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An American National Standard

Standard Practice for Determining the Field Performance of Commercial Kitchen Demand Control Ventilation Systems[1]

This standard is issued under the fixed designation F2976; 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 practice determines the energy savings potential of Commercial Kitchen Demand Control Ventilation (CKDCV) systems by outlining a procedure to measure system performance.

1.1.1 Fan energy savings potential of a Commercial Kitchen Demand Control Ventilation system will be determined.

1.1.2 Thermal energy savings potential of a Commercial Kitchen Demand Control Ventilation system will be determined.

1.2 This Standard Practice applies to commercial kitchen exhaust and supply demand control ventilation system in the following foodservice establishments: Casino hotel foodservice facilities, commercial cafeterias, full service restaurant, hotel foodservice facility, quick service restaurant, school cafeteria, supermarket, health care foodservice facility. See Appendix X1 for descriptions of facilities.

1.3 This CKDCV field test protocol does not apply to other demand control ventilation applications such as building heating, ventilation, and air-conditioning (HVAC) applications or laboratory applications.

1.4 *Units*—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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

F2975 Test Method for Measuring the Field Performance of Commercial Kitchen Ventilation Systems

2.2 *Other Standards:*

Standard 154 Ventilation of Cooking Processes[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *capture and containment (C&C)*—the 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 these products staying in the hood reservoir and not spilling out into the space adjacent to the hood.

3.1.2 *commercial kitchen ventilation system (CKV system)*—hoods, fans, make up air units, and other specialized equipment that comprise the system for ventilating a commercial kitchen.

3.1.3 *commercial kitchen exhaust demand control ventilation system (CKDCV system)*—a control system that varies the amount of airflow a kitchen ventilation system exhausts and makes up based on the cooking load.

3.1.4 *duty rating*—categories of cooking equipment based on the strength of the thermal plume and the quantity of grease, smoke, heat, water vapor, and combustion products produced. Categories include light duty, medium duty, heavy duty, and extra heavy duty.

3.1.5 *engineered hood*—a hood that has been engineered to facilitate the flow of exhaust air such that it may be exempt

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

from International and Uniform Mechanical code-specified exhaust rates if listed to UL 710.

3.1.6 *make up air (MUA)*—outside air brought into a building to replace exhausted air.

3.1.7 *make up air unit (MAU)*—the equipment that brings make up air into a building.

3.1.8 *non-engineered hood*—a hood that has not been listed to UL 710 and therefore must meet Model Code-specified exhaust rates per local jurisdictions.

3.1.9 *Type I exhaust hood*—a kitchen exhaust hood designed for removing grease and smoke, including gaseous, liquid, and solid contaminants produced by the cooking process and products of combustion. Typically used to cover equipment such as ranges, fryers, griddles, broilers or other equipment producing smoke or grease laden air.

3.1.10 *Type II exhaust hood*—a kitchen exhaust hood designed for removing heat and condensate. Typically used to cover equipment such as dishwashers, steam tables, ovens, steamers, and kettles if they do not produce smoke or grease laden vapor.

3.1.11 *variable frequency drive (VFD)*—a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor.

3.1.12 *hood styles:*

3.1.12.1 *backshelf, proximity or low profile*—a hood that is usually closed on three sides and low to the appliances. The front edge of the hood does not overhang the appliances, but is set back.

3.1.12.2 *eyebrow*—a hood mounted directly to a piece of cooking equipment.

3.1.12.3 *double island canopy*—a hood that covers cooking equipment that is in a back to back configuration.

3.1.12.4 *recirculating hood*—a hood that does not require venting or ducting to outside of the building.

3.1.12.5 *single island canopy*—a hood that covers cooking equipment in a single island configuration.

3.1.12.6 *wall mounted canopy*—a hood that covers cooking equipment located against a wall.

3.1.13 *make up air configurations:*

3.1.13.1 *air curtain supply*—make up air is introduced into the kitchen vertically through an integrated hood plenum along the front edge of the hood creating a vertical air curtain between the cooking area and the rest of the kitchen.

3.1.13.2 *backwall supply*—make up air is introduced into the kitchen vertically through an integrated hood plenum along the back edge of the hood that discharges down behind the cooking equipment.

