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An American National Standard

Standard Test Method for Measuring the Field Performance of Commercial Kitchen Ventilation Systems[1]

This standard is issued under the fixed designation F2975; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method can be used to measure and validate successful design, installation and commissioning of commercial kitchen HVAC and makeup air systems for specific installations.

1.2 This test method field evaluates commercial kitchen ventilation system airflows and pressures.

1.3 This test method field evaluates visual hood capture and containment performance.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

1.5 The data generated is specific to the field conditions as installed.

1.6 *This test method may involve hazardous materials, gasses (for example, CO) operations, and equipment. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1704 Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems

2.2 *Other Standards:*

ANSI/ASHRAE Standard 111-2008 Measurement, Testing, Adjusting and Balancing of Building HVAC Systems[3]

ANSI/ASHRAE Standard 154 Ventilation for Commercial Cooking Operations[3]

Testing, Adjusting and Balancing, Chapter 37 2007 HVAC Applications Handbook[4]

Kitchen Ventilation, Chapter 31 2007 HVAC Applications Handbook[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *airflow rate*—volumetric flow rate of air in units of ft^3/min (cfm) or m^3/s. When adjusted for standard air density the flow rate is designated by scfm.

3.1.2 *appliance*—cooking device used in kitchen and powered by gas, and/or electricity and/or solid fuel.

3.1.3 *barometric pressure*—absolute pressure of the air measured by a barometer or absolute pressure measuring device.

3.1.4 *capture and containment (C&C)*—the ability of a hood or other removal device to capture and contain all effluent generated by the appliances or processes during normal operation.

3.1.4.1 *Discussion*—For the purpose of this test method effluent may be simulated as defined in this test method.

3.1.4.2 *Discussion*—Successful C&C shall be demonstrated along the entire perimeter of the hood or removal device.

3.1.4.3 *Discussion*—Successful C&C may include rising effluent that when below the leading edge of the hood may extend out no more than 3 in. vertically beyond the leading edge of the hood and is completely recovered before reaching the leading edge of the hood or removal device and once inside the hood is completely contained. **F1704**

[1] This test method is under the jurisdiction of ASTM Committee F26 on Food Service Equipment and is the direct responsibility of Subcommittee F26.07 on Commercial Kitchen Ventilation.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

3.1.4.4 *Discussion*—For backshelf or passover style hoods effluent shall not rise more than 3 in. above the exterior leading edge of the hood and shall not extend more than 3 in. beyond the open front or sides of the cooking surface and shall be completely contained once reaching the hood.

3.1.5 *differential pressure gauge*—instrument that measures pressure difference between the two inlet ports. This can be a mechanical type such as a Bourdon gauge with an indicator on a dial face or an electronic type with a digital readout.

3.1.6 *dry bulb temperature*—sensible temperature of air as measured by a shielded thermometer or an electronic temperature measuring device.

3.1.7 *effluent*—emissions from cooking, dishwasher or other ventilated processes such as convective hot air, steam, vapor, products of combustion, smoke and/or particulate matter.

3.1.8 *exhaust fan*—also called power roof ventilator or centrifugal blower. A fan used to exhaust cooking effluent including, grease, smoke, steam, heat, and/or vapor collected by a hood. The majority of these fans have a centrifugal fan wheel.

3.1.9 *exhaust hood*—a device designed to capture and contain cooking effluent including, grease, smoke, steam, hot air, and vapor.

3.1.10 *flow hood*—an instrument that measures air flow rate using a pyramid shaped hood that is used to contain the air to be measured and is connected to a velocity pressure measuring device positioned at the outlet end of the hood. A compensating baffle may be installed so that measurements with the baffle open and closed can be used to estimate the air flow rate through the device being measured when the pressure drop imposed by the flow hood is eliminated.

3.1.11 *hood overhang*—the horizontal distance the lower edge of the hood extends beyond the outer horizontal edge of the cooking surface or outer perimeter of the appliance body.

3.1.11.1 *hood setback*—the horizontal distance between the lower front edge of the hood and the front of the edge of the cooking surface or outer perimeter of the cooking appliance. Setback is used for hood styles such as backshelf and/or passover that do not fully cover the entire cooking surface or appliance.

3.1.12 *hot-film anemometer*—an instrument for measuring air velocity at a single point. The instrument measures velocity past a heated sensor and requires calibration to correlate heat loss to air velocity.

3.1.13 *humidity measuring device*—an instrument for measuring the amount of moisture in the air. The instrument shall provide the moisture level as either a) relative humidity, b) wet bulb temperature or c) and/or dew point temperature.

3.1.14 *pitot tube*—a double walled probe with a 90 degree bend near the measuring end. The measuring end of the probe is oriented toward the oncoming air flow. The center opening, facing the oncoming airstream senses total pressure. Small holes located around the circumference of the outer tube sense static pressure. When connected to a differential pressure instrument the velocity pressure of the air is y measured as the difference between the total pressure sensed by the central tube and the static pressure sensed by the outer tube.

3.1.15 *replacement air*—outdoor air that is used to replace air removed from a building through an exhaust system. Replacement air may be derived from one or more of the following: Kitchen Supply, Makeup Air and/or Transfer Air. However, the ultimate source of all replacement air is outdoor air.

3.1.15.1 *kitchen supply*—air entering a space that contains hoods and originates from an air-handling device that serves both purposes of supplying replacement air as well as space conditioning. Supply air is generally filtered, fan-forced, and either heated and/or cooled and/or humidified and/ or dehumidified as necessary to maintain specified space temperature and/or humidity conditions.

3.1.15.2 *makeup air (dedicated replacement air)*—outdoor air supplied directly to a compensating hood or to supply air devices located in the immediate vicinity of the hood to replace air being exhausted through the hood. Makeup air is generally filtered and fan-forced, and it may be heated and/or cooled depending on the requirements of the application. Makeup air may be delivered through outlets integral to the exhaust hood or through outlets in the same room that are typically in the immediate vicinity of the hood.

3.1.15.3 *transfer air*—outdoor that has been conditioned to maintain comfort of and ventilate a space adjacent to the space in which the hood is located. Movement of this air may be caused by pressure differential between spaces, that are separated by adequately sized openings, or by fans and or grills connected by ductwork above ceilings and or through walls, and shall be used to supplement the comfort conditioning of the space in which the hood is located and to replace air exhausted through the hood.

3.1.16 *rotating vane anemometer (RVA)*—an instrument that measures air velocity using an electronic pickup to measure the rotating speed of the vane or propeller. The body of the anemometer is positioned perpendicular to the expected direction of the air velocity.

3.1.17 *smoke emitter*—device that produces smoke particles from a chemical reaction. The rate of smoke production is sufficient to be followed with the naked eye.

3.1.18 *standard air*—air with a density of 0.075 lb/ft^3.

3.1.19 *velocity grid*—a velocity measuring device that consists of an array of holes on both sides of a matrix. The holes serve as pressure taps on the upstream and downstream sides of the device. When connected to a differential pressure monitor and calibrated, it will provide the average air velocity across the matrix.

4. Summary of Test Method

4.1 All systems that supply comfort conditioning, replacement air and/or supply air, makeup air, exhaust systems and cooking appliances in the kitchen shall be installed and operational.

