Smoke Alarm Paradox

What could save you…hopefully doesn't endanger you!

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Directorate for Engineering Sciences
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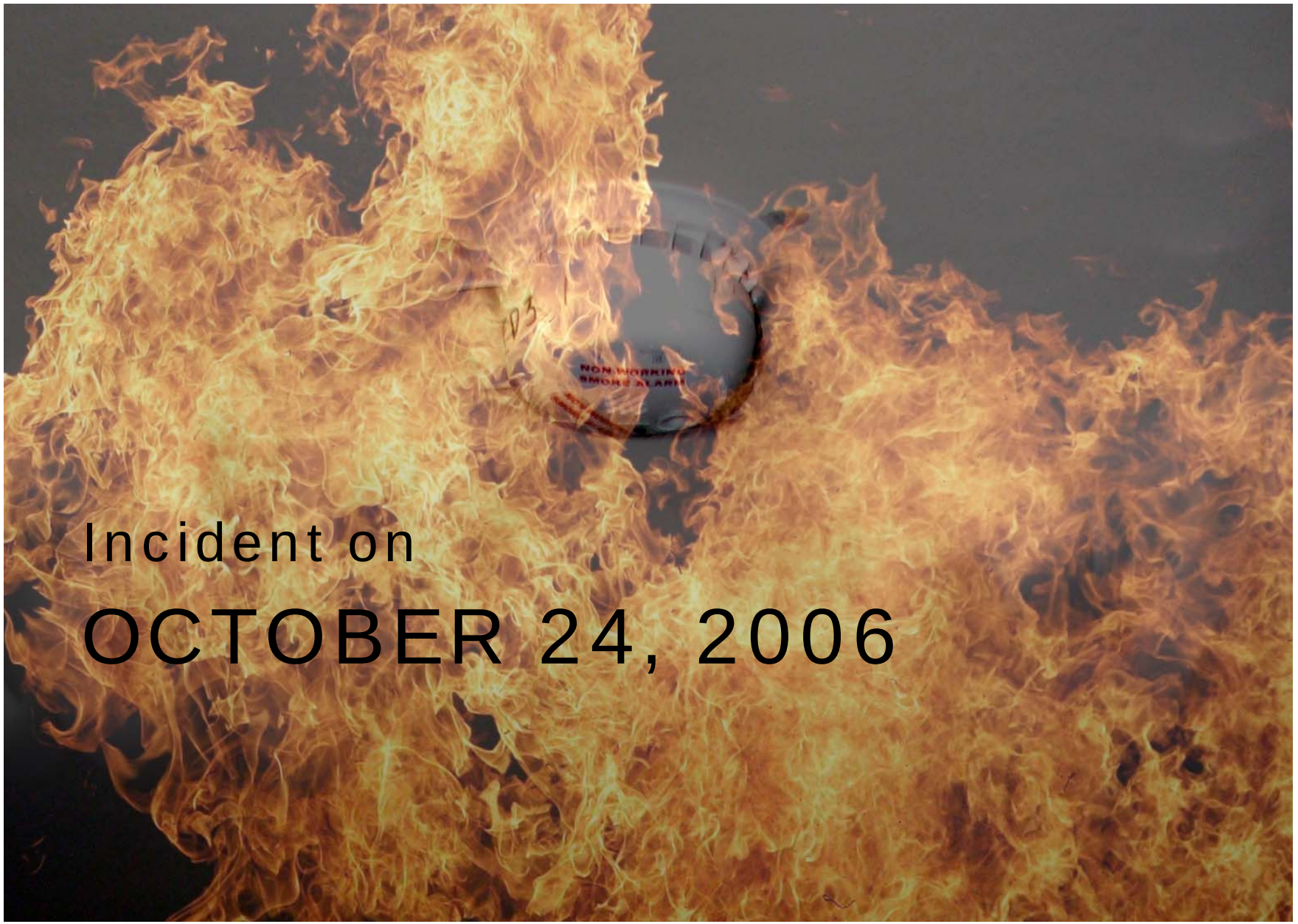
*These comments are those of the CPSC staff.
They have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

In perspective…

The failure mode addressed by the study covered in this presentation is rare and may not be a typical end-of-life scenario for smoke alarms.


