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Kewaunee Scientific Corporation
Standard Operating Procedure for
ASHRAE 110-2016 Testing

The following is the compilation of procedures Kewaunee Scientific uses to test to ASHRAE 110. The procedures herein comply with the testing procedures in ASHRAE 110 – 2016. Please read through the procedure and sign off at the end confirming everything was understood before continuing. For more details on procedures and definitions refer to ASHRAE 110 – 2016.

PREPARED BY: Matthew Vann DATE: 9/16/16

APPROVED BY: KR DATE: 9/16/16

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1. Purpose

The purpose of this document is to give a better understanding of the degree to which hoods are tested and how ASHRAE testing procedures are carried out. These procedures were derived from those stated in the ANSI/ASHRAE 110-2016 Standard “Methods of Testing Performance Laboratory Fume Hoods” to provide a quantitative and qualitative test method to gauge a laboratory fume hood’s level of containment.

2. Scope

This test procedure is designed to provide users with a tool to test the functionality and performance of laboratory fume hood. As such, it is also a valuable tool that is used in the design of every fume hood. This procedure holds within it the ASHRAE 110 testing procedures Kewaunee Scientific applies to the fume hoods it produces. These are just the testing procedures and do not set any pass/fail criteria. The procedures and performance criteria are subject to be modified depending on the desires of the customer.

As defined by SEFA[1] “a laboratory Fume Hood is a safety device specifically designed to carry undesirable effluents (generated within the hood during a laboratory procedure) away from laboratory personnel and out of the building, when connected to a properly designed laboratory ventilation system.” The hood specifications should be set up in such a way that concentrations of gasses inside of fume hoods are never to exceed explosive or exposure limits. It is the recommendation of Kewaunee Scientific that facility Departments of Health and Safety be aware of the chemicals being used or generated in a laboratory fume hood and that they ensure proper safety routines are in place to prevent these limits from being reached. The procedures in this document are excellent templates for safety checks that can be integrated into facility safety routines.

These procedures provide a means to effectively gauge the performance of fume hoods by means of observation and experimentation. The procedures include what data should be reported and the specifications that generated this data. This procedure is designed for factory testing but may also serve as a guide to evaluate fume hoods installed in the field.

2.1. Setting of Laboratory Conditions

The Fume Hood Test Room has three exhaust fans and one supply fan. Exhaust fans should be set in such a way as to provide adequate exhaust to the fume hood so the desired face velocity is reached. The supply fan should be set below the total exhaust so that the room is held under slight negative pressure.

2.2. Face Velocity Measurements

Sash openings for the fume hood being tested are set to operating height as defined by the end user. Face velocity is measured in a grid pattern to determine an average face velocity, as well as, observe the uniform air flow through the plane of the sash.

2.3. Flow Visualization

The smoke challenge is executed in two ways; the local challenge and the large volume challenge. The local challenge demonstrates the flow around the opening of and just inside the hood. The large volume challenge demonstrates the air patterns inside the hood. Observations from the demonstrations are used to evaluate the performance of the fume hood.

2.4 Tracer Gas Test

The Tracer Gas Test is the ultimate test for the containment of a fume hood. The test simulates a lab technician using a fume hood. The test uses a mannequin to represent the lab technician and a probe is placed in what would be the technicians breathing zone. The probe runs to an analyzer that logs the tracer gas concentration while testing. The tracer gas flows through an ejector at a set rate. The performance of the hood is reported based on the results of the test.

2.5 Sash Movement Containment Test

Opening and closing a sash creates a situation that could cause a contaminant to escape from the hood. The Sash Movement Containment Test is used to quantify the results of opening or closing a sash.

3. Definitions and Abbreviations

3.1 Definitions

This section contains terms how they are defined in ASHRAE 110-2016[2]

ASHRAE 110: ASHRAE 110-2016 "Methods of Testing Performance of Laboratory Fume Hoods" is a sequence of testing procedures developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) for gauging the performance of laboratory fume hoods. While testing procedures are specifically for fume hoods they may be adapted for other types of enclosures.

Air Supply Fixture: devices or openings through which air flows into the laboratory room (e.g. Grille, Diffuser, Perforated Ceiling, Register).

Auxiliary Air: unconditioned or partially conditioned supply or supplemental air delivered to a laboratory at the laboratory fume hood to reduce room air consumption.

