



**RIVER PROTECTION PROJECT – WASTE TREATMENT PLANT**

**ENGINEERING SPECIFICATION**

**FOR**

**Nuclear Grade High Efficiency Particulate Air (HEPA) Filters  
(ASME AG-1 Section FK Filters)**

Content applicable to ALARA?

Yes  No

ADR No.  
24590-WTP-ADR-HV-04-0002

Rev  
1

Specification changes retroactive?

Yes  No  
 N/A (alpha revision or revision 0)

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NOTE: Contents of this document are Dangerous Waste Permit affecting.

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**SPECIFICATION No.**  
24590-WTP-3PS-MKH0-T0002

**Rev**  
4

Please note that source, special nuclear, and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA) are regulated at the U. S. Department of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that pursuant to AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.

**Revision History**

Revision	Reason for Revision
4	Incorporate alternative system specific testing, pack designs, filter media, and initial five percent efficiency test. Changes support resolution of technical issues identified in 24590-WTP-TIES-ENG-12-0010, <i>WTP Technical Issues Sheet -October 2012 Update</i> , Technical Issue 2011-0001, "HEPA Filter Combined Loading Test Failure". <b>Complete Revision No Change bars.</b>
3	Administrative update to source document to incorporate outstanding changes and supersede permit document no longer required by Project. Incorporated 24590-WTP-3PN-MKH0-00022. Supersedes 24590-WTP-3PS-MKH0-TP002, Rev 3.
2	<p>Issued to support design qualification testing and production.</p> <p>Completely revised. This revision includes, but is not limited to, changes to incorporate:</p> <ol style="list-style-type: none"> <li>1) Specification Change Notice 24590-WTP-3PN-MKH0-00018 incorporated as follows:           <ul style="list-style-type: none"> <li>• 1st change: 24590-WTP-SDDR-PROC-05-00116 superceded by 24590-WTP-SDDR-HV-06-00008. This later SDDR is incorporated by reference.</li> <li>• 2nd change: Second sentence "If a date or revision..." not incorporated. Justification: Proposed text would violate procedure 24590-WTP-3DP-G04B-00049 Engineering Specifications, Rev. 10, Article 3.6.2.</li> <li>• 3rd change: Not incorporated. SCN text is no longer consistent with text as presented in RPP-WTP Safety Requirements Document Volume II 24590-WTP-SRD-ESH-01-001-02 Appendix C 35.0 (see Subarticle FK-4100).</li> <li>• 4th change: Not incorporated. SCN text is no longer consistent with text as presented in RPP-WTP Safety Requirements Document Volume II 24590-WTP-SRD-ESH-01-001-02 Appendix C 35.0 (see Table FK-4001). For the Safe Change HEPA filter, the specification requirement article 3.2.4 is stated for a more stringent pressure drop maximum (i.e., 1.3 in.wg.) than the allowed maximum (1.6 in. wg.) as stated in the SRD.</li> <li>• 5th change: Incorporated.</li> <li>• 6th change: Editorial- The correct article cross reference has been made.</li> </ul> </li> <li>2) New title to clarify intent of specification on RPP-WTP.</li> <li>3) ASME AG-1 Section FK requirements, replacing Section FC requirements throughout document. Revised edition of ASME N509 from 1989 to 2002. These changes were made in accordance with CCN 128654, Approval of Authorization Basis Amendment Request 24590-WTP-SE-ENS-04-0212 Rev. 1.            (Note: There are no SRD implementing codes or standard deviations in the following changes.)</li> <li>4) Requirements to test all HEPA filters in accordance with approved Trend TN-24590-03-01317, "QA Testing of HEPA Filters at DOE Filter Test Facility". Specification Sections 1.2, 1.5, 3.1, 3.2, 6.3, 7.2, 7.3, 7.6 and 8.2.</li> <li>5) Specification requirements for Type 3 HEPA filters (used primarily for safe change HEPA housing vacuum relief during maintenance filter replacement).</li> <li>6) Remote change HEPA filter design cross-reference and criteria related to remote handling process (Specification Section 3.1).</li> <li>7) Expanded discussion regarding filter seismic qualification test plan and test report requirements (Specification Section 3.2).</li> <li>8) Added HEPA Filter Data Sheet (Appendix A).</li> <li>9) Expanded Shipping and Handling Instructions (Specification Section 7.6).</li> <li>10) Clarified code and project required supplier quality assurance (Specification Section 8.2) and submittal requirements (Specification Section 10).</li> </ol>

**24590-WTP-3PS-MKH0-T0002, Rev 4**  
**Nuclear Grade High Efficiency Particulate Air (HEPA) Filters**  
**(ASME AG-1 Section FK Filters)**

Revision	Reason for Revision
1	Issued to support design development. NOT TO BE USED FOR FABRICATION OF QL-1 OR QL-2 FILTERS.  Complete Revision. Conforms Spec to Current Project Requirements. Incorporate Spec Change Notice (SCN): 24590-WTP-3PN-MKH0-00004. SCN 24590-WTP-3PN-MKH0-00008 not incorporated. Incorporate Supplier Deviation Disposition Requests (SDDRs): 24590-WTP-SDDR-PROC-04-00134, 24590-WTP-SDDR-PROC-03-0155, and 24590-WTP-SDDR-PROC-03-0193.
0	Issued for Purchase

## Notice

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# 1 Scope

## 1.1 Project Description and Location

The River Protection Project - Waste Treatment Plant (RPP-WTP) is a complex of waste treatment facilities where the Department of Energy's (DOE) Hanford site tank waste will be put into stable glass form. The WTP Contractor will design, build, and start up the WTP pretreatment and vitrification facilities for the Office of River Protection (ORP). The waste treatment facilities will pretreat and immobilize the low activity waste (LAW) and high level waste (HLW) currently stored in underground storage tanks at the Hanford Site.

The Hanford Site occupies an area of about 560 square miles and is located along the Columbia River, north of the city of Richland, Washington. The WTP Facility will be constructed at the East End of the 200 East Area of the Hanford Site.

## 1.2 Equipment, Material, and Services Required

The Supplier shall design, fabricate, qualify, and test HEPA Filters in accordance with:

- This specification and the requirements of ASME AG-1 Section FK
- WTP Project HEPA Filter Datasheets (prepared per template, Appendix A)
- HEPA Filter Test Plan, 24590-WTP-3PS-MKH0-T0014

The specification covers the following HEPA Filter types:

- Safe Change HEPA Filters, ASME AG-1, FK-4111 (b), Type 1 Radial Flow HEPA Filters, with Gelatinous Seals, rated for 2,000 ACFM, and as depicted in ASME AG-1-2009, Figure FK-4100-2.
- Remote Change HEPA Filters, ASME AG-1, FK-4111 (d), Type 1 Radial Flow HEPA Filters, with Gelatinous Seals, rated for 2,000 ACFM, and as depicted in ASME AG-1-2009, Figure FK-4100-4.
- ASME AG-1, FK-4113 and FK-4114, Type 3 Axial Flow Filters, with rectangular or circular filter element in an enclosure with inlet and/or outlet connections as depicted in ASME AG-1-2009, Figures FK-4100-7 or FK-4100-8, and used for example as Valved Bleed Filters on Safe Change HEPA Filter housings, or breather filters on process bulges.

Per ASME AG-1, Article FK-3130, filter media for the above filter types shall conform to the requirements of ASME AG-1, Mandatory Appendix FC-I, unless otherwise specified. The selected filter medium pack shall meet the bounding environmental and process conditions of 200 inches WC differential pressure, 100% relative humidity, and 170°F.

Per Section 4.1.1.6, filters may be specified with alternative filter medium packs with respect to ASME AG-1 Mandatory Appendix FC-I. The filter medium may include reinforced HEPA filter medium with glass cloth backing, boron silicate microfiber high strength reinforced microfiber,

sintered metal, or other options. Additional non-mandatory information for alternative metal medium HEPA filters and high strength HEPA filters are described in Appendix B and Appendix C, respectively. The filter medium may be fabricated with separators, spacers, or other structural mechanical devices to maintain a rigid filter pack as required to prevent filter pleat collapse for the bounding conditions of 200 inches WC differential pressure, 100% relative humidity, and 170°F.

System specific testing and ASME AG-1 required qualification testing, as modified for the resistance to pressure test using liquid flows as documented in the HEPA Filter Test Plan, 24590-WTP-3PS-MKH0-T0014, shall be performed and certified by an independent test facility. Production of the WTP Radial Flow HEPA Filters shall not commence until the qualification tests are successfully completed and the results are accepted by the Buyer.

This specification also incorporates select supplemental requirements from Department of Energy (DOE) standard, DOE-STD-3020-2005, *Specification for HEPA Filters Used by DOE Contractors*. This specification includes requirements to conduct independent quality assurance testing at a DOE Filter Test Facility (FTF). With the exception of replacement of FTF failed filters, the Supplier is not responsible for FTF applicable specification requirements. Reference Section 6.3 of this specification for FTF failed filter requirements. Reference Section 7.2 and 7.3 for FTF labeling requirements.

### **1.3 Work by Others**

1.3.1 Material unloading and storage at job site

1.3.2 Installation labor

### **1.4 Definitions**

1.4.1 Certificate of Conformance. A written statement, signed by a qualified party, certifying that items or services comply with specific requirements.

1.4.2 Challenge Aerosol. Poly-disperse droplets used as challenge aerosol for testing installed HEPA filters for leaks. The poly-disperse aerosol used for leak testing of systems differs in size from the 0.3 micrometer mono-disperse DOP aerosol used for efficiency testing of individual HEPA filters by manufacturers.

1.4.3 Filter Burst Strength. A typical value of filter pressure differential at which a filter design has been proven to fail as indicated by an irreversible increase in aerosol penetration.

1.4.4 Filter Medium. The fiber matrix in a filter which captures suspended particles from an air or a gas stream. The plural form of "filter medium" is "filter media."

1.4.5 Grab Ring. Ring provided at the inlet of a Remote Change HEPA Filter to facilitate insertion and removal operations by remote systems.

- 1.4.6 HEPA Filter. High Efficiency Particulate Air Filter. A throwaway, extended medium dry type filter with a rigid casing. The filter shall exhibit a particle removal efficiency of 99.97% when tested with essentially mono-dispersed 0.3 micrometer diameter test aerosol particles. Test aerosol particles shall be DOP (dioctyl phthalate), DOS (dioctyl sebacate) or PAH (poly-alpha olefin).
- 1.4.7 High Strength HEPA Filter: A HEPA filter having a significantly higher filter burst strength, than filters qualified to the performance requirements of ASME AG-1 Sections FC and Section FK. The higher strength results from an inherently greater ultimate tensile strength of the filter medium and enhanced filter pack robustness and stability. Definition does not include metal filter medium, which would also provide a high filter burst strength but is treated separately in this specification.
- 1.4.8 High Strength HEPA Filter Medium. A non-metal HEPA filter medium having a significantly higher ultimate tensile strength than a filter medium qualified to the performance requirements of Appendix FC-I of ASME AG-1 Article FC.
- 1.4.9 Metal Medium HEPA Filter. A device having one HEPA filter element formed from a sintered metal filter medium assembled in an ASME AG-1 Section FK Type 1 radial flow HEPA filter configuration, for removing suspended particles from air or gas that is passed through the filter.
- 1.4.10 Process Bulge. A confinement structure to provide for the safe operation and maintenance of "hands-on" maintainable process equipment such as pumps, valves, instruments and associated equipment.
- 1.4.11 Production Test. A test made on an individual production item to verify its performance in accordance with specified requirements.
- 1.4.12 Qualification Tests. Test performed on HEPA filters, prior to production, by an independent test facility in accordance with the requirements of ASME AG-1, Article FK-5100 except the resistance to pressure test is replaced with a high pressure liquid flow test.
- 1.4.13 Remote Change. Remote change implies that the Remote Change HEPA filter requires an integral grab ring that works in conjunction with a mechanical filter handling tool as required for remote installation and removal.
- 1.4.14 Safe Change. Safe change implies that the Safe Change HEPA filter can be manually installed and removed by an operator without remote equipment and without breaking confinement.
- 1.4.15 Type 1. Radial flow HEPA filters as defined by ASME AG-1 Article FK-4100 and FK-4111. Also referred to as "Safe Change" and "Remote Change" HEPA filters throughout this specification.

- 1.4.16 Type 3. Axial flow rectangular or circular enclosed filters as defined by ASME AG-1 Article FK-4100, FK-4113, and FK-4114.
- 1.4.17 Water Column (WC). The units for air pressure typically expressed in inches of water column height (e.g., 2.5 inches WC).

## **1.5 Abbreviations**

- 1.5.1 ACFM, Actual Cubic Feet per Minute
- 1.5.2 ANSI, American National Standards Institute
- 1.5.3 ASHRAE, American Society of Heating, Refrigerating and Air-Conditioning Engineers
- 1.5.4 ASME, American Society of Mechanical Engineers
- 1.5.5 ASTM, American Society for Testing and Materials
- 1.5.6 CAS, Chemical Abstract Service
- 1.5.7 CM, Quality Level "CM" (for commercial material)
- 1.5.8 DOE, Department of Energy
- 1.5.9 EEQ, Equipment Environmental Qualification
- 1.5.10 FTF, Department of Energy Filter Test Facility
- 1.5.11 HEPA, High Efficiency Particulate Air (Filter)
- 1.5.12 PPOE, Parent Piece of Equipment
- 1.5.13 RPP-WTP, River Protection Project - Waste Treatment Plant
- 1.5.14 Q, Quality Level "Q" (meeting quality requirements of ASME NQA-1)
- 1.5.15 SDDR, Supplier Deviation Disposition Request
- 1.5.16 SC-I, SC-II, SC-III, and SC-IV, Seismic Categories
- 1.5.17 SC, Safety Class
- 1.5.18 SS, Safety Significant
- 1.5.19 UL, Underwriters Laboratories, Inc.
- 1.5.20 WC, Water Column

## 1.6 Safety and Quality Classifications

Type 1 HEPA filters provided under this Specification are expected to meet RPP-WTP Project requirements for one of the following applications:

- Safety Class (SC) or Safety Significant (SS), Quality Level Q, Air Permit, and Seismic Category SC-I or SC-II service in a WTP Remote Change HEPA Filter Housing.
- SC or SS, Quality Level Q, Air Permit, and Seismic Category SC-I or SC-II service in a WTP Safe Change HEPA Filter Housing.
- Non-safety or Air Permit, Quality Level Q, and Seismic Category SC-III or SC-IV service in a WTP Safe Change HEPA Filter Housing.

Type 3 HEPA filters provided under this Specification are Non-safety, Commercial Material (CM) components and are not credited for seismic purposes (SC-IV) unless otherwise stated in the procurement documentation.

## 2 Applicable Documents

The following documents form a part of this specification to the extent specified herein. In the event of conflict between the document referenced herein and the contents of this specification, the Buyer shall be notified of the conflict. The latest document edition and addenda shall apply unless otherwise noted. For the codes and standards listed below, the specific revision or effective date identified, as well as the specific revision or effective date of codes and standards that they incorporate by reference (daughter codes and standards), shall be followed. The effective dates and revisions listed in Section 2 shall apply to subsequent references to the codes and standards within this specification.

### 2.1 ANSI/ASME – American Society of Mechanical Engineers

- 2.1.1 ASME AG-1-1997 with ASME AG-1a-2000 Addenda, Code on Nuclear Air and Gas Treatment (herein referred to as ASME AG-1).
- 2.1.2 ASME N509-2002, Nuclear Power Plant Air Cleaning Units and Components.
- 2.1.3 ASME N510-1989, Reaffirmed 1995, Testing of Nuclear Air Treatment Systems.
- 2.1.4 ASME NQA-1-89, Quality Assurance Program Requirements for Nuclear Facilities.
- 2.1.5 UL-586-1990, Underwriters Laboratories Inc., Test Performance of High Efficiency Particulate, Air Filter Units.
- 2.1.6 ASME NQA-1-2004 Quality Assurance Requirements for Nuclear Facility Applications. (Limited Application - Packaging and Storage Requirements Only)

2.1.7 ASME AG-1 Section FK, Special Round and Duct Connected HEPA Filters (Section FK was approved by the ASME Board on Nuclear Codes and Standards in 2005, and is available in ASME AG-1-2009).

## **2.2 U.S. Department of Energy Standards**

2.2.1 DOE-STD-3020-2005, Specification for HEPA Filters Used by DOE Contractors

2.2.2 DOE-STD-3025-99, Quality Assurance Inspection and Testing of HEPA Filters

## **2.3 Other Reference Documents and Drawings**

2.3.1 24590-WTP-3PS-MKH0-T0001, Engineering Specification for HVAC Safe Change HEPA Filter Housings.

2.3.2 24590-WTP-3PS-MKH0-T0003, Engineering Specification for HVAC Remote Change HEPA Filter Housings.

2.3.3 24590-HLW-3PS-MQL0-T0003, Engineering Specification for Filter/Filter Lid Grapples.

2.3.4 24590-WTP-M0-M10T-00023, PTF/HLW Vitrification System PFH/HFH Design Proposal Drawing Filter Grapple.

2.3.5 24590-WTP-3PS-G000-T0001, Supplier Quality Assurance Program Requirements.

2.3.6 24590-WTP-3PS-G000-T0003, Engineering Specification for Packaging, Handling, and Storage Requirements.

