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Normative Annex 5
(formerly Annex F)

Field tests

Factory testing shall be done according to Annex N-1.

N-5.1 Field certification preconditions and intervals

This Annex contains the field tests that define the methods and acceptance criteria that are appropriately applied for determining qualification for field certification of all Class II BSCs. These field certification procedures are intended to confirm that an installed cabinet evaluated under the current version of the Standard has met all design criteria contained in NSF/ANSI 49 and currently meets all criteria contained in this Annex. All cabinets shall be field tested using the procedures described in this Annex, with the exception of the downflow velocity test. When the downflow velocity test is performed, the procedure by which the cabinet was certified should be used; however, the acceptance criteria outlined in the 2002 Standard shall be applied. Downflow velocity readings shall be taken 4 inches (100 mm) above the bottom edge of the sash only when so stated on the manufacturer's data plate label or when the manufacturers' data plate label indicates the cabinet was listed to NSF/ANSI 49-2002 or later.

To ensure that all cabinet operating criteria contained in this Annex continue to be met, each cabinet should be field tested at the time of installation and at least annually thereafter. In addition, field recertification should be performed whenever HEPA/ULPA filters are changed, maintenance repairs are made to internal parts, or a cabinet is relocated.[38] More frequent field recertification should be considered for particularly hazardous or critical applications or workloads. It is customary for the person conducting the designated tests to affix to the cabinet a certificate of satisfactory performance when the cabinet meets all field test criteria.

Field certification of a cabinet is not intended to provide complete verification that the cabinet conforms to all of the requirements of NSF/ANSI 49.

N-5.1.1 Tests directly related to containment (i.e., personnel and environmental protection) and product protection.

The following physical tests shall be conducted on-site for a certification to be considered for the statement "*Field Certified in accordance with NSF/ANSI 49*":

- downflow velocity profile test;
- inflow velocity test;
- airflow patterns test;
- HEPA/ULPA filter leak test;
- site installation assessment tests; and
- cabinet integrity test (positive pressure plenum cabinets only).

For Type A cabinets with exposed biologically contaminated positive pressure plenums, either a pressure decay or soap bubble leak test is mandatory. The tests shall be performed at the time of installation, when positive pressure containment panels are removed, and after relocation of the BSC.

[38] Microbiological equipment that has been used with microorganisms should be decontaminated prior to repair or replacement of components located in contaminated plenums, prior to cabinet relocation, and in some cases prior to field recertification. See Section I-2.1, Recommended biosafety cabinet decontamination procedure. When equipment has been used with chemical or radioactive agents, appropriate protective clothing and safety procedures should be used during chemical decontamination.

The site installation assessment tests shall include:

- alarm functions as required by this Standard;
- blower interlock; and
- exhaust system performance (proper exhaust duct negative pressure and canopy performance).

N-5.1.2 Tests related to worker comfort and safety

The following tests are for worker comfort and safety and are performed at the request of the customer or at the discretion of the field certification provider:

- lighting intensity;
- vibration;
- noise level; and
- electrical leakage, ground circuit resistance, and polarity tests.

N-5.2 Downflow velocity

N-5.2.1 Purpose

This test measures the velocity of air moving through the cabinet workspace 4 inches (10 cm) above the bottom edge of the sash and shall be performed on all cabinets accepted under Section N-1.6.

N-5.2.2 Apparatus

A thermal anemometer with an accuracy of ± 3 ft/min (± 0.015 m/s) or 3% of the indicated velocity, whichever is larger, shall be used. The device shall be calibrated in accordance with the thermal anemometer manufacturer's instructions or IEST-RP-CC-013[13] if instructions are not provided. When the conditions vary from sea level by more than 1,000 feet (300 m), or the temperature varies from 70 °F (21 °C) by more than 5 °F (2 °C), or both, an appropriate correction for altitude, or temperature, or both, shall be used. The manufacturer's manual for the thermal anemometer or the *Industrial Ventilation Manual*[β] shall be consulted for the appropriate correction calculation.

N-5.2.3 Method: setting nominal set point

The removable equipment nonessential to cabinet operation (acceptable option components) shall be removed prior to setting the nominal set points to replicate the as-manufactured conditions tested by the testing organization when required. The air measurement probe shall be held rigidly in a freestanding fixture that permits accurate positioning and does not distort the airflow pattern. This includes a ring-stand and clamp or similar fixture. The anemometer probe shall not be hand held for any downflow velocity measurements.

