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DOE STANDARD

AIR CLEANING SYSTEMS IN DOE NUCLEAR FACILITIES

U.S. Department of Energy AREA SAFT

Washington, DC 20585

FOREWORD

This Department of Energy (DOE) Standard (STD) has been approved to be used by DOE, including the National Nuclear Security Administration, and their contractors.

Beneficial comments (recommendations, additions, and deletions), as well as any pertinent data that may be of use in improving this document, should be emailed to **nuclearsafety@hq.doe.gov** or addressed to:

Office of Nuclear Safety (EHSS-30)
Office of Environment, Health, Safety and Security
U. S. Department of Energy
19901 Germantown Road
Germantown, MD 20874
Phone (301-903-2996)

In 2019, DOE initiated a revision of the *Nuclear Air Cleaning Handbook*, DOE-HDBK-1169, last issued in 2003. This handbook's predecessor documents date back to the 1960s, when the center of research on this topic was Oak Ridge National Laboratory (ORNL). In 1966, the following document was issued:

> *Filters, Sorbents, and Air Cleaning Systems as Engineered Safeguards in Nuclear Installations* - G. W. Keilholtz, ORNL-NSIC-13, October 1966. [ABSTRACT] Purposes of the review were (1) to examine some of the gas-cleaning methods used at nuclear installations, (2) to present pertinent information on the physical and chemical properties of fission products as they relate to trapping (filtration and sorption), and (3) to indicate recent advances in the trapping of these radiation emitters. High efficiency particulate air filters, sorbents, and air-cleaning systems were described. Their uses as engineered safeguards for trapping radioactive aerosols and gases were evaluated. (abstract)

This document was re-issued in 1970 as ORNL-NSIC-65, *Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application*. In 1976, one year after the 1975 breakup of the Atomic Energy Commission, the designation ERDA 76-21 was applied to the document, now bearing the revised title *Nuclear Air Cleaning Handbook* (NACH). This handbook remained in effect for the next 27 years and in 2003 was re-issued using the DOE designation DOE-HDBK-1169-2003.

Several developments since 2003 support issuing a new edition of the NACH. First, the industry code, The American Society of Mechanical Engineers (ASME), Code on Nuclear Air and Gas Treatment (AG-1), has undergone a number of revisions since 2003. Second, DOE's approach to the design and operation of nuclear safety systems has evolved considerably over the same period. Finally, the DOE standards and directives system in its current form does not permit use of a "handbook" to impose requirements. The 2003 version of the NACH contains nearly 700 requirement statements, yet a "handbook" is now defined in DOE Order (DOE O) 252.1A as "a compilation of good practices, lessons-learned, or reference information" that provides "general, textbook-type information on a variety of subjects." Requirements in the form of "must" or "shall" statements are properly located in DOE orders and standards.

Accordingly, the valuable technical content of the NACH is being separated into a DOE standard, which contains "shall" requirements and "should" guidance statements, and a handbook, which consists of "good practices, lessons-learned, or reference information." The new standard and the revised handbook have been updated and made consistent with the current version of industry codes such as AG-1, and with related DOE standards such as DOE-STD-1020 (2016), *Natural Phenomena Hazards Analysis and Design and Performance Criteria for DOE Facilities*, and DOE-STD-1066-2016, *Fire Protection*.

The AG-1 code is routinely revised. DOE will evaluate subsequent changes to AG-1, and when appropriate, DOE-STD-1269 will be updated.

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1.0 INTRODUCTION

1.1 Purpose and Scope

This standard has three purposes:

- Provide requirements for safety class and safety significant air cleaning and confinement ventilation systems at DOE nuclear facilities;
- Provide guidance for non-safety air cleaning systems at DOE nuclear facilities; and,
- Increase DOE use of applicable industry consensus codes and standards, where appropriate.

1.2 Applicability

This information contained in this standard is intended for use by new and existing Hazard Category 1, 2, and 3 nuclear facilities as follows:

- New facilities at the design stage shall apply the design, operations, testing and maintenance provisions of this standard.
- Existing facilities should apply the operations, testing and maintenance provisions of this standard to operational air cleaning systems, and the design criteria of this STD to major modifications using the procedure in Section 5 of DOE-STD-1189-2016.

1.3 Relationship to Other DOE Standards and Directives

This standard contains "shall" requirements and "should" guidance statements, many of which were found in DOE-HDBK-1169 (2003). DOE-HDBK-1169-2022 now contains "good practices, lessons-learned, or reference information." DOE-HDBK-1169 (2003) will be archived on the website of the DOE Technical Standards Program, https://www.standards.doe.gov.

1.4 Use of Applicable Standards

An applicable standard (i.e., DOE technical standard or industry code or standard) is one for which it has been determined by the contractor (typically with approval by DOE) that it will be used for a specific facility/site. A summary section describing applicable standards is added in Section 7 of DOE Order 420.1C, Chg. 3. DOE Order 420.1C, Chg. 3 allows some flexibility in determining which standards will be applicable but once so determined, the Order requires that the applicable standards be followed unless relief is obtained.

2.0 TERMINOLOGY

2.1 Shall, Should, and May

In this standard, the word "shall" denotes a requirement; the word "should" denotes a recommendation; and the word "may" denotes permission, neither a requirement nor a recommendation. To claim full compliance with this standard, all "shall" statements must be met.

3.0 SYSTEM REQUIREMENTS

3.1 Introduction

This section of the standard provides system-level requirements for air cleaning systems used in Hazard Category 1, 2 and 3 DOE nuclear facilities. Subsection 3.1 provides a general introduction to air cleaning systems. Subsection 3.2 contains requirements for air cleaning systems relied upon for safety of the public and workers (safety class and safety significant). Subsection 3.3 contains requirements for air cleaning systems used in DOE nuclear facilities but not explicitly relied on for public or worker safety.

For purposes of this section, an air cleaning system consists of some or all of the following components and support systems:

- Ventilation fans and motors
- Ducts, valves, and dampers
- Hoods and gloveboxes
- Electric heaters, heat exchangers and cooling coils
- High-Efficiency Particulate Air (HEPA) filters, medium efficiency filters, low efficiency filters
- Scrubbers
- Charcoal adsorbers
- Moisture separators
- Fire protection features
- Structural support
- Electrical power and cabling
- Instrumentation and control

The system will be described in design documentation as having one or more of the following purposes:

- Provide a clean, healthy atmosphere for in-facility workers
- Clear smoke or toxic fumes in an abnormal or accident situation
- Provide environmental conditioning to maintain local environments
- Prevent release of hazardous materials
- Provide confinement of radioactive material during normal and off-normal conditions

Design documentation will also describe:

- Air moving performance criteria
- Filtration criteria
- Environmental conditions
- Support systems and power needs
- Procurement specs
- Required maintenance and surveillance

- In-operation and shutdown testing requirements and protocols

Finally, safety documentation such as the facility's Documented Safety Analysis (DSA) will identify additional design and functional requirements on certain air cleaning systems. These additional requirements are the subject of the next sections.

