SECTION 23 40 00

HVAC AIR CLEANING DEVICES (AIR FILTERS)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Air filters for Autopsy suite exhaust and filter housing.

B. Definitions: Refer to ASHRAE Standard 52.2 for definitions of face velocity, net effective filtering area, media velocity, initial resistance (pressure drop), MERV (Minimum Efficiency Reporting Value), PSE (Particle Size Efficiency), particle size ranges for each MERV number, dust holding capacity and explanation of electrostatic media based filtration products versus mechanical filtration products. Refer to ASHRAE Standard 52.2 Appendix J for definition of MERV-A.

1.2 RELATED WORK

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION: General mechanical requirements and items, which are common to more than one section of Division 23.

B. Containment filter housing assemblies.

C. Pre filters.

D. High efficiency particulate air (HEPA) filters.

E. High efficiency gas absorbers (HEGA).

F. Housing accessories (i.e. differential pressure gages).

1.3 QUALITY ASSURANCE

A. Air Filter Performance Report for Extended Surface Filters:

1. Submit a test report for each Grade of filter being offered. The report shall not be more than three (3) years old and prepared by using test equipment, method and duct section as specified by ASHRAE Standard 52.2 for type filter under test and acceptable to Resident Engineer, indicating that filters comply with the requirements of this specification. Filters utilizing partial or complete synthetic media will be tested in compliance with pre-conditioning steps as stated in Appendix J. All testing is to be conducted on filters with a nominal 24 inch by 24 inch face dimension. Test for 150 m/min (500 fpm) will be accepted for lower velocity rated filters provided the test report of an independent testing laboratory complies with all the requirements of this specification. Witness testing is required by the Project Manager on bag-in bag-out systems.

2. Guarantee Performance: The manufacturer shall supply ASHRAE 52.2 test reports on each filter type submitted. Any filter supplied will be

required to maintain the minimum efficiency shown on the ASHRAE Standard 52.2 report throughout the time the filter is in service. Within the first 6-12 weeks of service a filter may be pulled out of service and sent to an independent laboratory for ASHRAE Standard 52.2 testing for initial efficiency only. If this filter fails to meet the minimum level of efficiency shown in the previously submitted reports, the filter manufacturer/distributor shall take back all filters and refund the owner all monies paid for the filters, cost of installation, cost of freight and cost of testing.

3. The manufacturer shall supply ASHRAE 52.2 test reports on each filter type submitted. Any filter supplied will be required to maintain the minimum efficiency shown on the ASHRAE Standard 52.2 report throughout the time the filter is in service. Within the first 6-12 weeks of service a filter may be pulled out of service and sent to an independent laboratory for ASHRAE Standard 52.2 testing for initial efficiency only. If this filter fails to meet the minimum level of efficiency shown in the previously submitted reports, the filter manufacturer/distributor shall take back all filters and refund the Owner all monies paid for the filters, cost of installation, cost of freight and cost of testing.

B. Filter Warranty for Extended Surface Filters: Guarantee the filters against leakage, blow-outs, and other deficiencies during their normal useful life, up to the time that the filter reaches the final pressure drop. Defective filters shall be replaced at no cost to the Government.

C. Comply with UL Standard 900 for flame test.

D. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size, rated efficiency, UL classification, and file number.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's Literature and Data:

1. Extended surface filters.
2. Holding frames. Identify locations.
3. Side access housings. Identify locations, verify insulated doors.
4. HEPA filters.
5. Magnehelic gages.
6. Interface locations and sizes.
7. Mounting base anchor bolt plans.
8. Service clearance dimensions.

9. Filter and differential pressure gage requirements for each housing tag number.
10. Submit an uncontrolled copy of the manufacturer's quality assurance manual.

