Lessons Learned From Commercial Kitchen Fire Investigations

BY DOUG HORTON

According to a report from the National Fire Protection Association, "U.S. fire departments responded to an estimated average of 7,640 structure fires per year in eating and drinking establishments between 2006 and 2010. These fires caused average annual losses of two civilian deaths, 115 civilian injuries, and $246 million in direct property damage per year. Three out of five (57%) of these fires involved cooking equipment."[1]

From a recent *ASHRAE Journal* article, "Fires in commercial kitchens most often start in or near appliances. Notable examples include ignition from natural gas or solid fuel flames, such as with charbroilers; ignition of cooking oil in deep fat fryers; and ignition of grease deposits in or near appliances, exhaust hoods, and ducts."[2]

This article describes many factors contributing to the cause and spread of fires in commercial kitchens. Some of the descriptions come from forensic fire investigations in which the author participated, while other descriptions come from public reports. The high proportion of deep fat fryer fires among the fires described here likely relates more to the author's particular investigation assignments than to the actual proportion of fryer fires nationwide.

Fire Case Studies From the Author

Total loss of quick service restaurant and play area. A large amount of burnt grease was found inside the backs of three fryers, suggesting ignition from the gas burner flues. Although the fire suppression system activated, fire spread throughout the building, which totally collapsed as shown in *Photo 1.* Investigators noted that the kitchen equipment installation did not meet code and standards requirements for clearance to wood construction behind the appliances and exhaust hood, likely contributing to the spread of fire.

Near total loss of barbecue restaurant. Fire likely started in one of three fryers, which was found nearly empty of cooking oil, causing overheating and autoignition, in spite of built-in safety devices. The fire suppression system discharged, although appliances had been rearranged from the original layout, resulting in a mismatch of suppressant nozzles and appliances, with less suppressant discharge to the burning fryer. Fire spread was accelerated by wood facing on walls and ceiling.

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Total loss of quick service restaurant. Fire started in fryers under a low profile hood. The fire suppression system did not activate automatically, likely because fusible links were coated with hardened, decomposed grease, as shown in *Photo 2,* nor was the system manually activated by workers. Fire escaped the hood through a 4 in. by 12 in. (100 mm by 300 mm) rectangular hole inappropriately cut into the rear top of the hood for passage of electric conduits for fryer cooking timers. Fire spread to the void space between the duct and surrounding fascia metal, and because of inappropriate sealing of the duct at the ceiling, fire spread to the attic and roof, where wood construction burned and two-thirds of the building collapsed.

PHOTO 1 Total loss fire damage at quick service restaurant.

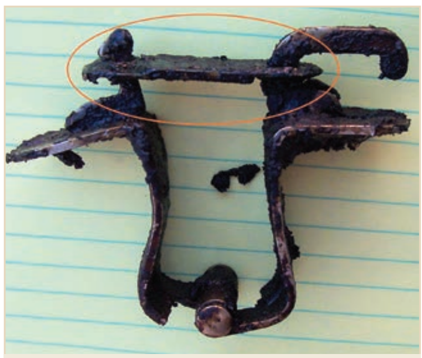

PHOTO 2 Grease covered fusible links that did not separate during fire.

PHOTO 3 Insufficient clearance allowed ceiling joists to ignite from heat of fire in duct.

Total loss of two-story building with Italian-themed restaurant. After closing, fire started in a deep fat fryer that was not properly turned off. Post-fire testing confirmed that the fryer thermostat did not work properly and the separate high-limit switch was improperly wired, enabling runaway heating and auto-ignition of the cooking oil.

Because the fryer was halfway outside of the left end of the exhaust hood, rising flames were not contained by the hood and ignited the ceiling and second story. Also, the improper fryer position likely delayed fire detection because there was less heat near the fusible links. After activation, the suppression system discharged only one of two liquid agent cylinders, while fire spread to the entire building.

Total loss of convenience store and café portion of two-story motel. This fire started in a fryer under a low profile hood. The unique hood design likely delayed automatic activation of the fire suppression system, and manual activation of the fire system was not attempted because there was no manual pull station in the front kitchen in which the fire occurred. Instead, for this single-fire system that covered hoods and appliances in two kitchens, the manual pull station was in the back kitchen.

Firefighters extinguished the fire under the fryer hood and left the scene after posting a fire watch outside. Flames were later seen burning through the second story roof. Investigators concluded that after firefighters left the first time, fire continued to burn in the fryer hood duct and ignited wood ceiling joists that were only 3 in. to 4 in. (75 mm to 100 mm) from the duct, with insufficient clearance, as shown in *Photo 3.* Although firefighters returned to fight the fire, the entire two story structure was destroyed.

Total loss of quick service restaurant. Fire started in a group of several fryers. The fire suppression system activated, but a small rubber sealing washer was missing in the threaded connector between the propellant gas cylinder and the release mechanism. This allowed gas pressure to dissipate immediately after activation and no liquid suppression agent was discharged. The black washer was found in a pool of blackened grease on the bottom of the fire system cabinet.

