Grease Removal

and Kitchen Exhaust Systems

Changes in grease-control for commercial kitchens stem from research, code revisions, and improved equipment

By PETER C. D'ANTONIO, PE
PCD Engineering Services Inc.
Longmont, Col.

Each year, grease fires result in over $100 million dollars in direct property damage within U.S. commercial kitchens.[1] The National Restaurant Association forecasts that restaurant-industry sales for the estimated 878,000 restaurant locations across the U.S. will reach a record $440.1 billion in 2004, equivalent to 4 percent of U.S. gross domestic product.[2] That's big business. In addition to fire, kitchen grease-induced damage primarily includes roof damage and the annoyance of greasy film on neighboring property. The properly designed kitchen ventilation system provides safety, comfort, effluent control, and cleanliness and does so in a manner that is as energy efficient as practical.

This article will examine the ins and outs of grease removal in kitchen exhaust systems. Grease control in commercial kitchen exhaust has seen some significant changes in recent years. The changes are a primarily a result of research, code revisions, and improvements in grease filtration and extraction technology.

THE GREASE REMOVAL SYSTEM

The basic commercial kitchen grease exhaust system is composed of three components: the Type I hood (with integral grease filtration), ductwork, and the fan. A control interlock exists in this system that assures sufficient make-up air (roughly 90 percent of exhaust volume) when the exhaust system is in operation.

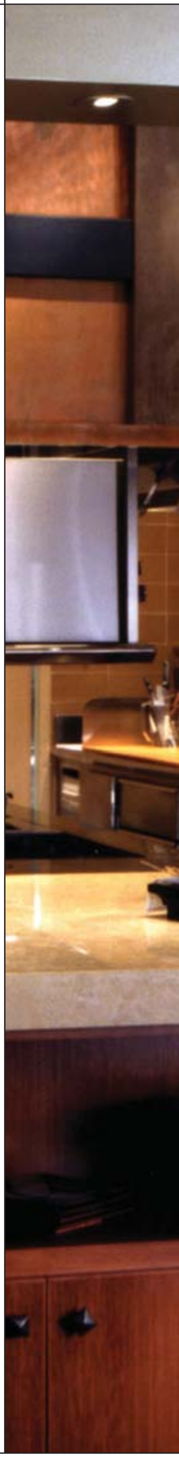
THE HOOD

At the heart of the kitchen exhaust system is the Type I hood, equipped with grease filtration and extraction device(s). Section 507.11 of the 2000 International Mechanical Code (IMC) specifies minimum distances between the lowest edge of a grease filter and the cooking or heating surface for Type I hoods. The hood exists to capture the plume of heated air rising from the hot cooking surface. Most of the effluent (gaseous, liquid, and solid contaminants) released from the food and the heat source is entrained in this plume. Capture and containment of the plume is affected by draft. Therefore, placing 4-way diffusers near the hood is to be avoided. As a general rule, make-up air velocity near the hood should be less than 75 fpm. Effluent consists of grease particles, grease vapor, heat, odor, moisture, and VOCs. Hoods must be Underwriters Laboratory (UL)-tested and listed (UL 710, *Standard for Safety for Exhaust Hoods for Commercial Cooking Equipment*) and grease filters must also be separately tested and listed (UL 1046, *Grease Filters for Exhaust Ducts*).

FILTERS

Historically, grease filtration and extraction devices have been, in essence, fire-protection devices. Three main types of grease filters and extractors in use today include the baffle filter, water wash filter, and dry-cartridge (or removable) filter. Removing submicron grease particles and grease vapor, which

An innovator in energy- and environmentally efficient design and construction since 1989, Peter C. D'Antonio, PE, is founder and president of PCD Engineering Services Inc. (www.pcdengineering.com), a provider of sustainable mechanical/electrical-design, energy-management, and integrated-building-system solutions. With bachelor's and master's degrees in civil engineering from the University of Maryland and the University of Colorado, respectively, he is a LEED accredited professional and certified energy manager. He can be reached at peter@pcdengineering.com *or at (303) 678-1108.*



