FLOW SCIENCES, INC.

CERTIFICATION GUIDELINES

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BENCHTOP/ SCALE UP | PILOT PLANT/ MANUFACTURING | LAB AUTOMATION/ ROBOTIC EQUIPMENT | LABORATORY ANIMAL RESEARCH | SPECIALTY HOODS | CUSTOM DESIGN/BUILD

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Contents

Always consult with on-site Industrial Hygiene or Safety Officer for recommended face velocity levels before beginning any certification procedures.

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Introduction

The contents of this document are intended to aid customers and certification professionals with proper installation and operational setup of Flow Sciences enclosures. The topics discussed include installation tips, relevant standards for correct operation and common installation issues and their remedies.

Flow Sciences offers containment solutions for a variety of processes and enclosures can be broadly described as being either a 'negative' or 'positive' pressure system. As such, each type has different certification requirements based upon their design.

'Negative' pressure system means that the air pressure inside the enclosure is negative to the outside (ambient/lab/room) area which leads to a net airflow **into** the enclosure. The air is 'sucked' through the enclosure either through the use of a Flow Sciences fan or by connection directly to a house exhaust system. Enclosure types that fall into this category include the ETA vented balance enclosures, EHA/P/G hybrid style enclosures, ECP/G combination units and EGP/G glove box workstation series.

'Positive' pressure system means that the pressure inside the enclosure is positive to the outside (ambient/lab/room) area which leads to a net airflow **out** of the enclosure. The air (or inert gas) is 'pushed' out of the enclosure. Enclosure types that fall into this category include the END style units and 'H' version of the ETA series.

What Style Enclosure Is Being Certified?

Flow Sciences has a wide range of enclosures, designed to offer the correct containment solution to the end user. Many of the styles use the same test standards and therefore only a select series of certification techniques will be needed to certify and operate these enclosures. Additionally, almost all of the 'custom' units supplied by Flow Sciences are based on a standard type of enclosure. The user manual for every unit will identify the 'series' that the enclosure belongs to. This information can usually also be found on the serial tag. The following tables give a broad overview of the enclosure classes and the pertinent certification testing.

Enclosure Series	Certification Test	
	Recommended	**Optional**
ECP/ECG Open Side	Face Velocity Filter breakthrough - Primary	Filter breakthrough – Secondary Smoke, tracer gas
ECP/ECG Glove Box Side	Face Velocity Filter breakthrough - Primary Interior Cleanliness (particle counts)	Filter breakthrough – Secondary Filter breakthrough - Inlet
EHA	Face Velocity Filter breakthrough - Primary	Filter breakthrough – Secondary Smoke, tracer gas
EHG/EHP	Face Velocity Filter breakthrough - Primary	Filter breakthrough – Secondary Smoke, tracer gas
ETA with BIBO	Face Velocity Filter breakthrough - Primary	Filter breakthrough – Secondary Smoke, tracer gas
ETA without BIBO	Face Velocity Filter breakthrough	Smoke, tracer gas
EGP/EGG	Face Velocity Filter breakthrough - Primary Interior Cleanliness (particle counts)	Filter breakthrough – Secondary Filter breakthrough - Inlet
EVA	Face Velocity Filter breakthrough – Standalone Fan	Filter breakthrough – Secondary Smoke, tracer gas
EVP	Face Velocity Filter breakthrough – Standalone Fan	Filter breakthrough – Secondary Smoke, tracer gas

Enclosure Series	Certification Test	
	Recommended	**Optional**
END	Pressure Decay Test	
ETA 'H' Series	Face Velocity Interior Cleanliness (particle counts)	

Enclosure Installation

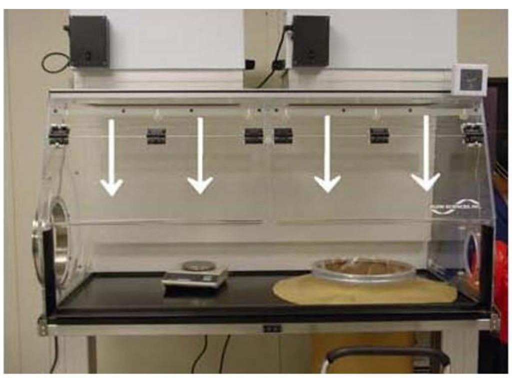
General Considerations

The appropriate manual for setup of the enclosure and any accessories are shipped with each system and many certification issues can be eliminated or minimized when the enclosure is installed as recommended in the manual.

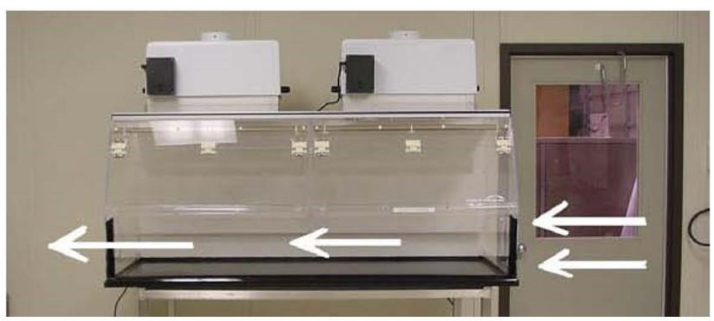
The correct installation site for any enclosure is paramount to the effectiveness of its ability to provide the protection for which it was purchased. Often the most common issues encountered during the setup and certification of Flow Sciences enclosures are caused by transient airflow patterns within the laboratory or room that the unit is being installed.

Negative Pressure Systems

In negative pressure systems, cross drafts and shearing can have a detrimental effect on the ability of the enclosure to contain hazardous materials. These systems should not be located in high traffic areas, such as near a door, or directly underneath a non laboratory grade HVAC diffuser. Additionally, if the air from the enclosure is being recirculated into the room, it is important that the air from the fan should be directed away from the enclosure, walls, ceiling or any flat surface that may deflect the air across the front access area. Before getting started verify that the velocity of shearing or cross drafts do not exceed 30 linear feet per minute (lfpm) (0.15 m/sec) (see below).



Shearing



Cross-draft

All Flow Sciences negative pressure enclosures undergo factory acceptance testing (FAT) that contains components of the latest ASHRAE-110 standard. The standard describes the procedure for determining the following: 1). Average face velocity measurement; 2). Smoke visualization tests; 3). Tracer gas analysis.

Most certification can be accomplished with just the first component, but the second can be very useful in troubleshooting any issues encountered during the process.

Positive Pressure Systems

While these enclosures are not affected as much as negative pressure counterparts by transient air currents, it is still advisable to follow the same guidelines described above. For enclosures that use inert gases to create a controlled environment (END and customs units based on this design), a thimble connection for house exhaust extraction or a means to measure percent oxygen in a room must be used to prevent the possible generation of an unsafe environment for personnel.

