Energy Efficient
Kitchen Ventilation Design

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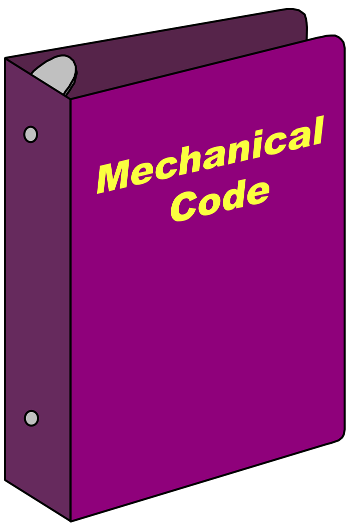
Learning Objectives

- Kitchen design objectives
- Kitchen control technology
- DCV application and design

Design Objectives

- Comply with local and industry codes
  - IMC Section 507 – Commercial Kitchen Hoods
  - NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
  - ASHRAE 90.1 - Energy Standard for Buildings
- Minimize cost

IMC Section 507
Commercial Kitchen Hoods



507.1 General.
Commercial kitchen exhaust hoods shall comply with the requirements of this section. Hoods shall be Type I or Type II and shall be designed to capture and confine cooking vapors and residues.

Exception:
1. Factory-built commercial exhaust hoods which are tested in accordance with UL 710, listed, labeled and installed in accordance with Section 304.1 ***shall not*** *be required to comply with* ***Sections 507.4, 507.7, 507.11, 507.12, 507.13, 507.14*** *and* ***507.15****.*

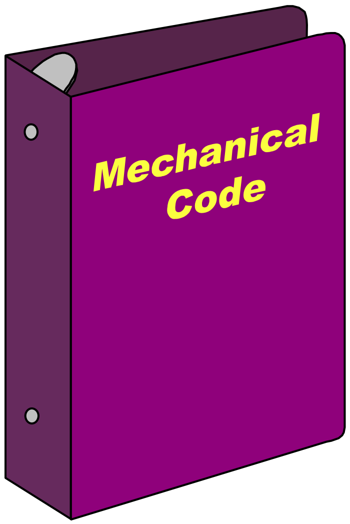
Scope of UL 710

1.1 These requirements cover exhaust hoods intended for placement over commercial cooking equipment. Exhaust hoods with and without exhaust dampers are covered by these requirements.

