COMMONWEALTH OF MASSACHUSETTS

MASSACHUSETTS SENATE

STATE HOUSE BOSTON 02133

SENATOR EDWARD P. KIRBY
PLYMOUTH AND BARNSTABLE
DISTRICT
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COMMITTEES:
RULES
CRIMINAL JUSTICE
ENERGY
JUDICIARY

March 12, 1991

United States Nuclear Regulatory Commission
Region I
475 Allendale Road
Kign of Prussia, Pennsylvania 19406
Attn: Mr. Lee H. Bettenhausen, Chief, Operations Branch,
Division of Reactor Safety

Re: Pilgrim II Nuclear Facility, Plymouth, MA

Dear Mr. Bettenhausen:

Senator Kirby asked me to write you in regard to the enclosed news item that appeared in the Cape Cod <u>Times</u>, last week.

As a strong supporter of the nuclear industry, the Senator was interested in the circumstances surrounding the disciplinary action resulting from Pilgrim II staffers issuing "false and misleading reports" to the NRC about the state of readiness of Pilgrim II prior to the plant's reopening.

Specifically, the Senator would like to request a copy of the NRC inspector's July report criticizing the staff and any other information you could provide about what facts issued by the Pilgrim II staff were "false and misleading."

Thanks very much for your help in this matter.

Sincerely,

Ronald K. Morgan,
Assistant to Senator Edward P. Kirby,
Plymouth and Barnstable District

RKM
cc file

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NRC staffers reprimanded

false and what were true facts!

Cited for false Pilgrim data

By PAMELA GLASS
OTTAWAY NEWS SERVICE

WASHINGTON – Nuclear Regulatory Commission staffers who gave misleading information to the commissioners about the Pilgrim nuclear plant in Plymouth have been disciplined, a top NRC official told Congress yesterday.

James M. Taylor, NRC Director of Operations, said his deputies have spoken directly to the staffers involved and issued "letters of instruction" to some of them. He did not elaborate on what these letters contained, and an agency spokesman said later that he couldn't provide details because it was a personnel matter.

An NRC inspector's report issued last July criticized the staff for providing inaccurate and false information about the adequacy of emergency plans for the Pilgrim nuclear power plant as the commission was considering whether to allow the reactor to restart in 1988. The report also faulted the staff for not verifying information supplied by Pilgrim owner Boston Edison.

In response to questions by Rep. Peter Kostmayer, D-Pa., chairman of the House subcommittee on Energy and the Environment, Taylor said the staffers were called in for what he called "personal counseling" – in other words, a "good talking to."

No one, however, was removed from their positions or fired, and no major changes in staff procedures have been instituted, officials said.

Taylor told Kostmayer that he was satisfied with this disciplinary action. He said that the false statements were not made deliberately to mislead NRC commissioners.

NRC chairman Kenneth Carr, in response to a question from Kostmayer, said he, too, was satisfied with the disciplinary action. Kostmayer and other members of the subcommittee did not challenge these statements.

Taylor said the NRC is taking steps to avoid the exchange of misleading information to commissioners in the future.

There was a disagreement at the hearing, however, over whether the false information given to NRC commissioners was corrected before the vote was taken to restart.

Kostmayer wanted to know why it took pressure from the public and Massachusetts officials for the NRC to realize it had received false information about Pilgrim's fitness to reopen after a three-year shutdown due to mechanical or managerial problems.

Carr responded: "We assured you (at a congressional hearing last October) in Plymouth that the inaccurate information was corrected before the (restart) decision was made."

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

DRAFT REGULATORY GUIDE

March 1991
Division 1
Task DG-1013

Contact: C.W. Nilsen (301)492-3834

4th TD 2-13-91

DRAFT REGULATORY GUIDE DG-1013

PROPOSED REVISION 3 TO REGULATORY GUIDE 1.52

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

A. INTRODUCTION

General Design Criteria 41, 42, and 43 of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," require that containment atmosphere cleanup systems be provided as necessary to reduce the amount of radioactive material released to the environment following a postulated design basis accident (DBA). They also require that these systems be designed to permit appropriate periodic inspection and testing to ensure their integrity, capability, and operability. General Design Criterion 61 of Appendix A to Part 50 requires that fuel storage and handling systems, radioactive waste systems, and other systems that may contain radioactivity be designed to ensure adequate safety under normal and postulated accident conditions and that they be designed with appropriate containment, confinement, and filtering systems. General Design Criterion 19 requires that adequate radiation protection be provided to permit access to and occupancy of the control room under accident conditions and for the duration of the accident without personnel radiation exposures in excess of 5 rems to the whole body.

This guide presents methods acceptable to the NRC staff for implementing the Commission's regulations in Appendix A to 10 CFR Part 50 with regard to

design, testing, and maintenance criteria for air filtration and iodine adsorption units of engineered-safety-feature (ESF) atmosphere cleanup systems in light-water-cooled nuclear power plants. This guide applies only to post-accident engineered-safety-feature atmosphere cleanup systems designed to mitigate the consequences of postulated accidents. It addresses the ESF atmosphere cleanup system, including the various components and ductwork, in the postulated DBA environment.

This guide does not apply to atmosphere cleanup systems designed to collect airborne radioactive materials during normal plant operation, including anticipated operational occurrences. Guidance is being developed as Proposed Revision 3 to Regulatory Guide 1.140, "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," to provide guidance for normal ventilation exhaust systems.

Any information collection activities mentioned in this draft regulatory guide are contained as requirements in 10 CFR Part 50, which provides the regulatory basis for this guide. The information collection requirements in 10 CFR 50 have been cleared under OMB Clearance No. 3150-0011.

B. DISCUSSION

Atmosphere cleanup systems are included as engineered safety features in the design of light-water-cooled nuclear power plants to mitigate the radiological consequences of postulated accidents. The mitigating action of ESF atmosphere cleanup systems is limited to the removal of radioactive iodine and particulate matter (aerosols) that may be released in an accident; the removal of fission product noble gases by ESF atmosphere cleanup systems is negligible. ESF atmosphere cleanup systems should be designed to operate under the environmental conditions resulting from design basis accidents.

In this guide, ESF atmosphere cleanup systems that must operate under postulated DBA conditions inside the primary containment are designated as "primary systems." ESF systems required to operate outside the primary containment under postulated DBA conditions that are generally less severe are designated as "secondary systems." Secondary systems include such systems as the standby gas treatment system and the atmosphere cleanup systems for the spent fuel handling, control, and shield or annulus buildings.

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

An ESF atmosphere cleanup system consists of some or all of the following components: dampers, moisture separators, heaters, prefilters, high-efficiency particulate air (HEPA) filters, iodine adsorption units, fans, and associated ductwork, motors, valves, and instrumentation.

The principal purpose of dampers in an ESF atmosphere cleanup system is to shut off or seal the system components from air or gases flowing in a designated flow path. A typical unit has dampers both upstream and downstream of the "train" of components, i.e., upstream of the moisture separator and downstream of the last HEPA filter or iodine adsorber. The dampers prevent or isolate unwanted flow or circulation of the normal air or gas stream through the system components in order to preserve or extend the useful service life of the filtration and iodine adsorption media. ESF system dampers may also serve one or more secondary functions such as flow control, pressure control, balancing, pressure relief, or backflow prevention. This guide does not address the fire prevention aspect of dampers in ESF atmosphere cleanup systems.

The principal purpose of a moisture separator is to remove entrained water droplets (sensible moisture) from the inlet gas stream, thereby protecting HEPA filters and iodine adsorbers from water damage and plugging. Moisture separators may serve several other potentially important safety functions in accident situations, such as (1) shock attenuation, (2) fire protection, and (3) particulate matter overload protection; however, the design functions and principal purposes discussed in this guide are limited to the removal of entrained water droplets from the inlet gas stream. Moisture separators may also function as prefilters in some system designs.

Heaters normally follow the moisture separators in the cleanup train and are designed to heat the incoming stream to reduce the stream's relative humidity upstream of the HEPA filters and iodine adsorbers to minimize adsorption of water vapor from the air by the iodine adsorbers. Such action promotes the long-term retention of radioiodine, minimizing the potential for early desorption and release. In some designs, space heaters are used to prevent condensation

within the isolated components of the cleanup unit, while the cleanup units are not in service.

Prefilters and HEPA filters are installed to remove particulate matter from the gas stream. Prefilters remove the larger airborne particles from the gas stream and prevent excessive loading of the HEPA filters. The HEPA filters remove the fine discrete particulate matter to minimize fouling of the adsorbers. The adsorbers remove gaseous iodine (elemental iodine and organic iodides) from the air stream. HEPA filters downstream of the adsorption units collect carbon fines and provide additional protection against particulate matter release in case of failure of the upstream HEPA filter bank.

The exhaust fan is usually the final item in an atmosphere cleanup train. Such a location is advantageous in that upstream components of the train operate at negative pressure (with respect to surrounding spaces), minimizing the potential for outward leakage of radioactive materials to surrounding spaces. If the fan is located at some other upstream point in the atmosphere cleanup train, special care must be taken in design and construction to prevent leakage or exfiltration from those portions of the train downstream of the fan that may be near or above the atmospheric pressure of the surrounding spaces.

The environmental operating conditions preceding a postulated DBA may affect the performance of ESF atmosphere cleanup systems during and following a DBA. Industrial contaminants, pollutants, high temperature, and high relative humidity contribute to the aging and weathering of filters and adsorbers and may reduce their effective capability to perform their design functions. Therefore, aging and weathering, both of which will vary according to site-specific conditions, should be considered during design, operation, and maintenance. The potential for condensation of moisture inside ESF atmosphere cleanup systems when in a shutdown or standby mode of operation should also be given design consideration, e.g., provision for space heaters. The effects of these environmental factors on the performance of the ESF atmosphere cleanup system should be determined by scheduled periodic testing during operation.

All components of ESF atmosphere cleanup systems should be designed for reliable performance under accident conditions. Initial testing and proper maintenance are primary factors in ensuring the reliability of the ESF atmosphere cleanup system. Careful attention during the design phase to problems of ESF system maintenance can contribute significantly to the reliability of the system by increasing the ease of such maintenance. Of particular importance in the design is a layout that provides accessibility and sufficient working

space so that the required maintenance functions can be performed safely and efficiently. Periodic testing during operation to verify the efficiency of the components is another important means of ensuring reliability. Built-in features that will facilitate convenient access for in-place testing are important in ESF system design.

DOP, an acronym for dioctyl phthalate or di-2-ethylhexyl-phthalate (DEHP), is the standard challenge aerosol used in the testing of HEPA filters. DOP has been considered to be a substance of low toxicity by all routes of human intake. The National Cancer Institute has conducted carcinogenesis bioassay tests on DOP; preliminary findings showed DOP to be potentially carcinogenic in mice and rats, but the reports made no determination of risk to humans. If definitive recommendations are made by the National Institute for Occupational Safety and Health, specific guidance on the use of DOP will be issued.

Activated carbon is often impregnated with iodide or amine compounds to enhance radioiodine retention under high humidity conditions. It has been suggested that the use of potassium iodide-impregnated carbon in primary containment recirculating ESF atmosphere cleanup systems may result in the release of free nonradioactive iodine, which could interact by isotopic exchange with the relatively stable $Cs^{131}I$ deposited on containment surfaces in a DBA, making free ^{131}I available in the containment atmosphere. This exchange of nonradioactive iodine and deposited ^{131}I may increase the airborne radioactive iodine fraction (Ref. 1) in the containment atmosphere. While the existence of such conditions in a DBA has not been conclusively demonstrated, licensees should consider the use of carbons co-impregnated with both potassium iodide and a tertiary amine to minimize the potential for release of free iodine from the carbon impregnant and to minimize the potential for the formation of airborne radioactive iodine within containment.

Standards acceptable to the NRC staff for the design and testing of ESF atmosphere cleanup systems include portions of ASME N509-1989, "Nuclear Power Plant Air-Cleaning Units and Components" (Ref. 2), ASME N510-1989, "Testing of Nuclear Air-Treatment Systems" (Ref. 3), and ASME/ANSI AG-1-1988 "Code on Nuclear Air and Gas Treatment" (Ref. 4). Other standards referenced in this guide include ASTM D3803-1989, "Standard Test Methods for Nuclear-Grade Activated Carbon" (Ref. 5), and ASTM D4069-81, "Impregnated Activated Carbon Used To Remove Gaseous Radioiodines from Gas Streams" (Ref. 6).

ERDA 76-21, "Nuclear Air Cleaning Handbook" (Ref. 7), provides a comprehensive review of air filtration and adsorption systems. While ERDA 76-21 is not a standard, it discusses a number of design alternatives that have been found acceptable by the NRC staff in case-by-case reviews.

Section 2 of ASME N509-1989 (Ref. 2) and Section 2 of ASME N510-1989 (Ref. 3) list additional related documents that may be of interest.

C. REGULATORY POSITION

1. ENVIRONMENTAL DESIGN CRITERIA

ESF atmosphere cleanup systems should be designed for environmental conditions in accordance with the requirements of Section 4 of ASME N509-1989 (Ref. 2) as modified and supplemented by the following:

1.1. The design of an ESF atmosphere cleanup system should be based on the anticipated range of operating parameters of temperature, pressure, relative humidity, radiation levels, and airborne iodine concentrations likely during and following the postulated DBA. Table 1 describes typical accident conditions for ESF atmosphere cleanup systems.

1.2. The design of each ESF atmosphere cleanup system should be based on the radiation dose to essential services in the vicinity of the adsorber section, integrated over the 30-day period following the postulated DBA. The radiation source term should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 8), 1.4 (Ref. 9), and 1.25 (Ref. 10). Other ESFs, including pertinent components of essential services such as power, air, and control cables, should be adequately shielded from the ESF atmosphere cleanup systems.

1.3. The design of each adsorber should be based on the concentration and relative abundance of the iodine species (elemental, particulate, and organic) and should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 8), 1.4 (Ref. 9), and 1.25 (Ref. 10).

1.4. The operation of any ESF atmosphere cleanup system should not degrade the operation of other ESFs such as a containment spray system nor, conversely, should the operation of ESFs such as a containment spray system degrade the operation of any ESF atmosphere cleanup system.

1.5. Components of systems connected to compartments that are unheated during a postulated accident should be designed for the postaccident effects of both the lowest and highest predicted temperatures.

1.6. The design of an ESF atmosphere cleanup system should consider any significant contaminants that may occur during a DBA such as dusts, chemicals, excessive moisture, or other particulate matter that could degrade the cleanup system's operation.

2. SYSTEM DESIGN CRITERIA

ESF atmosphere cleanup systems should be designed in accordance with the requirements of Section 4 of ASME N509-1989 (Ref. 2) as modified and supplemented by the following:

2.1. ESF atmosphere cleanup systems designed and installed for the purpose of mitigating accident doses should have redundant units (trains) to provide assurance that a unit will function during the DBA. Each unit should consist of the following sequential components: (1) moisture separator, (2) prefilter, (3) HEPA filter, (4) iodine adsorber (impregnated activated carbon), (5) postfilter, (6) fan, and (7) interspersed ducts, motors, dampers, and related instrumentation. A heater should be used when relative humidity is to be controlled before filtration.

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

2.3. All components of an ESF atmosphere cleanup system should be designated as seismic Category I (see Ref. 11, Regulatory Guide 1.29) if failure of a component would lead to the release of significant quantities of fission products to the working or outdoor environments.

2.4. In the mechanical design of the ESF system, the high radiation levels that may be associated with buildup of radioactive materials on the ESF system components should be given particular consideration. ESF system construction materials should effectively maintain their intended function under the postulated radiation levels. The effects of radiation should be considered not only

for moisture separators, heaters, HEPA filters, adsorbers, motors, and fans, but also for any electrical insulation, controls, joining compounds, dampers, gaskets, and other organic-containing materials that are necessary for operation during a postulated DBA. In addition to the consideration of high radiation levels, the mechanical design of the ESF system should be based on consideration of other harsh conditions that may occur during a DBA such as high humidity, containment rain-out, or high temperatures and pressures.

2.5. To ensure reliable in-place testing, the volumetric air flow rate of each cleanup unit should be limited to approximately 50,000 cfm. If a total system air flow in excess of this rate is required, multiple units should be used.

2.6. The power supply and electrical distribution system for the ESF atmosphere cleanup system should be designed in accordance with Regulatory Guide 1.32 (Ref. 12). All instrumentation and equipment controls should be designed to IEEE Standard 279 (Ref. 13). The ESF system should be qualified and tested under Regulatory Guide 1.89 (Ref. 14). To the extent applicable, Regulatory Guides 1.30 (Ref. 15), 1.100 (Ref. 16), and 1.118 (Ref. 17) and IEEE Standard 334 (Ref. 18) should be considered in the design.

2.7. Unless the applicable ESF atmosphere cleanup system operates continuously during all times that a DBA can be postulated to occur, the system should be automatically activated upon the occurrence of a DBA by (1) a redundant ESF actuation signal (e.g., temperature, pressure) or (2) a signal from redundant seismic Category I radiation monitors.

2.8. To maintain radiation exposures to operating and maintenance personnel as low as is reasonably achievable, ESF atmosphere cleanup systems and components should be designed to control leakage and facilitate maintenance, inspection, and testing in accordance with the guidance of Regulatory Guide 8.8 (Ref. 19). The ESF atmosphere cleanup unit should be totally enclosed. To minimize the potential contamination of the area when maintaining the ESF atmosphere cleanup system, the system should be designed and installed in a manner that permits replacement of an entire unit or a minimum number of segmented sections without removal of individual components.

2.9. Outdoor air intake openings should be equipped with louvers, grills, screens, or similar protective devices to minimize the effects of high winds, rain, snow, ice, trash, and other contaminants on the operation of the system. If the atmosphere surrounding the plant could contain significant environmental contaminants, such as dusts and residues from smoke cleanup systems from adjacent

coal burning power plants or industry, the design of the system should consider these contaminants and prevent them from affecting the operation of any ESF atmosphere cleanup system.

3. COMPONENT DESIGN CRITERIA AND QUALIFICATION TESTING

Components of ESF atmosphere cleanup systems should be designed, constructed, and tested in accordance with the requirements of Section 5 of ASME N509-1989 (Ref. 2) as modified and supplemented by the following:[1]

3.1. Filter and adsorber banks should be arranged in accordance with the recommendations of Section 4.4 of ERDA 76-21 (Ref. 7).

3.2. HEPA filters used in ESF atmosphere cleanup systems should be designed, constructed, and tested in accordance with Section 5.1 of ASME N509-1989 (Ref. 2), should have fiber glass media and steel sides, and should be compatible with the chemical composition and physical conditions of the air stream.

3.3. HEPA filters should meet the construction, material, and test requirements of military specifications MIL-F-51068 (Ref. 20) and MIL-F-51079 (Ref. 21). The requirements of these specifications concerning listing on the Department of Defense Qualified Products List (QPL) need not apply if the manufacturer maintains a quality assurance program consistent with the requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50.

3.4. Each HEPA filter should be tested by the manufacturer (or by a qualified filter test facility) for penetration of DOP in accordance with the procedures of MIL-F-51068 (Ref. 20) and MIL-STD-282 (Ref. 22).[2] Testing and documentation should be in accordance with a quality assurance program consistent with the requirements of Appendix B to 10 CFR Part 50.

A report certifying that the HEPA filters meet Regulatory Positions 3.2, 3.3, and 3.4 of this guide, including identification of quality assurance documents and test reports that support such certification, should be furnished to the licensee.

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[1]The pertinent quality assurance requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Reprocessing Plants," to 10 CFR Part 50 apply to all activities affecting the safety-related functions of HEPA filters.

[2]The U.S. Department of Energy (USDOE) operates a number of filter test facilities qualified to perform HEPA filter efficiency tests.

3.5. Adsorption units function most efficiently, with respect to retention of adsorbed iodine, at an input relative humidity of 70% or less. If an ESF atmosphere cleanup system services an area where moisture concentration and/or humidity approaching 100% relative humidity is expected to occur in an accident situation (e.g., standby gas treatment system or ECCS area ventilation), the system should be provided with heaters for controlling the relative humidity to 70% or less of air entering the adsorber section. For other ESF atmosphere cleanup systems, if the relative humidity of the entering air is expected to exceed 70% according to paragraph 4.1(e) of ASME N509-1989 (Ref. 2), heaters should be provided in the system design for controlling the relative humidity of the air entering the system. Heaters should be capable of reducing the worst case relative humidity of system influent air to 70% or less in the system space between the system inlet and the prefilter or HEPA stage at the maximum system design flow rate, considering normal and off-normal supply voltages. Heaters should be designed, constructed, and tested in accordance with Section 5.5 of ASME N509-1989 (Ref. 2).

3.6. The adsorber section of the ESF atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency. However, since impregnated activated carbon is used almost exlusively, only impregnated activated carbon is discussed in this guide.

3.7. Each original or replacement batch or lot of impregnated activated carbon used in the adsorber section should meet the requirements for adsorbent contained in Section 5.2.3 of ASME N509-1989 (Ref. 2) and in Section 16 of ASTM D4069-81 (Ref. 6).[3,4] In ASTM D4069-90, a test performed "only for qualification

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[3]A "batch of activated carbon" or a "batch of impregnated activated carbon" is the maximum quantity of adsorbent (not to exceed 10 cubic meters) manufactured from the same base material, processed throughout its manufacturing cycle in the same equipment and under the same manufacturing procedures, that can be homogenized at one time in one blending device and for which certified results of appropriate tests of physical and chemical properties are available. This constitutes a "batch" to be presented for radioactive or other specified tests under conditions and within tolerances specified (Ref. 2).

[4]A "lot of activated carbon" or a "lot of impregnated activated carbon" is that quantity of adsorbent consisting of one or more batches of the same type and grade, each of which meets the specified performance, physical, and chemical requirements, and is shipped to the same purchaser by the same manufacturer for the same job requirement (Ref. 2).

purposes" should be interpreted to mean a test that establishes the suitability of a manufacturer's product for a generic application, normally a one-time test establishing typical performance of the product. Tests not specifically identified as being performed only for qualification purposes should be interpreted as "batch tests." Batch tests are tests to be made on each production batch of product to establish suitability for a specific application. Test conditions and acceptance criteria for batch tests should be the same as, or more stringent than, those specified in the plant's technical specifications for the specific application.

3.8. If an adsorbent other than impregnated activated carbon is proposed or if the mesh size distribution or other physical properties of the impregnated activated carbon are different from the specifications in 3.7 above, the proposed adsorbent should have the capability to perform as well as or better than activated carbon satisfying the specifications in Section 5.2.3 of ASME N509-1989 (Ref. 2).

3.9. If impregnated activated carbon is used as the adsorbent, the adsorber system should be designed for an average atmosphere residence time of at least 0.25 second per two inches of adsorbent bed. The adsorption unit should be designed for a maximum loading of 2.5 mg of total iodine (radioactive plus stable) per gram of activated carbon. No more than 50 mg of total impregnant per gram of carbon should be used. The radiation stability of the type of impregnated carbon specified should be demonstrated and certified (see Regulatory Position 1.2 of this guide for the design source term).

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

3.11. Water drains should be designed in accordance with the recommendations of Section 4.5.8 of ERDA 76-21 (Ref. 7). Special design features, such as water traps for each drain, should be incorporated into drain systems to prevent contaminated air bypassing filters or adsorbers through the drain system.

4. MAINTAINABILITY CRITERIA

Provisions for maintaining ESF atmosphere cleanup systems should be incorporated in the system design in accordance with Section 4.8 of ASME N509-1988 (Ref. 2) as supplemented by the following:

4.1. Accessibility of components for maintenance should be considered in the design of ESF atmosphere cleanup systems. In addition to the provisions of Section 4.8 of ASME N509-1989 (Ref. 2), the design should consider the provisions of Section 2.3.8 of ERDA 76-21 (Ref. 7).

4.2. Each ESF atmosphere cleanup train should be operated at least 10 hours per month, with input air at less than 70% relative humidity, in order to reduce potential or accumulated buildup of moisture on the adsorbers and HEPA filters. Units equipped with heaters should be operated with heaters energized.

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

5. IN-PLACE TESTING CRITERIA

In-place testing of ESF atmosphere cleanup systems and components should be performed in accordance with Sections 5 through 14 of ASME N510-1989 (Ref. 3) as modified and supplemented by the following:

5.1. In-place DOP leak testing of ESF atmosphere cleanup systems should be performed: (1) initially, (2) at least once per 18 months or once per refueling outage, (3) after each partial or complete replacement of a HEPA filter bank, (4) following detection of, or evidence of, penetration or intrusion of water or other foreign material into any portion of an ESF atmosphere cleanup system, and (5) following painting, fire, or chemical release in any ventilation zone communicating with the system, whether the system was in operation at the time or not, and the HEPA filter section could thereby have deteriorated or been loaded to such an extent that the HEPA filter section performance would be unacceptable. The test should be performed in accordance with Section 10 of ASME N510-1989 (Ref. 3). The leak test should confirm a combined penetration and leakage (or bypass) of the ESF atmosphere cleanup system of less than 0.05%

of the challenge aerosol at rated flow. To be credited with a 99% removal efficiency for particulate matter in accident dose evaluations, a HEPA filter bank in an ESF atmosphere cleanup system must demonstrate a DOP leak test result of less than 0.05% of the challenge aerosol at rated flow.

5.2. HEPA filter sections in ESF atmosphere cleanup systems that fail to satisfy the appropriate leak-test conditions should be examined to determine the location and cause of leaks. Repairs, such as alignment of filter frames and tightening of filter hold-down bolts, may be made; however, repair of defective, damaged, or torn filter media by patching or using caulking materials is not permissible in ESF atmosphere cleanup systems, and such filters should be replaced and not repaired. HEPA filters that fail to satisfy test conditions should be replaced with filters qualified pursuant to Regulatory Positions 3.2, 3.3, and 3.4. After repairs or filter replacement, the ESF atmosphere cleanup system should be retested in accordance with Section 10 of ASME N510-1989 (Ref. 3). The above process should be repeated as necessary until combined penetration and leakage (bypass) of the system is less than 0.05%.

5.3. In-place adsorber leak testing should be conducted (1) initially, (2) at least once per 18 months or during each refueling outage thereafter, (3) following removal of an adsorber sample for laboratory testing if the integrity of the adsorber section is affected, (4) after each partial or complete replacement of carbon adsorber in an adsorber section, (5) following detection of, or evidence of, penetration or intrusion of water or other foreign material into any portion of an ESF atmosphere cleanup system, and (6) following painting, fire, or chemical release in any ventilation zone communicating with the system, whether the system was in operation at the time or not, and the adsorber section could thereby have deteriorated or been loaded to such an extent that the adsorber section performance would be unacceptable.

The test should be performed in accordance with Section 11 of ASME N510-1989 (Ref. 3). The leak test should confirm a combined penetration and leakage (or bypass) of the adsorber section of 0.05% or less of the challenge gas at rated flow.

Where credited with a 99% or greater removal efficiency of elemental iodine or organic iodide in accident dose evaluations, a carbon adsorber section in an ESF atmospheric cleanup system must demonstrate a leak test result of 0.05% or less of the challenge gas at rated flow. In no case may the leak test result be greater than 1%.

5.4. Adsorber sections that fail to satisfy the appropriate leak-test conditions should be examined to determine the location and cause of leaks. Repairs, such as alignment of adsorber cells, tightening of adsorber cell hold-down bolts, or tightening of test canister fixtures, may be made; however, the use of temporary patching material on adsorbers, filters, housings, mounting frames, or ducts should not be allowed. After repairs or adjustments have been made, the adsorber sections should be retested in accordance with Section 11 of ASME N510-1989 (Ref. 3). The above process should be repeated as necessary until the combined penetration and leakage (bypass) of the adsorber section is less than the acceptance criteria.

5.5. If any welding repairs are necessary on, within, or adjacent to the ducts, housing, or mounting frames, the filters and adsorbers should be removed from the housing prior to performing such repairs. The repairs should be completed prior to re-installation of filters and adsorbers; the system should then be visually inspected and leak tested as in Regulatory Positions 5.1 and 5.3.

5.6. An appropriate refrigerant gas may be injected upstream of HEPA filters in order to test a downstream adsorber section since it has been shown that prefilters and HEPA filters in the duct have no effect on the refrigerant gas test (Ref. 7) and that refrigerant gases have no adverse effect on HEPA filters (Ref. 3) when an appropriate refrigerant is used.

6. LABORATORY TESTING CRITERIA FOR ACTIVATED CARBON

Laboratory testing of samples of activated carbon adsorber material from ESF atmosphere cleanup systems should be performed in accordance with Section 15 of ASME N510-1989 (Ref. 3), ASTM D3803-1989 (Ref. 5), and Table 2 of this guide as supplemented by the following:

6.1. Representative[5] samples of activated carbon adsorbent should be collected at the time of installation or replacement of adsorber material and submitted for analysis. Test results will provide a base or reference for subsequent sampling and analysis to show the variation of adsorbent condition with time.

6.2. Sampling and analysis should be performed (1) after each 720 hours of system operation, (2) at least once per 18 months for systems maintained in a standby status, (3) following painting, fire, or chemical release in any ventilation zone communicating with the system, whether the system was in operation at the time or not, and the adsorbent could thereby have deterioriated or been loaded to such an extent that the adsorber efficiency would be unacceptable, and (4) following detection of, or evidence of, penetration or intrusion of water or other foreign material into any portion of an ESF atmosphere cleanup system.

6.3. For accident dose evaluation purposes, the activated carbon adsorber section of an ESF atmosphere cleanup system should be assigned the appropriate decontamination efficiency given in Table 2 for elemental iodine and organic iodides if the following conditions are met:

1. The adsorber section meets the leak-test conditions given in Regulatory Position 5.3 of this guide.

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[5]For the definition of "representative sample," see Appendix A of ASME N509-1989 (Ref. 2). For carbon beds 4 inches or greater in depth, full-depth representative samples should be used in laboratory testing indicated in Table 2; the organic iodide penetration should be determined directly, provided the analytical methods used are sufficiently sensitive for this application. Where this is not the case, a lesser depth (e.g., 2-inch) representative sample may be used in laboratory testing. This representative sample may be prepared by dumping a full-depth representative sample into a suitable receptacle, mixing the sample thoroughly, then transferring part of the homogenized mixture into a standard 2-inch (50 mm) depth sample canister. The organic iodide penetration for a full-depth sample can be determined from that obtained for the 2-inch sample according to the relation:

$$P_f = (P_2)^n$$

Where P_2 = fractional penetration determined directly for a 2" sample
P_f = fractional penetration for a full-depth bed
n = equivalent number of 2-inch samples in a full-depth bed (e.g., for a 6" bed, n = 3)

2. New activated carbon meets the performance and physical property specifications given in Regulatory Position 3.7 of this guide, and
3. Representative samples of new or used activated carbon pass the applicable laboratory tests specified in Table 2 of this guide.

If the new activated carbon fails to meet any of the above conditions, it should not be used in adsorbers in ESF atmosphere cleanup systems.

6.4. The activated carbon adsorber section should be replaced with new unused activated carbon meeting the performance and physical property specifications of Regulatory Position 3.7 of this guide if (1) testing in accordance with Regulatory Positions 6.1 and 6.2, above, results in a representative sample failing to pass the applicable test in Table 2 of this guide, or if (2) no representative sample is available for testing. Alternative methyl iodide penetration acceptance criteria may be established and used on a case-by-case basis for replacing the activated carbon if justified by trending based on previous laboratory test results or established procedures providing for periodic sampling and analysis at frequencies greater than (1) after each 720 hours of system operation and (2) at least once in 18 months for systems maintained in a standby status. In all cases, assurance should be provided that the performance of the adsorption unit is consistent at all times with the iodine removal efficiency assumed in the radiation dose calculations.

D. IMPLEMENTATION

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

This proposed revision has been released to encourage public participation in its development. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the guidance to be described in the active guide reflecting public comments will be used by the NRC staff in its evaluation of the design, testing, and maintenance of postaccident ESF atmosphere cleanup systems for the following light-water-cooled nuclear power plants:

1. Plants for which the construction permit application is docketed after the issue date of the final guide;

2. Plants for which the operating license application is docketed 6 months after the issue date of the final guide;

3. Plants for which the licensee voluntarily commits to the provisions of the final guide.

TABLE 1. Typical Accident Conditions for ESF Atmosphere Cleanup Systems

Environmental Parameter	Typical Atmosphere Cleanup System Accident Conditions		
		Outside Primary Containment	
	Inside Primary Containment	SGTS or ECCS Area Service[a]	Fuel Handling or Control Building[a]
Pressure surge	Result of initial blowdown	Generally less than inside primary containment	< 5 inches water gauge
Maximum pressure	60 psig	~ atmospheric	~ atmospheric
Maximum temperature of influent	~280°F (~140°C)	~ 180°F (~80°C)	~ 100°F (~40°C)
Minimum temperature of influent	Specific to plant design	~ 80°F (~30°C)	~ 70°F (~20°C)
Maximum relative humidity of influent	100% plus condensing moisture	100%	70%
Average radiation level[b]			
For airborne radioactive materials	10^6 rads/hr	10^5 rads/hr	10^5 rads/hr
For iodine buildup on adsorber	10^9 rads	10^9 rads	10^9 rads
Average airborne iodine concentration[a]			
For elemental iodine	100 mg/m^3	10 mg/m^3	1 mg/m^3
For methyl iodide and particulate iodine	10 mg/m^3	1 mg/m^3	0.1 mg/m^3

[a] These are examples of types of facilities for each category of system outside primary containment.

[b] These values are based on the source term specified in Regulatory Guide 1.3 (Ref. 8) or 1.4 (Ref. 9), as applicable.

TABLE 2. Laboratory tests and assigned decontamination efficiencies for new and used activated carbon samples for ESF atmosphere cleanup system units. Laboratory tests are conducted in accordance with ASTM D3803-1989 (Ref. 5). Tests are conducted at 95% relative humidity, except 70% relative humidity is used when the air entering the carbon adsorber is maintained at ≤ 70% relative humidity.

Total depth of activated carbon cells in adsorber section	Maximum assigned credit for activated carbon decontamination efficiencies		Test temperature and methyl iodide penetration acceptance criterion
2 inches. System designed to operate inside primary containment.	Elemental iodine Organic iodide	90% 30%	80°C; penetration less than 10%
2 inches. System designed to operate outside the primary containment.	Elemental iodine Organic iodide	99% 95%	30°C; penetration less than 1%
4 inches or greater. System designed to operate outside the primary containment.	Elemental iodine Organic iodide	99.8% 99%	30°C; penetration less than 0.2%

The operating conditions of temperature and relative humidity in Table 2 are based on typical anticipated operating conditions. The established test conditions should consider the observations that tests conducted at higher temperatures or at lower relative humidities produce lower methyl iodide penetration results. Therefore, to provide a safety margin the plant-specific test temperatures and relative humidities should be representative, respectively, of the lowest and the highest portions of the average of the anticipated plant-specific operating conditions.

