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Light Gas (Hydrogen) Dispersion Screening Tool

Background: There are emerging and established technologies that require the use of lighter than air gases such as hydrogen. To perform safety evaluations for code development, code compliance, permitting, and safety analyses a simple analytical tool is required to predict the concentrations of releases of gas in various hazard scenarios. There are Computational Fluid Dynamic (CFD) models available, but they are expensive and require extensive training to run. A simple, user-friendly dispersion models are referred to as screening models because they over-predict impacts and are often used to screen out the scenarios of greater concern. The key element to simple screening models is that they will over predict impacts. Therefore, the simple model can be used to quickly compare a number of release scenarios and make relative comparisons of the impacts of the various release scenarios. This type of tool is particularly effective when performing a screening analysis, an analysis to determine the release scenarios of greatest concern. The user can always perform a more complex modeling analysis for a release scenario of concern if a more accurate concentration estimate is required.

Project Goal: The goal of this project is to develop a simple open domain dispersion screening model tool along with a basic user documentation that will predict the concentrations of unintended releases of lighter than air gases.

LEARN MORE: Download the final report and tool here.

Research by:
The University of Texas at Austin Fire Research Group

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Summary:

As the commercial use of hydrogen becomes more widespread, tools are required to ensure that hydrogen systems meet safety standards. Screening models are important because they are fast and can allow for a first order comparison of many release scenarios. This report summarizes the implementation of a user-friendly hydrogen release screening tool available as a Microsoft Excel Spreadsheet.

The report outlines the motivations behind the implementation of the tool. It compares various dispersion models available in the literature and explains why an "integral" lower-order model was chosen for the screening tool. It also outlines the shortcomings of the model chosen: for example, the model has only been experimentally validated for small leaks and does not take wind into account.

At a high level, the integral model breaks the hydrogen plume into five zones and solves for thermodynamic properties in the first three. In the last two zones, the model solves the Navier-Stokes equations in integral form under the assumption that the hydrogen density, velocity, and hydrogen concentration profiles are of Gaussian form. Validation of the model with experimental results from literature is also presented.

Additionally, the report gives a high-level explanation of how the code works. The source code is written in Python and can run on Windows and Apple operating systems. For the Microsoft Excel version of the tool, Python interfaces with Microsoft Excel using the add-in Xlwings. The web application was developed using Dash. The user must input several conditions for the model to run such as hydrogen release pressure and temperature as well as ambient conditions.

The output of the screening tool for three different cases: two for which the hydrogen flow is choked at the exit and one for which it is not presented. Output plots are available for the plume centerline velocity and concentration of hydrogen as a function of distance along the plume trajectory. Contour plots highlighting a user-specified contour (for example, 4% hydrogen) are also presented for the three cases.

The report discusses opportunities for future improvements such as including the effect of wind into the model or giving the user the possibility to prescribe a non-circular orifice.