U.S. Consumer Product Safety Commission
LOG OF MEETING

SUBJECT: Suppression, Detection and Signaling Research and Applications Conference (SUPDET® 2018)

DATE OF MEETING: September 11 and 12, 2018

LOG ENTRY SOURCE: Arthur Lee, ESEF

DATE OF LOG ENTRY: September 17, 2018

LOCATION: Embassy Suites, Cary, NC

CPSC ATTENDEE(S):
Arthur Lee, Directorate for Engineering Sciences (ES)

NON-CPSC ATTENDEE(S):
Open to the public

SUMMARY OF MEETING:
Attended conference presentations (see attached program). The Suppression portion of the conference was cancelled due to Hurricane Florence. Staff presented on the topic, *Investigation into Failures of Smoke Alarms in Non-fire Scenarios*. See attached presentation.

No follow-up schedules or needed.

RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

Suppression, Detection and Signaling Research and Applications Conference (SUPDET® 2018)

Program

September 11 – September 14, 2018
Embassy Suites Raleigh-Durham-Research Triangle East, Cary, NC

Last Updated: 28 August 2018

DETECTION PROGRAM

Tuesday, September 11, 2018

9:00 Welcome
2017 Ronald K. Mengel Award

9:15 Keynote
Research Needs for the Fire Safety Engineering Profession: The SFPE Roadmap
Chris Jelenewicz, SFPE

Session I: Testing

10:00 Impacts of Real and Simulated Test Smoke on Electronic Circuitry
Joshua Dinaburg and Rachel Bourassa, Jensen Hughes

10:30 Break sponsored by GENTEX CORPORATION

Session I: Testing (continued)

11:00 Challenges in Utilizing Multi-Criteria Smoke Sensing to Pass the New UL Fire Tests and Why Artificial Intelligence is Needed
Eric Gonzales, Vistatech Labs Inc.

Session II: Residential

11:30 Development of Tools to Evaluate the Impact of New Residential Fire Protection Technology
Paul Reneke, Morgan Bruns, Richard Peacock, Thomas Cleary, and Stanley Gilbert, National Institute of Standards and Technology

12:00 Lunch on own

Session II: Residential (continued)

2:00 Investigation into Failures of Smoke Alarms in Non-Fire Scenarios
Arthur Lee, Consumer Product Safety Commission

2:30 Development of a Pre-Ignition Detection Algorithm for Kitchen Cooktop Fires
Amy Mensch and Anthony Hamins, National Institute of Standards and Technology

3:00 Break sponsored by VIKING®

Session III: Modeling

3:30 Modeling Smoke Detector Activation
Thomas Cleary, National Institute of Standards and Technology
Gabriel Taylor, Nuclear Regulatory Commission

4:00 Scattering Matrix Analysis of Fire and Non-fire Aerosols for Classification and Implications for Smoke Detector Design
Qixing Zhang and Yongming Zhang, State Key Laboratory of Fire Science, University of Science and Technology of China

4:30 CFD Modeling Study on Smoke Detection in Clean Rooms and Code Requirements
Steven Joseph, Xtralis
Yun Jiang, Xtralis

5:30 – 7:00 Reception

Wednesday, September 12, 2018

Session IV: Integrated Systems and Smart Buildings

8:30 Big Data and Real Time Analytics: Use of a Hierarchical Temporal Memory Continuous Learning Algorithm for Fire State Determination
Noah L. Ryder and Justin A. Geiman, Fire & Risk Alliance, LLC
Elizabeth J. Weckman, University of Waterloo

9:00 Emerging Technology and the Intelligent Building
Maria Marks, Siemens

9:30 The Internet of Things (IoT) and its Impact on Fire Protection Systems Design & Installation
Wayne Moore, Jensen Hughes

10:00 Break sponsored by SIEMENS

Session IV: Integrated Systems and Smart Buildings (continued)

10:30 Challenges with the Use of Power over Ethernet (PoE) for Fire Alarm
Casey Grant, Fire Protection Research Foundation

11:00 Are you Ready and do you have the Skill Sets?
Lance Rütimann, Siemens

11:30 Closing Comments, Feedback

1:00 – 5:00 pm – Special Event
Protection of Energy Storage Systems (ESS) in Buildings
Design Challenge Workshop
(open to all symposium attendees)

