Fire risk from solid fuel commercial cooking

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12/08/2014

Learning objectives

- Understand the characteristics of creosote deposits and related fire risk in commercial kitchen exhaust hoods and ducts.
- Identify issues related to creosote and grease fires, including ignition, spread, detection, and likelihood of suppression.
- Know recommendations for improved fire prevention, detection, and suppression though new technologies, improved equipment, compliance with codes and standards, and owner/employee practices.

Though codes and standards specify Type I hoods and approved automatic fire suppression systems for cooking operations that emit smoke and grease, recent fire reports suggest that risk of fires from solid-fuel cooking, mostly using wood, are not fully understood by commercial kitchen designers, engineers, and owners. Important findings are that solid fuel cooking often leads to flammable creosote deposits in exhaust systems and conventional fire suppression systems sometimes do not extinguish resulting fires. Because solid-fuel cooking is increasingly common in restaurants, related fire risks are increasing. Prudent design requires more robust construction, full code and standards compliance, state-of-the-art fire suppression systems, and other preventive measures.

Creosote: A highly flammable product of solid-fuel cooking

The role of grease as fuel in commercial kitchen fires is well known. Solid-fuel cooking with wood causes creosote to deposit in hoods and ducts as additional fuel. Creosote is well known for its fire threat in residential chimneys above wood-burning fireplaces, and it's also a growing cause of restaurant fires. What is creosote? According to online source InspectAPedia:

"Creosote is a black, oily wood-tar condensate...that forms inside of chimneys and flues when burning wood[...].Creosote tar is carried into the chimney as a vapor[...] but this creosote tar vapor condenses as a liquid onto the cooler chimney sides as smoke passes up the chimney and flue. As the creosote deposits cool they harden to a shiny black coating that can be difficult to remove, especially if the creosote deposits are left over a period of time. Creosote will continue to accumulate on chimney surfaces until it is removed[...]. Once ignited, the deposits of creosote burn at very high temperature, so hot, in fact, that depending on the amount of creosote that is burning, a runaway...fire occurs, making a sound like a roaring freight train."

Thus, solid-fuel cooking adds creosote as a source of flammable fuel for fires in commercial kitchen hoods and ducts, in addition to grease. The combination of creosote and grease in exhaust hood plenums and ducts is assumed to ignite and burns hotter than creosote alone.

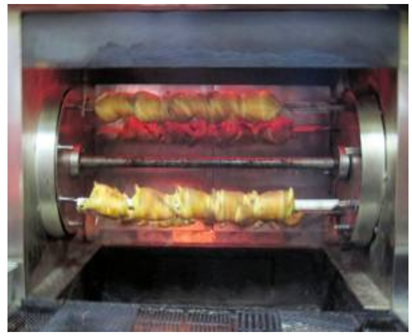
Extremely low flash point

The most surprising property of wood-based creosote is its extremely low flash point-the lowest temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air. According to the New Jersey Dept. of Health's report, the flash point of wood tar creosote is 165 F. (Yes, that low.) Combustion at the flash point requires a source of ignition, and with solid-fuel cooking the source of ignition can be airborne sparks or embers. If the temperature is much higher, on the order of 600+ F, creosote can auto-ignite.

Creosote fire risk comes with appliances that burn any form of wood, generally to add flavor, such as charbroilers, rotisseries, pit barbeques, ovens (including brick ovens), and smokers. Some appliances burn wood and natural gas simultaneously. Wood fuel is available in various species, shapes, and sizes: chips, bricks (compressed chips and sawdust), and logs. In some cases, wetted wood is used, which burns at a lower temperature and is known to produce more creosote.

Recent fires from high-risk solid-fuel cooking

Reports of fires with solid-fuel cooking confirm that creosote increases risk, and surprisingly, conventional fire suppression systems are being reported as not detecting or extinguishing related fires in hoods and ducts. Below are brief descriptions of three recent fires from solid-fuel cooking that highlight risk issues.

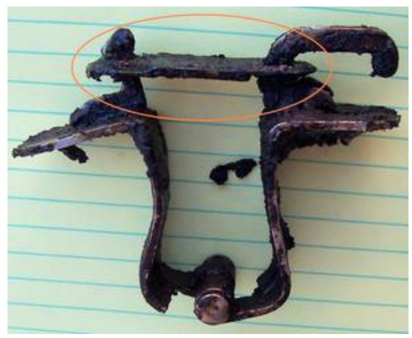


1. Duct fire above wood-fired rotisserie: This fire ignited in the exhaust duct over a wood-fired rotisserie in a full-service restaurant. After the fire, a service technician assessed the condition of the water-wash hood and associated wet-chemical fire system and found several problems. Most significantly, the hood's water valves had been closed because of leaks above the ceiling.

