University of North Florida
Performance Requirements
For
Laboratory Fume Hoods

As Manufactured Performance Tests

As Installed Performance Tests

As Used Performance Tests

October 27, 2010

University of North Florida
Office of Environmental Health and Safety

ACRONYM AND ABBREVIATIONS

ACH	air changes per hour
ADA	Americans with Disabilities Act
AFV	average face velocity
AI	as installed
AIHA	American Industrial Hygiene Association
AM	as manufactured
AU	as used
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BZ	breathing zone (as defined by ASHRAE 110)
CAV	constant air volume
CFM	cubic feet per minute
EHS	Environmental Health and Safety Office
FPM	feet per minute
GFCI	ground fault circuit interrupter
HVAC	heating, ventilating, and air conditioning
LFH	laboratory fume hood
NFPA	National Fire Protection Association
PPM	parts per million
PTP	performance test procedure
SEFA	Scientific Equipment & Furniture Association
SME	sash movement effect
TAB	testing, adjusting, and balancing
UNF	University of North Florida
VAV	variable air volume

PURPOSE AND INTRODUCTION

This document describes the test procedures to evaluate the performance of laboratory fume hoods (LFHs) at University of North Florida (UNF) laboratories. UNF operates numerous laboratories on campus and relies upon LFHs to provide safe working conditions. The three types of tests included in the document are as follows:

- **"As manufactured" (AM) tests,** which fume hood manufacturers perform before UNF purchases and LFH to determine whether the fume hood meets UNF's performance criteria. *(UNF facilities must confirm that LFH's meet the performance criteria based on the performance test in Sections 5 and 6 of this document prior to accepting the delivery of a new LFH. UNF's Environmental Health and Safety (EHS) maintains a list of manufacturers and fume hood models that have demonstrated conformance with UNF's AM performance criteria.)*

- **"As installed" (AI) tests,** which the LFH manufacturer or a third-party, independent testing agency conducts immediately following installation and after the testing and balancing (TAB) report has been reviewed by EHS. These tests (1) verify proper performance integration with mechanical heating, ventilating, and air conditioning (HVAC) systems and (2) establish a benchmark for the performance of the fume hood system.

- **"As used" (AU) tests,** which UNF laboratory personnel or qualified contractors conduct annually to ensure long-term sustainable performance of the fume hood systems. These tests verify the continued long-term performance of the fume hood system.

The test procedures apply to hood types that have vertical and/or combination sashes (vertical sash with horizontal panels), including:

- Constant volume bypass hoods (bench-top, floor-mounted, and distillation types);

- Hoods designed to comply with the Americans with Disabilities Act (ADA);

- Low average face velocity fume hoods (low velocity hoods); and

- Variable air volume (VAV) hoods (conventional or special design hoods that are operated with controls that adjust air flow volumes for different sash opening configurations or occupancy conditions).

Performance requirements and construction criteria for other types of hoods and exhaust devices, such as laminar airflow equipment, biological safety cabinets, snorkels, canopy hoods, and glove boxes are available through UNF's Environmental Health and Safety office (904-620-2019).

LFH's must meet all the performance ratings included in Section 3, and the performance criteria in Section 4 and 5. Section 2 summarizes which performance tests listed in Section 4 are required for each AM, AI, and AU performance test.

2.0 PERFORMANCE TEST CONDITIONS AND CONFIGURATIONS

The UNF performance tests use a modified application of the American National Standards Institute (ANSI)/ American Society of Heating, Refrigerating, and Air-Conditioning Engineers' (ASHRAE) Standard 110, *Method of Testing Performance of Laboratory Fume Hoods* (herein referred to as ANSI/ASHRAE 110). The tests are intended to verify the performance of a fume hood operating in accordance with UNF specifications under the conditions described as follows.

2.1 Test Laboratory Conditions

Unless otherwise specified, all the requirements of ANSI/ASHRAE 110 shall be met. In addition, the test laboratory must have mechanical air supply systems capable of maintaining a temperature of 74 degrees Fahrenheit ±3 degrees. The test laboratory must be maintained at a negative differential pressure of 0.005 to 0.05 inches of water gage with respect to adjacent non-laboratory spaces.

2.2 Equipment Calibration

Unless otherwise specified, the equipment and instruments used during UNF's performance tests shall meet the specifications in ANSI/ASHRAE 110. In addition, the model, serial number, and recent calibration information for each piece of test equipment shall be recorded and provided with each performance test report. The following procedures verify that test instruments are properly calibrated and operating in compliance with the manufacturer's specifications.

1. Record the name of the manufacturer, model, and serial number of all test equipment.

2. Confirm that all thermoanemometers (velocity meters) and pressure meters to be used during the tests have been calibrated within one year of the test date, and verify that calibration certificates are available (AM, AL, and AU performance tests). All equipment must be traceable to the National Institute of Standards and Technology with signed and dated calibration less than one calendar year prior. Copies calibration certificates shall be included with all reports.

3. Verify that the tracer gas detector and tracer gas ejector have been calibrated within eight hours preceding the tests and within eight hours following the tests (AM and AI performance tests).

4. Verify ejector flow rate (AM and AI performance tests).

2.3 Data Recording

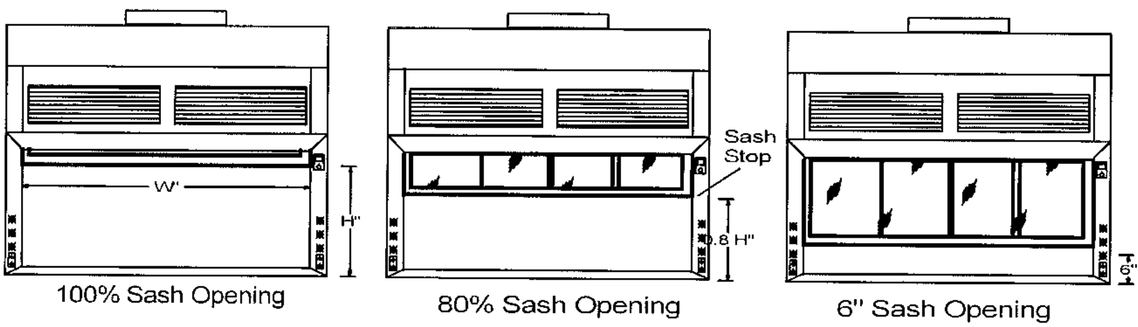
The results of each test shall be recorded on UNF's fume hood performance data sheets or equivalent. (See Appendix A of this document for data sheets.)

2.4 Sash Opening Configurations

UNF requires tests to be conducted at a variety of sash openings depending on the sash type.