4.2 The general ventilation system or systems for any portion or portions of the building that are adjacent to the kitchen and/or supply transfer air to the kitchen shall be installed and operation during the test procedure and shall maintain the design air pressure in adjacent spaces and shall supply the necessary transfer air.

4.3 The airflow rates for HVAC, Replacement Air and kitchen exhaust shall be those specified.

4.4 All ventilation systems associated with the kitchen and spaces adjacent to the kitchen shall be turned on and operated as under full load cooking conditions.

4.5 The flow rate of air exhausted through the kitchen hood shall be measured and computed using the apparatus and methods defined in this test method. Results shall be adjusted and reported in standard cubic feet per minute (scfm).

4.6 When the computed air flow rate is not within 5 % of the specified value from 4.3, adjustments, such as changing fan speed shall be made until the measured computed air flow rates are within 5 % of specified values.

4.7 The total flow rate of air supplied to the kitchen shall be determined by measuring the flow rate through each supply diffuser and makeup air unit and reporting the corresponding air flow rates as standard cubic feet per minute (scfm). The total amount of air supplied to the kitchen shall be the sum of the measurements from the individual units.

4.8 When the measured air flow rate through any of the supply or makeup air units is less than 95 % of the specified value from 4.3, adjustments shall be made such as increasing fan speed and/or adjusting damper positions until the computed and specified air flow rates are within 5 % for each supply and makeup air unit.

4.9 With the supply air, makeup air, and exhaust air flow rates set to within 5 % of their design values, the ability of all exhaust hoods to capture and contain cooking effluent shall be evaluated. All cooking appliances shall be turned on to idle conditions and allowed to warm up for one hour. Smoke emitters shall be used to ensure that the smoke enters all the hoods without spillage around the entire perimeter of each exhaust hood.

4.10 If spillage occurs, the exhaust air flow rate in the hood must be increased, or the replacement air redirected, and the test repeated until no spillage is observed. The increase in exhaust flow rate is usually accomplished by increasing the fan speed.

4.11 The differential static pressure shall be measured between the kitchen and adjacent areas in the same building such as the dining area and dry storage areas, and the kitchen and outdoors.

4.12 When the kitchen static pressure is within 0.02–0.05 ± 0.005 of the static pressure of the dining area or any adjacent occupied area in the building, at least one kitchen exhaust system shall be adjusted to exhaust a larger amount of air until the pressure in the kitchen is a minimum of 0.005 in. water less than the surrounding areas.

4.13 When the total exhaust air flow rate from the kitchen has been increased more than 10 % above the design value to provide adequate capture and containment of the effluent, and the air pressure in the kitchen is more than 0.200 in. water less than the air pressure in adjacent spaces, the makeup air flow rate or supply air flow rate to the kitchen must be increased until the pressure differential is reduced to between 0.050 and 0.200 in. water.

5. Significance and Use

5.1 Successful kitchen exhaust hood performance requires the complete capture and containment of the effluent plume along the hood's entire perimeter. Any effluent leakage moving beyond 3 in. from the hood face will be deemed as having escaped from the hood, even if it may appear to be have been drawn back into the hood. If effluent spills from the hood, hot and greasy kitchens may be the result and the cause of the performance failure needs to be determined and corrected. Oftentimes, the exhaust flow rate needs to be increased to achieve proper hood performance for particular field conditions. As a result, the supply air to the kitchen will need to be increased to maintain the air balance. However, drafty room conditions due to incorrectly placed supply diffusers, cross drafts from windows and doors, return and supply at opposite ends of the kitchen, etc. could also severely degrade hood performance. Incorrectly designed supply systems may not be corrected by increasing the exhaust rate and could be corrected in a much more efficient and economical manner, such as by replacing a 4-way diffuser with a 3-way diffuser directed away from the hood. Likewise, if the plume is strongly captured, the hood may be over-exhausting and reducing the exhaust rate could be considered, along with a corresponding reduction of room supply air to maintain the building's air balance.

5.2 An appropriate airflow balance ensures adequate replacement air for the necessary exhaust conditions and allows the desired air pressure distribution to be maintained.

5.3 Negative air pressure in the kitchen with respect to the adjacent indoor spaces ensures that the air flow is from these spaces into the kitchen so that odors and cooking effluent are contained within the kitchen. However, too great a pressure imbalance will severely degrade hood performance by creating a wind tunnel effect. Negative air pressure in the dining area with respect to the outside is usually an indication that the supply air rate is inadequate and as a result the exhaust air system is not performing as specified.

6. Apparatus

6.1 *Velocity Grid,* for measuring average velocity across the face of a grease filter or extractor mounted in an exhaust hood and makeup air devices with a range of 25 to 2500 fpm and an uncertainty of ±3 % of reading.

6.2 *Barometer—Direct Reading or Electronic,* for measuring barometric or atmospheric pressure which is required to correct airflow readings to standard air density conditions. The instrument may be either a Bourdon tube type or an electronic type with accuracy of ±1 % of full scale.

6.3 *Differential Pressure Gauge,* for measuring the pressure difference across filter banks, supply air diffusers, makeup air devices or between rooms and for reading the velocity pressure when using Pitot static tubes for velocity measurement. Required instrument range is 0 to 1.0 in. water with an accuracy minimum of ±1 % of full scale.

6.4 *Flow Hood,* a pyramid-shaped hood connected to a differential pressure measuring device that may be used to collect all the air from a terminal and guide it over a flow measuring system to provide the total air flow rate in cfm. Required range is 25–2500 cfm with accuracy of ±3 % of reading.

6.5 *Hot-Film Anemometer,* for measuring air velocity at a single point. Typical range is 10 to 8000 fpm (0.05 to 40 m/s). Instrument accuracy is ±3 % of full scale.

6.6 *Pitot-Static Tube,* for measuring air velocity in ductwork.

6.7 *Humidity Measuring Device,* for measuring the amount of moisture in the air which is necessary to convert the measured air flow rate into standard air flow rate. The instrument shall provide the moisture level as either a) relative humidity, b) wet bulb temperature or c) dew point temperature. Relative humidity instruments shall have a range of 20 to 90 % at 70°F with an accuracy of ±3 %. Wet bulb and dew point instruments shall have a range of 32 to 100°F with an accuracy of ±0.1°F.

6.8 *Rotating-Vane Anemometer—4 in.,* for measuring the velocity distribution near an air discharge or exhaust opening. Lower end of velocity range is 200 fpm and accuracy is ±2 % of reading.

6.9 *Rotating-Vane Anemometer—2¾ in.,* for measuring the velocity distribution near an air discharge or exhaust opening. Lower end of velocity range is 200 fpm and accuracy is ±2 % of reading.

6.10 *Ammeter, True RMS, Clamp-On,* for measuring current draw of fan motors. Accuracy 1.5 % of reading, resolution 10 mA.

6.11 *Tachometer,* optical or contact type for measuring rotational speed of motor, fan, or pulley. Accuracy 0.05 % of reading, resolution 0.1 rpm.

6.12 *Thermometer, Digital Electronic,* for measuring air dry bulb temperature that consists of a thermocouple, thermistor or resistance temperature device (RTD) connected to a digital readout. Typical range is +14 to +248°F (–10 to 120°C). Instrument accuracy shall be ±0.5°F (0.3°C).

