FUME HOOD CERTIFIED

Tri-Color Laboratory Fume Hood Dynamic Containment Protocol

October 2022

Methodology For Dynamic Containment Testing for Chemical Fume Hoods

*Building on ASHRAE 110-2016, **Tri-Color Airflow Visualizer** adds dynamic elements as suggested in the standard. Additionally, Tri-Color can be used as an alternative to SF6 Containment Testing. A modified ASHRAE 110 report can be produced using the Tri-Color data. Our **Fume Hood Performance Tracker** online software provides a format for viewing actual test results.*

This protocol was developed by the experts at Fume Hood Certified. Since 2007, lasers have been effectively used to help visualize airflow. But like the standard ASHRAE 110, it took a highly trained technician to get any actionable results. In an effort to promote more fume hoods being tested in a meaningful way, the use of this laser enhancement had to be simple to perform and the results easy to interpret and understand. Tri-Color is simple and easy to use - and the results are very visual - so anyone can see how a fume hood is performing.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance)

FOREWORD

This voluntary testing protocol is built on enhancing ASHRAE 110 testing and as a replacement for simple average face velocity readings as a method for determining a fume hood's safe performance. The following is from the ASHRAE 110-2016 standard:

> *It is important to evaluate the performance of the laboratory hood under dynamic conditions. This performance test method may be modified to evaluate a dynamic challenge. Specific operations, such as a pedestrian walking past the hood, laboratory doors opening, and specific actions at the hood, are only a few of the challenges that could be expected at the hood. This test method addresses only the dynamic challenge of sash movement. VAV hoods place a significant emphasis on the sash movement and the potential effect on hood performance. However, some constant-volume hoods may also experience a decrease in protection when the sash is moved.*

Building on this, the Tri-Color Airflow Visualizer is a series of tests designed to demonstrate fume hood airflow and containment. The protocol is designed for visualizing air flow and challenging fume hood containment in a realistic way.

Testing Protocols such as ASHRAE 110, EN 14175, and MD-15128 are excellent tests in many situations, they are also complicated, expensive, and require a trained tester. It is also difficult to really understand the reports generated from the test data.

Tri-Color has an added element, it allows you to visually see the results. If you can't see a problem, you can't fix it. Testing with Tri-Color is simple, affordable and you can see the results in real-time. Tri-Color has been developed to be a DIY Test or to be performed by a trained and certified Tri-Color Tester. The goal is to have more fume hoods tested on a regular basis. Testing is the only way to know how a fume hood is performing and whether it is providing the level of safety and protection it was designed to.

Building on the ASHRAE110 protocol for a face velocity profile and smoke visualization, along with the Canada MD-15128 standard, Tri-Color takes visualization to the next level.

CONTENT

Testing Performance of Laboratory Fume Hoods Utilizing the Tri-Color Fume Hood Visualizer

Tri-Color offers an easy upgrade to the Fume Hood Certifications that rely on face velocity testing as the primary component. There is no direct relationship between face velocity and containment. In fact, the majority of fume hoods that fail containment testing have acceptable face velocities.

Tri-Color is also an alternative to the SF6 testing utilized in the ASHRAE 110 standard. Given that SF6 is a strong greenhouse gas and is expensive and difficult to obtain in many places, it should be reserved for troubleshooting.

Tri-Color makes fume hood testing safe and simple. In addition, it is an excellent educational tool because you can see the results - you will see cause and effect in real time.

To assist with recordkeeping and compliance, we have developed the HIN (Hood Identification Number) Program that gives each hood a unique serialization.

HOOD
INDENTIFICATION
NUMBER
22-A69 P49

SCAN ME

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The HIN number interfaces with our "**Fume Hood Performance Tracker**" software. Here, each hood has a home page and is supported with test data, photos, videos, and other related data and information. It is the intent of this protocol to develop a very visual collection of content to document the hood's performance over time.