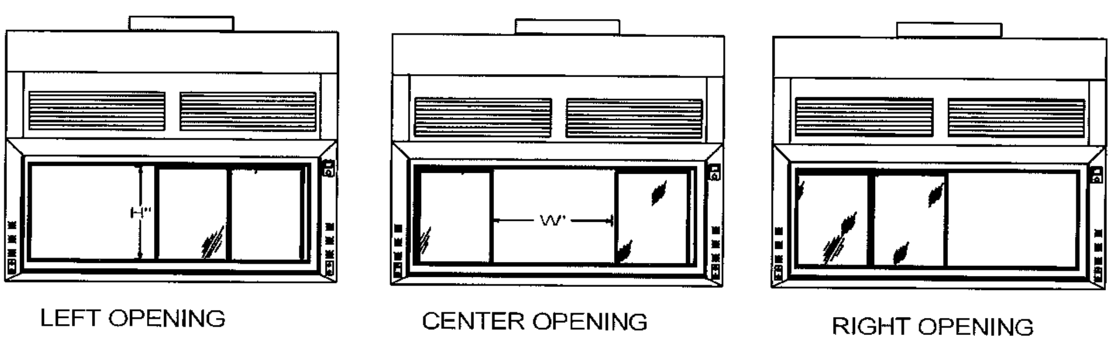
- **Single Vertical Sash:** Bench-top hoods equipped with a vertical sash shall be tested at the 100-percent maximum opening, the 80-percent (design) sash opening, and the 6-inch sash opening height, as shown in Figure 1.

Figure 1. Sash Configuration for Bench-Top Hood Equipment With Vertical Sliding Sash



- **Horizontal Sash Hood:** The required sash openings for hoods equipped with horizontal sashes are shown in Figure 2 and include the maximum left, center, and right opening. Unless otherwise specified, the design sash opening for horizontal sashes shall not exceed a width of 30 inches.

Figure 2. Sash Configuration for Bench-Top Hood Equipped With Horizontal Sliding Sash



- **Combination Sash Hoods:** Hoods equipped with combination sashes must be tested at the vertical and horizontal sash openings as shown in Figures 1 and 2.

2.5 Fume Hood AFV

For VAV system fume hoods designated as “low-flow”, “low-velocity”, or “high-performance” shall be tested at the 100 percent sash opening with an AFV of < 80 fpm and at the design sash opening (i.e., 80 percent vertical sash opening) at an AFV of < 80 fpm. For conventional (standard) LFHs, unless otherwise specified, the tests shall be conducted at the 100 percent sash opening with the resultant face velocity of >80 fpm and at the design sash opening (i.e., 80 percent vertical sash opening) with an AFV of 100 fpm (-10 to +10 percent).

3.0 PERFORMANCE TESTS

Performance tests are conducted to evaluate the capability of LFH’s to meet UNF design, construction, and performance criteria. The tests are based on guidelines and recommendations contained in:

- ANSI/American Industrial Hygiene Association (AIHA) Z9.5 *American National Standard for Laboratory Ventilation;*

- ANSI/ASHRAE Standard 110, *Method of Testing Performance of Laboratory Fume Hoods;* and

- The Scientific Equipment & Furniture Association (SEFA) document entitled *Laboratory Fume Hoods Recommended Practices.*

For all referenced standards, the most recent revisions apply. Unless otherwise specified, all terms used in this document are defined as described in ANSI/ASHRAE 110. The test procedures have been modified where appropriate to accommodate UNF-specific requirements.

Table 1 lists the elements that compromise LFH performance testing and indicate when each component is required. Section 5 provides a detailed description of the procedures that should be followed for each of the testing elements listed in Table 1.

Table 1. Performance Test Procedures
(“As Manufactured” [AM], “As Installed” [AI], and “As Used” [AU])

Laboratory Fume Hood Performance Test Procedures	AM	AI	AU
Inspections			
Hood inspection	X	X	X
Laboratory Inspection	X	X	X
Exhaust system inspection	X	N/A	N/A
Operating Conditions Tests			
Lab Environment Tests: • Room differential Pressure	X	X	X

• Room temperature			
Cross-draft velocity tests	X	X	X
Face velocity test	X	X	X
Hood monitor	X	X	X
Exhaust flow and hood static pressure measurement	X	X[1]	N/A
Auxiliary air velocity tests	X	X	X
Dynamic VAV response and stability tests	X	X	X
Containment Performance Tests			
Airflow visualization tests (smoke)	X	X	X
Tracer gas containment test (static mannequin)	X[2]	X[2]	N/A

Notes:
N/A – Test not applicable.
[1] – Refer to testing and balancing (TAB) report for exhaust flow data (TAB must preced AI performance tests).
[2] – All low-velocity LFHs or as deemed necessary by UNF EH&S must be SF_6 tracer gas tested.

3.1 As Manufactured (AM) Performance Tests

The AM tests are conducted prior to acceptance or purchase of any type, model, or size of fume hood. These tests evaluate the design and performance of the fume hood under prescribed operating conditions. For acceptance of any fume hood, the following conditions apply to AM test:

1. The LFH manufacturer, in a test facility provided by the manufacturer, and at no cost to the University , shall verify the proper performance of the fume hood in accordance with UNF's performance criteria.

2. All AM tests shall be furnished to a UNF EHS Representative prior to model acceptance.

3. The LFH manufacturer shall provide UNF with the specifications and shop drawings and any other descriptive information for the LFH to be tested.

4. A UNF representative may witness the AM performance tests to observe the test procedure and to aid in UNF's verification of the results. Failure to meet performance requirements is cause for rejection of the LFH. UNF reserves the right to verify calibration of test equipment, photograph or videotape the tests, or take independent measurements during the tests.

5. When the LFH manufacturer renames, sells, or transfers the model design to a new company/entity or insignificantly redesigns a fume hood model, UNF may adopt the hood based on the existing approved model data. UNF would adopt the pre-existing model's data only if UNF believes that the change does not negatively impact hood performance. The LFH manufacturer must provide an updated drawings and list of components that have been modified in any way from previously approved model.

Refer to Table 2 for a description of the applicable test, operating configurations, and criteria for the AM fume hood performance evaluation. Figure 4 provides a flow chart showing the recommended sequence for conducting the AM tests.

