TECHNICAL FEATURE

60 Years of Commercial Kitchen Fire Suppression

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Fire suppression systems for commercial kitchens have progressed significantly in the past 60 years to keep up with increasing challenges such as:

- Higher power appliances for faster cooking or cooking larger volumes of food;
- Increased numbers of deep fat fryers, particularly in the quick service sector;
- Expansion of natural gas and solid fuel charbroilers for flavor enhancement; and
- Overall expansion of the number of food service facilities.

In addition to these challenges, the expansion of food service facilities often has included a push for low-cost construction, particularly for smaller facilities. Reduced costs have sometimes impacted adherence to building and fire codes, particularly for clearances to combustibles of appliances, exhaust hoods, and ducts. Proper application and maintenance of suppression systems is also an ongoing challenge. Because of these challenges, there has been a significant evolution over the last half century in fire suppression systems for commercial cooking applications.

Commercial Kitchen Fire Characterization and Suppression

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 overheated cooking oil in deep fat fryers; and ignition of grease deposits in or near appliances, exhaust hoods, and ducts. Fires are also sometimes related to inoperative appliance safety devices.

The transition of cooking oils from inclusion of animal fats to vegetable oil blends has been good news in terms of higher auto-ignition temperatures; however, if auto-ignition occurs, there is a larger store of heat energy that must be cooled to prevent reignition. While generic “grease” might have an auto-ignition temperature in the vicinity of 400°F (204°C), auto-ignition of cooking oils occurs in the range of the high 600s °F (316°C) to the high 700s °F (371°C), depending on the blend of oils. The challenge is to extinguish fires and simultaneously cool fuel sources to prevent auto-ignition.

The systems described in this article are automatic, pre-engineered, fixed fire suppression systems designed to protect commercial cooking areas. Commercial

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cooking areas include associated ventilating equipment such as exhaust hoods, filters, plenums, exhaust ducts, and fans; as well as commercial cooking appliances. Commercial kitchen fire suppression systems are generally suitable for use in restaurants, hospitals, nursing homes, hotels, schools, airports, banquet services, and other food service facilities.

First Hood Cleaning and Fire Suppression System

In the period from 1957 to 1965, an inventive entrepreneur received U.S. patents for exhaust hood features that included grease extracting baffles, a fire damper, water or steam cleaning of the hood plenum, and fire suppression by water.[1] Systems included automatic control of hood cleaning, and thermostatic control of the fire damper and water-based fire suppression. These patents are significant in their descriptions and understanding of the challenges of grease fires in exhaust hoods and ducts, and these patents foreshadowed many subsequent developments.

Fire Detection by Fusible Links

There is a long history of using fusible links for fire detection, and this type of automatic detection is still in widespread use. The construction of fusible links includes two metal links, which are held together by a temperature-rated metal alloy. Different temperature ratings are available based on needs of applications. When the rated temperature is reached, the alloy fuses (melts) and a cable attached to the links activates the system. A comparison of fusible links and alternative detection devices is provided in the accompanying sidebar text.

Early Dry Chemical Systems

Systems with dry chemical suppression agents were developed during the late 1950s, coincident with the rapid expansion of quick service restaurants, many of which included deep fat fryers. These fire systems became especially popular after a large chemical and equipment manufacturing company released its first generation pre-engineered, automatic system in 1962. This system employed one or two sensing assemblies, each with a spring and fusible links in the hood plenum. When the links separated, steel aircraft cable inside 3/8 in. (9.5 mm) diameter galvanized piping was pulled by the spring to trigger the release mechanism, which then punctured a gas cylinder mounted on the outside of the chemical cylinder. The dry chemical agent then flowed through piping to spray heads designed for this purpose. These systems were typically installed to protect the hood plenum and ducts only.

Limitations of this early technology included open exposure of the release mechanism, gas cartridge, and chemical cylinder. Also, the pulled cable system was limited to two detector assemblies, which were connected in parallel to a tee, from which the release mechanism was activated.

