BEYOND COOKING: SMOKE ALARM NUISANCE SOURCES EVALUATED

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INTRODUCTION

RESIDENTIAL SMOKE ALARM NUISANCES

- Background and Previous Work
- Changes to Standard Tests – Cooking Source
- Water Mist Nuisance Source
- Contamination From Dust
- Conclusion & Questions

PREVIOUS WORK

LITERATURE REVIEW CONDUCTED FOR FPRF (2014 [1])

- Phase 1 Literature Review
  - Fire loss statistics
  - Household surveys
  - Experimental test data
- Identified gaps to creation of standard
  - Quantify impact of nuisance resistant devices
  - Standardize test space (size of room, exhaust, etc.)
  - Characterize nuisance particulate and compare to real fire particulate
  - Characterize non-cooking nuisance particulate
  - Define standard tests and device evaluation criteria

- Scope of nuisance problem
- Identified common sources
- Basic characteristics of particulate and detection

PREVIOUS WORK

NUISANCE SOURCE PARTICLE CHARACTERIZATION (FPRF 2015 [2])


- Phase 2 Experiments
  - Cooking
  - Water Mist
  - Standard Fire Sources
- Compared particulate and alarm responses between nuisances and real fire sources
  - More ionization response (MIC) than obscuration response for cooking
  - Cooking particulate smaller than standard fire particulate
  - Both photoelectric and ionization alarms responded to normal cooking
    - Ionization smoke alarms more likely to respond to cooking at same distance
    - Toast – Ionization response within 10 ft only
    - Broiling – Ionization response within 20 ft only
    - Frying – Both photoelectric and ionization response

BACKGROUND

REQUIREMENT FOR HOUSEHOLD SMOKE ALARMS/DETECTORS

- **NFPA 72 (2016) 29.7.3 Resistance to Nuisance Source**. Effective January 1, 2019, smoke alarms and smoke detectors used in household fire alarm systems shall be listed for resistance to common nuisance sources [3].

- **UL 217, Standard for Smoke Alarms [4]**, amended to include a test for resistance to a standardized cooking nuisance source
  - Broiling hamburgers
    - Selected as representative for both small and large particle source
    - Tested by UL and JENSEN HUGHES
  - No alarm activation < 1.5 %/ft obscuration

NUISANCE ALARM PROBLEM

Up to ~1200 annual deaths could potentially be affected by eliminating nuisance alarms (deaths with missing/disconnected alarms)

Related Statistical Observations:

- 14% of people would disable an alarm due to nuisances [5]
- 25% increase in non-functional alarms in kitchens compared to rest of home [6]
- 2.5% of people disable alarms because of nuisances, while 17% of all alarms not functional [7]
- Among non-functional alarms, 70% disconnected power, 16% physically removed alarm [8]
- Battery lifetime and hush features increase likelihood of alarms remaining operational [9,10]
- 15% of alarms have missing/disconnected batteries (4.8% removed due to nuisance, 4.5% forgot to replace battery) [11]
- 59% of failed alarms are disconnected and 28% of disconnected alarms had nuisance problems [12]

OTHER NUISANCE SOURCES

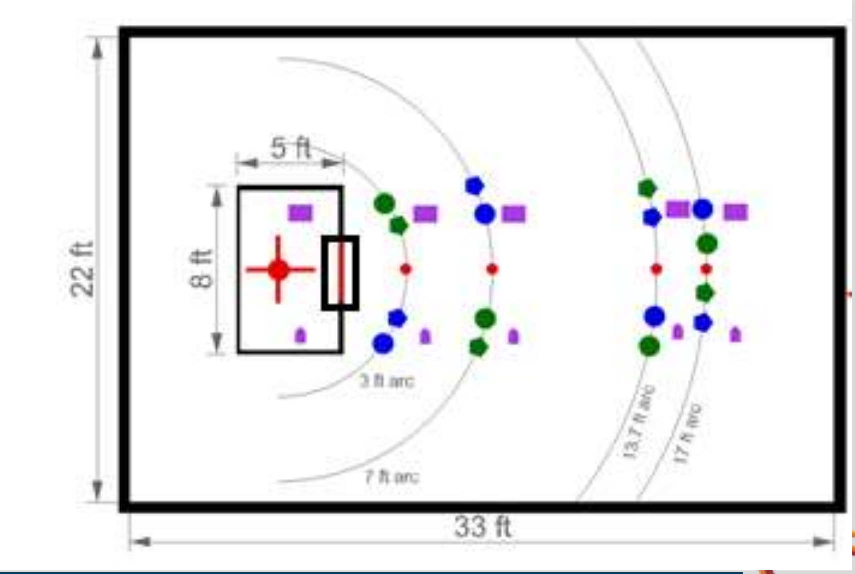
COOKING NUISANCES ARE NOT THE WHOLE PROBLEM

- Current test method only evaluates resistance to cooking type nuisances
  - Cooking responsible for 30-90% of nuisances reported in surveys and studies [12,13]
  - Up to 70% of alarms installed in kitchens were disabled in CDC 10 year smoke alarm study [6]
- Water mist from showers caused 40% of the nuisances reported in study of 595 distributed and installed alarms [7]
- Long term exposure to dust or cigarette smoke creates contamination correlated to increases in nuisance alarms [8, 14]
  - Nuisance occurrences of 57%, 71% and 80% for homes with 0, 1, or 2 smokers, respectively [8]
  - 33 alarms with nuisance problems collected by CPSC [12]
    - 1/3 were excessively dirty
    - 3 with broken covers allowing additional infiltration

WATER MIST TESTING

ENCLOSED SHOWER BUILT IN LARGE ROOM [2]

