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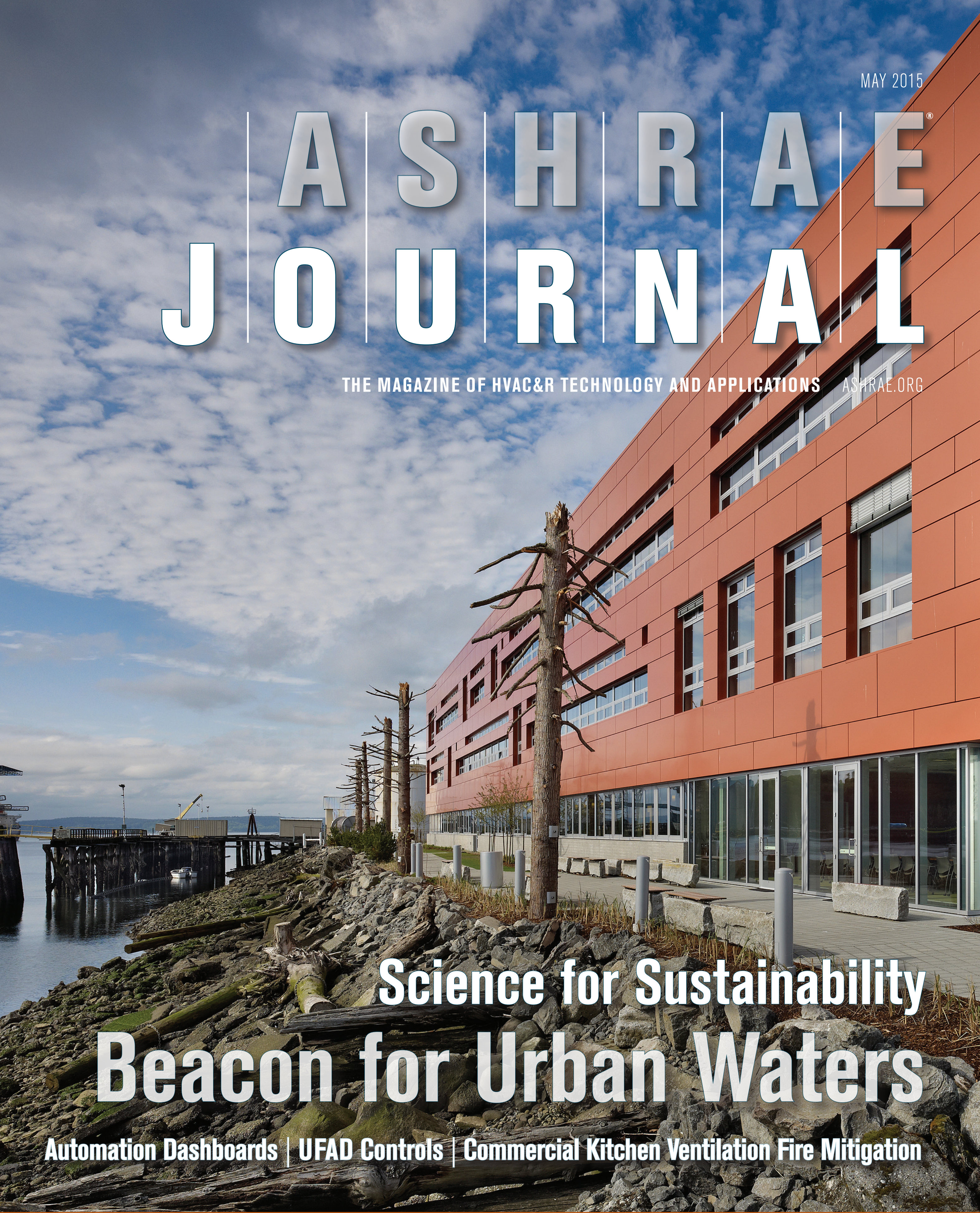

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Automation Dashboards | UFAD Controls | Commercial Kitchen Ventilation Fire Mitigation

Inside | The Path to a Net Zero-Ready School

PHOTO 1 Grease exhaust fans with backdraft dampers locked in open position. Maintenance personnel got tired of dealing with dampers found stuck in the closed position.

