Smoke Alarms and Detectors
UL Standards For Safety –
UL 217 and UL 268

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Agenda

March 26, 2019

1. Introductions and a bit of history
2. How did we get here?
   - Fire science community research efforts
   - The value of field data
   - The modern fire environment
3. Enhancements to UL 217 and UL 268
4. Is a smoke alarm really smart?
5. Working together for a safer world

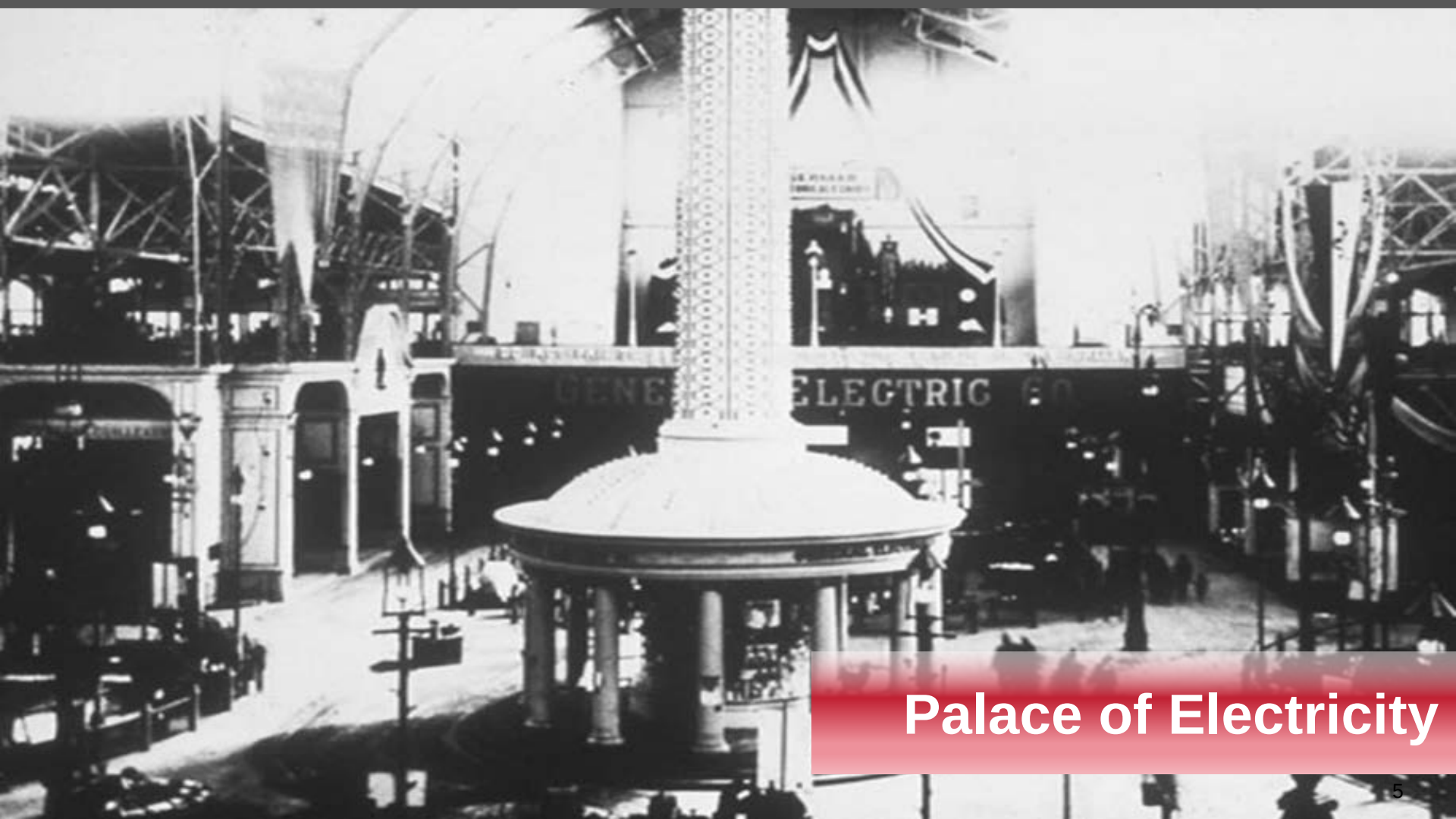
UL’s Founder William Henry Merrill

William Henry Merrill

1866-1923

He was a skilled and highly trained Boston electrical inspector hired by the Chicago Underwriters Bureau to resolve problems with automatic fire alarms in the city of Chicago in 1893.

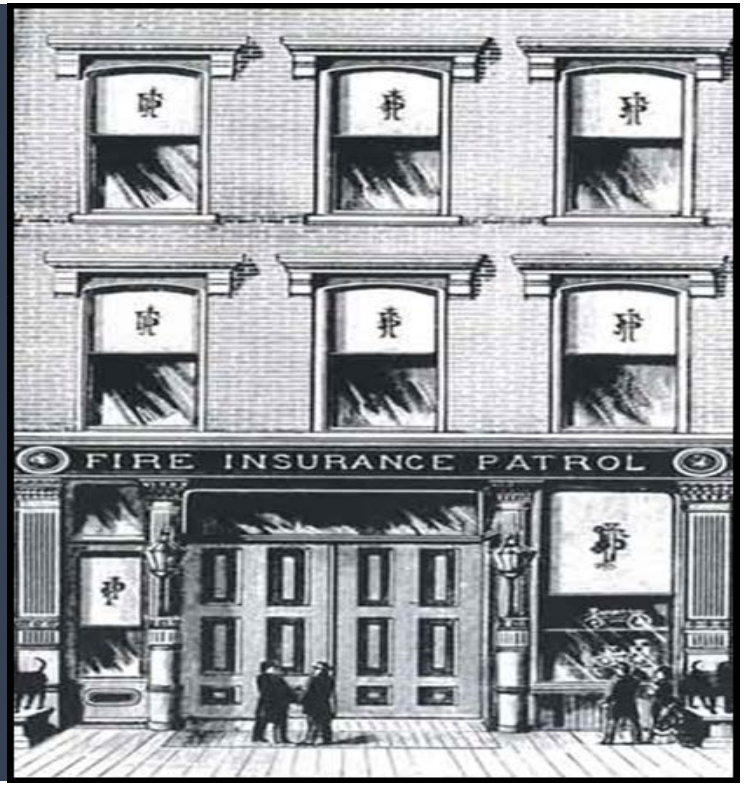
1893 Chicago World's Fair



Palace of Electricity

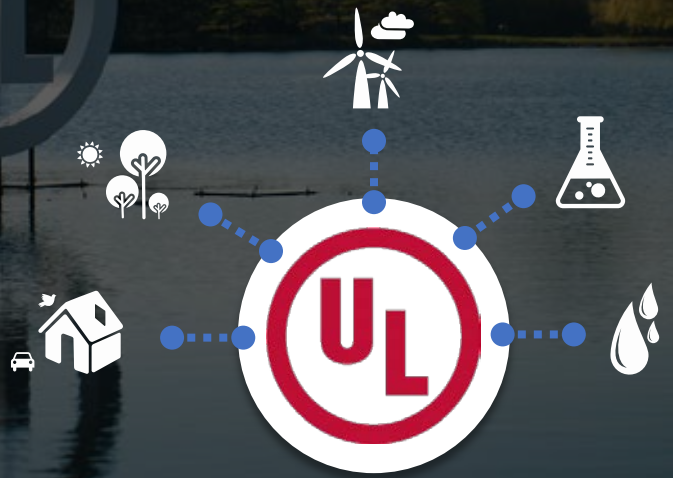
Underwriters Electrical Bureau - 1894

The location was a small one room laboratory above Fire Patrol Station #1 on Monroe St. in downtown Chicago, IL.



Underwriters Laboratories

To promote safe living and working environments through the application of safety science and hazard-based safety engineering.



Empowering Trust™

UL operates in more than

143

COUNTRIES

and across more than

20

INDUSTRIES

UL HAS ENHANCED TRANSACTION SECURITY FOR:

500+ banks

20+ payment schemes

60+ mobile network operators

50+ governments/ transport operators

UL has helped to set

MORE THAN

1,600

standards defining safety, security, quality and sustainability

Science and global expertise

UL software is used by

10,000+

ORGANIZATIONS *in*

OVER 10 INDUSTRIES

UL'S SUSTAINABILITY CERTIFICATIONS are referenced in

900+

sustainable product specifications or purchasing guidelines around the globe

UL SERVES

1 OUT OF **3**

Fortune 500 companies

WORKING FOR A
SAFER WORLD
since **1894**

UL reaches more than
1 BILLION

GLOBAL CONSUMERS
annually with safety messages

88%
of U.S. BUILT ENVIRONMENT AUTHORITIES trust and accept the UL Mark

Brand presence and leadership

UL *has supported a*
CENTURY OF INNOVATION
from electricity to nanotechnology

UL MARKS APPEAR on more than
22 BILLION
products *globally*

3 OUT OF **4**

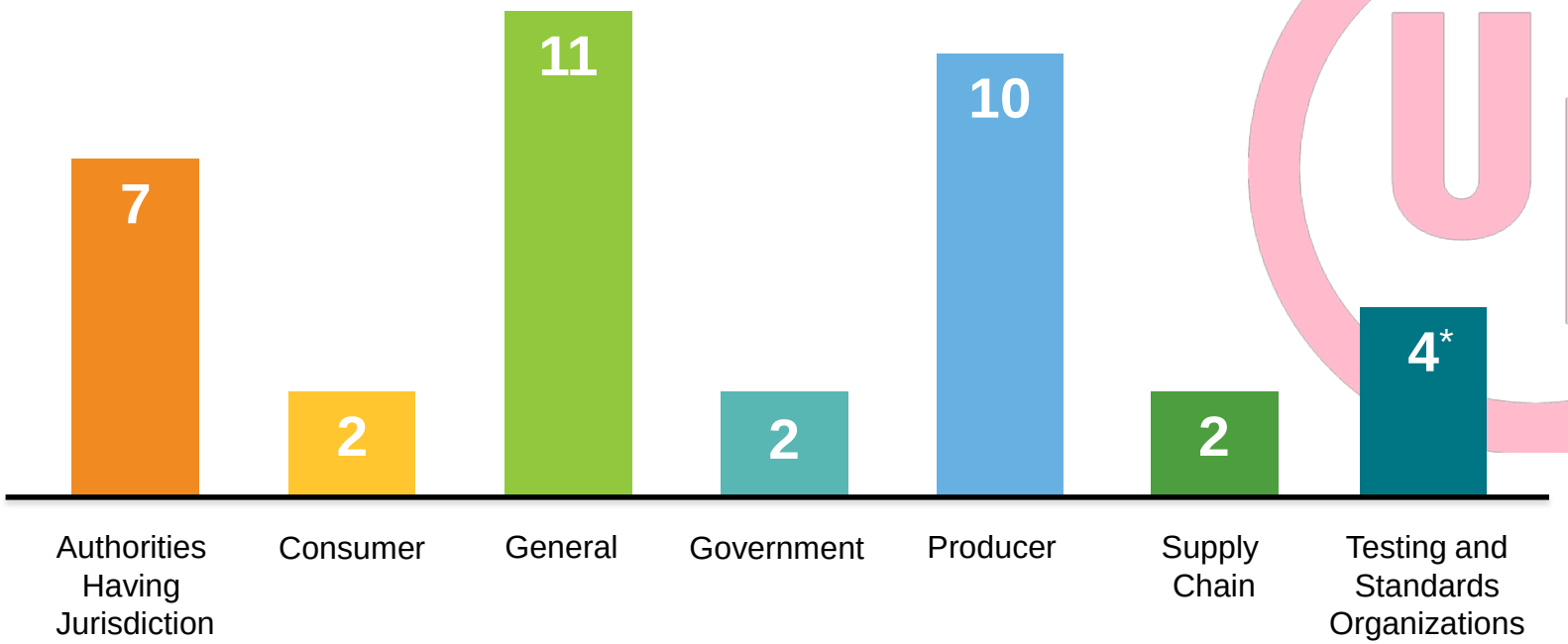
U.S. consumers are
FAMILIAR with **THE UL MARK**

UL WORKS TO PROTECT THE MARKET FROM COUNTERFEIT GOODS from life jackets to hoverboards, *we assisted in seizures of more than* **2.2 MILLION PRODUCTS** bearing a counterfeit UL Mark

UL Standards Technical Panel (STP)

- Consensus-based process
- Diverse representation

NUMBER OF VOTING SEATS HELD



*UL holds one voting seat in this category
A full list of roster members is publicly available at this link: http://csds.ul.com/STPinfo/Roster_list.aspx

Empowering Trust™

How Did We Get Here?

