Technical Standard for Radiological Air Cleaning and Ventilation Systems at Jefferson Lab

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1. Purpose and Scope

This manual provides an acceptable methodology for Jefferson Lab to ensure that HEPA filtered radiological air-cleaning systems are procured, operated, tested and maintained in a manner that ensures their effectiveness and is consistent with general industry standards.

This manual applies to single stage, high efficiency air cleaning systems of less than 2000 cfm, including portable HEPA ventilation units, vacuum cleaners, ventilation systems for glove boxes, containment tents and fume hoods used for radiological purposes. Permanent (engineered, facility-integral) radiological HEPA systems are not currently in use at JLab. Use of any such systems will require evaluation and revision of this manual. This standard is expected to be implemented through a phased process, with full implementation expected by the end of CY 2007.

2. Abbreviations/Definitions

Acceptance test – testing performed on an air cleaning device or component prior to putting the device into initial service.

Aerosol – A stable suspension of particles, solid or liquid, in air (particle size less than 100 μm).

CFM – Airflow volume in cubic feet per minute

DOP – Dioctyl phthalate – a compound historically used for HEPA penetration testing, which use has been almost completely abandoned – especially for in-place testing

FPM – Linear flow velocity in feet per minute

FTF – DOE Filter Test Facility

HEPA – High Efficiency Particulate Air filter

In-Place testing – testing performed on an air cleaning device at established routine intervals.

RCD – Radiation Control Department, RadCon
Penetration – Leakage of the challenge aerosol past the components between the upstream and downstream sample ports:

\[ P = 100 \left( \frac{C_d}{C_u} \right) \]

Where:
- \( P \) = % penetration
- \( C_d \) = downstream aerosol concentration
- \( C_u \) = upstream aerosol concentration

3. References


3.3 ASME AG-1 – 1997, “Code on Nuclear Air and Gas Treatment”


3.5 DOE-STD-3022-98, DOE Standard: “DOE HEPA Filter Test Program”


4. General Information

4.1 Facility Description

Jefferson Lab is a non-nuclear, low-hazard accelerator research facility. Ventilation systems at the lab do not serve as Vital Safety System elements. Requirements for nuclear safety such as those set forth in 10CFR830 are not applicable to activities at the Lab. In addition, recommendations of the DNFSB and Secretarial memoranda related to HEPA filter use in nuclear facilities are also not generally applicable. Use of high efficiency air treatment equipment for radiological purposes at the lab can be regarded as a minor and incidental part of the overall radiation safety program. However, the non-critical, low priority, and/or low frequency use of this equipment can lead to problems or incidents due to a failure to follow best practices
in its use and maintenance. Jefferson Lab has established a radiological HEPA program that combines many of the DOE nuclear facility requirements with general industry practices. This ensures a program that exceeds minimum requirements and is tailored specifically to the scope and character of radiological HEPA use at the lab.

4.2 Types of Systems

Radiological HEPA-filtered air treatment systems at Jefferson Lab currently consist of the following three types.

**Portable ventilation units** – these units consist of integrated blower/filter assemblies (often mounted on wheeled carts or other portable platforms) which are designed to provide portable, local ventilation capability for a number of uses. The suction side of the unit usually has provision for attaching flexible ventilation hose which can be routed directly to an area of concern for prevention, control and containment of airborne radioactivity. Examples of this type of use include working in contaminated spaces such as beam dump enclosures, where positive control of air movement helps ensure that airflow moves from the “clean” space into contaminated space, and that disturbance of local surface contamination is not likely to result in airborne radioactivity in the space or contamination in adjacent spaces. This is accomplished by routing the suction ventilation hose well into the contaminated area, which establishes a negative local ventilation condition due to typically restricted entryways. Directed ventilation may also be used in a more localized fashion, such as within a target chamber, or other small, contained area, to ensure that contamination disturbed by work activities is positively directed away from workers and captured in the ventilation system filter. Depending on the conditions, this is sometimes accomplished by the use of HEPA vacuum cleaners. Portable HEPA units can also be configured to provide negative ventilation for containment tents or glove boxes/bags (care needs to be taken to ensure proper matching of ventilation rate to the size of the enclosure). In addition, portable HEPA systems are often used as operational controls for ALARA purposes to limit the spread and buildup of contamination in a beam enclosure by placing the HEPA suction point in an area of known airborne radioactivity production during beam operations.