PHOTO 2 Stretched, cracked and almost broken belt. This is common for restaurant exhaust fans. Despite calls for proper maintenance by codes, this is often ignored.

Commercial Kitchen Ventilation Fire Mitigation

BY STEPHEN K. MELINK, P.E., MEMBER ASHRAE

Food-service establishments are notoriously prone to kitchen fires that emanate from high-energy cooking appliances and often spread to the hood and duct system and sometimes beyond. This is why insurance companies classify such establishments in a higher-risk category than most other commercial buildings. And, this is why a properly designed kitchen ventilation and fire suppression system for cooking equipment is required by code.[1]

According to the U.S. Fire Administration, cooking was the leading cause of commercial building fires in years 2007–11, averaging over 25,000 such fires per year. The second leading cause averaged less than 10,000 fires per year. In addition, the dollar loss for cooking-related fires averaged almost $50 million per year during this five-year period. And, although deaths and injuries are not shown for specific causes, there were 3,005 deaths and 17,500 injuries due to all fires in just 2011.[2]

Therefore, it is relevant to ask how engineers can mitigate these costs and risks going forward. Do we continue to design the way we always have and accept the above statistics as outside of our control? Or do we seek

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opportunities to improve fire safety in areas within our control?

So often the emphasis gets placed on specifying the right commercial kitchen hoods and fire suppression system.[3] Yes, if a fire ever occurs, having a listed hood and fire suppression system is important. We want the fire properly contained at the source and immediately extinguished. However, the previous statistics suggest more is necessary.

The purpose of this article is to suggest that additional emphasis should be placed on fire mitigation strategies. Fire suppression, by definition, is about extinguishing a fire after it has already started. Fire mitigation, on the other hand, is about reducing risks so that a fire is less likely to occur in the first place or less likely to spread and cause subsequent damage/injuries.

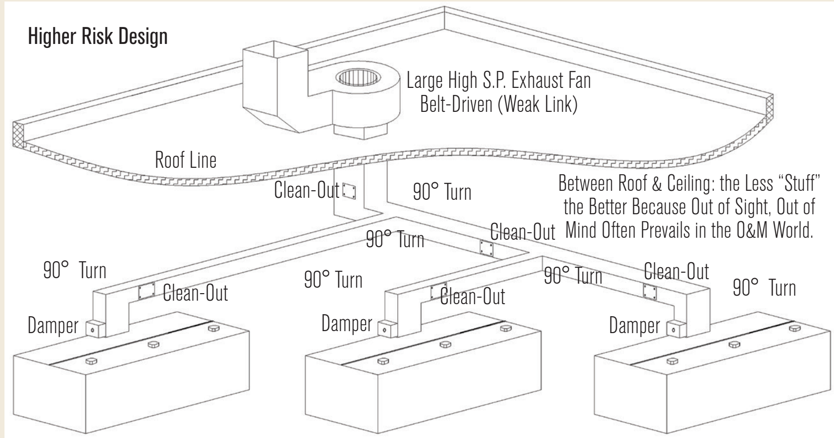
Looking at the entire heat/grease system from the cooking equipment to the exhaust fan, the area with the least published research and most design variability from application to application is the grease duct. While listed grease ducts are also available, they are usually only specified where reduced clearances to combustibles dictate their use.[4] Otherwise, the more common practice is to custom design the grease ducts in accordance with codes.[5] But this is typically done out of habit or to reduce construction costs—and not necessarily as a conscious effort to improve fire safety.

Where there is custom design, there is custom installation. And where there is custom installation, there is a higher probability of field errors by the mechanical contractor. This often includes using the wrong sheet metal and leaving holes in weld seams. There is also a tendency for engineers to rely on codes as their sole basis of design and not fully recognize improvement opportunities.