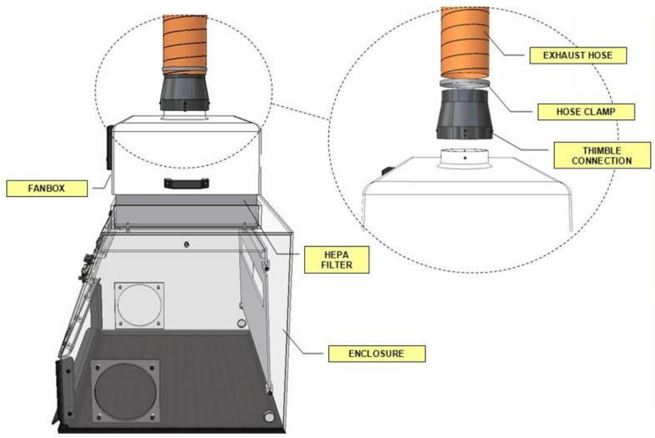
Setup

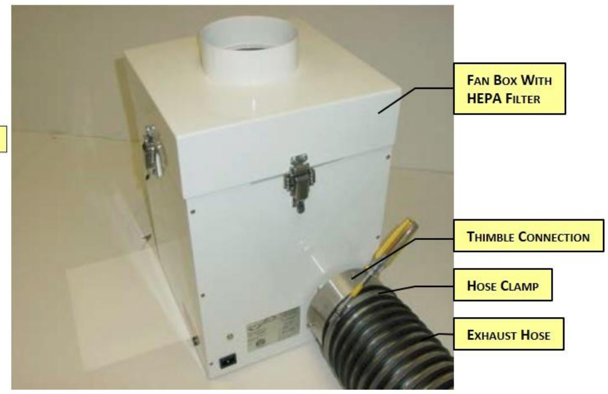
Refer to the User Manual supplied for each enclosure for details on the correct setup for the unit. There are a variety of peripheral accessories that can be attached to Flow Sciences enclosures, and each component needs to be correctly installed to allow for proper certification of the unit. For example, if a waste chute is installed on the side of an enclosure, it is vitally important that the waste chute bag is also installed. Failure to install the bag will lead to improper airflow into the face opening of the enclosure and can lead to unsatisfactory containment and nuisance alarm issues.

Thimble Connection

When connecting a fan directly in line with house exhaust duct work, **a thimble must be used for proper removal of contaminants. This connection has an air gap that prevents complications that result from having competing fans in the duct work. The Figures below** show the appropriate set up. Flow Sciences recommends that the face velocity be set prior to connecting the thimble. Once the desired face velocity has been achieved, the thimble connection can be attached. It is recommended that the house exhaust be 10-15% greater than the enclosure fan CFM. For example, if the enclosure fan is pushing 250 CFM (0.118 m^3/sec), then the house exhaust should be pulling 275-288 CFM (0.130-0.135 m^3/sec). This prohibits any resistance between the two fan units. A simple way of checking the thimble installation is to **hold a smoke stick near the inlet of the thimble. The smoke should rush into the thimble with no reversions.**

After the thimble connection has been installed, verify that the face velocity has not changed. It is often seen that the additional force of the house exhaust fan creates a negative pressure which could slightly increase the face velocity. Refer to the face velocity section and adjust accordingly.





Enclosure Certification

The following guidelines describe a series of tests that are typically performed by certifiers or other authorized personnel tasked with ensuring that the enclosures are installed and setup correctly. These guidelines may also be used to assist in troubleshooting some common issues.

Negative Pressure Systems

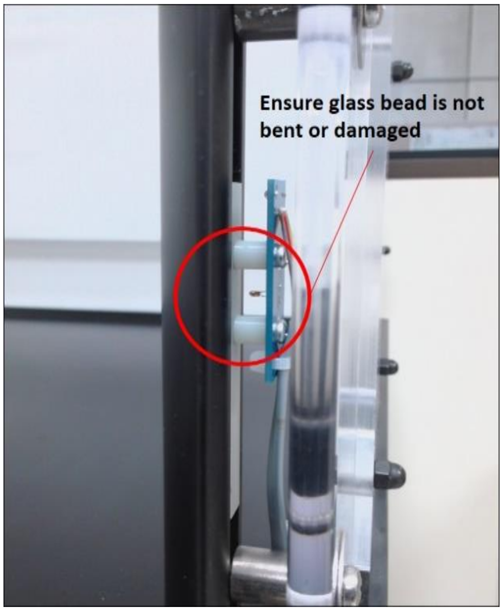
Alarm Calibration

The Flow Sciences FS1650 Face Velocity Alarm is designed to continuously monitor airflow through Flow Sciences' Enclosures. Once the FS1650 is installed and properly calibrated, this device provides both a visual and audible alarm to alert the end user to abnormal airflow conditions in the enclosure.

The face velocity alarm may be integrated into the top mount fan unit. If the face velocity alarm is a 'stand-alone' component, it may be mounted either integrally on the exterior of the enclosure or on an adjacent surface with the adhesive strips provided with the unit. The module is connected by cable(s) to the flow sensor, which is snapped into the base or side airfoil on the enclosure. During operations, a green light indicates normal flow conditions. If the flow deviates a programmed amount from the ideal conditions a red indicator light signals low flow. After a pre-set period of time at these conditions, an audible alarm sounds. The audible alarm can be silenced by pressing the acknowledge button (ACK) on the face of the alarm.

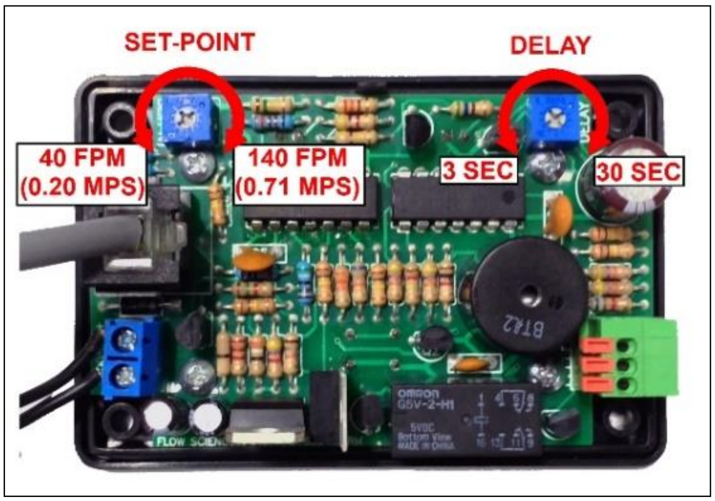
NOTE: An orange warning label is attached to the alarm face prior to shipping from the factory indicating that the alarm has not been field calibrated. This label should be removed after alarm calibration. The (ACK) button is located on the left side of the alarm face.