Improved Dry Chemical Systems

Soon after the initial development and increasing adoption of dry chemical systems, improvements were implemented, including use of inexpensive electric conduit as cable piping and development of pulley-elbows to minimize possible cable fouling at piping turns. Additionally, the spring was moved from the detector area to the gas and agent cylinder location. With this arrangement, the cable

Fire Suppression Evolution

1957 to 1965	Patents issued for hood with water cleaning and fire suppression
1959	First dry chemical system
1961	NFPA 96 first published
1962	Improved dry chemical systems
1964	First wet chemical system
1969	Fuel shutoffs introduced
1982	Large chain acceptance of wet chemical systems
1992	UL Standard 300 published
1992 and beyond	Systems retested to UL 300
1994	UL Standard 300 approved and required on all new installations
1998	Hybrid systems developed with wet chemicals and water
2007	First electronically controlled fire suppression and hood cleaning system

FIGURE 1: Typical fusible links and bracket assembly.

was under continuous tension, and multiple detectors could be connected in series. Significantly, protection for appliances was added at this time.

Another improvement was the development of sealable metal cabinets to hold the dry chemical cylinder, gas cylinder, and pressure-regulated release assembly. The cabinet would be unsealed and accessed only during periodic maintenance by an authorized technician. Cabinets were mounted on walls, the ends of exhaust hoods, or inside special appliance cabinets, which also provided locations for manual pull stations. At some point, electric contacts were added to release systems to facilitate code requirements for operating fuel shutoffs and controlling makeup air and exhaust fans during fires.

Fryer Reignition Issue

In the late 1970s, one rapidly growing quick service restaurant chain noted that occasional fires in its deep fat fryers were often extinguished initially but soon reignited. With no further suppression available after the gas cylinder and dry chemical cylinder had emptied, the re-ignited cooking oil fires were difficult to extinguish. Often, fryers burned vigorously until extinguished by firefighters, causing major damage to structures and contents, as well as business interruption.

Fires need fuel, heat, oxygen, and a continuous chemical reaction. Extinguishing a fire depends on removing one or more of these elements. With dry chemical systems, oxygen was removed initially to extinguish fires, but heat was not removed sufficiently to limit reignition from continued oil vapor generation. Boiling and turbulence of the burning cooking oil often caused disruption of the dry chemical "barrier" on the oil. Also, heat from the cooking appliances would continue to support the fire if the suppression system's automatic fuel shutoffs did not operate properly or were not part of the system. Dry chemical systems were also inconvenient for the cleanup problem they presented, particularly from accidental activations.

Early Wet Chemical Systems

Two companies released the first wet chemical systems for commercial kitchens in the mid 1960s. This development was spurred in part by the U.S. Navy's concern with fires in shipboard galleys. CO_2 or dry chemical systems were problematic, not only for reignition and cleanup issues, but also for the risk of contaminating shipboard environments, particularly in submarines. A sprinkler company pioneered one of the early wet chemical systems, which featured a misting nozzle. This was also the first system to include multiple wet chemical cylinders.

Fire Detection Devices

Fusible Links

A fusible link assembly is installed within each exhaust duct opening and above each protected cooking appliance per NFPA 17A. Fusing (melting) during a fire allows the links to separate, typically relaxing a small diameter, spring-tensioned cable to activate the release assembly.

Linear Fusible Links

Multiple fusible links are cabled in series at fixed intervals over the entire length of the hazard zone. There also must be a fusible link in each duct opening. Fusing of any one device activates the system.

Pneumatic Tubing

Pressurized pneumatic tubing is placed along the full length of the hazard zone. Heat from a fire causes the tubing to deform or melt, reducing the pressure sensed by a pressure switch that activates the system.

Electronic Fire Detectors

Listed electronic temperature sensors are installed within each exhaust duct opening, and optionally, other locations. A variety of temperature settings is available, and some sensor products also activate fire suppression based on the rate of temperature rise.

Expansion of Wet Chemical Systems

Wet chemical systems gained widespread acceptance in the early 1980s when one large manufacturer's system was adopted for new restaurant construction by the growing quick service chain mentioned previously. Wet chemical systems are mechanically similar to dry chemical systems, except for differences in piping type, size, and nozzles. Additional tanks can be added for larger hazard coverage, and optional accessories such as alarms and warning lights can be added.

The wet chemical agents are proprietary mixtures of potassium carbonate, potassium acetate, potassium citrate, or a combination, in water with other additives to form an alkaline fire suppressant, which enhances saponification. This is the reaction between a strong alkali and animal or vegetable fats, which with heat, produces a soapy foaming action that reduces the temperature of the fuel below its auto-ignition temperature. An engineer from the cooperating restaurant chain worked with the largest manufacturer of wet chemical systems to verify satisfactory performance during test fires in samples of the chain's custom-made fryers.

