Designation: F1704 – 05

An American National Standard

Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems[1]

This standard is issued under the fixed designation F1704; 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 Characterization of capture and containment performance of hood, appliance(s), and replacement air system during cooking and non-cooking conditions (idle):

1.2 Parametric evaluation of operational or design variations in appliances, hoods, or replacement air configurations.

1.3 The test method to determine heat gain to space from commercial kitchen ventilation/appliance systems has been re-designated as Test Method F2474.

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

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1275 Test Method for Performance of Griddles
F1361 Test Method for Performance of Open Deep Fat Fryers
F1484 Test Methods for Performance of Steam Cookers
F1496 Test Method for Performance of Convection Ovens
F1521 Test Methods for Performance of Range Tops
F1605 Test Method for Performance of Double-Sided Griddles
F1639 Test Method for Performance of Combination Ovens
F1695 Test Method for Performance of Underfired Broilers
F1784 Test Method for Performance of a Pasta Cooker
F1785 Test Method for Performance of Steam Kettles
F1787 Test Method for Performance of Rotisserie Ovens
F1817 Test Method for Performance of Conveyor Ovens
F1991 Test Method for Performance of Chinese (Wok) Ranges
F1964 Test Method for Performance of Pressure and Kettle Fryers
F1965 Test Method for Performance of Deck Ovens
F2093 Test Method for Performance of Rack Ovens
F2144 Test Method for Performance of Large Open Vat Fryers
F2237 Test Method for Performance of Upright Overfired Broilers
F2239 Test Method for Performance of Conveyor Broilers
F2474 Test Method for Heat Gain to Space Performance of Commercial Kitchen Ventilation/Appliance Systems

2.2 *ASHRAE Standards:*[3]

ASHRAE Guideline 2-1986 (RA90) Engineering Analysis of Experimental Data

2.3 *ANSI Standard:*[4]

ANSI/ASHRAE 51 and ANSI/AMCA 210 Laboratory Method of Testing Fans for Rating

NOTE 1—The replacement air and exhaust system terms and their definitions are consistent with terminology used by the American Society of Heating, Refrigeration, and Air Conditioning Engineers, see Ref (**1**).[5] Where there are references to cooking appliances, an attempt has been made to be consistent with terminology used in the test methods for commercial cooking appliances. For each energy rate defined as follows, there is a corresponding energy consumption that is equal to the average energy rate multiplied by elapsed time. Electric energy and rates are expressed in W, kW, and kWh. Gas Energy consumption quantities and rates are expressed in Btu, kBtu, and kBtu/h. Energy rates for natural gas-fueled appliances are based on the higher heating value of natural gas.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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

Current edition approved March 1, 2005. Published March 2005. Originally approved in 1996. Last previous edition approved in 1999 as F1704 – 99. DOI: 10.1520/F1704-05.

[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 Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] The boldface numbers in parentheses refer to the list of references at the end of these test methods.

3.1.1 *aspect ratio*, *n*—ratio of length to width of an opening or grill.

3.1.2 *energy rate*, *n*—average rate at which an appliance consumes energy during a specified condition (for example, idle or cooking).

3.1.3 *cooking energy consumption rate*, *n*—average rate of energy consumed by the appliance(s) during cooking specified in appliance test methods in 2.1.

3.1.3.1 *Discussion*—In this test method, this rate is measured for heavy-load cooking in accordance with the applicable test method.

3.1.4 *exhaust flow rate*, *n*—volumetric flow of air (plus other gases and particulates) through the exhaust hood, measured in standard cubic feet per minute, scfm (standard litre per second, sL/s). This also shall be expressed as scfm per linear foot (sL/s per linear metre) of exhaust hood length.

3.1.5 *fan and control energy rate*, *n*—average rate of energy consumed by fans, controls, or other accessories associated with cooking appliance(s). This energy rate is measured during preheat, idle, and cooking tests.