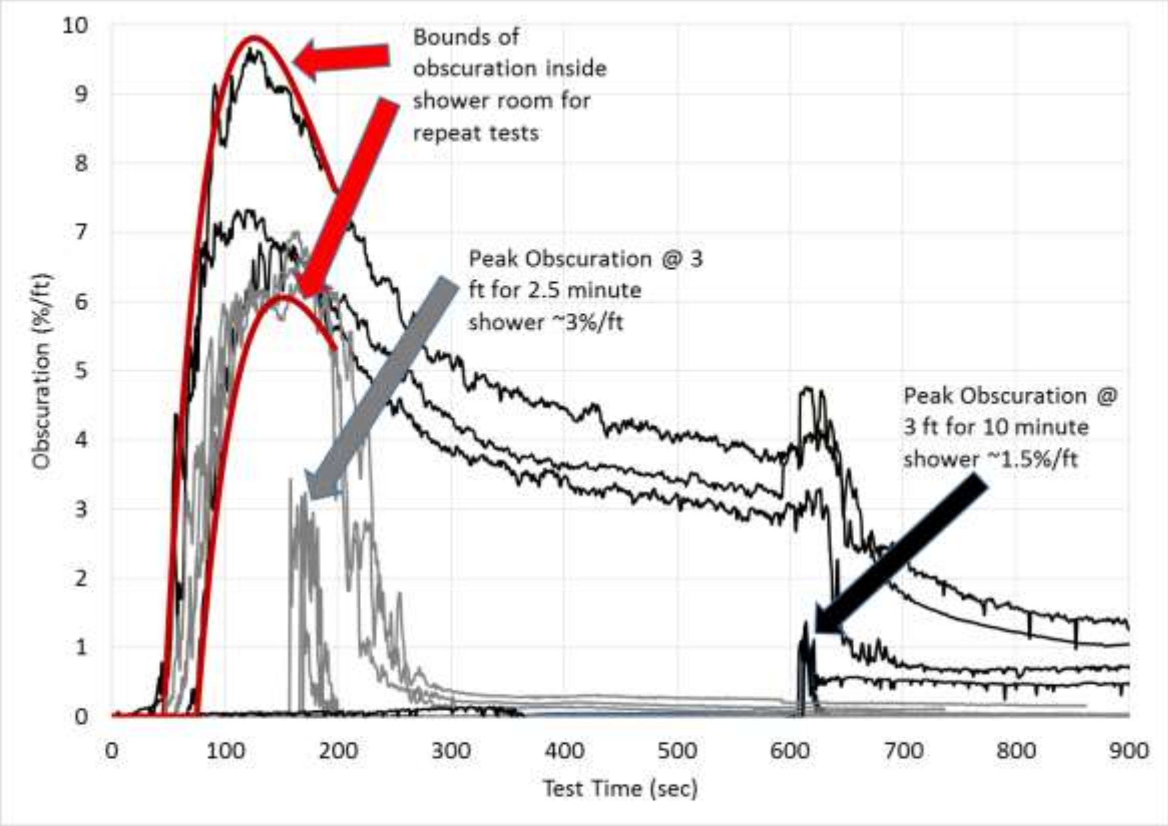
- Sliding door gives even exposure across alarm arc
- Alarms 3, 7, 14, and 17 ft from door
- Measured obscuration and air temperature



WATER MIST TESTING

OBSCURATION PEAK AND DECAY

- Peak after 2-3 minutes
- Conducted 10 minute and 2.5 minute shower tests



WATER MIST TESTING

DETECTION RESPONSE

- Obscuration levels in space decreased with length of shower
  - Likely heat capacity/transfer, air saturation, droplet interaction
  - Greatest detection response when door opened after 2.5 min

- Photoelectric alarm/detector response only
  - At 3 ft location for 10 minute showers
  - At 3 and 7 ft locations for 2.5 minute showers