Portable HEPA units are typically small enough to be transported by one person, and relatively easily moved about. The units are often modular, allowing removal and replacement of the entire filter assembly as a unit that is self-contained in order to minimize contamination spread during changeout. The extra stress caused by movement of these units is taken into consideration by applying limits on their use found in section 5.
HEPA vacuum cleaners – HEPA-Vacs are used to control localized contamination on surfaces to prevent the spread of the material beyond the controlled surface contamination zone and to prevent airborne contamination. They are also used for decontamination of areas and equipment and general cleanup within contamination areas. It is important to use only HEPA filtered vacuum cleaners within potentially contaminated areas, as a non-HEPA vacuum can create airborne radioactivity or a spread of surface contamination by passing contamination through its filter system back out into the environment. Generally, HEPA-vacs are for dry-only work, but may be outfitted with wet transfer apparatus in order to operate as wet/dry vats. A HEPA-vac may also act as a local negative ventilation source for a small containment enclosure such as a glove box. When used in this manner, it is important that the vacuum be tested in this configuration to ensure its integrity. In addition, a documented evaluation of the ventilation system design must be conducted for such use. In general, HEPA-vacs are also more subject to damage and leakage due to handling and transport. The testing program is designed to take this into consideration. Proper selection of radiological vacuum cleaners is important, as there are no recognized industry standards specific to vacuum cleaners. Of importance are the integrity of the seal between the vacuum head and the waste collection chamber, and the robustness of the entire unit in terms of its ability to withstand rough handling. All fittings, valves and enclosure seals should have provision for positive clamping/locking.

Laboratory fume hood – The Radiation Control Department (RadCon) currently operates only one radiological fume hood. The fume hood is located in building 52 and is used to conduct certain types of sample preparation and analyses and to facilitate inspection/work on small contaminated items. This work is infrequent, but it is important that a controlled enclosure is available for activities such as production of calibration standards from high specific activity materials, handling any unsealed radioactive sources or obtaining samples from contaminated media such as resin or filter materials. In addition, the hood is used for distillation of environmental and other samples requiring the use of small amounts of caustic materials. Since mild acids or bases are sometimes used in the hood, it is important to take this into consideration when selecting components of the system and in the surveillance and inspections of the system. For example, HEPA filters used in the system are specified to be resistant to nitric acid. The hood is of the constant volume type, and is fitted with integral water supply and sink. The sink drain is configured so that any contaminated effluents can be routed to a small holding tank for disposal. The exhaust flow from the hood is routed through a modified high-volume portable HEPA unit, which has been installed in a semi-permanent arrangement in building 52. The exhaust from the unit is ducted to the exterior of the building, and utilizes an automatic damper to prevent back-wash of the filter unit when not operating due to the effect of air currents and wind. The fume hood also employs a face velocity measuring and flow alarm unit. This unit is to be
tested and calibrated each time the hood is tested. In addition to the common tests performed on all HEPA units, the fume hood is also tested for face velocity and containment. These tests shall be conducted in accordance with ANSI/ASHRAE 110, sections 6.1 and 6.2, as described in section 5 and Appendix A of this document.

5. Implementation Policy

In general, the standards specified in this section apply to all types of HEPA-filtered radiological air treatment equipment at the lab. Certain specific requirements may apply only to some types of equipment, and are noted in the applicable sections of this standard. Exceptions may be authorized by the RadCon manager, but shall be documented appropriately.

5.1 Purchase specifications

5.1.1 All new (as of October 1, 2006) radiological HEPA systems shall be specified to meet ASME AG-1 standards, where applicable. In the event a particular device is not certified to AG-1 standards (some vacuum cleaners may not technically meet this standard), every effort to ensure functional equivalence with the AG-1 standard shall be made.