3.1.6 *hood capture and containment*, *n*—ability of the hood to capture and contain grease-laden cooking vapors, convective heat, and other products of cooking processes. Hood capture refers to the products getting into the hood reservoir from the area under the hood while containment refers to the products staying in the hood reservoir.

3.1.7 *idle energy consumption rate*, *n*—average rate at which an appliance consumes energy while it is idling, holding, or ready-to-cook, at a temperature specified in the applicable test method from 2.1.

3.1.8 *measured energy input rate*, *n*—maximum or peak rate at which an appliance consumes energy measured during appliance preheat, that is, measured during the period of operation when all gas burners or electric heating elements are set to the highest setting.

3.1.9 *rated energy input rate*, *n*—maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the appliance nameplate.

3.1.10 *replacement air*, *n*—air deliberately supplied into the space (test room), and to the exhaust hood to compensate for the air, vapor, and contaminants being expelled (typically referred to as make-up air); can be dedicated make-up air directed locally in the vicinity of the hood, transfer air, or a combination.

3.1.11 *replacement air configurations*, *n*—see below.

3.1.11.1 *ceiling diffuser, n*—outlet discharging supply air parallel to the ceiling either radially or in specific directions (for example, two-way, three-way, or four-way).

3.1.11.2 *displacement diffuser, n*—outlet supplying low velocity air at or near floor level.

3.1.11.3 *grille, n*—frame enclosing a set of either vertical or horizontal vanes (single deflection grill) or both (double deflection grill).

3.1.12 *integrated hood plenums*, *n*—see below.

3.1.12.1 *air curtain supply, n*—replacement air delivered directly to the interior plenum of an exhaust hood such that it is introduced vertically downward, typically from the front edge of the hood.

3.1.12.2 *backwall supply, n*—replacement air delivered behind and below the cooking appliance line, typically through a ducted wall plenum. Sometimes a referred to as rear supply.

3.1.12.3 *front face supply, n*—replacement air delivered directly to an interior plenum of the exhaust hood such that it is introduced into the kitchen space through the front face of the hood.

3.1.12.4 *internal supply, n*—replacement air delivered directly to the interior of an exhaust hood such that it is exhausted without entering the occupied space. Sometimes referred to as short-circuit supply.

3.1.12.5 *perforated perimeter supply, n*—replacement air delivered through perforated supply plenums located at or slightly below ceiling level and directed downward.

3.1.12.6 *perforated diffuser, n*—face of this ceiling diffuser typically has a free area of about 50 %. It can discharge downward or are available with deflection devices to provide for a horizontal discharge.

3.1.12.7 *register, n*—grilled equipped with a damper.

3.1.12.8 *transfer air, n*—air transferred from one room to another through openings in the room envelope.

3.1.12.9 *slot diffuser, n*—long narrow supply air grill or diffuser outlet with an aspect ratio generally greater than 10 to 1.

3.1.13 *supply flow rate*, *n*—volumetric flow of air supplied to the exhaust hood in an airtight room, measured in standard cubic feet per minute, scfm (standard litre per second, sL/s). This also shall be expressed as scfm per linear foot (sL/s per linear metre) of active exhaust hood length. It consists of the make-up air supplied locally to the exhaust hood (that is, through plenums, diffusers, and so forth) and general replacement air supplied through transfer or displacement diffusers.

3.1.14 *threshold of capture and containment*, *n*—conditions of hood operation in which minimum flow rates are just sufficient to capture and contain the products generated by the appliance(s). In this context, two minimum capture and containment points can be determined, one for appliance idle condition, and the other for heavy-load cooking condition.

3.1.15 *throw*, *n*—horizontal or vertical axial distance an air stream travels after leaving an air outlet before maximum stream velocity is reduced to a specified terminal velocity, for example, 100, 150, or 200 ft/min (0.51, 0.76, or 1.02 m/s).

3.1.16 *uncertainty*, *n*—measure of the precision errors in specified instrumentation or the measure of the repeatability of a reported result.

