IH62400
Local Exhaust Ventilation System Measurements

1.0 Purpose/Scope

This procedure provides standardized methods for evaluating local exhaust ventilation (LEV) systems. An evaluation includes an initial test of the effectiveness of control of hazards by measurements (such as face velocity, duct velocity, and/or capture velocity) and periodic re-testing at set intervals to verify the exhaust ventilation is still operating at the levels found in the Initial test.

2.0 Responsibilities

This procedure is maintained by the SHSD Industrial Hygiene Group.

3.0 Definitions

Airfoil: Located along the bottom of the sash opening that streamlines airflow into the hood, preventing turbulent eddies that can carry vapors out of the hood. The space below the bottom airfoil provides a source of room air for the hood to exhaust when the sash is fully closed. Removing the airfoil can cause turbulence and loss of contaminant.

Area (A) **-** surface area of hood opening or duct of rectangular face opening: is measured as: A = length x width, in square feet (ft^2) or square meters (m^2).

Average Face velocity: air speed necessary to overcome opposing air currents and contain a contaminant in the hood for exhaust to the outdoors. Unit typically expressed as feet per minute (fpm).

Baffles: Moveable partitions used to create slotted openings along the back of the hood. Baffles keep the airflow uniform across the hood opening, thus eliminating dead spots and optimizing laminar flow.

Capture velocity*:* air speed necessary to overcome opposing air currents and draw a contaminant into a hood or intake. Acceptable capture velocity depends on the mass of the particulate being captured, the prevailing air currents outside the hood, thermal properties of the contaminant (ex., hot fumes rise), and the velocity of the particulate or gas relative to the hood flow (ex. belt sander throwing dust into or away from exhaust line).

- A typical value is usually about 1000 fpm for tools like saws and belt sanders.
- May be less than 100 fpm for welding gases and fumes under a canopy hood.

Constant Volume Hood: A hood, which maintains a constant volume of airflow in the exhaust duct regardless of the sash position. Proper positioning of the sash is critical in this type of hood as the face velocity changes with the sash position to maintain a constant flow. Note: Face velocities in excess of 200 feet per minute cause excessive turbulence and loss of containment.

Exhaust plenum: An important engineering feature connects the hood to the exhaust ductwork and helps to distribute airflow evenly across the hood face. Materials such as paper towels drawn into the plenum can create turbulence in this part of the hood resulting in areas of poor airflow and uneven performance.

Face: The imaginary plane running between the bottom of the sash to the airfoil. Hood face velocity is measured across this plane.

Hood Face Velocity (V): Air velocity at the plane of and perpendicular to the opening of an exhaust hood.

Hood Air Flow Rate (Q): The total volume of air that moves across the hood opening per unit time. Where Q=VxA and A=area of hood opening and V=average face velocity. The measured hood airflow rate should be within 10% of the designed flow rate if it is known. A better measure of exhaust airflow is the duct airflow.

Horizontal hood: The sash of the hood moves sideways, i.e. the tracks of the sash travel in are horizontal.

Perchloric Acid Hoods: When heated above ambient temperature, perchloric acid will vaporize and may condense on hood, duct and fan components. In addition to being highly corrosive, condensed vapors can react with hood gaskets, greases and other collected materials to form explosive perchloric acid salts and esters. A perchloric acid hood is built with welded stainless steel hood surfaces, ductwork and fan to minimize the corrosive and reactive effects. They also have a wash-down system of water fog nozzles dispersed throughout the hood and exhaust system. Washing down the hood and ductwork removes and prevents the build up of hazardous perchlorates.

Sash: The sliding door to the hood. By using the sash to adjust the front opening, airflow across the hood can be adjusted to the point where capture of contaminants is optimized. Each hood is marked with the maximum sash opening. The sash should be held in this position or lower when working in the hood and closed completely when the hood is not in use. The sash may be temporarily raised above this position to set up equipment, but must be returned prior to generating contaminants inside the hood.

Variable Air Volume Hoods: These hoods maintain a constant face velocity as sash height changes. As the sash is moved the exhaust volume is adjusted. It is best to use these hoods with the sash half open, as this provides more even air flow and a degree of face protection in case of an unexpected spill, fire or explosion in the hood. When not in use the sash should be closed to save energy.

Velocity (V): - speed of air passing a point in space. Units: English- feet per minute (fpm), Metric- meters per sec (m/s)

Walk-in Hood: A vertical or horizontal sash hood in which the sash opening goes to floor level. The sash opening allows temporary access of personnel and equipment for set-up of experimental apparatus. Occupancy during hazardous operations is not allowed.

4.0 <u>Prerequisites</u> Observe area postings and obtain approval to enter the test area, as required

5.0 Precautions

Hazard Determination: This test may be done in areas where chemicals or radiological contamination is known or suspected to be present. Have these hazards evaluated by a cognizant ESH professional. The test equipment design does not cause significant ergonomic concerns in routine use.

Personal Protective Equipment

- Eye: Safety Glasses with side shields are required.
- Hand: Contact with work surfaces should be minimized. If in areas of known or suspected chemical or radiological contamination, use of disposable, splash gloves. Acceptable elastomers are: Nitrile, PVC, and Natural Rubber.
- Body: If contact of the body with contaminated surfaces is anticipated, a disposable suit should be used. Acceptable Chemical Protective Clothing (CPC) materials include: Tyvek®, KleenGuard®, and cotton. Disposable garments must be discarded as per Hazardous Waste Management Division instruction.
- Foot: If contact of the feet is anticipated with contaminated surface, disposable shoe coverings, boots or booties should be used. Acceptable CPC material include: Tyvek®, KleenGuard®, and rubber.
- Respiratory: Under normal use, respiratory protection is not required. If chemical or radiological levels from contamination in the area cause the OSHA, ACGIH, or DOE standards to be exceeded, respirators are required.

Environmental Impact: This operation may involve release of and exposure to hazardous chemical (tracer gas and smoke tubes). Air testing meters used in this procedure do not generate Hazardous Wastes. The tracers and smoke testing equipment may generate a very low airborne concentration that is not of environmental or personal exposure consequence under typical exposure levels. Do not intentionally breathe the mist from the smoke tube/ generator. Consult the MSDS for personnel precautions

Work Planning: All requirements of work permits and work planning system reviews must be met in performing this procedure.

Job Risk Assessment: Consult the *Job Risk Assessment* SHSD-JRA-02 for the risk analysis of this operation based on the hazards and controls of this SOP.

6.0 Procedure

6.1 Inspection of LEV systems

- Verify that the exhaust ventilation system is operating.
- Inspect the exhaust system ductwork and mechanical components for any obvious signs of damage (e.g., missing or damaged seals, breached ductwork, excessive rust, or unusually loud motor noise). Notify Plant Engineering and the system owner of these conditions. Do not test if the system is not of adequate integrity.

6.2 Observe conditions in the work area, such as:

- Doors and windows: open or shut,
- HVAC system: on or off, central or room unit,

- Traffic and movement of people around the system.

6.3 Measure the controlled work place hazard: When there is reason to expect that airborne levels of the hazard may not be adequately controlled by the exhaust system (such as a capture hood on a welding operation), measure the airborne workplace exposure level.

- Verify that the current operation representatives typical conditions (i.e. hazards are being generated at full rate & system is operating fully).
- With the ventilation system on and the source generating the hazard, follow an appropriate Industrial Hygiene SOP (in section IH75) to measure the worker exposure and close to the source for the hazardous substance.
  - If the occupational exposure limit and action level are not exceeded (real-time) at the source: It is appropriate to consider the exhaust system as a non-mandatory, *best management practice*. Recommend voluntary periodic testing, as appropriate.
  - If the occupational exposure limit and action level are exceeded at the source: The exhaust system is critical and annual or more frequent validation testing is needed. Establish appropriate re-testing frequency and measurement parameters and convey them in writing to the owner(s) of the exhaust system.
  - If the occupational exposure limit and action level are exceeded at the worker breathing zone: The exhaust system is inadequate and respiratory PPE is required. Convey in writing to the owner(s) of the exhaust system the need for corrective actions.

6.4 Prior to testing a local exhaust system, verify the calibration and operability of the test equipment.

6.5 Measure appropriate operational parameter(s) for the ventilation system, using the appropriate measurement technique(s) in the Attachments or follow the manufacturer's recommended procedure. Some typical measurement parameters are:

- Pressure in ducts: total pressure, velocity pressure, static pressure,
- Differential pressure across filters,
- Velocity: capture velocity, face velocity, duct velocity traverses,
- Smoke tube/candle plume observation,
- Tracer gas measurements.

6.6 Record the test results on the appropriate *Test Record [see section 10 Forms]*. Make a drawing of the system (or take a digital photograph) and incorporate the photo/drawing into the *Test record*, as appropriate. Safety & Health Representative or Facility Support Representative may sign as the Reviewer.

Provide a copy of the form to the exhaust system owner, ESH Coordinator, Facility Project Manager, Research/Cognizant Space Manager and post the form on the ventilation system. Retain the original form in accordance with the BNL record keeping requirements.

6.7 Based on measurement of the operating parameters establish the re-testing parameter(s). SHSD's recommendation for periodic testing is:

- **12** months (or per manufacturer's recommendation) when OELs at the source are exceeded or have not been measured,
- **36** months when OELs at the source are not exceeded,

- After major modifications to the system,
- On start-up of a system that has been out-of-service, and
- When complaints of poor performance are made by operating personnel.

7.0 **Implementation and Training** Demonstrate competency in performing the tests using Attachment *Job Performance Measure* or by examination offered by the IH Group SME.

