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13.30 KITCHEN EQUIPMENT

The purpose of an exhaust system for kitchen equipment is to control heat, smoke, odor, humidity, and grease vapor released into the space by cooking or dishwashing equipment. A secondary consideration is the control of combustion products associated with the heat source which may be vented separately or through the hood itself.

Kitchen hoods are generally designed to satisfy NFPA Standard 96 and model building codes or local codes where they apply. There are two types of kitchen hoods. Type I hoods are designed for the removal of grease and smoke. They have some type of grease removal system and fire suppression equipment. Type II hoods are for the removal of vapors, heat and odors. For Type II hoods, a means of grease removal and fire suppression is not required; thus, they are used over dishwashers and steam tables (VS-30-01). Only a Type I hood can be used over fryers, griddles, broilers and other cooking equipment where smoke or grease vapors may be present. Type I hoods can be used where Type II hoods are allowed, but the reverse is not true.

Type I hoods fall into two categories: Conventional and Listed. Conventional hoods are built to satisfy national and local codes. Listed hoods are those listed according to Underwriters Laboratories (UL) Standard 710 and usually have lower exhaust flow rates than unlisted hoods. These hoods have been tested and have shown that they provide an equal or better safety performance than found in the model code requirements.

Conventional, or “unlisted” hoods are designed to have an overhang of 6 inches [150 cm] beyond the edge of the top horizontal surface of appliances on all open sides of canopy style Type I or Type II hoods. The overhang is normally 12 inches [300 mm] for a single island canopy hood, and six inches for a double island canopy and wall mounted canopy. No overhang is required for eyebrow and back shelf hoods or for canopy hoods where the outer edge of the cooking surface is closed to the appliance side with noncombustible end walls or side panels.

Hood exhaust flow rates vary on the hood style, the amount of overhang, the presence of side panels, the type of cooking, the distance from the cooking surface and the food being cooked. Hot cooking surfaces create thermal plumes that have an upward velocity that can approach 150 fpm [0.75 m/s]. The hood airflow is determined by the plume velocity with safety factors added for the style of hood, cross air currents and flare-ups. The plume velocities are categorized by a duty of cooking appliance:

- Extra heavy duty – solid burning equipment up to 700 F [371 C].
- Heavy duty – upright broilers, charbroilers and woks up to 600 F [316 C].
- Medium duty – large kettles, ranges, griddles and fryers up to 400 F [204 C].
- Light duty – ovens, steamers and small kettles up to 400 F [204 C].

The exhaust rate of a hood is based on the equipment under the hood. The highest duty appliance determines the duty for the hood. The VS prints on kitchen range hoods (VS-30-10 and -11) realize these duty categories to identify the exhaust airflow rate.

National Fire Protection Association (NFPA) Standard 96[13.30.1] describes grease filter construction as well as hood construction necessary to maintain hood integrity in the event of a fire. Welded seam construction is preferred and sometimes required by public health authorities to assure cleanability and ease of maintenance. The National Sanitation Foundation Standard No. 4[13.30.2] also lists hood construction requirements for cleanability and integrity in the cooking and food zones within the hood. In all cases, the local health authorities having jurisdiction should be consulted for construction requirements prior to hood fabrication.

Fire is a primary concern with all cooking equipment. Each hood will require some type of fire suppression consistent with local fire code requirements. The system selected must not compromise sanitation or endanger workers due to location or system activation. Hood or duct penetrations by fire suppression piping, etc., must be sealed to prevent short circuiting of air or loss of fire arrestance.

For high temperature situations such as exposed flames or charcoal, the grease filters must be sufficiently removed from the heat source to prevent ignition (VS-30-12). Fan selection may require use of high temperature fan components and consideration of the effect of change in air density.

Energy conservation, capture and containment performance, and worker comfort in commercial kitchens have become significant industry concerns over the past two decades. Research over that period using new technology, such as schlieren flow visualization, has improved hood designs and replacement air distribution, and resulted in new standards, Ventilation for Commercial Cooking Operations.[13.30.3] It addresses hood performance and energy use in kitchen ventilation systems. In turn, other standards and model building codes have adopted portions of Standard 154.

ASHRAE Standard 90.1-2012, Energy Standard for Buildings Except Low-Rise Residential Buildings, has been adopted by reference in model codes, such as the International Energy Conservation Code.[13.30.4] It has several sections dealing with energy use by commercial kitchen exhaust systems.

Notable changes in ASHRAE Standard 90.1 include:

1. Limiting replacement air introduced directly into the hood cavity to 10% or less of hood exhaust airflow rate. Compensating, or short-circuit, hoods were developed in the 1970s as a means of introducing untempered replacement air directly into the hood

cavity while meeting the code exhaust rate at the exhaust collar. Many of these types of hoods introduced as much as 80% of replacement air directly into the hood. Laboratory testing has demonstrated that introducing this much replacement air into the hood cavity caused spillage.