REFERENCES

1. J. Louis Kovach, "The Evolution and Current State of Radio-Iodine Control," in Proceedings of the 16th DOE Nuclear Air Cleaning Conference, Held in San Diego, CA, M. W. First, Editor, CONF-801038,[1] February 1981.

2. American Society of Mechanical Engineers, "Nuclear Power Plant Air-Cleaning Units and Components," ASME N509-1989.[2]

3. American Society of Mechanical Engineers, "Testing of Nuclear Air-Treatment Systems," ASME N510-1989.[2]

4. American Society of Mechanical Engineers, "Code on Nuclear Air and Gas Treatment," ASME/ANSI AG-1-1988.[2] Also see ASME/ANSI AG-1a-1989, Addenda to ASME/ANSI AG-1-1988.

5. American Society for Testing and Materials, "Standard Test Methods for Nuclear-Grade Activated Carbon," ASTM Standard D3803-1989.[3]

6. American Society for Testing and Materials, "Impregnated Activated Carbon Used To Remove Gaseous Radioiodines from Gas Streams," ASME D4069-81.[3]

7. C. A. Burchsted, J. E. Kahn, and A. B. Fuller, "Nuclear Air Cleaning Handbook," Oak Ridge National Laboratory, ERDA 76-21,[1] March 31, 1976.

8. U.S. Nuclear Regulatory Commission (USNRC), "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," Regulatory Guide 1.3,[4] Revision 2, June 1974.

9. USNRC, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors," Regulatory Guide 1.4,[4] Revision 2, June 1974.

10. USNRC, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors," Regulatory Guide 1.25.[4]

11. USNRC, "Seismic Design Classification," Regulatory Guide 1.29.[4]

12. USNRC, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants," Regulatory Guide 1.32.[4]

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[1]Copies may be obtained from the National Technical Information Service, Springfield, VA 22161.

[2]Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

[3]Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

[4]Copies may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082.

13. Institute of Electrical and Electronics Engineers, "Criteria for Protection Systems for Nuclear Power Generating Stations," IEEE Std 279[5] (latest edition).

14. USNRC, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Regulatory Guide 1.89.[4]

15. USNRC, "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment," Regulatory Guide 1.30.[4]

16. USNRC, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," Regulatory Guide 1.100.[4]

17. USNRC, "Periodic Testing of Electric Power and Protection Systems," Regulatory Guide 1.118.[4]

18. Institute of Electrical and Electronics Engineers, "IEEE Standard for Type Tests of Continuous-Duty Class 1E Motors for Nuclear Power Generating Stations," IEEE Std 334-1974.[5]

19. USNRC, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," Regulatory Guide 8.8.[4]

20. "Filter, Particulate, High-Efficiency, Fire-Resistant," MIL-F-51068[6] (latest edition), Military Specification.

21. "Filter, Medium, Fire-Resistant, High-Efficiency," MIL-F-51079[6] (latest edition), Military Specification.

22. "Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance-Test Methods," MIL-STD-282,[6] Military Standard, May 1956.

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[5]Copies may be obtained from the Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017.

[6]Copies may be obtained from the Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

DRAFT VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

Revision 2 of Regulatory Guide 1.52 provides guidance to applicants and licensees on design, testing, and maintenance for postaccident engineered-safety-feature (ESF) atmosphere cleanup systems for light-water-cooled nuclear power plants. This proposed action is to issue Revision 3 to Regulatory Guide 1.52, first as a proposed revision for public comment and then in final form.

1.2 Need

Revision 2 of Regulatory Guide 1.52 is the basic document used in commercial nuclear power plant technical specifications for the testing of ESF postaccident air-cleaning systems. However, Revision 2, which was issued as an active guide in March 1978, is considered to be significantly outdated and in error in many significant technical areas. This Revision 3 updates guidance on testing and maintenance of ESF postaccident air-cleaning systems and is consistent with present policies, recent standards revisions in ANSI N509 and N510, new filter system design and testing data, and present licensing practice concerning testing and maintenance of ESF air-cleaning systems.

1.3 Value/Impact

1.3.1 NRC

The primary effect of the proposed action on the NRC staff would be to facilitate implementation of current NRC positions with regard to ESF filter system testing and maintenance. It would improve the basis for communication between NRC staff and licensees and would reduce staff effort that might otherwise be spent answering questions about acceptable means for testing ESF filter systems.

1.3.2 Other Government Agencies

The principal effect on other Government agencies would be to inform them of NRC's policies on ESF filter system testing and maintenance. Department of Energy (DOE) review would be useful, because one of the areas addressed by the revision is HEPA filter system testing at DOE test facilities.

1.3.3 Industry

The guide will be useful to industry because it will notify them in a consistent manner of changes in ESF filter system testing and maintenance provisions and will thus promote understanding of current NRC positions and prevent any unnecessary costs being applied to meet a provision no longer recommended by the NRC staff. None of the changes is expected to impose significant additional burdens on applicants or licensees. Some of the changes may relax certain guide positions but without compromise to safety, thereby reducing cost and effort. Any costs associated with the revised positions related to testing and maintenance of new and used charcoal would be limited but unavoidable, because the existing criteria are based on obsolete methods for radioiodine testing of activated charcoal.

1.34 Public

The proposed action will enhance the protection of the public health and safety by providing that postaccident ESF filter systems will be tested and maintained in accordance with up-to-date technical information and NRC positions.

2. TECHNICAL APPROACH

Major technical questions related to ESF filter system design, testing, and maintenance were considered in developing the previous revisions of Regulatory Guide 1.52. Revision 3 will address endorsement of ASME N509-1989, "Nuclear Power Plant Air-Cleaning Units and Components," and ASME N510-1989, "Testing of Nuclear Air-Treatment Systems"; radioiodine testing of activated carbon adsorber materials; quality assurance aspects of HEPA filter manufacturing, installation, and testing; use of DOP as a test aerosol for in-place leak testing of HEPA filters; and limitation of the volumetric air flow rate of single filter trains.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

NRC procedures that may be used for making this information available include the following:

- Regulation
- NUREG-series report
- Branch position paper
- Regulatory guide

A regulation is not suitable for incorporating the degree of detail presented in this guide. As regulatory positions are stated, it would be inappropriate to publish this material as a NUREG-series report. Branch technical positions (BTP) are sometimes prepared for specific guidance, however, it would be most appropriate to update Regulatory Guide 1.52 and prepare clear regulatory guidance for licensees and applicants.

3.2 Decision on Procedural Approach

A revision to the regulatory guide should be prepared.

4. STATUTORY CONSIDERATIONS

4.1 NRC Authority

Authority for the proposed action is derived from the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, and implemented through the Commission's regulations.

4.2 Need for NEPA Assessment

Issuance or amendment of guides for the implementation of regulations in Title 10, Chapter I, of the Code of Federal Regulations is a categorical exclusion under paragraph 51.22(c)(16) of 10 CFR Part 51. Thus, an environmental impact statement or assessment is not required for this action.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

This guide was developed in support of General Design Criteria 41, 42, 43, and 61 of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50. These criteria require that containment atmosphere cleanup systems be provided as necessary, be designed to permit appropriate periodic inspection and testing, and be designed to reduce the amount of radioactive material released to the environment following a postulated design basis accident.

6. CONCLUSIONS

Revision 3 of Regulatory Guide 1.52 should be issued to update the current staff positions and to inform its users of the current staff positions.

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

DRAFT REGULATORY GUIDE

March 1991
Division 1
Task DG-1014

Contact: C.W. Nilsen (301) 492-3834

4th TD 2-13-91

DRAFT REGULATORY GUIDE DG-1014

PROPOSED REVISION 2 TO REGULATORY GUIDE 1.140

DESIGN, TESTING, AND MAINTENANCE CRITERIA FOR NORMAL VENTILATION EXHAUST SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

A. INTRODUCTION

General Design Criteria 60 and 61 of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," require that filtering systems included in the nuclear power unit design suitably control the release of radioactive materials in gaseous effluents during normal reactor operation, including anticipated operational occurrences and fuel storage and handling operations. In addition, 10 CFR 50.34a, "Design Objectives for Equipment To Control Releases of Radioactive Material in Effluents--Nuclear Power Reactors," and 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors," of 10 CFR Part 50 require that means be employed to ensure that release of radioactive material to unrestricted areas during normal reactor operation, including expected operational occurrences, is kept as low as is reasonably achievable.

Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation To Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50 provides guidance and numerical values for design objectives to help applicants for, and holders of, licenses for nuclear power plants meet the requirements of 10 CFR 50.34a and 50.36a. Appendix I requires that each light-water-cooled nuclear power reactor unit not exceed an annual dose design

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review and does not represent an official NRC staff position.

Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Regulatory Publications Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by

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objective of 15 mrem to any organ of any individual in an unrestricted area via all exposure pathways from airborne radioactive iodine and particulate releases. Appendix I also requires that additional radwaste equipment be provided if the equipment has reasonably demonstrated technology and the cost-benefit ratio is favorable.

This guide presents methods acceptable to the NRC staff for implementing the Commission's regulations in 10 CFR Part 50 and in Appendices A and I to 10 CFR Part 50 with regard to the design, testing, and maintenance criteria for air filtration and adsorption units installed in the normal ventilation exhaust systems of light-water-cooled nuclear power plants. This guide applies only to atmosphere cleanup systems designed to collect airborne radioactive materials during normal plant operation, including anticipated operational occurrences. An atmosphere cleanup system installed in a normal ventilation exhaust system consists of some or all of the following components: heaters or cooling coils used in conjunction with heaters, prefilters, high-efficiency particulate air (HEPA) filters, iodine adsorption units, fans, and associated ductwork, dampers, and instrumentation. The instrumentation covered by this guide is that used to measure air flow and differential pressure.

This guide does not apply to postaccident engineered-safety-feature atmosphere cleanup systems that are designed to mitigate the consequences of postulated accidents. Revision 3 to Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Postaccident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants" (DG-1013), is being developed to provide guidance for these systems.

Any information collection activities mentioned in this draft regulatory guide are contained as requirements in 10 CFR Part 50, which provides the regulatory basis for this guide. The information collection requirements in 10 CFR Part 50 have been cleared under OMB Clearance No. 3150-0011.

B. DISCUSSION

Particulate filtration and radioiodine adsorption units are included in the design of the ventilation exhaust systems of light-water-cooled nuclear power plants to reduce the quantities of radioactive materials in gaseous effluents released from building or containment atmospheres during normal operation,

including anticipated operational occurrences. All such cleanup systems should be designed to operate continuously under normal environmental conditions.

In this guide, cleanup systems that should operate to meet the "as low as is reasonably achievable" guidelines of Appendix I to 10 CFR Part 50 inside the primary containment (recirculating units) are designated as "primary systems." Primary systems generally include a containment cleanup system (kidney filtration system). Systems that operate outside primary containment are designated as "secondary systems." Secondary systems generally include cleanup systems installed in the ventilation exhaust systems for the reactor building, turbine building, radwaste building, auxiliary building, mechanical vacuum pump, main condenser air ejector, and any other release points that may contain particulates and gaseous radioiodine species. In some instances, filtration equipment installed in a postaccident hydrogen purge exhaust system may be designed to the recommendations of this guide, e.g., where a removal efficiency of 90% or less for radioiodine species is sufficient for the hydrogen purge exhaust system when the sum of the calculated loss-of-coolant accident (LOCA) dose and the post-LOCA hydrogen purge dose is less than the guideline values of 10 CFR Part 100.

Normal environmental conditions that these atmosphere cleanup systems should withstand are inlet concentrations of radioactive iodine up to 10^{-6} $\mu Ci/cm^3$, relative humidity of the influent stream up to 100%, temperatures of the influent stream up to 125°F (52°C), and normal atmospheric pressure. The system should be designed, tested, and maintained in such a manner that radiation levels of airborne radioactive material and radioiodine buildup on the adsorber do not degrade the performance of the filter system or any component.

Atmosphere cleanup system heaters are designed to heat the influent stream to reduce its relative humidity before it reaches the filters and adsorbers. HEPA filters are installed to remove particulate matter, which may be radioactive, and pass the air stream to the adsorber. The adsorber removes gaseous iodine (elemental iodine and organic iodides) from the air stream. HEPA filters downstream of the adsorber units collect carbon fines and provide redundant protection against particulate release in case of failure of the upstream HEPA filter bank. The fan is the final item in an atmosphere cleanup system. Consideration should be given to installing prefilters upstream of the HEPA filters to reduce the particulate load and extend their service life.

The environmental history will affect the performance of the atmosphere cleanup system. Industrial contaminants, pollutants, temperature, and relative

humidity contribute to the aging and weathering of filters and adsorbers and reduce their capability to perform their intended functions. Therefore, aging, weathering, and poisoning of these components, which may vary from site to site, need to be considered during design and operation. Average temperature and relative humidity also vary from site to site, and the potential buildup of moisture in the adsorber warrants equal design consideration. The effects of these factors on the atmosphere cleanup system can be determined by scheduled testing.

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

Standards for the design and testing of atmosphere cleanup systems include ASME N509-1989, "Nuclear Power Plant Air-Cleaning Units and Components" (Ref. 1), and ASME N510-1989, "Testing of Nuclear Air-Treatment Systems" (Ref. 2).

Other standards are available for the construction and testing of certain components of systems. If such standards are acceptable to the NRC staff, they are referenced in this guide. If no suitable standard exists, acceptable approaches are presented in this guide. ERDA 76-21, "Nuclear Air Cleaning Handbook" (Ref. 3), provides a comprehensive review of air filtration systems. It is not a standard but a guide that discusses a number of acceptable design alternatives.

Not all the documents mentioned in ASME N509-1989 (Ref. 1), ASME N510-1989 (Ref. 2), or other standards referenced in this guide have been the subject of an evaluation by the NRC staff as to their applicability or acceptability. The specific applicability or acceptability of these listed documents, as well as documents listed in other standards referenced in this guide, has been or will be covered separately in other regulatory guides, if appropriate. These standards are to be used in a manner consistent with regulatory practice.

C. REGULATORY POSITION

1. ENVIRONMENTAL DESIGN CRITERIA

1.1. The design of each atmosphere cleanup system installed in a normal ventilation exhaust system should be based on the anticipated range of operating parameters of temperature, pressure, relative humidity, and radiation levels.

1.2. If the atmosphere cleanup system is located in an area of high radiation during normal plant operation, adequate shielding of components and personnel from the radiation source should be provided.

1.3. The operation of any atmosphere cleanup system in a normal ventilation exhaust system should not degrade the expected operation of any engineered-safety-feature system that must operate after a design basis accident.

1.4. The design of the atmosphere cleanup system should consider any significant contaminants such as dusts, chemicals, or other particulate matter that could degrade the cleanup system's operation.

2. SYSTEM DESIGN CRITERIA

2.1. Atmosphere cleanup systems installed in normal ventilation exhaust systems need not be redundant nor designed to seismic Category I classification, but should consist of the following sequential components: (1) HEPA filters before the adsorbers, (2) iodine adsorbers (impregnated activated carbon), (3) fans, and (4) interspersed ducts, dampers, and related instrumentation. If it is desired to reduce the particulate load on the HEPA filters and extend their service life, the installation of prefilters upstream of the initial HEPA section is suggested. Consideration should also be given to the installation of a HEPA filter section downstream of carbon adsorbers to retain carbon fines. Heaters or cooling coils used in conjunction with heaters should be used when the humidity is to be controlled before filtration. Whenever an atmosphere cleanup system is designed to remove only particulate matter, a component for iodine adsorption need not be included.

2.2. To ensure reliable in-place testing, the volumetric air flow rate of a single cleanup unit should be limited to approximately 50,000 ft^3/min. If a total system air flow in excess of this rate is required, multiple units should be used.

2.3. Each atmosphere cleanup system should be instrumented to monitor and alarm pertinent pressure drops and flow rates in accordance with the recommendations of Section 5.6 of ERDA 76-21 (Ref. 3).

2.4. To maintain the radiation exposure to operating and maintenance personnel as low as is reasonably achievable, atmosphere cleanup systems and components should be designed to control leakage and facilitate maintenance, inspection, and testing in accordance with the guidance in Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonable Achievable" (Ref. 4).

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

2.6. Atmosphere cleanup system housings and ductwork, as defined in Section 3 of ASME N509-1989 (Ref. 1), should be designed to exhibit on test a maximum total leakage rate as defined in Section 4.14 of ASME N509-1989. Duct and housing leak tests should be performed in accordance with the provisions of Section 6 of ASME N510-1989 (Ref. 2).

3. COMPONENT DESIGN CRITERIA AND QUALIFICATION TESTING

3.1. Adsorption units function efficiently at a relative humidity of 70% or less. If the relative humidity of the atmosphere entering the air cleanup system is expected to be greater than 70% during normal reactor operation, heaters or cooling coils used in conjunction with heaters should be designed to reduce the relative humidity of the adsorption unit entering atmosphere to 70% or less. Heaters should be designed, constructed, and tested in accordance with the requirements of Section 5.5 of ASME N509-1989 (Ref. 1) exclusive of sizing criteria.

3.2. The HEPA filters should be designed, constructed, and tested in accordance with the requirements of Section 5.1 of ASME N509-1989 (Ref. 1). Each HEPA filter should be tested for penetration of dioctyl phthalate (DOP) in accordance with the provisions of MIL-F-51068 (Ref. 5) and MIL-STD-282 (Ref. 6).

3.3. Filter and adsorber mounting frames should be designed and constructed in accordance with the provisions of Section 5.6.3 of ASME N509-1989 (Ref. 1).

3.4. Filter and adsorber sections should be arranged in accordance with the recommendations of Section 4.7 of ASME N509-1989 (Ref. 1) and Section 4.4 of ERDA 76-21 (Ref. 3).

3.5. System filter housings, including floors and doors, and electrical conduits, drains, and piping installed inside filter housings should be designed and constructed in accordance with the provisions of Section 5.6 of ASME N509-1989 (Ref. 1).

3.6. Ductwork associated with the atmosphere cleanup system should be designed, constructed, and tested in accordance with the provisions of Section 5.10 of ASME N509-1989 (Ref. 1).

3.7. The adsorber section of the atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency. Since impregnated activated carbon is commonly used, it is the only adsorbent discussed in this guide. Each original or replacement batch of impregnated activated carbon used in the adsorber section should meet the qualification and batch test results summarized in Table 1 of this guide.

If an adsorbent other than impregnated activated carbon is proposed or if the mesh size distribution is different from the specifications in Table 1, the proposed adsorbent should have demonstrated the capability to perform as well as or better than activated carbon in satisfying the specifications in Table 1. If impregnated activated carbon is used as the adsorbent, the adsorber system should be designed for an average atmosphere residence time of at least 0.25 second per 2 inches of adsorbent bed.

3.8. Adsorber cells should be designed, constructed, and tested in accordance with the requirements of Section 5.2 of ASME N509-1989 (Ref. 1).

3.9. The system fan and motor, mounting, and ductwork connections should be designed, constructed, and tested in accordance with the requirements of Sections 5.7 and 5.8 of ASME N509-1989 (Ref. 1).

3.10. The fan and motor used in the atmosphere cleanup system should be capable of operating under the environmental conditions postulated for its use.

3.11. Ducts and housings should be laid out with a minimum of ledges, protrusions, and crevices that could collect dust and moisture and that could impede personnel or create a hazard to them in the performance of their work.

Turning vanes or other air flow distribution devices should be installed where required to ensure representative air flow measurement and uniform flow distribution through cleanup components.

3.12. Dampers should be designed, constructed, and tested in accordance with the provisions of Section 5.9 of ASME N509-1989 (Ref. 1).

3.13. If prefilters are used in the atmosphere cleanup system, they should be designed, constructed, and tested in accordance with the provisions of Section 5.3 of ASME N509-1989 (Ref. 1).

4. MAINTENANCE

4.1. Accessibility of components and maintenance should be considered in the design of atmosphere cleanup systems in accordance with the provisions of Section 2.3.8 of ERDA 76-21 (Ref. 3) and Section 4.8 of ASME N509-1989 (Ref. 1).

4.2. For ease of inspection and maintenance with minimum danger of damage to the system, its design should provide for a minimum of 3 feet clear access space in each compartment after allowing for the component dimension itself and the maximum length of the component during changeout.

4.3. The system design should provide for permanent test probes with external connections in accordance with the provisions of Section 4.13 of ASME N509-1989 (Ref. 1).

4.4. The cleanup components (e.g., HEPA filters and adsorbers) should be installed after construction is completed.

5. IN-PLACE TESTING CRITERIA

5.1. A visual inspection, in accordance with the provisions of Section 5 of ASME N510-1989 (Ref. 2), of the atmosphere cleanup system and all associated components should be made before each in-place airflow distribution test, DOP (dioetyl phthalate) test, or activated carbon adsorber section leak test.

5.2. The airflow distribution to the HEPA filters and iodine adsorbers should be tested in place for uniformity both initially and after maintenance affecting the flow distribution. The distribution should be within ±20% of the average flow per unit when tested in accordance with the provisions of Section 9 of "Industrial Ventilation" (Ref. 7) and Section 8 of ASME N510-1989 (Ref. 2).

5.3. The in-place DOP test for HEPA filters should conform to Section 10 of ASME N510-1989 (Ref. 2). HEPA filter sections should be tested in place initially and at intervals of approximately 18 months thereafter. The HEPA filter bank upstream of the adsorber section should also be tested following painting, fire, or chemical release in any ventilation zone communicating with the system in such a manner that the HEPA filter section could become adversely affected by the fumes, chemicals, or foreign materials. DOP penetration tests of all HEPA filter banks should confirm a penetration of less than 0.05% at rated flow. A filtration system satisfying this condition can be considered to warrant a 99% removal efficiency for particulates. HEPA filters that fail to satisfy the in-place test criteria should be replaced with filters qualified pursuant to Regulatory Position 3.3 of this guide. If the HEPA filter section is entirely or only partially replaced, an in-place DOP test should be conducted.

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

5.4. The activated carbon adsorber section should be leak-tested with a gaseous halogenated hydrocarbon refrigerant in accordance with Section 11 of ASME N510-1989 (Ref. 2) to ensure that bypass leakage through the adsorber section is less than 0.05%. Adsorber leak testing should be conducted (1) initially, (2) at intervals of approximately 18 months thereafter, (3) following removal of an adsorber sample for laboratory testing if the integrity of the adsorber section is affected, and (4) following painting, fire, or chemical release in any ventilation zone communicating with the system in such a manner that the charcoal adsorber section could become adversely affected by the fumes, chemicals, or foreign materials.

6. LABORATORY TESTING CRITERIA FOR ACTIVATED CARBON

6.1. The activated carbon adsorber section of the atmosphere cleanup system should be assigned the decontamination efficiencies given in Table 2 for radioiodine if the following conditions are met:

1. The adsorber section meets the conditions given in Regulatory Position 5.4 of this guide,
2. New activated carbon meets the physical property specifications given in Table 1, and
3. Representative samples of used activated carbon pass the laboratory tests given in Table 2.

If the activated carbon fails to meet any of the above conditions, it should not be used in adsorption units.

6.2. The efficiency of the activated carbon adsorber section should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the adsorber section. Each representative sample should be not less than 2 inches in both length and diameter, and each sample should have the same qualification and batch test characteristics as the system adsorbent. There should be a sufficient number of representative samples located in parallel with the adsorber section to estimate the amount of penetration of the system adsorbent throughout its service life. The design of the samplers should be in accordance with the provisions of Appendix A to ASME N509-1989 (Ref. 1). Where the system activated carbon is greater than 2 inches deep, each representative sampling station should consist of enough 2-inch samples in series to equal the thickness of the system adsorbent. Once representative samples are removed for laboratory testing, their positions in the sampling array should be blocked off.

Sampling and analysis should be performed (1) initially, (2) at intervals of approximately 18 months thereafter, (3) following painting, fire, or chemical release in any ventilation zone communicating with the system, whether the system was in operation or not, and the adsorbent could thereby have deteriorated or been loaded to the extent that the adsorber efficiency would be unacceptable, and (4) following detection of, or evidence of, penetration of water or other foreign material into any portion of the filter system.

Laboratory tests of representative samples should be conducted, as indicated in Table 2 of this guide, with the test gas flow in the same direction as the flow during service conditions. Similar laboratory tests should be performed on an adsorbent sample before loading into the adsorbers to establish an initial point for comparison of future test results. The activated carbon adsorber section should be replaced with new unused activated carbon meeting

the physical property specifications of Table 1 if (1) testing in accordance with Table 2 results in a representative sample failing to pass the applicable test in Table 2 or (2) no representative sample is available for testing.

D. IMPLEMENTATION

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

This proposed revision has been released to encourage public participation in its development. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the guidance to be described in the active guide reflecting public comments will be used by the NRC staff in its evaluation of the design, testing, and maintenance of air filtration and adsorption units in normal exhaust systems for the following light-water-cooled nuclear power plants:

1. Plants for which the construction permit application is docketed after the issue date of the final guide;
2. Plants for which the operating license application is docketed 6 months after the issue date of the final guide;
3. Plants for which the licensee voluntarily commits to the provisions of this guide.

TABLE 1

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

Test	Acceptable Test Method	Acceptable Results
1. Particle size distribution	ASTM D2862 (Ref. 8)	Retained on #6 Sieve: 0.0% Retained on #8 Sieve: 5.0% max. Through #8, retained on #12 Sieve: 40% to 60% Through #12, retained on #16 Sieve: 40% to 60% Through #16 Sieve: 5.0% max. Through #18 Sieve: 1.0% max. (Ref. 9)
2. Hardness number	RDT M16-IT, Appendix C (Ref. 10)	95 minimum
3. Ignition temperature	RDT M16-IT, Appendix C (Ref. 10)	330°C minimum at 100 fpm
4. CCl_4 Activity[b]	CCl_4 Activity, RDT M16-IT, Appendix C (Ref. 10)	60 minimum
5. Radioiodine removal efficiency		
a. Elemental iodine, 25°C and 95% relative humidity	RDT M16-IT (Ref. 10), para. 4.5.1, except 95% relative humidity air is required	99.5%
b. Methyl iodide, 25°C and 95% relative humidity	RDT M16-IT (Ref. 10), para. 4.5.3, except 95% relative humidity air is required	95%
6. Bulk density	ASTM D2854 (Ref. 11)	0.38 g/ml minimum
7. Impregnant content	State procedure	State type (not to exceed 5% by weight)

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

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

TABLE 2

Laboratory tests and assigned decontamination efficiencies for new and used activated carbon samples for normal ventilation system atmosphere cleanup system units. Laboratory tests are conducted in accordance with ASTM D3803-1989 (Ref. 12). Tests are conducted at 95% relative humidity, except 70% relative humidity is used when the air entering the carbon adsorber is maintained at ≤ 70% relative humidity.

Total depth of activated carbon cells in adsorber section	Maximum assigned credit for activated carbon radioiodine decontamination efficiencies	Test temperature and methyl iodide penetration acceptance criterion
2 inches. System designed to operate inside primary containment.	90%	80°C; penetration less than 10%
2 inches. System designed to operate outside the primary containment.	70%	30°C; penetration less than 30%
4 inches. System designed to operate outside the primary containment.	90%	30°C; penetration less than 10%
6 inches. System designed to operate outside primary containment.	99%	30°C; penetration less than 1%

The established test conditions should consider the observations that tests conducted at higher temperatures or at lower relative humidities produce lower methyl iodide penetration results. Therefore, to provide a safety margin the plant-specific test temperatures and relative humidities should be representative, respectively, of the lowest and the highest portions of the average of the anticipated plant-specific operating conditions.

REFERENCES

1. American Society of Mechanical Engineers, "Nuclear Power Plant Air-Cleaning Units and Components," ASME N509-1989.[1]

2. American Society of Mechanical Engineers, "Testing of Nuclear Air-Treatment Systems," ASME N510-1989.[1]

3. C. A. Burchsted, J. E. Kahn, and A. B. Fuller, "Nuclear Air Cleaning Handbook," ERDA 76-21,[2] Oak Ridge National Laboratory, March 31, 1976.

4. U.S. Nuclear Regulatory Commission, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," Regulatory Guide 8.8.[3]

5. "Filter, Particulate, High-Efficiency, Fire-Resistant," MIL-F-51068,[4] (latest edition), Military Specification.

6. "Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance-Test Methods," MIL-STD-282,[4] Military Standard, May 28, 1956.

7. American Conference of Governmental Industrial Hygienists, "Industrial Ventilation," 14th Edition, 1976, Committee on Industrial Ventilation, P.O. Box 453, Lansing, Mich. 48902.

8. American Society for Testing and Materials, "Test for Particle Size Distribution of Granulated Activated Carbon," ASTM D2862-70.[5]

9. American Society for Testing and Materials, "Specifications for Wire Cloth Sieves for Testing Purposes," ASTM E11-70.[5]

10. RDT Standard M16-IT, "Gas-Phase Adsorbents for Trapping Radioactive Iodine and Iodine Compounds," USAEC Division of Reactor Research and Development, October 1973, Oak Ridge, Tenn. 37830.

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[1]Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

[2]Copies may be obtained from the National Technical Information Service, Springfield, VA 22161.

[3]Copies may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082.

[4]Copies may be obtained from the Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

[5]Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Penn. 19103.

11. American Society for Testing and Materials, "Test for Apparent Density of Activated Carbon," ASTM D2854-70.[5]

12. American Society for Testing and Materials, "Standard Test Methods for Nuclear-Grade Activated Carbon," ASTM D3803-1989.[5]

[5]Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Penn. 19103.

DRAFT VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

Regulatory Guide 1.140 provides guidance to applicants and licensees on design, testing, and maintenance for normal atmosphere cleanup systems for light water cooled nuclear power plants. This proposed action is to issue a Revision 2 to Regulatory Guide 1.140 to update its guidance.

1.2 Need

At present, Revision 1 to Regulatory Guide 1.140 is the basic document used in commercial nuclear power plants for the testing of normal air-cleaning systems. Revision 1 was issued as an active guide in October 1979 and is considered to be significantly outdated and in error in many significant technical areas. This proposed revision 2 updates guidance on testing and maintenance of normal air cleaning systems to be consistent with present policies, recent revisions in ANSI Standards N509 and N510, new filter system design and testing data, and present licensing practice concerning testing and maintenance of normal air cleaning systems.

1.3 Value/Impact

1.3.1 NRC

The primary effect of the proposed action on the NRC staff would be to facilitate implementation of current NRC positions with regard to normal filter system testing and maintenance. It would improve the basis for communication between the NRC staff and licensees and would reduce staff effort that might otherwise be spent answering questions about acceptable means for testing filter systems.

1.3.2 Other Government Agencies

The principal effect on other Government agencies would be to inform them of NRC's policies on filter system testing and maintenance. Department of Energy (DOE) review would be useful because one of the areas addressed by the revision is HEPA filter system testing at DOE test facilities.

1.3.3 Industry

The guide will be useful to industry because it will advise of changes in normal ventilation system testing and maintenance provisions and will thus promote understanding of current NRC positions and prevent any unnecessary costs being applied to meet provisions no longer recommended by the NRC staff. None of the changes is expected to impose significant additional burdens on applicants or licensees. Some of the changes may relax certain guide positions but without compromise to safety, thereby reducing cost and effort. Any potential costs associated with the revised positions related to testing and maintenance of new and used charcoal would be limited but unavoidable, because the existing criteria are based on obsolete methods for radioiodine testing of activated charcoal.

1.34 Public

The proposed action will enhance the protection of the public health and safety by providing that normal ventilation systems will be tested and maintained in accordance with up-to-date technical information and NRC positions.

2. TECHNICAL APPROACH

Major technical questions related to normal ventilation system design, testing, and maintenance were considered in developing the previous versions of Regulatory Guide 1.140. Revision 2 will address endorsement of ASME N509-1989, "Nuclear Power Plant Air-Cleaning Units and Components," and ASME N510-1989, "Testing of Nuclear Air-Treatment Systems"; radioiodine testing of activated carbon adsorber materials; quality assurance aspects of HEPA filter manufacturing, installation, and testing; use of DOP as a test aerosol for in-place leak testing of HEPA filters; and limitation of the volumetric air flow rate of single filter trains.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

NRC procedures that may be used for making this information available include the following:

- Regulation
- NUREG-series report
- Branch position paper
- Regulatory guide

A regulation is not suitable for incorporating the degree of detail presented in this guide. As regulatory positions are stated, it would be inappropriate to publish this material as a NUREG-series report. Branch technical positions (BTP) are sometimes prepared for specific guidance, however, it would be most appropriate to update Regulatory Guide 1.140 and prepare clear regulatory guidance for licensees and applicants.

3.2 Decision on Procedural Approach

A revision to Regulatory Guide 1.140 should be prepared.

4. STATUTORY CONSIDERATIONS

4.1 NRC Authority

Authority for the proposed action is derived from the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, and implemented through the Commission's regulations.

4.2 Need for NEPA Assessment

Issuance or amendment of guides for the implementation of regulations in Title 10, Chapter I, of the Code of Federal Regulations is a categorical exclusion under paragraph 51.22(c)(16) of 10 CFR Part 51. Thus, an environmental impact statement or assessment is not required for this action.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

General Design Criteria 60 and 61 of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," require that filtering systems be included in the nuclear power unit design to suitably control the release of radioactive materials in gaseous effluents during normal reactor operation, including anticipated operational occurrences and fuel storage and handling operations. In addition, 10 CFR 50.34a, "Design Objectives for Equipment To Control Releases of Radioactive Material in Effluents--Nuclear Power Reactors," and 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors," of 10 CFR Part 50 require that means be employed to ensure that release of radioactive material to unrestricted areas during normal reactor operation, including expected operational occurrences, is kept as low as is reasonably achievable.

6. CONCLUSIONS

Revision 2 of Regulatory Guide 1.140 should be issued to update the current staff positions and to inform its users of the current staff positions.

NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.5.1 ESF ATMOSPHERE CLEANUP SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch (SPLB)

Secondary - Radiation Protection Branch (PRPB)

I. AREAS OF REVIEW

At the construction permit (CP) stage of review, SPLB reviews the information in the applicant's safety analysis report (SAR) in the areas listed below. At the operating license (OL) state, the SPLB review consists of confirming the design accepted at the CP stage and evaluating the adequacy of the applicant's technical specifications in these areas. The specific SPLB review areas are as follows:

1. The engineered safety feature (ESF) atmosphere cleanup systems designed for fission product removal in post-accident environments. These generally include primary systems, such as in-containment recirculation, and secondary systems, such as standby gas treatment systems and emergency or post accident air cleaning systems for the fuel handling building, control room, shield building and areas containing engineered safety feature components.

2. The system design, design objectives and design criteria. The SPLB reviews the methods of operation and the factors that could influence the filtration capabilities of the system, e.g., system interfaces and potential bypass routes. The components included in each atmospheric cleanup system and the seismic design category of each system are reviewed. Redundancy of the atmosphere cleanup systems, the physical separation of the redundant trains, and the volumetric air flow rate of each train are reviewed.

3. The environmental design criteria, the design pressure and pressure differential, relative humidity, maximum and minimum and temperature, and radiation source term.