NOTE: Upon start-up of the alarm the green light will illuminate and an audible sound is emitted. The audible alarm will sound until the system reference and measurement sensors equilibrate. See troubleshooting guide if alarm will not silence during initialization stage.



To begin, allow the fan to warm up by running it for approximately 15 minutes prior to setting the alarm. Next, verify that the glass bead on the air flow sensor is perpendicular to the airfoil as shown left. Make sure that the two filament leads connecting the glass bead are extended and not touching each other or bent over. This could give false velocity readings and compromise the alarm accuracy.

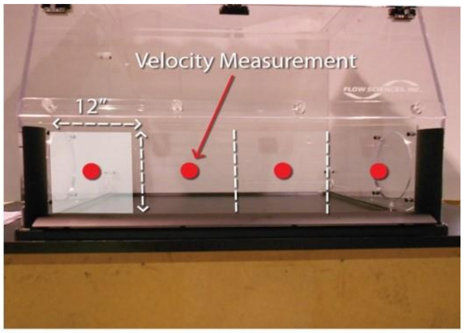
Flow Sciences recommends the face velocity alarm be set at 20% below the operational face velocity. Therefore, if 75 lfpm (0.38 m/s) is the desired velocity, a face velocity less than 60 lfpm (0.30 m/s) would force the alarm to trip. Begin alarm calibration by first setting the face velocity of the enclosure to 80% of the desired operating velocity. Next, gain access to the alarm controls by removing the four screws located on the face of the alarm**.** Next, adjust the delay to the site accepted value by adjusting the delay screw **(FSI recommends turning this all the way to the full 30s).** By doing so, quick disturbances in the face velocity will not trigger the audible alarm. Afterwards, adjust the set point screw until the red and green lights toggle between each other. This sets the alarm so that a consistent face velocity of less than 80% of operating value would sound the audible alarm.



Air Flow – EVA, ETA Series, ECP/G Series, Open Face Side and EHA/P/G Series with Draft Shield Removed

Establishing the appropriate face velocity is one of the most important factors in the overall performance of the enclosure. Most vented enclosures from Flow Sciences are engineered to operate between 60 to 100 lfpm (0.30 -0.50 m/s) with a factory recommended face velocity of **75 lfpm ± 5 lfpm (0.35-0.4 m/s).** This style of enclosure has been tested in accordance with the ASHRAE 110 protocol.

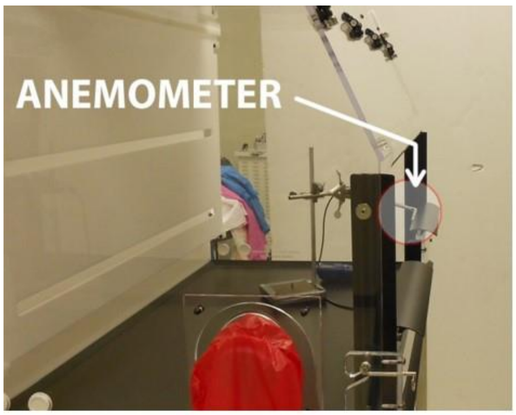
NOTE: While **75 lfpm ± 5 lfpm (0.35-0.4 m/s) is the Flow Sciences recommended setting,** the face velocity should be set in accordance with your site safety requirements or the design notes for the enclosure.

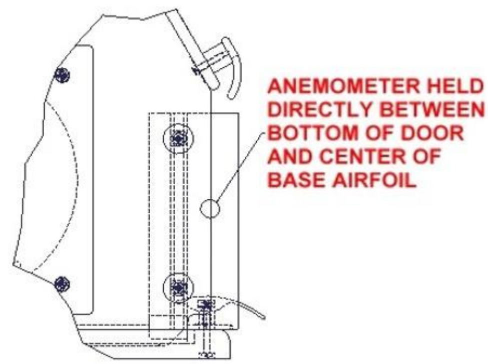


Setup grid for measurement locations per ASHRAE-110 guidelines

Follow guidelines from latest version of ASHRAE-110 for performing face velocity measurements. Flow Sciences recommends that an approximate 1.0 ft² grid pattern be formed by equally dividing the face opening into vertical and horizontal dimensions. Considering that most face openings are close to 12" high, simply measure 12" from edge and measure in center. Using a calibrated anemometer, velocity readings should be taken in the geometric center of the grid space.

It is critical to measure directly in the center of the face opening plane as off center measurements can be inconsistent. Refer to the figure below for proper alignment as studies have shown that one inch inside or outside the face opening plane can alter the true reading by 10-15%. The anemometer should be held perpendicular to the plane of the front access area with the tip placed at the center of the plane as shown.





Place anemometer tip in the plane of the face opening

Airflow speed can be adjusted using the set screw on the side of the fan box as shown below.

'4000' Series Remote Fan

'4700' Series Top Mount Fan

'4700' Series Dual Speed Top Mount Fan – High Volume

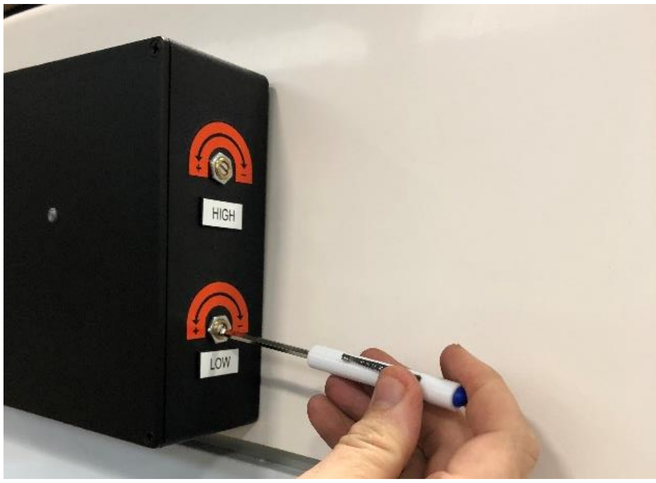
Air Flow –EHA/P/G Series with Draft Shield Installed

The hybrid series of enclosures has a removable draft shield with glove ports. This feature allows the unit to operate at a higher level of containment when needed by placing an extra barrier between the operator and any hazardous chemical they may encounter. With the draft shield installed the recommended slot velocity should be set between **100-150 lfpm (0.5-0.76 m/s)** for the 'EHA' series and **150-200 lfpm (0.75-1.0 m/s)** for the 'EHP/G' series. Adding the draft shield, decreases the area of the face opening and the face velocity is increased to maintain CFM requirements.

Anemometer placement should be performed in a similar manner to the procedure described above. With the decrease in height, it is easier to judge the exact center.

Place anemometer tip in the plane of the face opening. Measure values above and below draft shield.