With water valves shut, the continuous water mist in the hood was disabled and unable to quench airborne sparks and burning embers from the wood fire. These in turn ignited grease and creosote in the duct above the conventional suppression system's fusible links detector, and the suppression system did not activate. The duct fire was extinguished by workers with a portable extinguisher and confirmed out by firefighters. Though damage to the building was not extensive, there was significant cost for restoring operation of the older water-wash hood and fire suppression system.

2. Fire in exhaust duct: Fire occurred in the exhaust duct above a solid-fuel charbroiler. The fire spread quickly from the hood to the duct. The conventional wet chemical fire-suppression system activated but failed to extinguish the fire. Firefighters needed to disassemble the exhaust fan and cut into the duct to extinguish the fire. As reported in a local newspaper, there was creosote buildup in the wood-burning grill system. The fire damaged the restaurant's hood system, attic, and roof. There was water damage in the main dining room from fire hoses.

The damaged equipment was replaced with state-of-the-art components: a new hood with an electronically controlled and monitored fire-suppression and hood-cleaning system connected to an unlimited supply of a water/surfactant solution; factory-built, listed ductwork; and a newly designed curb-mounted "utility set" fan. The replacement equipment decision was made in concert with the ventilation-system supplier, which, according to some, for solid-fuel cooking will only sell state-of-the-art equipment.



3. Fire from brick pizza oven: In this fire loss incident, the restaurant used a combination natural gas and wood-fired pizza oven. In early mornings, the oven was used for baking for several restaurants, and later it was used for cooking pizza and other foods in the incident restaurant. The Baltimore Fire Investigation Bureau's report indicated:

"...this fire started as a result of too many bricks of wood burning inside the commercial oven causing an intense heat buildup," and "the heat became so intense, that it burned the buildup of creosote off the inner wall of the oven. The fire extended to the flue of the oven and then breached the firewall protection."

The fire spread from the oven flue to the hood and duct, and then it spread to additional spaces in the multi-tenant building because of insufficient clearance from the duct to combustible construction, that is, wood studs and joists. Additional factors included: failure of detection and suppression by the conventional suppression system, lack of required slope in the duct, and insufficient cleaning of grease and creosote in the exhaust duct, in part because of lack of required cleaning access panels. These hearth-type ovens can be purchased as gas fired, wood fired, or combination gas and wood fired.

Additional case studies

Appendix B of a report from NFPA includes brief summaries of 13 fire incidents in eating and drinking establishments. In five of the incidents, hood fire-suppression systems did not operate properly. In one of the incidents, the suppression system put out the fire under the hood, but the fire continued in the duct and was eventually extinguished by firefighters.

Detection

Reports confirm that some fires caused by solid-fuel cooking start in ducts above conventional fire-suppression-system detectors. These are ignited by sparks or burning embers, or from auto-ignition of grease or creosote in ducts. Other fires advance from hoods to ducts faster than conventional fusible links detectors can activate suppression systems, particularly if the links are embedded in grease. A flame front can advance very quickly. For example, with a duct velocity of 1500 ft per minute in a 15 ft long duct, it takes only 0.6s for a fire to travel in the exhaust stream, from fusible links at the duct opening, to the exhaust fan inlet. Flame travel time depends on duct length and exhaust velocity, and in typical restaurant buildings, the time is very short.

Duct integrity

Visits to operating foodservice facilities and fire scenes reveal many leaking grease ducts and access panels, resulting in grease on tops of hoods, on gypsum board ceilings, and permeating lay-in ceiling panels-all providing sources of fuel for fires outside ducts. A recent discovery is the observation during the UL 300 test of a new fire suppression system, of "fireballs" of grease exploding from a leaking test duct.

Codes and standards

There are specific code and standards requirements for solid-fuel cooking, such as the requirement for separate exhaust systems, included in the International Mechanical Code and NFPA Standard 96. Adapting to the trend of adding solid-fuel to gas charbroilers for flavoring, the 2014 NFPA 96 includes section 14.3.4, which lists 11 requirements, all of which must be met to not require a separate exhaust system for this type of cooking.

