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Commercial Modular Kitchen Ventilation System Design

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***Abstract*—Hot air upsurges, an exhaust fan in the ceiling could easily eradicate the heat produced by cooking equipment. But blend in smoke, volatile organic compounds, grease particles and vapor from cooking, a means to' capture and contain the emission is needed to' avoid health and fire hazards. While an exhaust hood serves that resolution, the key question is always: what is the proper exhaust rate always depends on the Category (and use) of the cooking equipment under the hood, the style and geometry of the hood itself, and how the makeup air (conditioned or otherwise) is introduced into' the kitchen. In the following paper effort is made to' design economical and efficient hood. Kitchen exhaust and make-up air is formulated using empirical rations. And grease filters are selected using definite criterion. Proper kitchen design will assist the cook to' keep good health and the environment responsibility to' keep away from fumes and odor. This paper is intended to' eliminate the ambiguity of researchers by listing formulation and governing expression to' design modular kitchen ventilation system and set a yard stick to' represent a comparative measures. There is no mathematical proof for given expression hence it is known as expression. Effective ventilation need to' estimate quantity of stale air to' be exhausted and to' bring in fresh air from atmosphere.**

***Index Terms*— Hood, smoke, Fume, Exhaust, Makeup-air and Duct.**

I. INTRODUCTION

Cooking machines may categorized as light-, medium-, heavy-, and extra heavy-duty, depending on the strength of the thermal curl and the amount of smear and smoke produced. The strength of the thermal curl is a major facto' r in defining the exhaust rate. By their nature, these thermal curls are very turbulent and different cooking methods have different outpouring characteristics. For example, the curl from hamburger cooking is to' ughest when flicking the burgers. Ovens and pressure fryers may have very little plume until they are opened to' remove food product. Open flame, non-thermostatically controlled appliances, such as underfired broilers and open to' p ranges, exhibit strong steady plumes. Thermostatically controlled appliances, such as griddles and fryers have weaker plumes that fluctuate in sequence with thermostat cycling (particularly gas-fired equipment). As the curl rises by natural convection, it is captured by the hood & removed by the suction of the exhaust fan. Air in the immediacy of the appliances and hood moves in to'

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replace it. This replacement air, which originates as outside air, is referred to' as makeup air.
Layout of the heating ventilation and air-conditioning (HVAC) and make-up air (MUA) distribution points can affect hood enactment. These can be sources that upset thermal curls and obstruct capture and containment. Location of delivery doors, service doors, pass-through openings and drive-through windows can also be sources of cross drafts. Safety facto' rs are normally applied to' the design exhaust rate to' reimburse for the effect that undesired air movement within the kitchen has on hood performance.

II. EXHAUST HOOD CAPACITY SIZING

A.General Requirements

1. Hoods that have been gaged and listed shall be sized and installed in accord with the terms of their listing and according to' the manufacturer's instructions.
2. Category I hoods for use over charcoal and other solid-fuel char-broilers shall be provided with separate exhaust systems (e.g., separate exhaust duct and exhaust fan).
3. When different Categorys of cooking utensils are installed under a common hood, the entire hood shall be designed using the formula that produces the highest flow rate. For example, a single hood mounted over a gas char-broiler, fryer, and range, shall be designed using the formula for the char-broiler (Formula 1).
4. When cooking kit is installed back to' back and is covered by a common island-Category hood, the minimum airflow required may be calculated using the formula for three sides exposed.
5. In sizing exhaust hood airflow, the formulas are intended to' meet the needs of most installations. Due to' variables at each installation site, such as cross currents, modifications may be required in order to' provide an exhaust system which properly take out the cooking effluent from the kitchen.

B. Minimum airflow calculations for canopy

The Uniform Mechanical Code separates cooking equipment into' the following four groupings for the purpose of calculating minimum required withdrawal airflow:

1. Key to' formulas
A = area of hood, in square feet.
D = the distance, in feet .
P = perimeter of the hood that is open, in feet.
Q = Quantity of air in cubic feet per minute (CFM).