N-5.2.3.1 Uniform downflow cabinets

a) The air velocity shall be measured at multiple points across the workspace, using equal points in the horizontal plane 4 inches (100 mm) above the bottom edge of the sash, as specified on the data plate.

b) Reported values shall be:

- individual velocity readings in the applicable grid;
- overall average of the velocity readings;
- minimum velocity reading;

— maximum velocity reading;
— acceptance criteria for average airflow velocity;
— acceptance criteria for airflow velocity uniformity; and
— name of test (uniform downflow velocity test).

c) The nominal set point shall be based on the above data in accordance with the manufacturer's instructions.

N-5.2.3.2 Nonuniform (zoned) downflow cabinets

a) The air velocity shall be measured at multiple points across the work space in zones, as specified on the data plate, 4 inches (100 mm) above the bottom edge of the sash.

b) Reported values for each zone shall be:

— individual velocity readings in the applicable grid;
— overall average of the velocity;
— minimum velocity reading;
— maximum velocity reading;
— acceptance criteria for average airflow velocity;
— acceptance criteria for airflow velocity uniformity; and
— name of test (nonuniform (zoned) downflow velocity test).

c) The nominal set point shall be based on the above data in accordance with the manufacturer's instructions.

N-5.2.4 Acceptance

N-5.2.4.1 Uniform downflow

A cabinet for which the cabinet manufacturer has specified a uniform downflow velocity shall conform to the following:

— the average downflow velocity shall be within ± 5 ft/min (± 0.025 m/s) of the value specified; and

— the individual point readings shall not vary more than ± 25% or 16 ft/min (0.081 m/s), whichever is greater, from the average downflow velocity.

N-5.2.4.2 Nonuniform downflow

A cabinet for which the cabinet manufacturer has specified a nonuniform (zoned) downflow velocity shall conform to the following:

— the individual zone average downflow velocities shall be within ± 5 ft/min (± 0.025 m/s) of the values specified by the manufacturer; and

— the individual point readings shall not vary more than ± 25% or 16 ft/min (0.081 m/s), whichever is greater, from the average downflow velocity of each zone.

N-5.3 Inflow velocity (face velocity) test

N-5.3.1 Purpose

This test determines the measured and calculated inflow velocity through the work access opening.

N-5.3.2 Apparatus

The following devices may be used to carry out inflow velocity testing:

— a direct inflow measurement (DIM) instrument with an accuracy of ± 3% of reading ± 7 ft^3/min (± 12 m^3/h) or in accordance with Annex N-2;

— a thermal anemometer with an accuracy of ± 3 ft/min (± 0.015 m/s) or 3% of the indicated velocity, whichever is larger;

— a pitot tube constructed according to the dimensions given in the *Industrial Ventilation Manual*;[3] and

— a freestanding fixture that permits accurate positioning of the thermal anemometer probe that does not distort the airflow pattern (ring-stand and clamp).

N-5.3.3 Methods

One of these methods was validated per cabinet model and provided by the manufacturer, which was reviewed and approved by the testing organization. Manufacturer validation procedures contained no fewer than ten replicate tests. The testing organization's approval will be based on review of data and successful reproduction of test results. The validated alternate method is on the manufacturer's data plate.

N-5.3.3.1 General

When the testing organization has determined the nominal set point on a given model and size of cabinet using a DIM device, and an appropriate alternative method has been validated for that cabinet by the testing organization, this alternate method may be used to establish the set point on the same model and size of cabinet in the field.

N-5.3.3.2 Direct inflow measurement method

a) Seal by taping the device to the center of the front opening of a BSC. Seal the open areas on either side of the capture hood portion of the DIM as necessary.

b) All cabinet and exhaust blowers shall be operating. Take at least five nonback pressure compensated readings and average them to determine inflow volume rate. Care should be taken not to restrict the airflow through the instrument intake area.

c) Calculate the average inflow velocity in ft/min (m/s) by dividing the average inflow volume rate in ft^3/min (m^3/s) by the work access opening area in ft^2 (m^2).

d) Include the following in reported data: individual inflow volume rate readings, average inflow volume rate, work access opening dimensions and area, directly measured average inflow velocity, and the methods used to determine them.

e) Reported values shall be:

— individual volume readings;
— overall average of the volume;
— calculated inflow volume;
— work access opening area;
— view screen opening height;
— correction factor used (if applicable);
— acceptance criteria for average airflow volume;
— acceptance criteria for calculated inflow velocity;

— inflow velocity test method; and
— name of test (inflow velocity test).
—

N-5.3.3.3 Alternate inflow measurement methods

If the DIM method cannot be used, one of the alternative methods below may be used to determine the inflow velocity, if provided by the manufacturer.