7. Reagents and Materials

7.1 Smoke emitters (creating less than 400 cfm) for visualizing the air flow during the capture and containment tests.

8. Sampling

8.1 *Ventilation System*—The fully installed and operational HVAC system associated with a commercial kitchen and the surrounding spaces in the building shall be selected for air balancing.

9. Preparation of Apparatus

9.1 *General:*

9.1.1 Choose a day with no wind or only very light occasional winds. (Continuous high winds and gusty winds create pressure imbalances that are difficult to analyze by these methods, and will generally result in a building with too much outside air).

9.1.2 Ensure that doors to the outside remain closed during the tests so that the makeup and exhaust air flow rates and internal building pressure are controlled by the mechanical ventilation systems.

9.1.3 The entire replacement air and exhaust systems shall be fully operational and ready for balancing.

9.2 *Duct Systems:*

9.2.1 *Preliminary Checks:*

9.2.1.1 Inspect the entire supply air duct system from each makeup air unit to the last air supply terminal to make certain the installation matches the drawing specifications.

9.2.1.2 Inspect the entire exhaust duct system from each exhaust hood to the exhaust fan to make certain the installation matches the drawing specifications.

9.2.1.3 Verify the ductwork is complete and installed correctly. There shall be no openings in the ductwork, no missing end caps, and all access doors shall be closed and secured tight.

9.3 *Hood Filters:*

9.3.1 The correct size and type of filters shall be installed in all exhaust hoods. When permanent filters are used, they shall be the correct size and type per the drawing specifications.

9.3.2 The filters shall be clean from grease and debris.

9.3.3 The filter frames shall be properly installed and airtight.

9.4 *Appliance Placement:*

9.4.1 *Appliances Under Canopy Hoods:*

9.4.1.1 All appliances shall be in their correct positions and held in place with the wheels locked. The rear of each appliance shall be as close as possible to the rear wall of the canopy hood or center of a back to back island hood arrangement.

9.4.1.2 All gas-fired appliances shall be connected to a gas line with the required capacity.

9.4.1.3 All electric appliances shall be connected to an electrical supply with the required capacity.

9.4.2 *Grills and Fryers under Backshelf Hoods:*

9.4.2.1 Each appliance shall be tightly seated into the hood and held in place with a locking bar, capping piece or wheel locks.

9.4.2.2 The rear of each appliance shall be tightly sealed against the rear wall of the hood so there is no air bypass at this location.

9.4.2.3 If the hood is designed with flue bypass, the flue restrictors shall be properly set for gas heated equipment and flue passage shall be completely sealed off for electric heated equipment.

10. Procedure

10.1 *General:*

10.1.1 All exterior doors from outside to the kitchen shall be closed. All doors between the kitchen and the adjacent interior spaces shall be closed. Exceptions are pass-through openings and walkways that are normally open.

10.1.2 The barometric pressure, air dry bulb temperature and relative humidity in the kitchen shall be measured and recorded as initial values when the testing begins. Ambient weather conditions for the day shall be recorded including ambient dry bulb temperature, wind speed and direction, and relative humidity. Ambient conditions may be obtained from the nearest NOAA weather recording station.

10.1.3 All kitchen exhaust fans shall be turned on to achieve design exhaust air flow rates necessary for full load cooking. The cooking appliances shall be turned at hot ready-to-cooking condition for the air flow balance measurements. The exhaust air flow rates through all exhaust hoods shall be measured, compared with design values and adjusted as necessary until each is within ±5 % of the design value.

10.1.4 The replacement air flow rate, whether part of combined HVAC units or separate makeup air units, shall be set to ±5 % of the design value through each outlet, with the approximate correct settings on the outside air flow rate. Then, the correct outside and return air flow rates shall be set proportionately for each unit, as applicable.

10.1.5 Outside air shall be set with all fans (exhaust and supply) operating. The pressure difference between inside and outside shall be checked to see that (1) the non-kitchen zones of the building are at a positive pressure compared to outside and (2) the kitchen zone pressure is 0.050 to 0.200 in. of water negative compared to the surrounding zones and negative or neutral compared to outside.

10.1.6 For applications with modulating exhaust, every step of exhaust and replacement shall be shut off, one step at a time. Each combination of operation shall be rechecked to be sure that the design pressures and flows are maintained within each zone and between zones. This requires that the replacement airflow rate compensate automatically with each increment of exhaust. It may require some adjustments in controls or in damper linkage settings to get the correct proportional response.

10.1.7 Capture and containment of the cooking effluent shall be demonstrated for each exhaust hood with the appliances at idling/ready to cook condition using a smoke emitter.

10.1.8 The air dry bulb temperature, relative humidity, and barometric pressure within the kitchen shall be recorded at the end of the day as final values.

10.1.9 When the above steps are complete, the system is properly integrated and balanced. At this time, all fan speeds and damper settings (at all modes of operation) shall be permanently marked on the equipment and in the test and balance report. The air balance records of exhaust, supply, return, fresh air, and individual register airflows must be completed. These records shall be kept by the food service facility for future reference.

10.1.10 For new facilities, after two or three days in operation (no longer than a week and usually before the facility opens), all belts in the system should be checked and readjusted because new belts wear in quickly and could begin slipping.

10.1.11 Once the facility is operational; the performance of the ventilation system should be checked to verify that the design is adequate for the actual operation, particularly at maximum cooking and at outdoor environmental extremes. Any necessary changes should be made, and all the records should be updated to show the changes. Rechecking the air balance should not be necessary more than once every 2 years unless significant changes are made in facility operation. If there are major changes, such as a new type of cooking equipment or added or deleted exhaust connections, the system should be modified accordingly and rebalanced.

10.2 *Exhaust Air Flow Rate Measurements Through Kitchen Exhaust Hoods:*

10.2.1 The total air flow rate through each exhaust hood shall be determined using one of the following methods with the cooking appliances turned at hot ready-to-cooking condition.

10.2.1.1 When a specific air flow rate measurement protocol is specified by the hood or filter manufacturer, the protocol developed by the manufacturer shall be followed.

10.2.1.2 When the filters under test have no protocol from the manufacturer but has a protocol specified in this document, the method of test specified in this document shall be followed.

10.2.1.3 When the filters under test have no protocol from the manufacturer and do not have a protocol specified in this document, or one or more obstructions prevents proper use of face velocity measuring instruments, a duct traverse method shall be used to determine the total air flow rate through an exhaust hood using a Pitot-static tube. The Log-Tchebycheff rule shall be used for rectangular ducts and the Log-linear rule for circular ducts as specified in ANSI/ASHRAE Standard 111-2008, "Measurement, testing, adjusting and balancing of building HVAC systems".

10.2.2 *Hoods with Baffle Filters:*

10.2.2.1 These measurements are limited to the use of a 4 in. rotating vane anemometer with its body parallel to and positioned flush to the filter face.

FIG. 1 Baffle Filter

10.2.2.2 Each filter in an exhaust hood must be evaluated separately and the flow rate through each filter added to determine the total airflow rate through the entire exhaust hood.