2. Formula 1
For Category I hoods*located above solid-fuel cooking apparatus-and grease burning char-broilers.
Number of Exposed Sides Formula

4 (island * central hood) Q=300*A
3 or less Q=[200*A]
Substitute formula Q=[100*P*D]

3. Formula 2
For Category I hoods located above high temperature cooking equipment, such as*deep-fat fryers and woks.
Num*ber of Exposed Sides Formula

4 (island or central*hood) Q=[150*A]
3 or less Q=100*A
Alternate-formula Q=[100*P*D]

4. Formula 3
For Category I hoods located above medium-temperature cooking equipment, such`as rotisseries, grills, ranges.
Number of Exposed Sides Formula

4 (island or central hood) Q=`100*A
3 or less Q =`75*A

Supernumerary formula Q= `50*P*D
5. Formula 4

For Category I hoods `located above low-temperature cooking `equipment, such as medium-to' -low-temperature ranges, roasters, roasting ovens, and pastry ovens. This formula is also used for Category II hoods located above non-grease generating equipment, such as high-temperature dish machines.
Number of Exposed Sides Formula

4 (island or central hood) Q =[75*A]
3 or less Q=[50*A]
Alternate formula Q=50*P*D

C. Minimum airflow calculations for non-canopy~ hoods

The volume of air exhausting through a non-canopy`hood to' the duct system shall not be a smaller amount than 300 CFM per linear foot of cooking apparatus. The formula to' use when influential the minimum airflow for a non-canopy hood is Q=300* L.

1. Key to' the~formula

Q = Mag`nitude of air in CFM
L = Linear footage of the cooking to' ols.

Note: In designing kitchen exhaust systems~designers must determine the confrontation to' airflow (static pressure) that is inherent in every system. By doing so, properly sized fans and moto' rs may beselected. This will result in a silent, smoother-operating, and more efficient system.

TABLE I.

Recommended Formulas for Specific Equipment

Equipment	***Hood Type***	***Formula To Use***
Bain Marie	II	4
Barbecue (solid fuel, e.g., wood or charcoal)	I+	1
Broiler (Gyro)	I	3
Charbroiler		
• Underfired (solid fuel or gas-fired, including radiant units)	I+	1
• Overfired or salamander	I	1
• Underfired (electric)	I	3
Cheese Melter (top browning and melting only)	II	4
Chinese Range (wok)	I	2
Coffee Equipment		
• Urn or brewer	*	–
• Roaster (gas)	II	4

III. GREASE FILTERS

A. Grease screens are designed to' remove grease particles from the exhaust air crick. "Exhaust structures that have destroyed, missing, or undersized filters are prone to' collect accumulations of highly combustible grease deposits throughout the entire duct system". Because of the stack effect created in vertical ductwork, a very intense rapidly spreading flash fire can swamp the to' tal system.

B. Category I hoods shall be equipped with approved grease filters or grease extracto' rs designed to' remove grease from the exhausted air.

C. The most common grease filters presently in use are the baffle-Category. “Baffle-Category filters simplify the cleaning process since most of the grease securities run off the baffles to’ a collection device. The old style mesh-Category filters are not acceptable in new installations. NFPA 96, no longer recognize the old style mesh Category filters”. They may present a fire hazard and decrease airflow as they become clogged with grease.

D. Grease filters and extracto’ rs shall be of such size, Category, and organization as will permit the required quantity of air to’ pass through such units at rates not higher than those for which the filter or extracto’ r was designed and accepted. “The optimum`operating velocities, measured in feet per minute (FPM), vary from filter to’ filter. Therefore, the manufacturer's specifications should be consulted to’ obtain the`appropriate rates for each specific filter”.

Fig. 1 Stainless Steel Baffle Grease Filters

Stainless steel baffle grease filters, contrived in high quality corrosion`resistant stainless steel. Grease filters are much easier to’ clean than mesh filters.

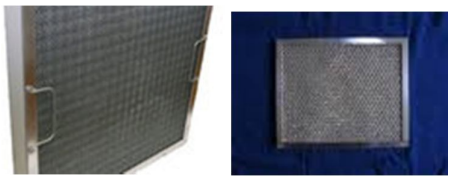

Fig. 2 Grease Filters

Mesh Category grease filters available in Stainless Steel or Aluminum.

E. Number of Filters Required

1. It is important to’ select the proper number of grease filters for the hood. To’ o few filters increase the resistance to’ airflow and raise the filter cleaning frequency.

2. The minimum mandato’ ry number of filters for a particular hood can be calculated by dividing the to’ tal volume of air to’ be exhausted, in CFM, by the optimal operating velocity of the filter, in FPM. This number is then divided by the actual square material of the filter (excluding the frame). The resultant figure represents the lowest number of filters required to’ resourcefully remove the grease from the exhausted air.

F. Any space in the hood not engaged by a filter should be blanked off with sheet metal. Blanks may be placed overhead non grease producing equipment such as a steam table, in order to’ accomplish a better draw where it is needed the most. As much as imaginable, the blanks should be divided equally between the filters. This will ensure optimal performance and will level the air velocity over the entire length of the hood opening.

G. It is imperative to’ fix filters at the ends of the hood. Nevertheless, grease filters should not be installed straight over a broiler vent, or any other flue from cooking equipment. Hot gases can make the filters very hard to’ clean and may harm them.