Airflow speed can be adjusted using the set screw on the side of the fan box as shown below.



Balancing Multiple Fans

Larger Flow Sciences enclosures utilize multiple fan units to generate the appropriate CFM requirements. Extra care is to be taken when setting the face velocity for these types of enclosure. We recommend that each fan be adjusted to within 5% of each other. This minimizes interior turbulence and increases the overall efficiency of the unit.

Depending on the desired face velocity, each fan may need to be turned down considerably. Try to maintain consistency between the adjustments of each fan. When the face velocity approaches the desired level, verify that each fan is pulling equal volumes of air. This can be accomplished by comparing the plenum slot velocities. As shown below, hold the anemometer perpendicular to the face opening of a plenum slot and record readings. Afterwards, measure the same slot on the next plenum in a mirrored fashion. These velocity measurements should be within 5% of each other.

In many laboratories, air can be quite turbulent due to many variables. This turbulence can sometimes cause the enclosure face velocity to be inconsistent. It is here that measuring slot velocities becomes very important. When the face velocity is inconsistent, always refer to slot velocities to achieve even air flow. **If these slot velocities are not similar (one fan is pulling more air), a vortex is created within the enclosure leading to decreased performance and making the face velocity extremely difficult to set.**

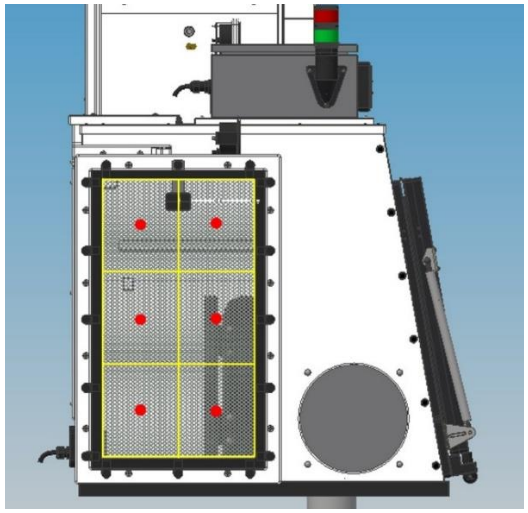
NOTE: With new BIBO installations (i.e. new filters, etc.) a method to help quickly balance fans is to match the pressure differential gauge readings during fan setup.

Air Flow –EGP/EGG Series, ECP/ECG Series, Glove Box Side

The Flow Sciences EGP/EGG series of enclosures are designed for both personnel and product protection. The unit uses an inlet HEPA filter to create a 'clean zone' with a cleanliness level of ISO Class 5 or better.

The EGP/EGG series has been engineered to operate between 110 and 130 lfpm (0.55 -0.65 m/sec) (as measured at the inlet filter), however the air flow should be set in accordance with your site safety requirements. Refer to the design notes for the enclosure for any specific airflow (CFM) requirements.

It is recommended that a 1.0 ft (300mm) grid interval pattern be formed by equally dividing the inlet filter cross section into even horizontal and vertical dimensions. Using a calibrated anemometer, velocity readings should be taken in the geometric center of the grid space. According to ASHRAE 110 operating procedures, at least four face velocity readings should be taken over a minimum of five seconds for each grid.



The fan speed may be adjusted by turning the set screw on the side of the fan box.

Fan speed adjustment

Series	Operating Range (LFPM (m/s))	Recommended (LFMS (m/s)	Where Measured
ETA, EHA (draft shield removed), EHP/G (draft shield removed), ECP/G (open face side)	60-100* (0.3-0.5)	75 ± 5 (0.37 ± 0.03)	Plane of face opening
EHA (draft shield installed)	100-150 (0.5-0.75)	125 ± 5 (0.6 ± 0.03)	At slots above and below draft shield
EHP/G (draft shield installed)	150-200 (0.75-1.0)	175 ± 5 (0.85 ± 0.03)	At slots above and below draft shield
EGP/G, ECP/G (glovebox side)	110-130 (0.55-0.65)	120 ± 5 (0.57 ± 0.03)	At inlet filter

*Some EHA/P/G models have a maximum face velocity of 90 LFPM (0.45 m/s).

Verify Alarm Function

After the alarm and face velocity for the unit has been set, verify that the alarm functions as intended. If the airflow into the enclosure is within an acceptable velocity range, a steady green light should be lit. If the red light is illuminated, the airflow is in an unacceptable status and corrective actions need to be performed. If the lights 'toggle' back and forth it indicates that the alarm set point is too close to the air flow velocity or that there are transient air currents in the room. Corrective action is required to prevent 'nuisance alarms' occurring.

Face velocity within acceptable velocity range

Face velocity outside of acceptable velocity range

Aerosol Challenge

Each Flow Sciences HEPA filter undergoes a stringent quality assurance test by the manufacturer to verify that the filter efficiency is within acceptable parameters. The test data document is included with the filter. To confirm the in-place efficiency of the unit and HEPA filter, many companies elect to perform a final certification of the HEPA filters. This proves that the HEPA filters are installed correctly and are not damaged prior to using the enclosure with potent powders. The following sections of this document will describe how to perform HEPA leak tests.

After the correct installation has been verified, the aerosol challenge can begin. Flow Sciences recommends that an aerosol be introduced into the enclosure. Certifiers should use the methods described in the user manuals for the test equipment for proper introduction and measurement of the aerosol.

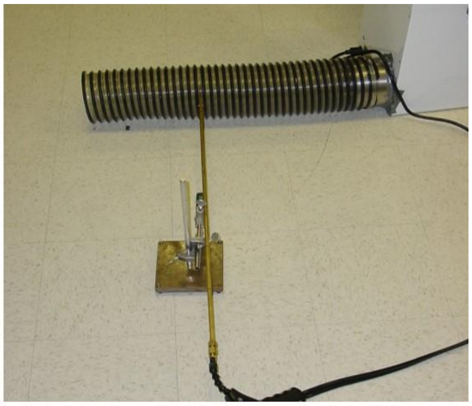
Remote Fans – EVA, EVP Series

Turn the aerosol generator to the on position, introducing adequate aerosol. **If a 100%** baseline measurement is required, it is essential to position the probe in a place where the most accurate representation of air to aerosol mixture is found. For this reason, the photometer probe should be located approximately 30 inches down the flex duct. To avoid ruining the entire flex hose, it is recommended to make a sample port close to the end of the duct. Following the test, this section can be cut off.

Introduce aerosol into enclosure

Example of enclosure setup

With the 100% baseline concentration established, measure the downstream concentration as a percentage of the upstream. Considering a known upstream concentration (in percentage form) and the known filter efficiency (99.99%), perform a total leak test to determine the percentage of breakthrough. An aerosol detection of over 0.01% would constitute a failure.