4. The component design criteria, qualification requirements, and qualification testing of heaters, moisture separators, prefilters, and high-efficiency particulate air (HEPA) filters, design requirements of the filter and adsorber mounting frames, system filter and adsorber housings, and water drains, the adsorbent used for removal of gaseous iodines (in the preliminary safety analysis report, PSAR), the physical properties of the adsorbent and the design of the adsorber section of the filter trains (in the final safety analysis report, FSAR). Provisions to inhibit offdesign temperatures in the adsorber section and the design criteria of the system fans or blowers, ductwork, and housings are also reviewed.

5. Designs provisions incorporated in the equipment and features to facilitate operation and maintenance. The design of doors to the filter housings, the spacing of components, alignment and support of filter elements, the spacing of filter elements in the same section, design of test probes, and provisions for adequate lighting in the filter housing are also reviewed.

6. The design criteria for inplace testing of the air flow distribution to the HEPA filters, dioctyl phthalate (DOP) testing of the HEPA filter sections, and gaseous halogenated hydrocarbon refrigerant bypass leak testing of the activated carbon adsorber section.

7. The laboratory test criteria for the activated carbon adsorbent, qualification and batch tests, provisions for obtaining representative adsorbent samples for laboratory testing in order to estimate the amount of penetration of the system adsorbent throughout its service life (PSAR), and the provisions and conditions for each field and laboratory test (FSAR).

The review of the ESF atmosphere cleanup systems involves review evaluations performed by other branches. The conclusion from their evaluations are used to complete the overall evaluation of the facility. SPLB will coordinate other branches' evaluations that interface with the overall review of the system as follows: the Structural and Geosciences Branch (ESGB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4 and 3.8.5. The Mechanical Engineering Branch (EMEB) determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The reviews for Technical Specifications and Quality Assurance are coordinated and performed by the Technical Specifications Branch (OTSB) and the Quality Assurance Branch (LQAB) as part of their primary review responsibility for SRP Sections 16.0 and 17.0, respectively. The Instrumentation and Control Systems Branch (SICB) and Electrical Systems Branch (SELB) review the associated instrumentation including the power supply and electrical distribution systems as part of their primary review responsibility for SRP Sections 7.3, 7.5, and 8.2. The Radiation Protection Branch (PRPB) calculates the doses that could result as a consequence of postulated accidents as part of its primary review responsibility for SRP Sections 6.4, 6.5.2 through 6.5.4, 15.1.15, 15.4.8, 15.4.9, 15.6.2 through 15.6.5, 15.7.4, 15.7.5, and 15.8. Upon request, PRPB will calculate filter loadings of all the iodine isotopes under accident conditions to enable SPLB to complete its overall evaluation of the ESF atmosphere cleanup systems. The SPLB reviews the qualification of

essential power or electrical control cables associated with the ESF atmosphere cleanup system as part of its primary responsibility for SRP Section 3.11.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The installed ESF atmosphere cleanup system is needed to mitigate the consequences of postulated accidents by removing from the atmosphere radioactive material that may be released in the event of an accident. SPLB acceptance criteria for the ESF atmosphere cleanup systems are based on meeting the relevant requirements of the following regulations (Ref. 1):

A. General Design Criterion 19 as it relates to systems being designed for habitability of the control room under accident and LOCA conditions.

B. General Design Criterion 41 as it relates to the design of systems to be used for containment atmosphere cleanup following postulated accidents, and to control releases to the environment.

C. General Design Criterion 42 and General Design Criterion 43 as they relate to the inspection and testing of containment ESF atmosphere cleanup systems.

D. General Design Criterion 61 as it relates to the design of systems for radioactivity control under normal and postulated accident conditions.

E. General Design Criteria 64 as it relates to monitoring radioactive releases under normal, anticipated operational occurrences and postulated accident conditions from ESF atmosphere cleanup systems.

Relevant requirements of the Commission's regulations identified above are met by using the regulatory positions contained in Regulatory Guide 1.52 (Ref. 2) as it relates to the design testing and maintenance of ESF atmosphere cleanup system air filtration and adsorption units.

Specific criteria necessary to meet the relevant requirements of the Commission's regulations are as follows:

The ESF atmosphere cleanup systems should be designed so that they can operate after a design basis accident (DBA) and can retain radioactive material after a DBA. The system should have provisions to prefilter air, remove moisture and meet the Regulatory Guide 1.52 requirements for charcoal adsorption. The systems should be redundant, be designed to seismic Category I requirements, be able to actuate automatically, and be limited to an air flow rate of approximately 50,000 cfm.

Design of instrumentation for ESF atmosphere cleanup systems should conform to the guidelines of Regulatory Guide 1.52 and to the recommendations of ASME N509 (Ref. 3). Minimum instrumentation, readout, recording, and alarm provisions for ESF atmosphere cleanup are given in Table 6.5.1-1 of this SRP section.

Environmental design guidelines for acceptability are based on the conditions following a DBA. Radiation source terms should be consistent with the guidelines in Regulatory Guides 1.3, 1.4, 1.7, and 1.25 (Ref. 4, 5, 6 and 7).

Components such as moisture separators, heaters, prefilters, HEPA filters, mounting frames, filter housings, adsorbent, fans, ductwork and dampers should be designed, constructed and tested in accordance with ANSI 509 design and qualification testing criteria. Water drain design and the accessibility of components and ease of maintenance should be in accordance with the recommendations of ERDA 76-21 (Ref. 8) and ASME 509.

Acceptability with respect to inplace testing should include meeting the requirements of ASME N510 (Ref. 9). For laboratory testing of activated carbon adsorbent, conformance with ASME N509 will be used as an acceptability criterion.

SPLB will accept the following deviations from the above acceptance criteria for the post loss-of-coolant accident (LOCA) containment hydrogen purge cleanup system:

1. If the calculated dose (sum of the long-term doses from the LOCA and the purge dose at the low population zone outer boundary) is less than the guidelines of 10 CFR Part 100, no filtration system is required.

2. If a radioiodine decontamination factor of 10 or less is needed for the calculated dose to be below Part 100, an atmosphere cleanup system that meets the acceptance criteria listed in Item 5 of Acceptance Criteria in SRP Section 11.3 is acceptable.

3. If a radioiodine decontamination factor of greater than 10 is needed for the calculated dose to be below Part 100, the ESF atmosphere cleanup system meeting all of the above acceptance criteria with the exception of Items 2b and 2c of Part C of Regulatory Guide 1.52, is acceptable.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

1. In the SPLB review the plant design is reviewed to determine where ESF atmosphere cleanup systems are needed. This effort is coordinated with PRPB.

2. The SPLB review is carried out by making a detailed comparison of atmosphere cleanup system designs with the acceptance criteria of Section II, above. The capability of a system to remove fission products from the atmosphere after a DBA is reviewed, based on a design loading of 2.5 mg of total iodine (radioactive plus stable) per gram of activated charcoal adsorbent. Designs consistent with General Design Criteria 19, 41, 42, 43, 61 and 64, and the guidelines of Regulatory Guide 1.52 will be assigned the system efficiencies for removal of elemental iodine and organic iodides given in Table 2 of Regulatory Guide 1.52 and a system efficiency of 99% for removal of particulate matter resulting from a DBA. The assigned efficiencies are for PRPB use in accident analyses to calculate offsite doses and control room personnel doses.

TABLE 6.5.1-1 Minimum instrumentation, readout, recording and alarm provisions for ESF atmosphere cleanup systems

References: ASME N509

Sensing location	local readout alarm	Remote continuously manned control panel (main control room or auxiliary control panel if manning is a technical specification requirement) readout/alarm
Unit inlet or outlet	Flow rate (indication)	Flow rate (high alarm and low alarm signals)
Moisture separator	Pressure drop (indication, optional high alarm signal)	
Electric heater	Status indication	
Space between heater and prefilter	Temperature (indication, high alarm and low alarm signals)	Temperature (indication, high alarm, low alarm, trip alarm signals)
Prefilter	Pressure drop (indication, high alarm signal)	
Pre-HEPA	Pressure drop (indication, high alarm signal)	Pressure drop (high alarm signal)
Space between adsorber and postfilter	Temperature (indication, two-stage high alarm signal)	Temperature (indication, two-stage high alarm signal)
Postfilter	Pressure drop (indication, high alarm signal)	
Fan	(Optional hand switch and status indication)	Hand switch, status indication
Valve/damper operator	(Optional status indication)	Status indication
System inlet to outlet		Summation of pressure drop across total system (high alarm signal)*
Fire protection system**	Temperature (indication, trip alarm signal)	Temperature (trip alarm signal)

Notes:

* Optional if equivalent is provided with other instrumentation.

** Manual valves are recommended with local indication at valve. Power actuated valves, if used, should have local handswitches and indication, and trip alarms on local and remote continuously manned control panels. Flow of extinguishing agent should be alarmed on local and remote continuously manned control panels.

IV. EVALUATION FINDINGS

SPLB verifies that sufficient information has been provided and that the review is adequate to support conclusions of the following type, to be included in the staff's safety evaluation report:

> The staff concludes that the design of the ESF atmosphere cleanup systems including the equipment and instrumentation to control the release of radioactive materials in gaseous effluents following a postulated design basis accident are acceptable. This conclusion is based on the applicant having met the requirements of General Design Criteria 19, 41, and 61 by providing ESF atmosphere cleanup systems on the control room habitability, containment and associated systems. The applicant has met the requirements of General Design Criteria 41, 43 and 64 by providing a program for inspecting and testing the ESF atmosphere cleanup systems and monitoring for radioactive materials in effluents from these systems. In meeting these regulations the applicant has provided an evaluation that demonstrates that the design of the ESF atmosphere cleanup systems meets the guidelines of Regulatory Guide 1.52 and the ASME N509 and N510 industry standards. We have reviewed the applicant's system descriptions and design criteria for the ESF atmosphere cleanup systems. Based on our evaluation, we find the proposed ESF atmosphere cleanup systems are acceptable, and the filter efficiencies given in Table 2 of Regulatory Guide 1.52 are appropriate for use in accident analyses.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room," Criterion 41, "Containment Atmosphere Cleanup," Criterion 42, "Inspection of Containment Atmosphere Cleanup Systems," Criterion 43, "Testing of Containment Atmosphere Cleanup Systems," Criterion 61, "Fuel Storage and Handling and Radioactivity Control," and Criterion 64, "Monitoring Radioactivity Releases."

2. Regulatory Guide 1.52, Rev. 3, "Design, Testing, and Maintenance Criteria for Post Accident Engineering-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

3. ASME N509, "Nuclear Power Plant Air-Cleaning Units and Components," American National Standards Institute (1989).

4. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors."

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

6. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

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

8. ERDA 76-21, "Nuclear Air Cleaning Handbook," Oak Ridge National Laboratory, C. A. Burchsted, I. E. Kahn and A. B. Fuller, March 31, 1976.

9. ASME N510, "Testing of Nuclear Air-Treatment Systems," American National Standards Institute (1989).

AN AMERICAN NATIONAL STANDARD

NUCLEAR POWER PLANT AIR-CLEANING UNITS and COMPONENTS

ASME N509-1989

(REVISION OF ANSI/ASME N509-1980)

The American Society of Mechanical Engineers

345 East 47th Street, New York, N.Y. 10017

Date of Issuance: June 15, 1989

This Standard will be revis d when the Society approves the issuance of a new edition. There will be no Addenda issued to ASME N509-1989.

Please Note: ASME issues written replies concerning interpretations of the technical aspects of this document. The interpretations are not part of the document. N509-1989 is being issued with an automatic subscription service to the interpretations that will be issued to it up to 1994.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The Consensus Committee that approved the code or standard was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment which provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

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FOREWORD

(This Foreword is not part of ASME N509-1989.)

This Standard covers requirements for the design, construction, and testing of components which are utilized in Nuclear Air Treatment Systems (NATS) installed in nuclear power plants. This revision was developed by the ASME Committee on Nuclear Air and Gas Treatment (CONAGT), which was assigned responsibility for maintaining ANSI/ASME N509 in 1976.

This is the third revision of this Standard. The previous revisions were issued in 1976 and 1980. 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 five 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 N509's companion standard ANSI/ASME N510.

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.

It is the intent of CONAGT to replace N509 and N510 with ASME AG-1, Code On Nuclear Air and Gas Treatment, in the future. AG-1 was initially issued in 1985. Those sections of AG-1 which were published when this revision of N509 was being developed have been incorporated by reference. ASME CONAGT considers the AG-1 code requirements to be acceptable alternates to N509 requirements and therefore encourages users to utilize the latest AG-1 code requirements whenever practical. Copies of AG-1 can be obtained from ASME.

After approval by the Committee on Nuclear Air and Gas Treatment and the sponsor, and after public review, this Standard was approved and designated as an American National Standard by the American National Standards Institute, Inc. on April 7, 1989.

ASME COMMITTEE ON NUCLEAR AIR AND GAS TREATMENT

(The following is the roster of the Committee at the time of approval of this Standard.)

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NUCLEAR POWER PLANT AIR-CLEANING UNITS AND COMPONENTS

1 SCOPE

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

1.1 Limitations

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

1.2 Purpose

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

2 APPLICABLE DOCUMENTS

The following documents supplement this Standard and are a part of it to the extent indicated in the text. The issue of the referenced document noted below shall be in effect. If no date is listed, then the issue of the referenced document in effect at the time of the purchase order shall apply. ANSI/ASME AG-1-1988 contains code requirements for nuclear air and gas treatment equipment. These code requirements may be substituted for the requirements listed herein.

2.1 U.S. Atomic Energy Commission (AEC), Currently the U.S. Department of Energy (DOE)

ERDA-76-21	C. A. Burchsted, A. B. Fuller, and J. E. Kahr, Nuclear Air Cleaning Handbook
MSAR-71-45	Entrained Moisture Separators for Fine Particle, Water-Air-Steam Service — Their Performance, Development, and Status
NYO-3250-6	Moisture Separator Study

2.2 American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

ASHRAE 52 (1976)	Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE Handbook (1982)	Applications
ASHRAE Handbook (1983)	Equipment

ASHRAE Handbook (1984)	HVAC Systems
ASHRAE Handbook (1985)	Fundamentals

2.3 Underwriters' Laboratories, Inc. (UL)

UL 900 (1986)	Test Performance of Air-Filter Units
UL 586 (1985)	High-Efficiency, Particulate, Air-Filter Units

2.4 Air Movement and Control Association, Inc. (AMCA)

AMCA 99 (1983)	Standards Handbook
AMCA 201 (1973)	Fan Application Manual — Fans and Systems
AMCA 210 (1985)	Test Code for Air Moving Devices
AMCA 211 (1985)	Certified Ratings Program Air Performance
AMCA 300 (1985)	Reverberant Room Method for Sound Testing of Fans
AMCA 301 (1975)	Method for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500 (1983)	Test Methods for Louvers, Dampers and Shutters

2.5 American Society of Mechanical Engineers (ASME)

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

ASME Boiler and Pressure Vessel Code, 1986 Edition — Section III, Section V, Section IX

ANSI/ASME B31.1-1986 Edition	Power Piping Code
ASME N510-1989	Testing of Nuclear Air Treatment Systems
ANSI/ASME NQA-1-1986 Edition	Quality Assurance Program Requirements for Nuclear Facilities
ANSI/ASME NQA-2-1986 Edition	Quality Assurance Requirements for Nuclear Facilities

2.6 American Welding Society (AWS)

AWS D1.1 (1986)	Structural Welding Code
AWS D1.3 (1981)	Structural Welding Code — Sheet Steel

2.7 Air Conditioning and Refrigeration Institute (ARI)

ANSI/ARI 410 (1981)	Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 680 (1986)	Standard for Residential Air Filter Equipment

2.8 Institute of Electrical and Electronics Engineers (IEEE)

IEEE 85 (1973)	Test Procedure for Airborne Sound Measurements on Rotating Electrical Machinery
IEEE 112 (1984)	Test Procedure for Polyphase Induction Motors and Generators
ANSI/IEEE 323 (1984)	Standard for Qualifying Class 1E Electrical Equipment for Nuclear Power Generating Stations
ANSI/IEEE 334 (1974)	Guide for Type Test of Continuous Duty Class I Motors Installed Inside the Containment of Nuclear Power Generating Stations
ANSI/IEEE 344 (1975)	Recommended Practices for Seismic Qualification of Class 1E Equipment in Nuclear Power Generating Stations

2.9 American National Standards Institute (ANSI)

ANSI N512 (1974)	Protective Coatings (Paints) for the Nuclear Industry
ANSI N101.2 (1972)	Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities
ANSI/ANS N51.1 (1983)	Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactors

ANSI/ANS 52.1 (1983)	Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants
ANSI/ASQC Z1.4 (1981)	Sampling Procedures and Tables for Inspection by Attributes

2.10 National Electrical Manufacturers' Association (NEMA)

NEMA MG-1 (1978)	Motors and Generators

2.11 American Society for Testing and Materials (ASTM)

ASTM A 36 (1984)	Structural Steel
ASTM A 123 (1978)	Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips
ASTM A 240 (1984)	Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM A 283 (1984)	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes, and Bars
ASTM A 284 (1984)	Low and Intermediate Tensile Stength Carbon-Silicon Steel Plates for Machine Parts of General Construction
ASTM A 525 (1984)	General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 526 (1980)	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM A 527 (1980)	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality
ASTM A 570 (1984)	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A 606 (1984)	Steel Sheet and Strip, Hot-Rolled and Cold-Rolled, High-Strength, Low Alloy with Improved Atmospheric Corrosion Resistance
ASTM A 607 (1984)	Steel Sheet and Strip, Hot-Rolled and Cold-Rolled, High-Strength, Low-Alloy Columbium and/or Vanadium
ASTM A 666 (1984)	Authentic Stainless Steel, Sheet, Strip Plate and Flat Bar for Structural Applications
ASTM B 633 (1978)	Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D 3843 (1980)	Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities
ASTM D 3911 (1980)	Standard Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Loss of Coolant Accident (LOCA) Condition
ASTM D 3912 (1980)	Standard Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants
ASTM E 165 (1975)	Recommended Practices for Liquid Penetrant Inspection Method
	Manual of Coating Work for Light-Water Nuclear Power Plant Primary Containment and Other Safety-Related Facilities, First Edition, 1979, Chapter 8
ASTM E 300 (1973)	Recommended Practice for Sampling Industrial Chemicals

2.12 Industrial Perforators Association (IPA)

IPA (1985)	Designers, Specifiers and Buyers Handbook for Perforated Metal

2.13 Military Standards (MIL)

MIL-F-51068E (1981)	Filter, Particulate, High Efficiency, Fire-Resistant
MIL-F-51079D (1980)	Filter Medium, Fire-Resistant, High Efficiency

2.14 National Fire Protection Association (NFPA)

NFPA-803 (1983)	Standard for Fire Protection for Light-Water Nuclear Power Plant

2.15 Sheet Metal and Air-Conditioning Contractors' National Association, Inc. (SMACNA)

SMACNA (1975)	High-Pressure Duct Construction Standards

SMACNA (1985)	HVAC Duct Construction Standards — Metal and Flexible

2.16 Nuclear Regulatory Commission

NUREG 0017 - 1985	Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE CODE), Rev. 1

2.17 Nuclear Construction Issues Group (NCIG)

NCIG-01 (1985)	Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants

2.18 Code of Federal Regulations - Energy

Title 10, Part 29	Occupational Safety and Health Act
Title 10, Part 20	Standards for Protection Against Radiation
Title 10, Part 50, Appendix A	General Design Criteria for Nuclear Power Plants
Title 10, Part 50, Appendix R	Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979
Title 10, Part 100	Reactor Site Criteria
Title 10, Part 50.49	Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants

2.19 Air Cleaning Conference

CONF-740807	"Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19," Murphy, K. G. and Compe, K. M., 13th AEC Air Cleaning Conference Proceedings, 1974, p. 401
CONF-801038	"A Consistent Approach to Air-Cleaning System Duct Design," Miller, W. H., Ornberg, S. C., Rooney, K. L., 16th DOE Air Cleaning Conference Proceedings, 1980, p. 252

2.20 American Conference of Governmental Industrial Hygienists

Industrial Ventilation: A Manual of Recommended Practice — 1986

3 TERMS AND DEFINITIONS

adsorbent, batch of — the maximum quantity of material (not to exceed 10 m^3) manufactured from the same base material, processed throughout its manufacturing cycle in the same equipment and under the same manufacturing procedures, which can be homogenized at one time in one blending device and for which certified results of appropriate tests of physical and chemical properties are available. This constitutes a batch to be presented for radioactive and/or other specified tests under conditions and within tolerances specified.

adsorbent, lot of — that quantity of material consisting of one or more batches of the same type and grade, each of which meets the specified performance, physical and chemical requirements, and is shipped to the same purchaser by the same manufacturer for the same job requirement

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

air-cleaning unit — an assembly of components comprising a self-contained subdivision of a complete air cleaning system. It includes all the components necessary to achieve a unit air cleaning function such as removing particulate matter (filter) or iodine vapor (adsorber). A unit includes a housing plus internal air cleaning components and may include one or more auxiliary air treatment components such as prefilters, postfilters, heaters, coils, and moisture separators.

ALARA — as defined in 10 CFR 20.1(c), in addition to complying with the regulations of 10 CFR 20, the design should make every reasonable effort to maintain in-plant radiation exposures during operation and maintenance, and releases of radioactive material in effluents "as low as is reasonably achievable"

(ALARA). The term ALARA means as low as is reasonably achievable taking into account the state of technology and the economics of improvements in relation to benefits to public health and safety, and other societal and socieconomic considerations, and in relation to the utilization of atomic energy in the public interest.

bypass — a pathway through which contaminated air can escape treatment by the installed HEPA and/or adsorber banks. Examples are leaks in filters and filter mounting frames, defective or inefficient isolation dampers that result in uncontrolled flow through adjacent plenums, and unsealed penetrations for electrical conduits, pipes, floor drains, etc.

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

components, active — a component whose function is characterized by mechanical motion in response to an imposed design basis load or signal demand upon the component. Examples are motors, fans, damper operators, etc. Active safety-related components are required to perform their active function when subjected to the applicable design basis loading and environment.

components, air-cleaning — equipment that is contained in nuclear air treatment systems. Typical components may include dampers, demisters or moisture separators, heaters, prefilters, HEPA filters, charcoal adsorbers, and fans.

components, external — accessory components not normally included within an air-cleaning unit

components, internal — elements normally contained within an air-cleaning unit

contaminated space — any enclosed or outdoor space with measured or potential airborne concentrations of toxic or radioactive materials which may cause one or both of the following:

(*a*) unacceptable damage or dose to personnel or equipment occupying the space, based on 10 CFR 20, 10 CFR 50 Appendix A (General Design Criterion 19), 10 CFR 50 Appendix I limits, or plant ALARA guidelines.

(*b*) contamination of other spaces.

damper — an operable device used to control pressure or flow by varying the air path area

decontamination factor (DF) — the ratio of the concentration of a contaminant in the uncleaned (untreated) air to its concentration in the clean (treated) air

design, functional — the establishment of air cleaning efficiency, air flow rates, components to be employed, general layout spatial requirements, and operational objectives and criteria

design, mechanical — the design or selection of components, structural design of ducts and housings, sizing and layout of ducts, etc., to meet the requirements of the criteria established by the functional design. The design and layout of hardware to accommodate the criteria established in functional design.

designer or engineer — as used in this document, the individual or organization designated by the owner to be responsible for the design of air and gas treatment systems. In particular, he is responsible for the determination of the performance parameters for the system.

DOP — dioctyl phthalate (di-2-ethyl hexyl phthalate), an oily, clear, noncorrosive liquid that forms an aerosol of repeatable dimensions under given parameters of temperature, pressure flow, etc. (Note: DOP is a plasticizer and will soften many plastics on contact. Great care must be taken in the selection of organic materials used for contact with DOP.)

DOP aerosol — a polydisperse 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

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

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

engineer or designer — as used in this document, the individual or organization designated by the owner to be responsible for the design of air and gas treatment systems. In particular, he is responsible for the determination of the performance parameters for the system.

engineered safety feature (ESF) — an air-cleaning unit or nuclear air treatment system that serves to control and limit the consequences of releases of energy and radioactivity in the event of occurrences as described in ANSI/ANS N51.1 and N52.1

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 pe-

rimeter of a duct, plenum, or vault cross section; sometimes referred to as a stage

habitability system — a nuclear air treatment system whose function is to assure that plant operators are adequately protected against the effects of accidental releases of toxic and radioactive gas-borne contamination to the degree that they can safely operate the plant in case of an accident. Habitability systems must meet the requirements of 10 CFR 50, Appendix A, General Design Criteria 4, 5, and 19.

HEPA filter — a high efficiency particulate air filter having a fibrous medium with a particle removal efficiency of at least 99.97% for 0.3 μm particles of dioctyl phthalate

housing — the portion of an air-cleaning unit that encloses air cleaning components and provides connections to adjacent ductwork

interspace — any space other than the contaminated space or the protected space where the nuclear air treatment system or its parts may be located. The interspace may be considered "contaminated" if its concentration of airborne radioactivity is higher than the concentration inside that part of the nuclear air treatment system located within the interspace. The interspace may be considered "clean" if its concentration of airborne radioactivity is lower than the concentration inside the part of the nuclear air treatment system located within the interspace

leak-tightness — the condition of a component, air-cleaning unit, or system where air leakage through or around the pressure boundary or component is less than a specified value at a specified differential pressure

manifold — a device to uniformly disperse or collect test agent mixed with air over a defined area from or into a single pipe or tube

maximum permissible concentration (MPC) — the maximum permissible concentration of radioactive materials in a given volume as specified in Appendix B in Title 10 of the Code of Federal Regulations, Part 20

mounting frame — a structure against which filters and adsorber cells may be snugly mounted and supported in a position that permits the passage of air and provides a surface to hold the sealing gasket, thereby avoiding a potential bypass or leakage path for non-filtered air

nuclear air treatment system (NATS) — 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, after-filters, heaters, coils, and moisture separators. Accessories such as dampers, ducts, plenums, and fans are included when they are within or are a part of a defined pressure boundary.

owner — the organization which is awarded a construction permit from the Regulating Authority for the construction of a nuclear facility and/or the organization legally responsible for the operation, maintenance, and safety of the nuclear facility

photometer — a device to detect aerosol concentrations in air over a specified concentration range of 10,000:1

postfilter — a medium efficiency air filter having a fibrous medium with a nominal average atmospheric dust spot efficiency of not less than 95% when tested in accordance with ASHRAE Standard 52 which is used to retain carbon fines downstream of carbon adsorbers

pressure, leak test — the static pressure, acting in the direction of the operating pressure (positive or negative), used for establishing leakage rates. This pressure usually equals or exceeds the highest operating pressure of the item being tested but does not exceed structural capability pressure.

pressure, maximum design — the static pressure to which air-cleaning units and components may be subjected to and required to remain intact and which is used as the starting point for structural design. This pressure shall equal or exceed the maximum operating pressure and/or test pressure, whichever is greater. Refer to para. 4.6.5 for further information.

pressure, maximum operating — the maximum static pressure the air-cleaning units and components will be subjected to and still 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. Refer to para. 4.6.4 for further information. The maximum operating pressure shall equal or exceed the normal operating pressure and may be equal to the maximum design pressure but may not exceed it.

pressure, normal operating — the static pressure that corresponds to the design operating mode of the air-cleaning unit, component, or system but does not include the static pressure which may be experienced

in off-normal operating modes during which the system is required to continue to perform its air-cleaning function

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 design pressure due to inclusion of a margin of safety.

pressure drop, dirty filter — the maximum operating static pressure differential (inches water gauge) of the filter elements in an nuclear air treatment system used for the design of the system

protected space — any enclosed or outdoor space where concentrations of airborne toxic or radioactive materials are limited to acceptable levels by the action of a nuclear air treatment system

residence time — the time that a contaminant or test agent theoretically remains in contact with an adsorbent, based on active volume of adsorbent and air or gas volume flow rate through the adsorber bed (e.g., volume of adsorbent in cubic feet in contact with flowing air multiplied by 60 sec/min divided by total air or gas flow rate in cubic feet per minute equals theoretical residence time in seconds)

test, acceptance — a test made upon completion of fabrication, receipt, and installation, or after modification of an installed component, air-cleaning unit, or system to verify that it meets the requirements specified

test, performance (also known as production test) — a test made on an individual production item or lot of product to verify its performance in accordance with specified requirements. Where a performance test repeats a qualification test or a previous performance test, the results of the performance test shall be within specified tolerances.

test, qualification — a test which establishes the suitability of a component (item) for a given application, generally made on either a prototype or on a typical production lot of the component

test, surveillance — an in-place leak test and visual inspection performed periodically to establish the current condition of a nuclear air treatment system and its components, with respect to bypasses and damage to filters and adsorber. Also, a laboratory test made periodically on a representative sample to determine the radioiodine removal characteristics of an adsorbent batch.

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

test cannister — 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 (refer to para. 5.2 and Appendix A) may be substituted for the test cannister for the purposes of providing material for specific laboratory tests.

4 FUNCTIONAL DESIGN

4.1 General

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

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

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

(*c*) Adsorbers are required when air cleaning units are designed for removal of iodine and iodine compounds.

(*d*) Moisture separators (demisters) are required when entrained water droplet concentration may be greater than 1 lb of water per 1000 cfm of airflow.

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

(*f*) *Postfilters.* When adsorbers are used in ESF air-cleaning units, provision shall be made for a postfilter to retain carbon fines. Postfilters should also be considered in non-ESF air-cleaning units discharging into occupied spaces where carbon fine carryover is not acceptable.

4.2 Design Parameters

Values of the following design parameters shall be specified when invoking this Standard and shall be

used wherever referenced:

(*a*) volumetric air flow rate, acfm;

(*1*) minimum flow rate;

(*2*) maximum flow rate;

(*3*) design flow rate;

(*b*) design pressures, in. w.g.;

(*1*) maximum operating pressure;

(*2*) leak test pressure;

(*3*) maximum design pressure;

(*4*) structural capability pressure (usually determined by component designer);

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

(*d*) maximum and minimum gas temperature (F) and density, lb/ft^3;

(*e*) maximum inlet relative humidity (percent);

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

(*g*) concentrations of specific contaminants in airstream;

(*h*) required decontamination factors for each contaminant;

(*i*) component radiation integrated life dose and maximum dose rate (rad.);

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

(*k*) structural loadings;

(*l*) duct and housing maximum permissible leak rate (scfm) and associated operating pressure, in. w.g.;

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

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

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

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

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

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

4.3 Size (Installed Capacity) of Air-Cleaning Unit

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

4.4 Environmental Design Conditions

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

Environmental qualification requirements are contained in 10 CFR 50.49 and IEEE 323.

4.5 Structural Load Requirements

ESF systems and all of their components shall be shown, either by testing or by a mathematical technique, to remain functional under the structural loading specified in para. 4.2(k) and described in para. 5.10.3.

4.6 Design Pressures

4.6.1 The nuclear air treatment system shall be designed to withstand the normal and transient pressures, to which the system may be subjected during its design life, without loss of its ability to perform its design function.

4.6.2 Four categories of design pressure are used to define the pressure the nuclear air treatment system and its components may experience. These are:

(*a*) Operating Pressure

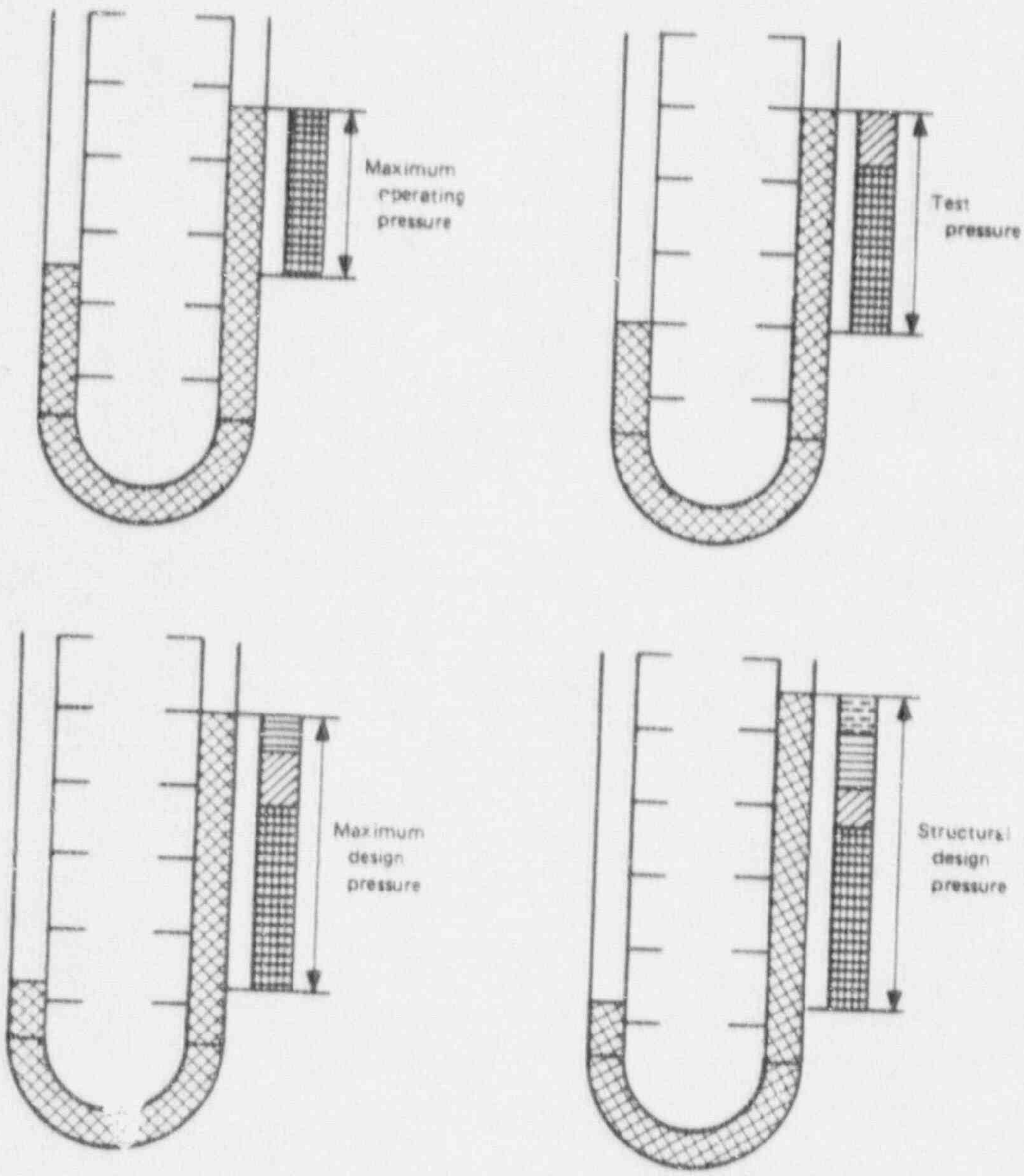
(*b*) Leak Test Pressure

(*c*) Maximum Design Pressure

(*d*) Structural Capability Pressure

Figure 4-1 depicts, in general terms, the relationship among these design pressures.

