AEROSOL AND SPGG TECHNOLOGY FIRE SUPPRESSION SCREENING METHODS

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The search for alternatives to halons for fire suppression applications has identified not only new compounds which have physical properties similar to the bromochlorofluorocarbon family, but also inert gaseous agents that are released from a solid state and condensed phase agents that may be misted or generated pyrotechnically. Industry is already investigating innovative ways that these multiple technologies can be blended or hybridized to create an optimum fire fighting agent/release mechanism for specific applications. The traditional cup burner method is unable to evaluate these not-in-kind replacement systems. Two new concepts for testing liquid aerosol and solid propellant gas generator (SPGG) fire suppression technologies are presented here. (See also ref. 1.)

The first concept is for a bench-scale suppression screen suitable to compare the ability of dispersed fluids with differing chemical and physical properties to extinguish a propane flame in a counter-flow burner based upon the design by Tsuji and Yamaoka[2]. The porous fuel tube ($\approx$ 25 mm dia.) is placed across a uniform air stream as show in Figure 1. The advantages of this arrangement are that (1) the flame is laminar, two-dimensional, and very stable in the forward stagnation region; (2) the flow field of the flame is simple, thus allowing the evaluation and modeling of experimental results; (3) the flame can be controlled quite easily over a wide range of fuel and oxidizer velocities; (4) the flame extinction limit can be observed with little ambiguity and good reproducibility; (5) the flame front can be easily accessed by intrusive or non-intrusive probing techniques, thus enabling detailed studies of flame structure; and (6) the burner has been used for powder inhibitors with very encouraging results[3].

Two different methods of generating aerosols are envisioned. For 25 μm to 250 μm diameter particles, a multiple orifice piezoelectric droplet generator[4,5] will be used. The aerosol literature will be scanned to identify candidate techniques for generating droplets in the 0.25 to 25 μm range. Aqueous and fluorocarbon aerosols can be introduced directly into the burner air stream. However, no existing technique may be suitable for some fluids such as slurries, emulsions, or chemically-generated aerosols. A separate aerosol chamber will be needed in those cases into which high concentrations of agent can be injected using whatever technique envisioned in practice. The size distribution, number density and other characteristic of the aerosol may not be independently controllable, but if the aerosol is stable in time (over at least tens of seconds), critical properties can be measured. The aerosol will be transported from the generating chamber to the burner where it can be metered into the air stream. Aerosol uniformity measurements will be made within the burner using either a PDPA or stroboscopic micro-photography, and the air and fuel flows will be precisely monitored to ensure the above effects can be separated from the physical/chemical effects of the different aerosols.

The second concept is for a facility to test SPGG-based agents and release mechanisms. Potential fire environments can be broken into forced flows and otherwise quiescent situations. In the forced flow scenario, the flow assists in the mixing and transport of agent to the fire location, but it also carries the agent away from the fire. In the quiescent environment, the mixing and transport of the agent to the fire zone depends almost entirely on the momentum of the effluent with obstacles and wall boundaries impacting the flow. Two facets separate typical SPGGs from the "clean agents" addressed in NFPA 2001[6]: the elevated temperature and the composition of the effluent. In addition, hybrids could contain solid or liquid particulates. These factors pose problems regarding the use either of the cup-burner or of an explosion flask for obtaining inerting concentration. If the only application of the SPGG or hybrid system were a quiescent total flooding scenario, a suitable test fixture could be a fire established in a small enclosure, blocked from direct impact of the discharge. Scaling based on the volume of the enclosure would provide the design criterion. However, applications such as engine nacelle protection where an air flow is always present are quite different. There is no accepted NFPA test for evaluating agent effectiveness for a fire established in a forced flow. The NIST turbulent spray burner and the Walter Kidde Aerospace baffle stabilized pool fire configuration (both described in ref. 7) are forced flow apparatuses that do provide measures of effectiveness. With these systems, the effects of flow velocity, agent concentration, and discharge duration can be explored. Of these two facilities, the baffle-stabilized pool fire is