TEST PROCEDURES

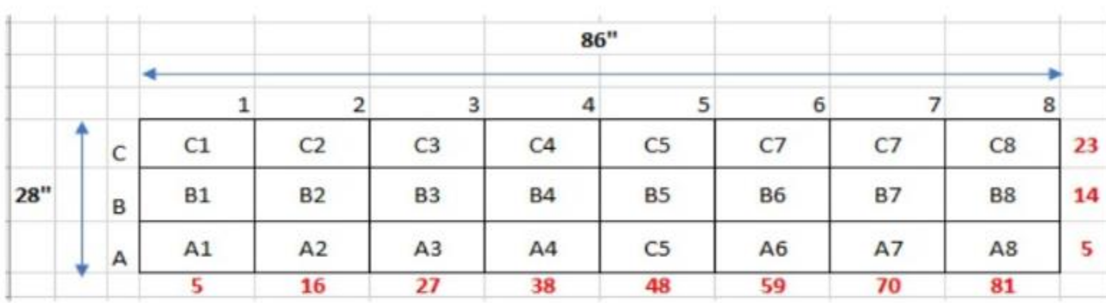
FACE VELOCITY PROFILE

Sash Stop or 18” (Design Opening)

Establish a uniform grid pattern across the face of the hood.
The cells shall be no more than 12” x 12”.

Example:

Mark Grid With Tape



Red numbers are the center of the cells

Purpose

The purpose of the face velocity profile is to understand turbulence. As air enters the sash opening it is entrained into the flow patterns within the fume chamber. Fume Hoods are very turbulent; it is this instability and dynamic airflow patterns that contribute to loss of containment.

There is no direct relationship between face velocity and containment. In fact, most hoods that fail containment testing (SF6) have acceptable face velocities. Given that the classification of the fume hood is an “Exposure Control Device”, we should focus on containment when evaluating fume hood performance - looking at just the average face velocity has no real meaning.

With the Face Velocity Profile, we can better understand what is happening at the face of the hood near the user’s breathing zone.

In a perfect world, the readings from the various grid cells would be identical, but labs are not perfect worlds and room conditions greatly influence fume hood behavior and performance.

Procedure

Whether you are using a hand-held hot wire anemometer or an array of hot wire transducers, they shall be mounted on a stand and not handheld. In each cell of the grid, take a minimum of 20 readings, one reading per second. Use this date to develop an average velocity for each cell.

This test is an indication of turbulence in the hood and a predictor of containment. The less variation from cell to cell the better the fume hood will contain.

Note: Capture photos of each test to show the setup. These should be uploaded to the Fume Hood Performance Tracker Software.

Full Open

Record reading from the center of each cell (20 readings @ 1 per second) and calculate the cell's average velocity. Once all cells have been recorded, calculate an overall average. Record the highest and the lowest cell's readings. All the cells should be plus or minus 10% of average. The difference between the high and the low reading shall be less than 20%.

Sash Stop or 18" (Design Opening)

This test is the same as the full open test but is performed at the operating position.

Record reading from the center of each cell (20 readings @ 1 per second) and calculate the cell's average velocity. Once all cells have been recorded, calculate an overall average. Record the highest and the lowest cell's readings. All cells should be plus or minus 10% of average. The difference between the high and the low reading shall be less than 20%.

Note: Best Practices are for each hood tested to have a reference ASHRAE 110 AM test report as a baseline. The As Manufactured (AM) test was performed in a test lab with near perfect conditions. When field results vary significantly from the AM test results, it is an indication that there are issues with the room conditions.

Note: For the following exercises and challenges it is imperative to record ample video to adequately capture the performance results.