NBS GCR 75-51

Titled – Detector Sensitivity and Siting Requirements For Dwellings

- ✓ Commonly referred to as the “Dunes Study”
- ✓ Conducted in 1975 - 1976
- ✓ Some Key Conclusions

Helped shape the fire science communities understanding related to

- smoke alarm performance

and

- escape time needed during fires

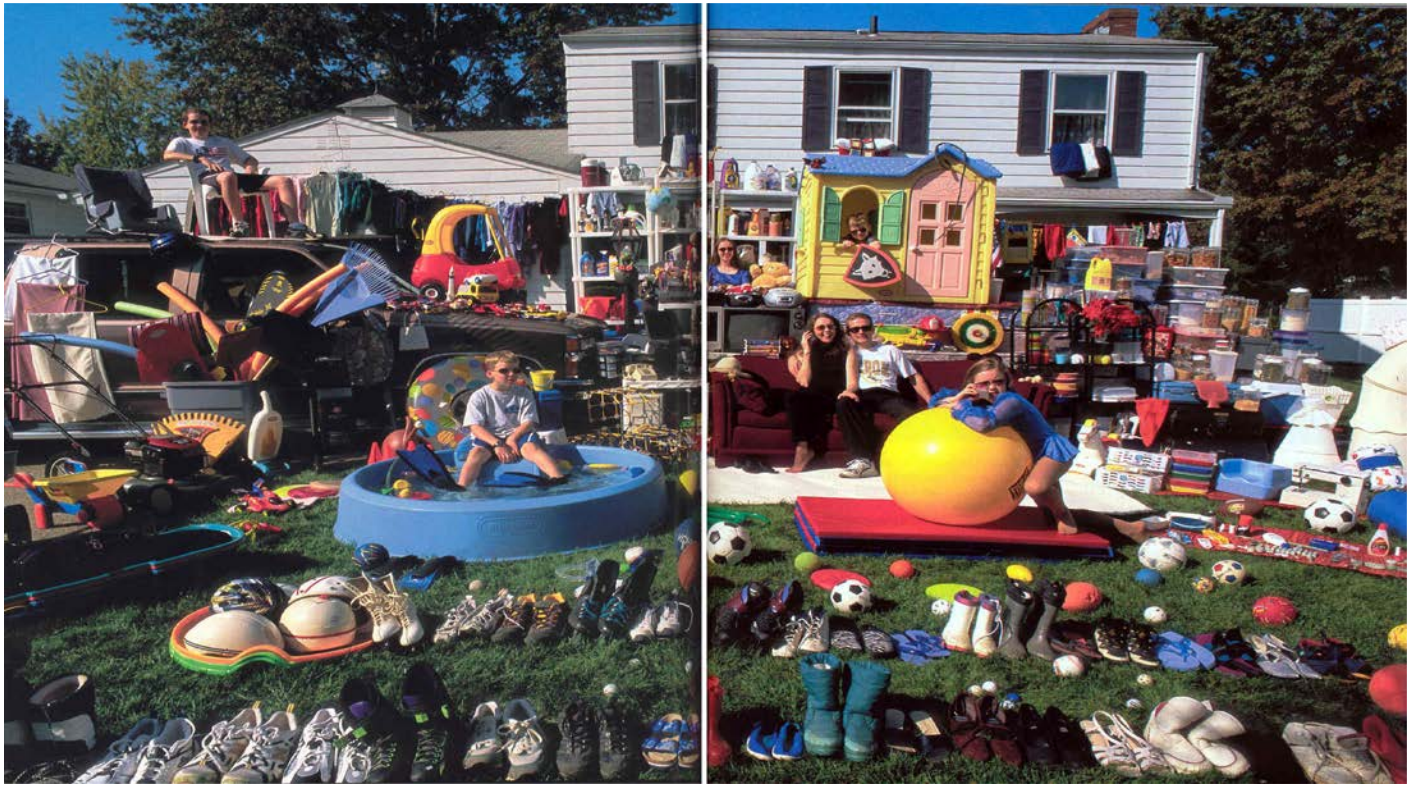
NIST Technical Note 1455-1

Titled - Performance of Home Smoke Alarms, Analysis of the Response of Several Available Technologies in Residential Fire Settings

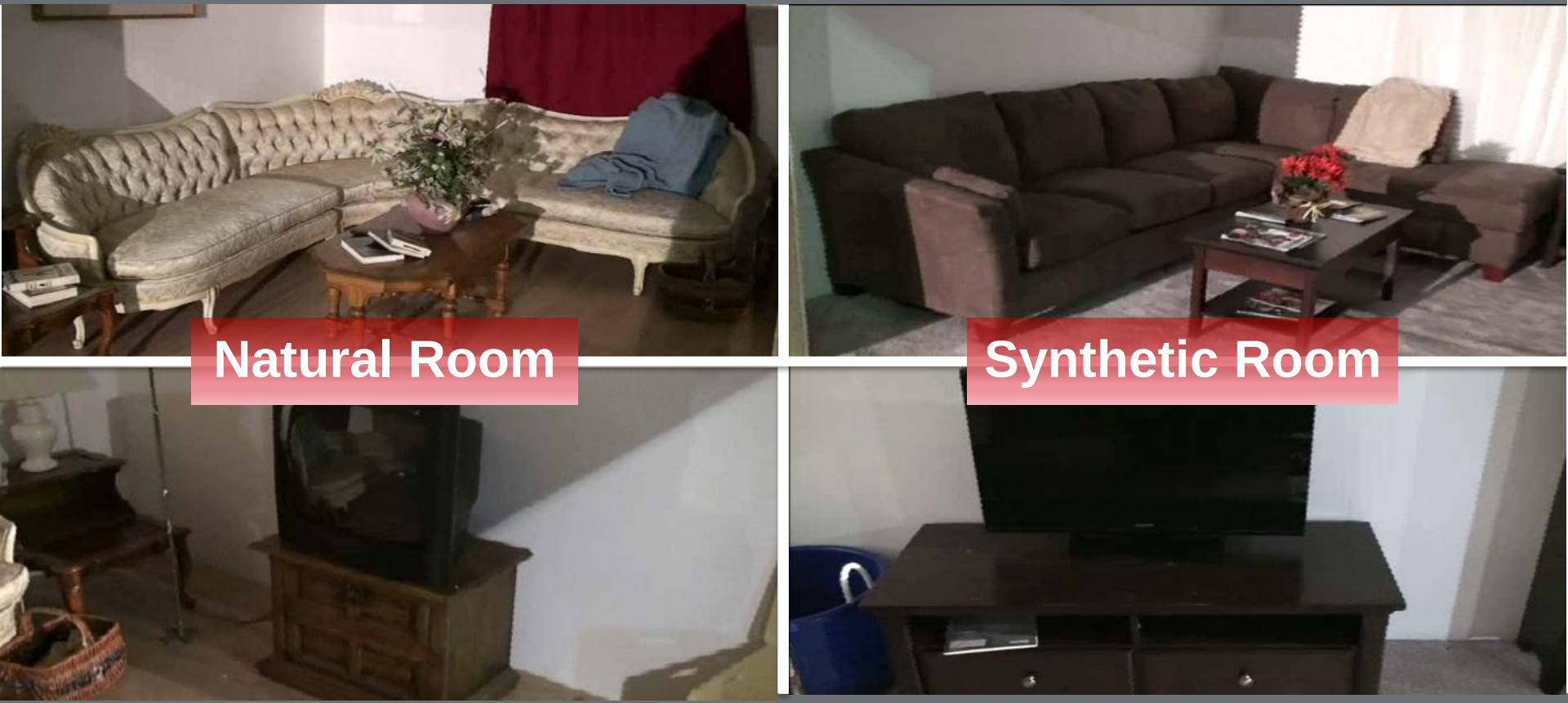
- ✓ Commonly referred to as the “Dunes II Study”
- ✓ Some Key Conclusions

1. Smoke alarms to be installed in every bedroom and every level of the home
2. Bedroom doors should be closed when sleeping
3. Recommended the use of multiple station smoke alarms
4. Reduction in escape times
5. Additional research was needed to understand the fuel sources that were causing the reduced escape times.

Higher Fuel Loads



Increased Fuel Loads - Experiment



Comparison of Room Furnishings

Natural Room

Synthetic Room

00:00

Changing Fire Dynamics

1978

approx
17 min

Natural materials and furnishing

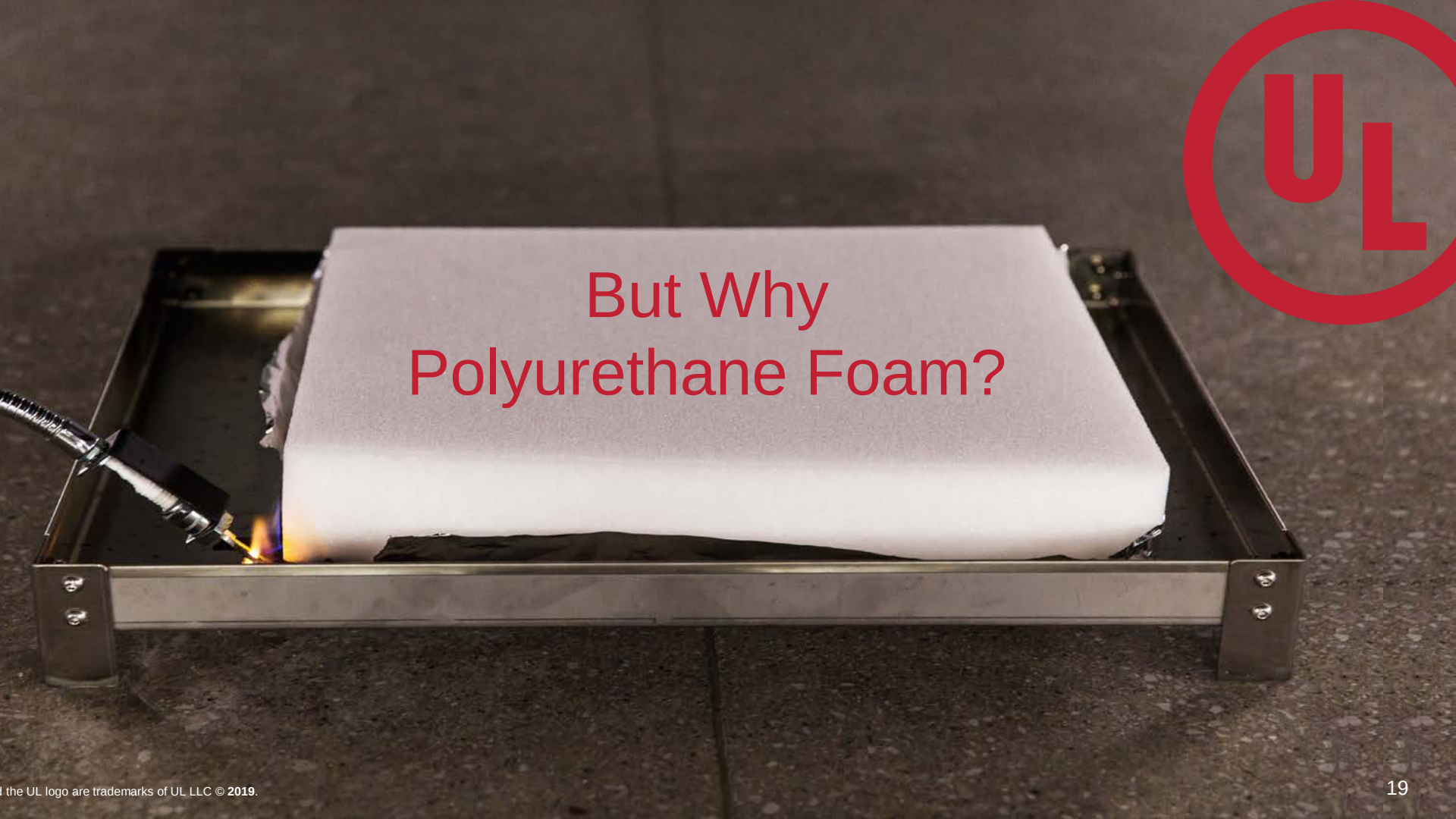
2018

approx
3 min

Synthetic materials and open floor plans

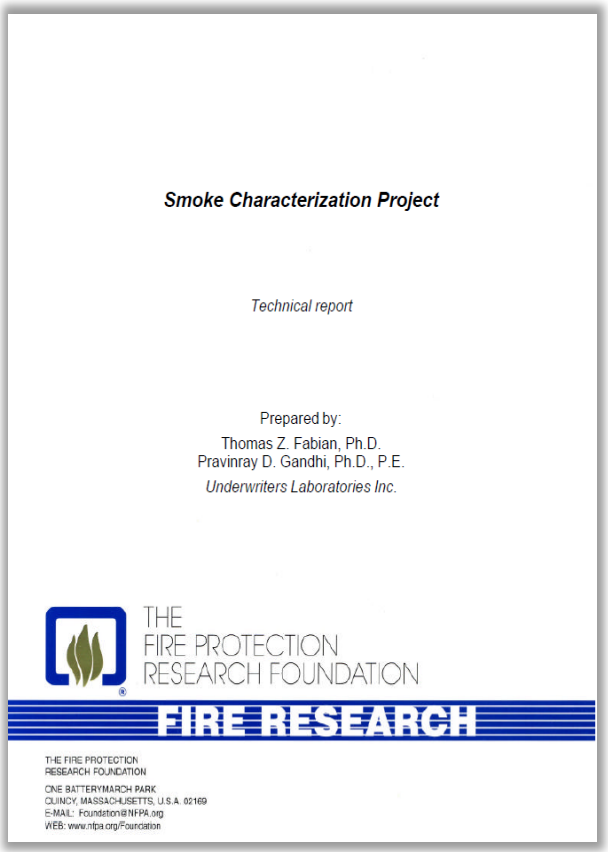
Escape times in a home fire have decreased from approximately **17 minutes** to approximately **3 minutes** over the last 40 years, due to changes in materials and floorplans in modern homes.

Modern Furniture



Smoke Characterization Project
(published April 24, 2007)

- Identified 21 different common household items
  - Bedroom and Living Room
  - Kitchen
  - Storage Areas



Smoke Characterization Project Summary
(List of common Household Items)

- Identified the common base material and samples

Residential Area	Common Items	Common Base Materials
Bedroom and Living Room	Appliance wiring	Flexible PVC (plasticized)
	Bed clothing	Cotton, Polyester, Acrylic, Blends
	Candles	Hydrocarbon wax, Cotton wick
	Carpeting	Polyolefin, Nylon, Polyester
	Drapes and blinds	Cotton, Linen, Wood, PVC
	Mattress	Polyurethane foam, Cotton, Polyester
	Paper products	Paper
	Plastic enclosures for electrical products	Polyolefin, ABS, Nylon
	Upholstered furniture	Polyurethane foam, Polyester, Cotton, Wood
	Wallpaper	Paper, PVC plastisol, Polyacrylates coatings
	Wood furniture	Wood, Polyurethane, Cotton, Polyester, Adhesives
Kitchen	Appliance enclosures	Polyolefins, ABS, Polycarbonate
	Appliance wiring	Flexible PVC (plasticized)
	Cabinets	Wood, MDF, Adhesives
	Counter tops	Laminates, Acrylics, Wood
	Food containers	Polyolefins, PVDC
	Foods	Fats, Oils, Carbohydrates, etc.
	Wallpaper	Paper, PVC plastisol, Polyacrylates coatings
Storage Areas	Paints	Acrylic latex, Oil, Polyurethane, Thinner
	Fuels	Hydrocarbons
	Packaging materials	Paper, Polystyrene, Starch

Smoke Characterization Project Summary (Test Samples)

- 14 Residential samples were selected for testing
- 5 Existing fire test materials were also included
- Selection of items was based on prevalence of items in homes
- Natural and/or Synthetic