8.0 References

8.1 American Conference of Governmental Industrial Hygienists (ACGIH). Industrial Ventilation: A Manual of Recommended Practice 27th Ed. 2010.

8.2 ANSI/ASHRAE 110-1995, "Method of Testing Performance of Laboratory Fume Hoods;

8.3 ANSI/AIHA Z9.5- 2012, "Laboratory Ventilation."

8.4 BNL SBMS Subject Area *Exhaust Ventilation.*

9.0 Attachments

4.1 Lab hood Face Velocity Measurements- Constant Volume Hoods
4.2 Lab hood Face Velocity Measurements- Variable Volume Hoods
4.3 Smoke Tests of Lab Hoods
4.4 Capture Velocity Measurements
4.5 Duct Velocity Measurements
4.6 Tracer Gas Measurements
4.7 In-place Sorbent Efficiency Testing
4.8 Exhausted Laminar Flow Hoods
4.9 *Job Performance Measure*

10.0 Labels & Forms

10.1 Sample Labels
10.2 Exhaust Ventilation forms

- *LEV Initial Evaluation Record form*
- *Periodic Evaluation Record form*
- *Capture Velocity form*
- *Round Dust Traverse form*
- *Rectangular Dust Traverse form*
- *Laboratory Hood Face Velocity Test- Constant Volume form*
- *Laboratory Hood Face Velocity Test- Variable Volume form*
- *Tracer Gas Evaluation form*

11.0 Documentation

ISM Review - Hazard Categorization	☐ High	☒ Moderate	☐ Low/Skill of the craft
Validation:	☐ Formal Walkthrough	☒ Desk Top Review	☐ SME Review

Rev	Revision History
0	New Procedure. Prepared By: R. Selvey 11/20/02;Reviewed By: J. Peters 11/22/02; Facility Support Rep. C. Weilandics;11/22/02; Approved By: R. Selvey IH Manager 11/22/02
1	Revised Section 7 and added new Section 10 format. Added JPM Attachment 9.2. Reviewed By: R. Selvey 10/31/05
2	Minor text changes to Section 1 for clarity. Section 2 updated to reflect responsibilities of non-SHSD organizations. Section 5 re-ordered for clarity and added the JRA. Document Control Rev dates added to Attachments 9.2 and 9.3. Reviewed By: R. Selvey 5/31/07
3	Total re-write of the SOP to merge IH 62400, 62410, 62420, 62460, 62480. Section 1 Scope merged and streamlined. Attachments were update with new form numbers. Reviewed By: R. Selvey 09/14/09
4	Merged IH62390 and 62425 as Attachments. Reviewed By: R. Selvey 10/05/09
5	Replaced “Building Manager” with “Facility Project Manager” in all locations and forms. Reviewed By: R. Selvey 12/06/11
6	Full review of all sections. Added Attachment on variable Volume Hood testing. Reviewed By: W. Litzke, R. Selvey 08/28/13
7	Addressed comments from RCD on Attachment 9.1; 9.2, and 9.3 Reviewed By: D. Ryan; R. Selvey 08/28/13
8	Changed step in Attachment 9.1 on constant volume Hood to use the “1 sq.ft’ sample size. This makes the CV and the VAV methods the same technique. Reviewed By: W. Litzke, R. Selvey 09/09/13.
9	Changed acceptance criteria and test method for face velocity in Attachments 9.1 and 9.2 and on their corresponding forms. SME Reviewer/Date W. Litzke 10/14/13
10	Removed smoke matches in the processes in Attachments 9.1 and 9.2 and on their corresponding forms (VAV and CV face velocity). Minor editorial changes. SME Reviewer/Date W. Litzke 12/17/13
11	Revised format of Section 11. Reviewer: R. Selvey 03/06/14

Attachment 9.1

Laboratory Hood Face Velocity Measurements for Periodic Surveillance of Constant Volume Hoods

This procedure provides a standardized method for conducting periodic face velocity measurements of chemical hoods.

Equipment:

- Calibrated air velocity meter such as the swinging vane anemometer or thermal anemometer.
- Airflow visualization such as smoke tubes.
- Measuring ruler, ring-stand to hold velocity measurement probe.
- Labels/Signs for acceptable face velocity, sash height and failure notice.

Method:

1. Notify the hood user/owner that "smoke" will be used for visual verification. Verify the approval of the experimenter to use this material regarding its effect on the experimental equipment. Dry Ice can be used as a substitute when "smoke" is not acceptable.

2. Verify that the exhaust ventilation system is operating.

3. Observe any airflow warning device for proper operation. Test for proper operation if possible.

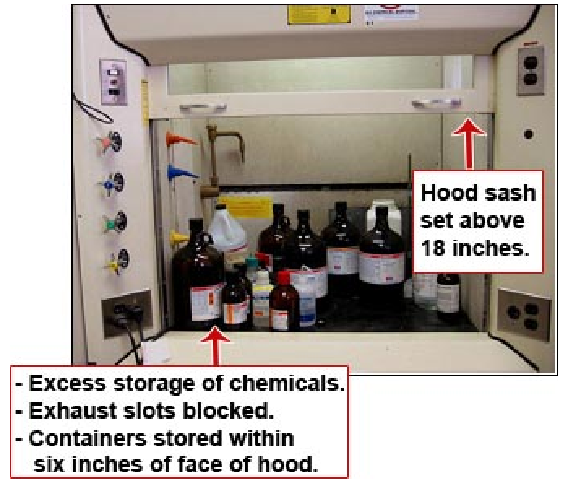
4. Visually observe the hood enclosure, visible ductwork in the room, and readily visible mechanical components for any obvious signs of damage (e.g., non-functioning sash, missing or damaged parts, breached ductwork, excessive rust, unusually loud motor noise, etc). Notify the system owner of these conditions so they can contact the Facility Project Manager. Do not test if the system is not operable or not of adequate integrity.

5. Ensure that multi-speed systems are functioning at all levels (as each level is to be tested independently.)

6. For HEPA filtered hoods: Observe the Differential Pressure gauge reading records. If the pressure readings exceed 2 inches gauge water pressure (from its initial pressure), then the filter needs replacement. Report the status to the owner. Check for a test label that indicates a current HEPA surveillance test has been performed.

7. Evaluate the existing use of the hood for chemical container storage and experimental equipment problems such as: excessive chemical containers or equipment blocking air intakes or outflows (such as furnaces or ovens). Notify the lab owner if the system has conditions that adversely affect airflow through the face. Do not test a system with blocked airways.

8. Look for conditions that can have adverse impact on the effectiveness of the LEV system. Work with the system owner to make any "quick fixes". Use the "Comments" section of the survey form to document any of these conditions:
   - Open doors and windows that impact the negative pressure of the hood to adjoining spaces.
   - HVAC system not supplying adequate air flow.
   - Excess people and equipment traffic around the system.
   - Unacceptable storage of equipment around the system.
   - Unacceptable storage of equipment inside the unit.
   - Multiple hoods or other equipment competing for airflow.



9. **Smoke Test**: Perform a smoke test per Attachment 9.3

10. Remove the "Maximum Opening" sticker from the hood if it has been previously tested.

11. **Face Velocity Measurements:** The equipment and containers for normal operations should be in place within the hood at the time the face velocity test is performed.

12. Set the sash to a height of 12-24 inches to start testing. If necessary, conduct measurements for a higher sash height if required by the experimenter. A sash height of less than 19 inches provides eye protection for most hoods and should be the maximum setting when possible.

13. Divide the hood opening into an imaginary grid with boxes of equal size, each with maximum area of 1.0 ft^2. A measurement is to be taken at the center of each imaginary box.

Example: LabCrafters, Air Sentry

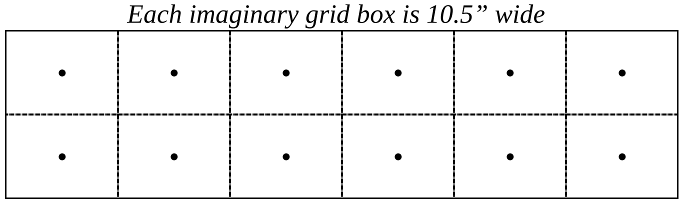
Example: A hood has an opening 63" wide and a 100% height (i.e. locked sash) of 18". The imaginary grid sizes are:

Number of grids	***Round up to next whole number***	***Size of grid***
Width: 63"/12 = 5.25 grids	*5.23 → 6 grids*	*63"/6 grids = 10.5" wide*
Height: 18"/12 = 1.5 grids	*1.5 → 2 grids*	*18"/2 grids = 9" high*

For this example:

Each imaginary grid box is 10.5" wide

Each imaginary grid box is 9" high



14. Secure the velocity probe on a stand (ring stand or microphone stand) and place the probe head in the proper orientation at the center of each grid. Place the probe in the plane of the hood sash, perpendicular to the hood face and in vertical alignment with the sash. Stand to the side during measurement so as to affect the airflow as little as possible.

15. Measure the face velocities at each point over a period of at least **5 seconds**. Take the average of at least **four readings** at each point (i.e. total of 20 seconds at each imaginary grid box center).

16. Record the readings at each sample location on the *Laboratory Hood Face Velocity Periodic Validation* form. If the velocity is below 80 fpm in any section, lower the sash height and repeat the test.

17. When all readings in each section are at least 80 fpm, calculate the average of all sample locations. If the average is <100 fpm, lower the sash and repeat.