2.3.7 24590-WTP-3PS-G000-T0015, Engineering Specification for Environmental Qualification of Mechanical Equipment. This specification is for information only and is not a direct requirement for this specification. Reference Section 3.6 for clarification.

2.3.8 WTP Project HEPA Filter Datasheets (prepared per template, Appendix A, and included with purchase requisition).

2.3.9 24590-WTP-RPT-ENG-12-047. High Efficiency Particulate Air (HEPA) Filter Test Plan.

## **2.4 WTP Project Design Drawings**

The assembled HEPA filters shall be designed to be installed in the current design of the WTP filter housings, and shall reflect the overall dimensions, tolerances, and all required interfaces depicted in the following documents.

2.4.1 24590-QL-POA-MKH0-00003-03-01, Drawing - Shop Detail Safe Change Gel Seal.

- 2.4.2 24590-QL-POA-MKH0-00003-03-05, Drawing - Outline Drawing Safe Change Filter Datasheet.
- 2.4.3 24590-QL-POA-MKH0-00003-03-09, Drawing - Assembly Safe Change Gel Seal.
- 2.4.4 24590-QL-POA-MKH0-00003-03-00013, Drawing - Detail Remote Change Type 1, Urethane Sealant.
- 2.4.5 24590-QL-POA-MKH0-00003-03-00014, Drawing - Assembly Remote Change Type 1, Urethane Sealant.
- 2.4.6 24590-QL-POA-MKH0-00003-03-00017, Drawing - Remote Change Type 1 HEPA Filter.
- 2.4.7 24590-QL-POA-MKH0-00001-04-23, Drawing - LAW C5V Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit.
- 2.4.8 24590-QL-POA-MKH0-00001-04-05, Drawing - LAW C5V Safe Change HEPA Filter Retainer Detail.
- 2.4.9 24590-QL-POA-MKH0-00001-04-00035, Drawing - LAW/LAB Safe C2V and C3V Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit.
- 2.4.10 24590-QL-POA-MKH0-00001-04-00041, Drawing - LAW/LAB C2V and C3V Safe Change HEPA Filter Retainer Detail.
- 2.4.11 24590-QL-POA-MKH0-00001-04-00052, Drawing - LAB C5V Safe Change HEPA Filter Retainer Detail.
- 2.4.12 24590-QL-POA-MKH0-00001-04-00053 , Drawing - Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit.
- 2.4.13 24590-QL-POA-MKH0-00001-04-00133, Drawing - Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit.
- 2.4.14 24590-QL-POA-MKH0-00001-04-00140, Drawing - Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit for -115 Inches WC.
- 2.4.15 24590-QL-POA-MKH0-00001-04-00141, Drawing - Safe Change HEPA Filter Housing Assembly Details 4 Filter Unit for -115 Inches WC.
- 2.4.16 24590-QL-POA-MKH0-00002-07-00074, Drawing - HLW C5V/PJV Remote Change HEPA Filter Housing Assembly Details 5 Filter Unit.
- 2.4.17 24590-QL-POA-MKH0-00002-07-00124, Drawing - HLW HOP Remote Change HEPA Filter Housing Assembly Details 2 Filter Unit.

## 2.5 Informational Reference Documents

The following codes and standards are not specifically invoked on the WTP Project, but were used to the extent referenced herein or by ASME AG-1 as a source of information in development of technical and performance requirements.

2.5.1 DOE-HDBK-1169-2003, DOE Nuclear Air Cleaning Handbook

## 2.6 Design Changes Incorporated By Reference

2.6.1 24590-WTP-SDDR-HV-06-00008 (Supersedes 24590-WTP-SDDR-PROC-05-00116)

# 3 Design Requirements

References to ASME AG-1 Section FK requirements are made throughout this specification. The Section FK references and requirement excerpts provided herein are not intended to imply non-applicability of any Section FK requirement that is not specifically included. Unless explicitly stated otherwise, all ASME AG-1, Section FK requirements apply.

## 3.1 General

- 3.1.1 This specification relates to Type 1 and Type 3 HEPA filters as specified in ASME AG-1 Section FK. More specifically, the Type 1 HEPA filters are further described as Safe Change and Remote Change Radial Flow HEPA Filters with a maximum rated airflow of 2,000 ACFM (950 liters per second) per filter and suitable for manual and remote change housing installations, respectively. Type 3 HEPA filters design requirements are further described in Section 3.1.17 and 3.1.18.
- 3.1.2 Type 1 HEPA filter performance requirement design criteria as identified in ASME AG-1 Table FK-4000-4 and resistance to 200 inches WC differential pressure, 100% relative humidity, and 170°F.
- 3.1.3 Safe Change Radial Flow HEPA Filters shall include a gelatinous seal and be suitable for horizontal installation in multi-filter cabinet style housings specified in 24590-WTP-3PS-MKH0-T0001, Engineering Specification for HVAC Safe Change HEPA Filter Housings. In addition, the assembled safe change HEPA filters shall be designed to be installed in the current design of the WTP Safe Change HEPA Filter Housing, and shall reflect overall dimensions and interfaces as depicted on WTP Project drawings (Section 2.4). The filter Supplier shall provide a seal rated for a differential pressure range of 1 inch WC to 200 inches WC. The filter Supplier shall submit to the Buyer a test report as objective evidence that the seal is suitable for a differential pressure range of 1 inch WC to 200 inches WC.
- 3.1.4 Remote Change Radial Flow HEPA Filters shall include a gelatinous seal and be suitable for vertical installation in remotely operated multi-filter cabinet style housings

specified in 24590-WTP-3PS-MKH0-T0003, Engineering Specification for HVAC Remote Change HEPA Filter Housings. In addition, the assembled remote change HEPA filters shall be designed to be installed in the current design of the WTP Remote Change HEPA Filter Housing, and shall reflect overall dimensions and interfaces as depicted on WTP Project drawings (Section 2.4). The filter Supplier shall provide a seal rated for a differential pressure range of 1 inch WC to 200 inches WC. The filter Supplier shall submit to the Buyer a test report as objective evidence that the seal is suitable for a differential pressure range of 1 inch WC to 200 inches WC.

- 3.1.5 For design development purposes, limiting criteria for Remote Change Radial Flow HEPA Filters are shown in Table 1, below. These criteria may be superseded by Supplier design drawings submitted for Buyer review and permission to proceed. The Supplier design drawings will be used to document the final design.

<b>Table 1 Remote Change Radial Flow HEPA Filter Limiting Criteria</b>	
<b>Criteria</b>	<b>Basis Statement</b>
The outer diameter (OD) of the filter, inclusive of all design features (e.g. seal channel) and fabrication tolerances, shall not exceed 21 inches.	Export of waste filter from facility C5 cave requires use of remote equipment, export basket, and 55-gallon waste container. This process limits the dimensions of the waste item (i.e., filter).
The length of the filter, inclusive of all design features and fabrication tolerances, shall not exceed 26-1/2 inches.	The current design of the export basket limits the filter size which may be inserted into the basket. The basket is inserted into a 55-gallon waste container.

- 3.1.6 Design of the Type 1 Safe Change and Remote Change Radial Flow HEPA filters shall conform to applicable portions of ASME AG-1, Section FK, and applicable portions of the documents listed in Section 2 of this specification. Where conflicts between the Supplier's design and ASME AG-1, Section FK, exist, the Supplier shall identify the respective code articles that do not apply and notify the Buyer via a Supplier Deviation Disposition Request prior to initiation of filter design qualification testing. For filter designs that have been previously qualification tested, the Supplier shall notify the Buyer of code conflicts during design submittal review (e.g., prior to fabrication). Deviations to ASME AG-1 Section FK requirements identified within this Specification do not require Buyer notification.
- 3.1.7 As required by ASME AG-1, Article FK-3130, the filter medium shall comply with ASME AG-1, Article FC, Mandatory Appendix FC-I and shall also comply with Section 4.1.1.6 whereby the medium shall maintain performance at 200 inches WC differential pressure, 100% relative humidity, and 170°F.
- 3.1.8 Type 1 filter packs shall comply with ASME AG-1, FK-4111. Other ASME AG-1 Section FK articles pertaining to filter pack design also apply (e.g., FK-4116, FK-4120, and FK-4130).

- 3.1.9 Installation and removal of the safe change HEPA filter shall be based on bag-in bag-out procedure.
- 3.1.10 Installation and removal of the remote change HEPA filter shall be based upon use of a sequencing grapple that is remotely positioned onto the filter using a crane and hook. The remote change HEPA filter requires an integral grab ring that shall work in conjunction with a filter grapple. The physical configuration of the remote change HEPA filter grab ring shall match the filter grapple. It shall be the Supplier's responsibility to confirm the physical configuration and interfaces of the grapple, remote change HEPA filter, filter grab ring, and filter housing to ensure the assembly meets all tolerance requirements. Reference 2.3.2, 2.3.3, and 2.3.4 for interface requirements.
- 3.1.10.1 The Supplier shall complete a structural capability test on the remote change HEPA filter using a static load of 1500 pounds.
- 3.1.10.2 The structural capability test is intended to simulate the loads associated with the grapple operating sequence, and shall include a weight of 1500 pounds associated with the weight of the sequencing grapple, crane hook, and crane cable block.
- 3.1.10.3 The structural capability test shall be completed with a remote change HEPA filter oriented, as installed, open end up.
- 3.1.10.4 The 1500 pound static weight shall be applied six (6) times to the remote change HEPA filter. The weight shall be applied uniformly.
- 3.1.10.5 The structural capability test fixture shall be sized to support a remote change HEPA filter and shall include a knife edge seal. The filter shall be supported by the knife edge only. The 1500 pound load shall be centered on a 15 inch diameter surface. The load shall be aligned with the vertical centerline of the filter. As a suggestion, the test fixture could be manufactured from a 24 or 26 inch diameter pipe, 36 inches in length, with the knife edge welded to one end of the pipe. The knife edge shall be aligned in the center of the filter gelatinous seal material.
- 3.1.10.6 Before initiating the structural capability test, the Supplier shall confirm the flatness tolerance of the remote change HEPA filter by taking measurements every 60 degrees using a straight edge and feeler gauges. The measurements shall be recorded and submitted to the Buyer if requested.
- 3.1.10.7 After the structural capability test, the Supplier shall demonstrate that the remote change HEPA filter is capable of withstanding the static load without permanent deformation or deterioration and provide "like-new" filter performance after the structural capability test.

- 3.1.11 The Safe Change Radial Flow HEPA Filters shall use a gel filled channel located on the inner diameter of the filter inlet. The channel shall be manufactured from ASME AG-1 compatible material and either fully integrated into the filter inlet flange (preferred) or affixed in position using a continuous seal weld. The construction method shall ensure that the gel channel remains in place and does not contribute to filter bypass during operation or fail structurally during filter installation and removal.
- 3.1.12 The Remote Change Radial Flow HEPA Filters shall use a gel filled channel located on the outer diameter of the filter inlet. The channel shall be manufactured from ASME AG-1 compatible material. The construction method shall ensure that the gel channel remains in place and does not contribute to filter bypass during operation or fail structurally during filter installation and removal.
- 3.1.13 Filter seals shall perform the following functions:
  - 3.1.13.1 Provide a leak tight seal between the filter and the mating surface in the HEPA filter housing. See Section 2.4 for dimensional drawings of filters that are dimensionally compatible with current housing designs.
  - 3.1.13.2 Accommodate maximum fabrication tolerances of the housings mating knife edge without compromising seal integrity.
  - 3.1.13.3 The gel seal material shall remain in the gel seal channel during installation and removal cycles that would be normally expected to occur during operation of the system, as well as during design basis seismic events.
- 3.1.14 Handles on Safe Change Radial Flow HEPA Filters used for installation and removal shall:
  - 3.1.14.1 Facilitate manual handling without damage to the filter.
  - 3.1.14.2 Be attached to withstand installation and removal loads.
- 3.1.15 Grab Rings on Remote Change Radial Flow HEPA Filters used for installation and removal shall:
  - 3.1.15.1 Facilitate remote mechanical handling without damage to the filter.
  - 3.1.15.2 Be attached to withstand installation and removal loads.
  - 3.1.15.3 Be compatible with remotely operated mechanical systems (provided by others) to facilitate insertion and removal operations by remote systems.
- 3.1.16 The design of the remote change HEPA filter shall include internal and external grille retention strips. The purpose for the retention strip is to ensure the filter end caps do not separate.

- 3.1.17 The Type 3 HEPA filters are axial flow filters with a maximum rated airflow and pressure drop as specified on the related equipment datasheets. Type 3 HEPA filters are typically intended for non-safety related use as vacuum relief (e.g., bleed) filters for manual Safe Change HEPA housing maintenance, or for process bulge breather or inlet filters, and are typically not subjected to deleterious environments. Type 3 Axial Flow HEPA Filters shall conform to applicable portions of ASME AG-1, Section FK and applicable portions of the documents listed in Section 2 of this specification, except as otherwise specified on equipment datasheets or procurement documentation. Type 3 Axial Flow HEPA Filters shall be compatible with the equipment interface. For Type 3 filter designs that have been previously qualification tested, the Supplier shall notify the Buyer of code conflicts during design submittal review (e.g., prior to fabrication).
- 3.1.18 Connection fittings selected for fabrication of Type 3 HEPA filters, intended for use as vacuum relief (e.g., bleed) filters, shall be compatible with the couplers specified for use on the Safe Change HEPA housings (Reference 2.3.1) or other equipment (e.g., process bulges) as applicable.
- 3.1.19 All filters shall be inspected and tested at a DOE FTF prior to Buyer acceptance.

### **3.2 Performance**

The performance of Safe Change and Remote Change Radial Flow HEPA Filters shall conform to applicable portions of ASME AG-1, Section FK, and applicable portions of the documents listed in Section 2 of this specification, including, but not limited to the following requirements:

- 3.2.1 Filter Medium Efficiency: ASME AG-1, FK-1130: 99.97% when tested with an aerosol of essentially 0.3 micron diameter test aerosol particles.
- 3.2.2 Seismic: ASME AG-1, FK-4300. Type 1 HEPA filters shall be seismically qualified as part of the filter housing by the proof testing method in accordance with ASME AG-1, Article FK-4300 and AA-4350. The acceptance criteria shall be per FK-4300.
- 3.2.2.1 The specification for the parent piece of equipment (e.g., filter housing) shall be used to document Buyer seismic test and load criteria to be used for this qualification testing.
- 3.2.2.2 The Supplier may submit a prior report qualifying use of a filter in a given installation provided that the Supplier can prove the following:
- (a) The equipment proposed to be used on the WTP Project is identical to that used in the prior qualification report. If they are not identical, the Seller shall demonstrate how the differences would not affect the seismic qualification.
  - (b) The WTP Project equipment functional requirements during and after the Design Basis Event (DBE) are similar or less stringent than those in the prior qualification report.

- (c) Potentially significant aging mechanisms related to equipment performance as identified for the prior qualification report bound the aging characteristics expected for the given WTP system installation.
  - (d) The equipment support used in the testing is identical to that proposed for use on the WTP Project, and, prior qualification report based on Total Response Spectrum envelopes the WTP Required Response Spectrum.
- 3.2.2.3 A seismic qualification test plan shall be provided to the Buyer for review and approval prior to testing. This test plan shall be a submittal requirement of the parent piece of equipment specification (i.e., filter housing specification) and is not a submittal requirement of this specification.
- 3.2.3 System specific testing shall be required by an independent test facility in accordance with WTP Project HEPA Filter Datasheets prior to acceptance and production.
- 3.2.4 Qualification Testing: ASME AG-1, FK-5100, except the resistance to pressure test. Article FK-5140, shall be replaced with the resistance to pressure using the liquid flow test. Testing prior to acceptance and production, and certified by an independent test facility.
- 3.2.5 Resistance to Airflow: The following alternate criteria are approved for use for Type 1 HEPA filter designs regarding ASME AG-1 Articles FK-4100 and FK-5110. These resistance criteria apply when tested in accordance with paragraph FK-5120.
- 3.2.5.1 Article FK-4100 Code Requirement Text: The total media area provided within the filter pack shall be such that the maximum media velocity is 5 feet per minute at the rated flow. Accepted WTP Replacement Requirement Test for Article FK-4100: The total filter medium area provided within the RPP-WTP radial filter pack shall be such that the maximum filter medium velocity is 6.5 feet per minute at the rated airflow. For alternative HEPA medium, such as the high strength glass fiber and the steel fiber medium, the lowest possible media velocity will be considered.
  - 3.2.5.2 Table FK-4000-1 Code Requirement Text: Type 1 Radial Flow HEPA Filter Nominal Rating: Maximum Resistance of 1.3 inches WC at 2000 ACFM maximum rated airflow. Accepted WTP Replacement Requirement Text for Table FK-4000-1: For Type 1 Remote Change HEPA Filter Only, Nominal Rating: Maximum Resistance of 1.55 inches WC at 2000 ACFM maximum rated airflow. Table FK-4000-1 requirements continue to apply as-is to Type 1 Safe Change HEPA filters. For alternative HEPA media such as the high strength glass fiber and the steel fiber medium the lowest possible media resistance will be considered.
- 3.2.6 Test Aerosol Penetration: ASME AG-1, FK-5120, 0.03% at rated (i.e., maximum) flow rate and 5% of rated flow rate, where rated flow rate is 2,000 ACFM.