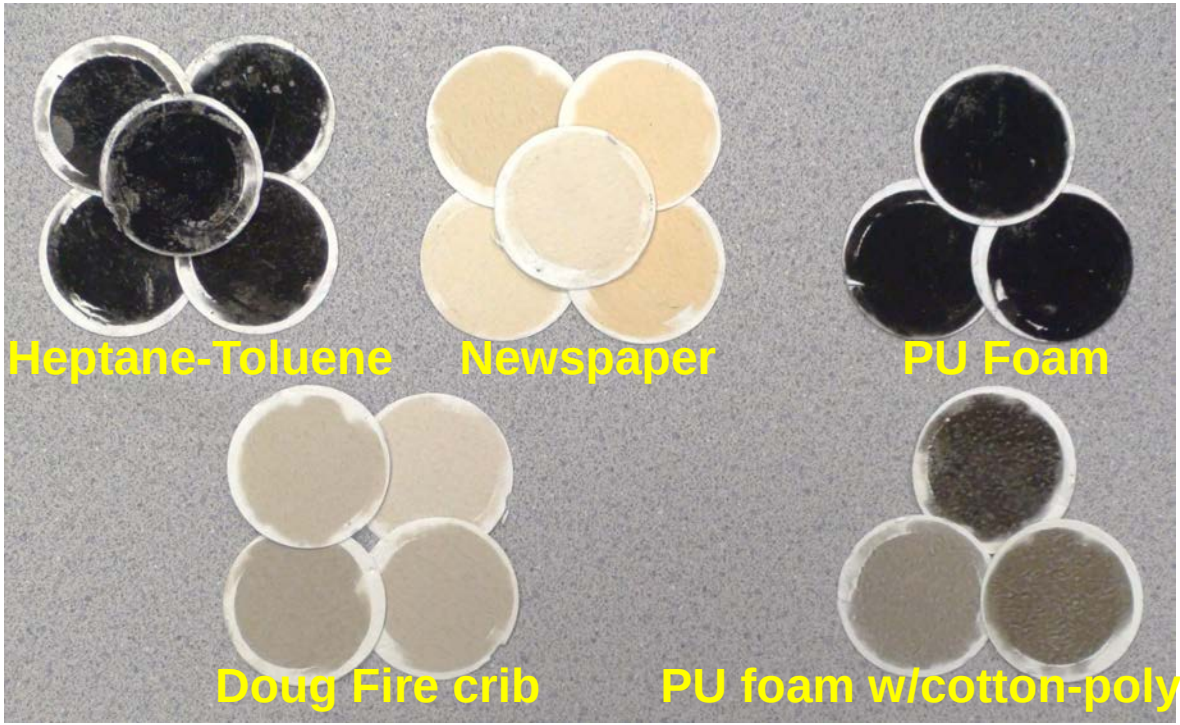
Test Sample	Comment
3:1 Heptane/Toluene mixture	UL 217 test material – mixture of short straight chain and simple aromatic hydrocarbon molecules
Douglas fir	UL 217 test material
Newspaper	UL 217 test material
Ponderosa pine	UL 217 test material
Heptane	Hydrocarbon liquid – short straight chain hydrocarbon
HDPE	Polyolefin plastic – long straight chain hydrocarbon
Bread	Potential nuisance source
Lard	Used in cooking; Potential nuisance source
Cooking oil	Hydrocarbon liquid – "intermediate" length hydrocarbon
Mattress composite	Natural and synthetic materials; Commonly found in home furnishings
Mattress PU foam	Synthetic; Flexible, open cell structure; Commonly found in home furnishings
Cotton batting	Natural material; Commonly found in home furnishings
Polyester pillow stuffing	Aromatic; Commonly found in home furnishings
CA TB 117 50:50 Cotton/ Polyester blend fabric	Natural and synthetic materials blend; Commonly found in bed clothing and apparel
Rayon fabric	Synthetic; Commonly found in apparel
Nylon carpet	Synthetic; Commonly found as a flooring product
PET carpet	Synthetic; Commonly found as a flooring product
Polyisocyanurate insulation foam	Synthetic; Rigid, closed cell structure; Commonly found as insulation
PVC wire	Common electrical wiring

Smoke Characterization Project Summary
ANSI/UL 217, ANSI/UL 268 Fire Test Room

Flaming Tests	Mean Diameter (μm) at:	
	0.5 %/ft	10 %/ft
UL 217 Douglas fir	0.13	0.17
UL 217 Newspaper	0.17	0.18
UL 217 Heptane/Toluene	0.19	0.30
Coffee maker	0.17	0.18
PU foam	0.08	NA*
PU foam in Cotton/Poly	0.09	NA*
Nylon carpet	0.10	NA*

* Test did not achieve 10 %/ft obscuration.

SMOKE CHARACTERIZATION PROJECT SUMMARY
ANSI/UL 217, ANSI/UL 268 FIRE TEST ROOM

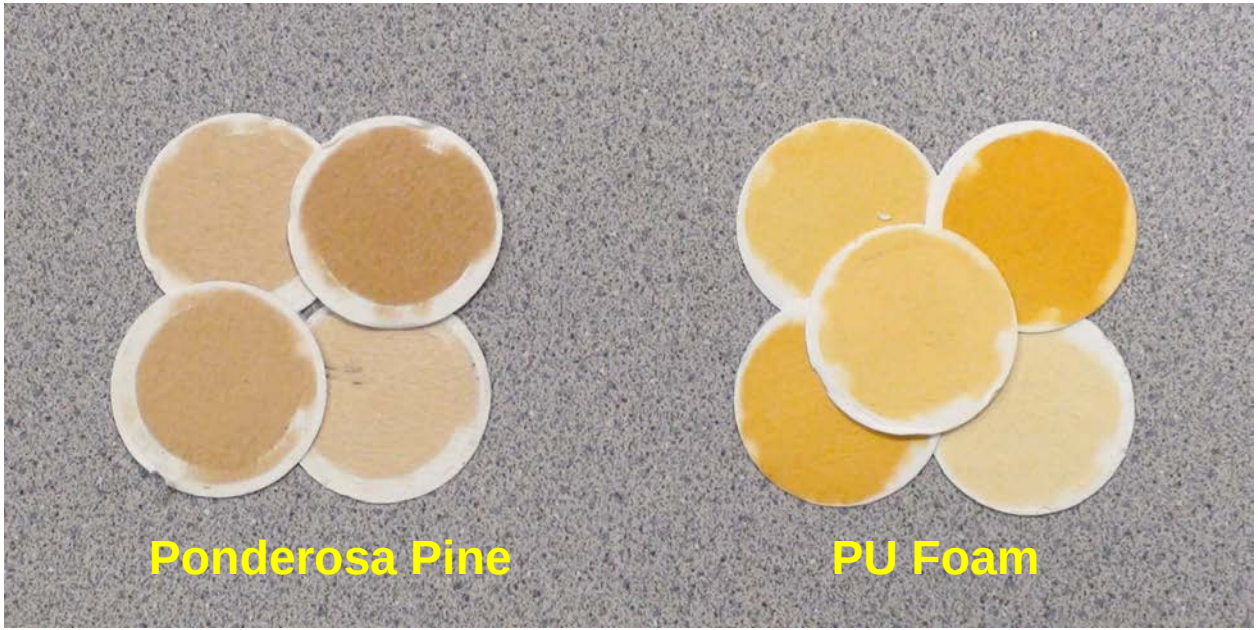


Smoke Characterization Project Summary
ANSI/UL 217, ANSI/UL 268 Fire Test Room

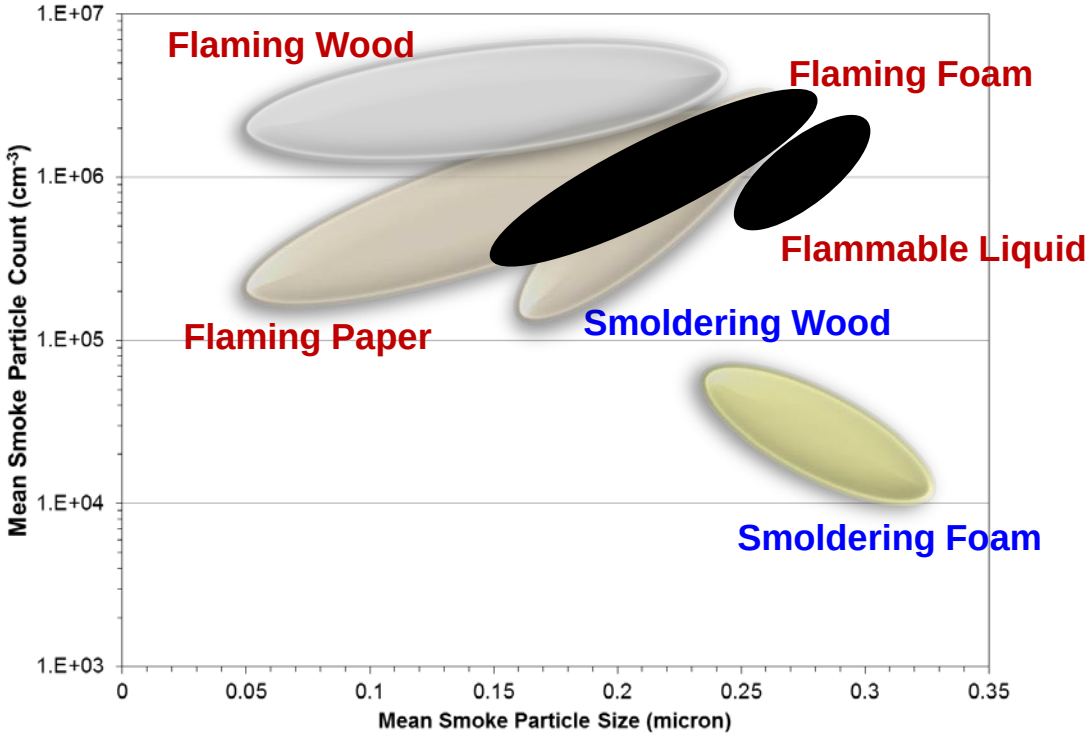
Smoldering Tests	Mean Diameter (μm) at:	
	0.5 %/ft	10 %/ft
UL 217 Ponderosa Pine	0.16	0.26
PU foam	0.20	0.23
PU foam in Cotton/Polyester	0.22	NA*
PU foam in Polyester	0.20	NA*

* Test did not achieve 10 %/ft obscuration.

Smoke Characterization Project Summary
Fire Test Room – Flaming Test Smoke Color



Smoke Characterization Project Highlights
UL 217/268 Fire and Foam Signatures



Smoke Characterization Project Summary

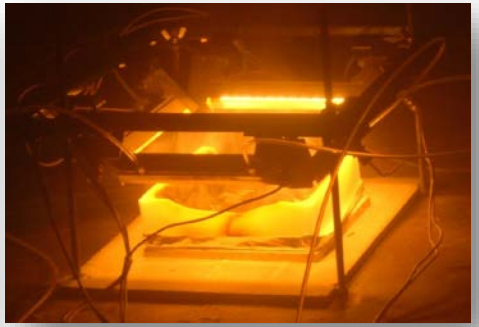
Polyurethane Foam:

- Faster Ignition
- Generated greater heat and smoke release rates than natural materials
- Generated smaller sized particles than most UL 217 test materials
- Accumulated smoke comprised of smaller particles than for the UL 217 test materials
- Produce darker color smoke than UL 217 newspaper or wood
- Prevalent in residences (mattresses, upholstered furniture, etc.)

PU Foam and Nuisance Task Groups

TG1 - Increase available egress time for non-specific fires by expanding alarm responsiveness to other smoke signatures by expanding the range of smoke colors and particle sizes currently represented by UL 217 test materials.

⇒ Small, dark color particles



⇒ Large, light color particles

TG2 - reviewing smoke detector and alarm requirements for opportunities to further reduce nuisance alarms (dust, cooking, steam, etc.)

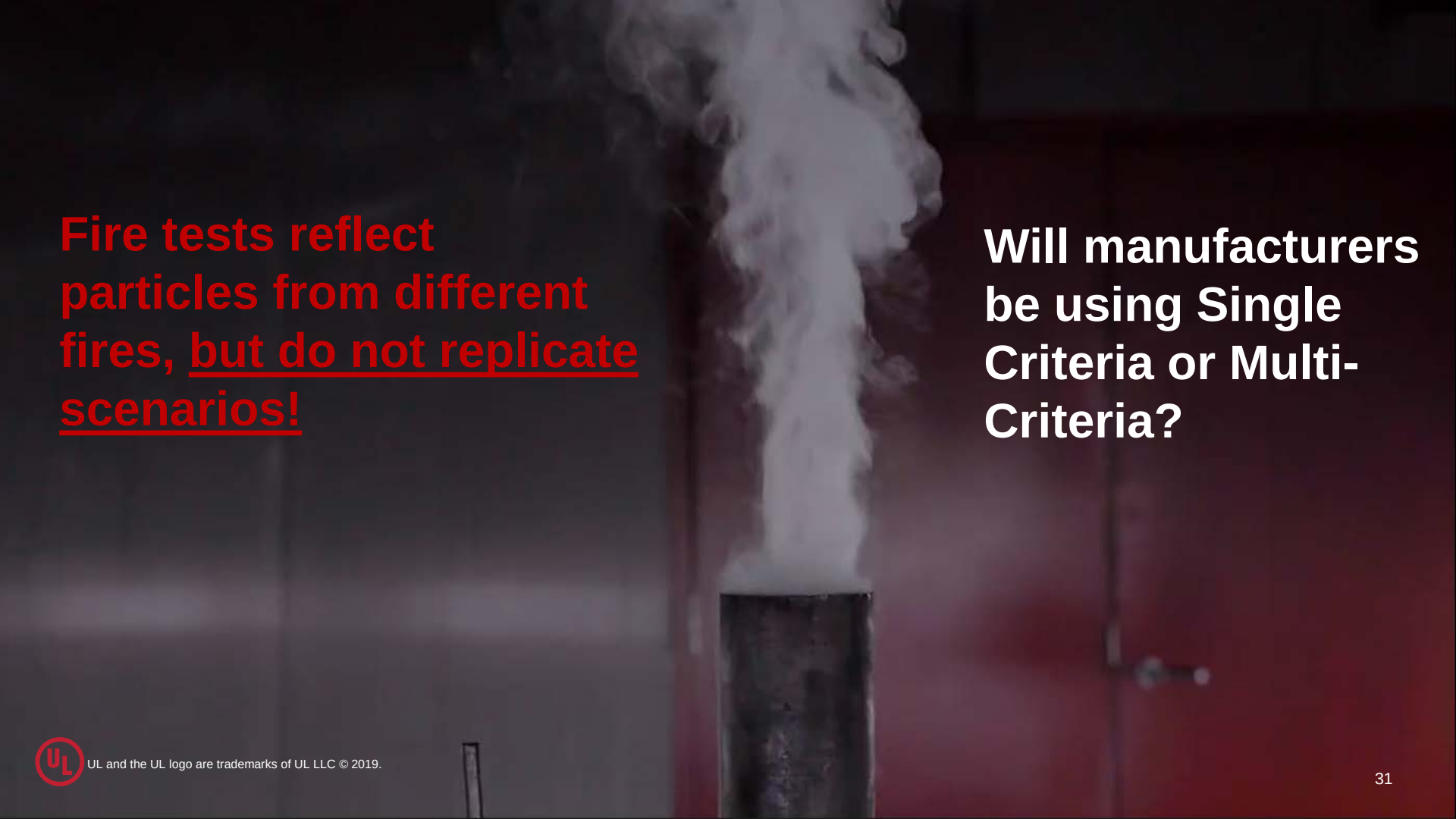
TG1 - Foam TG and Tests

TG Flexible PU Foam Selection

- Reviewed 5 common types of PU foam
- Settled on PU foam with a density of 1.8 lb/ft^3 - most common type of foam in home/furniture
- Burns more consistently
- Most readily available
- Density affects the smoldering and/or burning
- California TB117-2013 was modified and aligns with foam defined in ANSI/UL 217 (Density changed to 27.2 - 30.4 kg/m^3 (1.8 ± 0.1 lb/ft^3 and No Flame Retardants)
- Foam already specified in ANSI/UL 1626