C. Air Filter performance reports.
D. Suppliers warranty.
E. Field test results for HEPA filters as per paragraph 2.3.E.3.
F. Delivery Documentation:
1. Submit housing leak test reports.
2. Submit seal surface leak test reports.
3. Submit filter fit report.
4. Submit three (3) copies of operations and maintenance manuals.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
B. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
52.2-2007.....Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size, including Appendix J
C. American Society of Mechanical Engineers (ASME):
NQA-1-2008.....Quality Assurance Requirements for Nuclear Facilities Applications
D. Underwriters Laboratories, Inc. (UL):
900;Revision 15 July 2009 Test Performance of Air Filter Units

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS CONTINGENT OF COMPLIANCE WITH SPECIFICATIONS

A. Camfil (basis of design).
B. Substitutions.
1. Due to life safety concerns, this specification section describes highly specialized equipment and components known to be included in the basis of design. Equipment and component substitutions may not be made at the time of bid. However, a full evaluation package shall be submitted with the alternate manufacturer's proposal. The offeror shall clearly state the proposed manufacturer's offers of all equipment and components specified under this section. The offeror shall provide a complete and detailed response to each paragraph of

the contract specification. The offeror shall clearly note after each specification paragraph one of the following responses: 1. Comply, 2. Deviate, or 3. Exception. For deviation or exception responses, the offeror shall fully explain the deviation or exception. Detailed equipment drawings shall be furnished to demonstrate full compliance with the dimensional requirements shown on the contract drawings. Any deviation shall be clearly shown on the drawings of the proposed equipment. Any alternative bids not including the above required information will be rejected. The contractor shall bear to the responsibility to furnish equipment in complete compliance with this specification. The Owner or its representative reserves the right to reject any deviation or exception if it does not meet the intent or the requirements of this project.

2. All acceptable manufacturers shall be the producer of all of the products specified in this section. Vended products shall be limited to raw sheet metal materials, fasteners, gages, damper operators and valves. The specified filters shall be considered a vended product and shall be produced by the same company that produces the filter housings. The offeror shall clearly identify all purchased components, weldments and assemblies from outside sources. Failures to comply shall result in the rejection of the offered product.

2.2 CONTAINMENT FILTER HOUSINGS

A. General:

1. The containment filter housing assemblies shall be camfil camcontain series housing units that have been fabricated, assembled and pressure decay tested in the same factory. Each system shall consist of the following housing sections and components assembled into a complete containment system:
   a. Flanged inlet transition.
   b. Prefilter section.
   c. Hepa Filter section.
   d. Assembly welded on to a mounting structure.
2. The system shall be designed for the scheduled cfm as indicated on the contract documents at 15 inches water gage and the maximum design temperature shall be 130°F. The furnished system shall be sized not to exceed the scheduled “clean” pressure drop across the containment system from inlet and outlet bubble-tight dampers. The scheduled “dirty” pressure drop assumes the “clean” hepa filter initial pressure drop times two.
3. Sealing Mechanism:

a. All high efficiency filters and absorbers shall be mechanically sealed by means of a compressible gasket fixed to the filtering device.
b. The filter sealing mechanism shall be replaceable.
c. The filter clamping mechanism shall be operated from outside of the housing by means of a standard wrench.
d. The filter clamping mechanism shall be designed with mechanical stops. When the mechanism has reached the mechanical stop, it shall be fully engaged and the clamping shall be exerted solely by means of its pressure compensating springs. The clamping mechanism shall include two pressure channel assemblies with eight (8) springs per filter for full-width filters nominal 24” wide and shall exert a minimum filter sealing force of 1,400 pounds for full high, full wide filters. The force shall be applied as an even, uniform load along at least 80 percent of the top and bottom of each filter outer frame. The clamping assembly shall penetrate through the housing wall and shall be sealed airtight.

4. Bagging Ring:
   a. Each filter housing section shall have a bagging ring around each access port. The bagging rings shall have two (2) continuous ribs to secure the PVC filter change-out and scan bags. The outer edge of the ring shall be hemmed to prevent the PVC bag from tearing.
5. Access Doors:
   a. The filter access port shall be covered with an access door. Each access port and bagging ring shall be covered by an access door having an extruded silicone gasket that is replaceable (if damaged) after the door has been removed. When closed, the door shall not press against the bag-out port and PVC bag, thus eliminating the possibility of the bag being cut by pressure from the door to the bag and bag-out port.
   b. There shall be four (4) tie down latches per access door. Each latch assembly shall comprise of a 300-series threaded stud and an aluminum star knob. The access door shall be provided a means to fit over the threaded stud array and shall be sealed against the filter housing front by tightening the star knobs.
6. Orientation and Handedness:
   a. The contract drawings shall determine the filter access side of each housing. The handedness of a housing shall be designated as right hand or left hand. When looking in the direct of airflow (i.e. As if standing inside of the housing with the air flow

hitting the person’s back) of the hepa filter, if access is required on the right side, then the housing shall be determined to be right hand access. If access if required on the left side from the above stated vantage, then the housing shall be determined to be left hand access.