3 ft distance

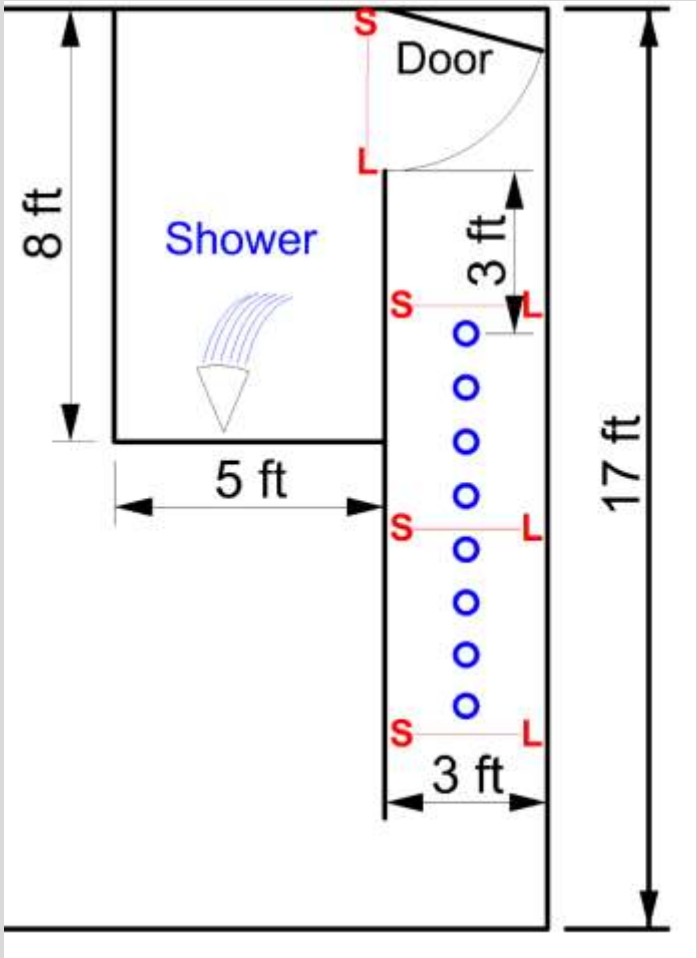
7 ft distance

Sliding Door

WATER MIST TESTING

CLOSED BATHROOM WITH SWINGING DOOR AND CORRIDOR

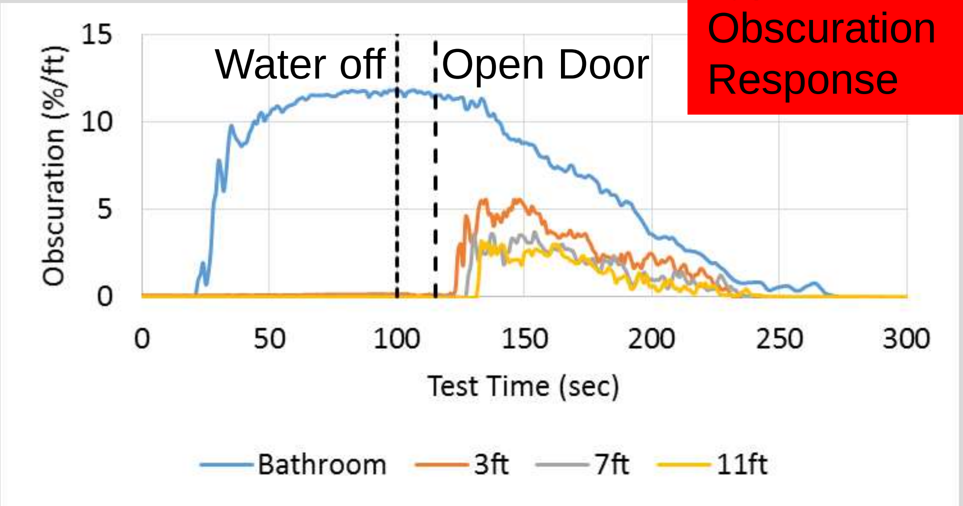
- Alarms installed at 1 ft spacing down center of hallway
  - 3 ft from door out to 10 ft
  - Optical density meters installed in hallway
- Multiple alarm types tested in each installation location
  - Photoelectric
  - Ionization
  - Combination photo/ion
  - Dual wavelength photoelectric



WATER MIST TESTING

CLOSED BATHROOM WITH SWINGING DOOR AND CORRIDOR

- Shower run 100 seconds, door opened 15 sec later
  - Short shower produced higher obscuration
  - Same result as plastic test space in previous testing
- Peak obscuration levels (average ± standard deviation)
  - Bathroom – 10.2 ± 1.9 %/ft
  - 3ft – 4.4 ± 1.4 %/ft
  - 7ft – 2.9 ± 1.0 %/ft
  - 11ft – 2.6 ± 0.9 %/ft



Typical Obscuration Response

WATER MIST TESTING

ALARM RESPONSES

- Photoelectric
  - 3 devices
  - All alarm out to 10ft distance
- Dual wave photo
  - 2 devices
  - No responses
- Ionization
  - 3 devices
  - No responses
- Photo/Ion
  - 3 devices
  - 1 of 3 alarmed to 10ft distance
  - Other 2 – no responses

Alarm Response
Y – Yes
N - No

Device Type	ID	Distance (ft)							
		3	4	5	6	7	8	9	10
Photoelectric	A	Y	Y	Y	Y	Y	Y	Y	Y
	B	Y	Y	Y	Y	Y	Y	Y	Y
	C	Y	Y	Y	Y	Y	Y	Y	Y
Dual wave photo	A	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N
Ionization	A	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N
Photo/Ion	A	Y	Y	Y	Y	Y	Y	Y	Y
	B	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N

DUST CONTAMINATION

LONG TERM BUILDUP

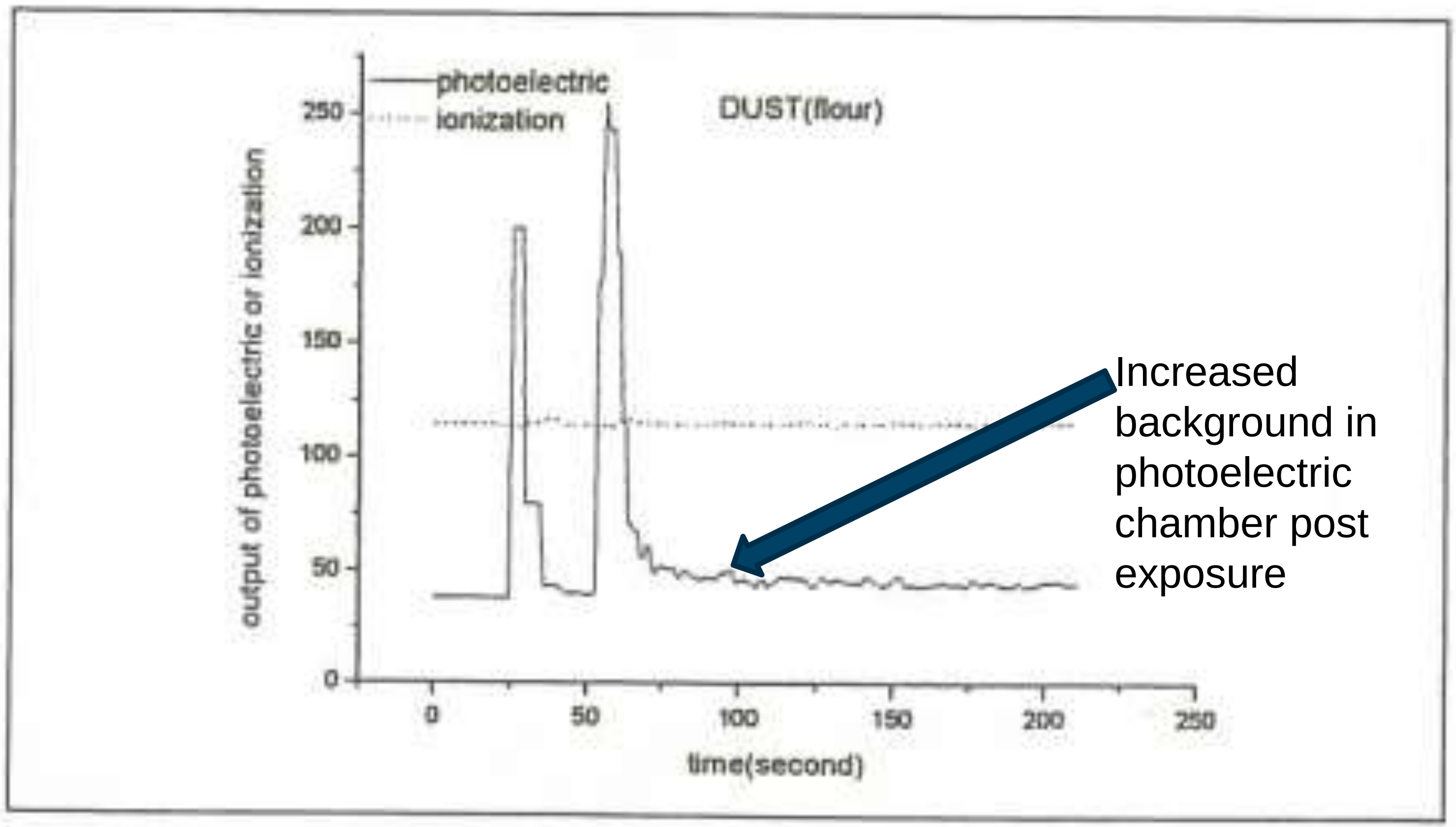
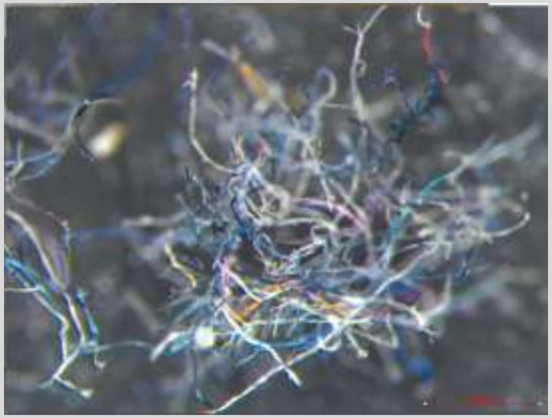