3.1.17 *ventilation*, *n*—that portion of supply air that is outdoor air plus any recirculated air that has been treated for the purpose of maintaining acceptable indoor air quality.

4. Summary of Test Method

4.1 This test method uses flow visualization to determine the threshold of capture and containment (C&C) of a hood/appliance combination under cooking and idle conditions.

5. Significance and Use

5.1 *Threshold of Capture and Containment*—This test method describes flow visualization techniques that are used to determine the threshold of capture and containment (C&C) for idle and specified heavy cooking conditions. The threshold of C&C can be used to estimate minimum flow rates for hood/appliance systems.

5.2 *Parametric Studies*—This test method also can be used to conduct parametric studies of alternative configurations of hoods, appliances, and replacement air systems. In general, these studies are conducted by holding constant all configuration and operational variables except the variable of interest. This test method, therefore, can be used to evaluate the following:

5.2.1 The overall system performance with various appliances, while holding the hood and replacement air system characteristics constant.

5.2.2 Entire hoods or characteristics of a single hood, such as end panels, can be varied with appliances and replacement air constant.

5.2.3 Replacement air characteristics, such as make-up air location, direction, and volume, can be varied with constant appliance and hood variables.

6. Apparatus

6.1 The general configuration and apparatus necessary to perform this test method include either an airtight or a non-airtight as shown schematically in Fig. 1 and Fig. 2. The minimum volume of the room shall be 6000 ft^3. The method of airflow measurement differs between the types of room used. The exhaust hood under test is hung and connected to an exhaust duct and fan. The terminal devices of the make-up air configuration, if applicable, are ducted and connected to a make-up air fan. The test facility includes the following:

6.2 *Airtight Room*, with sealable access door(s), to contain the exhaust hood and make-up air configuration to be tested, with specified cooking appliance(s) to be placed under the hood. The room air leakage shall not exceed 20 scfm (9.4 sL/s) at 0.2 in. w.c. (49.8 Pa). Complementary replacement air fans are controlled to balance the exhaust rate, thereby maintaining a negligible static pressure difference between the inside and outside of the test room. Such a facility is described in detail in Ref (**2**). Examples of test facilities are described in Refs (**5**, **3**, **4**).

Note 2—Because of potential problems with measurement in the hot, possibly grease-laden exhaust air stream, exhaust air flow rate can be determined by measuring the replacement air flow rate on the supply side. This requires the design of an airtight test facility that ensures the supply rate equals the exhaust rate since air leakage outside the system boundary, that is, all components between supply and exhaust blowers making up the system, is negligible.

6.2.1 *Exhaust and Replacement Air Fans*, with variable-speed drives, to allow for operation over a wide range of exhaust air flow rates.

6.2.2 *Control System and Sensors*, to provide for automatic or manual adjustment of replacement air flow rate, relative to exhaust flow rate, to yield a differential static pressure between inside and outside of the airtight room not to exceed 0.05 in. w.c. (12.5 Pa).

6.2.3 *Air Flow Measurement System*, AMCA 210 or equivalent nozzle chamber, mounted in the general replacement or make-up airstream, or both, to measure airflow rate.

Note 3—Laminar flow elements have been used as an equivalent alternative to the flow nozzles in AMCA 210 (see 2.3).

6.3 *Non-Airtight Room*, to contain the exhaust hood and make-up air configuration to be tested, with specified cooking appliance(s) to be placed under the hood. The room is

