

Impact on Smoke Alarm Performance Considering New Nuisance and Fire Tests

**Thomas Cleary
National Institute of Standards and Technology
Gaithersburg, MD**

**Suppression, Detection and Signaling Research
and Applications Symposium (SUPDET 2016)
March 1-4, 2016**



Acknowledgement

This work is a collaborative research project with funding support from the U.S. Consumer Product Safety Commission.

Arthur Lee is the technical point of contact



Outline

- **Background**
- **Objective**
- **Experimental Details**
- **Measurements**
- **How to Present Results**
- **Schedule**
- **Smoke Box Results**
- **Summary**



Background

- The issuance of ANSI/UL 0217 Standard for Smoke Alarms (8th Ed.) introduced requirements in the form of new flaming and smoldering polyurethane foam tests, and a new cooking nuisance aerosol test.
- During the extensive development of the new test requirements, limited information was gathered on the performance of existing smoke alarms to the new proposed tests, notably,
 - The Fire Protection Research Foundation's study conducted by Jensen Hughes, and
 - The fire and cooking nuisance test development work at UL.
 - NIST studies



Background

The timeframe between now and the roll out of new smoke alarms meeting this Standard provides an opportunity to examine performance of currently available smoke alarms.



New Test Descriptions

- Smoldering Flexible Polyurethane Foam
 - Heated foam block to induce smoldering
 - Passing criterion – must alarm before 12 %/ft obscuration
- Flaming Flexible Polyurethane Foam
 - Flaming ignition of a foam block
 - Passing criterion – must alarm before 5 %/ft obscuration
- Broiled Hamburger
 - Electric Range, frozen hamburger 75/25 blend
 - Passing criterion – No alarm before 1.5 %/ft obscuration



Research Motivation

- To what extent will the new tests challenge current smoke alarm designs?
- What is the potential performance enhancement of new smoke alarm designs?
- How appropriate is a single nuisance source test in representing a broad range of cooking activities?



Objective

To gather data for a snap shot of current smoke alarm models on their performance to new UL 217/268 tests and additional cooking scenarios,

To analyze the data to answer the questions posed by the **Research Motivation** slide and

To make available the complete data set.



Experimental Details

- Experimental sources
 - Flaming foam
 - Smoldering foam
 - Broiled hamburger
 - Light toast
 - Dark toast
 - Heated cooking oil
 - Stir fry vegetables
- The cooking experiments produce mean particle sizes from $\sim 0.1\mu\text{m}$ to over $1\mu\text{m}$



Experimental Details

- 45 Alarm Models from 8 Manufacturers
 - 14 Ionization
 - 14 Photoelectric
 - 7 Ionization/Carbon Monoxide
 - 4 Photoelectric/Carbon Monoxide
 - 4 Combination Ionization/Photoelectric
 - 2 Photoelectric/Thermal
- Six units for every model, each smoke alarm checked in the smoke box with cotton wick smoke before and after experiments



