ASME N511-2022

(Revision of ASME N511-2017)

In-Service Testing of Nuclear Air-Treatment, Heating, Ventilating, and Air-Conditioning Systems

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: June 30, 2022

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FOREWORD

This Standard covers the requirements for in-service testing of nuclear air-treatment, heating, ventilating, and air-conditioning systems in nuclear facilities that are designed, built, and acceptance tested in accordance with ASME AG-1.

This Standard provides a basis for the development of test programs, in-service test procedures, and corrective action requirements.

In 1971, what is now the ASME Committee on Nuclear Air and Gas Treatment was organized as ANSI N45.8 to develop standards for high-reliability air-cleaning equipment for nuclear facilities and corresponding tests to confirm performance of the equipment. In 1976, under the accredited organization rules, the Committee was reorganized as the ASME Committee on Nuclear Air and Gas Treatment. The scope of responsibility was broadened to include the development of codes and standards for design, fabrication, inspection, and testing of air-cleaning and air-conditioning components and appurtenances, as well as air-cleaning components used in engineering safety systems in nuclear facilities.

The first edition of ASME N511 was approved by the ASME Committee on Nuclear Air and Gas Treatment and the ASME Board of Nuclear Codes and Standards, and was subsequently approved as an American National Standard by the American National Standards Institute (ANSI) on October 30, 2007. ASME N511-2017 was approved by ANSI on November 1, 2017. ASME N511-2022 was approved by ANSI on June 22, 2022.

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, Standards Committee on Nuclear Air and Gas Treatment
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

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Interpretations. Upon request, the Standards Committee on Nuclear Air and Gas Treatment (CONAGT) will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of CONAGT.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of CONAGT at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

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Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

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SUMMARY OF CHANGES

Following approval by the ASME N511 Committee and ASME, and after public review, ASME N511-2022 was approved by the American National Standards Institute on June 22, 2022.

Throughout this Standard, the term "flow rate" has been changed to "airflow." In addition, ASME N511-2022 includes the following changes identified by a margin note, **(22)**.

Page	*Location*	*Change*
1	1.1	Revised
1	1.5	(1) First paragraph revised (2) Note added to definition of *challenge aerosol* (3) Definitions of *acceptance test*; *adsorbent*; *adsorber*; *aerosol*; *challenge aerosol*; *HEPA filter (high-efficiency particulate air filter)*; *preconditioning*; *pressure, maximum operating*; and *reference value(s)* revised (4) Definition of system test added
2	2	Updated
4	Table 3.1-1	Revised, and Note (3) added
3	3.1.4.1	Revised
3	3.2.1	First sentence editorially revised
3	3.2.2	Second sentence editorially revised
4	3.3.1	Last sentence revised
4	3.3.4	Revised
4	Table 3.3.4-1	Notes deleted
5	4.1	First sentence revised
5	Table 5.2.1-1	Revised, and General Note added
5	5.1.1	Added
5	5.1.2	Added
6	Table 5.3.1-1	Note (1) revised, and General Note added
7	Table 5.4.1-1	Note (1) revised, and General Note added
7	5.5.3.1	Revised
7	5.5.3.2	Revised
7	Table 5.5.1-1	(1) Revised (2) Note (1) revised, and General Notes added
7	5.5.4	Paragraphs 5.5.4.3 and 5.5.4.4 deleted
7	5.5.5	Paragraphs 5.5.5.1, 5.5.5.2, and 5.5.5.5 deleted and subsequent paragraphs redesignated
8	Table 5.6.1-1	(1) Revised (2) Note (1) revised, and General Note added
8	5.7.1-1	Note (1) revised, and General Note added
9	5.7.1	Second sentence revised

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Page	*Location*	*Change*
9	5.8	Title and paragraph revised
9	Table 5.8.1-1	Title and Note (1) revised
9	5.8.2	Revised
10	5.9.2	Third sentence revised
10	5.10.1	Second sentence editorially revised
10	5.10.2	First sentence revised
10	5.11	Second sentence editorially revised
10	6.2	Revised
10	7	Last sentence editorially revised
11	9.2	Revised
13	I-7	Subparagraphs (c) and (d) revised
13	I-8	Title revised
14	II-2	Revised
15	II-5.2	Steps 4 and 6 revised
15	II-5.3	Revised
16	III-5	Steps 1, 4, and 8 revised
17	IV-2	First sentence revised
17	IV-3	Second sentence editorially revised
17	IV-4	Revised in its entirety
19	Nonmandatory Appendix B	(1) First paragraph revised
		(2) Subparagraphs (a), (b), and (c) revised
20	C-1	First sentence revised
20	C-3	(1) Second sentence revised
		(2) Note editorially revised
20	C-4	In first paragraph, first and last sentences revised
21	C-5	Revised
22	Table C-5.3-2	Revised and General Note added
21	C-6	Added
24	Nonmandatory Appendix D	Revised

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IN-SERVICE TESTING OF NUCLEAR AIR-TREATMENT, HEATING, VENTILATING, AND AIR-CONDITIONING SYSTEMS

1 INTRODUCTION

(22) 1.1 Scope

This Standard covers the requirements for in-service testing of nuclear air-treatment, heating, ventilating, and air-conditioning systems within nuclear facilities.

1.2 Purpose

The purpose of this Standard is to provide requirements for in-service testing, the results of which are used to verify that the nuclear air-treatment, heating, ventilating, and air-conditioning systems perform their intended functions.

1.3 Applicability

This Standard applies to the in-service testing of nuclear air-treatment, heating, ventilating, and air-conditioning systems that have been designed, built, and acceptance-tested in accordance with ASME AG-1. Sections of this Standard may be used for technical guidance when testing air-treatment, heating, ventilating, and air-conditioning systems designed and built to other standards.

1.4 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. Based on the system design and its function(s), the owner shall develop a test program and acceptance criteria.

Nonmandatory Appendices A through D provide additional information and guidance.

(22) 1.5 Definitions

These definitions are consistent with the ASME AG-1 Divisions I through IV and supplement those listed in ASME AG-1, Article AA-1000.

abnormal incident: any event or condition that may adversely affect the function of the nuclear air-treatment, heating, ventilating, and air-conditioning systems.

acceptable preconditioning: the alteration, variation, manipulation, or adjustment of the physical condition of a component before in-service testing for the purpose of protecting personnel or equipment or meeting the manufacturer's recommendations. This may include routine and scheduled maintenance for optimum equipment and system performance. Preconditioning for purposes of personnel protection or equipment preservation should outweigh the benefits gained by testing only in the as-found condition. This preconditioning may be based on the equipment manufacturer's recommendations or industry-wide operating experience to enhance equipment and personnel safety. This preconditioning should be evaluated and documented prior to the in-service test.

acceptance test: a test made upon completion of fabrication, installation, repair, or modification of a unit, component, or part to verify to the user or owner that the item meets specified performance requirements.

adsorbent: a solid of high specific surface area having the ability to attract and concentrate gaseous phase substances on its surface.

adsorber: a device or vessel containing adsorbent that is used to remove and hold back substances in a gaseous phase from an air or gas stream.

adsorber bank or filter bank: one or more filters or adsorbers 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.

aerosol: a stable suspension of particles, solid or liquid, in air or gas.

as-found condition: the condition of a component between in-service tests without preconditioning.

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

challenge aerosol: an aerosol used for in-place leak testing of installed HEPA filter systems.

NOTES:

(1) Acceptable aerosol liquid materials for the Q-76 or the Q-107 penetrometer are dicoctylphthalate (DOP), dioctylsebacate (DOS/DEHS), and 4 centistoke polyalphaolefin (PAO). If

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using a penetrometer with a particle counter, the aerosol material shall be as defined in IEST-RP-CC007, section 4.2.9.

(2) The polydisperse aerosol used for in-place leak testing of systems differs in size from the 0.3 μm size DOP aerosol particles used for efficiency testing of individual HEPA filters by manufacturers. For potential substitutes for DOP, reference ASME AG-1, Article TA-2000.

challenge gas: a gas of known characteristics used for in-place testing of adsorbers.

