Demonstration Testing: Extinguishment of Kitchen Fires and the Effect of Sprinklers in a Residential Setting

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Prepared by:

Jason P. Huczek
Southwest Research Institute® (SwRI®)
Fire Technology Department
San Antonio, TX 78238
jason.huczek@swri.org

This paper describes the results of a project conducted at SwRI in January 2006, in support of an episode of "Crash Test Human," produced by Pangolin Pictures, for broadcast on the National Geographic Channel. This episode focused on safety in the home and three of the segments were related to fire safety, two of which were filmed at SwRI.

The two main objectives of the work were:

1. To determine the effectiveness of common household items in extinguishing a stovetop oil fire, compared to a kitchen fire extinguisher.

2. To demonstrate the difference a residential sprinkler can make in a typical bedroom fire scenario.

Results from this project are discussed and test data, photographs, and the video were shared in the presentation.

Extinguishment of Kitchen Fires

These tests focused on a typical kitchen fire scenario. A commercially available electric stovetop was placed against a wall and corner with a ceiling mockup to simulate part of the geometry of a standard residential kitchen. A vegetable oil fire was started in a small skillet by heating the oil to its auto-ignition temperature. A stovetop burner was used to heat the skillet and ignition was triggered by removing the skillet lid after the oil had reached its estimated auto-ignition temperature (~750 ºF).

After the oil fire was allowed to preburn for several seconds, suppression and extinguishment of the fire was attempted with several common household items, as well as a kitchen fire extinguisher, purchased locally. The household items included water, sugar, salsa, flour, aerosol whipped cream, cornstarch, coffee, and baking soda.

Figure 1 shows a photograph from a demonstration test after the oil fire was attempted to be extinguished with water.

Figure 1. Snapshot of Video During Attempted Extinguishment of Oil Fire with Water.

Table 1 provides a summary of the results. Video clips of most of these tests will be presented at the conference.

Table 1. Summary of Results for Kitchen Extinguishment Tests.

"Fire Extinguishing Agent"	Results	
	Observed Extinguishment	Comments
Water	No	Large fireball
Sugar	No	The sugar is combustible
Salsa	No	Fireball from water in salsa
Flour	No	No real effect
Aerosol Whipped Cream	No	Propellant is flammable
Cornstarch	No	Small fireball
Coffee	No	Oil in coffee is combustible
Baking Soda	Yes	Smothered the fire well
Pan Lid – Suffocation	Yes	Cleanest solution if safe
Kitchen Fire Extinguisher	Yes	Requires substantial cleanup

Residential Bedroom Fires

This part of the project consisted of two identical tests of a typical residential bedroom setting, one with and one without standard sprinkler system protection. Each bedroom was 10 by 12 by 8-ft high and was furnished by SwRI staff with the following: full mattress with mattress pad on a bed frame, bedding, dresser, TV, coffee table, chair, nightstand, trash can, wall decorations, table lamp, carpet, painted walls and ceiling, photo-electric and ionization smoke detectors, carbon monoxide (CO) detector, and heat detector. Figure 2 shows a photograph of the bedroom scenario prior to testing.

Ignition for each test was provided by a burning matchbook placed into a plastic trashcan, half-filled with loosely crumpled newspaper, adjacent to the bed.

The first test was conducted for the room without the sprinkler system. SwRI's client requested that one of their hosts be allowed to occupy part of the room for the test with a sprinkler system in place. For this reason, during the first test, temperature measurements were recorded in the area where the host would be standing or kneeling during the second test. Flashover of the test compartment was observed after approximately 4 minutes and 30 seconds. Figure 3 shows flames emerging through the doorway subsequent to flashover in the first test.

The second test was conducted for the room with the sprinkler system. The system consisted of one residential pendant sprinkler head (k=4.3, T_{act}=155 ºF) centered in the room, set at a design density of 0.1 gpm/ft^2. NFPA 13R (2002 Edition) requires a minimum of 0.05 gpm/ft^2 for listed sprinklers. Flashover was not observed for this test and, in general, the room conditions were more tenable than in the first test.

Figure 2. Setup of Bedroom Fire Scenario.

Figure 3. Flashover of Bedroom Without Sprinkler Protection.

For each of these tests various measurements were taken including heat and smoke release rate, room temperatures and activation times of sprinklers and detectors. Smoke and heat detectors were purchased at a local retail store.