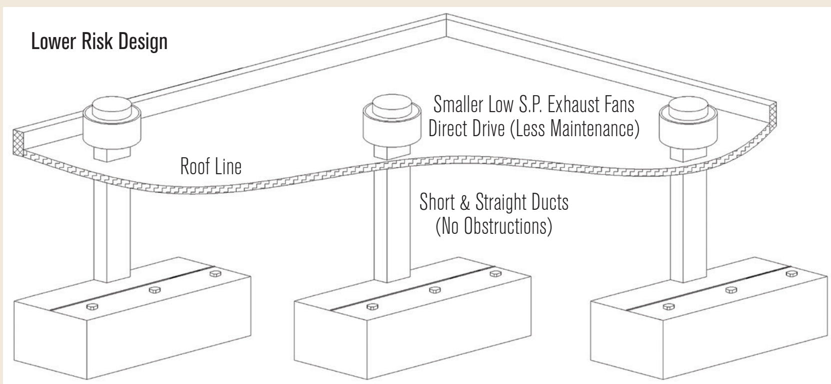
As many engineers already know, since commercial kitchen ventilation (CKV) systems are a type of HVAC system, it would behoove our profession to educate architects on the need to move CKV out of the food-service section of the plans and specifications, and into the mechanical section. The hoods are located in the kitchen, but so are other HVAC components such as grilles, registers, and diffusers. More importantly, the food-service consultant usually has little or no knowledge of the "V" in CKV or HVAC, and should not be specifying hoods, controls, and other features to which they may not understand the consequences of their choices.

The engineer is uniquely positioned to ensure the entire system is designed for optimal fire safety—as well as energy efficiency—for the life of the building. And though listed hoods for food-service applications are widely available, there is more to designing than just specifying listed equipment.

FIGURE 1 Higher- and lower-risk designs of grease ducts.



Typical Grease Duct Design with Single Exhaust Fan. Long duct runs, multiple 90-degree turns and dampers add significant resistance to airflow—increasing fan energy during most all operating conditions. Also, more expensive to install, maintain and clean. Liability is also a concern with more surfaces and obstructions for grease to collect. Thus, clean-outs. Finally, one fan failure (belt/motor) can bring down the entire kitchen.



Improved Grease Duct Design with Dedicated Exhaust Fans. Short duct runs, without 90-degree turns and dampers, reduce resistance to airflow—minimizing fan energy. Also, very simple to install, maintain and clean. Liability is minimized by creating a direct path for heat/smoke/grease to easily move up and out of the building. Finally, multiple fans provide safe redundancy in case of any problems.

PHOTO 3 Direct-Drive Exhaust Fan. No belt can fail and cause heat/smoke issues. Also no belt drive losses and belt maintenance required.

PHOTO 4 Exhaust Fan with Grease on Roof. Indicates how extensively grease can contaminate duct and fan system. Therefore best to keep them short, straight and vertical.

Nevertheless, the focus of this article is the portion of the CKV system *above* the ceiling and how it can be designed to improve fire safety. As such, following are six design practices to consider in order of priority for your future projects.

1. Design short, straight, and vertical grease ducts whenever possible—and design horizontal ducts only if necessary. Grease, like oil, is a highly flammable substance. If you've ever seen a grease fire along with its thick black smoke, you understand the serious nature of your work. Therefore, don't mess around. Design the grease ducts so that they provide the shortest path for the heat and smoke to travel outside the building as possible.

Long ducts provide more surface area for this grease to collect and eventually serve as a potential fuel source for a fire. And horizontal ducts provide a surface for heavy grease particles to fall out of the airstream and collect at a higher rate than vertical surfaces.[5] In fact, grease often "pools" in horizontal grease ducts, and this is a major reason why clean-outs need to be installed. Yes, these ducts are required to be sloped to facilitate draining, but such drainage does not always occur due to inadvertent low spots in the duct, the high viscosity of grease, and/or entrainment caused by the operating exhaust fan. And yes, conventional practice is to blame the hood and duct cleaner if this happens, but smart design should dictate that you eliminate the potential for grease collection in the first place. Moreover, a horizontal duct usually involves at least two 90-degree turns, and this additional resistance requires more fan energy to move the design airflow. When you can design for both fire safety and energy efficiency, all the better.