4.6.3 Operating Pressure. Operating (static) pressure shall be determined by summing the losses in total pressure of all air path components between the open atmosphere and the point in the system under consideration and deducting one velocity head from the total pressure, if positive, and adding one velocity head to the total pressure, if negative. Losses shall be based on the most severe condition of resistance to rated air



GENERAL NOTE
See para. 3 for terms and definitions.

FIG. 4-1 PRESSURE RELATIONSHIPS

flow for the design basis operating condition and will vary throughout the nuclear air treatment system.

It is recommended that the method for determining pressure losses be derived from the ASHRAE Handbook of Fundamentals, chapter on Duct Design.

In addition to determining the normal operating pressure, the engineer shall review the system operation and determine the maximum operating pressure to which the components may be subjected to due to off-normal conditions. Examples of off-normal operating conditions where the condition will not render the system inoperable and may not be noticed, or corrected, in a short time period are closure of branch dampers or registers. The pressure associated with rapid closure of fan isolation dampers which would subsequently render the system inoperable should not be considered as a maximum operating pressure. However, this pressure should be considered in determining the maximum design pressure as discussed in para. 4.6.5.

An engineer shall include the maximum operating (static) pressure in specifications for all nuclear air treatment system components, including ducts. Fan specification requirements shall be based on either total pressure or Fan Static Pressure as defined in para. 5.7 and AMCA 201. Calculations shall document the operating pressure as the basis for determining the required test pressure (refer to para. 4.6.4) and for determination of allowable pressure boundary leakage (para. 4.14).

4.6.4 Leak Test Pressure. The pressure to be used to shop and/or field test air-cleaning units and components (such as ducts, housings, and component mounting frames) to determine air leak rates shall be specified by the engineer. The test pressure shall be the static pressure, acting in the direction of the operating pressure. This pressure usually equals or exceeds the highest operating pressure of the item being tested. The test pressure shall not be less than 4 in. w.g. for duct and housing leak tests and not less than 1 in. w.g. for mounting frame leak tests and shall not exceed the structural capability of the component (para. 4.6.6).

The test pressure for each component to be tested shall be documented by the engineer along with the operating pressure (para. 4.6.3) and included by the testing organization in the test procedures.

4.6.5 Maximum Design Pressure

4.6.5.1 Nuclear air treatment systems shall be structurally designed to withstand the maximum pressure differential which each component may experience due to normal operating pressure; test pressure; or transient pressure conditions due to rapid closure of dampers, or anticipated system upsets which would render the system inoperable. The maximum design pressure shall be equal to or greater than the maximum pressure differential after allowing for the venting effect of permanent openings and pressure relief devices in the system.

4.6.5.2 ESF nuclear air treatment systems located inside a containment structure shall be designed either to withstand the maximum differential between the primary containment structure design pressure and the normal primary containment structure operating pressure as specified in para. 4.3; or be equipped with a self-restoring pressure-relief device to limit the pressure differential from the initial post-accident transient to levels that will not cause collapse, structural damage, or loss of function.

4.6.5.3 It is not necessary to use the maximum design pressure as the basis for leak testing components if the maximum design pressure is due to transient conditions which would not be coincident with high radioactivity levels inside the pressure boundary or would not significantly alter the health physics analysis in para. 4.14.

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

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

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

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

4.6.6 Structural Design Capability Pressure

4.6.6.1 The structural design capability pressure shall equal or exceed the maximum design pressure and shall be the static pressure to which the air-cleaning unit can be safely loaded without permanent distortion. This pressure is typically a minimum of 1.25 times the maximum design pressure.

4.6.6.2 The engineer and/or component manufacturer shall document the structural design capability pressure for each component. This documentation shall be provided to the owner.

4.6.7 Example

4.6.7.1 A duct section located in a branch far from the fan is subjected to a normal operating positive pressure of 1.0 in. w.g. Under upset conditions (e.g., closure of a fire damper) the pressure could increase to 3 in. w.g. upstream of the fire damper. Furthermore, failure of the isolation damper on the fan discharge would subject a section of duct between the fan and damper to 20 in. w.g. The fan discharge duct, under normal operating conditions, experiences a static pressure of 6 in. w.g. It is expected that due to register/balancing damper closure the maximum design pressure would be 8 in w.g. The following design pressures would be specified:

Branch Duct

Normal Operating Pressure for Branch Duct	+1.0 in. w.g.
Maximum Operating Pressure	+3.0 in. w.g.
Test (Leak) Pressure	+4.0 in. w.g. (min.)
Maximum Design Pressure (Selected to envelope operating and transient pressures)	+5.0 in. w.g.
Structural Design Capability Pressure	+7.0 in. w.g. (5 × 1.25 = 6.25)

Fan Discharge Duct

Normal Operating Pressure	+6 in. w.g.
Maximum Operating Pressure	+8 in. w.g.
Duct Leak Test Pressure	+8 in. w.g.
Maximum Design Pressure (Selected to envelope Maximum Operating Pressure)	+10 in. w.g.
Structural Capability Pressure	+13 in. w.g. (10 × 1.25 = 12.5)

NOTE: All pressures noted above are static pressure.

4.6.7.2 An air-cleaning unit is located on the discharge side of an air-cleaning unit fan and is subjected to a normal operating pressure of 7 in. w.g. and maximum operating pressure of 10 in. w.g. (dirty filter conditions). It is determined that failure of discharge damper at housing outlet would subject housing to a maximum design pressure of 20 in. w.g. The following design pressures are specified:

Normal Operating Pressure	+7 in. w.g.
Maximum Operating Pressure	+10 in. w.g.
Test Pressure	10 × 1.25 = +12.5 in. w.g. use +13 in. w.g.
Maximum Design Pressure	+20 in. w.g.
Structural Design Capability Pressure	+20 × 1.25 = +25 in. w.g.

4.7 Nuclear Air Treatment System Configuration and Location

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

Nonmandatory Appendix B, Figs. B-4, B-5, and B-6, schematically depict examples of possible combinations and location of fan and air-cleaning unit to minimize impact of system contaminated outleakage on surrounding clean spaces and interspaces as well as contaminated inleakage into a cleaner system component.

General guidance for various applications is as indicated in paras. 4.7.1 through 4.7.3.

4.7.1 Effluent Nuclear Air Treatment System (Once-Through)

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

(*b*) With air-cleaning unit located in a clean interspace, locate exhaust fan downstream of air-cleaning unit in order to keep air-cleaning unit under negative

pressure. Any leakage through fan shaft will be from clean interspace.

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

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

4.7.2 Habitability Systems

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

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

(*c*) The makeup air fan shall be located:

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

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

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

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

4.7.3 Recirculating Nuclear Air Treatment Systems

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

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

(*c*) The length of ductwork outside the space served should be kept to a practical minimum.

4.8 Maintainability Criteria

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

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

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

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

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

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

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

(*g*) Ducts that will have to be cleaned out periodically shall be equipped with low leakage access hatches at strategic points.

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

4.9 Monitoring of Operational Variables

4.9.1 External Effects. The designer should consider condensation, flooding, seismic requirements, temperature, humidity, radiation exposure, and vibration, as applicable, in the design of all instrument installations.

4.9.2 Instrumentation, Alarms, and Handswitches

(*a*) As a minimum, the designer shall provide the appropriate monitoring instruments, alarms and handswitches on or adjacent to each air-cleaning unit and redundant instruments, alarms, and handswitches at a remote manned control panel in accordance with Table 4-1 for ESF air-cleaning units and Table 4-2 for non-ESF air-cleaning units.

(*b*) For non-ESF air-cleaning units, a common alarm of all local alarms shall be provided on the main control room panel for each air-cleaning unit. Individual alarms may be provided on the main control room panel for each local alarm if desired in lieu of a common alarm.

(*c*) For ESF air-cleaning units, local controls shall be secured to prevent unauthorized use.

4.9.3 Qualification of Instrumentation, Alarms and Handswitches for ESF Air-Cleaning Units

(*a*) Local instrumentation and associated mountings (excluding transmitters, handswitches, limitswitches and associated mountings) shall be qualified to remain intact, but not necessarily functional under the structural loading and environment specified in para. 4.2(k).

(*b*) Local transmitters, handswitches, limitswitches and associated mountings shall be qualified to remain intact and completely functional under the structural loadings and environment specified in para. 4.2(k).

(*c*) Instrumentation, alarms and handswitches at the remote manned control panel shall be qualified to remain intact and functional for the structural loadings that may occur in the area in which the panel is located.

4.9.4 Equipment Status. Each item powered or controlled electrically (fan motor, valve or damper operator, fire protection systems, solenoid valves, etc.) shall be provided with status indication for the energized mode, located in accordance with Table 4-1 for ESF air-cleaning units and Table 4-2 for non-ESF air-cleaning units, to show the operational status of the item.

4.10 Adsorbent Cooling

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

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

4.11 Fire Protection

4.11.1 General. Nuclear air treatment systems shall be designed, fabricated, and installed so as to minimize the use of combustibles. Filter media, sealants, gaskets, and insulation shall meet the requirements in Section 5.

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

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

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

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

4.11.6 Water Deluge Systems. Deluge nozzles should be permanently mounted within the housing and located to ensure that both the deep-seated or

TABLE 4-1 INSTRUMENTATION FOR ESF AIR-CLEANING UNITS

Sensing Location [Note (1)]	Readout/Alarm Location: Local	Readout/Alarm Location: Remote Manned Control Panel	
Unit Inlet (High Velocity Portion)	F(I) alternately at location No. 16, T(I) alternately at location No. 2 or No. 4	F(AH, AL) alternately at location No. 16	
Space	. . .	. . .	
Demister	ΔP(I,AH*) [NOTE (2)]	. . .	
Space	. . .	. . .	
Electric Heating Coil	SL	. . .	
Space	T(I,AL,AH)	T(I,AH,AL,AT)	
Prefilter	ΔP(I,AH)	. . .	
Space	. . .	. . .	
Pre-HEPA	ΔP(I,AH)	ΔP(AH)	ΣP(AH) optional [Note (4)] (applies to Space through Space)
Space	. . .	. . .	
Adsorber	. . .	. . .	
Space	T(I,AH-2 STAGE) [Note (3)]	T(I,AH-2 STAGE) [Note (3)]	
Postfilter	ΔP(I,AH)	. . .	
Space	. . .	. . .	
Fan	HS* SL* [Note (2)]	HS,SL	
Unit Outlet (High Velocity Portion)	See location No. 1	See location No. 1	
Valve/Damper Operator	SL* [Note (2)]	SL	
Fire Protection System	I,AT [Note (5)]	AT [Note (5)]	

Parameters (A) [Note (6)]

F = Flow
T = Temperature
ΔP = Differential Pressure
ΣΔP = Summation Alarm (ΔP)

Instrument Function (x) [Note (6)]

I = Indication
AH = High Alarm
AL = Low Alarm
AT = Trip Alarm
SL = Status Indication
HS = Handswitch
R = Record

NOTES:

(1) The "Sensing Location" indicates the location within an air treatment unit where the specified sensors shall be located. The components are listed in the sequence they are typically used, with "Space" indicating the component between two components.

(2) All instruments are required except those marked with an (*) which are recommended.

(3) 1st Stage signals an alarm only, 2nd stage signals an alarm and permits manual actuation of fire protection system.

(4) Total air-cleaning unit ΔP alarm is optional if each component whose pressure drop is subject to change over time has individual alarm or indication in Main Control Room.

(5) Manual valves are recommended with local indication at valve. Power actuated valves, if used, shall have local handswitches, and indication; and trip alarms on local and remote manned control panels. Flow of extinguishing agent shall be alarmed on local and remote-manned control panels.

(6) A(x): Measurment of parameter A requires instrument function x.

TABLE 4-2 INSTRUMENTATION FOR NON-ESF AIR-CLEANING UNITS

Sensing Location [Note (1)]	Readout/Alarm Location: Local [Note (2)]	Readout/Alarm Location: Remote Manned Control Panel
Unit Inlet (High Velocity Portion)	F(I) alternately at location No. 16, T(I) alternately at location No. 2 or 4	
Space	. . .	. . .
Demister (if applicable)	ΔP(I,AH*) [Note (3)]	. . .
Space	. . .	. . .
Electric Heating Coil	SL	. . .
Space	T(AH,AL,AT)	. . .
Prefilter	ΔP(I,AH) [Note (3)]	. . .
Space	. . .	. . .
Pre-HEPA	ΔP(I,AH*) [Note (3)]	. . .
Space	. . .	. . .
Adsorber	. . .	. . .
Space	T(I,AH-2 STAGE) [Note (4)]	T(I,AH-2 STAGE) [Note (4)]
Postfilter	ΔP(I)	. . .
Space	. . .	. . .
Fan	HS,S	L
Unit Outlet (High Velocity Portion)	See location No. 1	. . .
Valve/Damper Operator	SL* [Note (3)]	. . .
Fire Protection System	[Note (5)]	[Note (5)]

Parameters (A) [Note (6)]

F = Flow
T = Temperature
ΔP = Differential Pressure

Instrument Function (x) [Note (6)]

I = Indication
AH = High Alarm
AL = Low Alarm
AT = Trip Alarm
SL = Status Indication
HS = Handswitch
R = Record

NOTES:
(1) The "Sensing Location" indicates the location within an air treatment unit where the specified sensors shall be located. The components are listed in the sequence they are typically used, with "Space" indicating the component between two components.
(2) For air-cleaning units located inside containment, the requirement for LOCAL controls for handswitches, flow indication, and alarms for high differential pressure, low and high flow and high temperature shall mean controls shall be located on a panel located outside containment.
(3) All instruments are required except those marked with an (*) which are recommended.
(4) 1st Stage signals an alarm only, 2nd stage signals an alarm and permits manual actuation of fire protection system.
(5) See Note (4) in Table 4-1.
(6) A (x): Measurement of parameter A requires instrument function x.

surface fires can be extinguished. Nozzles shall be piped to an accessible location outside the housing and provided with redundant leak-tight isolation (O.S.&Y.) valves and a connection suitable for manual attachment to the plant's fire protection system. Permanently connected fire protection systems are not recommended, but may be used in lieu of manual hose connections.

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

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

4.11.9 Returning Air-Cleaning Unit to Service. If carbon does become wet, the wet carbon shall be removed from the adsorber to prevent structural damage to the adsorber due to chemical interaction. Before placing the air-cleaning unit back in service, the adsorber shall be thoroughly dried, visually inspected for corrosion damage, dried carbon shall be laboratory tested per para. 5.2.3, and adsorber leak testing shall be performed per ASME N510-1989.

4.12 Insulation

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

4.13 Testability

(*a*) To ensure that the testing requirements of this Standard can be met, sufficient permanently installed halide and DOP injection and sampling ports shall be provided to permit accurate testing in accordance with ASME N510.

Where required for proper challenge agent mixing and/or sampling, multiple inlet or outlet distribution manifolds shall be provided to allow injection and sampling per ASME N510. Refer to para. 5.6.5 for detailed requirements on sampling and injection manifolds.

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

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

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

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

4.14 Pressure Boundary Leakage

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

(*a*) control room habitability;

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

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

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

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

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

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

4.14.3 Leak Test Parameters. Components shall be designed, fabricated, and installed so as not to exceed allowable leakage at specified operating pressure.

Where shop and/or field tests are required by Table 9-1 and ASME N510, the system designer shall specify the test pressure and corresponding maximum allowable leak rate (scfm). Test pressure shall be selected based on the test procedures in ASME N510 and the maximum operating (static) pressure.

If the leak rates are measured at a test pressure not equal to the operating static pressure, the measured leak rates shall be converted as follows to allow comparison to allowable unit leak rates at operating pressure:

$$L_t = L_{op} \left(\frac{P_t}{P_{op}} \right)^{1/2} \qquad (1)$$

where

L_t = allowable unit leak rate at test pressure, cfm/ft^2

L_{op} = allowable unit leak rate at operating (static) pressure, cfm/ft^2

P_t = selected test pressure, in. w.g.

P_{op} = operating (static) pressure, in. w.g.

NOTE: This assumes fully turbulent flow at both test pressure and operating pressure. If flow is not fully turbulent, then the appropriate relationship between airflow rate and pressure shall be used.

5 COMPONENTS

5.1 HEPA Filters

HEPA filters shall meet the construction, material, test, and qualification requirements of military specification MIL-F-51068, except that listing of manufacturer's HEPA filter products on the U.S. Army's Qualified Products List is not required. Glass fiber media shall conform to the requirements of military specification MIL-F-51079. To be acceptable, filters shall have documentation showing that they have passed and tests designated by MIL-F-51068 for:

(a) newly designed HEPA filters,

(b) HEPA filters from a new manufacturer or a new manufacturing facility,

(c) HEPA filters being rerated for a higher airflow than originally qualified for.

Requalification is required to be performed by the manufacturer every 5 years.

5.1.1 Construction. Filters for use in containment or in ESF systems shall be metal case type (Type II frames as defined by MIL-F-51068) and shall be compatible with the chemical composition of the air stream. Filter systems exposed to temperatures greater than 200°F shall have steel cell sides.

5.1.2 Radiation Resistance. Radiation resistance of filter media shall meet the requirements of MIL-F-51079 and conditions listed in para. 4.2.1.

5.1.3 Documentation

5.1.3.1 A Certificate of Conformance shall be provided to the owner certifying that:

(a) the filter assembly has been designed in accordance with para. 5.1;

(b) the materials of construction comply with paras. 5.1, 5.1.1, and 5.1.2;

(c) the filters and filter media have been qualified in accordance with para. 5.1;

(d) the filters and filter media have been tested in accordance with para. 5.1;

(e) the filters have been packaged in accordance with para. 6.

5.1.3.2 In addition, the following documentation shall be provided:

(a) copies of the production test results required by Military Standards;

(b) copies of all filter case material certifications, if required by the owner's purchasing documents.

5.1.3.3 Listing of Manufacturer's HEPA filter products on the U.S. Army's Qualified Products list is not required.

5.2 Adsorbers

5.2.1 Flat Bed and Pleated Bed Adsorber Cells. Tray-type and deep bed adsorber cells shall meet the requirements for Type II or Type III cells, respectively, of ASME/ANSI AG-1-1988, Sections FD, Type II Adsorbers, and FE, Type III Adsorbers; and shall be filled with an adsorbent, each batch of which meets the requirements of para. 5.2.3.

5.2.2 Adsorber Design

5.2.2.1 Joints which are gasketed, caulked, or sealed with elastomeric materials shall not be employed between the upstream and downstream sides of the adsorbent bed, frames, or any part of the installation. Test cannisters for Type II Adsorbers, or reservoir covers for Type III Adsorbers shall be gasketed to the mounting surface. Perforated metal shall be installed with the smooth side in contact with carbon.

5.2.2.2 The adsorbent bed shall be so arranged that no air can bypass the adsorbent and the minimum residence time of air in the adsorbent is 0.25 sec per 2 in. bed depth. If there is significant potential for adsorber degradation due to "poisoning" from contaminants in the airstream, a bank of unimpregnated carbon may be installed upstream of the impregnated adsorbent. There shall be no internal structures within the adsorbent bed, such as through-bolts, where air bypass can occur.

5.2.2.3 Screens shall be supported by stiffeners which are external to the adsorbent bed to assure uniformity and integrity of the bed.

5.2.2.4 Means shall be provided for filling the air-cleaning unit with absorbent and compacting it to uniform packing density throughout all cross sections of the bed. In a vertical direction, this density shall vary only to the extent that the lower portion of the bed supports the weight of the adsorbent placed above it. Adsorbers shall be filled in accordance with Appendix D of ASME/ANSI AG-1-1988, Section FE. For designs in which a fill hopper is included in the design, a 5% by weight reserve capacity beginning one bed depth above the perforated screen shall be included.

5.2.2.5 All materials in contact with the adsorbent shall be Type 300 Series stainless steel.

5.2.2.6 Means shall be provided for emptying adsorbent, including wet or caked adsorbent. Direct access to the top and bottom portion of the air-cleaning unit should be provided for emptying adsorbent. The manufacturer of the air-cleaning unit shall provide instructions for removing the adsorbent under a variety of conditions, including while wet and caked. ALARA considerations should be incorporated into manufacturer's design.

5.2.3 Adsorbent Requirements

5.2.3.1 Adsorbent media used in ESF adsorbers shall meet the requirements of ASME/ANSI AG-1-1988, Section FF, Adsorbent Media.

5.2.3.2 Adsorbent media used in non-ESF adsorbers shall meet the requirements of ASME/ANSI AG-1-1988, Section FF, Adsorbent Media.

5.2.3.3 For ESF and non-ESF adsorbent, tests shall be conducted on unused adsorbent for the conditions specified in the plant's Technical Specifications. These tests shall be referred to as benchmark surveillance tests. Acceptance criteria shall be in accordance with Technical Specifications. These results may be used as a benchmark for comparing adsorbent test performance after acceptance testing and following each periodic surveillance test.

5.2.4 Drawings. Outline drawings showing major dimensions, dimensional tolerances, methods of sealing and baffling, and method of installation shall be furnished. The drawings for all adsorbers shall show the materials of construction and screen details (hole diameter and spacing, open area) in accordance with the IPA Designers, Specifiers and Buyers Handbook for Perforated Metal.

5.2.5 Documentation

5.2.5.1 Standard Adsorber Cells. A report giving the information specified in Sections FD, FE, and FF of ASME/ANSI AG-1-1988 shall be furnished to the owner.

5.2.5.2 Other Adsorber Designs. A report giving the information specified in para. 5.2.5.1 shall be furnished to the owner. A detailed written procedure for filling and emptying the adsorber shall also be furnished.

5.3 Prefilters and Postfilters

Prefilters and postfilters shall be replaceable, extended media, dry type, meeting the requirements for Group III filters of ARI 680, and shall be listed as Class 1 filters in the current UL Building Materials Directory. Media shall be moisture resistant.

5.3.1 Rating. Filters shall have published ratings, in accordance with ARI 680, as follows:

(*a*) average atmospheric dust-spot efficiency in accordance with ASHRAE Standard 52, for postfilters of 95%, and 45% for prefilters;

(*b*) airflow capacity: same as or greater than HEPA filters for the same filter frame face area.

5.3.2 Size. It is recommended that the filter frame face dimensions of prefilters be approximately the same (i.e., within ± 1 in.) as the filter frame face dimensions of the HEPA filters with which they will be used.

5.3.3 Documentation. A report giving the outline dimensions, description of construction, materials of construction, certification of conformance with UL-900, and certification of efficiency in accordance with ASHRAE Standard 52 shall be furnished to the owner.

5.4 Moisture Separators

Moisture separators shall be of a design that has been qualified by testing in accordance with the procedures described in MSAR-71-45, NYO-3250-6, or an equivalent program. Moisture separators shall be found by test to be capable of:

(*a*) removing at least 99% by weight of the entrained moisture in an airstream containing approximately 1.5 to 2 lb of entrained water per 1,000 cu ft, and

(*b*) at least 99% by count of 5 to 10 μm diameter droplets, without visible carryover, when operating at rated airflow capacity.

The pressure drop at rated flow, when dry and when wet, shall be established by qualification testing. Materials of construction (media, gaskets, etc.) shall be such that the moisture separator can perform its design function under the radiation dose specified in para. 4.2. Liquid removed by the moisture separators shall be sent to a liquid radwaste system or a building equipment drain sump. The selection of the system to which this liquid is sent should be based upon its capability to handle the quantity and radioactivity level of the liquid associated with the anticipated moisture separator drainage. Drainage should not be open and ALARA considerations should be accounted for in drainage design. The drainage system shall be designed so that it does not result in a bypass around air cleaning components. Drains shall meet the requirements of para. 5.6.2.

5.4.1 Drawings. Drawings showing the details of construction, methods of sealing, baffling, and draining, dimensions, dimensional tolerances, resistance characteristics, and method of installation shall be furnished to the owner. The locations and sizes of drains to remove collected water, materials of construction, and other information required to properly install, use, and maintain the moisture separators shall be included on the drawings.

5.4.2 Documentation. A report showing the results of satisfactory qualification testing of the type of moisture separator proposed shall be furnished to the owner if the equipment supplied has not been previously satisfactorily tested and reported in available published literature as in MSAR-71-45, NYO-3250-6, or other documents of comparable detail.

5.5 Air Heaters

Heaters shall be electric and capable of meeting the requirements of para. 4.5 of this Standard. Qualification tests may be made on small scale models of the complete heating assembly. Heaters shall be designed for replacement without metal cutting or welding. Heaters shall not be attached directly to or grounded to the adsorber mounting frame. Heaters shall be physically sized such that face velocity exceeds manufacturer's minimum requirement. This will usually result in a heater with a smaller cross-section that prefilter or HEPA filter banks. Heaters should therefore be located relative to HEPA filters such that a uniform airflow distribution at the HEPA filter can be obtained. The design of the air-cleaning unit should incorporate diffuser plates or other means to achieve uniform airflow distribution at the HEPA filters in accordance with ASME N510, if necessary.

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

5.5.2 Drawings. Drawings showing the details of construction, dimensions, dimensional tolerances, size and location of services (i.e., electrical connections), and method of installation shall be furnished to the owner.

5.5.3 Heaters for ESF Systems. Heaters in ESF air-cleaning units shall be qualified to meet the requirements of IEEE 323 and IEEE 344.

5.5.4 Documentation. A report containing description and results of qualification testing, and the resistance, certification and serial number(s) of the heaters purchased shall be furnished to the owner. If small scale model tests are the bases of design, scaled-up calculations must be provided. Heat transfer calculations shall be submitted to the owner if requested.

5.6 Filter Housing

5.6.1 General Requirements. Housings shall be designed and constructed to meet the structural and pressure loadings of Section 4. Welding shall conform with para. 7.3. Layout of the housing and banks of components within the housing shall provide for access to both sides of each bank of components for maintenance and testing; and for uniform airflow (within ± 20% of average) through each bank of components; the completed housing shall meet the requirements of the air-flow uniformity test of ASME N510. It is recommended that no filter or adsorber bank be higher than three 24 in. × 24 in. HEPA filters or nine Type II adsorber cells unless permanently installed service galleries are provided at approximately 7 ft. intervals with permanently installed ladders to provide for access to upper tiers of components for service and testing.

HEPA filter and adsorber mounting frames shall meet the requirements of para. 5.6.3, and shall be sealed into the housing by welding; no mastics, sealants, or caulking compounds shall be used to seal the mounting frame. Duct and fan connections shall be located with respect to the air distribution uniformity requirement specified above. Housings shall be tested by the manufacturer in accordance with para. 5.6.5.

5.6.2 Mechanical Design of Housings

(*a*) *Housing Doors*

(*1*) *Design*. Doors and door frames shall be of marine bulkhead type or equivalent airtight construction capable of meeting the pressure-leak requirement of para. 5.6.1.

Doors shall be of sufficient strength to withstand the worst-case combination of possible loads without deformation that would impair function or unacceptably impact pressure boundary integrity. This shall include both long term loads (i.e., door clamps, door weight, pressure differential) and short term loads (such as pressure surges, closing/opening door, etc.).

Housing doors should avoid the use of sharp edges which could catch or tear protective clothing.

(*2*) *Size*. Doors shall be of sufficient size that passage is possible by a person wearing anticontamination clothing and a respirator, and carrying the largest routinely replaceable component used in that compartment. Where the housing size is less than the door required, alternate methods of clamping, replacement, inspection, and testing must be provided. Man-entry doors shall have a minimum clear opening of 20 in. wide × 50 in. high.

(*3*) *Seals*. Sealing surfaces between door and door frame shall be designed for compression sealing. Door design shall incorporate means for adjusting compression forces and gasket compression. Gaskets shall be installed on door and a "knife edge" sealing surface for the gasket shall be provided. Gasket shall be neoprene or silicone rubber with a recommended 30-40 Shore-A durometer.

The gasket shall be installed in as few pieces as possible to minimize number of joints. Gasket joints shall be dovetailed-type to prevent leakage due to misfitting butt joints.

The gasket shall be protected from possible damage when the door is opened by installing gasket within a channel or with a metal bar between door edge and gasket to protect it in an equivalent manner.

(*4*) *Hinges and Latching Lugs*. Door hinges shall be of sufficient strength to hold the door in correct position for gasket sealing. They shall allow free, low-torque movement of the door. Hinges shall be articulated so the door will seal against the gasket in the same manner as if only a single axis was provided.

Latching lugs shall be of sufficient number, design, location, and strength for long-term life and use. Spacing shall enable a compression of at least 50% of nominal gasket thickness and provide a gasket compression uniformity of ± 20%.

(*a*) Lugs shall be located on all four sides of each door.

(*b*) There shall be a minimum of six or eight lugs, depending on door size (one top, one bottom, two or three on each side). Doors with a width greater than 30 in. shall be provided with a minimum of two lugs on top and bottom.

(*c*) Lugs shall seal in less than 270 deg. motion.

(*d*) Lugs shall not have more than one handle per location; that is, there shall not be a handle to

position the inside clamp and a separate handle to tighten the clamp down.

(*e*) Lugs shall be configured so that when open, gravity will hold them in the open position.

(*f*) Lugs shall indicate (or have permanent indication on the door) which direction to turn to open or close. This shall be for each lug, or if all work the same, then indicated once on each door.

(*g*) Lugs should open and seal with only the torque that can reasonably be applied by an average person while suited up. If additional torque is required, a specific tool to provide the torque shall be supplied for each door, and so attached as to reasonably assure that it will be available during the life of the plant.

(*h*) Latching lug assemblies shall have a minimum number of components and be designed so no loose components can fall off.

(*i*) Latching lugs shall be designed to operate with no lubricant required within the pressure boundary.

Doors shall have provisions for locking and be fitted with inspection windows. Windows should be wire glass or high-strength plastic selected for the operating environmental conditions. Doors shall be operable from both sides. Sufficient clearance shall be provided to enable doors to be opened so that they do not block access to service aisles and can be opened sufficiently to enable access for testing, filter replacement, repair, or inspection.

Drawings for each type and size door shall be submitted to the owner for review prior to fabrication. Door drawings shall show location and details of hinges, latching lugs, and viewports. Details on latching lug design (including shims and washers) and gasket installation shall be included.

(*b*) *Lighting*. Housings shall be fitted with vapor-tight lights between each bank of components. Lighting fixtures shall be flush-mounted and serviceable from outside the housing. Lighting levels shall be determined based on personnel safety and inspection and testing needs. Supplemental lighting for periodic inspection may also be used. The light switch for each light shall be located on the outside immediately adjacent to the door to the space served by the light. Conduits shall be located on the outside of the housing.

(*c*) *Drains*. Each housing compartment shall have floor drains which meet all allowable air leakage criteria.

When piped to a common drain system, individual drainlines shall be valved, sealed, trapped, or otherwise protected to prevent bypassing of contaminated air around filters or adsorbers through the drain systems, inducing air from contaminated interspaces into the air-cleaning unit, or blowing contaminated air from the air-cleaning unit to a clean interspace.

Special consideration shall be given to additional drains depending on required services or components within each compartment. For example, additional drains may be required for:

(*1*) moisture separators

(*2*) condensing cooling units

(*3*) adsorber water deluge fire protection sprays

The size selected for each drain furnished in a housing shall be verified by calculation or test, and documented.

The number of normally open drains should be kept to a minimum (i.e., drains should be manually valved off when not needed during operation) to reduce the possibilities of degrading the pressure boundary or bypassing the air-cleaning unit or filter banks.

Traps or loop seals when used should be designed for the maximum operating (static) pressure the air-cleaning unit may experience during system startup, normal operation, system transients, or system shutdown. Provision should be made for manual or automatic fill systems to ensure water loop seals do not evaporate. If manual filling is utilized, a periodic inspection or filling procedure shall be implemented. A sight glass should be considered to aid in inspection. The same applies if a local sump is included in the design.

The drain system shall be designed so that unacceptable backup of liquids into the housing will not occur. Hydraulic calculations shall be prepared to document this feature of drain system design. Provision shall be made in plant radwaste system to treat maximum coincident flow rate.

Initial testing of the drain system shall be performed by the owner on site, after installation, to demonstrate operability.

When shutoff valves or check valves are utilized, they shall be initially tested on site, after installation, and periodically thereafter for operability and leakage.

Valve leakage shall be considered as part of the allowable housing leakage criteria derived in para. 4.14. For check valves, surveillance inspections for operability and leakage shall be performed periodically in accordance with air-cleaning unit Technical Specification requirements.

(*d*) *Housing Penetrations*. All penetrations shall be sealed by welding or having adjustable compression gland-type seals.

All penetrations by electrical conduit piping and sample and test manifolds shall be arranged and

individually sealed or valved so that bypassing of HEPA filters or adsorbers cannot take place. Electrical conduit open to the inside of the housing shall be internally sealed to meet the allowable leakage specified in para. 4.14.

(*e*) *Housing Connections*

(*1*) Duct-housing interconnections shall be designed with consideration for air distribution uniformity requirement of ASME N510-1989. Provision shall also be made to bolt on access covers on the housing inlet and outlet connections to facilitate in-place leakage testing.

(*2*) Connection flange requirements shall be in accordance with para. 5.10.

(*3*) To allow for periodic housing pressure surveillance testing, a 6 in. diameter, 1 ft long, flanged connection with a welded longitudinal seam shall be provided at the housing inlet or the housing outlet for connection to leak test blower assembly. A flanged, gasketed cover plate shall be bolted to the connection.

(*f*) *Flexible Connections*

(*1*) Flexible connections shall be designed to meet the requirements of paras. 4.2, 4.6, and 4.14.

(*2*) Flexible connections shall be rated by pressure and qualified life. The qualified life shall be determined by testing and/or calculation and based on the environmental conditions provided by the Design Specification. Minimum physical properties (i.e., tensile strength) that are required to satisfy design function and which are subject to degradation due to the environment shall be the basis of qualified life.

(*3*) Flexible connection pressure rating shall be determined by an ultimate strength test. The pressure rating of the connection shall be no greater than 50% of burst pressure. Calculation of burst pressure can be done in lieu of a test. Burst pressure shall exceed structural capability pressure.

(*4*) For qualification, flexible connections shall be stressed over a minimum of 10 cycles and then leak tested to demonstrate leak-tight integrity. Allowable leakage and test pressure (fabric leakage and joint leakage) shall be determined in accordance with para. 4.14.

(*5*) If adhesive is used in fabrication or installation of flexible connections, it shall be environmentally qualified for use in expected environmental conditions.

(*g*) *Housing Drawings*. Housing drawings showing location and size of each door, drain, and housing duct or pipe connection shall be submitted to the owner prior to fabrication. Drawings should also show location of lights, switches, and other appurtenances. Location of heaters, coils, filter banks, and service space between banks shall be dimensioned. Drawings shall include sufficient detail to allow calculation of internal volume for housing and frame leak testing.

Detailed drawings and operating instructions in accordance with para. 5.6.2(*g*) shall be submitted prior to fabrication.