Damage to fryer area of quick service restaurant. Investigators discovered that fire started in a power distribution assembly behind multiple electric fryers. One high power receptacle was found to be completely disintegrated, and black "carbon tracking" was visible on the corresponding white-bodied power plug. Grease deposits in the receptacle apparently carbonized and became conductive, forming an electric short circuit that heated grease deposits sufficiently to ignite the fire.

PHOTO 4 Burnt truss near duct (in circle) and loose fitting thin metal sleeve joint (in rectangle).

PHOTO 5 Burnt grease in area of ignition near hot burner flue.

Total loss of quick service chain restaurant. Investigators determined that a grease deflector baffle was missing from the fryer hood, such that liquid grease flowed downward from the hood and duct into the center fryer flue, where it was ignited by the gas burners. The fire system activated but failed to discharge suppressant because the propellant gas cartridge was not installed in the release assembly. Instead, it was lying on the bottom of the fire system cabinet.

Fire spread was aided by two issues related to the fryer exhaust duct, as shown in *Photo 4*.

- From a previous remodel, the fully welded steel duct was cut and extended with a section of thin galvanized vent piping, with loose fitting sleeve connections that allowed fire to escape from the duct into the attic; and
- There was insufficient clearance from the duct to wood trusses in the attic.

Total loss of quick service restaurant in remodeled historic building. Fire started in the rear of a set of fryers. The fire was caused by an accumulation of grease inside the fryers near the hot gas burner flues, as shown in *Photo 5*. Some of the grease sprayed toward the flue area from a cooking oil leak in plastic piping added with the installation of a third-party cooking oil disposal and replenishment system. The fire system activated but did not prevent fire spread and loss of the entire historic building.

Damage to fryer area in a quick service restaurant, with significant smoke and water damage. Fire likely ignited in a fryer with its cooking oil level below the level of the operating thermostat, leading to continuous heating. Separate high-temperature limit switches were not operational on three of the four fryer vats, including the burning vat.

From a security video, fire system automatic activation was delayed about eight minutes, likely because of two issues that reduced hood airflow and heating of the fusible links:

- Old, unlisted mesh filters in the fryer hood were clogged with grease; and/or
- The fryer exhaust fan was not operating because of a broken drive belt.

The security video also showed that instead of activating the manual pull and then optionally using the appropriate Type K extinguisher, workers discharged an ABC extinguisher toward the fire, resulting in an unwelcome powder flare-up. Thereafter, workers looked closely at the nearby manual pull station for a few seconds, but they did not manually activate the fire system before evacuating the building.

Major damage to an Italian-themed family restaurant. Investigators determined from interviews that workers placed a larger than normal amount of raw meat onto the hot grates of a gas-fueled charbroiler, causing a large flare-up and ignition of grease in the hood and its two ducts. Fire likely escaped from the hood because the hood was not continuously welded liquid-tight, ducts were not properly connected to the hood, and/or heat in the hood auto-ignited wood ceiling joists to which the hood was mounted with insufficient clearance. Flames burned through the ceiling, attic and roof, and there was smoke and

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water damage throughout the building. A variety of additional fire and mechanical code violations were observed.

Other observations. At several fire sites, there were large accumulations of grease in appliances, hoods, and ducts. Several ducts had imperfect welds and were not liquid tight, and required duct accesses for cleaning were often lacking and/or leaking.

Fire Cases From Official Reports

Solid fuel fire at full-service restaurant in airport terminal. A fire ignited in a hood and duct over a solid fuel charbroiler and a solid fuel rotisserie. The fire inspector's report included these observations:[3]

- Fire occurred in plenum and duct of solid fuel cooking appliance hood;
- Grease filters had build-up of ash and grease;
- Extensive charring and ash in plenum of hood; and
- Grease build-up on wall under hood.

Firefighters extinguished the fire with limited damage, and although the gas cartridge seal was found punctured, the fire inspector noted several issues with the fire system:

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

From the inspector's observations, it's likely the gas cartridge was previously used or it was improperly installed in the release mechanism, either of which suggests improper maintenance of the system.

Partial damage from solid fuel cooking fire. According to the fire report:[4] "The cook said when the fire in the pit got going, a fire started in the flue (duct). 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." The report implies that the fire suppression system activated but did not extinguish the fire in the duct.

Partial damage of bowling center snack bar. A fire ignited in the cooking area of a bowling center snack bar, reportedly from a deep fat fryer, and it spread upward into a long vertical duct. According to the fire marshal's report:[5]

- FM (fire marshal) arrived on scene and found fire coming from the hood exhaust fan on the roof;

FIGURE 1 Typical placard for mounting over Type K extinguisher.

- The suppression system operated but did not extinguish the fire; and
- Witnesses advised hood suppression activation seemed to be delayed.

The author's opinion is that the fire, aided by exhaust airflow, spread upward into the long vertical duct quicker than the suppression system could act on it.

Other Cases

Appendix B of Reference 1 includes brief summaries of 13 fire incidents in eating and drinking establishments. The descriptions include five incidents in which hood fire suppression systems did not operate, or did not operate properly. In one case, the suppression system put out the fire under the hood, but the fire continued in the duct and was eventually extinguished by firefighters.