10.2.2.3 The dimensions of the open portion, height and width (H and W), of each filter shall be measured with an accuracy of ± ¼ inch and the results recorded.

10.2.2.4 The center of the rotating vane anemometer shall traverse the entire face of the filter in a back-and forth motion. The minimum time to traverse the entire filter face shall be 30 s. An example is shown in Fig. 2. Average velocity readings shall be measured and recorded at each location.

10.2.2.5 The body of the instrument shall remain flush to the exterior surface of the filters, and be kept parallel to it.

10.2.2.6 Airflow through the instrument shall not be obstructed by the operator's hand or fingers.

10.2.2.7 The velocity measurements in a filter bank shall be measured beginning with the filter at one end of the filter bank and ending with the filter at the opposite end.

10.2.2.8 The procedure described above shall be repeated twice more to obtain the average velocity for all three readings at each location in feet per minute (FPM).

10.2.3 *Hoods with Cyclone Filters:*

10.2.3.1 These measurements are limited to the use of a 2¾-in. diameter rotating vane anemometer with its body parallel to and positioned 2 in. from the filter face.

10.2.3.2 Each filter in an exhaust hood must be evaluated separately and the flow rate through each filter added together to determine the total airflow rate through the entire exhaust hood.

10.2.3.3 The gross dimensions (height and width) of the opening areas of each filter shall be measured and recorded.

10.2.3.4 The velometer shall traverse each opening a minimum of 30 s. Fig. 4 shows the positions by "X" for an entire filter bank of cyclone filters. Average velocity readings shall be measured and recorded at each location.

10.2.3.5 The body of the anemometer must remain 2 in. from the exterior surface of the filters, and be kept parallel to it. A small indicator shall be attached to the exterior body of the anemometer to maintain the 2 in. spacing.

10.2.3.6 The vane must attain full speed at each position before the velocity is recorded.

10.2.3.7 The airflow through the anemometer shall not be obstructed by the operator's hand or fingers.

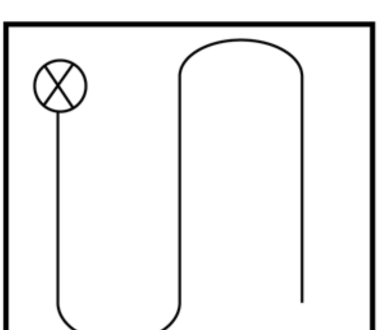

FIG. 2 The Start of the Traverse of the 4 in. Rotating Vane Anemometer is Denoted by "X"

FIG. 3 Cyclone Filter

10.2.3.8 The velocity measurements in a filter bank shall be measured beginning with the filter at one end of the filter bank and ending with the filter at the opposite end.

10.2.3.9 The procedure described above shall be repeated twice more to obtain the average velocity for all three readings at each measurement position in feet per minute (FPM).

10.2.4 *Hoods with Slot Filters (Cartridge—Removable or Stationary):*

10.2.4.1 These measurements are limited to the use of a 2.75 in. rotating vane anemometer positioned at the slot opening. Each filter in an exhaust hood must be evaluated separately and the flow rates through each filter added together to determine the total airflow rate through the entire exhaust hood.

10.2.4.2 The body of the anemometer must remain parallel to the slot opening with one side in the same plane as the opening.

10.2.4.3 The center of the anemometer shall be traversed across the center of the slot opening.

10.2.4.4 Velocity measurements shall be made as a traverse through the center of each of the slot areas. The minimum time to uniformly traverse a slot opening shall be 30 s.

10.2.4.5 The airflow through the anemometer shall not be obstructed by the operator's hand or fingers.

10.2.4.6 The fan blade shall attain full speed before recording any velocity data.

10.2.4.7 The average velocity through each slot filter shall be measured starting at a filter at one end of the filter bank and ending with the filter at the other end of the bank.

10.2.4.8 The procedure shall be repeated twice more to obtain the average velocity for all three readings for each filter in feet per minute (FPM).

10.2.5 *Exhaust Duct Velocity Traverse:*

10.2.5.1 This method shall be used to determine the total air flow rate through an exhaust hood when velocity measurements at the filter face are not possible or have no established protocols.

10.2.5.2 Instrumentation is limited to a Pitot-static tube connected to a differential pressure measuring device.

10.2.5.3 The number and position of velocity measurement points within the duct shall conform to the values documented in ANSI/ASHRAE Standard 111-2008.

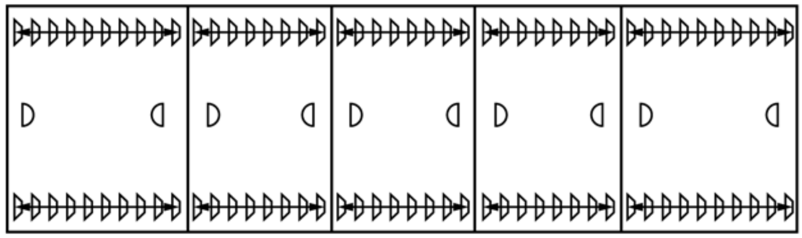

FIG. 4 Measurement Positions for a 2¾-in. Rotating Vane Anemometer Indicated by "X" on a Cyclone Filter Bank With Two Different Sized Filters

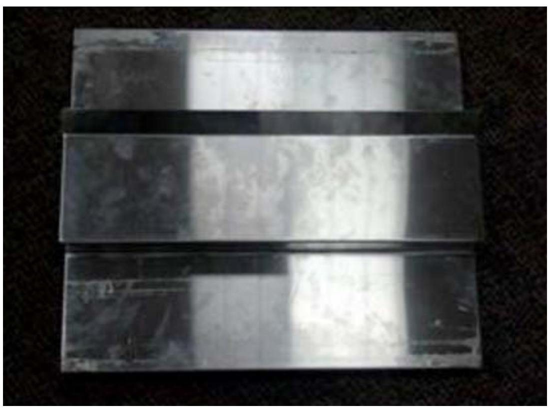

FIG. 5 Slot Filter

10.2.5.4 An accessible straight section of duct is required for the traverse.

10.2.5.5 If the duct is insulated, the insulation shall be removed to expose the exterior surface of the duct to allow holes to be drilled at the appropriate locations.

10.2.5.6 Conduct the velocity measurements according to ANSI/ASHRAE Standard 111-2008.

10.2.5.7 Repeat the velocity measurements twice more for triplicate readings.

10.2.5.8 Upon completion of all duct velocity measurements, seal the holes used for the traverse measurements (weld liquid-tight or install UL Listed fittings).

10.2.5.9 If the duct is insulated, any insulation removed shall be replaced and resealed.

10.3 *Exhaust Airflow Rate Adjustments:*

10.3.1 All kitchen exhaust air flow rates shall be within ±5 % of the specified value. If an initial value falls below 5 % of the specified value, the air flow rate shall be adjusted to fall within 5 % of the specification.

10.3.2 Raise or lower the exhaust fan speed to achieve the specified airflow rate.

10.3.2.1 To adjust the fan speed for belt-driven fans, shut the fan off, loosen the tension on the belt and remove it. Loosen the set screw on the adjustable motor pulley and screw the two halves toward each other to increase speed, and screw them away from each other to reduce speed. Be sure to tighten the set screw *only* on a flat on the pulley hub to avoid damaging the threads.

