INTERNATIONAL

~~Designation:F2474–05~~ Designation: F2474 – 09

Standard Test Method for Heat Gain to Space Performance of Commercial Kitchen Ventilation/Appliance Systems[1]

This standard is issued under the fixed designation F2474; 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 covers the determination of appliance heat gain to space derived from the measurement and calculation of appliance energy consumption, energy exhausted, and energy to food, based on a system energy balance, parametric evaluation of operational or design variations in appliances, hoods, or replacement air configurations.

~~1.2The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.~~

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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
F1704 Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems
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

2.2 *ASHRAE Standard:*[3]

ASHRAE Guideline 2-1986 (RA96) Engineering Analysis of Experimental Data
ASHRAE Terminology of Heating, Ventilation, Air-Conditioning, and Refrigeration

[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.

~~Current edition approved March 1, 2005. Published March 2005. DOI: 10.1520/F2474-05.~~

Current edition approved Oct. 1, 2009. Published November 2009. Originally approved in 2005. Last previous edition approved in 2005 as F2474 – 05. DOI: 10.1520/F2474-09.

[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

2.3 *ANSI Standards:*[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.[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:*

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

3.1.2 *appliance/hood energy balance*, *n*—mathematical expression of appliance, exhaust system, and food energy relationship.

[actual appliance energy consumption]
= [heat gain to space from appliance(s)] + [energy exhausted] + [energy-to-food, if any]

3.1.3 *cold start*, *n*—condition in which appliances are energized with all components being at nominal room temperature.

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

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

3.1.5 *exhaust energy rate*, *n*—average rate at which energy is removed from the test system.

3.1.6 *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 active exhaust hood length.

3.1.7 *energy-to-food rate*, *n*—average rate at which energy is transferred from the appliance to the food being cooked, using the cooking conditions specified in the applicable test methods.

3.1.8 *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.

3.1.9 *heat gain energy rate from appliance(s)*, *n*—average rate at which energy is transferred from appliance(s) to the test space around the appliance(s), exclusive of the energy exhausted from the hood and the energy consumed by the food, if any.

3.1.9.1 *Discussion*—This gain includes conductive, convective, and radiant components. In conditions of complete capture, the predominant mechanism of heat gain consists of radiation from the appliance(s) and radiation from hood. In the condition of hood spillage, heat is gained additionally by convection.

3.1.10 *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.

3.1.11 *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.

3.1.12 *latent heat gain*, *n*—energy added to the test system by the vaporization of liquids that remain in the vapor phase prior to being exhausted, for example, by vapor emitted by products of combustion and cooking processes.

3.1.13 *makeup air handling hardware:*

3.1.13.1 *diffuser, n*—outlet discharging supply air in various directions and planes.

3.1.13.2 *grille, n*—covering for any opening through which air passes.

3.1.13.3 *register, n*— grille equipped with a damper.

3.1.13.4 *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).

3.1.14 *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.

3.1.15 *radiant heat gain*, *n*—fraction of the space energy gain provided by radiation.

3.1.15.1 *Discussion*—Radiant heat gain is not immediately converted into cooling load. Radiant energy must first be absorbed by surfaces that enclose the space and objects in the space. As soon as these surfaces and objects become warmer than the space air, some of their heat is transferred to the air in the space by convection. The composite heat storage capacity of these surfaces and objects determines the rate at which their respective surface temperatures increase for a given radiant input and thus governs

[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.

the relationship between the radiant portion of heat gain and its corresponding part of the cooling load. The thermal storage effect is critically important in differentiating between instantaneous heat gain for a given space and its cooling load for that moment.

3.1.16 *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.

3.1.17 *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 makeup air).

3.1.18 *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.

3.1.19 *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 are determined, one for appliance idle condition, and the other for heavy-load cooking condition.

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

3.1.21 *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 is used to characterize the performance of commercial kitchen ventilation systems. Such systems include one or more exhaust-only hoods, one or more cooking appliances under the hood(s), and a means of providing replacement (makeup) air. Ventilation system performance includes the evaluation of the rate at which heat is transferred to the space.