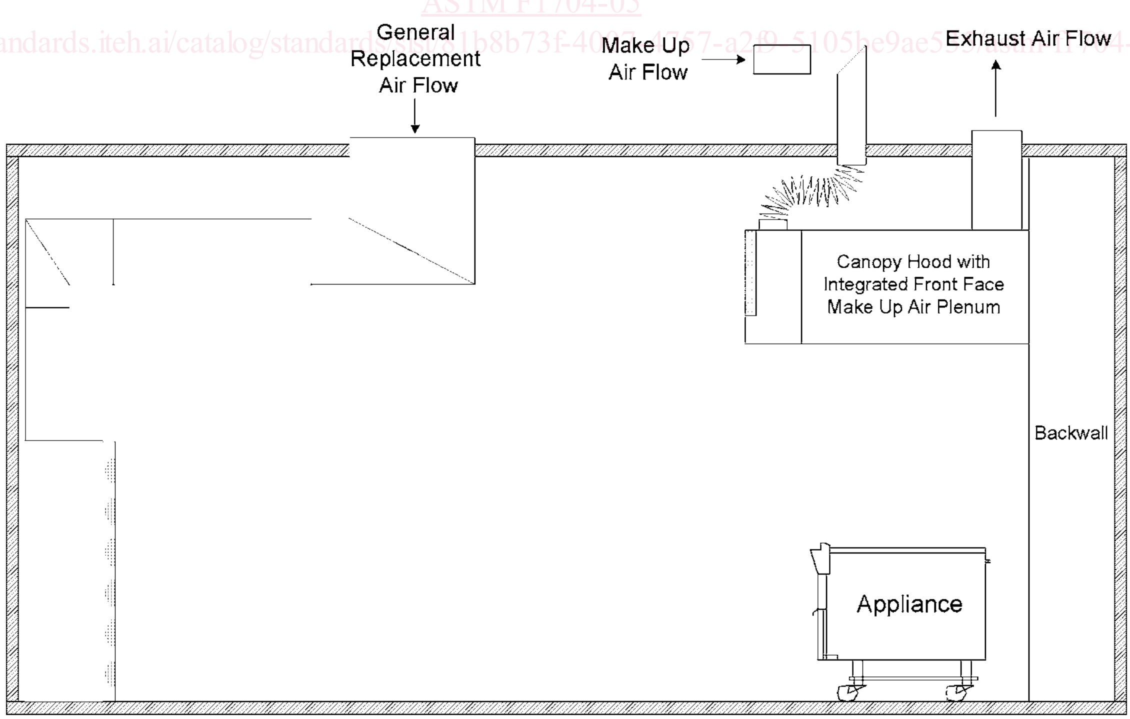

FIG. 1 Airtight Test Space Cross Section

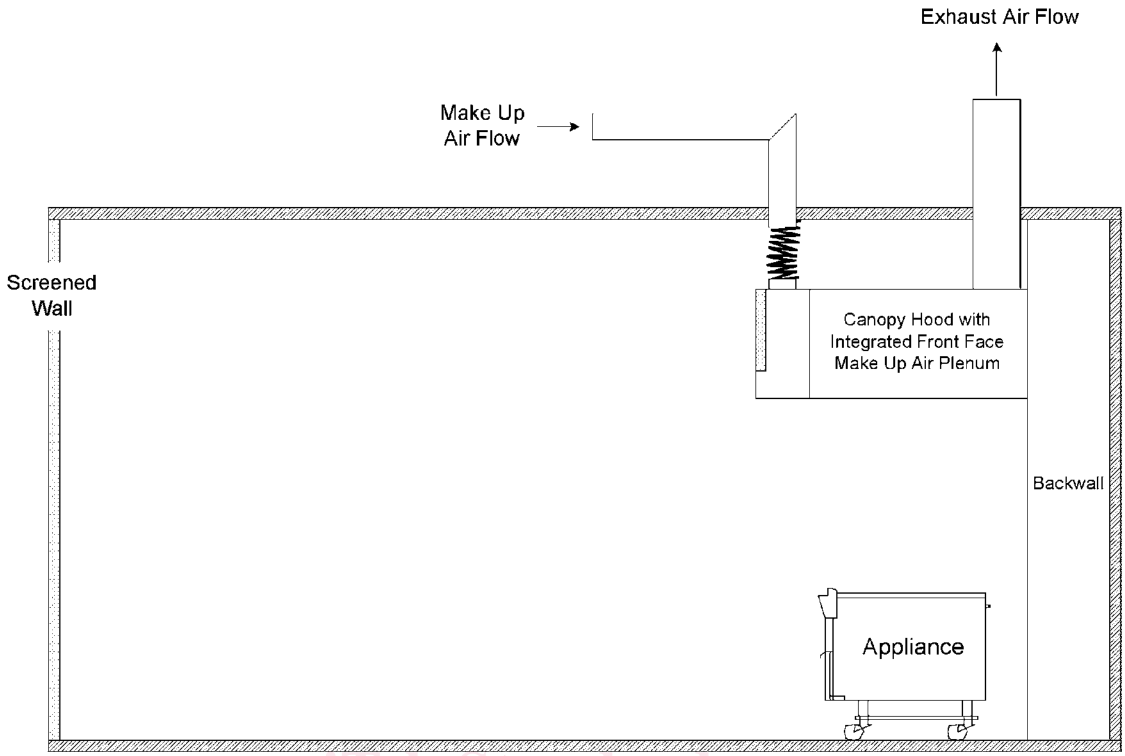

FIG. 2 Non-Airtight Test Space Cross Section

configured such that it allows replacement air to approach the entire front face of the exhaust hood slowly, as through a screened wall.

6.3.1 *Exhaust Fan*, with variable speed drive, to allow for operation over a wide range of exhaust airflow rates.

6.3.2 *Control System and Sensors*, to provide for automatic or manual adjustment of exhaust airflow rate.