Details of flexible connection construction, installation, and qualification shall be submitted prior to fabrication.

Details of drain systems showing location, pipe size, type of seals (valves, loops) shall be submitted to owner prior to fabrication. Detailed valve drawings shall be submitted, if used. Hydraulic calculations and leakage test results shall be submitted prior to shipping.

5.6.3 Component Mounting Frames. Mounting frames for all components (moisture separators, prefilters, heaters, HEPA filters, adsorbers, and postfilters) shall be all-welded construction and seal-welded into the housing to prevent trapping of contamination between frame and housing.

HEPA filter frames shall be of a face-sealed design meeting the structural requirements of para. 4.3 of ERDA 76-21 or be otherwise designed to prevent relative flexure between the frame and the components mounted on the frame. Clamping of HEPA filters and adsorbers which employ gaskets for sealing to the frame shall be by a method which will produce a gasket compression-deflection of at least 50% without exceeding a stress in the clamping device of 67% of its yield strength, and which will produce a uniformity of gasket compression within ±20% of the average compressed thickness. Threaded latching devices shall be stainless steel with non-galling mating parts. Adsorber frames shall be of a type which will adequately support the type of adsorber used; faces of the frame shall meet the tolerances of HEPA filter frames given in Table 4-2 of ERDA 76-21, and clamping devices shall meet the requirements specified above for HEPA filter frames. Frames should be vertical (horizontal airflow); horizontal mounting frames are not recommended. There shall be no penetrations of any component mounting frame, except for test cannisters. HEPA filters and Type II adsorber cells shall be individually clamped to their mounting frames. Recommendations for mounting frames and component installation are given in paras. 4.3 (for bank installations) and 6.2.1 (for single filter installations) of ERDA 76-21. Drawings of clamping devices for HEPA filters and Type II adsorber cells shall be submitted to the owner prior to fabrication.

5.6.4 Materials and Protective Coatings

5.6.4.1 Materials of Construction. Carbon, stainless, and galvanized steel, aluminum, copper, bronze, or glass used for the fabrication of parts, components, air-cleaning units, and systems covered by this Standard shall meet the requirements of, and be furnished in accordance with, ASTM standards applicable to the type of material or item. The ASTM number(s) for all such material and copies of supporting documentation (i.e., test reports and/or materials-manufacturer's certification) shall be filed by the fabricator and made available to the owner on request. Where a specific ASTM standard is required for an item covered by this Standard, the designer shall specify and the fabricator shall use such material. Where post accident spray chemistry may cause H_2 generation, the use of any material incompatible with the spray chemistry shall be avoided.

5.6.4.2 Internal and external surfaces of both ESF and non-ESF housings located inside containment shall be stainless steel or be treated with a paint or protective coating that meets the requirements of ANSI N101.2[1] (for light-water reactors) or the requirements for "severe exposure" of ANSI N512[2] (for nuclear facilities other than light-water reactors): the selection, application, and inspection of paints and coatings shall conform to and be documented in accordance with the requirements of ASTM D 3843.[3] Bronze, copper, aluminum and glass need not be coated. Where conditions do not restrict its use (e.g., when no chemical additives are used in containment spray systems), galvanized steel and aluminum are acceptable for external and internal housing surfaces.

5.6.4.3 Internal surfaces of ESF systems located outside of containment shall be stainless steel, galvanized or electrolytic-zinc-coated steel, or treated with a paint or protective coating meeting the requirements for Service Level I, of ANSI N512 and Table 5-1; the selection, application, and inspection of paints and protective coatings (including zinc to the extent applicable) shall conform to and be documented in accordance with the requirements of ASTM D 3843. Bronze, copper, aluminum, and glass need not be coated. Internal surfaces of normally operating systems shall be treated to meet the requirements of Service Level II of ANSI N512 if environmental conditions do no significantly change between normal and postaccident operation. For Service Level II coatings, the requirements of Table 5-1 apply; however, the requirements of ASTM D 3843 do not.

Nongalvanized carbon steel external surfaces shall be coated or painted for corrosion resistance. Where conditions exist outside of containment (e.g., in systems containing sprays with chemical additives) which restric the use of aluminum, galvanized or electrolytic-zinc-coated steel, external and internal surfaces of ESF housings shall be in accordance with para. 5.6.4.2.

5.6.4.4 Internal and external carbon steel surfaces of non-ESF systems located outside of containment may be galvanized steel, electrolytic-zinc-coated steel, or painted.

5.6.4.5 Galvanized surfaces shall meet the requirements of ASTM A 123; electrolytic-zinc-coated surfaces shall meet the requirements of Type GS of ASTM A 164. Edges of steel sheared after coating, welds, and areas in which the galvanized coating has been removed for any reason shall be treated with inorganic zinc rich paint (qualified to ANSI N101.2) to restore the corrosion resistance of those areas.

Galvanized surfaces that have been damaged shall be repaired with an appropriate qualified material per ANSI N101.2. The damaged areas shall be coated to provide an equivalent to the original coating.

5.6.5 Testing

5.6.5.1 Sampling and injection manifolds installed within the filter housing should be designed for permanent installation within the housing. If permanently installed manifolds cannot be provided, then manifolds shall be designed to be removable with each manifold piece numbered, tagged with permanent metal tags, and marked for reinstallation prior to each test. It should be noted that permanent manifold installations are highly recommended in order to obtain better repeatability of test results and to eliminate the need to enter housings which will decrease personnel radiation exposure. As a minimum, injection and sampling manifolds are required between each pair of HEPA filter banks and between each pair of carbon adsorber banks. For systems with no inlet ducts or no outlet ducts, injection manifolds and sampling manifolds shall be located within the housing. Manifolds

[1] ASTM D 3911 shall be substituted in the applicable paragraphs of ANSI N101.2 regarding DBA requirements.
[2] ASTM D 3912 shall be substituted for chemical resistance tests in ANSI N512. ASTM D 4256 shall be substituted in applicable paragraphs for decontaminability tests of N512. ASTM D 4082 shall be substituted in applicable paragraphs for radiation tolerance tests of N512.
[3] ASTM D 3843 shall be substituted for ANSI N101.4 in applicable paragraphs of ANSI N101.2 and N512.

TABLE 5-1 COATING PERFORMANCE REQUIREMENTS[1]

System Type	Surface	General Exposure Condition [Note (2)]	Radiation Exposure, rads	Decontamination Factor [Note (3)]	Chemical Resistance [Note (4)]	Physical Properties [Note (5)]
Air treatment	Internal	Light	$<5 \times 10^8$	10, min.	Chem. exposure	All
Air treatment	External	Light	$<5 \times 10^8$	5, min.	Chem. exposure	All, except abrasion

NOTES:
(1) Coating performance requirements in accordance with ANSI N512.
(2) General Exposure Conditions per Section 2 of ANSI N512.
(3) Decontaminability per Section 4 of ANSI N512. Minimum value specified.
(4) Chemical resistance test (lining test or chemical exposure test) per Section 5 of ANSI N512.
(5) Physical tests (abrasion, adhesion, direct-impact resistance, weathering) per Section 6 of ANSI N512.

should conform with the general guidance given in Appendix C.

Manifolds shall be:

(*a*) located to provide uniform mixing and sampling of the test agent,

(*b*) located to allow for maintenance of the filter elements, and

(*c*) designed such that they do not impair the function of the adjacent filter banks or the structural integrity of the filter frames or housing when subjected to the structural loadings listed in para. 4.2.

Each injection and sampling manifold shall be shown on a drawing which indicates location within the housing, distance from components, support detail, tube diameters, hole locations and diameters, location of valves and plugs, manifold identification number, and manifold internal volume.

Drawings shall be submitted to the owner for review prior to fabrication and final as-built drawings submitted to the owner after shop testing.

Manifold design and location shall be qualified by shop tests per paras. 5.6.5.5 and 5.6.5.6.

5.6.5.2 Housings shall be visually inspected in the shop prior to shipping. Visual inspection shall be performed in accordance with applicable sections of ASME N510-1989, Section 5. Observed deficiencies shall be documented on a visual inspection checklist, required corrective action noted, and results of reinspection documented. Visual inspection documentation shall be transmitted to the owner for his records.

5.6.5.3 All HEPA filter frame and adsorber bed welds which could result in leakage bypassing HEPA filters or adsorber beds shall be shop tested with magnetic particle or liquid penetrant in accordance with the requirement in para. 7.3. In addition, each HEPA and adsorber frame shall be pressure leak tested in the shop in accordance with ASME N510, Section 7. Leakage shall not be greater than 0.1% of rated flow.

5.6.5.4 Housings or housing sections shall be leak tested in the shop prior to shipment, in accordance with ASME N510, Section 6. Leakage shall be no greater than acceptance criteria provided by the owner. Results of housing leak tests shall be transmitted to the owner for his records.

5.6.5.5 Airflow distribution testing shall be performed in the shop prior to shipment in accordance with ASME N510, Section 8 to provide assurance that manufacturer's design provides uniform air distribution. Shop tests shall simulate actual field entrance and exit duct connections as closely as possible. Field testing shall also be conducted in accordance with ASME N510.

Air-cleaning units which are duplicates in design layout, and fabrication to other air-cleaning units which have been successfully tested and documented, need not be shop tested for airflow distribution. Acceptance criteria shall be as given in ASME N510. Results of airflow distribution tests shall be documented and transmitted to the owner for his records.

5.6.5.6 Air-aerosol mixing uniformity tests shall be performed in the shop for each manifold which is provided by the manufacturer to be mounted within the filter housing. Air-cleaning units and test manifolds which are duplicates in design, layout, and fabrication to other air-cleaning units which have been successfully tested and documented need not be shop tested for air-aerosol mixing uniformity. Qualification testing of sampling manifolds shall be conducted in accordance with Appendix D. Qualification testing of injection manifolds shall be performed in accordance with ASME N510, Section 9. Results of tests shall be documented and transmitted to the owner. These results shall qualify the design and installation of the sample manifolds prior to shipment. Acceptance criteria shall be as given in ASME N510. Field

testing shall also be conducted in accordance with ASME N510 after installation.

5.7 Fans

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

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

Fan selection shall also allow for test conditions in accordance with ASME N510. The system designer shall identify the maximum allowable differential pressure for each filter bank plus a margin to accommodate filter loading which may occur prior to the next surveillance (typically 25% of the coincident dirty filter differential pressure). The fan and system characteristic curves shall be included in the system documentation. The fan shall be selected to operate on the stable portion of its pressure curve under all operating conditions. Provision shall be made in the design to maintain stable operation under the design flows and varying pressure range. Inlet vanes, inlet/outlet damper modulation, variable speed fan control are acceptable alternatives.

The method of fan selection, together with all pertinent data, shall be documented. Direct-drive fans are recommended for systems located inside containment. Belts, elastomeric seals, bearing lubricants, protective coatings, and other nonmetallic items and materials shall be selected to perform their required function under the environmental conditions specified in para. 4.2. Fan construction, arrangement, and other characteristics shall be established in accordance with AMCA 99. Materials and protective coatings of fan housings shall be in accordance with para. 5.6.4.

5.7.2 Rating or Test. ESF fans shall be tested in accordance with AMCA 210 and the applicable special sections of AMCA 211A. Only one fan of each size and type must be tested. Non-ESF fans shall be either rated and listed in accordance with AMCA 211A or tested the same as ESF fans. The rating or fan test shall be based on the standard test configuration most closely representative of the manner in which the fan will be installed in the nuclear air treatment system. As an alternate to the above, testing may be done in accordance with the owner's instructions to simulate, as nearly as possible, actual operating conditions that the fan(s) will be subjected to in operation. Copies of the rating report or test report shall be obtained from the fan manufacturer, together with copies of pertinent catalog data, performance data, and operating and service manuals for inclusion with the documentation for the system. Sound ratings for the fan, based on data obtained in accordance with AMCA 300 and reported in accordance with AMCA 301, shall be furnished.

5.7.3 Balancing and Vibration. Fan wheels shall be dynamically balanced prior to final assembly of the fan. Records shall be maintained in vendor's file.

The double amplitude of vibration in any plane measured on the bearing cap at the rotational rotor speed shall not exceed the following:

Rotational Speed (rpm)	Double Amplitude (mil)
600	3.2
720	2.7
900	2.1
1200	1.6
1800	1.1
3600	0.5

Displacement may be interpolated for other speeds.

Final balancing shall be performed after fan installation is completed.

5.7.4 Drawings. Certified drawings showing outline dimensions, base or mounting dimensions, dimensional tolerances, duct connections, method or details of motor attachment, and other information

necessary to install, use, and maintain the fan shall be furnished to the owner and included in the documentation. The drawings shall also show the recommended motor, belts (if any), couplings, drive units, materials of construction, protective coatings, and lubricants.

5.7.5 Documentation. A report giving a description and results of qualification tests shall be furnished to the owner. The report shall include all calculations and descriptions of any analytical or mathematical modeling techniques, a description of any computer codes used with reference to computer code validation documentation, or other tests made in conjunction with the certification or qualification of the fan or fan assembly.

5.8 Fan Drives

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

Motors shall be of the type specified for the intended service. The operating characteristics to be specified shall be: voltage, frequency, operating environment including total radiation does and maximum dose rate anticipated, environmental temperature, and any identifiable special considerations such as abnormal pressures or pressure transient conditions.

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

Bearings shall be rolling-element type and shall require lubrication no more frequently than annually under constant, normal operating conditions. Bearings shall be rated in accordance with the Anti-Friction Bearing Manufacturers' Association standard for the minimum life specified. Lubricants shall be satisfactory for the environmental conditions specified in para. 4.2.

Motors shall be equipped with thermal overload protection. Provisions to indicate bearings and winding temperatures, vibration limit switches and heaters should be considered.

Motors shall be equipped with terminal boxes of sufficient size to accommodate both motor and line leads without severe distortion of either set which might impose excess stress on the wire insulation. Terminal boxes shall be gasketed to prevent inleakage of the surrounding environment. Separate terminal boxes shall be provided for accessory equipment and instrumentation connections. All connections shall be made by the mechanical method specified. All connections shall be clearly marked or labeled to identify correct function.

Motors shall be eq[illegible] with eyes, lugs, or other lifting provisions.

Noise level shall be determined in accordance with IEEE 85

Motor nameplates shall have, as a minimum, the information specif[illegible] NEMA MG-1.

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

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

5.8.3 Drawings and Documentation. Certified motor data sheets and dimension drawings showing major dimensions, dimensional tolerances, base or mounting dimensions, and other data needed for installation of the motor shall be furnished to the owner. Documentation specified in the IEEE standard cited in para. 5.8.2 shall also be furnished for ESF system motors.

5.9 Dampers

5.9.1 Classification. Dampers for nuclear air treatment systems, are classified by function, configuration type, construction class, and leakage class as follows.

5.9.1.1 Functions

(*a*) *Flow Control.* Varying or maintaining a flow within a nuclear air treatment system in response to a signal.

(*b*) *Pressure Control.* Varying or maintaining a pressure within a nuclear air treatment system or a space served by same in response to a signal. Also, varying or maintaining a differential pressure between parts of a nuclear air treatment system or between spaces in response to a signal.

(*c*) *Balancing*. Fixing the position of one or more dampers to establish flow or pressure relationship in a nuclear air treatment system.

(*d*) *Shutoff*. Stopping flow through some portion of a nuclear air treatment system.

(*e*) *Isolation*. Sealing a system or a portion of a system from selected flow paths.

(*f*) *Backdr... Prevention*. Preventing reversal of flow.

(*g*) *Press... ...f*. Limiting differential pressures across a du... ...g, or building wall to a predetermined value.

5.9.1.2 Configurations

(*a*) *Parallel Blade Damper*. A multiblade damper having blades which rotate in the same direction (see AMCA 500).

(*1*) With centrally pivoted balanced blades.

(*2*) With eccentrically pivoted or edge-pivoted blades.

(*b*) *Opposed Blade Damper*. A multiblade damper having blades which rotate in opposite directions (see AMCA 500).

(*c*) *Butterfly Valve*. A valve with one centrally pivoted balanced blade, designed for high pressure (25 psi minimum rating) and which meets the requirements of Construction Class A.

(*d*) *Single Blade Damper*. A damper having one blade.

(*1*) With a centrally pivoted balanced blade.

(*2*) With an eccentrically pivoted or edge-pivoted blade.

(*e*) *Wing Blade Damper*. A damper with two blades eccentrically pivoted or pivoted from a central post.

(*f*) *Poppet Damper*. A single blade damper with linear blade motion which is always perpendicular to the seat.

(*g*) *Slide Gate Damper*. A damper with one or two blades which move in, and are supported by, parallel guides.

5.9.1.3 Construction

(*a*) Class A meets ANSI B31.1.

(*b*) Class B meets para. 5.9.3.2.

5.9.1.4 Leakage Class

(*a*) Class I, bubble tight as determined by the test of para. 5.9.7.3.

(*b*) Class II, Maximum leakage as specified in Table 5-3.

(*c*) Class III, Maximum leakage as specified in Table 5-3.

(*d*) Class IV, leakage not a consideration.

5.9.2 Design Considerations. The following supplemental parameters shall be considered for each damper when establishing design requirements in addition to those delineated in para. 4.2:

(*a*) function of damper

(*b*) configuration

(*c*) construction classification

(*d*) leakage classification

(*e*) dimensions and space required for installation and service

(*f*) maximum pressure differential across closed damper

(*g*) maximum pressure drop across wide-open damper at rated airflow, in. w.g.

(*h*) air stream and ambient temperature range

(*i*) normal operating position of blade(s)

(*j*) damper orientation (horizontal or vertical) and method of mounting and direction of airflow

(*k*) blade orientation relative to frame of damper

(*l*) failure position

(*m*) operator type, power source

(*n*) maximum closure or opening time

(*o*) seismic requirements

(*p*) shaft sealing

(*q*) bearings and lubrication

(*r*) position indication, limit switches, and other options

Recommended damper minimum requirements for leakage and construction are given in Table 5-2. Maximum permissible damper leak rates for Classes II and III are shown in Table 5-3. Table 5-4 provides multipliers for obtaining maximum permissible leakage rates when dampers are tested at higher pressures.

5.9.3 Design Requirements. Dampers shall be constructed to meet the applicable design considerations within the following requirements.

5.9.3.1 Construction Class A. Construction Class A dampers meet the requirements for valves of ANSI/ASME B31.1.

5.9.3.2 Construction Class B. Construction Class B dampers shall be industrial quality construction: all parts, including frame, blades, pivots, shafts, bearings, linkages, and operators, shall be designed to the following minimum criteria.

(*a*) *Frame*. Frames shall be rolled, formed, or fabricated into a channel shape having a minimum width of 4 in., minimum flange height of 1½ in., and a minimum thickness of ⅛ in.

Frame deflection under design loadings shall not exceed 1/360 of the span in any direction.

TABLE 5-2 DAMPER CLASSIFICATION FOR CONSTRUCTION AND LEAKAGE

Function of Damper [Note (1)]	Construction Class [Note (2)]	Leakage Class [Note (3)]
Flow control	B	III
Pressure control	B	III
Balancing	B	IV
Shutoff		
(a) Contaminated air stream	A,B	I
(b) Noncontaminated air stream [Note (4)]	B	II
Isolation		
(a) Contaminated air stream	A,B	I
(b) Noncontaminated air stream [Note (4)]	B	II
Backdraft prevention		
(a) Contaminated air stream	B,A	I,II
(b) Noncontaminated air stream [Note (4)]	B	II
Pressure relief	B	II

NOTES:
(1) Where a damper serves more than one function, for example, flow control and shutoff, then the more stringent leak class governs.
(2) Refer to para. 5.9.1.2.
(3) Refer to para. 5.9.1.4.
(4) Where the calculated biological effects on complete damper failure are within governmental guidelines for continuous exposure, the air stream may be considered noncontaminated.

TABLE 5-3 MAXIMUM PERMISSIBLE DAMPER LEAK RATE, CLASS II AND III

Damper Blade Length or Diameter, in.	Maximum Permissible Leak Rate scfm/sq ft of Damper Face Area, at 1 in. w.g. Differential Pressure [Note (1)]	
	Leakage Class II	Leakage Class III
12	15	60
24	10	40
36	8	32
48	8	32

NOTE:
(1) Interpolation may be used for other blade lengths. Extrapolation is not recommended.

TABLE 5-4 MULTIPLYING FACTORS FOR OBTAINING MAXIMUM PERMISSIBLE LEAKAGE RATES AT HIGHER PRESSURES

Differential Pressure, in. w.g.	Multiplier [Note (1)]
2	1.4
3	1.7
4	2.0
5	2.2
6	2.4
7	2.6
8	2.8
9	3.0
10	3.2
11	3.3
12	3.5

NOTE:
(1) Multiplier = (differential pressure, in. w.g.)$^{1/2}$ which is applied to leakage noted in Table 5-3.

Duct-mounted dampers should have predrilled mounting flanges, and should be designed for mounting between flanged sections of ductwork. Balancing dampers may be designed for flanged or slip-in mounting.

(*b*) *Blade and Shaft.* Blade edge and shaft deflection shall not exceed 1/360 of span or 1/4 in., whichever is less, under the forces produced by operation of the damper at 1.5 times the design conditions for flow and pressure, and shall not cause the leakage criteria to be exceeded. Shafts shall be solid and extend the full blade length with minimum diameters of 3/4 in., except dampers smaller than 19 in. by 19 in. may be designed with minimum shaft diameter of 1/2 in. Blades shall be welded or through bolted to the shaft in such a manner that the integrity of the attachment can be verified.

Minimum blade thickness shall be 16 gage (0.059 in.) and 18 gage (0.047 in.) for single and double thickness steel blades, respectively.

Blade and edge seals shall be radiation and corrosion resistant.

(*c*) *Linkage.* Linkage should be located outside of the air stream, and component design shall include at least the following minimum requirements.

(*1*) Brackets, arms, and levers shall be of sufficient length and stiffness to provide stable operation of the damper blades without flutter or binding, at all blade positions.

(*2*) The linkage system shall be designed to deliver sufficient torque to each blade to properly set the seals of each and every blade.

(*3*) All linkage components shall be designed to transmit the required torque without exceeding the maximum stresses listed in para. 5.10.3.3. The required torque shall be defined as twice that portion of the damper torque the component is expected to transmit or the maximum actuator torque capability when the component may be required to transmit the full torque capability of the actuator.

(*d*) *Bearings.* Bearings shall be flange-mounted, lubricant impregnated, sintered bronze type or rolling element type for temperatures of 200°F or less. Dampers which must be operable in temperatures exceeding 200°F shall have external rolling element type bearings. All rolling element bearings shall be provided with grease fitting for lubrication. Bearings for vertically oriented blades shall be designed for thrust loads.

(*e*) *Stress.* Allowable stress for frames, blades, shafts, and linkage shall be in accordance with para. 5.10.3.3.

5.9.4 Welding. Welding of Construction Class A dampers shall comply with the requirements of ANSI/ASME B31.1. Welding of Construction Class B dampers shall comply with para. 7.3.

5.9.5 Operators. Operators should be located outside of the air stream and should be factory-mounted by the damper manufacturer. Operator torque requirements shall be specified by the damper manufacturer. Operators shall be designed to provide a minimum of 1.5 times the torque to meet specified maximum leak rate requirements or dynamic requirements, whichever are greater. Electrically powered operators, solenoid valves, and limit switches used in ESF systems shall be qualified to meet the requirements of IEEE 323 and IEEE 334. Positive locking devices shall be provided on balancing damper manual operators.

5.9.6 Position Indicators. Dampers with external rotating shafts shall have a mechanical position indicating arm and escutcheon plate; dampers which will be remotely indicated shall also have the necessary switches, relays, or other devices necessary to meet the requirements of para. 4.8. Electrical switches used for remote indication of the damper position in an ESF system which are specified to perform additional safety-related functions shall be required to meet the requirements of IEEE 323.

5.9.7 Tests

5.9.7.1 Qualification Tests. Flow characteristic and pressure drop for dampers shall be

determined in accordance with AMCA 500. Leakage rates for Leakage Class I shall be determined by the method described in para. 5.9.7.3. Leakage rates for Leakage Classes II land III shall be determined in accordance with AMCA 500. Copies of test reports for Leakage Classes I and II shall be furnished to the owner; copies of test reports for Leakage Class III shall be furnished to the owner when specified. Listing of Leakage Class II and III dampers in the Directory of Products Licensed to Bear the AMCA Certified Rating Seal, current edition, shall be evidence of meeting the qualification test requirements.

5.9.7.2 Shop Tests. Each damper (except manual balancing dampers) and its accessories shall be cycled at least 10 times from the full-open to the full-closed position to check the free operation of all parts and correct adjustment, positioning and seating of blades. On completion of cycling, the alignment shall be reworked, if necessary, to correct deficiencies before shipment. When shop leakage tests are required, they shall be performed after the cycling test and after the deficiencies have been corrected.

5.9.7.3 Bubble Test. The following test shall be conducted on each leakage Class I damper assembly. The damper assembly shall be bolted to a sealed chamber which is then pressurized to the specified pressure; there shall be no bubbles when tested with a soap solution in accordance with the Bubble Method of leak detection in ASME N510-1989.

5.9.8 Reports

The manufacturer shall furnish the following items to the owner:

(*a*) pressure drop, in. w.g., at design airflow capacity, with AMCA 500 apparatus setup figure;

(*b*) air leakage rate, cfm/ft^2, in full-closed position at specified pressure differential, and torque with AMCA 500 apparatus setup figure;

(*c*) maximum torque required by damper, ft-lb;

(*d*) operator torque available in position corresponding to maximum damper torque;

(*e*) shop leak test report when required;

(*f*) IEEE qualification reports on electric-powered operators and electric accessories.

All reports, data, and manuals furnished by the manufacturer shall be marked to show the manufacturer's name and damper identification.

5.9.9 Drawings. Certified Drawings showing the general arrangement and principal dimensions of the equipment including operators and accessories, and cross sections through the equipment shall be submitted to the owner. This shall include size, type, and location of all support connections.

All drawings shall properly dimension and locate the position of the operator in three directions to permit verification of adequate clearance and access for maintenance. Each drawing shall include all damper unique performance and design parameters such as failure mode, leakage, and torque requirements, etc.

Certified copies of manufacturer's outline prints of electrical control equipment, wiring diagrams, and schematic diagrams covering all electrical equipment that is factory-wired shall be submitted to the owner.

Drawings of mechanical components of control equipment (if any), including diagrammatic layouts of the control system shall also be submitted to the owner.

Drawings shall contain details of damper linkage, coupling between damper shaft and operator, attachment of damper blade to shaft and attachment of damper seals.

5.9.10 Preparation for Shipping. Dampers shall be prepared for shipment in accordance with para. 6.1.

5.9.11 Coatings. Coatings shall be in accordance with para. 5.6.4.

5.10 Ducts

5.10.1 General. The duct system shall be designed and constructed to meet the structural and pressure loading, and leaktightness of Section 4, while transporting possibly contaminated or treated air or gas stream from the point(s) of collection to the point(s) of intersection with plant ventilation system or discharge to a plant vent stack.

5.10.2 Design Considerations. The following supplemental parameters shall be considered for the duct system when establishing design requirements in addition to those delineated in paras. 4.2, 4.4, 4.5, and 4.6:

(*a*) duct size

(*b*) methods of support

(*c*) system operating pressure

5.10.3 Structural Requirements

5.10.3.1 General. Transverse joints and longitudinal seams shall be designed to retain their structural and sealing integrity when subject to the design loads.

5.10.3.2 Loadings. Stresses and deflections, or charts used to determine them, shall be based on calculations that consider the following loads where applicable.

(*a*) Differential pressure across the duct wall as affected by:

(*1*) maximum positive or negative pressure during all conditions of operation accounting for possible damper positions;

(*2*) pressure transients due to:

(*a*) pipe breaks, including both postulated Loss-of-Coolant Accident (LOCA) and lesser pipe break incidents which may cause external pressure rises and/or internal pressure pulses originating in sections of duct with openings in possible pipe break areas;

(*b*) extreme wind conditions, including tornado, hurricane;

(*c*) rapid damper, plenum door, or valve closure;

(*b*) duct weight, including insulation;

(*c*) duct sections with exposed top surfaces, which could be used as a walkway or crawl space, shall be capable of supporting a 250 lb weight concentrated midway between hangers;

(*d*) seismic forces;

(*e*) thermal expansion.

5.10.3.3 Stress. Allowable stress shall be 0.6 of the yield stress for loads encountered during normal plant operation and shutdown, and shall be 0.9 of the yield stress for combined loads which include the Safe Shutdown Earthquake and Design Basis Tornado.

5.10.3.4 Static Deflection. Allowable static deflections shall not exceed the following values:

(*a*) plate or sheet: 1/8 in. per ft of the maximum unsupported panel span in direction of airflow but not more than 3/4 in. relative to stiffeners;

(*b*) stiffeners and flange connections: 1/8 in. per ft of span but not more than 3/4 in;

(*c*) flange connection to dampers and fans: 1/360 of the span or 1/8 in. maximum.

5.10.4 Duct Construction. Transverse joints shall be gasketed flange, seal-welded flange, or butt-welded. Longitudinal seams shall be either all-welded, seal-welded mechanical, or in accordance with SMACNA — High Pressure Duct Construction Standards (Pittsburgh Lock or ASME Lock Seam) as required to meet structural and leaktightness requirements of paras. 5.10.3 and 4.14, respectively.

Mechanical lock seams, if used, must meet seismic structural design requirements. For all-welded joints, the minimum duct thickness shall be 18 gauge (0.047 in.) to ensure reliability of the weld. Turning vanes, where used, shall be reinforced and fastened to the duct elbow by welding to withstand the loading specified. Radius elbows, where used, should have a minimum centering radius of 1.0 times the width or diameter of the duct in the plane of the bend.

Placement and design of hangers and supports shall meet the stress criteria given in para. 5.10.3.3 when considering the sources of load given in para. 5.10.3.2.

Stiffeners shall be of sufficient size and quantity and welded to the duct to meet the structural requirements of para. 5.10.3. Stiffener materials shall be compatible with the material of the duct.

Supports shall be formed of fabricated structural members of a material compatible with the duct and stiffeners. Supports shall be securely fastened to building members by welding or by the use of bolts. Supports shall be fastened to the duct or stiffeners in accordance with the structural requirements.

Accessories shall be provided, as required, for the termination of the duct at outlets and inlets. Access doors shall be provided for inspection and maintenance of devices mounted inside the duct. Access doors shall be designed and installed to minimize leakage in accordance with the allowable leakage of para. 4.14.

Duct ends of flexible connectors shall be supported and positioned such that they do not tension the fabric.

5.10.5 Welding. Welding shall be in accordance with para. 7.3.

5.10.6 Materials. Ducts may be fabricated from stainless steel, carbon steel, galvanized steel sheet, plate, pipe, or rolled structural sections. Structural members may be fabricated from plain or galvanized carbon steel.

Stainless steel shall conform to ASTM A 666 or ASTM A 240. Carbon steel shall conform to ASTM A 36 for structural shapes or ASTM A 283 Grade C or D, or ASTM A 284 Grade C or D for plate. Carbon steel shall be hot-rolled pickled and oiled per ASTM A 570, or hot-rolled pickled and oiled, or cold-rolled per ASTM A 606 or A 607. Galvanized steel shall be in accordance with ASTM A 526 or A 527, coated to ASTM A 525, Coating Designation G90.

Use of nonmetallic materials in fabrication or installation of ducts and duct components shall, in addition to considerations of allowable stress, be based on resistance to deterioration from contaminants, heat,

pressure, and radiation, and shall not support combustion.

5.10.7 Coatings. Coatings shall be in accordance with para. 5.6.4.

5.10.8 Testing

5.10.8.1 Air Leakage Test. Except where excluded below, duct sections shall be subjected to air leak tests as described in ASME N510-1989 using the criteria given in para. 4.14.

A duct section need not be subjected to quantitative measurement of leakage if one of the following conditions is satisfied. However, a procedure to pressurize the system and locate and seal all audible leaks shall be applied.

(*a*) All ESF and non-ESF ducts serving the protected space, are located within the protected space, regardless of length.

(*b*) All negative pressure ESF and non-ESF ducts that pass through clean interspace.

(*c*) All positive pressure ESF and non-ESF ducts that pass through contaminated interspace with an MPC within the duct (C_d) less than or equal to 1.1 times the room MPC (C_r):

$$C_d \leq 1.1\, C_r \tag{2}$$

(*d*) Non-ESF and ESF positive pressure ducts that pass through a "Clean Interspace," and the effective concentration within the duct is less than 5 MPC.

(*e*) Non-ESF and ESF negative pressure ducts that pass through a contaminated interspace with an MPC (C_r) that is no greater than 1.1 times the MPC within the duct (C_d):

$$C_r \leq 1.1\, (C_d) \tag{3}$$

(*f*) All plant vent stacks or ducts that are located outside plant buildings and no high-level or mixed-mode release credit is required to meet offsite dose limits.

5.10.8.2 Structural Capability Test. A pressure test shall be performed on those portions of ducts and housings of once-through and recirculation nuclear air treatment systems which could be subjected to fan peak pressure due to closure of dampers on suction or discharge of fan. The test shall be performed at the structural capability pressure established in para. 4.6.6. When duct construction is greater than SMACNA-recommended duct construction for the maximum design pressure, then Structural Capability testing is not required. If required, ducts shall be tested in accordance with Structural Capability pressure test of ASME N510. Upon completion of the pressure test, ductwork exhibiting permanent distortion or breach of integrity shall be repaired or replaced. The pressure test shall be repeated after repairs until no permanent distortion or breach of integrity is observed.

5.10.9 Balancing. Prior to declaring the nuclear air treatment system operable, all duct systems shall be balanced to achieve design flow rate at the fan(s) and to maintain spaces at the required pressure differential. Upper and lower flow limits shall be established by owner such that design function of the system is maintained and equipment capabilities are not exceeded.

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

6.1 Preparation for Shipping

Adsorber cells (Type I or II) shall be prepared for shipping in accordance with applicable Sections of ANSI/ASME AG-1-1988. Prefilters and after filters shall be packaged in accordance with manufacturer's standard practice. Moisture separators, HEPA filters, heaters, Type III adsorbers, motors, fans, and dampers should be packaged in accordance with ANSI/ASME NQA-2-1986 (level as appropriate for each component) and shall be crated or skidded, or both, in a manner that will protect the item from physical damage and exposure to dirt, weather (including road spatter), and vibration during shipment and subsequent storage at the installation site for conditions in para. 4.2 of this Standard. Housing openings larger than 6 in. shall be covered with weather resistant panels thick enough, or reinforced sufficiently to limit deflection to less than one-half of the panel thickness under a pressure of 3 in. w.g. Panels shall be bolted to flanges or otherwise attached so they cannot be torn loose during shipping. Openings 6 in. in diameter and smaller shall be sealed or capped with plastic plugs. Unpainted carbon steel surfaces shall be coated with a rust inhibitor before packaging.