Though clean-outs are required for gaining access[6] they introduce another potential weak link in the system. Not only can grease leak at these clean-outs due to an improper seal—and drip onto the hood and ceiling, the covers are sometimes forgotten and left to allow the exhaust air to short-cycle and cause impaired hood performance. Moreover, if there is not a mezzanine with proper access and lighting, leaving it up to duct cleaners to find a way to navigate a ceiling full of electric conduit, water lines, and cabling in the dark is a recipe for problems.

Certainly, many existing buildings that are retrofitted with commercial kitchens do not have the same design flexibility as new construction. And even some new construction has constraints on where the hoods, ducts, and fans can be located. But to the degree designers have influence on a project, we should speak to the architect and owner with fire safety in mind, first and foremost. Who knows, perhaps the discussion will open up new possibilities. Perhaps the kitchen can extend to the side of the main building on the first floor with the ducts and fans immediately above it. Or perhaps the kitchen can be moved to the top floor with better views and where the ducts and fans can be positioned immediately above it. Building owners do not want to incur undue risks and liabilities, and so we need to speak up.

2. Eliminate obstructions such as dampers, filters, coils, and 90-degree turns in grease ducts whenever possible. Remember, the purpose of a kitchen ventilation system is to remove potentially dangerous heat and smoke from the building as efficiently as possible. And so designing obstructions in the duct only make this more difficult.[7] Yes, dampers, filters, coils, and 90-degree turns are a fact of life for most HVAC systems—but grease ducts are a different animal. Most HVAC systems are not prone to collecting a highly combustible substance and moving high-temperature air through them. And, most HVAC systems are not as prone to catching fire. So design the grease ducts as aerodynamically as practical.

Think of your gas grille on the patio of your home. Would you ever consider moving it into your kitchen and installing a hood with modulating dampers, a bag filter, heat exchanger, and four 90-degree turns before it exits your second-floor roof? If not, why would you do this for a hotel, hospital, or college with hundreds of times more property value and occupant lives at stake? And while you may be maintenance savvy as an engineer what about the restaurant owner or his low-cost helper? Energy efficiency is increasingly important in today's world, but it should never come at the expense of fire safety.

Another reason not to design long grease ducts with multiple turns is the hood fire suppression system will be less effective if the inside of the duct catches fire. A single nozzle aimed into the grease duct will cover less surface area if the duct is not short and straight.

3. Specify listed grease ducts. Factory-built systems are designed with a double-wall construction and are therefore stronger and more durable than single-wall grease ducts. In addition, they are less apt to be installed with holes/gaps in the seams and allow grease leaks to occur because the assembly and welding mostly takes place in a controlled environment. Experience shows that trying to weld a liquid-tight vessel above the ceiling where it is dark and easy to miss holes/gaps is largely dependent on the quality of the welder. And since the low-bid mechanical contractor usually gets the job, the owner usually gets what he paid for. Finally, factory-built systems are manufactured with stainless steel, which has a higher temperature rating than black iron sheet metal. This is important if/when a fire ever does occur because if the grease duct fails, the fire will be able to spread that much more quickly. Stainless steel buys more time.

But if a listed grease duct cannot be specified and used for whatever reason, then serious consideration should be given to how the field-fabricated and welded grease duct will be protected above and beyond the minimal threshold of code compliance. For example, even if the required clearance to combustibles is met, the grease duct should ideally be wrapped with insulation or enclosed so that a fire inside the duct cannot easily spread outside the immediate surrounding area. Again, fire mitigation is about preventing a fire from spreading and becoming an out-of-control fire.