Incident on
OCTOBER 24, 2006

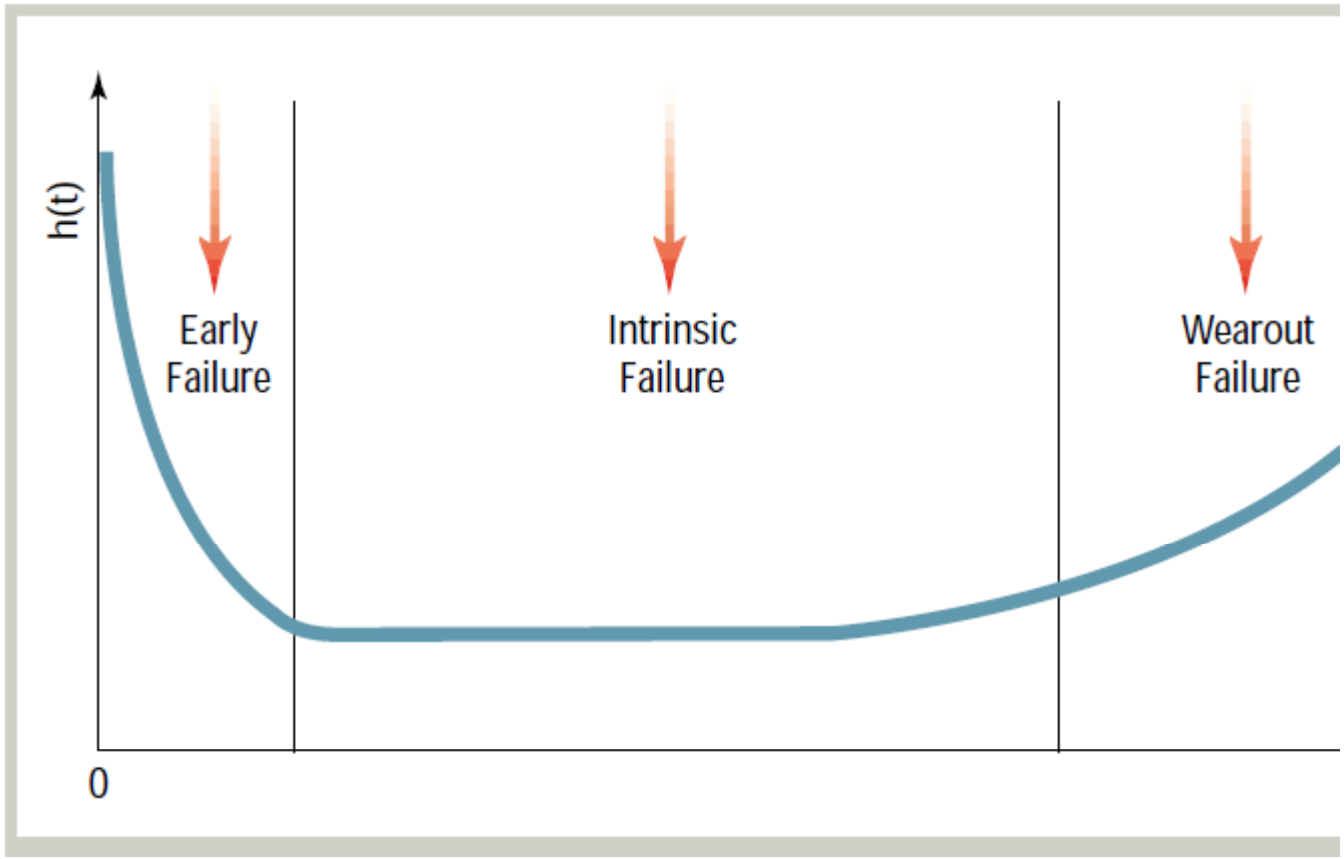
Smoke alarms are devices designed to provide life safety in the event of a fire, but what happens when the smoke alarm itself is the cause of a fire?

Topics:

- Do smoke alarms with internal plastic components pose a hazard when they ignite?
- Review smoke alarm reliability: Component failure, 10-year replacement, and weekly replacement.
- Review documented incidents of AC-powered smoke alarms' electrical components overheating.
- Determine whether a smoke alarm's internal plastic components propagate a fire beyond the housing, if ignited.