Control Level: The average measured concentration of tracer gas, in parts of tracer gas per million of parts of air by volume (ppm), that is not exceeded at the hood face with a 4.0 Lpm release rate.

Design Opening: the position of the sash at which the design team assumes that the hood will be operation. The design opening is critical for determining the volumetric flow through the laboratory hood.

Face Velocity: the average velocity of air moving perpendicular to the hood face, usually expressed in feet per minute (fpm) or meters per second (m/s).

Fume Hood System: an arrangement consisting of a fume hood, its adjacent room environment, and the air exhaust equipment, such as blowers and ductwork, required to make the hood operable

Hood Face: the plane of minimum area at the front portion of a laboratory fume hood through which air enters when the sash is or sashes are full opened, usually in the same plane as the sash for a hood with a vertical sash. For hoods with horizontal sashes, combinations sashes, or multiple vertical sashes, the hood face is the plane corresponding to the surface of the outer-most sash panel.

Laboratory Fume Hood (sometimes referred to as a fume cupboard): a box-like structure enclosing a source of potential air contamination, with one open or partially open side, into which air is moved for the purpose of containing and exhausting air contaminants.

Lazy Airflow: an airflow problem in a hood that is revealed when the smoke generated in a smoke challenge remains on the work surface without smoothly flowing to the back baffle.

Maximum Opening: the position of the sash at which the hood has the largest opening.

Operating Opening: the position of the sash at which the hood user places the sash while working at the face of the hood.

Performance Rating: a rating designated by a series of letters and numbers consisting of the letters AM, AI, or AU and a two- or three-digit number:

AM yyy

AI yyy

AU yyy

Where:

AM identifies an “as manufactured” test, that is, the laboratory hood is built and assembled by the manufacturer and testing is performed at the factory.

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

AU identifies and “as used” test, that is, the test is conducted after the hood has been installed and used by the chemist. The typical equipment remains in the hood and other activities in the laboratory continue.

yyy is the control level of tracer gas established by the test in ppm.

Positional control level: the average tracer gas concentration at a position during a test.

Release Rate: the rate of release, in actual liters per minute (Lpm), of tracer gas during a hood test.

Reverse flow: an airflow problem in the hood that is revealed when the smoke released in the hood moves forward toward the front of the hood. The term does not apply to the forward motion of the roll inside the hood that occurs in the upper cavity of the hood above the hood opening or to the cyclonic motion that occurs behind a closed horizontal sash.

Roll: the rotation of air behind the sash or in the upper cavity of the hood.

Sash Movement Effect: the maximum 45-second rolling average of the tracer gas concentration observed during a series of sash movement tests at the center of the hood opening.

Sash Movement Performance Rating: a rating designated by a series of letters and numbers consisting of the letters SME-AM, SME-AI, or SME-AU and a two- or three-digit number:

SME-AM yyy

SME-AI yyy

SME-AU yyy

Where:

SME means "sash movement effect"

AM means "as manufactured"

AI means "as installed"

AU means "as used"

yyy is the sash movement effect in ppm.

Specified Rating: the hood performance rating as specified, proposed, or guaranteed either in the purchase of the hood or in the design and construction of the laboratory, or both.

Test Opening: the position or positions of the sash(es) at which the hood is to be tested.

Titanium Tetrachloride: a chemical, $TiCl_4$, used to generate the white visible fumes required for preliminary testing in laboratory hoods.

3.2 Abbreviations

Lpm	liters per minute
ppm	parts of tracer gas per million parts of air by volume
fpm	feet per minute
cfm	cubic feet per minute
m/s	meters per second

4. Associated Equipment and Materials

Standard equipment used by Kewaunee during ASHRAE 110 testing consists of:

a) TSI Velocicalc Air Velocity Meter – Figure 2
b) MSA Ventilation Smoke Tube Kit (P/N 458481)
c) LabHoodPro Fog Generator (Model SG-301) and associate fogging columns
d) Miran 103 Vapor Analyzer – Figure 3
e) Pico Data Logger – Figure 3
f) Tracer Gas Ejector – Figure 3
g) Mannequin

4.1. Air Flow Measurement

4.1.1. Face Velocity Measurement Instrument:

Velocity readings shall be taken from a calibrated anemometer. The anemometer shall be capable of measuring in a range of 30 fpm to 400 fpm with an accuracy of ± 3% or ± 3 fpm, whichever is greater.