7. Filter Removal Rods:
   a. Multi-wide filter housing sections shall be equipped with a filter removal rod to draw the filters to the change-out position. The removal rod shall be operated from inside the change-out bag and shall remove the filter by pulling against the bottom of the filter frame. There shall not be any penetrations through the housing for operation of the removal rod. All change-out operations shall be within the bag so there is a barrier between the worker and filter at all times.
8. Hardware:
   a. All hardware on the filter housing such as the filter clamping mechanism components, door handles, door studs, and labels, shall be 300 series stainless steel. The threaded pivot blocks in the filter clamping mechanisms shall be brass. The filter access door knobs are cast aluminum (to prevent galling of threads).
9. Flanges:
   a. The upstream and downstream flanges shall have a 1-1/2 inch minimum flange width. Flanges shall be turned to the outside of the airstream to prevent contamination build-up and allow the customer to connect mating ductwork from outside of the housing.
10. Welding:
   a. All “pressure retaining” weld joints and seams shall be continuously welded. Joints and seams requiring only intermittent welds, such as reinforcement members, shall be intermittently welded. Housing will be free of all burrs, and sharp edges. All weld joints and seams that are a portion of any gasket setting surface, (duct connection flanges and filter sealing surfaces), shall be ground smooth and flush with adjacent base metals.
   b. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME boiler and pressure vessel code, Section IX. All welded joints and seams shall be wire brushed to remove heat discoloration. All production welds shall be visually inspected by qualified personnel, per camfil procedure number cfw-10001, visual inspection of welds, which incorporates the workmanship acceptance criteria described in Section 5 and 6 of

AWS D9.1, “specification for welding of sheet metal” the nondestructive test personal shall be qualified to the requirements of anst-snt-tc-la.

11. Quality Assurance:
    a. The filter housing shall be manufactured under a quality assurance program has been assessed and independently certified to meet the requirements of ISO 9001:2000 for design, manufacture and distribution of containment and HVAC air filtration products. Additionally, filter housing shall be manufactured under a quality assurance program that meets all of the basic reqwuirements of ASME NGA-1, “quality assurance program requirements for nuclear facilities”. The manufacture shall submit documented evidence they have been independently audited by customers at least three (3) times within the last five (5) years to ASME NGA-1 requirements, and successfully passed all three (3) audits. The final containment filtration system shall be completely fabricated, assembled, tested and cleaned at the manufacturer’s facility. Sub-assemblies from outside sources will not be acceptable. The offeror shall certify their compliance with this paragraph.
    b. The filter housing shall be factory tested for filter fit, operation of filter clamping mechanism, and seal surface tested for flatness. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the “pressure decay method” in accordance with n510-2007, “testing of nuclear air cleaning systems”, paragraphs 6 and 7. The filter sealing surface shall be tested at +10” water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume. The overall system pressure boundary shall be leak tested at +15” water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume.
12. Service Clearance: A minimum of four (4) feet clearance in front of each access door on the hepa containment filter assembly shall be reserved for filter replacement and in-place testing.
    a. pb/pn: prefilter section: The prefilter housing shall be side access camfil camcontain model pb for a bag-in/bag-out style or pn for a non-bag-in/bag-out style. The housing shall be side servicing for filter installation and change-out. Housing design and filter arrangement shall allow air to enter and exit housings without changing direction. The housing shall accommodate standard size filters that do not require any special attachments or

devices to function properly in the housing. Housing shall accommodate a 2″, 4″, or 6″ nominal depth prefilter. Housing shall accommodate a 2″ nominal depth prefilter and a 12″ nominal depth secondary filter. Filters shall be industry standard ½ (12″ by 24″) or full (24″ by 24″) size. The upstream and downstream ductwork connections shall have 1-1/2″ outward-turned flanges. Sizes shall be noted on enclosed drawings or other supporting materials.

b. Fb/gb/fn/gn: hepa filter section: The hepa filter housing shall be side access camfil camcontain model gb for a bag-in/bag-out style. The housing shall be side servicing for filter installation and change-out. Housing design and filter arrangement shall allow air to enter and exit housings without changing direction. The housing shall accommodate standard size filters that do not require any special attachments or devices to function properly in the housing. The upstream and downstream ductwork connections shall have 1-1/2″ outward-turned flanges. Sizes shall be hoted on enclosed drawings or other supporting materials.