HEPA filter: a high-efficiency particulate air (HEPA) filter. This is a throwaway, extended-medium 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 0.3 μm diameter test aerosol particles.

in-service test: a test to determine the operational readiness of a system or component.

preconditioning: the modification, manipulation, or adjustment of a component performed just prior to or during an in-service tests that could affect the results of the in-service test. This may include activities such as cycling, cleaning, lubricating, agitating, or other specific maintenance or operational activities performed prior to or during in-service testing that could affect the ability to determine component degradation. This excludes normal scheduled routine maintenance to keep optimum component performance.

pressure, maximum operating: the maximum pressure the system components will be subjected to during operations. The allowable pressure during abnormal operating conditions that will not physically damage the system or component (e.g., sudden closure of dampers or registers) is the maximum operating pressure.

pressure, operating: the pressure that corresponds to the normal design operating mode of the system. This pressure is less than or equal to the maximum operating pressure.

pressure, structural capability: the pressure, including transients, that verifies the component or system can be safely operated without permanent distortion.

reference value(s): one or more values or test parameters that are measured, observed, or determined when the equipment or system is known to be operating acceptably within its design basis range.

system: an assembly of components, including associated instruments and controls, required to perform the function of a nuclear air-treatment, heating, ventilating, and air-conditioning system.

system test: an in-place leak test that includes the HEPA filter or adsorber bank in addition to other potential system bypasses such as bypass ducts and associated dampers.

test boundary: the physical limits of the component, system, or device being subjected to a specified test.

test canister: a specially designed sample holder containing adsorbent for laboratory tests that can be removed from an adsorber bank, without disturbing the remainder of the adsorber, to provide representative samples for laboratory testing.

test program: a documented plan for in-service testing based upon system design specifications and functional requirements, including required tests, test frequency, detailed procedures, and acceptance criteria.

unacceptable preconditioning: any activity performed prior to or during an in-service test that alters one or more measured parameters in a way that results in unacceptable test results. This may include activities such as cycling, cleaning, lubricating, agitating, or other specific activities performed prior to or during an in-service test that could mask degradation. The impact may depend on the design of the component. For example, stem lubrication has essentially no impact on a motor-operated damper; however, it may influence the test result of an air-operated damper.

2 REFERENCES (22)

The following is a list of publications referenced in this Standard. Unless otherwise specified, the latest edition shall apply.

ASME AG-1, Code on Nuclear Air and Gas Treatment
ASME NQA-1, Quality Assurance Requirements for Nuclear Facility Applications
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ASTM D3803-2014, Standard Test Method for Nuclear-Grade Activated Carbon
Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

HVAC Systems Testing, Adjusting and Balancing, 3rd ed., 2002
Publisher: Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), 4201 Lafayette Center Drive, Chantilly, VA 20151-1219 (www.smacna.org)

IEST RP-CC007-, Testing ULPA Filters
Publisher: Institute of Environmental Sciences and Technology (IEST), 1827 Walden Office Square, Suite 400, Schaumburg, IL 60173 (www.iest.org)

Industrial Ventilation: A Manual of Recommended Practice for Design, 30th ed.

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Publisher: American Conference of Governmental Industrial Hygienists (ACGIH), 3640 Park 42 Drive, Cincinnati, OH 45241 (www.acgih.org)

INPO AP-913, Equipment Reliability Process Description
Publisher: Institute of Nuclear Power Operations (INPO), 700 Galleria Parkway, SE, Suite 100, Atlanta, GA 30339-5943 (www.inpo.info)

National Standards for Total System Balance, 7th ed., 2016
Publisher: Associated Air Balance Council (AABC), 2401 Pennsylvaia Avenue, NW, Suite 330, Washington, DC 20037 (www.aabc.com)

NRC RG 1.201, Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to Their Safety Significance
Publisher: United States Nuclear Regulatory Commission (NRC), One White Flint North, 11555 Rockville Pike, Rockville, MD 20852-2738 (www.nrc.gov)

Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, 7th ed., 2005
Publisher: National Environmental Balancing Bureau (NEBB), 8575 Grovemont Circle, Gaithersburg, MD 20877 (www.nebb.org)

3 GENERAL INSPECTION AND TEST REQUIREMENTS

All inspections and tests shall be conducted in accordance with the requirements within this Standard and the specific requirements of sections 6 and 8. Activities discussed in this Standard may involve the use of hazardous materials, operations, and equipment. This Standard does not purport to address all the safety requirements associated with their use. The owner's test program shall establish appropriate safety and health practices and determine the applicability of regulatory requirements.

3.1 Test Instruments

A calibration program shall be established in accordance with ASME NQA-1 requirements. All permanent and temporary test instruments used in the conduct of tests required by this Standard shall be in calibration. Instrument accuracy shall meet or exceed the requirements of Table 3.1-1.

3.1.1 Range Requirements. The full-scale range of instruments shall be limited as necessary to ensure that the readings are within the accuracy requirements of Table 3.1-1.

3.1.2 Instrument Fluctuation. Symmetrical damping devices or averaging techniques may be used to reduce random signal fluctuations. Hydraulic instruments may be damped by using gage snubbers or throttling valves in instrument lines.

3.1.3 Evaluation Following Test Instrument Loss, Damage, or Calibration Failure. When a test instrument is lost, damaged, or otherwise fails to meet the requirements of Table 3.1-1 during calibration, all test results obtained using the instrument shall be evaluated, dating back to the previous calibration. If the evaluation does not confirm that the instrument met the acceptance criteria for the test(s) in question, the test(s) shall be repeated with calibrated instruments.

3.1.4 Specific Instrument Accuracy Requirements

3.1.4.1 Vibration Instrument. Vibration instrument accuracy shall be at least ±10%. The minimum frequency response range of the vibration-measuring instrument shall be approximately one-third of the minimum shaft speed. The maximum frequency response range shall be at least the blade pass frequency at maximum design speed or the highest bearing fault frequency (whichever is highest). For rotating components, the maximum frequency response range shall be at least 2 times the rotational shaft speed of the component being measured. For reciprocating components, the maximum frequency response range shall be at least 2 times the speed of the rotating element, times the number of unique planes occupied by a piston throw. (22)

3.1.4.2 Challenge-Aerosol-Measuring Instrument. The challenge-aerosol-measuring instrument shall be verified to have a linear range of at least 10^5 times the minimum detectable quantity of the instrument.

3.1.4.3 Challenge-Gas-Measuring Instrument. The challenge-gas-measuring instrument shall be verified to be capable of distinguishing challenge gas from background and measuring challenge gas over a linear range of at least 105 times the minimum detectable quantity of the instrument.

3.2 Reference Values

3.2.1 Establishment of Reference Values. Reference values are determined during acceptance testing (see ASME AG-1, Article TA-4000), when the equipment or system proves it operates within the acceptable limits of the design specification. Operating tests and inspections specified in ASME AG-1, Article TA-4000, are performed under conditions readily reproducible during subsequent in-service tests to allow for direct comparison of test results. All test results and associated analyses are included in the test procedure documentation. (22)

3.2.2 Re-establishment of Reference Values Following Component Replacement, Repair, or Modification. Following component replacement, repair, or modification requiring disassembly, an evaluation shall be conducted to determine the effect on current reference values. Whenever the evaluation indicates any of the reference values have been affected, new reference values shall (22)

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(22) **Table 3.1-1**
Instrument Accuracy Requirements

Measurement	Range	Accuracy [Note (1)]
Pressure	>1 psig [>7 kPa (gage)]	+2.0%
	1 in. wg to 1 psig [0.25 kPa to 7 kPa (gage)]	±0.1 in. wg (±0.025 kPa)
	0.1 in. wg to 1 in. wg [25 Pa to 250 Pa (gage)]	±0.01 in. wg (±2.5 Pa)
Temperature	Variable	±2°F (±1°C)
	Variable	±0.5°F (±0.25°C) [Note (2)]
	Variable	+0.1°F (+0.05°C) [Note (3)]
Vibration	Variable	(per para. 3.1.4.1)
Flow	Variable	±5%
Velocity (airflow)	Variable	±3%
Speed	Variable	±2%
Time	Variable	±1 sec
Electrical voltage	Variable	±1%
Electrical resistance	Variable	±1%
Challenge aerosol	1 to 10^5	±2%
Challenge gas	1 to 10^5	±2%

NOTES:
(1) References as percent of full-scale unless otherwise noted.
(2) This is required for pressure testing in Mandatory Appendix II.
(3) This is required for hydronic heating and cooling performance testing.

be established in accordance with para. 3.2.1 or the previous reference values shall be reverified. Evaluation of the new reference values shall verify that the component conforms to the acceptance criteria prior to accepting it as fully operational. The evaluation to determine the effect on reference values shall be documented.

