Relationship of the American Society of Mechanical Engineers Code on Nuclear Air and Gas Treatment with the U. S. Department of Energy Standards for High Efficiency Particulate Air Filters

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ABSTRACT

The Department of Energy (DOE) provides direction to its contractors for the procurement and required inspection and testing of high efficiency particulate air (HEPA) filters used in DOE nuclear facilities. The American Society of Mechanical Engineers (ASME) AG-1, *Code on Nuclear and Air Gas Treatment,* [1] is the primary national consensus standard used to develop the provisions of the DOE Technical Standards for HEPA filtration. DOE Technical Standards are applicable to axial and radial flow HEPA filters with glass fiber media as per Sections FC and FK of the ASME AG-1 code. DOE Technical Standards specify additional quality assurance (QA) inspection and testing be performed at an independent Filter Test Facility (FTF) prior to installation at DOE nuclear facilities. This is in addition to the inspection and testing done by the filter manufacturers. DOE has found ASME AG-1 to be an effective standard in determining specifications for the design, construction, procurement, and required testing of HEPA filters used in DOE nuclear facilities.

INTRODUCTION

DOE provides direction through the use of two Technical Standards. The two Technical Standards were developed by subject matter experts from across the DOE complex including several that are members of the ASME AG-1 code committee.

DOE-STD-3020, *Specification for HEPA Filters Used by DOE Contractors,* [2] establishes specifications, including QA requirements, for the procurement, packaging, shipping and storage of HEPA filters. This Standard also specifies minimum requirements to be included in the contractor's purchase order and/or technical specification.

The DOE-STD-3025, *Quality Assurance Inspection and Testing of HEPA Filters,* [3] provides direction to the independent FTF on the QA requirements for HEPA filter inspection and testing that are to be performed by the FTF, which is under contract with the DOE. The DOE Technical Standards specifically state that inspection and testing are

to be performed at an independent FTF prior to filter installation at DOE nuclear facilities. This is in addition to the inspection and testing performed by the filter manufacturers.

DOE is required to refer to national consensus standards, such as ASME AG-1, when applicable and establish guidance or requirements when not addressed by national consensus standards or when DOE requirements need to be more stringent. ASME AG-1 was the primary national consensus standard used to develop the provisions in DOE-STD-3020.

HEPA filters are required to be manufactured and qualified per ASME AG-1, Sections FC or FK, as applicable. In addition, the filters are to be manufactured and qualified per Section 5.0 HEPA Filter Procurement and Section 6.1 Quality Assurance as shown in DOE-STD-3020.

DOE-STD-3020 is applicable to axial and radial flow HEPA filters with glass fiber media as per Sections FC and FK of the ASME AG-1 code. There are other classes of HEPA filters with different media, such as high-strength, metal, and ceramic, which are currently under various stages of testing, development and review by the ASME AG-1 code committee. Other classes of filters will be considered for incorporation into the DOE Standard after the ASME AG-1 code committee has developed requirements for their use.

DOE Technical Standards periodically undergo revision to reflect changes in the ASME AG-1 code and other national consensus standards. DOE-STD-3020 was recently revised in June 2015 primarily to clarify requirements and update the provisions related to materials and construction of filters to be consistent with the ASME AG-1 code. The revision also added and revised requirements for legacy filters. DOE's legacy filters are HEPA filter configurations allowed under historic ASME codes or predecessor agency contractual requirements that are needed for continued confinement in existing DOE nuclear facilities. Also, the revised Standard ensured consistency with quality assurance requirements provided in DOE Order 414.1D, *Quality Assurance* [4]. In addition, a team of subject matter experts is currently completing a revision of DOE-STD-3025 to align it with the recent changes to DOE-STD-3020.

Usually, DOE technical standards, such as DOE-STD-3020, do not establish requirements for DOE contractors. However, all or part of the provisions in a DOE Technical Standard can become requirements when they are explicitly stated as requirements in a DOE requirements document or an organization makes a commitment to meet a Technical Standard in a contract, implementation plan or program plan. DOE-STD-3025 is required per the existing contract with the operators of the Filter Test Facility.

DISCUSSION

A Secretarial memo directed DOE to perform one hundred percent QA testing of certain HEPA filters at the DOE FTF [5] prior to use in DOE facilities. These HEPA filters are primarily used in nuclear facility confinement ventilation systems that perform a safety function, or are designated as important to safety (i.e., safety class or safety significant per DOE-STD-3009, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*) [6]. The HEPA filters necessary for habitability systems that protect workers who must not evacuate in emergency situations are also included in this mandatory testing.

HEPA filters used in other applications for confinement ventilation systems for radioactive airborne particulates are considered for testing at the FTF. For these applications, DOE sites are to develop and document an independent tailored filter quality assurance testing program that includes the testing of a sample of filters at the FTF. The size of the sample to be tested is to be large enough to provide sufficient statistical power and significance to assure the required level of performance.