2.3 COMMON HOUSING ACCESSORIES:

A. Weather Cover:

1. Filtration systems located in unsheltered areas shall be protected by use of an integral weather cover. The weather cover shall be fabricated from the same material as the filter housing and intermittently welded to the filter housing.
2. If differential pressure gages are included on the filter housing assembly, they shall be covered with the same material as the filter housing. A means to access the gages shall be provided.

B. Change-out Bags:

1. One (1) PVC change-out bag shall be furnished for each access port. Each bag shall have its stock number rolled in the hem. The PVC bag material shall be 8 mil thick, yellow in color, with a translucent, taffeta textured finish and shall not stick together.
2. For visibility during filter change-out, this bag shall include approximately 16 inches of clear PVC at the mouth. Three (3) glove sleeves shall be built into the bag to facilitate handling the filter curing change-out.
3. All PVC bags of this design shall be produced by filter housing manufacturer and shall have been tested by an independent laboratory to prove the bag’s operability at extreme temperature ranges of 0°F - 130°F (a test report verifying this test shall be furnished upon

request). A 3/16-inch diameter elastic shock cord shall be hemmed into the mouth of the bag so that it fits securely when stretched around the bagging ring. To prevent the bag from sliding off the bagging ring during the change-out operation, one (1) nylon security strap shall be provided with each filter access port. Additionally, one (1) nylon cinching strap shall be provided with each access port to tie off the slack in the PVC bag while the ventilation system is operating.

C. Banding Kit:

1. One complete banding kit shall be provided with the filtration unit(s) equipped with a bag-in/bag-out assembly. The banding kit shall provide a secure clamping of the bag between the housing and the spent filtration element. Each kit shall contain the following items:
   a. Heavy duty tie-banding tool.
   b. Bag cutting tool.
   c. 1/4 inch socket wrench with 3 inch long extension.
   d. 1-5/16 inch hex socket.
   e. 13 inch cinching strap with buckle fastener.
   f. Set of ten (10) 100 pound tensile strength 14 inch long plastic ties.
   g. Set of twenty (20) stainless steel bands.
   h. Plastic case/apron.
2. The banding kit and the change-out bags shall be manufactured by the same manufacturer as the housing. Additional tools required to complete the bag-in/bag-out procedure shall also be provided.

D. Differential Pressure Gages:

1. Differential pressure gages shall be dwyer series 2000 magnehelic pressure gage or equal. Unless otherwise indicated select gage scale ranges to read at 75 percent full range (rounded up) at the expected dirty filter pressure drop. Typical ranges follow:
   a. Filters with 25 to 30% efficiency 0-1.0 inches water column based on atmospheric dust spot test.
   b. Filters with 31 to 99% efficiency 0-3.0 inches water column based on atmospheric dust spot.
   c. Hepa filters 0-3.0 inches water column.
   d. Hegas 0-3.0 inches water column.
2. Gages shall be furnished for each filter bank, including gages across each individual filter bank in built-up rack assemblies, suitable for

flush mounting in a panel. All sensing tubing shall be 1/4 inch o.o. 300-series stainless steel tubing.