4.2 Air Flow Visualization

4.2.1. Local Visualization:

A source of observable smoke shall be present to generate small controlled volumes inside the fume hood. Recommended smoke sources consist of ventilation smoke tubes or smoke sticks, as manufactured by MSA, or smaller capacity fog generators such as the Zero Wizard Stick. The composition of some smoke generated should be kept in mind as they could potentially be corrosive or hazardous, such as titanium tetrachloride. It is always advised that users be aware of the hazards these devices may cause.

4.2.2. Large Volume Visualization Challenge:

A source of observable smoke shall be available to generate a large volume of smoke in the fume hood. Recommended smoke sources include smoke candles or theatrical fog generators. It is important that the apparatus generating the smoke does not produce an air velocity high enough that it affects the airflow pattern inside the hood.

4.3. Tracer Gas Test

4.3.1. Tracer gas:

The tracer gas tracer gas used for testing shall be chemically pure sulfur hexafluoride, SF_6. The cylinder shall be capable of maintaining 30 psig at a release rate of at least 4 Lpm for 30 minutes.

4.3.2. Ejector System:

The ejector for the tracer gas will follow specifications provided in the ASHRAE 110.

4.3.3. Detection Instruments:

The detector instrument shall be a continuous reading instrument set up for the tracer gas. A minimum detection range of 0.01 to 20 ppm is required. The instrument will be accurate to ± 10% of the reading or 0.025, whichever is greater. The instrument will have the ability to log data digitally.

4.3.4. Calibration:

The detector shall be calibrated with a known concentration of SF6 no more than 24 hours before and immediately after testing.

4.3.5. Mannequin:

The mannequin shall be a three dimensional mannequin that accurately portrays human proportions. The mannequin will be clothed in a smock, coveralls, or clothing typical to that worn in a laboratory setting.

4.4 Miscellaneous Items

Various equipment, such as measuring tape, extension cords, small wrenches, or notepads, shall be used as necessary.

5. Procedures

5.1 Factory Testing Laboratory (Figure 1)

a) The test lab shall be balanced to give the amount of exhaust needed to the fume hood at the required specifications. The supply shall be set so that it is slightly less than the exhaust, to put the room under negative pressure. The room will be able to maintain a pressure differential of approximately 0.02in WG below the adjacent room, unless testing criteria requires a different differential.
b) The test lab must be set so that the temperature is that of a typical laboratory. The temperature inside the room should be 72℉± 5℉.
c) The test lab must be set up so that it restricts room cross drafts 1.5 ft. in front of the hood face to no more than 30 fpm.

5.2 Hood Condition

a) The hood shall be properly installed in the test lab to reflect what will be in the field
b) The hood sash shall be positioned at the specified testing position.

5.3. Face Velocity Measurement Procedure

a) An imaginary grid shall be formed with spaces less than 1 ft^2 with the larger side no greater than 13 in.
b) The measuring probe shall be mounted on an adjustable stand and not handheld. It is important to stand out of the way when measuring airflow.
c) The readings shall be taken from the center of each grid rectangle at a rate of one per second for 20 seconds and averaged by the reading device.
d) The recorded average for each grid shall be averaged to give the total average face velocity for the fume hood.

5.4 Flow Visualization Procedure

5.4.1 Local Visualization Challenge

a) Smoke shall be released under the airfoil.
b) Smoke shall be released along the sidewalls.
c) Smoke shall be released along the work surface.
d) Smoke shall be released around the any equipment that may be in the way.
e) Smoke shall be released inside the hood above the bottom of the sash.
f) Smoke shall be released behind the sash for horizontal sash or combination sash hoods.
g) Smoke shall be released in the cavity above the hood opening
h) Smoke shall be released outside the hood

5.4.2 Large Volume Visualization Challenge

a) Smoke shall be released under the airfoil.
b) Smoke shall be released along the sidewalls.
c) Smoke shall be released along the work surface.
d) Smoke shall be released around the any equipment that may be in the way.
e) Smoke shall be released inside the hood above the bottom of the sash.
f) Smoke shall be released behind the sash for horizontal sash or combination sash hoods.
g) Smoke shall be released in the cavity above the hood opening
h) Smoke shall be released outside the hood

5.4.3 Evaluation of Smoke Tests

a) Airflow patterns shall be evaluated and recorded
b) If any smoke persists on the worktop without steadily flowing to the back of the hood then the airflow shall be described as “lazy.”
c) If smoke moves in the direction of the sash then it shall be described as “reverse flow.” A small amount of reverse flow is common, especially at the edge of the work surface. Reverse flow does not include the roll behind the sashes.