- 3.2.7 Resistance to Rough Handling: ASME AG-1, FK-5130.
- 3.2.8 Resistance to Pressure: ASME AG-1, FK-5140, shall be replaced with the liquid flow test.
- 3.2.9 Resistance to Heated Air: ASME AG-1, FK-5150. Underwriters Laboratories test results or UL 586 designation shall be traceable to the actual design. Qualification based on the same filter medium or similar filter designs tested by UL is not acceptable as objective evidence of compliance with FK-5150.
- 3.2.10 Spot Flame Resistance: ASME AG-1, FK-5160. Underwriters Laboratories test results or UL 586 designation shall be traceable to the actual design. Qualification based on the same filter medium or similar filter designs tested by UL is not acceptable as objective evidence of compliance with FK-5160.
- 3.2.11 Supplier performed production inspection and testing shall be in accordance with ASME AG-1, Articles FK-5500 and FK-5600.
- 3.2.12 All production testing results are subject to validation through FTF quality assurance testing.

### **3.3 Design Conditions**

- 3.3.1 Anticipated filter service conditions of 200 inches WC differential pressure, 100% relative humidity, and 170°F.
- 3.3.2 HEPA filters are not to be used for installations where there is a possibility of condensation forming on them, unless otherwise indicated on the WTP Project HEPA Filter Datasheets. This restriction applies only to HEPA filters using the standard glass fiber medium and not to the reinforced glass fiber medium or steel fiber medium.

### **3.4 Temperature**

As a minimum, per ASME AG-1, Article FK-1121, filters built to Section FK shall be acceptable for continuous use at a maximum operating temperature of 250°F, unless more stringent temperature requirements are specified on system specific WTP Project HEPA Filter Datasheets.

### **3.5 Aging**

The maximum life for a HEPA filter specified below is based upon guidance in the DOE Nuclear Air Cleaning Handbook (Reference 2.5.1 Section 3.3.8.1) for HEPA filters using standard glass fiber medium specified in ASME, FC-1.

The maximum total life (storage and in-service) for a HEPA filter is considered to be 10 years from the date of manufacture for applications in dry systems and 5 years in applications where the filter has the potential to become wet (e.g., more than once for short periods). If a filter gets wet, it should be replaced expeditiously.

The maximum life for a HEPA filter using high strength HEPA medium or steel fiber medium is expected to be significantly greater than the values for standard glass fiber medium specified above. The Supplier shall provide evidence to justify recommended shelf life and service life of filters.

### **3.6 Equipment Environmental Qualification**

3.6.1 Equipment environmental qualification (EEQ) is performed on HEPA filter housings in accordance with specification 24590-WTP-3PS-G000-T0015, Engineering Specification for Environmental Qualification of Mechanical Equipment. EEQ requirements apply to HEPA filter housings that are classified Safety Class (SC) or Safety Significant (SS). The HEPA filters are consumable components that support the safety function of the corresponding HEPA filter housing .

3.6.2 HEPA filters shall be tested in accordance with Section 6 of this specification. The environmental conditions for the ventilation or process airstreams in which the filters are located are listed on system-specific WTP Project HEPA Filter Datasheets for normal, abnormal, and post-DBE conditions. Specification 24590-WTP-3PS-G000-T0015 does not apply to HEPA filter qualification.

### **3.7 Supplemental Design Information for Metal Medium HEPA Filters**

Additional non-mandatory design information for Metal Medium HEPA Filters is provided in Appendix B.

### **3.8 Supplemental Design Information for High Strength HEPA Filters**

Additional non-mandatory design information for High Strength HEPA Filters is provided in Appendix C.

## **4 Materials**

### **4.1 Construction**

4.1.1 Materials of construction for the Safe Change and Remote Change Radial Flow HEPA Filters shall conform to ASME AG-1, Article FK-3000, and applicable portions of the documents listed in Section 2 of this specification.

4.1.1.1 Type 1: ASME AG-1, FK-1121 Type A, C, or D filter medium pack with urethane adhesive. Types A and D prescribe separators as part of the filter medium pack. Alternative separator designs are also acceptable, with Buyers approval, if they can be qualified by testing per the requirements of this specification. This filter type shall be developed and qualification tested for each type of housing (Remote Change and Safe Change).

Reference the Material Requisition 24590-QL-MRA-MKH0-00003 for quantity required.

- 4.1.1.2 Type 3: ASME AG-1, FK-1121 Type C filter medium pack with urethane adhesive. Reference the Material Requisition 24590-QL-MRA-MKH0-00001 for quantity required.
- 4.1.1.3 Case Material Thickness and Material Type: ASME AG-1, FK-3110: ASTM A240 Type 304 or 304L (annealed) is preferred, however, alternate materials subject to Article FK-3220 requirements and Buyer review may be proposed for use.
- 4.1.1.4 Grilles: ASME AG-1, FK-3170: ASTM F 1267 Type II Class 3 Expanded Stainless Steel fabricated from Type 304L (annealed) stainless steel sheets as specified in ASTM A666. The finish of the expanded metal grille shall have no sharp edges. The Supplier shall provide expanded metal grilles with mechanical treatment (e.g., sand blasting) or chemical treatment.
- 4.1.1.5 Gasket Material: Gelatinous Seal per ASME AG-1, FK-3122.
- 4.1.1.6 Filter Medium: ASME AG-1, FK-3130 with hydrofluoric acid resistant filter medium formulation. Per FK-3130, the filter medium shall conform to the requirements of Mandatory Appendix FC-I and be resistant to 200 inches WC differential pressure, 100% relative humidity, and 170°F. Alternatively, the Buyer may specify HEPA filter medium that meets the requirements in ASME AG-1 FK-3130 and is resistant to 200 inches WC differential pressure, 100% relative humidity, and 170°F using metal fiber medium, reinforced glass fiber medium, or other options. Additional information for metal medium and high strength medium is given in Appendix B and C respectively.
- 4.1.1.7 Adhesive: ASME AG-1, FK-3150.

## 4.2 Prohibited Materials

- 4.2.1 For materials in contact with stainless steel, the following shall apply: Low melting point metals (i.e., lead, zinc, tin, antimony, cadmium, mercury) shall not exceed 1% by weight, with mercury not exceeding 50 parts per million. Halides shall not exceed 200 parts per million. This prohibition applies to use of tools, fixtures, paints, coatings and sealing compounds, and any other equipment or materials used by the Supplier during handling, assembly, and storage of stainless steel parts or components.
- 4.2.2 Asbestos shall not be included in any component of the Safe Change and Remote Change Radial Flow HEPA Filter.

### 4.3 Material for Metal Medium HEPA Filters

Additional non-mandatory information on material for Metal Medium HEPA Filters is provided in Appendix B.

### 4.4 Material for High Strength HEPA Filters

Additional non-mandatory information on material for High Strength HEPA Filters is provided in Appendix C.

## 5 Fabrication

### 5.1 General

5.1.1 Fabrication of the Type 1 Safe Change and Remote Change Radial Flow HEPA Filters shall be as specified in ASME AG-1, Article FK-6000 with the following exceptions.

5.1.1.1 Article FK-6211 (a) Code Requirement Text: Type 1 filter flange and end cap tolerances shall meet the following criteria: parallel within 1/16 in. (1.6 mm), square to the filter centerline axis to within 1/16 in. (1.6 mm) over the total filter length, flat within 1/16 in. (1.6 mm). Accepted WTP Replacement Requirement Test for Article FK-6211 (a): Type 1 filter flange and end cap tolerances shall meet the following criteria: parallel within 1/8 in., flat within 1/16 in. Circular run-out of inlet flange with respect to outlet end cap shall not exceed 3/32 in.

5.1.1.2 Article FK-6212 (a) Code Requirement Text: Type 1 filter length shall be  $\pm 1/16$  in. (1.6 mm), filter sealing ring diameter  $\pm 1/16$  in. (1.6 mm), sealing face diameter  $+1/32$  in./-0 in. (+0.8 mm/-0 mm), concentricity shall be 1/16 in. (1.6 mm), all other dimensions  $\pm 1/16$  in. ( $\pm 1.6$  mm). Accepted WTP Replacement Requirement Text for Article FK-6212 (a): Type 1 filter length shall be (+0/-1/8 in.), circular run-out of filter flange with respect to the filter end cap shall be within 3/32 in., all other dimensions  $\pm 1/16$  in. with exception that design filter medium to grille (i.e., faceguard) gap shall be  $\pm 1/8$  in. (i.e., to maintain a minimum filter medium to grille gap of 1/8 in. For the reinforced glass fiber medium and the steel fiber medium, there shall be no gap between the filter medium and the grill to prevent media ballooning at high air flow resistance.

5.1.2 Fabrication of the Type 3 axial flow rectangular or circular HEPA filters shall be as specified in ASME AG-1, Article FK-6000 unless otherwise accepted by the Buyer (e.g., Supplier Deviation Disposition Request).

## 5.2 Fabrication of Metal Medium HEPA Filters

Additional non-mandatory fabrication information for Metal Medium HEPA Filters is provided in Appendix B.

## 5.3 Fabrication of High Strength HEPA Filters

Additional non-mandatory fabrication information for High Strength HEPA Filters is provided in Appendix C.

# 6 Tests and Inspections

## 6.1 General

- 6.1.1 The test and inspection of Type 1 and Type 3 HEPA Filters shall conform to ASME AG-1, Article FK-5000 except the resistance to pressure test, FK-5140, shall be replaced with the high pressure liquid flow test. Refer to Section 3.2 for specific test requirements.
- 6.1.2 The Suppliers test and inspection personnel shall be formally trained to perform assigned duties in accordance with the Suppliers training qualifications program. This program shall be documented and shall be in accordance with recognized standards.
- 6.1.3 Type 1 Safe Change and Remote Change Radial Flow HEPA Filters shall require qualification testing prior to acceptance and production. Filter testing shall be performed and certified by an independent test facility as specified by ASME AG-1, Article FK-5100 except the resistance to pressure test, FK-5140, shall be replaced with the high pressure liquid flow test. Type 3 HEPA filters may be qualified as specified by ASME AG-1, Article FK-5300, or based on the prior qualification of a similar qualified Type 2 circular axial flow filter as specified by ASME AG-1, Article FK-5200. Type 1 Safe Change and Remote Change Radial Flow HEPA Filters and Type 3 HEPA filters shall be seismically qualified under a separate requirement in the Materials Requisition for the HEPA filters. Type 1 Safe Change and Remote Change Radial Flow HEPA Filters shall also be qualified by an independent test laboratory in additional tests to determine (1) filter loading capacity of three aerosol sizes and (2) resistance to particle loading under high temperature and humidity conditions as specified in 24590-WTP-3PS-MKH0-T0014, Rev A, High Efficiency Particulate (HEPA) Filter Test Plan.
- 6.1.4 Each Type 1 and Type 3 HEPA Filter shall bear the UL-586 label indicating successful testing of these filter types in conformance with UL procedures as required by ASME AG-1.
- 6.1.5 Each Type 1 and Type 3 HEPA Filter manufactured for delivery shall be inspected and production tested in accordance with ASME AG-1, Sections FK-5500 and

FK-5600. The results of the production test shall be marked on the label of each filter. Additional attributes to be inspected for Type 1 HEPA Filters are circular run-out and parallelism. Reference Article 5.1.1.

- 6.1.6 The Supplier shall provide objective evidence acceptable to the Buyer that the requirements of ASME AG-1 Mandatory Appendix FC-I, Articles I-3000 and I-5000, have been satisfied. Reference ASME AG-1 Mandatory Appendix FC-I-4120. Otherwise, the Supplier shall provide objective evidence acceptable to the Buyer that an alternative filter medium meets or exceeds these requirements.

## 6.2 Site Tests

Buyer's startup personnel will perform in-place tests after initial installation. Supplier shall provide startup assistance at Buyer's request.

## 6.3 DOE Filter Test Facility Quality Assurance Testing

- 6.3.1 Uniform Commercial Code (UCC) requirements governing acceptance and disposition of nonconforming goods apply. If during FTF receipt inspection, a filter is identified as damaged and unacceptable for use, the FTF shall contact the buyer and seller (supplier) and inform them of the damage immediately.
- 6.3.2 FTF inspection and testing shall be performed in accordance with DOE-STD-3020-2005. As a condition of acceptance, all production filters must successfully pass FTF inspection and testing requirements per sections 6 and 7 of DOE-STD-3020-2005. Testing at the FTF of filters fabricated to support design development or qualification is not required unless otherwise requested by the buyer. Testing at the FTF of filters fabricated to support design development for Phase 1 tests specified in 24590-WTP-3PS-MKH0-T0014, High Efficiency Particulate (HEPA) Filter Test Specification is not required. Testing at the FTF of filters is required for all other qualification tests.
- 6.3.3 FTF shall prepare a report to document the test results and apply permanent test labels on the filter case and the filter shipping carton.
- 6.3.4 Rejected filters shall be addressed in accordance with DOE-STD-3020-2005.
- 6.3.5 If filter(s) fail inspection or testing, the FTF shall notify both the buyer and supplier. The supplier shall be responsible for either replacing failed filter(s), or crediting the buyer, unless other accommodations are agreed upon between the buyer and the supplier.
- 6.3.6 After completion of required inspections and tests, but immediately preceding repackaging of the filter, FTF personnel shall re-inspect the fluid seal (if so equipped) to verify the gelatinous seal was not inadvertently damaged during FTF handling.
- 6.3.7 FTF shall repack accepted filters in a manner comparable to the original packaging received.

6.3.8 FTF activities involving packaging, shipping and storage of HEPA filters shall conform to ASME AG-1 Article FK-7000 requirements (i.e., Level B per ASME NQA-1-2004).

#### **6.4 Testing and Inspection of Metal Medium HEPA Filters**

Additional non-mandatory test and inspection information for Metal Medium HEPA Filters is provided in Appendix B.

#### **6.5 Testing and Inspection of High Strength HEPA Filters**

Additional non-mandatory test and inspection information for High Strength HEPA Filters is provided in Appendix C.

#### **6.6 Additional HEPA Filter Test Requirements**

ASME AG-1 provides requirements for the design, construction, and performance of clean nuclear grade HEPA filters. Materials of construction prescribed in ASME AG-1 protect the function of the HEPA filters from a wide range of exhaust airstream conditions due to upstream processes normally found in nuclear facilities.

WTP accident conditions could exceed the structural strength of a standard ASME AG-1 HEPA filter. Therefore, additional test criteria, over and above what ASME AG-1 requires, must be imposed on the WTP HEPA filters to handle the range of WTP specific process conditions.

WTP HEPA filters will be tested under combined parameters for temperature, relative humidity, and aerosol loading at a subcontracted test facility. The Supplier shall comply with the combined parameters for testing of WTP HEPA filters documented in the High Efficiency Particulate Air (HEPA) Filter Test Plan, 24590-WTP-RPT-ENG-12-047.

## **7 Preparation for Shipment**

### **7.1 General**

HEPA Filters shall be packaged, shipped, handled, and stored in accordance with ASME AG-1, Article FK-7000, and in accordance with requirements of Reference 2.3.4.

### **7.2 Filter Marking and Identification**

7.2.1 Each HEPA Filter shall be identified in accordance with requirements of ASME AG-1, Article FK-9100. The marking and labeling requirements of Reference 2.3.4 are also applicable.

7.2.2 Filter nameplates shall be affixed to the filter end cap in the most readily visible location.

7.2.3 In addition to the information required by ASME AG-1 FK-9100, filter labeling shall include the following information:

- Date of Penetration Test
- Purchase Order (PO) Number and PO Line Item Number
- Procurement Specification Number and Revision
- FTF Test Label (applied by FTF personnel)

7.2.4 Review purchase order to ensure additional filter identification and labeling requirements are not applicable.

### **7.3 Package Marking and Identification**

7.3.1 Marking and labeling for each filter carton shall conform to the requirements of ASME AG-1 Article FK-9200.

7.3.2 In addition to the information required by ASME AG-1, FK-9200, filter package marking shall include the following information:

- Project Number, Purchase Order (PO) Number and PO Line Item Number
- Filter Serial Number
- Procurement Specification Number and Revision
- FTF Test Label (applied by FTF personnel)
- Marking or label indicating the need for special storage environment (e.g., "Special Storage Requirements: ASME NQA-1-2004 Level B Storage or Equivalent is Required").

### **7.4 Packaging**

Packaging shall be in accordance with ASME AG-1, Article FK-7000. The packaging requirements of Reference 2.3.4 are also applicable.

### **7.5 Documentation**

Reference Section 10 of this Specification. Shipping documentation shall accurately reflect specific traceability to the items being shipped.

### **7.6 Shipping and Handling Instructions**

7.6.1 Shipping and Handling of items shall be in accordance with ASME AG-1, Article FK-7000.

7.6.2 Filters shall not be shipped by rail unless prior approval is obtained from the Buyer (Reference 2.5.1 Appendix A.). For large shipments, it is recommended that the entire shipment be shipped in a sealed dedicated trailer. At all times, the filters must be

handled with care and oriented properly. Handling requirements (unique to filters) shall be clearly visible on the shipping carton.

- 7.6.3 Unless otherwise approved by the buyer, filters shall be shipped palletized or crated to minimize unit handling, particularly at public carrier interchange points. Standard pallet sizes shall be used by the supplier.
- 7.6.4 No other materials shall be placed on top of the filters during shipment. A packing list shall be glued securely to the outside of one carton. The packing list shall clearly state if the shipment is a partial shipment. When requested and authorized by the buyer, airfreight shipments shall also be palletized in accordance with this specification.
- 7.6.5 Arrangements shall be made by the Supplier to ensure filters are shipped directly to the DOE-FTF. Note: Filters fabricated to support design development or qualification are not required to be shipped to the DOE-FTF.
- 7.6.6 The carrier shall be instructed that the buyer's personnel will be responsible for unloading filters at the buyer's receiving facility.
- 7.6.7 The following information, taken from the content of Appendix A of Reference 2.5.1, is provided for those arranging shipment of HEPA filters. It should be considered as guidance information only.

