SECTION 15 - VENTILATION

All rooms of a permitted retail food establishment should be adequately ventilated and kept reasonably free of grease, excessive heat, steam, condensation, vapors, smoke, and fumes. Mechanically introduced make-up air shall be provided as necessary. Ventilation systems shall be designed and installed according to state building codes.

The following information is provided to offer guidance in meeting the requirement for ventilating cooking equipment. There are several methods used in calculating the volume of air movement, measured in Cubic Feet per Minute (CFM), necessary to effectively and efficiently ventilate cooking equipment. While these methods are used in general applications, it must be noted that engineered exhaust systems which are customized for specific equipment under specific use conditions may also be approved by the building code official or fire marshall.

General Principles of Exhaust

The purpose of an exhaust hood is to provide a method of collecting, as nearly as possible, all of the grease produced from the cooking process, while furnishing a means of removing heat, smoke, and odors from the cooking area.

For the hood to fulfill its purpose there must be a sufficient volume of air movement (capture velocity) to draw grease particles and cooking vapors directly from the cooking surface to the grease extractors. This air flow removes cooking odors and keeps grease particles from settling onto nearby surfaces.

An effective capture velocity shall be sufficient to overcome opposing air currents, capture the grease and cooking vapors, and transport them directly to the grease extractors.

Grease extractors are ineffective in removing grease vapors. Only when grease vapors cool and condense can an extractor remove grease particles by directed air flow, contraction, and expansion (drop out). It is essential to have a sufficient volume of air flowing to cool and condense the grease vapors into grease particles prior to reaching the grease extractors.

Non-toxic smoke bombs may be used to evaluate and regulate kitchen exhaust hoods and supply systems. No fabricator of exhaust hoods can create all the conditions in the plant that the hood must cope with on the job site to function correctly.

In the case of heat and steam producing equipment, the purpose of the hood or ventilation system (such as a pants-leg duct system) is to control humidity, heat, and unwanted condensation.

A major cause of unacceptable hood performance is a lack of coordination between the Heating, Ventilation, and Air Conditioning (HVAC) system and the exhaust hood system. These systems should be coordinated prior to installation, and balanced when installation is completed, to ensure the proper performance of both.

Fire Protection

Exhaust ventilation systems for all grease producing cooking equipment is under the jurisdiction of the State Fire Marshal's Office and local fire and building officials. System designers and/or owners should contact these officials regarding fire safety plan review and inspection.

Hood Size

1. Canopy hoods and island hoods shall have a minimum depth of two feet and shall extend at least six inches beyond any equipment being ventilated, except that no overhang will be required on sides where aprons are installed. The dimensions of the hood are, in all cases, larger than the cooking surface to be covered by the hood. The amount of overhang of the hood depends upon the clearance or distance between the base of the hood and the top of the cooking equipment. A rule of thumb for the overhang on canopy hoods is 0.4 of the distance from the cooking surface to the bottom of the hood, but in any case, no less than six inches.

Example:

Hood overhang = distance from bottom of hood to top of range = 0.4 x 3.25 ft. = 1.30 ft., or approximately 1 foot, 4 inches

Canopy hoods shall be installed so that the bottom of the hood is between 6.5 feet and 7 feet above the finished floor.

(Figure 15 illustrates a canopy hood.)