3.3 Inspection and Test Requirements

The owner's test program shall define system test boundaries and evaluate system performance with respect to system functional requirements. The following categories of tests shall be implemented as applicable and in accordance with this paragraph:

(a) periodic in-service tests (section 5)
(b) tests following an abnormal incident (section 7)
(c) tests following component replacement, repair, or modification (para. 3.2.2)

(22) **Table 3.3.4-1**
In-Service Test Intervals

Interval	Test Frequency	Symbol
Monthly	Once per 31 days	M
Quarterly	Once per 92 days	Q
Yearly	Once per 366 days	Y
Biennial	Once per 2 yr	2Y
10 yr	Once per 10 yr	10Y

3.3.1 Inspection and Test Parameters. Parameters that need to be observed, calculated, and recorded to meet the requirements of this Standard shall be identified for each system based on the owner's test program functional requirements. (22)

3.3.2 System Operating Conditions. Operating conditions required for in-service testing shall be determined for each system.

3.3.3 Procedure Requirements. The owner shall be responsible for the development and implementation of written test procedures that meet the requirements of this Standard. Each section on equipment testing consists of common (section 4) and in-service (section 5) test requirements and acceptance criteria that apply to each of the systems. The owner shall document which requirements are applicable (see Mandatory Appendices I through IV for development guidance).

3.3.4 In-Service Tests. In-service tests shall be conducted at intervals not to exceed those specified in section 5 or the owner's test program, whichever is most limiting. In-service test intervals are maximum intervals allowed by this Standard and should not be used as default intervals in the absence of system-specific evaluations. For in-service tests other than regular interval testing, see para. 3.2 or section 7. Specific system test intervals should be determined upon the basis of system design use. Frequencies for in-service test intervals are defined in Table 3.3.4-1. (22)

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(22) **Table 5.2.1-1**
Fan In-Service Tests

Test	Measure	Observe	Interval [Note (1)]
Visual inspection	...	X	Q
Leak test	X	...	10Y
Mechanical run test	X	...	Q
Airflow test	X	...	2Y
Static pressure test	X	...	2Y
Rotational speed test	X	...	2Y
Vibration test	X	...	Q

GENERAL NOTE: Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used as guidance for test frequencies of nonreactor facilities.

NOTE: (1) See Table 3.3.4-1 for definitions of interval symbols.

3.3.5 As-Found Conditions and Preconditioning. Components shall be tested in the as-found condition whenever possible. Preconditioning shall not be performed unless an evaluation is made prior to in-service testing. See the definitions for "preconditioning" and "acceptable preconditioning" in para. 1.5.

4 COMMON TESTS

Tests as specified in paras. 4.1 through 4.3 shall also be used in section 5 where applicable.

(22) 4.1 Visual Inspection

Visual inspections shall be conducted in accordance with the applicable portions of Mandatory Appendix I. The in-service visual inspections listed in section 5 shall verify that no unacceptable damage or degradation, which could impair function, has occurred to the equipment or system.

4.2 Pressure Boundary Tests

Pressure boundary tests consist of leak tests for ducts and housings, including fan and damper housings. These leak tests shall be conducted using either the pressure decay or the constant pressure method to verify that the leak rate for the duct or housing does not exceed the allowable limits established for the system. Testing shall be conducted in accordance with Mandatory Appendix II. Leak testing performed to satisfy ASME AG-1, Sections SA (ducts) and HA (housings), may be used to meet these test requirements when the test method is compatible with Mandatory Appendix II.

4.3 Vibration Test

Vibration measurements shall be taken on the accessible motor, fan, compressor, and pump bearing housings in at least two different orthogonal planes approximately perpendicular to the line of the rotating shaft. When the bearing housing is not accessible, the frame of the component may be used if it will be representative of bearing housing vibration. When portable vibration instruments are used, reference points shall be clearly identified on the component being measured to permit duplication in both location and plane.

5 IN-SERVICE TEST REQUIREMENTS

5.1 General

In-service tests shall be conducted at the required time intervals after the completion of the field acceptance tests outlined in ASME AG-1, Article TA-4000.

5.1.1 Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used as guidance for test frequencies of nonreactor facilities. (22)

5.1.2 Nuclear power plants applying this Standard will need to develop their testing frequencies based on their licensing commitment. The frequency of maintenance and test activities be may either time based or condition based and would depend on the safety-significance categorization of the equipment as defined in NRC Regulatory Guide 1.201 and INPO AP-913. However, in the absence of the aforementioned information, this Standard may be used as guidance for test frequencies as needed. (22)

5.2 Fan Tests

This paragraph provides the in-service test requirements for fans and related accessories. Integrated system testing shall be conducted in accordance with para. 5.10.

5.2.1 Test Requirements. In-service tests listed in Table 5.2.1-1 shall be conducted at the specified interval. Test results shall be verified to be within the acceptance limits of the owner's test program and section 6 and compared with the reference values obtained in acceptance tests in ASME AG-1, section TA-4100.

5.2.2 Visual Inspection. A visual inspection of the fan and associated components shall be conducted in accordance with para. 4.1 and section I-2.

5.2.3 Pressure Boundary Leak Test. When a fan housing is part of the system pressure boundary, a pressure boundary leak test shall be conducted to verify the leak tightness of the fan housing, shaft seal, and attached interfaces in accordance with para. 4.2 and Mandatory

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(22) **Table 5.3.1-1 Damper In-Service Tests**

Test	Measure	Observe	Interval [Note (1)]
Visual inspection	...	X	2Y
Leak test	X	...	2Y
Mechanical run test	X	...	Q
Position indication test	...	X	2Y
Exercise test	...	X	2Y
Flow control test	...	X	2Y
Static timing test	X	...	2Y
Fire damper test	...	X	2Y
Dynamic time test	X	...	2Y
Interlock test	...	X	2Y

GENERAL NOTE: Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used as guidance for test frequencies of nonreactor facilities.

NOTE: (1) See Table 3.3.4-1 for definitions of interval symbols.

Appendix II. The fan housing, shaft seal, and attached interfaces may be tested concurrent with the duct-and-housing leak test specified in para. 5.4.3.

5.2.4 System Functional Tests. Paragraphs 5.2.4.1 through 5.2.4.5 shall be conducted in the same time frame.

5.2.4.1 Mechanical Run Test. The fan shall be operated at the design airflow for at least 15 min and stable system operation (no surging) verified.

5.2.4.2 Airflow Test. The fan airflow shall be measured. Recommended procedures are contained in ACGIH Industrial Ventilation or equivalent.

5.2.4.3 Static Pressure Test. The fan inlet and outlet static pressure and velocity pressure shall be measured and the overall fan static pressure determined.

5.2.4.4 Rotational Speed Test. Direct drive configurations may be tested at the fan or motor. When a fan does not have a direct drive coupling to the motor, the rotational speed of the fan shaft shall be measured.

5.2.4.5 Vibration Test. The vibration of each fan and motor bearing shall be measured in accordance with para. 4.3.

5.3 Damper In-Service Tests

This paragraph provides the in-service test requirements for dampers and related accessories. Integrated system testing shall be conducted in accordance with para. 5.10.

5.3.1 In-Service Test Requirements. In-service tests listed in Table 5.3.1-1 shall be conducted at the specified interval and test results verified to be within the acceptance limits of the owner's test program and section 6 and compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4200.

5.3.2 Visual Inspection. A visual inspection of the dampers and associated components shall be conducted in accordance with para. 4.1 and section I-3.

5.3.3 Pressure Boundary Leak Test, Damper Seat. When dampers have seat leak rate limits, a dynamic pressure boundary leak test shall be conducted in the direction the damper is expected to function, in accordance with para. 4.2 and Mandatory Appendix II. Seat leakage shall be tested by blanking off or otherwise isolating a duct section upstream of the damper. The leak test shall be performed with the damper cycled closed using its normal closing mechanism (exclusive of any additional assistance).

5.3.4 Component Functional Tests. Component functional tests shall verify that the damper is operational prior to conducting the system functional tests specified in para. 5.3.5.

5.3.4.1 Position Indication Test. Dampers having remote position indicators shall be observed during operation to verify that the damper position corresponds to the remote indicator.

5.3.4.2 Exercise Test. Power-operated dampers shall be fully cycled using a control switch or other actuating device to verify operation. Manual dampers, which have a shutoff function, shall be fully cycled to verify operation. Fire dampers shall be tested in accordance with para. 5.3.5.2.

5.3.4.3 Static Timing Test. Power-operated dampers that are required to operate within a specified time limit shall be tested by measuring the time to fully open or close (as required by the owner's test program).

5.3.5 System Functional Tests

5.3.5.1 Flow Control Test. Power-operated dampers that control airflow shall be observed under throttled flow conditions to verify freedom of movement and stable operation.

5.3.5.2 Fire Damper Test. Fire dampers shall be tested using a normal or simulated actuation signal to verify activation under design flow.