SUPPRESSION PROGRAM

Thursday, September 13, 2018

8:30 Welcome
2017 William M. Carey Award

Session I: Storage Protection

8:45 Automatic Sprinklers and Pick Modules
Stuart Lloyd, Zurich Insurance Company Ltd.
Richard Gallagher, The Zurich Services Corporation

9:15 Storage Protection in the Presence of Horizontal Barriers or Solid Shelving
Garner A. Palenske, Jensen Hughes

9:45 Use of SMART Sprinklers to Reduce Water Demand for Occupancies with Low-Piled Storage of Plastics
Yogish Gopala, Stanislav Kostka, Benjamin Ditch, and Yibing Xin, FM Global

10:15 Break sponsored by

Session I: Storage Protection (continued)

10:45 Digital Technology and Incident Command for Sprinkler Protected Warehouses
Christina Francis, P&G

Session II: Energy Storage Systems

11:15 Energy Storage System Research and Engineering Design Challenges
Casey Grant, Fire Protection Research Foundation

12:00 Lunch on own

Session II: Energy Storage Systems (continued)

2:00 Fire Fighter Safety in Battery Energy Storage System Fires
Kevin Marr and Erik Archibald, University of Texas

2:30 Update on Development of Sprinkler Protection for Li-Ion Battery based Energy Storage Systems
Benjamin Ditch, FM Global

3:00 Break sponsored by Victaulic

Session III: Special Suppression Applications

3:30 Exterior Fire Suppression Systems for High-Rise Buildings with Combustible Cladding
Pedriant Pena and Zachary L. Magnone, Johnson Controls

4:00 Not your Average K-Factor: A Novel Sprinkler Comparison Tool
Stephen Jordan, Fire & Risk Alliance, LLC

5:00 – 6:30 Reception

Friday, September 14, 2018

Session IV: Gaseous and Clean Agents

8:30 **A Case Study in Oxygen Reduction Systems: Protecting the Star Spangled Banner**
James H. Call, Smithsonian Institution

9:00 **Discharge Characteristics of the Super-Pressurized Halocarbon Clean Agents**
Arash Aran, Johnson Controls Inc.

9:30 **Noise Measurement Technique and Metrics for Fire Suppression Nozzles**
Sudarshan Koushik, Duane McCormick, and May Corn, United Technologies Research Center (UTRC)
Paul Johnson, United Technologies

10:00 **Break**

Session VI: Gaseous and Clean Agents (continued)

10:30 **Carbon Dioxide Flow Calculations**
Eric Forssell, Jensen Hughes

11:00 **A First Look at NFPA 770, *Standard on Hybrid (Water and Inert Gas) Fire Extinguishing Systems***
Barry Chase, NFPA

11:30 **Closing Comments, Feedback**

INVESTIGATION INTO FAILURES OF SMOKE ALARMS IN NON-FIRE SCENARIOS

ARTHUR LEE

U.S. CONSUMER PRODUCT SAFETY COMMISSION, BETHESDA, UNITED STATES

THE VIEWS EXPRESSED IN THIS PRESENTATION ARE THOSE OF THE CPSC STAFF AND HAVE NOT BEEN REVIEWED OR APPROVED BY, AND MAY NOT NECESSARILY REFLECT THE VIEWS OF, THE COMMISSION

CPSC Staff-Documented Incidents

- Incidents documented by CPSC field staff from 2014 to 2018.
- Smoke alarms and detectors failed to operate as intended, without exposure to smoke or fire.
- All incident smoke alarms and detectors were listed to UL 217 and/or UL 268 at the time of failure.
- CPSC staff collected samples of exemplar and incident smoke alarms and detectors to evaluate the causes of the reported failures.

1. Unknown Chirping

Narrative

- In 2009, approximately 600 combination smoke/CO alarms installed in a newly constructed 112-unit apartment complex.
- In 2011, the maintenance technician began receiving tenant complaints of smoke/CO alarms randomly sounding.