3.2 Air Cleaning Systems Designated Safety-Class or Safety-Significant

3.2.1 Requirements of DOE Order 420.1C

Safety class and safety significant air cleaning systems are required to meet the applicable requirements of Chapter 1 of Attachment 2 to DOE O 420.1C, *Nuclear Safety Design Criteria*. Applying these Order requirements to ventilation systems is subject to the guidance found in DOE Guide (DOE G) 420.1-1A: Section 5.4.12, *Design of Ventilation Systems*, and Table A-1, "Confinement Ventilation System Design and Performance Criteria."

For new nuclear facilities and major modifications (See DOE-STD-1189-2016) to existing nuclear facilities, the design criteria of DOE G 420.1-1A, Section 5.4.12 and Table A-1, shall be evaluated for applicability to the air cleaning system design based on the safety classification of the confinement ventilation system. If found to be applicable, the criteria shall be followed unless a technical basis is provided for a different approach.

3.2.2 Additional Requirements

3.2.2.1 Use of ASME AG-1. The design shall meet the applicable design criteria in ASME AG-1, in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria and Code of Record of the facility.

3.2.2.2 Contaminants. The types of contaminants in the gas stream shall be identified and evaluated to properly design and size the system.

3.2.2.3 Temperature Conditions. The design shall ensure that all components of the system will function between the maximum and minimum temperature conditions for the specified application.

3.2.2.4 Environmental Qualification. With respect to environmental qualification of an air cleaning system, the design shall address thermal expansion and the heat resistance of ducts, dampers, filter housings, component mounting frames and clamping devices, fans, belts, and sheaves.

3.2.2.5 Electrical and Electronic Components. Electrical and electronic components shall be designed and qualified for safety class and safety significant systems in accordance with ASME AG-1, IEEE 323, *Standard for Qualifying Class 1E Electrical Equipment for Nuclear Generating Stations,* IEEE 344, *Recommended Practice for Seismic Qualification of Class 1E Equipment in Nuclear Generating Stations*, and DOE-STD-1195-2011, *Design of Safety Significant Safety Instrumented Systems used at DOE Nonreactor Nuclear Facilities*.

3.2.2.6 Corrosive Environments. The design shall ensure that the system will function in any expected corrosive environment.

3.2.2.7 Emergency Power. Emergency power, standby power, uninterruptible power, and alternate power feeds shall be provided to operate the system during normal, abnormal. or accident conditions as specified by facility design requirements and safety documentation.

3.2.2.8 Work Area Ventilation. The design of a work area ventilation system should ensure that concentrations of radioactive gases and aerosols in the air of occupied and occasionally occupied areas do not exceed the derived air concentrations (for radioactive materials) or occupational exposure limits (for chemical compounds) established for occupationally exposed persons, under normal or abnormal operating conditions.

3.2.2.9 Airflow. Airflow shall be sufficient to continually maintain acceptable air quality considering the generation rate, toxicity of the contaminants, and the relevant provisions of the facility DSA.

3.2.2.10 Pressure Differentials. The design shall ensure that in an abnormal or accident[1] condition, the system maintains pressure differentials consistent with confining hazardous gases and particulates and the relevant provisions of the facility DSA.

3.2.2.11 Maximum Flow Rate. The maximum size of a safety class or safety significant filtration housing shall not exceed 30 filtration components (e.g., medium efficiency filter, moisture separator, HEPA filter or adsorber cell) per stage. When significantly greater air flow than this is needed, multiple systems shall be used in parallel.

3.2.2.12 Criteria for Design and Operation of Hot Cells, Caves, and Canyons (Primary Confinement) for Control of Transuranic Compounds.

1. Primary confinement air pressure shall be at least 1 in. water gauge (wg) lower than the secondary containment area pressure for process cells involving transuranic compounds or alpha contamination. When this differential pressure is not achievable, a technical basis shall be provided for meeting an alternative requirement.
2. Confinement exhaust should be at least 10 percent of cell volume/minute to minimize possible explosion hazards due to the presence of volatile solvents and to ensure that, in the event of cell pressurization due to an explosion, the confinement will be returned to normal operating pressure (1 in. wg) in a specified time. Analysis shall be provided to demonstrate that the exhaust flow rate is sufficient to provide adequate mixing to eliminate localized concentrations of explosive volatile solvents.
3. The maximum permissible leak rate shall not exceed 1 percent of cell volume/minute for unlined cells and 0.1 percent of cell volume/minute for lined and sealed cells at a differential pressure of 2 in. wg to ensure minimal release of radioactive material in the event of cell pressurization.
4. The maximum permissible leak rate for ductwork shall be 0.1 percent of duct volume/ minute at a differential pressure equal to 1.5 times the operating static pressure of ductwork. Hot cells, caves, and canyons should not be hermetically sealed.

[1] All abnormal and accident scenarios should be addressed.

5. Seals and doors should withstand a differential pressure of at least 10 in. wg to ensure the integrity of closures and penetrations under all operating and design basis upset conditions.
6. The confinement structure shall withstand the seismic DBA for that facility without structural damage or loss of function.[2]
7. Combustible/flammable control programs and procedures shall be designed to limit flammable and smoke-producing materials and solvents within amounts that can be accommodated by the ventilation system without endangering the functionality of the air cleaning system.

3.2.2.13 Airflow Design Criteria for Gloveboxes (Primary Confinement).

1. A negative differential pressure shall be maintained between the glovebox and the surrounding room. If a numerical value is specified in the DSA based on the glovebox application, that value shall be maintained. The latest edition of the American Glovebox Society's (AGS) *Guidelines for Gloveboxes*, AGS-G001, and the American Conference of Governmental Industrial Hygienists (ACGIH)[3] *Industrial Ventilation – A Manual of Recommended Practice*, may be consulted for guidance concerning ventilation of gloveboxes.
2. The exhaust rate should be adequate for the heat load and dilution requirements of operations conducted in the glovebox. For example, operations with flammable materials should maintain concentrations below accepted safe limits and with a margin of safety.
3. Sufficient system airflow should be provided to meet two separate and independent criteria: (a) provide an adequate face velocity at the passthrough port to the glovebox [50 linear feet per minute (fpm)]; (b) maintain an inward velocity of at least 125 linear fpm (with higher velocities mandated by some operators for gaseous effluents) through one open gloveport. This requirement applies to each standalone glovebox and to interconnected gloveboxes with combined exhaust flow rate sufficient to maintain the required face velocities during normal operations. The guidance in AGS-G006-2017, *Standard of Practice for the Design & Fabrication of Nuclear Application Gloveboxes*, should be considered concerning the need for additional or alternate controls due to materials reactivity to oxygen or moisture.
4. Room turbulence and disturbing air movement should be modeled and considered in airflow calculations.