2. For kitchens with a total exhaust rate of 5,000 acfm [2.36 am^3/s] or greater, there is a table of maximum exhaust rates for each style of exhaust hood and duty rating of appliances. The maximum rates are about 30% less than the minimum exhaust rates for Conventional (unlisted) hoods in the table shown in Figure VS-30-05. In effect, this requirement outlaws Conventional hoods in commercial applications where the total kitchen exhaust rate is 5,000 acfm [2.36 am^3/s] or greater.
3. For kitchens with a total exhaust rate of 5,000 acfm [2.36 am^3/s] or greater, one of the following requirements must be met: (1) at least 50% of replacement air must be transfer air that would otherwise be exhausted, or (2) demand ventilation controls on at least 75% of the exhaust air, or (3) a heat recovery system with sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow.

Several sections of the 2012 International Mechanical Code also influence energy use by kitchen exhaust systems. For example, it requires that the temperature differential between replacement air and air in a conditioned space with kitchen exhaust hoods not exceed 10 F (6 C), except when the means of introducing the replacement air does not decrease kitchen comfort. In addition to improving worker comfort, this requirement also promotes greater use of transfer air, which reduces overall kitchen ventilation system energy use.

REFERENCES

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13.30.2 National Sanitation Foundation: Commercial Food Equipment Standards. Ann Arbor, MI (2015).

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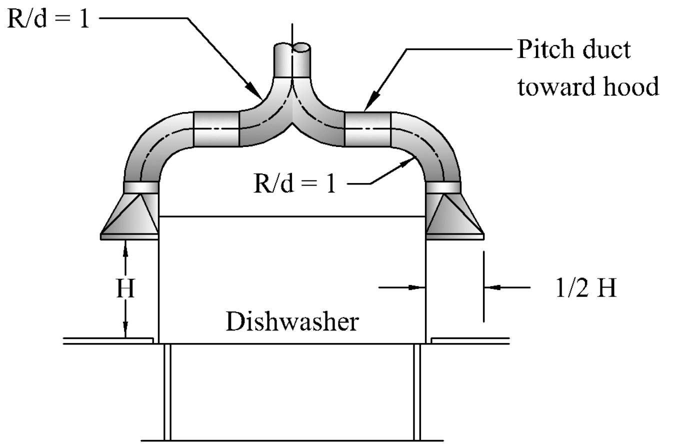
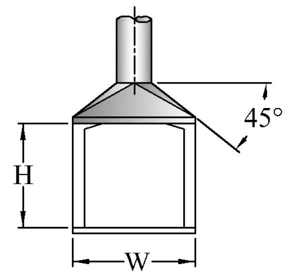
13.30.4 American Society of Heating, Refrigerating and Air Conditioning Engineers: Energy Standard for Buildings Except Low-Rise Residential Buildings. Standard 90.1 (2012).

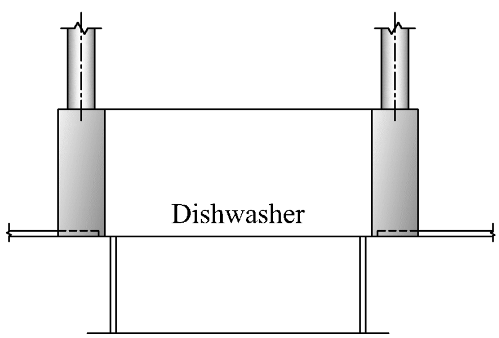
FIGURE VS-30-01



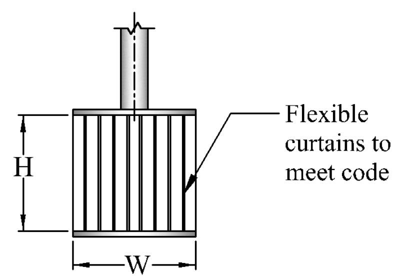
CANOPY HOODS



Q = 250 acfm/ft^2 [1.25 am^3/s/m^2] of door area – each end
Duct Velocity = 3,000 fpm [15 m/s]
F_h = 0.25



EXHAUSTED VESTIBULES



Q = 150 acfm/ft^2 [0.75 am^3/s/m^2] of door area – each end
Duct Velocity = 3,000 fpm [15 m/s]
F_h = 0.60

Note: If direct exhaust connections are provided from dishwasher body, cap these connections and use external hoods.

ACGIH®	TITLE	FIGURE VS-30-01
	DISHWASHER VENTILATION	DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.