Upstream (100%) Measurement **Downstream Measurement**

Top Mount Fans – EHX, EGX, ECX, ETA Series

The bag in – bag out (BIBO) housing is designed so that the primary (bottom) filter can be replaced without exposure to the operator to any contaminants that it has collected during operation. To perform an aerosol challenge on this type enclosure, the proper installation should be verified by ensuring correct airflow through the system has been established.

Note: Flow Sciences recommends only the primary filter be checked after installation.

Note: Flow Sciences does not require testing of the secondary HEPA filter. However, if the certifier or customer feels it is appropriate, the aerosol test of the secondary filter should be performed prior to testing the primary filter.

Primary Filter Testing

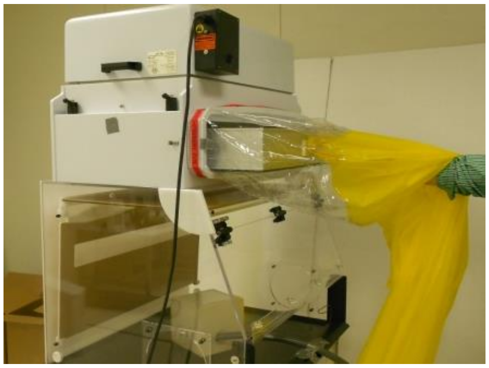
If a 100% baseline measurement is required, the first step to testing the primary filter is to establish an upstream concentration measurement. To perform this, release the primary filter by releasing the tension on the retaining latches. These are located under covers on each side of the BIBO. A center cover is also used with dual BIBO housings.

Pull filter clamps up and rotate to release primary HEPA filter

Remove BIBO bag cover, but DO NOT remove bag.

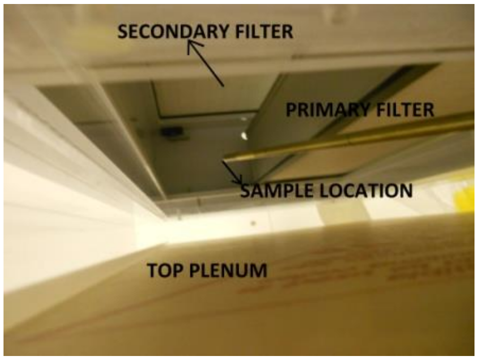
Remove BIBO cover

Pull primary filter forward approximately 6 inches (152 mm).



Pull primary filter forward

Measure ‘upstream’ concentration behind primary filter.



Measure upstream concentration

After the 100% baseline has been established, reinstall primary filter by reversing the steps above. To measure the primary filter breakthrough, insert the probe into the ½ inch hole above the primary filter and measure the downstream concentration as a percentage of the upstream. Considering a known upstream concentration (in percentage form) and the known filter efficiency (99.99%), perform a total leak test to determine the percentage of breakthrough. Flow Sciences recommends that several quadrants be measured

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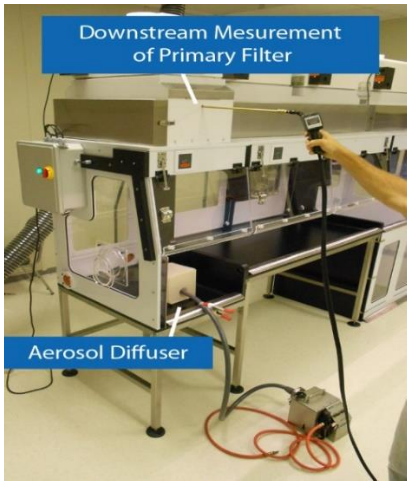
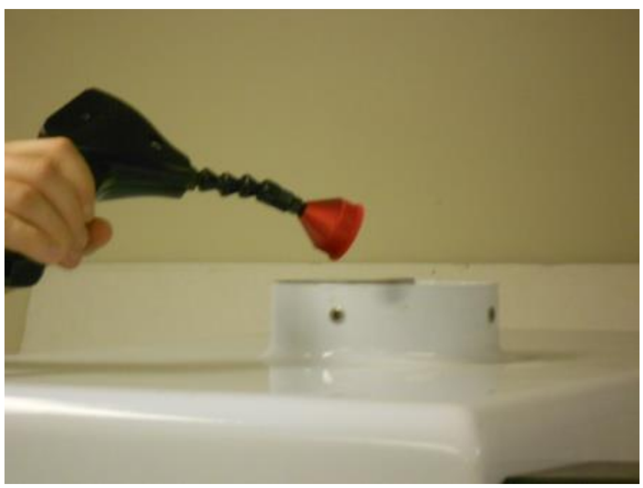
and averaged downstream of the primary HEPA filter. An average aerosol detection of over 0.01% would constitute a failure.



Measure downstream concentration

Secondary Filter Testing

Prior to reinstallation of the primary filter after taking the 100% upstream baseline concentration for the primary filter testing (see above), the breakthrough of the secondary filter can be established. After attaining the baseline concentration, measure the downstream concentration by measuring the exhaust port on the fan or in the ductwork connection to the house exhaust. Once again, an average leak rate of more than 0.01% would constitute a failure.



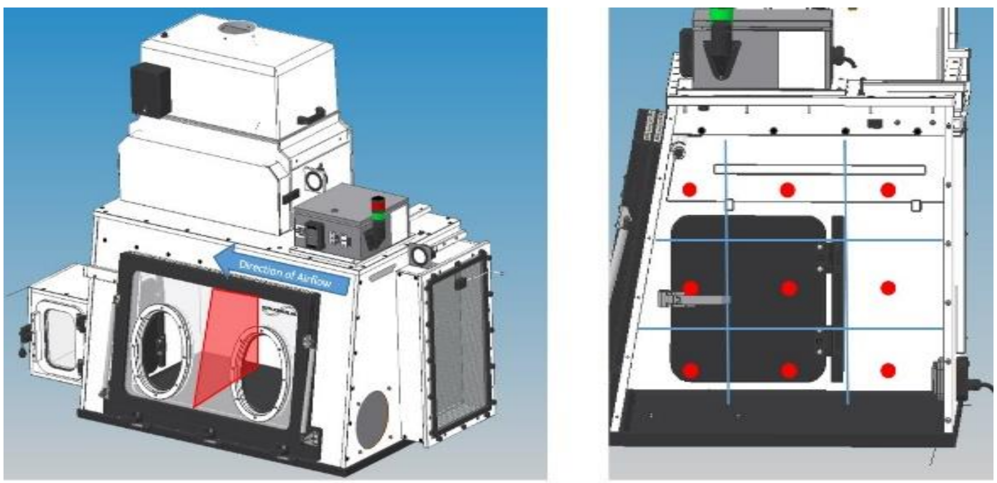
Secondary filter downstream concentration