Experimental Details

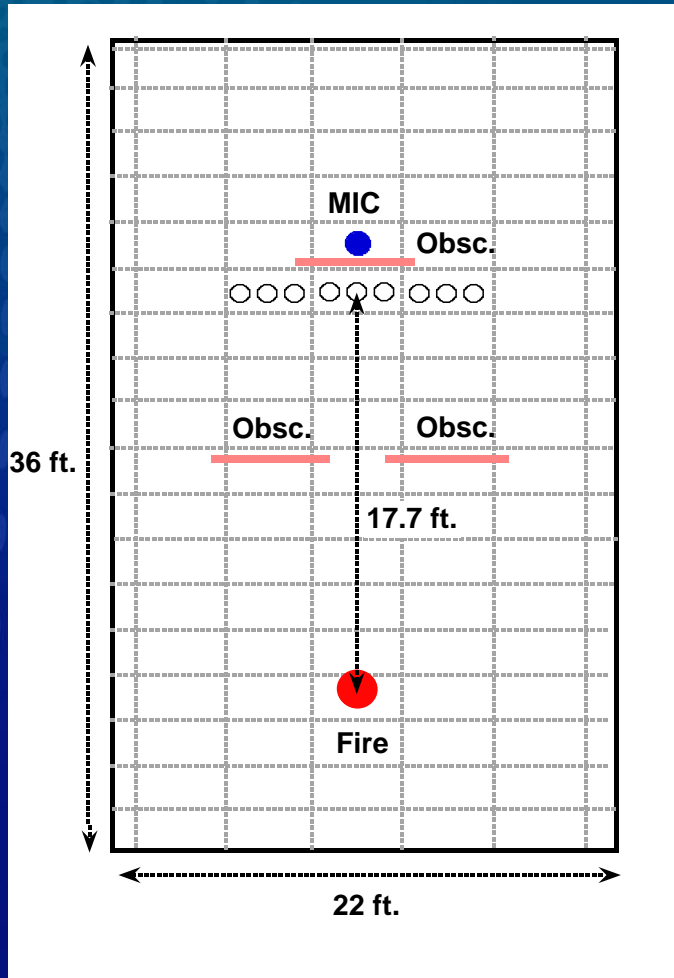
- The 45 smoke alarm models distributed to 15 test boards with three different alarms on each board
- Each fire and cooking experiment conducted three times for each set of nine alarms
- Nine smoke alarms (three test boards) per experiment, 15 (5x3) experiments per source
- The three test boards change position for each repeated experiment