FIGURE VS-30-05

Type of Kitchen Hood, acfm/Linear ft [am^3/s/Linear meter] of Hood Length				
Kitchen Appliance Duty	Wall Mounted Canopy	Island	Canopy	Back Shelf
		Single	Double Per Side	
Type 1				
Extra Heavy Duty	550 [0.85]	700 [1.09]	550 [0.85]	NA NA
Heavy Duty	400 [0.62]	600 [0.93]	400 [0.62]	400 [0.62]
Medium Duty	300 [0.47]	500 [0.78]	300 [0.47]	300 [0.47]
Light Duty	200 [0.31]	400 [0.62]	250 [0.39]	250 [0.39]
Type 2	200 [0.31]	400 [0.62]	250 [0.39]	250 [0.39]

Hood exhaust flow rates vary on account of the hood style, the amount of overhang, the presence of side panels, the type of cooking, the distance from the cooking surface and the food that is being cooked. Hot cooking surfaces create thermal plumes that have an upward velocity that can approach 150 fpm [0.75 m/s]. The hood airflow is determined by the plume velocity, with safety factors added for the style of hood, cross air currents, and flare-ups. The plume velocities are categorized by a duty of cooking appliances:

- Extra heavy duty – solid burning equipment up to 700 F [371 C].
- Heavy duty – upright broilers, charbroilers and woks up to 600 F [316 C].
- Medium duty – large kettles, ranges, griddles and fryers up to 400 F [204 C].
- Light duty – ovens, steamers and small kettles up to 400 F [204 C].

The exhaust rate of a hood is based on the equipment under the hood. The highest duty appliance determines the duty for the hood. The kitchen range hoods shown in VS-30-10 and VS-30-11 utilize these duty categories to identify the exhaust airflow rate.

ACGIH®

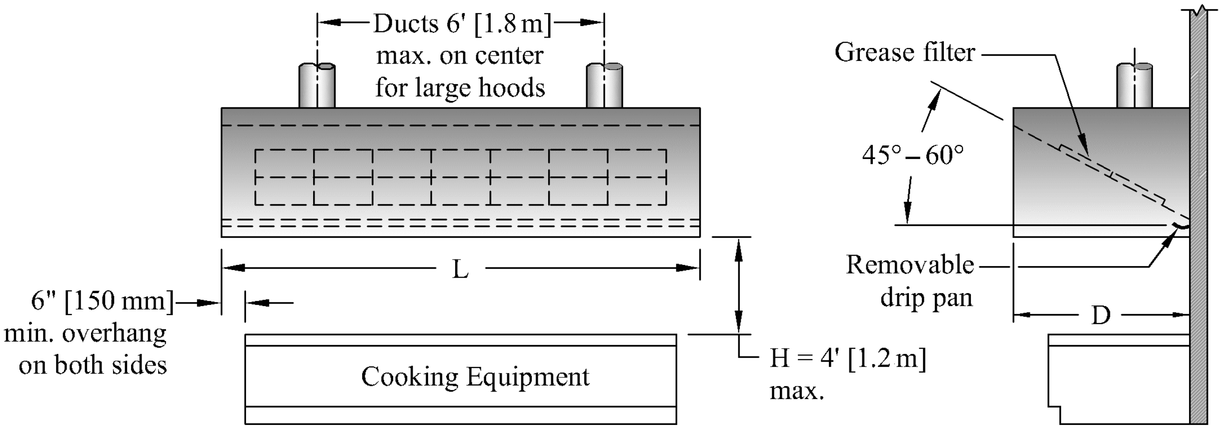
TITLE
KITCHEN HOOD EXHAUST FLOW RATES

FIGURE VS-30-05

DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.

FIGURE VS-30-10



See VS-30-05 for Hood Exhaust Flow

P = perimeter of hood = 2D + L

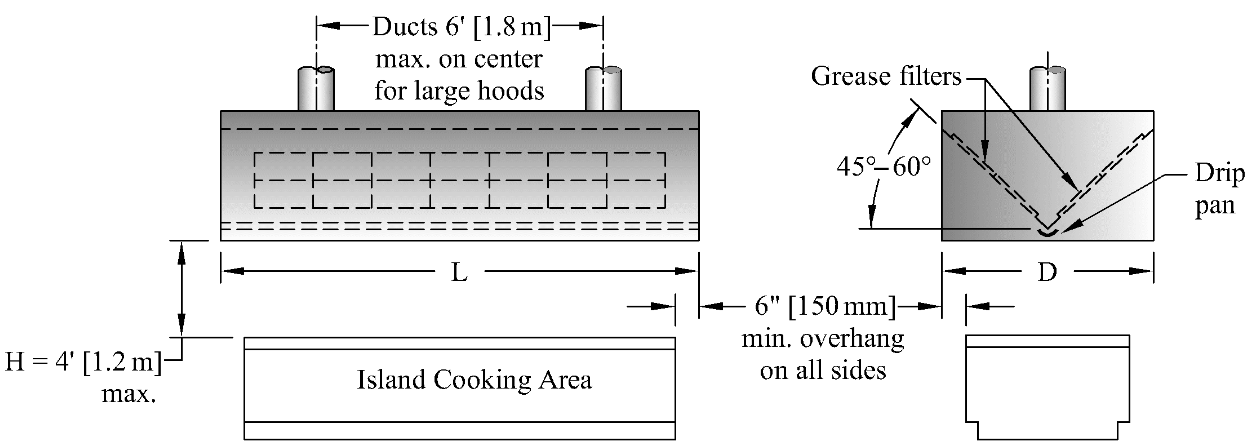
Duct Velocity = 1,000 – 4,000 fpm [5 – 20 m/s], to suit conditions