3.2.2.14 Airflow Design Criteria for Exhaust Hoods (Primary Confinement).

1. The exhaust rate of the fume hood shall maintain sufficient airflow face velocity into the hood to prevent the release of fumes from the hood to the room, even when the operator walks rapidly back and forth in front of and close to the hood face. The adverse effects

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[2] For related requirements and criteria, see DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*.
[3] American Conference of Governmental Industrial Hygienists.

from external cross drafts shall be evaluated and mitigated. For hoods with radiological hazards (non-tritium) a face velocity of 100 to 125 linear fpm is recommended. For hoods containing tritium, a face velocity of 125 to 150 fpm is recommended.[4] The latest edition of the American Industrial Hygiene Association's *American National Standard for Laboratory Ventilation*, Z9.5, may be consulted for guidance.

2. Each hood in the laboratory should be isolated or isolatable by means of dampers to prevent backflow through a hood when it is not in service.
3. Each hood used for handing radioactive material shall have a testable HEPA filter in its exhaust. The HEPA filter should be located as close to the hood as practical.

3.2.2.15 Airflow Design Criteria for Secondary Confinement Structures or Buildings.

1. A differential pressure equal to or greater than (more negative) 0.1 in. wg during operation should be maintained between the laboratory in which the fume hood is installed and the corridor from which the laboratory is entered.
2. Under emergency conditions, the building shall be capable of being maintained at a differential pressure of equal or greater than (more negative) of 0.1 in. wg relative to the atmosphere. For increased reliability and simplicity, some buildings are held at this pressure under normal operating conditions. If this is not practicable, the design should consider potential for pressurization in off-normal events and identify controls to protect facility and collocated workers. Potential controls include the capability to reduce building static pressure to 0.2 in. wg in 20 seconds or less, preventative controls to address causes of pressurization, low-leakage pressure boundaries, active CVS capable of reducing static pressure within the building or zone, and evacuation of personnel.
3. Ventilation systems within the building that do not exhaust through at least one stage of HEPA or Ultra Low Particulate Air (ULPA) filters or would serve to compromise cascading flow from areas of less contamination to areas of higher contamination should be interlocked to trip off in off-normal events or should be controlled to maintain differential pressure and cascading flow between zones.

3.2.2.16 Airflow Design Criteria for Air Handling Systems.

1. Safety class ventilation and offgas systems, including filters and fans, shall be designed so as to maintain confinement in the event of component failure, filter failure, power outage, or other operational upset.
2. Airflow should be from the less hazardous to the more hazardous area under both normal and upset conditions.
3. Air exhausted from occupied or occasionally occupied areas should be passed through medium efficiency filters and at least one stage of HEPA filters. Contaminated and potentially contaminated air exhausted from a hot cell, cave, canyon, glovebox, or other primary confinement structure or vessel should pass through at least two individually

[4] DOE's requirements for handling tritium are set out in DOE-STD-1129-2015, *Tritium Handling and Safe Storage*.

testable stages of HEPA filters in series, as well as medium efficiency filters, adsorbers, scrubbers, or other air cleaning components that are required for the particular application.

4. Moisture or corrosives in the exhaust that are capable of damaging or unduly loading the HEPA filters (or other components such as adsorbers) shall be removed or neutralized before they can reach downstream components.

3.3 Guidance for Air Cleaning Systems Not Relied on for Safety[5]

3.3.1 Introduction

In general, air cleaning systems that have no designated public or worker safety function should be designed to meet applicable industry codes and standards for design, operation, testing, and maintenance.

3.3.2 Guidance Drawn from Chapter 2 of the NACH (2003)(archived)

3.3.2.1 Maintaining of Operating Parameters. The ventilation and air cleaning systems of a building in which radioactive materials are handled or processed are integral parts of the building's confinement. In some situations, these systems may be shut down for required maintenance or because of an operational upset, power outage, accident, fire, or other emergency. In other situations, they may need to be kept in operation to maintain the airflows and pressure differentials between building spaces and between the building and the atmosphere as required to maintain confinement.

3.3.3 Industry Guidelines. Several industry organizations that provide guidelines for general service air cleaning systems are listed below. These guidelines are based on established and proven practices and should be considered for all air cleaning systems in DOE nuclear facilities:

- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), *HVAC Systems and Equipment Handbook, Fundamentals Handbook* and Design Guides
- ACGIH, *Industrial Ventilation: A Manual of Recommended Practice*
- Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), *HVAC Systems – Duct Design*
- Air Moving and Control Association (AMCA), *Fans and Systems*

[5] As determined by the DSA, for nuclear facilities; as determined by a Part 851 worker safety assessment for non-nuclear facilities.

4.0 COMPONENT LEVEL REQUIREMENTS

4.1 Filtration and Filter Testing

4.1.1 Introduction

Air cleaning systems rely on components to remove contaminants and moisture, and thus provide a means to protect the environment and workers at DOE facilities. System designs shall specify the components needed, as well as the suggested or mandated testing requirements of these individual components and the installed system.

4.1.2 Component Requirements Based on Chapter 3 of the NACH (2003)(archived)

4.1.2.1 End Points of Fasteners for Filter Cases. End points of fasteners for filter cases shall not penetrate the inside or outside surface of the casing.

4.1.2.2 Gaskets. Elastomers shall meet the requirements of ASME AG-1, Articles FC-3121 and FK-3121, and be designed in accordance with ASME AG-1 Articles FC-4141 and FK-4141. Gelatinous seals shall meet the requirements of ASME AG-1 Articles FC-3122 and FK-3122, and be designed in accordance with ASME AG-1 Articles FC-4142 and FK-4142.

4.1.2.3 Repairs. Following any repairs, the system shall be re-tested to meet the established criteria for leak-tightness.

4.1.2.4 Entrainment (Moisture) Separators. Moisture separators shall:

- Be capable of removing moisture droplets, from the smallest to the largest,
- Resist flooding by the largest droplets to ensure collected liquid is not released as entrained water, and
- Permit collected water to drain out of the cell before the cell becomes clogged.

4.1.2.5 Filter Integrity. HEPA filters shall maintain:

- Gasket integrity in both manual and remote handling situations;
- A reliable seal after installation; and
- Correct orientation as shown by arrow labels and fastening.

4.1.3 Use of ASME AG-1 in Design.

The following articles and sections of ASME AG-1 shall be applied to filtration components of air cleaning systems in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Other sections of ASME AG-1 may also be applied as relevant for the facility (e.g., Section FI, Metal Media Filters or Section FM, High-Strength HEPA Filters, in lieu of Section FC). Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails.