DOE-STD-3020 is applicable to the procurement of HEPA filters that are rated at a minimum of 20 actual cubic feet per minute (ACFM) airflow (34 m^3/hr) at an initial resistance not to exceed 1.3 inch (in) water gauge (wg) (325 pascal (Pa)) and are:

- to be installed in nuclear facility (Hazard Category 1, 2, 3, and radiological facilities) confinement ventilation systems; or
- to be installed in the habitability systems (e.g., filters that protect workers who must not evacuate in emergency situations because of the necessity to shut down or control the situation).

The DOE FTF performs the following QA inspections and testing of HEPA filters:

- Resistance at 100 percent rated flow
- Penetration at 20 and 100 percent rated flow
- Workmanship
    - Filter frame
    - Fluid seal
    - Gasket
    - Media
    - Out of Square
- Shipping damage or labeling issues

DOE filters that must be procured for installation at DOE nuclear facilities are to be compliant with DOE-STD-3020. It is imperative that the DOE purchasers provide the FTF a copy of the purchase order including any special requirements for the filter product. This aids the FTF in determining if the purchase order includes proper specifications and that the manufacturer meets the stipulations of the purchase order. The purchaser is notified of deviations from the purchase order specifications by the FTF manager before testing of the filters. The purchase order must have specified the manufacturing and testing requirements to ensure the filters are manufactured per ASME AG-1, Sections FC or FK, and are production-tested by the manufacturer per ASME AG-1, FC-5000 or FK-5000 as applicable prior to delivery at the FTF. Appendix A, *Purchase Order Information*, of DOE-STD-3020 provides the minimum information to be included in purchase orders for filters that are to be tested at the FTF. However, considering specific facility design requirements, the purchaser may specify in the purchase order or in the accompanying technical specification, additional performance criteria in excess of those established by ASME AG-1. Any additional purchase order requirements are to be clearly identified in the purchase order such as requests for special labeling, testing, or packaging. DOE filter procurements are not to specify any material containing cadmium as acceptable for treatment of HEPA filter cases or asbestos as an acceptable HEPA filter component due to environmental concerns.

Mandatory Requirements

The following examples of HEPA filter design, construction and performance requirements are contained in DOE Technical Standards and have been adopted from ASME AG-1 or other national consensus standards:

***Penetration*:** Aerosol penetration limits for HEPA filters shall be as specified in ASME AG-1, Sections FC-4000 or FK-4000.

Resistance: Airflow resistance across the HEPA filter shall conform to the limits listed in Table 1, *Nominal Sizes and Ratings for FC HEPA Filters*, for FC filters, Table 2, *FK Type 1 Radial Flow HEPA Filters – Nominal Rating* for FK Type 1 filters, and Table 3, *FK Type 2 Axial Flow Circular HEPA Filters – Nominal Rating*, for FK Type 2 filters. For FK Type 4 filters, the resistance at any rated air flow shall not exceed 1.3 in wg (325 Pa). Tests for resistance to airflow are conducted at flow rates expressed in ACFM.

Materials Requirements: Construction materials for HEPA filters shall be selected to mitigate generation of Environmental Protection Agency-regulated wastes as specified in 40 CFR 261, *Identification and Listing of Hazardous Waste*. [7]

Filter Medium: Filter medium shall be in accordance with ASME AG-1, FC-3000 or FK-3000.

Case Materials: Metal or wood cases shall be in accordance with ASME AG-1, Sections FC-3000 or FK-3000. This includes end caps and grilles for ASME AG-1, FK Type 1 filters.

Separator Material: Separator material, including acid resistant separators, shall be in accordance with ASME AG-1, Sections FC-3000 or FK-3000.

Adhesives: Adhesives shall be in accordance with ASME AG-1, Sections FC-3000 or FK-3000.

Gaskets and Seals: Two qualified methods for sealing the filter to its filter frame are elastomer gaskets and gelatinous seals. Two different methods or materials shall not be used on the same filter case. If non-qualified specialty gasket material is required, its use shall be documented.

Elastomer Gasket: Elastomer gasket materials shall be in accordance with ASME AG-1, Sections FC-3000 or FK-3000.

Gelatinous Seal: The sealant material shall be in accordance with ASME AG-1, FC-3000 or FK-3000. The gelatinous seal substance shall be corrosion resistant, shall not relax, crack, separate, or stick or adhere to the knife-edge, and shall be insoluble in water. Evaporation shall be less than 2% when tested in accordance with SAE AS 8660 [8] for 24 hours at 390 °F (198 °C). Additional requirements for the gelatinous seal are currently undergoing revision to reflect definitions developed by the National Fire Protection Association [9] and UL900 [10] requirements for the flash point of the gelatinous seal material.

Face Guards: Face guards shall be in accordance with ASME AG-1, Sections FC-3000 or FK-3000.