5.1.2 Replacement filters shall be Type B, nuclear grade, and shall meet AG-1, DOE STD-3020-2005 and UL586 specifications.

5.1.3 Filters for the fume hood application shall be treated for resistance to HNO₃, shall have corrosion-resistant cases (no particle board or wood) and shall not employ aluminum separators.

5.1.4 Portable devices must be designed with positive, tamper resistant filter attachment hardware. Preference shall always be given to devices which allow for filter changing in a manner that minimizes the potential for the spread of contamination.

5.1.5 Vacuum cleaners shall be designed such that emptying the contents of the waste container does not disturb the HEPA seal. In addition, waste canister attachment must be by positive means and allow for application of locks or other safety devices. Any drains on waste canisters must be lockable. Vacuum cleaner suction hose must be attached permanently to the device body, or be attached by mechanical devices such as metal clamps, bolted flanges or other robust means.

5.1.6 Vacuum cleaners shall employ a disposable dust bag to contain collected debris.

5.1.7 Purchase orders for replacement filters shall specify pre-testing at the DOE Filter Test Facility (FTF) prior to delivery to the lab. The
5.1.8 vendor must agree to replace any filter free of charge that does not pass the FTF tests.

5.1.9 Existing systems not meeting the purchase standards above shall be evaluated to determine if their continued use is warranted. In some cases, a system or component may be considered acceptable for continued use through modification or upgrade, or by specifying particular limitations on use. Such limitations shall be documented and incorporated into labeling or operating procedures for the device. When appropriate, systems failing to meet the applicable standard shall be placed out of service and decommissioned in accordance with Jlab radiological control practices.

5.2 Acceptance Testing

Acceptance testing consists of pre-delivery testing of HEPA filters at the DOE FTF (currently the Air Techniques International testing laboratory in Baltimore, MD) and certification at Jefferson Lab prior to initial use.

5.2.1 Purchase specifications shall require all filters to be shipped directly to the FTF. A separate, no-cost purchase requisition is written for the FTF testing and to cover shipping to Jlab (FTF conducts tests free of charge for DOE and its contractors). FTF testing protocol follows the DOE standards STD-3020-2005 and STD-3025-99.

5.2.2 Exceptions may be made for HEPA ventilation units and vacuum cleaners that are assembled as a unit if other compensatory measures are taken, such as additional final testing conducted on the assembled device by the manufacturer. In cases where the HEPA filter is easily installed and removed (most portable HEPA units), the purchase specification shall require that the filter be shipped separately to FTF.

5.2.3 Upon arrival at Jefferson Lab, filters shall be thoroughly inspected and installed in the applicable equipment. The device shall be tagged as out of service until initial in-service testing is conducted. An appropriately qualified vendor shall be used for in-place testing. Specifications for testing are given in section 5.3.

5.2.4 Spare filters shall be stored in a temperature-controlled environment, with a copy of the certification paperwork. Filters should be stored in their original carton and protected from damage. Box-type filters must be stored with pleats vertical (the orientation in which they are used).

NOTE: Extended storage periods affect the overall life of the filter. Filter lifetime limits in section 5.6 are based on total life of the filter, including storage.
5.3 In-Place Testing

In-place HEPA tests fall into two general categories: (1) pre-startup acceptance tests to verify that components are installed properly and that the system will operate as intended, and (2) surveillance tests made periodically after the system has been placed in operation to demonstrate its ability to continue to perform its function. In addition to these types of tests, a third type of testing may be done in order to verify integrity of a system that has been reconfigured, or is being used under conditions where system integrity is critical due to the potential impact of a failure. Specific requirements for frequency and testing criteria are given below.

5.3.1 Testing frequency shall be as follows.

5.3.1.1 All HEPA-equipped air-cleaning systems shall be initially tested prior to being used for any contamination control function.

5.3.1.2 All HEPA systems shall be retested after replacement of the HEPA filter, or if the HEPA filter seal is breached for any reason.

5.3.1.3 Any HEPA-equipped system suspected of having sustained damage, or of being directly exposed to liquid, extreme humidity (>95%), or high concentrations of corrosive materials shall be removed from service and retested prior to continued use.