VS

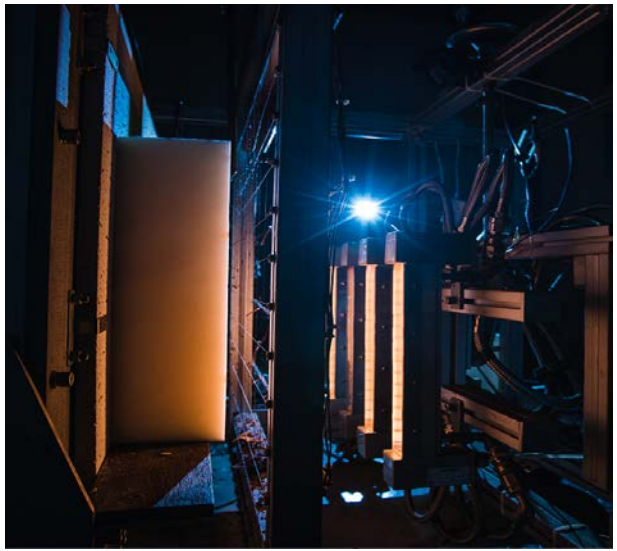
- EN 54-7 foam density not prevalent in homes
- Foam did not burn consistently
- Lower density, 20 kg/m^3 (~1.2 lb/ft^3)



PU Foam Trials

PU Foam Smoldering Trials

- 44 trials
- 4 different batches
- 8 months
- Multiple operators

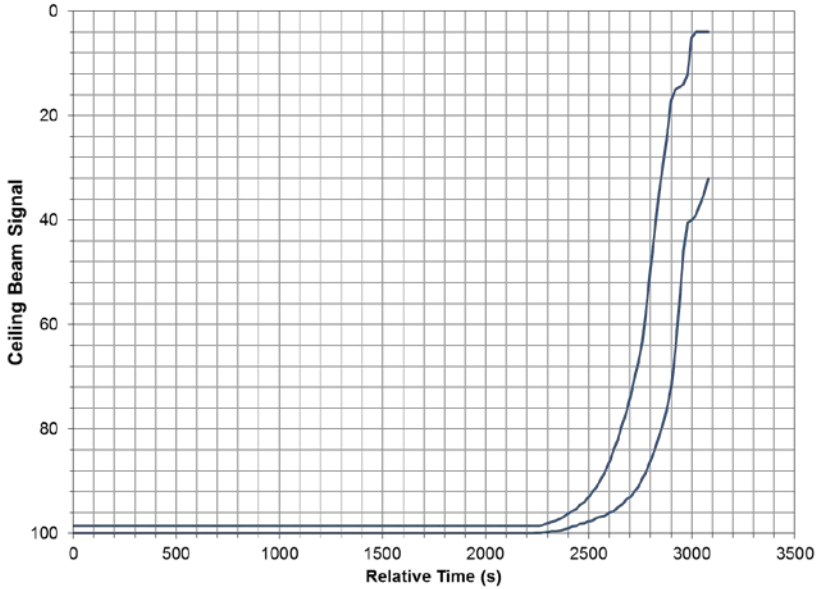


PU Foam Flaming Trials

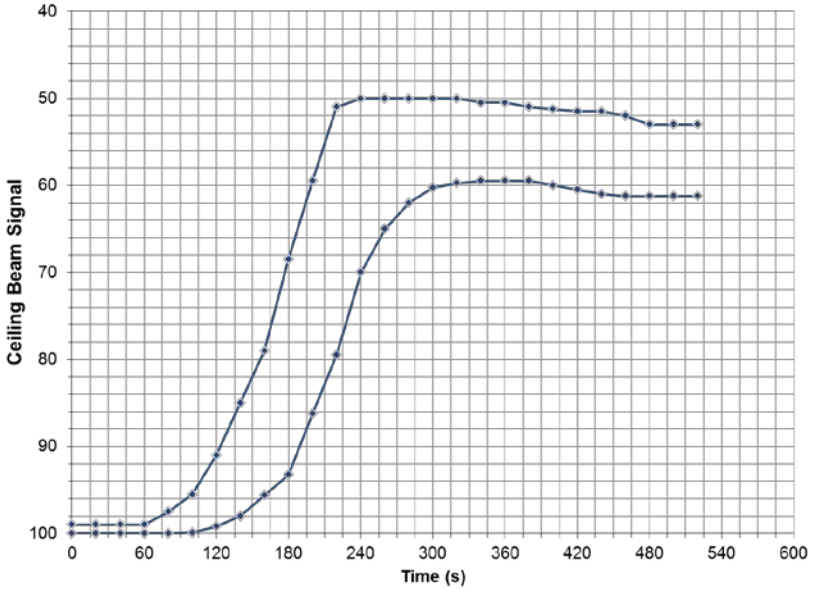
- 47 trials
- 4 different batches
- 8 months
- Multiple operators