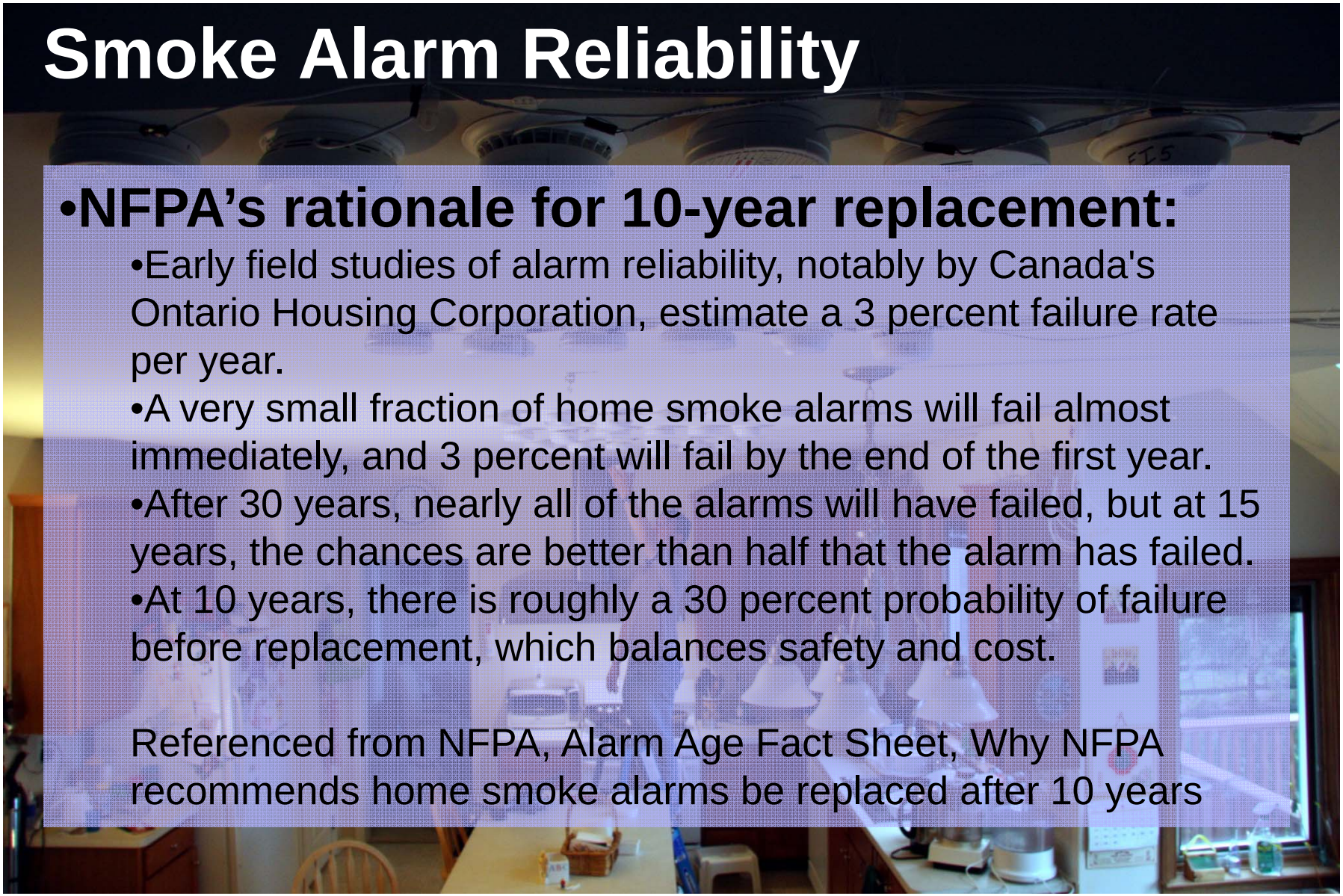
Failure of Electrical Components

- Components and assemblies tend to follow the typical “bathtub” failure rate curve.



Referenced from UL 268

Smoke Alarm Reliability



- **NFPA's rationale for 10-year replacement:**
  - Early field studies of alarm reliability, notably by Canada's Ontario Housing Corporation, estimate a 3 percent failure rate per year.
  - A very small fraction of home smoke alarms will fail almost immediately, and 3 percent will fail by the end of the first year.
  - After 30 years, nearly all of the alarms will have failed, but at 15 years, the chances are better than half that the alarm has failed.
  - At 10 years, there is roughly a 30 percent probability of failure before replacement, which balances safety and cost.

Referenced from NFPA, Alarm Age Fact Sheet, Why NFPA recommends home smoke alarms be replaced after 10 years

Weekly, Monthly, or Yearly Testing?

- Work done by Hjalmar Nelson, Jr., who showed statistically how test frequency impacts the length of unprotected time.
- Tested once a year, an estimated out-of-service time of 33.5 weeks.
- Tested monthly, an estimated out-of-service time of 5 weeks.
- Tested weekly, an estimated out-of-service time of 3 weeks.

*Assuming a failure rate of 4.0 failures per million hours and replaced within two weeks if found inoperative. Over a 10-year period.

Collected a history of smoke alarm fire incidents from the CPSC database and field investigations*

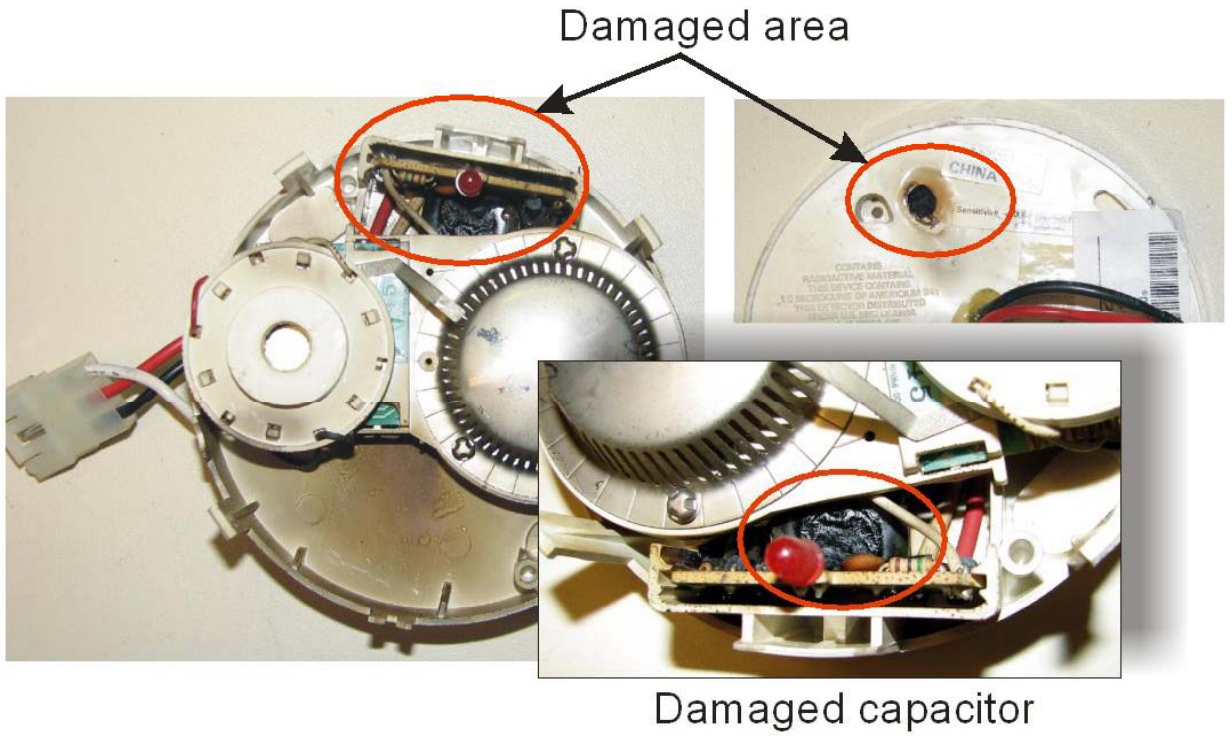
- Seventeen documented incidents from 1999 to 2011 (approx. 1.5/yr)
- Causes:
  - Failed electrical components (15), and
  - Electrical shorts (2)