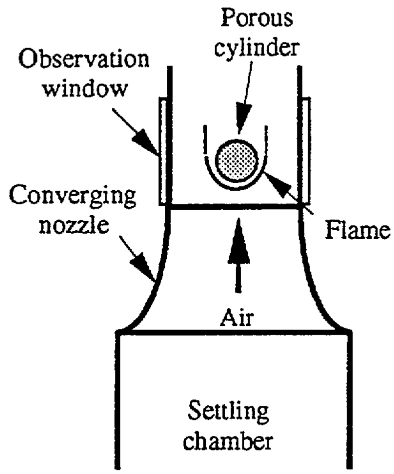

Figure 1. Schematic of Tsuji burner for aerosol suppressant screen.

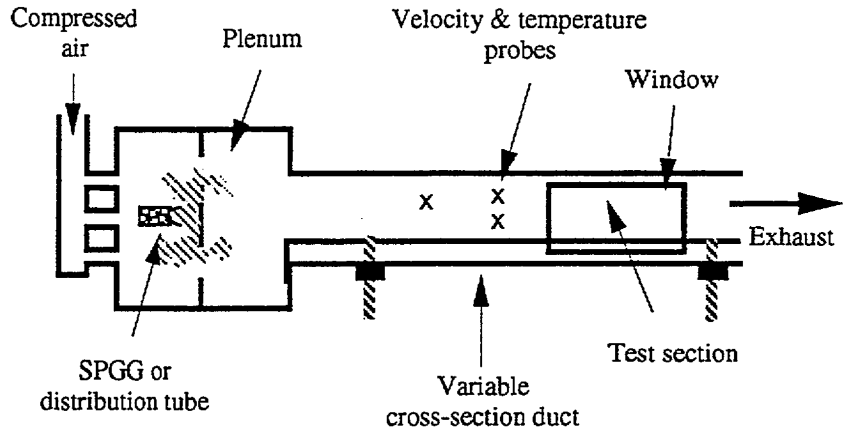

Figure 2. Schematic of SPGG suppressant screen.

more attractive because it appears to be more difficult to extinguish. The mixing time scale is longer and the minimum agent concentration is higher than for the turbulent spray flame.

A wind tunnel configuration is proposed to provide the forced flow and to facilitate the mixing of the SPGG discharge. Figure 2 is a schematic. The SPGG is discharged into a plenum and mixed with incoming air. The air will be provided from a compressed air bottle farm, or compressor at sufficient delivery pressure so that the SPGG discharge, itself, does not effect the air flow. From the plenum, the flow then moves into a duct that holds the test section. The duct will have a movable floor to control the cross sectional area which will readily change the flow velocity at the test section for a given volumetric flow. Temperature and axial velocity measurements will be made at a number of locations in the duct. The duct will have windows at the test section location for visible observation of flame extinction. The baffle-stabilized pool fire will follow the design of Hirst and Sutton[8] with some modifications. The flame is stabilized by the recirculation zone in the wake of a rearward facing step, 5 mm to 25 mm high. The pool, imbedded in an airfoil with an elliptical nose that extends the width of the duct (about 300 mm), will consist of a flat sintered metal burner about 120 mm on a side with gaseous propane fed at a specified rate. The test fixture will be put through a series of tests with inert compressed gases (such as nitrogen) with tighter flow control to probe sensitivities to the operating parameters such as fire scenario (including fuel and step height), velocity, duct cross-section, inert concentration and discharge duration. The results will be used to characterize the dynamics of the recirculation/fire zone in terms of a characteristic mixing time for flame extinction, as discussed by Hamins *et al.*[7]

Evaluations of SPGGs for directed discharge applications (as opposed to total flooding) must proceed on an *ad hoc* basis. The nature of the effluent flow is as important (or more so) than the chemical constituents. Proper discharge nozzle design, which depends on the application, in addition to sufficient agent mass flow are required for such cases. The test fixture proposed here will still be valuable in screening particular formulations for their efficacy once they reach the fire zone.

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