Combustible Creosote Joins Grease as Fire Risk

in Commercial Kitchens with Solid Fuel Cooking

By Doug Horton, MS, MBA

A National Fire Prevention Association (NFPA) 2012 report indicates that about 57% of fires in eating and drinking establishments involve cooking.[1] Historically, cooking oil and grease have been the materials first ignited fuels in cooking fires, but there's a new and increasing challenge: creosote deposits in hoods and exhaust ducts above solid fuel cooking operations.

Many restaurants have added live-fire solid fuel cooking to their operations for enhanced flavoring and marketing. This cooking method adds fire risk with appliances such as wood fueled charbroilers; pit barbeques; rotisseries; smokers; and hearth and brick ovens, especially for cooking pizza. In many cases natural gas and wood are burned in the same appliances, such as by two restaurant chains with a combined total of about 1700 locations.

With the increase in solid fuel cooking is an apparent increase in related fires, in view of fire reports reviewed by this writer. Not only are solid fuel cooking fires increasing, there is an increasingly troubling pattern of conventional fire suppression systems not reliably activating or extinguishing these fires; thus, the need for fire investigators and related fire professionals to understand and report details of this added risk and aid prevention.

This article describes the creosote the risk with solid fuel cooking, provides three selected case studies, discusses related issues, and offers recommendations. Figure 1 shows a wood-fired combined charbroiler and rotisserie above which a fire ignited in the exhaust duct at a restaurant in Maryland. The fire was not extinguished by the built-in fire suppression system, though it was extinguished by firefighters.

Figure 1. Commercial wood fired rotisserie and charbroiler (grates removed) above which fire ignited in the exhaust duct

Creosote Characteristics

Creosote is a well known fire risk in chimneys above residential wood-burning fireplaces. According to the Chimney Safety Institute of America:[2]

> "Creosote is black or brown in appearance. It can be crusty and flaky…tar-like, drippy and sticky…or shiny and hardened…. Whatever form it takes, creosote is highly combustible. If it builds up in sufficient quantities – and the internal flue temperature is high enough – the result could be a chimney fire. Certain conditions encourage the buildup of creosote. Restricted air supply, unseasoned wood, and cooler than normal chimney temperatures are all factors that can accelerate the buildup of creosote on chimney flue walls."

> From the Cornell Cooperative Extension Service:[3] "Creosote is made up of condensed volatile gases created by incomplete combustion of the wood. As these gases rise in the chimney, they cool, mix with water vapor, and form a tar-like substance that clings to the chimney walls…. Chimney fires can start quickly and be very powerful, shooting flames many feet above the chimney cap and producing a loud rumble like a freight train going by."

> From another reference:[4] "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…."

Creosote Risk

NFPA recognizes the creosote risk of solid fuel cooking.[5] From NFPA 96, Paragraph A.4.1.6, "When solid fuel is burned in cooking operations, increased quantities of carbon, creosote, and grease-laden vapors are produced that rapidly contaminate surfaces, produce airborne sparks and embers, and are subject to significant flare-ups…." In response to this risk, Chapter 14 of NFPA 96 provides standards for Solid Fuel Cooking Operations. These standards are mandatory when NFPA 96 is adopted by local jurisdictions and should be subject to periodic inspections.

A Midwestern insurance company that insures a large proportion of restaurants and taverns in a four state area also recognizes this risk, indicating in a four page white paper:[6] "Solid fuel appliances dial up fire threat with the addition of highly combustible materials." From the same paper: "Buildup of creosote, a by-product of wood burning, is the major cause of exhaust system fires, which result from poor preventive maintenance and housekeeping." A prominent fire

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investigator and author suggests:[7] "Buildup from solid fuel cooking can create a serious fire hazard in as little as a week."

Figure 2.

