Clean Extinguishing Agents and Continuously Energized Circuits

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Recent testing performed through the Modular Protection Group indicates that even low energy, 48 W and 192 W, Class C fire scenarios require elevated clean agent concentrations for proper mitigation of the hazard(flame extinguishment and inertion). Agents included for that study are recognized by the NFPA 2001 standard as follows: FC-3-1-10(CEA-410), HFC-227ea(FM-200), HFC-23(FE-13), IG-541(INERGEN). Phase I of this study extended that investigation to increased energy levels (up to 1200 W) for the halocarbon agents(not including INERGEN). It was suspect that a point of decreased performance would be reached at which time the agent concentrations may become excessive(above the LOAEL). Acid gas(HF) production was quantified to illustrate whether adverse effects to sensitive equipment located within the protected enclosure should be expected.

The purpose of this testing is to demonstrate the performance capabilities of various clean agents on continuously energized fuel/energy scenarios. A sample consisted of a polymethylmethacrylate cylinder wrapped with resistance wire(nichrome). Energy levels to 1200 W were tested for this series. Performance was evaluated concerning the following issues: concentrations required for a thirty(30) minute flame inertion and levels of acid gas(HF) produced during the inertion period. Inadequate agent performance was defined as satisfying <u>either</u> of the following criteria:

1.) Agent concentrations required for thirty(30) minute flame inertion, at a given energy level, compare to or exceed the agents listed LOAEL, as defined per NFPA 2001,

2.) Levels of HF generated, at a given power level, compare to or exceed the minimum levels to cause adverse effects to "sensitive" equipment. Reference was made to previous studies concerning the required levels of acid gas(HF) and the minimum exposure times necessary to cause adverse effects to such equipment.

Agent concentrations were elevated, at a given energy level, until reignition of the sample did not occur within thirty(30) minutes of agent discharge. Agent discharge times were maintained at or below limits set by NFPA 2001. Tests were conducted per agent at increasingly intense energy levels(300 W, 600 W, 900 W, and 1200 W).

Phase II encompassed a modification to the cup burner apparatus included in NFPA 2001 "Standard on Clean Agent Fire Extinguishing Systems - 1996 ed.". Two outputs from a 1.2 kW DC power supply were fixed to the top of the burner and a length of nichrome resistance wire was employed to complete the circuit. Two digital meters were incorporated within the circuit to monitor amperage and voltage. Circuit current was maintained to within ±0.01 of an ampere. The data illustrated the effects of electrical energy inputted to the system. Three agents; FC-3-1-10(CEA-410), HFC-227ea(FM-200), and HFC-23(FE-13), were tested at four wire temperatures, 0°C(0°F), 427°C(800°F), 649°C(1200°F), and 871°C(1600°F) to gain trends concerning energized fire hazards. N-heptane was employed as the fuel. The performance of the agents was discussed on a relative basis.

A third phase(Phase III) of experimentation was conducted to quantify the effects of wire temperature, wire surface area, agent concentration, and hold times on the products of thermal decomposition in a continuously energized scenario. Hydrofluoric gas generation rates are expected to increase with increases in; wire surface temperature, wire surface area, or agent concentration, for a given halocarbon agent discharge scenario. Correlations concerning HF generation rates were extracted from the data sets to provide additional tools for the designers of halocarbon fire suppression systems protecting continuously energized facilities.

The objective of this test series was to investigate the effects of wire surface temperature and wire surface area on acid gas production. There was no fuel source included for these experiments. Instead, various lengths and gauges of resistance wire(nichrome) were suspended within a test enclosure in a complete circuit. The circuits were energized, allowed to reach the steady state temperature, and the agent discharged. Following discharge, acid gas levels, agent concentration, and circuit amperage were continuously monitored via an FTIR analyzer and amperage ,meter, respectively. Sampling continued for the fifteen(15) minute period following agent discharge. Trends were discussed on a relative basis, and correlations, concerning wire temperature/surface area, were extracted from the various data sets.

Phase I and Phase III experimentation was performed in a 1.28 m^3(45 ft^3) enclosure, referred to as the "box". The box was constructed of polycarbonate sheeting and reinforced with angle iron and has two ports which provided access to its interior. The enclosure was fitted with a ventilation system, to provide preburn and post burn purging of the volume, and discharge system consisting of an agent cylinder, piping, and interchangeable discharge nozzles. The weight of agent required to achieve a given enclosure concentration was calculated employing equation (1) of NFPA 2001 "Standard on Clean Agent Fire Extinguishing Systems -1996 ed." Cylinders were super pressurized with nitrogen to 360 psig to ensure complete agent discharge and homogeneity within the enclosure. A data acquisition system was included to monitor nozzle pressure, agent cylinder pressure, and enclosure pressure. Circuits were energized with a 1.2 kW DC power supply. Data acquisition was performed via Labtech Notebook version 7.3.0W software for DOS.