*The IPII data system includes consumer letters, CPSC Hotline complaints, newspaper clippings, and medical examiner reports. This information is collected and input into the CPSC Database. CPSC field investigators may follow up on selected incidents by conducting In-Depth-Investigations (IDIs). Reports of these IDIs may contain interviews with the victim, witnesses, and the emergency personnel responding to the incident.

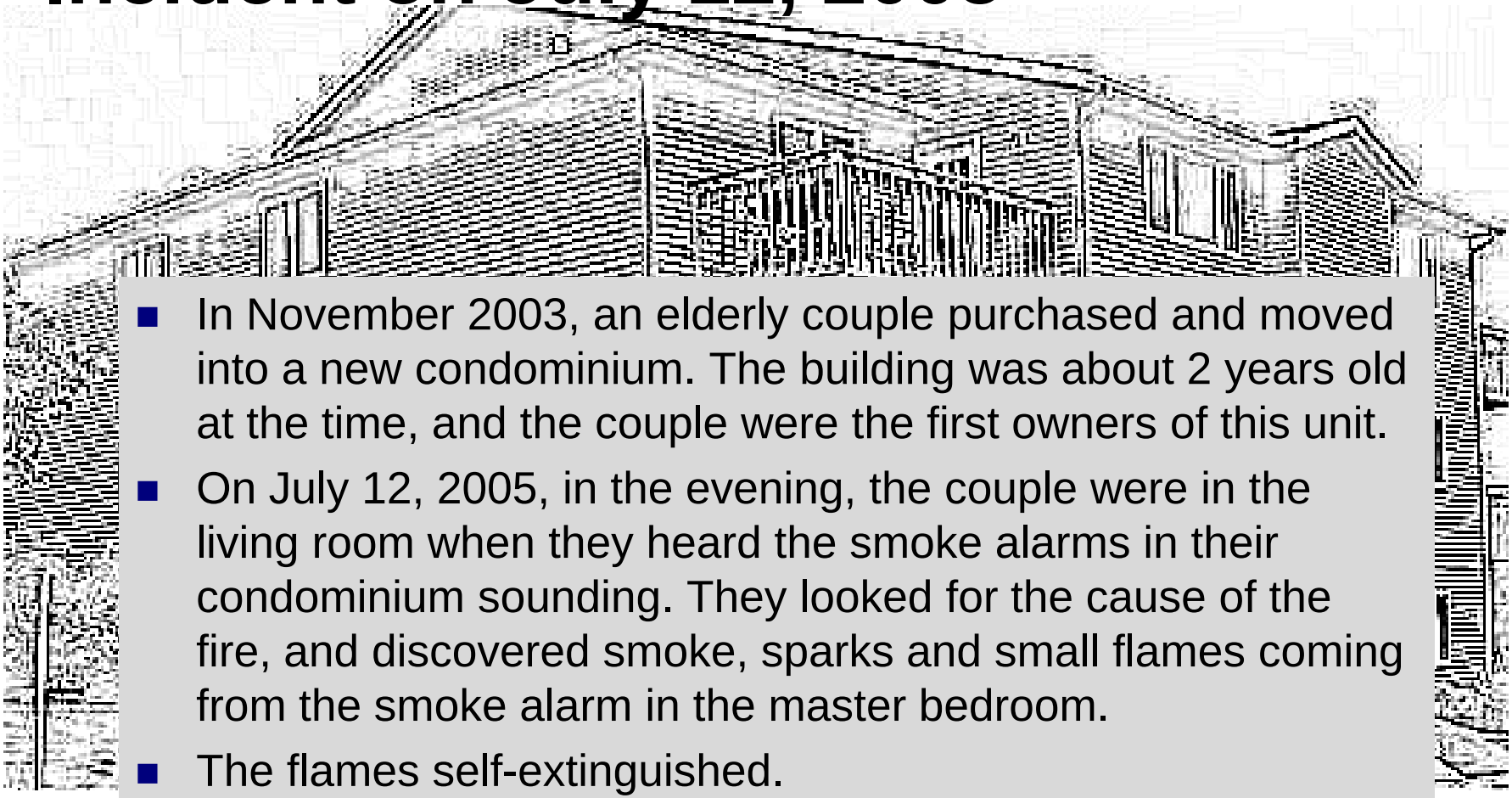
Analysis for incident on October 24, 2006

•The damage to the smoke alarm was consistent with a filter capacitor failure.

•Frequent or large-voltage spikes could have caused an increase in the leakage current through the dielectric material, resulting in the breakdown of the dielectric material in the capacitor, causing it to overheat.