Interior Cleanliness

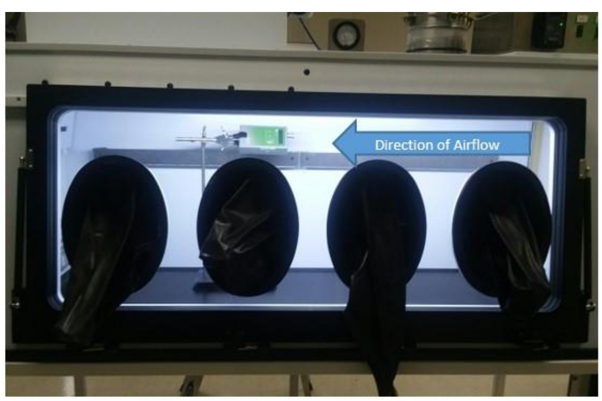
EGP/EGG, ECP/ECG Series

All Flow Sciences Glovebox Workstations (EGP, EGG, ECP and ECG series) are tested to the ISO-14644-1 standard: Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness. Each enclosure conforms to a cleanliness classification of ISO Class 5 or better for particles of size 0.3µm or larger.

Prior to performing particle counts, verify the airflow into the enclosure is set appropriately. Next, construct a cross-sectional imaginary grid in the center of the enclosure as shown in **the figure below.** This grid follows the ASHRAE-110 guidelines of areas not to exceed 1 Sq. ft. Once set, particle counts should be taken at the geometric center of each of the grid areas. The use of a ring stand to secure the particle counter is recommended during the testing. Ensure enough time has elapsed after closing any doors opened during equipment installation for the enclosure to clear the interior of particles. Particle count readings should be taken with the sampling nozzle of the counter pointing towards the upstream side of the airflow (i.e. towards the inlet filter).



Construct test grid at midpoint of the enclosure.



Have particle counter sampling port pointed towards incoming air

When concluding a pass/fail, be sure that the particle counter is set to the appropriate unit of measure or converted properly.

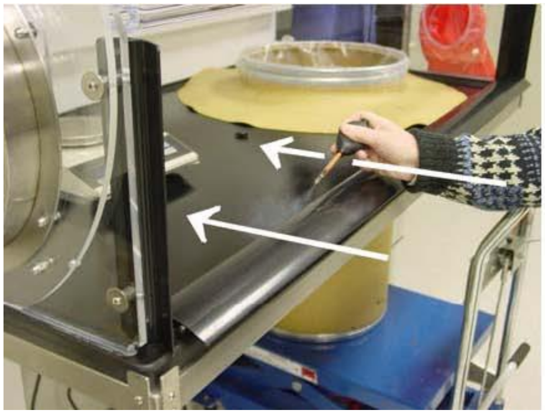
Optional Tests

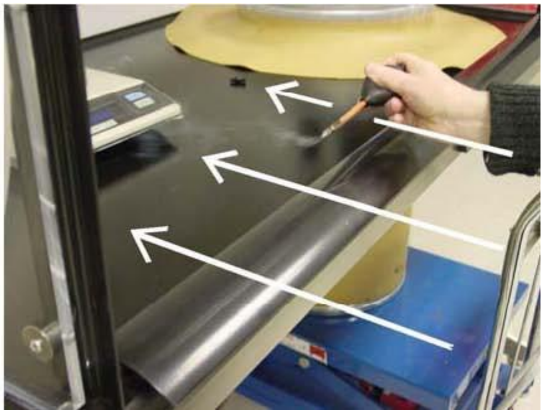
Flow Visualization

These tests are a visualization of an enclosure's ability to contain powders and vapors. These tests consist of both small and large volume smoke challenges to the enclosure. The objective of these tests is to render a visual observation of the enclosure as it is typically used. Additionally, these tests are useful in making observations of the effects of transient air currents within a room or laboratory and may aid in formalizing a plan in rectifying cross-draft and shearing issues that may be present.

Small Volumetric Smoke

A smoke stick or small smoke generator such as a 'Wizard Stick' can be used to visualize local air flow within the enclosure. A stream of smoke can be discharged along both walls and the floor of the enclosure in a line parallel to the enclosure face and 6 inches behind the face of the unit. If there is visible smoke flow out of the front of the enclosure the system should be rechecked to ensure that the enclosure and fan housing are properly installed and that shear or cross drafts are not affecting the containment performance.





Large Volumetric Smoke

The large volumetric challenge must be administered with a smoke generator capable of filling the enclosure with smoke. The smoke must be released 6 inches inside the face opening and blown through a diffuser as to minimize interference with normal airflow. Outflow of smoke from the front of the enclosure after cessation of the smoke generation would constitute a failure.

Tracer Gas

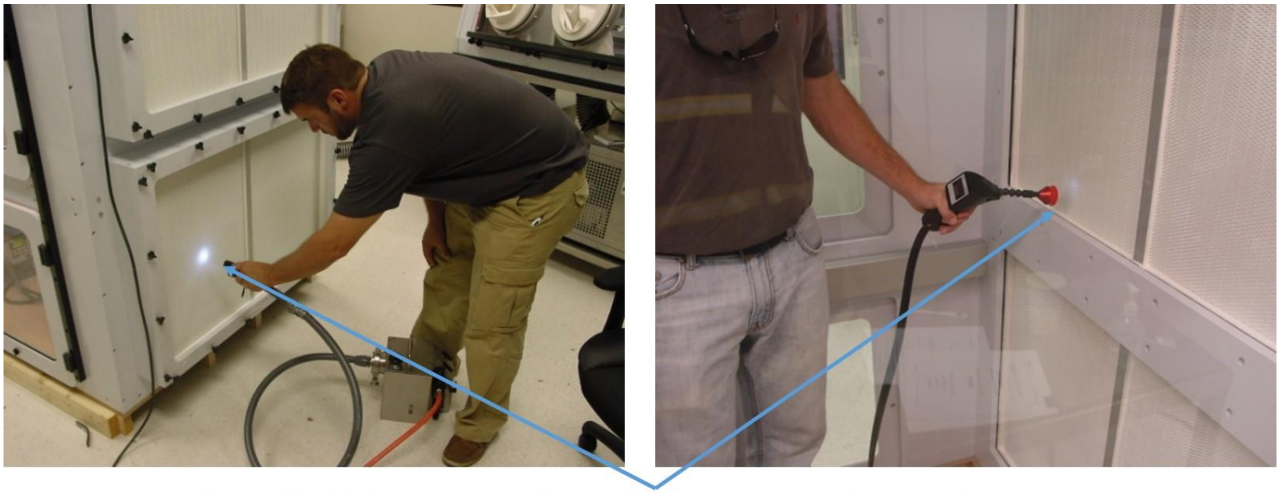
A tracer gas test is optional for certification and should **only** be performed if the system is connected to the house exhaust system. The tracer gas used during this portion of ASHRAE is to be commercial or reagent grade Sulfur Hexafluoride (SF_6) or acceptable substitute. It should be supplied from a cylinder capable of maintaining a release rate of 4.0 liters per minute (L/min). When performing a tracer gas test, make sure the unit is **connected to house exhaust** as HEPA filters will not contain these gases.