Table 2 shows detector activations for the room tests with and without sprinkler protection. Figures 6 and 7 show the time history of the heat release rate for the room without and with sprinkler protection, respectively. Figures 8 and 9 show the time history of the smoke release rate for the room without and with sprinkler protection, respectively. Figures 10 and 11 show the time history of the room temperatures for the room without and with sprinkler protection, respectively.

Table 2. Instrument Activation Times.

Detector Type	Activation Times (min:sec)	
	Test without Sprinkler System	Test with Sprinkler System
Heat Detector	1:43	0:53
CO Detector	5:28*	1:44
Ionization Smoke Detector	0:22	0:21
Photoelectric Smoke Detector	1:29	0:43
Sprinkler Head	2:31	1:44

* After fire was manually extinguished

The differences between the activation times for the heat detector and photoelectric smoke detector are not as great as they appear. They are in relatively good agreement, with respect to the fire growth in the room. The trashcan fire in the first test took slightly longer to ignite the

mattress, compared to the second test, so, in general, the activation times are higher for the first test (without sprinkler). In the case of the CO detector, for both tests, this instrument did not activate until water was put on the fire, either from the sprinkler head or from the manual suppression with the hose line.

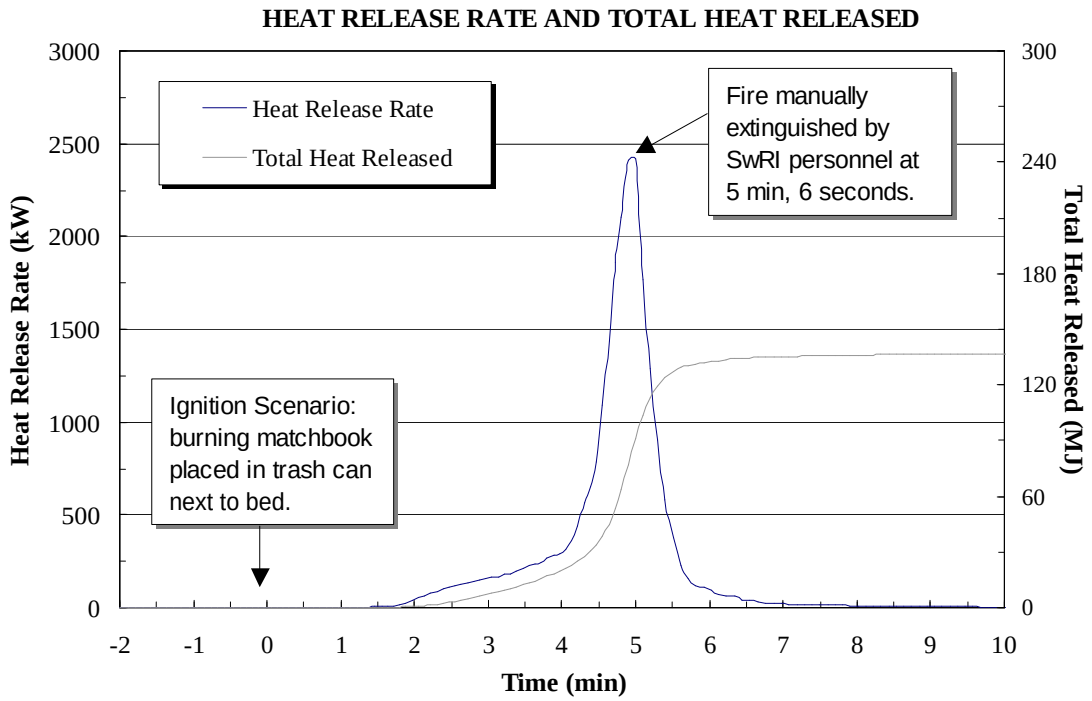

Figure 6. Heat Release Rate Time History for Bedroom without Sprinkler Protection.