3.1.13.3 *front face supply*—make up air is introduced into the kitchen horizontally through an integrated hood plenum along the front end of the hood such that air is blown perpendicularly from the hood into the kitchen.

3.1.13.4 *transfer air no dedicated makeup air supply*—no makeup air is provided. Exhaust air is replaced by building supply air to maintain balance.

3.1.13.5 *perforated perimeter supply*—make up air is introduced into the kitchen through a plenum in front and along the sides of the hood and dispersed vertically through a perforated air diffuser.

3.1.13.6 *short circuit supply*—make up air is introduced directly into the hood through an integrated hood plenum along the front of the hood.

4. Summary of Practice

4.1 The field evaluation includes three basic steps: 1) Baseline evaluation, 2) System retrofit or adjustment, 3) New system evaluation. The Standard Practice first addresses fan energy determination pre and post system retrofit or new system (section 6.2), then as they relate to heating and cooling energy determination (section 6.3).

5. Significance and Use

5.1 *Fan Energy*—This standard practice determines the fan energy requirements for a constant speed and demand controlled kitchen ventilation system and estimates the savings. It can be used to compare systems' fan savings potential.

5.2 *Heating and Cooling Energy*—This standard practice determines the heating and cooling energy requirements for a constant speed and demand controlled kitchen ventilation system and estimates the savings. It can be used to compare systems' heating and cooling savings potential.

6. Procedure

6.1 *Test Equipment:*

6.1.1 *Fan Energy Test Equipment:*

6.1.1.1 *Current Transformer*—Current transformers should be selected with an input range corresponding to the maximum amperage of each fan motor and must have an accuracy of ±1 % or better at 10 to 130 % of rated current.

6.1.1.2 *Power Meter*—Power meters (or energy loggers) must have an accuracy within ±1 % of reading, recording either average power or cumulative energy per logged interval. Secondary power meters to verify data quality must measure true root mean square (RMS).

6.1.2 *Heating and Cooling Energy Test Equipment:*

6.1.2.1 *Analog Input Signal Logger*—Analog input loggers must be capable of measuring the VFD output frequency reference signal, for example, 0–10V or 4–20ma.

6.1.2.2 Additional airflow measurement equipment may be required. Specific requirements will depend on the methodology used. Accuracy requirements are specified in ASTM F2975.

6.2 *Test Method for Fan Energy Consumption and Savings:*

6.2.1 *Baseline Evaluation:*

6.2.1.1 Gather site information: facility name, address, and contact information, facility market segment, operating hours per day, operating hours per year, shutdown schedules and major maintenance.

6.2.1.2 Gather information on CKV system configuration: existing CKV system control strategy, hood style(s), hood filter type(s), MUA configuration and, if dedicated MUA unit and tempered, MUA unit set points, HVAC system set points, number of hoods, length, depth & height of (each) hood, and distance of hood above the floor.

6.2.1.3 Gather information on the equipment under (each) hood including, at a minimum, a digital photo of the cook line and a list of the equipment types (for example, fryer, convection oven, steamer, etc.). Optional information may include the duty rating of equipment under hood(s), description of cooking process (made to order, batch) including typical loading per ASTM method if applicable, types of food cooked on equipment under (each) hood, appliance input fuels, hot water temperature, and any other information that may be pertinent to the performance of the CKV and DCV system.

6.2.1.4 Gather exhaust and supply fan motor nameplate data for each fan motor: manufacturer, model number, phase, voltage, current, speed, rated HP, nominal efficiency.

6.2.1.5 Gather VFD information, if applicable: manufacturer, model number, rated HP.

6.2.1.6 Gather design information for exhaust and supply airflow rates and motor speeds if available.

6.2.1.7 Verify CKV system capture and containment.

(1) 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.

(2) Capture and containment shall be verified visually by observing smoke or steam produced by actual cooking operation or by visually seeding the thermal plume using devices such as smoke candles or smoke puffers, or both. 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.

6.2.1.8 Monitor fan energy use of DCV system.

(1) For sites without a previously installed DCV system:

(a) Install electrical meters/loggers on each exhaust and supply fan electrical motor circuit at the breaker panel or within the VFD enclosure (input side of the VFD).