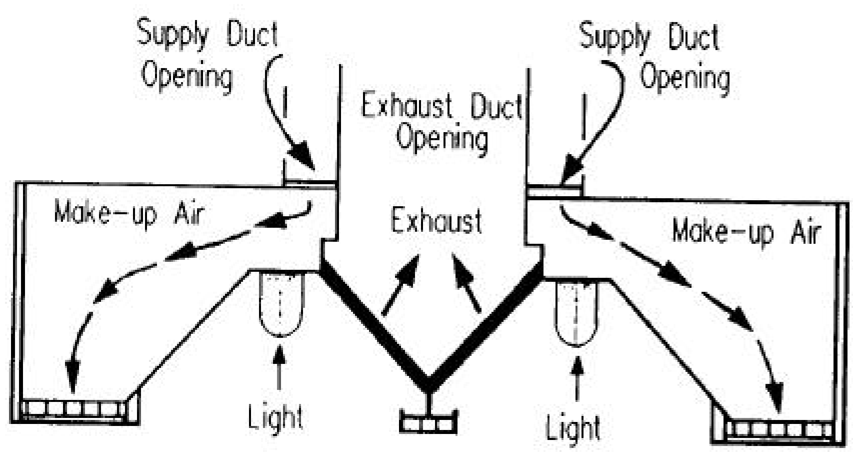

FIGURE 15.

2. Ventilator, or "backshelf", hoods are designed to mount to the wall directly behind the cooking equipment. This type of hood is often used where ceiling height is a factor. It is normally placed closer to the cooking surfaces than a canopy hood, and works well in light to medium duty cooking applications. The ventilator hood is not recommended for charbroilers or similar high heat and grease producing cooking equipment. It does not have the capture area of a canopy hood and is not able to effectively handle large surges of cooking emissions (steam, heat, vapors, etc.)

Several dimensions are essential in the proper installation of a ventilator hood. Ventilator hoods shall extend from the wall a minimum of 16 inches, and shall be installed so that the distance from the top of the cooking equipment to the bottom of the ventilator hood is no more than 24 inches. Equipment placed under a ventilator hood shall not extend beyond the sides of the hood or more than 36 inches from the back of the hood. These restrictions are necessary to ensure maximum capture and removal of cooking emissions.

(Figure 16 illustrates a ventilator hood.)

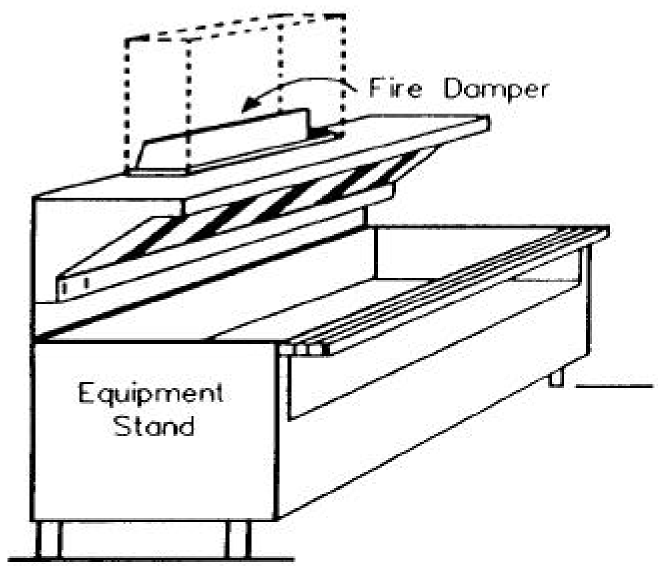

FIGURE 16.

3. Pants-leg exhaust systems are designed to remove the heat or steam close to the point of discharge from warewashers or conveyor cooking equipment. These systems must be sized to effectively ventilate the equipment served.

(Figure 17 illustrates a pants-leg duct system.)

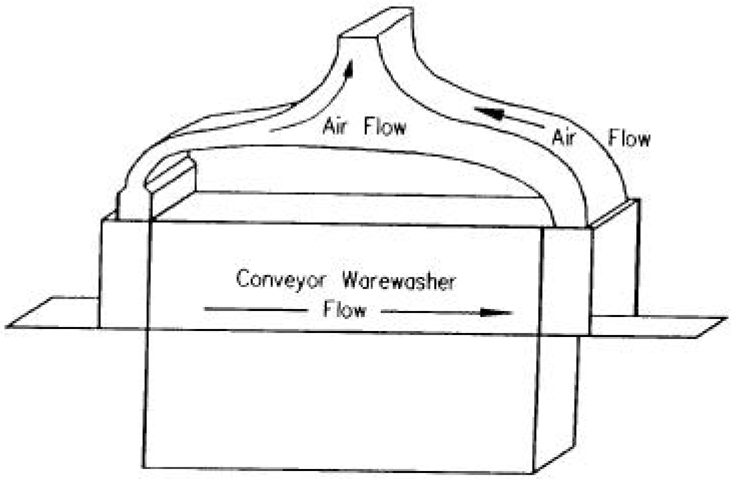

FIGURE 17.