18. The hood PASSES the surveillance test, when all of the following criteria are acceptable:
    - Smoke tests:
        - Smoke released outside the hood at the face flows inward (over the entire face of the hood).
        - Smoke released within the hood does not leave the hood.

    - Sash height provides at least 12 inches opening (at the 100 fpm average setting).
    - Average Face Velocity ≥ 100 fpm.
    - If the average flow ≥ 180 fpm, consult with the Exhaust Ventilation SME. A tracer gas test must be performed. Once the tracer gas test establishes that containment is acceptable, the maximum face velocity can be set based on the tracer gas study results.
    - No single face velocity measurement is < 80 fpm.
    - All results are +/- 20% of the average flow rate.

19. Post the Hood:
    - Post a label on the hood (at the passing sash height) noting the test date and name of tester.
    - Take a photo of the hood showing test conditions with all equipment/chemicals/gas cylinders and new position of the sash. Import the photo into the *Lab Hood Periodic Face Velocity Periodic Validation* form and post near the hood.
    - If the average is below 100 fpm: Lower the sash while observing the velocity until the readings are acceptable. Do not lower the sash less than a height of 12 inches. If the hood will not pass at 12 inch sash height it fails the standard testing. Post the *Laboratory Hood Testing Failure Notic*e label on the hood.

Attachment 9.2

Face Velocity Measurements for Periodic Surveillance of High Efficiency (Reduced-Flow) Hoods with Variable Volume

This procedure provides a standardized method for testing fume hoods that operate at average face velocities of less than the 100 fpm. At BNL, reduced flow hoods include balance enclosures for powder weighing, and energy efficient, high-performance fume hoods with variable air volume control (VAV).

A lower minimum face velocity may be set if the system passes a tracer gas containment test conducted as described in ASHRAE 110, Method of Testing Performance of Laboratory Fume Hoods or by a test recognized to be equivalent. A control level at a generation rate of 4 LPM passes at ≤0.05 ppm "As Manufactured" (AM), and ≤0.10 ppm "As Installed" (AI), and ≤ 0.10 ppm "As Used" (AU).

Equipment:
- Calibrated air velocity meter such as the swinging vane anemometer or thermal anemometer.
- Airflow visualization such as smoke tubes.
- Ruler, ring-stand to hold velocity measurement probe.
- Labels/Signs for acceptable face velocity, sash height and failure notice.

Method:
1. Notify the hood user/owner that "smoke" will be used for visual verification. Verify the approval of the experimenter to use this material regarding its effect on the experimental equipment. Dry Ice can be used as a substitute when "smoke" is not acceptable.

2. Verify that the exhaust ventilation system is operating.

3. Verify that low-flow alarms are properly operating. Raise or open the sash to reduce flows to below acceptable levels to activate the alarm.

4. Visually observe the hood enclosure, visible ductwork in the room, and readily visible mechanical components for any obvious signs of damage (e.g., non-functioning sash, missing or damaged parts, breached ductwork, excessive rust, unusually loud motor noise, etc). Notify the system owner of these conditions so they can contact the Facility Project Manager. Do not test if the system is not operable or not of adequate integrity.

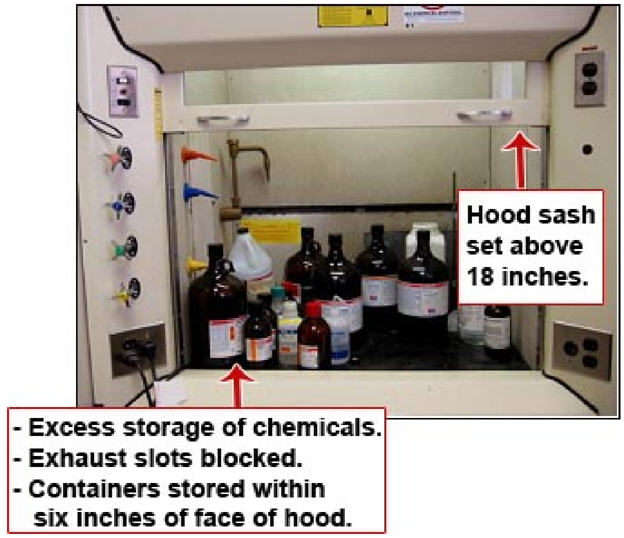
5. Ensure that multi-speed systems are functioning at all levels (as each level is to be tested independently.)

6. For HEPA filtered hoods: Observe the Differential Pressure gauge reading records. If the pressure readings exceed 2 inches gauge water pressure (from its initial pressure), then the filter needs replacement. Report the status to the

owner. Check for a test label that indicates a current HEPA surveillance test has been performed.

7. Evaluate the existing use of the hood for chemical container storage and experimental equipment problems such as: excessive chemical containers or equipment blocking air intakes or outflows (such as furnaces or ovens). Notify the lab owner if the system has conditions that adversely affect airflow through the face. Do not test a system with blocked airways.

8. Look for conditions that can have adverse impact on the effectiveness of the LEV system. Work with the system owner to make any "quick fixes". Use the "Comments" section of the survey form to document any of these conditions:
   - Open doors and windows that impact the negative pressure of the hood to adjoining spaces.
   - HVAC system not supplying adequate air flow.
   - Excess people and equipment traffic around the system.
   - Unacceptable storage of equipment around the system.
   - Unacceptable storage of equipment inside the unit.
   - Multiple hoods or other equipment competing for airflow.



9. **Smoke Test:** Perform a smoke test as per Attachment 9.3.Remove the "Maximum Opening" sticker from the hood if it has been previously tested.

10. Remove the "Maximum Opening" sticker from the hood if it has been previously tested.

11. F**ace Velocity Measurements:** The equipment and containers for normal operation should be in place within the hood at the time the face velocity test is performed.

12. Plan the first round of measurements with the sash at the desired or factory set operating full sash opening (100% height). Units with VAV control typically have a sash lock at a height of 18"; balance enclosures may have lower sash heights.

13. Divide the hood opening into an imaginary grid with boxes of equal size, each with maximum area of 1.0 ft^2. A measurement is to be taken at the center of each imaginary box.


Example: LabCrafters. Air Sentry

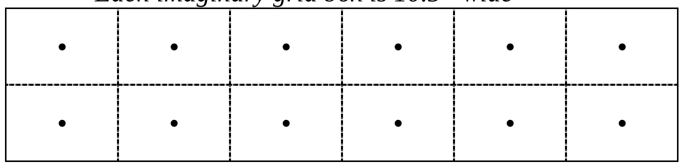
Example: A hood has an opening 63" wide and a 100% height (i.e. locked sash) of 18".
The imaginary grid sizes are:

Number of grids	***Round up to next whole number***	***Size of grid***
Width: 63"/12 = 5.25 grids	*5.23 → 6 grids*	*63"/6 grids = 10.5" wide*
Height: 18"/12 = 1.5 grids	*1.5 → 2 grids*	*18"/2 grids = 9" high*

For this example:

Each imaginary grid box is 10.5” wide

Each imaginary grid box is 9” high



14. Secure the velocity probe on a stand (ring stand or microphone stand) and place the probe head in the proper orientation at the center of each grid. Place the probe in the plane of the hood sash, perpendicular to the hood face and in vertical alignment with the sash. Stand to the side during measurement so as to affect the airflow as little as possible.

15. Measure the face velocities at each point over a period of at least 5 seconds. Take the average of at least four readings at each point (i.e. total of 20 seconds at each imaginary grid box center).

16. Record the readings at each sample location on the *Laboratory Hood Face Velocity Periodic Validation* form.

17. Determine if the face velocity is STABLE (i.e. “turbulent” or “laminar”). While conducting the four 5-second readings at each sample point, determine the change in face velocity over the 20 second period. A system is considered stable when velocities are within +/- 10% of the average velocity at that location. Note unstable conditions in the report form.

18. Determine if the Variable Air Volume (VAV) Control BIAS is acceptable. The average face velocities are expected to be about the same at the different sash positions (height of opening) if the controls are calibrated properly. However, some controls have an inherent bias in one direction or the other (i.e. the average velocity may increase or decrease with increasing sash position).

- Take face velocity readings along the horizontal traverse with the sash at 50% of the design height (i.e. lowered half-way). Calculate average face velocity at the 50% height.
- Take face velocity readings along the horizontal traverse with the sash at 25% of the design height. Calculate average face velocity at the 25% height.
- Compare the average face velocities at 100%, 50% and 25% heights. Note the type of response:

  Flat Response = face velocity remains relatively uniform at all sash heights,
  Positive Bias = face velocity goes down as the sash height is lowered;
  Negative Bias = face velocity goes up as the sash height is lowered.

The table below gives a ***hypothetical example*** *of the three types of basis:*

Sash Position	***Average Velocity (hypothetical example)***		
	Flat Response	***Positive Bias***	***Negative Bias***
100%	*84 fpm*	*105 fpm*	*83 fpm*
50%	*79 fpm*	*86 fpm*	*103 fpm*
25%	*82 fpm*	*69 fpm*	*127 fpm*
Average of (3) sash positions	*82 fpm*	*87 fpm*	*104 fpm*

19. The hood PASSES the surveillance test, when all of the following criteria are met:
    - Smoke tests:
        - Smoke released outside the hood at the face flows inward (over the entire face of the hood).
        - Smoke released within the hood does not leave the hood.
    - Face Velocity:
        - Average Face Velocity at full (100%) sash height (i.e. 18”) is within the range 70 – 150 fpm.
        - If the average flow >150 fpm, consult with the Exhaust Ventilation SME. A tracer gas test must be performed. Once the tracer gas test establishes that containment is acceptable, the maximum face velocity can be set based on the tracer gas study results.
        - No single face velocity measurement is <60 fpm at full sash height.
        - All traverse point average velocities are +/- 20% of the average face velocity at full sash height.
        - Mean velocity at each sash position is +/- 20% of the average of the (3) positions.

