RESEARCH FOUNDATION
RESEARCH FOR THE NFPA MISSION

PROJECT SUMMARY

Environmental Impact of Fire – Characterization of emission factors for relevant products

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Background: Concern for the health of the natural environment is growing as human population grows and as new levels of contamination of scarce resources are revealed. Current efforts to improve the sustainability of buildings focus on increasing energy efficiency and reducing the embodied carbon. This overlooks the fact that a fire event could reduce the overall sustainability of a building through the release of pollutants and the subsequent re-build.

Most fires occurring in the built environment contribute to air contamination from the fire plume (whose deposition is likely to subsequently include land and water contamination), contamination from water runoff containing toxic products, and other environmental discharges or releases from burned materials. The environmental impact also has economic consequences for communities and regions and while the direct and indirect costs of fire on a community can be devastating, they are not usually reported at a local scale beyond an account of the human deaths and injuries and the amount of property destroyed or damaged.

As a start to calculate the true cost of fire to society, the Foundation undertook a study that developed a research road map identifying needed research to be able to quantify the environmental impact of fire from the built environment and its economic consequences. This study identified the need to develop updated emissions factors (EF) for atmospheric emissions and couple this to the development of acceptable EF for emissions to water and soil considering both pure substances and relevant mixtures.

Research Goal: The goal of this project is to update existing emission factors (EFs) for a range of fire conditions and develop some new EFs for relevant building materials to produce a database of EFs that can be built on with future research.

Project Tasks:

Task 1: Literature re-evaluation

Identify existing sources of EFs for various products using the literature review presented in the report by McNamee et al. on a Research Roadmap for the Environmental Impact of Fires. All emissions will be considered, acute toxic products and chronic emissions (*Polycyclic aromatic hydrocarbons* (*PAHs*),

polychlorinated dibenzodioxins (*PCDD*), polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD), or particles) to benefit in the broadest manner to the assessment of environmental impact of fires onto all flora and fauna systems, water, air and soil. The available EFs will be re-evaluated in terms of the fire conditions for their evaluation and the relevance of the emissions based on material uses today. This task will focus on the both individual fuels and complex fuel combinations.

Collation of typical building materials will be based on publicly available life-cycle inventory type data. This will form the basis for selection of relevant material for testing in Task 2.

Deliverable will be an Excel 'database' of existing values of EFs that will provide an efficient way for identification of new and updated EF needs. Further, the database will include relevant building materials to identify which EFs apply to modern building materials and to prioritize which building materials should be investigated in the next task.

Task 2: Experimental design
Based on the findings from Task 1, the most relevant products and ventilation conditions to be considered experimentally will be selected. The selection criteria which will be discussed with the technical panel.

The database and collation of typical building materials from Task 1 will be considered as an input. For the quantification of EFs, it is crucial to consider the influence of the ventilation to reproduce, as closely as possible, large-scale fire conditions. In such large fires, combustion efficiency may vary from one part of the fire to another, and emissions can vary in the same manner. Consequently, it is important to know the influence of those parameters on the EFs. Therefore, a simulation of specific combustion conditions will be incorporated into the experimental design.

Deliver a detailed experimental design, including the experimental sequence, scale and species quantification planned during this campaign. This test plan will be carried out in Task 3. The focus will be on conducting a small number of large-scale experiments. Should this experimental design step indicate that small scale laboratory tests can provide relevant input to EFs these will be considered as part of the final experimental evaluation.

Task 3: Experimental evaluation
The products and ventilation conditions selected will be used to define a range of EFs using mainly small-scale testing supplemented by a small number of larger scale tests (number of tests to be determined based on the design).

Conduct an experimental evaluation of EFs. The current knowledge on that topic indicates that tests should be done at a large enough scale. Since some product formation depends on the temperature variation in the smoke cloud, it is important, during these tests, to keep cloud conditions as close as possible as in natural fires.

To meet the best compromise between large scale fire tests and lab-scale ones, manage fire tests in a 80 m3 compartment in a laboratory. This room will enable achieving fires up to about 1 MW and have an associated smoke treatment system.

The ventilation of the room will be fully controlled to allow the installation of analyzers and sampling systems to characterize the smoke composition.

Based on the current knowledge, install the following metrology, which will be finalized in the experimental design:

- a load-cell to evaluate continuously the sample weight during the fire test;
- Non-Dispersion InfraRed (NDIR) analyzers for CO and CO2 for CDG calorimetry;
- Paramagnetic analyzer for O2 measurement and OC calorimetry;
- Fournier Transform InfraRed (FTIR) spectrometer to measure gaseous species e.g. acid gases and HCN;
- Sampling system for laboratory analysis using dedicated filters for:
    - metallic particles,
    - PAH,
    - PCDD/F and PBDD/F.

Refine and include results from all tested fuels and mixtures in the Excel database developed in Task 1.

Deliverable is an interim draft report that includes a summary of Task 1 and the preliminary results of the testing from Task 2.

Task 4: Final report
Summarize information obtained via the literature re-evaluation and collation, describing the analysis, presenting outcomes of the analysis, and identifying needs for future research needed to fill gaps which are identified. The end goal is to have a very clear and concise presentation of the database of EFs updated and developed and clear identification of remaining gaps.

Implementation: This research program will be conducted under the auspices of the Research Foundation in accordance with Foundation Policies and 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.

Schedule: The report and database will be available in May 2021.

About us:

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. NFPA's membership totals more than 65,000 individuals around the world.