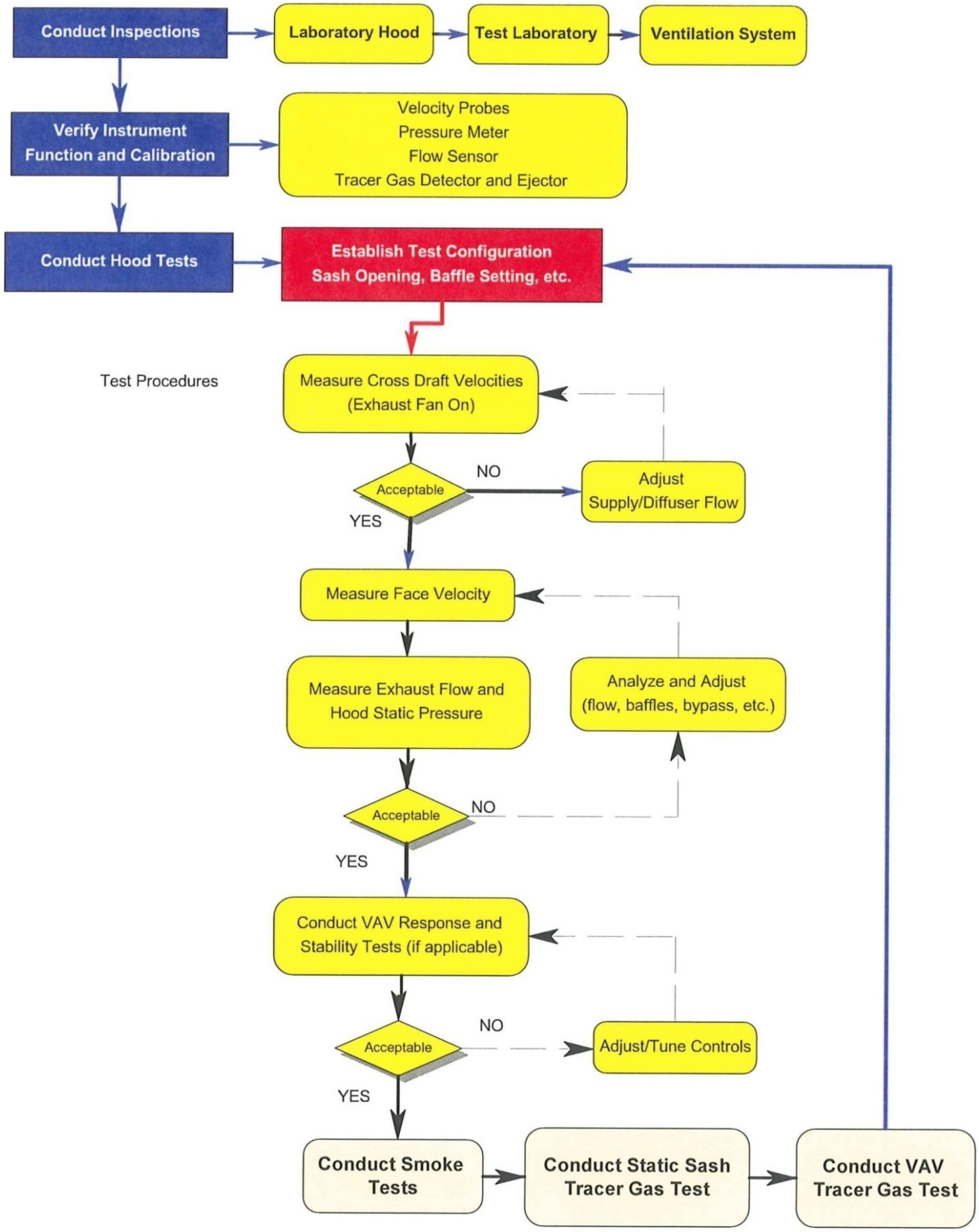
Table 2. "As Manufactured" Performance Test

AM Tests	Description/Configuration/Condition	Criteria
Inspection		
Laboratory Hood		Must Conform to UNF Specifications
Laboratory		
Exhaust System		
Operating Conditions Tests		
Laboratory Environment Tests	Room Differential Pressure (doors closed)	(-) 0.005 to (-) 0.05 inches of water gage
	Room Temperature (doors closed)	74 ± 3 degrees Fahrenheit
Cross-Draft Velocity Test	Vertical 80% open	30-second average cross-draft velocity ≤ 30 fpm
	Horizontal Max Center Opening	

AM Test	Description/Configuration/Condition	Criteria

Face velocity test	Vertical 100% Open	Standard Fume hoods, Constant Volume • Target AFV = 80 fpm (-0/+10 fpm) Low-Velocity Fume Hoods • Target AFV = 65 fpm (-0/+6 fpm)
	Vertical 18 in. Open	Standard Fume Hoods, Constant Volume Target AFV = 100 fpm ± 10 fpm
	Horizontal Max Openings (Left, Center, and Right)	Standard Fume Hoods • Target AFV ≥100 fpm (-0/+10 fpm) Low-Velocity Fume Hoods • Target AFV ≥ 65 fpm (-0/+6 fpm)
	Vertical Sash 6 in. Open	AFV < 300 fpm
Hood Monitor	All sash configurations used for face velocity tests	Indicated velocity or flow ≤5% variation from corresponding measured value. Low air alarm set point 80% target AFV High air alarm set point 120% target AFV
Exhaust Flow and Hood Static Pressure Measurement	Vertical Sash	• Manufacturer's specified flow ±5% to achieve UNF AFV criteria • Hood Static Pressure ≤0.25 in. w.g.
	Horizontal Sash Max Center Opening	
	Sashes Closed	
Dynamic VAV Response and Stability tests	Vertical 80% Open	• Response time ≤ 5 seconds • Flow stability ≤ 10% variation
	Horizontal Max Opening	
Containment Performance Tests		
Airflow Visualization Tests (smoke)	Vertical 100% Open	No visible escape beyond plane of sash
	Vertical 80% Open	
	Horizontal Max Openings (Left, Center, Right)	
Tracer Gas Containment Tests (static mannequin)	Vertical 100% Open • Left, Center and Right Test Positions • Tall Mannequin Height, 23 in. BZ • Short Mannequin Height, 18 in. BZ	• Average 5 minute concentration ≤0.05 ppm • Maximum 30-second rolling average ≤0.1 ppm • Peak concentration ≤0.5 ppm
	Vertical 80% Open • Left, Center and Right Test Positions • Tall Mannequin Height, 23 in. BZ • Short Mannequin Height, 18 in. BZ	
	Horizontal Max. Left, Center, and Right Openings • Left, Center and Right Test Positions • Tall Mannequin Height, 23 in. BZ • Short Mannequin Height, 18 in. BZ	
	Opening Scan • Vertical 80% Open • Horizontal Max Let, Center and Right Openings	
Sash Movement Effect Test (VAV Tracer Gas Containment Test)	Vertical 80% Open (Center)	
	Horizontal Max Center Opening	

Figure 3. Sequence for Conducting AM and AI Performance Tests



3.2 As Installed (AI) Performance Tests

The AI tests evaluate fume hood performance under the design operating conditions. They are conducted after testing, adjustment, and balance (TAB) and commissioning of the air supply and ventilation systems, but prior to occupancy and use of the hoods. For acceptance of any fume hood, the following conditions apply to AI tests:

1. The installer shall ensure that all fume hood components are properly installed and operating according to the manufacturer's specifications, prior to the AI performance testing.

2. The AI performance tests shall be conducted by the LFH manufacturer or manufacturer's representative, or a qualified third-party, independent testing agency with ASHRAE 110 experience and capabilities.

3. The installer shall contact EHS to coordinate its observation of the AI performance tests at least 45 days in advance of the proposed test date and set a firm testing schedule 15 days in advance of the established test date.

4. The installer shall provide EHS with the specifications, shop drawings, and any other descriptive information for the LFH to be tested.

5. An EHS representative may witness the performance tests to observe the test procedure and to aid in UNF's verification of the results. Failure to meet performance requirements is cause for rejection of the LFH, modification of the laboratory, or adjustment of the ventilation systems. UNF reserves the right to verify calibration of test equipment, photograph or videotape the tests, or take independent measurements during the tests.

Refer to Table 3 for a description of the applicable test, operating configurations, and criteria for the AI fume hood performance tests. Figure 4 provides a flow chart showing the recommended sequence for conducting the AI tests.