20. Post the Hood:
    - If the above criteria are met, then the hood PASSES the surveillance test.
        - Post a label on the hood (at the sash height) noting the test date and name of tester.
        - Take a photo of the hood showing test conditions with all equipment/chemicals/gas cylinders. This photo is to be imported to the *Lab Hood Face Velocity Surveillance Report* form and post near the hood.
    - If the above criteria are not met, then the hood FAILS the surveillance test.
        - Post the *Laboratory Hood Testing Failure Notic*e sign on the hood.

Attachment 9.3

Smoke Tests for Lab Hoods

A smoke test is used to evaluate conditions in an area surrounding a hood and conditions within a hood and the impact of airflow and the ability of the hood to contain contaminants and to verify airflow direction.

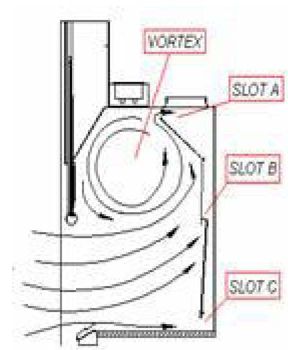
Conditions that can cause a hood to have an unacceptable smoke test include:

- Drafts from nearby doors and windows that conflict with the airflow into the hood.
- People and equipment traffic around the system that create eddies at the hood face.
- Storage of equipment around the system that blocks the airflow in front of the hood.
- Storage of equipment inside the unit that blocks acceptable air patterns.
- Adjacent hoods or other exhaust equipment that redirect the airflow.

Steps in performing a smoke test:

1. Notify the hood user/owner that "smoke" will be used for visual verification. Verify the approval of the experimenter to use this material regarding its effect on the experimental equipment. Dry Ice can be used as a substitute when "smoke" is not acceptable.

2. Observe airflow patterns and time for hood clearance. Using a "smoke" generating device, release smoke in patterns to test the air flow:



   - Release smoke outside the hood at various points along the vertical face of the hood and under the bottom airfoil to ensure inward flow at all locations. Smoke should flow smoothly into the hood and not be entrained in the vortex at the top of the hood.
   - Release smoke along both walls and the floor within the hood in a line parallel to the hood face about 6 inches into the hood, and along the top of the face opening. Smoke should remain within the hood.
   - Release a stream of smoke inside the hood at the back of the hood. There should be minimal air movement toward the face of the hood (reverse airflow). There should be no zones with lack of air movement (dead air space).
   - Release smoke at the work surface of the hood and along all equipment in the hood. All the smoke should be carried to the back of the hood and exhausted.

3. Where flow problems are observed, notify the system owner of the problem. Assist with the owner in correcting any condition(s) that can be addressed easily addressed, such as relocating chemical bottles and equipment. If problems cannot be corrected, stop further testing, and post a failure notice on the hood.

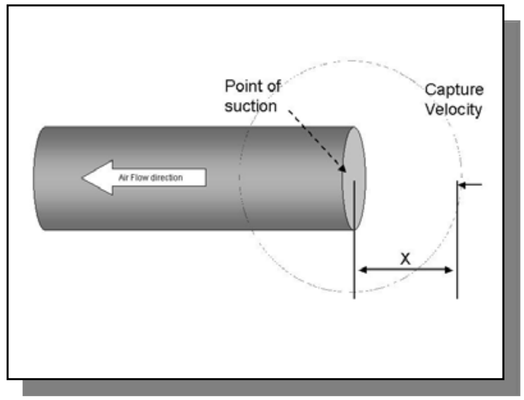
Acceptable Results: The hood PASSES the smoke test, when based on the following qualitative rating scale:

Rating	P/F	Observations
Bad	Fail	Smoke observed escaping from the hood.
Poor	Fail	Reverse flow of smoke near opening. Lazy flow into opening along boundary. Observed potential for escape.
Fair	Pass	Some reverse flow, but not at the opening. Smoke released outside the hood flows inward (over the entire face of the hood). Smoke released within the hood does not leave the hood.
Good	Pass	No reverse flows. Active flow streams into hood around boundary. Smoke released outside the hood flows inward (over the entire face of the hood). Smoke released within the hood does not leave the hood.

4. Record on the survey form that a smoke test was done. Also record the reasons for a test failure.

Attachment 9.4
Capture Velocity Measurements

This procedure provides a standardized method for determining the effectiveness of a local exhaust ventilation system (LEV) that capture a contaminant released outside of the ductwork, i.e., the capture efficiency. The "zone of capture" is visualized by releasing smoke from a smoke tube around the intake to the LEV. At numerous points in the vicinity of the intake, velocity measurements are to be made.



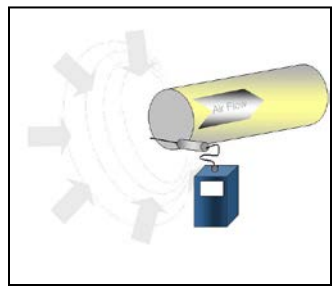
Equipment:

- Air velocity meter such as the swinging vane anemometer or thermal anemometer. Follow the appropriate SHSD IH SOP on the operation of the meter.
- Measuring ruler.

Method:

1. Smoke Tube: Release smoke tube vapor/fume into the air in the vicinity of the duct intake. Move the smoke release point to various locations around the duct opening until the zone of capture is visualized.

2. Place the velocity-measuring meter's probe at various locations around the duct opening until the zone of capture is measured.



3. Record the reading at each point tested. Optimum results are obtained when a systematic sampling pattern, such as radii, grids, or other suitable techniques are used. Record the test results on a *LEV Capture Velocity* form, or suitable alternative.

4. Compare results with the needed control velocity from the Table below or other suitable reference.

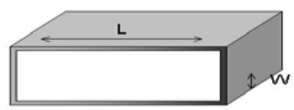
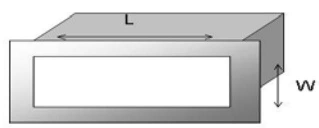
5. Transfer the velocity values to the *LEV System Initial Evaluation Test Record* or *LEV System Periodic Validation Test Record,* if applicable.

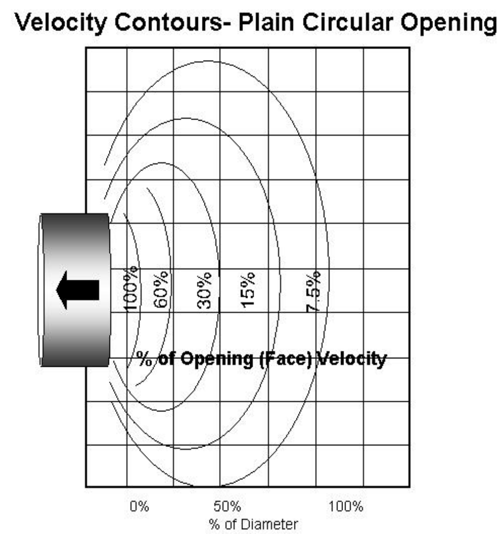
6. Post a label or tag on the LEV equipment noting the test date and name of tester.

Table 1: Reference on Capture Velocities

RANGE OF CAPTURE VELOCITIES		
Condition of Dispersion of Contaminant	**Example**	**Capture Velocity (fpm)**
Released with practically no velocity into quiet air	Evaporation from tanks, degreasing, etc.	50 - 100
Released at low velocity into moderately still air	Spray booths, intermittent container filling, low speed conveyors, welding, plating, pickling	100 - 200

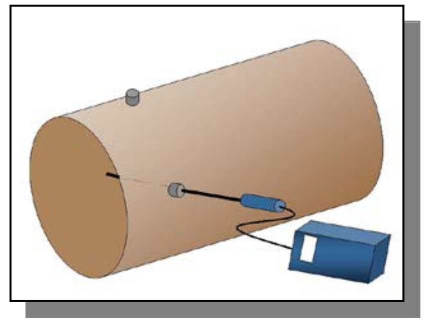
Active generation into zone of rapid air motion	Spray painting in shallow booth, barrel filling, conveyor loading, crusher	200- 500
Released at high initial velocity into zone at very rapid air motion	Grinding, abrasive blasting, tumbling	500 - 2000

Hood Type	Description
Slot [W/L <0.2] **Q= 3.7 LVX**	
Flanged Slot **Q = 2.6 LVX**	
Plain Opening **Q = V (10X^2+A)**	
Flanged Opening **Q = 0.75 V(10X^2+A)**	



Attachment 9.5

Duct Velocity Measurements



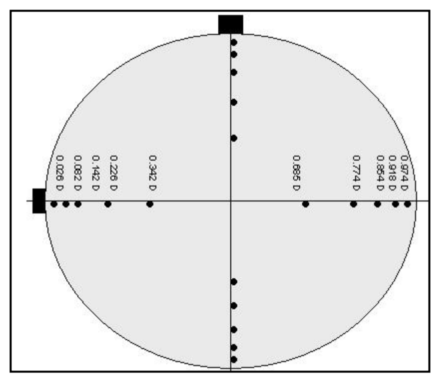
This procedure provides a standardized method for conducting a duct traverse to measure the velocity in a local exhaust ventilation (LEV) system. The duct traverse method offers a superior measurement over a single "center-line" measurement because it takes multiple measurements in equal areas across the surface area of a round or rectangular duct. This accounts for differences in airflow and density at various locations within the air pathway. These variations in flow result within a duct from the compression of the moving air. System components such as elbows, expansion, contractions, rough walls, protrusions, fans, and filters can cause the airflow at any given point in a duct to not be uniform.