3. Differential pressure gage ports: Static pressure ports shall be located on the filtration unit upstream and downstream of each prefilter, hepa filter, hega and overall system banks. The port connections shall be 1/4 inch 300 series stainless steel pipe half-couplings.
4. In-line gage hepa filters:
   a. In-line gage hepa filter shall be camfil farr gage guardian air filter, designed to protect diaphragm pressure indicating instrumentation (i.e. Magnehelic gages, photohelic gages, etc.) from particulate contaminants.
   b. Due to life safety concerns, and considering that the integrity of the pressure boundary of these filters is as critical as that of the containment housing, each filter shall be factory tested to assure it is leak free and bubble-tight at a pressure of +20″ w.g. By submerging the entire filter assembly in water, pressurizing the assembly to +20″ w.g. and visually inspecting for leaks. The presence of a single bubble generated by this method constitutes a leak. Each filter shall have a label indicating that it was leak tested. The filter media shall be hydrophobic with a minimum efficiency of 99.9995%. The filter body shall be manufactured from t-304 stainless steel with silicone gaskets or o-rings to ensure long service life. All wetted surfaces of the filter shall be chemically compatible with vaporous hydrogen peroxide and paraformaldehyde decontamination agents.
5. Gage decontamination ports: These ports shall be installed in the gage lines between the containment housing and gage(s) as shown on the drawings and shall be compatible with commercially available vaporous hydrogen peroxide and paraformaldehyde decontamination systems. Each port shall consist of a stainless steel ball valve with a 3/8″ female npt connection allowing for connection to commercially available paraformaldehyde or vaporous hydrogen peroxide decontamination system to enable decontamination of the gage lines and in-line hepa filter.
6. Gage calibration line: As shown on the drawings, stainless steel shutoff valves shall be provided to isolate each gage from the process stream. A stainless steel equalization valve shall be installed between the high and low pressure sides of each gage in such a manner that when the shutoff valves are closed, and the

equalization valve is open, the pressure across the gage equalizes for calibration purposes without the possibility of venting to the ambient space. Shutoff and equalization valves shall be 300 series stainless steel.

E. Lifting Lugs

1. Lifting lugs shall be provided on the housing as required. Lighting lugs shall be fabricated from 1/4 inch plate of the same material as the housing. Lifting lugs shall have a minimum of 1-1/2 inch diameter eyeholes and be located on the top and side of the housing. Lifting lugs shall be capable of supporting the housing (less adsorbers and filters) without causing housing deflection during transport and installation.
2. All portions shall be free of sharp edges and burrs. Six (6) lifting lugs are required on each double hepa assembly, and four (4) on each single hepa assembly.

2.4 FILTERS

A. Prefilters.

1. General
   a. Filter shall be camfil model farr 30/30 or equal.
   b. Air filters shall be medium efficiency ASHRAE pleated panels consisting of cotton and synthetic media, welded wire media support grid, and beverage board enclosing frame.
   c. Sizes shall be noted on drawings or other supporting materials.
2. Construction
   a. Filter media shall be a cotton and synthetic blend, lofted to a uniform depth of 0.15”, and formed into a uniform radial pleat.
   b. A welded wire grid, spot-welded on one-inch centers and treated for corrosion resistance shall be bonded to the downstream side of the media to maintain radial pleats and prevent media oscillation.
   c. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media on all sides to prevent air bypass. Integral diagonal support members on the air entering and air exiting side shall be bonded to the apex of each pleat to maintain uniform pleat spacing in varying airflows.
3. Performance
   a. The filter shall have a minimum efficiency reporting value of merv 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2007. It shall also have a merv-a of 8 when tested per appendix J

of the same standard. The media shall maintain or increase in efficiency over the life of the filter.

b. Initial resistance to airflow shall not exceed 0.31″ w.g. at an airflow of 500 fpm on 2″ deep models respectively.

c. The filter shall be classified by underwriters laboratories as UL Class 2.

d. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

e. Manufacturer shall guarantee the integrity of the filter pack to 2.0″ w.g.

4. Supporting Data

a. Provide product test report including all details as prescribed in ASHRAE Standards 52.2, including appendix J.

B. Hepa Filter (Very High Capacity)

1. General

a. Air filters shall be camfil model filtra 2000 or engineer-approved equal. Air filters shall be absolute grade hepa filters consisting of pleated media packs assembled in a v-bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket.

b. Sizes shall be as noted on drawings or other supporting materials.

2. Construction

a. Filter media shall be micro fiber glass formed into minipleat pleat-in-pleat v-bank design.

b. The media packs shall be potted into the enclosing frame with fire retardant polyurethane sealant.

c. An enclosing frame of anodized extruded aluminum shall form a rugged and durable enclosure.

d. The filter shall be a gasket seal type with a poured-in-place seamless sealing gasket included on the downstream side of the enclosing frame to form a positive seal between the filter and the filter housing.

3. Performance

a. Filter efficiency shall be 99.99% when evaluated according to the recommended practice. Each filter shall be labeled as to tested performance.

b. Initial resistance shall be 1.0″ w.g. target at rated airflow.

c. Filter shall be qualified as UL 586 and UL 900 class 2 per underwrites laboratories.

d. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

4. Supporting Documentation

a. The filter shall be labeled as to tested efficiency, rated/tested cfm, pressure drop and shall be serialized for identification.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install containment air filtration system in accordance with manufacturer’s instructions and applicable sections of ASME n-509, and in accordance with the manufacturer’s diagrams and recommendations.