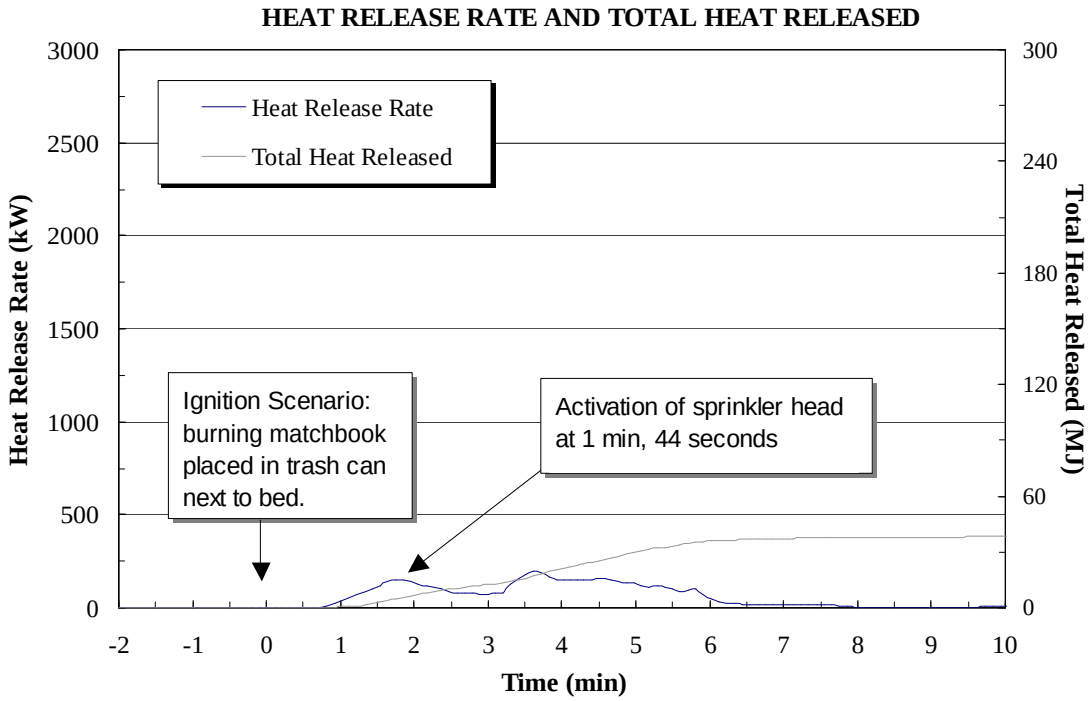

Figure 7. Heat Release Rate Time History for Bedroom with Sprinkler Protection.

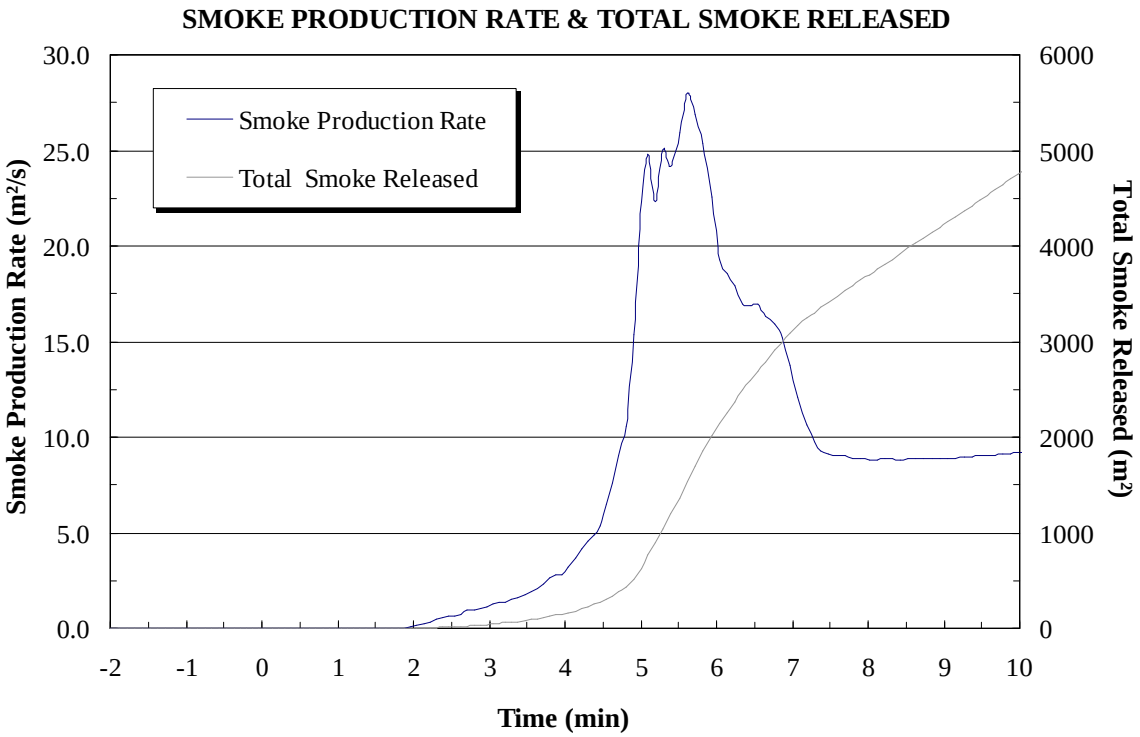

Figure 8. Smoke Release Rate Time History for Bedroom without Sprinkler Protection.

