WPI

Fire Protection Engineering Department

PhD Dissertation Proposal

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Zoom link:

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Inert Gas Extinguishing Dynamics of Total Flooding Systems

Committee

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Abstract

Total flooding clean agents help solve the fire protection problem of suppressing compartment fires without the use of water. Recently, there has been an increased interest in inert gas discharge systems as the Montreal Protocol and its amendments are incentivizing the industry away from halocarbon agents [1,2]. However, significant questions remain regarding how the standardized extinguishing test used to certify inert gas systems for use translates to real-life property protection.

Inert gas suppression systems are tested to the UL 2127 and FM 5600 or similar standards [3,4]. These standardized testing protocols use prescribed fire threats, such as wood cribs, to replicate the fire threat of Class A ordinary solid combustibles. The standardized test contains two criteria: extinguish the test article and prevent test article reignition after a 10-minute soaking period followed by exposure to fresh air.

Test article suppression is studied using an inert gas discharge system with IG-100, pure nitrogen. Two scales are used to research suppression and extinction dynamics: the full 100 m3 enclosure and a novel 33 m3 with a scaled test article and discharge system. The reduced-scale was proposed to decrease the time, resources, and cost of experimentation. Additional non-standard test articles were utilized at the reduced-scale to increase its validity as a tool for industry use and research.

During an inert gas discharge, the test article is subjected to the joint effects of a flow of agent and entrained air and a systematic oxygen reduction. No theoretical framework exists for studying the coupled effects simultaneously. To address this problem, the in-depth heat and mass transfer phenomenon are examined, and a general mass transfer B-Number is proposed for wood cribs. The methodology presented in this work encapsulates the oxygen reduction effects through the B-Number and the forced flow effects through the heat transfer coefficient.

The requirements, constraints, and scientific interest of this work formed three natural goals to structure this research. The first goal is to quantify the full-scale discharge dynamics in terms of the flow of agent and entrained air, oxygen concentration uniformity and rate of change, and test article extinguishing effects. The quantification and characterization of the full-scale will greatly influence further testing as well as inform the industry of what is fundamentally occurring during an inert gas discharge. The second goal is to scale the discharge system, test article, and enclosure while maintaining similarity to the previously defined full-scale discharge dynamics. With the reduced-scale, far more data and understanding can be collected in which to better study inert gas discharges. The third goal is to investigate the burning rate and extinction dynamics during the suppression period and soak period. Burning rate dynamics include the test article's response to the discharge. Extinction dynamics include the mass loss rate of the test article after the extinction of visible flames and any reignition during the soak period.

This work has led to the publication of 2 journal articles, 2 additional conference papers, 8 presentations to industry or scientific audiences, and 2 best presentation/paper awards.