Table 3. "As Installed" Performance Test

AI Test	Description/Configuration/Condition	Criteria
Inspection		
Laboratory Hood		Acceptable TAB report and must comply with table 2.
Laboratory		
Operating Condition Tests		
Laboratory Environment Tests	Room Differential Pressure (Doors Closed)	(-) 0.005 to (-) 0.05 inches of water gage
	Room Temperature (Doors Closed)	74 ± 3 degrees Fahrenheit
Cross-Draft Velocity Test	Vertical 100% and 80% Open	30-second average velocity ≤ 30 fpm
	Horizontal Max Center Opening	

AI Test	Description/Configuration/Condition	Criteria
Face Velocity Test	Vertical 100% open	Standard Fume Hoods, constant volume • Target AFV = 80 fpm (-0/+ 10fpm) Low Velocity Fume Hoods, VAV systems • Target AFV = 60 fpm (-0/+6 fpm)
	Vertical 80% Open	Standard Fume Hoods, constant volume Target AFV = 100 fpm (± 10 fpm)
	Horizontal Max Openings (Left, Center, and Right)	Standard Fume Hoods Target AFV 100 fpm ± (10 fpm) Low-Velocity Fume Hoods Target AFV ≥ fpm (-0/+6 fpm)
	Vertical Sash 6 in. Open	AFV < 300 fpm
Hood Monitor	All sash configurations used for face velocity tests.	Indicated velocity or flow ≤5% variation from corresponding measured value Low air alarm set point 80% target AFV High air alarm set point 120% target AFV
Exhaust Flow and Hood Static Pressure Movement	Vertical Sash 80% Open	• Manufacturer's specified flow ±5% to achieve UNF AFV criteria • Hood static pressure ≤ 0.25 in. w.g.
	Horizontal Sash Max Center Opening	
	Sashes Closed	
VAV Response and Stability Test	Vertical 80% Open	Response Time ≤ 5 seconds Flow Stability ≤ 10% variation
	Horizontal Max Opening	
Containment Performance Tests		
Airflow Visualization Tests (smoke)	Vertical 100% Open	• No visible escape beyond plane of sash
	Vertical 80% Open	
	Horizontal Max Openings (Left, Center and Right)	
Tracer Gas Containment Tests (Static Mannequin)	Vertical 80% Open • Left, Center, Right Test Positions • Tall Mannequin Height, 23 in. BZ • Short Mannequin Height, 18 in. BZ	• Average 5-minute concentration ≤ 0.05 ppm • Maximum 30-second rolling average ≤ 0.1 ppm • Peak Concentration ≤ 0.5 ppm
	Horizontal Left, Center and Right Max Openings • Center Test Position at each Horizontal Opening • Tall Mannequin Height 23 in. BZ • Short Mannequin Height 18 in. BZ	
	Opening Scan • Vertical 80% Open • Horizontal Max Left, Center, Right Openings	

Sash Movement Effects (VAV Tracer Gas Containment Test)	Vertical 80% Open (Center)	
	Horizontal Max Center Opening	

3.3 As Used (AU) Performance Tests

The AU performances tests are conducted periodically by UNF personnel or a qualified contractor to ensure that the LFH is performing adequately and meeting UNF specifications. Note that any substantive changes or modifications to the air supply or exhaust systems in a laboratory shall require the fume hoods to be subject to AI tests, instead of AU tests. For the proper use of any fume hood, the following conditions apply to AU tests:

1. UNF laboratory personnel or a qualified contractor shall evaluate the integrity of the hood.

2. UNF laboratory personnel or a qualified contractor shall ensure that operating conditions are equivalent to those found during the initial AI tests (i.e.; AFV is unchanged, and smoke containment is unchanged).

3. UNF laboratory personnel or a qualified contractor shall calibrate the hood monitor.

4. UNF laboratory personnel or a qualified contractor shall review the work practices of the fume hood operators.

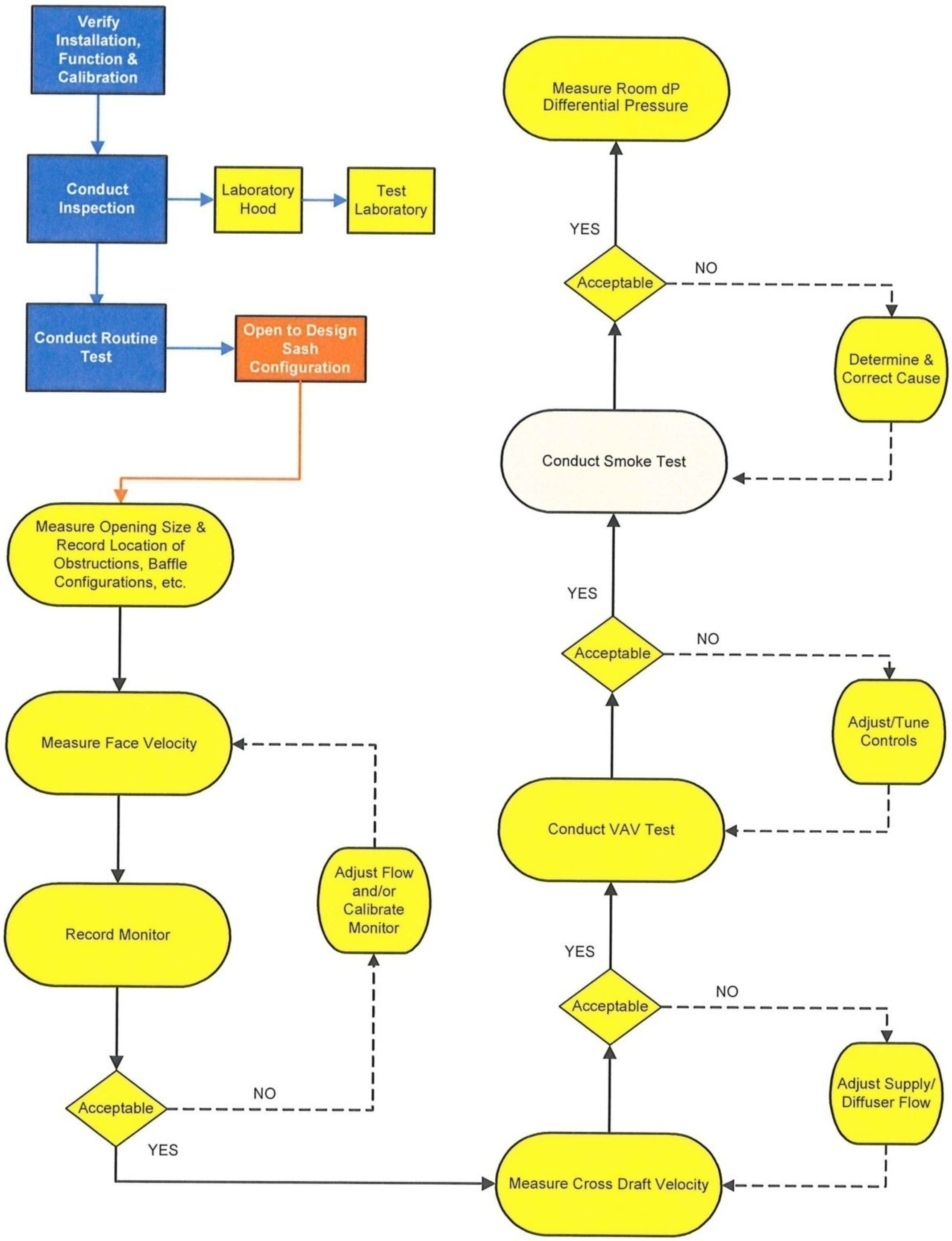
Refer to Table 4 for a description of the applicable tests, operating configurations, and criteria for the AU fume performance evaluation. Figure 5 provides a flow chart showing the recommended sequence for conducting the AU tests.