PU Foam Profiles Smoldering

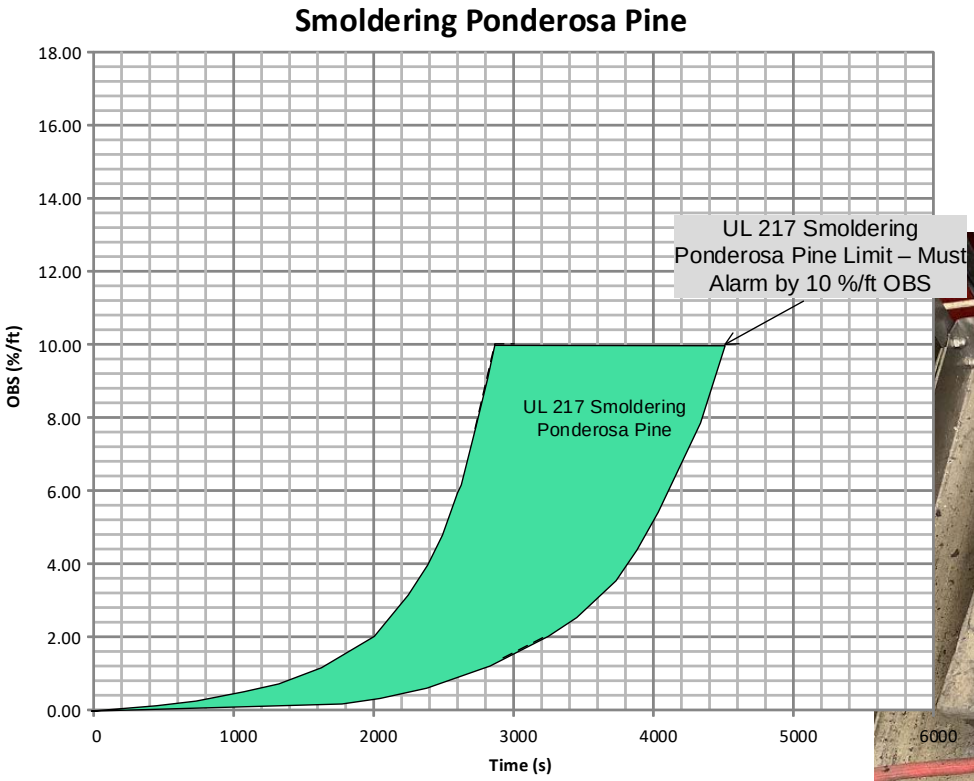
PU Foam Smoldering Profiles



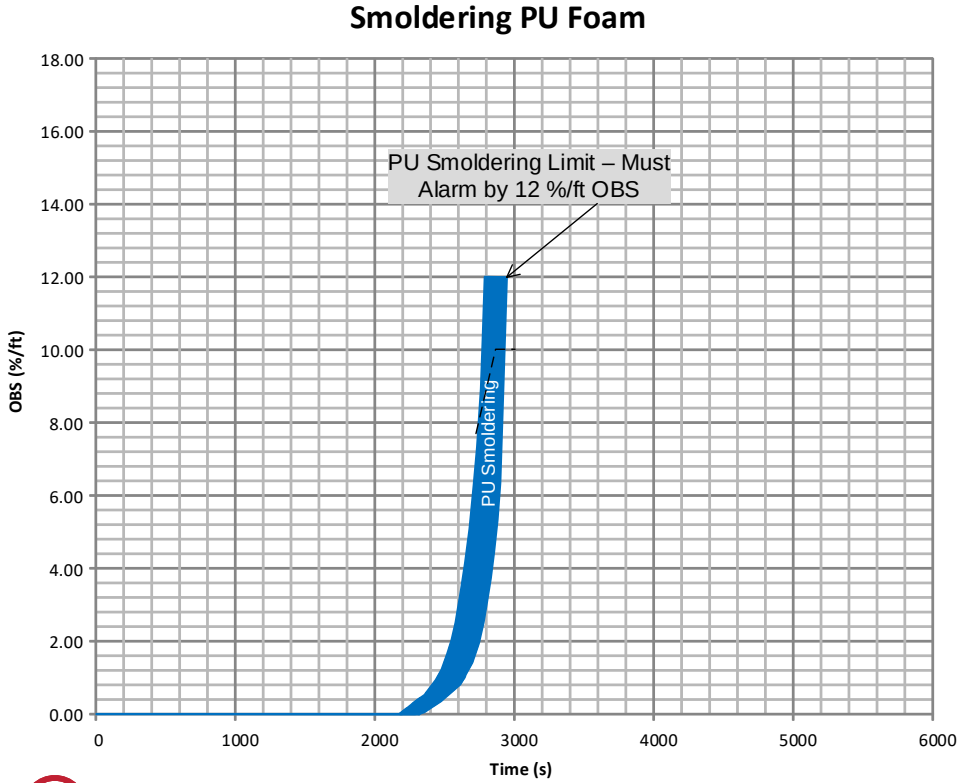
PU Foam Flaming Profiles



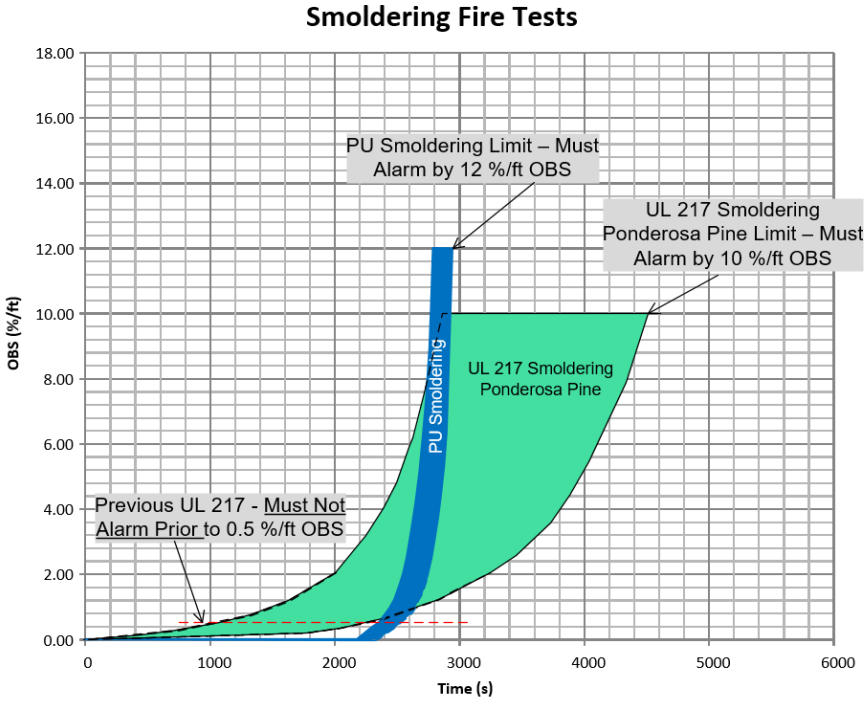
Ponderosa Pine Smoldering Test



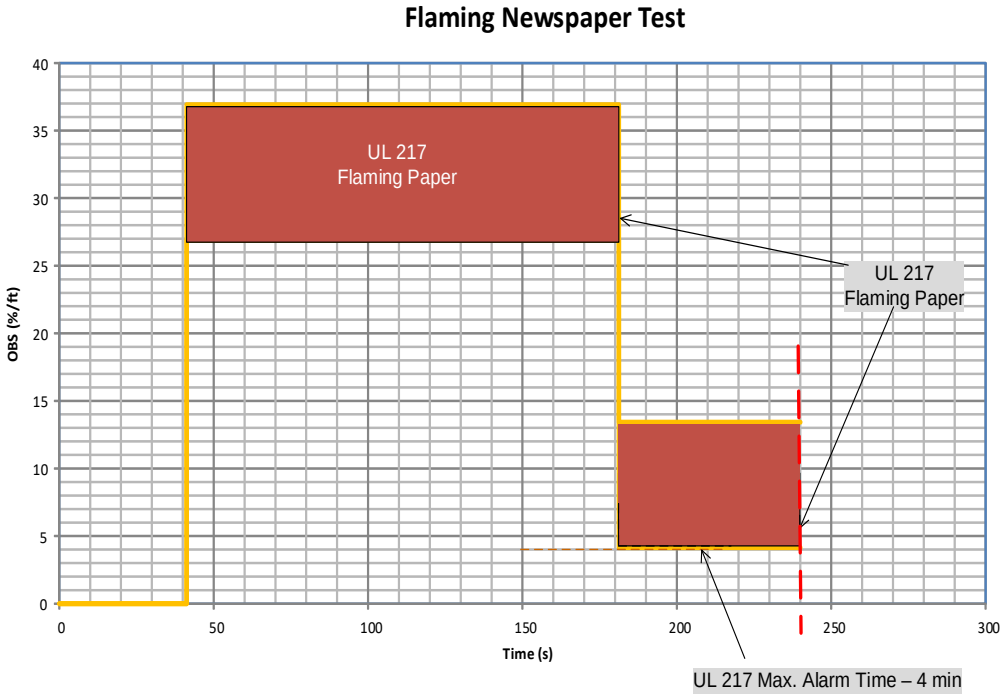
PU Smoldering Test



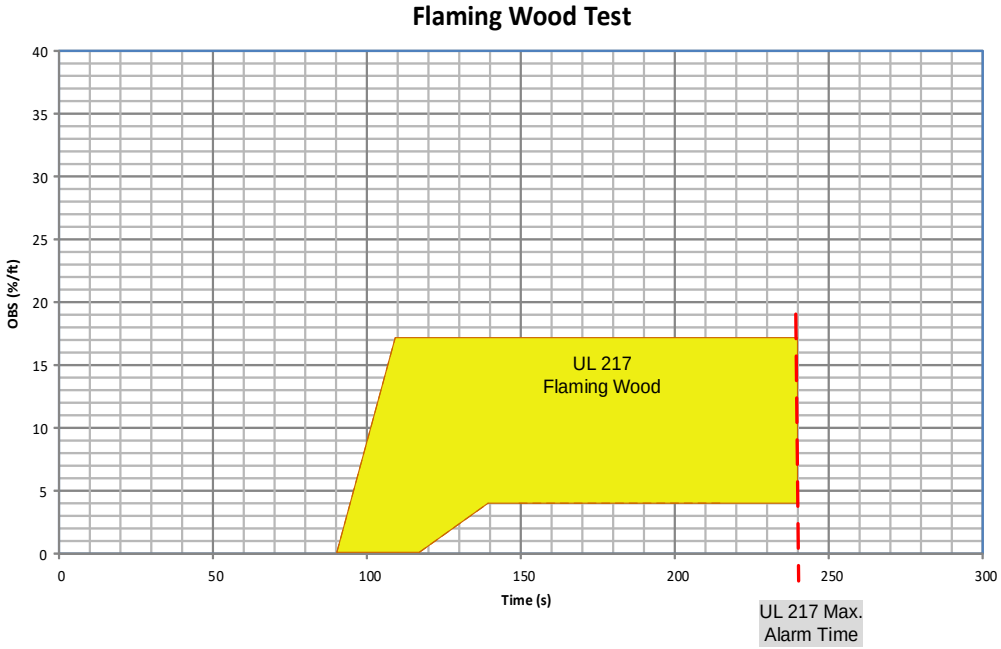
Smoldering Tests



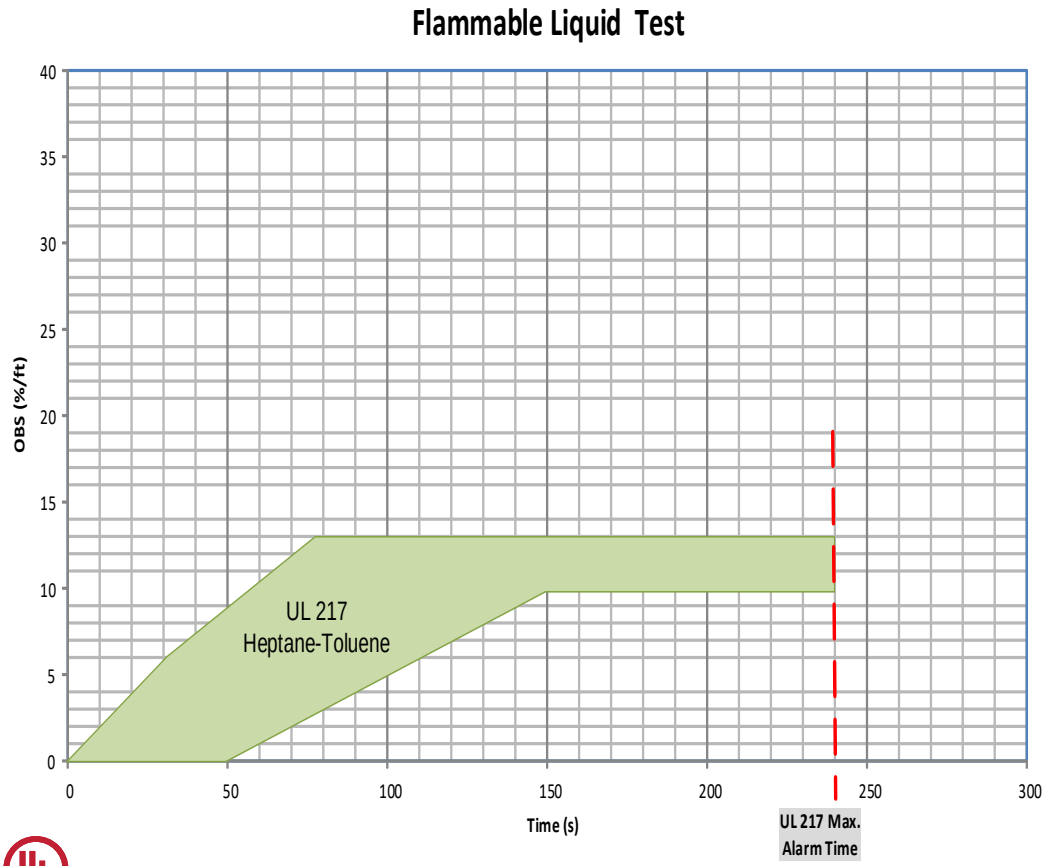
Flaming Paper Fire Test



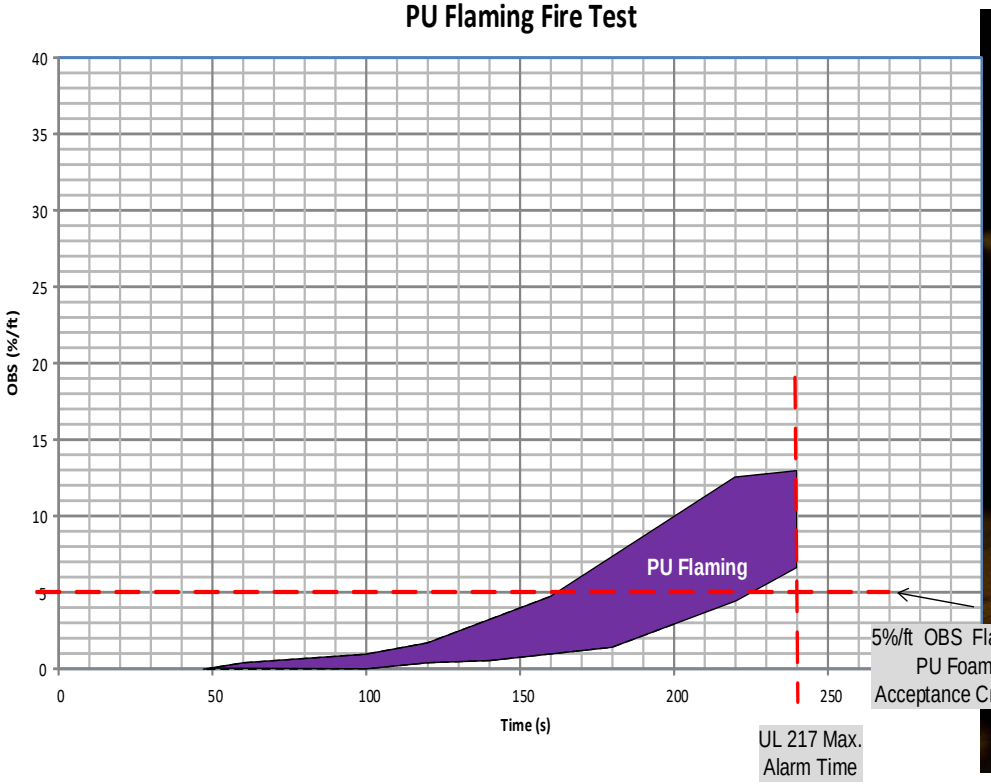
Flaming Wood Test



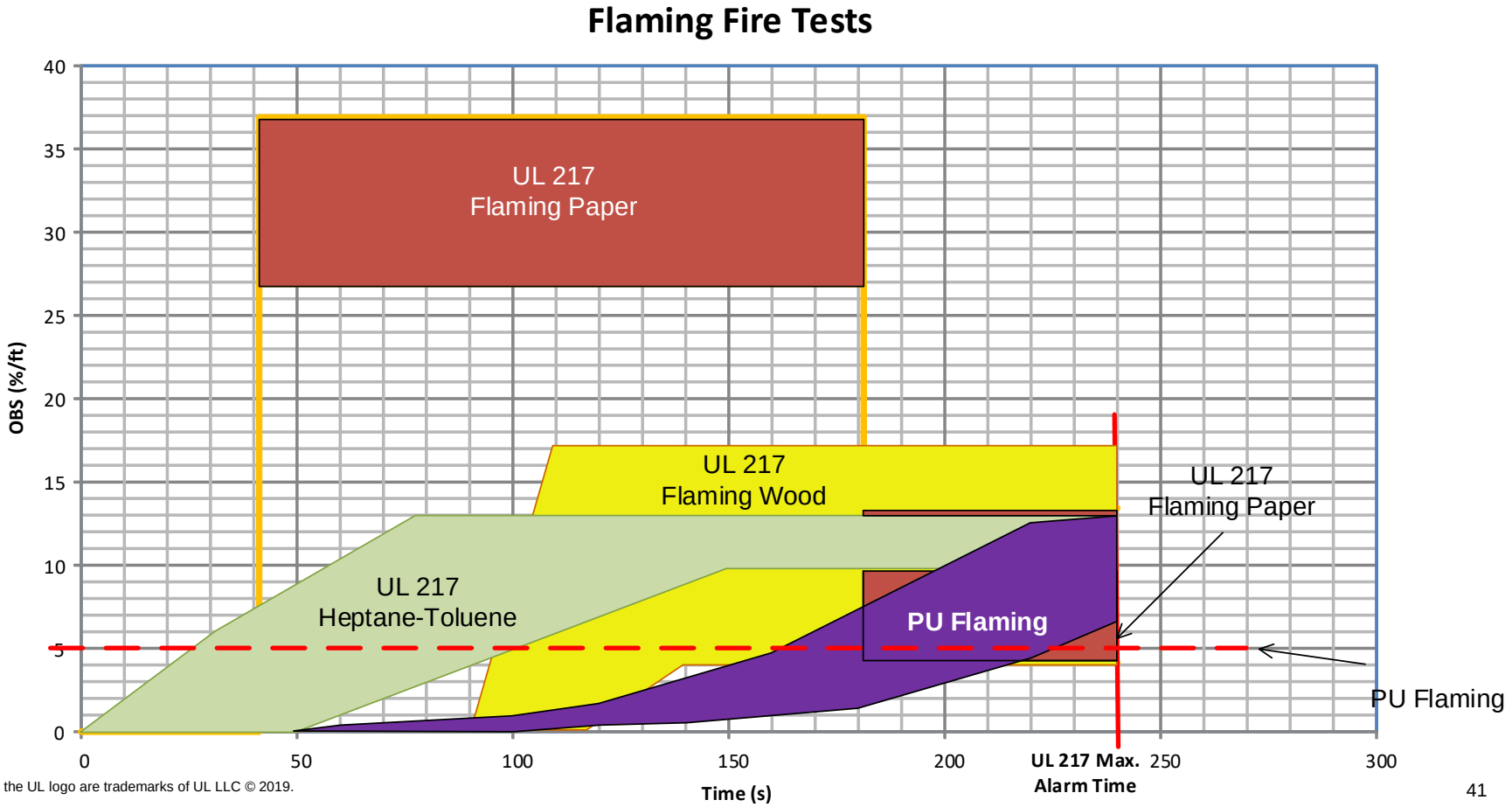
Flammable Liquid Test



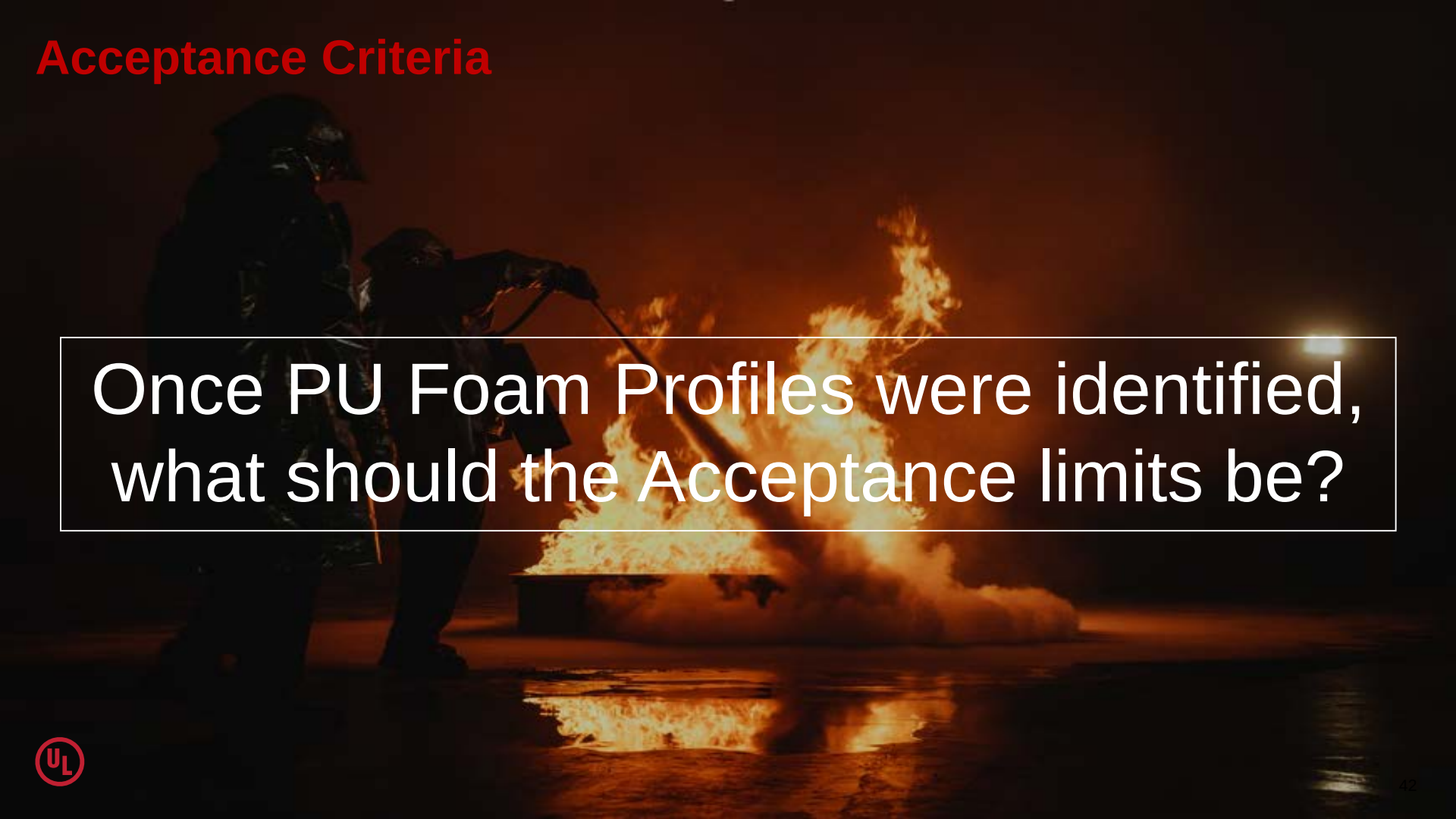
Flaming PU Foam Test



Flaming Test Comparisons



Acceptance Criteria



Once PU Foam Profiles were identified, what should the Acceptance limits be?