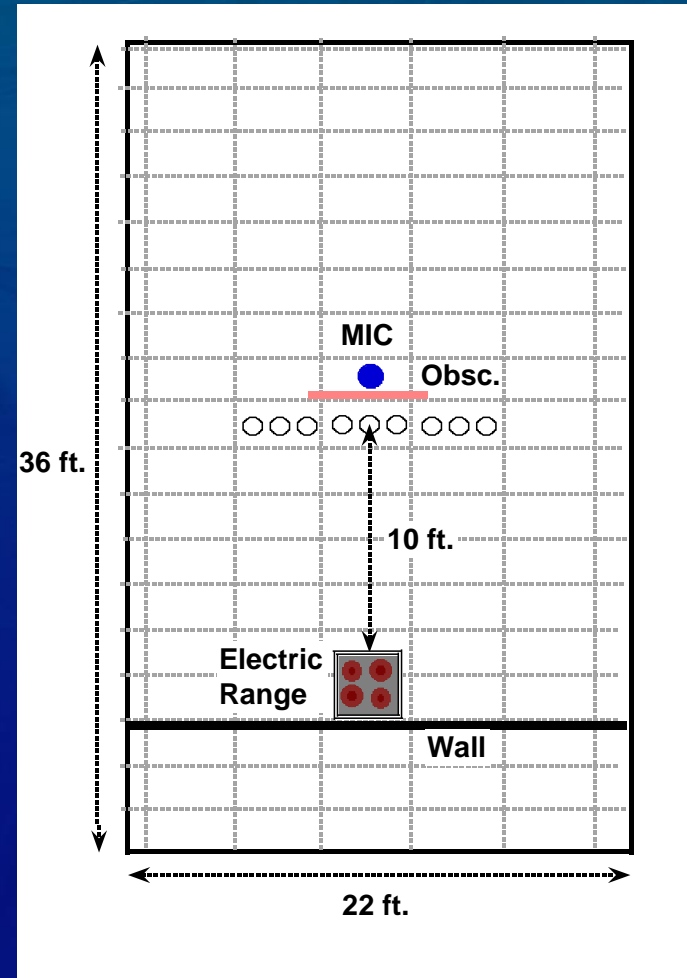
Experimental Layout

UL 217 test room in the NIST National Fire Research Laboratory

Fire Tests



Cooking Tests



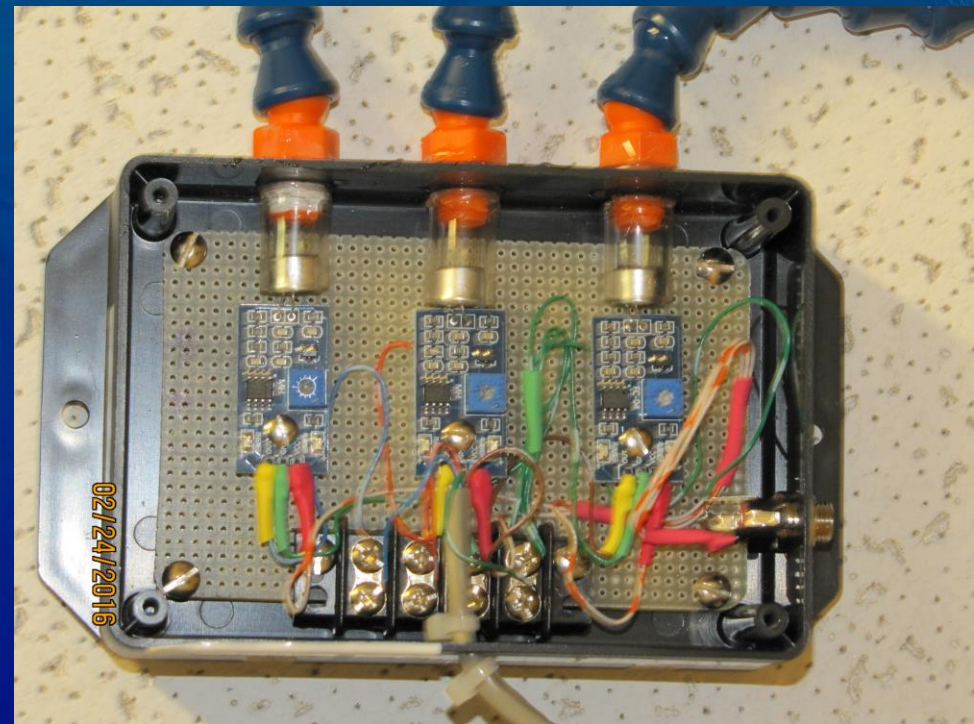
Measurements

- Time to Alarm
- Light Obscuration, MIC
- Temperature, Relative Humidity
- CO, CO₂, HCN
- Particle Size Distribution
- Light Scattering

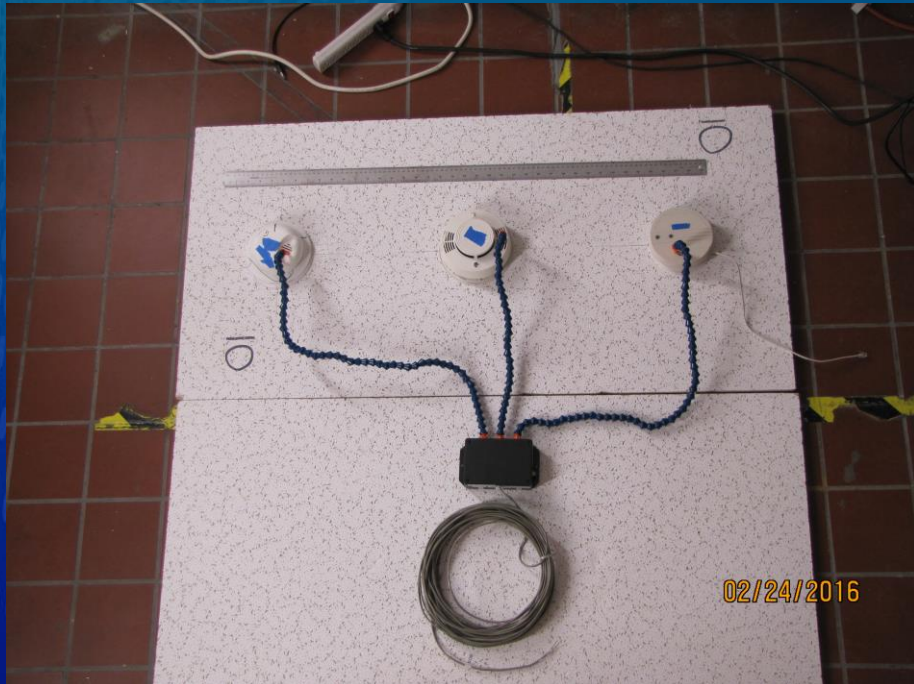


Measurements

- Recording Alarm Time
 - Horn sound directed through flex tubing to sound activated switch
 - Gain adjusted to reject background, pick up horn activation and eliminate cross-talk
 - Digital input recorded by data acquisition system