4. Design redundancy in the kitchen ventilation system by including more than one exhaust fan where there are multiple hoods. As already stated, the purpose of a kitchen ventilation system is to remove heat and smoke—and so when this vitally important function stops because a single belt or motor fails, this is as much a reflection of poor design as poor product quality and/or maintenance. Some functions are so mission-critical that unless the associated system components are 99.99% reliable in design, construction, operation, and maintenance, redundancy is a best-practice. That is why IT companies have servers located across the country. They cannot afford to lose customer data if one natural disaster or terrorist attack occurs. That is why airlines have at least two engines on planes flying across the ocean. There are too many lives at stake if a plane has just one engine and it fails in mid-flight.

Yet, kitchen exhaust fans are almost as mission-critical in applications like hotels, hospitals, schools, and high-rises occupied by hundreds of people. What do you do if a hotel banquet kitchen is preparing food for hundreds of people on a Saturday night and there is only one exhaust fan serving the kitchen—and then the motor burns out? From a safety standpoint, you should turn off the cooking equipment and apologize to your customers because a new motor will not be able to be installed very quickly. But in reality, the pressure to continue cooking could prevail as the staff would not necessarily be thinking about the possible risks.

And if a fire does start and overtake the hood and duct due to a fan failure and the resulting heat build-up, then who is to blame? It would be easy to dismiss our culpability as mechanical designers and blame it on the motor manufacturer, maintenance staff, kitchen cooks, or the fire suppression system. (Based on the statistics mentioned earlier, we should not assume fire suppression systems will necessarily put out all fires). But in this litigious society in which we live, lawyers will not necessarily see it that way.

If a second duct and fan had been designed into the overall kitchen ventilation system, it is possible any smoke-related damage and injuries/deaths could have been avoided. This would not have prevented the initial fire inside the hood with a motor failure, but it could have provided sufficient ventilation through the other hoods to keep smoke from reaching other parts of the building and getting into the eyes and lungs of kitchen staff as they might try to put out the fire or escape and call the fire department.

5. Eliminate the weak link when possible by specifying listed direct-drive exhaust fans. The fan belt is the infamous weak link of most every kitchen ventilation system out there. It's a relatively cheap part that is prone to stretching, cracking, and eventually breaking—and causing untold lost business revenue, employee wages, customer loyalty, and building damage and human injury/lives for the reasons mentioned earlier. And it often breaks at the most inopportune time when demand for food and thus ventilation is at its highest and the availability for repair service is at its lowest. Again, think Saturday night.

Conventional on/off motor starters add to the problem because they provide nearly instantaneous acceleration at start-up, which means these weak links are severely stressed—and stretched—every day when the hoods are turned on in the morning. And so before the belt actually breaks, it will gradually become loose within the pulley grooves and slip, resulting in slower and slower fan speeds over time.

The solution is to specify direct-drive exhaust fans and variable-frequency drives (VFDs) when possible to eliminate this problem. Conventional practice is to point the finger at maintenance for not regularly replacing these belts, but why not think proactively and design more reliable systems? Fan manufacturers have made major strides in recognizing this need and opportunity by expanding their fan lines to include direct-drive (up to approximately 3,000 cfm [1416 L/s], currently) over the last five to 10 years, and so it is up to the mechanical designer to take advantage of this when possible. Don't let a $10 part fail and cause a potential fire because "that's the way it's always been done."

And don't let the VFD become the next weakest link by allowing a low-quality drive to be used. Specify a top-tier brand with a national and preferably global reputation for quality.

6. Specify a listed demand control kitchen ventilation (DCKV) system. This allows the customer to gain more utility from the VFDs than just setting a fixed speed on direct-drive fans. It also allows the customer to gain more utility from minimally intelligent autostart systems now required by code. In fact, most codes now require an electrical or thermal interlock between the cooking equipment and hood fans to address the possibility that cooks may forget to turn the system on in the morning or off at night.[6,8] With little or no extra cost, the CKV system can be designed with DCKV capability and thereby modulate the exhaust and make-up fan speeds based on temperature and/or smoke to save energy.