5.3.1.4 All stationary equipment (fume hoods, installed glove boxes, etc.) shall be retested at least annually.

5.3.1.5 Portable HEPA units shall be retested at least annually. In addition, portable systems used for containment ventilation in an occupiable space, where:
(1) airborne radioactivity concentration greater than 10 DAC is likely; or,
(2) general area contamination levels greater than 1 M dpm/100 cm² are present or likely; or,
(3) a dispersible quantity of material in excess of the ALI is being directly handled or manipulated, shall be tested in the applicable configuration, prior to use.

5.3.1.6 HEPA vacuum cleaners shall be retested at least semi-annually, and in addition, if used as installed containment ventilation where conditions 5.3.1.5 (2) or (3) exist, shall be tested in the applicable configuration prior to use.
5.3.2 Test Procedures/Methods

All in-place testing of HEPA systems should be conducted under the general guidelines in DOE-HDBK-1169-2003, and shall follow the applicable specific test criteria in ASME-N510, as described below. Additional device-specific requirements (sufficient for use as vendor instructions) are found in the appendices to this document.

5.3.2.1 Leak testing shall be done in accordance with section 10 of ASME-N510, except that the challenge agent shall be Emery 3004, or an equivalent approved substitute.

5.3.2.2 The challenge aerosol shall meet the definition of “DOP aerosol” in section 3 of ASME-N510.

5.3.2.3 Prior to conducting leak tests, a thorough physical examination shall be made of the system. The inspection shall include operation of fans and dampers, integrity of connections, bypass valves, drains, etc., operation of installed flow and pressure sensors, duct condition, any sealant used (no sealant is allowed on the filter or the filter to housing seal area), corrosion, unacceptable buildup of dirt or dust in prefilters, and presence and function of tamper-resistance devices.

5.3.2.4 Pressure-drop across the system shall be measured.

5.3.2.5 Aerosol mixing uniformity is an important aspect of conducting penetration tests. However, equipment used for radiological air cleaning at JLab is typically not configured to allow for conducting the tests specified in section 9 of ASME-N510. In addition, the test delineated in the standard is designed for large filter banks, where the uniformity is established on a filter-to-filter basis, and uses installed test ports in the ventilation system. Since the devices under test at JLab contain only a single filter (rather than a filter bank), the test is not specifically applicable to JLab equipment. However, to ensure adequate mixing to the extent possible, the following guidance shall be used. (1) For portable units employing inlet hose collars, a length of hose at least ten times the diameter of the inlet shall be attached, into which the challenge aerosol is injected. The upstream aerosol concentration is measured at the hose collar (an adapter may be used to facilitate test probe operation). (2) For the fume hood, challenge aerosol shall be introduced within the workspace of the hood, with the sash open approximately 12”. Upstream concentration shall be measured at the filter inlet plenum near the hose collar. (3) For vacuum cleaners, a
mixing chamber shall be constructed (the chamber may simply be a length of flexible or rigid duct). The chamber must be 3” to 6” in diameter and at least six feet long, and is placed at the end of the vacuum suction hose. The aerosol is introduced at the inlet of the chamber, and the concentration measured just upstream of the vacuum hose connection.

5.3.2.6 Upstream concentration of the challenge aerosol shall be between 50 and 100 ug/L of air.

5.3.2.7 Downstream measurements of the aerosol shall be made at a point far enough downstream of the filter to ensure effective mixing of any challenge aerosol penetration. For a ducted system, this shall be a minimum of ten duct diameters downstream. For “blow-through” type systems, scanning of the downstream side of the filters is performed (JLab currently has no systems of this type). For portable HEPA systems, exhaust duct will normally have to be temporarily added to the blower outlet. Many vacuum cleaners exhaust the air radially from the vacuum head. For this type of vacuum, a suitable fixture (can be a flexible or rigid hood or cowling) shall be constructed to entrain the entire exhaust flow, to which is connected an exhaust duct at least several inches in diameter. The downstream measurements must be made at least ten duct diameters downstream from the connection of the duct to the hood.