1. Unknown Chirping

Engineering Staff Evaluation

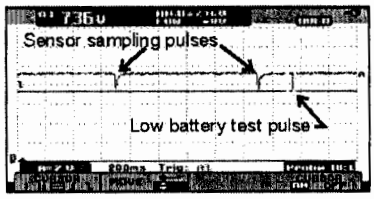
- Test Set-up
  - Microphones to monitor alarming
  - New 9 volt primary alkaline-manganese batteries
  - Sealed test chamber with no airflow

1. Unknown Chirping
Engineering Staff Evaluation

- Immediately, three of the five smoke/CO alarms began emitting a single chirp about every 60 seconds (low battery signal).
- After approximately 60 minutes, all the smoke/CO alarms were indicating low battery.
- After an additional 87 minutes, 4 of the 5 alarms went into full CO alarm. The fifth unit went into full CO alarm after 35 hours.

1. Unknown Chirping
Engineering Staff Evaluation

- The battery level dropped to around 7.36 volts during sensor sampling/low battery check.
- The excessive drop in voltage is likely sufficient to cause the alarm to emit a low-battery chirp, however the actual cause for the low battery drop was not determined.



2. Exploding Battery
Narrative

- Consumer purchased and installed multiple 10-year battery smoke alarms approximately 2 years prior to the incident.
- Consumer removed the most recently installed alarm due to persistent beeping a month before the incident placing it in a paper bag; Consumer subsequently removed all previously installed alarms and placed them in inside a plastic bag to be returned to the store.
- Consumer heard a "swoosh" and upon entering the kitchen, witnessed the bag containing the alarms on fire.

2. Exploding Battery
Engineering Staff Evaluation

- The smoke alarm electronics appeared intact.
- No evidence of melted wiring from the battery or battery connector.
- The incident resulted from a lithium battery that had entered into a thermal runaway condition.

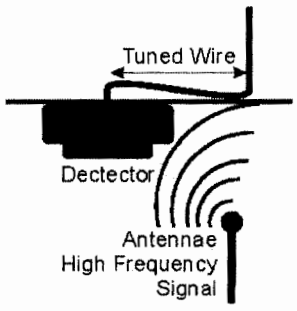
Incident Battery | Exemplar Battery

3. Electronic Noise Interference
Narrative

- A professional fire and security service provider encountered abnormal detector operation while performing routine maintenance work.
- The detector manufacturer determined the printed circuit board (PCB) used in the detectors was susceptible to interference from high-frequency radio waves.

3. Electronic Noise Interference
Engineering Staff Evaluation

- In a worst-case scenario the length of wiring to the detector became a tuned antenna picking up high frequencies emitted by adjacent transmitters.
- The noise on the wiring was conducted into the detector's circuit causing the unit to false alarm or enter into a sleep mode.



3. Electronic Noise Interference

Engineering Staff Evaluation

Improvements to the PCB eliminated noise susceptibility by:

- Separating signal and ground trace layers
- Removing uneven edges and 90° turns in the signal traces
- Adding ferrite beads on wiring leads
- Adding filter capacitors on the board

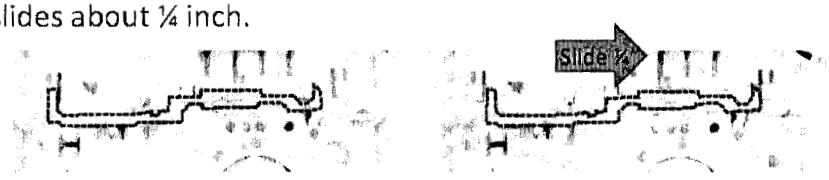
4. Jammed

Narrative

- In 2014, a fire department was installing 1,800 10-year smoke alarms in homes had problems switching on the alarms
- The smoke alarms required activation before installing by sliding a switch located on the rear of the alarm to the "off" position

4. Jammed
Engineering Staff Evaluation

Staff found that in normal operation when the switch is moved to the "on" position a piece of plastic within the alarm slides about ¼ inch.



Not activated

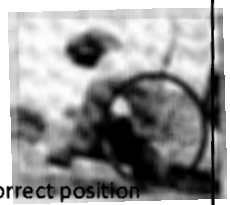
Activated

4. Jammed
Engineering Staff Evaluation

CPSC staff determined that the sliding plastic piece within the alarm were out of alignment or susceptible to jamming preventing the switch moving into the "on" position.

Interference

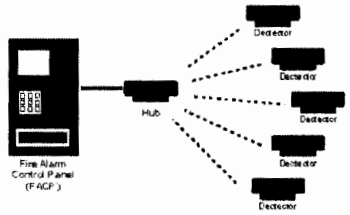
Incorrect position



Correct position

5. Drift Compensation
Narrative

- The manufacturer conducted a routine engineering test on the smoke detectors drift compensation in December of 2016 and found that the detectors may not communicate an alarm condition
- During normal operation the fire alarm control panel, hub, and detectors communicate frequently to determine whether a fire alarm condition is present.