Alternate inflow measurement methods shall only be used for any or all of the following reasons:

— the space between the face of the biosafety cabinet and permanent fixture directly opposite the access opening is less than 42 inches (1.1 m);

— the BSC was certified by the testing organization prior to NSF/ANSI 49-2002, when the DIM method for measuring inflow velocity was added to the standard;

— testing is completed on a biosafety cabinet not located in North America; and

— the owner / operator of the BSC requests use of a secondary method due to DIM instrument cleanability when the BSC is located in sterile area or clean room.

The DIM shall be used in all other circumstances.

Canopy-connected A1 and A2 cabinets must be tested with a method that measures the inflow volume at the work access opening.

N-5.3.3.3.1 Method for Type A1 and A2 cabinets that use a thermal anemometer to measure exhaust velocity to determine inflow velocity:

a) Take air velocity measurements at multiple points across the exhaust filter face on a grid as specified on the data plate. A clear 12 inches (300 mm) of space is required above the exhaust HEPA filter face for valid thermal anemometer measurements. The anemometer probe shall not be hand held. Acceptable methods include a ring-stand and clamp, manufacturer supplied probe holder or when the BSC manufacturer has made provisions for accurately locating the anemometer sensing element by resting the probe on the exhaust collar and a second lip for stability.

b) Use the effective open area of the exhaust HEPA/ULPA filter or exhaust port determined by the manufacturer and validated by the testing organization. Measure the effective exhaust area when the manufacturer has not provided it. Cabinets in which the exhaust filter is not accessible or exhaust port flow is nonuniform, such as caused by a damper or exhaust filter housing design, shall be tested as approved by the testing organization.

c) To obtain the exhaust flow volume rate in ft^3/min (m^3/s), multiply the average exhaust air velocity in ft/min (m/s) by the effective exhaust area in ft^2 (m^2).

d) Use the work access opening area as listed by the testing organization. Measure the work access opening area when the manufacturer has not provided it.

e) Calculate the average inflow velocity in ft/min (m/s) by dividing the average exhaust volume rate in ft^3/min (m^3/s) by the work access opening area in ft^2 (m^2).

f) Include the following in reported data: individual exhaust velocity readings, average exhaust velocity, exhaust volume rate, exhaust opening dimensions and area, work access opening dimensions and area, calculated average inflow velocity, and the methods used to determine them.

g) Reported values shall be:

- individual exhaust velocity readings;
- overall average of the exhaust velocity readings;
- calculated exhaust volume;
- calculated inflow velocity;
- exhaust opening dimensions;
- exhaust opening effective area;
- work access opening area and dimensions;
- correction factor used (if applicable);
- acceptance criteria for calculated inflow velocity;
- inflow velocity test method; and
- name of test (inflow velocity test).

N-5.3.3.3.2 Method for Type A1, A2, and B2 cabinets using a thermal anemometer to measure velocity through a constricted access opening to determine average inflow velocity:

a) Restrict the access opening as specified by the testing organization.

b) Take air velocity measurements at multiple points across the restricted opening as specified on the data plate. No fewer than two readings per 1 foot (0.3 m) of access opening width shall be taken. The air measurement probe shall be held rigidly in a freestanding fixture that permits accurate positioning and does not distort the airflow pattern. This includes a manufacturer supplied probe holder with height blocks (when applicable), ring-stand and clamp, or if specified by the BSF manufacturer, taping the probe to the inside or outside of the sash. The anemometer probe shall not be hand held.

c) Average the air velocity measurements. Multiply the average by the listed correction factor to obtain the average inflow velocity.

d) Include the following in reported data: height of restriction, individual velocity readings, average velocity, the listed correction factor, calculated inflow velocity, and methods used to determine them.

e) Reported values shall be:

- individual constricted velocity readings;
- overall average of the constricted velocity readings;
- calculated exhaust volume;
- calculated inflow velocity;
- constricted opening dimensions and area;
- work access opening area and dimensions;
- correction factor used (if applicable);
- acceptance criteria for calculated inflow velocity;
- inflow velocity test method; and
- name of test (inflow velocity test).

N-5.3.3.3.3 Method for Type B1 cabinets using a thermal anemometer to measure velocity through the access opening to determine average inflow velocity:

a) Turn off the blower(s) that recirculate air in the cabinet, if tested that way by the testing organization.

b) Set the sash to the height tested by the testing organization.

c) Take air velocity measurements at multiple points across the work access opening on a grid as specified on the data plate. The air measurement probe shall be held rigidly in a freestanding fixture that permits accurate positioning and does not distort the airflow pattern. This includes a ring-stand and

clamp, manufacturer supplied probe holder, or if specified by the BSC manufacturer, taping the probe to the inside or outside of the sash. The anemometer probe shall not be hand held.

d) Include individual inflow velocity readings, average inflow velocity, and methods used to determine them in the reported data.

e) Reported values shall be:

- individual inflow velocity readings;
- overall average of the inflow velocity readings;
- calculated inflow volume;
- work access opening dimensions and area;
- correction factor used (if applicable);
- acceptance criteria for average inflow velocity;
- inflow velocity test method; and
- name of test (inflow velocity test).