5.3.2.8 The laboratory fume hood shall be tested in accordance with ANSI/ASHRAE 110 sections 6.1 and 6.2. The tests shall be conducted for each fan speed/sash opening combination specified in Appendix A.

5.3.3 Test Acceptance Criteria

The following criteria at a minimum shall be established for acceptable test performance.

5.3.3.1 The physical inspection results shall note any condition or damage that would impair the ability of the component to perform its function.

5.3.3.2 Differential pressure across the system shall be less than 1.3 inches WC (1.5 inches is allowable for vacuum cleaners).

5.3.3.3 Total system leakage at the downstream sample point shall be less than 0.05%.

5.3.3.4 Fume hood average face velocity shall be maintained between 120 and 180 FPM at the designated sash positions.
5.3.3.5 Fume hood flow visualization tests shall meet the criteria in ANSI/ASHRAE 110.

5.3.3.6 Additional specific performance criteria may be specified in the testing specification provided to the vendor.

5.4 Configuration And Use

5.4.1 General

Radiological air cleaning equipment is to be used only under auspices of the RCD. Each HEPA-filtered air cleaning system placed into service shall bear a label indicating the last test date. In addition, this equipment shall be labeled with appropriate radiological hazard warnings indicating the presence of internal radioactivity. All HEPA-equipment shall be visually inspected before each use. A log shall be kept listing all HEPA equipment, its location and last test date. The radiological engineer shall ensure that HEPA equipment is retested at the appropriate interval, and that any units in continuous operation are inspected at least monthly (when accessible).

5.4.2 Mechanical Integrity

5.4.2.1 All closures (valves, drains, filter housing, waste canister, etc.) on HEPA-filtered equipment shall be equipped with devices that prevent the inadvertent release of the closure device. This may be done with lock-wire, locks or other suitable means.

5.4.2.2 Flexible duct and duct adapter connections shall be secured with metal band clamps. In some cases, this may need to be augmented by use of screws or additional retaining mechanisms (eg. where the attachment collar may not support the clamping force of the band clamp).

5.4.3 Location, Configuration and Movement

5.4.3.1 HEPA-equipped devices shall be stored at the RadCon field lab (building 52) when not in use.

5.4.3.2 Portable HEPA units and vacuum cleaners shall be surveyed for changes in radiological condition after each use. HEPA units in continuous service shall be surveyed during monthly inspections. The laboratory fume hood shall be surveyed at least annually. Surveys should include dose rate measurements and contamination surveys at exhaust points.

5.4.3.3 When not in use, inlet hoses or ducts shall be closed with a plastic bag or other positive method to prevent spread of contamination.
5.4.3.4 Any HEPA vacuum with a contact dose rate equal to or greater than 10 mrem/hr shall not be used until the debris bag is changed. If the contact dose rate on any vacuum cleaner having a new filter bag is greater than 5 mrem/hr, the vacuum shall be placed out of service pending decontamination, HEPA filter replacement or disposal.

5.4.3.5 When a portable HEPA unit reads greater than 5 mrem/hr on contact, the prefilter shall be changed. If the contact dose rate exceeds 1 mrem/hr with a new prefilter, the HEPA filter shall be changed.

5.4.3.6 Any movement of HEPA units and vacuum cleaners shall be done under the direction and surveillance of a qualified RCT.

5.4.3.7 Where possible, HEPA vacs should remain outside the contamination area where used. If used inside a contamination area, the vac should be located in an area of low contamination, and air samples shall be taken as appropriate to assess the affect of the exhaust. The vac should be protected from contamination to extent practicable.

5.4.3.8 HEPA ventilation equipment in use in the field shall be located such that it is protected from physical damage and extreme environmental conditions (including very high radiation levels) to every extent practicable. The radiological engineer shall visually inspect and concur in portable HEPA placement when in any continuous (unattended) use application.

5.4.3.9 Portable HEPA units shall be used for negative (suction) ventilation only – the exhaust shall not be directed into a contamination area. Inlet duct shall be supported adequately to avoid over-stressing the duct or causing a strain on the HEPA unit.