10.3.3 Measure the exhaust airflow rate into the exhaust hood using one of the procedures described in section 10.2.

10.3.4 Continue to adjust the fan speed until the measured air flow rate is within 5 % of the specified value.

10.3.5 Record the date, exhaust fan RPM setting measured with a tachometer, and the motor amp draw measured with a clamp-on ammeter at the correct exhaust flow rate, and use this for quick reference in the future (mark in indelible ink inside each motor dome for future reference).

10.3.6 After the final exhaust fan RPM has been set, (1) check that the fan and motor shafts in parallel and if not, adjust the motor or fan position by loosening and tightening the mounting bolts to achieve parallel shaft alignment, and (2) set the fan pulley and motor pulley on the same horizontal plane so the belt rides flat.

10.3.7 Secure the motor dome to the fan, making sure the dome seals out water from the motor compartment.

10.3.8 Repeat items 10.3.1 through 10.3.7 for all exhaust fans that require airflow rate adjustment.

10.4 *Proper Exhaust Fan Operation:*

10.4.1 The Venturi inlet of each fan shall seal completely against the gasket on the adapter plate.

10.4.2 The fan shall rotate in the direction of the arrow on the motor compartment plate.

10.4.3 The fan shall turn freely without binding on the Venturi rim.

10.4.4 The fan shaft bearings shall be properly lubricated.

10.5 *Supply and Makeup Air Flow Rate Measurements:*

10.5.1 *Supply Air Flow Rate Measurement:*

10.5.1.1 The supply air volumetric flow rate through each diffuser shall be measured using a flow hood with the open end of the hood sealed to prevent air flow from escaping.

10.5.1.2 Measurements shall be made with the internal baffle open and closed and the results used to estimate the flow rate when the hood is not present.

10.5.1.3 Measurements at each diffuser shall be made in triplicate and the average flow rate recorded.

10.5.1.4 The total supply air flow rate into the kitchen shall be the sum of the individual diffuser measurements.

10.5.2 *Makeup Air Flow Rate Measurement:*

10.5.2.1 The total air flow rate through each makeup air device shall be determined using one of the following methods with the cooking appliances idle/ready-to-cook.

(1) When a specific air flow rate measurement protocol is specified by the manufacturer, the protocol developed by the manufacturer shall be followed.

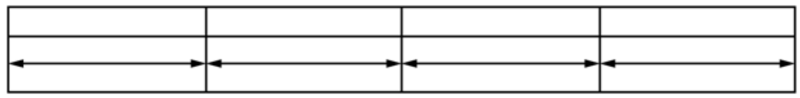

FIG. 6 Traverse Path for a 2.75 in. Rotating Vane Anemometer Indicated by "X" for a Slot Filter Bank Consisting of Four Filters

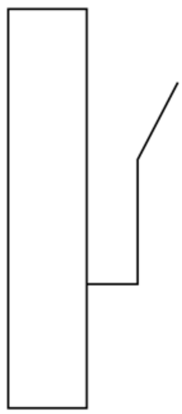

FIG. 7 Cross Section of Cartridge Filter

(2) When the makeup air device under test has no protocol from the manufacturer but has a protocol specified in this document, the method of test specified in this document shall be followed.

(3) When the makeup air device under test has no protocol from the manufacturer and does not have a protocol specified in this document, or one or more obstructions prevents proper use of face velocity measuring instruments, a duct traverse method shall be used to determine the total air flow rate through the device using a Pitot-static tube. The Log-Tchebycheff rule shall be used for rectangular ducts and the Log-linear rule for circular ducts as specified in ANSI/ASHRAE Standard 111-2008, "Measurement, testing, adjusting and balancing of building HVAC systems".

10.5.2.2 Measurements at each device shall be made in triplicate and the average flow rate recorded for each.

10.5.2.3 The total makeup air flow rate into the kitchen shall be the sum of the individual makeup air device measurements.

10.5.2.4 *Front Face With Perforated Plate Diffuser:*

(1) These measurements are limited to the use of a calibrated flow hood mounted flush to the face of the diffuser or a velocity grid positioned 1.5 in. from the diffuser surface. The flow hood shall be used except where obstructions prevent a proper seal along the entire diffuser surface of a makeup air unit. If a flow hood cannot be used, a velocity grid shall be used for the makeup air unit.

(2) Flow Hood:

(a) When the opening of the flow hood is larger than the width of the diffuser preventing a tight seal on all sides, the open area shall be blocked so that only air passing through the diffuser enters the flow hood. This can be accomplished by attaching a section of cardboard sealed to the end of the flow hood by tape.

(b) The flow hood shall be mounted in a sufficient number of positions over the perforated panel to measure all the air supplied by the diffuser.

(c) The flow hood shall be mounted such that no overlap occurs between any successive positions.

(d) At each position, the hood shall be used to measure the air flow rate with the internal damper open and closed. The two measurements shall be used to determine the air flow rate without the hood present using the hood manufacturer's procedure.

(e) The total air flow rate delivered by the diffuser shall be obtained by summing the air flow rates determined from the individual positions.

(3) The procedure described in sections 10.5.2.4*(2)(b)* through 10.5.2.4*(2)(e)* shall be repeated twice more to obtain the average air flow rate for all three readings in cubic feet per minute (CFM).

10.5.2.5 *Front Face With Louvers:*

(1) The total air flow rate supplied by a front face makeup air unit with louvers shall be measured using one of the procedures described in section 10.5.2.4.

10.5.2.6 *Perimeter:*

(1) The total air flow rate supplied by a perimeter makeup air unit shall be measured using described in section 10.5.2.4*(2)(b)*.

10.5.2.7 *Back Wall:*

(1) These measurements are limited to the use of a 4 in. rotating vane anemometer positioned at the bottom opening. The calculation involves the use of appropriate correction factors.

(2) The measurements shall be made with the cooking appliances moved away from the back wall unit to allow access to the slot at the bottom. If necessary the appliances may be disconnected.

(3) Each section in a back wall makeup air unit must be evaluated separately and the flow rate through each summed to determine the total airflow rate through the entire makeup air unit.

(4) Each section shall be divided into equal areas from end to end such that no area has a length longer than 12 in. Velocity measurements shall be made at the center of each of these areas. The average velocity in each section shall be determined by summing the measurements and dividing the result by the number of areas. Fig. 8 illustrates the locations necessary for a back wall unit 8 ft long that consists of two sections.

(5) The body of the anemometer must remain parallel to the opening with one side in the same plane as the opening.

(6) The center of the anemometer shall be centered across the opening from front to back.

(7) The airflow through the anemometer shall not be obstructed by the operator's hand or fingers.

(8) The fan blade shall attain full speed before recording any velocity data.

(9) The air velocity shall be averaged for all steps along the length of the opening in feet per minute (FPM).