make up a substantial portion of grease effluent, has historically been a shortcoming of these filters. New baffle filters have recently been developed that have larger surface areas than their predecessors. These serve to condense vapor and moisture and increase centrifugal separation to significantly improve efficiency. Filters also now exist which use a filter media to intercept grease particles. Ultra-violet (UV) treatment is also being incorporated into new hood design. UV light breaks down grease molecules into smaller harmless compounds of carbon dioxide and water vapor, which are carried out with the exhaust airflow. The UV treatment process does create ozone, which, depending on whom you speak to, may or may not be a problem. Multi-stage filters are now on the market that employ a combination of the above advances and afford high efficiencies. These new, improved filtration systems increase fire safety, reduce odors at the fan discharge, and promote environmental values while decreasing operating costs due to the reduction of grease deposit in the ductwork and fan system in addition to reduced maintenance/cleaning cost.

Several other technologies are available and can be applied to additionally treat the exhaust stack effluent. These particulate removal units are typically located downstream of the primary filtration devices located in the exhaust hood. They include:

- Electrostatic precipitator (ionization).
- Water cooling/cleaning units.
- Disposable pleated or bag filters.
- Activated carbon filters.
- Oxidizing pellet beds.
- Incineration.
- Catalytic conversion.

These technologies are not specifically addressed or approved in or by the codes, though they are receiving individual approval by local jurisdictions on a case-by-case basis.[3] The 2003 ASHRAE Handbook, HVAC Applications, provides a good summary of each particulate removal unit along with some qualifications and concerns about its use. The primary benefits of this additional level of grease exhaust treatment is discharge mitigation to the surrounding environment and reduction of system energy use, primarily through application of heat recovery devices. However, these devices are costly to install and maintain.

Common Problems

Some of the most common conditions found in poorly designed, constructed, and operated grease exhaust systems:

- Over designed exhaust/make-up air rates, leading to energy cost/waste.
- Make-up air is not sufficient (too little or too much) to provide proper capture and containment.
- Hoods are not located properly to provide capture and containment of effluent or drafts exist from neighboring supply diffusers that impede capture.
- A short-circuit hood is used causing spillage.
- Appliances are not grouped according to effluent production and the highest effluent producing appliances are not placed in the center of the hood system.
- Duct systems are not liquid tight. The contractor should perform a pressure test.
- Duct construction is less than the required 16-gage steel or 18-gage stainless.
- Improperly installed or sealed access panels.
- Inaccessible sections in the ductwork.
- Inadequate clearance to combustibles.
- Improperly sloped ductwork and grease drainage.
- Aluminum mesh filters are used or no filters at all.
- Under-powered fans or fans that cannot be tipped for cleaning.
- Improperly cleaned or maintained exhaust system.
- A proper air balance and system commissioning was never performed.

DUCTWORK

The grease exhaust ductwork needs to be designed and constructed in accordance with building codes and National Fire Prevention Association Standard 96, *Standards for Ventilation Control and Fire Protection of Commercial Cooking Operations* (NFPA 96). The ductwork should be constructed of at least 16-gage steel or 18-gage stainless steel. Duct systems should be constructed to provide adequate access for cleaning and be grease (and liquid) tight via external welds or brazes. If at all possible, grease exhaust ducts should be routed vertically to the roof with minimal offsets and turns to minimize pressure losses. Sidewall grease duct venting is possible in some instances but local codes and code official interpretations should be confirmed prior to construction. Grease hood/duct static pressure, including grease filter loading, is typically between 1.5 to 2.0 w.g., but will vary based on velocity. Dampers are disallowed in the exhaust system per NFPA 96. UL-listed prefabricated duct systems are also available and in use,per UL 1978, *Grease Ducts*. They provide the benefit of reduced clearance to combustibles, with the normal clearance being 18 in. Ductwork should pitch back to the hood and to a grease collection container. Foil-encapsulated, duct-wrap, fiber insulation is also available and offers the benefits of zero clearance to combustibles, eliminating the need for a rated enclosure around the ductwork.