5.4.3.10 Any HEPA-filtered device (except the fume hood) used for containment ventilation shall have the power supply administratively tagged to warn against disconnecting the unit. In addition, any such configuration shall be evaluated for airflow balancing considerations. Adequate containment inlet airflow must be achieved to prevent undue “collapsing” of the enclosure. In large tents this is usually designed into the enclosure, and simply requires that an adequate number of air intake vents be kept open. If using a HEPA unit for glovebox or glovebag ventilation, flow control may have to be adjusted via dampers or variable speed ventilation units. Small glovebags should normally not require forced ventilation.
5.5 Storage and Maintenance

Proper storage of HEPA equipment consists of ensuring contamination controls are maintained, avoiding water or extremely damp atmospheres, temperature extremes and caustic atmospheres. As with any powered device, electrical cables should be inspected upon each use. Fittings and closures should be inspected, adjusted and replaced as necessary. Flow control or indicating devices should be checked and maintained per manufacturer’s specification. Spare filters must be stored in the nominal orientation of use (pleats vertical).

5.6 Filter Life

HEPA filters have a finite lifetime, and deteriorate more rapidly under harsh conditions. Factors such as temperature, humidity, dust loading, rough handling and very high radiation levels can adversely affect HEPA life. HEPA filters are marked with their date of manufacture. Limits on lifetime are referenced to the manufacture date, not just the period of time actually in use.

Based on a review of industry data, good practice and a conservative approach, Jefferson Lab has established the following limits on HEPA filter use. Any HEPA filter reaching the age specified shall be replaced regardless of its field use history.

5.6.1 Portable HEPA units and vacuum cleaners – maximum age: 7 years
5.6.2 Laboratory fume hood – maximum age: 5 years

In addition, any visible signs of deterioration or premature failure of a filter shall be grounds to replace it.

Prefilters should be replaced each time a HEPA-filtered device is in-place tested.
Appendix A
Testing Specification For HEPA-Filtered
Radiological Fume Hood Located at Building 52

Scope

This specification applies to conducting in-place testing of the fume hood operated in Building 52 (Radiological Control Lab). It designates the standards to which the fume hood will be tested as well as the performance criteria that must be met.

General

The Radiological fume hood will be tested annually, after removal/replacement of the HEPA filter, or following any disturbance of the HEPA retaining hardware, blower system or enclosure forming the isolation barrier between upstream and downstream ducting.

The organization providing the certification shall provide all test data with the certificate of successful testing (or in the case of a test failure).

In addition to the tests specified, the entire fume hood and exhaust system will be inspected for general condition and proper operation of fan, exhaust damper, and other functionality. Any notable deterioration or performance degradation shall be brought to the attention of the Jlab representative overseeing the test.

Tests performed

The fume hood will be certified by conducting:

(1) an exhaust system efficiency (penetration) test
(2) a hood containment test
(3) face velocity tests
(4) calibration of flow indicator/alarm
(5) differential pressure across the system

Testing Procedures

A. The Penetration Leak Test shall be conducted in accordance with section 10 of ASME N510 (1995) with the following additions, exceptions/modifications.

1. The challenge agent shall be Emery 3004 or other pre-approved equivalent substitute for DOP.
2. The challenge agent injection point shall be inside the fume hood.
3. The fume hood sash shall be set at approximately 12” opening.
4. The aerosol generating equipment must produce aerosol meeting the requirements of section 3 of ASME N510 for “DOP aerosol”.
5. Upstream measurement of the challenge agent concentration shall be made just upstream of the filter/blower housing in the inlet collar area.
6. Aerosol concentration at the upstream sample point must be between 50 and 100 ug/L.
7. Penetration tests are to be conducted with the ventilation blower in “low speed” and “high speed” settings. Aerosol generation equipment shall be adjusted as necessary to maintain the upstream concentration stated in item 6.
Appendix A
Testing Specification For HEPA-Filtered
Radiological Fume Hood Located at Building 52

8. Downstream measurements shall be made at a location at least ten duct diameters downstream of the blower cabinet. Penetration shall be determined in accordance with ASME N510.

