Technology Brief

Natural Gas Dispersion Study

Description: **An experimental and numerical study of methane dispersion to help determine the optimal placement of methane detectors in residential settings. This effort will aid the ongoing effort to create a NFPA standard and update UL 1484.**

Status: **Phase II complete with assessment of impact of mechanical and natural ventilation**

BENEFITS

As the natural gas industry promotes the use of methane detectors, several issues need to be addressed. Two of these issues are: (a) the proper placement of these detectors in a residence, and (b) the gas concentration at which the detector should alarm. To be able to address these issues, detailed data regarding the dispersion of methane under various conditions and in various layouts is needed. This study will provide us with such data through actual monitoring of different structures (See Fig. 1)

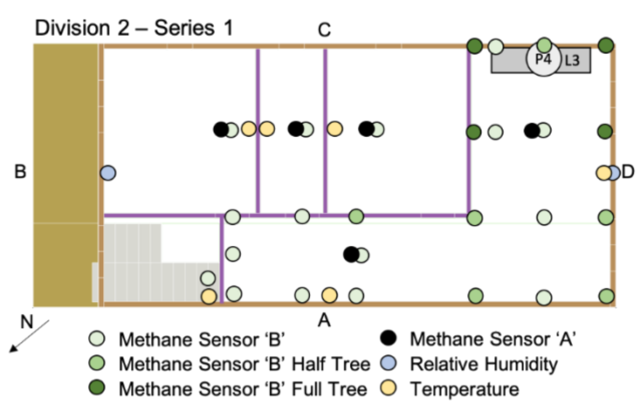

Figure 1: Residential test layout with sensor trees

The program is also validating a model to simulate such phenomena. The present state of the art in models simulating dispersion of methane in air under near-zero flow conditions does not allow for accurate simulation of laminar and turbulent flows. This study allows us to calibrate dispersion models to obtain increased accuracy. Improved modeling also allows better simulations of other layouts and scenarios. This unique study provides a benchmark for any additional studies that may be needed in the future.

BACKGROUND

The use of methane detectors in homes has emerged as a major issue for the industry, as safety concerns occupy public and regulators alike. Methane detectors are mandated by some jurisdictions and others are anticipated to follow. In addition, there is a need to formulate a Standard for the installation of methane detectors. In May 2018, NGA and Consolidated Edison were successful in gaining support from the AGA Building, Equipment, Codes and Standards Committee (BECs) for advancing an effort to develop such a standard with the National Fire Protection Agency (NFPA). However, to fully advance such a Standard, information is necessary on various elements of residential methane detection including ideal placement of the detector.

In addition, the industry, including NYSEARCH member companies, have taken an active role in promoting new methane detector technology as well as the revision of existing UL standard to improve the deployment of these detectors. Notably, the only study about dispersion of methane in homes is a British study from the late 1990s. While several layouts were studied under various gas release and infiltration scenarios, the data is limited.

Current standards require detectors to sound an alarm when concentrations reach 25% of the Lower Explosive Limit (LEL). Lowering this limit is a way of increasing safety. Given the temporal and spatial data gathered through experimental testing in a residence and subsequent modeling, we were able to offer guidelines on proper placement of detectors and proper alarm settings.

TECHNICAL APPROACH

The program is being carried out by Fire & Risk Alliance (FRA) to obtain experimental data on the time history of dispersion of natural gas inside three different residential layouts/structures and use that data to simulate additional layouts with a good degree of confidence using state-of-the-art computational fluid dynamics. The first task focused on modeling simulations to design the test setup and identify the best locations to place the gas sensors that measured methane concentrations throughout the structures. Later, experimental data from testing was used to optimize the computational fluid dynamics models that simulate gas dispersion. Then, several simulations were run to further enhance our understanding of gas dispersion in residential structures. In the second task, FRA built a two-story structure that simulates a small residence.

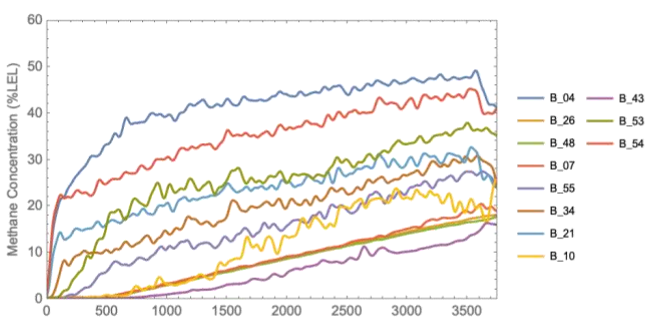

Figure 2: Measurement Results for Test Series 1

The three different layouts tested included: a single-story apartment; a two-story apartment with kitchen and living room area in the first floor and bedrooms in the second; and a two-story apartment with an open floor plan in the first floor (simulating a basement) and stairs to the second floor. The structure was instrumented with temperature, methane and relative humidity sensors. Natural gas release points were introduced to simulate gas release from a stove, a water heater, and an infiltrate

line from the "basement" floor. In the third task, the sensor responses were tested at various gas release flow rates, locations, and infiltration rates. While a testing matrix has been developed, the test matrix was finalized with input from the funders. The concentration of methane was measured as a function of time at more than 50 points in the structure to develop a comprehensive temporal/spatial map under varying conditions. The time that it took for the concentration of methane to reach the 10% LEL and 25% LEL thresholds at those sensor locations was recorded and analyzed. (See Fig. 2)

PROGRAM STATUS

The primary recommendations for additional testing at the end of Phase I were to include the installation of a functioning HVAC system to determine detection delays associated with air flows within the enclosure. Phase I testing was replicated in Phase II with mechanical and natural ventilation. Same source types, leak rates and floor layouts were used. Vents were installed on the ceiling, walls, and floor to simulate different systems of air flow seen in typical residence.

A big takeaway from this study was that the presence of an HVAC system (vents and ducts) provides additional pathways and volume for the gas to fill and reduces the gas concentration observed when compared to a space without HVAC. Hence, even when an HVAC system is not in operation, alarm activations may be delayed and at the 25% LEL threshold, activation was often not observed.

Both the studies have been shared with NFPA and the research foundation to aid the creation of the NFPA 715: Standard for the Installation of Fuel Gases Detection and Warning Equipment. Also, work is being done to revise the UL 1484 standard for residential gas detectors.

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