4.1.1 The heat gain from appliance(s) hood system is measured through energy balance measurements and calculations determined at specified hood exhaust flow rate(s). When heat gain is measured over a range of exhaust flow rates, the curve of energy gain to the test space versus exhaust rate reflects kitchen ventilation system performance, in terms of heat gain associated with the tested appliance(s).

4.1.2 In the simplest case, under idle mode, energy exhausted from the test system is measured and subtracted from the energy into the appliance(s) under the hood. The remainder is heat gain to the test space. In the cooking mode, energy to food also must be subtracted from appliance energy input to calculate heat gain to space.

4.1.3 Figs. 1-3 show sample curves for the theoretical view of heat gain due to hood spillage, an overall energy balance, and for heat gain versus exhaust flow rate for the general case.

5. Significance and Use

5.1 *Heat Gain to Space*—This test method determines the heat gain to the space from a hood/appliance system.

NOTE 2—To maintain a constant temperature in the conditioned space, this heat gain must be matched by space cooling. The space sensible cooling load, in tons, then equals the heat gain in Btu/h divided by the conversion factor of 12 000 Btu/h (3.412 W) per ton of cooling. Appliance heat gain data can be used for sizing air conditioning systems. Details of load calculation procedures can be found in ASHRAE, see Ref **(1)** and Ref **(2)**[5]. The calculation