- Article AA-4000, Structural Design
- Article AA-6000, Fabrication, Joining, Welding, Brazing, Protective Coating, Installation
- Section CA, Conditioning Equipment
- Section FA, Moisture Separators
- Section FB, Medium Efficiency Filters

- Section FC, HEPA Filters
- Section FF, Adsorbent Media
- Section FI, Metal Media Filters
- Section FK, Special HEPA Filters
- Section FJ, Low Efficiency Filters
- Section FL, Deep-Bed Sand Filters
- Section FM, High Strength HEPA Filters
- Section FN, Filter Media: High Efficiency
- Mandatory Appendices FD-II and FE-V, Sample Canisters

4.1.4 Procurement and Required Testing for HEPA Filters.

DOE-STD-3020-2015, *Specifications for HEPA Filters Used by DOE Contractors,* provides direction to DOE contractors for procurement and required testing of HEPA filters used in DOE nuclear facilities.

4.1.5 Quality Assurance, Inspection, and Performance Testing.

DOE-STD-3025-2007, *Quality Assurance Inspection and Testing of HEPA Filters,* establishes the requirements of a DOE program of quality assurance, inspection, and performance testing of HEPA filters installed in DOE facilities and within the scope of DOE-STD-3020-2015.

4.1.6 Component Qualification Testing Requirements of AG-1 (2019).

The following articles of ASME AG-1 shall be applied to the qualification and inspection testing requirements of filtration components in air cleaning systems in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility.

- Article BA-5000, Inspection and Testing (Fans and Blowers)
- Article DA-5000, Inspection and Testing (Dampers and Louvers)
- Article SA-5000, Inspection and Testing (Ductwork)
- Article HA-5000, Inspection and Testing (Housings)
- Article FA-5000, Inspection and Testing (Moisture Separators)
- Article FB-5000, Inspection and Testing (Medium Efficiency Filters)
- Article FC-5000, Inspection and Testing (HEPA Filters)
- Article FF-5000, Inspection and Testing (Adsorbent Media)
- Article FK-5000, Qualification, Inspection, and Production Testing (Special HEPA Filters)
- Article FM-5000, Inspection and Testing (High Strength HEPA Filters)
- Article FN-5000, Inspection and Testing (Filter Media: High Efficiency)
- Article FF-5210, Qualification Tests (Sorbent Media)

4.1.7 In-Place Testing Requirements of AG-1 (2019).

The sections of ASME AG-1 listed below shall be applied to field testing of components of air cleaning systems and integrated air cleaning systems in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Full compliance with the following criteria may not be achievable for legacy filter systems and those systems that are not designed in full accordance with ASME AG-1. For these systems, implementation of the ASME AG-1 criteria shall be in accordance with the specific design criteria of the facility.

- TA Article TA-3000, General Inspection and Test Requirements
- TA Article TA-4000, Field Acceptance Tests (Components)
- TA Article TA-4700, Types II, III, and IV Adsorber Bank Acceptance Tests
- TA Article TA-4900, Integrated System Tests
- Mandatory Appendices FD-II and FE-V, Sample Canisters

In-place leak testing shall be performed at the user facility with the filtration components installed in a filter housing. ASME AG-1 Section TA, *Field Testing of Air Cleaning Systems*, shall be used for equipment qualification and acceptance testing after field installation. ASME N511, *In-Service Testing of Nuclear Air Treatment, Heating, Ventilating, and Air Conditioning Systems,* shall be used for in-service testing to verify equipment availability and to obtain data for operational considerations. ASME N511 also provides procedures for surveillance (interval) testing to satisfy technical specifications or specific site surveillance requirements.

4.1.8 Corrective Action Requirements of AG-1 (2019).

Any corrective actions necessary when test results do not meet acceptance criteria shall meet the requirements of AG-1, Appendix TA, Article TA-5000.

4.1.9 Radioactive Iodine Tests.

If a DOE facility uses radioactive iodine for in-place adsorber bank testing, the following requirements apply:

a. A combination of injected radioactivity (in microcuries), sampling rate, and counting technique (usually dictated by the kind of counting equipment available) is developed to give the required test precision.

b. The amount of iodine-131 tracer is adjusted to give the target radioactivity count.

c. Preparation of the iodine and loading of the injector is performed in a laboratory equipped for handling radioactive materials.

d. All aspects of the test consider the impact of radioiodine on the worker and the environment. (see 10 Code of Federal Regulations (CFR) Part 835)

4.1.10 Nonmandatory Appendices.

The non-mandatory appendices of AG-1 (such as Non-Mandatory Appendix FK - A Determination of HEPA Filter Service Life) should be considered in the design and operation of both safety and nonsafety air cleaning systems and components in DOE nuclear facilities.

4.2 Glovebox Filtration

4.2.1 Introduction

Gloveboxes are windowed enclosures that enable manipulation of hazardous materials by operators through gloves without exposure to themselves, or subsequent unfiltered release of the material to the environment. Ventilation is key to successful operation of the glovebox system. Ventilation systems are required to prevent operators from inhaling radioactive particles, to ensure a clean and controlled workspace, and to minimize the potential for any releases of radioactive material to the environment. Gloveboxes provide containment for the prevention, minimization, and holdup of radioactive material through the use of a glovebox ventilation system.

4.2.2 Requirements Based on Chapter 7 of the NACH (2003)(archived)

4.2.2.1 Design Pressure. Design pressure shall be maintained inside the glovebox for effective ventilation.

4.2.2.2 Flow Criteria. Flow criteria of at least 125 feet per minute shall be maintained through a breached 8-inch diameter gloveport to maintain confinement. This criterion does not apply where pulling air into the glovebox would cause more of a hazard than allowing an inerted system to flood the glovebox with inert gas. Highly oxygen-reactive environments or productions are not required to satisfy this criterion as described in AGS-G006-2017 Section 4.9.5.

4.2.2.3 Ventilation Exhaust Capability. Exhaust capability shall be sufficient to provide (a) safety under abnormal conditions, including glovebox breach, and (b) safe access during planned activities, including routine access requiring breach of confinement or where confinement and contamination control cannot be managed during the planned activity.

4.2.2.4 Nuclear Criticality. Prior to admission of fissile material into a glovebox, a nuclear criticality review is performed and documented as required in DOE Order 420.1.c and in accordance with DOE-STD-3007-2017 which considers the quantity, form, and shape of fissile material or container to be added. In the criticality calculations, the maximum potential buildup of fissile material on filtration components and in drains shall be considered. All liquids in and around the glovebox shall also be taken into consideration.

4.2.2.5 Materials Compatibility for Glovebox Use. Glovebox design shall include a material compatibility evaluation for all construction and process materials. Prior to any changes in the processes conducted in the glovebox, or introduction of different materials, the compatibility of the materials shall be re-evaluated.

4.2.2.6 In-Place Testing. Filtration components shall have the capability of being in-place leak tested. Exhaust filters should be included as part of the glovebox confinement boundary, and are not subject to this requirement, so long as ductwork and downstream filtration components are credited for confinement and are in-place leak tested. Filters installed as sacrificial (i.e., low efficiency filters) to protect and extend the life of downstream credited filters need not be tested.