Please follow these dedicated video instructions:

1. **Placement of the video camera is critical to capturing loss of containment.**
    a. **Always mount the camera on a tripod or fixed mount - outside of the hood and off to the side.**
    b. **Place the video camera so that its line of sight is as parallel with the sash plane as possible.**
2. **The video camera will capture loss of containment much more effectively if the hood's interior light is turned off.**
3. **Maximum video quality will be achieved if the room's lights can be lowered and/or natural window light is minimized.**
4. **Record the video for each exercise/ challenge for a minimum of 30 seconds.**
    a. **When troubleshooting a hood, record for a minimum of 90 seconds. The green laser can be subtle, more recorded time is best.**
5. **All video should be uploaded to the Fume Hood Performance Tracker Software.**

SMOKE VISUALIZATION (AIRFLOW PATTERNS)

Purpose

This test is a visualization of a hood's ability to contain vapors. It consists of both a small local challenge and a large-volume challenge to the hood. The intent of this test is to determine performance of the hood as it is typically used. Because the tester is often at the face of the hood while performing the tests, care shall be exercised to ensure that the body of the investigator does not influence the smoke visualization. Under ideal conditions, the smoke will flow smoothly, drawn from the point of release toward the slots in the rear baffle.

The following definitions describe typical airflow problems as demonstrated by smoke visualization:

- If the smoke remains on the work surface without smoothly flowing to the back baffle, the airflow is described as "lazy."
- If the smoke moves forward toward the front of the hood, the airflow is described as "reverse flow."
- A minimal amount of reverse flow will nearly always occur at the marine edge of the work surface and is considered normal.
- Reverse flow does not apply to the forward motion of the roll inside the hood that occurs in the upper cavity of the hood above the hood opening or to the cyclonic motion behind a closed horizontal sash.

SMALL VOLUME LOW VELOCITY SMOKE VISUALIZATION

Procedure

1. Place the sash in the test position.
2. Test the operation of the bottom airfoil by releasing smoke from the small smoke source under the airfoil.
3. For a successful test, the smoke shall be exhausted smoothly and not be entrained in the vortex at the top of the hood.
4. Discharge a stream of smoke from the small smoke source along both walls and the work surface of the hood in a line parallel to the hood face and 6 in. (150 mm) behind the face of the hood, and along the top of the face opening. Carefully observe the action in the corners.
5. Release smoke along the work surface. Carefully observe the air flow behavior.
6. All air flow behavior shall be noted.
7. Release smoke above the bottom of the sash and inside the hood.
8. Observe the airflow behind the sash with specific attention to the airflow as the hood roll meets the bottom of the sash.
9. Release smoke outside the hood.
10. Observe the airflow into the hood and determine whether the room air currents appear to affect the airflow at the hood.
11. Where appropriate, observe the influence of air entering the hood between the sash and the header panel.
12. Release smoke in the cavity above the hood opening.
13. Observe the roll inside the hood.

   a. Pay particular attention to the clearance of the smoke, the slots the smoke enters, and any tendency of the roll to follow the inside of the sash toward the opening.
14. For "as used" (AU) tests:
    a. If hot plates or other heat sources are present, observe the influence of the heat sources on the airflow inside the hood.
    b. During the test, any lazy or reverse airflow observed may be caused by the equipment and should be noted and documented.
15. For horizontal sash or combination sash configurations:
    a. Open the horizontal windows and release smoke along the inside of the sash near the open vertical edge of the sash.
16. Continue this exercise until you are satisfied that you have demonstrated this hood's behavior adequately.
17. Allow the haze to be exhausted by the hood when this exercise is completed.

LARGE SMOKE VISUALIZATION

Procedure

1. A suitable source of smoke shall be used to release a large volume of smoke.
    a. Extra care in interpreting the observations is required because of the large volume of smoke and the momentum of the smoke. This is especially true when smoke is released outside the hood.
    b. Observation of the large-volume smoke release is often best done from the side of the hood face.
2. Release a large volume of smoke within the hood.
3. Pay particular attention to the air flow/smoke's behavior:
    a. Under the airfoil.
    b. Along the sidewalls.
    c. Along the work surface.
    d. Above the bottom of the sash.
    e. Release smoke in the cavity above the hood opening.
4. If equipment is in the hood, release smoke around the equipment.
    a. Observe the smoke's behavior around the equipment.
5. For horizontal sash or combination sash hoods observe the smoke's behavior behind the sash.
6. During an "as used" (AU) test, equipment in the hood, such as heating devices and agitators, shall be operating to determine whether they contribute to leakage.
7. For ALL hoods:
    a. Release smoke outside the hood.
8. For ALL the locations and conditions above, the airflow/smoke's patterns shall be observed and noted.
9. All of the smoke generated within the hood shall be carried to the back of the hood and exhausted.
10. Continue this exercise until you are satisfied that you have demonstrated this hood's behavior adequately.
11. Allow the smoke to be exhausted by the hood when this exercise is completed.