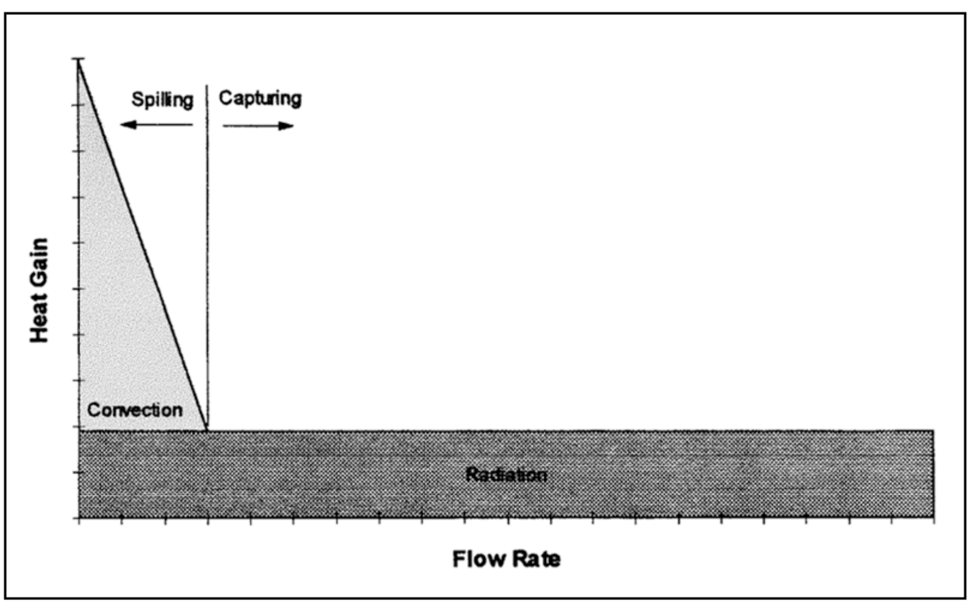

FIG. 1 Theoretical View of Heat Gain—Convective/Radiant Split

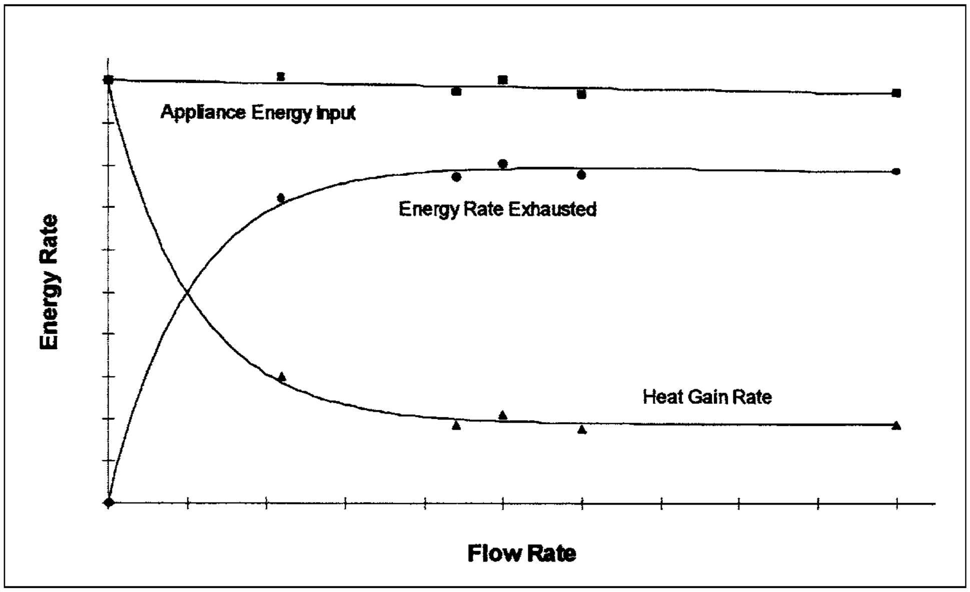

FIG. 2 Overall Energy Balance—Idle Condition

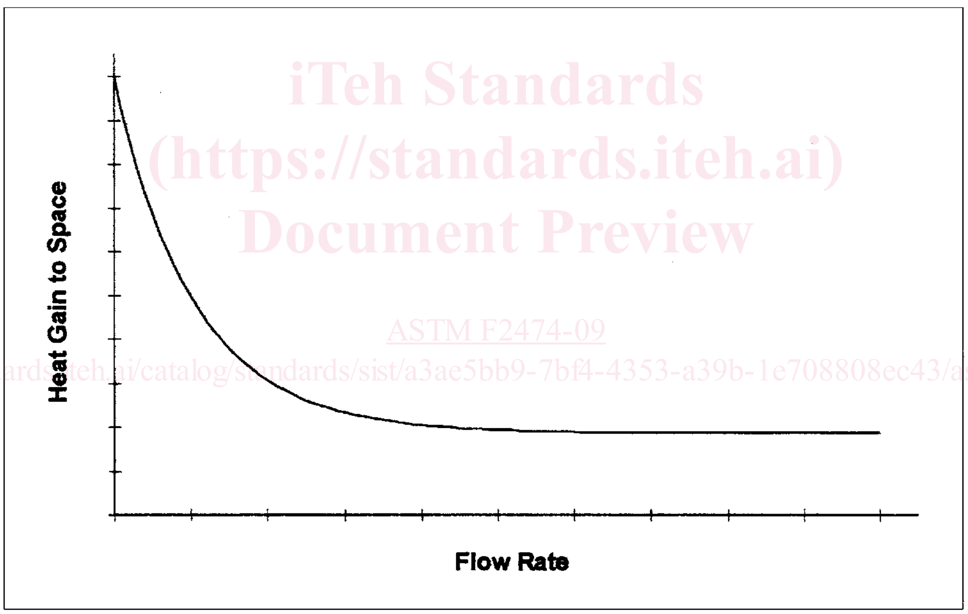

FIG. 3 Heat Gain Curve—Typical

of associated cooling loads from heat gains to the test space at various flow rates can be used along with other information by heating, ventilation, air conditioning (HVAC), and exhaust system designers to achieve energy-conservative, integrated kitchen ventilation system designs.

5.2 *Parametric Studies*:

5.2.1 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:

5.2.1.1 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 makeup 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 is shown schematically in Fig. 4 and described in detail in Ref **(3)**. Example test facilities are described in Refs **(6-5)**. The exhaust hood under test is connected to an exhaust duct and fan and mounted in an airtight room. The exhaust fan is controlled by a variable speed drive to provide operation over a wide range of flow rates. A complementary makeup air fan is controlled to balance the exhaust rate, thereby maintaining a negligible static pressure difference between the inside and outside of the test room. The test facility includes the following:

6.1.1 *Airtight Room*, with sealable access door(s), to contain the exhaust hood to be tested, with specified cooking appliance(s) to be placed under the hood. The minimum volume of the room shall be 6000 ft^3. The room air leakage shall not exceed 20 scfm (9.4 sL/s) at 0.2 in. w.c. (49.8 Pa).