4.2.2.7 Filters Inside the Glovebox. Any filters installed inside the glovebox shall be accessible via the gloves.

4.2.2.8 Pressure Instrumentation. Pressure instrumentation shall have a maximum design pressure (which may not be the display scale of the gauge) greater than the maximum system pressure (negative or positive). The measurement range of the gauge shall cover the normal operating range and maintenance testing conditions and shall be accurate (given the accuracy percent of full range) to provide glovebox pressure control or glovebox pressure sensing within the specified tolerance ranges.

4.2.3 Use of ASME AG-1 in Design.

The following articles and sections of ASME AG-1 should be applied to gloveboxes in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Gloveboxes are not explicitly covered in AG-1, hence the sections referenced below do not apply directly and cannot be invoked. However, the referenced AG-1 sections can and should be applied to individual glovebox components.

Other sections of ASME AG-1 may also be applied as relevant for the facility, for example, Section FI Metal Media Filters, or Section FM, High-Strength HEPA Filters, might be applied in lieu of Section FC. Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails.

- Section FB, Medium Efficiency Filters
- Section FC, HEPA Filters
- Section FF, Adsorbent Media
- Section FJ, Low Efficiency Filters
- Section FK, Special HEPA Filters
- Mandatory Appendices FD-II and FE-V, Sample Canisters

4.2.4 American Glovebox Society Guidelines.

The American Glovebox Society provides guidelines on a number of glovebox criteria, from conception to installation, operations, and maintenance. These guidelines are based on established and proven practices and should be considered for gloveboxes in DOE nuclear facilities:

- AGS-G001-2007, *Guidelines for Gloveboxes*
- AGS-G004-2014, *Standard of Practice for Leak Test Methodologies for Gloveboxes and Other Enclosures*
- AGS-G006-2017, *Standard and Practice for the Design and Fabrication of Nuclear Application Gloveboxes*
- AGS-G010-2011, *Standard of Practice for Glovebox Fire Protection*
- AGS-G013-2011, *Guideline for Glovebox Ergonomics*
- AGS-G015-2015, *Standard of Practice for Glovebox Inert Gas Recirculation Purification Systems*

4.3 Small Air Cleaning Units.

4.3.1 Introduction.

Small air cleaning units are used in air cleaning systems that utilize a single filter per stage of each air cleaning component. Single filter installations are used in the supply, exhaust, and recirculating air cleanup systems of rooms, gloveboxes, hot cells, chemical fume hoods, and similar contained spaces; in the offgas lines of process vessels and radiochemical operations; and other applications of less than 2000 cfm.

4.3.2 Requirements Based on Chapter 6 of NACH (2003)(archived).

4.3.2.1 Individual Filtration Components. Individual filtration components (e.g., moisture separators, HEPA filters, carbon adsorbers, medium efficiency filters) shall meet the qualification requirements of Section 4.1 of this standard. For other components, such as vacuum cleaner filters or portable HEPA filtration systems, the equivalent requirements contained in IEST-RP-CC001, *HEPA and ULPA Filters*, and IEST-RP-CC021, *Testing HEPA and ULPA Filter Media,* shall apply.

4.3.2.2 Housings. Housing design and layout for small air cleaning units shall meet the requirements of Section 4.4 of this standard.

4.3.2.3 Installation. Filtration component seal methods for clamping to mounting frames shall maintain a reliable seal when subjected to vibration, thermal expansion, frame flexure, shock, overpressure, and service conditions of temperature and pressure.

4.3.2.4 Clamping Pressure. Where clamps are used, clamping pressure required to properly seal filtration components shall be specified and uniform.

4.3.2.5 Bag In/Bag Out Systems. Bag in/bag out filter systems shall have shutoff (isolation) dampers upstream and downstream of the replaceable filtration component to permit isolation during the changeout, and to limit pressure differential between the inside and outside of the bag that could result in ballooning or collapsing in of the bag.

4.3.2.6 Portable Air Cleaning Units and HEPA-Vacs. For plasma-arc cutting or any other type of spark-producing activity, spark arrestors shall be added to medium-efficiency prefilters.

4.3.2.7 Nuclear Criticality Safety of HEPA-Vacs. A nuclear criticality safety review shall be performed and documented prior to the use of a HEPA-Vac for fissile material.

4.3.2.8 Testing of Small Air Cleaning Units. Testing of filtration components and systems testing of small air cleaning units shall meet the requirements of Section 4.1 of this standard.

4.3.2.9 Testing of Portable Air Cleaning Systems and HEPA-Vacs. Due to the rough handling and shock experienced during transport, portable air cleaning systems and HEPA-Vacs are required to undergo visual inspections by the operator prior to each use. Portable air cleaning systems and HEPA-Vacs shall be leak tested every six months, after HEPA filter replacement and after being subjected to mechanical trauma (e.g., being dropped, tipped over, impact with a hard object) following Section 4.1 of this standard.

4.3.3 Use of ASME AG-1 in Design.

The following articles and sections of ASME AG-1 shall be applied to small air cleaning units in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails.

- Section FK, Special HEPA Filters, for special round and duct-connected HEPA filters for cylindrical filters designed for axial or radial flow
- Sections FA, Moisture Separators, FB, Medium Efficiency Filters and FC, HEPA Filters, for filtration components used in portable air cleaning units and HEPA-Vacs
- Section FJ, Low Efficiency Filters

4.4 Housing Design and Layout

4.4.1 Introduction.

Housings comprise air cleaning, air handling, and air conditioning components. Internal components of housings generally include HEPA filters, medium efficiency filters, carbon adsorbers, moisture separators, cooling and heating coils, dampers, mounting frames, fans, and louvers. The requirements of this section apply to the two basic housing designs: man-entry, and side access. Side-access applications for both square and radial flow/round filters are included. The requirements apply to systems that use a single housing, or to each housing if the flow rate dictates multiple housings operating in parallel.

4.4.2 Requirements Based on Chapter 4 of NACH (2003)(archived).

4.4.2.1 Isolation Dampers. Each housing shall have inlet and outlet isolation dampers which, for systems with multiple housings, permit one housing to be held in standby or, when both are normally operated simultaneously, allows for one housing to be removed from service for maintenance, testing, and emergencies.

4.4.2.2 Leakage Potential. The design of nuclear air cleaning system housings shall consider the potential for leakage.

4.4.2.3 Coatings and Paints. Coating and paint requirements shall be consistent with the corrosion expected in a particular application.

4.4.2.4 Structural Design. Structural design of housings for both safety air cleaning units and non-safety units shall be based on the service conditions the housing may experience during normal, abnormal, and accident conditions.

