

Radiative Emission Fraction of Pool Fires Burning Silicone Fluids

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The steady-state mass burning flux and the radiative flux profiles to the surroundings were measured for a series of burning silicone fluids and organic fuels in 0.1-m, 0.3-m, 0.6-m and 1-m pool burners. Short-chain silicone oligomers and aliphatic/aromatic hydrocarbons exhibited a strong dependence of the mass flux and the radiative fraction on pool size. The longer chain length silicone fluids and alcohols exhibited both markedly lower mass fluxes and radiative components of heat release and these parameters were virtually independent of pool size. Silica, a gas-phase combustion product of the silicone fluids, was observed to deposit into the vaporizing liquid pool, the yield increasing with silicone chain length. This necessitated correcting the measured apparent mass flux for the liquid volume displaced by the silica. The measured radiative power emitted from flames burning silicone oligomers and hydrocarbons was substantially larger than the power radiated by flames burning long-chain silicone fluids or alcohols. The mass gasification flux and the radiative fraction of the silicones fluids and the organic fuels were well correlated by the ratio of the heat of combustion to the heat of gasification of the fluids. Copyright © 1997 by The Combustion Institute

INTRODUCTION

Silicones encompass a wide variety of materials, for example, fluids, foams, sealants, resins, and elastomers. Currently, silicon-based materials are being evaluated as potential replacements for halogenated compounds as cleaning solvents, cable compounds, fire-retardant additives, and other applications. In addition to their unique surface, physical, and chemical properties, several products (e.g., industrial transformer fluid, fire-barrier foam, thermal ablatives) rely to a large extent on the unique fire properties of silicones. Most notably, silicones exhibit low heat-release rates regardless of pool size [1–3] and fire severity [4]. Lipowitz et al. proposed a model for the combustion of these materials [5, 6]. Previous studies [1–3] of the pool burning of silicone fluids have been limited in the number of fluids tested and have not measured the spatial distribution of radiative flux nor the global radiation properties under steady mass burning flux conditions, an important consideration for measurement accuracy. Unique to this study, the importance of

silica ash deposition back to the burning pool and its influence on the apparent mass burning rate was quantified for a range of silicone fluids.

The fluids studied were octamethylcyclotetrasiloxane, $[(CH_3)_2SiO]_4$ and a series of trimethylsiloxy end-blocked polydimethylsiloxane (PDMS) fluids, $[(CH_3)_3Si-O[-Si(CH_3)_2-O]_n-Si(CH_3)_3]$, where n indicates the average chain length, that is, the number of siloxane units in the molecule. Commercial silicones are based on dimethyl substituents on silicon, hence the acronym PDMS. A convenient shorthand notation for PDMS molecules is: MD_nM where $M = (CH_3)_3SiO_{1/2}$, $D = (CH_3)_2SiO$, and n is the chain length. These fluids are typically referred to by their viscosity, which increases with the average chain length as shown in Table 1 [7]. For comparison, the properties of a number of organic compounds are also listed in Table 1. Other properties presented in Table 1 include the fluid boiling point (T_b), the heat of gasification (H_g), the net heat of combustion (H_c), and the ratio of the net heat of combustion to the heat of gasification (H_c/H_g), which is related to the diffusive transfer (B) number cited in the literature [8]. Table 1 shows that H_c/H_g has values similar to those of the organic fluids. The longer chain silicones, which consist of a distri-

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