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

6.1.3 *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).

6.1.4 *Air Flow Measurement System Laminar Flow Element*, AMCA 210 or equivalent nozzle chamber, mounted in the replacement or exhaust airstream, to measure airflow rate.

NOTE 3—Because of potential problems with measurement in the hot, possibly grease-laden exhaust air stream, exhaust airflow rate can be determined by measuring the replacement airflow 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.

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

6.2 *Aspirated Temperature Tree(s)*, for measurement of average temperature of makeup air from the test space crossing the plane of the tree(s) into the hood, see Fig. 5.

6.3 *Exhaust Duct Temperature Sensors*, a grid for measurement of the exhaust air temperature.

6.4 The test methods listed in 2.1 include descriptions of the necessary apparatus and procedures for determining cooking appliance energy quantities.

6.5 *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 test methods listed in Section 2.

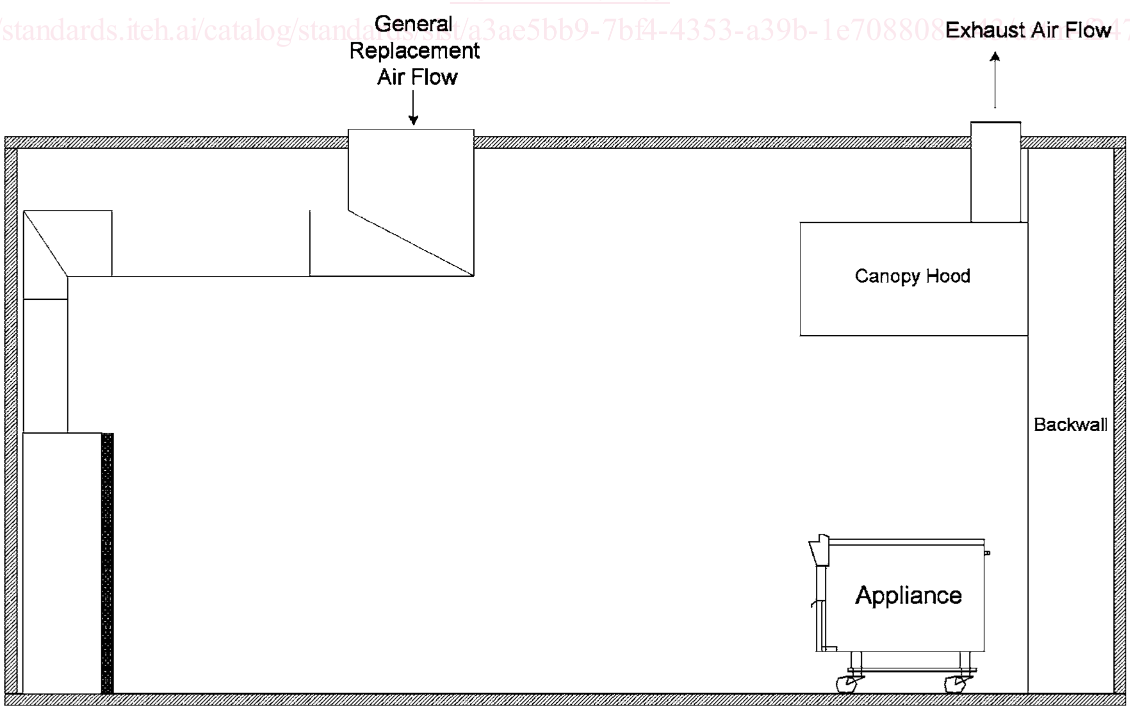

FIG. 4 Test Space Cross Section

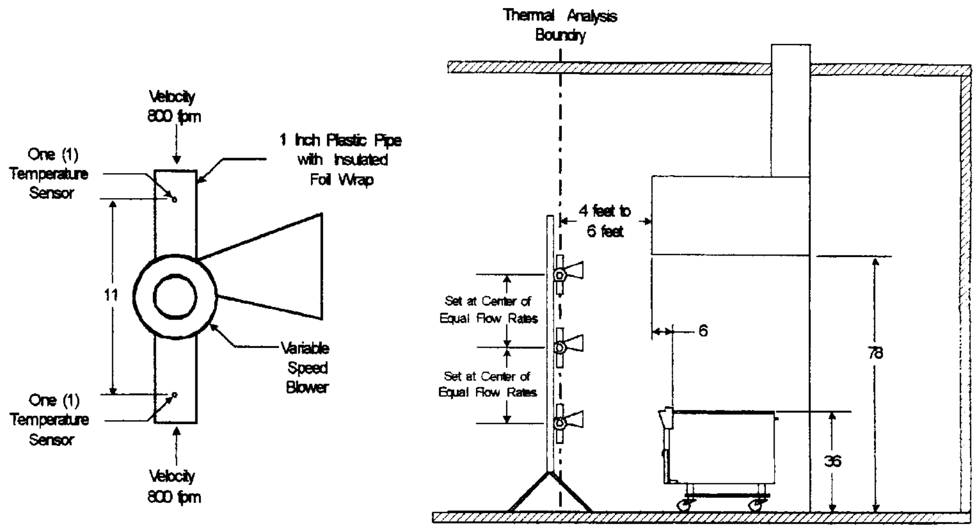

FIG. 5 Aspirated Temperature Tree Schematic and Setup

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 manufacturer's instructions or experimental design. When these instructions are not available, install wall canopy hoods flush against a wall or partition. Backshelf hoods shall be installed against a wall or partition. For wall canopy hoods, the lower front edge shall be a minimum of 78 in. (1.98 m) above the finished floor. Connect exhaust duct(s) to hood collar(s).

9.2 Install specified appliance(s) under the test hood in accordance with the applicable test methods (see Test Methods F1275, F1361, F1484, F1496, F1521, F1605, F1639, F1695, F1704, F1784, F1785, F1787, F1817, F1991, F1964, F1965, F2093, F2144, F2237, and F2239 listed in 2.1) or manufacturer's instructions if no test method exists. When such information is not available for griddles, fryers, and open top burners, allow a distance between the lowest edge of hood grease filters