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

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Underwriters Laboratories LLC
Manager, Industry Relations
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
The location was a small one room laboratory above Fire Patrol Station #1 on Monroe St. in downtown Chicago, IL.
To promote safe living and working environments through the application of safety science and hazard-based safety engineering.
UL operates in more than 143 COUNTRIES and across more than 20 INDUSTRIES.

UL has helped to set MORE THAN 1,600 standards defining safety, security, quality and sustainability.

UL’S SUSTAINABILITY CERTIFICATIONS are referenced in 900+ sustainable product specifications or purchasing guidelines around the globe.

Science and global expertise

UL HAS ENHANCED TRANSACTION SECURITY FOR:
- 500+ banks
- 20+ payment schemes
- 60+ mobile network operators
- 50+ governments/transport operators

UL software is used by 10,000+ ORGANIZATIONS in OVER 10 INDUSTRIES.

UL SERVES 1 OUT OF 3 Fortune 500 companies.

Fortune 500 companies
WORKING FOR A SAFER WORLD since 1894

UL reaches more than 1 BILLION GLOBAL CONSUMERS annually with safety messages

Brand presence and leadership

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

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**

<table>
<thead>
<tr>
<th>Category</th>
<th>Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorities Having Jurisdiction</td>
<td>7</td>
</tr>
<tr>
<td>Consumer</td>
<td>2</td>
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<td>General</td>
<td>11</td>
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<td>Government</td>
<td>2</td>
</tr>
<tr>
<td>Producer</td>
<td>10</td>
</tr>
<tr>
<td>Supply Chain</td>
<td>2</td>
</tr>
<tr>
<td>Testing and Standards Organizations</td>
<td>4*</td>
</tr>
</tbody>
</table>

*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](http://csds.ul.com/STPinfo/Roster_list.aspx)
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
- escape time needed during fires
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.

Commonly referred to as the “Dunes II Study”
Higher Fuel Loads
Increased Fuel Loads - Experiment

Natural Room

Synthetic Room
Comparison of Room Furnishings

Natural Room

Synthetic Room

00:00
Changing Fire Dynamics

1978

Natural materials and furnishing

approx 17 min

2018

Synthetic materials and open floor plans

approx 3 min

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.

20181978 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
But Why Polyurethane Foam?
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

<table>
<thead>
<tr>
<th>Residential Area</th>
<th>Common Items</th>
<th>Common Base Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Areas</td>
<td>Paints, Fuels, Packaging materials</td>
<td>Acrylic latex, Oil, Polyurethane, Thinner, Hydrocarbons, Paper, Polystyrene, Starch</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Test Sample</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:1 Heptane/Toluene mixture</td>
<td>UL 217 test material – mixture of short straight chain and simple aromatic hydrocarbon molecules</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>UL 217 test material</td>
</tr>
<tr>
<td>Newspaper</td>
<td>UL 217 test material</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>UL 217 test material</td>
</tr>
<tr>
<td>Heptane</td>
<td>Hydrocarbon liquid – short straight chain hydrocarbon</td>
</tr>
<tr>
<td>HDPE</td>
<td>Polyolefin plastic – long straight chain hydrocarbon</td>
</tr>
<tr>
<td>Bread</td>
<td>Potential nuisance source</td>
</tr>
<tr>
<td>Lard</td>
<td>Used in cooking; Potential nuisance source</td>
</tr>
<tr>
<td>Cooking oil</td>
<td>Hydrocarbon liquid – “intermediate” length hydrocarbon</td>
</tr>
<tr>
<td>Mattress composite</td>
<td>Natural and synthetic materials; Commonly found in home furnishings</td>
</tr>
<tr>
<td>Mattress PU foam</td>
<td>Synthetic; Flexible, open cell structure; Commonly found in home furnishings</td>
</tr>
<tr>
<td>Cotton batting</td>
<td>Natural material; Commonly found in home furnishings</td>
</tr>
<tr>
<td>Polyester pillow stuffing</td>
<td>Aromatic; Commonly found in home furnishings</td>
</tr>
<tr>
<td>CA TB 117 50:50 Cotton/</td>
<td>Natural and synthetic materials blend; Commonly found in bed clothing and apparel</td>
</tr>
<tr>
<td>Polyester blend fabric</td>
<td></td>
</tr>
<tr>
<td>Rayon fabric</td>
<td>Synthetic; Commonly found in apparel</td>
</tr>
<tr>
<td>Nylon carpet</td>
<td>Synthetic; Commonly found as a flooring product</td>
</tr>
<tr>
<td>PET carpet</td>
<td>Synthetic; Commonly found as a flooring product</td>
</tr>
<tr>
<td>Polyisocyanurate insulation foam</td>
<td>Synthetic; Rigid, closed cell structure; Commonly found as insulation</td>
</tr>
<tr>
<td>PVC wire</td>
<td>Common electrical wiring</td>
</tr>
</tbody>
</table>
## Smoke Characterization Project Summary
ANSI/UL 217, ANSI/UL 268 Fire Test Room

<table>
<thead>
<tr>
<th>Flaming Tests</th>
<th>Mean Diameter (µm) at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 %/ft</td>
</tr>
<tr>
<td>UL 217 Douglas fir</td>
<td>0.13</td>
</tr>
<tr>
<td>UL 217 Newspaper</td>
<td>0.17</td>
</tr>
<tr>
<td>UL 217 Heptane/Toluene</td>
<td>0.19</td>
</tr>
<tr>
<td>Coffee maker</td>
<td>0.17</td>
</tr>
<tr>
<td>PU foam</td>
<td>0.08</td>
</tr>
<tr>
<td>PU foam in Cotton/Poly</td>
<td>0.09</td>
</tr>
<tr>
<td>Nylon carpet</td>
<td>0.10</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Smoldering Tests</th>
<th>Mean Diameter (µm) at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 %/ft</td>
</tr>
<tr>
<td>UL 217 Ponderosa Pine</td>
<td>0.16</td>
</tr>
<tr>
<td>PU foam</td>
<td>0.20</td>
</tr>
<tr>
<td>PU foam in Cotton/Polyester</td>
<td>0.22</td>
</tr>
<tr>
<td>PU foam in Polyester</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* Test did not achieve 10 %/ft obscuration.
Smoke Characterization Project Summary
Fire Test Room – Flaming Test Smoke Color

Ponderosa Pine  PU Foam
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/ft³ - 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/m³ (1.8 ± 0.1 lb/ft³ 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/m³ (~1.2 lb/ft³)
Fire tests reflect particles from different fires, but do not replicate scenarios!