Duct with heavy deposits of creosote and grease

Selected Case Studies of Solid Fuel Cooking Fires

Three selected fire reports illustrate typical fire issues with creosote from solid fuel cooking, including conventional hood fire suppression systems not reliably activating and extinguishing these fires. Fires are often igniting directly in upper portions of ducts where creosote is deposited above conventional fusible links. In other cases, fires are igniting below fusible links and moving upward in ducts faster than fusible links can activate suppression systems.

Fire in Pizza Oven. This fire ignited during mid-morning bread baking operations in a tall rectangular hearth oven, which burned natural gas on one end and wood on the other end. The oven was located under a high quality, listed Type I exhaust hood with listed grease filters and a conventional fire suppression system. Combustion products exited the oven from a long rectangular flue centered a few inches under the hood. Beyond the grease filters, the exhaust duct turned horizontally a few feet above the hood, extended close to offices and other spaces in the multi-tenant, multi-story building, and the duct eventually turned upward toward the exhaust fan. From the official fire report:[8]

> "It is this investigator's opinion that this fire started as a result of too many bricks (sic) of wood burning… ."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 flu (sic) of the oven and then breached the firewall protection. The fire then entered into the void area around the flu (sic)…."

The conventional fire suppression system did not activate—the fusible links, similar to Figure 3, did not separate—and fire traveled from the oven flue though the hood, filters, duct, and eventually to "roofing materials." Subsequent investigation showed that duct cleaning was insufficient to remove grease and creosote deposits, in part because duct access panels did not meet code and standards requirements. The fire caused additional damage because required clearances to combustible construction were insufficient. The duct access and clearance issues should, of course, have been noted and resolved during building plan reviews and periodic fire safety inspections.

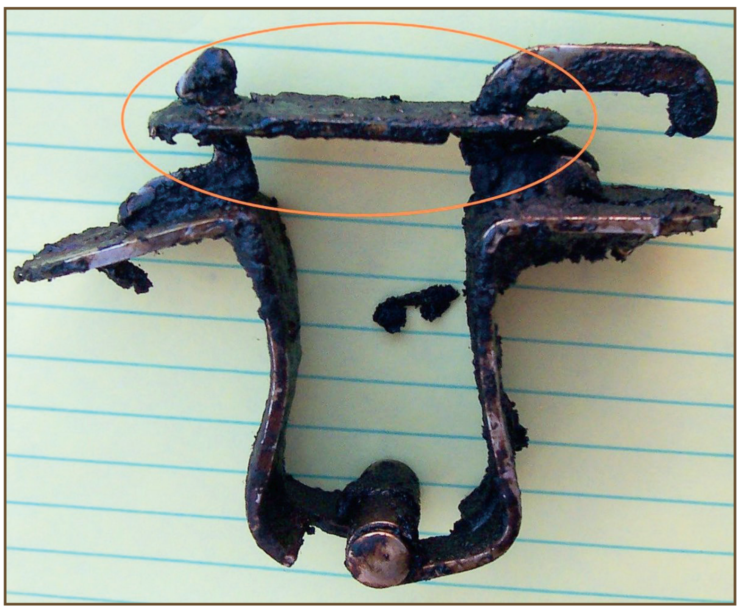

Figure 3. Grease encrusted fusible links that did not separate during a fire

Solid fuel cooking fire in Barbeque Pit. From the fire investigator's report:[9]

> "The cook said when the fire in the pit got going, a fire started in the flue. He was able to put the fire out in the pit and tried to put the fire out in the flue with his extinguisher. The flue fire wouldn't go out. They called 911 and evacuated the restaurant."

The report indicates that the fire suppression system activated but did not extinguish the fire in the exhaust duct. A participant in the investigation noted that only six of twelve fire suppression system nozzle caps blew off, which diminished suppressant application to the protected area.

The Origin and Cause section of the report indicated: "…some of the buildup of the grease and creosote that had burned in the flue had fallen during fire fighting operations and landed on the top surface of the grill." In the conclusions section of the report, the fire marshal stated that the "Item/material first ignited" was "grease and creosote."