NIST Technical Note 1837

Published in July 2014, Titled "Improving Smoke Alarm Performance – Justification for New Smoldering and Flaming Test Performance Criteria", Thomas G. Cleary

- **Some of the Assumptions and Limitations**
  - **ASET/RSET principles**
  - **Travel speed based on smoke density**
  - **Used multiple-station interconnected smoke alarms**
  - **Conducted 18 full scale tests**
  - **Developed possible matching pair acceptance criteria for the New PU Smoldering and Flaming Tests**

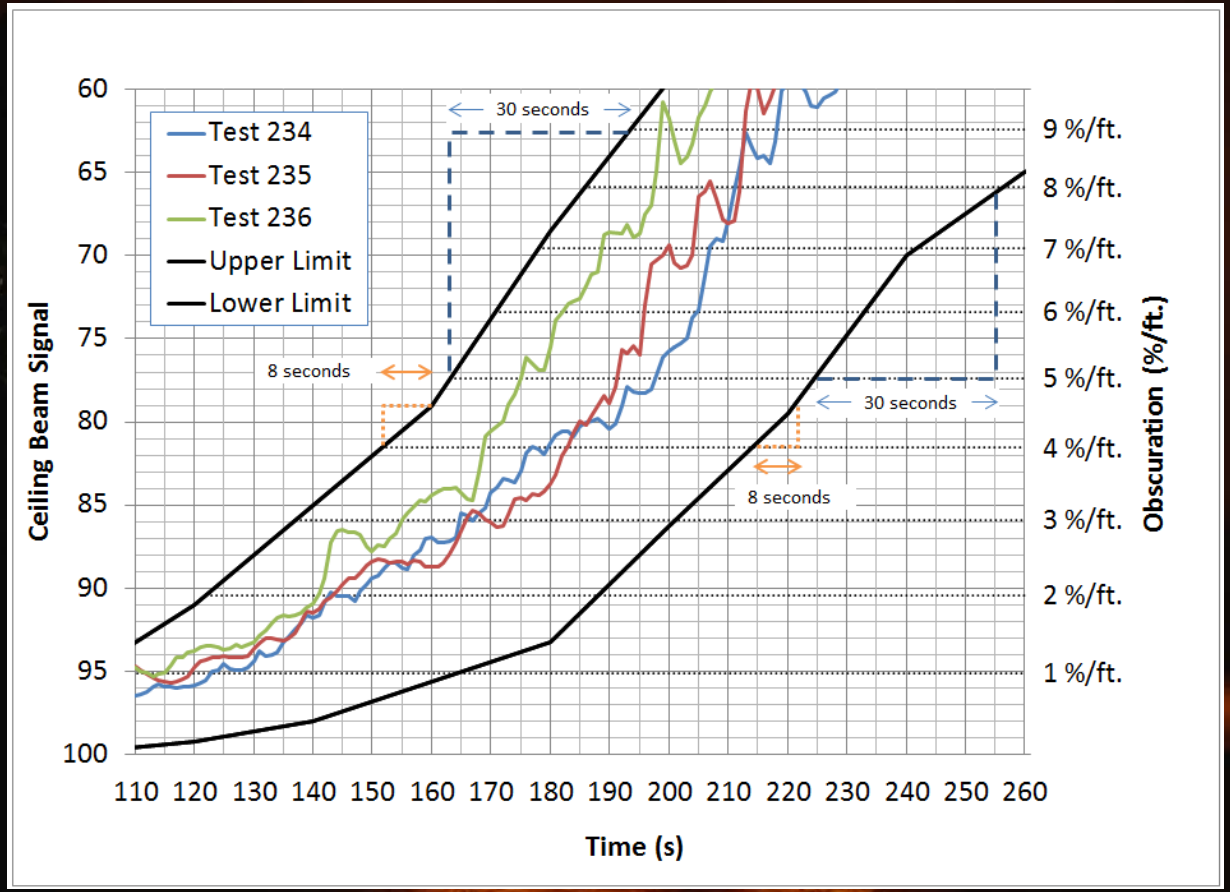
Table 4. Ceiling smoke obscuration required to achieve a calculated 95 % egress success rate for the target populations and optical density limits.

Optical Density Limit (m^{-1})	Pre-movement Distribution (median (s) /σ_g)	Initially smoldering fire scenario ceiling smoke obscuration to achieve 95 % egress success rate (%/ft obsc.)		Flaming fire scenario ceiling smoke obscuration to achieve 95 % egress success rate (%/ft obsc.)	
		Average of 9 experiments ± std dev	Value to achieve 95 % success rate across all 9 experiments	Average of 9 experiments ± std dev	Value to achieve 95 % success rate across all 9 experiments
0.25	35/1.6	17.2 ± 5.2	11.3	3.1 ± 1.7	2.5
	55/1.6	16.7 ± 5.1	10.7	0.9 ± 0.8	0.4
0.43	35/1.6	23.3 ± 7.6	18.3	5.6 ± 2.2	4.7
	55/1.6	22.3 ± 7.2	13.3	2.5 ± 1.7	2.0

Table 5. Ceiling smoke obscuration required to achieve a calculated 85 % egress success rate for the target populations and optical density limits.

Optical Density Limit (m^{-1})	Pre-movement Distribution (median (s) /σ_g)	Initially smoldering fire scenario ceiling smoke obscuration to achieve 85 % egress success rate (%/ft obsc.)		Flaming fire scenario ceiling smoke obscuration to achieve 85 % egress success rate (%/ft obsc.)	
		Average of 9 experiments ± std dev	Value to achieve 85 % success rate across all 9 experiments	Average of 9 experiments ± std dev	Value to achieve 85 % success rate across all 9 experiments
0.25	35/1.6	17.5 ± 5.3	12.7	5.0 ± 1.6	4.5
	55/1.6	17.1 ± 5.2	12.5	2.3 ± 1.5	2.1
0.43	35/1.6	24.6 ± 8.9	19.9	8.6 ± 3.2	7.5
	55/1.6	23.3 ± 7.8	18.9	5.5 ± 2.1	4.5

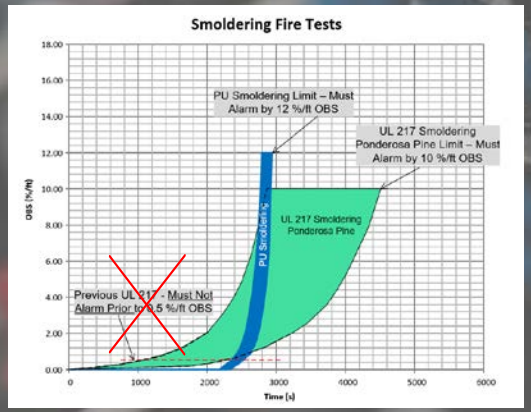
Flaming PU Test Progression

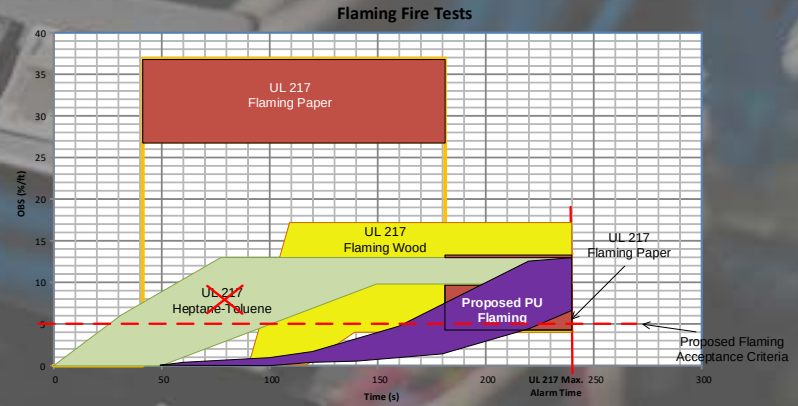


Fire Test Revisions

Based on scientific research, TG1 Objective was met

1. Flammable Liquid Fire requirement and replace with proposed Flaming PU Foam.
2. Remove Smoldering Smoke Test – Maximum Obscuration Without Alarm
3. New Polyurethane Smoldering Test with Acceptance Criteria of 12%/ft. OBS.
4. New Polyurethane Flaming with Acceptance Criteria of 5%/ft. OBS.





Nuisance Alarms

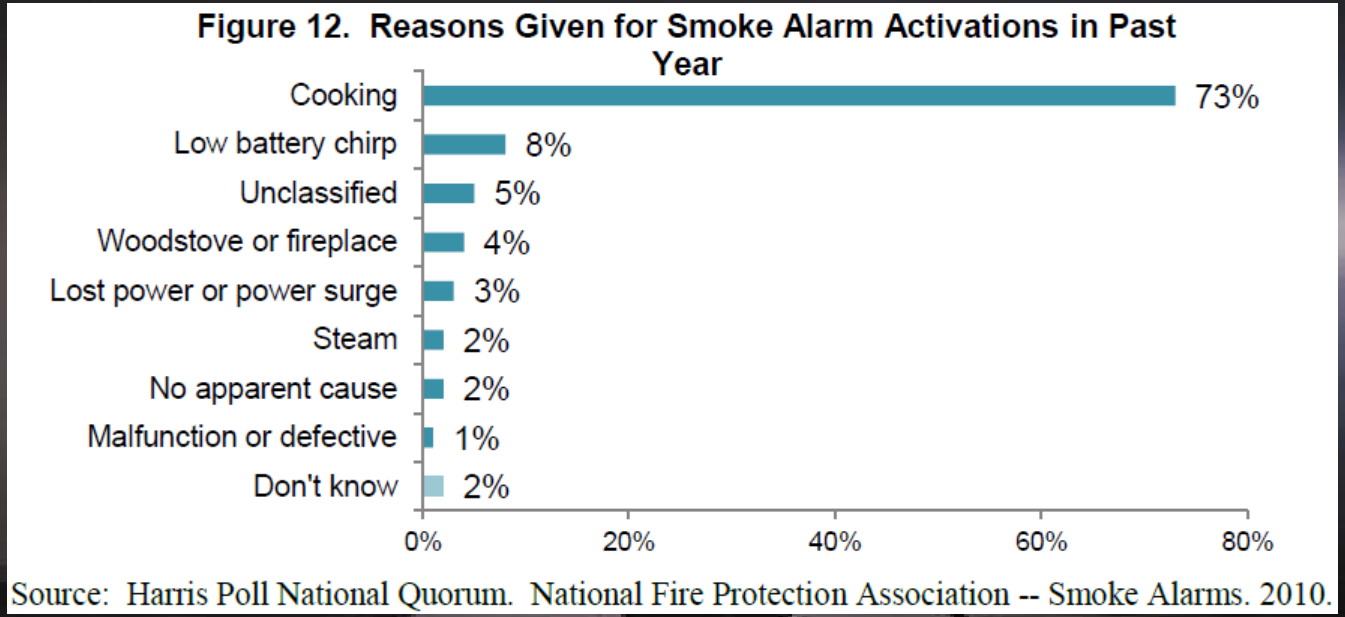
If PU Foam requirements increase the alarms responsiveness, would this increase nuisance alarms => alarm disablement?

Why Cooking Nuisance?

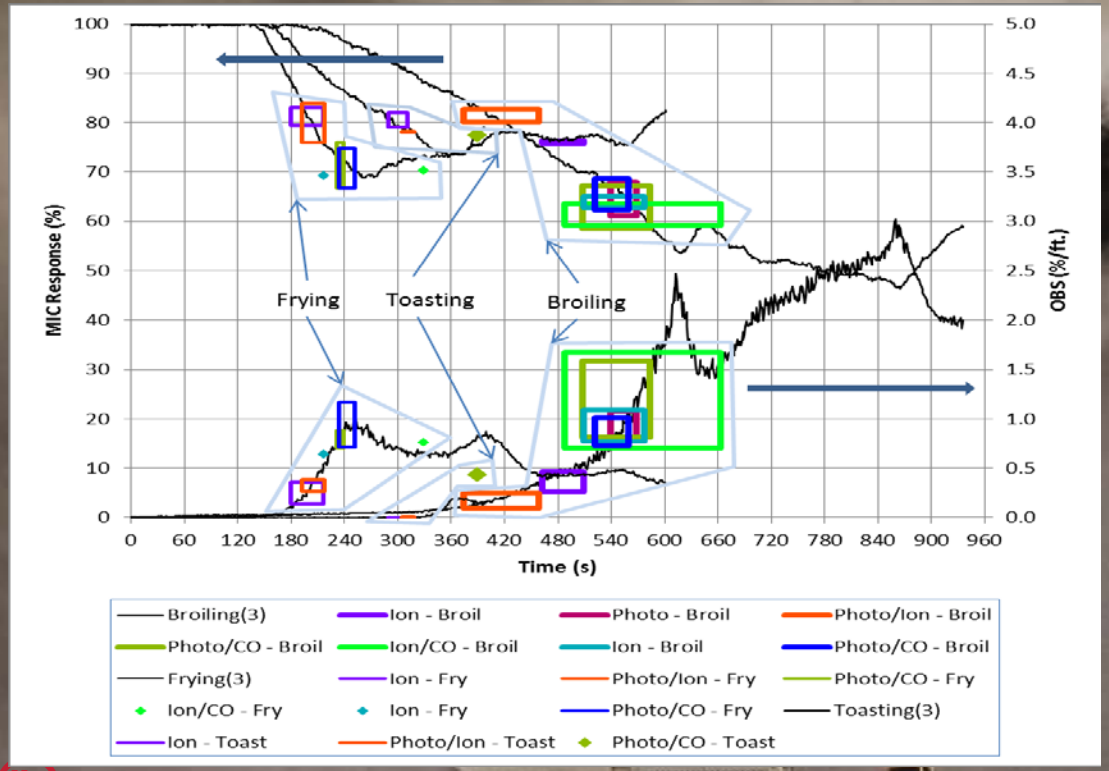
Common Nuisance Sources

Marty Ahrens March 2014 Report, titled “Smoke Alarms in U.S. Home Fires”