Impact of UL Standard 300

UL Standard 300 was published in 1992, and it became effective in 1994. The standard covers the fire testing of pre-engineered fire extinguishing systems with commercial cooking equipment. Among other revised requirements, the fryer reignition issue spurred inclusion of more rigorous tests for fryer fires, and it recognized the transition from animal fats to vegetable oils with higher auto-ignition temperatures.

To improve test pre-conditions, there were several revisions, including:

- Changing the test appliance from a fabricated pan simulating a fryer, to a commercial fryer with specified heating and cooling rates;
- Changing pre-burn after auto-ignition from one minute to two minutes;
- Revising the fryer condition during pre-burn from fuel-off to fuel-on; and
- Specifying a minimum grease auto-ignition temperature for cooking oil of 685°F (363°C).

FIGURE 2: Wet chemical system release assembly cabinet and agent cylinder.

Changes in the overall test requirements included:

- Flames in the appliance must be completely extinguished upon complete discharge of the extinguishing agent;
- For deep fat fryers, woks, and ranges, the system must not permit reignition of the grease or cooking oil for 20 minutes, or until the temperature of the grease or cooking oil decreases at least 60°F (15°C) below its observed auto-ignition temperature, whichever is longer; and
- For all appliances other than deep fat fryers, woks, and ranges, the system must not permit reignition for five minutes.

All UL-listed fire suppression systems were required to be retested to UL 300. Dry chemical systems were no longer compliant with UL 300, and all wet chemical systems required modifications to meet the UL 300 Standard.

Hybrid Systems: Wet Chemical and Water

Hybrid systems are very similar to wet chemical systems in terms of suppressant piping, nozzles, blow-off caps, detectors, gas cartridges, agent tanks, cable, piping, and pulley elbows. The difference is that the tank valve is changed to allow the wet chemical to discharge to the hazard area first, and then the valve automatically allows potable water to flow through agent piping and nozzles. The water is provided by the facility's potable water supply, or by means of an optional water tank, with a lockable (open) valve to ensure a continuous supply of water. Accessories are the same as for wet chemical-only systems.

Coinciding somewhat with the introduction of these systems, overlapping designs of pipes and nozzles were introduced as alternatives to customary appliance-specific pipe and nozzle designs. Appliances could then be changed or rearranged under the hazard zone, without the need for moving pipes and nozzles. Depending on local jurisdiction requirements, dedicated piping and nozzle protection might be required for appliances such as upright broilers, "salamander" over-fired broilers, and chain broilers because these appliances are generally not open on top to allow the downward flow of wet chemicals and water.

Electronically Operated Fire Suppression and Hood Cleaning System

The newest type of fire suppression system builds on the experience gained from earlier systems, with notable advances. These systems combine electronic fire detection and microcomputer controls to perform appliance, hood plenum, and lower duct fire suppression.

When fire is detected, unlimited cold potable water is sprayed for a preset time through hood, duct, and appliance nozzles, with overlapping coverage. Detergent-based surfactant is injected continuously to lower the surface tension of the water, allowing it to more quickly coat the burning fuel and enhance its cooling properties to help prevent reignition.

A significant advance with these systems is use of UL-listed electronic fire detectors to sense both the temperature and the rate of temperature rise, either of which can trigger activation. The standard temperature setting is 360°F (182°C) and other temperatures

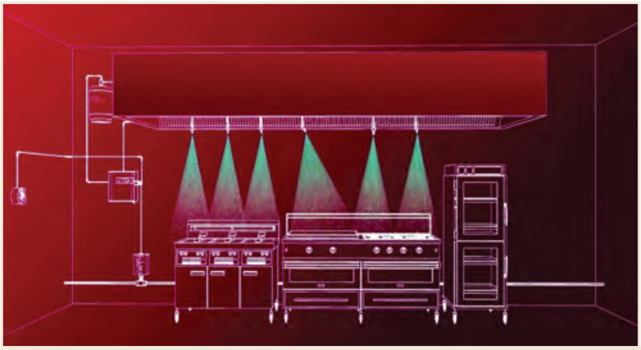

FIGURE 3: Appliance-specific pipe and nozzle design.