5. Drift Compensation
Engineering Staff Evaluation

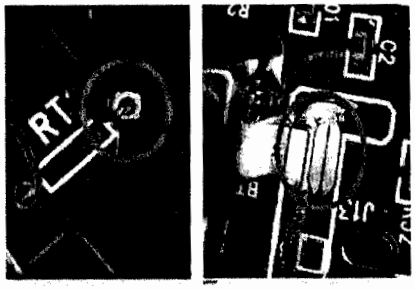
- Dust levels within the detector-sensing chamber would cause the drift compensation algorithm to be beyond the fire-detection range.
- Each step of the drift compensation amount would reduce the detector's maximum output by the same amount. Thus, the maximum level of smoke the sensor could detect was reduced, eventually exceeding the possible range.
- An adjustment to the firmware corrected the miscalculation.

6. Cold Solder
Narrative

- A smoke detector distributor discovered that some detectors had failed immediately upon first use.
- The manufacturer determined the thermistor component was not making a connection to the printed circuit board.

6. Cold Solder
Engineering Staff Evaluation

- The grounding plane was absorbing heat during the soldering process.
- The cold solder joints caused the connection to the thermistor and other components to be unreliable.
- Proper soldering and quality assurance/quality control procedures applied to the manufacturing process corrected the problem.

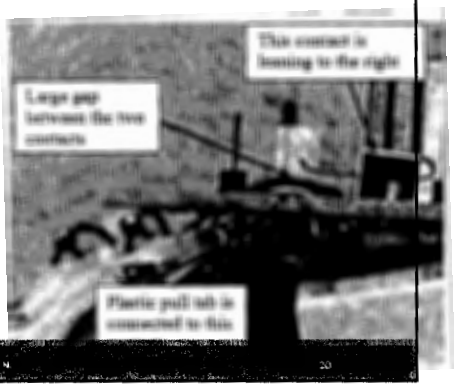


7. Misaligned Switch
Narrative

- A state distributed 10-year smoke alarms to various fire departments in 2016 to go door-to-door in neighborhoods to install them in homes.
- Some of the alarms did not activate/alarm after the battery-activation tabs were pulled.
- For some units, the installer would "smack" the alarm with their hand to get it to alert, and to get the test button to respond.

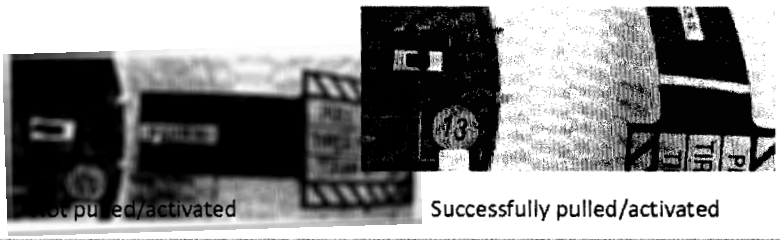
7. Misaligned Switch
Engineering Staff Evaluation

The reported malfunctions were caused mainly by a switch not making contact when the pull tab was removed



7. Misaligned Switch
Engineering Staff Evaluation

The manufacturer improved the activation switch by replacing it with a more reliable sliding switch for closing the circuit



Successfully pulled/activated

8. Misunderstood Chirps
Narrative

- In 2015, local fire officials were conducting routine tests on the smoke/CO alarms in a condominium complex.
- When the test buttons were pressed, the alarms failed to sound and/or activate other interconnected alarms.
- A month prior to the testing, the occupants heard the alarms chirping and proceeded to replace the batteries thinking they were low; when replaced, the alarms would stop chirping, and the green LED power light illuminated.

8. Misunderstood Chirps

Engineering Staff Evaluation

- CPSC field staff collected some of the chirping alarms. When engineering staff tested the chirping smoke/CO alarms with an aerosol spray and injected CO in a chamber, they failed to respond.
- During power-up, the unit alerts the user to press the test button. When the user presses the test button, the unit emits a 3-pulse tone, followed by "FIRE, FIRE" and then again the 3-pulse tone. The green LED ("Operate") illuminates after pressing the test button.