B. The Hood Containment test shall be conducted in accordance with the Flow Visualization test procedure in ANSI/ASHRAE 110, section 6.1.

C. The Face Velocity test shall include the following parameters.

1. Measurements will be made in accordance with ANSI/ASHRAE 110, section 6.2.
2. The test shall be conducted with several objects of apparatus in the hood (either actual or simulated).
3. Horizontal sash panels are to be closed except for step 6.
4. The measurement grid shall be established such that at least ten measurements are to be taken with the sash in the “maximum high fan” position (with fan in “high” setting).
5. The grid shall allow at least eight measurements to be taken with the sash in the “maximum low fan” position (fan in “low” setting).
6. With the sash closed and the fan on “low”, at least three measurements shall be taken with the horizontal sash open.
7. Measurements are to be averaged for each opening position.

D. Flow indicator/alarm calibration is performed as follows.

1. With the sash/fan settings as tested in step C., observe the indicated flow rate on the fume hood flow indicator. Note and record the indicated flow rate.
2. Adjust the flowmeter as necessary to bring the indicated flow rate within 10% of the average measured flow.
3. To adjust the flowmeter, press and hold the “Cal” button, then press the appropriate “Adjust” (up or down) button to change the reading.
4. Verify flow alarm settings by pressing the “low” and “high” buttons located under “view”. Note and record the settings. Low flow alarm should be set to 90 and high flow alarm to 360 fpm.

E. Differential Pressure

1. Differential pressure measurements will be made using the upstream and downstream test points, with the fan in the “High” position and the sash closed.
2. The differential pressure measurement will be compared to the reading on the installed gauge.
Appendix A
Testing Specification For HEPA-Filtered
Radiological Fume Hood Located at Building 52

Acceptance Criteria

A. Penetration tests shall indicate < 0.05% penetration of the challenge agent.
B. Flow visualization test shall meet the requirements of ANSI/ASHRAE 110.
C. Average face velocity for each test shall be in the range of 120-180 fpm, with all readings within 20% of the average for that position and no single reading less than 100 fpm.
D. The flow alarm shall sound when the indicated flow rate drops below 90 fpm or goes above 360 fpm.
E. Differential pressure shall be less than 1.3 inches of water. The reading should be within 20% of the gauge reading.
Appendix B
Testing Specification For Portable HEPA Ventilation Equipment

Scope

This specification applies to conducting in-place testing of portable radiological HEPA ventilation systems. It designates the standards to which these systems will be tested as well as the performance criteria that must be met.

General

Portable radiological HEPA systems will be tested annually, after removal/replacement of HEPA filters, or following any disturbance of the HEPA retaining hardware, or other component forming the isolation barrier between upstream and downstream side of the HEPA filter, and as otherwise required by this Technical Standard.

The organization providing the certification shall provide all test data with the certificate of successful testing (or in the case of a test failure).

In addition to the tests specified, the system under test will be inspected for general condition and proper operation of blower, connection of hoses, general security of the housing, gauges, etc. Any notable deterioration or performance degradation shall be brought to the attention of the Jlab representative overseeing the test.

Tests performed

All portable HEPA systems will be penetration tested, and have the differential pressure of the system measured.

Testing Procedures

A. The Penetration Leak Test shall be conducted in accordance with section 10 of ASME N510 (1995) with the following additions, exceptions/modifications.

1. The challenge agent shall be Emery 3004 or other pre-approved equivalent substitute for DOP.
2. The aerosol generating equipment must produce aerosol meeting the requirements of section of ASME N510 for “DOP aerosol”.
3. A length of flexible duct of approximately ten to twenty duct diameters in length shall be fixed to both inlet and exhaust sides of the HEPA unit.
4. The challenge aerosol will be injected into the inlet of the upstream duct.
5. Upstream measurement of the challenge agent concentration shall be made just upstream of HEPA filter. This may be done in the plenum section of the filter housing or at the connection collar.
6. Aerosol concentration at the upstream sample point must be between 50 and 100 ug/L.
7. Downstream measurements shall be made at least ten duct diameters downstream of the filter. Penetration shall be measured against the upstream concentration in accordance with ASME N510.
Appendix B
Testing Specification For Portable HEPA Ventilation Equipment

B. Differential Pressure Test

1. Differential pressure measurements will be made using the upstream and downstream test points.
2. If the HEPA unit is equipped, the installed gauge DP indication shall be recorded. The differential pressure measurement will be compared to the reading on the installed gauge.