5.5 Tracer Gas Test Procedure

5.5.1 Closed-Loop Method

a) The Miran 103 shall be given sufficient time to warm up and adjust to the conditions in the room.
b) Adjust the Miran 103 so that a zero reading is obtained on the meter scale
c) Connect a tube with an injection port to the Miran 103 with one in going on the input and the other end going on the output.
d) Using a syringe a known quantity of gas is injected into the loop.
e) Calculate concentration of gas by dividing the volume of gas injected into the system by the cell volume of the Miran 103, which is 2.4 liters.
f) The concentration of injected gas should read within 5% of the calculated concentration

5.5.2 Tracer Gas Test

a) The Miran 103 shall be given sufficient time to warm up and adjust to the conditions in the room.
b) The functionality of the instrument shall be tested using the closed-loop method before testing a hood can begin.

c) For typical fume hoods with vertical rising sashes the gas ejector shall be tested in 3 different positions. These positions, unless otherwise specified, are: 12 inches from the left sidewall, equidistant from both sidewalls, and 12 inches from the right sidewall.
d) The aluminum barrel of the ejector shall be positioned 6 inches behind the sash with the bonnet extending 1 inch closer to the sash.
e) The mannequin shall have a probe attached at the breathing zone. The end of this probe shall be located 9 inches from the plane of the ejector barrel, or 3 inches from the plane of the sash, and 22 inches above the plane of the worktop.
f) The gas shall be turned on and given 30 seconds before recording data.
g) Data shall be recorded for 5 minutes with readings being taken at least every second.
h) After testing is done at every position the performance rating of the hood shall be recorded as the highest control level recorded for all the positions.
i) Once testing is complete the functionality of the instrument shall be verified using the closed-loop method

5.6 Sash Movement Containment Test

a) The Sash Movement Containment Test shall be a 2 minute test that occurs at the end of each 5 minute Tracer Gas Test.
b) The sash shall be opened and closed every 30 seconds 3 times.
c) The performance rating for the sash movement effect (SME) shall be recorded as the highest control level recorded for all the positions.