F_h = 0.60 (straight takeoff)

F_h = 0.25 (tapered takeoff)

Add maximum filter resistance + 1" wg [25 Pa] to calculated hood static pressure

WALL MOUNTED CANOPY



See VS-30-05 for Hood Exhaust Flow

P = perimeter of hood = 2D + 2L

Duct Velocity = 1,000 – 4,000 fpm [5 – 20 m/s], to suit conditions

F_h = 0.60 (straight takeoff)

F_h = 0.25 (tapered takeoff)

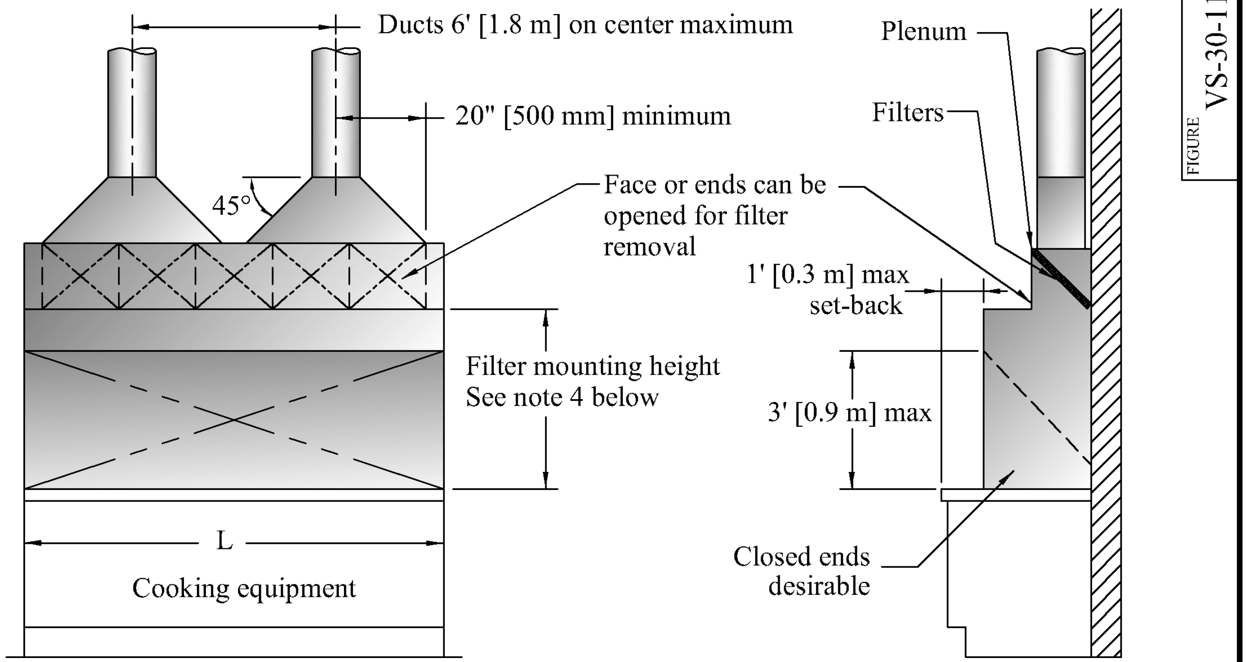
Add maximum filter resistance + 1" wg [25 Pa] to calculated hood static pressure

Note: See VS-30-11 for information about filters and fans for range hoods.

ISLAND TYPE HOOD

ACGIH®	TITLE: KITCHEN RANGE HOODS	FIGURE: VS-30-10 / DATE: 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.