Measurements



Measurements

Particle Size Distribution

- Electrical Low Pressure Impactor
 - 0.03 μm to 10 μm
 - Data Rate 1 Hz
 - 13 stage impactor
 - Classifies size based on aerodynamic diameter
- Fast Mobility Particle Spectrometer
 - 0.0056 μm to 0.560 μm
 - Data Rate 1 Hz
 - 32 size channels
 - Classifies size based on electrical mobility diameter



Measurements

- Light Scattering Measurements using NIST Smoke Nephelometer / Aerosol Polarimeter (SNAP)
- Details in the later talk: ***Multi-angle Multi-wavelength Light Scattering of Smokes and Cooking Aerosols***
- Smoke drawn from room and directed to particle sizing instruments and SNAP



Analysis

Possible Data Presentation for New Tests

Alarm	Flaming			Smoldering			Cooking Nuisance (no alarm)		
	3%/ft	5%/ft	7%/ft	7%/ft	12%/ft	17%/ft	2.25%/ft	1.5%/ft	0.75%/ft
Ion1	P	P	P	F	F	P	F	F	F
Ion2	P	P	P	F	F	F	F	F	P
.....									
Photo1	F	F	P	P	P	P	F	P	P
Photo2	F	P	P	P	P	P	F	F	P
.....									
P/I 1	P	P	P	P	P	P	F	F	F
P/I 2	F	P	P	P	P	P	F	P	P
.....									
I/CO 1	P	P	P	F	F	P	F	F	P
I/CO 2	P	P	P	F	P	P	F	P	P
.....									
P/CO 1	F	F	P	P	P	P	F	P	P
P/CO 2	F	P	P	P	P	P	F	P	P
.....									



Analysis

Possible Data Presentation for Nuisance Sources

Alarm	Broiled Hamburger (%/ft)			Stir Fried Vegetables (%/ft)			Light Toast (MIC pA)			Dark Toast (%/ft)			Heated Cooking Oil (%/ft)		
	2.25	1.5	0.75	2.25	1.5	0.75	50	60	70	2.25	1.5	0.75	2.25	1.5	0.75
Ion1	F	F	F	F	P	P	F	F	P	F	F	F	F	F	P
Ion2	F	F	P	F	P	P	F	P	P	F	F	P	F	P	P
.....															
Photo1	F	P	P	F	F	P	P	P	P	F	P	P	F	P	P
Photo2	F	F	P	F	F	P	P	P	P	P	P	P	F	P	P
.....															
P/I 1	F	F	F	F	F	P	F	F	F	F	F	P	F	F	P
P/I 2	F	P	P	F	P	P	F	F	P	F	F	P	F	F	P
.....															
I/CO 1	F	F	P	F	P	P	F	F	P	F	F	P	F	F	P
I/CO 2	F	P	P	F	P	P	F	P	P	F	F	P	F	P	P
.....															
P/CO 1	F	P	P	F	P	P	P	P	P	F	P	P	F	P	P
P/CO 2	F	P	P	F	F	P	P	P	P	F	P	P	F	F	P
.....															