Handling at interchange stations should be controlled to prevent temporary storage in conditions that would subject the filters to dampness, excessive heat or cold or rapidly changing temperatures. Proper attention to orientation of the cartons should be maintained consistent with the filter package instruction. Another control is to require that the filters be packed properly in a sealed truck trailer body or in a sealed containerized freight unit, not to be opened until arrival at the specified delivery point. Unloading should be performed by personnel who have been thoroughly instructed in the proper care and handling of HEPA filters. Mixed load shipments should be avoided.

- 7.6.8 The following information, taken from the content of Appendix A of Reference 2.5.1, is provided for those receiving and unloading HEPA filters. It should be considered as guidance information only.

As the shipment is being unloaded, each carton should be inspected for external damage and improper positioning in the cargo space (i.e., the carton placed with arrow direction horizontally). Damaged cartons, including those with corners dented and those improperly oriented in the truck, should be set aside for particularly careful inspection of their contents. Damage will be more prevalent when filter units are loaded with mixed cargoes or are shipped in a partially loaded carrier. The filter unit must be removed carefully from its carton. The acceptable method for removal is to open the top flaps of the container after removing the sealing tape. With flaps folded back, the carton should be inverted or upended gently to place the exposed end of the filter unit on a flat surface, preferably the floor. The surface must be clear of

protrusions. Withdraw the carton from the filter unit. Attempts to remove the filter unit from the carton by grasping below the exposed filter case can result in irreparable damage if fingers puncture the delicate filter materials.

If conflicting handling instructions are provided by the filter manufacturer, the manufacturer's instructions shall prevail.

## **7.7 Storage**

HEPA Filters shall be stored in a controlled environment consistent with Level B as identified in ASME AG-1 Article FK-7000 and as described in DOE-HDBK-1169-2003, Section A.4.

## **7.8 Shipping of Metal Medium HEPA Filters**

Additional non-mandatory shipment information for Metal Medium HEPA Filters is provided in Appendix B.

## **7.9 Shipping of High Strength HEPA Filters**

Additional non-mandatory shipment information for High Strength HEPA Filters is provided in Appendix C.

# **8 Quality Assurance**

## **8.1 Supplier Quality Assurance Program**

- 8.1.1 The supplier shall have in place a Quality Assurance program meeting the requirements of ASME NQA-1-1989 marked as applicable in the Supplier Quality Assurance Program Requirements Datasheet attached to the Material Requisition. The Supplier shall submit his Quality Assurance Manual with the Supplier's bid documentation.
- 8.1.2 The successful bidder must pass a pre-award survey by the Buyer. Supplier shall demonstrate that their quality program is in compliance with the procurement quality requirements listed in the Supplier Quality Assurance Program Requirements Datasheet. The Supplier's Quality Assurance Program, reviewed and accepted by the Buyer, shall apply to every sub-tier supplier to the Supplier. The Supplier shall allow Bechtel, its agent, and DOE access to their or any sub-tier supplier's, facility, and records pertaining to the purchase order for the purpose of Quality Assurance Audits and Surveillance at mutually agreed times.
- 8.1.3 All items shall be manufactured in accordance with the Supplier's Quality Assurance program that meets the requirements of ASME NQA-1-1989, and has been previously evaluated and accepted by the Buyer's Quality Assurance Organization.

8.1.4 Supplier shall submit their Quality Assurance program and work plan to Buyer for approval and permission to proceed prior to commencement of work. The work plan shall include documents and procedures to implement the work and include a matrix of essential Quality Assurance elements cross referenced with the documents/procedures.

## 8.2 Quality Assurance Requirements Specific to Item

8.2.1 Rejected Filters. The Buyer shall notify the Supplier of rejected filters, including the nature of the rejection. Unless otherwise negotiated between the Supplier and Buyer, the Supplier shall provide replacement filters until the stipulated quantity of filters is found acceptable. The Supplier shall provide, at the discretion of the Buyer, replacement filters or credit for any rejected filters.

8.2.2 The Buyer may elect to have qualification testing or verification of materials performed on any filters furnished to them. Failure of any filter submitted for qualification testing to meet specification requirements shall be cause for a reevaluation of the Supplier's quality assurance program.

8.2.3 Qualification Test Evidence. The Supplier shall show documented evidence that qualification tests have been conducted in accordance with ASME AG-1 Article FK-5100, except the resistance to pressure test in FK-5140 shall be replaced with the liquid flow test, and Mandatory Appendix FC-I or equivalent.

8.2.4 Identification of Items with Part Number/Model Number. All filters and filter packages shall be identified with the serial number and model number. Identification shall be in conformance with sections 7.2 and 7.3 of this specification.

**Note:** The following specification items are necessary to satisfy Bechtel Buyer G-321-V Form submittal requirements.

8.2.5 Quality Verification Documents shall be submitted in the form and quantities shown on Form G-321-V, Quality Verification Document Requirements of the procurement package.

8.2.6 Certificate of Conformance. Each shipment shall be accompanied by one copy of the Supplier's Certificate of Conformance, which meets or exceeds the requirements of ASME AG-1, Article FK-8200. The Certificate of Conformance shall include copies of all filter case material certifications.

The Supplier/Manufacturer shall provide documentation that is legible and reproducible. Supplier's/Manufacturer's authorized representative responsible for quality shall sign the Certificate of Conformance. The Certificate of Conformance shall indicate the appropriate Purchase Order/Contract Order number under which the material, equipment, item, or service is being supplied.

- 8.2.7 Identification of Items with Product Datasheet. The supplier shall submit a legible copy of the product datasheet (e.g., drawing, catalog page, brochure) that provides adequate information to enable the Buyer to verify the form and function of the item procured. One copy of the documentation, unless otherwise specified, shall accompany the applicable item(s) shipped.
- 8.2.8 Production Inspection and Test Report. The Supplier shall submit legible, reproducible copies of the production test results and Section 6.1 of this specification. The report(s) shall include the following:
- Identification of the applicable inspection and/or test procedure utilized.
  - Resulting data for all characteristics evaluated, as required by the governing inspection/test procedure.
  - Traceability to the item inspected/tested, (i.e., serial number, part number, etc.).
  - Signature of the Supplier's authorized representative or agency that performed the inspections/tests.
  - One copy of the documentation, unless otherwise specified, shall accompany the applicable item(s) shipped.
- 8.2.9 Filter Test Facility (FTF) Inspection and Test Report. A report or datasheet prepared by FTF personnel for each order. Minimum content requirements for this report are contained in Reference 2.2.2. Also, refer to Section 6.3.2 and 6.3.3 of this specification.

### **8.3 Substitutions**

- 8.3.1 Supplier shall be required to identify and promptly document all deviations from the requirements of the procuring documents. In addition, the Supplier shall be required to describe the recommended disposition based on appropriate analysis. Submittals of request for deviations from lower tier suppliers shall be through the prime supplier to the Buyer.
- 8.3.2 Supplier proposed deviations from procurement documents shall be initiated by use of the Supplier Deviation Disposition Request (SDDR) form attached to the Material Requisition.
- 8.3.3 As required in ASME AG-1 Article FK-5100, new or revised filter designs shall require qualification testing prior to acceptance and production. Furthermore, FK-3220 states that alternative materials found acceptable by the qualification tests of FK-5000, and the design requirements of FK-4000 and Article AA, will be acceptable for fabrication of HEPA filters. It is the responsibility of the Supplier to inform the Buyer when Buyer selected designs and/or materials deviate from these two requirements of ASME AG-1.

#### **8.4 Quality Assurance Requirements for Metal Medium HEPA Filters**

Additional non-mandatory quality assurance information for Metal Medium HEPA Filters is provided in Appendix B.

#### **8.5 Quality Assurance Requirements for High Strength HEPA Filters**

Additional non-mandatory quality assurance information for High Strength HEPA Filters is provided in Appendix C.

## **9 Configuration Management**

Each HEPA Filter shall be tagged in accordance with Section 7.2 of this specification.

## **10 Documentation and Submittals**

### **10.1 General**

Supplier shall submit to Buyer Engineering and Quality Verification documents in the forms and quantities shown in Form G-321-E, Engineering Document Requirements, and Form G-321-V, Quality Verification Document Requirements, attached to the Material Requisition.

### **10.2 Submittals**

Submittals for HEPA Filters shall include:

- 10.2.1 Product catalog datasheets with product description, service application, and limitations for all components.
- 10.2.2 Materials of construction for all components.
- 10.2.3 Pressure drop performance curves indicating PRESSURE DROP (Inch WC) versus FLOWRATE (ACFM).
- 10.2.4 HEPA filter maximum allowable pressure drop.
- 10.2.5 Recommended HEPA filter maximum shelf life and basis for this information.
- 10.2.6 Gasket material radiation tolerance.
- 10.2.7 Weight.
- 10.2.8 Filter dimensions.
- 10.2.9 Material Safety Datasheets.

- 10.2.10 Manufacturers Certificate of Conformance covering the ASME, ASTM, or other material specification, grade, class, (as applicable) for each material used in the filter designs.
- 10.2.11 Design Qualification Test Report prepared to support qualification of filter designs in accordance with ASME AG-1 Article FK-5100 and system specific WTP Project HEPA Filter Datasheets. Provide a Certificate of Conformance with this test report that summarizes Section FK conformance status of the filter designs. Reference ASME AG-1 Article FK-8200.
- 10.2.12 Objective evidence acceptable to the Buyer that the requirements of ASME AG-1 Mandatory Appendix FC-I, Articles I-3000 and I-5000, have been satisfied. Otherwise, the Supplier shall provide objective evidence acceptable to the Buyer that an alternative filter medium meets or exceeds these requirements.
- 10.2.13 Copies of the ASME AG-1, FK-5600 Production Test results.
- 10.2.14 Filter Inspection Record and Packaging Certificate to satisfy ASME AG-1 Articles FK-6300 and FK-5500.
- 10.2.15 Objective evidence, in the form of a test report, acceptable to the Buyer that the seal between the filter and filter housing knife edge is suitable for a pressure differential range of 1 inch WC to 200 inches WC.

### **10.3 Drawings**

- 10.3.1 All drawings shall be submitted as CAD drawings in MicroStation, or MicroStation convertible format.
- 10.3.2 Drawings showing the following information shall be submitted to Buyer for review prior to fabrication:
  - 10.3.2.1 The outline dimensions of the HEPA Filter, including outline and detail drawings for each component.
  - 10.3.2.2 Details of construction and fabrication drawings including fabrication tolerances.
  - 10.3.2.3 The weight of individual components.
  - 10.3.2.4 The ASTM or equivalent designation for materials.

### **10.4 Procedures**

Procedures to be submitted shall include:

- 10.4.1 Test procedures to support FK-5100 Qualification and FK-5600 Production Testing.

- 10.4.2 Test procedures or work plans to demonstrate compliance with system specific WTP Project HEPA Filter Datasheets.
- 10.4.3 Supplier's filter inspection, packaging, and shipping preparation procedure(s) as required to meet the intent of ASME AG-1 Articles FK-5500, FK-6300, and FK-7000.
- 10.4.4 Supplier recommendations (e.g., procedure) for receiving inspection and storage.

## **10.5 Calculations**

Calculations to be submitted shall include applicable engineering data, calculations, and performance charts that demonstrate compliance with this Specification.

## **10.6 Manuals**

Manuals and instructions to be submitted shall include a copy of the Supplier's Quality Assurance Manual.

## **10.7 Certificates of Conformance**

- 10.7.1 The Supplier shall provide Certificates of Conformance complying with ASME AG-1 FK-8200. The following clarifications apply:
  - 10.7.1.1 In regard to conflicts between the Supplier's design and ASME AG-1 Sections FK, the Supplier shall identify the respective code articles that do not apply. This may be accomplished by direct reference on the Certificate of Conformance to Buyer accepted submittal drawings or Supplier Deviation Disposition Request(s).
  - 10.7.1.2 Copies of all filter case material certifications shall be provided. These certifications shall state all applicable material standards with year or edition to permit compliance assessment with Article FK-2000.
- 10.7.2 Furnish UL-586 certificate to meet evidence requirement of Article FK-5160.
- 10.7.3 The Supplier shall provide a Certificate of Conformance with objective evidence that the materials used for the selected glass fiber medium, or reinforced glass fiber medium, or steel fiber medium for Type I Safe Change and Remote HEPA Filters conform to:
  - 10.7.3.1 ASME AG-1, Mandatory Appendix FC-I, Filter Media: Fire Resistance, High Efficiency.
  - 10.7.3.2 The chemical constituents identified in Appendix D.
  - 10.7.3.3 The chemical constituents identified on the current revisions of the HEPA Filter Data Sheets.

- 10.7.3.4 Objective evidence shall include, but not be limited to, documentation of chemical resistance and/or chemical reactivity of filter medium to the above identified constituents with specific emphasis on those constituents that are particularly aggressive to glass fiber medium, or reinforced glass fiber medium, or steel fiber medium.

## **10.8 Schedules**

Lists and schedules shall include schedule of engineering, material purchase, and fabrication. Lists and schedules shall be submitted to the Buyer's Expediter.

## **10.9 Materials Certificates and Statistics**

Reference Section 10.7 of this Specification.

## **10.10 Data**

- 10.10.1 The Supplier shall provide HEPA Filter performance datasheets or design drawings that include the following data.

10.10.1.1 Name of manufacturer, make, model number

10.10.1.2 Filter medium area

10.10.1.3 Pleat depth, pleat length

10.10.1.4 Capacity, initial resistance, temperature rating

10.10.1.5 Dimensions with fabrication tolerances

10.10.1.6 Seal diameter

10.10.1.7 Weight

10.10.1.8 Materials of construction

10.10.1.9 Sealant type

10.10.1.10 Gasket materials

## Appendix A:

### HEPA Filter Datasheet Template

<b>Quality Level Q (no exceptions)</b>	
RPP-WTP Facility & System:	Generic (RPP-WTP) <input type="checkbox"/> Yes Spare Part? <input type="checkbox"/> No
<b>Facility / System</b>	Dedicated Facility <input type="checkbox"/> Yes Spare Part? <input type="checkbox"/> No
ASME AG-1, Section FK Filter Type <u>1</u>	Potential for Wetting? <input type="checkbox"/> Yes <input type="checkbox"/> No
Safe or Remote Change :	Potential for Corrosive Atmosphere? <input type="checkbox"/> Yes <input type="checkbox"/> No
Filter Housing Quantity:	Potential exposure to HNO <sub>3</sub> <input type="checkbox"/> Yes <input type="checkbox"/> No
Filter Quantity:	Potential exposure to caustic materials <input type="checkbox"/> Yes <input type="checkbox"/> No
Safety Classification:	Potential exposure to HF <input type="checkbox"/> Yes <input type="checkbox"/> No
Seismic Category:	Potential exposure to NOX <input type="checkbox"/> Yes <input type="checkbox"/> No
	Potential for High Temperature (>200°F) <input type="checkbox"/> Yes <input type="checkbox"/> No
Recommended Manufacturer: <b>Flanders</b>	
Manufacturer's part number (as furnished): *	
<b>Performance Requirements</b>	
<b>Temperature</b>	Normal minimum °F (°C): __ Normal Maximum °F (°C): __
	Abnormal maximum Operating °F (°C): __ Maximum DBE °F (°C) __
<b>System Airflow Rate</b>	<b>Normal minimum</b> design flow:
	<b>Normal maximum</b> design flow:
	<b>DBE:</b> N/A:
<b>Relative Humidity</b>	
RH corresponding to normal minimum temperature	__%
RH corresponding to normal maximum temperature	__%
RH corresponding to abnormal maximum temperature	__%
RH corresponding to DBE maximum temperature	__%

<b>Chemical Exposure</b> (Concentration data for corrosive environments)	Normal operating condition: Upset condition & duration:
<b>Filter medium</b>	
<b>Systems Max Static Pressure (Inches WC)</b>	
<b>Particulate Load (grams)</b>	
<b>Pressure Spikes</b>	
<b>Structural Capability</b>	
<b>Radiation</b>	
<b>Biological Exposure</b>	
<b>Datasheet Referenced Notes:</b>	
<b>General Notes:</b>	
<b>Additional Instructions:</b>	
<ul style="list-style-type: none"> <li>• Vendor to fill in data fields marked with (*) asterisk</li> </ul>	

0		Issued for Purchase					
<b>Rev</b>	<b>Date</b>	<b>Purpose</b>	<b>Originator/System Engineer</b>	<b>Checked</b>	<b>EQ</b>	<b>E&amp;NS</b>	<b>Approved</b>

## Appendix B:

### Metal Medium HEPA Filters

#### B-1 Scope

- B-1.1 SCOPE. This non-mandatory appendix provides information for the materials, design, inspection, fabrication, packing, shipping, storage, and quality assurance of metal medium Type 1 radial flow High Efficiency Particulate Air (HEPA) filters used in nuclear safety and process related air and gas treatment systems in nuclear facilities. This information supplements the main body of this specification. This appendix describes metal medium HEPA filters for use in the WTP Remote Change HEPA Filter Housings.
- B-1.2 PURPOSE. The purpose of this non-mandatory appendix is to assure that filters of metal filter medium used in nuclear air and gas treatment systems are acceptable in all aspects of materials, design, inspection, fabrication, packing, shipping, storage, and quality assurance.
- B-1.3 APPLICABILITY. This non-mandatory appendix applies to metal medium HEPA filters that have application in a radioactive environment with HEPA filter efficiency. This specification applies to metal medium HEPA filters with the following fabrication:
- B-1.3.1 Filters in which the sealing between metal filter medium and is accomplished by the use of urethane potting compound.
  - B-1.3.2 Manufactured using the filter medium materials in Section B-9, Metal HEPA Filter Medium.
  - B-1.3.3 Wherein the urethane potting compound used is suitable for air streams at temperatures up to 250°F.
- B-1.4 DEFINITIONS AND TERMS
- B-1.4.1 Metal Filter Medium. The metallic porous particle removing material made from sintered fibers or powders. For a given filter this may be a homogeneous material or combination of materials.
  - B-1.4.2 Metal medium HEPA filter. A device having one filter element formed from metal filter medium assembled in an ASME AG-1 Section FK Type 1 radial flow HEPA filter configuration for removing suspended particles from air or gas that is passed through the metal filter medium.
  - B-1.4.3 High Efficiency Particulate Air (HEPA) Filter. A filter having a minimum efficiency of 99.97% when tested with an aerosol of essentially

monodispersed 0.3 micrometer dioctyl phthalate (DOP), dioctyl sebacate (DOS), or equivalent aerosol particles.

