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AEROSPACE RECOMMENDED PRACTICE

MAP 749A

Superseding ARP 749

Issued 9-10-65
Revised 9-31-81

AIRCRAFT TURBINE ENGINE FUEL SYSTEM COMPONENT ENDURANCE TEST (CONTAMINATED FUEL)

1. PURPOSE:

1.1 This recommended practice describes a method of conducting a room temperature endurance (contaminated fuel) test when the applicable specification requires non-recirculation of the contaminants. The objective of the test is to determine the resistance of the engine fuel system components to wear or damage caused by contaminated fuel.

1.2 The method described herein calls for non-recirculation of the contaminants and is intended to provide a uniform distribution of the contaminant at the engine fuel system inlet.

2. TEST SETUP (Ref. Figure I):

2.1 General Requirements:

2.2 Test Fluid: Fluid conforming to the applicable specification (The engine primary fuel is recommended).

2.3 Test Fuel Temperature: Control is not required.

2.4 Ambient Temperature: Control is not required.

2.5 Engine Fuel System Inlet Pressure: 0 to 34 kPa (0 to 5 psig) or as otherwise specified by the test specification.

2.6 Mounting: Each component shall be mounted by its normal mounting pad in level flight attitude. Actual installation plumbing should be used when possible for connection of test components if two or more components are tested together; where actual installation plumbing is not available, line sizes, lengths, and bends shall be duplicated as closely as possible.

2.7 Supply Tank: The size of the supply tank is optional. (Ref. Figure II).

2.8 Receiving Tank: The use of a receiving tank is optional. (The supply tank and the receiving tank may be combined).

2.9 Plumbing:

2.9.1 The supply line to the engine fuel system component inlet shall not be smaller than the diameter of the component inlet port. The length of the inlet piping from the supply tank shall not exceed 3.6 meters (12 feet). An inlet line downward slope of not less than 15° with no low spots or flat areas is recommended to insure even contaminant distribution and ingestion.

2.9.2 A sampling valve may be installed immediately upstream of the system or components being tested, if desired.

2.9.3 The routing of return plumbing to the supply tank from the discharge of the engine fuel system test components is not critical.

2.10 Facility Filters:

2.10.1 Facility filters equal to or finer than 0.5 micron absolute are recommended to remove the contaminant (solid or lint) from the fuel prior to the return of the fuel to the supply tank. Fine clean up filters will prolong the life of the water separator elements. It is recommended the filters have a minimum gravi-metric efficiency per MIL-F-27656. This value is 99.3% and is required to remove the iron oxide fines in a single pass.

2.10.2 The facility filter capacity shall be sufficient to allow a reasonable test period before cleaning is required, preferably in excess of 10 hours. It is recommended that the filter(s) be arranged in parallel banks so that one bank can be serviced while using the other(s).

2.11 Facility Water Separator: A facility water separator device is required to remove all the entrained salt water from the fuel prior to the return of the fuel to the supply tank.

2.12 Facility Heat Exchanger: If a facility heat exchanger is used to maintain fuel temperature, it shall be located downstream of the cleanup filter(s) and upstream of the water separator.

2.13 Functional Cycling Simulation: The cyclic variations in fuel flow shall be accomplished through the use of engine fuel control or fuel control simulator.

2.14 An example of a functional cycling requirement is shown in Figure IV. The applicable component specification will detail specific cycling operating ranges, rates of change, and shutdown periods.

2.15 The contaminants shall be introduced to the engine fuel system for all phases of the cycle except for shutdowns.

2.16 The scheduling of events can be programmed through the use of timers, solenoid valves, etc.

2.17 The contamination type, size and concentration shall be as described in the applicable specification.

2.18 Periodically, the test system may be stopped to recharge the contaminant and clean filters. Fuel may be changed as frequently as necessary to maintain supply tank fluid of less than 2 mg/litre (.264 gallons) residual contamination level and the interfacial tension at more than 25 mN/m (dynes/cm^2) or when it is 10 mN/m (dynes/cm^2) less than the initial measurement, whichever is higher. These tests shall be made at least once every 24 hours using fuel samples from the supply tank.