4. Eyebrow hoods are designed to immediately remove heat from an oven at the point of emission or as the door is opened. These hoods must effectively ventilate the door openings of the equipment served.

(Figure 18 illustrates an eyebrow hood.)

FIGURE 18.

Exhausted Air

The amount of air exhausted through a hood exhaust system is dependent upon the size of the hood, its particular installation, and its use. There are several methods available for determining the amount of air to be exhausted. With the exception of systems engineered for specific equipment and specific applications that are approved by the health authority, the following criteria shall be used to calculate the amount of air exhausted:

1. Canopy hoods.

A. Standard square foot method.

This method of calculating exhaust air volume is based on the size of the opening in the hood (length x width) and the capture velocity relative to the installation of the hood (see Table I).

Hood length x hood width = square feet ($ft.^2$) of hood opening.

$Ft.^2$ of hood opening x factor from Table I = CFM of air exhausted.

TABLE I.

Exposed sides	Factor(CFM/$ft.^2$)
4 (central island hood)	125
3 (wall hung hood)	100
2 (corner hung hood, or with aprons)	85
Steam or heat exhaust only	70

Example:

8 ft. (length) x 4 ft. (width) = 32 $ft.^2$
32 $ft.^2$ X 100 CFM/$ft.^2$ (wall hung hood) = 3200 CFM

B. Exposed linear foot method.

This method of calculating the exhaust air volume is based on the total exposed linear footage of the hood and the capture velocity relative to its application (see Table II).

Exposed linear footage of hood x factor from Table II = CFM of air exhausted.

TABLE II

Application Factor (CFM/in. ft.)	
Light duty (no grease, light grease)	150 - 250
Medium duty (fryers and griddles)	250 - 350
Heavy duty (heavy grease, charbroiler)	350+

Example:

4 ft. x 8 ft. hood (light grease), 3 exposed sides

4 ft. + 8 ft. + 4 ft. = 16 exposed linear ft.

16 exposed linear ft. x 250 CFM/linear ft. = 4000 CFM

C. Square feet of cooking surface method.

This calculation of the volume of exhausted air depends on the size, temperature, and design of the cooking equipment and the minimal capture velocity required to keep smoke, vapors, and fumes under the hood. The amount of air to be removed is calculated by multiplying the surface area of the equipment (f $t.^2$) by the appropriate updraft velocity factor (see Table III); total air exhausted is the sum of exhaust air volumes of all the equipment added to the minimal capture velocity.

$Ft.^2$ of cooking surface of each piece of equipment (length x width) x the updraft velocity factor from Table III = CFM of exhaust required for each piece of equipment.

TABLE III.

Application	Updraft velocity factor
Steam kettles, ranges, ovens, non-grease producing equipment	50 fpm
Fryers/griddles, grease Producing equipment	85 fpm
Charbroilers, high heat and grease producing equipment	150 fpm

Example:

Equipment	Square feet
oven	30" x 36" = 7.5 ft. ²
fryer	18" x 24" = 3.0 ft. ²
charbroiler	32" x 54" = 7.6 ft. ²
range	42" x 34" = 9.6 ft. ²
.2	

Ft.		Factor	Exhaust
7.5	X	50 fpm	375 CFM
3.0	X	85 fpm	255 CFM
7.6	X	150 fpm	1140 CFM
9.6	X	85 fpm	816 CFM
Total equipment exhaust volume =			2586 CFM