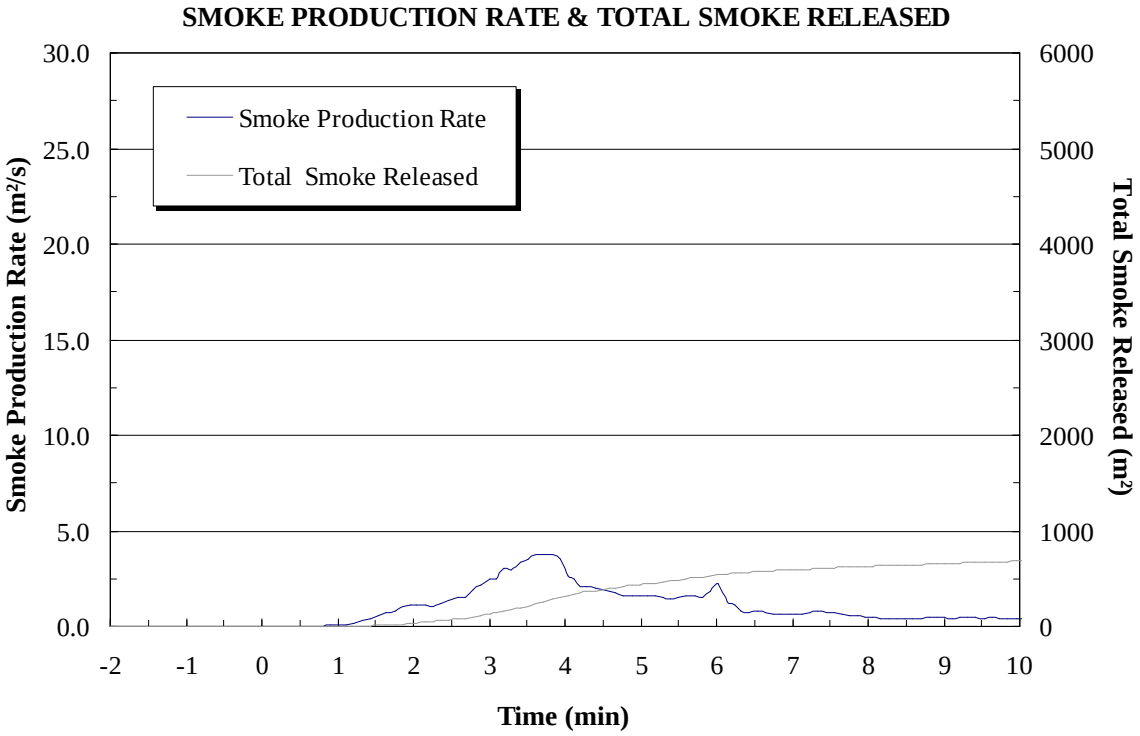

Figure 9. Smoke Release Rate Time History for Bedroom with Sprinkler Protection.