- B-1.4.4 Penetrometer. A device for generating essentially mono-disperse 0.3 micrometer DOP or DOS or equivalent aerosol particles for evaluating the aerosol penetration and air resistance of fabricated metal HEPA filters. The Q76, Q107, and Q127 penetrometers are examples of suitable penetrometers.
- B-1.4.5 Test Aerosol. Dispersion of particles in air containing a sufficient quantity of the most penetrating particle size based upon the filter medium structure, the air velocity, and the particle composition, as described in IEST-RP-CC007.1. For metal medium HEPA filters, the test aerosol is 0.3 micrometer DOP or DOS or equivalent aerosol.

## B-2 Materials

B-2.1 ALLOWABLE MATERIALS. Materials shall conform to the material specifications listed in ASME AG-1, Article FK-3110.

- B-2.1.1 CASE MATERIALS. The case shall be made from stainless steel Type 409, 304, 304L, 316, or 316L per ASTM A 240. Material thicknesses shall be sufficient to meet the performance requirements in this specification (e.g., test aerosol penetration, resistance to airflow, seismic qualification, qualification testing, resistance to rough handling, resistance to pressure, resistance to heated air, spot flam resistance, and certificate of conformance).
- B-2.1.2 GELATINOUS SEAL. Gelatinous seals shall be self-adhesive and self-healing cured gel seals made of poly-di-methyl-siloxane.
- B-2.1.3 FILTER MEDIUM. The filter medium of metal medium HEPA filters shall conform to the requirements of SECTION B-9, Metal HEPA Filter Medium.
- B-2.1.4 GRILLES. Metal medium radial HEPA filters shall be fitted with internal and external perforated grilles or flattened expanded metal grilles as shown in ASME AG-1, Figure FK-4100-2 and FK-4100-4. Flattened expanded metal grilles shall conform to ASTM F1267 fabricated from the materials indicated in ASME AG-1, Article FK-3110. Grilles shall be 18 gauge (minimum).
- B-2.1.5 ADHESIVES. Adhesives used to seal the metal filter medium to the hardware forming the filter element to the case shall be self-extinguishing when cured after direct contact with an open flame, as evidenced by testing in accordance with the spot flame test or UL-586. Adhesives may limit operating conditions for metal medium HEPA filters. Employment of adhesive material shall be accompanied by a statement of use restrictions.

B-2.2 GENERAL MATERIAL REQUIREMENTS. All materials used shall have properties and composition suitable for the application as defined by WTP Project HEPA Filter Datasheets. The general material requirements of ASME AG-1, Article FK-3200 shall apply.

## **B-3 Design**

B-3.1 GENERAL DESIGN. The assembled metal medium HEPA filters shall be designed to be installed in the current design of the WTP Remote Change HEPA Filter Housing, including overall dimensions and interfaces (e.g., gelatinous seal and lifting grapple).

B-3.2 METAL MEDIUM HEPA FILTERS. Metal medium HEPA filters shall be constructed to designs prepared by the Supplier in sufficient detail to provide a complete basis for manufacture in accordance with operating parameters set forth in the WTP Project HEPA Filter Datasheets.

### **B-3.3 METAL FILTER MEDIUM**

B-3.3.1 Metal filter medium covered by this section is available in various combinations of sintered metal powder, sintered metal fiber and integral wire mesh. Each type of filter medium has characteristic operating parameters, particularly pressure drop for a given filter medium velocity. Each category of filter medium can be fabricated from a variety of alloys. The filter medium can be selected for physical and chemical durability along with operating characteristics.

B-3.3.2 The metal filter medium shall conform to Section B-9, Metal HEPA Filter Medium.

B-3.3.3 Only the Supplier of the metal filter medium may correct defects in the metal filter medium as identified in Workmanship, Section B-9.8. Corrected or repaired defects shall not exceed 0.0625 inches in diameter. Correction or repairs shall be performed prior to any filter element fabrication steps, and shall be performed as follows:

B-3.3.3.2 Defects shall be corrected using materials exhibiting the same applicability as the potting compound employed.

B-3.3.3.3 Corrections and repairs to the filter medium shall be verified by testing the assembled filter element containing the corrected filter medium using Test Aerosol Penetration, Section B-3.6 and the appropriate test method.

B-3.4 SPLICES. Any side seams shall be either all metal heat bonded or sealed using adhesives exhibiting the same applicability as the potting compound employed. No splices or

patches in the filter media pack are allowed. Joining of the two ends in a radial flow filter pack is acceptable.

- B-3.5 PERFORMANCE REQUIREMENTS. Designs shall be qualified in accordance with Section B-4.
- B-3.6 TEST AEROSOL PENETRATION. The total test aerosol penetration through the filter medium, housing, and gasket shall be not greater than 0.03% of upstream concentration when tested at rated airflow accordance with Test Aerosol Penetration, Section B-4.3.
- B-3.7 RESISTANCE TO AIRFLOW. The resistance to airflow at the rated airflow of the clean filter shall not exceed 3.0 inches WC, when tested in accordance with Resistance to Airflow, Section B-4.2. Maximum rated airflow shall be as defined in Section 3.1.1 or as specified by Buyer.
- B-3.8 GELATINOUS SEAL. The gelatinous seal shall be designed in accordance with ASME AG-1, Article FK-4142.
- B-3.9 GRILLES. Metal medium radial flow HEPA filters shall be fitted with internal and external support grilles around the filter media per Section B-2.5.

## **B-4 Inspection and Testing**

### **B-4.1 QUALIFICATION TESTING**

- B-4.1.1 The assembled metal medium HEPA filter shall require qualification testing prior to acceptance and production. The assembled filter design shall be re-qualified at least every 5 years. Tests shall be performed and certified by an independent test facility or at a Supplier's facility under oversight of a suitably qualified independent entity. A summary report shall be prepared by the independent entity. A copy of this report shall be maintained by the Supplier for inspection by the Buyer. The qualification samples shall be tested against all the requirements herein.
- B-4.1.2 Qualification of Metal Medium HEPA Filters.
- B-4.1.3 All test filters shall be manufactured using the same methods, materials, equipment, and processes as will be used during production.
- B-4.1.4 The filters submitted for qualification testing will also be considered to be representative of filters of the same manufacture processes and materials if the following conditions are met:
- B-4.1.4.1 They are of the same design.
- B-4.1.4.2 They are manufactured in the same manner.

- B-4.1.4.3 They are manufactured using the same filter medium.
- B-4.1.4.4 They will be subjected to the same range of differential pressures.
- B-4.1.4.5 They have an element diameter considered equivalent to the filter elements being represented.
- B-4.1.5 Metal medium HEPA filters shall be tested in accordance with the sequence detailed in Table B-1.
- B-4.1.6 The filters used in the qualification sample shall be run sequentially through the tests in the order given in Table B-1.
  - B-4.1.6.1 If the Supplier intends to deliver filters with a seam in the filter medium, both of the qualification samples shall contain a seam.
  - B-4.1.6.2 Each filter in the qualification sample shall be visually examined for defects.
- B-4.1.7 The qualification samples shall be tested for all the requirements of this specification. Failure of any filter to comply with the requirements of this section shall be cause for the rejection of the qualification sample.

<b>Table B-1 Qualification Test Sequence for Metal Medium HEPA Filters</b>	
<b>Requirement</b>	<b>Test Paragraph</b>
Resistance to rated airflow	Section B-4.2
Test aerosol penetration at rate airflow and at 5% of rated airflow	Section B-4.3
Resistance to rough handling	Section B-4.4
Resistance to heated air	Section B-4.6
Resistance to pressure	Section B-4.5
Resistance to rated airflow	Section B-4.2
Test aerosol penetration at rated airflow	Section B-4.3
Resistance to spot flame	Section B-4.7
NOTE: Two Filters shall be tested sequentially as described in Qualification Testing, Section B-4.1.	

B-4.2 RESISTANCE TO AIRFLOW. The resistance to airflow of the clean filter shall meet the requirements of Section B-3.7 when tested in accordance with Test Aerosol Penetration, Section B-4.3.

B-4.3 TEST AEROSOL PENETRATION.

- B-4.3.1 The resistance to airflow and test aerosol penetration shall be determined by MIL-STD-282 for efficiencies between 99.97% - 99.99% at particle aerosol diameter of 0.3 micrometer.

- B-4.3.2 Modifications to the listed test methods may be required for metal medium HEPA filters having high pressure drops. For example any unit operated and tested at filter medium velocities sufficient to produce pressure drops in excess of 10 inches WC. The increase, if any, in filter pressure drop during the test shall be less than 5% of the initial pressure drop for the filter design to be accepted.
- B-4.3.3 For HEPA filters, the total test aerosol penetration through the filter for 0.3 micrometer aerosols shall be no greater than 0.03% of upstream concentration at rated airflow and at 5% of rated airflow.

#### B-4.4 RESISTANCE TO ROUGH HANDLING.

- B-4.4.1 The metal medium HEPA filters shall be tested on a rough handling machine for 15 minutes at 3/4 inches total amplitude at 200 cycles per minute in accordance with Test Method 105.10 of MIL-STD-282.
- B-4.4.2 The metal medium HEPA filter shall be placed on the machine in the orientation designated for shipment.
- B-4.4.3 At the conclusion of the shaking period, the filter shall be visually examined for damage.
- B-4.4.4 Cause for rejection shall include cracked or warped housings, cracked or warped filter medium, or cracked welds. Critical areas for inspection include end cap welds, seam welds and, for pleated elements, pleat edge cracks. After the rough handling test, the same filter shall meet the requirements of Resistance to Airflow, Section B-4.2 and Test Aerosol Penetration, Section B-4.3.

#### B-4.5 RESISTANCE TO PRESSURE.

All filter test requirements will be detailed in the High Efficiency Particulate Air (HEPA) Filter Test Plan, 24590-WTP-RPT-ENG-12-047. The specific test protocol for the new high-strength filters (both reinforced glass fiber medium and steel fiber medium) will be the particle loading tests at the subcontracted filter test facility up to 50 inches WC. The particle loading tests will be followed by a high pressure liquid flow test with an added pressure equal to the maximum static pressure under which a WTP HEPA filter can operate. After the high pressure liquid flow test, the filter will be dried and tested for efficiency and pressure differential at rated flow and twenty percent (20%) of rated flow. The high pressure liquid flow test is analogous to the ASME AG-1 wet over-pressure test.

#### B-4.6 RESISTANCE TO HEATED AIR

- B-4.6.1 For resistance to heated air, the metal medium HEPA filter shall be subjected to the rated flow of air heated sufficiently such that the filter exhaust air

temperature has reached the rated maximum temperature  $250^{\circ}\text{F} \pm 10^{\circ}\text{F}$  designated for the filter for no less than 60 minutes.

- B-4.6.2 The heated air test is conducted with air exiting the filter being released at ambient pressure. Thermocouples are used to measure the uniformity of the temperature across the inlet to the filter. The physical size and mass of the unit to be tested will dictate equipment and methods required to conduct testing. The filter shall be wrapped in insulation to minimize the heat loss.
- B-4.6.3 Following exposure, the filters shall meet the requirements in Resistance to Airflow, Section B-4.2 and Test Aerosol Penetration, Section B-4.3.

#### B-4.7 SPOT FLAME RESISTANCE

- B-4.7.1 The metal medium HEPA filter shall be mounted in the test duct and the airflow adjusted to rated airflow. The filter housing shall be removed in this test to allow access to the filter medium. A gas flame from a Bunsen burner shall be directed against the upstream face of the unit.
- B-4.7.2 The Bunsen burner shall be adjusted to produce a flame with a blue cone 2.5 inches long with a tip temperature of  $1750^{\circ}\text{F} \pm 50^{\circ}\text{F}$ , as measured by a thermocouple inserted in the flame. The tip of the cone shall be so applied that it touches the surface of the filter medium at a distance of not less than 2 inches from the filter case. The flame shall be applied for 5 minutes at each of three separate locations on the filter face.
- B-4.7.3 Testing of filter elements having seams shall be conducted with the Bunsen burner flame directed onto a portion of a seam in such a manner that the tip of the blue cone contacts the seam and sealing material. The flame shall be applied for a period of 5 minutes. The test shall be repeated upon in a similar fashion where the filter medium is joined to the coupling device at the top of the element. After removal of the test flame at each point of application, there shall be no sustained flaming on the downstream face of the unit.
- B-4.7.4 An Underwriters' Laboratories (UL-586) label shall be acceptable objective evidence of compliance with Structural Requirements, Section B-4.8.

#### B-4.8 STRUCTURAL AND SEISMIC QUALIFICATION REQUIREMENTS.

- B-4.8.1 Each filter or filter component in the sample shall be evaluated for structural integrity. Each filter or filter component shall satisfy that no structural damage shall be evident by visual examination. Airflow resistance and aerosol penetration requirements of Resistance to Airflow, Section B-4.2 and Test Aerosol Penetration, Section B-4.3 shall be met.
- B-4.8.2 In the case of Remote Change metal medium HEPA filters, the filter shall be qualified to withstand grapple loads by testing.

B-4.8.3 The metal medium HEPA filters shall be seismically qualified by test in accordance with ASME AG-1, Article FK-4300.

B-4.9 FILTER INSPECTION. Each filter shall be visually inspected to show conformance to size specification, and inspection to verify that the sticker indicates it has been tested and meets the flow rate, penetration, and resistance specification. Additional attributes to be inspected are length, width, concentricity, adherence of gelatinous seal, and proper channel fill with gel to tolerances as shown on WTP design drawings in Section 2.4. The filter medium shall be inspected to ensure that there are no holes, splices, or patches (for exception see Section B-3.4, Splices).

B-4.10 PRODUCTION TESTING. Each filter manufactured for delivery shall be tested for test aerosol penetration and resistance to airflow in accordance with Resistance to Airflow, Section B-4.2 and Test Aerosol Penetration, Section B-4.3. The results of these tests and the test method shall be marked on the label of each filter.

## **B-5 Fabrication**

B-5.1 GENERAL REQUIREMENTS. The metal medium HEPA filter shall be assembled from the materials designated in the Materials, Section B-2 in strict accordance with the design requirements established in the Design, Section B-3. Following assembly, the filter shall be inspected and qualified in accordance with Inspection and Testing, Section B-4. Production filters shall conform to Inspection, Section B-4.9.

B-5.2 FABRICATION AND ASSEMBLY. The general requirements for fabrication, installation and repair are contained in ASME AG-1, Article AA-6000.

B-5.3 TOLERANCES. Tolerances shall be as indicated in ASME AG-1, Section FK, unless otherwise stated on supplier design drawings accepted by the Buyer, and except as modified per Section 5.1.1 of this specification.

B-5.4 WORKMANSHIP. The assembled metal medium HEPA filter shall be free from foreign matter (dirt, oil, or viscous material) and damage, such as distorted or cracked case, deformation, or sagging of the filter medium, separators and faceguards, cracks in adhesive, and cracks, or holes in exposed portions of the filter medium. All required fasteners shall be securely installed. All the dimensional and performance requirements of this specification shall be directed toward achieving the highest quality and workmanship possible.

## **B-6 Packaging, Shipping, and Storage**

B-6.1 Packaging, shipping, and storage shall be in accordance with ASME AG-1 Article AA-7000 and ANSI/ASME NQA-1 Level B. Metal medium HEPA filters shall be individually packaged. Cartons shall have extra shock absorbing material at the corners of the filter that centers the filter within the carton to prevent damage.

- B-6.2 Filters shall be placed in the carton with the pleats vertical. The carton should be placed on skids or otherwise packed in such a manner that the pleats remain vertical during shipment.
- B-6.3 The metal medium HEPA filters with gelatinous seals shall be packaged in a manner to prevent the gelatinous compound from sticking to the packaging material. A means shall be provided to prevent the gelatinous seal from being gouged or pulled out of the continuous channel when the filter is removed from the shipping carton or plastic bag.
- B-6.4 The carton shall be clearly marked for proper orientation.