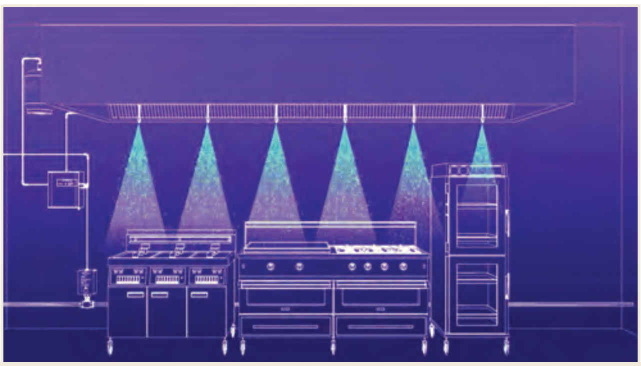

FIGURE 4: Overlapping pipe and nozzle design.

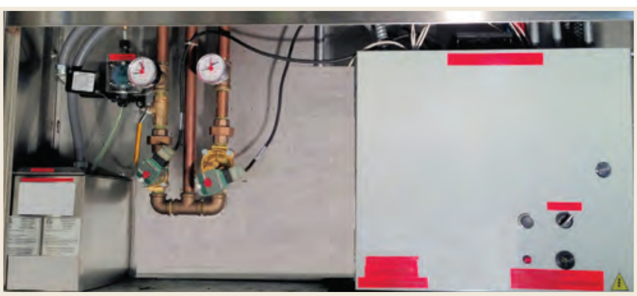

FIGURE 5: Electronic fire suppression system components in hood end utility cabinet.

are available. One sensor is placed within each duct opening, and optional sensors can be placed in other locations, such as exhaust fan inlets. Manual activation devices are electrically operated, so cables, cable piping, and pulley elbows are eliminated.

Another advance is the use of microcomputers to control and monitor all system components and circuits, including detectors, water valves, power supply, battery backup, and surfactant tank level, for example. If a fault is detected in the system, an audible alarm sounds, a related light flashes a fault code, and the system can send text messages to indicate the specific fault. Remote

Codes and Standards

Multiple standards and model codes apply to commercial kitchen fire suppression systems as adopted by states, counties, cities, and other jurisdictions. Listed below are the principal standards and model codes that relate to system requirements in the U.S. Similar codes and standards apply in Canada and other countries.

NFPA 17A: Standard for Wet Chemical Extinguishing Systems. Covers design, installation, operation, testing, and maintenance of pre-engineered wet chemical fire extinguishing systems.

NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations. Comprehensive standard for fire protection in commercial cooking, adoptable as code in many jurisdictions.

International Mechanical Code (IMC): Includes requirements for commercial kitchen exhaust duct and hood system design and performance, fire suppression systems, and clearance to combustibles.

UL Standard 33: Standard for Heat Responsive Links for Fire-Protection Service. Covers heat responsive links used for fire-protection service, categorized by various design factors.

UL Standard 300: Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment. Third Edition, May 2005 is current. See descriptive section above.

UL Standard 710: Exhaust Hoods for Commercial Cooking Equipment. Covers construction and performance of Type I (smoke and grease) hoods, including burn-out tests to verify that fires are contained in listed hoods.

UL Standard 762: Power Roof Ventilators for Restaurant Exhaust Appliances. Requirements for various types of fans for restaurant exhaust appliances, including an Abnormal Flare Up Test.

UL Standard 864: Control Units and Accessories for Fire Alarm Systems. Covers devices for monitoring, control, and indicating functions of commercial fire alarm systems.

UL Standard 1046: Grease Filters for Exhaust Ducts. Requirements for grease filter tests, including test to verify limited fire penetration through hood grease filters.

UL Standard 1978: Grease Ducts. Covers factory-built grease ducts and grease duct assemblies that are intended to be installed at reduced clearances, including several fire tests.

Uniform Mechanical Code (UMC): The 2012 version echoes and references most NFPA 96 requirements related to fire suppression for commercial cooking.

monitoring is also available, such as with building management systems. Controls are housed in a utility cabinet on one end of the hood or on a nearby wall.

To help prevent fires, electronically controlled systems also provide automatic hood cleaning at the end of the cooking cycle. Hot water is sprayed into the hood plenum and lower duct through the same piping and nozzles used for hood and duct fire suppression, and surfactant is intermittently injected to aid cleaning.

A battery backup power supply protects all system functions, including manual activation circuits, and operation of gas and electric shut-offs. Systems are listed to UL Standard 300 and ULC/ORD-C1254.6-1995, and they meet the requirements of NFPA standards 17A and 96. Controls are typically listed to UL Standard 864.

Acknowledgments

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