Figure 6. Outputs of smoke detectors due to dust (flour). [15]

DUST CONTAMINATION

LONG TERM BUILDUP

- Most testing conducted with non-representative household sources
  - Road dust
  - Cement
  - Loess
  - Gypsum
  - Flour

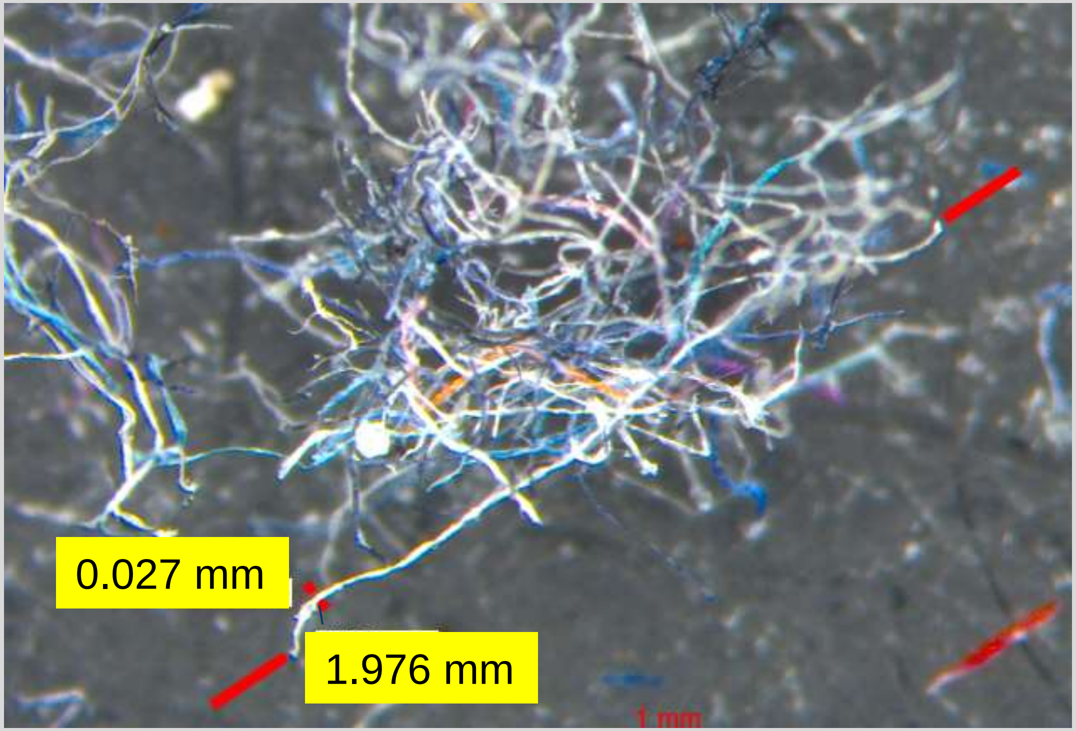


- Dryer lint or vacuum cleaner dust more representative
  - Long fiber lint
    - Long and thin shape profile
    - Cling readily to plastics and metals
  - Observed to cause nuisance/malfunction in hotels where daily vacuum and linens changes occur [17]

DUST SOURCES EXPLORED

DRYER LINT

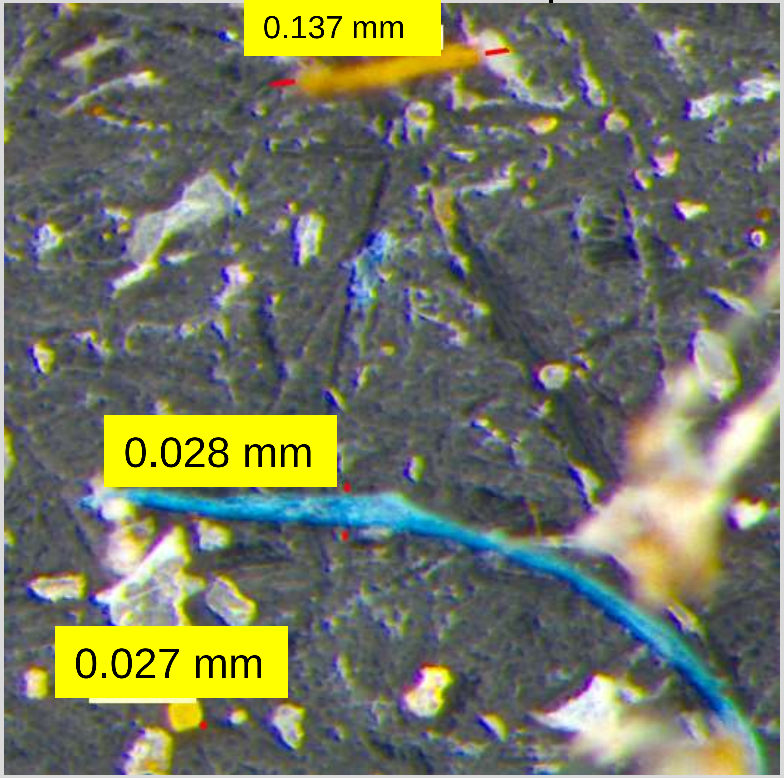
- Up to 1-2 mm long
- Less than 0.03 mm wide
- Many colors of fibers