The minimal capture velocity = [hood opening area (ft.²) cooking equipment surface area (ft.²) x 50 fpm

Example:

4 ft. x 15 ft. hood = 4 ft. x 15 ft. = 60 ft.² hood opening

Cooking equipment surface area (from above) = 7.5 ft.² + 3 ft.² + 7.6 ft.² + 9.9 ft.² = 28 ft.²

Minimal capture velocity = (60 ft.² - 28 ft.²] x 50 fpm = 32 ft.² x 50 fpm 1600 CFM

Total system exhaust volume = equipment exhaust volume + minimal capture velocity

Example:

Total system exhaust volume = 2586 CFM (from above) + 1600 CFM (from above) 4186 CFM

2. Ventilator and backshelf hoods.

Linear footage of hood x ventilator exhaust factor from Table IV = CFM of air exhausted.

TABLE IV.

Application	Exhaust Factor
Light duty (non-grease producing)	200CFM/ft.
Medium duty (light grease producing)	1275CFM/ft.
Heavy duty (heavy grease producing)	350 CFM/ft.

Example:

12 ft. ventilator hood, medium duty (light grease producing)
12 ft. x 275 CFM/ft. = 3300 CFM air exhausted

Duct Location and Size

Exhaust ducts should never be located at the sides of the hood. For hoods that are six feet or less in length, only one outlet should be provided. Long hoods should be provided with multiple outlets no closer than six feet apart and no further than 12 feet apart. For hoods equipped with multiple ducts, it is advisable to install a manual air volume damper on each outlet so that the system can be easily balanced.

A duct velocity of no less than 1500 fpm shall be provided to maintain suitable conditions in the duct work. In some cases, a greater duct velocity (i.e. 1800-2200 fpm) may be necessary for the system to function at its best. The cross-sectional area of the exhaust duct (in $ft.^2$) can be calculated by using the following formula:

Duct area required ($ft.^2$) = Volume of air exhausted (CFM) - Duct velocity (fpm)

Example:

Duct area required ($ft.^2$) = 3000 CFM ÷ 1500 fpm = 2 $ft.^2$

The area of round duct can be determined from Table V.

TABLE V.

Sizing Chart for Round Duct

Duct Diameter	**Duct Area ($In.^2$)**	**($Ft.^2$)**
10 inches	78.54	.545
12 inches	113.1	.785
13 inches	132.7	.9218
14 inches	153.91	.069
15 inches	176.71	.227
16 inches	201.01	.396
18 inches	254.41	.767
19 inches	283.51	.969
20 inches	314.12	.182
21 inches	346.32	.405
22 inches	380.12	.640
24 inches	452.33	.142

Once removed, the grease is drained into a collection container in the hood or elsewhere. Extractors have generally replaced wire mesh filters where grease removal is of prime concern and compliance with National Fire Protection Association (NFPA) codes is required. Wire mesh filters may be used to exhaust pizza ovens, bread and pastry ovens, and other similar equipment where grease is not of prime concern. Both wire mesh and extractor type filters have an efficient operating velocity range of 200 to 500 fpm; the operating velocity of the filters shall not be less than 200 fpm.

Grease Filter Area and Number of Grease Filters Required

There are two general types of grease filters: wire mesh and extractor filters. The extractor filter removes grease in the exhaust process by centrifugal motion or by impingement on a series of baffles. The manufacturer's optimum rating of the filter should be used in calculating the filter area required in the exhaust system. Standard size filters should be used to avoid additional cost and to allow ease of replacement. Any space in the filter bank not covered by filters/extractors shall be fitted with sheet metal blanks. If calculations indicate that a fraction of a filter is needed, add an additional filter. The filter area required for an exhaust system can be calculated by using the following formula:

Filter area needed (ft.^{2}) = Volume of air exhausted (CFM) - operating velocity of the filters (fpm)

Example:

Filter area needed (ft.^{2}) = 3200 CFM + 500 fpm = 6.4 ft.^{2}
Filters are sized and made removable so that they may be passed through a warewashing machine or cleaned under a steam jet. Standard size grease filters are:

12 inches x 16 inches
16 inches x 20 inches
16 inches x 25 inches
20 inches x 20 inches
20 inches x 25 inches

The following example illustrates how to determine the number and size of filters needed.

