test in accordance with Section 6 of this Standard.

12.3.2 For a DOP aerosol leak test or a halide leak test, injection and sample ports shall be located to ensure proper challenge to the damper and representative upstream and downstream samples.

12.4 Apparatus

12.4.1 For a DOP aerosol leak test or a halide leak test, the equipment shall be that listed in Sections 10 or 11, respectively.

12.4.2 For a pressure decay leak test, the equipment shall be that listed in Section 6.

12.5 Procedure

12.5.1 For a DOP aerosol leak test or a halide leak test, the procedure shall be that listed in Sections 10 or 11, respectively.

12.5.2 For a pressure decay leak, the procedure shall be that listed in Section 6.

12.5.3 If the calculated leakage exceeds the acceptance criteria, notify the owner.

12.6 Acceptance Criteria

Airflow leakage rates can be calculated in percentage penetration by the following formula:

$$\% \text{ penetration} = 100 \times \frac{\text{bypass leakage rate, cfm}}{\text{measured airflow capacity flow rate, cfm}}$$

Allowable penetration shall be in accordance with the test program or project specifications.

NOTE: Penetration value for bypass must be added to the acceptance criteria of Sections 10 or 11, or both, if the bypass is not challenged when challenging the filter banks.

12.7 Report

The test procedure shall include documentation of the results of the tests and conform to the owner's test program or project specifications.

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13 SYSTEM BYPASS TEST

13.1 Purpose

Systems using HEPA filters and adsorber banks may contain bypass dampers, ducts, conduits, floor drains, pipe penetrations, etc., which could potentially defeat the purpose of high efficiency nuclear air treatment components. Therefore, it is necessary to perform tests which challenge all these potential bypass leakage paths. In cases where performance of Sections 10, 11, and 12 can be shown to have challenged all potential bypass paths, then the requirements for the system bypass test may be considered to have been satisfied.

13.2 Summary of Method

Select injection and sample locations which encompass all possible bypass leakage paths to the treatment system. Testing is performed per Sections 10 or 11.

13.3 Prerequisites

13.3.1 Sections 10 and 11 of this Standard shall have been completed prior to the performance of this test.

13.3.2 For bypass leakage paths, uniform upstream challenge agent mixing is required to ensure adequate challenge during the test. If challenge cannot be verified during the system test, a separate test should be specified per Section 12.

13.4 Apparatus

The DOP or halide leak test equipment shall be that listed in Sections 10 or 11, respectively.

13.5 *Procedure*

13.5.1 Establish airflow through the system as specified by the test program or project specifications.

13.5.2 Connect sample lines from the detector(s) to upstream and downstream sample ports.

13.5.3 Check the background concentration levels. The levels shall not interfere with the detectors capability to detect leaks smaller than the maximum penetration allowed by the test program or project specifications.

NOTE: The injection and sample ports shall be located to encompass all possible bypass leakage baths.

13.5.4 Connect challenge generator to injection port. Start injection.

13.5.5 Record upstream and downstream readings per Sections 10 or 11 depending on type challenge used.

13.5.6 Calculate penetration (Section 3). If the calculated penetration exceeds acceptance criteria, notify the owner.

NOTE: Calculated penetration shall be adjusted for any background readings.

13.6 Acceptance Criteria

13.6.1 Allowable penetration shall be as stated in the test program or project specifications.

13.7 Report

The test procedure shall include documentation of the results of the test and conform to the owner's test program or project specifications.

14 AIR HEATER PERFORMANCE TEST

14.1 Purpose

14.1.1 This test is used to verify that the nuclear air treatment system air heater performance meets the test program or project specifications.

14.2 Summay of Method

14.2.1 Power-on electrical and mechanical tests shall be performed to verify correct operation and condition of the air heater.

14.3 Prerequisites

14.3.1 Visual inspection of the heater is completed (para. 5.5.1.7).

14.3.2 Electrical control and feed power is available and all safety interlocks have been checked.

14.4 Apparatus

14.4.1 Clamp-on ammeter and voltmeter accurate to ±5% of reading.

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14.4.2 Temperature indicating device accurate to ±1.0°F.