Fire-prevention features of a well-engineered DCKV system include an audible alarm if the exhaust air temperature rises within 100°F (38°C) of the activation temperature of the fire suppression system. Similar to new cars with sensors that tell you when you are getting too close to another object, new hoods should be specified to "beep" and tell you if the exhaust air temperatures are getting dangerously high. Another possibility is an automatic gas/electric shut-off capability if the exhaust air temperature continues to rise within, say, 50°F (10°C) of the activation temperature. Why wait until the fire suppression system is activated to shut-off the fuel source? In this day and age, intelligent hoods should monitor, communicate, and control to prevent a potential disaster from occurring. Specify accordingly.

Summary

In conclusion, no food-service establishment is fireproof, but we can help design them to be more fire safe.

More specifically, design grease ducts so that they are short, straight, and vertical whenever possible. Design them without obstructions so that the heat and smoke can exit the building in the most efficient manner possible. And, specify UL-listed grease ducts to provide an extra barrier between the potential fire source and combustibles. Furthermore, design the CKV system with more than one exhaust fan so that there is a level of redundancy in ventilation in case one fan goes down. To minimize this possibility, eliminate the belt by specifying direct drive fans where applicable. Lastly, specify a DCKV system so that the fans not only automatically start upon the detection of heat—but so that temperature alarms can signal if/when the exhaust temperature rises above normal and/or safe levels.

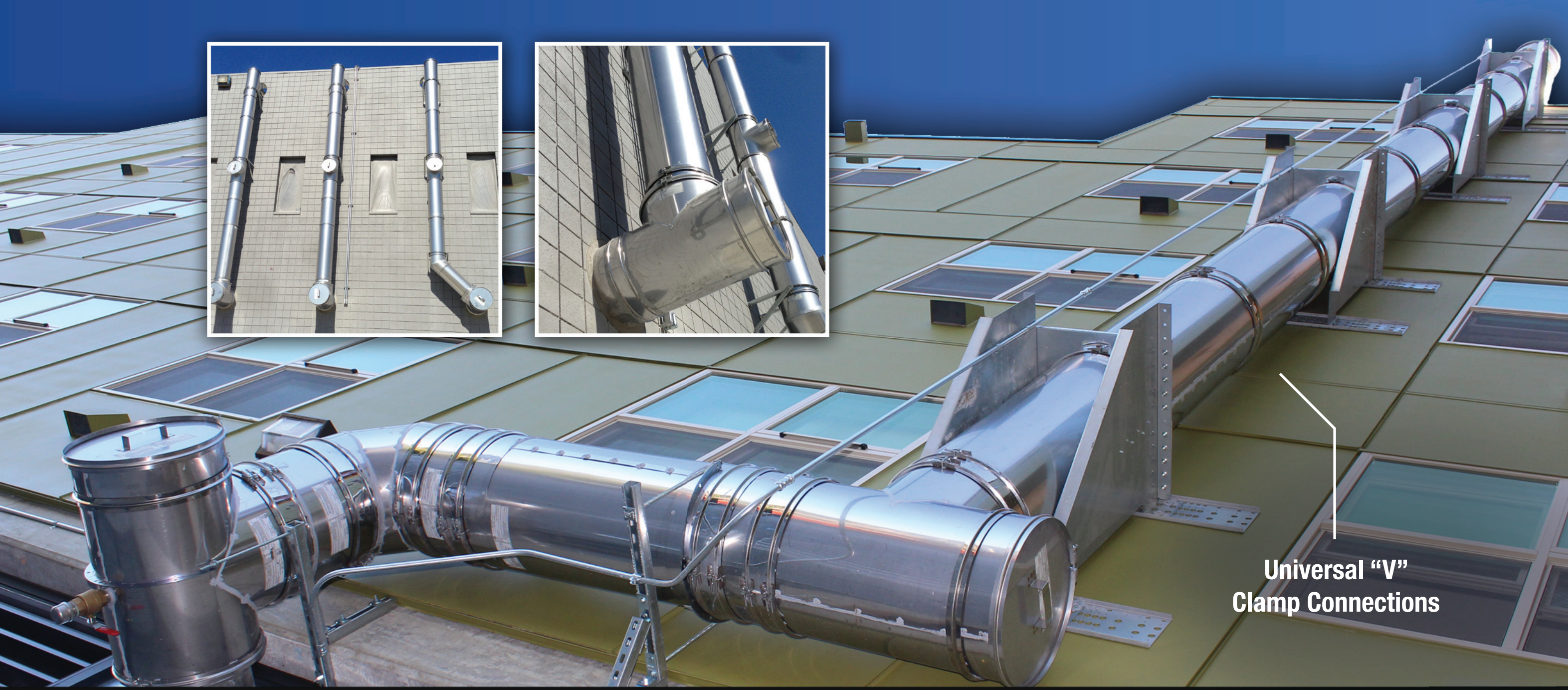
These design practices are especially important in buildings occupied by hundreds of people. And it is even more important for systems that may receive little preventive maintenance. Anything designed above the ceiling is not only out of sight—but very often out of mind until it fails.