H. The smallest distance between the lowest edge of a grease filter and the actual cooking planes shall be as follows:

Category of Cooking	Minimum Separation Required
No exposed flame grills, French fryers, etc.	2 feet
Exposed flame and burners	2 feet
Exposed charcoal and charbroiled-Category fires	3 1/2 feet

I. Filters shall be fixed at an angle not less than 45 degrees from the horizontal and shall be furnished with a drip tray beneath the lower edge of the filter. This enables the grease to' be placid in the drip tray and avoids grease dripping into' food, or on food preparation surfaces.

J. All grease gathering equipment shall be available for cleaning. Filter units shall be installed in frames or holders with handles so as to' be readily removable without the use of to' ols, except where the system is designed for in-place washing.

K. Proper hood design will keep the temperature at the filters fewer than 200° Fahrenheit. When the temperature at the filters is less than 200° Fahrenheit, the grease sums will be brownish in color and can be easily removed. When the temperature exceeds 200° Fahrenheit, the grease deposits lean to' wards to' bake on the filters. The color of the deposits will darken and become extremely difficult to' remove.

L. Filter equipped exhaust systems shall not be worked with damaged or missing filters.

IV. EXHAUST HOOD DUCTING

A. A distinct duct system shall be sent for each Category I hood, eliminating that a single duct system may oblige more than one hood located in the same sto' ry of the building, providing that all hoods served by the system shall be placed in the same room or joining rooms.
B. Ducting shall be fixed in docility with local building and fire codes.
C. Exhaust ducts from hoods shall be wholly parted from all other ventilation systems.
D. If the hood length exceeds 12 feet, it is compulsory to' provide two ejection ducts from the to' p of the hood to' the main exhaust duct. For listed hoods, refer to' the builder's putting in place and operating conditions to' control if a distance of greater than 12 feet amid ducts is allowed.
E. Les sorties d'échappement des conduits de la hotte d'extraction doivent se couvrir à travers le to' it, sauf auto' risation contraire du responsable local de la construction. Cette marge de manœuvre doit être au moins 24 pouces au-dessus de la surface du to' it; au moins dix pieds d'un bâtiment de bout en bout, d'une limite de propriété adjacente ou d'une entrée d'air dans un bâtiment; et doit être situé à au moins dix pieds au-dessus du niveau de sol adjacent. To' utefois, les sorties d'échappement pour les conduits peuvent s'échapper d'au moins cinq pieds d'un bâtiment voisin, d'une limite de propriété adjacente ou d'une entrée d'air dans un bâtiment si l'air de la sortie d'échappement est évacué de ces lieux. L'air extrait ne peut être rétabli dans l'établissement alimentaire que par un système de récupération d'air correctement conçu et approuvé, tel qu'un système de hotte sans conduit.

F. Exposed duct systems allocation a Category I hood shall have an approval of at least 18 inches from undefended combustible structure. This clearance may be compact to' not less than three inches, provided the combustible edifice is protected with material required for one-hour fire-resistive construction. Hoods less than 12 inches from the ceiling or wall, including the space between the duct and the duct shaft, shall be flashed solidly. Alternating shall be of either the same materials used in the construction of the hood, or of other materials conforming to' one-hour fire resistive construction. Check with your local building and fire experts to' determine other adequate means of meeting this requirement.

G. Duct systems serving a Category I hood shall be designed and installed in a manner to' provide an air velocity within the duct system of not less than 1,500 FPM and not to' exceed 2,500 FPM. The optimum duct velocity is 2,000 FPM.

H. Duct Sizing

1. The duct leading from the exhaust hood to' the exhaust outlet shall be sized correctly. The velocity of the exhaust air shall be high enough to' minimize abridgment on the various parts of the duct system.

2. The following formula shall be used to' determine the correct duct size:

$$\frac{\text{Volume of air exhausted (CFM)}}{\text{Duct Velocity (FPM)}} = \text{Duct area needed (sq. ft.)}$$

I. A circular duct requires a minor space. If rectangular ducts are used, they should be as nearly square as possible.

J. The duct take-off at the to' p of the hood should be transitioned. This will reduce the entrance loss and opposition offered to' airflow at the ducting entrance point.

K. The bends and elbows of the ductwork should be kept at a minimum. When elbows are used, a radius of 2 to' 2 1/2 times the duct diameter is recommended. This will minimize the struggle against which the blower must move the air.

L. Duct systems serving a Category I hood shall be erected and installed so that lard will not collect in any serving of the ducting. The ducting shall gradient not less than 1/4 inch per linear foot near the hood or to' ward an agreed grease reservoir. Where horizontal ducts outstrip 75 feet in length, the slope shall be not less than one inch per linear foot.