TRI-COLOR AIRFLOW VISUALIZATION WITH CHALLENGES (Loss of Containment)

Purpose

The purpose of Tri-Color is to have a fume hood containment test that is simple, economical, and the results are easy to understand.

Many have used a simple face velocity test as a basis for determining a fume hood's safe performance even though there is no direct relationship between face velocity and containment. Given that the primary role of a fume hood is as an Exposure Control Device, the only way to ensure safe performance (containment) is with dynamic containment testing in the lab's real-world conditions.

Looking at a hood's performance on a scale of 1 to 10, with one being non-operational and 10 being a well performing hood against all the challenges, the closer we get to 10 on the scale the more robust the hood's performance is. The purpose of the challenges is to determine how robust the hood is.

Tri-Color Air Flow visualization is as much about education as it is testing. Given that you can see the relationship of what is happening in and around the hood and its impact on performance.

Procedure

Building on ASHRAE 110 smoke visualization, Tri-Color adds several new dimensions. This new approach begins with five fixed lasers - one blue, two red and two green. One additional green laser is included as a handheld laser to specifically identify air flow in any area in and around the fume hood.

BLUE - The blue laser is mounted directly onto the Tri-Color Airflow Visualizer inside the fume chamber. This blue laser highlights a cross-section of the fume chamber with emphasis on the vortex.

(Pay particular attention to the airflow behavior at the roof of the fume hood while being challenged)

RED - By using the magnets and corresponding mounting plates, affix the two red lasers on the inside of the hood's sash just above the sash handle - one laser on the left side and one laser on the right. This pair of red lasers create a red light curtain just behind the sash plane.

Once adjusted, this will help visualize what is happening with the airflow just behind the sash and near the user's breathing zone. Once the haze is dispensed, the red lasers will dramatically highlight turbulent air flow.

(Pay particular attention to the airflow that clings to the inside sash glass and near the sash handle)

GREEN - Mounted on the outside of the sash, similar to the red lasers, there are a pair of green lasers. Once properly adjusted, these lasers create a green light curtain directly in front of the sash that highlights any haze escaping the hood (loss of containment). During the challenges, any loss of haze will generally be seen via the green color and indicate a potential problem. Of course, this loss of containment needs to be examined to determine how the loss has occurred.

(Pay particular attention to the micro-puffs of green that occur right near the lower edge of the sash handle and the vertical edges of the fume hood)

The sixth laser is a handheld green laser that allows you to focus on any area. (This can aid in identifying a very specific area of concern in or around the hood by directly aiming this green laser to that area)

FORCED FAILURE

Purpose

The purpose of the forced failure is to establish a baseline for what a failure looks like on the hood being tested. It confirms proper setup and allows you to capture a video showing a failure in containment.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Insert the 90-degree elbow into the fume simulator and point it directly towards the sash opening, this should cause a failure (loss of containment) and that loss will be highlighted by the green lasers. This will give you a baseline for a failure and ensures that the setup is correct.
3. Remove the 90-degree elbow when this challenge is completed.

FULL OPEN CONDITION

Purpose

The purpose of the full open condition is to determine the hood's performance level with the sash in the set-up position. A fully open sash is the worst case for fume containment. While the hood is not intended for operation in this position (setup only), it is important to understand how the hood performs in this sash position.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Dispense haze within the hood. Stand back from the hood so as not to disturb the airflow entering the hood.
4. Pay particular attention to the airflow around the sash opening, the rear baffles and the uppermost portions of the hood's interior.
5. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
6. Allow the haze to be exhausted by the hood when this challenge is completed.