DUST SOURCES EXPLORED

VACUUM CLEANER DUST

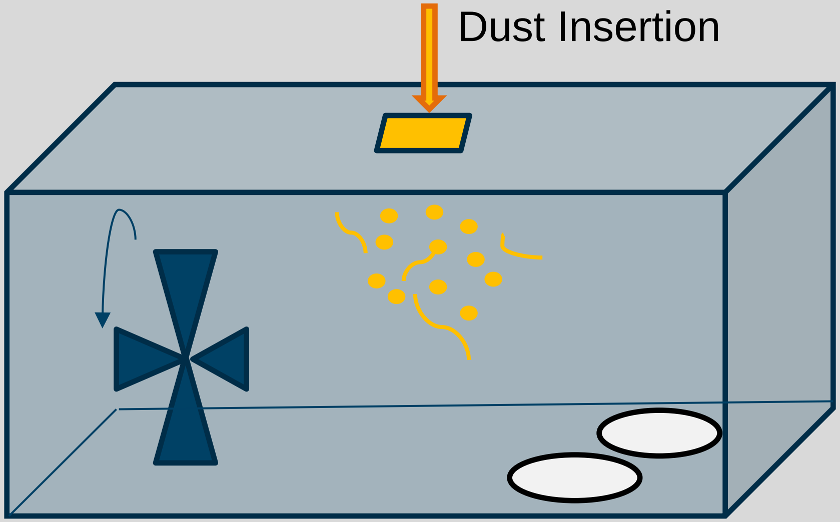
- Assortment of sizes and materials
  - Clothing, skin, dirt, hair
  - Collected without pet hair



DUST EXPOSURE

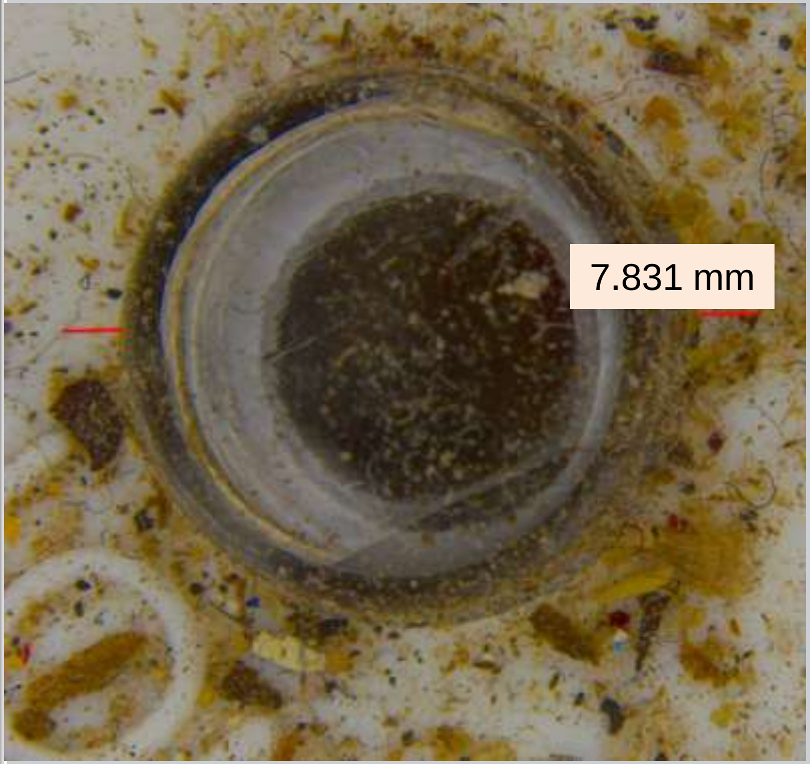
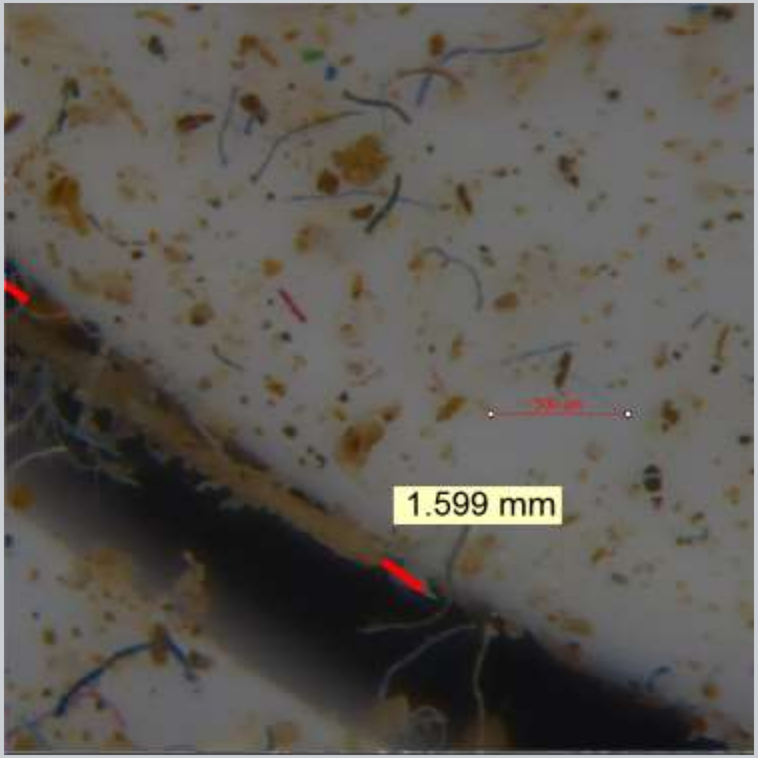
VACUUM DUST AND DRYER LINT EXPOSURE

- 15.5 x 22.5 x 12.5 inch box
- 75-100 fpm air velocity at alarms
- Add 1.0 g shredded dryer lint, 9.0 g shredded vacuum dust
- Recycle collected dust, ~4 hour exposure
- Photo alarm twice during exposure