6.3.3 *Air Flow Management System*—A Pitot tube traverse, nozzle chamber or equivalent in accordance with AMCA 210, mounted in the exhaust and make-up airstreams, to measure airflow rates.

NOTE 4—Laminar flow elements have been used as an equivalent alternative to the flow nozzles in AMCA 210 (see 2.3).

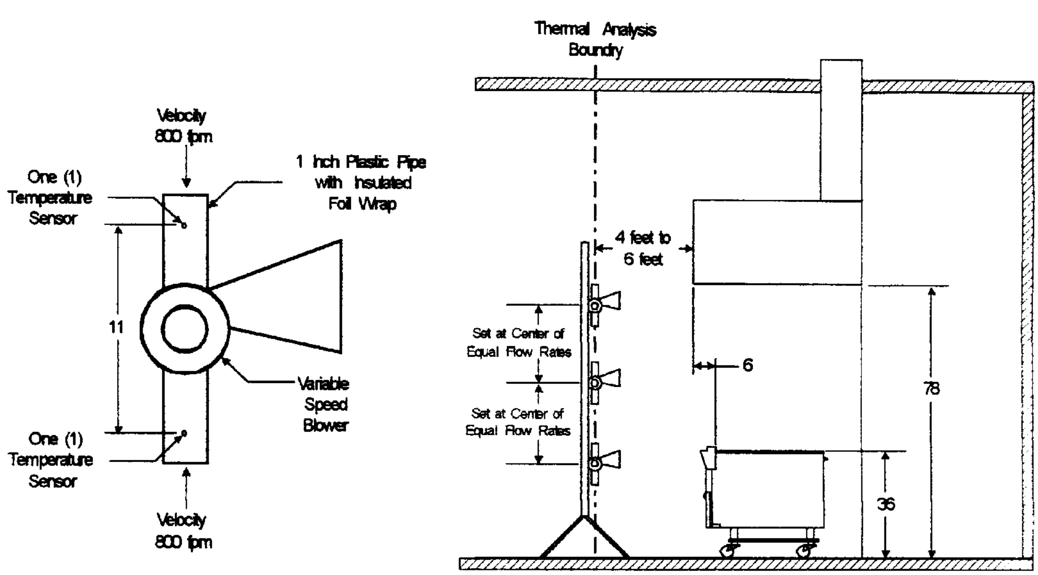

FIG. 3 Aspirated Trees and Schematic and Set-Up

6.4 *Aspirated Temperature Tree(s)*, for measurement of average temperature of replacement air from the test space crossing the plane of the tree(s) into the hood, see Fig. 3.