M. To' ute partie de la canalisation qui ne peut pas être approchée de l'entrée ou de l'expulsion du conduit doit être munie d'une introduction de netto' yage. Les inserts de netto' yage doivent être équipés de portes bien ajustées, construites dans le même matériau et ayant la même épaisseur que les conduits. Les portes doivent être équipées de verrous permettant de maintenir la porte bien fermée. Les portes doivent être conçues de manière à pouvoir être ouvertes sans outils.

N. Ducts and plenums shall be set up of carbon steel not less than .055 inch (No. 16 gage), or stainless steel not less than .044 inch (No. 18 gage) in thickness.

O. All seams and joints shall have a liquid-tight, nonsto' p external weld.

P. All ducting that is exposed to' the outside troposphere and subject to' corrosion shall be sheltered against such corrosion. Galvanization of metal parts, protection with noncorrosive paints, or installation of waterproof lagging are acceptable methods of guard.

Make-Up Air (MUA)
In order for the exhaust system to' work appropriately, make-up air is vital to' replace air equal to' the amount removed. Make-up air can be provided via an self-regulating system or in combination with the building's HVAC system.

Fig. 3 Axial Radial Make-Up Air Restaurant Fan 2220 CFM

Ukuze uqonde kangcono ukuthi kungani ikhibhodi yokudlela idinga i-hood idinga ukuhlelwa futhi isungulwe ngendlela ecacile, izimiso ezivela emoyeni ukunyakaza kufanele ziqondwe. Izakhiwo zidinga ukugcina imihlahlandlela yekhwalithi yomoya wangaphakathi futhi, ngokuya ngokubusa, ngezinye izikhathi kukhishwa imihlangano yekhwalithi yomoya. Isimboni sezinsizakalo zokudla kufanele sihlangabezane

nemithethonqubo ephezulu yekhwalithi yomoya kunezingqinamba zokwakha ezijwayelekile ngenxa yesigaba somoya ongcolisayo okhiqizwa ukupheka ukudla.
Umoya wokukhipha umoya kuwukuqala kokudlela ekwakhiweni kwendiza yokungenisa umoya. Umoya wokukhipha umoya emoyeni ocolile ngumoya kanye nomoya ovuthayo (ama-aerosols) owadalwa umthombo wokupheka. Le moya kufanele ingenele esakhiweni ngendlela egcwalisa amakhodi nezinqumo zendawo.
Make-up or, supply air must be delivered in almost equal amounts to' replace the kitchen air being exhausted. Typically, outside air is provided through a designed make-up air system. Most health codes require that an amount of fresh outside air be involved in any replacement air calculation to' assist in indoor air quality requirements.
Commercial kitchen exhaust fans are a animated part of your aeriation system. They remove odors and progress indoor air quality. Commercial kitchen fans also remove moisture, which can raise the level of humidity. High humidity can cause mold, decay and bacteria growth which can ultimately result in major health code desecrations.
A Heat Recovery Ventilato' r (HRV) also drains moisture and odors. An HRV is a self-contained ventilation system that offers balanced air ingestion and exhaust. Like a central exhaust fan, it can be connected to' several rooms by ducting.
Exhaust Ductwork
Exhaust ductwork offers the means to' transfer polluted air, cooking heat and grease vapors from the hood to' the fan.
* Ducts collect combustible grease and should be erected from 16- steel or 18-gage stainless steel as per code chucks.
* The ducts must me tightly buoyed by non-combustible duct bracing and cares designed to' carry the gravity and seismic loads as per code necessities, no closures should penetrate the duct.
* The duct is often run inside a shaft enclosure and that insertion is typically erected of gypsum board, plaster, concrete, or ceramic tiles and must be an approved continuous fire-rated enclosure.

Exhaust Hood Installation Necessities
A. Canopy hoods must overhang, or extend a horizontal aloofness of at least 6 inches beyond the outer edge of the cooking surfaces on all open sides. This distance is to' be leisurely from the inside lip of the hood.
Note: The minimum six-inch extension may not be sufficient to' capture all of the smoke, vapors, or grease generated by some cooking equipment. A 12-18 inch extension is recommended for large or overburdened ovens, conventional steamers, large tilting kettles, and Bain Marie. A 12-18 inch extension at the side of the hood is also suggested for char-broilers when the apparatus is located at the end of the cook line. (The minimum endorsed overhang around the border of an island hood installed over solid fuel cooking equipment is 12 inches.)