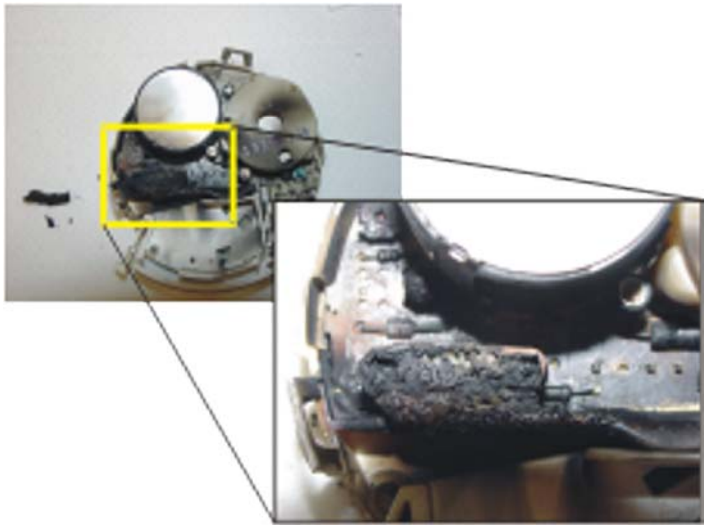
Incident on July 12, 2005

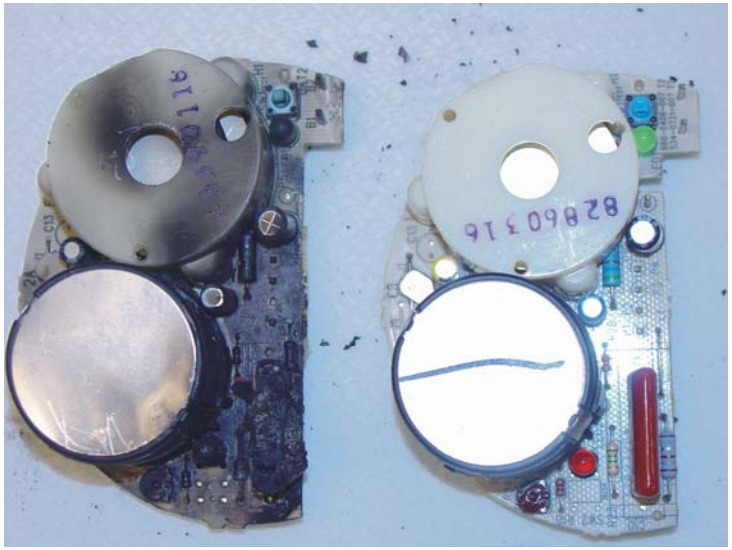


- In November 2003, an elderly couple purchased and moved into a new condominium. The building was about 2 years old at the time, and the couple were the first owners of this unit.
- On July 12, 2005, in the evening, the couple were in the living room when they heard the smoke alarms in their condominium sounding. They looked for the cause of the fire, and discovered smoke, sparks and small flames coming from the smoke alarm in the master bedroom.
- The flames self-extinguished.

Analysis for incident on July 12, 2005

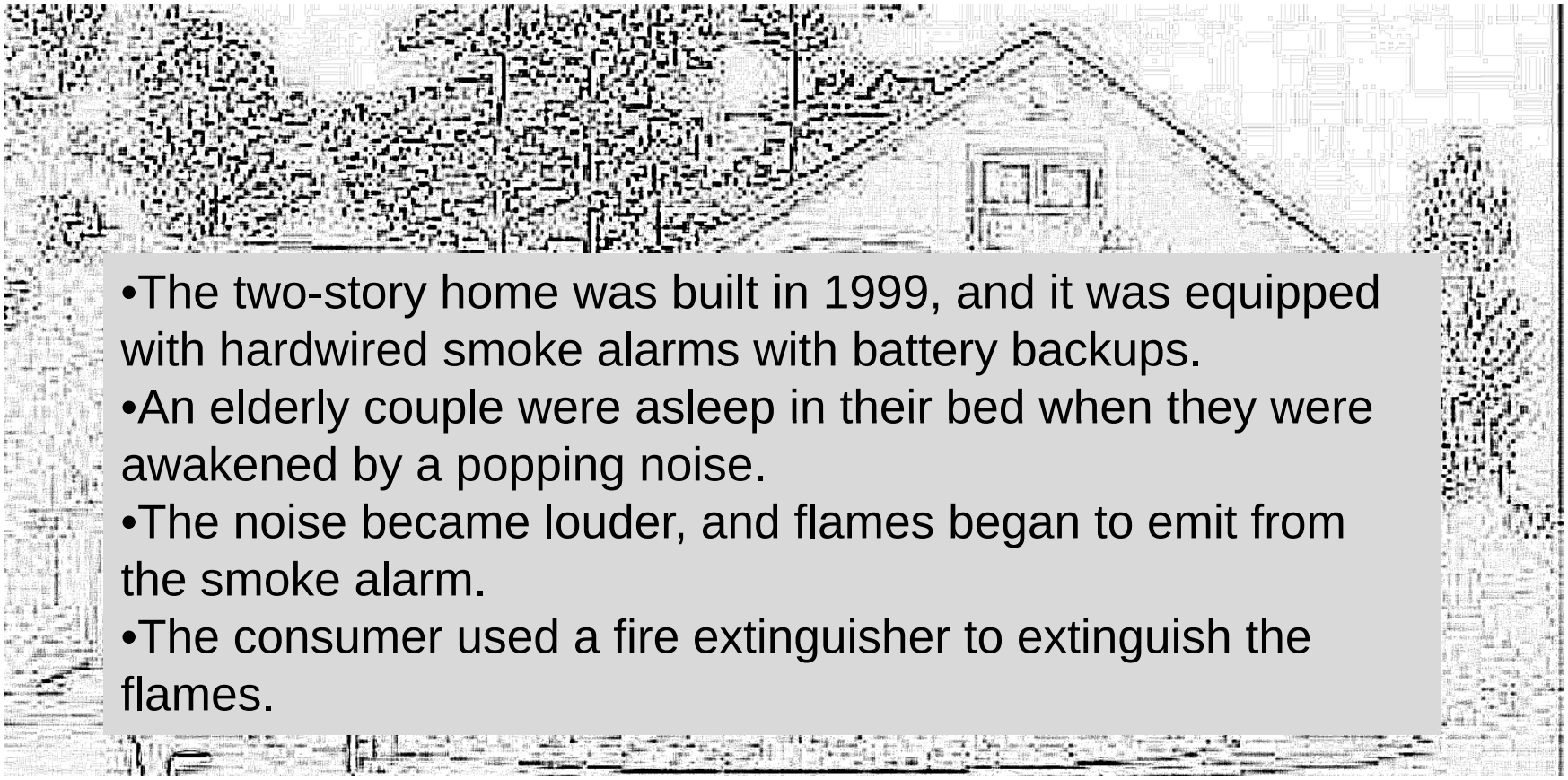
- The damage to the smoke alarm is consistent with a filter capacitor failure.
- The excessive current through the capacitor caused it to overheat.
- The overheated capacitor may have ignited, but the flames did not spread beyond the smoke alarm's housing.