6.5 *Flow Enhancement Visualization Systems*:

6.5.1 *Optical Systems*, such as schlieren visualization (see Fig. 4) and shadowgraph.

6.5.2 *Seeding Methods*, such as theater fog.

NOTE 5—The seeding process shall only introduce small amounts of tracer material to avoid disturbances to the airflow. A seeding process introduces a tracer that artificially seeds the thermal plume that is rising between the cooking surface and the perimeter of the hood for visualization, and thereby making it more visible. This flow path will be generated continuously throughout the determination of the threshold capture and containment flow rate by suitable equipment and introduced at a trace rate only and not at an appreciable volume.

6.5.3 *Illumination*, such as with high-intensity, focused lighting.

NOTE 6—A 300-W halogen lamp with a lens or a 1000-W freznel equipped theater spotlight and a dark backdrop in place aids in visualizing seeded effluent plume.

6.6 *Data Acquisition System*, to provide for automatic logging of test parameters.

7. Reagents and Materials

7.1 *Water and Test Food Products*—Use water and test food products to determine energy-to-food as specified in the standards listed in Section 2 (Test Methods F1275, F1361, F1484, F1496, F1521, F1605, F1639, F1695, F1784, F1785, F1787, F1817, F1991, F1964, F1965, F2093, F2144, F2237, and F2239).

8. Sampling

8.1 *Hood and Appliance(s)*—Select representative production models for performance testing.

9. Preparation of Apparatus

9.1 Install the test hood in the airtight room in accordance with the manufacturer's instructions, or as determined by particular experimental conditions.

9.2 Local make-up air shall be supplied to diffusers or plenums as determined by the test conditions. The specific arrangement shall be noted in the report.

NOTE 7—The general replacement air provided to the test space shall be admitted from diffusers or a wall located as far away from the hood as possible. The principal direction of replacement airflow from these diffusers shall be toward the front face of the exhaust hood in order to minimize the effects the airflow might have on the capture and containment process. The general arrangement of diffusers and replacement air are shown in Fig. 5 and Fig. 6. Document replacement air configuration and damper positions, following the manufacturer's recommendations.

9.3 Connect the appliance(s) to energy sources and test the instruments in accordance with the applicable test methods. Included is the connection to calibrated energy test meters and for gas equipment and the connection to a pressure regulator downstream of the test meter. Electric and gas energy sources are adjusted to within 2.5 % of voltages and pressures, respectively, as specified by the manufacturer's instructions or in accordance with applicable test methods.

9.4 Once the equipment has been installed, draw a front and side view of the test set-up.

10. Calibration

10.1 Calibrate the instrumentation and data acquisition system in accordance with device requirements to ensure accuracy of measurements.

10.2 Calibrate the flow measurement systems in accordance with the manufacturer's specifications and installed in accordance with AMCA 210. Other flow measurement systems must meet or exceed AMCA 210 accuracy requirements.

10.3 Calibrate humidity measuring instruments in accordance with the manufacturer's specifications annually against NIST-traceable reference meters. Relative humidity accuracy within ±0.5 % at 40 % RH and ±1.25 % at 95 % RH.

10.4 Calibrate all temperature sensors to within 2°F against a NIST-traceable temperature reference over the range of expected measurements.

11. Procedure

NOTE 8—The following procedures are the instructions for implementing the test method for determining the threshold capture and containment flow rate for appliance(s) during cooking and idle conditions and a hood with specific replacement air configurations. The procedure will establish two threshold capture and containment flow rates, for appliance heavy-load cooking, cfm_{cook} and for idling, cfm_{idle} (optional).

