Project Title: Hydrogen Flammability Limits and Implications on Fire Safety of Transportation Vehicles

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Student Involvement: One graduate student

Project Objective: Investigate the flammability of hydrogen-air mixtures and establish the lower limit and its dependence on various experimental parameters by designing and constructing a test apparatus for the accurate measurement of flame propagation and seek simple models to predict various properties of high-pressure hydrogen jet flames.

Project Abstract: Safety is a critical issue for the design and operation of transportation vehicles using hydrogen, whose properties are drastically different from traditional fuels. Key concerns are its low ignition energy, low luminosity, high flame speed, and wide flammability range. System and component design should accommodate the above special characteristics of hydrogen. The development of hydrogen-powered transportation vehicles will require safety guidelines for designing fueling stations, storage facilities, pipelines, and other supplementary infrastructure. Accidental hydrogen leaks from high-pressure storage units can lead to hazardous conditions because momentum-dominated large turbulent jet flames pose significant safety risks that need to be assessed. Design criteria for refueling stations requires the necessary distances between storage units and other materials/public places which can be determined by utilizing length, shape, and radiation heat of an ignited hydrogen plume.

The proposed research will experimentally determine the flammability of hydrogen-air mixtures and establish the lower limit and its dependence on different parameters. A test apparatus will be constructed for this purpose with certain modifications for improvement. Other features such as flame speeds of hydrogen and hydrogen/ethanol mixtures will also be explored to help establish guidelines for the much-needed safety codes and standards for hydrogen-powered buses and automobiles. Particular interest is the detection and handling of hydrogen-air fires that burn rapidly with little radiation heat loss.

Anticipated Benefits: Results obtained in this project will ultimately be utilized to develop necessary fire safety codes and standards for hydrogen-powered transportation vehicles. A preliminary database will be provided to help establish guidelines for the prevention and handling of hydrogen fires. Findings also have implications for the safe and efficient delivery of hydrogen fuel to fuels cells. The proposed project will therefore provide the much-needed experience in fuel cell bus operation where there is a lack of history of actual use.

Modal Orientation: Hydrogen transportation systems

Relationship to other Research/Projects: The proposed project is related to the development of a rural hydrogen transportation test bed that will demonstrate, evaluate and promote hydrogen-based technologies in a real-world environment.

Technology Transfer Activities:

1. Technical reports showing findings, conclusions and recommendations;
2. Technical papers for publication in conference proceedings and journals; and
3. Development of consensus codes and standards.

Transportation Research Board Keywords: Hydrogen Jet Flames, Flammability, Codes and Standards