Equipment:

- Air velocity meter such as the swinging vane anemometer or the thermal anemometer. Follow the appropriate SHSD IH SOP or instrument manual on the operation of the meter.
- Measuring ruler.

Method:

1. Locate the sampling ports.



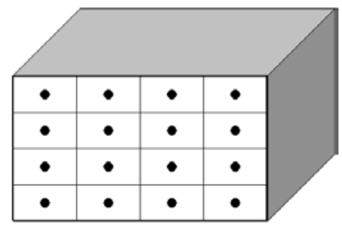
- Find the holes in the duct that are used for insertion of the test probe. They may have flanges, fitting, tape, or other sealing mechanism that will be removed.
- If no sampling ports are found, consult with an IH professional for placement of ports. Then contact Plant Engineering to install the ports. Wherever possible, the ports should be located at least 8 duct diameters downstream and 2 duct diameters upstream from any major air disturbance such as an elbow, fans, filters, branch entry, etc.
- For round ducts, at least two sample ports are needed at 12 and 3 or 9 o'clock.
- For rectangular and square duct, sufficient sampling ports must be installed to allow sampling a grid of at least 16 samples points evenly spaced across the surface of the duct.

2. Measure the duct inner diameter of round ducts or the length and width of rectangular duct. Acceptable measuring techniques are:
   - Round: Take measurements of the outer dimensions (minus any insulation thickness and duct wall thickness) and calculating the diameter via: D = circumference / 3.14),
   - Rectangular: Take measurements of the outer dimensions (minus any insulation thickness and duct wall thickness),
   - Insert a measuring device into the duct and measuring the inner dimension.
   - Corrugated duct: Insert a measuring device into the duct and measuring the inner dimension at the largest

point.

3. Mark the probe of the testing apparatus with unit measurements such as inches or centimeters so that the depth of insertion into the duct can be readily detected during the traverse.
   Note: Some meters come with the mark pre-etched into the probes. Make sure a collapsible probe is fully extended so the marks are correctly spaced.

4. Insert the probe of the testing apparatus into the duct and take readings into the equal area sections. The number of sample points in each traverse is determined by the size of the duct. For round ducts 6 inches and smaller: 6 traverse points per axis.
   - For round ducts larger than 6 inches: 10 traverse points per axis.
   - For very large round ducts and discharge stacks with wide variation in velocity: 20 traverse points per axis.
   - For square or rectangular ducts: divide the cross section into equal rectangular areas. Minimum number should be 16 and the greatest distance between points should be 6 inches. Take reading at center of each rectangular area.



5. Record the test results on a *LEV Round Duct Traverse* form, the *LEV Rectangular Duct Traverse* form, or equivalent.

Equal Surface Areas for Round Ducts larger than 6 inches in diameter

10 Traverse Points for LARGE circular duct	Distance of insertion of probe into duct (inches)									
Dia (inch)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	.026d	.082d	.146d	.226d	.342d	.658d	.774d	.854d	.918d	.974d
> 6	1/8	½	7/8	1 3/8	2	4	4 ¾	5 1/8	5 ½	5 7/8
8	¼	5/8	1 1/8	1 ¾	2 ¾	5 ¼	6 ¼	6 7/8	7 3/8	7 ¾
10	¼	7/8	1 ½	2 ¼	3 3/8	6 5/8	7 ¾	8 ½	9 1/8	9 ¾
12	3/8	1	1 ¾	2 ¾	4 1/8	7 7/8	9 ¼	10 ¼	11	11 5/8
24	5/8	2	3 ½	5 ½	8 ¼	15 ¾	18 ½	20 ½	22	23 3/8
36	1	3	5 ¼	8 1/8	12 3/8	23 3/8	27 7/8	30 ¾	33	35

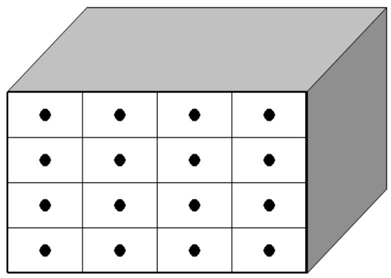
Equal Surface Areas for Round Ducts 6 inches and smaller in diameter

6 point Traverse Points for SMALL circular duct	Distance of insertion of probe into duct (inches)					
Diameter (inch)	**1**	**2**	**3**	**4**	**5**	**6**
	.043d	.146d	.296d	.704d	.854d	.957d
3	1/8	½	3/8	2 1/8	2 ½	2 7/8
4	1/8	3/8	1 1/8	2 7/8	3 3/8	3 7/8
5	¼	¾	1 ½	3 ½	4 ¼	4 ¾
6	¼	7/8	1 ¾	4 ¼	5 1/8	5 ¾

Conversion from diameter to surface area of round duct

Dia. (inch)	1	2	3	4	5	6	7	8	9	10	12	16	20	24	30	36
Area (ft²)	.005	.022	.049	.87	.136	.196	.267	.349	.442	.545	.785	1.40	2.18	3.14	4.91	7.07

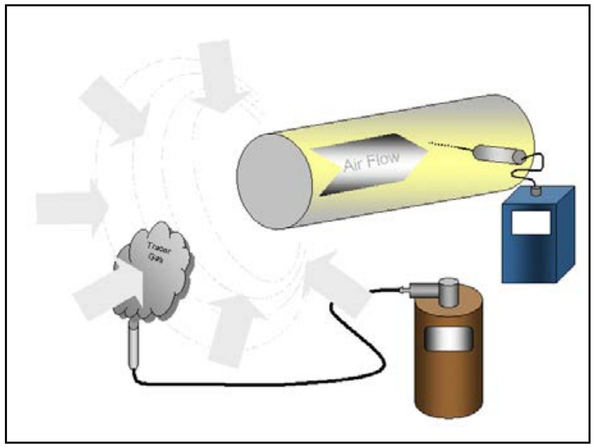
Rectangular Ducts

 **(Distance between centers <u>not</u> <u>more</u> than 6 inches.)**	Airflow and velocity in the cross section area of a duct may not be uniform. Velocity is typically less at the edges and at a maximum in the center of the duct. Measurement of the velocity at only one point in the duct or face will not yield a true value for the average within the duct. For the highest accuracy, it is necessary to average the velocity measured at points of EQUAL AREA within the duct. The figure to the left gives an example of where the sampling points should be taken across the face of the hood or duct. These points are the center of equal areas in the duct. **The maximum distance between the centers should not be more than 6 inches.** The total number of sample points is determined by the area of the duct.

Attachment 9.6

Tracer Gas Measurements

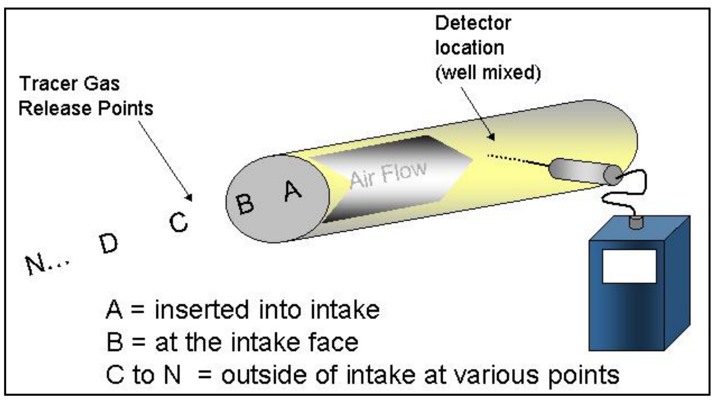
This procedure provides a standardized method for conducting tracer gas analysis of work areas where local exhaust ventilation (LEV) systems are used. The Tracer Gas test method offers a safe method to establish the effectiveness of engineering controls.



In this method, a relatively low toxicity gas (such as carbon dioxide or sulfur hexafluoride) is released under controlled circumstances into the area of capture of the exhaust system. The airborne concentration of the tracer gas is measured at fixed location in the duct. The tracer gas is injected at various points outside the system and is drawn into the exhaust ventilation system. By comparing the concentration of tracer gas entering the exhaust system, the effectiveness of the system to capture the hazard at its release point can be made. By moving the tracer gas release point in a systematic pattern, the region of capture can be detected.

Test Equipment:
- Direct reading meter that detects tracer gas. Follow the appropriate SHSD IH SOP or RCD SOP on the operation of the meter.
- Tracer Gas and gas distribution system.

Method:
1. Locate a sample probe port in the duct: Find a suitable hole in the duct for insertion of the test probe. If no sampling ports are found, consult with Plant Engineering to install the ports. Wherever possible, the ports should be located at least 8 duct diameters downstream and 2 duct diameters upstream from any major air disturbance such as an elbow, fan, filter, branch entry, etc.



2. Shut down the operation that generates the hazard.
3. Leave the exhaust ventilation system on.
4. Insert the meter probe into the duct at a point of well-mixed concentration. (See step 6.3) Measure the background level of the room and of the tracer gas in the duct prior to injecting any gas into the system.
5. Release tracer gas at various points near the intake and record the change in the meter reading. Places to release the gas include:
   - Inside the intake a few inches,
   - At the face of the exhaust system intake,
   - At the operation's point of hazard generation, and
   - At other points to establish the "zone of capture".