## B-7 Quality Assurance

Quality Assurance shall conform to the requirements of ASME AG-1, Article AA-8000 and the following:

- B-7.1 **RESPONSIBILITY.** The Supplier has the responsibility of providing all specified information and of assuring that the quality control, and detailed examination and tests required by this specification, are performed at the stages of construction necessary to permit them to be meaningful.
- B-7.2 **CERTIFICATE OF CONFORMANCE.** The Certificate of Conformance shall state that the metal medium HEPA filters conform to this specification.

## B-8 Nameplates

- B-8.1 **FILTER MARKING.** Marking or labeling of each metal medium HEPA filter shall be on the top of the filter when the pleats are vertical, of such size and legibility that it can be read at a distance of 3 feet. As a minimum, the following information shall be provided:
- (a) Supplier's name or symbol
  - (b) Model number
  - (c) Serial number
  - (d) Rated flow capacity
  - (e) Direction of airflow for penetration and pressure drop tests, no less than 6 inches high
  - (f) Pressure drop, in inches of water at one hundred percent (100%) rated flow
  - (g) Overall penetration at rated flow
  - (h) Overall penetration at five percent (5%) of rated flow
  - (i) UL label indicating successful testing per UL-586 if UL-586 if applicable
- B-8.2 **PACKAGE MARKING.** Marking or labeling of each shipping container (carton containing one metal medium HEPA filter) shall be of such size and type that it can be read at a distance of 6-feet. As a minimum, the following information shall be provided:

- (a) Supplier's name or symbol
- (b) Arrows and "THIS SIDE UP" indicating orientation for shipping and storage and "FRAGILE" in letters no less than 6 inches high.
- (c) Filter model number
- (d) Purchase order number or other identifying mark requested by Buyer.

## **B-9 Metal HEPA Filter Medium**

B-9.1 SCOPE. This specification section establishes requirements for the manufacture of high efficiency, fire resistant, metal filter medium for use in the construction of HEPA filters.

B-9.2 REQUIREMENTS. In order to ensure continuous, high efficiency particle removal during filter service, the inspection and testing of a metal HEPA filter medium shall include requirements for the strength and other performance criteria of the filter medium.

### **B-9.3 FORM AND SIZE**

- B-9.3.1 FORM. The metal filter medium for a given filter construction may be furnished flat or as recommended by the Supplier.
- B-9.3.2 SIZE. The dimensions of the sheet filter medium shall be recommended by the Supplier and approved by the Buyer.
- B-9.3.3 SPLICES. For fabricating filters, splices in sheet filter medium shall be by welding, or brazing, or other all metal heat bonding techniques, or by sealing using adhesives exhibiting the same characteristics in service as the potting compound to be employed.

### **B-9.4 METAL FILTER MEDIUM COMPOSITION**

- B-9.4.1 The metal filter medium can be manufactured by the sintering of metal powders or fibers or a combination. It is recognized that:
  - B-9.4.1.1 The properties and performance characteristics of this type of metal filter medium differ significantly and can represent a selection advantage for different applications.
  - B-9.4.1.2 Various metal compositions can be used in the manufacture of metal filter medium providing an additional dimension of options for corrosion resistance and durability.
- B-9.4.2 The Supplier shall recommend and justify the type of filter medium to be used and its metallic composition. The Supplier shall coordinate their recommended filter medium selection with the Buyer. The Supplier shall submit their recommended filter medium selection and justification to the

Buyer for approval. Table B-2 below provides a representative listing of metals that are commonly used in the manufacture of metal filter medium. This listing is not intended to be comprehensive since new alloys continue to be developed and specialty filter medium can be manufactured from uncommon metals.

304 Stainless Steel	316L Stainless Steel	FeCr Alloy
Haynes HR-120 Alloy	Hastelloy C-22	Inconel 601
Monel 400	Nickel 200	UNS NO6059

**B-9.5 AIRFLOW RESISTANCE.** The pressure drop across the metal filter medium shall meet the requirements of Section B-3.7.

**B-9.6 TEST AEROSOL PENETRATION.**

**B-9.6.1** The penetration of the metal filter medium by DOP or DOS of 0.3 micrometer particle size shall not exceed 0.03%, as determined by comparing upstream with downstream aerosol concentration with the air and aerosol mixture having the flow specified in the Design, Section B-3, when tested as specified in Inspection and Testing, Section B-4 using a Q-127 or Q-76 penetrometer.

**B-9.6.2** Aerosol penetration, when determined as stated in Test Aerosol Penetration, Section B-4.3, shall not exceed penetration values in Section B-4.3. Testing of pleated filter medium shall be accomplished using filter elements fabricated with representative folding patterns and final geometry. The penetration of the filter medium by the test aerosol shall not exceed the penetration values in Test Aerosol Penetration, Section B-9.6 after the filter medium is folded as required in Folding, Section B-9.7, when tested as specified in Airflow Resistance and Test Aerosol Penetration, Section B-9.11.1.

**B-9.7 FOLDING CHARACTERISTICS.** Metal filter medium to be pleated shall show no tears, breaks, or cracks when folded into the pleated configuration that will be employed in the final geometry of the filter element.

**B-9.8 WORKMANSHIP.** The metal filter medium shall be free from contamination (foreign matter), or damage, such as tears, cracks, holes, abrasions, corrosion, and punctures.

**B-9.9 QUALITY ASSURANCE PROVISIONS**

**B-9.9.1 SUPPLIER'S RESPONSIBILITY.** Unless otherwise specified, the Supplier is responsible for the performance of all inspection requirements as specified herein.

**B-9.9.2 OBJECTIVE EVIDENCE.** The supplier shall provide objective evidence acceptable to the Buyer that the requirements have been satisfied.

## B-9.10 QUALIFICATION

- B-9.10.1 **SAMPLE.** A qualification sample of sheet or tube filter medium sufficient to conduct the qualification tests in this section shall be manufactured using the same methods, materials, equipment and processes as will be used during regular production.
- B-9.10.2 **MATERIAL CHANGE.** Any change in materials or source of materials after qualification shall require a requalification of a standardized qualification metal medium HEPA filter element composed of the new materials.
- B-9.10.3 **REVERIFICATION OF QUALIFICATION.** The metal filter medium shall be re-qualified at least every five (5) years. Tests shall be performed and certified by an independent test facility.

## B-9.11 TEST PROCEDURES

- B-9.11.1 **AIRFLOW RESISTANCE AND TEST AEROSOL PENETRATION.** For flat metal filter medium, three test specimens with an exposed test area of 16 square inches shall be tested for airflow resistance and test aerosol penetration at a flow that corresponds to the rated flow of the unit to be assembled. Samples shall be processed by any heat treatment methods (annealing, etc.) representative of actual filter fabrication prior to testing.
- B-9.11.2 **WATER REPELLENCY.** This test shall be required for the filter medium to be used in metal medium HEPA filters only. For flat metal filter medium, three test specimen rectangles 2.75 inches by 5.5 inches shall be conditioned and tested for water repellency using the Q101 Water Repellency Indicator. The two surfaces of each test specimen shall be identified as top and bottom. The specimen shall then be cut into two equal squares. The top surface of one square and the bottom surface of the other square shall be tested. The lesser of the two results shall be considered the water repellency of the specimen. The water pressure which results in a visible penetration shall be noted.
- B-9.11.3 **THICKNESS.** The thickness of the metal filter medium shall be in accordance with TAPPI T411-OM-97 or Supplier's stated standards, where applicable.
- B-9.11.4 **BENDING CHARACTERISTICS FOR PLEATED METAL MEDIUM HEPA FILTERS:**
- B-9.11.4.1 **EXAMINATION.** Eight test specimens, cut 12 inches long and 6 inches wide, shall be bent 180 degrees around a 0.1875-inch wide mandrel. Four (4) specimens with the inlet side of the filter medium and four specimens with the exhaust side of the filter medium against the mandrel shall be bent. Examine the bent specimen for compliance with Metal HEPA Filter Medium, Folding Characteristics, Section B-9.7.

B-9.11.4.2 TEST. After examination the bent filter medium shall be unbent and the center of each test specimen containing the bend shall be tested for aerosol penetration in accordance with Metal HEPA Filter Medium, Test Procedures, Section B-9.11 for compliance with Metal HEPA Filter Medium, Folding Characteristics, Section B-9.7.

B-9.12 ACCEPTANCE OR REJECTION CRITERIA. If a sample fails when tested as specified in Section B-9.11, "Test Procedures", the lot represented shall be rejected.

B-9.13 QUALITY CONFORMANCE INSPECTION. Each batch of metal filter medium shall be examined for defects. Defects sufficient to require rejection include: abrasion marks, greater than 0.25 inches in diameter; cuts, holes, tears, punctures exceeding 0.0625 inches; thick or thin spots greater than 0.25 inches; burn holes, charring, or scorching; width plus (+) 0.25 inches out of specification; excessive number of splices; an excessive number of creases or fiber aggregates greater than 0.1875 inches; and excessive contamination (foreign matter) exceeding an area 0.15 inches by 0.25 inches.

#### B-9.14 PACKAGING AND SHIPPING

B-9.14.1 PACKAGING. Packaging shall conform to level B of ASME NQA-1 suitable for storage under level B of ASME NQA-1.

B-9.14.2 SHIPPING. Metal filter medium prepared for shipping shall bear packaging clearly identifying repair materials used and consistent filter types consistent with Namplates, Section B-8. This information shall be carried through in a manner consistent with Namplates, Section B-8 to the packaging of any finished goods prepared from said filter medium and shipped. Shipping of the filter medium shall be undertaken to assure the quality of the product upon arrival at the purchaser. Shipping containers shall comply with the rules and regulations applicable to the mode of transportation being utilized.

## Appendix C:

### High Strength HEPA Filters

#### C-1 Scope

C-1.1 SCOPE. This non-mandatory appendix provides information for the performance, design, fabrication, inspection, acceptance testing, and quality assurance for high strength, Type 1 radial flow high efficiency particulate air (HEPA) filters used in air or gas treatment systems in nuclear facilities. This information supplements the main body of this specification. This appendix describes high strength HEPA filters for use in the WTP Remote Change HEPA Filter Housing or the WTP Safe Change HEPA Filter Housing.

C-1.2 PURPOSE. The purpose of this non-mandatory appendix is to ensure that high strength HEPA filters are acceptable in all aspects of design and operation.

C-1.3 APPLICABILITY. This non-mandatory appendix applies to extended medium, dry type, high strength filters for use in air and gas streams operating at no more than 250°F maximum continuous temperature. One type of high strength HEPA filter and two levels of filter pack strength and robustness are addressed in this section.

#### C-1.4 DEFINITIONS AND TERMS

C-1.4.1 High Strength HEPA Filter. A HEPA filter as qualified according to this section to have a significantly higher filter burst strength, than filters qualified to the performance requirements of ASME AG-1 Articles FC and FK. The higher strength results from an inherently greater ultimate tensile strength of the filter medium and enhanced filter pack robustness and stability. Definition does not include metal medium filters, which would also provide a higher filter burst strength but are treated separately in Appendix B.

C-1.4.2 High Strength HEPA Filter Medium. A non-metal HEPA filter medium qualified, according to this specification, to have a significantly higher ultimate tensile strength than a filter medium qualified to the performance requirements of ASME AG-1, Article FC, Appendix FC-I.

C-1.4.3 Filter Medium. The fiber matrix in a filter, which captures suspended particles from an air, or a gas stream. The plural form of "filter medium" is "filter media."

## C-2 Materials

### C-2.1 ALLOWABLE MATERIALS

- C-2.1.1 CASE MATERIALS. The case shall be made from stainless steel Type 409, 304, 304L, 316, or 316L per ASTM A 240. Stainless steel sheet shall have minimum thickness equal to 0.0720 inches.
- C-2.1.2 FASTENERS. Consideration should be given when selecting the proper filter fasteners serving seismic and other unusual requirements. Approved fasteners used for the assembly of high strength HEPA filter cases are listed below:
- C-2.1.2.1 Stainless steel bolts, 300 series per ASTM A 320 or ASTM A 193
- C-2.1.2.2 Stainless steel nuts, 300 series per ASTM A 194
- C-2.1.2.3 Stainless steel lock washers, 300 series per ASME B18.21.1/  
B18.21.1.2M
- C-2.1.2.4 Stainless steel plain washers, 300 series per ASME B18.22.1/  
B18.22M
- C-2.1.2.5 Stainless steel rivets, 300 series per ASTM A 581
- C-2.1.3 GELATINOUS SEAL. Gelatinous seals shall be self-adhesive and self-healing cured gel seals made of poly-di-methyl-siloxane.
- C-2.1.4 FILTER MEDIUM. The filter medium shall conform to the requirements of High Strength HEPA Filter Medium in this specification.
- C-2.1.5 GRILLES. High strength radial flow HEPA filters shall be fitted with internal and external perforated grilles or flattened expanded metal grilles as shown in ASME AG-1, Figure FK-4100-2 and FK-4100-4. Flattened expanded metal grilles shall conform to ASTM F1267 fabricated from the materials indicated in ASME AG-1, Article FK-3110. Grilles shall be 18 gauge (minimum).
- C-2.1.6 ADHESIVES. Adhesives used to fasten gaskets to the filter case, and to seal the filter pack or faceguards to the case, shall be self-extinguishing.
- C-2.1.7 SEPARATORS
- C-2.1.7.1 If required, aluminum separators shall be made from corrugated aluminum, 0.0015 inch minimum thickness, conforming to ASTM B209, Alloy 5052 H338, 3003 H18, or 1100 H18 aluminum.
- C-2.1.7.2 If required, acid resistant aluminum separators shall be made from corrugated aluminum, 0.0015 inch minimum thickness, conforming to ASTM B 209, Alloy 5052 H39, 3003 H19, or 1145

H19 aluminum coated on both surfaces with a vinyl-epoxy coating. The coating should be tinted to verify the coverage of the separator.

C-2.1.7.3 If required, stainless steel separators shall be made from corrugated stainless steel, 0.0012 inch minimum thickness, conforming to ASTM A 580 stainless steel.

C-2.1.8 COATING. Aluminum separators shall meet the following tests after application of the coating to the separator:

C-2.1.8.1 The coating shall meet or exceed an adhesion rating of 3A when tested using Method A (X Cut Tape Test) of ASTM D 3359. The X-cut specimen shall be inspected for removal of coating where the 3A adhesion rating equates to jagged removal along the X cut incision up to 1/16 inch.

C-2.1.8.2 Off-gas volatiles, as determined by thermo-gravimetric analysis, shall not exceed 5% by weight when a 2 inch  $\pm$ 0 inch high by 2 inch  $\pm$ 0 inch wide sample of the coated separator is subjected to temperatures from 70°F to 1,800°F.

C-2.1.8.3 The coated separator shall pass a flexibility test in accordance with FED STD 141D, Method 6221.

C-2.2 GENERAL MATERIAL REQUIREMENTS. All materials used shall have properties and composition suitable for the application as defined by WTP Project HEPA Filter Datasheets. The general material requirements of ASME AG-1, Article FK-3200 shall apply.

## C-3 Design

C-3.1 GENERAL DESIGN.

C-3.1.1 In order to ensure continuous, high efficiency particle removal during filter service, the design and construction of high strength HEPA filters shall incorporate requirements for the strength, physical integrity, and other performance criteria of filter components and component materials. The high strength HEPA filters are characterized by a folded filter medium in a radial flow configuration as indicated by the ASME AG-1 Section FK, Type 1 filter. The design shall consider the following two classes of high strength HEPA filters characterized by:

C-3.1.1.1 A high strength filter medium only, and

- C-3.1.1.2 A high strength filter medium with additional design features to enhance pack robustness and stability by inhibiting loosening of the filter pack.
- C-3.1.2 The assembled metal medium HEPA filters shall be designed for installation and use in the current design of the WTP Remote Change HEPA Filter Housing or the WTP Safe Change HEPA Filter Housing, including overall dimensions and interfaces (e.g., gelatinous seal on both designs, and lifting grapple on Remote Change housing design).
- C-3.2 SPLICES AND PATCHES. No splices or patches in the pleated filter medium of the pack are allowed. Joining of the two ends in the radial flow filter pack is acceptable.
- C-3.3 FILTER CASE. Filter cases are used to enclose the pack of the high strength filter. All case joints shall be sealed.
- C-3.4 HIGH STRENGTH FILTER PACKS. Filter packs shall be made by folding the high strength filter medium to the required depth, with the reinforcement layer located on the pack downstream side. If required, the folded filter medium shall be supported with corrugated separators. If required, the filter medium pack shall be recessed by a minimum of 1/8 inch within the exposed ends of the separators. If required, separator fixed ends, when viewed from the upstream and downstream faces, shall be embedded in the adhesive/sealant. If required, the separators shall not extend beyond the ends of the case when the filter pack is bonded to the case. The filter pack shall be rigid within the case and shall be perpendicular to two opposite parallel sides of the case. The top and bottom of the pack shall be sealed in a reservoir of potting adhesive at least 1/16 inch deep, once the pack is installed in the filter case. Separators (if required) and filter medium shall not vary more than 1/4 inch from a straight line connecting the fixed ends. Abrupt deviations, as defined by a maximum deviation of one-half the pleat-to-pleat distance along any 2 inch length of pleat, are not acceptable.
- C-3.5 GELATINOUS SEAL. The gelatinous seal shall be designed in accordance with ASME AG-1, Article FK-4142.
- C-3.6 SEPARATORS. The separator material (if required) shall be capable of withstanding continuous service under all specified operating conditions without swelling, sagging, or melting.
- C-3.7 GRILLES. High strength radial flow HEPA filters shall be fitted with internal and external support grilles around the filter media per Section C-2.1.5.
- C-3.8 TEST AEROSOL PENETRATION. The total test aerosol penetration through the assembled filter shall not be greater than 0.03% of upstream concentration when tested at rated airflow and at 5% of rated flow when tested in accordance with the Inspection and Testing section of this specification. Filters with a rated airflow of less than 125 CFM shall be tested at the rated airflow only.