N-5.3.3.3.4 Calculated method for Type B2 cabinets using an anemometer and pitot tube if applicable:

a) Turn on the cabinet downflow blower and exhaust system blower.

b) Set the sash at the height specified by the testing organization.

c) Measure and calculate the exhaust volume in accordance with the testing organization's verified methodology, or with ASHRAE[8] standards for air velocity measurements in round or rectangular ducts, or with the *Industrial Ventilation Manual*.[3]

d) Measure the supply air velocity on a grid as specified on the data plate. The air measurement probe shall be held rigidly in a freestanding fixture (ring-stand and clamp) that permits accurate positioning and does not distort the airflow pattern (see Annex N-1, Figure 30). The anemometer probe shall not be hand held. Average the velocity readings and multiply by the area in ft^2 (m^2) of the plane in which the velocities were measured to determine the total filtered supply air volume flow rate in ft^3/min (m^3/s).

e) Subtract the supply air volume rate in ft^3/min (m^3/s) from the total exhaust volume rate in ft^3/min (m^3/s); the difference represents the calculated inflow volume rate in ft^3/min (m^3/s).

f) Divide the calculated inflow volume rate by the area of the access opening in ft^2 (m^2) to determine the average inflow velocity in ft/min (m/s).

g) Include the following in reported data: individual exhaust velocity readings, calculated average exhaust velocity, exhaust duct area, calculated exhaust volume, individual supply velocity readings, average supply velocity, effective supply area, calculated supply air volume, area of the work access opening, calculated inflow air volume, calculated average inflow velocity, and methods used to determine them.

h) Reported values shall be:

- individual duct velocity readings;
- overall average of the duct velocity readings;
- calculated exhaust volume;
- duct size, shape and area;
- work access opening dimensions and area;

— dimensions and area of the supply velocity measurement location (used to determine supply volume);

— individual supply velocity readings (not to be confused with downflow velocities);

— calculated supply air velocity and volume;

— calculated inflow velocity and method used for calculations;

— correction factor used (if applicable);

— acceptance criteria for average inflow velocity;

— inflow velocity test method; and

— name of test (inflow velocity test).

Canopy-connected A1 and A2 cabinets shall be tested with a method that measures the inflow volume at the work access opening.

N-5.3.4 Acceptance

The average work access opening inflow velocity shall be within ± 5 ft/min (± 0.025 m/s) of the nominal set point verified by the testing organization using the same method.

N-5.4 Airflow patterns test

N-5.4.1 Purpose

This test determines that the airflow along the entire perimeter of the work access opening is inward, that airflow within the total work area is downward with no dead spots or refluxing, that ambient air does not pass on or over the work surface, and that there is no escape to the outside of the cabinet at the sides and top of the sash.

N-5.4.2 Apparatus

The source shall be a visible aerosol or mist that is close to neutrally buoyant in air. The generation process should not create a velocity sufficient to interfere with the air patterns being observed.

NOTE — Titanium tetrachloride is corrosive and should be handled with care.

N-5.4.3 Method

N-5.4.3.1 Downflow test

a) Visible aerosol or mist shall be passed from one end of the cabinet to the other, along the centerline of the work surface, at a height of 4 inches (100 mm) above the top of the access opening.

b) Reported values shall be:

— name of test (airflow pattern downflow test); and
— pass or fail.

N-5.4.3.2 Sash retention test

a) Visible aerosol or mist shall be passed from one end of the cabinet to the other, 1 inch (25 mm) behind the sash, at a height 6 inches (150 mm) above the top of the access opening.

b) Reported values shall be:

— name of test (sash retention test); and
— pass or fail.

N-5.4.3.3 Work opening edge retention test

a) Visible aerosol or mist shall be passed along the entire perimeter of the work opening edges, approximately 1.5 inches (40 mm) outside the cabinet. Particular attention should be paid to corners and vertical edges.

b) Reported values shall be:

— name of test (work opening edge retention test); and
— pass or fail.