B. Clean all dirt, dust and debris that may be in the containment system or attached ductwork during construction and installation.

C. Store all filters and adsorbers in a secure and dry storage area.

D. The hepa filters shall be shipped separately and must be handled very carefully and stored in a safe, dry space until ready for installation. The filter trains should be totally installed, cleaned and operated for a minimum of one hour before any hepa filters are installed. The hepa filters must be handled carefully during storage and installation.

E. Refer to details on the drawings for different configuration requirements including which assemblies are to contain prefilters.

F. Co-ordinate location of mounting stand legs to ensure they do not conflict with light fixtures, access covers and pipe/conduit penetration plates located in the floor.

3.2 WELDING

A. Welding procedures, welders, and welding operators shall be qualified in accordance with ASME HPVC Section IX. All welding performed shall meet the requirements specified in ASME HPVC Section IX and as required by ASME N509. Pressure retaining weld joints shall comply with the requirements of ASME HPCV Section IX.

3.3 FACTORY QUALITY ASSURANCE PROGRAM

A. The filter housing shall be manufactured under a quality assurance program has been assessed and independently certified to meet the requirements of ISO 9001:2000 for design, manufacture and distribution of containment and HVAC air filtration products.

B. Additionally, the transition and/or plenums, housings, test sections and mounting components shall be manufactured and inspected under a quality assurance program that meets all of the basic requirements of ASME NQA-1, “Quality Assurance Program Requirements for Nuclear Facilities”. The

manufacturer shall submit documented evidence they have been audited by customers at least three (3) times to these requirements and successfully passed all three (3) audits.

C. All production welds shall be visually inspected to assure that they meet the workmanship acceptance criteria described in sections 5 and 6 of AWS D9.1m/DP.1:2006, specification for welding of sheet metal or ASME boiler and pressure vessel code section IX.

3.4 FACTORY ACCEPTANCE TESTS

A. All acceptance tests shall be in accordance with the procedures in ASME N510 proposed test schedules for adjusting and balancing, housing leak and pressure, air-aerosol mixing uniformity, damper operation and leakage, system bypass, and performance tests of systems, shall be provided at least 2 weeks prior to the start of related testing.

B. Visual Inspection.

1. Visual inspection shall be performed in accordance with ASME N510.
2. Housing leak and pressure test:
   a. The filtration system housing shall be factory leak tested in accordance with ASME N510, Section 6, using the pressure decay method. The housing shall be tested positively to the design pressure of 15 inches water gauge and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume.
3. Damper operation and leakage test:
   a. The damper shall be tested to verify that it operates as specified. The air leakage rate through loose isolation dampers shall be measured and recorded. The damper shall be functionally tested as required in ASME N510.
4. System bypass test.
   a. The filtration element housing and housing seal shall be tested in accordance with ASME N510 with test blanks. The maximum housing leakage rate acceptance criteria shall be 0.0005 cfm per cubic foot of housing volume at 10 inches water gauge pressure differential. The air that bypasses the test blank(s) shall be measured and recorded as an air leakage rate.

3.5 PREPARATION FOR SHIPPING

A. The filtration system shall be mounted with protective shipping skids, crated or covered, blocked, braced, and cushioned as necessary to prevent physical damage during shipping.

3.6 FIELD ACCEPTANCE TEST

A. After installation, the filtration system shall be field tested for leaks using a mechanical test method. The system shall also be tested for leaks between the filter element and its housing. Testing shall occur after installation and shall be performed by an independent testing agency in accordance with ASME N510. The test agency shall be certified in accordance with ASME NQA-1 or have demonstrated previous experience with similar systems as approved by the contracting officer.

3.7 FIELD TRAINING

A. The contractor shall conduct a training course for operating and maintenance personnel as designated by the contracting officer. The manufacturer shall determine the appropriate length of the training course. The field instruction shall cover all of the items contained in the approved operating and maintenance instructions.

3.8 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – Commissioning of HVAC Systems for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 – Commissioning of HVAC Systems and related sections for contractor responsibilities for system commissioning.

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