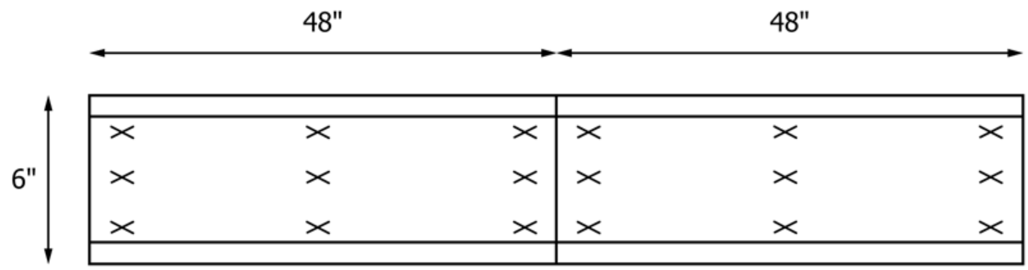

FIG. 8 Measurement Positions of a 4 in. Rotating Vane Anemometer for a Back Wall Makeup Air Unit 8 ft Long With Two Sections

(10) The procedure shall be repeated twice more to obtain the average velocity for all three readings for each section in feet per minute (FPM).

10.6 *Supply and Makeup Airflow Adjustments:*

10.6.1 Raise or lower the fan speed to achieve the specified airflow rate.

10.6.1.1 To adjust the fan speed for belt-driven fans, shut the fan off, loosen the tension on the belt and remove it. Loosen the set screw on the adjustable motor pulley and screw the two halves toward each other to increase speed, and screw them away from each other to reduce speed. Be sure to tighten the set screw only on a flat on the pulley hub to avoid damaging the threads.

10.6.2 Measure the revised supply or makeup airflow rate into the kitchen using one of the procedures described in section 10.5.

10.6.3 Continue to adjust the fan speed until the measured air flow rate is within ±5 % of the specified value.

10.6.4 Record the date, fan RPM setting measured with a tachometer, and the motor amp draw measured with a clamp-on ammeter at the correct makeup air level, and use this for quick reference in the future. Mark in indelible ink inside each motor dome for future reference.

10.6.5 After the final fan RPM has been set, (1) check that the fan and motor shafts are in parallel and if not, adjust the motor or fan position by loosening and tightening the mounting bolts to achieve parallel shaft alignment, and (2) set the fan pulley and motor pulley on the same horizontal plane so the belt rides flat.

10.6.6 Secure the motor dome to the fan, making sure the dome seals out water from the motor compartment.

10.6.7 Repeat items 10.6.1 through 10.6.6 for all supply or makeup air fans that require airflow rate adjustment.

10.7 *Proper Supply or Makeup Air Unit Operation:*

10.7.1 The doors and panels of the makeup air unit shall seal completely against the gaskets.

10.7.2 The fan shall rotate in the direction of the arrow on the motor compartment plate.

10.7.3 The fan shall turn freely without binding on the Venturi rim.

10.7.4 The fan shaft bearings shall be properly lubricated.

10.8 *Capture and Containment Verification:*

10.8.1 After measuring the exhaust airflow rate, performing the necessary adjustments and verifying the rate is within 5 % of the design specifications, the hood's capture and containment performance shall be evaluated for idle (ready to cook) conditions.

10.8.2 The cooking appliances shall be turned on and given one hour to fully warm up.

10.8.3 Cross drafts shall be minimized to reduce airflow disturbance.

10.8.4 A hood performance test shall be conducted with all appliances under the hood at operating temperatures, with all sources of outdoor air providing makeup air for the hood operating and with all sources of recirculated air providing conditioning for the space in which the hood is located operating.

10.8.5 Capture and containment shall be verified visually by observing smoke or steam produced by actual cooking operation and/or by visually seeding the thermal plume using devices such as smoke candles or smoke puffers. Smoke bombs shall not be used (note: smoke bombs typically create a large volume of effluent from a point source and do not necessarily confirm whether the cooking effluent is being captured). For some appliances (for example, broilers, griddles, fryers), actual cooking at the normal production rate is a reliable method of generating smoke. Other appliances that typically generate hot moist air without smoke (for example, ovens, steamers) need seeding of the thermal plume with artificial smoke to verify capture and containment.

10.8.6 When spillage is observed, the exhaust air flow rate shall be increased as described in section 10.3 and the test described in section 10.8.4 repeated until no further spillage is observed.

10.8.7 Following the capture and containment tests, it may be necessary to readjust the supply or makeup air flow rates to achieve the design pressure differentials.

10.9 *Pressure Differences:*

10.9.1 *Commercial Kitchens in Stand Alone Buildings:*

10.9.1.1 Air pressure within the dining area shall be within 0.050 to 0.100 in. of water above the ambient air pressure outside the building.

10.9.1.2 Air pressure within the kitchen shall be 0.050 to 0.200 in. of water negative with respect to the dining area and all adjacent storage or office spaces.

10.9.1.3 When the pressure differentials required in sections 10.9.1.1 or 10.9.1.2 are not met, adjustments shall be made on the makeup or exhaust systems until the required pressures are established.

10.9.2 *Commercial Kitchens in Larger Buildings*—Air pressure within the kitchen shall be 0.050 to 0.200 in. of water negative with respect to all adjacent rooms, storage areas and office space.

10.9.3 *Differential Pressure Measurement*—Differential pressures shall be measured using an electronic differential pressure gauge.

11. Calculation and Report

11.1 *General:*

11.1.1 Record the date, start and end times of the testing.

11.1.2 Measure and record the barometric pressure (in Hg), dry bulb temperature (F) and relative humidity (%) in the kitchen at the start and end of the testing.

11.1.3 Calculate and record the average barometric pressure (in Hg) during the testing according to the following relationship:

$$P_{ave} = (P_{start} + P_{end})/2 \quad (1)$$

where:

P_{ave} = average barometric pressure during the test, in Hg,
P_{start} = barometric pressure at the beginning of the test, in Hg, and
P_{end} = barometric pressure at the end of the test, in Hg.

11.1.4 Calculate and record the average indoor dry bulb temperature (F) during the testing according to the following relationship:

$$T_{ave} = (T_{start} + T_{end})/2 \quad (2)$$

where:

T_{ave} = average temperature during the test, F,
T_{start} = temperature at the beginning of the test, F, and
T_{end} = temperature at the end of the test, F.

11.1.5 Calculate and record the average relative humidity (%) during the testing according to the following relationship:

$$RH_{ave} = (RH_{start} + RH_{end})/2 \quad (3)$$

where:

RH_{ave} = average relative humidity during the test, %,
RH_{start} = relative humidity at the beginning of the test, %, and
RH_{end} = relative humidity at the end of the test, %.

11.1.6 Sketch the layout of the kitchen identifying all dedicated makeup units, all supplies, all locations of transfer air, and all exhaust hoods and return grilles. Describe the type of each dedicated makeup air unit and exhaust hood and label each for future reference in the test and balance report.

11.2 *Exhaust Hoods:*

11.2.1 *Airflow Area:*

11.2.1.1 Sketch the layout of the grease filters in the exhaust hood filter rack opening in each hood and label the filters from left to right. Measure the total width of each filter in inches and record on the sketch.

11.2.1.2 Sketch the layout of the grease filters in the exhaust hood filter rack opening in each hood and label the filters from left to right. Measure the total width of each filter in inches and record on the sketch.

(1) For a baffle filter, the height and width that includes the entire open area shall be measured.