5.3.5.3 Dynamic Timing Test. Isolation dampers having a required actuation response time shall be tested to the fully open or closed position (as required by the owner's test program) under design airflow conditions.

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(22) **Table 5.4.1-1**
Duct-and-Housing In-Service Tests

Test	Measure	Observe	Interval [Note (1)]
Visual inspection	...	X	2Y [Note (2)]
Leak test	X	...	10Y

GENERAL NOTE: Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used as guidance for test frequencies of nonreactor facilities.

NOTES:
(1) See Table 3.3.4-1 for definitions of interval symbols.
(2) Loop seal water level in duct or housing drain lines shall be maintained to ensure the integrity of the system pressure boundary at all times. Monthly or more frequent inspection of the water level in the loop seal may be required, depending on the system design.

5.3.5.4 Interlock Test. Dampers that have an opening or closing function interlocked with other components (e.g., fan, other dampers) shall be tested to verify interlock action.

5.4 Duct-and-Housing In-Service Tests

This paragraph provides the in-service test requirements for ducts and housings.

5.4.1 In-Service Test Requirements. In-service tests listed in Table 5.4.1-1 shall be conducted at the specified interval and test results verified to be within the acceptance limits of the owner's test program and section 6. Test results shall be compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4300.

5.4.2 Visual Inspection. A visual inspection of the ducts, housings, and associated attachments shall be conducted in accordance with para. 4.1 and section I-4.

5.4.3 Pressure Boundary Leak Test. A pressure boundary leak test shall be conducted on filter housings and applicable ductwork in accordance with para. 4.2 and Mandatory Appendix II.

5.5 Refrigeration Equipment In-Service Tests

This paragraph provides the in-service test requirements for refrigeration equipment. Integrated system testing shall be conducted in accordance with para. 5.10.

5.5.1 In-Service Test Requirements. In-service tests listed in Table 5.5.1-1 shall be conducted at the specified interval and test results verified to be within the acceptance limits of the owner's test program and section 6. Test results shall be compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4400.

5.5.2 Visual Inspection. A visual inspection of the refrigeration equipment components shall be conducted in accordance with para. 4.1 and section I-5.

5.5.3 Pressure Boundary Tests

5.5.3.1 Refrigerant Piping and Coils. The refrigerant system shall be monitored under normal operating conditions to verify no unacceptable refrigerant leaks greater than the limits specified in the applicable sections of ASME AG-1 and the owner's test program. (22)

5.5.3.2 Hydronic Piping and Coils. Hydronic piping and coils shall be observed to verify no unacceptable fluid leaks. Testing shall be conducted by inspecting the fluid system under normal operating pressure for evidence of leaks greater than the limits specified in the applicable sections of ASME AG-1 and the owner's test program. (22)

5.5.4 Component Functional Tests (22)

5.5.4.1 Fans. Fans shall be tested in accordance with para. 5.2.

5.5.4.2 Valve Position Indication Test. Valves with position indicators shall be observed during valve full-stroke operation to verify that the valve position corresponds to the remote indication.

5.5.5 System Functional Tests (22)

5.5.5.1 Performance Test. The refrigeration compressor inlet and outlet pressure and temperature shall be measured with the refrigeration equipment operating within its design load range.

Table 5.5.1-1
Refrigeration Equipment In-Service Tests (22)

Test	Measure	Observe	Interval [Note (1)]
Visual inspection	...	X	Q
Leak tests	...	X	Q
Performance test	X	...	2Y
Vibration test	X	...	Q

GENERAL NOTES:
(a) Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used for guidance for test frequencies of nonreactor facilities.
(b) Nuclear power plants applying this Standard will need to develop their testing frequencies based on their licensing commitment. The frequency of maintenance and test activities may either be time based or condition based and would depend on the safety-significance categorization of the equipment as defined in NRC Regulatory Guide 1.201 and INPO document AP-913. However, in the absence of mentioned information, this Standard may be used as guidance for test frequencies as needed.

NOTE: (1) See Table 3.3.4-1 for definitions of interval symbols.

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(22) **Table 5.6.1-1**
Conditioning Equipment In-Service Tests

Test	Measure	Observe	Interval [Note (1)]
Visual inspection	...	X	Q
Valve performance test	...	X	2Y
Mechanical run test	...	X	Q
Performance test	X	...	2Y
Vibration test	X	...	Q

GENERAL NOTE: Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used for as guidance for test frequencies of nonreactor facilities.

NOTE: (1) See Table 3.3.4-1 for definitions of interval symbols.

5.5.5.2 Vibration Test. The vibration on accessible motor, fan, compressor, and pump-bearing housings in the refrigeration system shall be measured in accordance with para. 4.3.

5.6 Conditioning Equipment In-Service Tests

This section provides the in-service test requirements for conditioning equipment. Integrated system testing shall be conducted in accordance with para. 5.10.

5.6.1 In-Service Test Requirements. In-service tests listed in Table 5.6.1-1 shall be conducted at the specified interval and test results verified to be within the acceptance limits of the owner's test program and section 6 and compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4500.

5.6.2 Visual Inspection. A visual inspection of the conditioning equipment components shall be conducted in accordance with para. 4.1 and section I-6.

5.6.3 Pressure Boundary Leak Test, Hydronic Piping, and Coils. With the conditioning system at normal operating pressure, hydronic piping, coils, and pressure vessels shall be observed to verify no unacceptable fluid leaks in excess of the limits specified in the applicable sections of ASME AG-1 and the owner's test program.

5.6.4 Component Functional Tests

5.6.4.1 Fans. Fans shall be tested in accordance with para. 5.2.

5.6.4.2 Refrigeration. Refrigeration components shall be tested in accordance with para. 5.5.

5.6.4.3 Valve Performance. Conditioning system valves shall be tested in accordance with paras. 5.5.4.1 and 5.5.4.2.

5.6.5 System Functional Tests

5.6.5.1 Hydronic System Flow Balance Verification Test. A verification of the hydronic system flow balance shall be conducted (refer to Nonmandatory Appendix C for guidance on scope and verification methods).

5.6.5.2 Flow Control Valve Test. Power-operated valves controlled by flow instrumentation shall be observed under throttled flow conditions to verify freedom of movement, stable operation, and ability to maintain the required flow rate.

5.6.5.3 Mechanical Run Test. The conditioning system pumps shall be operated at the reference flow rate for at least 15 min and stable system operation verified.

5.6.5.4 Performance Test. With the conditioning system pump operating at the reference flow rate, pump differential pressure and flow rate shall be measured.

5.6.5.5 Rotational Speed Test. Direct drive configurations may be tested at the motor or shaft. For conditioning system pumps that have variable speed drives or do not otherwise have direct drive operations, the rotational speed of the pump shaft shall be measured.

5.6.5.6 Vibration Test. The vibration of each bearing on the pump and associated motor in the conditioning system shall be measured in accordance with para. 4.3.

5.6.5.7 Electric Heater Performance Test. With design airflow through the heater bank, the electrical supply voltage, amperage, phase balance, and differential temperature shall be measured.

Table 5.7.1-1
Moisture Separator, Prefilter, HEPA Filter Bank In-Service Tests (22)

Test	Measure	Observe	Interval [Notes (1), (2)]
Visual inspection	...	X	2Y
Differential pressure test	X	...	M
In-place leak test [Note (2)]	X	...	2Y [Note (3)]

GENERAL NOTE: Nonreactor facilities applying this Standard will need to develop other testing frequencies appropriate for their operational requirements. However, this Standard may be used for guidance for test frequencies of nonreactor facilities.

NOTES:
(1) See Table 3.3.4-1 for definitions of interval symbols.
(2) In-place leak tests are not required on systems used for 100% recirculation (e.g., reactor containment cleanup units) unless the atmospheric cleanup rate is time dependent.
(3) Interval shall be as specified or after complete or partial filter bank replacement.

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(22) **Table 5.8.1-1 Type II, Type III, and Type IV Adsorber Bank In-Service Tests**

Test	Measure	Observe	Interval [Notes (1), (2)]
Visual inspection	...	X	2Y
Differential pressure test	X	...	M
In-place leak test [Note (2)]	X	...	2Y [Note (3)]
Electric heater performance test	X	...	2Y
Laboratory test of adsorbent media	X	...	2Y

NOTES:
(1) See Table 3.3.4-1 for definitions of interval symbols.
(2) In-place leak tests are not required on systems used for 100% recirculation (e.g., reactor containment cleanup units) unless the atmospheric cleanup rate is time dependent.
(3) Interval shall be as specified or after complete or partial adsorber bank replacement.