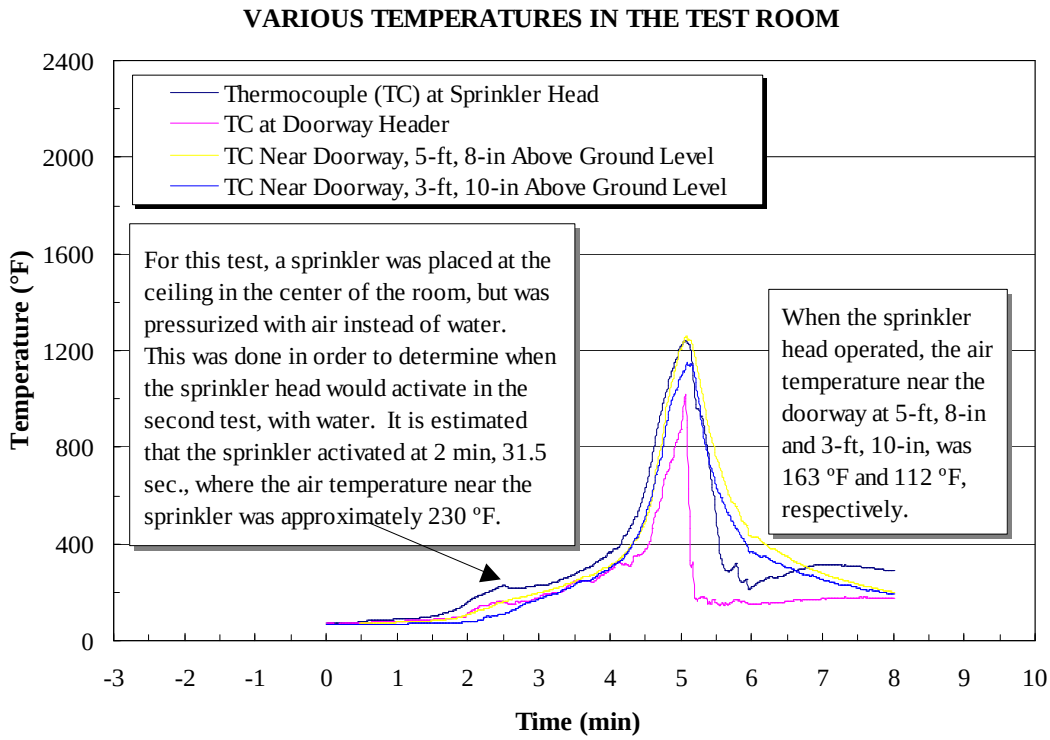

Figure 10. Room Temperatures for Bedroom without Sprinkler Protection.

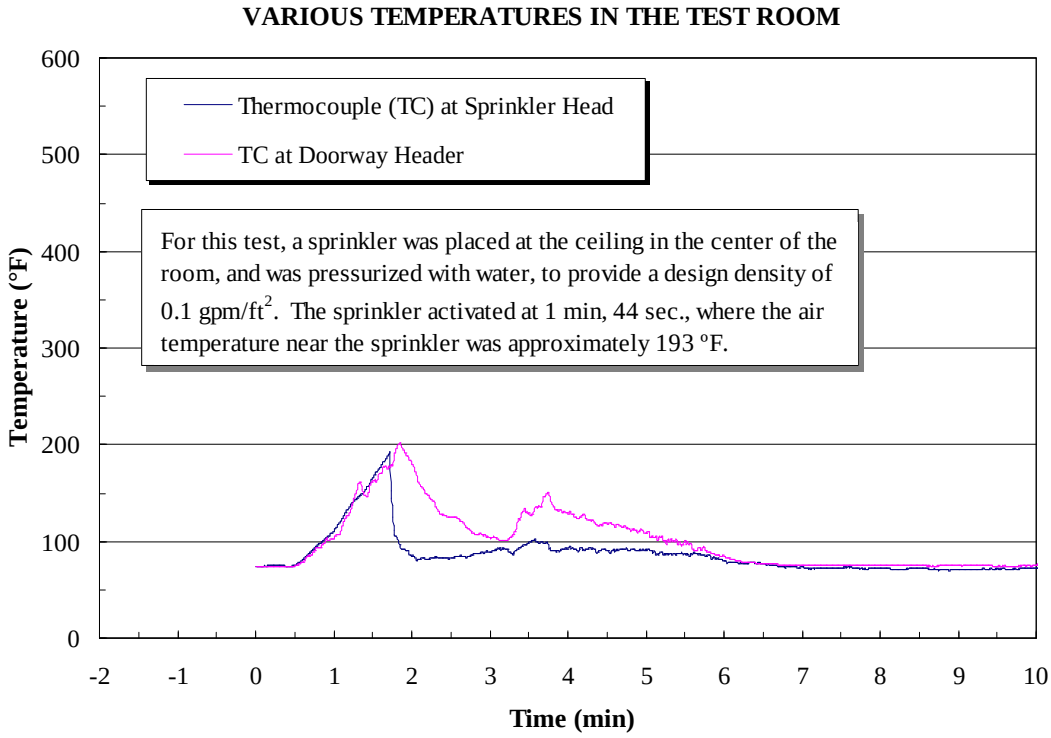

Figure 11. Room Temperatures for Bedroom with Sprinkler Protection.