8. Misunderstood Chirps

Engineering Staff Evaluation

- During CPSC testing, the units intermittently chirped every 30 seconds, which, according to the manufacturer's instructions, is actually an indication that the alarm has malfunctioned.
- Low battery is a chirp every 60 second.
- The occupants mistook the 30-second chirps for a low-battery warning and changed the batteries. This caused the alarm to reset and stop the 30-second chirp, but the units were still malfunctioning and not able to respond to smoke or CO.

Additional Case - Battery Size
Narrative

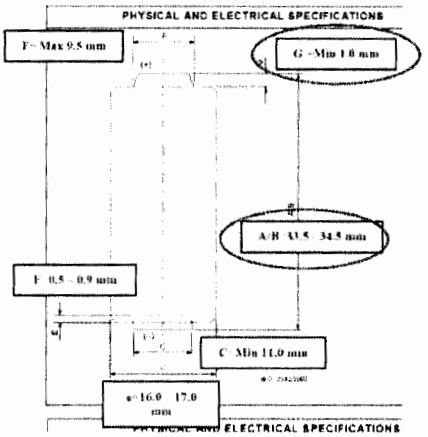
- The incident involved a smoke detector where there was nothing wrong with the design of the product.
- In 2018, the batteries in the smoke detectors were being replaced in an assisted living complex.
- The personnel accidently inserted one of the batteries in reverse polarity.
- The unit began to produce smoke and overheat.

Additional Case - Battery Size
Engineering Staff Evaluation

- The battery compartment for the detector uses two CR123A type lithium batteries.
- The batteries are intended to be installed in the same direction with the positive ends on one side and the negative ends on the other side.
- Unit contained a feature to prevent battery polarity reversal installation.

Additional Case - Battery
Engineering Staff Evaluation

- Three brands of CR123A type batteries tested in the alarm.
- CR123A Lithium batteries also known as CR17345 in the IEC 60086 standard.
- The IEC contains battery dimension specifications for CR123A.



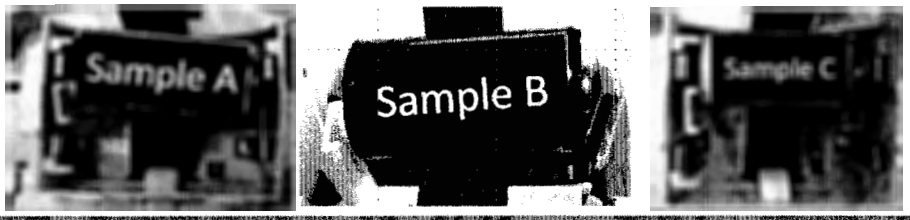
Additional Case - Battery Size
Engineering Staff Evaluation

Battery Samples	Dimensions mm								
	A/B		C	E		F	G	∅	
	Max.	Min.	Min.	Max.	Min.	Max.	Min	Max.	Min.
IEC 60086	34.5	33.5	11.0	0.9	0.5	9.6	1.0	17.0	16.0
Sample A	34.01, 34.03, 34.06 = **Average 34.03**		**11.96**	Not measured		**6.24**	32.80, 33.16, 33.07 = Average 33.01 **34.03-33.01=1.02**	16.45, 16.44, 16.43 = **Average 16.44**	
Sample B	34.42, 34.48, 34.35 = **Average 34.41**		**12.94**	Not measured		**6.33**	33.18, 33.20, 33.20 = Average 33.19 **34.41-33.19=1.22**	16.46, 16.40, 16.44 = **Average 16.43**	
Sample C (Incident brand)	33.40, 33.46, 33.51 = **Average 33.46**		**11.38**	Not measured		**6.98**	33.32, 33.32, 32.49 = Average 33.04 **33.46-33.04=0.42**	16.70, 16.63, 16.60 = **Average 16.64**	

Additional Case - Battery Size

Engineering Staff Evaluation

The Sample C battery dimensions are smaller than specified in IEC 60086, which allows the batteries to be fully seated in the battery slots, in the reversed polarity.



Closing Remarks

- Careful design and manufacturing in all aspects of the product is important.
- When smoke alarms are installed but fail to operate, it can result in consumers having reduced confidence.
- Today's engineering and technology allows the opportunity to manufacture products that are error-free, by incorporating improved quality control, quality assurance, and automation.