5.6.5.8 Hydronic Heating and Cooling Performance Test. With the conditioning system operating at design air and hydronic airflow, at the available heat load conditions, the following shall be measured: air side flow, differential pressure, differential temperature, and hydronic side flow.

5.7 Moisture Separator, Prefilter, HEPA Filter Bank In-Service Tests

This paragraph provides the in-service test requirements for installed moisture separator, prefilter, and HEPA filter banks.

(22) **5.7.1 In-Service Test Requirements.** In-service tests listed in Table 5.7.1-1 shall be conducted at the specified interval or after complete or partial bank replacement. Test results shall be verified to be within the acceptance limits of the owner's test program and section 6 and compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4600.

5.7.2 Visual Inspection. A visual inspection of the installed moisture separator, prefilter, and HEPA filter banks shall be conducted in accordance with para. 4.1 and section I-7.

5.7.3 System Functional Tests

5.7.3.1 Differential Pressure Test. With the system operating at design airflow (±10%), the differential pressure across each moisture separator, prefilter, and HEPA filter bank shall be measured.

5.7.3.2 In-Place Leak Test. With the system operating at design flow rate (±10%), the challenge-aerosol leak rate of each HEPA filter bank shall be measured in accordance with Mandatory Appendix III.

5.8 Type II, Type III, and Type IV Adsorber Bank In-Service Tests (22)

This paragraph provides the in-service test requirements for installed Types II, III, and IV adsorber banks.

5.8.1 In-Service Test Requirements. In-service tests listed in Table 5.8.1-1 shall be conducted at the specified interval and verified to be within the acceptance limits of the owner's test program and section 6 and compared with the reference values obtained in the acceptance tests in ASME AG-1, section TA-4700.

5.8.2 Visual Inspection. A visual inspection of the Types II, III, and IV adsorber banks shall be conducted in accordance with para. 4.1 and section I-8. (22)

5.8.3 System Functional Tests

5.8.3.1 Differential Pressure Test. With the system operating at design airflow(±10%), the differential pressure across each adsorber bank shall be measured.

5.8.3.2 In-Place Leak Test. With the system operating at design airflow (±10%), the challenge-gas leak rate of each adsorber bank shall be measured in accordance with Mandatory Appendix IV.

5.8.3.3 Electric Heater Performance Test. With design airflow (±10%) through each heater bank, the electrical supply voltage, amperage, phase balance of each heater circuit, and differential temperature and air flow across the heater coil shall be measured.

5.9 Adsorbent In-Service Tests

This paragraph provides the in-service laboratory test requirements for radioactive iodine penetration of the adsorbent bed.

5.9.1 In-Service Test Requirements. In-service laboratory tests shall be conducted using representative samples of adsorbent at least every 2 yr or 720 hr[1] of accumulated service time, whichever is sooner. This test measures the penetration of radioiodine through an adsorbent. Laboratory test results shall be verified to be within the acceptance limits of the owner's test program. Sample locations shall be selected to ensure samples are representative of the overall condition of the adsorbent in the adsorber bank. If the entire bank of adsorbent is being replaced, an in-service laboratory test is not required.

[1] A documented history of adsorbent degradation may be used in the evaluation of the design specification or technical specification to establish a longer adsorbent sample interval.

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(22) **5.9.2 Laboratory Analysis.** A laboratory analysis of the adsorbent shall be conducted in accordance with ASTM D3803-89 to measure the ability of the adsorbent to remove radioiodine. Test-bed depth used in the laboratory test shall be the same as the nominal adsorber depth in the adsorber bank being tested. The laboratory test should be performed at a face velocity of 40 ft/min (12.2 m/min) unless the actual system face velocity is greater than 44 ft/min (13.4 m/min). Otherwise, the test shall be conducted at the actual face velocity.

Samples shall be representative of the adsorbent in the bank and drawn from the bank test canisters or from the bank itself.

An in-place leak test of the bank shall be conducted following sample removal in accordance with para. 5.8 unless it can be demonstrated that the removal of the sample does not create a potential leak path around or through the adsorber bank.

5.10 Integrated System Tests

(22) **5.10.1 In-Service Test Requirements.** Each system shall be tested to verify that the functional performance within the range of design operating conditions is achieved. Integrated system tests shall be conducted to challenge all integrated control functions, including interlocks, computer logic, and manual or automatic actuation circuits (damper position changes, fan starts and stops, compressor and pump starts and stops, valve position changes, heater energization or de-energization). These actuations can be from a number of different sources, including radiation, temperature, chlorine, and pressure sensors; manual controls; and emergency safeguard signals. Sensor operation shall be verified in addition to control circuitry. Integrated system testing shall verify that the intended design function of the system is achieved in accordance with the owner's test program. The maximum test interval for integrated system tests shall be 10 yr; however, the frequency may need to be shorter based upon evaluations of the system's function.

(22) **5.10.2 HEPA Filter Bank and Adsorber Bank Integrated System Test Requirements.** All potential HEPA filter bank and adsorber bank bypass flow paths, including housing bypass ducts and associated dampers, shall be challenged to verify that leak rates are within the limits of the owner's test program. Bypass flow paths may be challenged during the in-place leak testing, specified in paras. 5.7.3.2 and 5.8.3.2, by ensuring that the aerosol or gas challenge test and sample ports encompass all potential bypass leak paths. If a potential bypass flow path is not challenged during these in-place tests, a separate test shall be performed, using the methods outlined in Mandatory Appendix III or Mandatory Appendix IV, to verify that the HEPA filter banks or adsorber banks are not being bypassed in excess of the limits specified in the owner's test program.

NOTE: Some bypass leak paths may not be measurable using Mandatory Appendix III or Mandatory Appendix IV. Use of other innovative testing methods may be required.

5.11 Air System Flow Balance Verification Test (22)

A verification of the system airflow balance shall be conducted. Recommended procedures include SMACNA, NEBB, ACGIH, AABC, or equivalent (see references in section 2 and Nonmandatory Appendix C for guidance on scope and verification methods). The maximum interval for air system flow verification testing shall be 10 yr.

6 ACCEPTANCE CRITERIA

Results of tests described in section 5 shall be subject to the acceptance criteria in section 6 and the owner's test program. Acceptance criteria are specified in section 5 only when they affect the quality of other tests. When test results do not meet the applicable acceptance criteria, the corrective actions required by section 8 shall be initiated. In-service test results shall be compared with the acceptance test reference values. Comparison should include a trend analysis designed to predict degradation rates of the components under test. Projected degradation rates that indicate probable loss of intended design function prior to the next scheduled in-service test should require corrective action prior to the predicted loss of intended design function in accordance with section 8.

6.1 Visual Inspection

Inspection results are acceptable when there are no indications of improper installation, physical damage, structural distress, or degradation that would impair the ability of the equipment or system to perform its intended function.

6.2 Pressure Boundary Tests (22)

Pressure boundary test results are acceptable when there are no leaks greater than the limits specified in the applicable sections of ASME AG-1 and the owner's test program.

6.3 Functional Tests

Functional test results are acceptable when they meet the requirements of the applicable sections of ASME AG-1 and the owner's test program.

7 TESTING FOLLOWING AN ABNORMAL INCIDENT (22)

Following an abnormal incident in which the system has been challenged, the applicable acceptance tests in ASME AG-1, Article TA-4000, shall be conducted to verify that the

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system is fully operational. This requirement shall apply only to those components that may have been affected by the incident. An evaluation shall be conducted and documented to determine the extent of the required actions.

8 CORRECTIVE ACTION REQUIREMENTS

Corrective action is required when test results do not meet the acceptance criteria specified. For equipment that is replaced, modified, or repaired such that the reference values change, a new set of reference values shall be obtained in accordance with the requirements of para. 3.2.2 and ASME AG-1, Article TA-4000. Additional guidance for corrective actions is included in Nonmandatory Appendix A.

9 QUALITY ASSURANCE

9.1 General

In-service testing of nuclear air-treatment, heating, ventilating, and air-conditioning systems shall be conducted in accordance with a documented quality assurance program meeting the requirements of ASME NQA-1.

(22) 9.2 Personnel

Tests shall be conducted by personnel who have demonstrated competence as evidenced by documented experience and training. Personnel shall be qualified in accordance with ASME NQA-1.

9.3 Documentation

In-service test procedures shall document the test results specified in section 5 and include a record of test failures with subsequent corrective actions and analysis of test data trends. These records shall be maintained for the life of the facility.