Solid fuel fire in airport terminal restaurant. Though fire damage was minor, this fire was significant because of its location in a busy airport terminal during daytime operations. The fire occurred in a hood and duct over a solid fuel charbroiler and a solid fuel rotisserie. From the fire investigator's report:[10]

- "Hood suppression release mechanism in cabinet indicating (sic) discharge;
- Manifold piping burst disk unaltered, indicating no discharge of liquid;
- Chemical suppression agent tanks full; and
- Gas cartridge seal punctured"

The fire suppression system activated mechanically, but the gas cartridge did not pressurize and discharge liquid suppression agent, suggesting that the system was not properly maintained.

Other case studies. Appendix B of Reference 1 includes brief summaries of thirteen fire incidents in eating and drinking establishments, without mention of whether solid fuel cooking was involved. Close reading reveals that in five of the incidents, 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 until it was extinguished by firefighters. These and other cases analyzed by the author suggest there's a reliability issue with conventional fire suppression systems for a variety of reasons.

Solid Fuel Fire Issues

Suppression System Activation. As mentioned above, some fires from solid fuel cooking start in ducts above conventional fire suppression system fusible links, or the fires move quickly into exhaust ducts before suppression systems activate. As an example of how quickly this can occur, consider a 15 foot long duct with a typical duct velocity of 1500 feet per minute. The time for the exhaust stream to travel from fusible links in a duct opening, to an exhaust fan inlet, is only six tenths of a second! Fusible link fouling by grease accumulation is another issue, especially if the grease has aged and hardened, as seen in Figure 3.

Persistent Use and High Temperature. Solid fuel can smolder for hours after cooking operations are completed, elevating the risk of fires overnight when reliable automatic operation of fire suppression systems is especially important. Some solid fuel cooking appliances are rarely or never shut down. From a restaurant review in the Chicago Tribune:11 "Since (restaurant name) opened 13 months ago, the wood-burning oven has never been extinguished."

No Automatic Shut-offs for Solid Fuels. Kitchen fire suppression systems operate gas valves and electric circuit breakers to shut off the respective cooking energy sources when associated fire systems are activated, but with solid fuel cooking, there is no means of turning off the fuel, so improved suppression is needed.

Suppression Time. Conventional fixed-tank fire suppression systems are limited to the amount of liquid fire suppressant in one or more prefilled canisters. Such systems spray the appliances, hood plenum, and lower duct for a limited time – on the order of 45 to 60 seconds. More suppressant tanks are often provided to cover more appliances, but this arrangement does not increase the spray time.

Codes and Standards Issues

There are specific code and standards requirements for appliances and exhaust systems for solid fuel cooking operations, such as included in 2014 NFPA 96 Chapter 14. One important requirement is the provision of separate exhaust systems for solid fuel cooking. Adapting to a trend of adding solid fuel to gas

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cooking appliances, the 2014 edition of NFPA 96 adds section 14.3.4, which includes eleven requirements, all of which must be met in order to not require a separate exhaust systems for solid fuel cooking.

Spark Arresters. NFPA 96 section 14.1.6 states that "solid fuel cooking operations shall have spark arrestors to minimize passage of airborne sparks and embers into plenums and ducts." However, there are no standards for application of spark arresters to solid fuel cooking applications, suggesting the need for research to develop test methods for classifications or listings. A manufacturer of a "spark arrester filter" cites specifications in NFPA 211, but this standard pertains to residential chimneys, defining "spark arrester" as a "screening material or a screening device attached to a chimney termination to prevent the passage of sparks and brands to the outside atmosphere."

Suppression Systems. NFPA 96 section 14.7.5 requires that listed fire-extinguishing equipment for solid fuel-burning cooking appliances "shall use water -based agents," and section 14.7.6 requires that the fire-extinguishing equipment "shall be rated and designed to extinguish solid fuel cooking fires." Code officials should verify that these and other section 14 requirements are met in jurisdictions where NFPA 96 is adopted as code.

