Smoke Alarm Research at NIST

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Outline

• Kitchen fire and nuisance alarm experiments (CPSC funded)
• New NIST kitchen pre-fire detection research
• Measurements for advanced detectors
• Codes and Standards
Kitchen Fire and Nuisance Experiments
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08/11/2011

03/04/2011
Kitchen Fire and Nuisance Experiments

- Alarms and Instrumentation
  - Various commercially-available smoke alarms
  - Aerosol characterization instrumentation
  - Carbon monoxide, carbon dioxide and oxygen concentrations (5 ft for tenability for fire tests)
  - Temperatures (ceiling and 5 ft for tenability)
  - Smoke extinction (5 ft for egress)
  - Ceiling air flows during nuisance tests
Cooking Experiments

• Cooking scenarios consisted of:
  – broiling a hamburger
  – broiling frozen pizza
  – frying a hamburger
  – making a grilled-cheese sandwich in a no-stick frying pan
  – stir-frying vegetables in a wok on the electric burner
  – frying bacon
  – toasting bread
    • Light, medium, and dark toast
  – toasting frozen bagels
Cooking Activities
Toasting
Cooking Activities
Frying
Cooking Activities
Broiling
General trends

• Propensity to alarm depended on alarm type and scenario.
• The rate of alarm decreased by a factor of between 2.5 to 4 as distance between the cooking source and alarm increased from 10 ft to 20 ft.
• Inside the kitchen, the rate of alarm varied from 40 % to 84% depending on the alarm, while at the farthest two locations the rate varied between 4 % to 28 %.
All Cooking Events
Alarm activation frequency for equal fractions of range top, oven and toasting activities

![Graph showing alarm activation frequency vs. distance from cooking source for different categories: P1, I1, D1, D2, M1, M2.](image)
Kitchen Fire Experiments

• Two cabinet types
  – Pressboard with solid oak doors
  – Pressboard with thin plastic veneer

• Two ignition scenario variations of an electric coil heating element ignition of roll of paper towels spreading flames to various combustibles
  – Scenario 1 including a small coffee maker
  – Scenario 2 including cooking oil soaked rag and paper towels
Kitchen Fire – Ignition Scenario 1

- Paper towels
- 5 foam plates
- Coffee maker
- Bag of potato chips
- Coil
- Burner
Kitchen Fire – Ignition Scenario 2

- Paper towels
- 10 foam plates under paper towels
- Oil-soaked dish rag
- 1 bag of corn chips
- Bag of potato chips
- Box of microwave popcorn
- Plastic plate with oil-soaked paper towels
Kitchen Fire HRR – Scenario 1A

Heat Release Rate (kW)

Time (s)

Peak HRR
Kitchen Fire – Scenario 2A

Peak HRR

Heat Release Rate (kW)

Time (s)
Kitchen Fire – Scenario 2B

Peak HRR

Heat Release Rate (kW)

Time (s)

HRR (kW)
Kitchen Fire – Scenario 1
Kitchen Fire Observations

- Ignition source and cabinet type affect fire growth rate
- Small space tended to limit oxygen to fire
- Installed smoke alarms at any distance provided safe egress times of greater than 90 s
Current Research
Kitchen Pre-fire Detection

Objectives

• (1) To experimentally determine the levels of smoke produced and other signatures, and corresponding times before ignition of cooking fires that existing measurement technologies can utilize to sense pre-fire conditions.

• (2) To provide the sensitivities and operating parameters for kitchen-deployable unattended cooking pre-fire detector that could interrupt power to offending appliances and/or alert consumers allowing intervention to prevent ignition of unattended cooking fires.
Kitchen Pre-fire Detection
Conducted in NIST Fire Detection Room
Planned Experiments

• Unattended cooking scenarios will include:
  – heating vegetable oil
  – frying chicken or potatoes with oil
  – frying bacon
  – caramelizing sugar among others

• Some heavy smoke-producing normal/attended cooking scenarios (e.g., broiling meat, and stir fry) will be included to differentiate cooking activities that most-likely will not ignite and spread fire.
Measurements

- Smoke concentrations (extinction, mass concentration, analog smoke alarm)
- CO and CO$_2$
- Thermal (surface and ceiling air temperature)
  With and without range hood running

Examine boundary between nuisance alarm activation and pre-fire conditions.
Advanced Detection Research

- Examine sensors and advanced algorithms that may provide early fire detection and robust discrimination of non-fire nuisance conditions
- Detailed measurements of smoke and nuisance aerosol concentrations, gas, thermal and other sensor outputs.
Advanced Detection Research
Smoke Nephelometer, Aerosol Polarimeter

- 16 simultaneous scattering measurements user configurable over 8 angles and 4 laser wavelengths
- Polarimeter measurements on steady smoke sources for detailed smoke and nuisance source characterization
- Propose and test discriminating algorithms for advanced smoke detection
Codes and Standards

- NIST experimental results and research being considered to define performance criteria for new UL 217/268 PU foam fire tests.
- NIST experimental data on cooking aerosols being used to develop new UL 217/268 nuisance alarm tests
- NFPA 72 household alarms (SIG HOU) has nuisance resistant alarm requirements (2019)
Thank you for your attention