Make-up Air
A. Each room provided with an exhaust system shall have supplied to' the room an amount of filtered and tempered make-up air equal to' the amounto' of air to' be exhausted. If make-up air were not provided, the building would be under a negative pressure which could cause the subsequent problems:

1. The exhaust fan would not be proficient of exhausting the design volume of air because the air would not be presented.

2. Negative pressure would cause unfitting venting of water heaters, space heaters, or other completely vented gas machines in the building.

3. A negative 'pressure will cause' a surge of limitless outside air into' the building whenever the doors are opened, which may also allow the entering of flies into' the facility.

B. In order to' provide an efficient air exchange system, the following facto' rs should be taken into' consideration when gaging a make-up air system:

1. The number and position of return air registers should be such as to' provide even distribution of make-up air throughout the facility, taking into' deliberation cross drafts, room configurations, and required air flows.

2. The use of correctly designed registers and diffusers will help to' slow down the air velocity and evenly distribute the make-up air.

3. The make-up air registers should be located so as to' prevent a short circuiting of the air being supplied for the exhaust system.

C. 'Windows and doors' shall not be used for the purpose of on condition that make-up air.

D. The exhaust and make-up air systems shall be coupled by an 'electrical interlocking' hardwired connecto' r so that one system cannot be operated when the other system is off.

E. Compensating hoods shall extract at least 20 percent of their required exhaust airflow from the kitchen area around the hood. Recompensing hoods, that have been evaluated and listed, shall be sized and fitted in accordance with the terms of their listing, and according to' the manufacturer's instructions.

Fire Extinguishing Systems

A. Approved auto' matic fire "quenching systems shall be provided for the defense of commercial-Category cooking equipment". The condition for protection does not include apparatus that does not create or generate grease-laden vapors, such as steam kettles and steam tables.

B. Deep fat fryers, ranges, griddles, broilers, and other cooking apparatus which may act as a source of ignition for grease in the hood, grease`deletion device, or duct, shall be endangered by approved fire extinguishing apparatus installed in accordance with the fire code adopted by the jurisdiction. Necessary approvals must be obtained from the local fire experts prior to' putting equipment into' operation.

C. The operation of any fire extinguishing system shall routinely shut off all sources of fuel and heat to' all equipment requiring protection by an extinguishing system. Any gas application not requiring protection, but 'located under ventilating apparatus, shall also be shut-off'. All shut-off devices shall be measured an integral part of the system, and shall function when the system is in operation. The auto' matic shut-off device must be manually resettable prior to' fuel or power being resto' red.

D. Exhaust hood fans shall continue to' operate after the fire extinguishing system has been stimulated, unless fan shutdown is required by any component of the ventilation system, or by the design of the extinguishing system.

APPENDIX I

Installation Codes and Standards

- Uniform Building Code
- International Building Code
- Uniform Fire Code
- International Fire Code
- Uniform Mechanical Code
- International Mechanical Code
- Uniform Plumbing Code
- International Plumbing Code
- International Fuel Gas Code
- National Electrical Code (NFPA 70)
- Standard for Ventilation Control & Fire Protection of Commercial Cooking Operations (NFPA 96)

Product Standards Used by Listing Agencies for Cooking System Components

- ANSI Z83.11, CGA 1.8 - Gas Food Service Equipment
- ANSI/NSF 2 – Food Service Equipment
- ANSI/NSF 4 – Commercial Cooking, Rethermalization and Hot Food Holding and Transport Equipment
- ASTM E814 – Fire Tests of Through Penetration Fire Sto' ps Backflow Protection for Grease Fire Suppression Systems
- ICBO AC101 – Grease Ducts, Flexible Enclosure Systems

ICBO AC105 – Recirculating Commercial Kitchen Hoods
ICBO AC121 – Grease Duct Systems, Self-Enclosed
UL 197 – Commercial Electric Cooking Appliances
UL 296 – Oil Burners
UL 300 – Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas
UL 710 – Exhaust Hoods for Commercial Cooking Equipment
UL 762 – Power Ventilato' rs for Restaurant Exhaust Appliances
UL 795 – Commercial-Industrial Gas Heating Equipment
UL 1046 – Grease Filters for Exhaust Ducts
UL 1254 – Pre-Engineered Dry Chemical Extinguishing System Units
UL 1479 – Fire Tests of Through Penetration Fire Sto' ps
UL 1570 – Fluorescent Light Fixtures
UL 1571 – Incandescent Light Fixtures
UL 1572 – High Intensity Discharge Fixtures
UL 2162 – Wood-Fired Baking Ovens – Refracto' ry Category
UL 2221 – Fire Endurance Performance of Grease Duct Enclosure Assemblies Grease Ducts

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