POOL BURNING OF SILICONE FLUIDS

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Siloxane fluids have a number of industrial applications including use as transformer fluids. The objective of the present study was to improve our understanding of the burning of siloxane fluids. The fluids studied are octamethylcyclotetra siloxane, $[(CH_3)_2SiO]_4$ which is known as D4, and trimethylsily end-blocked polydimethyl siloxane, $[(CH_3)_3Si\text{-}O[\text{-}Si(CH_3)_2\text{-}O]_n\text{-}Si(CH_3)_3]$, where n indicates the polymer chain length and the number of silicon atoms in the molecule. These fluids are ranked by viscosity which is related to the average polymer chain length as shown in Table 1.

Measurement of the burning rate and the radiative heat loss fraction (χ_r) for siloxanes with different average polymer chain lengths was determined for pool fires with diameters of 10, 30, and 60 cm. Flame ignition for the longer chain length fluids could only be accomplished after heating to more than 100 °C. Ash was observed both in the gas phase and on the surface of the liquid pool, where it collected and with time submerged. The apparent mass burning rate was corrected accordingly, based upon assays of the ash in the unburnt fuel at the conclusion of the experiment. The rate of ash deposition was largest for the slow burning long chain length fluids. The collected ash was analyzed for carbon, silicon, and hydrogen content and found to be predominantly silicon dioxide (silica). Because of capillary effects, deposition of silica on the fuel surface led to fuel dripping over the burner rim. The silica attached to the rim was moved with a stirring rod, preventing fuel leakage. The fuel level in the burner was maintained at a constant level using a number of systems including an overflow and a thermocouple controlled feedback device. The measured burning rate was found to be a strong function of chain length.

Silicon dioxide was apparent in the emission spectra of the siloxane flames as determined using an open-path FTIR spectrometer. Differences in the emission spectra between heptane and siloxane flames were related to broad band emission in the 8-10 μm region of the siloxane flame which was attributed to silica. Radiative emission was measured at multiple locations on the surface of a cylindrical control surface surrounding the fire after a nearly steady-state mass burning rate was achieved. Results showed that for the shorter chain length siloxanes, χ_r increased from ≈0.3 to 0.5 as the burner diameter increased from 10 to 60 cm. For the longer length siloxanes, however, χ_r remained nearly constant or decreased with pool diameter.

Measurements are currently underway to determine the rate of gasification of siloxanes using the BFRL Radiative Gasification Apparatus. The measured gasification rate was found to be a strong function of chain length.

Table 1 Average viscosity and chain length

Viscosity (cS, 298 K)	n
0.65	0
1.0	1
1.5	2
2.0	3
10	≈15
20	≈27
50	≈57

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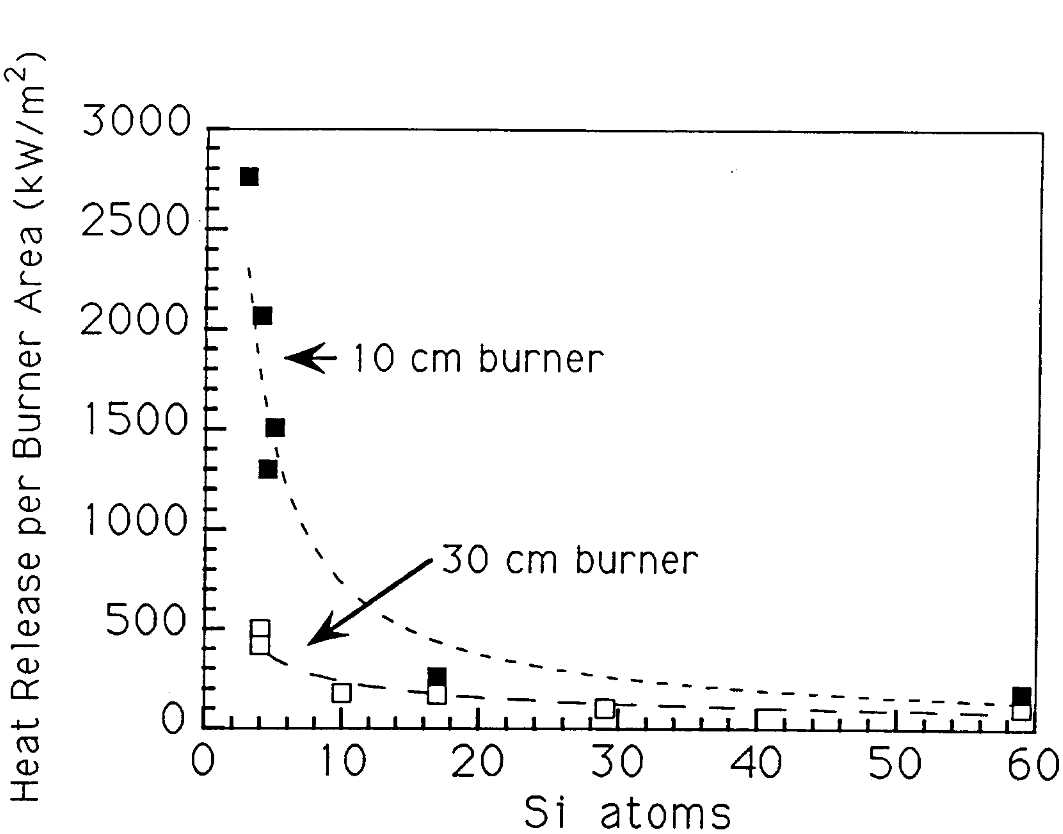