(b) Monitor electrical usage of the corresponding fan motor(s) for 14 consecutive days. Average power (kW), cumulative energy (kWh) and power factor shall be logged at intervals no greater than 5 min. Instantaneous power (kW) and cumulative energy (kWh) shall be sampled at a minimum of once every 1 min and averaged and logged at intervals no greater than 5 min.

(2) For sites in which a DCV system is already installed:

(a) Install electrical meters/loggers on each exhaust and supply fan electrical motor circuit at the breaker panel or within the VFD enclosure (input side of the VFD).

(b) Use the keypad or switched bypass to override the DCV system.

(c) Monitor electrical usage of the corresponding fan motor(s) for 14 consecutive days. Average power (kW), cumulative energy (kWh), and power factor shall be logged at intervals no greater than 5 min. Instantaneous power (kW) and cumulative energy (kWh) shall be sampled at a minimum of once every 1 min and averaged and logged at intervals no greater than 5 min.

6.2.2 *System Retrofit or Adjustment:*

6.2.2.1 For systems without DCV, install and commission the DCV system according to manufacturer instructions and industry best practices. Commissioning must include performance testing ensuring capture and containment under typical use conditions (both heavy and partial cooking capacity loads). See ASHRAE Standard 154 for guidance on capture and containment verification procedures.

6.2.2.2 For systems with DCV installed, restore the DCV system controls and verify proper system performance.

6.2.2.3 Any additional performance enhancements to the CKV system made at this time must be noted and reported.

6.2.3 *New System Monitoring:*

6.2.3.1 Use the previously installed electrical instrumentation on each exhaust and MUA circuit to monitor electrical usage of the corresponding fan motors for a minimum of 14 consecutive days. Average power (kW), cumulative energy (kWh) and power factor shall be logged at intervals no greater than 5 min. Instantaneous power (kW) and cumulative energy (kWh) shall be sampled a minimum of once every 1 min and averaged and logged at intervals no greater than 5 min.

6.3 *Test Method for Heating and Cooling Energy Consumption and Savings:*

6.3.1 *Baseline Evaluation:*

6.3.1.1 Take a one-time exhaust and, if dedicated MUA system, MUA airflow measurement at maximum exhaust airflow.

6.3.1.2 For systems without DCV previously installed:

(1) Measure exhaust and MUA airflow rates (CFM) during appliance idle conditions. Measurements must be direct measurements made using either the hood manufacturer's hood balance protocol (contact manufacturer for protocol) or industry best practices. Direct measurement must include data quality verification at the beginning of the test. When possible, compare original air balance reports with monitored data to reinforce validity of methodology and measurements.

6.3.1.3 For systems with DCV systems previously installed:

(1) If the DCV system does not have an integrated frequency monitoring system that meets data interval and recording requirements outlined below, install analog input signal loggers on the exhaust fan VFD and, if dedicated MUA system, MUA fan VFD.

(2) Use the keypad or switched bypass to override the DCV system.

(3) Use the previously installed instrumentation on the exhaust and MUA fan VFDs or the integrated frequency monitoring system to measure and record the exhaust and MUA VFD frequency output reference speed signals. The system must have reached and maintain a steady state at the

peak exhaust rate for the entire monitoring period (for example, VFD ramp up and ramp down periods may not be included in monitoring period).

6.3.2 *System Retrofit or Adjustment*—See Fan Energy Test Method.

6.3.2.1 *New System Monitoring:*

(1) Install analog input signal loggers on the exhaust fan VFD.

(2) Use the previously installed instrumentation on the exhaust fan VFD to measure and record the exhaust VFD frequency output reference speed signals for 14 consecutive days. Data should be sampled at a minimum of once per minute and averaged and recorded at intervals no greater than 5 min.