1.3 All exhaust hoods are intended for use with fire extinguishing system units.

IMC Section 507
Commercial Kitchen Hoods

- Factory-build kitchen exhaust hoods which are tested in accordance with UL 710



...shall not *be required to comply with*

Sections

507.4 - Type I materials

507.7 - Hood joints, seams and penetrations

507.11 - Grease filters

507.12 - Canopy size and location

507.13 - Capacity of hoods

507.14 – Non-canopy size and location

507.15 - Exhaust outlets

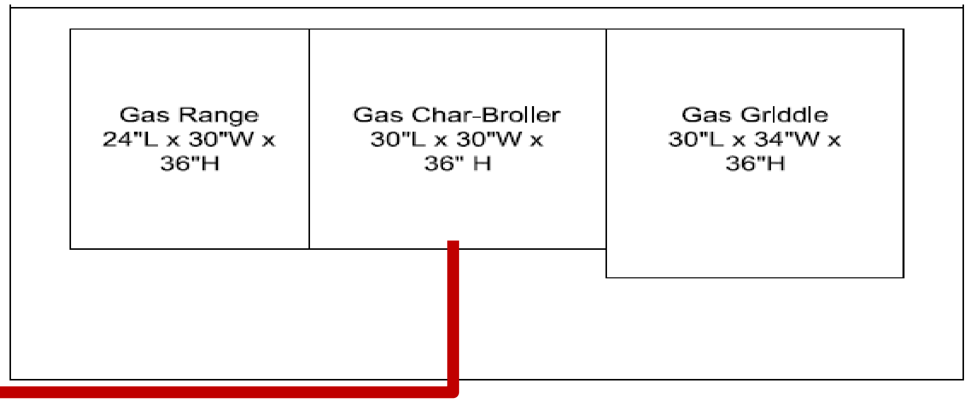
Capacity of Hoods

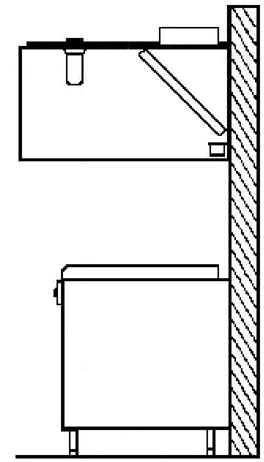
- 507.13*

  Commercial food service hoods shall exhaust a minimum net air in accordance with this section and section 507.13.1 through 507.13.4. The net quantity of exhaust air shall be calculated by subtracting any airflow supplied directly to a hood cavity from the total flow rate of a hood.

  Where any combination of heavy-duty, medium-duty and light-duty cooking appliances are utilized under a single hood, the exhaust rate required by this section for the heaviest duty appliance covered by the hood shall be used for the entire hood.

Calculation Using IMC





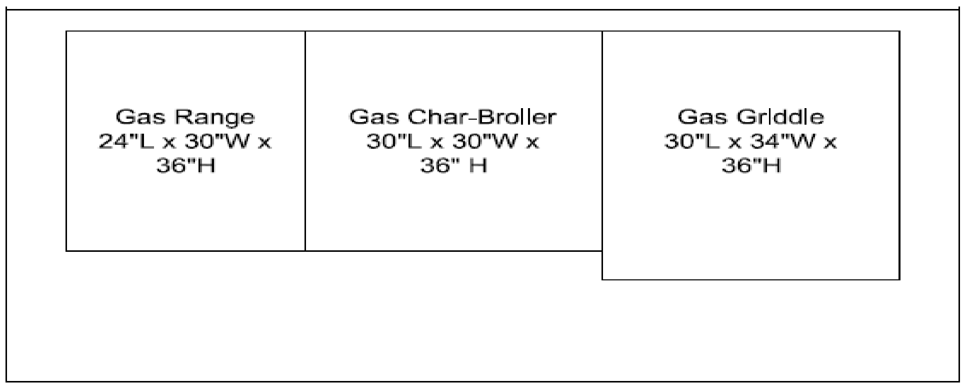
CFM = (Exhaust Rate) (Linear Foot of Hood)

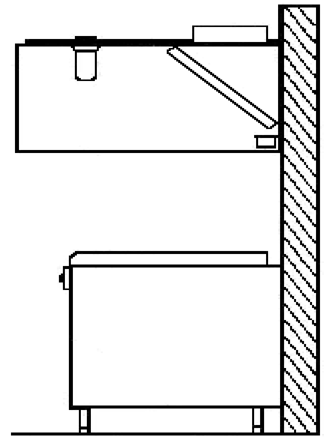
Exhaust rates:

Light-duty	200 cfm/ln. ft	(Ovens, steamers, kettles)
Medium-duty	300 cfm/ln. ft	(Electric ranges, griddles, fryers)
Heavy-duty	400 cfm/ln. ft	(Gas ranges, broilers, woks)
Extra heavy-duty	550 cfm/ln. ft	(Solid fuel cooking)

"*The above are for wall canopy hoods*"

Calculation Using IMC





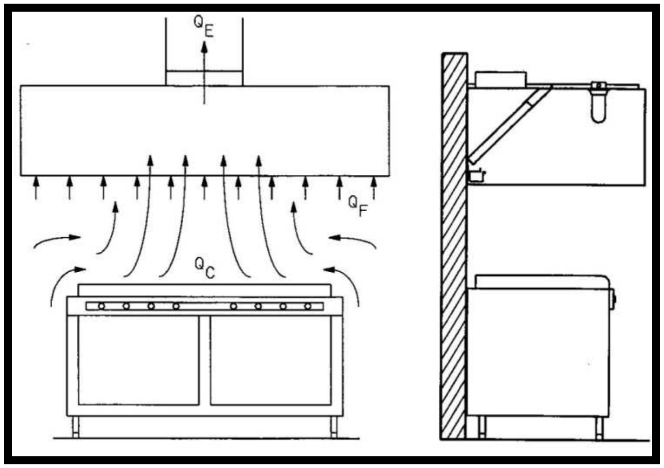
Char-broiler = Heavy-duty (400 cfm per linear foot)

