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Hot Surface Ignition

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ABSTRACT

Undesirable hot surface ignition of flammable liquids is one of the hazards in ground and air transportation vehicles, which primarily occurs in the engine compartment. In order to evaluate the safety and sustainability of candidate replacement fuels with respect to hot surface ignition, a baseline low lead fuel (Avgas 100 LL) and four experimental unleaded aviation fuels recommended for reciprocating aviation engines were considered. In addition, hot surface ignition properties of the gas turbine fuels Jet-A, JP-8, and JP-5 were measured. A test apparatus capable of providing reproducible data was designed and fabricated to experimentally investigate the hot surface ignition characteristics. A uniform surface temperature stainless steel plate simulating the wall of a typical exhaust manifold of an aircraft engine was used as the hot surface. Temperature uniformity of ±5℃ was achieved on the stainless steel plate by virtue of its being bolted to a copper plate in which five automatically controlled 1000 W electrical cartridge heaters were inserted. A programmable syringe pump was used to dispense ~25 μL fuel drops onto the hot surface. Testing was performed in a quiescent environment with the exception of a mild upward flow created by an exhaust fan aiding the buoyant plume created by the hot plate. Ignition and flame propagation events were recorded using visible and mid-infrared still and video imaging. The ignition and flame propagation events are transient and occur at randomly distributed locations on the hot surface. To characterize the ignition event statistically, the surface temperature leading to at least one ignition out of the number of drops and the surface temperature resulting in the ignition of all of the drops were recorded. The results of the experiment confirmed that the experimental variations in the drop size, drop velocity, plume characteristics, surface properties including temperature changes, and the nonlinear dependence of temperature of the chemical reaction rate lead to the probabilistic nature of the ignition event. The results of the experiment are of practical value in designing vehicular ignition and safety systems.

KEYWORDS

Hot surface ignition, alternative aviation fuels, aviation, fuel, fire safety.