DUST EXPOSURE

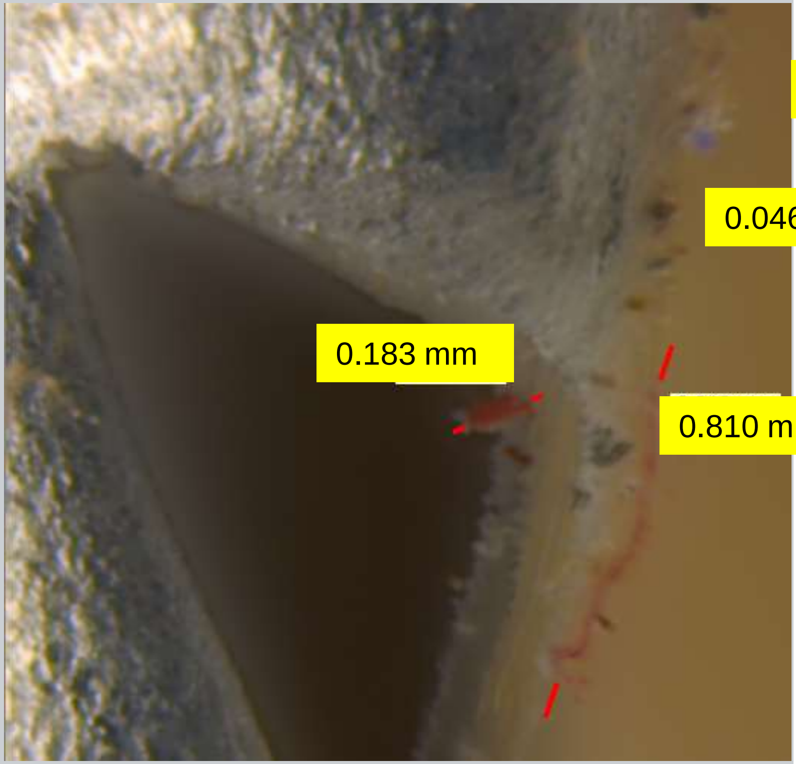
EXTERNAL CONTAMINATION

Ionization	Photoelectric
	

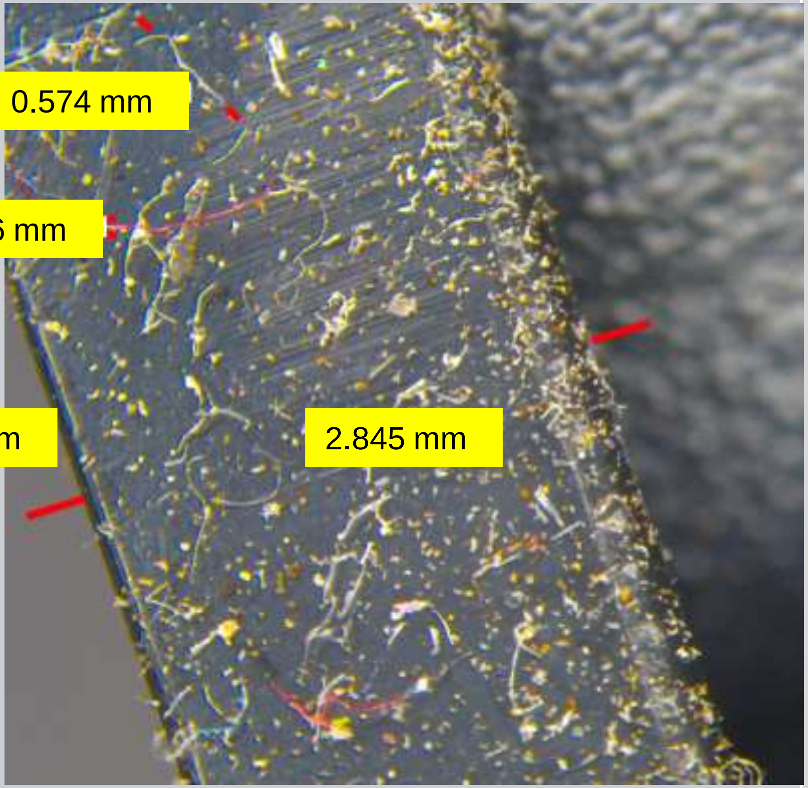
DUST EXPOSURE

CHAMBER SURFACE CONTAMINATION

Ionization

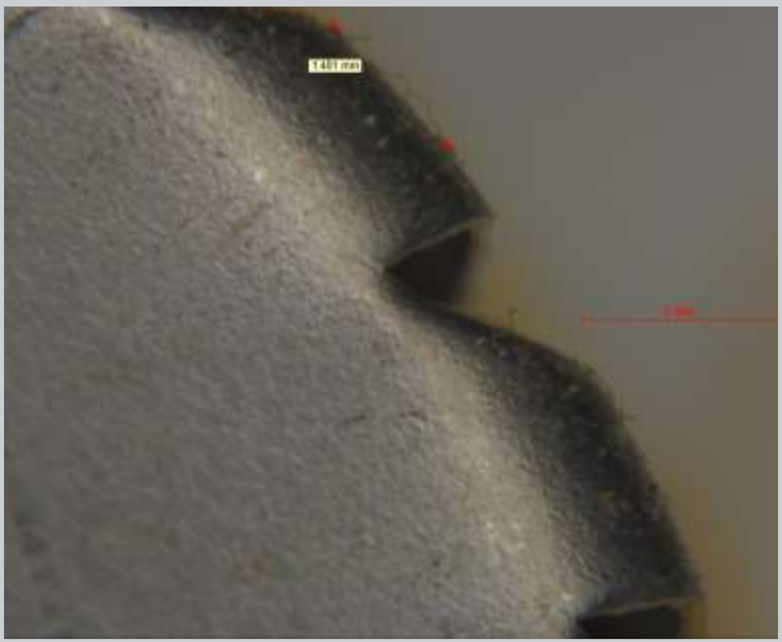
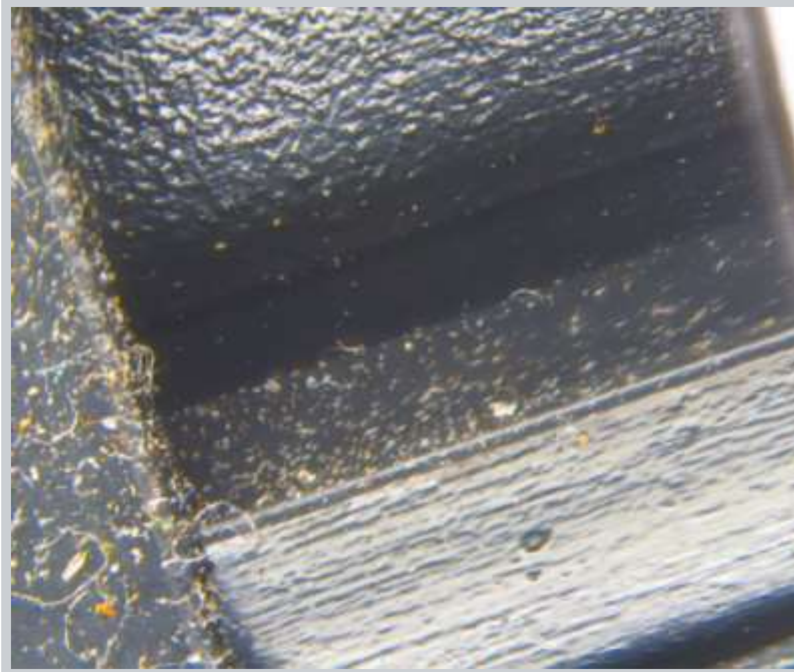