Note: Room conditions are very dynamic and are ever changing. This sash position often shows a hood failing occasionally. This is why the ASHRAE 110 SF6 containment tests run 5 minutes. It is not uncommon for a hood to lose containment only a few times during that 5-minute test.

DESIGN OPENING

Purpose

This challenge demonstrated how the hood is performing during normal operation. The design opening is the working sash height that the system was designed for. The design opening is often approximately 18”; many hoods have sash stops at this design position. Some hoods have matching arrows at the design position. This should be the position the sash is opened to when working.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Dispense haze within the hood. Stand back from the hood so as not to disturb the airflow entering the hood.
4. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment.
5. Close attention should be paid to the red highlighted haze at the bottom of the sash handle. This is the most common area for leakage to occur and is the closest to the user’s breathing zone.
6. Continue this challenge until you are satisfied that you have demonstrated this hood’s behavior adequately.
7. Allow the haze to be exhausted by the hood when this challenge is completed.

STANDING IN FRONT OF THE HOOD

Purpose

The purpose of this challenge is to validate the hood’s performance level while the operator is standing in front of the hood. While it is possible for a hood to have loss of containment even when an operator isn’t present, it is a much more common occurrence when a person is working in front of the hood. A person in front of the hood creates turbulence that can draw chemicals out of the hood.

Note: This challenge can be conducted with the sash in the design opening and/or the full open position.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Open the sash to either the design opening or full open position - depending on which challenge is being administered.
4. Dispense haze within the hood.
5. Stand directly in front of the hood as if you are the operator. Stand still with your arms slightly extended into the hood as if to be reaching for an object.
6. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment.
7. Close attention should be paid to the red highlighted haze at the bottom of the sash handle. This the most common area for leakage to occur and is the closest to the user’s breathing zone.

8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

RAPID SASH MOVEMENT

Purpose

The purpose of this challenge is to determine the hood's performance level during rapid sash movement. As the sash(es) are opened and closed they cause movement in the vortex within the hood. On a vertical sash, the vortex goes up and down with the sash. When there is rapid sash movement, it is possible for the sash to move faster than the vortex causing the potential for loss of containment.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Lower the sash to the closed position.
4. Dispense the haze within the hood.
5. While standing directly in front of the hood, raise the sash at a faster-than-normal rate to the design opening.
6. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment while the sash is in motion - especially at the edges of the sash.
7. Now, lower the sash to the closed position at a faster-than-normal rate. Again, check carefully for any signs of haze being detected by the green lasers - especially at the edges of the sash.

8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

COMBO SASH/ HORIZONTAL SASH

Purpose

The purpose of this challenge is to measure how well the hood performs with the sashes in multiple positions. Combination or Horizontal sashes create unique airflow conditions. Horizontal sash openings can create vertical multiple vortices; these vortices create significant airflow disruptions that are more prone to loss of containment than those from a traditional vertical sash design, especially along the vertical edges of the sash glass.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Lower the sash to the closed position (horizontal sashes) or lower the sash to the closed position (combo sash).
4. Determining the hood's level of performance will require moving the various sashes into multiple positions in order to detect if the hood is having difficulty containing.
5. Horizontal Sash - adjust the sashes to the positions below and check carefully for any signs of haze being detected by the green lasers, which would indicate loss of

containment - especially at the edges of the sash.

   a. Two (2) Sliding Sashes
      i. Left Opening
      ii. Right Opening
   b. Three (3) Sliding Sashes
      i. Left Opening
      ii. Center Opening
      iii. Right Opening

6. Combo Sash - Lower the entire sash to the closed position and adjust the sashes to the positions below.
   a. Two (2) Sliding Sashes
      i. Right Opening
      ii. Left Opening
   b. Three (3) Sliding Sashes
      i. Left Opening
      ii. Center Opening
      iii. Right Opening
7. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment - especially at the edges of the sash.