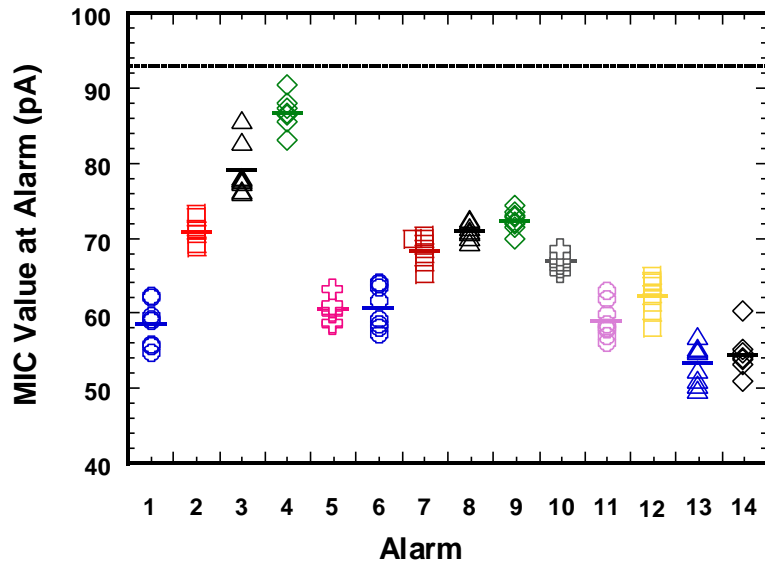
Test Schedule

- Identify and procure smoke alarms 😊
- Initial smoke box testing of each alarm 😊
- Conduct room fire and cooking experiments
- Post-test smoke box testing of each alarm
- Report with experimental data (summer 2016)