(2) For a cyclone filter with more than one set of openings, each set of openings shall be measured.

(3) For a slot filter, the total open area on the upstream side of the slot shall be measured.

11.2.1.3 Calculate and report the opening area for each filter in units of ft^2. For filters with more than one set of openings, the total area includes the sum of each separate opening.

$$A_{filter} = (H \times W)/144 \quad (4)$$

where:

A_{filter} = opening area, ft^2,
H = height, in., and
W = width, in.

11.2.2 *Average Measured Velocity Through Each Filter for Each Test:*

11.2.2.1 For baffle filters, the average measured velocity is the average of the five individual readings:

$$V_{ave} = (V_1 + V_2 + V_3 + V_4 + V_5)/5 \quad (5)$$

where:

V_{ave} = average measured velocity for each filter, fpm, and
V_1 *through* V_5 = velocity measured at the five measurement locations, fpm.

11.2.2.2 For cyclone filters, the average measured velocity is the average of three individual velocity readings over each opening area:

$$V_{ave} = (V_L + V_C + V_R)/3 \quad (6)$$

where:

V_{ave} = average measured velocity at each set of openings, fpm,
V_L = velocity measured over the left third of the opening, fpm,
V_C = velocity measured over the center third of the opening, fpm, and
V_R = velocity measured over the right third of the opening, fpm.

11.2.2.3 For slot filters, the average measured velocity is the average of three individual readings over the opening in each filter:

$$V_{ave} = (V_L + V_C + V_R)/3 \quad (7)$$

where:

V_{ave} = average measured velocity for the filter opening, fpm,
V_L = velocity measured over the left third of the opening, fpm,
V_C = velocity measured over the center third of the opening, fpm, and
V_R = velocity measured over the right third of the opening, fpm.

11.2.3 *Mean Measured Velocity for the Three Measurements Made at Each Filter:*

11.2.3.1 Calculate and report the mean of the three average measured velocity values obtained for each filter (fpm) according to the following relationship:

$$V_{mean} = (V_{Ave1} + V_{Ave2} + V_{Ave3})/3 \quad (8)$$

where:

V_{mean} = mean measured velocity at each filter, fpm,
V_{Ave1} = first average measured velocity, fpm,
V_{Ave2} = second average measured velocity, fpm, and
V_{Ave3} = third average measured velocity, fpm.

11.2.4 *Corrected Mean Velocity at Each Filter:*

11.2.4.1 Calculate and report the corrected mean velocity at each filter according to the following equations:

(1) For baffle filters with 4 in. rotating anemometer flush:

$$V_{corr} = V_{mean} \times K \quad (9)$$

where:

V_{corr} = corrected mean velocity at each filter, fpm,
V_{mean} = mean measured velocity at each filter, fpm, and
K = 0.91.

(2) For cyclone filters and 4 in. rotating vane anemometer measurements at 2 in. standoff:

$$V_{corr} = V_{mean} \times K \quad (10)$$

where:

V_{corr} = corrected mean velocity at each filter, fpm,
V_{mean} = mean measured velocity at each filter, fpm, and
K = 1.72.

(3) For slot filters and 2.75 in. rotating vane anemometer measurements at zero standoff:

$$V_{corr} = V_{mean} \times K \quad (11)$$

where:

V_{corr} = corrected mean velocity at each filter, fpm,
V_{mean} = mean measured velocity at each filter, fpm, and
K = 1.18.

11.2.5 *Corrected Flow Rate Through Each Filter:*

11.2.5.1 Calculate and report the corrected air flow rate through each filter according to the following equation:

$$Q_{act} = V_{corr} \times A_{filter} \quad (12)$$

where:

Q_{act} = actual air flow rate through filter, cfm,
V_{corr} = corrected mean velocity at filter, fpm, and
A_{filter} = filter opening area, ft^2.

11.2.6 *Total Volumetric Flow Rate Through Exhaust Hood:*

11.2.6.1 Calculate and report the total volumetric air flow rate exhausted through each hood using the following equation:

$$Q_{Hood} = sum(Q_{act}),\ cfm \quad (13)$$

where:

Q_{Hood} = total flow rate through a hood, cfm, and
$sum(Q_{act})$ = the sum of the flow rates determined through each filter in the hood, cfm.

11.2.7 *Exhaust Air Flow Rate at Standard Conditions:*

11.2.7.1 Calculate and report the air flow rate under standard density conditions for each exhaust hood according to the following relationship:

$$Q_{std} = Q_{Hood} \times 530 \times P_{ave}/((460 + T_{ave}) \times 29.92) \quad (14)$$

where:

Q_{std} = air flow rate under standard air density conditions, scfm,
P_{ave} = average barometric pressure in kitchen, in Hg, and
T_{ave} = average dry bulb temperature in kitchen, F.

11.2.8 *Deviation from Specified Air Flow Rates:*

11.2.8.1 Compare the total exhaust air flow rates determined in 11.2.7.1 to the specified values as follows:

$$\%_{dev} = 100 \times (Q_{specified} - Q_{std})/Q_{specified} \quad (15)$$

where:

$\%_{dev}$ = percent deviation,
$Q_{specified}$ = specified exhaust air flow rate through a given hood, scfm, and
Q_{std} = measured exhaust air flow rate through the hood, scfm.

11.2.8.2 If the percent deviation computed in 11.2.8.1 exceeds ±5 % for any exhaust hood, the flow rate through the hood shall be adjusted to fall within this requirement.

11.3 *Supply Air Units:*

11.3.1 *Mean Measured Air Flow Rate for the Three Measurements Made at Each Diffuser:*

11.3.1.1 Calculate and report the mean of the measured flow rate values obtained for each diffuser (cfm) according to the following relationship:

$$Q_{Diff} = (Q_1 + Q_2 + Q_3)/3 \quad (16)$$

where:

Q_{Diff} = mean measured flow rate at each diffuser, cfm,
Q_1 = first measured flow rate, cfm,
Q_2 = second measured flow rate, cfm, and
Q_3 = third measured flow rate, cfm.

11.3.2 *Supply Air Flow Rate at Standard Conditions:*

11.3.2.1 Calculate and report the air flow rate under standard density conditions for each supply air diffuser according to the following relationship:

$$Q_{std} = Q_{Diff} \times 530 \times P_{ave}/((460 + T_{ave}) \times 29.92) \quad (17)$$

where:

Q_{std} = air flow rate under standard air density conditions, scfm,
P_{ave} = average barometric pressure in kitchen, in Hg, and
T_{ave} = average dry bulb temperature in kitchen, F.

11.3.3 *Deviation from Specified Air Flow Rates:*

11.3.3.1 Compare the total exhaust air flow rates determined in 11.3.2.1 to the specified values as follows:

$$\%_{dev} = 100 \times (Q_{specified} - Q_{std})/Q_{specified} \quad (18)$$

where:

$\%_{dev}$ = percent deviation,
$Q_{specified}$ = specified supply air flow rate through a given diffuser, scfm, and
Q_{std} = measured air flow rate through the diffuser, scfm.

11.3.3.2 If the percent deviation computed in 11.3.3.1 exceeds ±5 % for any supply air diffuser, the flow rate through the diffuser shall be adjusted to fall within this requirement.

