Smoke Alarm Nuisance Source Characterization, Phase 1

Executive Summary

During the revision cycle for the 2010 edition of NFPA 72, National Fire Alarm and Signaling Code, the Technical Committee on Single- and Multiple-Station Alarms and Household Fire Alarm Systems (SIG-HOU) focused renewed attention on nuisance alarms. Based on the information in the NFPA report "Smoke Alarms in U.S. Home Fires" authored by Marty Ahrens, during the development of the 2013 edition of NFPA 72 the SIG-HOU Technical Committee added several new provisions to Chapter 29 to further reduce nuisance alarms.

At present there is a lack of characterization of common nuisance sources for the development of new performance test protocols. Accordingly, the Foundation initiated a project to work toward characterizing common nuisance sources for the development of new performance test protocols in ANSI/UL 217 and ANSI/UL 268 product standards in order to meet the NFPA 72-2013 requirements intended to reduce nuisance alarms. This Phase 1 project involved a literature review, gap analysis, and development of a research plan for Phase 2.

A test plan has been developed to specifically address the gaps in available data required for the development of a draft test standard to distinguish between cooking nuisance alarms and actual cooking fire scenarios. This test plan layouts a specific road map of research and outcomes directed toward the realization of a completed standardized evaluation test. The gaps have been assessed based on the specific aspects of the overall test development described above.

TASK (1) – Conduct Survey to Correlate Nuisance Alarms and Disablement and Removal

Gap Addressed:

- Quantify the impact of reducing nuisance alarms on fire deaths

Approach:

Although a range of alarm installation surveys have reviewed the occurrences of nuisances and the functionality of smoke alarms, there is still insufficient data to quantify the full impact of eliminating nuisance alarm on fire deaths.

A broad survey should be conducted with the specific aim of quantifying how many smoke alarms are intentionally removed and/or disabled specifically due to nuisance alarms. This number should be compared to the number of homes that had never installed an alarm, have dead batteries due to negligence, or removed/disabled alarms for other reasons. This information can be used to determine the number of total fire deaths expected to be saved by eliminating nuisance alarms. Ultimately, this could be used in a cost-benefit analysis of requiring nuisance resistant alarms.

TASK (2) – Selection of the Test Space

Summary of Gaps Addressed:

- Determine the range of common kitchen sizes; and,
- Obtain consensus on the dimensions of the standard test space.

Approach:

A study of common kitchen sizes, shapes, and dimensions should be conducted. This study would provide guidance on the smallest size kitchens and the distribution of sizes. A representative kitchen size (e.g., 20^{th} percentile) should be selected for standardized testing.

The kitchen size selected should at a minimum allow for the installation of an alarm/detector at a distance of 3.0 m (10 ft) to meet the criteria of NFPA 72 (listing for 1.8 m–3.0 m (6–10 ft) and listing for 3.0–6.1 m (10–20 ft).

The size of the test space is one of the most important criteria for causing nuisance responses in a standardized test. A smaller space will increase the concentrations of particulate and gases and increase the likelihood for nuisance alarms. Consensus should be reached based on information provided by the kitchen size study. A phone conference or meeting among the project steering committee should be conducted to discuss and obtain consensus.

TASK (3) – Initial Characterization of Cooking Nuisance Sources

Summary of Gaps Addressed:

- Evaluate reproducibility of small, medium, and large particle nuisance sources as defined by Chernovksy and Cleary [22]
- Systematic evaluation of the parameters that may influence cooking source effluent production, such as:
    - Fat content of ingredients;
    - Cooking temperature;
    - Pan size or material; and,
    - Heat source (gas v. electric).
- Select the set of standardized tests required to bound the particle sizes and produce the most challenging conditions for smoke alarm rejection;
- Establish the repeatability and reproducibility of potential standard tests;

- Determine if obscuration, MIC, and CO provide sufficient data for establishing repeatability; and,
- Provide data for determining threshold criteria for nuisance alarms v. valid alarms.