6. Results

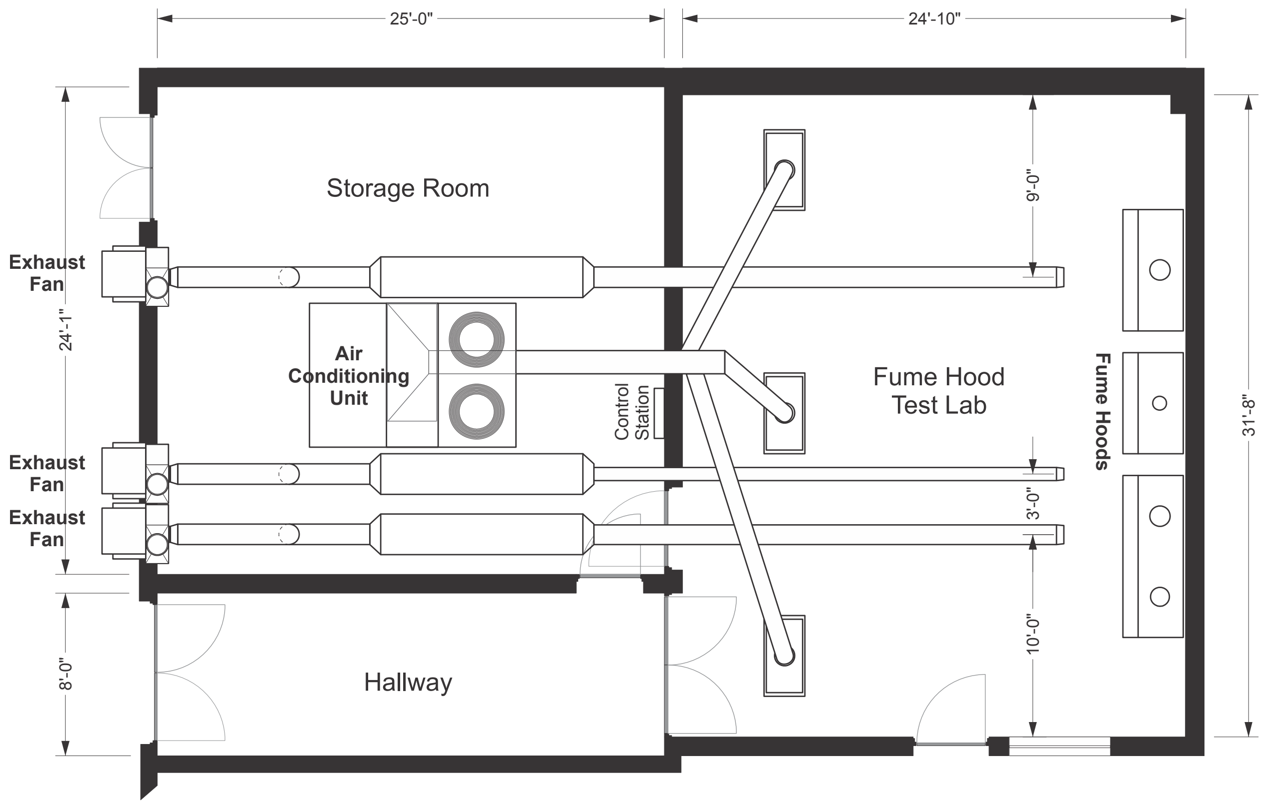
6.1 Reports

A final report (table 1) shall report all of the findings of the testing. Unless other performance criteria are given, fume hoods shall provide a performance rating of AM 0.05 ppm with a tracer gas release rate of 4.0 Lpm. This is the performance rating recommended by the American Conference of Governmental Industrial Hygienists. All final reports shall include a drawing of the laboratory the hood was tested in. This drawing will include the location of the hood and any other equipment that may affect the hood's performance.