11.1 Conduct the capture and containment test for idle and cooking conditions a minimum of three times. Additional test

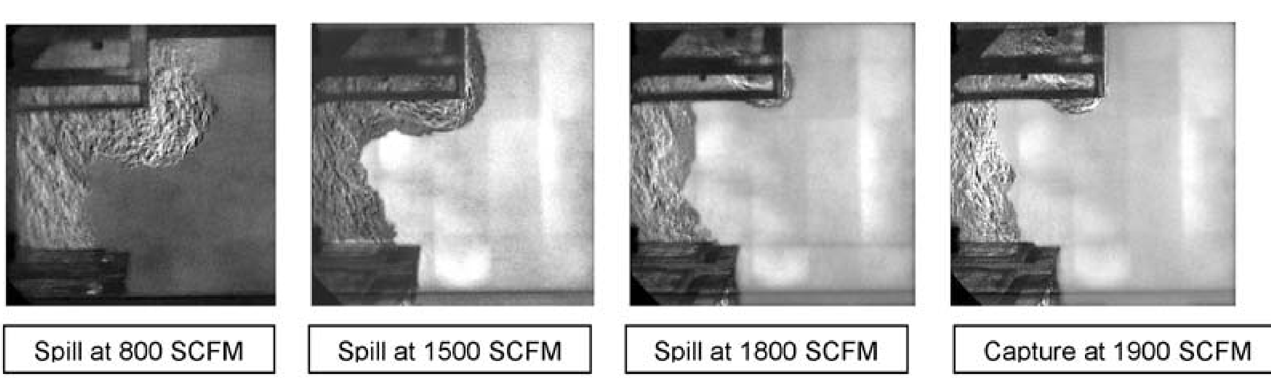

FIG. 4 Example of Schlieren Flow Visualization for Gas Charbroilers Under a Canopy Hood