Yes, there are some things outside of our control as the mechanical designer when it comes to fire mitigation. But there are also things within our control. The purpose of this article was to highlight the latter and advocate for a bias towards safety. The engineer should never abdicate his professional responsibilities to the owner, architect, manufacturer, contractor, or food-service consultant because "that's the way it's always been done." Sleeping well at night might depend on it someday.

Notes

1. NFPA. National Fire Protection Association Standard 96-2014, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.* Also the Uniform Mechanical Code, UMC 2012 borrows most NFPA 96 requirements related to fire suppression for commercial cooking. Moreover, the International Mechanical Code, IMC 2012 Chapter 5 covers this area.
2. U.S. Fire Administration. 2011. "Restaurant Building Fires." Topical Fire Report Series. U.S. Department of Homeland Security.
3. Griffin, B., M. Morgan. 2014. "60 years of commercial kitchen fire suppression." *ASHRAE Journal,* June.
4. UL. UL Standard 1978, *Grease Ducts.* Covers factory-built grease ducts and grease duct assemblies that are intended to be installed at reduced clearances.
5. Gerstler, W.D. 2002. "New Rules for Kitchen Exhaust." *ASHRAE Journal*, November.
6. IAPMO. 2012. *Uniform Mechanical Code* and ICC. 2012. *International Mechanical Code*.
7. Duda, S.W. 2014. "Fire & Smoke Damper Application Requirements." *ASHRAE Journal,* July. This states under Other Rules: Do not put any dampers in Type 1 grease exhaust systems.
8. California Energy Commission. Title 24, *Building Energy Efficiency Standards* and ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. ■

TAKE THE WORK OUT OF DUCTWORK



BENEFITS OF ROUND DUCTWORK

- 8 to 24” diameter available
- Reduced static pressure
- Reduced buildup of grease in the corners like traditional rectangular ductwork
- Factory dye-tested to prevent leaks

SIMPLIFIED INSTALLATION

- No on-site welding
- V-clamp connections between ductwork pieces
- Multiple accessories available including elbows, access doors and transition plates for duct termination

SINGLE & DOUBLE WALL MODELS AVAILABLE

DUCT MODEL	INNER DIAMETER (ID)	OUTSIDE DIAMETER	CLEARANCE TO COMBUSTIBLES
DW	8” - 24”	N/A	18”
DW - 2R	8” - 16”	ID + 4	3/4”
DW - 3R	8” - 24”	ID + 6	3/4”
DW - 3Z	8” - 24”	ID + 6	0”

MEETING THE STANDARD

- UL 1978 – Standard for Grease Duct
- UL 2221 – Fire Resistive Grease Duct Enclosure Assemblies
- NFPA 96 – Installation Standard
- ASTM E2336 – Test Method for Fire Resistive Grease Duct Enclosure Systems
- Equivalent Canadian Standards - CAN/ULC-S662 and CAN/ULC-S144

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