Approach:

A series of initial tests should be conducted in the standardized test space to characterize the particulate produced by the candidate test sources. At least one source from each of the small, medium, and large cooking particle groups should be selected and tested using clearly defined procedures (temperatures, pots/pans, range type, etc.). A parametric evaluation should be conducted to determine how slight alterations to the test conditions (ingredients, pans, temperatures) may increase the challenges to smoke alarms. Tests should be conducted both with and without forced airflow (but no outside ventilation).

Effluent should be measured and characterized at the ceiling located 1.8 m (6 ft) and 3.0 m (10 ft) from the cooking source. Measurements should include:

- Obscuration;
- MIC response;
- CO concentration;
- Particle size distribution;
- Particle number density;
- Particle mass concentration;
- Air velocity;
- Representative photoelectric, ionization, and CO alarms; and,
- Ambient temperature, humidity, and atmospheric pressure.

The particle sizes and concentrations measured will be used to verify the initial categorization of test methods to provide a range of source types. The results of the parametric study will be used to select the most challenging realistic scenarios with respect to producing nuisance alarms.

The test data should be evaluated to determine whether the response of the MIC, ODM, and CO analyzer can characterize the tests for repeatability. If repeatable measurements are made with these devices, it must be demonstrated that repeatable particle sizes and concentrations are measured for each source. If there is variability in the particulate without variation in the MIC or ODM response, than additional instrumentation must be specified for inclusion in the standard testing.

Normal cooking experiments should be continued until food samples are burned/ruined. This data will be used in a subsequent task to define thresholds for nuisance alarms relative to alarms of developing hazards.

TASK (4) – Characterization of Non-cooking Sources

Summary of Gaps Addressed:

- Evaluation of representative water mist/steam sources;
- Evaluation of representative dust exposure sources; and,
- Quantifying the effects of long term dust/cigarette smoke exposure on nuisance alarm proclivity

Approach:

Testing should be conducted to determine the nuisance alarm responses to dust and water mist/steam sources. Tests should be conducted in the standardized test space. The ability to induce nuisance alarm responses with steam/mist generated by boiling water and a hot shower should be comparatively investigated.

An investigation should be conducted into the ability to characterize long fiber dust sources. These sources are common to the household and can easily be found in vacuum cleaners or dryer lint traps. It will be necessary, however, to develop a method for characterizing (or filtering) this type of particulate for inclusion into standardized testing.

After characterizing fiber dusts exposure testing should be conducted. It should be determined whether exposures to suspended dust particulate can (1) induce nuisance alarms with short term exposure, and/or (2) increase the overall sensitivity to other nuisance sources after long term exposure. After long term dust exposure to smoke alarms, a selected set of cooking nuisance source tests should be repeated and any changes in response recorded.

Comparable long term exposure testing could be conducted with exposure to cigarette smoke. Smoke alarms should be subjected to high levels of smoke for a sustained period and any alterations in nuisance response evaluated.

TASK (5) – Committee Meeting to Determine Final Test Criteria

Summary of Gaps Addressed:

- Select standardized nuisance sources;
- Determine criteria for conduct of a valid test;
- Defining the threshold criteria for nuisance alarms vs. valid alarms; and,
- Defining minimum requirements for listing alarms/detectors as “nuisance resistant.”

Approach:

The initial cooking and non-cooking nuisance test data will be summarized and presented to the project steering committee. The committee will review the data and discuss to select the final sources and criteria for evaluation.

The sources will be selected based on demonstration that they are representative of a wide range of sources, bound the worst case realistic scenarios, and are reproducible. Criteria for conduct of a valid test will require demonstration of sufficient instrumentation and measurements and sufficiently narrow bounds for expected reproducibility.

A clear, quantitative distinction should be made between the nuisance portion and potential hazard portion of the tests conducted. When left unattended, the standard cooking procedures will likely progress to potentially hazardous conditions. A measureable quantity must be identified (obscuration, MIC response, air temperature, etc.) that can be used to distinguish between alarms occurring before and after this time during nuisance resistance testing.

Finally, the committee will review the nuisance test data and determine a minimum acceptable response to the array of tests to achieve a “nuisance resistant” listing. Consensus should be reached to provide a recommendation for this minimum level of performance.