Table 4. "As Used" Performance Test

AU Test	Description/Configuration/Condition	Criteria
Inspection		
Laboratory Hood		Must comply with UNF Specifications
Laboratory		
Operating Condition Tests		
Laboratory Environment Tests	Room Differential Pressure (Doors Closed)	(-) 0.005 to (-) 0.05 inches of water gage
	Room Temperature (Doors Closed)	74 ± 3 degrees Fahrenheit
Cross-Draft Velocity Test	Vertical 100% and 80% Open	30-second average velocity ≤ 30 fpm
	Horizontal Max Center Opening	

AU Test	Description/Configuration/Condition	Criteria
Face Velocity Test	Vertical 80% Open	Standard Fume Hoods, constant volume • Target AFV = 100 fpm (± 10 fpm) Low Velocity Fume Hoods, VAV systems • Target AFV = 60 fpm (-0/+6 fpm)
	Horizontal Max Openings (Left, Center, and Right)	Standard Fume Hoods Target AFV 100 fpm ± (10 fpm) Low-Velocity Fume Hoods • Target AFV ≥ fpm (-0/+6 fpm)
Hood Monitor	All sash configurations used for face velocity tests.	Indicated velocity or flow ≤5% variation from corresponding measured value
Auxiliary Air Velocity Test (if applicable)	Vertical 100% Open	Average Auxiliary Air Velocity ≤ 2.5 times the design opening AFV or ≤ 70% of the LFH exhaust volume
Dynamic VAV Response and Stability Test	Vertical 80% Open	Response time ≤ 5 seconds Flow stability ≤ 10%variations
	Horizontal Max Opening	
Containment Performance Test		
Airflow Visualization Tests	Vertical 100% Open	No visible escape beyond plane of sash
	Vertical 80% Open	
	Horizontal Max Openings (Left, Center, and Right)	

Figure 4. Sequence for Conducting AU Performance Tests



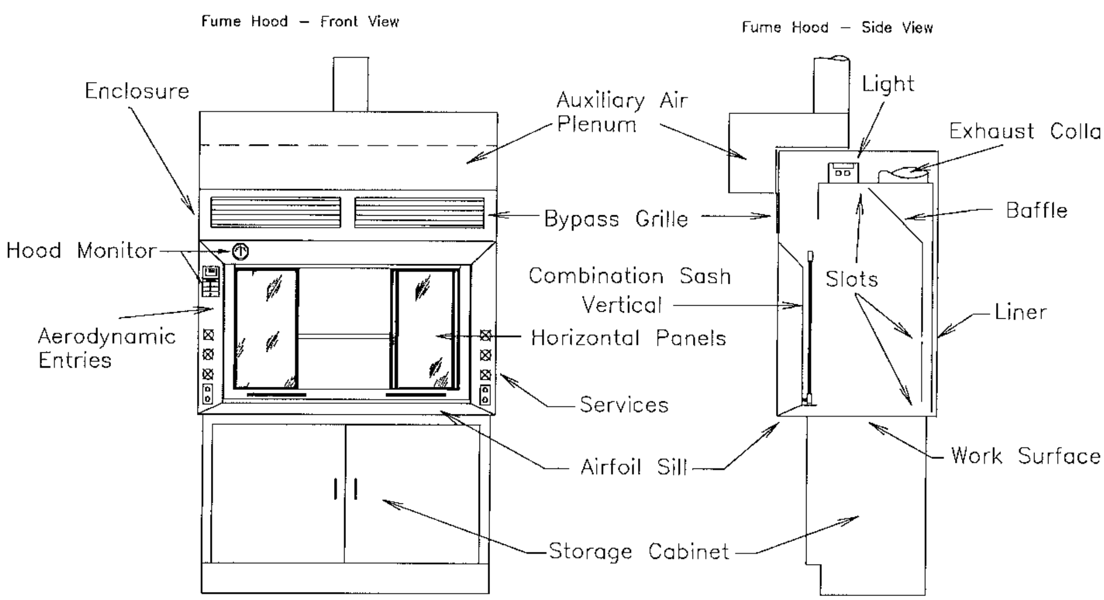
4.0 PERFORMANCE TEST PROCEDURES

The results of each test shall be recorded on UNF's performance test data sheets (see Appendix A of this document for test data sheets) or equivalent. The required number of test cycles shall be dependent on the hood type, sash type, baffle design, and specified AFV. All test equipment must comply with the requirements of this standard, and UNF reserves the right to verify calibration of test equipment, photograph or videotape the tests, or take independent measurements before, during, or rather the routine tests.

4.1 Inspection

The fume hood performance tests begin with inspections of the fume hood, laboratory, and exhaust systems. Figure 6 provides a diagram of a typical bench-top LFH for reference.

Figure 5 Typical Bench-Top LFH



4.1.1 Hood Inspection

1. Record all pertinent hood information to identify the design and type of LFH. Record the name and contact information of the person conducting the test.

2. Test for the proper sash operation. The sash should slide freely in its track without binding through the full open position to its completely closed position.

3. Test and confirm the operation of lights. Evaluate the bulb replacement procedure.

4. Check for the presence and proper installation of the airfoil sill.

5. Record the position of baffle, number of capture slots, and slot widths. If the baffle design enables multiple configurations and slot widths, evaluate a range of positions, and revise the test protocol accordingly. If applicable, confirm proper operation of mechanical baffle actuator.

6. Confirm the connection of exhaust collar to exhaust duct. (If this observation is not possible because hood is equipped with hood enclosing panels, inspect the superstructure for negative or positive leaks.)

7. Check the integrity and cleanliness of the work surface and the hood liner, ensuring there are no cracks, warping, or excessive leakage. Check for a sash sweep behind the sash at the top of the enclosure.

8. Record the type and manufacturer of the monitor. Verify visible and audible alarm operation.

4.1.2 Laboratory Inspection

1. Measure and record the test room (for AM test) or laboratory (for AI test) dimensions. Calculate the room volume.

2. Evaluate the air supply system, and record airflow control settings (for AM test only).

3. If a VAV system is present, record the manufacturer and type of controls.

4. Measure and record test room or laboratory differential pressure across all doors and to ceiling space above the hood.

5. Measure and record test room or laboratory temperature at the center of hood opening, 18 inches in front of the sash plane.

6. Note the number, location, type, and size of air supply fixtures.

7. Make a sketch of the test lab indicating hood, doors, supply diffusers, other exhaust devices, and the location of significant lab furniture.

8. Note possible sources of cross drafts (see Section 3.2.6 and Figure 7 for cross-draft velocity test procedures).

4.1.3 Exhaust System Inspection (only for use with the AM performance test)

1. Evaluate the hood exhaust system, and record airflow control settings.

2. If a VAV system is present, record manufacturer and type of controls.

3. Record hood outlet dimensions and exhaust duct diameter. Make note of any transitions within 10 feet of the hood outlet.

4.2 Operating Conditions Tests

The following procedures verify that the fume hood is operating to meet UNF specifications for face velocity, exhaust flow, laboratory supply, VAV or sash movement effect test (SME) response, and VAV stability.