9.3.1 Procedures. Written test procedures shall be used to document the in-service testing performed and the test results obtained in accordance with section 5.

9.3.2 Reports. A written report shall be provided to document the in-service testing performed in accordance with section 5. The report shall contain, at a minimum, the following:

(a) the system name, test/inspection procedure(s) used, date of test results, and the test performer's printed name and signature

(b) identification of instruments, equipment, tools, and documents to the extent that they, or their equivalent, can be identified for future examinations

(c) observations and dimensional checks specified by the respective test data and any reports developed during the inspection and testing

(d) conclusions and recommendations by visual examinations and testing personnel

(e) reference to previous reports if this report is for reinspection and testing

(f) test configuration and system operating conditions

(g) test data and results

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MANDATORY APPENDIX I VISUAL INSPECTION CHECKLIST

I-1 GENERAL

A specific inspection checklist for each component in the system shall be included in the in-service test procedures. This Appendix lists typical items for each component to be visually inspected per section 5 (in-service tests), if applicable to the installed equipment. The inspection shall be conducted in accordance with para. 4.1.

I-2 FAN INSPECTION CHECKLIST

(a) housing and duct interface
(b) fan impellers
(c) fan drives and guards/covers
(d) fan inlet and outlet connections
(e) interference with moving parts
(f) fan shaft seal
(g) drive adjustment and condition
(h) lubricant levels
(i) supports and attachments
(j) bolting and fasteners
(k) instrumentation
(l) electrical connections
(m) control system components
(n) pneumatic connections
(o) provisions on access for testing and maintenance

I-3 DAMPER INSPECTION CHECKLIST

(a) housing and duct interface
(b) actuator linkage, motor, and controller
(c) interference with moving parts
(d) damper shaft seal
(e) blade edge seals and damper seat
(f) limit switches
(g) supports and attachments
(h) bolting and fasteners
(i) instrumentation
(j) electrical connections
(k) pneumatic connections
(l) provisions on access for testing and maintenance

I-4 DUCT, HOUSING, AND MOUNTING FRAME INSPECTION CHECKLIST

(a) housing and duct connections (no caulking on ducts, housings, and mounting frames associated with nuclear air-treatment systems)
(b) access door seals and gaskets
(c) access door latches
(d) housing internal access ladders and platforms
(e) sample and injection ports, location, and caps
(f) supports and attachments
(g) bolting and fasteners
(h) instrumentation and connections
(i) electrical connections
(j) housing/duct penetration seals
(k) loop seals (water level) and drain connections
(l) lighting conduits and socket housing seals (flush mounted)
(m) HEPA filter/adsorber mounting frame continuous seal welds
(n) mounting frame penetrations seal welded
(o) mounting frame seating surface (weld spatter, flatness, scratches)
(p) sample canister installation
(q) mounting frame clamping devices
(r) provisions on access for testing and maintenance
(s) lighting for test and maintenance available

I-5 REFRIGERATION EQUIPMENT INSPECTION CHECKLIST

(a) housing or duct interface with refrigeration equipment
(b) fan, pump, compressor belt, and coupling guards
(c) interferences with moving parts
(d) drive adjustment and conditions
(e) fluid leaks
(f) lubricant levels
(g) supports and attachments
(h) bolting and fasteners
(i) instrumentation
(j) electrical connections
(k) control system components
(l) pneumatic connections and tubing (no crimping)
(m) provisions on access for testing and maintenance

I-6 CONDITIONING EQUIPMENT INSPECTION CHECKLIST

(a) housing or duct interface with conditioning equipment
(b) drive and coupling guards
(c) interferences with moving parts

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(d) drive adjustment and conditions
(e) fluid leaks
(f) lubricant levels
(g) supports and attachments
(h) bolting and fasteners
(i) instrumentation
(j) electrical connections
(k) control system components
(l) pneumatic connections and tubing (no crimping)
(m) drains and spray nozzles not plugged
(n) provisions on access for testing and maintenance

(22) I-7 MOISTURE SEPARATOR BANK, PREFILTER BANK, AND HEPA FILTER BANK INSPECTION CHECKLIST

(a) moisture separator media, frame, clamps, and gaskets
(b) moisture separator water collection system and drains
(c) prefilter medium, frame, clamps, and gaskets/seals
(d) HEPA filter medium, frame, clamps, and gaskets/seals
(e) sealant or caulking (none allowed)
(f) moisture separator, prefilter, and HEPA filter orientation (vertical)
(g) bolting and fasteners
(h) provisions on access for testing and maintenance

I-8 TYPES II, III, AND IV ADSORBER BANK INSPECTION CHECKLIST (22)

(a) Type II media, frame, screen, clamps, and gaskets
(b) sealant or caulking (none allowed)
(c) Type III media, screens, and frame
(d) test canisters
(e) bulk loading equipment
(f) fire protection system piping, nozzles, and instrumentation
(g) bolting and fasteners
(h) provisions on access for testing and maintenance

I-9 ACCEPTANCE CRITERIA

The acceptance criteria for these inspections shall be in accordance with section 6 and the owner's test program.

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MANDATORY APPENDIX II
DUCT-AND-HOUSING LEAK-TEST PROCEDURE

II-1 GENERAL

The procedure in this Appendix is used to test the leak-tightness of the ducts and housings including installed fan housings, damper housings, and fan and damper shaft seals.

(22) II-2 SUMMARY OF METHODS

Ducts and housings that form the pressure boundary of the system shall be leak-tested with air using one of the methods listed in this Appendix. Either method may be used and will produce a similar test result. The constant pressure method (para. II-5.1) is conducted at the maximum operating pressure for the system. The pressure decay method (para. II-5.2) is conducted by pressurizing to 1.25 times the maximum operating pressure, then allowing the pressure to decay for a fixed period of time or until the pressure decreases to 75% of the maximum operating pressure, whichever occurs first. Fans, dampers, and other components that are part of the pressure boundary shall be installed and tested with the pressure boundary to verify interface connection leak-tightness. If the measured leak rate is greater than the acceptance criteria, the leaks shall be located by one of the methods (para. II-5.4 or para. II-5.5) listed in this procedure. After leaks are repaired, the duct and housing shall be retested to verify leak tightness.

NOTE: This test procedure is written as if the operating pressure were positive, but it would be identical for negative pressure systems with appropriate change in signs used in the data collection and calculations.

II-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 shall be installed before the test is started. For pressure decay testing, the volume of the pressure test boundary must be determined.

II-4 TEST EQUIPMENT

(a) pressurization source (pneumatic, test fan with flow control, etc.)
(b) covers to seal test boundaries
(c) clock or timer
(d) pressure-indicating device
(e) flowmeter or totalizing gas volume meter (constant pressure method)
(f) temperature-indicating device
(g) bubble solution for detecting air leaks (bubble-leak location method)
(h) optional portable electronic sound detection equipment (audible leak method)
(i) barometer

II-5 PROCEDURES

II-5.1 Constant Pressure Test

Step 1. Connect the pressurization source to the duct or housing.

Step 2. Connect the flow meter or totalizing gas volume meter between the pressurization source and housing (downstream of the throttling valve, if used).

Step 3. Install temperature-indicating and pressure-indicating devices so that they will indicate representative temperature and pressure inside the duct or housing being tested.

Step 4. Seal test boundaries and close access doors in the normal manner. Do not use temporary sealant, duct tape, or similar temporary materials except for sealing the temporary blank-off panels.

Step 5. Start the pressurization source and operate until the maximum operating pressure is achieved. Maintain pressure constant with the flow control device until temperature remains constant within ±0.5°F (±0.25°C) for a minimum of 10 min. Record the initial stabilized pressure, temperature, and barometric pressure.

Step 6. Measure the airflow of the air being added to or removed from the duct or housing while maintaining the maximum operating pressure within ±0.1 in. wg [±0.025 kPa (gage)]. When using the flow meter, record flow readings once a minute for a 5 minute continuous period, and average the readings to calculate the measured leak rate. When using a totalizing gas volume meter, measure the total volume of air for a 10 minute continuous period, and divide the measured volume by time (10 min) to calculate the measured leak rate. Record final pressure, temperature, and barometric pressure.

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Step 7. Convert the final calculated leak rate to standard cubic feet per minute (cubic meters per second) in accordance with the method illustrated in ACGIH Industrial Ventilation (see references in section 2).

(22) II-5.2 Pressure Decay Test

Step 1. Connect the pressurization source (with a leak-tight shutoff valve) to the duct or housing.

Step 2. Install the temperature-indicating and pressure-indicating devices where they will indicate the representative temperature and pressure inside the duct or housing being tested.