2.19 Test Facilities Maintenance:

2.19.1 If testing is interrupted because of test facilities failure for more than one normal shutdown period or 12 hours, suggested action is as follows: The test components shall be flushed with the applicable clean test fluid without disassembly. The test components shall then be stored immersed in test fluid or put on low speed endurance until normal testing can resume. If test components have been stored because of facilities failures, the testing shall be resumed at the point where facility failure was experienced.

2.19.2 The test system between the fuel tank and the system clean-up filters shall not be disassembled for maintenance before a shutdown period is completed (if shutdowns are a requirement).

2.20 Termination of Test:

2.20.1 The test shall be terminated at the point where the engine fuel system components have been operated as required under the applicable specification.

2.20.2 The engine fuel system components shall be functionally tested using the specified clean fluid after completion of the contamination test requirements.

3. TEST CIRCUIT:

3.1 Circuit Schematic: A typical system arrangement is shown in Figure I.

3.2 Circuit Components:

3.2.1 Tanks: The recommended configuration of the supply tank is shown in Figure II. A mixing device may be used within the funnel, if needed, to prevent slugs of contaminant from entering the engine fuel system inlet. A pneumatic or electrically (explosion-proof) driven non-ferrous propeller is acceptable for the application.

3.2.2 Contaminant Conveyor:

3.2.2.1 The design of the conveyor is optional. A suggested design is shown schematically in Figure III.

3.2.2.2 The speed of the conveyor should be relatively proportional to fuel flow through the component inlet. The flow sensing system used should have a linear output from minimum to the component maximum rated flow.

3.2.2.3 The width, length and speed of the conveyor belt should be sufficient to handle the required amount of dry contaminant for a minimum of one hour without exceeding a depth of 13 mm (1/2 inch). This will minimize a tendency to produce dirt slugs.

3.2.3 The conveyor shall be oriented with respect to the supply tank so that the contaminant will drop off into the funnel section of the tank.

4. TEST METHOD:

4.1 Test Preparation:

4.1.1 All instrumentation shall be calibrated prior to the start of the testing.

4.1.2 The entire test setup shall be prepared for a start. Instrumentation "zero" readings shall be made and the empty conveyor belt shall be marked for start travel position.

4.1.3 The test setup shall be run for one hour with clean fuel.

4.1.4 At the completion of a one-hour trial period, the total flow and conveyor travel shall be recorded. The solid contaminant and quantity of salt water required shall be computed.

4.1.5 The solid contaminant, with the exception of lint, shall be thoroughly mixed by tumbling and then evenly distributed along the length of the conveyor, corresponding to the intended length of the run. The lint shall be evenly distributed along the conveyor as a separate ingredient.

4.1.6 Criteria for replacement and/or cleaning of engine system filter elements shall be established by test specification prior to start of test.

4.2 Test:

4.2.1 The salt water (the quantity determined from the system flow for the one-hour trial period) shall be introduced by a metering device into the funnel outlet neck portion of the supply tank. Introduction of the water at this point will help eliminate contaminant slugs from accumulating in the supply (inlet) line.

4.2.2 The test system will be started and advanced to the first test condition as required by the duty cycle at a rate as required by the applicable specification.

4.2.3 Within 10 seconds of reaching the first test condition, the dry contaminant conveyor and salt water introduction shall be started.

4.2.4 Establish the test cycle conditions as required by the applicable specification.

4.2.5 Recordings shall be made to insure component compliance with the applicable specification.

4.2.6 The test shall continue for the time or cycles specified in the applicable specification requirement.

4.2.7 The test component and contaminant conveyor shall be shut down within a 30 second period. The entire system shall remain undisturbed for the entire shutdown period (if shutdown periods are part of the applicable specification).

4.2.8 Control of ambient conditions during shutdown is not required.

4.2.9 After completion of the shutdown period, system maintenance may be performed.

4.2.10 Repeat paragraph 4.2.1 through 4.2.9 until completion of the required number of test hours or cycles.

5. PRE-TEST DATA:

Prior to the start of the Endurance Test, a detailed test procedure is usually prepared. Some of the information supplied in a typical procedure is:

5.1 Pre-test component inspection or performance data.

5.2 A detailed test system schematic showing all components and connecting plumbing.

5.3 Component installation instructions.

5.4 Cycling requirements.

5.5 Component performance checks during test.

5.6 Test Record: The following list is an example of recorded data that may be required, if applicable:

A. Component speed
B. Component discharge pressure
C. Component inlet pressure
D. Inlet fuel temperature
E. Engine flow
F. Bypass flow
G. Engine or pump filter differential pressure
H. Pressure and flow readings as required to monitor component(s) functioning
I. Date and time of day
J. Total operating time
K. Total number of functional cycles
L. Weight of contamination added since the last reading
M. Results of contaminant sampling
N. Salt water volume added since the last reading
O. Interfacial tension of the fuel in the receiving tank

5.7 Failure criteria.

5.8 Post-test component inspection or performance data.

5.9 Special instructions or unusual procedures.

LESSONS LEARNED

Severe, abnormal corrosion problems have been encountered during fuel contamination testing. Investigation into the causes has confirmed the following problem areas:

A. Corrosive slime found in several test components was traced to the corrosion of aluminum upstream in the test system. Specifically, the corrosion of an aircraft fuel filter element and its housing. The problem was eliminated when the aluminum filter components were replaced with stainless steel.

B. Micro-organisms previously identified as being involved in the corrosion of aluminum and possibly other materials were found to be present in the contaminant constituents.

On the basis of past experiences, the following recommendations are made:

1. Filter elements with any aluminum in their construction should not be used. Elements should be made of corrosion resistant stainless steel or confirmed inert materials.

2. No test system equipment containing fuel wetted aluminum should be used. If the aluminum cannot be eliminated, it should be protective coated with an epoxy or other suitable coating and periodically inspected. It has been found that anodizing and "hard-coating" are not suitable for long term exposure to contaminated fuel containing salt water.

3. The entire test system should contain only fuel wetted surfaces that are corrosion resistant stainless steel (300, 18-8 series), inert (plastic, etc.), or protective coated (epoxy).

4. The dry contaminants and salt water can be made free of microbial contamination by auto claving at 132°C (270°F) at 200 kPa (29 psi) for one hour.

5. Between test runs the system should be drained, cleaned, inspected, and filled with fresh fuel.

TEST TIPS

1. The particle distribution of the dry contaminants should be monitored closely. Custom grading of the constituents may be required to obtain proper certification of the material and particle size distribution.

2. The volume of the funnel portion of the fuel tank should be sized to prevent vortexing. The addition of a cross-type "vortex breaker" may be required.

3. The supply tank outlet line should be as short as possible, made of transparent material, with smooth radius bends. This will aid in detecting and preventing slugs of contaminant from being introduced to the test system inlet.

4. The test should be conducted without interruption except for required shutdowns. However, if stoppages in excess of 24 hours are experienced, the entire system should be flushed with clean fluid.

5. The addition of a "GO, NO-GO" type water barrier is a useful addition to the system downstream of the separator in case of separator failure or overload.

6. The lint should be added to the conveyor and the dirt placed over it. Large amounts of lint may cause erratic discharge from the conveyor.

7. Pre-conditioning of the test fuel is required to assure water saturation. This can be done by adding 25 cc (1 Oz) of distilled water to a 54-gallon (204 litre) drum of fuel, agitating, and then allowing the drum to set at test system temperature for 24 hours.

8. The conveyor may be fitted with a scraper bar or device to reciprocate across the conveyor to aid the even removal of the contaminant into the fuel tank. However, it has been found that a conveyor utilizing a paper belt pulled over a small diameter roller, at the point of drop-off, does not require a scraper to insure even contaminant removal.

9. The contaminant particles (especially the cotton linters) agglomerate, due to ambient humidity. A dry heat source, placed above the belt, will help alleviate the condition (must be of an explosion-proof design).

10. ASTM Method D971-50 may be used to determine interfacial tension.

11. All fuel tanks should be covered to prevent airborne contamination and reduce evaporation.

12. A variable speed peristaltic chemical pump, which can be modified to vary its output proportional to system flow, or a medical syringe pump, or gravity feed from a container suspended above the supply tank, with an adjustable restrictor in a flexible tube, have all been successfully used for salt water introduction.

13. When an Engine Fuel System Filter is required, the filter should have the same material of construction, filter media, and effective area as the corresponding airborne version. Filter media, especially depth and disposable type, vary greatly in removal efficiency. Using the actual aircraft system filter will provide the most meaningful test results.

PREPARED BY
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AEROSPACE FUEL, OIL & OXIDIZER SYSTEMS

TEST SETUP

FIGURE I