4.2.1 Laboratory Environment Tests (Room Differential Pressure and Temperature)

1. Room Differential Pressure

   - Close all doors and access openings to the lab. Close the sashes on all hoods.
   - While holding the pressure meter on one side of the door, run a length of tubing below the door into the adjacent non-lab space, and record the differential pressure.
   - Determine the average room differential pressure from those three consecutive measurements.
   - Repeat pressure measurements with sashes on all hoods open to the design opening area.

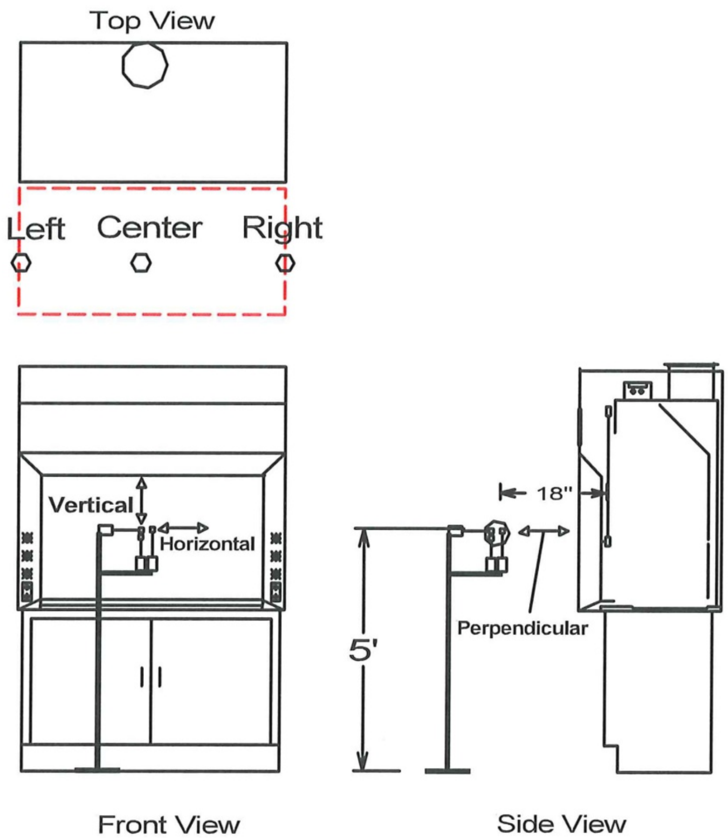
2. Room Temperature

   - Close all doors and access openings to the lab. Close the sashes on all hoods.
   - While holding the temperature probe near the thermostat, measure and record the room temperature.
   - Compare the measured temperature to the temperature reported by the room thermostat.
   - Repeat temperature measurements with sashes on all hoods open to the design opening area.

4.2.2 Cross-Draft Velocity Test

1. Cross-draft velocities are measured to determine the velocity of room air currents near the hood opening. Refer to Figure 6 for a diagram of a hood and locations for measurements of cross drafts.

Figure 6. Probe Location and Orientation to Determine Maximum Cross-Draft Velocity Near the Hood Opening



2. Fix the velocity meter probe at 18 inches in front of the hood enclosure and approximately 60 inches above the floor. The probe should be positioned to independently measure the horizontal, vertical, and perpendicular components of velocity at each of the three test locations. The test locations should correspond to the left side, center, and right sides of the hood.

3. Measure the cross-draft velocity with the probe oriented in the horizontal, vertical, and perpendicular directions at each test location. The perpendicular direction is normal to the sash plane.

4. Record the minimum, maximum, and average velocities measured over a period of at least 10 seconds

4.2.3 Face Velocity Test

For all steps of the face velocity test procedure, the hood interior chamber shall be empty for AM and AI test, except for the required test equipment and components provided with the hood. The AU tests are conducted as found, unless the equipment interferes with the probe.

1. Configure the sash for the appropriate test opening.

2. Measure the sash opening width and height, and calculate the face area in square feet. Be sure to include the area beneath the airfoil sill in the calculation of face area. The sash height is measured from the bench top to the bottom of the sash.

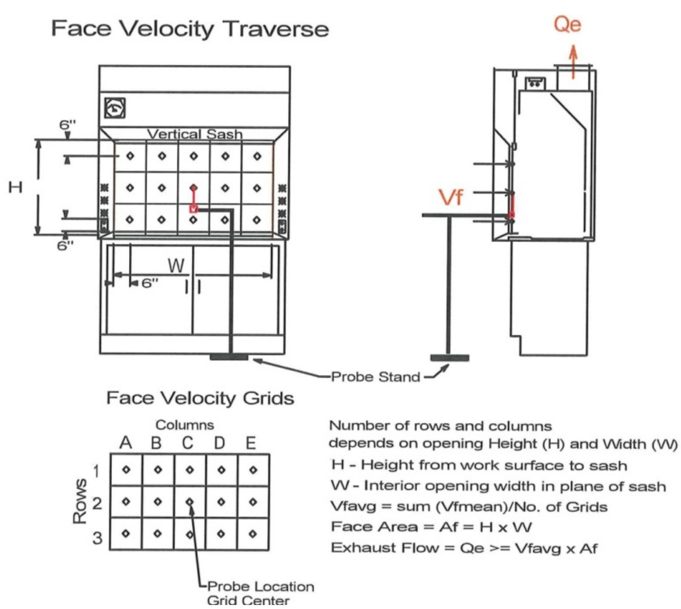
3. Ensure that the exhaust blower is operating, and adjust the flow to achieve the specified target AFV.

4. Divide the opening into the equal area grids of no greater than 1 ft^2 (see Table 5 for recommended grid array and Figure 8 for examples of grid patterns).

Table 5. Face Velocity Traverse Grids for Different Size Openings

Opening	**Width – ft.**							
Height –in.	**≤ 1 ft**	**≤ 2 ft**	**≤ 3 ft**	**≤ 4 ft**	**≤ 5 ft**	**≤ 6 ft**	**≤ 7 ft**	**≤ 8 ft**
≤ 12 in.	1 X 1	1 X 2	1 X 3	1 X 4	1 X 5	1 X 6	1 X 7	1 X 8
≤ 24 in.	2 X 1	2 X 2	2 X 3	2 X 4	2 X 5	2 X 6	2 X 7	2 X 8
≤ 36 in.	3 X 1	3 X 2	3 X 3	3 X 4	3 X 5	3 X 6	3 X 7	3 X 8

Figure 7. Sample Grid Configurations with Fixed Probe at Center of Traverse Grid



5. Measure velocity readings with a calibrated unidirectional hot-wire anemometer fixed at the center of each grid. Place the probe in the sash plane and stabilized using a ring stand or clamp or equivalent. Ensure the probe is aligned to measure the velocity vector perpendicular to the sash plane. The sash plane is defined as the front of the glass on the outermost sash panel.

6. Measure face velocity readings over a period of at least 10 seconds or 10 readings at each grid location. If the anemometer measures instantaneous point velocities, measure a minimum of 10 readings at each grid location. Be sure to stand to the side of the opening while taking readings to avoid disrupting airflow patterns.

7. Record the mean of 10 readings at each grid location. Unless specifically required by hood design, mean grid velocities not within a tolerance of ±20 percent of the target AFV shall require readjustment of the hood airflow and baffle position, or shall be sufficient cause for rejection of the hood.