4.4.2.5 Deflections. Deflections for man-entry housings shall be limited to values that will not cause:

- distortion of the airflow path cross-section, resulting in unacceptable increase in system pressure,
- damage to safety-related items such as instrumentation or other safety equipment or accessories,
- impingement of deflected elements on adjacent services such as equipment, pipe, cables, and tubing,
- loss of leaktightness in excess of leakage limit,
- buckling (refer to ASME AG-1, Section AA-4000), or
- functional failure of components attached to ductwork (e.g., instrument lines).

4.4.2.6 Tolerances. For proper performance and maintenance of installed filters, dimensional and surface-finish tolerances shall be specified and rigidly enforced. Table 4.4.1 below gives minimum tolerances for the installed frame.

4.4.2.7 Welds. Welds on the filter-seating side of the frame shall be ground flat, smooth, and flush.

4.4.2.8 Gaskets. Gel seal and knife edge gaskets shall be glued to the filter element rather than to the mounting frame. A sealant such as silicone may be applied lightly to the filter gasket.

4.4.2.9 Residue. Residue shall be removed before installing new filters as the sealant may be contaminated and could also prevent a proper seal.

Table 4.4.1 – Required Tolerances for HEPA Filter and Adsorber Mounting Frames

Alignment	a) Perpendicularity: maximum offset of adjoining members 1/64 inch/foot or 1/16 inch, whichever is greater. b) Planarity of adjoining members: 1/64-inch maximum offset at any point on the joint.
Flatness	a) Each filter surface plane within 1/16-inch total allowance. b) Entire mounting fixture plane within 1/2-inch total allowance in any 8-by 8-foot area.
Dimension	Length and spacing of members dimensionally correct within +0, -1/16 inch.
Surface-finish	a) Filter seating surfaces are 125 microinches (μin.) AA maximum, in accordance with ANSI Standard B46.1; pits, roll scratches, weld spatter, and other surface defects ground smooth after welding. b) Ground areas merge smoothly with the surrounding base metal; waviness not exceeding 1/32 inch in 6 inch is permissible, as long as the overall flatness tolerance is not exceeded.

4.4.2.10 Clamps. Filter units and adsorber cells shall be clamped to the mounting frame with enough pressure to enable the gasket to maintain a reliable seal when subjected to vibration, thermal expansion, frame flexure, shock, overpressure, and widely varying conditions of temperature and humidity that can be expected in service. Clamps should be adjustable to account for different filter sizes.

4.4.2.11 Nuts/Bolts. The nuts and bolts of the clamping system shall be made of dissimilar materials to prevent galling and seizing.

4.4.2.12 Corrosion Resistance. Bolting materials and clips shall be corrosion resistant.

4.4.2.13 Pleats/Beds. The pleats of Type I adsorber cells and the beds of Type II and Type III cells shall be installed horizontally to avoid adsorbent settling in the cells.

4.4.2.14 Negative Pressure. Filter housings for contaminated exhaust service shall be able to withstand negative pressures without damage or permanent deformation at least up to fan cutoff pressure.

4.4.2.15 Drain System. The drain system shall be tested for leakage as part of the housing leak test, as well as part of system bypass testing of the HEPA and charcoal adsorbent filters.

4.4.3 Use of ASME AG-1 in Design.

The sections of ASME AG-1 listed below shall be applied to housing design and system layout of air cleaning systems in nuclear facilities in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails.

- Article AA-4000, Structural Design
- Article AA-6000, Fabrication, Joining, Welding, Brazing, Protective Coating, Installation
- Article DA-4000, Design
- Article FC-6300, Workmanship
- Article FD-4000, Design
- Article FG-5000, Inspection and Testing
- Article HA-C-1000, Manifold Design Guidelines
- Article BA-4140, Leakage
- Article BA-4141 General
- Article FC-3100, Allowable Materials
- Article FC-4140, Gaskets
- Article FC-4141, Elastomer
- Article FD-3110, Adsorbent
- Article HA-3120, Protective Coatings
- Article HA-4100, General Design
- Article TA-4900, Integrated System Tests
- Article FG-4000, Design
- Article HA-4200, Design Criteria

4.5 External Components

4.5.1 Introduction.

External components of air cleaning systems include fans, heaters, intakes, ductwork, dampers, louvers, stacks, instruments, belts, sheaves, and other accessories associated with the movement, control, conveying, and monitoring of the air or gas flow.

4.5.2 Requirements Based on Chapter 5 of NACH (2003)(archived).

4.5.2.1 Ductwork.

The maximum permissible duct leak rate shall be specified in accordance with Levels 1 through 5 duct classes, as defined in the Nuclear Air Cleaning Handbook, DOE-1169-2022, Table 4.14.

Gaskets used in Levels 1 through 3 duct classes shall be made of materials that are compatible with the service conditions [6] as identified in ASME AG-1 Article SA-4420. Other materials may be used with documentation of performance parameters (e.g., maximum temperature). Gasket material dimensions shall be based on joint design. An acceptable criterion for compression of gasket material shall be established based on the gasket chosen. This acceptance criterion and the service life of the gasket material should be documented by an engineering evaluation or testing.

For DOE installations, Level 3 requirements are the same as Level 2, with these two exceptions:

(a) transverse joints have a full-flanged face width and use ¼ in thick gaskets made of ASTM D1056 grade 2C2 or 2C3 cellular neoprene; grade 2C3 or 2C4, 30 to 40 durometer, Shore-A, solid neoprene; or an equivalent silicone elastomer with interlocking notched corners; or EPDM 40-70 IRHD material; or ASTM D2000-18, Standard Classification System for Rubber Products in Automotive Applications.

(b) nonwelded longitudinal seams, transverse joints, or the entire exterior may have hard-cast treatment (polyvinyl acetate and gypsum tape system) or comparable fire-resistant, radiation-resistant, nonpeeling, leaktight treatment.

Level 4 ductwork requires all-welded construction with sheet-metal thickness and reinforcements according to ASME AG-1, Section SA. Level 5 ductwork meets leak-tightness requirements as specified in ASME AG-1, Section SA, Nonmandatory Appendix SA-B or American National Standard for Pressure Piping, ASME B31.3 (Process Piping), ASME B31.1 (Power Piping), or the ASME Boiler and Pressure Vessel Code.

4.5.2.2 Ductwork Paint and Protective Coatings. Coating and paint requirements of ductwork shall be consistent with the corrosion expected in the particular application.

4.5.2.3 Dampers. The linkage mechanism for dampers shall be designed to transmit actuator torque for the blades to achieve required leakage performance in accordance with ASME AG-1, Table DA-1-1000-1.

4.5.2.4 Damper Design. Dampers shall be designed to meet the following required performance specifications:

- Seat leakage
- Frame leakage
- Pressure drop leakage
- Closure (or opening time)
- Fire rating and closure

4.5.2.5 Damper Seat and Frame Leakage. Damper seat and frame leakage shall be in accordance with ASME AG-1, Article DA.

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[6] Special gaskets may be needed where tritium is present.