7. References

1. SEFA 1 – 2010, *Recommended Practices for Laboratory Fume Hoods.*

2. ANSI/ASHRAE Standard 110-2016, *Methods of Testing Performance of Laboratory Fume Hoods.*

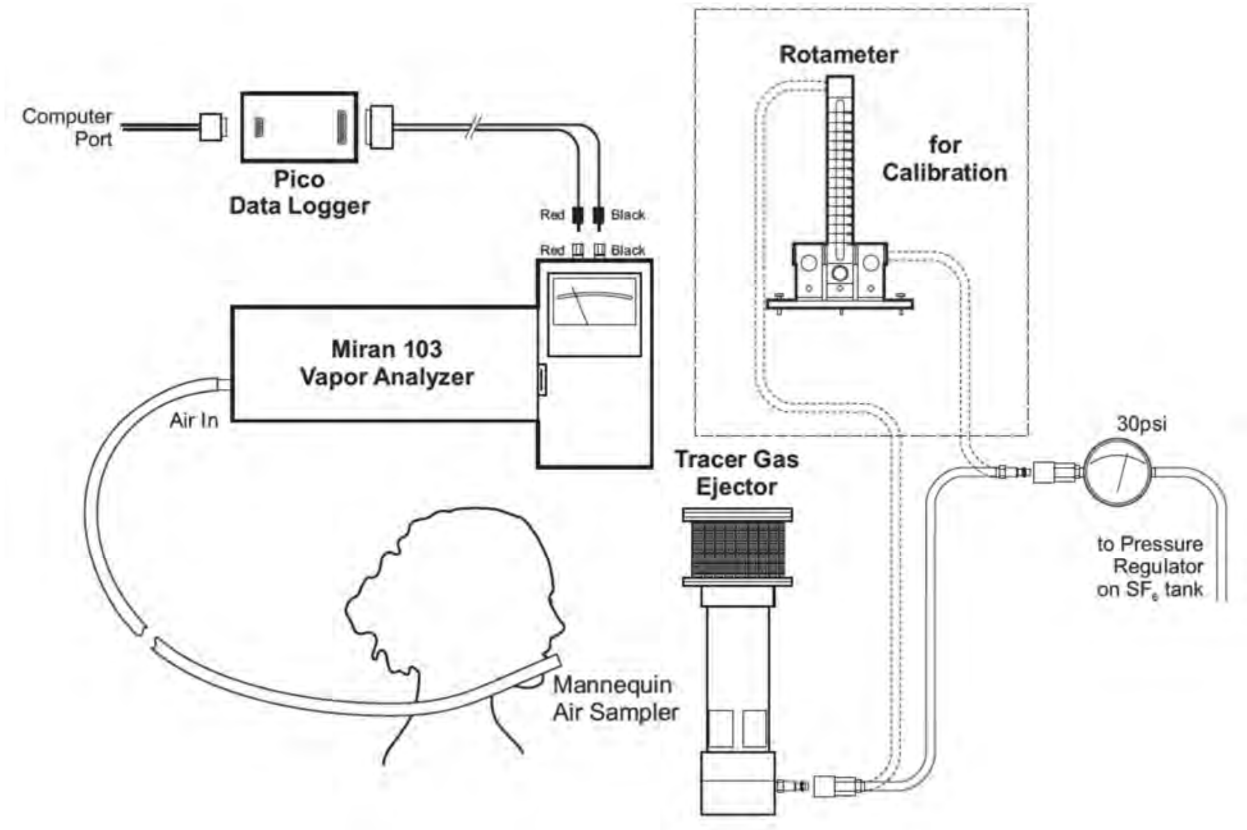


Kewaunee Fume Hood Test Laboratory
Statesville, North Carolina, USA

Figure 1

TSI VelociCalc

Figure 2



TRACER GAS TESTING PROCEDURE

Using Miran 103 Vapor Analyzer

Figure 3

Procedure: PD-16-001

Tracer Gas: Sulfur Hexafluoride @ 4 liters/minute

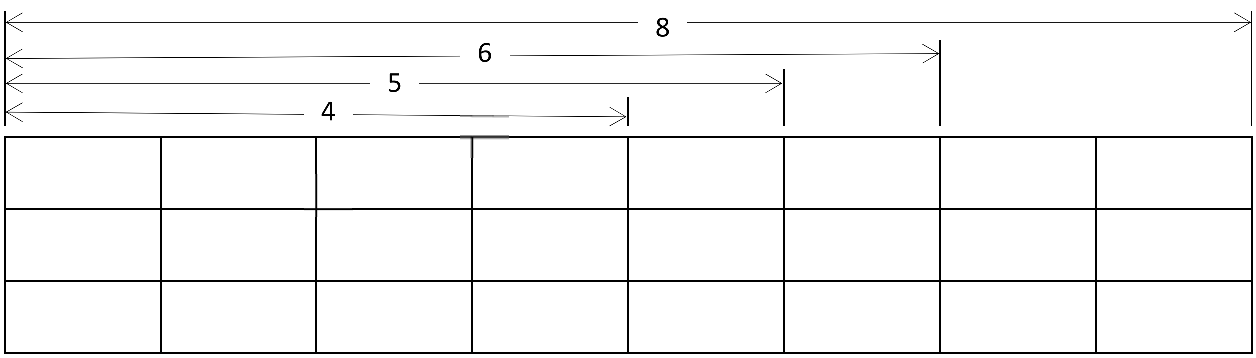
Detection instrument: Miran 103, minimum detectable concentration of 0.001 ppm

Time: 300 seconds of static testing and 120 seconds of sash movement

Hood Model:______________________**Sash Opening Height:**_________________________

Design Face Velocity:_________________________ft./minute

Exhaust Volume:______________________________________cubic ft./minute



Average Face Velocity = ________ FPM

Airflow Patterns: ______________

Positional Control Levels **Sash Movement Effect**

P1 Left position -____________________ppm ________________________ppm

P2 Center position -__________________ppm ________________________ppm

P3 Right position -___________________ppm ________________________ppm

Performance Rating: AM_____________________________________

Sash Movement Effect: SME-AM_________________________

Table 1

Local Smoke Visualization

______Fail ______Poor ______Fair ______Good

Comments:

____

____

____

High Volume Smoke Visualization

______Fail ______Poor ______Fair ______Good

Comments:

____

____

____

Performed By:____ **Date:**______________________

Witnessed/Approved By:______________________________ **Date:**______________________