Currently, there are no codes and standards that provide additional or alternative requirements for fire-suppression systems that protect solid-fuel cooking. The double threat of creosote and grease fires, which might not be quickly detected and suppressed, suggests the need for enhanced fire suppression requirements for solid-fuel cooking.

Persistent use and high temperature

Solid fuel can stay hot for hours after cooking operations are completed, elevating the risk of fires overnight, when automatic, dependable operation of fire suppression systems is especially important. Some solid-fuel cooking appliances are rarely or never shut down. For example, a recent Chicago Tribune restaurant review noted:

"... since [the restaurant] opened 13 months ago, the wood-burning oven has never been extinguished." Because high operating temperatures increase the risk of igniting grease and creosote, it's interesting to read from the same review, "during service time, the internal [oven] temperature rises to 800 degrees at its base, and 1,000 near the domed top where flames lick." Both cited temperatures are sufficient to cause auto-ignition of both grease and creosote.

No automatic shut-offs for solid fuels

Commercial kitchen fire suppression systems include interlocked gas valves or electric circuit breakers to shut off cooking energy sources, but there are no current means of turning off solid fuel sources other than extinction.

Suppression time

Because most conventional suppression systems function by spraying a liquid suppressant agent from one or more canisters, the amount of agent and time of discharge are limited, with spray time in the range of 45 to 60s. With modern, electronically operated water and surfactant systems, the amount of water and its cooling ability are unlimited, though systems are usually set for default maximum times on the order of 15 to 30 min to avoid flooding properties after fires are extinguished.

Recommendations

- **Water and surfactant based fire-suppression systems:** Modern fire suppression systems generate a shielding mist of water droplets that effectively form a thermal blanket at or below 212 F, which quickly eliminates fire spread. Water mist is extremely effective at reducing temperatures in a fire scenario because the energy required to vaporize water is higher than with nearly any other material. This is especially important when solid-fuel cooking appliances are involved as the solid-fuel will continue to burn and release heat until it is completely extinguished.

  Water mist provides another fire suppression function: as the liquid water droplets absorb heat from the fire and vaporize, the water vapor volume produced is more than 1000 times the volume of the liquid water supplied. This huge increase in water vapor volume displaces air and the oxygen it contains, further suppressing combustion. Water droplets that deposit on surfaces coated with grease or creosote will limit surface temperatures to 212 F to rapidly extinguish active combustion.

  This surface wetting feature is enhanced by the added surfactant. The thermal blanketing effect, oxygen displacement, and surface cooling occur wherever the water and surfactant are sprayed: over appliances; in exhaust hoods, exhaust filters, and plenums; and in exhaust ducts.

- **Improved detection:** For solid-fuel cooking operations, installation of state-of-the-art fire suppression systems include placement of additional electronic temperature sensors high in ducts under each exhaust fan inlet. These added sensors detect fires that start in or move quickly into ducts above the locations of conventional fire-suppression-system detectors. An innovation in electronic fire sensors is the dual capability of sensing high temperature and a high rate of temperature rise, either of which will activate fire suppression.

- **Listed exhaust ducts:** Factory-built, listed ducts are also highly recommended for solid-fuel cooking exhaust systems. A kitchen-ventilation system designed to high standards for safety and functionality almost always includes listed components; namely, exhaust hoods, grease filters, and exhaust fans. It makes sense to specify listed exhaust ducts to complete the "ventilation path" and complement the other listed components.

- **Hood and duct cleaning:** Customary exhaust system cleaning to remove grease may not be sufficient to remove creosote deposits. Owners and hood cleaners must recognize the need for more frequent and vigorous hood and duct cleaning to reduce the risk of fires from solid-fuel cooking. Use of certified duct cleaning contractors is highly recommended.

- **Clearance to combustibles:** Investigations of commercial and industrial kitchen fires indicate frequent lack of compliance with code and standard requirements for clearances to combustible construction. Strict compliance with these requirements is necessary in all facilities, and it's even more necessary in facilities with solid-fuel cooking and risk of highly combustible creosote in addition to grease.

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Acknowledgments: Thanks to F. M. (Tim) Farrell, consultant; and Bill Griffin, vice president engineering at CaptiveAire Systems; for editorial and technical support of this article.

-Edited by Joy Chang, digital project manager, CFE Media, jchang@cfemedia.com

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