BACK SHELF HOOD

See VS-30-05 for Hood Exhaust Flow

Q = 200 acfm/lineal ft [0.31 am^3/s/lineal meter of cooking surface]

Minimum duct velocity = 1,000–4,000 fpm [5.00–20.00 m/s], to suit conditions

F_h = 0.60 (straight takeoff)

F_h = 0.25 (tapered takeoff)

Add maximum filter resistance + 0.1" [25 Pa] to calculated Hood Static Pressure

NOTES FOR KITCHEN HOODS

Filters:

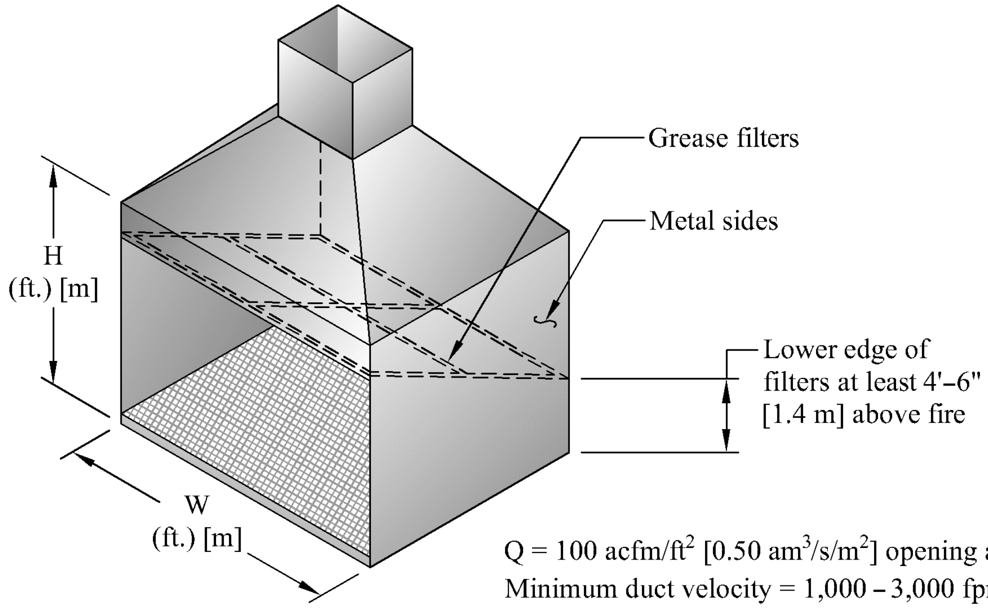
1. Select practical filter size.
2. Determine number of filters required from manufacturer's data. (Usually 2 acfm maximum exhaust for each square inch [1.5 am^3 for each square meter] of filter area)
3. Install at 45°–60° to horizontal. Never horizontal.
4. Filter mounting height (Reference 13.30.1)
   a. No exposed cooking flame – 18" [450 mm] minimum to lowest edge of filter.
   b. Charcoal and similar fires – 4' [1.2 m] minimum to lowest edge of filter.
5. Shield filters from direct radiant heat.
6. Provide removable grease drip pan.
7. Clean pan and filters regularly.

Fan:

1. Use upblast discharge fan. Downblast is not recommended.
2. Select fan for design Q and SP resistance of filters and duct.
3. Adjust fan specification for expected exhaust air temperature.

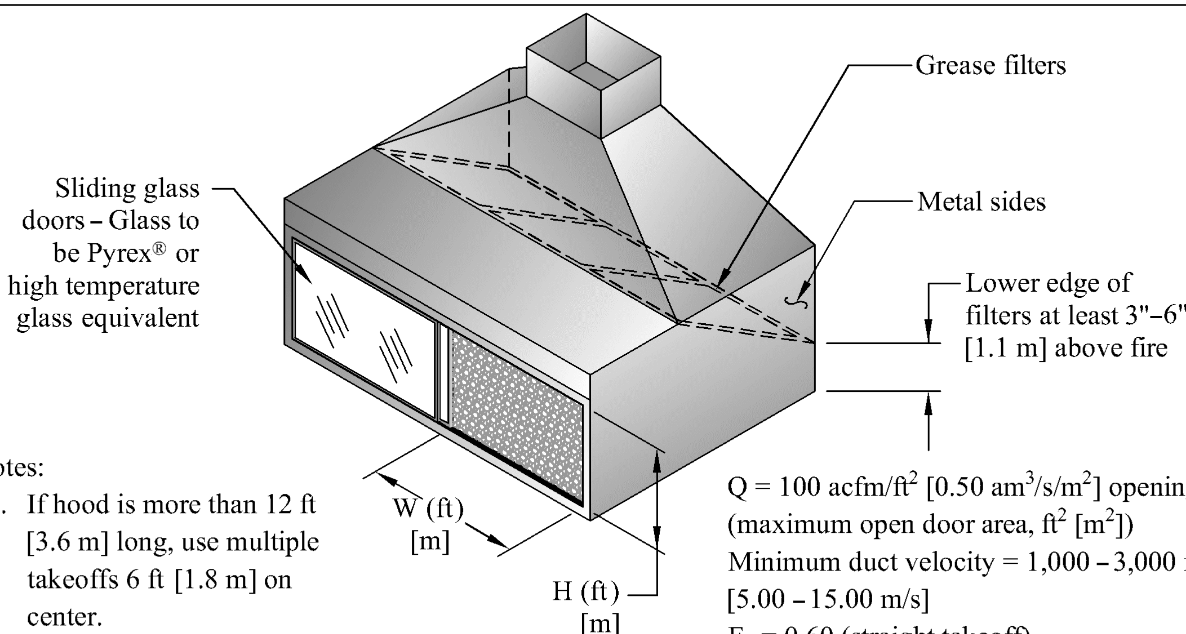
ACGIH®	TITLE	FIGURE
	KITCHEN RANGE HOOD	VS-30-11
		DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.