and the cooking surface between 1 ft (31 cm) and 2 ft (61 cm). For charbroilers, allow the range from 3.5 to 4 ft (107 to 122 cm). For wall canopy hoods, allow the minimum side and front overhangs to be 6 in. (15.3 cm). For backshelf hoods, allow the minimum side overhang to be 0 in. and the maximum front setback to be 12 in. (30.6 cm). If the hood is equipped with side panels, then the requirement of side overhang is ignored, provided that the cooking surface does not extend beyond the vertical plane of the hood sides. There shall be no obstructions or blockage of airflow for a minimum of 6 ft (183 cm) around the hood perimeter.

NOTE 5—Size the exhaust hood appropriately to match the above specified appliance(s).

9.3 Place the temperature trees 4 to 6 ft (1.2 to 1.8 m) in front of the hood or appliance(s) vertical, whichever is further into the test space, and maintain within the range from 75 to 78°F (24 to 26°C). At a minimum, place two trees in front of the hood, with optional trees placed around the hood/appliance system.

9.4 Replacement air may be supplied to diffusers in the test space. The specific arrangement shall be noted.

9.4.1 General replacement air provided to the test space shall be introduced from diffusers outside the thermal boundary. The general arrangement of replacement air diffusers and energy balance quantities are shown in Fig. 6.

NOTE 6—Document supply air configuration, louver, and damper positions.

9.5 Connect the appliance(s) to energy sources and test instruments in accordance with the applicable test methods listed in 2.1. 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.

9.6 Once the equipment has been installed, draw a front and side view of the test setup.

10. Calibration

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

10.2 *Temperature Sensors*—Calibrate all temperature sensors upon receipt to within ±0.1°F (0.5°C) against a NIST-traceable temperature reference over the range of expected measurements.

NOTE 7—The accuracy of the heat gain result is directly related to the difference between the exhaust and tree measurements. Experience indicates four-wire RTD sensors are the most practical.