Figure 1 Heat release rate per unit area of pool surface in 10 and 30 cm burners as a function of siloxane chain length (number of siloxane units).

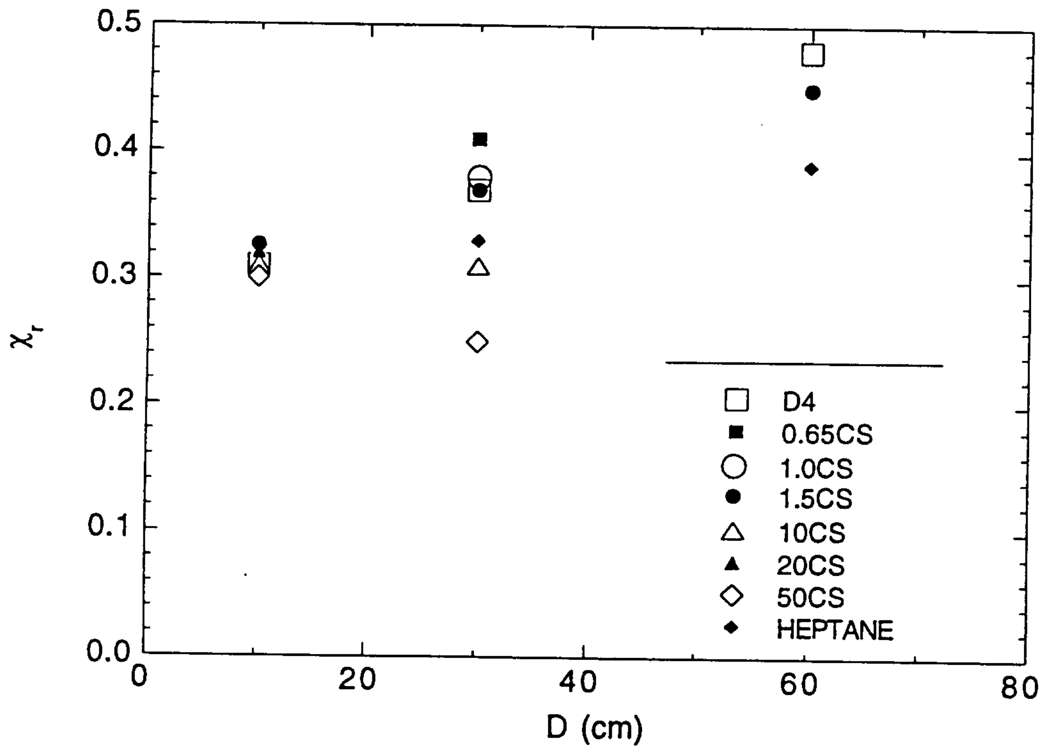

Figure 2 Radiative heat loss fraction as a function of pool diameter for siloxane fluids and heptane.