TECHNICAL BULLETIN

Compliance with ASHRAE 90.1, IECC, and NECB DCV Turndown Requirements

TB20-1021

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Background:

ASHRAE 90.1 (2019), the "Energy Standard for Buildings Except Low Rise Residential Buildings", includes several energy savings provisions which are required for kitchen facilities that exceed an exhaust rate of 5000 cfm. Similar provisions have existed in ASHRAE 90.1 dating back over a decade; however, enforcement is now becoming more prevalent.

Section 6.5.7.2.3 outlines 3 different paths to comply with the standard for buildings that meet this criterion:

ASHRAE 90.1

6.5.7.2.3

If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5000 cfm then it shall have one of the following:

a. At least 50% of all *replacement air* is *transfer air* that would otherwise be exhausted.
b. *Demand ventilation systems* on at least 75% of the exhaust air. Such *systems* shall be capable of and configured to provide at least 50% reduction in exhaust and *replacement air system* airflow rates, including *controls* necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.
c. Listed *energy* recovery devices that result in a sensible *energy* recovery ratio of not less than 40% on at least 50% of the total exhaust airflow. A 40% sensible *energy* recovery ratio shall mean a change in the dry-bulb temperature of the *outdoor air* supply equal to 40% of the difference between the *outdoor air* and entering exhaust air dry-bulb temperatures at *design conditions*.

Section C 403.7.5 of IECC (2018), the "International Energy Conservation Code", has adopted the exact same language as ASHRAE 90.1.
Similarly, NECB 5.2.3.4 (2017), the "National Energy Code of Canada for Buildings", has also outlined similar requirements for commercial kitchen ventilation systems.

NECB

5.2.3.4. Demand Control Ventilation Systems

1) Enclosed semi-heated spaces or *conditioned spaces* where fuel-powered vehicles or mobile fuel-powered equipment or appliances are intermittently used shall be provided with sensors and demand control ventilation systems capable of limiting the expected air contaminants to acceptable levels by
a) staging the ventilation fans, or
b) modulating the outdoor airflow rates.
(See Note A-5.2.3.4.(1).)

2) Commercial kitchen ventilation systems whose design exhaust fan airflow rate meets or exceeds the values shown in Table 5.2.3.4. for the applicable heating-degree day category shall be equipped with a demand control ventilation system, including necessary sensors and controls, that is capable of reducing the design exhaust and make-up airflow rates by at least 50% in response to appliance operation. (See Note A-5.2.3.4.(2).)

Table 5.2.3.4.
Demand Control Ventilation Threshold for Commercial Kitchen Ventilation Systems
Forming Part of Sentence 5.2.3.4.(2)

Heating Degree-Days of *Building* Location,(1) in Celsius Degree-Days					
Zone 4:(2) < 3000	Zone 5:(2) 3000 to 3999	Zone 6:(2) 4000 to 4999	Zone 7A:(2) 5000 to 5999	Zone 7B(2) 6000 to 6999	Zone 8:(2) ≥ 7000
Design Exhaust Fan Airflow Rate, L/s					
≥ 2360	≥ 2360	≥ 1880	≥ 1410	≥ 1410	≥ 1410

Notes to Table 5.2.3.4.:
(1) See Sentence 1.1.4.1.(1).
(2) See Note A-Table 3.2.2.2.

Discussion:

ASHRAE 90.1 and IECC state that there are 3 paths to comply with the energy usage requirements for kitchen facilities.

The first path involves obtaining at least 50% of all replacement air (commonly referred to as make-up air) from transfer air that would otherwise be exhausted. This implies that the building is bringing in a large amount of outdoor air for ventilation purposes, independently of the kitchen hood system, and that this air would otherwise be exhausted to maintain an adequate building balance. This is generally only achievable and incorporated into the HVAC design of very large facilities that require higher ventilation rates, or using DOAS technology, which provides fully conditioned and dehumidified air to be delivered in the general kitchen and dining spaces. If a DOAS unit is utilized for greater than 50% of the exhaust rate, Demand Controlled Ventilation is not required. Utilizing DOAS also generally allows for lower overall exhaust rates, following Hood Velocity Theory.

The second path to compliance requires the use of a "Demand Ventilation System" capable of reducing the exhaust and replacement airflow by at least 50%. This can be achieved by a properly designed kitchen hood control panel with the necessary sensors, logic and motor controls.