CHARCOAL BROILER

Q = 100 acfm/ft^2 [0.50 am^3/s/m^2] opening at face
Minimum duct velocity = 1,000 – 3,000 fpm [5.00 – 15.00 m/s]
F_h = 0.60 (straight takeoff)
F_h = 0.25 (tapered takeoff)
Other losses = maximum filter resistance + 0.1" wg [25 Pa]



BARBECUE PITS

Notes:

1. If hood is more than 12 ft [3.6 m] long, use multiple takeoffs 6 ft [1.8 m] on center.
2. See VS-30-11 for information about filters and fans for range hoods.

Q = 100 acfm/ft^2 [0.50 am^3/s/m^2] opening, (maximum open door area, ft^2 [m^2])
Minimum duct velocity = 1,000 – 3,000 fpm [5.00 – 15.00 m/s]
F_h = 0.60 (straight takeoff)
F_h = 0.25 (tapered takeoff)
Other losses = maximum filter resistance + 0.1" wg [25 Pa]

ACGIH®	TITLE: CHARCOAL BROILER AND BARBECUE PIT VENTILATION	FIGURE	VS-30-12
		DATE	1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL)
TO ENSURE THAT DESIGN IS COMPLIANT.

13.35 LABORATORY VENTILATION

The primary method of contaminant control within the laboratory is exhaust ventilation and, in particular, laboratory hoods. This section presents information on laboratory hoods but expands to other types of ventilation control such as biological safety cabinets, clean benches, and other local exhaust systems found in the laboratory.

13.35.1 Laboratory Hoods. In most cases, laboratory hoods will be purchased from manufacturers specializing in the design and construction of laboratory hoods. VS-35-01 shows a typical laboratory hood design. VS-35-02 describes general use laboratory hoods and VS-35-03 describes perchloric acid hoods. VS-35-04 describes work practices for laboratory hoods.

Several features are essential to the proper performance of the hood. The most important aspect of the hood is the aerodynamic entry characteristics. For the hood to adequately control contaminants, the entry must be smooth. This is usually achieved with an airfoil sill at the leading edge of the work bench. Often, beveled jambs at the side wall entry will improve the airflow.

In many cases, good performance correlates with uniform face velocity. To achieve a uniform face velocity, many hood manufacturers provide adjustable slots in the plenum at the back of the hood. Although the adjustment will allow for unusual conditions such as large hot plates for sample digestions, inappropriate adjustment of the slots can have a detrimental effect on hood performance.[13.35.1]

Supply Air Distribution: For typical operation of a laboratory hood, the worker stands at the face of the hood and manipulates the apparatus in the hood. The indraft at the hood face creates eddy currents around the worker's body that can drag contaminants in the hood along the worker's body and up to the breathing zone. The higher the face velocity, the greater the eddy currents. For this reason, higher face velocities do not result in greater protection as might be supposed.

Room air currents have a large effect on the performance of the hood. Thus, the design of the room air supply distribution system is as important in securing good hood performance as is the face velocity of the hood. American Society of Heating, Refrigerating and Air Conditioning (ASHRAE) research project RP-70 results, reported by Caplan and Knutson,[13.35.2] concludes in part:

1) Lower breathing zone concentrations can be attained at 50 acfm/ft^2 [0.25 am^3/s/m^2] face velocities with good air supply distribution than at 150 acfm/ft^2 [0.75 am^3/s/m^2] with poor air distribution. With a good air supply system and tracer gas released at 8 liters per minute inside the hood, breathing zone concentrations can be kept below 0.1 ppm and usually below 0.05 ppm.
2) The terminal throw velocity of supply air jets should be no more than one-half the hood face velocity; such terminal throw velocities are far less than conventional practice.
3) Perforated ceiling panels provide a better supply system than grilles or ceiling diffusers in that the system design criteria are simpler and easier to apply, and precise adjustment of the fixtures is not required.

For the reasons described, an increased hood face velocity may be self-defeating because the increased air volume handled through the room makes the low-velocity distribution of supply air more difficult.

Selection of Hood Face Velocity: The interaction of supply air distribution and hood face velocity makes any blanket specification of hood face velocity inappropriate. Higher hood face velocities will be wasteful of energy and may provide no better or even poorer worker protection. The ANSI/ASHRAE Hood Performance Test[13.35.3] may be used as a specification. The specified performance should be required of both the hood manufacturer and the designer of the room air supply system.