Incident Sample Undamaged Sample

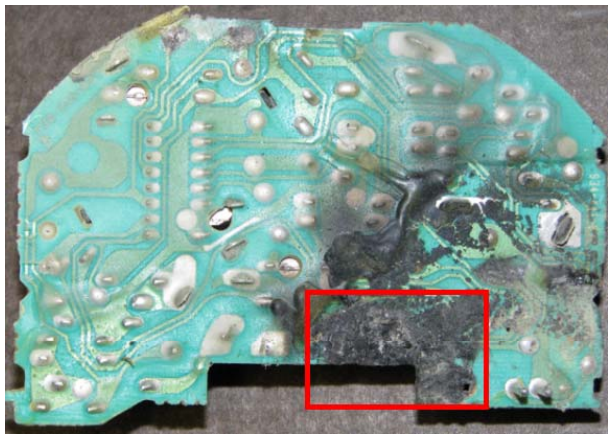
Incident on August 26, 2009

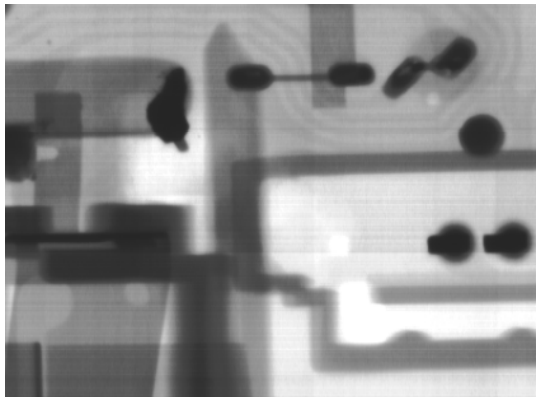


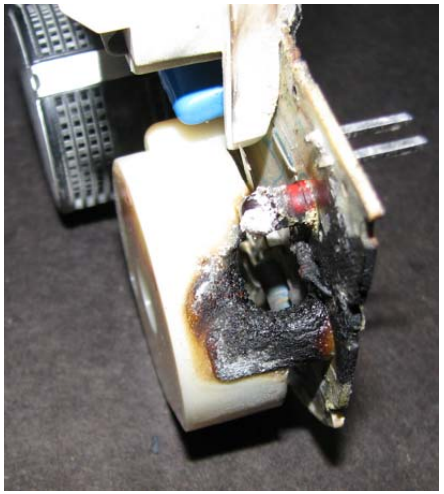
- The two-story home was built in 1999, and it was equipped with hardwired smoke alarms with battery backups.
- An elderly couple were asleep in their bed when they were awakened by a popping noise.
- The noise became louder, and flames began to emit from the smoke alarm.
- The consumer used a fire extinguisher to extinguish the flames.

Analysis for incident on August 26, 2009

•The smoke alarm sustained heat damage from an electrical short near the negative battery contact pad and the hot terminal pin.
•The flame or fire within the smoke alarm was caused by the plastic horn igniting from the charring of the PCB.
•The PCB and housing are UL-V0 rated and would self-extinguish once the flame is removed, but the horn housing was not self-extinguishing.





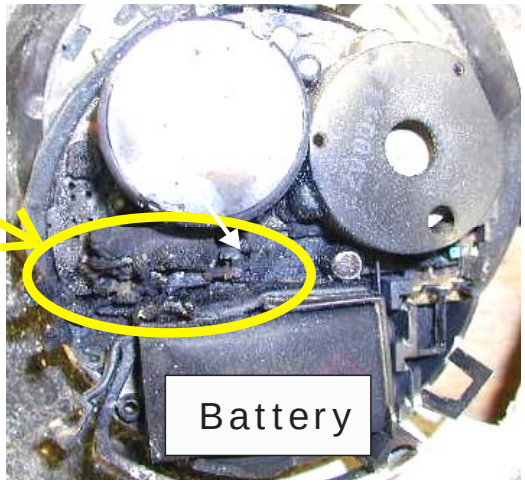


Incident on January 31, 2003

- A family (father, mother, and daughter) moved into a one-story house in December 2002.
- On the morning of January 31, 2003, the daughter was home in her bedroom when the smoke alarm sounded and began making a crackling noise. She also noticed the smoke alarm had a blue light flickering inside the alarm.
- The alarm stopped and, after investigating, she found nothing and dismissed it.
- Around noon, the bedroom smoke alarm began sounding again, along with all the other smoke alarms. When she entered the bedroom, she saw flames shooting from the alarm.
- She extinguished the smoke alarm with water.