400 cfm/ln. ft x 8 ft = **3,200 cfm**

Alternate Calculation Example
Manufacturer Method

Exhaust Air Volume

- Total required exhaust must equal contaminated airflow plus a minimum capture airflow



Q_C = Contaminated air generated by the cooking equipment

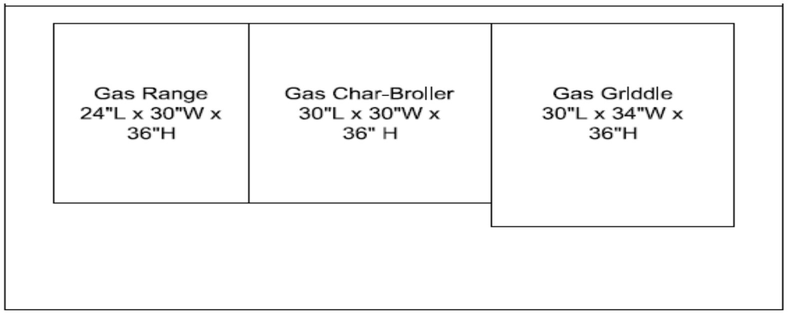
Q_F = Quantity of air to contain surges, cross drafts and turbulence.

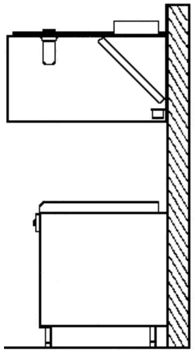
$Q_E = Q_C + Q_F$

Q_c – Contaminated Air Quantity

- Cooking appliances can be grouped into the following general categories, based upon **Thermal Updraft Velocity characteristics**:
  - Light-duty (ovens, steamers, ranges) 50 fpm
  - Medium-duty (griddles, fryers) 85 fpm
  - Heavy-duty (char-broilers) 150 fpm
  - Extra Heavy-duty (solid fuel) 185 fpm

Typical Equipment Battery





Equipment	Dimensions	Area (ft^2)	Updraft Velocity Factor	Contaminated Air (CFM)
Gas Range	24 x 30	5.00	50	250
Gas Char-Broiler	30 x 30	6.25	150	938
Gas Griddle	30 x 34	7.08	85	602
		Contaminated Airflow =		1790

Exhaust Volume Calculating Q_F

Total Hood Area (96 x 40) / 144 = 27.67 sq. ft

(Total Hood Area - Total Appliance Area) x 50

Q_F = (27.67 – 18.33) x 50 = 417 cfm

Total Exhaust Airflow

Q_E= 1790 (Q_C) + 417 (Q_F) = **2,207 cfm**

Comparison

Method	Exhaust CFM
IMC	3,200
Manufacturer Method	2,207

Save on required exhaust rates by using manufacturer methods

Kitchen Control Technology

Constant Volume Control

- System enable
  - Switch
  - Temperature interlock
- Single speed
  - Airflow determined by IMC or manufacturer method

Two Speed Systems

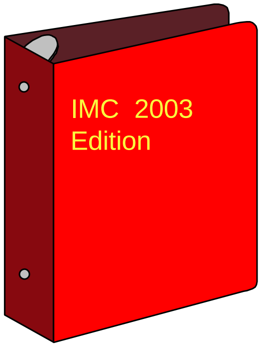
- Poor man's demand control
- High cost two speed motor
- Manual control required
- Over/Under ventilation

Demand Control Ventilation

- Provide the correct level of ventilation for the actual cooking load
- Modulate exhaust fan(s) and supply fan(s)

Changes Made to IMC 2003 (Current in 2010)

507.1 General. Commercial kitchen exhaust hoods shall comply with the requirements of this section. Hoods shall be type 1 or type 2 and shall be designed to capture and confine cooking vapors and residues.



Exceptions:

1. Factory built commercial exhaust hoods which are tested

2. Factory built commercial cooking recirculating systems

3. Net exhaust volumes for hoods shall be permitted to be reduced during no load cooking conditions, where engineered or listed multi-speed or variable speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this section.