11.4 *Front Face and Perimeter Makeup Air Units:*

11.4.1 *Total Volumetric Flow Rate Through Each Unit:*

11.4.1.1 Calculate and report the total volumetric air flow rate supplied through each unit using the following equation:

$$Q_{Tot} = sum(Q_{act}),\ cfm \qquad (19)$$

where:

Q_{Tot} = total flow rate through a unit, cfm, and
$sum(Q_{act})$ = the sum of the flow rate measurements made on the unit, more than one measurement will be required when the hood cannot capture all the air flow in a single measurement, cfm.

11.4.2 *Mean Measured Air Flow Rate for Each Unit:*

11.4.2.1 Calculate and report the mean of the three measured flow rate values obtained for each unit (cfm) according to the following relationship:

$$Q_{Makeup} = (Q_{Tot1} + Q_{Tot2} + Q_{Tot3})/3 \qquad (20)$$

where:

Q_{Makeup} = mean measured flow rate at each makeup air unit, cfm,
Q_{Tot1} = first measured total flow rate, cfm,
Q_{Tot2} = second measured total flow rate, cfm, and
Q_{Tot3} = third measured total flow rate, cfm.

11.4.3 *Makeup Air Flow Rate at Standard Conditions:*

11.4.3.1 Calculate and report the air flow rate under standard density conditions for each makeup air unit according to the following relationship:

$$Q_{std} = Q_{Makeup} \times 530 \times P_{ave}/((460 + T_{ave}) \times 29.92) \qquad (21)$$

where:

Q_{std} = air flow rate under standard air density conditions, scfm,
P_{ave} = average barometric pressure in kitchen, in Hg, and
T_{ave} = average dry bulb temperature in kitchen, F.

11.4.4 *Deviation from Specified Air Flow Rates:*

11.4.4.1 Compare the makeup air flow rates determined in 11.4.3.1 to the specified values as follows:

$$\%_{dev} = 100 \times (Q_{specified} - Q_{std})/Q_{specified} \qquad (22)$$

where:

$\%_{dev}$ = percent deviation,
$Q_{specified}$ = specified air flow rate through a given makeup air unit, scfm, and
Q_{std} = measured air flow rate through the unit, scfm.

11.4.4.2 If the percent deviation computed in 11.4.4.1 exceeds ±5 % for any makeup air unit, the flow rate through the unit shall be adjusted to fall within this requirement.

11.5 *Backwall Makeup Air Units:*

11.5.1 *Airflow Area:*

11.5.1.1 Measure and record the length and width of the unobstructed opening in units of inches.

11.5.1.2 Calculate and report the opening area in units of ft^2:

$$A_{Discharge} = (L \times W)/144 \qquad (23)$$

where:

$A_{Discharge}$ = opening area of discharge at the bottom, ft^2,
L = length, in., and
W = width, in.

11.5.2 Divide the length into equal sections of approximately 1 ft each. Measure and record the length of each section in inches.

11.5.3 Calculate and report the unobstructed flow area for each section as follows:

$$A_{section} = (L_{section} \times W)/144 \qquad (24)$$

where:

$A_{section}$ = flow area of a section of backwall unit, ft^2,
$L_{section}$ = length of a section, in., and
W = width of backwall unit opening, in.

11.5.4 Calculate and report the mean measured velocity at each section as follows:

$$V_{mean} = (V_1 + V_2 + V_3)/3 \qquad (25)$$

where:

V_{mean} = mean measured velocity at each section, fpm,
V_1 = first measured velocity, fpm,
V_2 = second measured velocity, fpm, and
V_3 = third measured velocity, fpm.

11.5.5 Calculate and report the corrected mean velocity at each section according to the following equation:

$$V_{corr} = V_{mean} \times K \qquad (26)$$

where:

V_{corr} = corrected mean velocity at each section, fpm,
V_{mean} = mean measured velocity at each section, fpm, and
K = 0.69.

11.5.6 Calculate and report the corrected volumetric air flow rate through each section according to the following equation:

$$Q_{act} = V_{corr} \times A_{Section} \qquad (27)$$

where:

Q_{act} = actual air flow rate through section, cfm,
V_{corr} = corrected mean velocity at section, fpm, and
$A_{Section}$ = open area for discharge in section, ft^2.

11.5.7 Calculate and report the total volumetric air flow rate delivered through each back wall unit using the following equation:

$$Q_{Backwall} = sum(Q_{act}),\ cfm \qquad (28)$$

where:

$Q_{Backwall}$ = total flow rate through a back wall unit, cfm, and
$sum(Q_{act})$ = the sum of the flow rates determined through each section, cfm.

11.5.8 Calculate and report the volumetric air flow rate delivered under standard density conditions for each back wall makeup air unit according to the following relationship:

$$Q_{std} = Q_{Backwall} \times 530 \times P_{ave}/((460 + T_{ave}) \times 29.92) \qquad (29)$$

where:

Q_{std} = air flow rate under standard air density conditions, scfm,

P_{ave} = average barometric pressure in kitchen, in Hg, and
T_{ave} = average dry bulb temperature in kitchen, F.

11.5.9 The total air flow rates determined in 11.5.8 shall be compared to the specified values as follows:

$$\%_{dev} = 100 \times (Q_{specified} - Q_{std})/Q_{specified} \quad (30)$$

where:

$\%_{dev}$ = air flow rate under standard air density conditions, scfm,
$Q_{specified}$ = average barometric pressure in kitchen, in Hg, and
Q_{std} = average dry bulb temperature in kitchen, F.

11.5.10 If the percent deviation computed in 11.5.9 exceeds ±5 % for any back wall unit, the flow rate through the unit shall be adjusted to fall within this requirement.

11.6 *Differential Pressure Measurements:*

11.6.1 *Commercial Kitchens in Stand-Alone Buildings:*

11.6.1.1 Measure and record the air pressure difference between the dining area and outside.

11.6.1.2 If the pressure in the dining area is less than 0.05 in. water above the outside pressure, the makeup air system shall be adjusted to achieve a 0.05 in. water pressure difference.

11.6.1.3 Measure and record the air pressure difference between the dining area and the kitchen.

11.6.1.4 If the pressure in the kitchen is less than 0.05 in. water below the pressure in the dining area, one or more kitchen makeup air units or exhaust hoods shall be adjusted to maintain a pressure difference of 0.05 in. water.

11.6.2 *Commercial Kitchens in Larger Buildings:*

11.6.2.1 Measure and record the air pressure difference between the kitchen and all adjacent rooms, storage areas and office spaces.

11.6.2.2 If the pressure in the kitchen is not between 0.05 and 0.2 in. water negative with respect to the adjacent rooms, one or more makeup air unit or exhaust hoods shall be adjusted to achieve a 0.05 in. water negative pressure with respect to the adjacent dining area.

12. Precision and Bias

12.1 *Precision*—No statement can be made concerning the precision of the procedures in this test method because there are no accepted values for the parameters reported.

12.2 *Bias*—No statement can be made concerning the bias of the procedures in this test method because there are no accepted values for the parameters reported.

13. Keywords

13.1 air flow balancing; air flow testing; capture and containment; commercial kitchen ventilation system; field performance