C-3.9 RESISTANCE TO AIRFLOW. The resistance to airflow at the rated airflow of the clean high strength filter shall not exceed 1.55 inches WC, when tested in accordance with the Inspection and Testing section of this specification. Rated airflow shall be as defined in Section 3.1.1 or as specified by Buyer.

## C-4 Inspection and Testing

### C-4.1 FILTER INSPECTION

C-4.1.1 Each high strength HEPA filter in a qualification or production sample shall be visually inspected to show conformance to Section C-5, Fabrication, of this specification, and to verify that the sticker indicates it has been tested and meets the flow rate, penetration, and flow resistance. Additional attributes to be inspected are: length, depth, height, concentricity, and adherence of gaskets. The high strength filter medium shall be inspected to ensure there are no holes, splices, or patches. Section C-3.2, Splices and Patches.

C-4.1.2 Each filter in a sample shall be visually examined for any defects. The acceptance criterion for the filter pack is no visual indication of damage to the filter medium, no tears on the surface edge of the filter pleats, and no tears where the filter pack is embedded in the adhesive at the top and bottom of the filter case, or where it is sealed to the two sides of the case. The acceptance criterion for the metal case is no visual indication of dents or deformation. The acceptance criterion for the gel channel is no visual indication of dents that may interfere with proper sealing. The acceptance criterion for the gelatinous sealant is no visual indication of gouges or separation from the gel channel, and proper channel fill with gel to tolerances as shown on WTP design drawings in Section 2.4.

C-4.1.3 Acceptance shall be contingent upon no visual indications of improper assembly, physical damage, structural distress, or any degradations that would impair the ability of a component to perform its intended function.

### C-4.2 QUALIFICATION TESTING.

C-4.2.1 The assembled filter shall require qualification testing prior to acceptance and production. The assembled filter design shall be re-qualified at least every 5 years. Tests shall be performed and certified by an independent test facility. The qualification samples shall be tested against all the requirements herein below.

C-4.2.2 Each high strength filter in the qualification sample shall be visually examined for defects. A qualification sample consists of 8 (eight) high strength filters, or 4 (four) filters if the Supplier is providing objective evidence of compliance with UL 586.

- C-4.2.3 The high strength HEPA filters shall be manufactured using the same methods, materials, equipment, and processes as will be used during production. Failure of any filter to comply with any of the requirements of this specification shall be cause for the rejection of the qualification sample.
- C-4.2.4 The Supplier shall provide the supplier's name and part number, or name for materials that do not have a referenced industry specification in this document, to the Independent Filter Test Laboratory at the time of qualification.
- C-4.2.5 The filters used in the qualification sample shall be run sequentially through the tests in the order given in Table C-1.

<b>Table C-1 Test Group and Sequence for High Strength HEPA Filters</b>	
<b>Quantity</b>	<b>Requirement</b>
4	Resistance to rated airflow (Section C-4.3)
	Test aerosol penetration at 100% and 5% of rated airflow (Section C-4.4)
	Resistance to rough handling (Section C-4.5)
	Resistance to pressure (Section C-4.6)
	Test aerosol penetration at 100% and 5% of rated airflow (Section C-4.4)
NOTE: The tests shall be conducted in the order listed above.	

C-4.3 RESISTANCE TO AIRFLOW. The clean filter resistance to airflow meet the requirements of Section C-3.9 when tested at actual air conditions in accordance with the requirements below.

C-4.4 TEST AEROSOL PENETRATION.

- C-4.4.1 The test aerosol penetration shall be determined in accordance with Table C-1. The test conditions shall be actual air conditions.
- C-4.4.2 The total aerosol penetration through the assembled filter shall be no greater than 0.03% of upstream concentration at rated airflow and at 5% of rated airflow when challenged with 0.3 micrometer diameter particles.
- C-4.4.3 Suitable penetrometers include the Q 76. Penetrometers using laser particle counters in accordance with the methods and procedures of IEST RP CC 007 are also acceptable. When using a penetrometer with a particle counter the penetration of the 0.3 micrometer particle size shall be reported. Acceptable aerosol materials for the Q 76 or the Q 107 penetrometer are di-octyl-phthalate (DOP), di-octyl-sebacate (DOS), and 4 centistoke poly-alpha-olephin (PAO). If using a penetrometer with a particle counter, the aerosol material shall be 4 centistoke poly-alpha-olephin (PAO) or as defined in IEST RP CC 007.

#### C-4.5 RESISTANCE TO ROUGH HANDLING

- C-4.5.1 High strength filters shall be tested on a rough handling machine for 15 minutes at 3/4 inch total amplitude at 200 cycles per minute in accordance with Test Method 105.110 of MIL STD 282. The filter shall be placed on the machine with the faces and pleats in a vertical position.
- C-4.5.2 At the conclusion of the shaking period, the filter shall be visually examined for damage. Cause for rejection shall include cracked or warped cases, loose corners or joints, cracked adhesive, loose or deformed filter medium, separators, or faceguards.

#### C-4.6 RESISTANCE TO PRESSURE

All filter test requirements will be detailed in the High Efficiency Particulate Air (HEPA) Filter Test Plan, 24590-WTP-RPT-ENG-12-047. The specific test protocol for the new high-strength filters (both reinforced glass fiber medium and steel fiber medium) will be the particle loading tests at the subcontracted filter test facility up to 50 inches WC. The particle loading tests will be followed by a high pressure liquid flow test with an added pressure equal to the maximum static pressure under which a WTP HEPA filter can operate. After the high pressure liquid flow test, the filter will be dried and tested for efficiency and pressure differential at rated flow and twenty percent (20%) of rated flow. The high pressure liquid flow test is analogous to the ASME AG-1 wet over-pressure test.

#### C-4.7 RESISTANCE TO HEATED AIR

- C-4.7.1 For resistance to heated air, the high strength filter shall be installed in the test chamber and subjected to 40% or greater rated flow of air heated to 700°F ±50°F for no less than 5 minutes. Ramping to this temperature shall be accomplished in no more than 15 minutes.
- C-4.7.2 Following exposure to heated air and cooling of the filter in place, the filter shall be tested in accordance with ASME AG-1 Article TA-4634 at rated flow for test aerosol penetrations through the assembled filter. The penetration shall not exceed 0.03%.
- C-4.7.3 Either an Underwriters Laboratories' label, which through its traceable UL control number, or a UL 586 designation shall be objective evidence of compliance.

#### C-4.8 SPOT FLAME RESISTANCE

- C-4.8.1 The high strength filter shall be mounted in the test duct and the airflow adjusted to rated airflow. A gas flame from a Bunsen burner shall be directed against the upstream face of the unit. The Bunsen burner shall be adjusted to produce a flame with a blue cone 2.5 inches long with a tip temperature of 1750°F ±50°F, as measured by a thermocouple inserted in the flame. The tip of the cone shall be so applied that it touches the surface of the filter medium

at a distance of not less than 2 inches from the filter case. The flame shall be applied for 5 minutes at each of three separate locations on the filter face.

- C-4.8.2 The Bunsen burner flame shall then be directed into a top corner of the filter unit in such a manner that the tip of the blue cone contacts the case, filter pack, and sealing materials. The flame shall be applied for a period of 5 minutes. The test shall be repeated upon the opposite top corner of the sample filter unit.
- C-4.8.3 After removal of the test flame at each point of application, there shall be no sustained flaming on the downstream face of the unit.
- C-4.8.4 Either an Underwriters Laboratories label, which through its traceable UL control number, or a UL 586 designation shall be objective evidence of compliance.

#### C-4.9 STRUCTURAL AND SEISMIC QUALIFICATION REQUIREMENTS.

- C-4.9.1 Each filter or filter component in the sample shall be evaluated for structural integrity. Each filter or filter component shall satisfy that no structural damage shall be evident by visual examination.
  - C-4.9.2 In the case of Remote Change high strength medium HEPA filters, the filter shall be qualified to withstand grapple loads by testing.
  - C-4.9.3 The assembled high strength HEPA filter shall be seismically qualified by testing in accordance with ASME AG-1, Article FK-4300.
- C-4.10 REQUIREMENTS FOR RESIDUAL PHYSICAL INTEGRITY. Each component in the high strength filter shall be visually inspected for residual physical integrity after each test performed. It shall be confirmed during all visual examinations that each filter in the sample remains free of contaminants and degradations in conformance with Section C-5, Fabrication, requirements in this specification.
- C-4.11 PRODUCTION TESTING. Each high strength filter manufactured for delivery shall be inspected according to requirements in this section and tested for test aerosol penetration and resistance to airflow in accordance with this specification. Test results shall be marked on the label of each filter.

## C-5 Fabrication

- C-5.1 GENERAL REQUIREMENTS. The high strength HEPA filter shall be assembled from the materials designated in Section C-2, Materials, of this specification in accordance with the design requirements established in Section C-3, Design, of this specification. Following assembly, filters for qualification shall be inspected and qualified in accordance with Section C-4, Inspection and Testing, requirements in this specification.

Production testing of qualified high strength filters shall conform to Section C-4, Inspection and Testing, requirements in this specification.

- C-5.2 MANUFACTURE AND ASSEMBLY. The general requirements for fabrication and installation are contained in ASME AG-1 Articles AA-6200 and AA-6300.
- C-5.3 TOLERANCES. Tolerances shall be as indicated in ASME AG-1, Section FK, unless otherwise stated on supplier design drawings accepted by the Buyer, and except as modified per Section 5.1.1 of this specification.
- C-5.4 INSTALLATION OF HIGH STRENGTH FILTER MEDIUM. The high strength filter medium shall be fastened to the sides and ends of the filter case with adhesive to completely seal the edges of the filter medium to the filter case. Patching of holes or tears in the filter medium shall not be permitted.
- C-5.5 WORKMANSHIP. The high strength filter shall be free from foreign matter (dirt, oil, or viscous material) and damage, such as distorted or cracked case, deformation, or sagging of the filter medium, separators and faceguards, cracks in adhesive, and cracks, or holes in exposed portions of the filter medium. All required fasteners shall be securely installed. All the dimensional and performance requirements of this specification shall be directed toward achieving the highest quality and workmanship possible.

## **C-6 Packaging, Shipping, and Storage**

- C-6.1 Packaging, shipping, and storage shall be in accordance with ASME AG-1 Article AA-7000 and ANSI/ASME NQA-1 Level B. High strength filters shall be individually packaged. Cartons shall have extra shock absorbing material at the corners of the filter that centers the filter within the carton to prevent damage.
- C-6.2 Filters shall be placed in the carton with the pleats vertical. The carton should be placed on skids or otherwise packed in such a manner that the pleats remain vertical during shipment.
- C-6.3 HEPA filters with gelatinous seals shall be packaged in a manner to prevent the gelatinous compound from sticking to the packaging material. A means shall be provided to prevent the gelatinous seal from being gouged or pulled out of the continuous channel when the filter is removed from the shipping carton or plastic bag.
- C-6.4 Cartons for high strength HEPA filters shall not be stacked more than 6.5-feet high during packaging, handling, shipping, and storage.
- C-6.5 The carton shall be clearly marked for proper orientation.

## C-7 Quality Assurance

- C-7.1 Quality Assurance shall conform to the requirements of ASME AG-1, Article AA-8000 and the following.
- C-7.2 RESPONSIBILITY. The Supplier has the responsibility of providing all specified information and of assuring that the quality control, and detailed examination and tests required by this specification, are performed at the stages of construction necessary to permit them to be meaningful.
- C-7.3 CERTIFICATE OF CONFORMANCE. The Certificate of Conformance shall state that the high strength filters conforms to this specification.

## C-8 Nameplates

- C-8.1 Filter Marking. Marking or labeling of each high strength filter shall be on the top of the filter when the pleats are vertical, of such size and legibility that it can be read at a distance of 6-feet. As a minimum, the following information shall be provided:
- C-8.1.1 Manufacturer's name or symbol
  - C-8.1.2 Model number
  - C-8.1.3 Serial number
  - C-8.1.4 Rated flow capacity
  - C-8.1.5 Direction of airflow for penetration and pressure drop tests, no less than 6 inches high
  - C-8.1.6 Pressure drop, in inches of water at one hundred percent (100%) rated flow
  - C-8.1.7 Overall penetration at rated flow
  - C-8.1.8 Overall penetration at five percent (5%) of rated flow
  - C-8.1.9 UL label indicating successful testing per UL 586 if UL 586 if applicable
- C-8.2 PACKAGE MARKING. Marking or labeling of each shipping container (carton containing one high strength filter) shall be of such size and type that it can be read at a distance of 6 feet. As a minimum, the following information shall be provided:
- C-8.2.1 Manufacturer's name or symbol
  - C-8.2.2 Arrows and "THIS SIDE UP" indicating orientation for shipping and storage and "FRAGILE" in letters no less than 6 inches high.

C-8.2.3 Filter model number

C-8.2.4 Purchase order number or other identifying mark requested by Buyer.

## **C-9 High Strength HEPA Filter Medium**

C-9.1 SCOPE. This specification section establishes requirements for the manufacture of high strength, high efficiency, fire resistant, filter medium for use in the construction of high strength HEPA filters.

C-9.2 REQUIREMENTS. In order to ensure continuous, high efficiency particle removal during filter service, the inspection and testing of a high strength HEPA filter medium shall include requirements for the strength and other performance criteria of the filter medium.

### **C-9.3 FORM AND SIZE**

C-9.3.1 FORM. The high strength filter medium shall be furnished in rolls. The filter medium shall be tightly and evenly wound on nonreturnable fiber or paperboard cores with a minimum inside diameter of 3 1/16 inch  $\pm$  1/8 inch and a minimum wall thickness of 3/8 inch.

C-9.3.2 SIZE. The width of the roll shall be specified at the time of procurement. The tolerance on the specified width shall be plus (+) 1/4 inch and minus (-) zero inches. The weight or length of filter medium on the roll shall be clearly marked on the outside of the roll.

C-9.4 SPLICES. The location of splices within the rolls shall be marked with paper tabs of contrasting color extending from each end of the roll. The number of splices permitted per roll shall not exceed the whole number obtained by dividing the length of the roll (measured in ft) by 1000.

### **C-9.5 PHYSICAL AND CHEMICAL**

C-9.5.1 AIRFLOW RESISTANCE. The pressure drop across the high strength filter medium shall meet the requirements of Section C-3.9 with ambient room temperature airflow through the filter medium at a velocity of 10.5 feet per minute, when tested as specified in Section C-9.15, TEST PROCEDURES.

C-9.5.2 TEST AEROSOL PENETRATION. The penetration of the high strength filter medium by a test aerosol of 0.3 micrometer light scattering particle size shall not exceed 0.03%, as determined by the ratio of the downstream to upstream aerosol concentration when testing in accordance with Section C-9.15, TEST PROCEDURES, with ambient temperature airflow through the filter medium at a velocity of 10.5 feet per minute.

### **C-9.6 TENSILE STRENGTH**

- C-9.6.1 Tensile Strength and Elongation. The average ultimate tensile strength of the high strength filter medium shall be not less than 38 pounds per inch width in the machine direction, not less than 32 pounds per inch width in the cross direction, and the average elongation in both directions shall be no less than 0.5% at rupture when tested.
- C-9.6.2 Tensile Strength After Heated Air. The average ultimate tensile strength of the high strength filter medium shall be not less than 24 pounds per inch width in the cross direction after exposure to heated air at 700°F ±50°F in a forced draft oven for 5 minutes when tested.
- C-9.6.3 Wet Tensile Strength. The average ultimate tensile strength of the wet high strength filter medium, after being twice folded around a 0.19 inch diameter mandrel and soaked for 15 minutes in water at room ambient temperature, shall be not less than 16 pounds per inch width in the cross direction when tested.
- C-9.6.4 Tensile Strength After Gamma Irradiation. The average ultimate tensile strength of the high strength filter medium shall not be less than 16 pounds per inch width in either the machine or cross direction after the filter medium is exposed to gamma irradiation for an integrated dose of  $6.0 \times 10^7$  to  $6.5 \times 10^7$  rads at a dosage rate not to exceed  $2.5 \times 10^6$  rads per hour when tested.

#### C-9.7 WATER REPELLENCY

- C-9.7.1 Initial Water Repellency. The average water repellency of the high strength filter medium shall not be less than 20 inches WC with no single value being less than 18 inches WC when tested.
- C-9.7.2 Water Repellency After Gamma Irradiation. The average water repellency of the high strength filter medium shall be no less than 6 inches WC with no single value being less than 5 inches WC after the filter medium is exposed to an integrated dose of  $6.0 \times 10^7$  to  $6.5 \times 10^7$  rads at a dose rate not to exceed  $2.5 \times 10^6$  rads per hour when tested.