8. Calculate the average of the mean grid velocities, and record the result as the AFV.

9. Compare the AFV to the face velocity criterion. Velocity measurement shall be repeated at each test configuration as defined herein.

4.2.4 Hood Monitor

1. Record the manufacturer, model, and type of monitor.

2. Record the monitor reading, and not the range or readings while conducting the face velocity traverse.

3. Compare the average monitor reading to the measured AFV.

4. If out of compliance, calibrate the monitor according to the manufacturer's recommended procedure.

4.2.5 Exhaust Flow and Hood Static Pressure Measurements

1. If data is not available from a testing and balancing (TAB) report or has not been collected previously to compare calculated exhaust flow to measured flow, then the exhaust flow shall be measured by conducting a Pilot tube traverse in the exhaust duct connected to the hood in conformance with ASHRAE 41.2, *Standard Methods for Laboratory Air-Flow Measurement.* Calculated flow from the opening are multiplied by the measured face velocity is not acceptable.

2. Measure flow at the Pilot tube traverse at the design sash opening and with the sashes closed in the exhaust duct.

3. Inspect the exhaust ductwork above the hood and locate an accessible run of straight duct of at least seven duct diameters in length. Straight duct runs may be difficult to locate and shorter runs may increase measurement error. Note on the test report if the Pilot tube traverse is conducted in a less than desirable location.

4. At the downstream end of the straight run of duct, drill two 3/8-inch holes at right angles in the duct. Ensure the holes are plugged after conducting tests.

5. Measure the inside diameter of the duct, and calculate the area of the duct using the equation:

$$Ad = \frac{(D^2 \pi)}{4}$$

Where:

Ad	=	Area
D	=	Diameter
π	=	Pi

6. Determine exhaust air temperature, elevation, and barometric pressure to correct for prevailing air density. Ensure measurements are corrected for non-standard conditions. If data requires correction, be sure to record corrected and non-corrected data.

7. Connect static and total pressure ports on the Pilot tube to the manometer using flexible tubing. Insert the Pilot tube probe in each hole and take velocity pressure or velocity readings at the center of annual rings of equal area. A minimum of 10 readings shall be taken across each cross section. The reading shall be taken at distances equal to the duct diameter multiplied by the factors listed in Table 6.

Table 6. Pilot Traverse Points in a Circular Duct of Known Duct Diameter

Traverse Point	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Distance = D ×	0.026	0.082	0.146	0.226	0.342	0.685	0.774	0.854	0.918	0.974

8. If velocity pressure readings were taken in Step 7, convert these readings to velocities. Calculate the sum and average of the velocities. Negative values, if recorded during the traverse, are added in at zero value but are counted in the number of sample locations for calculation of the average. A negative value indicates a non-uniform duct velocity and an inaccurate traverse. Calculated flow from inaccurate traverse should be noted.

9. Record the average duct velocity. Multiply the duct area by the duct velocity to obtain the resultant exhaust flow. Record exhaust flow.

10. Measure and record the hood static pressure at the outlet collar or traverse test location if applicable. The hood static pressure should be measured as close to the hood as possible, given any turbulence or an inability to penetrate the duct at the collar. Record the location of hood static pressure measurement.

4.3 Containment Performance Tests

The following procedures verify that the fume hood provides acceptable containment according to UNF specifications for smoke and tracer gas containment.

4.3.1 Airflow Visualization Tests (smoke)

Verify the hood exhaust blower is operating. For all steps of the visualization test procedure, the hood interior chamber shall be empty, except for the required test equipment. For the local visualization challenge, conduct the smoke tests with the vertical and horizontal sashes fully open and again with the sash at the design opening height (usually 80 percent open).

The visual test of containment using smoke shall be conducted in the absence of the mannequin. Results are reported as a qualitative judgment of airflow distribution according to the ratings described in Table 7. If this test result is a rating other than fair or good, this shall be sufficient cause to reject the LFH.

Table 7. Rating of Observed Airflow Patterns

Rating	Description
Fail	• Smoke was visually observed escaping outside the plane of the sash
Poor (Low Pass)	• Reverse flow of smoke is evident within 6 inches of opening • Lazy flow into hood along openings • Slow capture and clearance (greater than 1 minute) • Observed potential for escape
Fair (Pass)	• Some reverse flow in hood not within 6 inches of sash plane • Limited turbulent vortex flow inside hood • Smoke is captured and clears readily (less than 1 minute) • No visible escape
Good (High Pass)	• Good capture and quick clearance • Limited vortex flow inside hood • No reverse flow regions • No visible escape

1. Low Volume Visualization Challenge

- While holding a smoke tube, smoke stick, or smoke generator in the hood, begin generation of the smoke in accordance with the manufacturer's recommendations[1]. Generate the smoke along the openings and along the airfoil sill. Observe and record airflow patterns. The smoke should flow smoothly into the hood.

- Run the smoke slowly beneath the airfoil sill and observe the flow patterns. The smoke should be exhausted smoothly across the work surface and not be entrained in the vortex at the top of the hood.

- Discharge a stream of smoke or swab the smoke stick along the work surface and interior walls of the hood at 6 inches inside the sash plane. Observe and record airflow patterns, capture by the slots and exhaust. Look for areas of lazy flow, reverse flow, and vortex development in top of hood. Define air movement towards the opening of the hood as reverse flow.

- If any smoke is observed escaping the hood opening, stop generation and correct problems immediately. Use caution to avoid exposure to or inhalation of smoke sources.

2. High Volume Visualization Challenge

- Using a suitable source of smoke for visual challenge, release a large volume on the work surface and in the top of the hood approximately 6 inches behind the plane of the sash. Ensure that the smoke source does not have high-velocity components in the direction of the opening. Observe and record airflow patterns, capture, and time of clearance after generation has ceased. Tests shall be halted if any smoke is observed escaping the hood opening.

- Refer to Table 7 for evaluation and rating of hood airflow patterns.

4.3.2 Tracer Gas Containment Tests (static mannequin)

Unless otherwise specified, the trace gas test procedure and test requirements shall follow the methods described in the ANSI/ASHRAE 110, *Method of Testing Performance of Laboratory Fume Hoods.* Tracer gas tests during AM performance testing shall include at least two series of tests at two mannequin heights for each sash configuration (minimum of two vertical sash heights-sash 80 percent open sash 100 percent open). See Table 8 for required test

[1] Note that two sources of smoke are required – low volume and high volume. A smoke bomb is only appropriate for high volume test. Aerosol cans of smoke are not acceptable for UNF performance testing.

configurations. Additional series of tracer gas tests may also be required to evaluate all possible baffle configurations and effects of flow changes. All low-velocity LFH tracer gas tests during AM performance tests shall include at least one series of tests at the design sash opening with one mannequin height. In addition, UNF may require tracer gas testing for any fume hoods when deemed necessary.

The LFH shall not be approved for use at flow rates or sash positions that do not meet UNF performance criteria. Failure to meet the performance requirements during performance tests shall be sufficient cause to reject the hood.