4.5.2.6 Fire Dampers. For fire dampers installed within duct systems where the airflow normally flows continuously and the damper is required to isolate portions of the duct system in case of fire, the damper shall be designed for closure under airflow in accordance with ANSI/AMCA 500-D, *Laboratory Methods of Testing Dampers.*

4.5.2.7 Qualification Tests of Dampers. Qualification tests shall be performed prior to fabrication in accordance with ASME AG-1, Article DA-4315.

4.5.2.8 Qualification of Fire and Smoke Dampers. Fire and smoke dampers shall be tested in accordance with ANSI/AMCA 500-D, UL-555, *Fire Dampers,* and UL-555S, *Smoke Dampers*, respectively, when dampers are required in fire- or smoke-rated barriers.[7]

4.5.2.9 Louvers. Louvers shall meet the same structural seismic loading requirements as the rest of the nuclear air cleaning system if the louvers are required to function during and after a design basis accident.

4.5.2.10 Qualification of Instrumentation and Controls. All instruments used in safety class or safety significant air cleaning systems shall be qualified for environmental and seismic conditions in accordance with the DSA, IEEE 323, IEEE 344, ISA-TR 84.00.06, ASME AG-1 Article AA-4430 (for seismic qualification[8]), and ASME AG-1, Article IA-4420 (for environmental qualification).

4.5.3 Use of ASME AG-1 in Design.

The sections of ASME AG-1 listed below shall be applied to external components in nuclear air cleaning systems in a manner consistent with (a) other DOE design requirements and (b) the specific design criteria of the facility. Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails.

- Section BA, Fans and Blowers
- Section DA, Dampers and Louvers
- Section SA, Ductwork
- Section HA, Housings
- Section IA, Instrumentation and Controls
- Section CA, Conditioning Equipment
- Section FM, High Strength HEPA Filters

[7] See also the requirements of DOE-STD-1066-2016.

[8] See also the requirements of DOE-STD-1020-2016.

5.0 SPECIAL TOPICS

5.1 Fire Protection

5.1.1 Introduction

Air cleaning systems relied upon for safety in DOE nuclear facilities may be subject to the threat of damage by fire. The DSA and the Fire Hazards Analysis (FHA) for a nuclear facility will identify the design basis fire events, internal or external, threatening air cleaning systems. The DSA or FHA may also document the general design approach to be taken to protect the air cleaning system from the threat of fire. To accomplish the smooth integration of fire protection requirements with ventilation system requirements, subject matter experts from both disciplines should be drawn into the design team at an early stage of project development.

5.1.2 Requirements of DOE Order 420.1C, Facility Safety

Safety class and safety significant air cleaning systems are required to be protected according to the applicable fire protection requirements of Chapter II, "Fire Protection," of Attachment 2 to DOE O 420.1C. The Order states that "DOE-STD-1066-2016 [*Fire Protection*] is the applicable fire protection standard for use at DOE facilities."[9] The Order also states:[10]

> <u>Fire Protection Systems</u>. DOE-STD-1066-2016, *Fire Protection*, provides acceptable methods for the design of fire protection systems. Design requirements for safety class and safety significant fire barriers, water supplies, and wet pipe sprinkler systems are provided in Appendix A of DOE-STD-1066-2016. Fire protection system designs are also required to address the applicable design requirements for similar safety systems provided in this attachment.

5.1.3 Requirements of DOE-STD-1066-2016, Fire Protection

Section 4.2.5.1 of DOE-STD-1066-2016 states the following in regard to ventilation systems in general:

> **Ventilation Systems.** NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems*, or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*, are the applicable NFPA standards for design and installation of ventilation systems. NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, is the applicable NFPA standard for exhaust conveyance systems. Once-through ventilation systems do not require shutdown upon activation of duct smoke detectors unless the FHA establishes that shutdown is needed to prevent the spread of fire or for emergency management.

[9] Att. 2, Ch. II, 3.b.(2).
[10] Att. 3, Ch. II, 3.b. (7).

The fire protection criteria for nuclear ventilation systems are found in Section 4.4.4 of DOE-STD-1066-2016, "Nuclear Confinement Ventilation System Fire Protection." The requirements stated there are incorporated by reference here.[11]

5.1.4 Requirements Based on Chapter 10 of NACH (2003)(archived)

5.1.4.1 Use of Fire Models. When fire modeling is to be relied upon, validated, and verified fire models referenced in the DSA or other Authorization Basis documents shall be used.

5.1.4.2 Design Basis Fires. The designer of a nuclear air cleaning system is responsible for analyzing the effects of the calculated design basis fire on system functionality. This analysis may be qualitative, based on judgment and experience, or quantitative, based on use of approved fire models. In the latter case, the chosen fire shall be sufficiently conservative (severe) to be an upper bound for the mitigative features protecting the function of the confinement ventilation system.[12]

5.1.4.3 UL Qualification. Nuclear air and gas treatment filters shall meet the following requirements:

- HEPA filters: Underwriters Laboratory UL-586, *High-Efficiency, Particulate, Air Filter Units*
- Prefilters: UL-900, *Performance of Air Filter Units*
- *ASME AG-1 HEPA filter qualifications per FC-5100, Qualification Testing*

5.1.4.4 Electrical Systems. Electrical systems shall be installed in accordance with NFPA 70, the *National Electrical Code* (NEC).[13, 14]

5.1.4.5 Fire Detection Equipment. Detection equipment for early warning of fire conditions shall be provided in all HEPA filter housings (except for portable HEPA systems), in accordance with NFPA 72.[15]

5.1.4.6 Suppression Systems. Automatic sprinkler extinguishing systems shall be designed to comply with the requirements of NFPA 13, *Standard for the Installation of Automatic Sprinkler Systems,* and NFPA 15, *Water Spray Fixed Systems For Fire Protection*. Long-term viability of the suppression system should be considered. For example, the additional cost of welded stainless-steel piping and stainless steel or coated sprinklers may be modest compared to the costs of replacement in a contaminated enclosure.[16] Hybrid suppression and clean agent suppression systems may be used as alternatives to water-based suppression. If these systems are used, the

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[11] Note that the 1999 version of DOE-STD-1066 contains design criteria in Section 14.6.2. These criteria were moved to footnote 48 in the 2016 version of DOE-STD-1066.

[12] A sufficiently conservative fire is based not only on the combustible load but also on ventilation into the space. There can be situations where a fire is ventilation controlled versus fuel controlled. Both inputs should be included in the analysis of a design basis fire and documented in the DSA and FHA.

[13] Article 500 of the NEC will need to be invoked if flammable or combustible dusts, mists, or atmospheres are possible or expected.

[14] Use of NFPA 70 is also mandated by DOE-STD-1066-2016.

[15] For further details, see Section 4.4.4.10 of DOE-STD-1066-2016.