7. Calculations and Report

7.1 *Calculations:*

7.1.1 Percent average kW reduction = ((Average kW without DCV – Average kW with DCV) / (Average kW without DCV)) × 100

7.1.2 Estimated daily operating hours = (Sum of demand occurrences × 5 min) / operating days

7.1.3 Daily energy consumption = Average kW × daily operating hours

7.1.4 Percentage fan energy consumption reduction = (daily energy consumption without DCV – daily energy consumption with DCV) / (daily energy consumption without DCV) × 100

7.1.5 Calculated average airflow rate with DCV = measured airflow rate without DCV at full fan speed × measured average motor frequency with DCV / measured actual operating motor frequency without DCV (i.e., 60 Hz)

7.1.6 Percentage average airflow reduction = (measured airflow rate without DCV – measured average airflow rate with DCV) / (measured average airflow rate without DCV) × 100

7.1.7 *Estimated Annual Makeup Air Energy Savings:*

7.1.7.1 Determine average exhaust airflow rates with and without DCV system.

7.1.7.2 Use Outdoor Airload Calculator or building simulation software to estimate energy consumption for each scenario (with and without DCV system). For each scenario:

(1) Select location of facility or a location with the same Climate Zone.

(2) Enter customer specific operating hours, space or duct thermostat set points as appropriate and outdoor airflow. Consideration must be given to kitchen balance point.

(3) Uncheck the dehumidification box on the dehumidification setup.

(4) Unless the customer locks out heating and cooling in certain months, check all boxes on the lockout months setup. If the customer locks out heating or cooling in certain months, uncheck as appropriate.

(5) Do not change any assumptions on the fan setup. Because fan energy has been measured directly, fan energy calculations from the Outdoor Airload Calculator are not necessary.

7.1.7.3 Determine the reduction in heating and cooling requirements to condition the outside air for the exhaust rates with and without the DCV system.

7.1.7.4 Determine the energy savings by applying verified site coefficient of performance (COP) for direct expansion cooling and furnace efficiency, if known, or by applying a COP of 2.5 for Dx cooling and a furnace efficiency of 80 %.

7.2 *Reporting Requirements:*

7.2.1 *Test Site and Testing Organization Reporting Requirements:*

7.2.1.1 Date and personnel conducting the tests.

7.2.1.2 *Site and System Information*—Facility name, address, and contact information, facility market segment, operating hours per day, operating hours per year.

7.2.1.3 *CKV System Configuration*—Existing CKV system control strategy, hood style(s), hood filter type(s), MUA configuration and, if dedicated MUA unit and tempered, MUA unit set points, HVAC system set points, number of hoods, length, depth & height of (each) hood, and distance of hood above the floor.

7.2.1.4 *Equipment Under Hood*—Digital photo of the cook line and list of equipment under the hood. Optional information may include the duty rating of equipment under hood(s), description of cooking process (made to order, batch) including typical loading per ASTM method if applicable, types of food cooked on equipment under (each) hood, appliance input fuels, hot water temperature, and any other information that may be pertinent to the performance of the CKV and DCV system.

7.2.1.5 *Exhaust and MUA Fan Motor Nameplate Data for Each Fan Motor*—Manufacturer, model number, phase, voltage, current, speed, rated HP, nominal efficiency.

7.2.1.6 *DCV System Information*—Manufacturer and model number, product specification sheet, product price, installation price, total price paid by customer (not to include costs associated with conducting the test).

7.2.1.7 *VFD Information, if applicable*—Manufacturer and model number, rated HP, product specification sheet, product price, installation price, total price paid by customer (if separate from DCV system) (not to include costs associated with conducting the test).

7.2.1.8 *Test Equipment Information*—List of equipment used to perform tests.

7.2.2 *Fan Energy Test Reporting Requirements:*

7.2.2.1 *Baseline Performance Data*—Average exhaust system demand (kW); Average make up air system demand (kW); Average daily energy consumption of exhaust system (kWh/day); Average daily energy consumption of makeup air system (kWh/day); Total average CKV system demand (kW); Total average CKV system energy consumption (kWh/day); Average exhaust system power factor; Average makeup air system power factor.

7.2.2.2 *Post-Retrofit Performance Data*—Average exhaust system demand (kW); Average make up air system demand (kW); Average daily energy consumption of exhaust system (kWh/day); Average daily energy consumption of makeup air system (kWh/day); Total average CKV system demand (kW); Total average CKV system energy consumption (kWh/day); Average exhaust system power factor; Average makeup air system power factor.

7.2.2.3 *Calculated Data*—Percentage average demand reduction from exhaust fan (kW); Percentage average demand