6. Compare the reading at each release point outside the duct with the reading when the gas was released inside the duct. Determine the percentage of control from:

$$\%\text{ of Control} = \frac{\text{Concentration at outside release point}}{\text{Concentration at release inside the exhaust system}} \times 100$$

7. Record the existing test results on a *LEV Tracer Gas Evaluation* form or equivalent.

SHSD Environmental Evaluation of SF_6 Tracer Gas Studies

Frequency of Operation: 0-1 times per year

Environmental impact:
The SF_6 is considered a low hazard to occupants. In a test, the gas is released in concentrations that result in a few ppb within the building volume of air. All of the gas is eventually discharged to the environment via exhaust stacks, HVAC, or infiltration from the building by natural air currents and occupant movement in and out of the building.
SF_6 is an ozone depleting substance. Verify the use of SF_6 with the Environmental Compliance Representative prior to use. Consider an alternative gas when practical.

Waste Disposal: None, all the gas is intentionally released into the atmosphere.

ATTACHMENT 9.7

In-place Sorbent Efficiency Testing

This procedure provides methods for the in-place efficiency testing of exhaust chemical sorbent systems at BNL (adsorbent or absorbent units). The test described in this SOP involves an organic chemical being injected into an absorber/adsorber exhaust ventilation system during testing. Penetration of this challenge agent through the sorbent is measured downstream of the injection site and adsorber.

Upon installation and use in the field, absorber/adsorbers may need to be periodically evaluated to verify that saturation of the sorbent has not occurred. This evaluation is known as “in-place” testing and is designed to measure the removal efficiency of the sorbent. The criteria for the acceptance of an in-place test is a removal efficiency of >/= 99.97%, (i.e., a change in downstream airborne concentration of >/= 99.97% from upstream concentration). However, if the facility being tested has its own BNL approved performance specification, that specification will be used.

Equipment:

- An organic chemical (use of an OSHA/ACGIH carcinogen is prohibited).
- Chemical vapor detector (such as the Miran SapphIRe or TVA 1000)
- Sampling train (Tygon/teflon tubing and probes)

1. Identify the vapor release and sampling point locations. The upstream adsorber sampling point should be at least 10 duct diameters from the vapor release/system entry point to provide for a well-mixed suspension in the air mass. Similarly, the downstream sampling point should be located at least 10 duct diameters downstream from the adsorber housing. Where sampling points cannot be located at these distances due to the physical configuration of the ductwork, efforts should be made to maximize these distances to the greatest possible extent.

2. Activate the ventilation system or otherwise verify that the ventilation system is operating.

3. Inspect the external surface of adsorber system and its associated ductwork and mechanical components for any obvious signs of damage, e.g., missing or damaged seals, breached ductwork, excessive rust, unusually loud motor noise. Notify Plant Engineering e of these conditions.

4. Attach sample collection tubing to the detector and warm-up the chemical test meter as per the SOP for operation of the meter. Calibrate and zero the instrument according to manufacturer’s procedures.

5. Insert sample probes into the duct centerline at both the upstream and downstream sampling points. For sampling locations with existing sampling ports or nozzles, insert the sampling probe as appropriate.

6. Assemble the vapor generator system. Place the chemical vapor generator nozzle into air stream, upstream of adsorber, at a point as described above. For laboratory hood systems, it is often most expedient to release the challenge vapor directly into the fume hood.

7. On the chemical meter, measure the vapor concentration in the ventilation system until a stable measurement is obtained.

8. Measure upstream and downstream vapor concentrations as follows:
   a. Record static pressure drop across adsorber(s) if a gauge is present
   b. Measure upstream vapor concentration
   c. Return to “clear” mode and re-zero instrument if necessary
   d. Measure downstream vapor concentration
   e. Return to “clear” mode and re-zero instrument if necessary
   f. Repeat steps b - e until sequential upstream and downstream readings are within ±5% of their previous readings
   g. Record upstream and downstream concentrations.

9. Calculate vapor removal efficiency of the adsorber as follows:

$$\text{Removal Efficiency (\%)} = \frac{C_u - C_d}{C_u} \times 100$$

Where: C_d = downstream vapor concentration
C_u = upstream vapor concentration

10. Record data and findings on a test report form. Unless otherwise specified in the SBMS Subject Area: *Exhaust Ventilation* or the equipment operating specifications, the acceptable absorber/adsorber removal efficiency results are >/= 99.97%.

11. Affix results sticker at test location, fume hood face, or other appropriate location.

Attachment 9.8

Exhausted Laminar Flow Hoods

This procedure provides a standardized method for conducting periodic validation of the effectiveness of exhausted laminar flow (ELF) hoods in clean room facilities. This procedure provides for routine testing of the acceptable operating parameters of the system based on manufacturer's recommendations for periodic balancing follow-up and retesting.

By completing this SOP, BNL will document performance of ELF systems and verify operation in accordance with design specifications. The initial test and the operating parameters were conducted by the manufacturer; this SOP addresses the periodic testing.

The recommended testing frequency throughout the life of the system is a 12 month frequency. Repeat testing:

- Whenever major modifications are made to the system
- On start-up of a system that has been dismantled, out-of-service, and reassembled, and
- When complaints of poor performance are made by operating personnel.

Equipment:

- o Anenometer
- o Smoke tubes or candles.

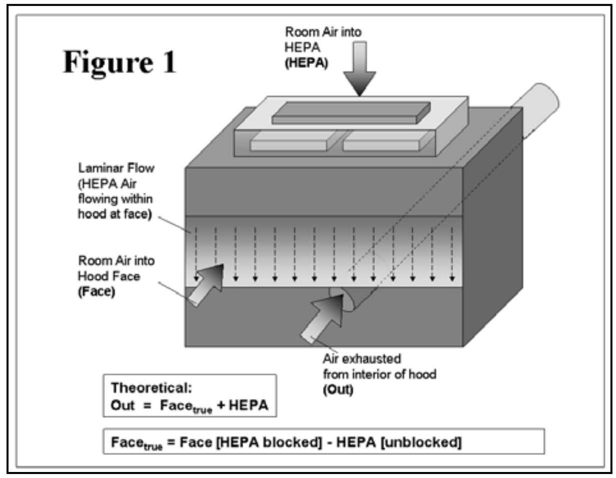
1. Pre-Testing Inspection of equipment
   a. Verify that the exhaust ventilation system is operating at the manufacturer's recommendations.
   b. Have the exhaust system and its associated ductwork and mechanical components inspected for any obvious signs of damage (e.g., missing or damaged seals, breached ductwork, excessive rust, or unusually loud motor noise). Do not test if the system is not operable or not of adequate integrity.
   c. If there are concerns regarding the operation of the system, notify Plant Engineering and the system owner of these conditions. Have the original design drawing, manufacturer's literature, or any other appropriate information reviewed.
   d. Check that the hood is not used for permanent, long range storage. Only necessary equipment should be inside the hood to minimize disruption to the laminar flow and maintain a high level of cleanliness.

2. Exhaust Failure Alarm and Pressure Gauge
   a. Check the pressure gauge (magnahelic or photohelic) that monitors duct pressure in the fume hoods exhaust plenum.
   Microvoid™ 4F55 Normal gauge readings are between 0.25 – 0.50 in. water, while the hood is operating at the recommended exhaust volume.
   Investigate any reading outside this range. If the reading is outside the normal range do not test and notify the Facility Project Manager . Have the appropriate F&O or CFN designated personnel refer to the manufacturer's operating manual to set the low and high alarm set points if not already set. Electrical shutdown will occur and an alarm will sound if the exhaust pressure falls outside of the alarm set points.

3. Laminar Flow Hood Operation:

a. Check the pressure drop across the HEPA filters as measured by a pressure gauge. As the filter becomes dirty, greater fan speed is required by the blower system to maintain a proper air flow. If the fan speed is not increased, flow within the hood will decrease.

b. If outside the normal range notify the user and Facility Project Manager.
Microvoid™ 4F55: When the gauge reads between 0.8-1.0, have the F&O or CFN designated personnel turn the control counterclockwise half way to increase air flow through the HEPA filter. When the gauge reads between 1.0- 1.2, have the F&O or CFN designated personnel adjust the control to high. Refer to the manufacturer's manual for instructions on replacement of pre-filters and HEPA filters.



4. <u>Measuring Operational Parameters:</u> Make observations and measurements of the face velocity with a calibrated hot wire anemometer per the proper IH62 series SOP for the meter. Measure the proper balance of the total exhaust flow and the HEPA down flow volumes, as follows (see ***Figure 1***):

   a. Measure the face velocity of the air into the HEPA filter inlet [V_{HEPA}]. Measure the surface area of the HEPA opening [$Area_{HEPA}$]. Calculate the flow as:
   Q_{HEPA} = [V_{HEPA}] x [$Area_{HEPA}$].

   b. Measure the face velocity of air into the hood face (with HEPA intake grilles closed off) [$V_{face\text{- blocked HEPA}}$]. Measure the surface area of the hood face opening [$Area_{face}$]. Calculate the flow as: Q_{Face} = [$V_{Face\text{- block HEPA}}$] x [$Area_{Face}$].

      i. Calculate the flowrate at the hood face (when the HEPA is not obstructed) by: $Q_{Face\text{-actual}} = Q_{Face} - Q_{HEPA}$

      ii. Calculate the face velocity into the hood as:
      $V_{Face\ actual}$ = [$Area_{face\text{- actual}}$] / [$Q_{Face\text{-actual}}$].