Photoelectric



DUST EXPOSURE

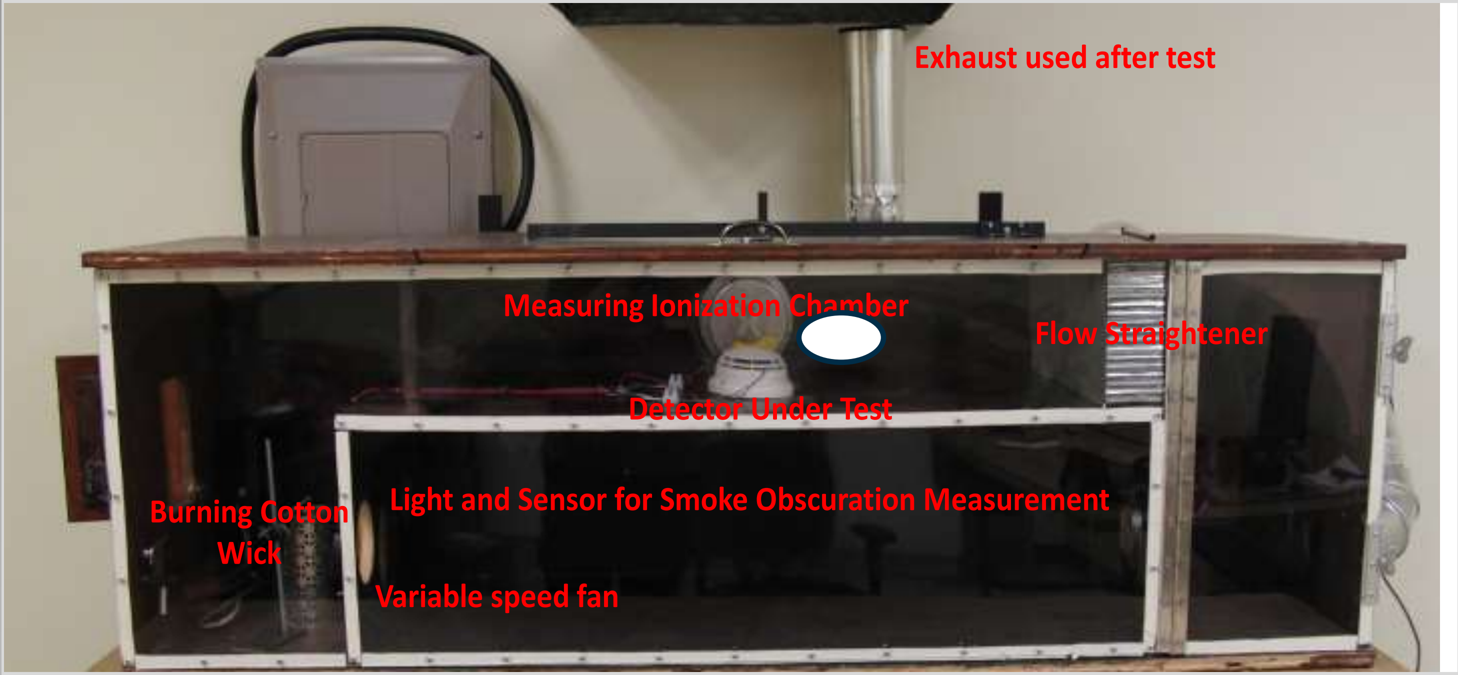
CHAMBER SURFACE CONTAMINATION

Ionization	Photoelectric
	

SENSITIVITY TESTING

SMOKE BOX

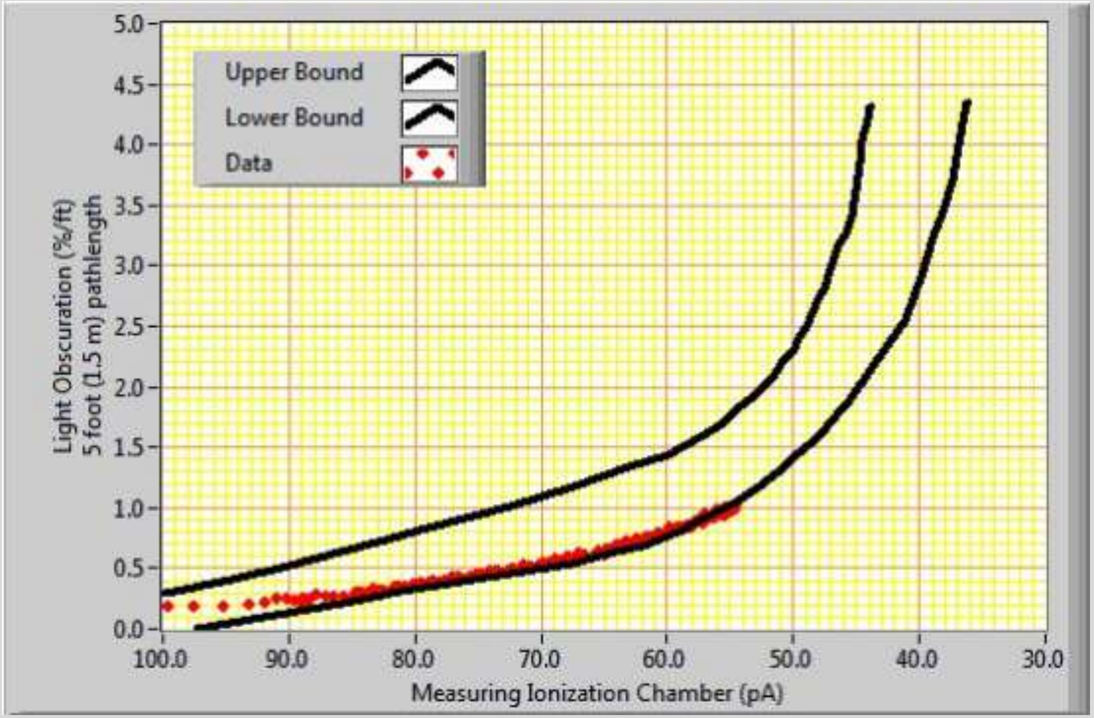
- Smoldering cotton wick recirculated smoke
- Standard alarm sensitivity testing method
- Pre and post dust exposure testing