Step 3. Seal test boundaries and close access doors in the normal manner. Do not use temporary sealants, duct tape, or similar temporary materials except for sealing the temporary blank-off panels.

Step 4. Start the pressurization source and operate until the pressure is 1.25 times the maximum operating pressure (but does not exceed the structural capability pressure). Maintain this pressure at a constant level with a flow control device until temperature remains constant within ±0.5°F (±0.25°C) for a minimum of 10 min. Close shutoff valve.

NOTE: If the structural capability pressure for the duct or housing is less than 1.25 times the maximum operating pressure, the initial and final test pressures shall be calculated as follows to achieve an average test pressure equal to the maximum operating pressure:

$$P_f = (0.80 \times \mathrm{OP}_{\max}) + [(1.25 \times \mathrm{OP}_{\max}) - \mathrm{SCP}]$$
$$P_i = (\mathrm{OP}_{\max} - P_f) + \mathrm{OP}_{\max}$$

where

$\mathrm{OP}_{\max}$ = maximum operating pressure
P_f = final test pressure
P_i = initial test pressure
SCP = structural capability pressure

Step 5. Record the initial time, pressure, temperature, and barometric pressure.

Step 6. Record pressure readings once a minute until pressure decays to 75% of the initial test pressure or for a minimum of 15 min [see Note in Step 4].

Step 7. Record final time, pressure, temperature, and barometric pressure.

Step 8. Calculate leak rate from the following:

(U.S. Customary Units)

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

(SI Units)

$$Q_{avg} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f}\right)\left(\frac{V}{R \times \Delta t \times 60 \times 1.201}\right)$$

where

P_f = final pressure within test boundary, lb/ft^2 (absolute) [Pa (absolute)]
P_i = initial pressure within test boundary, lb/ft^2 (absolute) [Pa (absolute)]
Q_{avg} = average leak rate, ft^3/min (L/s) [air density is 0.075 lb/ft^3 (1.201 kg/m^3)]
R = gas constant for air
= 53.35 ft-lb/lb-°R (0.286 kJ/kg-K)
T_f = absolute temperature at end of test, °R (K)
T_i = absolute temperature at start of test, °R (K)
V = volume within test boundary, ft^3 (m^3)
Δt = time difference, min
= $t_f - t_i$
t_f = time at end of test
t_i = time at start of test

II-5.3 Acceptance Criteria (22)

Pressure boundary test results are acceptable when there are no leak rates greater than the limits specified in the applicable sections of ASME AG-1 and the owner's test program. If the calculated leak rate exceeds the acceptance criteria specified in the owner's test program, locate leaks in accordance with one of the techniques outlined in para. II-5.4 or para. II-5.5. Where portions of the air cleaning, air cooling, and ventilation systems cannot be quantitatively measured in the operating nuclear facilities, exceptions shall be technically justified and specifically documented with basis by the owner or designee.

II-5.4 Bubble-Leak Location Method

Step 1. Pressurize the test boundary to the maximum operating pressure for the system.

Step 2. With the test boundary under continuous pressure, apply bubble solution to areas to be tested. Identify places where bubbles are found, and then perform corrective actions.

Step 3. Following corrective actions, retest in accordance with para. II-5.1 or para. II-5.2.

II-5.5 Audible Leak Location Method

Step 1. Pressurize the test boundary to the maximum operating pressure for the system.

Step 2. With the test boundary continuously pressurized, locate audible leaks (electronic sound detection equipment optional), and perform corrective actions.

Step 3. Following corrective action, retest in accordance with para. II-5.1 or para. II-5.2.

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MANDATORY APPENDIX III
HEPA FILTER BANK IN-PLACE LEAK-TEST PROCEDURE

III-1 GENERAL

The procedure in this Appendix is used to leak-test HEPA filter banks.

III-2 SUMMARY OF METHOD

The system is operated at design airflow. Challenge aerosol is injected upstream of each bank through the qualified injection ports. The concentration of the challenge aerosol is measured upstream and downstream of the HEPA filter bank. The ratio of the downstream and upstream concentration represents the HEPA filter bank leak rate.

III-3 PREREQUISITES

(a) Components shall be visually inspected.

(b) Airflow capacity shall be verified in accordance with para. 5.2.4.2.

(c) The injection and sample locations shall be qualified to provide uniform air-aerosol mixing in accordance with ASME AG-1, Appendix TA-V.

III-4 TEST EQUIPMENT

(a) challenge aerosol generator

(b) challenge-aerosol-measuring instrument

(c) challenge aerosol (e.g., DOP aerosol) for in-place leak testing of installed HEPA filter systems shall be a polydisperse liquid aerosol having an approximate light scattering droplet size distribution as follows:

(1) 99% less than 3 µm diameter

(2) 50% less than 0.7 µm diameter

(3) 10% less than 0.4 µm diameter

NOTE: Sample line length should be minimized to reduce sample response time and the lengths of the lines should be approximately equal.

III-5 PROCEDURE (22)

Step 1. Connect challenge aerosol particle generator to the injection port.

Step 2. Place the challenge-aerosol-measuring instrument sample probes upstream and downstream of the bank to be tested.

Step 3. Start the system and then verify a stable airflow to be within ±10% of design airflow.

Step 4. Measure the upstream and downstream aerosol particle background concentrations. The preinjection background levels shall be stable to ensure correct instrument response and shall not interfere with the detector's ability to detect leak rates greater than the maximum allowed by the acceptance criteria.

Step 5. Start the challenge-aerosol injection.

Step 6. Record the upstream and downstream concentrations. Repeat until at least three of the readings are stable.

Step 7. Stop the injection.

Step 8. Use the final set of readings meeting the stability and tolerance criteria to calculate the bank leak rate using the following equation:

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

where

C_d = downstream concentration

C_u = upstream concentration

L = percent of leak

III-6 ACCEPTANCE CRITERIA

The acceptance criteria for these inspections shall be in accordance with section 6 and the owner's test program.

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MANDATORY APPENDIX IV
ADSORBER BANK IN-PLACE LEAK-TEST PROCEDURE

IV-1 GENERAL

The procedure in this Appendix is used to leak-test adsorber banks.

(22) IV-2 SUMMARY OF METHOD

The system is operated at ±10% design airflow. Challenge gas is injected upstream of each bank through the injection port. The concentration of challenge gas is measured upstream and downstream of the bank. The ratio of the downstream and upstream concentrations represents the bank leak rate.

(22) IV-3 PREREQUISITES

(a) Components shall be visually inspected. (Any samples of adsorbent required for laboratory testing should be removed at this time.)

(b) Airflow capacity shall be verified in accordance with para. 5.2.4.2.

(c) The injection port shall be qualified to provide uniform air-aerosol mixing in accordance with ASME AG-1, Appendix TA-V.

(22) IV-4 TEST EQUIPMENT

(a) Challenge Gas Generator. The test preset value of the challenge gas output shall be established as at least 4 times the minimum workable threshold sensitivity (MWTS) of the challenge-gas-measuring instrument divided by the maximum acceptable leak rate, expressed as a fraction of total system airflow. The MWTS is the minimum concentration of challenge gas that will produce response on the readout of the challenge-gas-measuring instrument. The challenge gas generator output shall be held within ±20% of the test preset value.

(b) Challenge-gas-measuring Instrument. The challenge-gas-measuring instrument shall demonstrate the capability to distinguish the challenge gas from the background, and accuracy shall meet or exceed the requirements of ASME AG-1, TA-3243.

(c) System fan or auxiliary blower.

IV-5 PROCEDURE

Step 1. Connect challenge gas generator to the injection port.

Step 2. Place the challenge-gas-measuring-instrument sample probes upstream and downstream of the bank to be tested.

Step 3. Start the system and then verify stable airflow to be within ±10% of design airflow.

Step 4. Measure the upstream and downstream challenge-gas background concentration. The preinjection background levels shall be stable to ensure correct instrument response and shall not interfere with the detector's ability to detect challenge-gas leaks less than the maximum allowed by the acceptance criteria.

Step 5. Start the challenge-gas injection.

Step 6. Record the upstream and downstream concentrations, as rapidly as instrument response time allows, until sufficient data have been recorded to allow calculation of adsorber bank leak rate. Care must be taken to obtain sufficient readings quickly after injection.

Step 7. Terminate challenge-gas injection.

Step 8. Using the upstream and downstream concentration data, calculate the adsorber bank leak rate using the following equation:

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

where

C_d = downstream concentration

C_u = upstream concentration

L = percent of leak

IV-6 ACCEPTANCE CRITERIA

The acceptance criteria for these inspections shall be in accordance with section 6 and the owner's test program.

