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Aircraft Turbine Fuel Contamination History and Endurance Test Requirements

RATIONALE

This document has been revised to: (1) Add reference to JSSG 2007, (2) Include the EASA CS-E670 requirements for contaminated fuel testing, (3) Include a paragraph discussing SAP contamination from Filter Monitors, (4) Update paragraph 3.9 to reference biofuels and FAME contamination, (5) Clarify the cyclic endurance test time for the 92 hour Cold testing in specification XPP-36C, (6) Add footnotes on the current status of the referenced MIL standards, and (7) Include editorial changes for clarity.

FOREWORD

Information for this document was provided by members of SAE Committee AE-5, Aerospace Fuel, Inerting & Lubrication Systems and other government and civilian sources. This document provides background information as to the origin and evolution of fuel contamination and contaminated fuel endurance test requirements imposed on aircraft turbine engine fuel system components for certification and qualification. Included is a history of the inconsistencies of commercially available contaminant materials in meeting specification requirements and the recent successful effort to provide high-quality, certified constituents. This document is to be used for information only.

The fuel system of a modern aircraft gas turbine engine is complex. The protection of components from suspended fuel contaminants includes fuel filtration and contamination-resistant component design. To prove a design, standard tests have evolved that subject fuel system components to a controlled, severe, contaminated-fuel environment. These tests, although used in Military Specification documents, have frequently been criticized by industry spokesmen and some within the military as well. This document is an overview of existing contamination problems, contamination testing requirements, and the future outlook.

After World War II, the number of incidents of fuel contamination increased for turbine-powered aircraft as compared to those for piston-powered aircraft. Contamination was worse due to the higher viscosity of jet fuels and high fuel flow rates. Reports, from the Korean and Vietnam conflicts of jet fuel being hand pumped into aircraft from uncovered tarpaulin-lined pits, have documented real field contamination problems. In Vietnam a number of fighter bombers were put out of action due to contaminated fuel from an offshore tanker. Helicopters in combat, refueled on-the-fly, also were subjected to severe fuel contamination. These events created the need for test requirements reflecting typical severe field conditions.

The concern about military aviation turbine fuel contamination increased in the late 1940s and early 1950s. The initial concern was probably generated in the Navy by the fuel storage requirements imposed by carrier operations. Only naval aircraft were fueled at high rates from rusty "water bottom" tanks, with only a single filter water removal operation between storage and aircraft. It soon became apparent that piston-engine components were able to cope with more sediment and water than turbine engine components. Turbine engine fuel control valves differed greatly from the reciprocating-engine carburetor. Very close clearances were required in turbine engine control valves to provide the accuracy necessary for successful operation. These small clearances made components susceptible to solid contamination and water-related corrosion. Other problems included the frequent plugging of engine fuel filters with ice and other solids.

The quality problem of turbine fuel supplies was further complicated by other factors. A large piston engine required 90 to 120 gallons of aviation gasoline per hour, while the turbine engine used at least 500 to 800 gallons of fuel per hour. Assuming the same level of contamination, the turbine engine was required to handle five times as much solid contamination and water per hour as the piston engine.

The nature of jet fuel also contributed to the problem. High viscosity, wide cut distillation, high density and the low interfacial tension of turbine fuel complicated the problem of sediment and water removal. Filter separators rated at 225 gpm with gasoline had to be operated at 160 to 180 gpm to perform satisfactorily with JP-4. In storage tanks, a 5 μm solid particle that settled approximately 1.5 feet per hour in aviation gasoline, would settle only 4 inches per hour in JP-4 fuel, and only 2 inches per hour in JP-8 (Jet-A). Jet fuels also tended to loosen more rust from the walls of storage tanks than gasoline.

One aspect not addressed by most of the current test specifications is the potential for fuel contamination by new aircraft fuel tanks, which can contain large amounts of debris until it is flushed out by use. Particles of explosion suppression foam, cotton linters, metal chips, excess sealant, silica sand, etc. have been found in heat exchangers, fuel strainers, and filters of new aircraft. These problems may be further complicated by the increased use of composites, which may produce new types of contamination for which there is a limited experience base for their impact on fuel system operation and component wear; for example, carbon fibers can pass through relatively fine filters, end on, whereas other polymeric fibers (such as Kevlar) could matt and block filters. Specifications requiring the addition of carbon fiber contamination to traditional fuel contamination are emerging, and future specifications may include other types of contaminants referenced above.

Other fuel contamination issues include: (1) Copper contamination in jet fuel and its impact on fuel thermal stability, (2) The impact of contamination in low lubricity fuels (low sulfur fuels, synthetic fuels such as Fischer Tropsch fuels, or potential bio-fuels) on fuel system components and operation, and (3) The impact of filter monitor media migration on fuel control systems.

It should be noted that there is a diversity of test requirements and an unlikelihood of agreement on what the universal test and contamination requirements should be for the near future.

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