Lessons Learned

Here's a summary of lessons learned from the fires described above, published reports, and fire scene observations by the author.

Fire training. Restaurant workers must be trained in fire protection and suppression procedures, including: activating fire alarms and/or calling 911; manual activation of fire suppression systems; optional use of Type K, not ABC extinguishers; and orderly evacuation of themselves and customers. As shown in *Figure 1*, a required placard mounted over Type K liquid fire suppressant extinguishers warns that fire suppression systems should be manually activated before use of Type K extinguishers.

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Fire system maintenance and performance. Specified maintenance is required by codes, standards, and listings, with minimum performance and other checks at least every six months. Newer, electrically supervised fire systems can alert workers to situations that might prevent systems from functioning properly. Also, modern fan controls can be integrated with hoods and fire systems to anticipate hazards and disable cooking appliances before a fire event occurs.

Hood overhang and appliance placement. Design overhang of hood fronts and ends over appliances must be maintained, not only to aid hood capture and containment performance, but also to minimize fires spreading outside hoods. From another perspective, appliances must be located within the design hazard zone of the fire system and properly positioned under fire system nozzles. When appliances are rearranged, fire system piping and nozzles must be adjusted to conform to new appliance locations, unless overlapping coverage is provided. Full height end panels, caster locks, caster cups, and tethers are examples of appliance locating mechanisms.

Clearance to combustibles. Clearance issues often cause small fires to spread and increase damage. The most frequent non-conforming issue observed by the author is hoods and ducts mounted without required clearances to nearby wood construction. Clearance requirements are contained in model codes and standards, including the *International Mechanical Code®*, *Uniform Mechanical Code*, and *NFPA 96® Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*.

Hood and duct integrity. In some of the previous cases, code-required integrity of Type I hoods was compromised by improper design, construction, and installation. With cooking that produces grease and smoke, requiring Type I hoods, it is common to specify:

- Listed hoods (UL 710 – Exhaust Hoods for Commercial Cooking Equipment);
- Listed grease filters (UL 1046 – Grease Filters for Exhaust Ducts); and
- Listed exhaust fans (UL 762 – Power Roof Ventilators for Restaurant Exhaust Applications).

The additional specification of factory-built, listed duct products (UL 1978 – Grease Ducts) is a means of significantly improving duct integrity.

Hood, duct, and appliance cleaning. Depending on the types of cooking and foods cooked, hoods and ducts must be frequently and thoroughly cleaned to remove flammable grease. Cleaning should also include removal of grease from inside and around appliances. Hoods and ducts over appliances with solid fuel cooking need more frequent and aggressive cleaning to remove flammable creosote as well as grease. Hoods are available with daily self-cleaning functions for the hood plenum and duct, and there is a professional organization that certifies commercial kitchen exhaust system cleaners and supervisors.

Electricity and grease don't mix. When grease from cooking deteriorates, its auto-ignition temperature decreases as it carbonizes and becomes conductive. This can lead to grease ignition in electrical connections and receptacles, and hood fire suppression systems might not protect cramped areas behind appliances.

Exhaust fan maintenance. Exhaust fan operation is important; specified airflow carries heat toward fire detectors, as well as grease into filters and other cooking emissions out of the facility. Broken exhaust fan belts are common, and preventive maintenance should include periodic installation of new belts. Exhaust air proving controls are recommended to ensure that exhaust fans are running and exhaust air is moving.

Solid fuel cooking. Reference 6 suggests, "Solid fuel appliances dial up the threat with the addition of highly combustible materials." While nearly all cooking releases grease particles and vapors from foods, leading to deposit in hoods and ducts, solid fuels also produce embers and creosote. With or without grease deposits, creosote fires can ignite in hoods and ducts, possibly above the position of conventional fire suppression system detectors. Also, conventional fire suppression systems have a fixed volume of suppressant and they discharge the suppressant for a limited time—in the range of 45 to 60 seconds. This time may be insufficient to extinguish fires and prevent re-ignition, particularly in burning hoods and ducts with creosote deposits.

For solid fuel cooking, the author suggests that designers and engineers consider specifying the latest technology for commercial kitchen fire suppression systems, such as systems with electronic monitoring

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and operation, electronic detection by temperature and rate of temperature rise, battery backup, unlimited cold water for suppression, automatic daily hood cleaning with hot water, and surfactant addition for both suppression and cleaning to reduce the surface tension and make water "wetter" for improved removal of flammable deposits. These systems add an electronic detector under each exhaust fan inlet to better detect duct fires over solid fuel cooking, and listed ducts are highly recommended. Codes and standards requirements for solid fuel cooking should be strictly followed, including the use of spark arresters.

Summary

There are many causes of commercial kitchen fires, and kitchen fire suppression systems sometimes don't extinguish fires, leading to spread of fires with increased damages. Lessons learned suggest that designers, builders, building code and fire officials, equipment suppliers, owners, and others should work toward improved fire prevention and suppression in commercial kitchens. Codes and standards serve a real purpose in preventing fires, although education, strict inspection, and full compliance are necessary.

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