NOTE: Vertical edges of horizontal and combination sashes tend to create vortices at those locations which can cause loss of containment. The sash edge vortices combined with the vortices created at the roof of the sash are especially challenging for these hoods.

8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

WALK-BY

Purpose

The purpose of the walk-by challenge is to examine the effects of moving pedestrian traffic while the hood is in normal operation. This walk-by is a very difficult challenge; even the most robust hood can show loss of containment while passing all other challenges. Pedestrian traffic in front of the hood can easily draw chemicals out of the hood as the body passes by. The purpose of this challenge is to replicate pedestrian traffic and movement in front of the hood. People moving by create low pressure areas behind them that can draw chemical out.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Raise the sash to the design opening position.
4. Dispense haze within the hood.
5. Have a walking pedestrian pass parallel along the full face of the hood at a normal walking pace.
6. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment, while the pedestrian is in motion - especially at the edges of the sash.
7. Have the pedestrian repeat the pass from the opposite direction.
8. Check again for any signs of haze being detected.
9. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.

10. Allow the haze to be exhausted by the hood when this challenge is completed.

RAPID HAND MOVEMENT

Purpose

The purpose of this challenge is to demonstrate and document the effects of rapid hand movement. Rapid hand movement inside the fume chamber can disrupt airflow, create turbulence and cause loss of containment. The purpose of this challenge is to see if the hood is robust enough to maintain containment during rapid hand movement while reaching into the hood in a normal and customary way.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Raise the sash to the design opening position.
4. Dispense haze within the hood.
5. While standing directly in front of the hood, reach into the hood as if to be making adjustments or moving objects within the hood in a normal and customary way.
6. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment, especially around the operator's hands and arms. Pay particular attention to loss of containment in and around the breathing zone of the operator along the lower edge of the sash handle.
7. Repeat the challenge at various positions along the face of the hood.
8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

MATERIAL EXITING HOOD

Purpose

The purpose of this challenge is to determine the hood's performance level when moving objects in and out of the hood. When removing items from the hood, it is possible to drag chemicals out of the hood and pull these escaping chemicals directly into the operator's breathing zone.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Raise the sash to the design opening position.
4. Dispense haze within the hood.
5. While standing directly in front of the hood, move objects (i.e. flasks, scales, stands or similar items or props) in and out of the hood in a normal and customary way.
6. Check carefully for any signs of haze being detected by the green lasers, which would indicate loss of containment, especially around the operator's hands, arms and the objects. Pay particular attention to loss of containment in and

around the objects as they are moved through the sash plane.

7. Repeat the challenge at various positions along the face of the hood.
8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

LAB DOOR TEST

Purpose

The purpose of the lab door test is to determine the hood's reaction when lab room doors are opened and closed. The lab is normally under slight negative pressure compared to the hallways. When the door is opened, air rushes in. This changes the room pressure and depending on how negative the hood pressure was, this change in pressure can cause loss of containment. Containment is greatly impacted by the air balance of the room.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Raise the sash to the design opening position.
4. Dispense haze within the hood.
5. While standing directly in front of the hood, raise the sash to the design opening position.
6. Have the lab's door opened and closed in a normal way. Walk in and out of the opening, closing the door between exit and entrance.
7. Carefully check for any signs of haze being detected by the green lasers, which would indicate loss of containment while the lab door is being opened and closed.
8. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
9. Allow the haze to be exhausted by the hood when this challenge is completed.

OTHER HOODS OPENING AND CLOSING THEIR SASHES

Purpose

The purpose of this challenge is to determine the fume hood's performance when other hoods in the lab are opening or closing their sashes. Most labs have VAV (variable air volume) supply systems. Many hoods also have VAV controls. As other hoods in the system open and close their sashes, the pressure is always changing. This change in pressure can cause loss of containment when the room's balance shifts.

Procedure

1. Place the Tri-Color Fume Hood Visualizer inside the hood and correctly connect the unit, allowing for a short warm up period.
2. Ensure all the lasers are correctly in place and operational.
3. Raise the sash to the design opening position.
4. Dispense haze within the hood.
5. Randomly open and close other lab hoods, at normal speeds, leaving the sashes open long enough for the test hood to react fully to the change in pressure.

