



Smoke Detector Spacing in High Ceiling Spaces – Phase II

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 smooth ceilings over 10-ft (3 m) that can be used as the technical basis for any changes to codes and standards.

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, ULC 524) 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.



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- **Task 2.2: Develop a Taxonomy:** Determine a taxonomy for that data in terms characteristics 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:



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- **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 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 5.5 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.

Deliverables

- Interim Draft Report #1 documenting findings from Tasks 1 – 3. Review with panel and incorporate feedback.
- Interim Draft Report #2 documenting the testing and model validation results from Task 4.
- Interim Draft Report #3 documenting the modeling and recommendations from Task 5 and 6.
- Draft Final Report documenting the findings from the entire effort (Tasks 1 – 6).
- Final Report
- Presentation to the NFPA 72 Technical Committee and at the NFPA Conference
- Presentation to at least one other technical conference.



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Schedule and Costs

This is a fixed price project in the amount of \$50,000. All indirect and travel costs incurred are intended to be included within this fixed price. The Foundation does not have a limit on indirect costs, but the total proposal cannot exceed this fixed price. Proposals for this project shall include a breakdown of costs by task. The proposed schedule is provided in the table below. Suggested modifications to the proposed schedule can be provided with substantiation.

Tasks/Milestones	Deliverable Timeline	Estimated Due Dates
Proposals due		October 14, 2022
Selection of Contractor	Within 2 weeks of proposal deadline	October 28, 2022
Kick off meeting with panel	Within 2-weeks following contractor selection	Date TBD
Task 1: Literature Review	6 weeks from project initiation	December 9, 2022
Task 2: Data Collection	6 weeks from project initiation	December 9, 2022
Task 3: Gap Analysis	6 weeks from project initiation	December 9, 2022
Interim Report 1	6 weeks from project initiation	December 9, 2022
Panel Review	Within 2-weeks of delivery of interim draft report	December 23, 2022
Task 4.1 – 4.2: Experimental test plan	10 weeks from project initiation	January 6, 2023
Panel Meeting #2: Review Test Plan	Within 1 week of delivery of experimental test plan	Date TBD
Task 4.3 – 4.4: Implementation and Analysis of Experimental Test Plan and Model Validation	16 weeks from project initiation	February 17, 2023
Interim Draft Report 2: Document results of tests and model validation	16 weeks from project initiation	February 17, 2023
Task 5.1 – 5.3: Develop modeling plan	22 weeks from project initiation	March 31, 2023
Panel Meeting #3: Solicit feedback on Interim Draft Report 2 and modeling plan	Within 1 week of delivery of modeling plan	Date TBD
Task 5.4 – 5.5: Implement Modeling Plan and document results	28 weeks from project initiation	May 12, 2023
Task 6: Develop Recommendations	28 weeks from project initiation	May 12, 2023
Interim Draft Report 3: Document results of modeling and recommendations	28 weeks from project initiation	May 12, 2023
Panel Meeting #4: Review results from modeling and recommendations	Within 2 weeks after delivery of third interim report	Date TBD
Draft Final Report	32 weeks from project initiation	June 9, 2023
Panel Review	Within 2 weeks of delivery of draft final report	June 23, 2023
Final Report	37 weeks from project initiation	July 14, 2023



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Implementation

This research project is led by 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. At least four panel meetings will be held, as noted in the schedule. The Foundation will provide documentation of all Panel meetings. All proposals must meet the overall schedule as noted in the above table.

Intellectual Property

The Research Foundation will retain rights to all project deliverables including, the project report, which will be published on the Foundation website. The project deliverables may also include test data collected and modeling input and output developed over the course of the project.

How to Respond

Letter proposals shall be submitted electronically to Victoria Hutchison, Research Project Manager, of the Foundation, at vhutchison@nfpa.org no later than **5:00 pm Eastern time October 14, 2022**. For additional details see the “[Research Foundation Policies for the Conduct of Research Projects](#)”, the [Foundation Operating Principles](#), and “[Research Project Guidelines for Contractors](#)” on the Foundation website at: <https://www.nfpa.org/foundation>.

Each proposal shall include a description of the following weighted evaluation criteria: problem understanding (30 %), technical merit (include scope and approach) (30 %), prior relevant experience and personnel expertise (30%). An additional criterion, current level of active foundation engagement, will be considered as the remaining 10 % weighted evaluation criteria. Please note, the body of the research proposal submittals shall not exceed six pages in length, including a short bio of the proposed personnel and not including the cover page. Any additional relevant information (e.g., Project participants’ CVs or resumes, letters of support, detailed description of past relevant experience, detailed description of RFP-Respondent’s organizational facilities, competencies, other capabilities, and references) not covered in the body of the proposal should be appended to the proposal, with a maximum combined page limit of 12 pages, including the body of the proposal and appendices.

Additionally, all bidders must submit a completed [disclosure statement](#) with the proposal (this does not count towards the page limit). This form can be downloaded [here](#).

Note: This project will proceed only on the basis of receipt of a proposal deemed acceptable to the Foundation and the project sponsor(s). Information on the Foundation’s policies for the conduct of research can be found on our [website](#). Services received are subject to our [standard contractual terms](#).