6.2 Receipt and Storage

HEPA filters and adsorbers should be stored in their original cartons in an environmentally controlled room. HEPA filters shall be oriented vertically with their pleats vertical, and be stacked no more than three

cartons (slightly over 6 ft) high unless intermediate bracing or flooring is provided to prevent the weight of the upper tier from bearing on the lower tier. Tray type (Type II) adsorber cells shall be stored horizontally and stacked no more than 5 high unless intermediate bracing or flooring is provided. Unless there is obvious damage to the cartons, HEPA filter and adsorber cartons should not be opened prior to use, or removed from shipping pallets or skids until immediately ready for installation. Adsorbent shall be packaged, and stored in accordance with ANSI/ASME AG-1 Section FE.

Where possible, items such as motors, dampers, heaters, etc., should be stored on racks or platforms, off the floor. While in storage, items should be checked periodically (weekly recommended) to ensure that wrappings are not disturbed. Storage areas should be uncluttered and permit easy access to items without the necessity of moving other items to get to them. An item-control procedure should be established in the storage area to ensure that items are not removed from the area without proper authority, and to prevent improper or rejected items from being installed in the system. Materials and components shall be moved and handled in a manner that does not damage the item or its packaging. If plugs, caps, or wrappings are removed for receiving inspection, they shall be replaced and positively sealed immediately upon completion of the inspection. Receiving and storage personnel shall be informed of the necessity of proper handling of all components, especially the HEPA filters and carbon adsorber cells.

7 INSTALLATION AND ERECTION

7.1 Drawings

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

7.2 Erection

All ducts, housings, fans, dampers, hangers, anchors, and services (electrical, steam, drains, etc.) shall be installed in strict conformance with the layout drawings; deviations of more than the design tolerance from the location in any plane from the position shown in the drawings shall be approved by the system designer or other responsible engineer, and shall be documented by "as-built drawings." Prefabricated duct subassemblies should be made as large as practicable to minimize field joints and field welding. Housings shall not be used to support other equipment of the facility for which it was not designed; field runs of pipe, duct, or conduit or other systems of the facility shall not be permitted to penetrate the housing. Internal components (filters, adsorbers, etc.) shall not be installed until immediately before the system is presented for testing, and shall not be removed from their cartons or crates until they are ready to be installed. The recommendations for handling and installation of HEPA filters given in Appendix C of ERDA 76-21 shall be complied with.

7.3 Welding

Welding procedures, welders, and welding operators shall be qualified in accordance with ANSI/ASME AG-1-1988. For material thickness greater than or equal to 0.125 in., AWS D1.1 or ASME Section IX shall be used. For material thickness less than 0.125 in., AWS D1.3 shall be used. Performance qualification test samples for materials used in filter housing pressure boundary construction shall be inspected with liquid penetrant or magnetic particles on both root and face surfaces in accordance with Section 6, Part 1 of AWS D1.1 or ASME Boiler and Pressure Vessel Code, Section V. Liquid penetrant used inside containment shall have a low chloride/fluoride content. Production welds shall be visually inspected in accordance with AWS D1.1, AWS D1.3, or ASME BPVC Section IX as applicable. Acceptance criteria for welds produced to AWS D1.1 standards shall be per NCIG-01. Acceptance criteria for welds produced per AWS D1.3 shall be in accordance with that standard. Acceptance criteria for welds produced per ASME BPVC Section IX shall be in accordance with the applicable ASME design section of the Code, except that visual acceptance criteria per NCIG-01 may be utilized for those components which are not required to be fabricated to a specific ASME design section of the Code.

7.4 Installation of HEPA Filters and Adsorbers

Installation personnel shall be instructed in the proper handling of the HEPA filters and carbon cell

adsorbers prior to the installation and clamping of the filters.

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

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

8 QUALITY ASSURANCE

8.1 Quality Assurance Program

The design organization, manufacturers of components, and constructors (including subcontractors) shall each establish and comply with a comprehensive quality assurance program and plan which meets the requirements of ANSI/ASME NQA-1-1986.

8.2 Summary of Required Documentation

As a minimum, the following shall be documented and submitted to the owner:

Documentation	Ref. Paragraph
Design Parameters	4.2
Maximum Operating Pressure	4.6
Test Pressure	4.6
Structural Capability Pressure	4.6
Test Cannister Qualification	4.11
Basis and Quantity for Maximum Allowable Leakage	4.14
HEPA Filter Qualification Report	5.1.3
Adsorber Drawings and Qualification Report	5.2.4/5.2.5
Prefilter and Postfilter Qualification Reports	5.4.1
Moisture Separator Drawings and Qualification Report	5.4.1/5.4.2
Heater Drawings and Qualification Report	5.5.2/5.5.4
Housing Drawings	5.6.2(g)
HEPA and Adsorber Clamping Device Drawings	5.6.3
Manifold Drawings	5.6.5.1
Factory Visual Inspection Reports	5.6.5.2
Factory Housing Leak Test Results	5.6.5.4
Factory Airflow Distribution Test Results	5.6.5.5
Factory Air-Aerosol Mixing Uniformity Test Results	5.6.5.6
Fan Drawings and Qualification Test Report	5.7.4/5.7.5
Fan Motor Drawings and Data Sheets	5.8.3
Damper Drawings and Reports	5.9.8
Test Acceptance Criteria	Table 9-1
System Layout Drawings	7.1

9 ACCEPTANCE TESTING

Acceptance tests shall be made in accordance with the procedures of ASME N510. It is recommended that prefilters be installed before fan is first turned on to protect filters and fans from construction debris, and the system fan(s) should be operated for at least 24 hr before installation of HEPA filters and adsorbers to clean up the worst of construction dirt (artificial resistance may have to be added during this operation to prevent overloading of the fan motor). Prefilters may have to be replaced after this. For personnel protection, personnel should not enter housing until fan has operated for a sufficient period of time to remove air entrainable debris. After installing the HEPA filters and adsorbers, the system heaters should be operated, where provided, to reduce, if necessary, the relative humidity of the air prior to making tests on the adsorbers.

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

The system designer (engineer) shall provide the acceptance criteria in Table 9-1 to the owner to incorporate in his acceptance and surveillance test procedure and project specification in accordance with ASME N510 requirements.

TABLE 9-1 SUMMARY OF CRITERIA FOR ACCEPTANCE TESTING

N510 Test	N510 Section	Information and Acceptance Criteria Provided by System Engineer	N509 Reference
Visual Inspection	5	None required from system engineer	5.6.5.2
Housing Leak Test	6	Test pressure(s) and tolerance	4.6.4
		Maximum allowable leakage at test pressure boundary to be tested	4.14, 4.2
Mounting Frame Leak Test	7	Identification of frames to be tested	5.6.5.3
		Test pressure(s) and tolerance	4.6.4
		Maximum allowable leakage	4.14
Duct Leak Test	6	Boundaries to be tested, applicable test pressure (and tolerance), and maximum allowable leakage	4.14, 4.2, 4.6.4
		Justification for duct test exceptions	5.10.8
Airflow Capacity and Distribution	8	Required minimum design airflow rate for each operating mode	4.14, 4.2
		Maximum allowable airflow rate	4.14, 4.2
		Design flow rate	4.2
		Minimum filter housing pressure drop with clean filter components and test pressure tolerance	4.2
		Maximum filter housing pressure drop with coincident dirty filter pressure drop and test pressure tolerance	4.2
Air-Aerosol Mixing Uniformity	9	Design airflow rate	4.2
In-Place HEPA Leak Test	10	Design airflow rate	4.2
		Maximum (dirty) and minimum (clean) filter bank pressure drop	4.2
		Maximum allowable penetration	PSAR/FSAR/Technical Specification
In-Place Adsorber Leak Test	11	Design airflow rate	4.2
		Maximum allowable penetration	PSAR/FSAR/Technical Specification

TABLE 9-1 SUMMARY OF CRITERIA FOR ACCEPTANCE TESTING (CONT'D)

N510 Test	N510 Section	Information and Acceptance Criteria Provided by System Engineer	N509 Reference
Duct Damper Bypass Test	12	Test boundary to be tested	4.14
		Design airflow rate	4.2
		Operating pressure differential across damper	4.6
		Maximum allowable penetration	4.14
System Bypass Test	13	Test boundary to be tested	4.14
		Design airflow rate	4.2
		Operating pressure differential	4.6
		Maximum allowable penetration	4.14
Air Heater Performance Test	14	Design airflow rate	4.2
		Design capacity	4.2
		Design temperature differential (leaving temperature − entering)	4.2
		Design current (amps), each circuit at design voltage	5.5
Laboratory Testing of Adsorbent	15	Design airflow rate	4.2
		Bed thickness	4.2, 5.2
		Design velocity	4.14, 5.2
		Minimum residence time	PSAR/FSAR/Technical Specification
		Test conditions	PSAR/FSAR/Technical Specification
		Maximum allowable penetration	PSAR/FSAR/Technical Specification

MANDATORY APPENDIX A
SAMPLING OF INSTALLED ADSORBENTS FOR SURVEILLANCE TESTING

(This Appendix is an integral part of ASME N509-1989, and is placed after the main text for convenience.)

A1 SCOPE

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

A representative sample is defined as one that has experienced flow within ± 20% of the average flow of the system (as confirmed by testing per Section 8 of ASME N510-1989). The detailed means to achieve this is left to the designer of each system, but detailed supporting data (either theoretical or empirical) shall be presented to substantiate that the flow is representative and the sample is, therefore, representative of the entire adsorber bank.

A2 DESIGN BASIS FOR SAMPLERS

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

A3 GENERAL TYPES OF SAMPLES (SAMPLERS)

A3.1 Individual Samplers

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

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

Each sampler shall have at least the following data attached:

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

The details of sampler design shall include a method to ensure that no bypass will occur, that the sampler(s) will be halide leak tested along with the main bank per Section 11 of ASME N510 as part of an integrated filter bank leak test, and that the flow path shall be sealed leaktight after the sampler is removed. Consideration should be given in the design to allow insertion of the sampler into a laboratory test apparatus for determination of methyl iodide penetration without disturbing any of the adsorbent.

A3.2 Test Tray Assemblies

A *test tray assembly* is an adsorber cell modified to provide for removal of a portion of the adsorbent (usually one-eighth) without disturbing the remainder of the adsorbent. Its use is acceptable as an alternative to individual samplers described in Section A.3.1 of this Appendix for obtaining representative samples.

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

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

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

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

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

A3.3 Sampling by Adsorber Cell Removal

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

A3.4 Slotted-Tube Sampling

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

NONMANDATORY APPENDIX B
Additional Guidance for Determination of Allowable Leakage

(This Appendix is not part of ASME N509-1989, and is included for information purposes only.)

B1 PURPOSE

The purpose of this Appendix B is to provide additional guidance for a system owner or designer to determine allowable leakage for nuclear air treatment systems that can be used to determine design, fabrication, installation, and test requirements.

This Appendix examines a method for determining allowable leakage based on health physics requirements (such as radioactivity concentration, maximum permissible concentration, and iodine protection factor) and provides typical example problems.

In addition, optional guidance is provided to assist an owner or system designer to determine additional leakage criteria based on prescribing a system effectiveness tolerance, or representative system installation quality.

B2 ALLOWABLE LEAKAGE BY HEALTH PHYSICS CRITERIA

B2.1 General

10 CFR 20, Appendix B, Table 1 sets limits on airborne radioactive concentrations in areas of the nuclear power plant in which plant personnel may be present.

This section also provides procedures to determine maximum duct outleakage based on the maximum permissible concentration (MPC) as determined by 10 CFR 20.103, paragraphs a and b.

B2.2 Procedure to Determine Allowable Leakage by MPC Method

(*a*) The following describes a procedure for determining allowable leakage in cfm/ft^2 of positive pressure duct surfaces in either normal or transient conditions:

(*1*) Determine approximate radioactivity concentration C_d in MPCs expected inside the duct.

(*2*) Determine approximate radioactivity concentration C_r in MPCs that can be expected in the room. For continuous occupancy C_r must be less than 1.

(*3*) Enter Fig. B-1 with C_r/C_d ratio and determine allowable unit leakage, cfm/ft^2 duct surface. The value taken from the chart will be applicable at the operating pressure.

Nomenclature

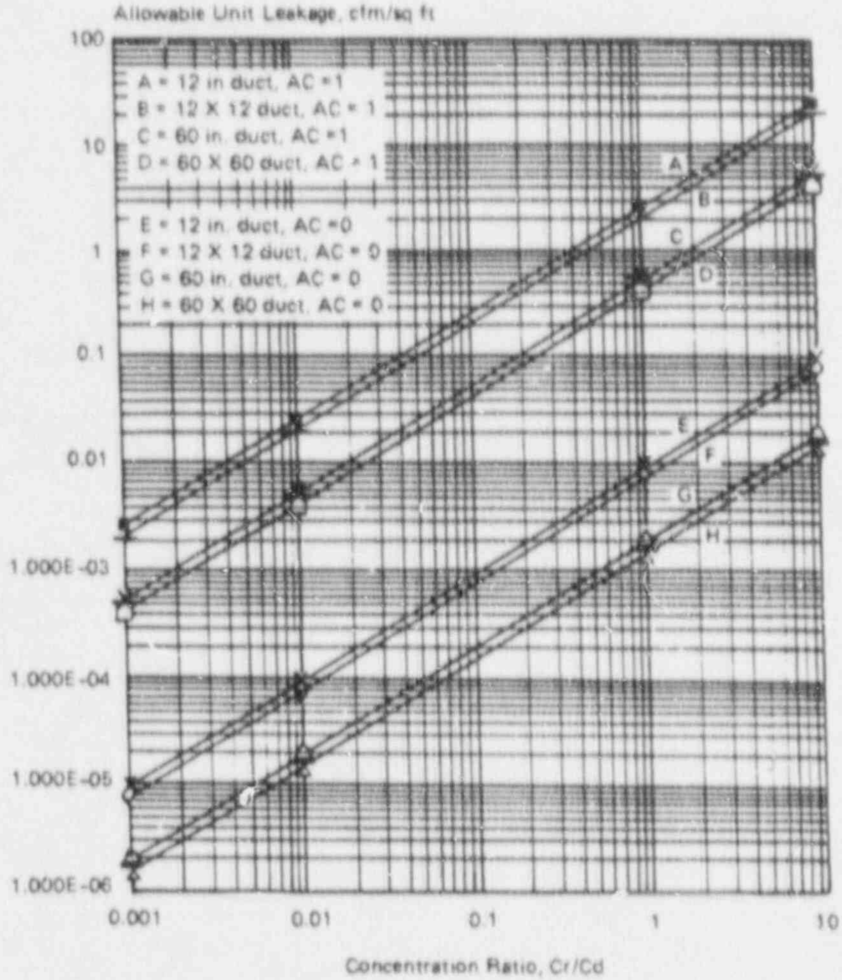
L = allowable duct leakage per unit surface area, cfm/ft^2
A = duct surface area, ft^2
h = duct height, in.
b = duct width, in.
ld = duct length, ft
D = duct diameter, in.
l = room length, ft
W = room width, ft
H = room height, ft
Vr = room volume, ft^3
$\overline{A}C$ = room ventilation rate, air changes per hr or $60\ qv/(H/w)$
qv = room ventilation rate, cfm
C_r = radioactivity concentration in room, μCi/cc
C_d = radioactivity concentration in duct, μCi/cc
G = contamination source term, μCi/hr
$T\frac{1}{2}$ = nuclide half life, hr
λ = radioactivity decay constant, hr^{-1}
MPC = maximum permissible concentrations

Duct to room contamination source term:

$$G = 1.7 \times 10^6\ C_d\ LA \qquad \text{(B1)}$$

Equilibrium concentration in the room which results from outleakage is:

$$C_r = \frac{G}{28320\ Vr\left(\lambda + \frac{60\ qv}{Vr}\right)} \qquad \text{(B2)}$$



GENERAL NOTES

(a) Based on eq. (B-1) in para. B.2.1(d) and a 25 sq ft room X 20 ft high. For other duct (and room) lengths and heights, prorate chart values by

$$L = L_{chart} \times \frac{\text{duct length}}{25} \times \frac{\text{room height}}{20}$$

(b) Contamination assumed to mix uniformly in space.

(c) I-131 assumed to be contaminating nuclide.

(d) Allowable unit leakage applies to maximum operating pressure *Pd* as defined in para. 4.6.3.

FIG. B-1 ALLOWABLE UNIT LEAKAGE FROM DUCT OR HOUSING TO OCCUPIED SPACE

Eqs. (B1) and (B2) conservatively assume no reduction in C_r due to exfiltration of air from a room at the duct leakage rate. Room volume is:

$$Vr = Hlw \qquad (B3)$$

For a rectangular duct, the surface area is:

$$A = \frac{ld}{6}(h + b) \qquad (B4)$$

where h and b are in inches.
Substituting Eqs. (B1), (B3), and (B4) into Eq. (B2) and transposing, the general equation for a rectangular duct is:

$$L = \frac{Hlw}{10\, ld\,(h + b)} \left(\frac{C_r}{C_d}\right)\left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad (B5)$$

If we assume that the duct cross section is square ($b = h$) and that the room is square ($w = l$), Eq. (B5) reduces to:

$$L = \frac{1}{20}\left(\frac{C_r}{C_d}\right) \frac{Hl^2}{hld} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad (B6)$$

If we further assume that the room height is 20 ft:

$$L = \left(\frac{C_r}{C_d}\right) \frac{l^2}{hld} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad (B7)$$

If the contaminating nuclide is I-131 ($T^{1/2}$ = 193.6 hr) and l = 25 ft and ld = 25 ft,

$$L = \left(\frac{C_r}{C_d}\right) \frac{25}{h} \left(0.00358 + \overline{AC}\right) \qquad (B8)$$

For a sealed room, $\overline{AC} = 0$

$$L = \frac{1}{11.17}\left(\frac{C_r}{C_d}\right)\frac{1}{h} \qquad (B9)$$

For a room with $\overline{AC} = 1$:

$$L = \left(\frac{C_r}{C_d}\right) \frac{25.09}{h} \qquad (B10)$$

For a round duct, Eq. (B4) is replaced by:

$$A = \pi \left(\frac{D}{12}\right) ld \qquad (B11)$$

and general Eq. (B5) becomes:

$$L = \frac{1}{15.7}\left(\frac{C_r}{C_d}\right) \frac{Hlw}{ldD} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad (B12)$$

Where N nuclides are present in the duct, it can be shown that:

$$L = \frac{Hlw}{10\, ld\,(h + b)} \; \frac{\sum_{n=1}^{N} Crn/MPCn}{\sum_{n=1}^{N} \frac{Cdn/MPCn}{0.693/T^{1/2}/2n + \overline{AC}}} \qquad (B13)$$

where
MPC = maximum permissible concentration, μCi/cc

In most nuclide groupings, the term (0.693/$T^{1/2}$ is neglible when compared to even minimal ventilation air change rates used in practice.
Hence, Eq. (B13) simplifies to:

$$L = \frac{hlw\,\overline{AC}}{10\, ld\,(h + b)} \; \frac{\Sigma\,(Crn/MPCn)}{\Sigma\,(Cdn/MPCn)} \qquad (B14)$$

Since $\sum_{n=1}^{N} Crn/MPCn$

is by 10 CFR 20, the equivalent concentration in MPCs, it can be seen that for a ventilated room Eq. (B14) and Eq. (B5) are essentially the same. It can be concluded that Eq. (B5) is applicable to multinuclide duct leakage as well. Finally, the ratio

$$\sum_{n=1}^{N} (Crn/MPCn)$$

represents the fraction of maximum permissible dose for the stated period of exposure — usually a 40 hr week.

Determine leak test requirements from para. 5.10.8. If testing is required, determine test method from ASME N510 and required test pressure. Adjust

allowable leak rate for test pressure in accordance with para. 4.12.

(b) For spaces required to be maintained at a negative pressure with respect to surrounding areas, the effect of inleakage into negative pressure ducts, outside of the space served, must be evaluated to determine the reduction in air exchange rate and corresponding increase in room MPC. The procedure is as follows.

(1) Determine source terms and parameters for event (e.g., pump seal leak rate, concentration of leakage fluid, space volume, required MPC).

(2) Determine minimum air exchange rate (airflow rate/room volume) required to maintain minimum MPC based on ALARA program.

(3) Determine minimum flow rate to maintain space at design negative pressure.

(4) Determine space design flow rate (this may be selected to ventilate space and maintain environmental conditions).

(5) Determine minimum tolerance [para. (1) above − para. (2) above or para. (4) above − para (3)].

(6) Determine surface area of duct under negative pressure outside space served.

(7) Divide para. (5) above by para. (6) above at allowable unit leak rate (cfm/ft^2) at maximum operating pressure.

(8) Determine leak test requirements from para. 5.10.8. If testing is required, determine test method from ASME N510 and required test pressure. Adjust leak rate for test pressure in accordance with para. 4.14.

(9) This procedure may not be required if the system is designed, tested, and adjusted such that the minimum design flow from the space served can be achieved and the fan sized to handle the minimum flow plus the infiltration.

(c) Sample Problems

(1) Given: a 30 in. × 12 in. × 50-ft-long duct section at the fan discharge represented by Scheme No. 7 of Fig. B5 has a rated flow of 10,000 cfm. The total surface area of the duct system is 1,050 ft^2. This duct section is under 4 in. w.g. positive pressure and passes through an occupied area 25 ft × 25 ft × 20 ft high where the C_r shall not exceed .32 MPC. The discharge for this ductwork is credited with high-level release. The air change rate in the surrounding room is at least 1 air change.

Determine allowable leakage based on health physics requirements.

Solution: If this same duct is exhausting a contaminated space with an effective radioactivity concentration of 1000 MPCs, it is assumed to have a concentration, C_d, of 100 MPC after passing through the filters. If the occupied space around the duct is to be limited to 0.32 MPC, $C_r/C_d = 0.32/100 = 0.0032$.

Solving Eq. (B1) of B.2.1(d)

$$L = \frac{(H)(1)(W)}{(10)1_d(h+b)}\left(\frac{C_r}{C_d}\right)\left(\frac{0.693}{T^{1/2}} + AC\right) \qquad \text{(B15)}$$

where $T^{1/2}$ = 193.6 hr

$$L = \frac{20\times 25\times 25}{10(50)\,(30+12)}\,(0.0032)\left(\frac{0.693}{T^{1/2}} + 1\right) \qquad \text{(B16)}$$

$$L = 0.0019 \text{ cfm/ft}^2 \text{ or } 0.002 \text{ cfm/ft}^2 \qquad \text{(B17)}$$

(2) Given: a cubicle containing a normally operating pump with a leak rate of 1 gal/hr at a concentration of 0.15 μCi/cc (see Fig. B-2). Determine:

(a) the required minimum room ventilation rate to maintain ⅓ MPC;

(b) allowable duct inleakage if exhaust fan is rated at 1500 cfm;

(c) unit leakage if duct system consists of 100 ft of 12 in. × 12 in. ductwork outside of cubicle.

Solution: Consider a case with the following parameters:

$$C_f = 0.15\ \mu\text{Ci/cc (I-131)}$$

allowable C_r = ⅓ MPC = ⅓ (9 × 10^{-9} μCi/cc) = 3 × 10^{-9} μCi/cc

PF = .0075 [reference NUREG-0017 (para. 2.2.5.2), Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from PWRs, April 1976]

$$qL = \frac{\text{gal}}{\text{hr}} = \frac{1\text{ gal}}{\text{hr}} \times \frac{\text{hr}}{60\text{ min}} \times 3785\,\frac{\text{cc}}{\text{gal}} = 63\,\frac{\text{cc}}{\text{min}} \qquad \text{(B18)}$$

To meet C_r under the above conditions,

$$Q_1 = QL \times C_f \times PF/C_r \qquad \text{(B19)}$$

$$= 63\,\frac{\text{cc}}{\text{min}} \times 0.15\,\frac{\mu\text{Ci}}{\text{cc}} \times .0075/3 \times 10^{-9}\ \mu\text{Ci/cc} \qquad \text{(B20)}$$

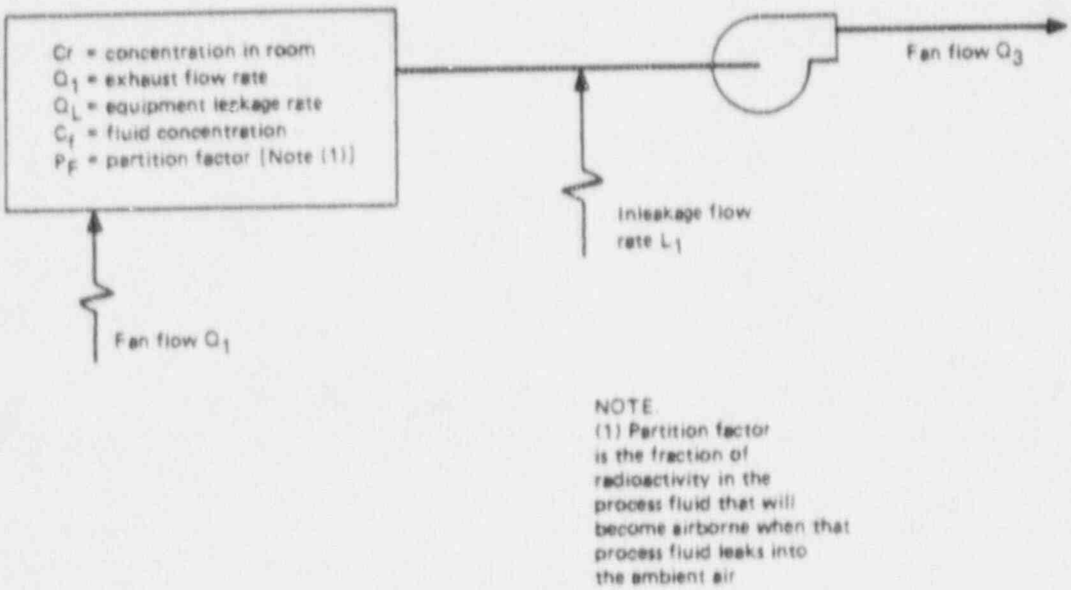


FIG. B-2 SYSTEM PARAMETERS

$$= 2.363 \times 10^7 \frac{cc}{min} \times \frac{ft^3}{30.48\ cm} = 834\ cfm \qquad (B21)$$

If the fan is sized to handle 1500 cfm for this system, then the allowable clean air inleakage is:

$$1500 - 834 = 666\ cfm \qquad (B22)$$

However, it is also a design criterion to maintain a linear air velocity of 50 ft/min while the 25 ft^2 door is open. (This criterion is set forth to maintain control of airborne radioactivity even though the door is open.) In order to meet this criterion, a flow rate of Q_i of 50 ft/min. × 25 ft^2 = 1250 cfm is required. The allowable clean air leakage is then 1500 − 1250 = 250 cfm.

The unit duct leakage is therefore equal to:

$$\frac{250\ cfm}{(duct\ length)(duct\ perimeter)} = \frac{250\ cfm}{(50)\ \frac{2(30) + 2(12)}{12}}$$

$$= 0.7 \frac{cfm}{ft^2} \qquad (B23)$$

B.2.3 Allowable Leakage by Iodine Protection Factor Reduction

(a) General. The Iodine Protection Factor, IPF, is used to quantify the protection offered to plant personnel by nuclear air treatment systems in protected areas of the nuclear facilities design to remain habitable during the following design basis accidents.

The location of the air cooling, ventilation and nuclear air treatment system components, whether inside or outside of the habitability envelope, will affect the value of the IPF. When portions of these systems are located outside the habitability envelope, the effect of duct inleakage or outleakage is a reduction of the IPF value.

(b) Determination of IPF

(1) All System Components Inside Habitability Envelope. The location of all components of the

habitability area air cooling, ventilation and nuclear air treatment systems within the habitability envelope is considered here as the ideal case, from a leakage standpoint, and the basis of evaluating duct leakage.

The IPF is defined as follows:

$$\text{IPF} = \frac{\text{dose}^{*} \text{ without protection}}{\text{dose with protection}} \quad \text{(B24)}$$

*due to radioactive iodine

The value of the IPF for the configuration shown by Fig. B-3 is determined by the following:

$$\text{IPF} = \frac{F_1 + \eta F_2 + F_3}{F_1(1-\eta) + F_3} \quad \text{(B25)}$$

$$\text{IPF} = \frac{F'_1 + \eta F_2 + F_3}{F'_1(1-\eta) + F_3} \quad \text{(B26)}$$

where

$$F'_1 = F_1 + (L_f - L_{o1}) \text{ (cfm)} \quad \text{(B27)}$$

$$F'_3 = F_5 + (L_{o2} - L_u) - F_3 \text{ (cfm)} \quad \text{(B28)}$$

$$F_1 = F_5 + (L_{o1} - L_{f1}) + (L_{o2} - L_u) - F_3 \text{ (cfm)} \quad \text{(B29)}$$

F_5 = control room boundary exfiltration, (cfm)
L_f = duct and housing inleakage with subsequent infiltration, cfm
L_{o1} = outleakage from positive pressure NATS ducts and housings, cfm
L_u = duct and housing inleakage without filtration, cfm
L_{o2} = duct and housing outleakage from positive pressure air conditioning system, cfm

NOTE: $(L_{o1} - L_{f1}) + (L_{o2} - L_u)$ represents the additional makeup air required in order to maintain Control Room Pressurization due to nuclear air treatment system and air conditioning ducts and housings leakage.

(c) Procedure to Determine Allowable Leakage by IPF Value Reduction. The following procedure quantifies the reduction of the effectiveness of the habitability area nuclear air treatment system due to duct leakage, in terms of IPF value reduction. By limiting the percent reduction of IPF value, with respect to duct leakage, the effectiveness of the nuclear air treatment system in limiting personnel dose is maintained.

(1) The determination of the nuclear air treatment system flow rate usually involves an iterative process because it is based on:

(a) the amount of airflow required to maintain a positive pressure differential (approximately 0.125 in. H_2O) across the control boundary, including leakage through the duct system; and

(b) the amount of filtered recirculation air required to achieve the required iodine protection factor (IPF).

(2) The air required to pressurize the control room is first calculated and an assumed quantity for duct leakage added to it. After duct and housing leakage calculations have been performed for the system configuration and layout, the original assumption is revised accordingly. The makeup airflow rate should be equal to the control room exfiltration air plus duct outleakage minus the duct inleakage and control room infiltration (if any).

(3) The filtered recirculation air quantity is determined by calculating the ratio of recirculated air to outside air required to meet a conservative IPF. The conservative IPF is determined by calculating the minimum acceptable IPF required to meet General Design Criterion 19 limits and multiplying this by a safety factor which will allow for a decrease in IPF due to duct leakage. The recirculation air quantity is then rechecked and revised as necessary when evaluating the iodine protection factor reduction due to duct leakage.

(4) After the outside air and recirculated air quantities are initially determined and the equipment located, the ductwork can be sized and routed. The pressure in the duct relative to the surrounding area must also be determined for the purpose of duct leakage calculations.

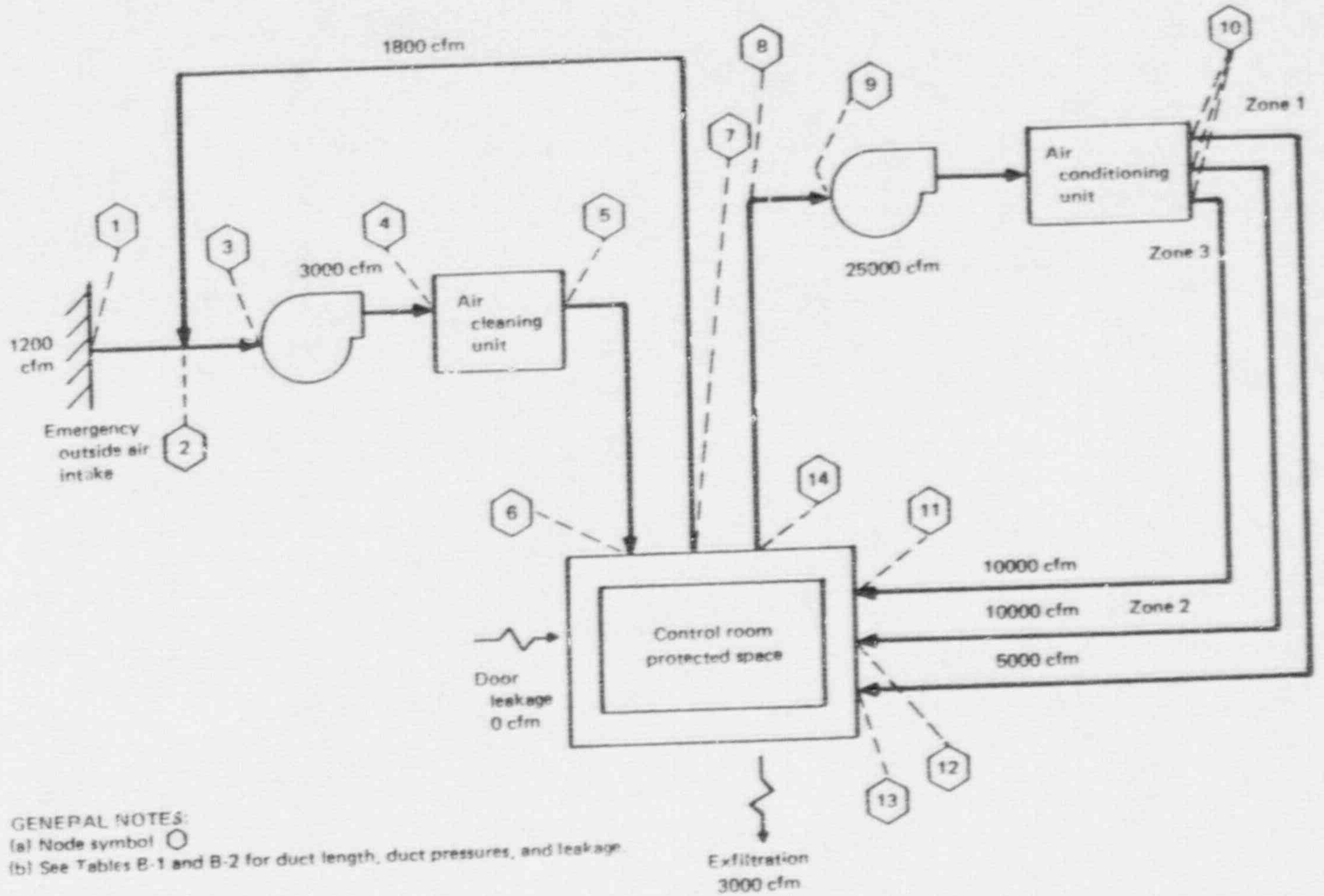
(5) Next, calculate duct surface areas outside of habitable zone, classify as positive pressure, filtered recirculation, unfiltered recirculation.

(6) Based on a parametric analysis, using the Eqs. (B25) through (B29), determine the maximum allowable leak rates for L_f, L_{o1}, L_{o2}, L_u such that the IPF is achieved.