6. Carefully check for any signs of haze being detected by the green lasers, which would indicate loss of containment while the other sashes are being opened and closed.
7. Continue this challenge until you are satisfied that you have demonstrated this hood's behavior adequately.
8. Allow the haze to be exhausted by the hood when this challenge is completed.

AS MANUFACTURED (AM), AS INSTALLED (AI) AND AS USED (AU)

As Manufactured (AM)

AM identifies an "as manufactured" test, that is, the laboratory hood is built and assembled by the manufacturer and testing is performed at the factory. It is very important to understand that AM testing is accomplished under "perfect" conditions within a manufacturer's hood testing room. The purpose of this test is to evaluate the hood's design characteristics solely. There are no outside influences such as diffusers, cross drafts, temperature issues, pedestrians, etc. that can influence the hood's performance. The results of this test may have no correlation to the hood's performance once installed within an actual laboratory ventilation system.

As Installed (AI)

AI identifies an "as installed" test, that is, the laboratory hood is installed at the location of the customer. The hood is tested empty, but with the ventilation system in the installation balanced and the hood in its final location.

Tri-Color is intended to be used for **As Installed** testing. As per the ASHRAE 110 definition, this is an empty hood and is intended to verify the integration of the hood with the overall laboratory ventilation system. Since the fume hood is not a standalone device, its performance is highly dependent on room conditions. Using the AM test as a baseline, the AI results should mimic the AM results. If the AI results differ greatly from the AM results, this is an indication of a problem with the room conditions, not the hood.

As Used (AU)

AU identifies an "As Used" test, that is, the test is conducted after the hood has been installed and used by the chemist. The typical equipment remains in the hood and other activities in the laboratory continue.

In the **As Used (AU)** test, the concept is to mimic how the hood is used during its normal operation. The equipment inside the hood remains and the test is conducted accordingly.

Operator behavior is also a major component of the hood's ability to contain. Many of the challenges described earlier are intended to duplicate an operator's normal behavior to determine the hood's performance during the AU test. About 25% of fume hood failures are caused by work practices.

Using the AI test as a baseline, the AU results should mimic the AI results. If the AU results differ greatly from the AI results, this is an indication of a problem rooted in the equipment load of the hood, the operator's work habits and/or related activity, not a hood problem.

Note: Tri-Color is intended to be used for As Used (AU) testing. The Tri-Color Visualizer has an available AU adapter that allows the main Tri-Color unit to remain outside the hood and not impede any of the equipment that is inside the hood.

TEST MODIFICATIONS TO BETTER ACCOMMODATE SPECIAL SITUATIONS

There is a huge diversity of fume hoods with many different sizes and sash configurations. There are also many special application fume hoods. Regardless of the situation, the hood is designed to minimize harmful user exposure to the chemicals in the fume chamber.

The goal with Tri-Color Visualizer is to demonstrate any potential loss of containment regardless of sash configuration or dimensions; although it may be necessary to modify the protocol in order to achieve these results.

Listed below are the Tri-Color Visualizer tests and their related components.

Basic Tri-Color Test

The basic Tri-Color test is full open, design opening, and a walk-by. Regardless of the hood's configuration, the challenge remains the same, but to achieve an accurate test, modifications may be required (i.e. re-positioning of the lasers, using additional lasers, conducting multiple tests differently…)

Full Tri-Color Test

The full Tri-Color starts with the Basic Test and adds the other challenges if applicable. Much as above, modifications may be required to achieve an accurate test.

Modified ASHRAE 110 Tests

When using Tri-Color as an alternative to SF6 tracer gas for containment, there is other data that must be recorded in the Fume Hood Performance Tracker software in order to be able to generate the ASHRAE 110 report. Similar to a modified ASHRAE 110 test - SF6, the modified Tri-Color ASHRAE 110 test shall take into account the various hood configurations. Modify the tests in order to achieve an accurate test.

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