ASHRAE 90.1

ASHRAE 90.1-2010 and Demand-Controlled Ventilation (DCV) Systems for Kitchens

ASHRAE 90.1-2010 adopts new language regarding demand-based ventilation system(s) for kitchens. Section 6.5.7.1.4 states the following: *"If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm then it shall have one of the following:*

- At least 50% of all replacement air is transfer air that would otherwise be exhausted. In most applications, the transfer air would be from a rooftop unit in an adjacent dining area.
- Demand ventilation system(s) capable of at least 50% reduction in exhaust and replacement air system airflow rates, including the controls necessary to modulate airflow in response to appliance operation."

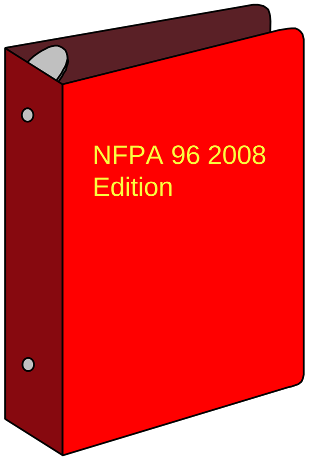
ASHRAE 189.1

Standard for the design of high-performance green buildings

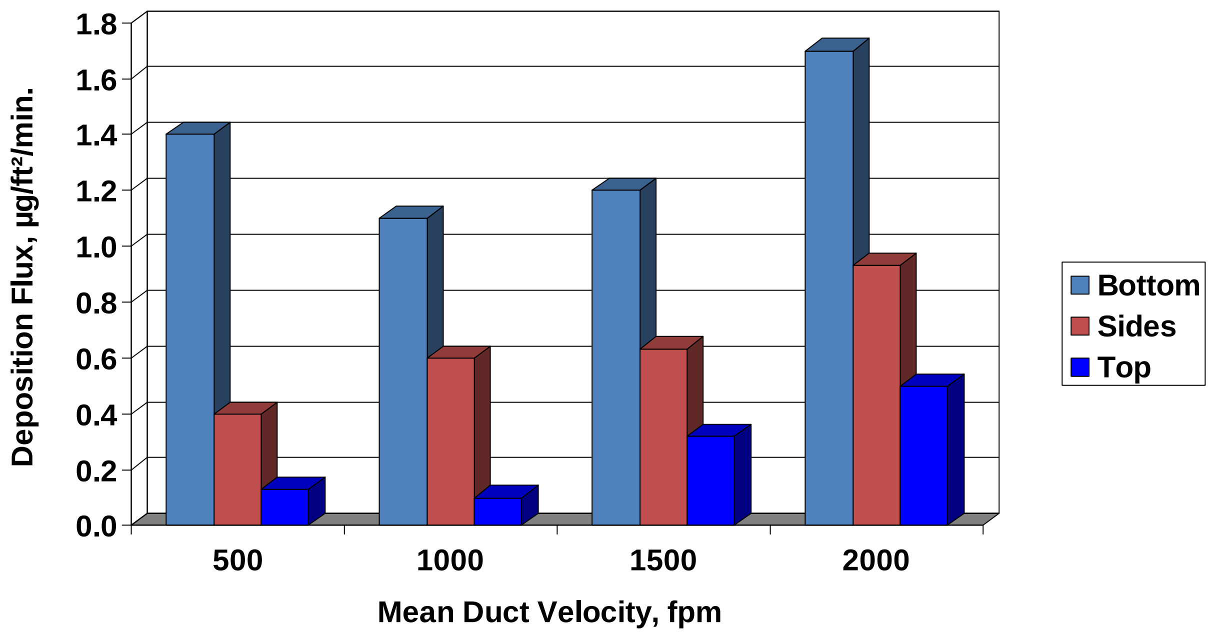
- Section 7.4.3.7 – Variable Speed Fan Control
  - In addition to the requirements in [ASHRAE] Standard 90.1, commercial kitchen type I and type II hoods shall have variable speed control for exhaust and make-up air fans to reduce hood airflow rates at least 50% during those times when cooking is not occurring…
- Not all manufacturers meet this requirement!