(7) Determine unit leak rate by dividing allowable leak rates in para. (c)(6) above by surface areas in para. (c)(4) above. This is the unit leak rate at operating pressure.

(8) Determine leak test method to be used from ASME N510 and determine test pressure.

(9) Adjust allowable leak rate for test pressure in accordance with para. 4.14.



GENERAL NOTES:
(a) Node symbol ○
(b) See Tables B-1 and B-2 for duct length, duct pressures, and leakage.

FIG. B-3 CONTROL ROOM SYSTEM FLOW DIAGRAM

(d) Sample Problems

(1) Given: A control room complex is provided with a safety-related nuclear treatment system and a cooling system. Figure B-4 shows the configuration of the system. During accident conditions, the nuclear air treatment system is required to provide a minimum IPF value of 200.

The air-cleaning unit and the air cooling unit are located outside of the protected area (i.e., the habitability envelope) in a contaminated interspace. System parameters are given in Table B-1 and Table B-2.

Determine: Allowable leakage for L_{f1}, L_{o1}, L_{o2}, L_u to meet or exceed the minimum IPF.

Ductwork and Housing Leakage Classifications: From Fig. B-7, Scheme No. 19, the leakage classes for the recirculation air-cleaning unit are determined as Class II. Note, since the makeup air is not filtered prior to entering the return duct, the return duct is assigned leakage Class I.

The leakage classes of the air-conditioning unit are Leak Class I for the negative pressure return air duct, because any inleakage would be unfiltered, and Leak Class II for the positive pressure supply duct (assuming control room boundary pressure requirements can be maintained).

Solution: For this example, a nuclear air treatment system of 3000 cfm flow capacity has been selected based on 1200 cfm required for pressurization and a ratio of recirculation airflow to outside air flow of 1.5. This ratio has been selected in order to obtain an initial conservative IPF of 248. For this hypothetical case, a minimum acceptable IPF of 200 will be assumed. In addition to the nuclear air treatment system, the control room also requires a recirculating type air-conditioning system with an assumed capacity of 25,000 cfm (approximately 100 tons of cooling capacity). The exfiltration has been determined to be 1000 cfm maximum at 0.125 in. w.g.

The maximum allowable duct leakage that will satisfy the health physics requirements is determined for this example by evaluating the reduction in the iodine protection factor (IPF). The iodine protection factor is used to express the reduction in radioiodine concentration within the control room as a result of filtration and recirculation.

For this example, the IPF is determined assuming an unfiltered inleakage (through the control room boundary) of zero since all doors have airlock vestibules and a filter efficiency of 99%. Using Eq. (B12) gives:

$$IPF = \frac{1200 + (0.99)(1800) + 0}{(1 - 0.99)\,1200 + 0} = 248.5 \qquad (B30)$$

For this particular example, a minimum IPF of 200 is required in order to meet the dose requirements of General Design Criterion 19.

In this case, as long as there is no duct leakage, the minimum required IPF is exceeded. However, the IPF is reduced when the duct inleakage and outleakage are accounted for. This must, therefore, be evaluated to determine if the reduced IPF is still acceptable.

The surface area for the air cleaning duct and housing under a negative pressure which would experience infiltration with subsequent filtration L_f is:

Nodes	Surface Area
1-2	131
2-3	84
7-2	236
	451 ft^2

The surface area of the nuclear air treatment system under a positive pressure is:

Nodes	Surface Area
3-4	2[illegible]
4-5	842
5-6	283
	1153 ft^2

For the air-conditioning systems, the corresponding negative pressure area is:

Nodes	Surface Area
14-8	750
8-9	375
	1125 ft^2

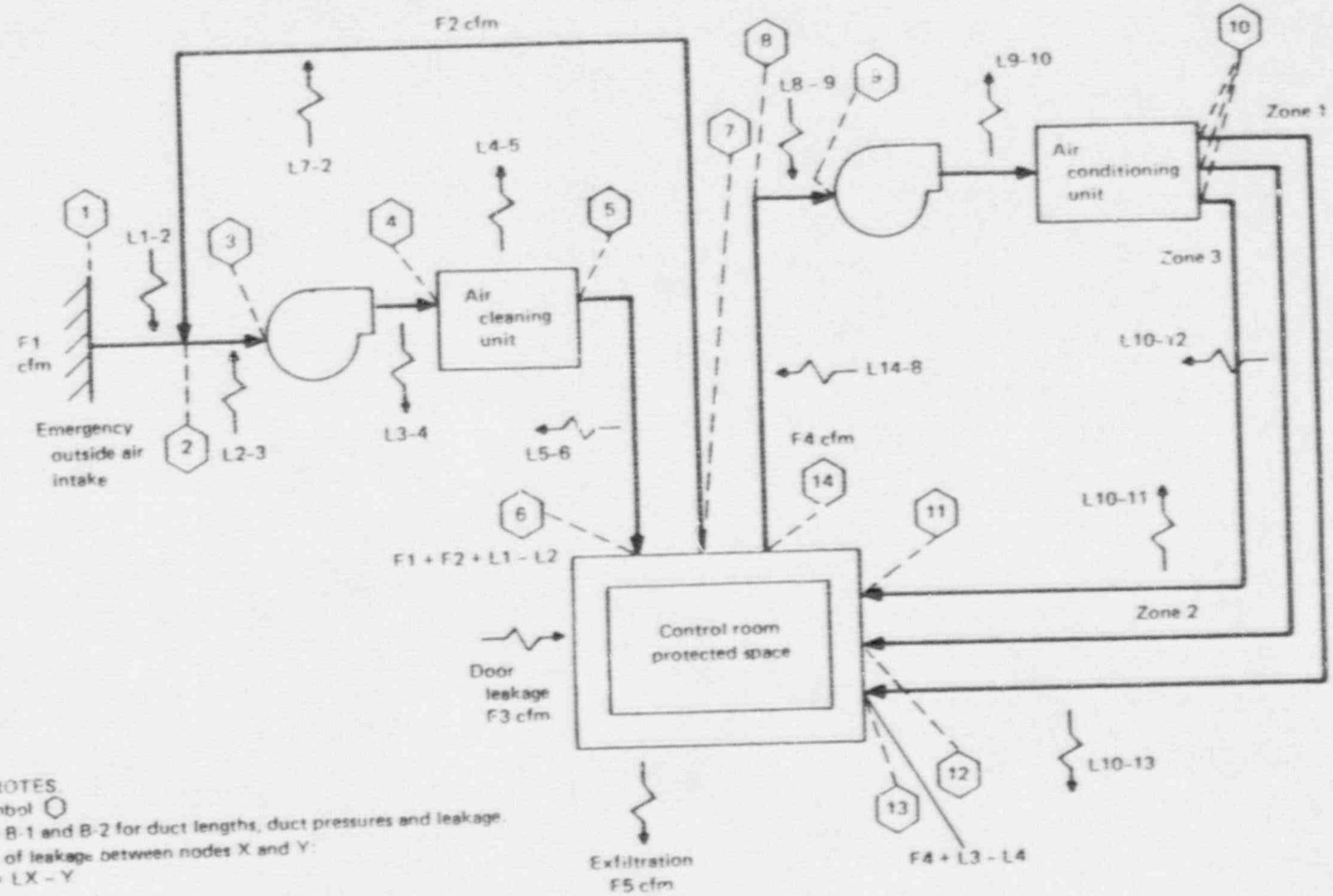
and under a positive pressure:

Nodes	Surface Area
9-10	376
10-11	400
10-12	400
10-13	250
	1426 ft^2

For the nuclear air treatment system we will assume, based on prior test experience and the type of duct construction used, that the air-cleaning unit leak rate, in the operating pressure range specified, will be 0.025 cfm/ft^2. This results in:

$$L_f = 451\ ft^2 \times 0.025\ cfm/ft^2 = 11.3\ cfm \qquad (B31)$$

$$L_{o1} = 1153\ ft^2 \times 0.025\ cfm/ft^2 = 28.8\ cfm \qquad (B32)$$



GENERAL NOTES

(a) Node symbol ⬡

(b) See Table B-1 and B-2 for duct lengths, duct pressures and leakage.

(c) Direction of leakage between nodes X and Y:
—∿→ LX – Y

FIG. B-4 CONTROL ROOM SYSTEM FLOW DIAGRAM WITH LEAKAGE PATHS

TABLE B-1 CONTROL ROOM NUCLEAR AIR TREATMENT SYSTEM PARAMETERS FOR LEAKAGE ANALYSIS

Nodes From–To	Duct Size	Duct Length, ft	Duct Surface Area, ft^2	Duct Pressure, in. w.g.	Leakage Class
1-2	10 in.	50	131	− 1.0	II
2-3	16 in.	20	84	− 2.0	II
3-4	22 in. × 12 in.	5	28	+ 10.0	I
4-5	3 ft 0 in. × 7 ft 0 in. [Note (1)]	40	842	+ 10.0	I
5-6	22 in. × 12 in.	50	283	2.0	II
7-2	12 in.	75	236	1.0	I

NOTE:
(1) Housing dimensions.

TABLE B-2 CONTROL ROOM AIR CONDITIONING SYSTEM PARAMETERS FOR LEAKAGE ANALYSIS

Nodes From–To	Duct Size	Duct Length, ft	Duct Area, ft^2	Duct Pressure, in. w.g.	Leakage Class
14-8	60 in. × 30 in.	50	750	− 2.0	I
8-9	60 in. × 30 in.	25	375	− 3.0	I
9-10	6 ft. 0 in. × 8 ft. 0 in. H [Note (1)]	10	376	+ 5.0	I
10-11	40 in. × 20 in.	40	400	+ 4.0	II
10-12	40 in. × 20 in.	40	400	+ 4.0	II
10-13	26 in. × 12 in.	40	250	+ 4.0	II

NOTE:
(1) Housing dimensions.

Nuclear air treatment system net leakage = $(L_{o1} - L_{f1}) = +17.5$ exfiltration.

For air-conditioning systems, assume the leak rate to be 0.07 cfm/ft^2:

$$L_u = 1125\ \text{ft}^2 \times 0.07\ \text{cfm/ft}^2 = 78.8\ \text{cfm} \quad \text{(B33)}$$

$$L_{o2} = 1426\ \text{ft}^2 \times 0.07\ \text{cfm/ft}^2 = 99.8\ \text{cfm} \quad \text{(B34)}$$

Net air-conditioning system leakage = $(L_{o2} - L_{o1}) = +21$ cfm exfiltration. Furthermore, with airlock vestibules $F_3 = 0$.

Inserting into Eqs. (B27) and (B28) gives:

$$F'_1 = F_1 + (L_f - L_{o1}) \quad \text{(B35)}$$

$$F'_1 = 1200 + (11.3 = 28.8) = 1182.5 \quad \text{(B36)}$$

$$F'_5 = F_5 + (L_{o2} - L_u) - F_3 \quad \text{(B37)}$$

$$F'_5 = 1000 + (99.8 - 78.8) - 0 = 1021 \quad \text{(B38)}$$

Using Eq. (B26):

$$\text{IPF} = \frac{1021 + (0.99)(1800) + 0}{(1182.5)(1 - 0.99) + 0} \quad \text{(B39)}$$

$$= 237$$

Since IPF is greater than the required IPF with margin, the duct leakage is acceptable.

Based on this analysis, the actual leakage from each duct segment and housing should be calculated based on actual operating pressure to determine actual allowable leakage. This value should then be corrected for test pressures to establish acceptance criteria for duct/housing leak testing.

Subsequently, if actual test results indicated that the inleakage was:

$L_f = 50$ cfm
$L_{o1} = 30$ cfm
$L_u = 200$ cfm
$L_{o2} = 50$ cfm

the IPF would be determined:

$$F'_1 = 1200 + (50 - 30) = 1220 \quad \text{(B40)}$$

$$F'_5 = 1000 + (50 - 200) = 850 \quad \text{(B41)}$$

$$\text{IPF} = \frac{850 + 0.99\,(1800)}{(1220)\,(.01)} = 215.7 \quad \text{(B42)}$$

which is still above the minimum IPF and still provides a margin.

B3 ADDITIONAL LEAKAGE CRITERIA

Additional leakage criteria may be developed by the owner or system designer to meet plant specific ALARA criteria at the owner's option. Additional criteria may take the form of specifying nuclear air treatment system effectiveness or system quality parameters. It is recommended that the bases for these additional criteria be documented to allow future evaluation of test data. Examples of criteria which could be established are as follows.

B3.1 Nuclear Air Treatment System Effectiveness

One approach to establishing values for allowable leakage rates based on nuclear air treatment system effectiveness is to provide arbitrary values for percent of nuclear air treatment system flow rate based on leakage classification (refer to para. B.4).

The values that have been historically used are shown in Table B-3. However, these rates may not be representative of actual system design margin since system design flow rates may be established due to non-air-cleaning requirements. For these cases, the procedure for establishing air-cleaning unit leakage rates should follow the format used in para. B.2.1(a)(2). Determine minimum requirements, establish flow rate tolerance and proportion across duct surface area.

B3.2 System Quality

There may be a desire to establish benchmark leakage rates for various leakage classes and/or types of construction in order to determine quality during the installation process.

The owner or system designer should establish the leak rate associated with the type of construction by previous test experience, calculation, or by a shop or field test at the beginning of the installation.

The owner or his designee shall randomly select sections of ducts or individual housings to leak test *in situ*. Selection of duct sections may be chosen based

TABLE B-3 MAXIMUM ALLOWABLE LEAKAGE[1] FOR AIR CLEANING EFFECTIVENESS (PERCENT OF RATED FLOW)

Leakage Class [Note (2)]	ESF			Non-ESF		
	Duct [Note (3)]	Housing	Total [Note (4)]	Duct [Note (3)]	Housing	Total [Note (4)]
I	0.10	0.10	...	0.50	0.10	0.6
II	1.00	0.20	1.2	5.00	1.00	6.0

NOTES:
(1) Leak rate at operating pressure
(2) Refer to Section B4 for configuration that determines leakage class. Leakage is apportioned to surface area by

$$L_S = \frac{a}{A} \times \frac{P \times Q}{100}$$

where
L_S = allowable leakage in duct section, scfm
P = allowable percent leakage
Q = system rated flow, cfm
a = surface area of the duct section, ft^2
A = surface area of the total system ductwork per leakage class, ft^2
$\frac{L_S}{a}$ = the allowable unit leakage by this criteria, cfm/ft^2
(3) All ducts under positive pressure which discharge into the plant stack for high level release credit shall be leakage Class I.
(4) Assumes housing surface area is 20% of duct surface area. Duct and housing leakages shall be adjusted for actual housing and duct surface area ratios, but the total percent leakage shall not exceed the sum of the listed percent leakages for duct and housing.

on ANSI/ASQC Z1.4 or other equivalent standard; however, this is not mandatory.

B4 NUCLEAR AIR TREATMENT SYSTEM CONFIGURATIONS AND LEAKAGE CLASSES

A nuclear air treatment system can be defined schematically in terms of three spaces and two components.

The three spaces (refer to para. 3 definitions) may be either exterior or interior and are:

(a) the contaminated space
(b) the protected space
(c) the interspace
  (1) contaminated
  (2) clean

The two components are:

(d) fan
(e) air-cleaning unit

All three of the above spaces represent possible locations for the different parts of the nuclear air treatment system. The contaminated and protected spaces also include the points of system origin and termination, respectively. The interspace refers to all other spaces — contaminated or clean — where the nuclear air treatment system or its parts may be located.

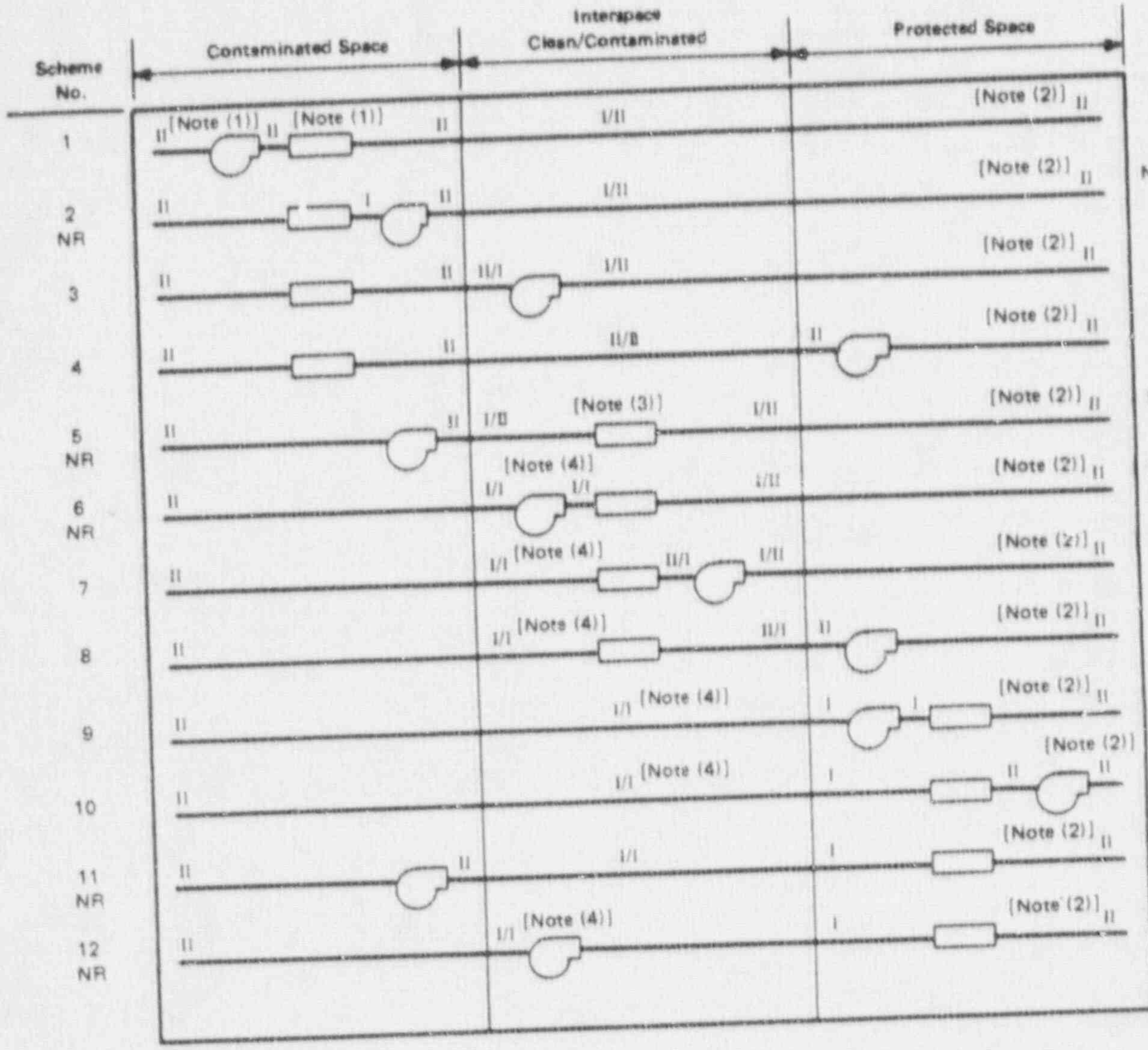
Examples of contaminated space/interspace/protected space arrangements are:

Contaminated Space	Interspace	Protected Space
Containment	Plant spaces	Offsite
Plant site	Equipment room	Control room
Secondary containment	Equipment room	Offsite

For recirculating systems, the contaminated space and protected space merge into one "contaminated and protected space."

Leakage Classes I and II have been assigned to the various sections of each nuclear air treatment system to represent the qualitative effect of leakage on the nuclear air treatment system function. Thus, Leakage Class II classification indicates that due to system configurations and location a higher leak rate may be allowable. Conversely, a Leak Class I classification indicates a more stringent leak rate is required.

Leakage Classes are noted on Figs. B-5, B-6, and B-7.



NOTES:

Air Cleaning Unit

Fan

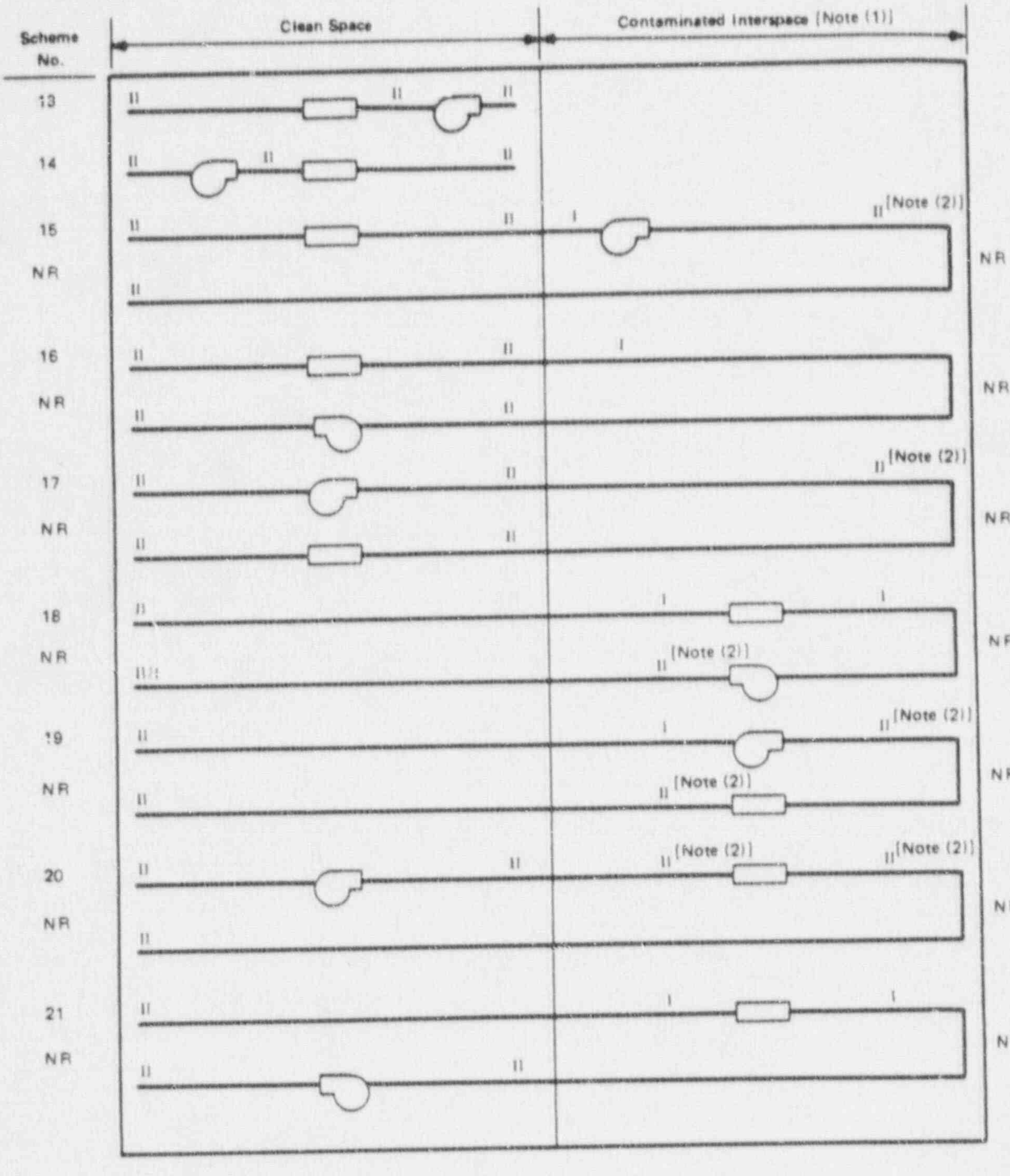
(1) Symbols –
NR -- Not Recommended

(2) All ducts under positive pressure which discharge into the plant stack for high level release credit shall be leakage Class I.

(3) Space classification is based on the relative concentration of the space with respect to the duct (e.g., *Contaminated Interspace* means concentration within space is greater than duct or housing at that point). Thus, as duct concentration changes due to filtration, the space classification will change in a given area.

(4) Noted duct section which pass through a Clean Interspace and which are under a negative pressure for all modes of operation may be leakage Class II.

FIG. B-5 SINGLE PASS AIR CLEANING SYSTEM CONFIGURATIONS

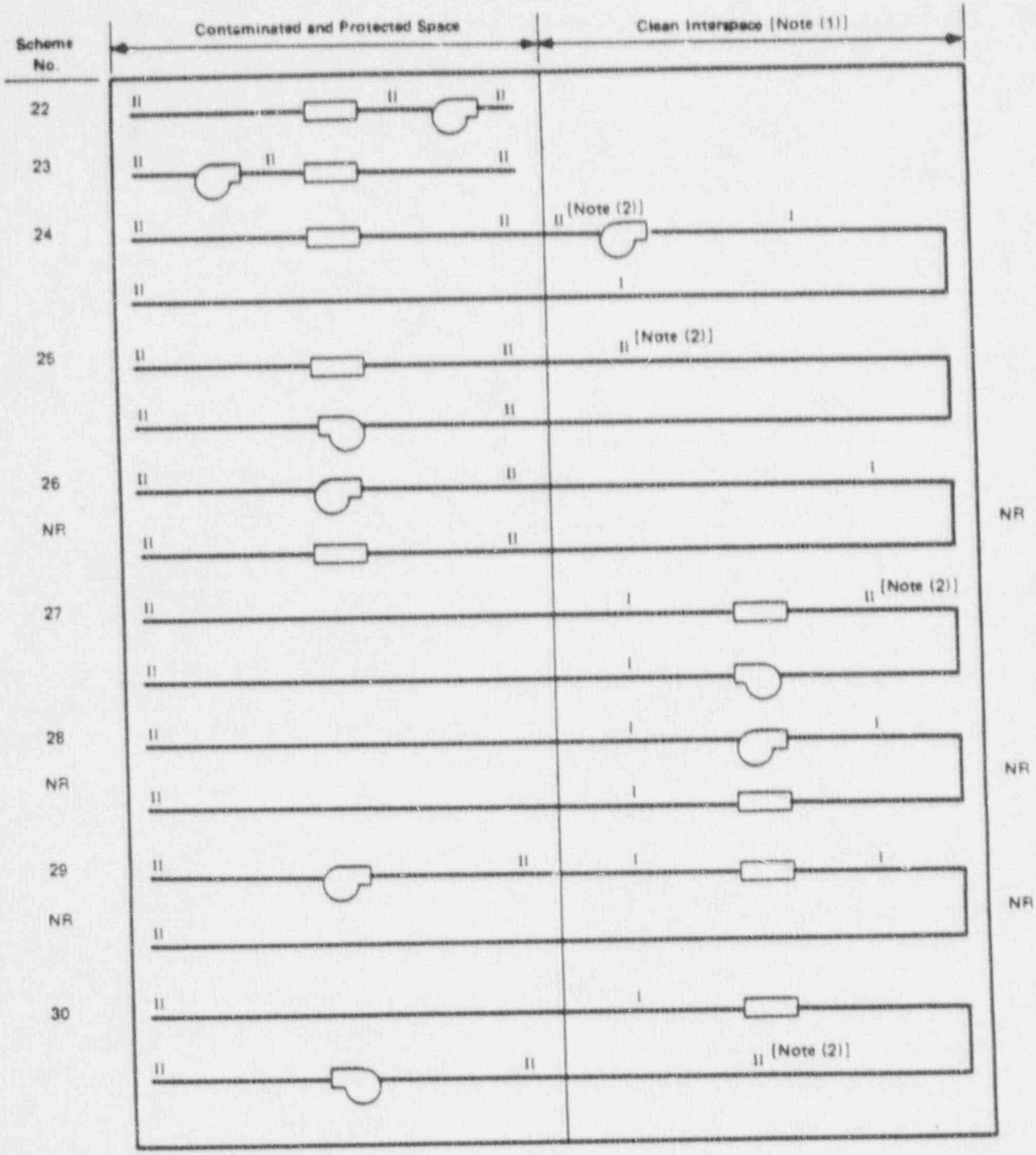


NOTES

(1) Contamination level of Fluid within ductwork < contamination level of interspace.

(2) Leak Class I shall be used if ductwork is under negative pressure with respect to interspace during normal or transient system operation.

FIG. B-6 RECIRCULATING AIR CLEANING SYSTEM CONFIGURATIONS — I



NOTES:
(1) Contamination level of Fluid within ductwork > > contamination level of interspace.
(2) Leakage Class I shall be used if ductwork is under positive pressure with respect to interspace during normal or transient system operation.

FIG. B-7 RECIRCULATING AIR CLEANING SYSTEM CONFIGURATIONS — II

NONMANDATORY
APPENDIX C
Manifold Design Guidelines

(This Appendix is not part of ASME N509-1989, and is included for information purposes only.)

C1 GENERAL

C1.1 Test manifolds discussed in this Appendix are those required for test agent injection and sampling to perform in-place aerosol tests per ASME N510-1989.

C2 MANIFOLD REQUIREMENTS FOR IN-PLACE TESTS

C2.1 Housing and frame leak tests usually do not require specific provision for testing; only simple threaded penetrations are needed.

C2.2 Determination of airflow rate and velocity distribution may require access ports for traverse measurements of airflow velocity on systems too small or too contaminated for entry of a person to take the necessary data. Specifically, there must be provision to measure the airflow rate which is best measured in a straight duct run on the basis of standard pitot tube traverse. If these conditions do not exist where the velocity is greater than 600 fpm, then the measurements should be taken downstream of a HEPA filter bank. This is the same location the airflow distribution test data is usually taken.

The ports shall provide sufficient access to allow at least 10 measurements to be taken evenly over the face of the HEPA filter bank. Systems with more than 10 filters will be large enough to allow entry unless unusual contamination restricts entry.

C2.3 Challenge/air mixing uniformity testing requires access similar to that required for airflow distribution. The difference is that the measurements must be taken upstream of the HEPA or adsorbent bank. Large systems usually allow entry for personnel to locate the sample lines by hand, but small or unusually contaminated systems must be tested using a remotely controlled traverse.

C2.4 The most common situation that requires initial preparation for manifold design is leak testing component banks in series. There are many possible configurations that create this situation but the most common is the series placement of components in a filter housing. HEPA-Carbon is the most common arrangement but, HEPA-HEPA, Carbon-Carbon, HEPA-Carbon-Carbon arrangements also may require the use of manifolds. Refer to Fig. C-1.

C2.5 Manifolds may be necessary in a housing without components in series. An example where an injection manifold is required to obtain uniform test agent distribution is a recirculation system with no inlet duct before the filter bank.

C2.6 Manifolds are required whenever injection of a test agent at a single point does not result in the required distribution of the agent over the inlet face of the filter bank required for the performance of a leak test or where sampling is required from an unmixed stream.

C3 ADDITIONAL REASONS FOR USE OF PERMANENTLY INSTALLED MANIFOLDS

C3.1 Permanently installed manifolds, which have passed ASME N510 acceptance testing, provide a quick and simple means to repeat leak tests.

C3.2 Alternate methods of testing when a single point sample cannot be used, including temporary manifolds, are more time consuming than using a permanently installed manifold system.

C3.3 Other methods require entering the air-cleaning unit to install a temporary manifold, take multiple samples, place a shroud, remove a component, etc. This not only takes time, but can be a personnel exposure and contamination control problem with a contaminated system.

C3.4 A permanently installed manifold system allows a bank leak test of the air-cleaning unit without turning the air-cleaning unit off or breaching the pressure boundary that could affect system operation.

C3.5 Properly designed temporary manifolds can be installed in a few minutes except for very large systems (where the time frame for any alternate procedure is equally extended). Once installed, and the access door closed, the time constraints for ALARA or system nonavailability is usually reduced.

C3.6 Properly designed and tested permanently or temporarily installed manifolds provide a more technically defensible test result than alternate methods.

C3.7 Manifolds, in general, require less training and technical depth for use than alternate methods.

C4 INJECTION MANIFOLDS

C4.1 An injection manifold is a device which is used to produce a uniform distribution of the injected test agent over the cross section of a housing to permit proper leak testing of a filter bank. The test agent must be uniform, within ± 20% of the average, across the face of the bank including frame-to-housing interface and confirmed by the air-aerosol mixing uniformity Test per Section 9 of ASME N510.

C4.2 The complexity in design and execution of an injection manifold varies greatly depending on the air-cleaning unit configuration. An injection manifold downstream of a Type III adsorber is relatively simple because the sample manifold will follow the adsorber slots and take advantage of the high velocity flow exiting the slots. Refer to Fig. C-2, Sheets 1-2.

On the other extreme, a HEPA-HEPA configuration may be very difficult because the air filter bank is at low velocity and usually laminar exiting the first HEPA. The distance between component banks affects the design significantly.

C4.3 DOP injection manifolds require larger diameter and additional design consideration than for R-11 manifolds. R-11 is a normally gas at ambient conditions so condensation and plateout is *usually* not a problem. As DOP aerosol is subject to plateout, condensation and agglomeration; the following recommendations are more critical. The design of DOP manifolds is based on experience.

C4.4 General Rules Appliable to All Injection Manifolds

C4.4.1 The total area of the exit holes is typically 1.25 times the cross section of the pipe which the holes are located.

C4.4.2 Headers should have a cross section 1.25 times the sum of the cross sections of all the branches. [Four branches each 1 in. (0.8 in^2) results in a header of (1.25)(4)(0.8 in^2) = 3.9 in^2 or 2¼ in. diameter header.]

C4.4.3 Paras. C.5.4.1 and C.5.4.2 are subject to allowances for standard drill and pipe dimensions. When compromise must be made it is better to err on the high side of hole or branch area.

C4.4.4 Valves should be used only to isolate branches. If possible it is better to avoid them because valve settings may change and require reverification of manifold design or adjustment.

C4.4.5 The low point of each branch should have a screw cap to allow the leg to be drained if necessary.

C4.4.6 Sharp radius changes of direction should be avoided. Compound bends are preferable to multiple elbows. When elbows are used, they should be kept to the minimum. Two 45 deg. elbows in series are better than one 90 deg. elbow.

C4.4.7 The ID of the manifold should be smooth and free from sharp edges, burrs, crevices.

C4.4.8 Existing high-velocity areas and/or turbulences (if any) within the air-cleaning unit should be used to enhance mixing and therefore simplify the manifold design.

C4.4.9 The inlet to the injection manifold should be at a location accessible for connecting the generator.

C4.4.10 The location of permanent manifolds should be checked for possible interference with component changeout and other maintenance access requirements.

C4.4.11 Manifold outlet holes should be oriented to take advantage of the flow path for mixing. Configurations that would subject the manifold holes to direct velocity pressure from the air flow should be avoided in all but the most exceptional circumstances. Holes should be on a staggered pattern, 90 deg. to each other, 45 deg. on the centerline. Refer to Figs. C-2 and C-3.

C4.5 The design of aerosol injection manifolds is dependent on the bank and housing configuration.

C4.5.1 All injection manifold designs need to be tested to assure meeting the Air/Aerosol Mixing Uniformity requirements of Section 9 of ASME N510.