5. <u>Evaluating results to the Air Balancing and Velocity Specifications of the</u> *Microvoid™ 4F55:* This hood is designed to meet both *ASHRAE 110-1995* (containment performance) and *ISO 14644* (process/ product protection). Because this ELF hood is a "hybrid" positive/negative pressure environments (net environment slightly negative), balancing is critical when first installed and **annually** thereafter. The air sweeping the face of the hood (laminar flow) has been HEPA filtered but it becomes "dirty" as it comes in contact with the outside air at the hood face. The laminar flow air is contained at the unit's front perforated lip and exhausted underneath the work surface, so as to not contaminate product.

- While traditional chemical fume hood have face velocities of 80-120 fpm, that high of flow will sweep "dirty" air across the surface and into the hood, defeating the purpose of HEPA filtered down flow supply air. A face velocities **as low as 60 fpm** pass ASHRAE 110 with this ELF hood.
- The *Microvoid™ 4F55* is designed to exhaust all of the HEPA supply air plus air coming in through the face opening. The CFM requirements are therefore calculated by: *Exhaust Flow Rate (CFM) = HEPA surface area x 72 fpm + (face area x 60 fpm minimum).*
- Sash heights with this mode are recommended at no higher than 14", i.e. **10-14 inches,** with sash stops/alarm

features. Since the 4F is slightly negative to the outside, with HEPA filtered down flow laminar flow air pushing particulates "down and to the rear," it is important to minimize cross drafts and keep vertical sash closed as much as possible.

- The 4F is equipped with exhaust failure alarm and photohelic gauge. The gauge monitors pressure in the hood's exhaust plenum. **Normal gauge reading are between 0.25 – 0.50 in. water**, while operating the hood at recommended exhaust volumes. Once the hood is balanced, the gauge lower set point should be at 0.10 inches above the operating pressure of the hood.
- The 4F is equipped with magnehelic gauge, which indicates pressure drop across the HEPA filter(s). A new filter has a pressure drop of 0.5 in. water with the laminar flow set at 90 fpm. When the pressure drop reaches 1.0 – 1.2 in. water, the filters should be changed. All 4F hoods have supply blower speed controllers so that fan speed may be adjusted as filter loads, increasing the life of the HEPA filters. The inexpensive pre-filters, which are provided, should be changed frequently to preserve the life of the HEPAs.

Attachment 9.9
Local Exhaust Ventilation
Job Performance Measure (JPM) Completion Certificate

Candidate's Name (Print Name)	Candidate's Signature	Life Number:
Qualification Number: **HP-IHP-62400**	Evaluator's Signature	Date:

Knowledge of the Principles of Exhaust Ventilation Investigations

Criteria	Qualifying Standard	Unsatis-factory	Recov-ered	Satisf-.actory
Hazard Analysis	Understands the need to perform a hazard analysis of the sampling area and potential exposure to the sampler.			
Personal Protective Equipment	Understands the need to be aware of potential exposures to the sampler and how to determine appropriate PPE.			
Analysis of data	Understands the need to perform analysis on the sampling data to assess the effectiveness of the ventilation system and potential exposure to the sampler, worker, public and environment. Also, to recommend corrective actions as necessary.			

Practical Skill Evaluation: Demonstration of Sampling Methodology

Criteria	Qualifying Performance Standard	Unsatis-factory	Recov-ered	Satisf-.actory
Obtaining design specifications	Describe sources that can be used to find out the design specifications of the equipment .			
Selecting the proper parameters to measure	Knows the fundamental operating principles of exhaust ventilation systems and can describe appropriate design specifications and an acceptable variation in measured versus design values.			
Measurements Techniques	Knows the measurement procedure and proper meters that would be used to conduct [check only measurement procedures demonstrated/exam]:	-	-	-
	☐ Face Velocity Measurement- Constant Volume			
	☐ Face Velocity Measurement- VAV			
	☐ Capture Velocity Measurement			
	☐ Duct Velocity Measurement			
	☐ Tracer Gas Measurement			
	☐ In-Place Sorbent Efficiency			
	☐ Laminar Flow Hood Test			
Data Analysis	Knows the correct criteria and operating ranges. Shows how to correctly analyze data and compare to acceptable criteria.			
Record forms	Shows how to correctly and completely fill all forms associated with this SOP.			
Report preparation and distribution	Knows how to document the assessment and the correct distribution.			

Attachment 10.1
SAMPLE LABELS

(equivalent labels/tags are acceptable)

Label for Passing Hoods

MAXIMUM

OPENING →

FOR REQUIRED

FACE VELOCITY

TESTED BY:

Laboratory Hood Testing Failure Notice

CAUTION

THIS HOOD FAILED
FACE VELOCITY TESTING

DO NOT USE THIS HOOD
FOR ANY OPERATION
REQUIRING A FUME HOOD.

Posted by: (Print) ____________ ____Signature ____________ Date ____________

Exhaust System Test Sticker/Label

Local Exhaust System test			
Equipment ID:			
Operating Parameters Validation Test			
Test Date	Test by: Full Name	Pass/Fail	Next Due

Adsorber/Absorber System Test Results Sticker/Label

In-Place Adsorber/Absorber test			
Date	Efficiency (%)	Pass/Fail?	Tester
Report any problem to: Safety & Health Services Division ext. 3900			

Attachment 10.2
Exhaust Ventilation forms

The following forms are provided as recommended Test Records.
Other formats and content are acceptable.

- *LEV-Initial Evaluation Record form*
- *LEV- Periodic Evaluation Record form*
- *Capture Velocity form*
- *Round Duct Velocity Traverse form*
- *Rectangular Duct Velocity Traverse form*
- *Tracer Gas Evaluation form*
- *Laboratory Hood Face Velocity Test form*
- *In-place Sorbent Test Report form*

Field Sampling forms follow this section of the procedure
--- End of SOP ---

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400

Local Exhaust Ventilation

INITIAL EVALUATION

Form Revision 08/28/13

System Identification

DIVISION	BUILDING	ROOM/AREA
SYSTEM DESCRIPTION		
SYSTEM TYPE	MANUFACTURER	
BNL ID#	MODEL	SERIAL#
FACILITY PROJECT MANAGER	ESH Coordinator	OTHER CONTACT

EVALUATOR(S) NAME	SIGNATURE	TEST DATE

System Description (Photograph or Drawing)

Design Specifications

Rated Velocity:	Rated Amperes:	Other:
Rated Flow Rate (CFM):	Horsepower:	Other:

Field Observations and Measurements- potential parameters to be evaluated

Fan Static Pressure	Duct Velocity (V)	Fan Speed
Pressure Drop across filters	Volumetric Flow Rate (Q)	Motor Speed
Smoke Tube Test	Air Temperature	Motor Amperes
Tracer Gas Test	Moisture Content of duct air	Motor Rotation

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400

Local Exhaust Ventilation

LEV- PERIODIC VALIDATION

Form Revision 08/28/13

System Identification

DIVISION	BUILDING	ROOM/AREA
SYSTEM DESCRIPTION		
SYSTEM TYPE	MANUFACTURER	
EQUIPMENT ID#	MODEL	SERIAL#
FACILITY PROJECT MANAGER	ESH Coordinator	OTHER CONTACT

EVALUATOR(S) NAME	SIGNATURE	TEST DATE

System Description (Photograph or Drawing)

IH62400 LEV- Periodic Validation form (page 2 of 2)

Field Observations and Measurements-

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

METER:	METER SN		
METER CALIB. DATE	COMMENTS		
Parameter:	Point	Acceptable Operational specification	Observed Measurement
	A		
	B		
	C		
	D		

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400

Local Exhaust Ventilation

CAPTURE VELOCITY

Form Revision 08/28/13

DATE:	SURVEYOR(S):

I. AREA INFORMATION

DEPT:	BLDG:		ROOM:	
EXHAUST SYSTEM I.D.:				
EQUIPMENT EXHAUSTED:				
STATUS OF ROOM/AREA:	Windows: Open / Closed	Doors: Open / Closed	HVAC: On / Off	Other:

II. SURVEY INSTRUMENT INFORMATION

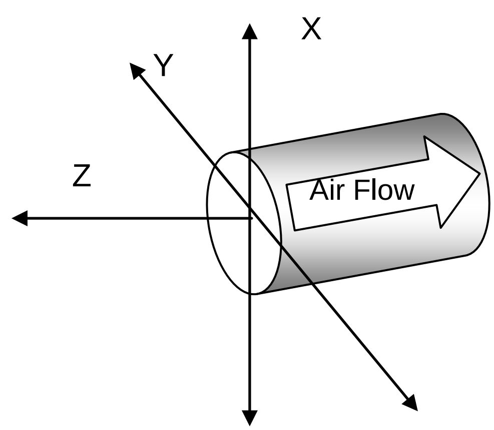
INSTRUMENT:	CALIBRATION DATE:
MODEL:	SERIAL#:

III. RESULTS

REQUIRED VELOCITY:	ACCEPTABLE VELOCITY RANGE:	SASH HEIGHT: (IF APPLICABLE)
HEIGHT:	WIDTH:	SURFACE AREA:
FLOW FORMULA: **Q = V x A**	FLOW:	TEMPERATURE OF AIR STREAM:

SITE	X	Y	Z	FPM
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				

Sample Locations



Sketch of System and Sample Location

Indicate
- Source
- Duct Face
- Operator

Safety & Health Services Division
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Local Exhaust Ventilation

ROUND DUCT VELOCITY TRAVERSE

Form Revision 08/28/13

DATE:	SURVEYOR(S):