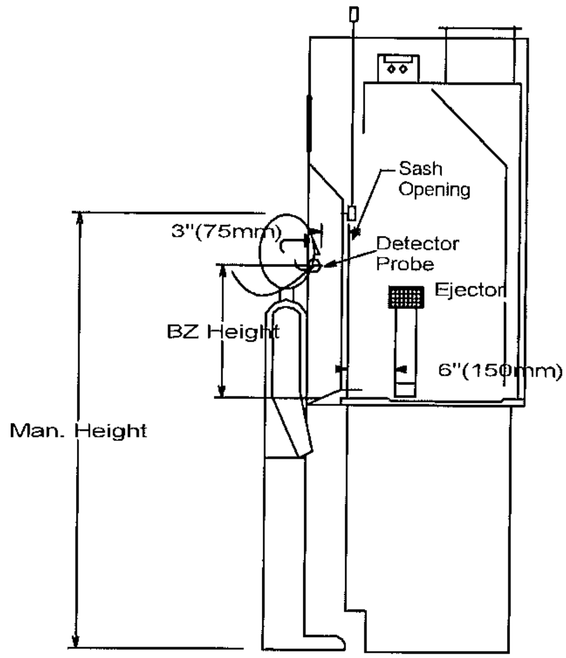
1. Mannequin Height. The mannequin heights shall be based on the hood type and sash type. For bench-top hoods, the mannequin height is based on the height of the breathing zone (BZ) above the work surface where the BZ correlates to the center of the mannequin's lips. The corresponding mannequin height shall be maintained for all tracer gas tests. Where appropriate, the fume hood will be tested at two mannequin heights during AM and one mannequin height during AI performance tests. Refer to Table 8 for specified mannequin heights at each hood type, sash configuration, and test type.

Table 8. Mannequin Heights for Tracer Gas Tests of Different Fume Hood Types

Hood Type	Sash Type	Tracer Gas Test[1]	Mannequin Height – in.	BZ Height – in.	AM	AI
Bench-Top Hood	Vertical	1	n/a[2]	23	X	X
		2	n/a[2]	18	X	X
Bench-Top Hood	Horizontal	1	n/a[2]	23	X	X
		2	n/a[2]	18	X	X

2. Ejector Location. For all LFHs, the ejector shall be located 6 inches behind the plane of the sash. The plane of sash is vertical plane corresponding to the front of the glass panel on the forward most sash panel. For bench-top hoods or fume hoods having interior tables, the ejector shall be placed on the work surface (table top) and located in front of the mannequin at each test position. For distillation and floor-mounted hoods that are not equipped with internal tables, the ejector shall be placed on the lower surface or bottom of the hood (see figures 10, 11, and 12). The ejector flow rate shall be 4 liters per minute of at least 98 percent pure sulfur hexafluoride.

Figure 8. Placement of Mannequin and Tracer Gas Ejector for Bench-Top LFHs



3. Tracer Gas – Opening Scan. With the mannequin removed from the face of the hood and the block valve open to the ejector, the periphery of the hood openings shall be traversed with the probe with the sash fully open. While standing away from the face of the hood, the probe shall be held 1 inch (25mm) away from the edge of the hood opening and moved slowly around each opening at a rate of no more than 3 inches (75mm) per second. The maximum concentration and location observed during the traverse shall be recorded. Stand to the side during measurement to affect flow as little as possible.

4.3.3 Sash Movement Effect (SME or VAV Tracer Gas Containment Test)

The sash movement effect (SME or VAV tracer gas containment test) is conducted to determine the potential for escape from the hood following movement of the sash from closed to the design opening height (typically 80 percent open). This method is applicable to both constant air volume (CAV) and VAV hood systems but it is only required for VAV hood systems (see Tables 2, 3, and 6 for pass or fail criteria).

1. Using the same mannequin and tracer gas ejector arrangement as the tracer gas tests, locate the mannequin and ejector at the center position of the hood opening.

2. Close the sash or sashes.

3. Begin generation of gas at 4 liters per minute.

4. After 30 seconds, begin recording the tracer gas concentrations at a rate of one sample per second using a data logger.

5. After 30 seconds, open the sash from the closed position to the design opening height at a rate of approximately 105 ft/sec. Note the time corresponding to the beginning of sash movement.

6. After 60 seconds, close the sash at a rate of approximately 1.5 ft/sec.

7. Repeat Steps 5 and 6 two more times to obtain a total of three sash opening/closing cycles.

8. Close sash for 30 seconds.

9. Calculate the average tracer gas concentration for the 5-minute test. Note the maximum 30-second rolling average associated with each opening and closing of the sash.

5.0 AM AND AI FUME HOOD PERFORMANCE CRITERIA

Test	Criteria	Notes
Cross-Draft Test	• Vcd ≤30 fpm • Max ≤50 fpm or 50% of AFV	• Design Sash opening.
Face Velocity – Maximum Sash Opening	• Vfag = 80 fpm • Vfmin ≥ 80 fpm • Vfmax ≤ 90 fpm	• VAV hoods may have 100 fpm face velocity at 100% sash full open.
Face Velocity – Design Sash Opening	• Vfag = 100 fpm • Vfmin ≥ 100 fpm • Vfmax ≤ 110 fpm	• Mechanical sash stop installed at 80% of sash opening • Monitor must indicate within 5% of actual face velocity
Face Velocity – Maximum sash Opening Low-Velocity Fume Hoods	• Vfag = 60-75 fpm • Vfmin ≥ 60 fpm • Vfmax ≤ 75 fpm	• Monitor must indicate within 5% or 5 fpm (lesser of two values) of actual face velocity. • Criteria applicable to low-velocity fume hood or equivalent design.
Face Velocity – 6 in. Opening	• Vfavg < 300 fpm for CAV hoods • Vfavg ≥ 100 fpm for VAV hoods	• The maximum velocity is for practical reasons and test bypass effectiveness

Test	Criteria	Notes
Exhaust Flow and Hood Static Pressure	• Flow required to achieve AFV. • Hood static pressure shall be less than 0.25 in. water gage at design sash opening and 100 fpm face velocity	
Dynamic Response and Stability Test	VAV Response Test: • Time required for VAV to modulate flow with sash closed to 90% of steady state flow with sash at design opening must be less than or equal to 5 seconds • The time for VAV to modulate flow shall not exceed 5 seconds	• The response time includes the required time to raise the sash
	VAV Stability Test: • The variation determined by the coefficient of variation shall be less than 10% of the steady state flow with the sash closed or with the sash at the design sash opening.	• The coefficient of variation is calculated as: • %COV = 100 × (3 × Standard deviation) / average steady state flow
Airflow Visualization Tests (Smoke)	• Smoke observed beyond plane of sash when generated 6 inches inside the plane of the sash fails the test • Hood must have a smoke rating of Fair or Good. • A rating of Low Pass or Poor may constitute failure of the hood.	• Smoke should not be discharged at high velocity and directed towards the opening. • VAV hoods should undergo an additional challenge by raising and lowering the sash during the smoke tests.
Tracer Gas Containment Tests (static mannequin) and Sash Movement Effect test(VAV Tracer Gas Containment Tests)	• The maximum 5-minute average BZ concentration must be ≤0.05 ppm for AM and AI performance tests. • The maximum 30-second rolling average shall be lsess than 0.1 ppm. Rolling average is the average of any consecutive 30 second period. • The peak BZ concentration shall not exceed 0.5 ppm.	• The maximum 5-minute average concentration applies to any test configuration or mannequin position. • 30-second rolling averages shall be calculated during opening scan and sash movement tests. The 30-second rolling average negates instrument detection methods and replaces peak escape.