

Protection of Engine Enclosures Using Aerosol Generators

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Engine enclosures for small gas turbine power plants have historically been protected with Halon 1301. Halon phase-out, plus past problems with enclosure leakage, required an investigation of alternatives. Design parameters of alternatives such as HCFC-227ea and water mist could be easily characterized. Aerosol generators, using a solid propellant compound to distribute a fine powder fire suppression agent, offered significant potential installation advantages: considerable weight savings; lower installed and life cycle costs, small space requirements; and, low maintenance. Design parameters for this technology are not as well developed compared to other alternatives. Two aerosol generators were selected for evaluation. A high pressure water mist system and prototype inert gas generator system were also evaluated.

Fire experiments were conducted in a surplus turbine enclosure having a volume of approximately 5.7 m³ (200 ft³). Two leakage areas associated with the volume were assessed: 0.175 m² (271 in²) and 0.122 m² (188 in²). The following performance parameters were established:

1. Extinguish all fires within 30 seconds of the end of the discharge;
2. Prevent re-ignition for a period of 15 minutes after extinguishment; and,
3. Prevent ignition of materials near the generator discharge - establish combustible-free zone where temperatures are > 200 °C (392 °F).

For the application of interest, the agent/system had to be freeze-protected, and low overall system weight was highly desirable.

The high pressure water mist system tested operated at 79 bar (1,000 psi) using two spray nozzles directed downward from the overhead of the enclosure. The total flow rate was 2.6 LPM (0.7 gpm) with a volumetric flux of 0.45 LPM/m³ (0.0034 gpm/ft³). The fire extinguishment was adequate, but not excellent. Obstructions in the space caused plating of the mist, resulting in a higher than expected design water flux. To meet the re-ignition criteria, continuous water application would be required, adding to the overall weight impact. Freeze-protective additives would be needed; a representative additive tested did not degrade or improve fire performance.

The fire threat was heptane pan and spray fires of nominal heat release outputs of 18–100 kW. Relatively small fires were used since these are generally the most challenging fires to totally extinguish: there is relatively low oxygen depletion; there is low steam generation (helpful for water mist systems); and, adequate enclosure mixing of the agent must occur for small, shielded fires to be extinguished.

The aerosol generator systems consist of propellant gas and powder which is pyrotechnically generated from a solid compound. The gas is a mixture of N_2 , CO, CO_2 and H_2O . The powder is a mixture of K_2NO_3 , $KHCO_3$, and K_2CO_3 . The propellant gas-to-powder ratio and overall composition varies by manufacturer. One unit had approximately an 85:15 ratio, while the other had approximately a 65:35 ratio. The lower gas: powder ratio allows for lower design loading, a longer burn duration, and lower discharge temperature. The nominal corresponding design loadings were 109 and 60 g/m^3 , respectively. Both units tested have approvals from listing laboratory agencies and are commercially available.

The high leakage area scenario was a challenge for the aerosol generators, as it was for the water mist system. Neither system was effective at the highest loading tested, 176 g/m^3 . With the leakage area reduced to 0.122 m^2 (188 in^2), both units were able to extinguish the test fires. One system was successful at a loading of 132 g/m^3 (using one small and one large canister), while the other system was successful at a 176 g/m^3 loading (using two large canisters). Safe temperature clearance in front of the generator ranged from 15 to 50 cm (6 to 20 in).

Given the success of the generators for the controlled leakage environment, the overall system design parameters were established and compared to a water mist system. A thirty percent design safety factor was added to the tested loading. Back-up generators were included for each area of application, and structural modifications were suggested for the turbine enclosure to improve mixing/dispersion within the protected volume. The aerosol gas generator system met all extinguishing, marine, collateral damage, personnel safety, low/high temperature, environmental impact, commercial availability, and shipping/logistics objectives at one third the weight impact compared to gaseous clean agent or water mist alternatives.

A prototype inert gas generator was also tested. Like the aerosol generators, the design loading had to be increased due to the enclosure leakage area. Optimization of the prototype design is required to make this system similar to the aerosol generator systems. It offers the potential to be used in normally occupied spaces.