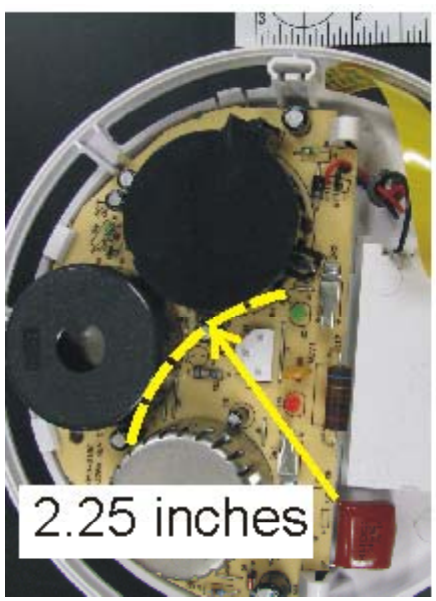
Analysis for incident on January 31, 2003

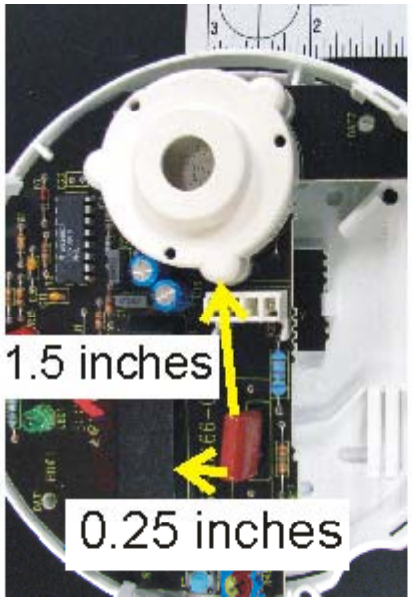
•The smoke alarm sustained heat damage from a filter capacitor failure.
•The flame or fire within the smoke alarm was caused by the capacitor igniting.
•The flames did not appear to have ignited the plastic components, but they did cause the plastic to deform.

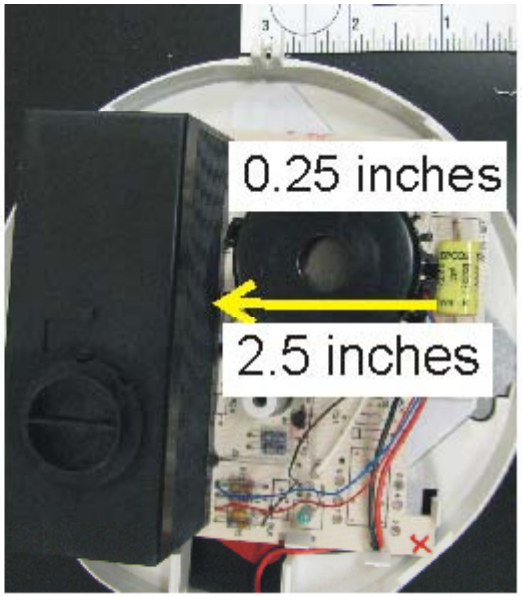


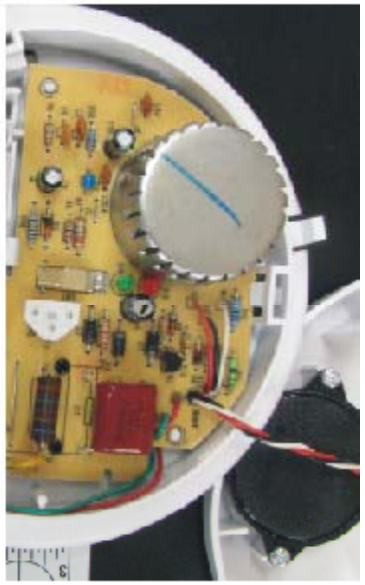
Sampled smoke alarms for testing

- 11 different models
- 5 different manufacturers
- Evaluated location of capacitor relative to internal plastics, such as horn and sensor housing