[16] For further details, see Sections 4.4.4.11 to 4.4.4.15 of DOE-STD-1066-2016.

design should follow NFPA 770, *Standard on Hybrid (Water and Inert Gas) Fire Extinguishing Systems*, or NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, as applicable.

5.1.4.7 Backup System. When called for by the FHA or DSA, an alternative method of fire protection or other compensatory measures shall be provided to account for failure of the primary fire protection system. For water-based suppression systems, backup generally includes a redundant, and in some cases an independent water supply such as a pressure tank.[17]

5.1.5 ASME AG-1 (2019).[18]

The requirements of Section FN, Filter Media: High Efficiency, shall apply to the manufacture of high efficiency, fire-resistant, filter media for use in the construction of HEPA filters installed in DOE nuclear facilities.[19]

5.2 Natural Phenomena Hazards

5.2.1 Introduction.

Air cleaning systems relied upon for safety in DOE nuclear facilities may be subject to Natural Phenomena Hazards (NPH) of various kinds, for example, earthquakes and floods. The DSA for the facility will state which NPH phenomena are to be considered in the design and may also state the general design approach to be taken. The air cleaning system is then designed to withstand the identified NPH challenges in accordance with DOE O 420.1C and DOE-STD-1020-2016.

5.2.2 Requirements of DOE Order 420.1C and DOE Guide 420.1-1A.

Safety class and safety significant air cleaning systems are required to meet the applicable NPH requirements of Chapter 1 of Attachment 2 to the Order, *Nuclear Safety Design Criteria*. Applying these Order requirements to ventilation systems is subject to the guidance found in DOE G 420.1-1A: Section 5.4.12, *Design of Ventilation Systems*, and Table A-1, *Confinement Ventilation Systems Design and Performance Criteria*.

5.2.3 Requirements of DOE-STD-1020-2016.

Nuclear air cleaning systems and components relied on for safety in the DSA are expected to withstand certain types of natural phenomena hazards. Such hazards theoretically include seismic, high winds, floods, lightning, extreme precipitation, and volcanoes, all of which are analyzed in DOE-STD-1020-2016. Depending on the site and the construction of the facility, some or perhaps nearly all of these hazards will not threaten safety air cleaning systems, which are normally protected by the building structure.

Nonetheless, the design and hazard evaluation approaches in DOE-STD-1020-2016 are applicable to nuclear air cleaning systems to ensure that such systems function as described in

[17] For further details, see Appendix A to DOE-STD-1066-2016.
[18] Note that AG-1 is cited as guidance ("should") in several subsections of Section 4.4.4, "Nuclear Confinement Ventilation System Fire Protection," of DOE-STD-1066-2016.
[19] This is also required by DOE-STD-3020-2015, Section 4.2.

the DSA and meet minimum life safety requirements. The following sections of DOE-STD-1020-2016, which deal with design approaches to mitigating specific hazards, shall be considered:

- 2.3.3 Criteria and Guidance for Establishing NPH Design Categories for Safety SSCs
- 3.5 Building and Equipment Response Analysis to Determine Seismic Demand
- 3.6 Building and Equipment Capacity Evaluation
- 4.4 SSC Design to Mitigate Wind-Related Hazards
- 5.5 SSC Design and Evaluation to Mitigate Flood-Related Hazards
- 6.0 Criteria and Guidelines for Lightning Design
- 7.5 SSC Design and Evaluation to Mitigate Precipitation-Related Hazards
- 8.4 Design Considerations for Volcanic Hazards
- 9.4 NPH Evaluation of SSCs in Existing Hazard Category 1, 2 and 3 Nuclear Facilities

5.2.4 Requirements Based on ASME AG-1 (2019).

Seismic and structural design requirements are generally located in ASME AG-1 Article AA-4000, “Structural Design.” As of the time of publication of this standard, ASME has undertaken a major revision of Section AA, one purpose of which is to provide requirements and guidance applicable to DOE nuclear facilities. When ASME’s revision is complete, this standard may be revised to incorporate the new code provisions.

In the interim, the provisions of Article AA-4000 may be consulted and used to construct a Code of Record for a new DOE nuclear facility, provided this does not create a conflict with other DOE NPH requirements.

5.3 Occupational Safety and Health

5.3.1 Introduction.

This Standard adds no requirements for occupational safety and health related to air cleaning systems. For convenience, existing requirements are listed in the next section. Section 5.4 of DOE-HDBK-1169-2022 contains additional information and best practices on applying these requirements. See also the ACGIH Industrial Ventilation Manual for useful guidance.

5.3.2 Requirements.

a. 10 CFR Part 851, *Worker Safety and Health Program*

b. OSHA Rule 29 CFR 1910, *Occupational Safety and Health Standards* [20]

c. 10 CFR Part 835, *Occupational Radiation Protection*

d. DOE-STD-1098-2017, *Radiological Control*

[20] Incorporated by reference in 10 CFR Part 851.

5.4 Deep-Bed Sand Filters

5.4.1 Introduction.

Deep-Bed Sand (DBS) filters have been used by DOE for radiological filtration since 1948. This type of filter has been used at the Hanford Site in Washington State and at the DOE Savannah River Site in South Carolina to support reprocessing facilities.

Because DOE is the primary United States user of DBS filters for radiological filtration, it created its own design criteria for these structures. These criteria were contained in various editions of the NACH, the latest being NACH 2003 (Sections 3.5 and 9.3). Since 2003, however, substantial material on DBS filters has been added to ASME AG-1 with the participation of DOE. The next section provides requirements drawn from each of these sources.

5.4.2 Design Requirements for Deep-Bed Sand Filters.

5.4.2.1 Structural Stability. The DBS filter housing is a poured concrete structure, usually located partially underground, with walls capable of withstanding the Design Basis Event without cracking and the design basis flood without leaking. The floor has channels for distributing the incoming air and is covered by hollow block, perforated distribution blocks, or a raised stainless steel grating platform in accordance with ASME AG-1, Section FL-4120. The floor and the distribution system shall be designed to bear the weight of the sand column above it.

5.4.2.2 Site Selection. To ensure that the selected location of the DBS filter meets the intended technical function, the location shall be suitable for near surface disposal in accordance with the requirements of 10 CFR Part 61, Subpart D.

5.4.2.3 ASME AG-1, Section FL-4100, General Deep-Bed Sand Filter Design. The requirements of this section and its associated mandatory appendices shall be applied to DBS design in a manner consistent with (a) other applicable DOE design requirements and (b) the specific design criteria of the facility. Where there is a conflict between a listed provision of AG-1 and a DOE design requirement, the DOE requirement prevails. The guidance contained in Nonmandatory Appendix FL-B, “Guidelines for Deep Bed Sand Filters,” should be considered in conjunction with information and best practices in Section 5.4 of DOE-HDBK-1169-2022.