



Smoke Detector Spacing in High Ceiling Spaces – Phase 2

Background

NFPA 72, National Fire Alarm and Signaling Code, does not address spacing consideration for smoke detection based on ceiling heights. However, there is a table that allows for reduction of spacing for heat detection. There has been confusion in design and code enforcement on what to do when smoke detectors are installed on ceilings higher than 10 ft. A previous literature review and gap analysis study on smoke detectors in high ceiling spaces was published by the Research Foundation in 2017. The outcomes of this study indicated that there was limited context and significant knowledge gaps that preclude the formulation of scientifically justified prescriptive requirements regarding smoke detector spacing relative to ceiling height. This study outlined a path forward to better characterize smoke detector spacing in high ceilings, such as by establishing a performance metric for smoke detectors that can be applied to high ceilings. The fire protection industry needs additional information on the impact of ceiling height and detector spacing on smoke detection performance.

Research Goal

The goal of this research project is to develop guidance for the installation of smoke detectors on ceilings over 10-ft (3 m) that can be used as the technical basis for any changes to codes and standards.

Project Sponsors

This project is generously sponsored by the following organizations: Automatic Fire Alarm Association, Canadian Fire Alarm Association, Fire and Life Safety Section (FLSS) of the IAFC, FireRay (FFE), Honeywell, National Electrical Manufacturers Association (NEMA), Siemens, and Wagner USA.

Scope

The scope is limited to the installation of smoke detectors on flat-ceilings.

Project Tasks

This research project will involve the following tasks:

Task 1: Literature review. Review, update and modify, as appropriate the literature review from the 2017 report of the impact of ceiling height and detector spacing on smoke detection performance as well as research related to smoke plume and/or ceiling jet formation with respect to ceiling height, which includes:

- **Task 1.1: Review Regulatory Requirements.** Review relevant requirements in applicable codes and standards (e.g., NFPA 72, CAN/ULC -S524, BS 5839-1, VdS 2095, DIN VDE 0833-2, NEN 2535, R7, DBI 232, AS 1670.1) and the requirement's technical substantiation.
- **Task 1.2: Review recent literature.** Review and summarize all research on this topic published within the last 5 years.
- **Task 1.3: Summarize findings.** Analyze the newly available information and provide a summary and any recommendations on smoke detection spacing for high ceilings.

Task 2: Data collection.

- **Task 2.1: Consolidate all available data.** Review and consolidate all currently available test data from graphs, tables, text, etc. from the sources identified through this literature review, and the literature identified in the 2017 Phase I report.
- **Task 2.2: Develop a Taxonomy.** Determine a taxonomy for that data in terms characteristics



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and parameters important to smoke detector spacing in high ceiling locations.

- **Task 2.3: Develop a database:** Which,
 - Exists and is usable
 - Exists but requires analysis
 - Does not yet exist, but is needed
 - Could be used for validation purposes.

Task 3: Gap Analysis. Building on the knowledge gaps identified in the Phase I report, identify additional knowledge gaps based on the findings of Tasks 1 and 2 to inform the proceeding tasks. An interim draft report shall be developed to document the findings of Tasks 1, 2, and 3.

Task 4: Model verification and validation. This task should be implemented following the performance-based approach to designing and analyzing fire detection systems detailed in Annex B of NFPA 72. This should be accomplished through the following sub-tasks:

- **Task 4.1 Define fire scenarios and representative designs for validation testing.** Develop a limited number of representative scenarios for the validation testing. This should include building characteristics, occupant characteristics, and fire characteristics. The detection strategy, specifying the types and location of smoke detection in each scenario, should also be specified.
- **4.2: Define the validation tests.** Establish a validation test plan, to include a minimum of 5 validation tests, to establish data to validate the models in Task 4.4. Review the experimental test plan with the technical panel before proceeding to implementation.

- **4.3: Implement the validation test plan.** Conduct a series of validation tests based on the representative fire/design scenarios and validation test plan established in Task 4.1 and 4.2. Analyze and report the results of the experimental tests.
- **Task 4.4 Model Validation.** Simulate all experimental tests implemented in Task 4.3 through an appropriate modelling tool. Compare the model results against the experimental testing results.
- **Task 4.5: Interim Report.** Analyze and document the results in an interim draft report and review with the project technical panel. Solicit feedback to inform the subsequent modeling plan.

Task 5: Develop and implement the modeling plan. This task should be implemented following the performance-based approach to designing and analyzing fire detection systems detailed in Annex B of NFPA 72. This should be accomplished through the following sub-tasks:

- **Task 5.1: Establish performance criteria.** Define performance criteria that are in line with the goal of NFPA 72 to evaluate the model results.
- **Task 5.2: Define fire scenarios and representative designs for modeling.** Develop representative scenarios for the modeling analysis. This should include building characteristics, occupant characteristics, and fire characteristics. The detection strategy, specifying the types and location of smoke detection in each scenario, should also be specified.
- **Task 5.3: Develop a modeling plan** to predict smoke obscuration and help develop guidance



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for the spacing of smoke detectors in spaces with ceiling heights exceeding 10 ft. The modeling plan should include at least, but not be limited to, 50 simulations. Model geometry, variables, and model parameters should also be specified. The models should apply the design scenarios prescribed in Task 5.2 to code allowed smoke detector spacing to gather baseline data. Review the modeling plan with the technical panel before proceeding to implementation.

- **Task 5.4: Implement modeling.** Implement the modeling plan, prescribed in the previous tasks.
- **Task 5.4: Analyze Modeling Results.** Analyze modeling results against the established performance criteria. Identify the most impactful variables influencing detector activation with respect to location and spacing.

Task 6: Develop Preliminary Recommendations.

Based on the modeling and validation results, provide recommendations for detector spacing at various ceiling heights. Any limitations of the recommendations and where they can be applied, should be specified.

Implementation

This research project will be conducted under the auspices of the Fire Protection Research Foundation and will be conducted in accordance with the “Research Foundation Policies for the Conduct of Research Projects”. The project will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and research results, and review the final project report.

About the Fire Protection Research Foundation

The [Fire Protection Research Foundation](#) plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission.

[All NFPA codes and standards can be viewed online for free.](#)

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