NFPA 96 – Grease Duct

- 8.2 airflow
  - 8.2.1 air velocity
  - 8.2.1.1 The air velocity through any duct shall be not less than 152.4 m/min (500 ft / min)



ASHRAE Research
Test Results – Duct Velocity



Variable Volume Systems

- Temperature Based

- Temperature and Optics based

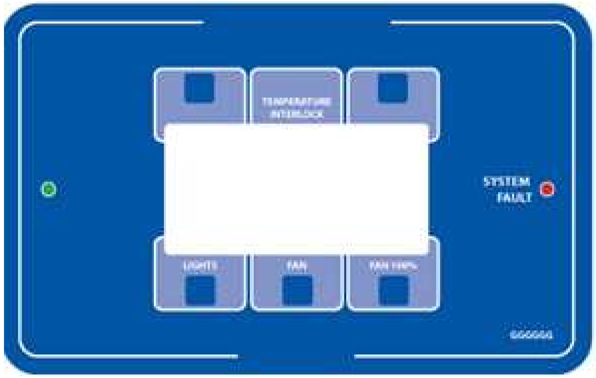
Variable Volume Options

- Temperature Based
  - Temp Sensors monitor heat
  - High Heat Applications

- Optics Based
  - Temp Sensors
  - Optic Sensors
  - Low Heat/High Steam Applications

Variable Volume User Interface

- Keypad with LCD display
  - Controls fans and lights
  - Most Common
- Touch screen
  - Independent light and fan control
  - Live system operation dashboard to monitor energy savings



Variable Volume and BMS

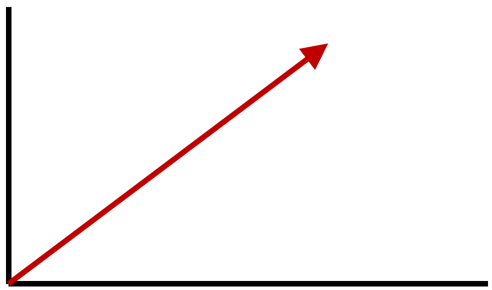
- Building management system interfacing
  - LONworks
  - BACnet MSTP
  - BACnet IP
  - Modbus

Variable Volume with EC Motors (ECMs)

- EC motors are compatible with the VAV system
  - Eliminates the need for a variable frequency drive
  - Provides additional electrical motor energy savings of 20-70%
  - Eliminates belt maintenance

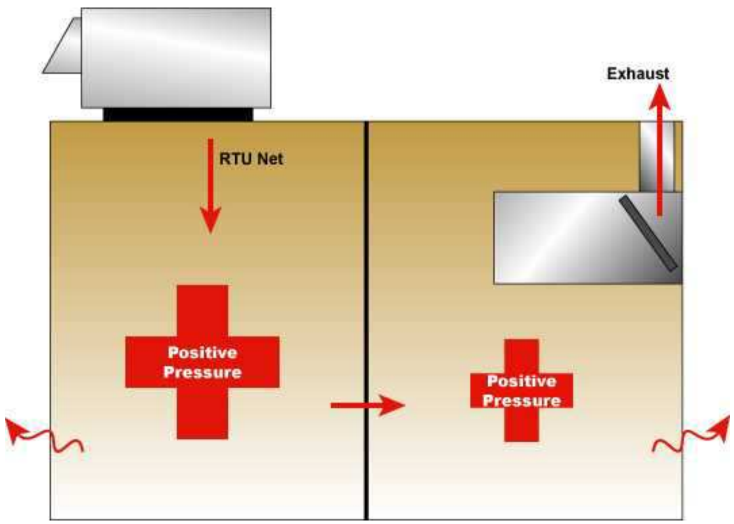
Supply Fan Control

- Proportional tracking
  - Based on the weighted average speeds of the exhaust fans
  - Issues
    - Forward curve vs. backward incline wheels on exhaust and supply fans
    - Direct gas make-up air



Supply Fan Control

- Static pressure
  - Based on building static pressure between the kitchen and dining room (adjacent space)
  - Based on building static pressure between the kitchen and the outside



In our world of automation, kitchen ventilation systems are operating in the dark ages

