Laboratory and Field Measurements of Hydrogen Fluoride Produced in Inhibited Flames Using Near-Infrared Tunable Diode Laser Spectroscopy

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Chemical suppression of fires in occupied areas must be accomplished while minimizing toxic gas production. For most former and proposed halocarbon fire suppressants (e.g. CF_3Br, C_3F_7H), the main toxic gas formed during inhibition is hydrogen fluoride (HF). The work described here employs near-infrared tunable diode laser spectroscopy to measure HF formation, in-situ, in real time, in chemically suppressed laboratory-based static fires and in real-fire scenarios which confront military vehicles.

In these experiments, tunable diode laser spectroscopy, employing near-infrared radiation and frequency-modulation detection techniques, is used to measure HF gas production in fires inhibited by halocarbons. Two types of inhibited fires are investigated. The first type of fire is a static low-pressure counterflow diffusion methane-air flame, to which small amounts of inhibitant are added to either the fuel or oxidizer stream. Results from measurements of the spatial distribution of HF and of temperature within the counterflow diffusion flame are compared with calculations based on a chemical kinetic model of the flame.

The second type of fire investigated using near-infrared tunable diode laser spectroscopy is a dynamic, JP-8 (jet or turbine fuel) - air fire within the crew compartment of a military combat vehicle. For these measurements, inhibition is accomplished using the onboard fire-suppression system. Two types of crew compartment fire suppression scenarios are investigated. The first scenario uses a JP-8 pool fire burning in air. Figures 1 and 2 show results of measurements of HF production versus time for such a fire, following appplication of the inhibitant C_3F_7H. Figure 1 shows HF production with time when the JP-8 pool fire is successfully suppressed. Figure 2 shows HF production with time when the JP-8 pool fire is not successfully suppressed. The second fire scenario investigated is suppression of a mist fireball explosion following penetration of the onboard fuel cell by a shaped charge.

Results from measurements of HF production during suppression of real fires by halocarbon inhibitants are compared, when applicable, to results from measurements of HF in counterflow diffusion flames.

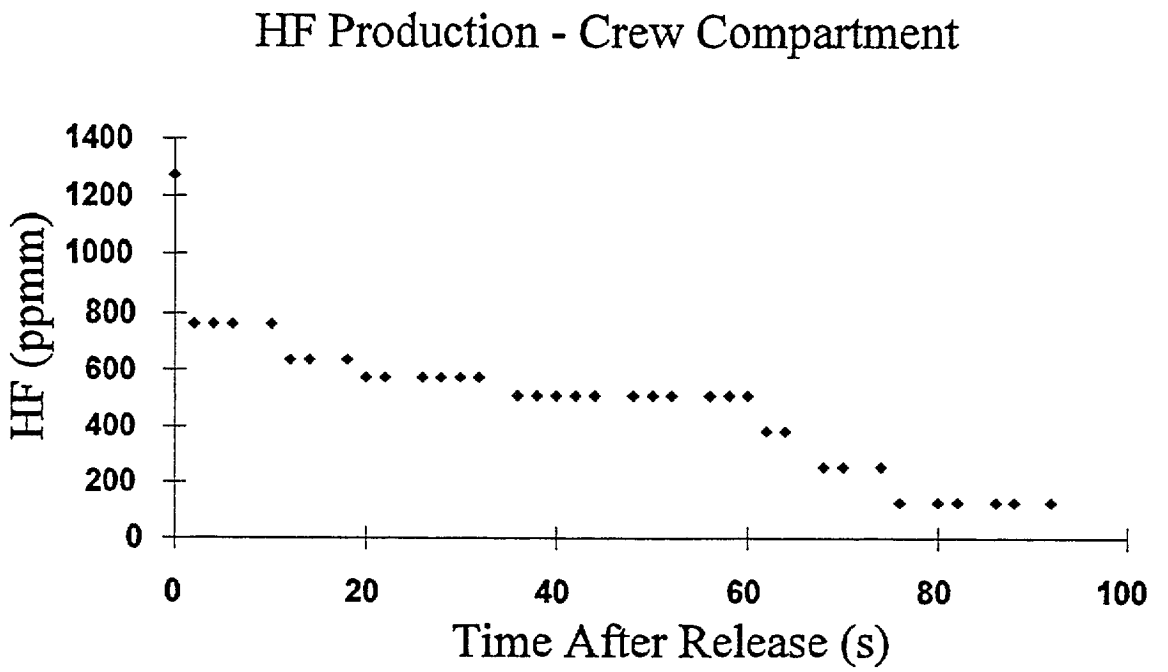

Figure 1: A graph of HF production (ppmm - parts per million meter) versus time after release of C_3F_7H inhibitant (FM-200) for a JP8 fuel pool fire occurring within the crew compartment of an Army combat vehicle. For this test, the inhibitant extinguished the fire.

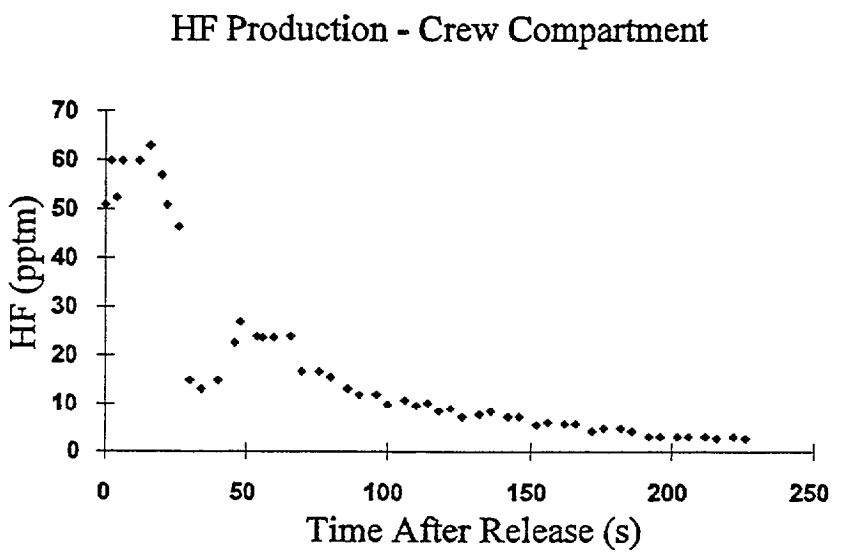

Figure 2: A graph of HF gas production (pptm - parts per thousand meter) versus time immediately after release of C_3F_7H (FM-200) into a JP8 fuel pool fire burning within the closed crew compartment of an Army combat vehicle. Unlike the data shown in Figure 2, for this test the fire was not extinguished by the inhibitant. The dip in HF concentration near 40 s is due to activation of the back-up CO_2 extinguisher system.