According to current version of ASHRAE-110, the tracer gas discharge nozzle is to be placed 6 inches from the face opening. Typical enclosures should be measured at three locations: left, center, and right. Smaller enclosures may only need two locations, as ASHRAE suggests the right and left side should be measured 12 inches from the inside wall of the enclosure. The tracer gas diffuser should be placed 6 inches (150mm) inside the enclosure (as measured from the face opening plane). The sampling location of the mannequin should be located directly in front of the diffuser, 3 inches (75 mm) from the face opening and 22 inches (560 mm) above the work surface. ANSI/AIHA Z9.5 section 6.1.2.7 states that tracer gas escaping the enclosure should be an average of no greater than 0.1 ppm (100ppb) "as installed".

Safety considerations suggest that a scheduled inspection and documentation be set up for each enclosure at least annually. Flow Sciences includes a maintenance log with every enclosure for this purpose. It is located in the back of each user manual. Optional testing can include tracer gas (SF_6) and/or surrogate powder testing, at the discretion of the safety department. An inspection notice should be adhered to the enclosure indicating when the enclosure was tested, what the face velocity was, that the enclosure was operating properly, and the next required certification date.

Inlet Filter Aerosol Challenge – EGP/EGG, ECP/ECG Series

Ensure that the correct airflow has been established for the enclosure as described above. The inlet HEPA filter test for this style of enclosure is best performed with two people. One person should introduce the aerosol to a specific area of the filter at a distance of 4-6 inches from the face of the filter. The second person then measures the breakthrough from the inside of the enclosure in the same area that the aerosol is being introduced. As seen in the figures below, a flashlight held with the aerosol injector assists the person measuring the downstream concentration. This certification is more of a filter scan rather than total leak test. An average breakthrough over the surface of the HEPA filter greater than 0.01% would constitute a fail.



Use of flashlight upstream aids proper measurement location downstream

Positive Pressure Systems

Leak Tightness - END Series

All Flow Sciences positive pressure systems are tested in accordance with the ISO 10648-2 standard, following the Pressure change method (section 5.2). In this test, all valves and openings are sealed. The enclosure is then pressurized to at least 1" (250Pa) above ambient pressure. Measurements are taken at the start of the test and at 15 minute intervals for 1 hour. The first and final pressure readings are then used, in conjunction with temperature and atmospheric pressure readings, and a leak rate is determined using the calculation shown below (a worksheet is included for convenience).

Care should be taken to maintain the following during testing:

1. Internal relative pressure change shall not exceed 30% of initial pressure;
2. Internal temperature variations of the test enclosure should not be greater than 0.3°C (0.54°F);
3. Atmospheric pressure variations should not exceed 100Pa (0.4" WC);
4. Temperature variation within the room should not exceed 1.0°C (1.8°F).

The pass criteria for enclosures is a decay of less than or equal to 0.0025 hr^{-1} based on the formula below.

Reference Number	Formula Variables	Variable Names	Variable Value	Initial Date
1		Test Begin time		
2		End Test Time		
3	t	Test Duration in Minutes (Subtract Line 1 from Line 2)		
4		Test Begin Atmospheric Pressure (mB)		
5		Test Begin Atmospheric Pressure (Pa) (Multiply Line 4 by 100)		
6		Pressure above ambient (outside) Inside END at start of test (Pa)		
7	P_1	Test Begin Absolute Pressure (Pa) (Add Lines 5 and 6))		
8		End Test Atmospheric Pressure (mB)		
9		End Test Atmospheric Pressure (Pa) (Multiply Line 8 by 100)		
10		Pressure above ambient (outside) Inside END at end of test (Pa)		
11	P_n	End Test Absolute Pressure (Pa) (Add Lines 9 and 10)		
12		Test Begin Temperature (C)		
13	T_1	Test Begin Temperature (K) (Add 273.15 to Line 12)		
14		End Test Temperature (C)		
15	T_n	End Test Temperature (K) (Add 273.15 to Line 14)		

$$T_f = \frac{60}{t} \times \left(\frac{p_n T_1}{p_1 T_n} - 1 \right)$$

Interior Cleanliness - ETA 'H' Series

The Flow Sciences ETA 'H' enclosure is a 'downflow' style unit based upon the ETA style series. The units utilize a top mount fan that is inverted on the upper HEPA filter such that the air is 'pushed' down through the filter to create a clean work surface within the enclosure. Airflow should be setup as per the other ETA parameters above. In addition, the unit is tested to the IEST-RP-CC002.3: Unidirectional Flow, Clean-Air Devices recommended practice. All Flow Sciences ETA 'H' series enclosures are capable of achieving ISO Class 5 or better for particles 0.3 µm or larger.

Once the airflow has been established, particle counts should be taken inside the enclosure at the approximate height of the anticipated work space. Certification of the enclosure is established by the interior cleanliness level, as determined by the ISO 14644-1 standard. The particle size and desired cleanliness level should be determined by the end user.

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Troubleshooting

Air Flow

1. No Airflow

Verify	Corrective Action
Check that fan switch is in the "ON" (I) position.	Turn the fan switch in the "ON" (I) position.
Check to make sure the power cord is fully plugged in to both the power outlet and the fan electrical box.	Plug the power cord in to both the power outlet and the fan electrical box.
Check to verify filters are properly installed and that no packing material is obstructing airflow path	Remove any material obstructing the airflow path.
Check that the variable speed control is not over rotated in the counter clockwise direction. Turning the adjustment screw beyond the maximum setting, until it clicks, will turn the fan OFF. (NOTE – This check not applicable to 220VAC models)	Mark the adjustment screws position before making any change. Turn the variable speed control in the clockwise direction. If it clicks the variable speed control was in the OFF position. Reset the variable speed control until the correct face velocity is achieved.
Check the internal fuse and verify that it is still good.	With the unit unplugged use a small screw driver to press in and turn counter clockwise to remove the fuse in the side of the fan electrical box. Replace if necessary and repeat test.
Ensure exhaust cap/port is connected to house exhaust	Connect enclosure to house exhaust

2. Low Airflow

Verify	Corrective Action
Check that fan is properly seated on the filter	Move fan housing until it rests properly on top of the filter.
Check/Inspect filters to see if they have become clogged	Replace if necessary.
Check for restriction on the fan discharge and verify that nothing is impeding airflow at this point	Remove any blockage from airflow path.
Check that top and rear plenums are properly installed	Properly seat the plenums in their correct position.
Check to verify filters are properly installed and that no packing material is obstructing airflow path	Remove any material obstructing the airflow path.