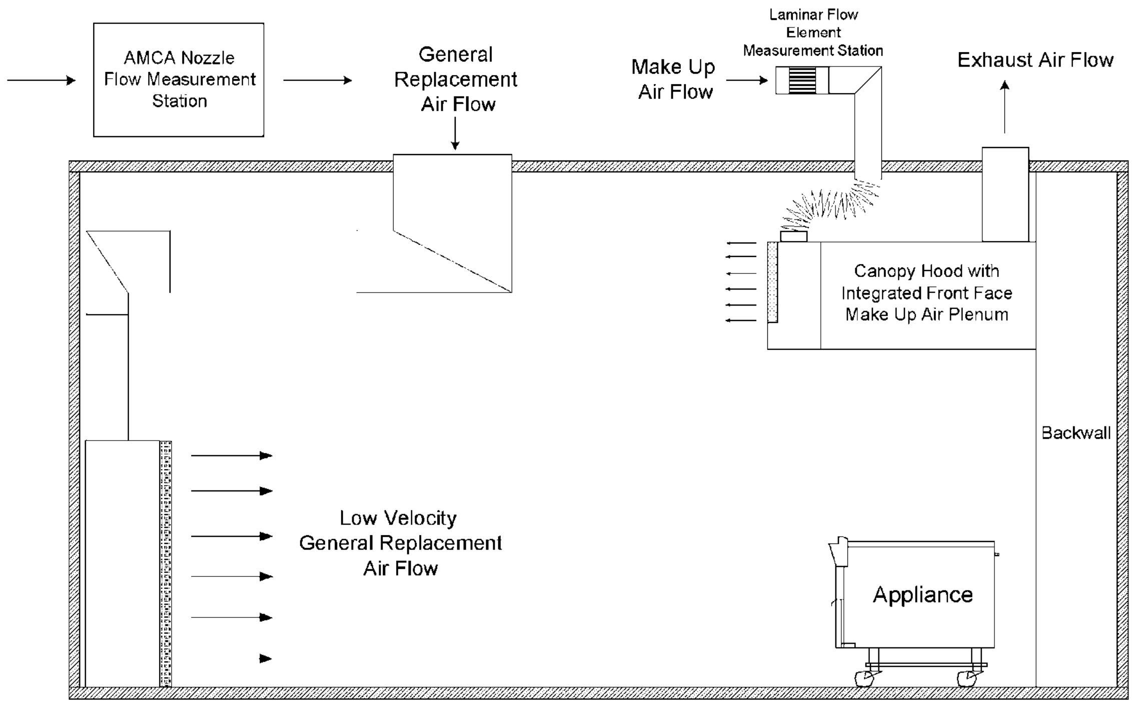

FIG. 5 Replacement Air Configuration for an Airtight Test Space

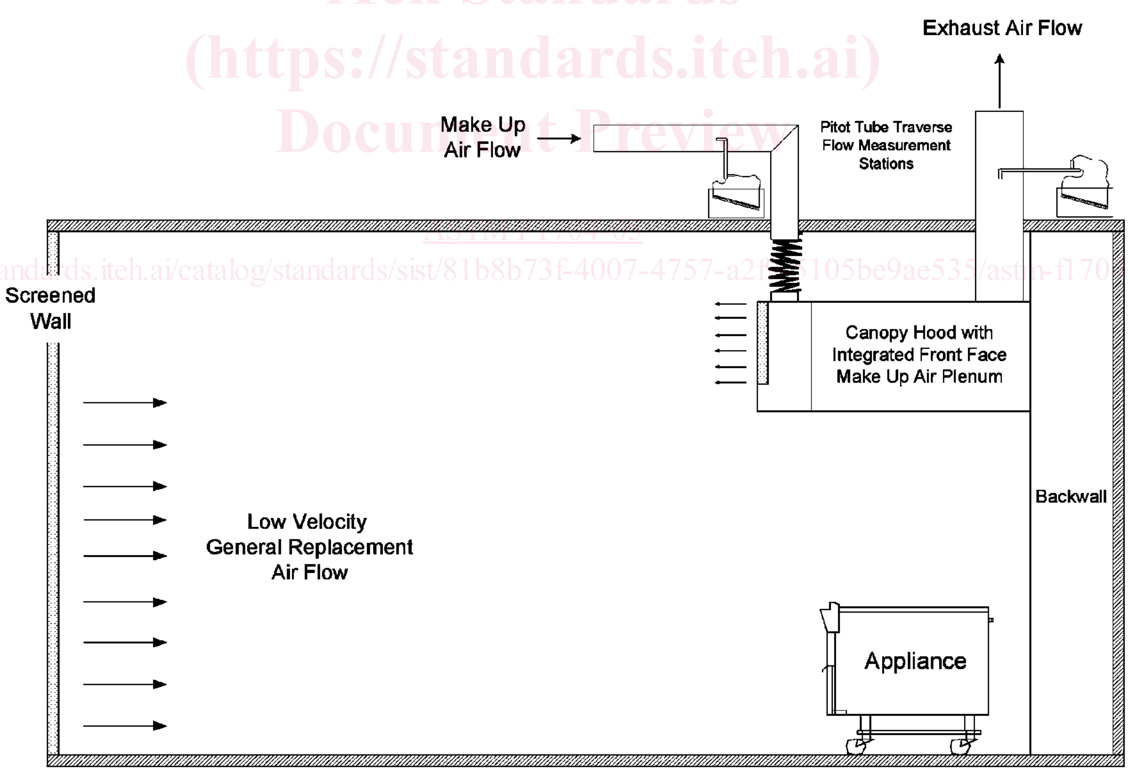

FIG. 6 Replacement Air Configuration for a Non-Airtight Test Space

runs may be necessary to obtain the required precision of the reported test results (Annex A1).

11.2 Set the initial airflow rates.

11.2.1 Set the initial local make-up airflow rates, if applicable, to the make-up air plenums or ceiling diffusers as specified by the manufacturer.