N-5.4.3.4 Sash seal test

a) Smoke shall be passed up the inside of the sash 2 inches (50 mm) from the sides and along the top of the total work area, 1 inch (25 mm) behind the sash, starting and ending 6 inches (150 mm) above the bottom edge of the sash.

b) Reported values shall be:

— name of test (sash seal test); and
— pass or fail.

N-5.4.4 Acceptance

N-5.4.4.1 Downflow test

The visible aerosol or mist shall show smooth downward flow with no dead spots or reflux (upward flow).

N-5.4.4.2 View screen retention test

The visible aerosol or mist shall show smooth downward flow with no dead spots or reflux. No visible aerosol or mist shall escape from the cabinet.

N-5.4.4.3 Work opening edge retention test

No visible aerosol or mist shall be refluxed out of the cabinet once drawn in, nor shall visible aerosol or mist billow over the work surface or penetrate onto it.

N-5.4.4.4 Sash seal test

There shall be no escape of visible aerosol or mist from the cabinet.

N-5.5 HEPA/ULPA filter leak test

N-5.5.1 Purpose

This test determines the integrity of downflow and exhaust HEPA/ULPA filters, filter housings, and filter mounting frames. The cabinet shall be operated within ± 5 ft/min (0.025 m/s) of the nominal set point, with the exception of the downflow HEPA/ULPA filters on B1 cabinets.

N-5.5.2 Apparatus

N-5.5.2.1 An aerosol photometer with linear or expanded logarithmic scale shall be used. The instrument shall be capable of indicating 100% upstream concentration with a minimum aerosol concentration of 10 µg/L of polydisperse dioctylphthalate (DOP) particles, or an equivalent fluid that provides the same particle size distribution (e.g., polyalpha olefin [PAO] di[2-ethylhexyl], sebecate, polyethylene glycol, and medicinal-grade light mineral oil)[39] produced by the generator described in Section N-1.3.2.2 or equivalent. It shall also be capable of detecting an aerosol concentration in the downstream equal to 10^{-5} of the upstream concentration of the same particles. The sampling rate of air shall be 1 ft^3/min (28 L/min) ± 10%. Probe area shall have a maximum open area of 1.7 in^2 (1100 mm^2) and a minimum dimension of 0.50 inches (13 mm). The photometer shall be set up in accordance with the photometer manufacturer's instructions or IEST-RP-CC-013[13] if instructions are not provided.

N-5.5.2.2 An aerosol generator of the Laskin Nozzle type conforming to Annex N-1, Figure 12 or equivalent shall be used to create an aerosol by flowing air through liquid DOP or equivalent substitute. When a Laskin nozzle generator is used, the compressed air supplied to the generator should be adjusted to a minimum of 20 psi (140 kPa), if using DOP or 23 psi (160 kPa) if using PAO, measured at the generator manufacturer’s recommended location. The nozzles shall be covered with liquid to a depth not to exceed 1.25 inches (31 mm).

N-5.5.2.3 A pressure gauge for the generator having a maximum range of 0 to 80 psi (0 to 550 kPa) with resolution and accuracy of 1 psi (7 kPa) calibrated by the manufacturer or in accordance with the manufacturer's instructions shall be used.

N-5.5.3 Method of testing HEPA/ULPA filters

N-5.5.3.1 Filters that can be scanned

a) Turn on the cabinet blower and lights (Types A1 and A2 and B2 downflow filter test). Remove the filter diffusers and protective covers if any are present. Place the generator so the aerosol is introduced into each cabinet fan upstream of the HEPA/ULPA filter(s). When the manufacturer has not identified the aerosol introduction point(s), introduce the aerosol in a manner to ensure thorough mixing in the cabinet airflow. For example, a T-connection can be fitted to the aerosol generator output to enable distribution of challenge into both entrances of a single blower or entrances of multiple blowers. The manufacturer shall determine the aerosol introduction point that provides the most uniform distribution.

b) Turn on the photometer and adjust it in accordance with the manufacturer's instructions.

c) Determine the aerosol concentration upstream of the HEPA/ULPA filter:

— when the challenged airflow is not contaminated, sample the aerosol concentration upstream of the HEPA/ULPA filter;

[39] Hinds, W., J. Macher, M.W. First, "Size Distributions of Aerosols Produced from Substitute Materials by the Laskin Cold DOP Aerosol Generator," presented at the 16th Dept. of Energy Nuclear Air Cleaning Conference; and Yan, X., M.W. First, S.N. Rudnick, "Characteristics of Laskin Nozzle Generated Aerosols," Proc. 21st Nuclear Air Cleaning Conf., M.W. First, Ed., NTIS., Springfield, VA. Feb. 1991. p.116.