14.5 Procedure

14.5.1 Power-On Electrical Tests. With power on, and system operating at rated airflow, measure the voltage and current of all power circuits.

14.5.2 Power-On Mechanical Tests. With heater energized and system operating at rated airflow, measure the temperature of the entering and leaving air. A sufficient number of measurements shall be taken to determine average entering and leaving temperatures.

14.5.3 If measured values do not meet acceptance criteria, notify the owner.

14.6 Acceptance Criteria

14.6.1 Operating currents, voltages and change in temperature shall be within the limits of test program or project specifications.

14.7 Report

14.7.1 The test procedure shall include documentation of the results of the test and conform to the owner's test program or project specifications.

15 LABORATORY TESTING OF ADSORBENT

15.1 Purpose

15.1.1 These tests shall be performed to verify the acceptability of the adsorbent in the adsorber bank on periodically withdrawn samples.

15.2 Summary of Method

15.2.1 Adsorbent samples shall be tested in the laboratory to determine the overall efficiency of the entire bank for the retention of radioiodine.

15.3 Prerequisites

15.3.1 Refer to Table 1, Note (3).

15.4 Apparatus

15.4.1 The laboratory apparatus required for the performance of these tests is that specified in ASTM D 3803.

NOTE: Refer to Nonmandatory Appendix B.

15.5 Procedure

15.5.1 Test adsorbent samples in accordance with ASTM D 3803.

NOTE: Refer to Nonmandatory Appendix B.

15.5.2 If results do not meet acceptance criteria, notify the owner.

15.6 Acceptance Criteria

15.6.1 Adsorbent test criteria shall be as stated in the test program or project specifications.

15.7 Report

15.7.1 The test procedure shall include documentation of the results of the test and conform to the owner's test program or project specifications.

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APPENDIX A
DISCUSSION OF HOUSING AND FRAME LEAK TESTS

(This Appendix is not part of ASME N510-1989, and is included for information purposes only.)

This Appendix discusses the background, problem areas and equation derivation for housing and frame leak testing. A problem of parameter sensitivity applies to any test method designed to determine a quantitative measure of leakage across the system boundary. This discussion applies to low pressure systems, operating at approximately ±1 psig. As the absolute pressure increases significantly, the sensitivity of the test method to a given parameter will change significantly.

Analysis of the following variables:

(a) temperature
(b) relative humidity
(c) density
(d) barometric pressure
(e) test pressure vs design pressure
(f) time (duration) of test
(g) secondary heat sources

shows that these parameters are either of no significance to the calculated leak rate, taken into account in the equation for the pressure decay method, or of significance and therefore critical (of no significance is having an effect of less than a few percent of the calculated leak rate for the worst conceivable situation). Of the parameters listed, relative humidity is of no significance, Test pressure, density, barometric pressure, and time are taken into account in the equation. This leaves secondary heat source and temperature. Since a heat source will change the temperature, a heat source and temperature may be considered as having the same effect and are of critical significance. In any method used to measure or calculate gas leakage into or out of a system near atmospheric pressure, the system must be either isothermal or the temperature change must be measured during the test.

A change of 1°F may have a significant effect on the leak rate. Since the volume of the housing is included in the equation it is not possible to have a one to one correlation of temperature change vs error.

Derivation of the equation in para. 6.5.3.9:

$$\overline{Q} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right) \frac{V}{R\Delta t(0.075)}$$

where

$\overline{Q}$ = average volumetric leak rate based on density of standard air 0.075 lb/ft³ average density, SCFM
V = volume of enclosure, ft³
P_i = initial pressure of gas (air) in enclosure, lb/ft² absolute
P_f = final pressure gas (air) in enclosure, lb/ft² absolute
T = ambient temperature of gas (air) in enclosure at time of test, °R
m = average mass flow leak rate, lb/min
M_i = initial mass of gas (air) in enclosure, lb
M_f = final mass of gas (air) in enclosure, lb
Δ_t = elaped time for pressure to change from t_i to t_f, min
t_f = time at which final pressure is recorded, min
t_i = time at which initial pressure is recorded, min
p = average density of gas (air) to test conditions, lb/ft³
R = gas constant for air

$$53.35 \left(\frac{\text{ft lb}}{\text{lb °R}}\right)$$

NOTE: 1 in. w.g. = 5.204 lb/ft

Assumptions:

(a) Barometric pressure must be determined if absolute pressures are to be computed from gage measurements.