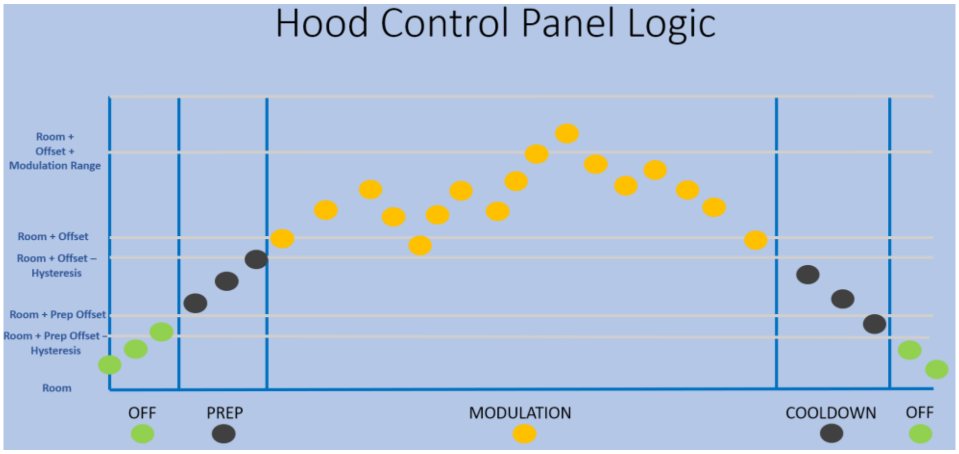
The third and final path to compliance is through the use of an energy recovery device that can recapture energy from the exhaust airflow. It also outlines that such a device should be able to recover no less than 40% of the sensible energy of at least 50% of the exhaust airflow. The capital required to implement this approach may make it cost prohibitive for most applications. Most importantly, the nature of the grease laden exhaust airflow in commercial kitchen applications makes it hard to find a practical, financially sound and sustainable solution that can deliver the specified results. As such, there are very few technologies on the market available to meet this requirement.

A thorough analysis of the three options that incorporates upfront costs, variable costs, maintenance and sustainability leads us to the conclusion that there are two effective approaches: The use of DOAS equipment, or the use of Demand Controlled Kitchen Ventilation (DCV). Note that the use of DOAS equipment and DCV are not mutually exclusive, and both are commonly utilized in conjunction to offer maximum comfort and energy savings.

CaptiveAire's DCV Basic Operating Principles

CaptiveAire's "Demand Control Ventilation" system works by modulating the speed of exhaust fans and make-up air units based on the feedback received from hood mounted temperature sensors. These temperature sensors serve as indicators that appliances are in operation. Several factory settings dictate how the system operates. Some of the most relevant ones are:

- Sensor Assignment: Creates a link between a duct sensor and an exhaust fan.
- Prep Offset: Defines the differential between room temperature and duct temperature at which prep mode is activated
- Offset: Defines the differential between room temperature and duct temperature at which modulation is activated
- Modulation Range: Defines the temperature range above the activation temperature at which the specific fan will modulate.
- Exhaust Fan High Speed: Defines the high speed of the fan, which is reached at room temperature + offset + modulation range.
- Exhaust Fan Low Speed: Defines the low speed of the fan, which is reached at room temperature + offset.
- Hysteresis temperature: Creates a buffer that prevents fans from cycling by setting the deactivation temperature a few degrees below the activation temperature



As highlighted in the graphic, the automatic operation of DCV has 3 different states.

- The system is **OFF** (0% speed for exhaust and supply fans) whenever the duct temperature differential is below the prep offset or prep offset minus hysteresis threshold, depending on its previous state.

- During **prep mode and cool down mode**, the exhaust fans operate at a factory **default speed of 20%,** exceeding the turndown requirements of the three applicable codes. This operating mode is intended to cover instances where appliances are ON, but cooking has not begun, or cooking has just ended. In this state, the supply fans run at 0% speed.

- When cooking begins and the system reaches **modulation**, the fans will automatically ramp up to their low speed setting. This setting is **editable**. R&D testing has shown that a default low modulation speed of 80% is adequate in most scenarios to capture effluents without compromising hood performance. However, the low speed can be changed as needed based on the application. As the load increases and the duct sensor readings are higher, the system will ramp up linearly all the way to full speed based on the fan modulation range. Supply fan speed follows the same percent modulation as the exhaust fans.

DCV incorporates remote monitoring, controls and data trending through a cellular connection to CASLink, CaptiveAire's cloud-based building management system. This allows technical support teams to fine tune the settings that drive the operation of DCV remotely by making informed decisions using jobsite feedback and trended operating data.

CaptiveAire's DCV Code Compliance

CaptiveAire's DCV compliance to ASHRAE 90.1 section 6.5.7.2.3, IECC Section C 403.7.5, and NECB 5.2.3.4 is founded upon the following premises:

- DCV uses temperature sensor data to activate and modulate exhaust and supply fans in response to appliance operation
- The turndown required by the standards is 50%. DCV modulates all the way down to 0% if temperature data indicates that the appliances are idle.
- Prep mode and cool down mode allow the system to turn all the way down to 20% when activity is detected.
- In the upper end of modulation, fan low speed is editable.

For the reasons listed above, CaptiveAire's DCV system exceeds the 50% turndown requirement listed by these standards.