C-9.8 THICKNESS. The thickness of the high strength filter medium shall be a minimum of 0.015 inches and a maximum of 0.040 inches when measured.

C-9.9 COMBUSTIBLE MATERIAL. The combustible material in the high strength filter medium shall not exceed 7.5% by weight when tested.

#### C-9.10 FLEXING CHARACTERISTICS

- C-9.10.1 Examination After Flexing. The high strength filter medium shall show no tears, breaks, cracks, or fiber separation after it is drawn back and forth, five times, around a 0.19 inch (4.8 mm) diameter mandrel and moving through an arc of at least 180 degrees.

C-9.10.2 Test Aerosol Penetration After Flexing. The penetration of the high strength filter medium by test aerosol of 0.3 micrometer light scattering particle size shall not exceed 0.03% after the filter medium is drawn back and forth, when tested as specified in Section C-9.13.2.1, Airflow Resistance and Test Aerosol Penetration.

C-9.11 MILDEW RESISTANCE. If a mildew resistant filter medium is required the filter medium shall show no growth when tested as specified in Section C-9.13.2.7, Test for Mildew Resistance. This test is only required if requested explicitly by the Buyer of the filter medium. A filter medium requiring mildew inhibitor shall be re-qualified for mildew resistance at least every five years by an independent test facility.

C-9.12 WORKMANSHIP. The high strength filter medium shall be free from contamination (foreign matter), thick or thin spots, wrinkles, and damage, such as tears, cracks, holes, abrasions, and punctures.

C-9.13 INSPECTION AND TESTING

C-9.13.1 QUALIFICATION TESTING

C-9.13.1.1 SAMPLE. A qualification sample of 10 linear feet, full width, shall be manufactured using the same methods, materials, equipment and processes as will be used during regular production. This sample shall be tested for the properties specified in Table C-2.

<b>Table C-2 High Strength Filter Medium Qualification and Production Tests</b>				
<b>Filter Medium Property</b>	<b>Test Req.</b>	<b>Test Procedure</b>	<b>Qualification Test</b>	<b>Production Test</b>
Airflow Resistance	C-9.5.1	C-9.13.2.1	X	X
Test Aerosol Penetration	C-9.5.2	C-9.13.2.1	X	X
Tensile Strength and Elongation	C-9.6.1	C-9.13.2.2 (a)	X	X
Tensile Strength After Heated Air	C-9.6.2	C-9.13.2.2 (b)	X	
Wet Tensile Strength	C-9.6.3	C-9.13.2.2 (c)	X	X
Tensile Strength After Gamma Irradiation	C-9.6.4	C-9.13.2.2 (d)	X	
Initial Water Repellency	C-9.7.1	C-9.13.2.3 (a)	X	X
Water Repellency After Gamma Irradiation	C-9.7.2	C-9.13.2.3 (b)	X	
Thickness	C-9.8	C-9.13.2.4	X	X
Combustible Material	C-9.9	C-9.13.2.5	X	X
Examination After Flexing	C-9.10.1	C-9.13.2.6 (a)	X	
Test Aerosol Penetration After Flexing	C-9.10.2	C-9.13.2.6 (b)	X	
Workmanship	C-9.12	C-9.13.3	X	X

C-9.13.1.2 MATERIAL CHANGE. Any change in materials or source of materials after qualification shall require a new qualification sample.

C-9.13.1.3 REVERIFICATION OF QUALIFICATION. A high strength filter medium shall be re-qualified at least every five (5) years. Tests shall be performed and certified by an independent test facility.

#### C-9.13.2 QUALIFICATION TEST PROCEDURES

C-9.13.2.1 AIRFLOW RESISTANCE AND TEST AEROSOL PENETRATION. Three test specimens shall be tested for airflow resistance and aerosol penetration at a filter medium velocity of 10.5 feet per minute using a Penetrometer (e.g., Q 127) according to ASTM D737 and ASTM D2986. Optionally, the Most Penetrating Particle Size penetration may be determined according to IEST RP CC021.1.

#### C-9.13.2.2 TENSILE STRENGTH

- (a) Tensile Strength and Elongation. Ten test specimens, five taken in each direction, shall be tested for ultimate tensile strength and elongation at rupture in accordance with TAPPI Standard T494 except that the test specimens shall 1.00 inches  $\pm$  0.05 inches wide with sides parallel within 4/1000 inch and long enough to be clamped in the jaws when the test span is 4.0 inches  $\pm$  0.2 inches, leaving enough length so that any slack can be removed from the strip before clamping. Use a motorized tensile testing machine that has a constant rate of elongation and a flat jaw clamping device. The rate of separation of the jaws shall be set at 0.5 inches per minute or at a rate that will complete the test in 10 seconds  $\pm$  2 seconds, whichever is greater. The rate shall be constant to  $\pm$ 4%.
- (b) Tensile Strength After Heated Air. Four test specimens 6 inches by 6 inches shall be subjected to heated air using a suitable commercial forced draft oven, capable of allowing full circulation of air to each test specimen. The test specimen shall be placed in the oven for five minutes after the temperature has reached 700°F  $\pm$  50°F. After the exposure, the specimen shall be removed from the oven and conditioned in accordance with TAPPI Standard T402. One test strip, 1.00 inch  $\pm$  0.05 inches wide with sides parallel within 4/1000 inch and long enough to be clamped in the jaws when the test span is 4.0 inches  $\pm$  0.2 inches, leaving enough length so that any slack can be removed from the strip before clamping taken in the cross direction width shall be tested for ultimate tensile strength in accordance with Section C-9.13.2.2(a), Tensile Strength and Elongation.
- (c) Wet Tensile Strength. Three test specimens, 1.00 inches  $\pm$  0.05 inches wide with sides parallel within 4/1000 inch and long enough to be clamped in the jaws when the test span is 4.0 inches  $\pm$  0.2 inches, leaving enough length so that any slack can be removed from the strip before clamping taken in the cross direction width shall be submerged in water at a depth of 10 inches for 15 minutes and then tested for ultimate tensile strength as specified in Section C-9.13.2.2(a), Tensile Strength and Elongation.

- (d) Tensile Strength after Gamma Irradiation. Six (6) test specimens 7 inches by 3 inches  $\pm 0.2$  inches, three (3) with the 7 inch side in the machine, and three (3) with the 7 inch side in the cross direction, shall be exposed to irradiation in a ventilated chamber as specified in Section C-9.5.4, Tensile Strength after Gamma Irradiation. A test strip, 1.00 inches  $\pm 0.05$  inches wide with sides parallel within 4/1000 inch and long enough to be clamped in the jaws when the test span is 4.0 inches  $\pm 0.2$  inches, leaving enough length so that any slack can be removed from the strip before clamping taken from each of these specimens shall be tested for ultimate tensile strength in accordance with Section C-9.13.2.2(a), Tensile Strength and Elongation.

#### C-9.13.2.3 WATER REPELLENCY

- (a) Initial Water Repellency. Three test specimens  $2 \frac{3}{4} \pm \frac{1}{8} \times 5 \frac{1}{2} \pm \frac{1}{4}$  inch shall be conditioned in accordance with TAPPI T402 and tested for water repellency using the Q 101 Water Repellency Test (125 8 1). The two surfaces of each test specimen shall be identified as top and bottom. The specimen shall then be cut into two  $2 \frac{1}{4} \pm \frac{1}{8} \times 2 \frac{1}{4} \pm \frac{1}{8}$  inch squares. The top surface of one and the bottom surface of the other square shall be tested. The lesser of the two results shall be considered the water repellency of the specimen.
- (b) Water Repellency After Gamma Irradiation. Three test specimens  $7 \pm \frac{1}{4} \times 5 \pm \frac{1}{4}$  inches shall be exposed to irradiation in a ventilated chamber as specified in Section C-9.6.4, Tensile Strength after Gamma Irradiation and subsequently tested in accordance with Section C-9.13.2.3(a), Initial Water Repellency.

C-9.13.2.4 THICKNESS. The thickness of samples of a high strength filter medium shall be determined in accordance with TAPPI T411.

C-9.13.2.5 COMBUSTIBLE MATERIAL. The percentage of material combusted from the sample shall be determined as specified in the IEST RP CC021.1.

#### C-9.13.2.6 FLEXING CHARACTERISTICS.

- (a) Examination After Flexing. Eight test specimens,  $6 \pm \frac{1}{4} \times 12 \pm \frac{1}{4}$  inches in the machine direction shall be bent perpendicular to the machine direction over a  $\frac{3}{16} \pm \frac{1}{32}$  inch mandrel so that  $10 \pm \frac{1}{2}$  inch of filter medium are drawn five times through an arc of  $180^\circ$ . Four specimens with the screen/wire side against the mandrel and four specimens with the felt side against the mandrel. Examine the flexed filter medium  $10 \pm \frac{1}{2}$  inch section for compliance with Section C-9.10.1, Examination After Flexing.
- (b) Test Aerosol Penetration After Flexing. The penetration of the high strength filter medium by test aerosol of 0.3 micrometer light scattering particle size shall not exceed 0.03% after the filter medium is drawn back and forth as required in Section C-9.10.1, Examination After Flexing, when tested as specified in Section C-9.10.2, Test Aerosol Penetration After Flexing.

C-9.13.2.7 TEST FOR MILDEW RESISTANCE. When mildew resistance is required, the filter medium shall be tested in accordance with MIL STD 810G, Method 508.6.

C-9.13.3 WORKMANSHIP. Each roll of high strength filter medium shall be inspected for defects. Defects such as abrasions greater than 1/4 inch diameter; burn holes, charring or scorching from the drying operation; and deviations outside the width tolerance are reasons for rejection. All the dimensional and performance requirements of this specification shall be directed toward achieving the highest quality and workmanship possible.

#### C-9.13.4 PRODUCTION TESTING

C-9.13.4.1 PRODUCTION LOT. A production lot shall consist of the rolls of filter medium produced sequentially by one manufacturer using the same methods, materials, equipment, processes, and design. The production lot is assigned a lot number or identifier to permit traceability to test results and reports.

C-9.13.4.2 SAMPLING. At minimum, a full width sample shall be taken every fourth set for testing. A set consists of the amount of linear filter medium needed to produce a final roll by the full width utilized of the manufacturing equipment. If a production lot is smaller than four sets, the beginning and end of the lot shall be sampled for testing. A purchaser may require more frequent testing from the filter medium supplier based on process capability or experience with the supplier.

C-9.13.4.3 TESTS. Each sample taken as specified shall be tested for the properties specified in Table C-2, Filter Medium Qualification and Production Tests.

#### C-9.14 QUALITY ASSURANCE PROVISIONS

##### C-9.14.1 RESPONSIBILITY FOR INSPECTION

C-9.14.2 SUPPLIER'S RESPONSIBILITY. Unless otherwise specified in the contract or purchase order, the Supplier is responsible for the performance of all inspection requirements as specified herein.

C-9.14.3 OBJECTIVE EVIDENCE. The Supplier shall provide objective evidence acceptable to Buyer that the Section C-9, High Strength HEPA Filter Medium, specification requirements have been satisfied.

#### C-9.15 PACKAGING, SHIPPING, AND STORAGE

C-9.15.1 PACKAGING. Packaging shall conform to Level B of ASME NQA 2 suitable for storage under Level B of ASME NQA 2.

C-9.15.2 SHIPPING. Shipping of the high strength filter medium shall be undertaken to ensure the quality of the product upon arrival at the purchaser. Shipping shall comply with the rules and regulations applicable to the mode of transport being utilized.

## Appendix D:

### Projected PTF/LAW/HLW HEPA Filter Loading

The tables below provides a listing of the anticipated HEPA filter gas-phase chemical and particulate loadings at the inlet of the HEPA filters.

With the exception of the Pretreatment HEPA Filters (PVP-HEPA-00012A/B) loads, these results reflect the anticipated constituent concentrations experienced during normal operations, as predicted by the Aspen Process Performance Simulation (APPS) runs performed for the Process Inputs Basis of Design (PIBOD), 24590-WTP-DB-PET-09-001, Revision 1.

The temperature and relative humidity conditions listed in the table represent the maximum values realized from the set of 23 runs performed for the PIBOD. Again, these values reflect normal operating conditions for the WTP.

The HLW HEPA filter values were obtained using the “Bounding Flowsheet” scenario presented in 24590-HLW-M4C-HOP-00011, Revision 1 and the associated Engineering Calculation Change Notice, 24590-HLW-M4E-HOP-00006.

The LAW HEPA filter values were obtained using the “Bounding Flowsheet - 3 Melters” scenario presented in 24590-LAW-M4C-LOP-00001, Revision 1 and the associated/relevant ECCN, 24590-LAW-M4E-LOP-00009.

The results presented for the PJV HEPA filter loadings were obtained using bounding results from the APPS runs performed for the PIBOD, 24590-WTP-DB-PET-09-001, Revision 1.

The PVV HEPA filter constituent concentrations reflect those predicted for the “normal operating conditions with all vessels at max solids contribution” case, as presented in Tables 8-1 and 8-10 of 24590-PTF-M4C-M11T-00001, Revision C.

The gas-phase concentrations listed in the table below are in units of parts per million by volume (ppmV); the particulate loadings are in units of mass-based parts per million (ppm) in units of milligrams per kilogram (mg/kg). Other than the conservative assumptions that went into the inputs and assumptions used to generate the conditions and compositions for the streams, none of these results reflect adjustment to include any safety-factor and/or design margin values.

Appendix D (Continued)

WTP PTF/LAW/HLW HEPA Filter Inlet Stream Conditions During Normal Operations

Component	Inlet Stream	Mass Flow (kg/hr)	Flow (ACFM)	T (°F)	Relative Humidity
HOP-HEPA-00001A/B & -00002A/B	HOP17	3555	3012	160	38.7
HOP-HEPA-00007A/B & -00008A/B	HOP17	3555	3012	160	38.7
PJV-HEPA-00004A/B & -00005A/B	PJV33	3855	2270	98	27
LVP-HEPA-00001A/B, -00002A/B & -00003A	LVP04	11400	9544	182	28
PJV-HEPA-00003A/B	PJV13a	6170	3830	202	2
PJV-HEPA-00001A/G & -00002A/F	PJV08	88000	49200	82	70
PVV-HEPA-00004A/B	PVP07d	316	200	185	2
PVV-HEPA-00001A/B & -00002A/B	PVP07a	3890	2400	87	70

Component	Inlet Stream	ppmV					
		NH <sub>3</sub>	VOC/SVOC	Hg	HCl	HF	SO <sub>2</sub>
HOP-HEPA-00001A/B & -00002A/B	HOP17	14	~0	9.8	3.7	6.2	2.4
HOP-HEPA-00007A/B & -00008A/B	HOP17	14	~0	9.8	3.7	6.2	2.4
PJV-HEPA-00004A/B & -00005A/B	PJV33	0	0.00035	~0	0.012	0.04	0.011
LVP-HEPA-00001A/B, -00002A/B & -00003A	LVP04	42.7	192	3.88	45.5	2.81	4.76
PJV-HEPA-00003A/B	PJV13a	0	0	0	0	0	0
PJV-HEPA-00001A/G & -00002A/F	PJV08	0	0.108	0.00004	0.139	0.167	0.132
PVV-HEPA-00004A/B	PVP07d	0	0	0	0	0	0
PVV-HEPA-00001A/B & -00002A/B	PVP07a	0	0.021	~0	0.027	0.039	0.026

Appendix D (Continued)

WTP PTF/LAW/HLW HEPA Filter Inlet Stream Conditions During Normal Operations

Component	Inlet Stream	Particulate (ppm)
HOP-HEPA-00001A/B & -00002A/B	HOP17	0.0059
HOP-HEPA-00007A/B & -00008A/B	HOP17	0.0059
PJV-HEPA-00004A/B & -00005A/B	PJV33	1.01
LVP-HEPA-00001A/B, -00002A/B & -00003A	LVP04	21.32
PJV-HEPA-00003A/B	PJV13a	0
PJV-HEPA-00001A/G & -00002A/F	PJV08	1.01
PVV-HEPA-00004A/B	PVP07d	0
PVV-HEPA-00001A/B & -00002A/B	PVP07a	4.81

Component	Inlet Stream	References
HOP-HEPA-00001A/B & -00002A/B	HOP17	24590-HLW-M4C-HOP-00011, Rev. 1, "Bounding Flowsheet" case
HOP-HEPA-00007A/B & -00008A/B	HOP17	24590-HLW-M4C-HOP-00011, Rev. 1, "Bounding Flowsheet" case
PJV-HEPA-00004A/B & -00005A/B	PJV33	24590-WTP-DB-PET-09-001, Rev. 1 (PIBOD Run 1)
LVP-HEPA-00001A/B, -00002A/B & -00003A	LVP04	24590-LAW-M4C-LOP-00001, Rev. 3, "Bounding Flowsheet, 3 Melters" case
PJV-HEPA-00002A/B	PJV13a	24590-WTP-DB-PET-09-001, Rev. 1 (PIBOD Run 1)
PJV-HEPA-00012	PJV08	24590-WTP-DB-PET-09-001, Rev. 1 (PIBOD Run 1)
PVV-HEPA-00004A/B	PVP07d	24590-WTP-DB-PET-09-001, Rev. 1 (PIBOD Run 1)
PVV-HEPA-00001A/B & -00002A/B	PVP07a	24590-PTF-M4C-M11T-00001, Rev. C (p. 74 & 91); 24590-WTP-DB-PET-09-001, Rev. 1 (PIBOD Run 01)