Acceptance Criteria

A. Penetration tests shall indicate < 0.05% penetration of the challenge agent.
B. Differential Pressure across the system shall be less than 1.3 inches of water. The reading should agree within 20% of the reading on the installed gauge, if equipped.
Appendix C

Testing Specification For Radiological Vacuum Cleaners

Scope

This specification applies to conducting in-place testing of radiological vacuum cleaners. It designates the standards to which HEPA-Vacs will be tested as well as the performance criteria that must be met.

General

Radiological Vacs (HEPA-Vacs) will be tested semi-annually, after removal/replacement of HEPA filters, or following any disturbance of the HEPA retaining hardware, or other component forming the isolation barrier between upstream and downstream side of the HEPA filter, and as otherwise required by this Technical Standard.

The organization providing the certification shall provide all test data with the certificate of successful testing (or in the case of a test failure).

In addition to the tests specified, the HEPA-Vac under test will be inspected for general condition and proper operation of blower, connection of hoses, general security of the housing, valves, etc. Any notable deterioration or performance degradation shall be brought to the attention of the Jlab representative overseeing the test.

Tests performed

All HEPA-Vacs will be penetration tested, and have the differential pressure of the system measured.

Testing Procedures

A. The Penetration Leak Test shall be conducted in accordance with section 10 of ASME N510 (1995) with the following additions, exceptions/modifications.

1. The challenge agent shall be Emery 3004 or other pre-approved equivalent substitute for DOP.
2. The aerosol generating equipment must produce aerosol meeting the requirements of section 3 of ASME N510 for “DOP aerosol”.
3. Excessive lengths of vacuum hose should be avoided. The vacuum cleaner’s hose should be no more than 10 feet in length.
4. An aerosol mixing chamber will be attached to the inlet of the vacuum hose. The mixing chamber shall be a length of rigid or flexible tubing, 3-6 inches in diameter and approximately six feet long. The mixing chamber will be provided by Jefferson Lab.
5. Upstream measurement of the challenge agent concentration shall be made just upstream of the point of the connection of the mixing chamber to the vacuum hose.
6. Aerosol concentration at the upstream sample point must be between 50 and 100 µg/L. Caution should be used not to overload the vacuum with aerosol.
7. Penetration shall be measured against the upstream concentration in accordance with ASME N510.
Appendix C
Testing Specification For Radiological Vacuum Cleaners

8. Most HEPA vacuums do not have a specific, single exhaust point. In cases where there may be a discrete exhaust port, downstream concentration shall be determined by fixing a length of similarly sized hose to the exhaust point, ten to twenty hose diameters in length. The downstream measurement will be taken approximately ten hose diameters downstream. For vacuums that do not have an exhaust port connection, downstream concentration will be determined as follows. A hood or plenum will be fitted over the discharge area of the vacuum (the hood will be constructed by Jefferson Lab). The hood will incorporate a length of tubing sufficient to allow mixing of the exhaust flow (10-20 diameters). Measurements of downstream concentration will be made at least 10 hose diameters downstream of the hood. Figure 1 shows a schematic view of the configuration.

![Figure 1](image)

B. Differential Pressure Test

1. Differential pressure measurements will be made using the upstream and downstream test points.
2. If the vacuum is equipped, the installed gauge DP indication shall be recorded. The differential pressure measurement will be compared to the reading on the installed gauge.

Acceptance Criteria

A. Penetration tests shall indicate < 0.05% penetration of the challenge agent.
B. Differential Pressure across the system shall be less than 1.5 inches of water. The reading should agree within 20% of the reading on the installed gauge, if equipped.