3. Hi Airflow

Verify	Corrective Action
Check that variable speed control is not over rotated in the counter clockwise direction.	Turn the variable speed control in the clockwise direction. Adjust the variable speed control until proper face velocity is achieved.
Check for cross drafts from any HVAC diffusers, open doors and windows	Remove the cause for the draft or move the enclosure to a new location.
Check discharge to verify that any other house exhaust does not influence discharge rate	Remove the cause for the draft or move the enclosure to a new location.
Check that top and rear plenums are properly installed	Properly seat the plenums in their correct position.

4. Unstable Airflow

Verify	Corrective Action
Check for cross drafts from any HVAC diffusers, open doors and windows	Remove the cause for the draft or move the enclosure to a new location.
Check that fan is properly seated on the filter	Move fan housing until it rests properly on top of the filter.
Check for balance across multiple fans/connections if so equipped	Measure discharge velocity from each individual fan/connection to see if they are all moving the same amount of air. Adjust individual fans/connections until they are all operating at the same level. Verify face velocity is still correct, and if required adjust all fans/connections until correct face velocity is achieved.
Check that top and rear plenums are properly installed.	Properly seat the plenums in their correct position.
Check for deflection of fan exhaust due to proximity of obstructions.	Install diffuser to fan exhaust or move the enclosure to a new location.

Filter Sealing

1. Leakage

Verify	Corrective Action
Check that the filter is sitting flat on its mount or filter frame.	Move the filter until it rests properly on its mount or filter frame.
Check to make sure clamping levers on the primary HEPA filter are in their lowered position pressing down on the filter (BIBO Housings)	Twist the clamping levers until they drop into their slots.
Check to see the filter is installed in right orientation with the arrow pointing toward the fan	Flip the filter over if the arrow does not point toward the fan.
Check to see if the filter pleats look undisturbed and no damage has happened to the filter media during installation	Replace the filter if it is damaged.

Alarm

1. Alarm will not silence during start-up

Verify	Corrective Action
Check that alarm is correctly connected.	Ensure all connections between alarm sensor and alarm are securely connected. Securely connect cables between sensor and alarm.
Broken wire or thermistor on sensor.	A quick visual check may be performed to verify that the thermistors and wires are not broken or shorted.
Sensors can equilibrate. If airflow across sensor is too fast, equilibration is not possible.	Reduce airflow across sensor during initiation stage by blocking airflow or reducing fan speed.

2. Face velocity good, alarm in "RED" alarm condition continuously on

Verify	Corrective Action
Check that face velocity is correct.	Use an anemometer to verify that the airflow is still set at the correct speed. Reset fan speed if necessary.
Sensor lead plugged in.	Make sure all cables from the sensor to the alarm are securely connected.
Broken wire or thermistor on sensor.	A quick visual check may be performed to verify that the thermistors and wires are not broken or shorted.
Sensitivity set too low for proper operation	Adjust set point on alarm circuit board. See alarm manual.
Obstructions ahead of and behind the sensor that are disturbing airflow	Remove obstruction from in front of and behind sensor.

3. Face velocity good, alarm in "RED" alarm condition intermittently on/off

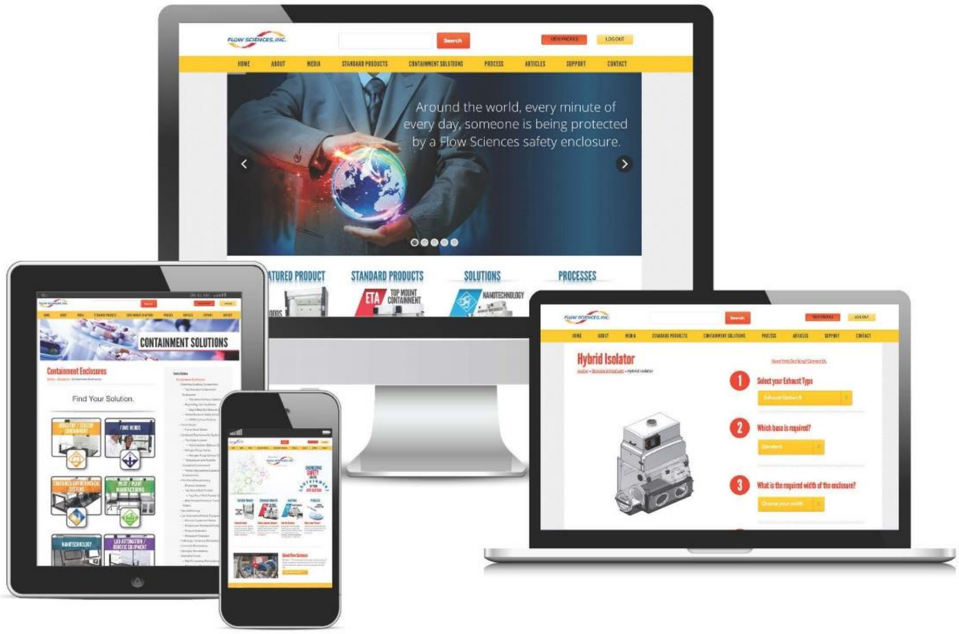
Verify	Corrective Action
Obstructions ahead of and behind the sensor that are disturbing airflow	Remove obstruction from in front of and behind sensor.
Fluctuations in the exhaust HVAC systems that affect the airflow entering the enclosure	Operate system when no fluctuations are occurring to establish cause and effect relationship. Examine HVAC piping and correct.
Room pressure fluctuations due to door openings	Operate system when no fluctuation are occurring to establish cause and effect relationship. Locate in area that is free from frequent door openings.
Room pressure fluctuations due to opening and closing fume hood sashes, creating sudden demands for both make-up air and exhaust capacity	Operate system when no fluctuations are occurring to establish cause and effect relationship. Locate in area that is free from frequent and sudden air changes.

3. Face velocity bad, alarm in "GREEN" normal condition

Verify	Corrective Action
Alarm never indicates low air flow.	Block sensor to eliminate airflow. If alarm goes off, adjust set point on alarm circuit board. See alarm manual.
Alarm never indicates low air flow and sensor is blocked to eliminate airflow.	Replace alarm

Sensor appearance

A quick visual check may be performed to verify that the thermistors are not broken or shorted. This is most common with the center measuring thermistor. It may be become broken from damage that occurred during installation or cleaning. Due to its small size and sensitivity, the wires connecting it to the sensor's PCB can become broken or bent. If the measuring thermistor has a broken wire, this will result in an open circuit. If the wires beneath the bead are touching, this will result in a shorted circuit. Either condition will cause a continuous alarm.



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