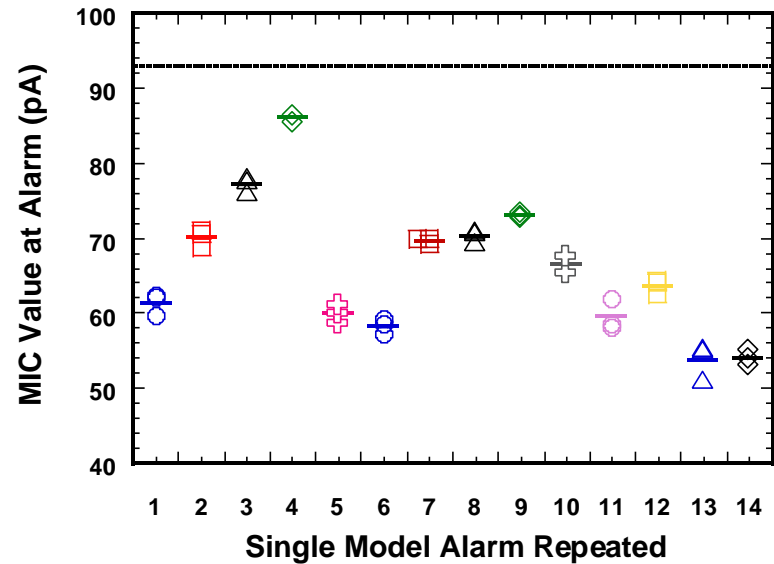


Smoke Box Results

Ionization Alarms

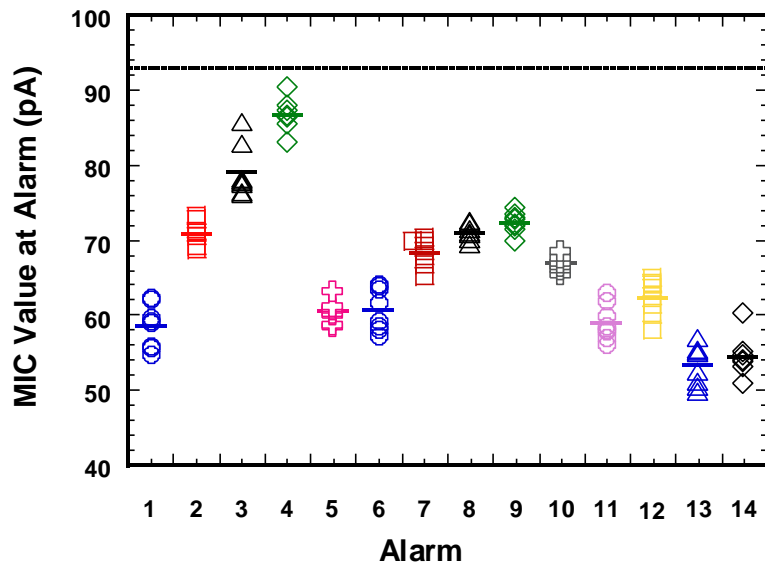


Ionization Alarms

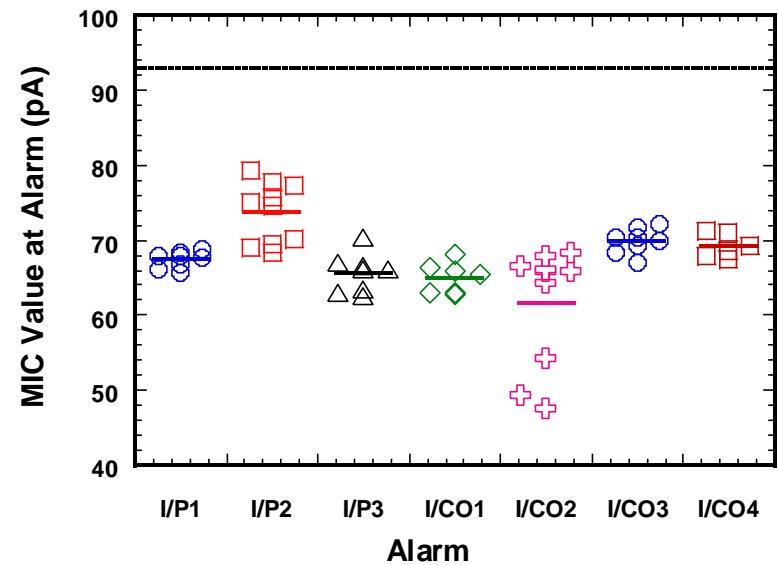


Smoke Box Results

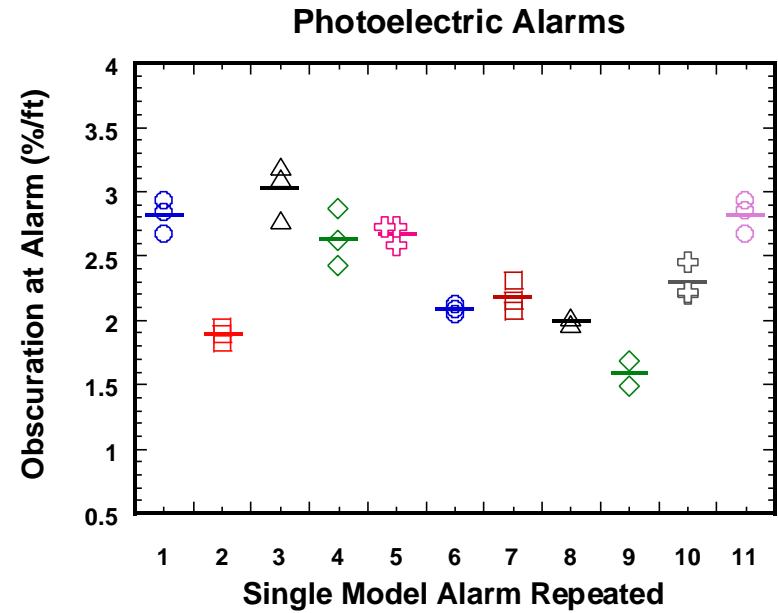
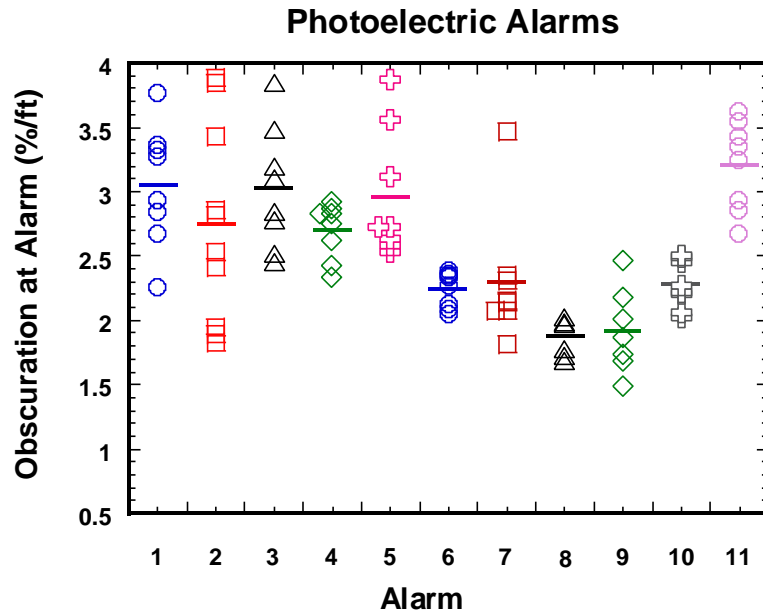
Ionization Alarms