Example:

1 ft.^{2} = 144 in.^{2}; a 16 in. x 20 in. filter = 320 in.^{2}

320 in.^{2} ÷ 144 in.^{2} = 2.22 ft.^{2}

3 filters of 16 in. x 20 in. = 6.66 ft.^{2}; therefore, 3 filters of 16 in. x 20 in. will meet the filter area requirement of 6.4 ft.^{2} calculated in the previous example.

Calculating Static Pressure

To select the proper size fan, the volume of air to be moved and the total resistance to its movement must be known. There are a number of restrictions in an exhaust system which affect air flow. The resistance to air movement is measured in inches of water, and this friction loss is called static pressure (S.P.).

The static pressure against which the exhaust fan must work is considered to be the sum of the following five items:

1. The resistance of the grease filters measured under heavy use. A value of .2 inches of water is ample for most filters.

2. The "entrance loss" of static pressure occurring where the exhaust duct attaches to the hood will be about .1 inch of water.

3. The resistance created by natural winds blowing on the exhaust duct opening is a matter of judgement; the average wind pressure is approximately .15 inches of water.

4. The energy, or accelerating pressure, required to accelerate the air to the duct velocity, usually about .20 inches of water.

5. The resistance of the exhaust ducting, which is determined by the total length of the straight duct plus the number and type of elbows.

The values used to determine the static pressure that a fan must overcome are specified in Table VI.

TABLE VI.

Type of resistance	Amount of resistance	
filter	.20	inches
hood entrance loss	.10	inches
wind pressure	.15	inches
accelerating pressure	.20	inches

DUCT RESISTANCE

straight duct - .0025 inches per linear ft.

angles -	90º	.20 inches each
	45º	.10 inches each
	30º	.05 inches each

Example: An exhaust hood with a straight duct of 8 feet with two 45º elbows

		Static Pressure	
Duct (8 ft. x .0025)	=	.02	inches
Elbows (2 x .10)	=	.20	inches
Filter resistance	=	.20	inches
Hood entrance loss	=	.10	inches
Wind pressure	=	.15	inches
Accelerating pressure	=	.20	inches
Total	=	.87	inches

Fan Size

The exhaust fan shall be sized to remove the amount of air to be exhausted at the required static pressure.

Make-up Air

The term "make-up air" is used to identify the supply of outdoor air to a room or building to replace the air removed by an exhaust system. For a consistent and regulated flow, make-up air should be mechanically introduced by a fan, swamp cooler, etc. Mechanically introduced make-up air shall be supplied as part of the exhaust system when the amount of air to be exhausted exceeds 1500 CFM.

Make-up air is critical to the design of a ventilation system. It is generally recognized that all systems exhausting more than 1500 CFM need mechanically introduced make-up air to ensure a balanced system. Mechanical engineers recommend that make-up air be supplied at 85 to 90 percent of the exhausted air. Make-up air controls should be interlocked with exhaust controls to ensure that the units operate simultaneously. Replacement air shall be filtered and may also be tempered by a separate control. The air velocity through the make-up air system should be low enough to avoid the possibility of drafts. It is desirable to have the kitchen under a very slight negative pressure to prevent any filtration of cooking odors from the kitchen into the dining room. The supply of make-up air is frequently introduced at some point within the hood, or in close proximity to the hood, to avoid the removal of conditioned air that has been heated or cooled.

The make-up air inlet should be located at least 10 feet from the exhaust fan to comply with NFPA requirements.

Air conditioning may also serve as a source of make-up air, with each ton of an air conditioning system supplying 400 CFM of outside air.

Reference: South Carolina Department of Health And Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201, “Food Equipment Installation Manual”