I. AREA INFORMATION		
DEPT:	BLDG:	ROOM:
EXHAUST SYSTEM I.D.:		
EQUIPMENT EXHAUSTED:		
CONTAMINANT(S):		

II. SURVEY INSTRUMENT INFORMATION	
INSTRUMENT:	CALIBRATION DATE:
MODEL:	SERIAL #:

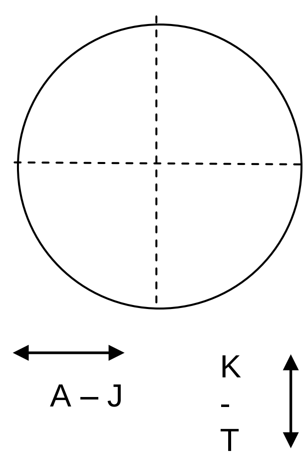
III. RESULTS		
REQUIRED VELOCITY:		AVERAGE VELOCITY:
DUCT DIAMETER:	DUCT RADIUS:	DUCT AREA:
FLOW FORMULA (Q): Q = V x A	FLOW:	TEMPERATURE OF AIR:

Note Location of A - T TRAVERSE POINTS in inches from duct wall

	DISTANCE INSERTION	FPM	M/S
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			

	DISTANCE INSERTION	FPM	M/S
K			
L			
M			
N			
O			
P			
Q			
R			
S			
T			

SKETCH OF TRAVERSE POINTS



Traverse points	Duct Diameter (inch)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
10	.026d	.082d	.146d	.226d	.342d	.658d	.774d	.854d	.918d	.974d
6	.043d	.146d	.296d	.704d	.854d	.957d	---	---	---	---

Sketch of Area/System and sampling locations

Reference

Conversion from diameter of round duct to surface area of round duct

Dia. (inch)	1	2	3	4	5	6	7	8	9	10	12	16	20	24	30	36
Area (ft^2)	.005	.022	.049	.87	.136	.196	.267	.349	.442	.545	.785	1.396	2.18	3.14	4.91	7.07

BROOKHAVEN NATIONAL LABORATORY

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400

Local Exhaust Ventilation

RECTANGULAR DUCT TRAVERSE

Form Revision 08/28/13

DATE:	SURVEYOR(S):

I. AREA INFORMATION

DEPT:	BLDG:	ROOM:
EXHAUST SYSTEM I.D.:		
EQUIPMENT EXHAUSTED:		
CONTAMINANT(S):		

II. SURVEY INSTRUMENT INFORMATION

INSTRUMENT:	CALIBRATION DATE:
MODEL:	SERIAL#:

III. RESULTS

REQUIRED VELOCITY:	AVERAGE VELOCITY:	
HEIGHT:	WIDTH:	SURFACE AREA:
FLOW FORMULA: **Q = V x A**	FLOW:	TEMPERATURE OF AIR STREAM:

SITE	FPM
A (1)	______________
B (2)	______________
C (3)	______________
D (4)	______________
E (5)	______________
F (6)	______________
G (7)	______________
H (8)	______________
I (9)	______________
J (10)	______________
K (11)	______________
L (12)	______________
M (13)	______________
N (14)	______________
O (15)	______________
P (16)	______________

Sample Locations (no closer than 6 inches each direction to other points)

A	B	C	D
E	F	G	H
I	J	K	L
M	N	O	P

Sketch of System and Sample Location

BROOKHAVEN NATIONAL LABORATORY

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

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Local Exhaust Ventilation

TRACER GAS EVALUATION

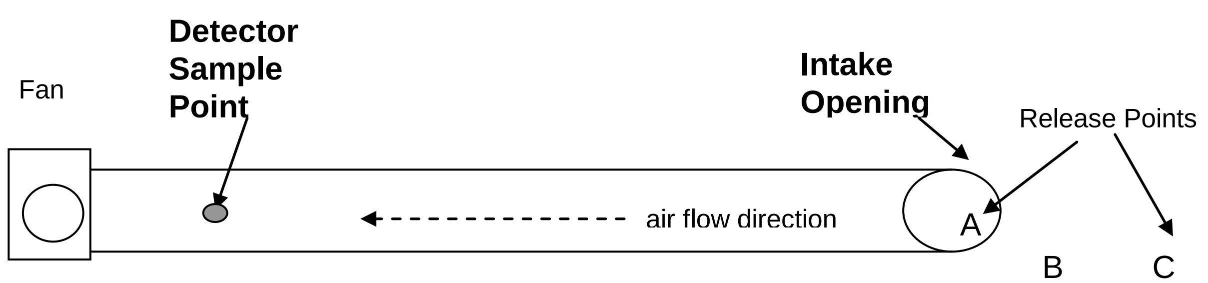
Form Revision 08/28/13

System Identification

DIVISION	BUILDING	ROOM/AREA
SYSTEM DESCRIPTION		
SYSTEM TYPE	MANUFACTURER	
BNL ID#	MODEL	SERIAL#
FACILITY PROJECT MANAGER	ESH Coordinator	OTHER CONTACT

EVALUATOR(S) NAME	SIGNATURE	TEST DATE

System Description (Photograph or Drawing)



METER:	METER SN					
METER CALIB. DATE	COMMENTS					
Parameter:	Point	Location	Conc.		Location	Conc.
	A	(inside duct)		G		
	B	(at face)		H		
	C			I		
	D			J		
	E			K		
	F			L		

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400
Hood Face Velocity – Constant Volume

Form Revision 10/14/13

System Identification

DIVISION	BUILDING	ROOM/AREA
FACILITY PROJECT MANAGER	ESH COORDINATOR	OTHER CONTACT (owner)

System Description

HOOD TYPE ☐ Bypass ☐ Aux Bypass ☐ Vertical ☐ Horizontal ☐ Walk In ☐ Perchloric Acid ☐ Other		AIRFOIL PRESENT ☐ Y ☐ N
MANUFACTURER	MODEL	EQUIPMENT ID# or SERIAL#
HEPA Filtered ☐ Y ☐N Magnehelic Gauge ☐ Y ☐N	CONTINUOUS FLOW METER/ALARM ☐ Y ☐ N TYPE ALARM CALIBRATION DATE ☐ Pass ☐ Fail	
Gauge Reading Current: Previous:	Last SHSD/RCD Surveillance Test Date	

SMOKE TEST TYPE: ☐ tube ☐ bottle ☐ generator		Smoke Test ☐ Pass ☐ Fail
METER:	METER SN:	METER CALIB. DATE:

Photograph – As Used	Velocity Measurements

Average Face Velocity = _____ fpm

Surface Area of Hood at max sash height:_____

Overall: ☐ Pass ☐ Fail

Maximum Sash Height:

COMMENTS:

EVALUATOR(S) NAME/ SIGNATURE	REVIEWER NAME/SIGNATURE	TEST DATE

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

IH62400
Hood Face Velocity – Variable Volume
Form Revision 10/12/13

Division:	Building	Room/Area:
Facilities/ Space Mgr:	ESH Coordinator:	Contact (Owner):

System Description

Hood Manufacturer:		Hood Model:		ID Equipment# or Serial#
Hood Type	☐ Bypass	☐ Aux Bypass	☐ Variable Air Volume	Airfoil Present ☐ Y ☐ N
	☐ Vertical	☐ Horizontal	☐ Walk In	HEPA Filtered ☐ Y ☐ N
	☐ Perchloric Acid	☐ Other:		Continuous Flow Alarm ☐ Y ☐ N Type: Alarm Calibration Date:
ASHRAE 110 Acceptance Test Date:		Last Face Velocity Surveillance Test Date:		Magnehelic Gauge ☐ Y ☐ N Reading Current: Previous:

Smoke Test:	☐ Tube ☐ Smoke Bottle ☐ Generator	**Smoke Test** ☐ **Pass** ☐ **Fail** **Flow Alarm Test** ☐ **Pass** ☐ **Fail**

Velocity Meter:	Meter SN#:	Meter Calib. Date:

Photograph – As Used

Face Velocity Measurements (fpm)

100%						
50%						
25%						

Average Face Velocity (fpm) =	**Velocity Test** ☐ **Pass** ☐ **Fail**
Area (sq. ft.):	Sash height (in.): 100%: 50%: 25%:
Hood opening (in.): Width: Height:	

Comments:

EVALUATOR(S) NAME/ SIGNATURE	REVIEWER NAME/SIGNATURE	Test Date:

Safety & Health Services Division
INDUSTRIAL HYGIENE GROUP

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Local Exhaust Ventilation

IN-PLACE SORBENT TEST

Form Revision 08/28/13

DATABASE RECORD ID#	SHSD UNIT ID#

DIVISION	BUILDING	ROOM/AREA
FACILITY PROJECT MANAGER	FS REP/TECH	OTHER CONTACT
SYSTEM DESCRIPTION		
SYSTEM TYPE ☐ FIXED IN-PLACE ☐ PORTABLE HANDLR	MANUFACTURER	SORBER NUMBER
SITE OF ADSORBER		

GENERATOR METHOD & VAPOR	
DETECTOR	DETECTOR SN
DETECTOR CALIB. DATE	COMMENTS

LEVEL 1 TESTER	SIGNATURE	TEST DATE

Sorbent Unit/ Room Number	**ΔP**	**Upstream Reading**	**Downstream Reading**	**Removal Efficiency[1]**	**Comments**

[1]Based upon formula:

$$\text{Removal Efficiency(\%)} = \frac{C_u - C_d}{C_u} \times 100$$

Where: C_d = downstream vapor concentration
C_u = upstream vapor concentration