FANS

The fans for kitchen ventilation must handle the hot, grease-laden air. Three exhaust fan types are in common use: the upblast fan, utility set, and inline fans. All use a centrifugal wheel with backward-inclined blades. To comply with NFPA 96, a ventilated curb, grease trap and hinge kit must be used. NFPA 96 requires that ductwork extend a minimum of 18-in. above the roof surface. Further-

more, if ductwork terminates into the base of an upblast discharge exhaust fan, there must be at least 40-in. of clearance between the exhaust fan discharge and the roof surface. Ventilated mounting curbs assure clearances are maintained between hot ducts and combustible building materials. The use of a ventilated curb permits the duct to pass through the roof opening and fasten to the curb without the hot exhaust duct contacting other parts of the building or roof members. Flanged duct sections can be inserted through the curb or pedestal from the top side for easy installation. Insulation is not provided on ventilated curbs. The grease traps exist to collect grease from the airstream that may have escaped the primary filtration and protect the roof from grease damage. The hinge kit exists to facilitate inspection and cleaning of the fan assembly and duct system.

DESIGNING FOR OPTIMUM EFFICIENCY

Restaurants consume more energy per square foot than any other commercial use, and eight times as much as office space. Kitchen ventilation is a major contributor to a restaurant's high energy use. The key to reduced energy costs is to adopt a design that minimizes exhaust and make-up air rates while assuring proper capture and containment by the hoods and proper filtering and extraction by the filters. The California Energy Commission recently published a design guide for improving commercial kitchen ventilation (CKV) system performance and energy efficiency, and it lists a number of good ideas for reducing make-up air operating costs in constant volume kitchen systems.[4] The results of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) research project, 1033-RP, addressing the relationship between grease deposition and exhaust velocity, led to the NFPA reducing the minimum exhaust velocity from 1,500 fpm to 500 fpm in March 2002. This code revision has led to the introduction of variable-air-volume, kitchen exhaust control systems. Reduced airflow is typically controlled by optical smoke and temperature sensors in the hood. When evaluating the application of these systems, first consider the part-load operating profile of the project kitchen. Generally speaking, if there are significant periods of light load, it is worth a longer look. A primary consideration is that the reduced velocity is adequate for capture and containment at the hood. Another consideration is insulation of ductwork. ASHRAE 1033-RP found that in cases of constant effluent generation and variable concentration in exhaust, the rate of grease accumulation decreases with reduced velocity in well insulated ducts (R-10 or greater).[5] This may be a prohibitive cost in retrofit applications.

FILTER EFFICIENCY TESTS

UL Standards 1046 and 710 do not include grease extraction tests. The CKV industry currently lacks a test protocol for measuring grease extraction performance that is widely accepted, reliable, and representative of real life commercial effluent. Grease extraction rates published by filter and hood manufacturers are derived from independent third party test laboratories retained by the manufacturer. Test methods and results vary greatly. ASHRAE 745-RP was undertaken in 1998 at the University of Minnesota to identify and characterize effluents from various cooking appliances and processes. ASHRAE 851-RP was undertaken in 1998 to design a testing protocol that could repeatedly determine the collection efficiency of in-line grease removal devices. 851-RP collected data to provide a baseline for determining the efficiency of several in-line grease removal devices. ASHRAE Technical Committee 5.10, Kitchen Ventilation, is currently working to develop a test method to determine the efficiencies of grease removal devices under 1151-RP *Development of a Draft Method of Test for Determining Grease Removal Efficiencies*. This research will accomplish two goals: allow filter/system manufacturers to quantify the performance of their technologies and, consequently, permit engineers and other end-users to make a comparison of competing technologies for grease removal effectiveness. The objective of this research project is to develop a repeatable and accurate method of testing that characterizes grease filters and/or grease removal systems for grease removal efficiency. The removal efficiency rating will be based on a measured difference between a base-case concentration and the measured concentration with the implemented filter or system in-place. Under Phase I of this project, a standard grease generator, which generates both grease vapor and particulate matter, is being developed. At a minimum, the generator must produce grease distributions similar to those produced by charbroilers, griddles, and deep fat fryers while cooking food products. The vapor and particulate generators may be separate or combined processes. The base-case grease emissions are defined to be equivalent to the cooking process grease emissions. Measurements are made downstream of the filter or system to determine the filter efficiency.

Know the Codes, Standards and Test Protocols

The 2000 International Mechanical Code addresses commercial kitchen hood, exhaust ducts and exhaust equipment in Sections 506 and 507.

Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations (NFPA 96) details the minimum fire safety requirements (preventative and operative) related to the design, installation, operation, inspection, and maintenance of all public and private cooking operations, excluding single-family residential usage. These requirements include, but are not limited to, all manner of cooking equipment, exhaust hoods, grease-removal devices, exhaust ductwork, exhaust fans, dampers, fire extinguishing equipment, and all other auxiliary or ancillary components or systems that are involved in the capture, containment, and control of grease-laden cooking effluent.

2003 ASHRAE Handbook: HVAC Applications addresses kitchen ventilation in Chapter 31. The chapter covers cooking effluent, exhaust hoods, exhaust systems, replacement (make-up) air systems, systems integration and balancing, energy considerations, fire protection, operation and maintenance and residential kitchen ventilation.

UL 710 test protocol was established to determine minimum exhaust rates for 400 F, 600 F, and 700 F (solid fuel) surface temperature appliances. The air-flow portion of the test is a visual one made by a U.L. inspector, who observes the removal of visible cooking vapors. If, in the judgement of the inspector, the hood captures and contains this visible effluent, then the tested exhaust air flow rate passes the test. What UL 710 does not test for is the amount of heat escaping the hood at a given air flow. Listed hoods can have a fire damper to protect ductwork and maintain temperatures below 375 F or can exist without a fire damper. UL 710 does not cover evaluation of the exhaust hoods with respect to their grease extraction efficiency.

UL 1046 test protocol was established for grease filters used in exhaust systems with Type I restaurant type cooking equipment. Grease filters are investigated to insure they remove grease from the effluent, drain-off of the collected grease in such a manner that it does not fall back on to the cooking surface, and limit the projection of flames into the exhaust ductwork when fire breaks out on the upstream face of the filter and after exposure to grease-laden air.

UL Subject 762, Power Roof Ventilators for Restaurant Exhaust Appliances covers roof or wall-mounted ventilators for restaurant exhaust appliances. Power ventilators for restaurant exhaust appliances covered by these requirements are intended for installation in accordance with NFPA.

INSPECTION AND MAINTENANCE

Even a properly designed and installed grease exhaust systems must be maintained. NFPA 96 is generally recognized as the governing standard regarding ongoing inspection and maintenance of commercial kitchen exhaust system, and states the exhaust systems "shall be cleaned to bare metal." This is not accomplished in kitchens for a variety of reasons:

- Poor maintenance on the part of the kitchen staff.
- Inadequate cleaning frequency.
- Incomplete cleaning services.
- Poor service accountability.
- Restaurant owners who do not want to pay for a proper service.

Proper inspection and maintenance is key in eliminating potential damage to the building housing the grease exhaust system as well as abutting properties. NFPA requires that the exhaust be inspected and cleaned by a person "properly trained, qualified and certified…acceptable to the authority having jurisdiction," but does not state what certified means. Training is becoming more available to meet the NFPA requirements and some jurisdictions have created a certification/licensing program.

FUTURE RESEARCH

ASHRAE continues to fund research to better understand and remove grease in kitchen applications. Some planned research projects related to grease removal include:

- Development of Method of Test to Determine Whether a Type I Hood is Required Over a Cooking Process.
- Characterization of Effluent from Solid Fuel Cooking Processes.
- Variable Flow and Savings Potential in CKV Exhaust Systems.
- Assessment of Roof Exhaust Discharge on Surrounding Environment.

CONCLUSIONS

Grease fires pose a major safety and property-loss threat in the United States. Grease removal in kitchen exhaust systems is a continually evolving subject. Proper and effective grease removal is a combination of properly designed, installed, and maintained exhaust systems. A practical, maintainable and cost-effective grease removal design will have the best chance of overall success in mitigating the risk of proliferating a grease fire and protecting surrounding property and the environment.

REFERENCES

1) Floyd, V. (2003 March).Technology Update for Grease Duct Protection. *The Construction Specifier.*

2) National Restaurant Association (2004). 2004 Restaurant Industry Forecast. *www.restaurant.org/research.*

3) McGuire, A. (2001 April). Degreasing the Modern Kitchen. *HPAC Engineering.*

4) Design Guide, Improving Commercial Kitchen Ventilation System Performance (2002). California Energy Commission's Pubic Interest Energy Research Program, December, 2002

5) Gerstler, W. (2002, November). New Rules For Kitchen Exhaust, *ASHRAE Journal.*