Fasteners: The following are approved fasteners for the assembly of metal HEPA filter cases:

- Stainless steel bolts: 300 series per ASTM A 320 [11] or ASTM A 193 [12]
- Stainless steel nuts: 300 series per ASTM A 194 [13]
- Stainless steel washers: 300 series per ASME B 18.21.1 [14]
- Stainless steel rivets: 300 series per ASTM A 581 [15]

Table 1. Nominal Sizes and Ratings for FC HEPA Filters

Number Designation	Dimensions (inches)	Dimensions (millimeters)	Minimum Rated Airflow		Maximum Resistance	
			ACFM	m^3/hr	in wg	Pa
1	8 x 8 x 3-1/16	203x203x78	25	42	1.3	325
2	8 x 8 x 5-7/8	203x203x150	50	85	1.3	325
3	12 x 12 x 5-7/8	305x305x150	125	212	1.3	325
4	24 x 24 x 5-7/8	610x610x150	500	850	1.0	250
5	24 x 24 x 11-1/2	610x610x292	1000	1700	1.0	250
6	24 x 24 x 11-1/2	610x610x292	1250	2125	1.3	325
7	24 x 24 x 11-1/2	610x610x292	1500	2550	1.3	325
8	24 x 24 x 11-1/2	610x610x292	2000	3400	1.3	325
9	12 x 12 x 11-1/2	305x305x292	250	425	1.3	325

Notes:

1. Adopted from ASME AG-1, Table FC-4110 (see note 5).
2. Dimensions are height by width by depth.
3. The rated airflow for Section FC filters is listed in ASME AG-1 in SCFM. However, this Standard specifies ACFM which is based on tests performed indoors at an atmospheric pressure close to sea level. The temperature and pressure under which the tests have been conducted are to be recorded, but are not to be used to correct rated flow.
4. Number designation 4 filters must be qualified independently of the qualification of any larger, similar filter sizes.
5. Table FC-4110 shows a value of 320 Pa for 1.3 in wg. The actual converted value should be 325 Pa.

Table 2. FK Type 1 Radial Flow HEPA Filters – Nominal Rating

Maximum Rated Airflow		Maximum Resistance	
ACFM	m^3/hr	in wg	Pa
40	68	1.3	325
100	170	1.3	325
250	425	1.3	325
500	850	1.3	325
1000	1700	1.3	325
1500	2550	1.3	325
2000	3400	1.3	325

Notes:

1. From ASME AG-1, Table FK-4000-1.
2. The rated airflow in ACFM is based on tests performed indoors at an atmospheric pressure close to sea level. The temperature and pressure under which the tests have been conducted are to be recorded, but are not to be used to correct rated flow.

Table 3. FK Type 2 Axial Flow Circular HEPA Filters – Nominal Rating

Maximum Rated Airflow		Maximum Resistance	
ACFM	m^3/hr	in wg	Pa
20	34	1.0	250
35	60	1.0	250
100	170	1.0	250

Notes:

1. From ASME AG-1, Table FK-4000-2
2. The rated airflow in ACFM is based on tests performed indoors at an atmospheric pressure close to sea level. The temperature and pressure under which the tests have been conducted are to be recorded, but are not to be used to correct rated flow.

CONCLUSIONS

The Department has found ASME AG-1 useful in determining specifications for the design, construction, procurement, and testing of HEPA filters used in DOE nuclear facilities. Even though the DOE Technical Standards also use other national consensus standards for determining additional requirements and specifications, ASME AG-1 is the primary consensus standard used to develop DOE HEPA filtration standards. Specific sections of the ASME AG-1 code are readily adoptable to axial and radial flow HEPA filters with glass fiber media which are currently the predominant filters installed in DOE nuclear facilities. The DOE Office of Environment, Health, Safety and Security will continue to follow future revisions to the ASME AG-1 code and other national consensus standards that are applicable to HEPA filters to ensure the DOE Technical Standards are consistent with the national consensus standards.

REFERENCES

1. ASME AG-1, *Code on Nuclear Air and Gas Treatment*

2. DOE-STD-3020, DOE Technical Standard, *Specification for HEPA Filters Used by DOE Contractors*

3. DOE-STD-3025, DOE Technical Standard, *Quality Assurance Inspection and Testing of HEPA Filters*

4. DOE Order 414.1D, *Quality Assurance*

5. Abraham, Spencer, Secretary of Energy letter to John T. Conway, Chairman of the Defense Nuclear Facilities Safety Board, *100 Percent Quality Assurance Testing of HEPA Filters at the FTF*, June 4, 2001.

6. DOE-STD-3009, DOE Technical Standard, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*

7. 40 CFR 261*, Identification and Listing of Hazardous Waste*

8. SAE AS 8660, *Silicon Compound, NATO Code Number S-736*

9. National Fire Protection Association 921, *Guide for Fire and Explosion Investigations,* 2014 Edition

10. UL900, Underwriter's Laboratory *Standard for Air Filter Units*. Edition 8, April 21, 2015.

11. American Society for Testing and Materials A 320, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service*

12. American Society for Testing and Materials A 193, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

13. American Society for Testing and Materials A 194, *Standard Specification for Carbon and Alloy-Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

14. American Society of Mechanical Engineers B 18.21.1, *Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)*

15. American Society for Testing Materials A 581, *Standard Specification for Free-Machining Stainless Steel Wire and Wire Rods*