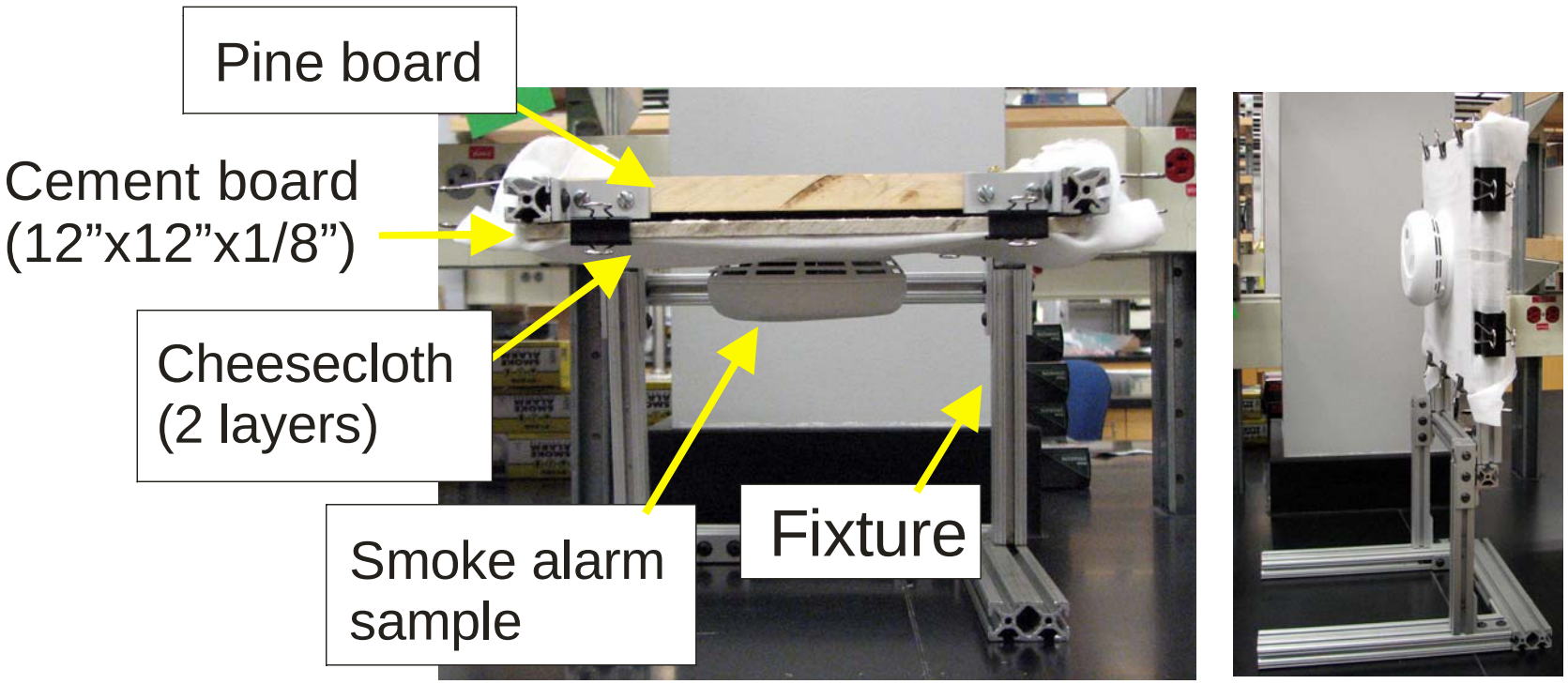






Flame test of internal plastics

- Two samples - two different manufacturers
- Evaluate the smoke alarm as mounted on the wall and ceiling.
- Evaluate likelihood for flames to escape the housing by igniting the internal plastics (horn and/or sensor cover).



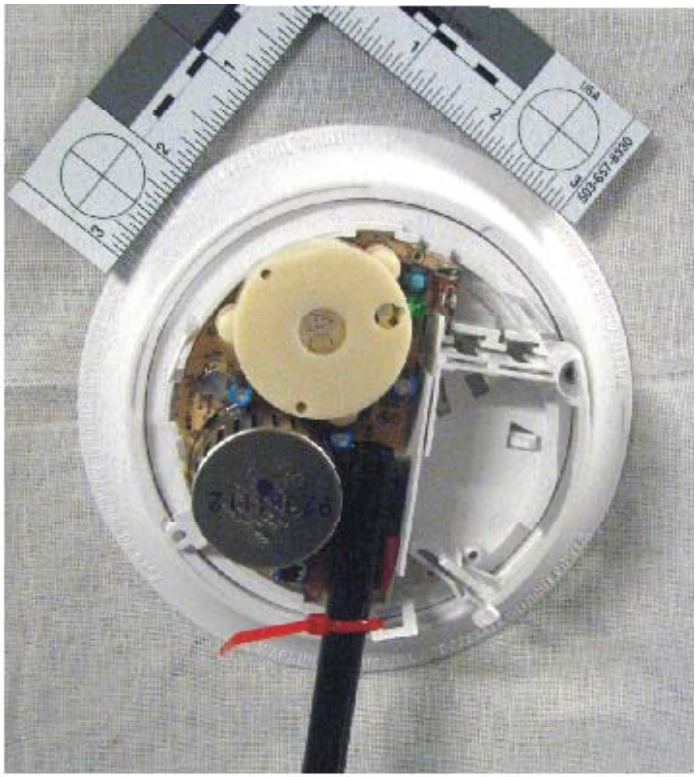
Ceiling position

Wall position

Open-flame test

- ½ inch flame from a butane lighter
- Applied 30 sec., waited 60 sec., reapplied 30 sec.

Sample 1



Sample 2

Test videos

Sample 1

- 30-seconds flame application
- Smoked for approx. 2 minutes
- Self-extinguished

Sample 2

- 30-seconds flame application
- Flames escaped
- Manually extinguished

Conclusions

- A majority of samples evaluated (15 of 17) contained self-extinguishing plastics.
- Flames escaped in 1 of 2 samples tested after igniting the internal plastics.
- Vertically mounted smoke alarms may burn more readily than horizontally mounted alarms.
- Possible recommendations to UL 217:
  - Set a maximum amount of HB plastics, or
  - Set a minimum distance between specific electrical components to HB plastics in AC-powered smoke alarms.