Fire Reporting Issues

Fire reports reviewed by the writer range from detailed narratives by well-trained investigators, to "We don't write reports if we deem fires to be accidental." Given that most kitchen fires are accidental, this policy means few reports are issued, and information that might help prevent fires is not available. Another improvement to fire reports would be reporting the descriptions, actions, and relative effectiveness of kitchen fire suppression systems, portable extinguishers, and building sprinkler systems.

Hood and Duct Issues

Clearance to Combustibles. Clearance issues often cause small fires to expand into larger fires and increase damage. From the author's experience, the most frequently seen non-conforming code and standard issue is appliances, hoods, and ducts mounted without the required clearances to combustible construction. A simple solution is specification of metal studs, joists, and trusses within 18 inches of planned locations of appliances, hoods, and ducts meets usual code and standard clearance requirements.

Appliance, Hood, and Duct cleaning. With solid fuel cooking, appliances, hoods, and ducts must be frequently and aggressively cleaned to remove combustible grease and creosote. NFPA 96 2014 Section 11.4 requires that exhaust systems be inspected for grease buildup by properly trained, qualified, and certified persons. NFPA 96 Table 11.4 indicates that systems serving solid fuel cooking operations shall be inspected monthly, though as mentioned above, inspecting more often might be necessary, depending on cooking practices.

Listed Exhaust Ducts. With continuing observations of unlisted, fabricated-on-site ducts leaking grease and not meeting clearance requirements, the author recommends specification of factory-built, listed ducts as a minimum requirement for solid fuel cooking exhaust systems, if not all exhaust systems. With modern high standard kitchen ventilation systems including listed hoods (UL 710), grease filters (UL 1046), and exhaust fans (UL 762), it's logical to specify listed exhaust ducts (UL 1978, etc.) for what goes in between the other listed components. For more information on ducts and fire issues, see Reference 12.

Figure 4. Assortment of listed double-wall duct components

Improved Fire Suppression

New Technologies. For use with solid fuel cooking as a minimum, there are now available, effective fire suppression systems. These systems include electronic detection, operation, and monitoring; power supply backup; discharging unlimited cold water and surfactant for fire suppression, and for fire prevention, automatically dispensing hot water and surfactant for daily hood plenum and lower duct cleaning. These systems are tested and listed to UL 300, and they meet NFPA standards 96 and 17A, with typical controls show in Figure 5.

Figure 5. Electronically operated fire suppression system, showing surfactant tank and pump, along with hot and cold water pipes, valves and gauges

These electronically operated systems generate a shielding mist of water droplets, enhanced by surfactant, to coat grease and creosote and provide a thermal blanket to limit surface temperatures to 212°F (at sea level). The water mist droplets absorb heat from the fire and vaporize, expanding more than 1000 times to displace oxygen and further suppress combustion. With no automatic shut-offs of solid fuel, this is especially important. More details on this system are available in Reference 13.

Improved Detection. Especially for solid fuel cooking operations, and to overcome fusible link placement issues, electronically-operated fire suppression systems include placement of additional electronic temperature sensors high in ducts under each exhaust fan inlet. The selected sensors increase protection and speed of activation by detecting either high temperature (usually 360°F) or a high rate of temperature rise.

Figure 6. Electronic fire detector that senses both temperature and rate of temperature rise

Summary

Solid fuel cooking is increasing in restaurants, and combustible creosote deposits are adding to fire risk. Ongoing reviews of fire incidents show that conventional fire suppression systems with fusible links and limited, short time suppression agent disbursal, are often challenged to activate and extinguish fires from solid fuel cooking.

Creosote deposition from solid fuel cooking, ignition temperatures, and fire characteristics in ducts are a fertile area for research. Codes and standards requirements should be updated for solid fuel cooking fire risks and prevention, especially for spark arresters. Improved fire reporting and analysis will also aid understanding and prevention. Meanwhile, listed duct products and electronic fire suppression systems are available to provide greater confidence in suppression of solid fuel cooking fires.

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