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NONMANDATORY APPENDIX A
CORRECTIVE ACTION GUIDANCE

Corrective action may consist of replacement, repair, modification, maintenance, or analysis to demonstrate that the equipment will fulfill its design function. A revised set of reference values, as described in para. 3.2, should be established after the corrective action has been taken.

Results of a failed test should not be resolved simply by a successful repetition of the test. A successful repetition of the test should be preceded by corrective action.

If the cause of the test failure cannot be determined by inspection or analysis, the corrective action may consist of the recalibration of test instruments and subsequent retesting. If it is determined that the test failure is due to an equipment malfunction, instead of difficulties with the test equipment or test procedure, the equipment should be declared unavailable for service until the specific cause has been determined and the condition corrected.

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NONMANDATORY APPENDIX B
SELECTION CRITERIA FOR CHALLENGE-GAS SUBSTITUTE (22)

Alternative test agents (challenge gas) may be used to perform in-place testing of adsorbers, as required in Mandatory Appendix IV, when their selection meets the following characteristics:

(a) The test agent gives similar in-place leak test results as any of the refrigerants approved by the owner.

(b) The test agent has similar retention times on activated carbons, at the same concentration levels, as any of the refrigerants approved by the owner.

(c) The test agent has similar lower detection limit sensitivity and precision in the concentration range of use as one of any of the refrigerants approved by the owner.

(d) The test agent exhibits chemical and radiological stability under the test conditions.

(e) The test agent causes no degradation of the carbon and its impregnant(s) or of other nuclear air-treatment system components under the test conditions.

(f) If the alternative test agent is toxic, then it shall be listed in the BIOVIA Registry of Toxic Effects of Chemical Substances (RTECS), formerly known as the Toxic Substances List, to comply with the Occupational Safety and Health Act of 1970. (The list is available from Dassault Systèmes, 4305 Hacienda Drive, Suite 550 Pleasanton, CA 94588 (www.3ds.com.)

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NONMANDATORY APPENDIX C
TEST PROGRAM DEVELOPMENT GUIDANCE

(22) C-1 OVERVIEW

The scope of the periodic in-service test program for nuclear air-treatment, heating, ventilating, and air-conditioning systems should be developed commensurate with the system performance function(s). The overall depth of the performance-monitoring effort should be flexible, with various tests added, modified, or deleted as results and industry experience warrant. This Appendix provides guidance in developing a test program that will meet the requirements of this Standard.

C-2 DEFINITIONS

The following definitions are applicable to this Appendix:

analyzed system configuration: the alignment and condition (on or off) of various components, hand switches, controls, valves, piping, etc., that have been analyzed as being capable of accomplishing a specific system function.

analyzed system performance: the predicted performance as determined in the appropriate analysis (safety, system, or component), or the acceptable limit as defined in the technical specification basis. This value is in the conservative direction when related to the design limit, with the difference between the two defining the analysis margin.

design basis: that information that identifies the specific functions to be performed by a structure, system, or component of a facility and the specific values or range of values chosen for controlling parameters as reference bounds for the design. These values may be restraints derived from generally accepted "state-of-the-art" practices for achieving functional goals or requirements derived from analysis (based on calculation and/or experiment) of the effects of a postulated accident for which the structure, system, or component must meet its functional goals (see 10 CFR 50.2).

parameters: the variables or measurable qualities of a system or component that are used to define acceptable operation or can be restricted to ensure that performance remains within design limits.

system performance function: the goal or task that the system is required to accomplish or support.

Examples of system performance functions, which may be applicable to nuclear air-treatment, heating, ventilating, and air-conditioning systems, include the following:

(a) provide a habitable environment (temperature, humidity, filtration, ventilation) for facility personnel

(b) provide an acceptable environment (temperature, humidity, ventilation) to support equipment operability and environmental qualification requirements

(c) prevent the uncontrolled release of airborne radioactivity and limit offsite dose in accordance with 10 CFR 50 Appendix I, 10 CFR 20, and 10 CFR 100

C-3 TEST PROGRAM DEVELOPMENT (22)

The owner should perform a detailed review of all design basis documentation applicable to each system. After this review, a test basis document should be prepared for each nuclear air-treatment, heating, ventilating, and air-conditioning system in the facility to identify the following:

(a) system performance function(s).

(b) analyzed system configuration for each identified performance function.

(c) the critical performance parameters that will define acceptable system operation for each performance function.

(d) the parameter design limits. These are the design or analysis limits that govern the system performance and bound the system.

NOTE: NUMARC 90-12 and NUREG-1397 provide further detail on methods for determining the various design basis functions.

C-4 AIR/HYDRONIC SYSTEM BALANCE VERIFICATION GUIDANCE (22)

Under the scope of the preoperational test program, all nuclear air-treatment, heating, ventilating, and air-conditioning systems are tested, adjusted, and balanced to the requirements of ASME AG-1, Section TA. It is not the intent of this Standard to mandate the reperformance of the initial testing, adjusting, and balancing program. This Standard, however, does require a periodic verification that the degree of air/hydronic system balance necessary to achieve the functions of the system(s) has been maintained.

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Table C-5.3-1
Performance Parameters and Parameter Design Limits

Performance Function	Performance Parameters	Parameter Design Limit
C-5.1(a) and C-5.1(b)	Heat Removal	850,000 Btu/hr
	Total system airflow	30,000 SCFM min.
	Air temperature at coil outlet	60°F max.
	Chilled water flow to coil	114 GPM min.
	Chilled water supply temperature	45°F max.
	Control room ambient air temperature	80°F max.
C-5.1(c)	Radiation Protection	...
	Outside airflow (pressurization)	400 SCFM min.
	Outside airflow	900 SCFM max.
	HEPA filter bypass leakage	1% max.
	Adsorber bypass leakage	1% max.
	Adsorbent methyl iodide removal efficiency	99% min.
	Humidity control at adsorber	70% max.
	Control room complex pressure	+0.25 in. wg (relative to all adjacent areas)
	Isolation damper leakage	Bubble-tight at 15 in. wg
	Isolation damper closure time	25 sec max.
	Filter unit total pressure drop	8 in. wg max.

The keys to determining the scope and methodology for periodic system air/hydronic balance verification are the proper initial identification of the critical safety function (s) of the system and determination of the performance parameters required to be measured and compared with previously established reference values. The goal of the monitoring effort is to provide reasonable assurance that the system performance functions are achieved.

(22) C-5 SAMPLE TEST PROGRAM

For a sample control room complex emergency HVAC system consisting of a fan, ductwork, dampers, chilled water-cooling coils, nuclear air-filtration unit (electric preheater, prefilter, HEPA filters, adsorber), controls, etc., the system test basis document may be structured as specified in paras. C-5.1 through C-5.3.

C-5.1 System Performance Functions

(a) Provide a habitable environment for control room complex personnel in the event of a design basis accident.

(b) Maintain the control room complex environment to ensure equipment operability.

(c) Limit radiological dose to control room complex personnel in accordance with GDC-19 requirements.

C-5.2 Analyzed System Configuration

To achieve performance functions in paras. C-5.1(a) through C-5.1(c), the following should be in place: one essential air-filtration unit in service, normal ventilation system isolated, and an essential chilled water system in service.

C-5.3 Critical Performance Parameters and Parameter Design Limits

For critical performance parameters and parameter design limits, see Table C-5.3-1.

Based upon the identified critical performance parameters for the sample control room complex emergency HVAC system, the periodic in-service test program would be appropriate as shown in Table C-5.3-2.

C-6 REFERENCES (22)

NUMARC 90-12-1990, Design Basis Program Guidelines
Publisher: Nuclear Utilities Management and Resources Council (NUMARC); now Nuclear Energy Institute (NEI), 1201 F Street NW, Suite 1100, Washington, DC 20004-1218www.nei.org)

NUREG 1397-1991, Assessment of Design Control Practices and Design Reconstitution Programs in the Nuclear Power Industry
Publisher: Nuclear Regulatory Commission, Superintendent of Documents, U.S. Government Publishing Office (GPO), 732 North Capitol Street NW, Suite 1100, Washington, DC 20401www.gpo.gov)

U.S. Nuclear Regulatory Commission., "Standards for Protection Against Radiation." Code of Federal Regulations, Title 10, Part 20

U.S. Nuclear Regulatory Commission., "Domestic Licensing of Production and Utilization Facilities." Code of Federal Regulations, Title 10, Part 50, Section 50.2, Definitions

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