C4.5.1.1 If adjustments are required in a manifold to pass the uniformity test, they should be permanent. This will eliminate a need to repeat the uniformity test each time a leak test is performed.

C4.5.1.2 Examples of permanent adjustments would be:

(*a*) drilling out holes to a larger diameter,

(*b*) closing (full or partial) holes with solder or weld metal,

(*c*) addition of holes,

(*d*) addition of orifice plates,

(*e*) addition of permanent baffles to manifold,

(*f*) basic change of design.

C5 SAMPLING MANIFOLDS

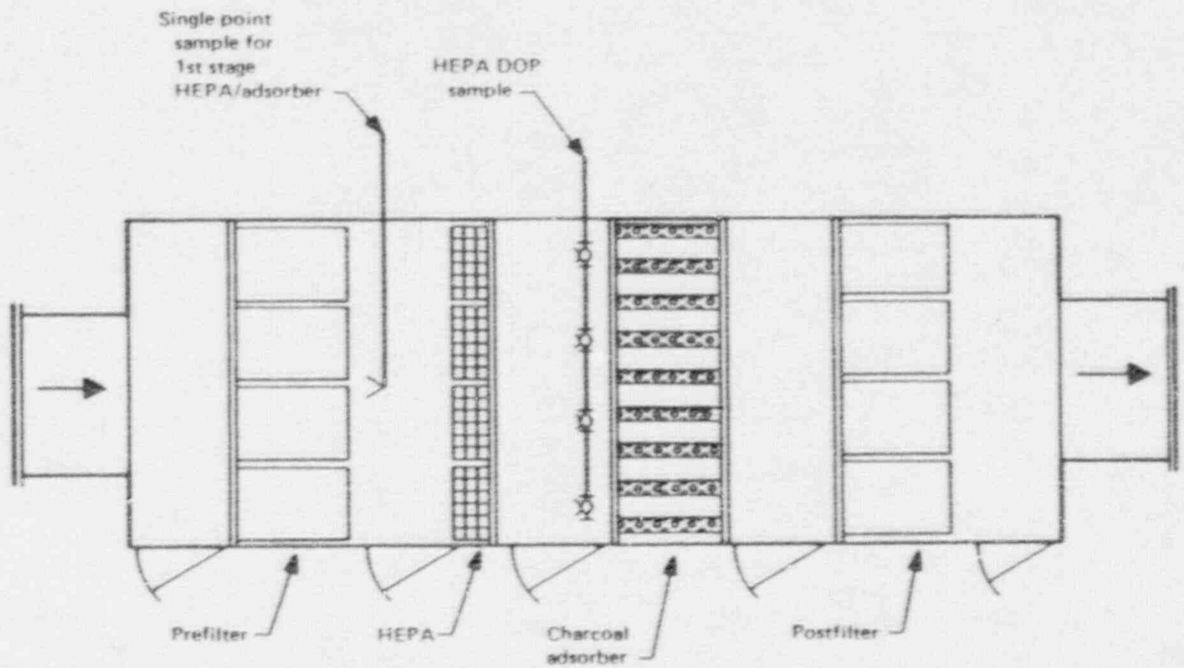
C5.1 In general, all the design points mentioned for injecting manifolds apply to sampling manifolds. The main difference is the low reduced concentration of the challenge agent, on the order of a fraction 1,000 to 100,000 less. This greatly reduces the problem of aerosol agglomeration and plateout. Further, the challenge agent is usually in thermal equilibrium with the airstream and manifold so condensation should not be a problem.

C5.2 A major point to stress is that the aerosol size used for ASME N510 testing contains particle size less than 5 microns; therefore, isokinetic sampling is not required. For gases, such as halide, isokinetic sampling is not required.

C5.3 A larger number of branches is required to ensure detecting a leak point; the diameters are based on airflow considerations.

C5.4 Even with small diameter sampling manifolds, the sampled volume is usually significant as far as the time needed to reach the detector element. Sample pumps in most detectors are sized for standard ¼ in. nylon lines; therefore, an auxiliary pump/blower is usually required to avoid delays in the sample from the furthest point reaching the detector. This delay is calculated from the internal volume and layout of the manifold and the capacity of the pump. The delay must be factored into the penetration calculations for adsorber beds.

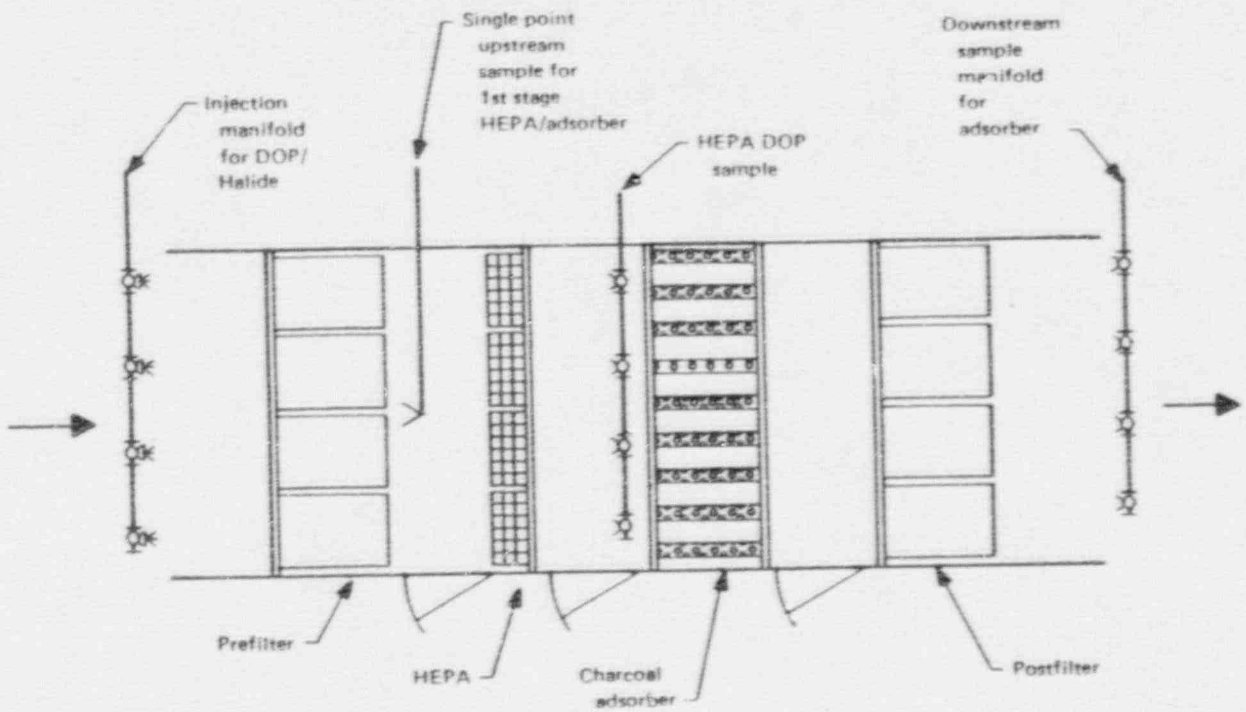
C5.5 As most detectors are designed to operate at or near ambient pressures, care is required in connecting the detector to an auxiliary blower system. It must not be "hard piped" to a closed system or subject to the positive output pressure of the blower. An open hole in the main sample line or a "tee" before the blower is preferred. The setup must not allow dilution air to enter the *detector* sample line (dilution of the sample past the takeoff point is not relevant). It must not allow velocity pressure from the auxiliary blower to change the pressure in the detector sample. The connection must be firm enough that no change will occur during the test.



GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct.
(b) Downstream DOP/Halide sample port may be located in outlet duct

Plan A – Ducted Inlet/Outlet
HEPA-Carbon Configuration

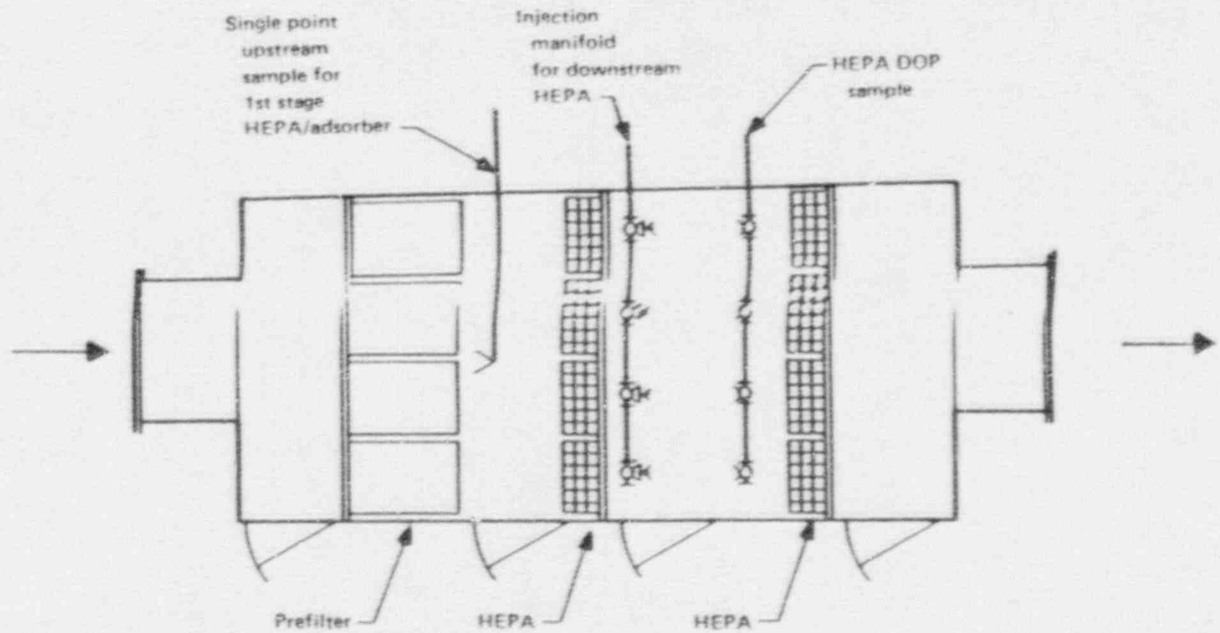
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS



GENERAL NOTES:
(a) If an inlet duct is provided the DOP/Halide injection can be located in the inlet duct.
(b) If an outlet duct is provided the downstream sample can be located in the outlet duct.

Plan B — Unducted Inlet/Outlet
HEPA-Carbon Configuration

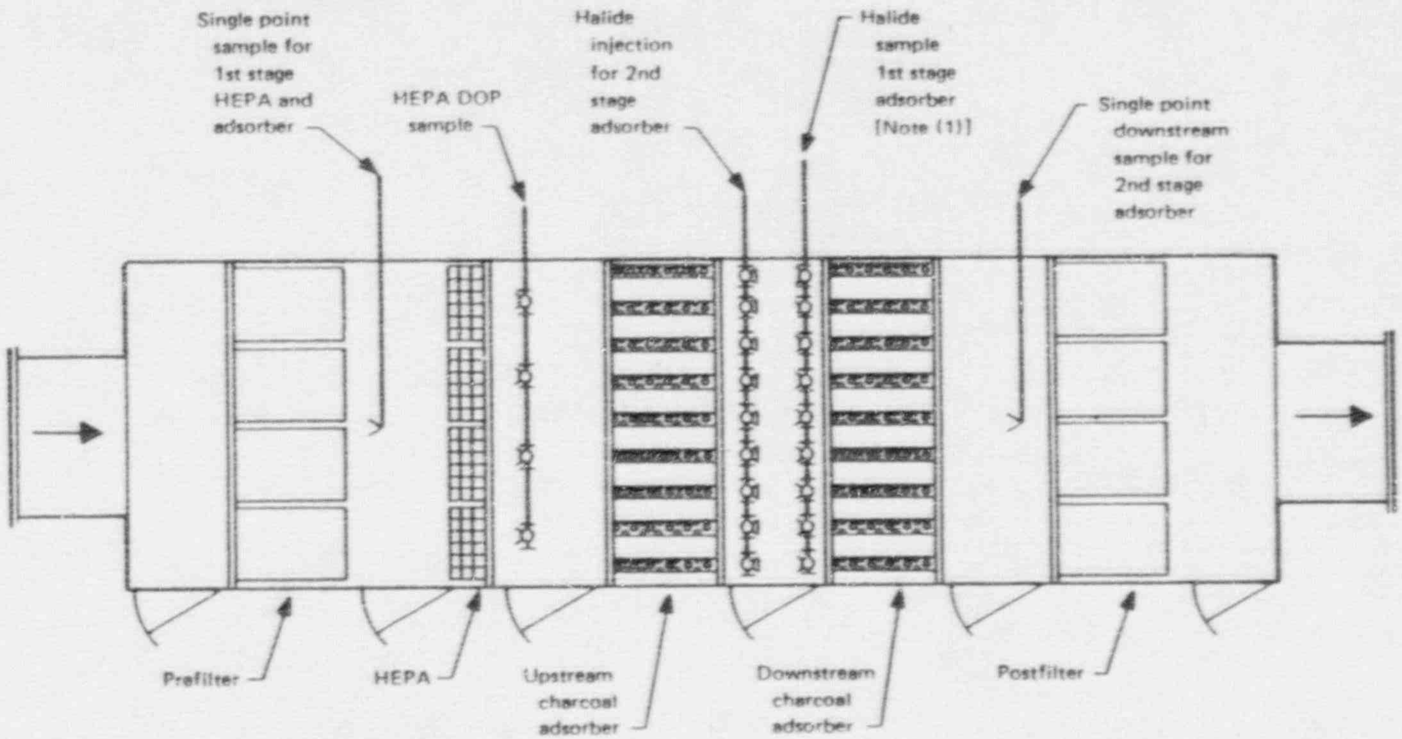
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)



GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct
(b) Downstream DOP/Halide sample point may be in outlet duct

Plan C -- Ducted Inlet/Outlet
HEPA-HEPA Configuration

FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)

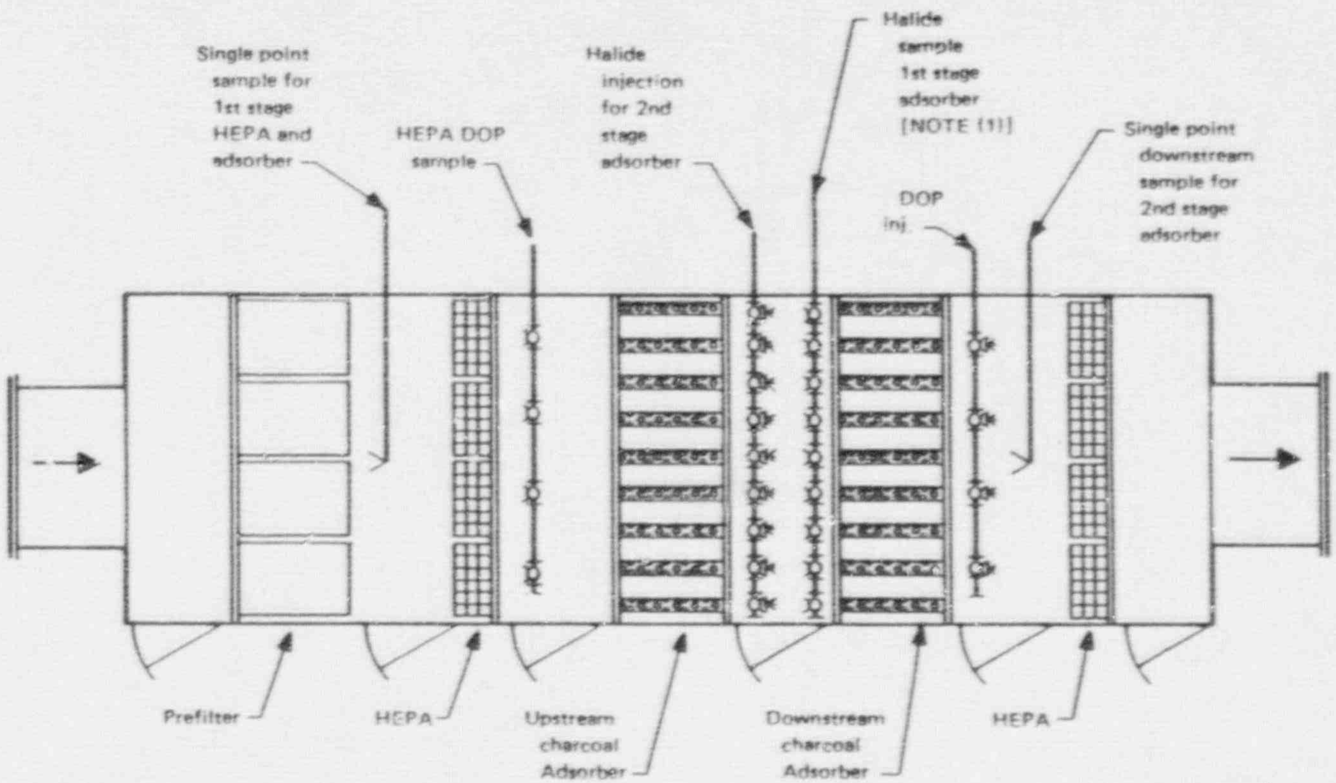


GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct
(b) Downstream DOP/Halide sample point may be in outlet duct

NOTE:
(1) 1st stage Halide sample point can be used for 2nd stage upstream sample in lieu of single point sample

Plan D — Ducted Inlet/Outlet
HEPA-Carbon-Carbon Configuration

FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)



GENERAL NOTES:

(a) Injection of DOP/Halide is in inlet duct

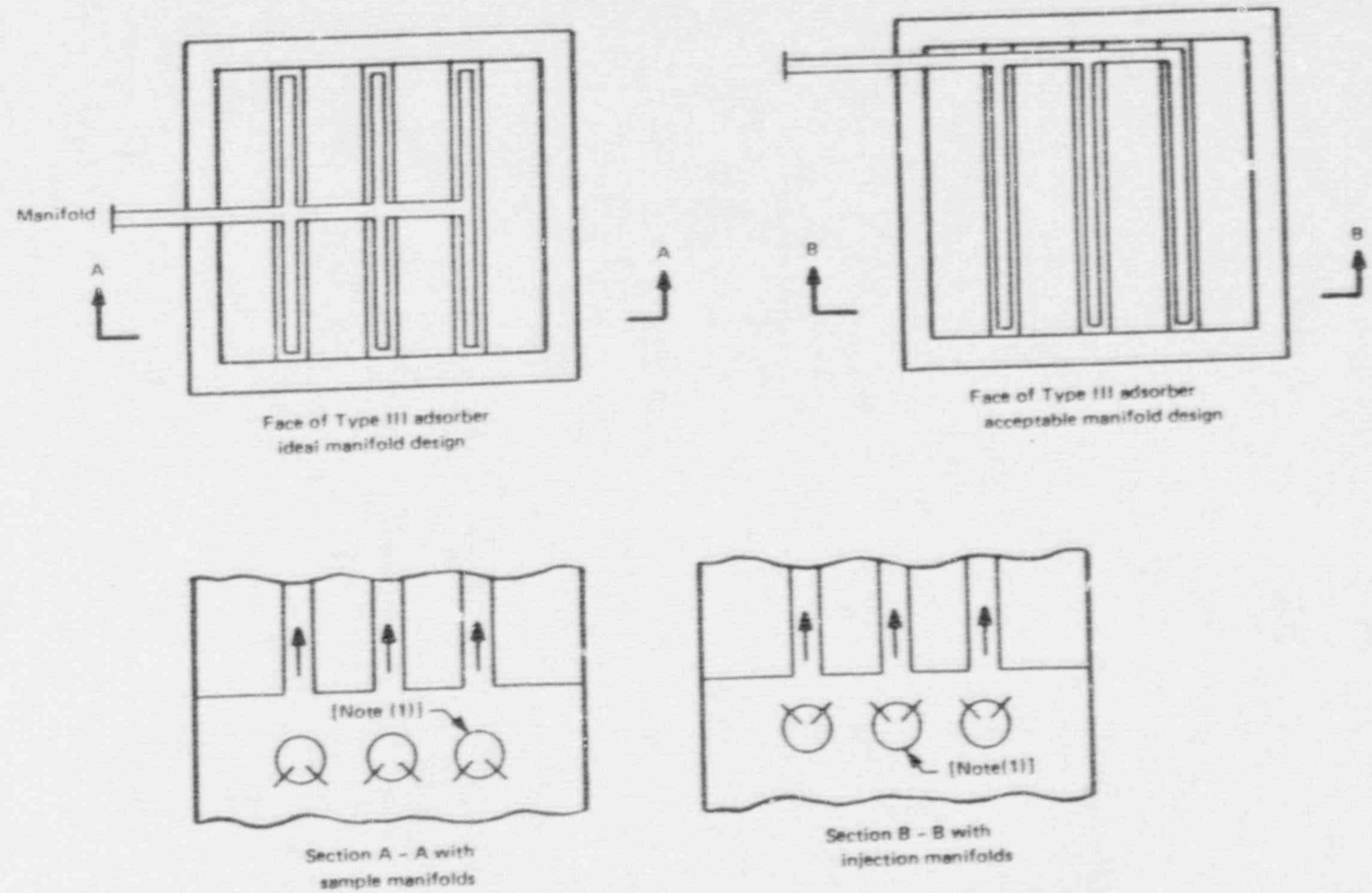
(b) Downstream DOP/Halide sample point may be in outlet duct

NOTE:

(1) 1st stage Halide sample point can be used for 2nd stage upstream sample in lieu of single point sample

Plan E – Ducted Inlet/Outlet
HEPA-Carbon-Carbon-HEPA Configuration

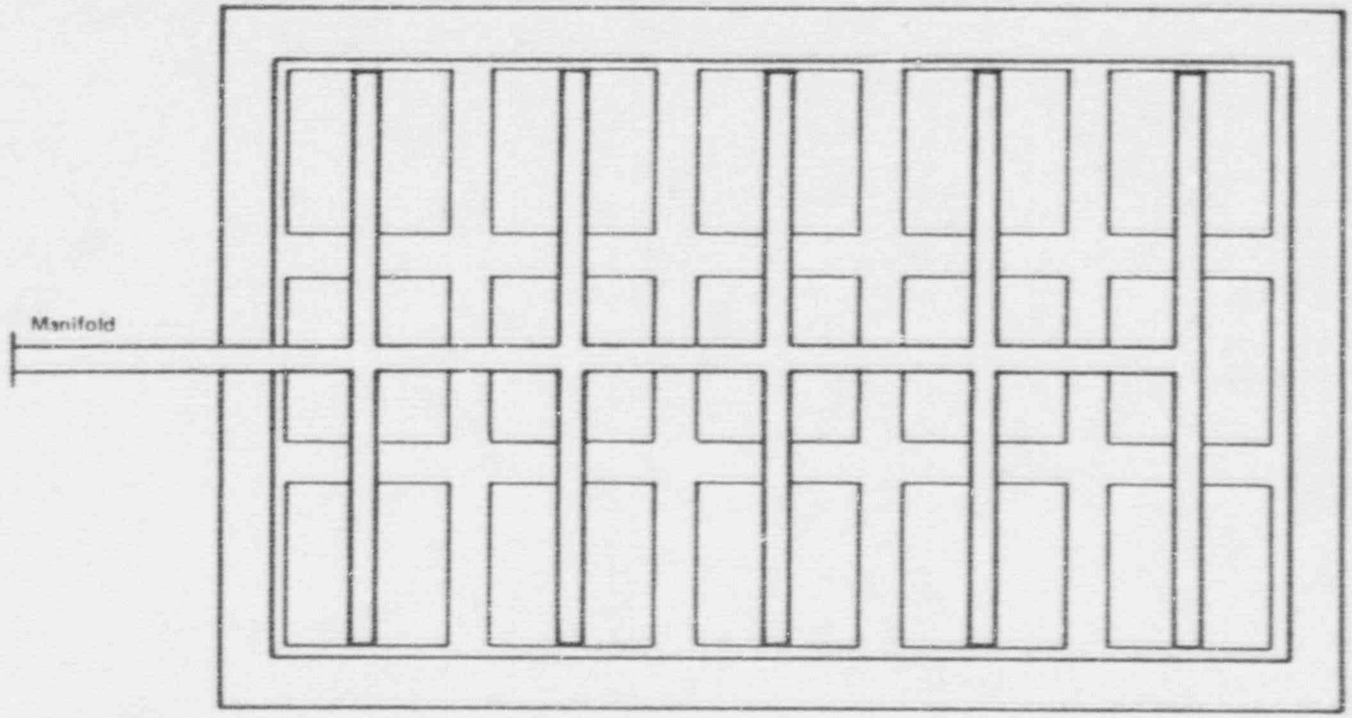
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)



NOTE:
(1) Manifold with 2 holes. See Fig. C-3 for alertnate when turbulence is required.

Sample and Injection Manifolds With Type III Adsorbers

FIG. C-2 GENERAL APPROACH TO MANIFOLD DESIGN



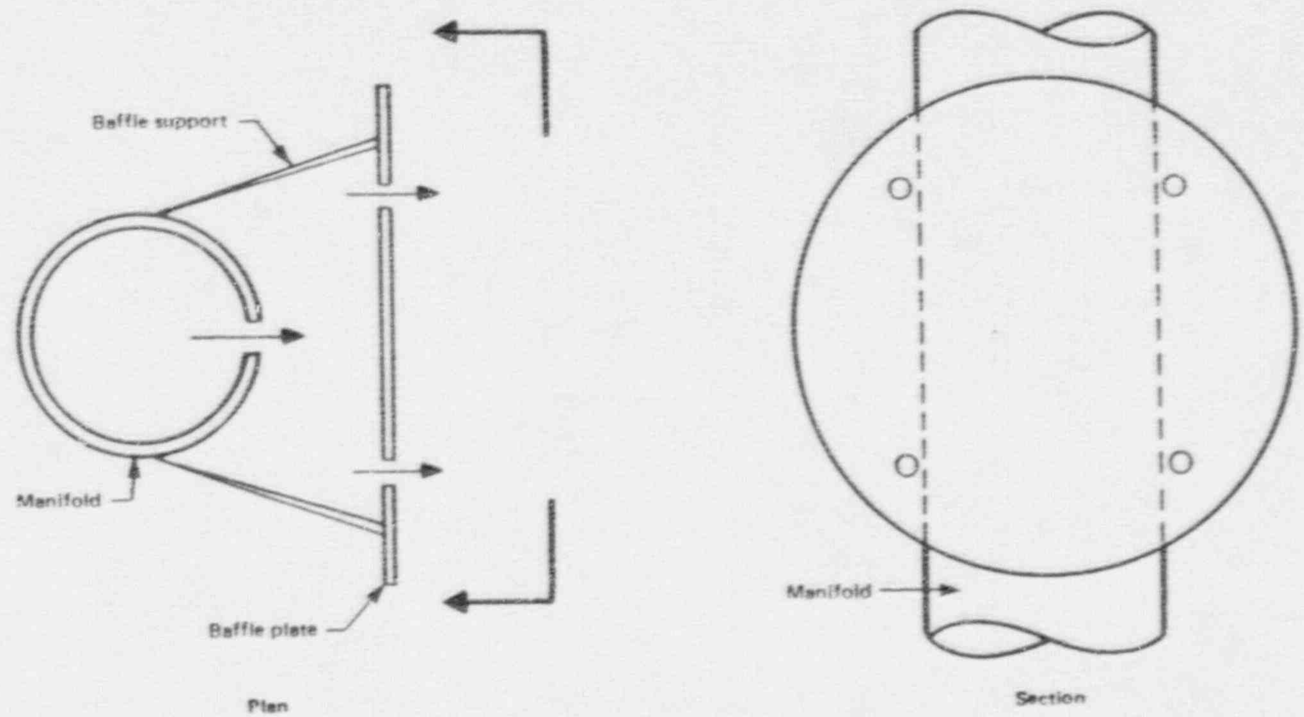
Face of HEPA filter bank

Ideal Manifold Design

GENERAL NOTE:
Many more sample points are required for Type II adsorbers and HEPA filters than for Type III adsorbers.

Sample and Injection Manifolds With Type II Adsorbers or Downstream HEPA Filters

FIG. C-2 GENERAL APPROACH TO MANIFOLD DESIGN (CONT'D)



Alternate Detail for Injection
Sampling Manifold Baffle Design
When Turbulence is Required

FIG. C-3 ALTERNATE DETAIL FOR INJECTION SAMPLING MANIFOLD BAFFLE DESIGN WHEN TURBULENCE IS REQUIRED

MANDATORY APPENDIX D
Performance Test for Qualification of Sampling Manifolds

(This Appendix is an integral part of ASME N509-1989, and is placed after the main text for convenience.)

D1 PURPOSE

The purpose of this test is to provide objective data that installed sampling manifolds provide a representative sample for subsequent component bank leak tests performed in the field per ASME N510-1989.

D2 LIMITS

This is a factory test for sampling manifolds. IT CANNOT BE PERFORMED IN THE FIELD.

D3 TEST REQUIREMENTS

D3.1 The housing, component banks, and sampling manifolds shall be complete and in their final ready-for-use configuration. Any later modifications shall invalidate this test.

D3.2 DOP aerosol shall be used to qualify all sampling manifolds including, halide sampling manifolds.

D3.3 DOP aerosol test equipment shall conform to the requirements of ASME N510 for DOP aerosol leak testing of HEPA filter banks.

D3.4 The test shall be conducted at the housing design flow rate ± 10%. If more than one flow rate is required for operation, a manifold performance test shall be performed at each flow rate. If the design has a variable flow rate, then the minimum and maximum (± 10%) shall both be used to perform the tests. Airflow distribution testing per para. 5.6.5.5 shall be performed as a prerequisite to manifold qualification tests.

D3.5 A temporary duct and fan shall be provided downstream of the housing. The duct shall be long enough and have provisions sufficient to guarantee mixing so that a representative single point sample may be taken. Baffles, vanes, or other means of providing good mixing are acceptable in the duct assembly. These shall be clearly shown on the sketch and documented sufficiently for independent review. The basis for 100% mixing shall be documented. When downstream of sampling a fan, mixing may be assumed acceptable.

In other configurations, the number of sample points shall be in accordance with Chapter 9 of Industrial Ventilation. If necessary the number of sampling points, mixing, or duct length shall be increased so each sampled concentration is ± 5% of the calculated average.

D3.6 The temporary duct and fan assembly shall be leak tight so no dilution air can enter or leave the test boundary. This shall be confirmed by a documented leak test in accordance with ASME N510.

D3.7 A visual inspection using applicable sections of ASME N510 Visual Inspection checklist shall be performed after the test setup is completed, but before the test is performed. Nonconformances shall be resolved before the test is performed.

D3.8 Test engineers and technicians shall be qualified in accordance with ANSI/ASME NQA-1. A Level II Test Engineer shall prepare the test procedure and review the test results for acceptance.

D4 TEST METHOD

D4.1 The basis of the test is to compare the single-point aerosol concentration taken in the temporary

test duct with that obtained from the sampling manifold under test.

D4.2 Test data shall be taken with all filter elements and adsorbent installed, and:

(*a*) without any aritificial leak paths;

(*b*) with one or more aritificial leak paths, as follows:

(*1*) the artificial leak paths shall be located, one at a time, to simulate leaks in the filter/adsorbent face, the frame-to-wall welds (including floor and ceiling), and gasket-to-frame seals (where applicable), and at structural welds on Type III adsorbers;

(*2*) the number and exact placement of the artificial leak paths depends on the size and configuration of the bank and housing, but shall be no less than 10 with at least four at frame-to-wall floor ceiling locations. Tests with multiple leak paths are permissible after the required 10 tests with single leak paths are performed.

D4.3 Concentration shall be measured in the temporary duct and then using the sampling manifold. For each test condition the single-point sample concentration shall be the average of the traverse readings in the temporary duct.

D4.4 If the sample manifold concentration does not correspond to the single point sample within ±5%, the sample manifold shall be modified to produce a sample within ±5% for all test conditions.

D4.4.1 One method to determine where the nonuniformity in concentration exists is to scan in front of the manifold while the challenge aerosol is flowing. This will provide data to assist the redesign/modification of the manifold.

D4.5 Upon successful completion of the test, any excess DOP shall be removed from the housing, manifold, and associated hardware to avoid false readings in the future.

D5 ACCEPTANCE CRITERIA

D5.1 Single-Point Sample

The traverse concentration measurements taken at the single-point sample location shall be within ±5% of the calculated average concentration.

D5.2 Sample Manifold

The sample manifold concentration shall be within ±5% of the single-point sample concentration for all aritificial leak paths.

D6 DOCUMENTATION

D6.1 A sketch of the factory test setup shall be provided. It shall provide sufficient dimensions and detail to allow analysis by the owner prior to start of testing.

D6.2 The details of the test instruments for airflow and DOP generation and detection shall be provided. They shall include, as a minimum, the manufacturer, model, serial number, and calibration date.

D6.3 Test procedure shall be submitted to the Owner for review prior to the start of testing. All quantitative data shall be presented in a manner that will allow independent analysis of the test.

D6.4 The location, date, and test engineers/technicians shall be listed with signatures.

D6.5 An ANSI/ASME NQA-1, Level II Test Engineer shall sign the test report to be submitted to the owner for review prior to shipping the air-cleaning units.

D7 ACCEPTANCE OF RESULTS

D7.1 The owner shall review the detailed test procedure, including drawings of the temporary duct and hardware, before the test is performed and shall provide comments to the testing organizations

D7.2 The owner shall review the results of the test before the housings are shipped. It is recommended that such approval be before the test assembly is dismantled. The owner shall advise the manufacturer, in writing, of acceptance of sampling manifold qualification test results prior to the unit's being shipped.

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

345 East 47th Street, New York, N.Y. 10017

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This document will be revised when the Society approves the issuance of a new edition. There will be no Addenda issued to ASME N510-1989.

Please Note: ASME issues written replies to inquiries concerning interpretation of technical aspects of this document. The interpretations are not part of the document. N510-1989 is being issued with an automatic subscription service to the interpretations that will be issued to it up to 1994.

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.

ASME COMMITTEE ON NUCLEAR AIR AND GAS TREATMENT

(The following is the roster of the listed Committees at the time of approval of this Standard.)

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Table

Nonmandatory Appendices

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

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

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

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/ft³.

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

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.

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.

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 progr.. 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.

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.

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
Δt = $t_f - t_i$
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.

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.

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.

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.

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.

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.

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.

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.

NONMANDATORY 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/ft^3 average density, SCFM
V = volume of enclosure, ft^3
P_i = initial pressure of gas (air) in enclosure, lb/ft^2 absolute
P_f = final pressure gas (air) in enclosure, lb/ft^2 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/ft^3
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.

(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 ($Z = 1$):

$$M_i = \frac{P_i V}{T_i R} \qquad (1)$$

$$M_f = \frac{P_f V}{T_f R} \qquad (2)$$

The change in mass is equal to the total leakage:

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

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

$$\Delta \bar{m} = M / \Delta t \qquad (4)$$

Therefore, the average mass flow leak is:

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

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

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

NONMANDATORY
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.