Flame Suppression Properties of HFC-227ea: Fundamental Studies and Suppression of Real-World Class A Hazards

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ABSTRACT

During the past several decades the use of the highly efficient, clean, nontoxic fire suppression agent Halon 1301 in total flooding applications has prevented the loss of human life, and billions of dollars worth of equipment worldwide are protected by Halon 1301. However, due to its implication in the destruction of stratospheric ozone, the production of Halon 1301 was halted on January 1, 1994. As a result, intensive research efforts have been undertaken in the industrial, academic and governmental sectors with the goal of developing a replacement for Halon 1301.

One of the more widely investigated Halon 1301 replacements is HFC-227ea (CF_3CHFCF_3, FM-200®). HFC-227ea is an active fire suppressant, providing extinguishment of flames through a combination of physical and chemical mechanisms. The physical contribution to flame suppression stems mainly from the heat absorbing ability of the agent, which results in a lowering of the flame temperature and a slowing of the radical chain reactions occurring in the flame. HFC-227ea also acts chemically by removing key chemical species involved in the flame chain reactions, breaking the chain reactions responsible for flame propagation.

While numerous halon replacements have been proposed, and limited testing of some of these agents on Class B fires has been reported, very little information is available addressing the performance of these agents on those hazards most commonly protected by gaseous suppression systems, i.e., Class A materials such as those found in electronic data processing (EDP) and telecommunication facilities. We describe here the results of small and field-scale testing of HFC-227ea for the suppression of flames of Class A hazards.

The suppression of flames of typical Class A materials with HFC-227ea was investigated in two enclosures, the smaller enclosure having a total volume of 14.5 m^3, and the larger enclosure of a total volume 72.6 m^3. Each of the enclosures was fully instrumented to allow the monitoring of enclosure temperatures and pressures, agent concentration and combustion and decomposition product concentrations. Rectangular slabs of typically encountered Class A materials, vertically mounted within a metal cabinet, were ignited via an electrical resistance coil, allowed a predetermined preburn period, and extinguished with HFC-227ea. The test configuration was designed so as to produce a high degree of baffling of the flame, in order to

remove any aerodynamic contributions to flame extinguishment (i.e., "blowing out" of the flame). Materials investigated included slabs of PMMA (black and clear), polypropylene, polyethylene (low and high density), PVC and ABS; the suppression of pine crib fires was also investigated. The results of this investigation indicate that the extinguishment of typically encountered Class A materials occurs at concentrations of less than 5.8% v/v HFC-227ea.

The ultimate purpose of conducting fire suppression tests should be to ascertain whether the system design will perform as intended under the assumed challenge. In order to design meaningful large-scale fire tests, it is necessary to understand the fundamentals of fire growth and fire suppression systems, and to understand the nature of the particular real-world hazard being protected. When developing a fire test protocol it is important to have the fire occur in a way which is as realistic as possible based upon the worst-case scenario envisioned for a particular hazard. Failure to fully consider any special hazards can lead to underdesign of the suppression system, resulting in inadequate protection. Similarly, testing under conditions so far removed from the realistic worst-case that the occurrence of such conditions is of zero probability leads to unnecessary overdesign of the suppression system, and the accompanying waste of relatively expensive suppression agent.

The objectives of the second phase of this study were to quantify the amount of decomposition products formed under conditions typical of those encountered in EDP industry applications, and to assess the damage potential for electronics exposed to the post-suppression environment. Suppression testing of HFC-227ea on realistic Class A fires was conducted in the large test enclosure. For this series of tests, the enclosure was equipped with an ionization detector located 4.3 m from the fire location. The hazards investigated included fires involving PVC cables, printed circuit boards, waste paper and magnetic tape. Fire sizes ranged from approximately 4 to 35 kW at detection plus 30 seconds (following detection, a 30 second delay was allowed before commencement of agent discharge). The results of this second phase of testing will be discussed in detail.