SENSITIVITY TESTING

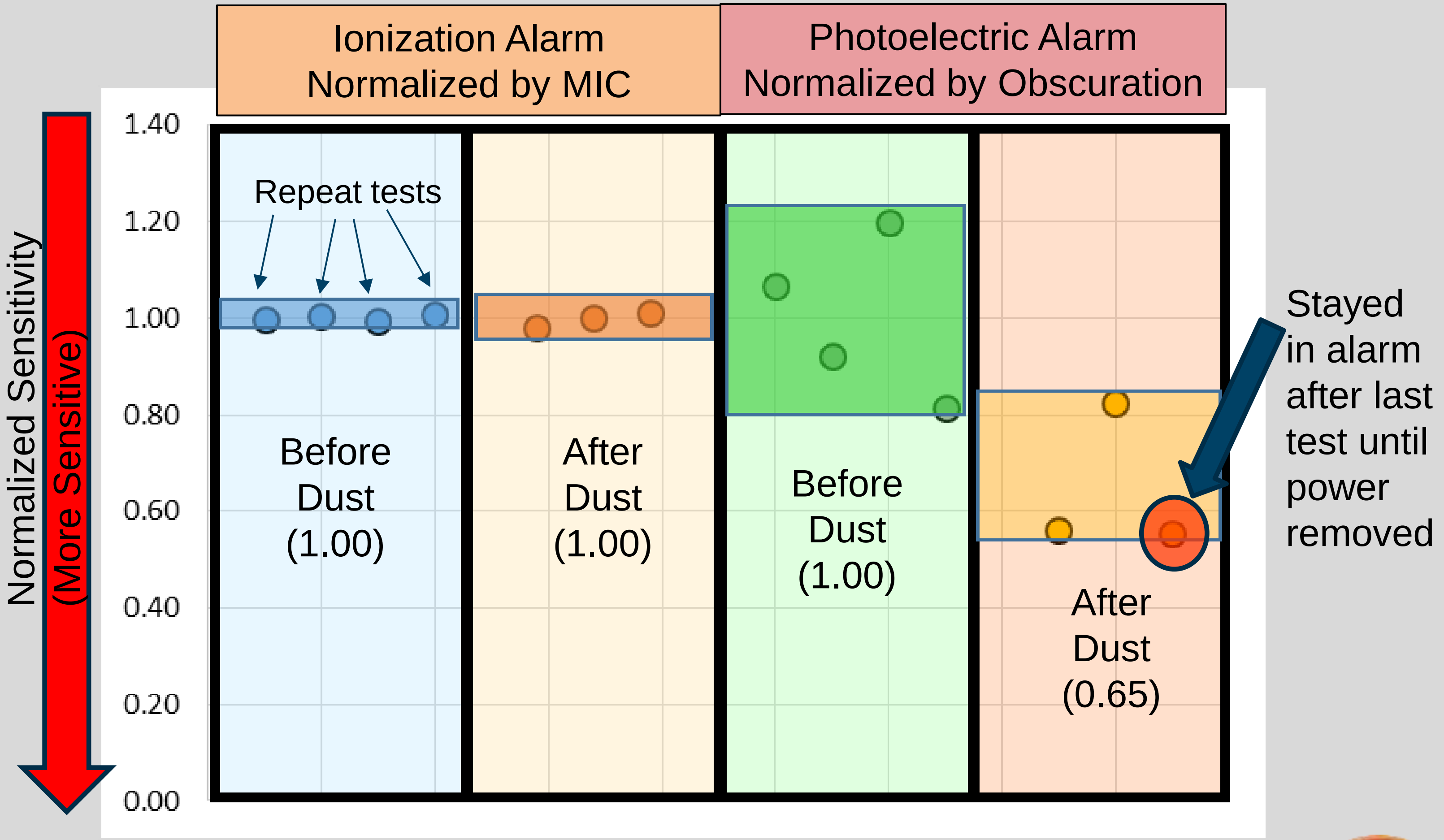
SMOKE BOX

- Smoke measured by obscuration and measuring ionization chamber (MIC)
- Must follow defined profile



DUST EXPOSURE

SENSITIVITY SHIFT



CONCLUSIONS

WATER MIST

- Some devices alarmed at all distances in corridor
  - 3ft spacing is insufficient to prevent problem
  - >2.5 %/ft obscuration at 10 ft distance
- Only devices with photoelectric sensors responded to water mist
  - All photoelectric only devices
  - 1/3 photo/ion combos
  - No dual wavelength photos
  - No ionization only
- Alarms are brief, 2-3 beep cycles

CONCLUSIONS

DUST CONTAMINATION

- Long fiber dryer lint and vacuum dust (no pet hair) tested
- Dust was able to penetrate the alarm covers and collect on the outside of the detection chambers
  - Dust was very clingy to surfaces
  - Fibrous shape and static
- Photoelectric alarm ~35% more sensitive to post exposure smoke test obscuration
  - Alarm twice during exposure testing
  - Stayed in alarm after final smoke test until power removed
- Ionization alarm response appeared unaffected

- Long term collection of dust inside detection chambers likely contributes to residential nuisance alarm problem
  - Resistance test may be warranted
  - Further study needed
  - Buildup of cooking aerosols

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QUESTIONS?

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