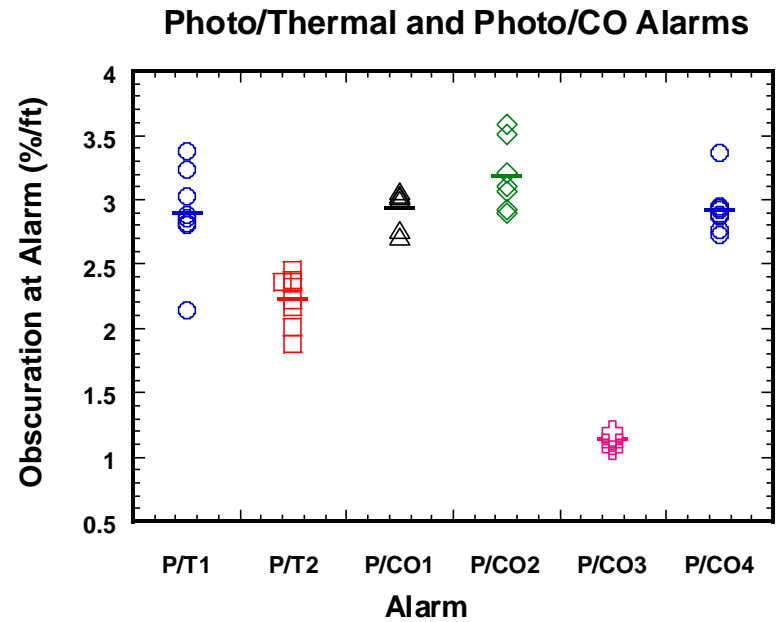
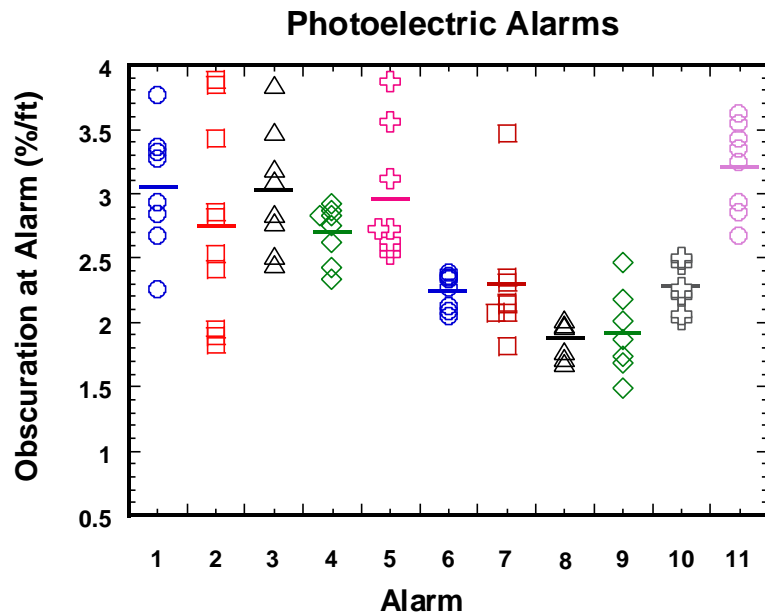
Ionization / Photoelectric and CO Combination Alarms



Smoke Box Results



Smoke Box Results



Summary

- Experiments planned to evaluate the performance of current smoke alarms to new fire tests in UL 217/268 and additional cooking scenarios.
- 45 different smoke alarm models with a fairly wide range of sensitivities
- New data will be collected on the fire and nuisance tests added to UL 217/268



What Else?