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(b) The enclosure and its gas (air) contents must be at the surrounding ambient temperature.

(c) The enclosed volume must not change significantly with pressurization or evacuation.

(d) The P_i and P_f of the test are chosen so that their average is approximately the operating pressure (positive or negative) for which a leak rate is being determined.

Derivation:

Applying the perfect gas law (assuming compressibility factor ($Z = 1$):

$$M_i = \frac{P_i V}{T_i R} \tag{1}$$

$$M_f = \frac{P_f V}{T_f R} \tag{2}$$

The change in mass is equal to the total leakage:

$$\Delta M = M_i - M_f = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right) \frac{V}{R} \tag{3}$$

The average mass flow rate is obtained by dividing the total leakage by the elapse in time:

$$\Delta \overline{m} = M/\Delta t \tag{4}$$

Therefore, the average mass flow leak is:

$$\overline{m} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right) \frac{V}{R\Delta t} \tag{5}$$

Convert to scfm, based on air density of 0.075 lb/ft^3:

$$\overline{Q} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right) \frac{V}{R\Delta t(0.075)} \tag{6}$$

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APPENDIX B
ADDITIONAL GUIDANCE FOR USE OF ASTM D 3803, 1979

(This Appendix is an integral part of ASME N510-1989, and is placed after the main text for convenience.)

NOTE: At the time of this printing, a revision to ASTM D 3803, 1979 was in progress and should implement the additional guidance of this Appendix when issued.

This Appendix should be used to provide improved repeatability and accuracy to the results when performing laboratory testing of adsorbents per ASTM D 3803, 1979. The current version of ASTM D 3803, 1979 "Standard Method for Radioiodine Testing of Nuclear-Grade Gas-Phase Adsorbents," contains inadequate lab instrument tolerances. The problem of interlaboratory radioiodine penetration test reproducibility of ASTM D 3803, 1979 as evaluated by ASME Committee on Nuclear Air and Gas Treatment (CONAGT) and the U.S. Nuclear Regulatory Commission – Idaho National Engineering Laboratory EG&G Idaho, Inc. (NRC-INEL) round robin testing and reported in "Final Technical Evaluation Report for NRC/INEL Activated Carbon Testing Program," Report No. EGG-CS-7653 (April 1987). A new procedure has been developed for the most critical methyl iodide test (30°C, 95% RH), which establishes the tolerances of parameter control to result in the required precision and accuracy according to ASTM E 691 "Practice For Conducting an Interlaboratory Test Program to Determine the Precision of Test." This procedure is currently under consideration by the ASTM D 28 committee.

The 30°C, 95% RH methyl iodide test is considered by INEL and the Nuclear Regulatory Commission to be the most reliable test method to establish the methyl iodide removal efficency of any adsorbent. However, nuclear facilities often require test parameters (temperature, humidity, etc.) which are based on different operating conditions. When tests are required to be performed either under ASTM D 3803, 1979, or any other conditions following the ASTM test precedure, the parameter tolerances need to be tightened for both new and used carbon testing.

The following maximum parameter tolerances were found to result in acceptable reproducibility in several of the test laboratories:

Parameter	Tolerance
Temperature	±0.2°C
Relative humidity	+1, -2%
Hours	±0.1 hr
Minutes	±1.0 min
Gas velocity	±0.3 m/min
Pressure	±0.5 kPa
Bed depth	±1.0 mm

Recommendations:

(a) It is recommended that the tolerances given in ASTM D 3803, 1979, or in any other radioiodine test procedures used, to be revised to the above tolerances.

(b) To consistently meet these tolerances the experience of the CONAGT and NRC-INEL round robins performed indicates the requirement of frequent NBS traceable calibration of sensors and the continuity in the data logging and parameter control are necessary to ensure repeatability in test results.

(c) The CONAGT and NRC-INEL round robins have indicated that the humidity pre-equilibration of 30°C for used carbons results in a more conservative test than the current ASTM D 3803, 1979, required non pre-equilibration.

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