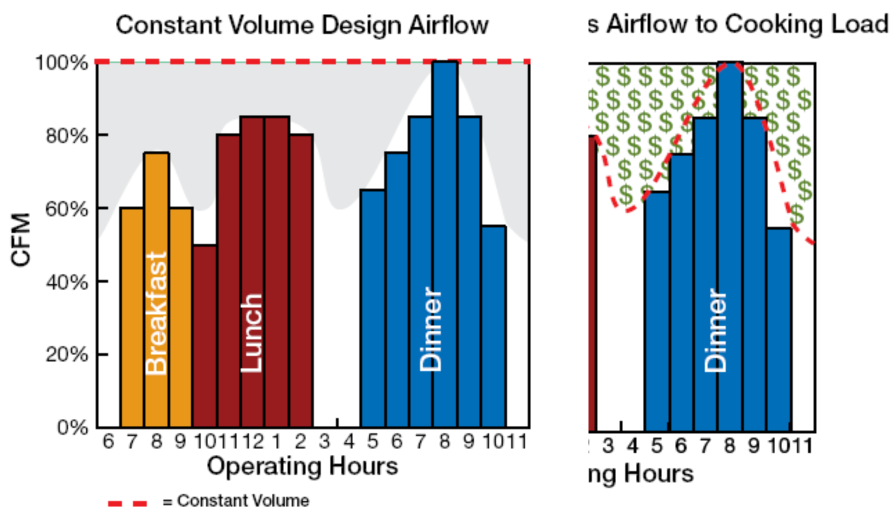
"Would you buy a car without a throttle?"

"Would you buy a house without a thermostat?"

DCV Benefits

Variable Volume Systems

- Monitors cooking activity and matches airflow to the cooking load



Energy Savings

- Increases overall hood efficiency by up to 20-50%
- Fan energy savings:
  - 50% speed reduction = 88% savings
- Conditioned air savings: $1-$3/cfm per year
- Payback: 1-3 years depending on system

Savings - Example

Airflow	3,000 CFM
Operating	15 hours per day
Cost of conditioning	$3/cfm per year
40% Reduction in airflow	1,200 cfm
Generates conditioned (H&C) air savings of $2,250 per year	

Benefits

- Reduced electrical costs
  - Exhaust and supply fan motors
- Reduced heating and cooling costs
  - The majority of the energy saving is in the conditioned air
- Low fan maintenance
- Prolonged equipment life
  - VFD soft start
- Enhanced employee comfort
  - Reduced fan noise

Benefits

- Serves as IMC 2006 section 507.2.1.1 compliant device
  - Hood and appliance interlock
- Potential to contribute toward LEED credits
  - Innovation and design
  - Optimize energy performance
- Many states offer rebates to owners for purchasing and installing variable volume systems

Ideal DCV Applications

- Over 12 operating hours per day
- Hoods over 8 feet long
- Variable cooking loads throughout day
- Areas with high gas and/or electric rates

Other Energy Saving Options

Lighting

Example:

- 50 foot-candles
- 9’ x 4’ hood
- 14 hours a day
- $0.10 kWh

Incandescent Lights

6 Lights (100 W bulbs)

Cost/yr. = $306.60

Compact Fluorescent (CFL)

6 Lights (26 W bulbs)

Cost/yr. = $79.72

Fluorescent

1 - 3’ Light Fixture (2 - 32 W lights)

Cost/yr. = $32.70

LED lights

1 - 3’ LED Fixture (2 – 18 W lights)

Cost/yr. = $18.40

Design Considerations

- Attention must be given to all building sources of outside air
  - Dining room RTU (economizers)
  - Kitchen make-up air
- Minimum airflow requirements for gas fired make-up air and cooling coils
  - Furnace turn-down (temperature rise)
- Independent fan for each hood
  - Allows for increased savings
- Side skirts
  - Allows for slightly lower airflows

Design Considerations

- Supply lower velocity make-up air from multiple sources
  - When the supply limit is reached on the hood supply plenum, add perforated ceiling diffusers for the remainder
  - Use ASP/Perimeter supply on three sides of hood
  - Use face supply with perforated ceiling diffusers
  - Use back supply/rear discharge with face supply hood

Thank you for your time.

Questions?

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