Will manufacturers be using Single Criteria or Multi-Criteria?
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

Smoldering Ponderosa Pine

UL 217 Smoldering Ponderosa Pine Limit – Must Alarm by 10 %/ft OBS

Smoldering OBS (%/ft)

0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00 18.00

Time (s)
0 1000 2000 3000 4000 5000
PU Smoldering Test

Smoldering PU Foam

PU Smoldering Limit – Must Alarm by 12 %/ft OBS
Smoldering Tests

Smoldering Fire Tests

PU Smoldering Limit – Must Alarm by 12 %/ft OBS

UL 217 Smoldering Ponderosa Pine Limit – Must Alarm by 10 %/ft OBS

Previous UL 217 - Must Not Alarm Prior to 0.5 %/ft OBS
Flaming Paper Fire Test

**Flaming Newspaper Test**

- UL 217 Flaming Paper
- UL 217 Max. Alarm Time – 4 min

[Graph showing time vs. O2 (%/ft) with UL 217 Flaming Paper highlighted]
Flaming Wood Test

Flaming Wood Test

UL 217 Max.
Alarm Time

UL 217
Flaming Wood

Time (s)

OBS (%/ft)

0 50 100 150 200 250 300

0 5 10 15 20 25 30 35 40
Flammable Liquid Test

UL 217 Max. Alarm Time

Heptane-Toluene
Flaming PU Foam Test

PU Flaming Fire Test

UL 217 Max. Alarm Time

5%/ft OBS Flaming PU Foam Acceptance Criteria
Flaming Test Comparisons

Flaming Fire Tests

UL 217 Flaming Paper

UL 217 Flaming Wood

UL 217 Heptane-Toluene

PU Flaming

UL 217 Max. Alarm Time

Time (s)

OBS (%/ft)

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Once PU Foam Profiles were identified, what should the Acceptance limits be?
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**
Flaming PU Test Progression

- Test 234
- Test 235
- Test 236
- Upper Limit
- Lower Limit

Ceiling Beam Signal

Obscuration (%/ft.)
- 9 %/ft.
- 8 %/ft.
- 7 %/ft.
- 6 %/ft.
- 5 %/ft.
- 4 %/ft.
- 3 %/ft.
- 2 %/ft.
- 1 %/ft.

Time (s)
- 110
- 120
- 130
- 140
- 150
- 160
- 170
- 180
- 190
- 200
- 210
- 220
- 230
- 240
- 250
- 260

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

Why Cooking Nuisance?
Common Nuisance Sources

- 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)

Figure 12. Reasons Given for Smoke Alarm Activations in Past Year

- Cooking: 73%
- Low battery chirp: 8%
- Unclassified: 5%
- Woodstove or fireplace: 4%
- Lost power or power surge: 3%
- Steam: 2%
- No apparent cause: 2%
- Malfunction or defective: 1%
- Don’t know: 2%

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

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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

Flaming Fire Tests

UL 217 Flaming Paper

UL 217 Flaming Wood

PU Flaming

1.5%/ft OBS Flaming

PU Foam

Acceptance Criteria

UL 217 Max. Alarm Time
Will manufacturers be using Single Criteria or Multi-Criteria?
Introducing Multi-Criteria

Large SMOKE PARTICLES

Small and Large SMOKE PARTICLES

NOx

CO

HUMIDITY

Small SMOKE PARTICLES

HUMIDITY

HEAT

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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?
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.
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.”
Approximate Number of Standard Revisions

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

800+ • Total Revisions
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

Package and promotion

HELPS REDUCE COOKING NUISANCE ALARMS

UL 217 8th Ed.

SMOKE ALARMS CERTIFIED BY UL TO UL 268 7TH EDITION

Product

Package and promotion

HELPS REDUCE COOKING NUISANCE ALARMS

UL 268 7th Ed.

Helps Reduce Cooking Nuisance Alarms

UL 217 8th Ed.

UL 268 7th Ed.

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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

Child Found
Isolation Saves Lives

Even Hollow Core Doors Help!

Hollow Core Door

Bedroom with Child
UL firefightersafety.org
CLOSE YOUR DOOR
(FIRE’S GETTING FASTER)

It sounds like a little thing, but it could save your life in a fire.
It also sounds really good when you sing it.

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

Access fire safety resources

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

closeyourdoor.org
Thank You!

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


“Only 3% of consumers find advertised brand claims believable.” About.com, “The Trust Factor,” July 2012


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

“88% of consumers would stop buying…” Cone Communications, “2013 Social Impact Study,” 2013

“Over $1 Trillion (USD/Year) is spent on product safety-related injury…” Global Recalls Database, (globalrecalls.oecd.org), May 2017

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


“52% of people globally say they check a brand’s social and environmental commitment…” Nielsen, “The Nielsen Global Survey on Corporate Social Responsibility,” October 2014

“There are over 400 sustainability reporting instruments…” Nielsen, “The Nielsen Global Survey on Corporate Social Responsibility,” October 2014