- Steam Nuisance alarms account for no more than 2% of nuisance alarms (down from 5% in 2004)
- Cooking Nuisance alarms account for 73% of nuisance alarms (up from 69% in 2004)



Cooking Nuisance



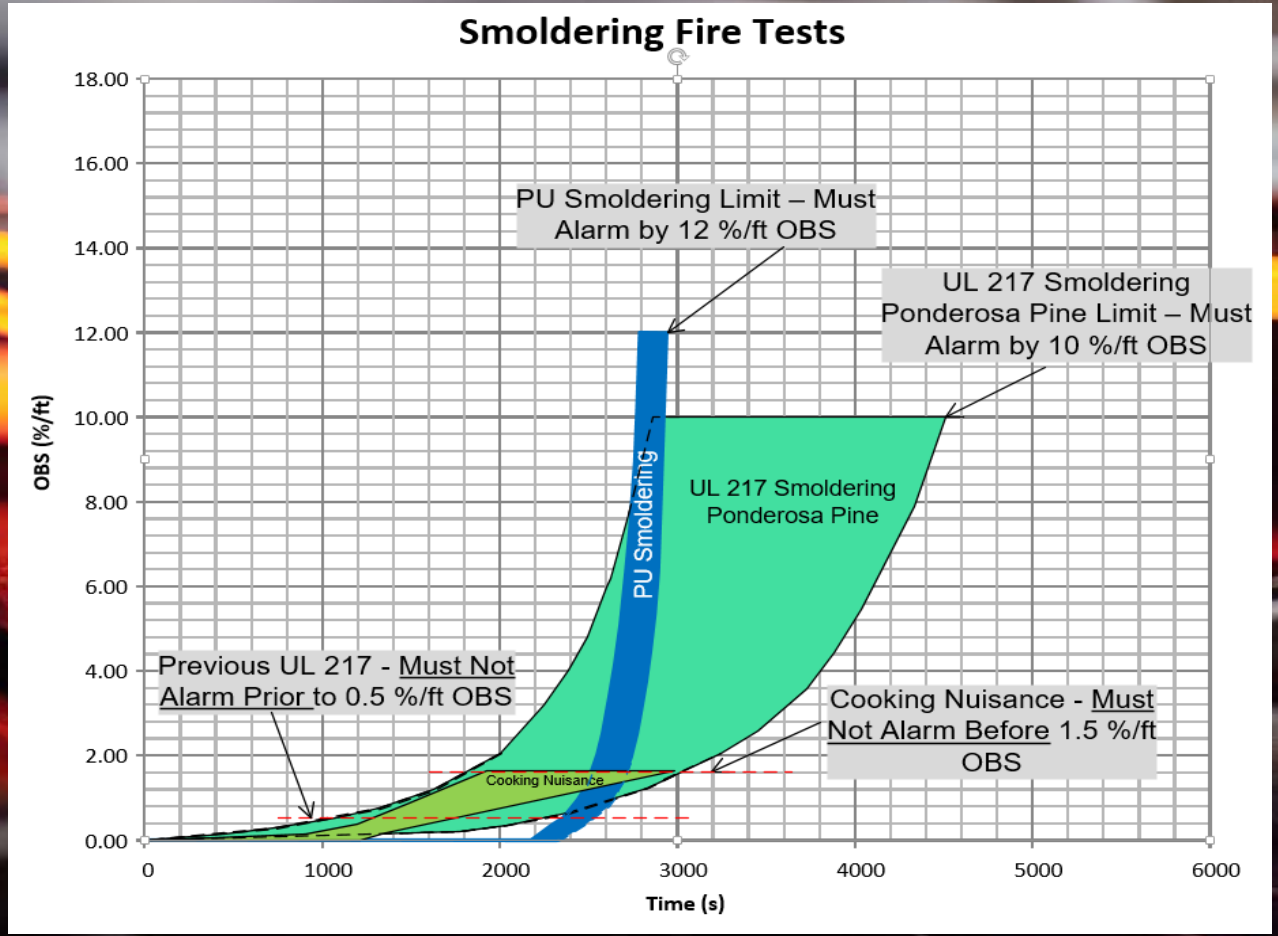
Three cooking scenarios provide unique obscuration and MIC signals

- Toasting bread (2 slices) resulted in negligible (< 0.5%/ft) OBS but produced elevated MIC response
- Pan frying hamburger (single) resulted in both OBS and MIC response when the burger was heated
- Broiling hamburger (single) resulted in MIC response initially followed by OBS signal.
- Broiling activated the alarm signal for all types of smoke alarms used in the testing.

Smoldering Test Comparisons

Added New Cooking Nuisance

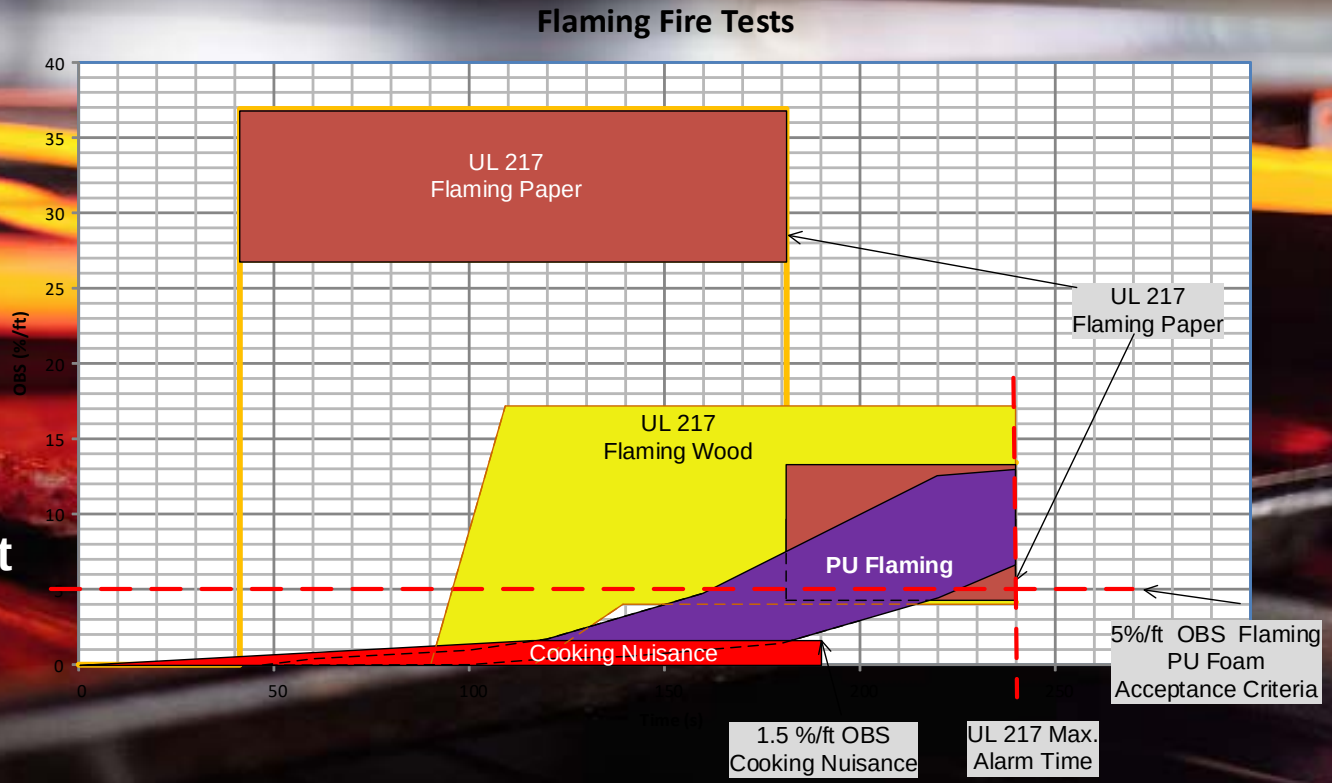
- Must not alarm before 1.5% OBS/ft



Flaming Test Comparisons w/Cooking Nuisance

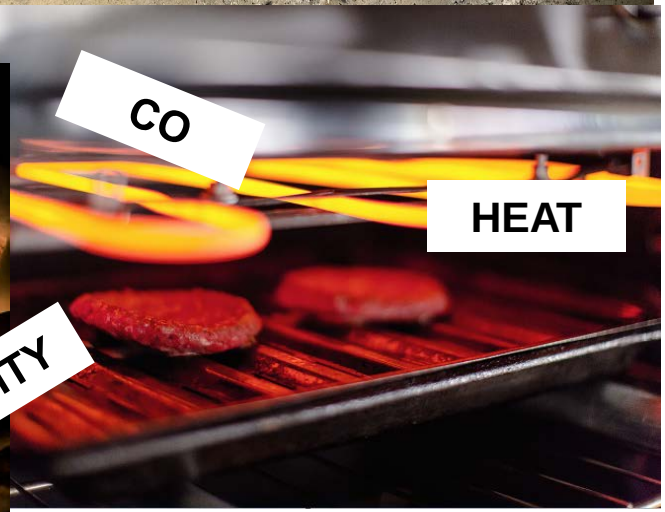
Added New Cooking Nuisance

- Must not alarm before 1.5% OBS/ft



Will manufacturers be using Single Criteria or Multi-Criteria?

Introducing Multi-Criteria

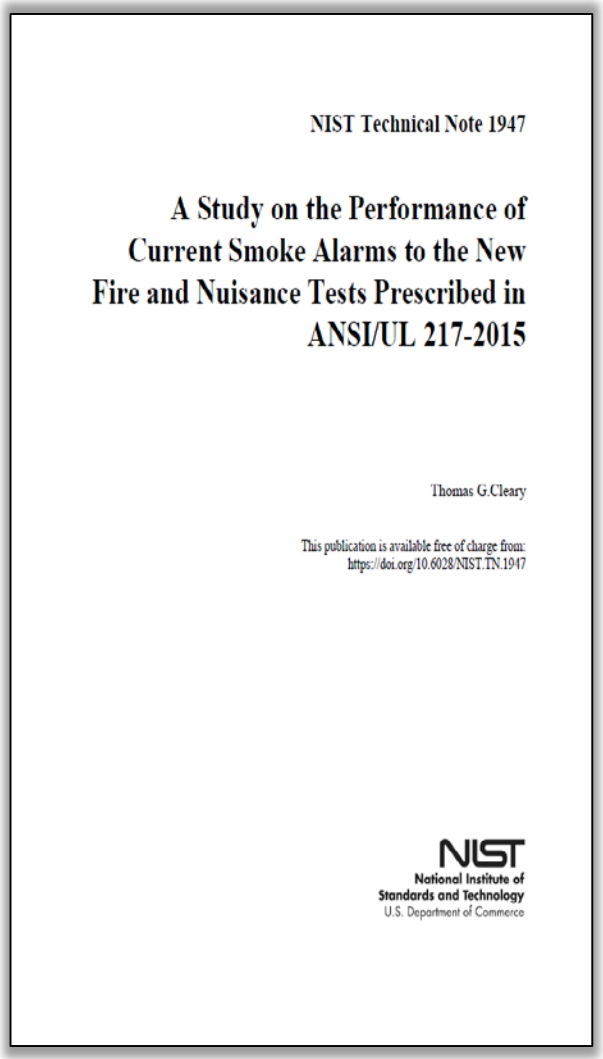


Will the new tests challenge current smoke alarms?

But How Will Alarms Perform?

Research Objectives

- How will new tests affect current smoke alarms.
- What is the potential performance enhancement for new smoke alarms.
- Can a single nuisance test represent the broad range of cooking scenarios?



NIST Technical Note 1947

A Study on the Performance of Current Smoke Alarms to the New Fire and Nuisance Tests Prescribed in ANSI/UL 217-2015

Thomas G.Cleary

This publication is available free of charge from:
https://doi.org/10.6028/NIST.TN.1947

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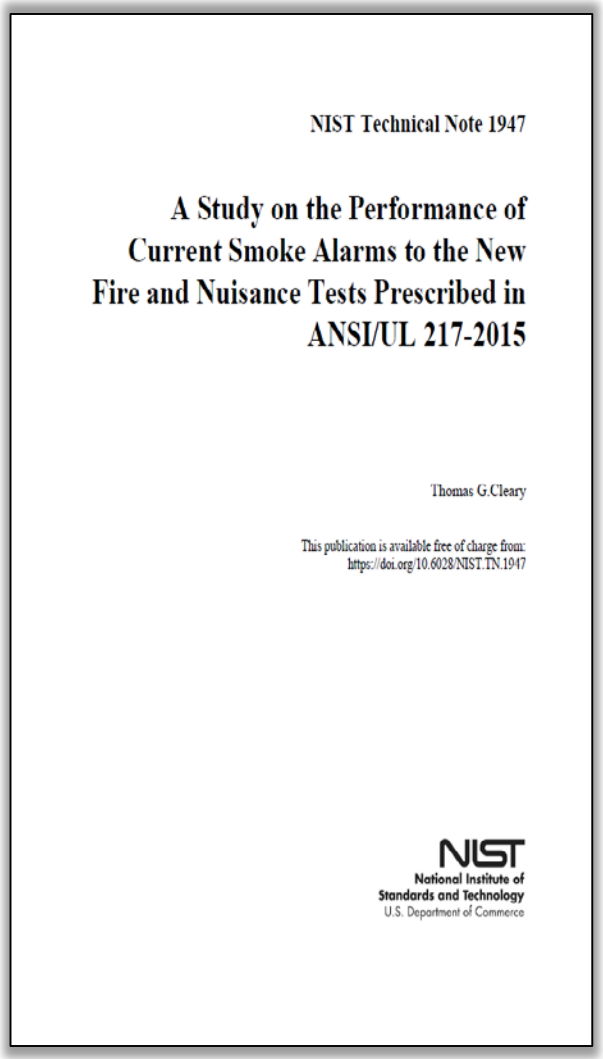
But How Will Alarms Perform?