The specification takes the form: AU_{yyy}, AI_{yyy}, or AM_{yyy}

where: AU identifies an "as used" test,
AI identifies an "as installed" test,
AM identifies an "as manufactured" test, and
yyy = control level, ppm, at the breathing zone of the worker.

Any well-designed airfoil hood, properly balanced, can achieve < 0.10 ppm control level when the supply air distribution is good. Therefore, it would seem appropriate that the "AM" requirements would be < 0.10 ppm. The "AU" requirement involves the design of the room supply system and the toxicity of the materials handled in the hood. The "AU" specification would be tailored to suit the needs of the laboratory room location.

For projected new buildings, it is frequently necessary to estimate the cost of air conditioning early — before the detailed design and equipment specifications are available. For that early estimating, the guidelines listed in Table 13-35-1 can be used.

13.35.2 Biological Safety Cabinets. Biological safety cabinets (BSCs) are classified as Class I, Class II; Types A, B1, B2, and B3; and Class III.

Class I BSC provides personnel and environmental protection but does not protect the product. The front panel can be open, allowing room air to enter the cabinet, sweep the inner surfaces, and exhaust out the duct. A front closure panel with glove ports may be installed. If gloves are installed, air is drawn through a secondary opening equipped with a roughing filter. A laboratory hood, as shown in VS-35-20, could be considered a Class I BSC if the exhausted air is passed through HEPA filters prior to release to the atmosphere.

Class II BSCs provide personnel, product and environmental protection. Class II cabinets differ in the proportion of air recirculated within the cabinet; velocity of airflow to the work

TABLE 13-35-1. Laboratory Hood Ventilation Rates

	Condition	acfm/ft² [am³/s/m²] Open Hood Face
1.	Ceiling panels properly located with average panel face velocity < 40 fpm [< 0.20 m/s].(13.35.2) Horizontal sliding sash hoods. No equipment in hood closer than 12 inches [300 mm] to face of hood. Hoods located away from doors and trafficways.*	60 [0.30]
2.	Same as 1 above; some traffic past hoods. No equipment in hoods closer than 6 inches to face of hood. Hoods located away from doors and trafficways.*	80 [0.40]
3.	Ceiling panels properly located with average panel face velocity < 60 fpm [< 0.30 m/s](13.35.2) or ceiling diffusers properly located; no diffuser immediately in front of hoods; quadrant facing hood blocked; terminal throw velocity < 60 fpm [< 0.30 m/s]. No equipment in hood closer than 6 inches [150 mm] to face of hood. Hoods located away from doors or trafficways.*	80 [0.40]
4.	Same as 3 above; some traffic past hood. No equipment in hood closer than 6 inches [150 mm] to face of hood.	100 [0.50]
5.	Wall grilles are possible but not recommended for advance planning of new facilities.	

*Hoods near doors are acceptable if: 1) there is a second safe egress from the room; 2) traffic past hood is low; and 3) door is normally closed.

surface; where the exhausted air is discharged; and whether the contaminated air plenum is under positive pressure. A Type A cabinet (VS-35-10) may discharge the exhausted air, after HEPA filtration, directly into the room. Type A cabinets that discharge into the work area are not recommended for use with gases or vapors. A primary application is for sterile packaging. Care is required while decontaminating the cabinet.

Type B hoods (VS-35-11) discharge the exhaust but may recirculate within the cabinet. Type B1 cabinets recirculate about 30% of the air within the BSC and typically exhaust the remainder outside the laboratory (i.e., exhaust air is not discharged back into the room). The contaminated plenum is under negative pressure. Type B2 cabinets are referred to as “total exhaust” cabinets as the contaminated air is exhausted to the atmosphere after HEPA filtration without recirculation in the cabinet or return to the laboratory room air. Type B3 BSCs have HEPA filtered downflow air that is a portion of the mixed downflow and inflow air from a common exhaust plenum.

Class III BSCs (VS-35-20) provide the highest level of protection to personnel and the environment. The cabinet is totally enclosed with operations conducted through attached gloves. See “National Sanitation Foundation Standard No. 49”(13.35.4) for descriptions and requirements of the various classes of BSCs.

13.35.3 Clean Benches. Clean benches can be divided into laminar flow and exhausted clean benches.

Laminar flow clean benches provide product protection only. In a laminar flow clean bench, room air is HEPA-filtered, directed across the work area, and discharged back to the room. Air may be directed horizontally as depicted in VS-35-30 or vertically as in VS-35-31. Neither of these hoods provide worker protection. Workers using the Horizontal Laminar Flow Clean Bench are exposed to the product as the air sweeps across the product into the worker’s face. Workers’s arms or other objects protruding into the Vertical Laminar Flow Clean Bench opening may cause contaminated air to spill into the room. Personal protective equipment or general ventilation should be provided as needed.

