Factors of Fire Ignition and Spread – A Multi-Restaurant Case Study

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Background:

An interesting report [1] describes three restaurant fires in which the authors cite pyrolysis, or the thermal decomposition of materials at elevated temperatures in an inert atmosphere [2], as an ignition factor.
In these fires, wood was charred or ignited after being exposed to higher than normal temperatures, but lower than typical auto-ignition temperatures for wood, due to conduction heat transfer from appliance mounting hardware into combustible materials. Citing 482°F as a commonly recognized ignition temperature for wood [3], the authors' case studies and experiments concluded that wood could be ignited at as low of a temperature as 256°F when exposed 12 to 16 hours per day for about 21 months.

Case Studies and Experiments:

Concerning the three case studies from the report, the first restaurant was destroyed with fire igniting after closing and employee departure. In the second fire, the restaurant was occupied at the time of the fire, employees smelled smoke and called the fire department, and the fire was quickly extinguished. In the third and final fire, information about the time the fire occurred was not available but the restaurant's structure was destroyed, even though construction around its cooking line was of a newer design.

Investigation reports of the three restaurant fires, which were all franchisees of the same restaurant chain, spanned a five-year period, and pointed to the fires starting near the "cheese melter" appliances in each restaurant. These appliances were mounted with lag bolts on the wall behind the main cooking line in each restaurant with 2"x6" wall studs and a 2"x12" piece of blocking between studs for attachment of the cheese melter. See Figure 1 and 2.

Further inspections after the fires pointed to the fires starting in or around closed wood cavities behind the cheese melters. The questions the report strove to answer were: how and why?

Figure 1. Origin area in the wall behind the cheese melter with the appliance removed.

Figure 2. View of the back of the cheese melter with heat pattern on the right corresponding to the origin area on wall.

With three similar fires, and major damage to two of the restaurants, similar closed cavities behind the cheese melters were checked in three other of the chain's restaurants that had not experienced fires. Investigators removed the cheese melters and other materials, including portions of the stainless steel backsplashes, to access the closed cavities behind the cheese melters. These observations revealed charring on cement board, drywall and wood blocking in several locations in the closed cavities, especially near lag bolts that penetrated from the cheese melter hanging brackets to the closed cavities. See Figure 3-5.

Figure 3. Heat damage on Durock© cementboard covering the wood blocking where the cheese melter hung

Figure 4. Heat damage on drywall covering the wood blocking where the cheese melter hung.

Figure 5. Heat damage on wood blocking.

Two overlapping conclusions stand out from the referenced report:

1. "The only competent ignition source…was excessive conduction heat transfer into the horizontal wood blocking…through the lag bolts."
2. Combined laboratory and manufacturer testing "demonstrate that low temperature ignition of wood clearly occurs."

Spread Issues

Surprisingly, the referenced report does not cover fire spread issues, including code and standard requirements for clearance to combustibles. Experience with investigations of commercial and industrial kitchen fires indicates frequent lack of compliance with code and standard requirements for clearances. Frequently, construction behind the appliances is a stainless steel backsplash on a layer of wallboard, mounted to wood studs. This construction often does not meet the typical 18-inch clearance requirements. An alternative, improved construction, which usually meets applicable codes and standards, is the specification of metal studs, joists, and trusses, etc. within 18 inches of planned appliances and other heat sources.

Strict compliance with clearance requirements is necessary in all facilities, and it's even more necessary with the high temperatures usually associated with solid fuel cooking. Among other issues, as was seen in this report, with less than required clearances, combustible materials can host ignition by pyrolysis and other mechanisms.

References:

1. Jerry R. Tindal, MS, P.E., and Jeffery H. Warren, Ph.D, PE, CSP. "Low Temperature Ignition of Wood," The Warren Group. *The Journal of The National Academy of Forensic Engineers*, June 2009.
2. "Pyrolysis." https://en.wikipedia.org/wiki/Pyrolysis
3. Babrauskas, Vytenis, "Ignition Handbook", *Fire Science Publishers/Society of Fire Protection Engineers*, 2003.