Summary

- Ionization alarms performed well when subject to flaming PU Foam.
- Photoelectric alarms performed well when subject to Smoldering PU Foam.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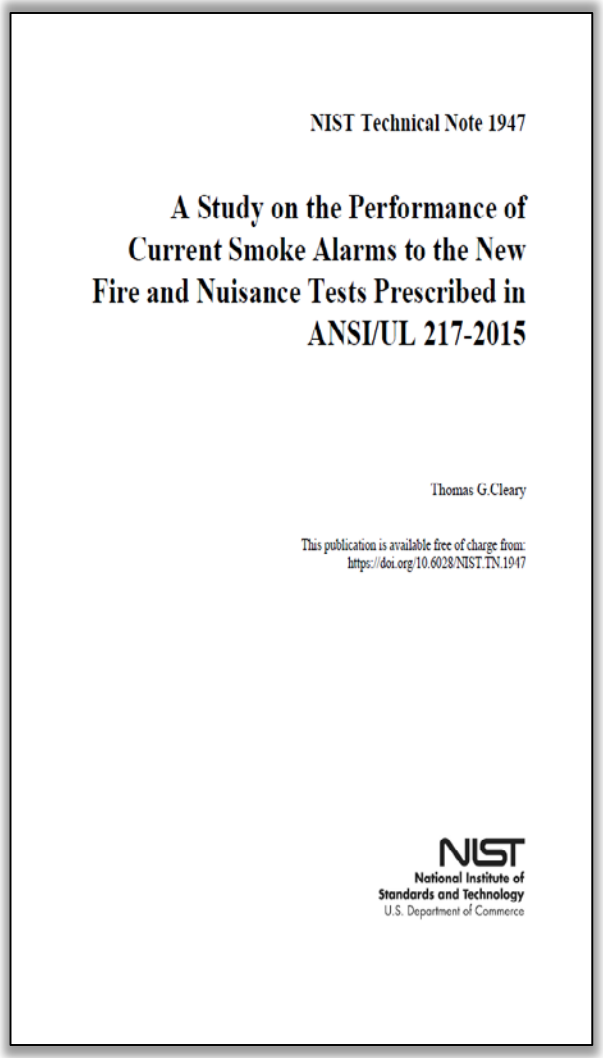
But How Will Alarms Perform? NIST Technical Note 1947

- No current smoke alarm would meet the new requirements
  - Three model photoelectric alarms came closest
- An across the board change to comply with UL 217/268 would "…. Significantly improve the overall performance…"
- New fires and nuisance tests "… make it challenging for manufactures to meet the requirements by simply using a combination of photoelectric and ionization sensor, …."

- Cooking particle build-up rates varied thus impacting the alarms response
- Toasting bread
  - No measurable obscuration
  - No measurable CO
  - No significant heat
  - Ionization alarms responded
- Broiling hamburger test challenged the majority of smoke alarms
  - Test may be considered conservative
  - Cooking nuisance tests on compliant alarms will help determine this tests effectiveness

But How Will Smoke Alarms Perform? NIST Technical Note 1947

"it is concluded that smoke alarms meeting the performance criteria in ANSI/UL 217-2015 would demonstrate significantly improved overall performance by expanding range of fire scenarios alarms must respond to while requiring greater resistance to nuisance alarms than a wide range of currently available models."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Approximate Number of Standard Revisions

251+

- Revisions to the standard-most requiring testing, or engineering assessment

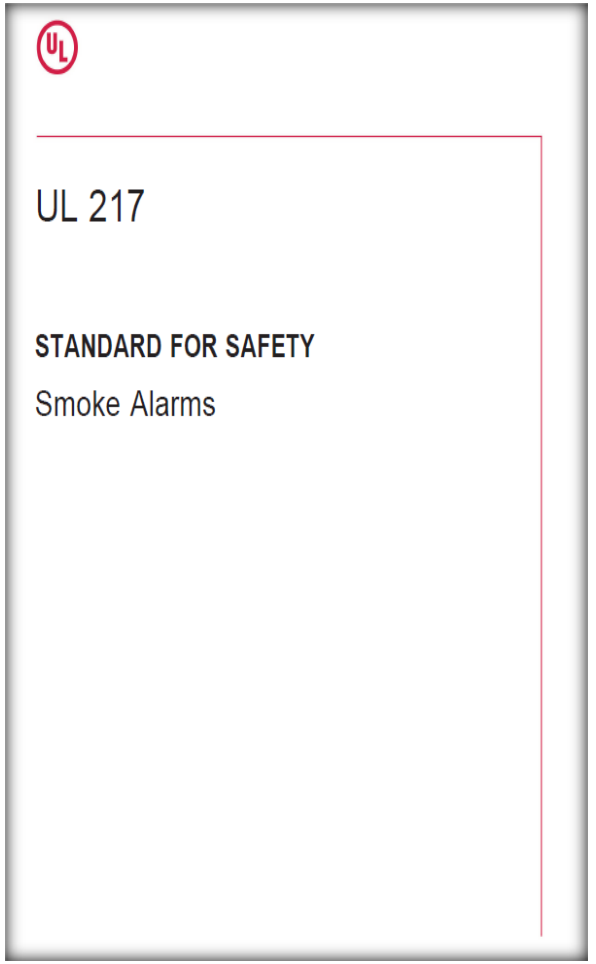
800+

- Total Revisons

Additional Key Changes to ANSI/UL 217 and ANSI/UL 268

- ✓ Multi-Criteria
- ✓ End-of-Life
- ✓ Alarm Silence
- ✓ Wireless Supervision
- ✓ Firmware Updates
- ✓ Flaming PU Foam after Cooking Nuisance
- ✓ Polyurethane (PU) Foam
- ✓ Cooking Nuisance Alarm Requirements

UL, LLC - Effective date for the 8th edition of ANSI/UL 217 is May 2020.



Enhanced Product Certification Mark and Promotional Marking

SMOKE ALARMS CERTIFIED BY UL TO UL 217 8TH EDITION

Product

Helps Reduce Cooking Nuisance Alarms

UL 217 8th Ed.

Package and promotion

SMOKE ALARMS CERTIFIED BY UL TO UL 268 7TH EDITION

Product

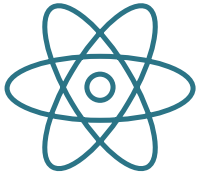
Helps Reduce Cooking Nuisance Alarms

UL 268 7th Ed.

Package and promotion

Key Messages for the Public

Working smoke alarms
will continue to provide protection
through the end
of their 10-year life span



At the end of the 10-year span,
install an alarm with enhanced
technology

Have an escape plan
and act on it when a
smoke alarm sounds

Best Case Success Story

4 y/o Child Saved and Successfully Revived After a Successful Transitional Attack that was Initiated from the Front Yard

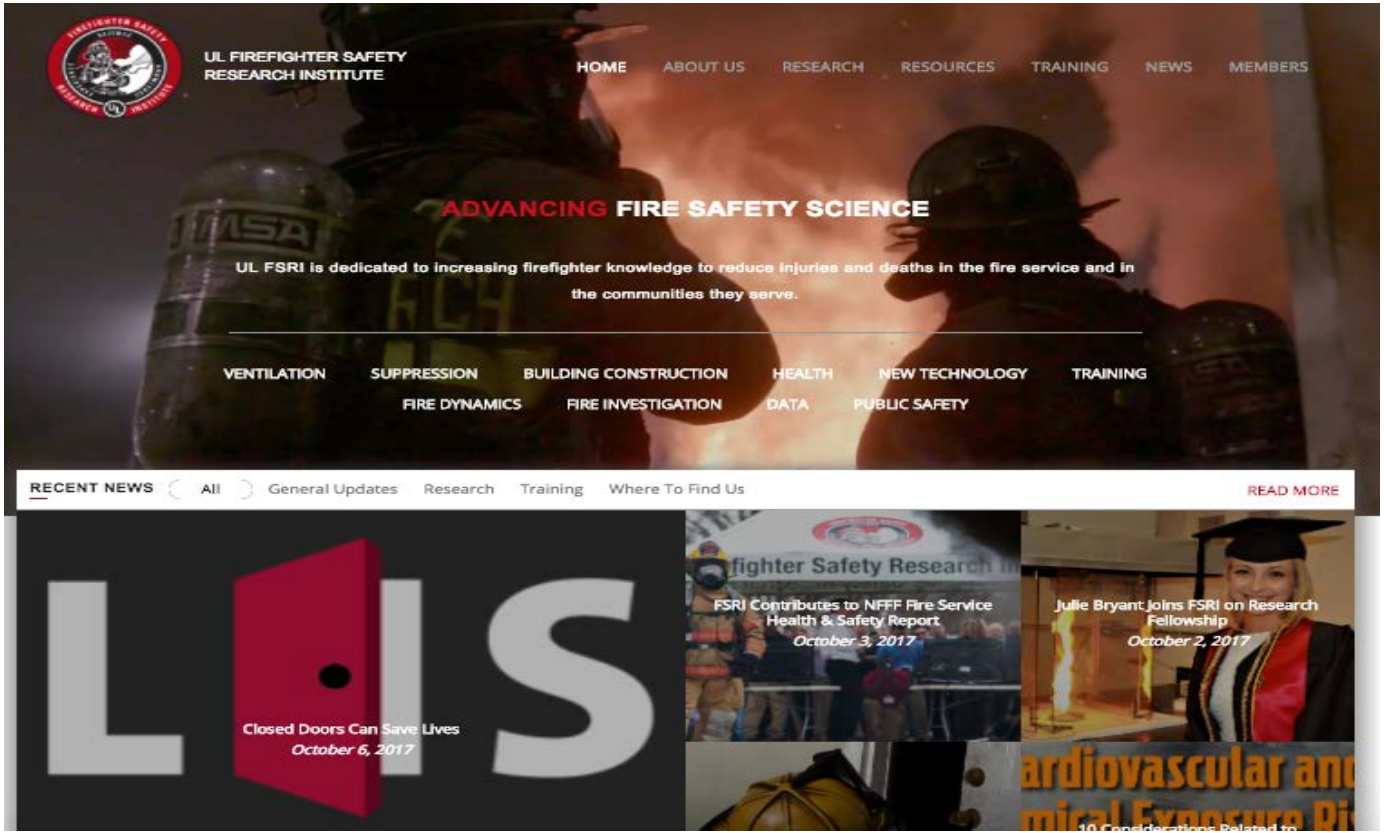
Isolation Saves Lives

Even Hollow Core Doors Help!

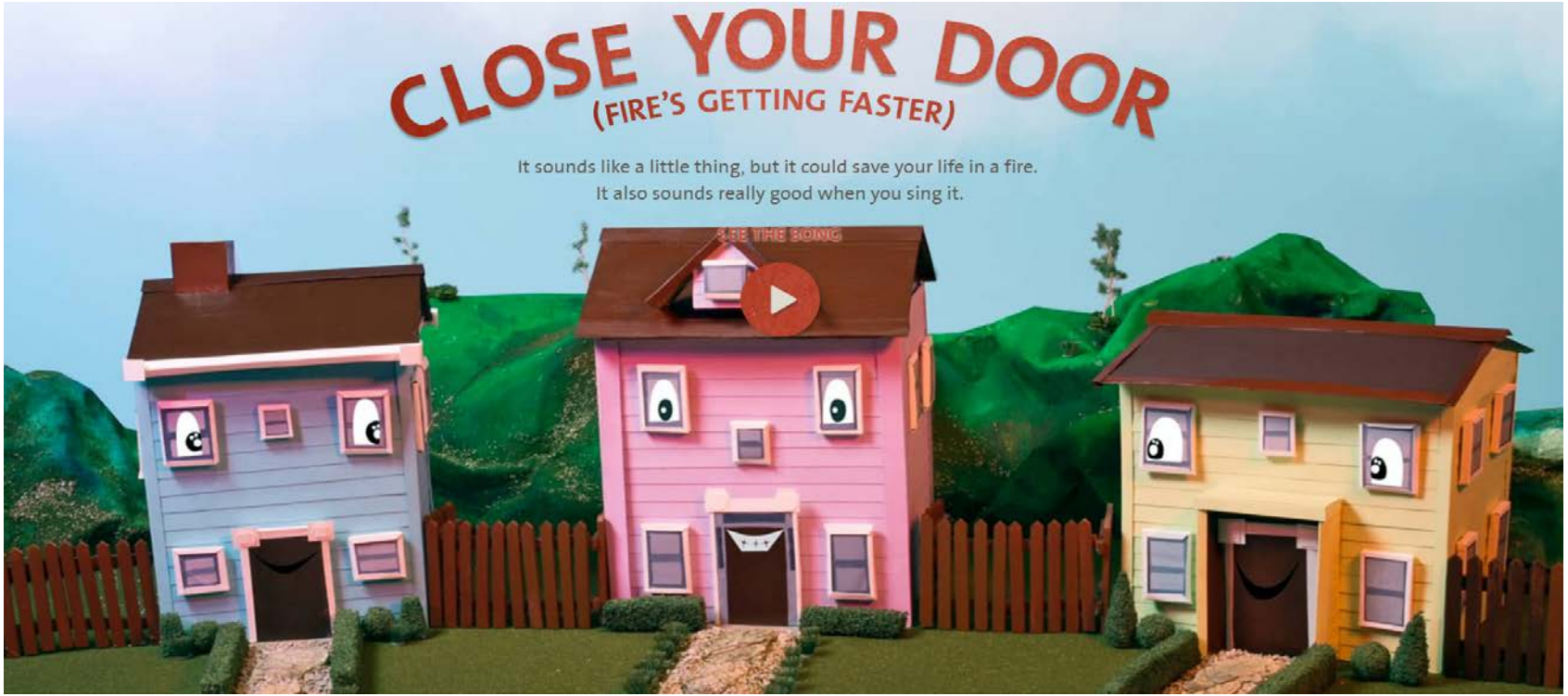
Hollow Core Door

Bedroom with Child

ULfirefightersafety.org



www.closeyourdoor.org



UL Offers Potentially Life-Saving Tip For Home Fire Safety: Close Before You Doze

Close Before You Doze

Actions You Can Take

Share the key safety messages on the previous slide with the public

CLOSE BEFORE YOU DOZE

closeyourdoor.org

Access fire safety resources

Visit smokealarms.ul.com for new resources from now until May 2020

Thank You!

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End Notes

"94% of executives believe managing complexity is important to the success of their company." KPMG, **"Confronting Complexity: Research Findings and Insights,"** May 2011

"54% of companies report no supply chain visibility." The Sustainability Consortium, **"2016 Impact Report,"** April 2016

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"Counterfeiting is an issue across all market segments…" 1: American Health and Drug Benefits, **"The Health and Economic Effects of Counterfeit Drugs,"** June 2014. 2: International Journal of Academic Research in Business and Social Sciences, **"Counterfeit Products within China…"** September 2012

"58% of consumers believe manufacturers value sales over product safety." UL**, "The Product Mindset,"** 2013

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"153 work-related accidents happen every 15 seconds, globally." International Labour Association, ILA website (ILO home>Topics> **Safety and health at work**), May 2017

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