Other types of clean benches incorporate the same general principles of biological safety cabinets and utilize HEPA filtered laminar flow within the hood to provide product protection and exhaust sufficient air to ensure flow into the hood at the face to provide operator protection.

13.35.4 Laboratory Equipment. Some laboratory equipment such as evaporation hoods (VS-35-40), discharge from instruments such as ICP or AA, and some ovens (VS-35-41) require local exhaust ventilation to adequately control contaminant releases. Often, especially designed ventilation specific to the operation provides better control than using a laboratory hood to control these releases.

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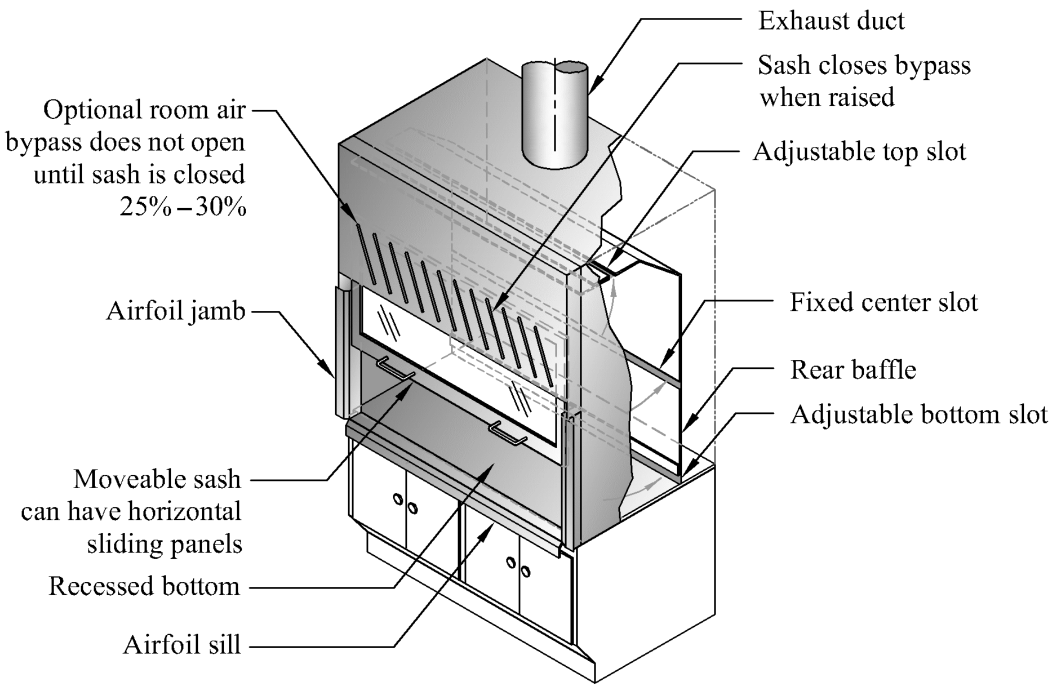
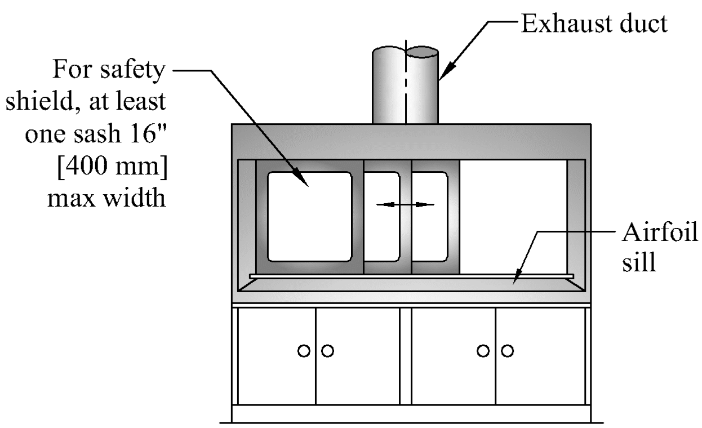
FIGURE VS-35-01



VERTICAL SASH
AIRFOIL HOOD



HORIZONTAL SASH
AIRFOIL HOOD

Design specifications:
General use laboratory hoods – See VS-35-02
Perchloric acid – See VS-35-03
Work practices – See VS-35-04
"Auxiliary Air" or "Compensating" hoods furnish some replacement air at hood face; design varies with vendor.

Q = 80–100 acfm/ft^2 [0.40–0.50 am^3/s/m^2] of full open area depending on quality of supply air distribution and the uniformity of face velocity
Minimum duct velocity = 1,000 – 2,000 fpm [5.00 – 10.00 m/s]
F_h = 0.60

ACGIH®	TITLE	FIGURE VS-35-01
	TYPICAL LABORATORY HOOD	DATE 1-19

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.