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ACCEPTANCE TEST PROCEDURES AND STANDARDS TO INSURE CLEAN FUEL SYSTEM COMPONENTS

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1. SCOPE: To describe general guidelines for achieving selected levels of cleanliness in gas turbine engine fuel system components and to describe laboratory type methods for measuring and reporting the contamination level of the wetted portion of fuel system components. As in SAE J1227 (covering hydraulic components) this practice includes guidelines for levels of acceptance but does not attempt to set those levels.

2. PURPOSE: To provide standards and procedures for processing and verification to insure an acceptable level of product cleanliness in gas turbine engine fuel system components.

3. APPLICABLE DOCUMENTS: The documents listed below form a part of this document to the extent defined herein.

Military Specifications

MIL-C-16173 Grade 2	Corrosion Preventive Compound, Solvent Cutback, Cold Application
MIL-C-15074	Corrosion Preventive, Fingerprint Remover
MIL-P-116E	Preservation, Methods of
MIL-C-7024C Type II	Calibrating Fluid, Aircraft and Fuel System Components

Federal Standards

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment

SAE Publications

SAE ARP 598A	Procedure for the Determination of Particulate Contamination of Hydraulic Fluids by Particle Count Method
SAE ARP J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems

ISO Publications

ISO No. 4021 (1977)	Hydraulic Fluid Power - Particulate Contamination
DOS 4401	Automatic Particle Counter

ANSI Publications

ANSI B93.44 (1978)	Extracting Fluid Samples from a Reservoir of an Operating Hydraulic Fluid Power System

4. BIBLIOGRAPHY: Other government documents are available which are related to this subject. A partial list for reference information is as follows.

Military Standards

MIL-STD-105D	Sampling Procedures and Table for Inspection by Attributes

Military Specifications

MIL-F-87154	Fuel Systems

Military Technical Standards

T.O. 42B-1-1 (1983)	Quality Control of Fuels and Lubricants

ISO Publications

ISO 3722 (1976)	Verification of Sample Bottle Cleanliness
DIS 4402	Calibration of Automatic Particle Counters
DIS 3938	Reporting Contamination Analysis Data
DIS 4406	ISO Solid Contaminant Code

ANSI Publications

ANSI B93.29 (1973)	Method for Calibration of Liquid Automatic Particle Counters Using AC Fine Test Dust

NAS Publications

NAS 1638 (1964)	Cleanliness Requirements of Parts Used in Hydraulic Systems

5. GUIDELINES FOR ACHIEVING PROPER LEVELS OF CLEANLINESS: Most manufacturers of gas turbine engine fuel system components rely on process control to maintain the necessary degree of cleanliness in the products they produce. However, a quantitative cleanliness requirement, issued by the airframe or engine manufacturer, consistent with the contamination tolerance of the most sensitive components in the fuel system, will establish a logic for each component manufacturer to follow. Sub-tier vendors would then have a clearly established allowable cleanliness level for their particular application which would be included as a detailed specification for that component. The vendor specification should define two terms in order to be consistent with existing hydraulic system cleanliness guidelines.

5. (Continued):

a. Allowable Cleanliness Level: The allowable cleanliness level must be consistent with the contamination tolerance of the most sensitive component in the fuel system. It will be abbreviated throughout the remainder of the ARP for simplicity and called "ACL". The ACL is organized as a series of particle sizes per 100 ml of test fluid arranged into classes. The classes are defined in this ARP in Table III.

b. Recommended Cleanliness Level: The recommended cleanliness level is the initial cleanliness of all the test apparatus used for measuring ACL and should be specified as not more than 10% of the count permitted for ACL. This will insure that test apparatus will have a minor impact on the ACL measurement. This level will be abbreviated throughout the ARP as "RCL".

The sub-tier vendor will then select appropriate processes consistent with the specification and could, if required, verify on a statistical basis, compliance with that requirement. The phases of production which must be controlled and monitored to achieve satisfactory levels of cleanliness will be described in this section. No order of preference for methods is implied. No attempt will be made to establish what level of control is required to lead to a level of cleanliness. This must be established and verified separately by each supplier in his own facility. The proof of conformance will be with periodic verification tests of the end product against the specified system allowable level.

5.1 Cleaning of Detail Parts: The cleaning of mechanical and electromechanical parts must be performed on a 100% basis with procedures compatible with the materials of the part. Special precautions are advised on parts which have cavities not visually inspectable. The basic methods which follow are for use as guidelines and do not prohibit the user from using other procedures which can be proven effective.

5.1.1 Vapor Degreasing: Operator must visually check parts to see that they are free of all chips, burrs and surface stains.

5.1.2 Sonic Cleaning: Part must be oriented to maximize the effect of sound vibrations in assisting to remove contamination.

5.1.3 Probing: Ports, cavities, intersecting holes, etc., may require probing using a suitable wire to help dislodge chips or foreign material.

5.1.4 Vacuum Cleaning: In the same manner as probing, ports, cavities, intersecting holes, etc., may require vacuuming.

5.1.5 Flushing - Flushing with a liquid or air at a constant pressure level in all ports, cavities, intersecting holes, etc., may be required. Since removal of particles from surfaces is proportional to the turbulence in the system, the flushing should be performed at Reynolds numbers at least equal to, and preferably higher than, those seen by the article in normal service. Vibration and shock of the article during flushing may assist in obtaining the necessary degree of cleanliness. If a liquid is used it must be drained following flushing. Cleaned parts should be placed in sealed clean plastic bags following this operation to prevent recontamination.

5.1.6 Rinsing: Simple parts with no complex passages or cavities may be simply rinsed with a standard degreasing medium and placed in a clean container or clean plastic bags.

5.2 Inspection of Detail Parts: Detail parts shall be inspected under the conditions of magnification and lighting specified in Table I for an allowable cleanliness level. The part shall be free of all chips, burrs, and films perceptible under the conditions specified.

Table I

Allowable Cleanliness Level Code	Magnification	Lighting Intensity Min Foot Candles
ACL 1	1X	100
ACL 2	3X	100
ACL 3	5X	150
ACL 4	10X	300
ACL 5	15X	300
ACL 6	30X	300

5.2.1 Particle Contamination: The inspection of detail parts per Table I is intended to allow inspection personnel to make a judgement relative to the ACL level specified and to be described in this ARP in Table III. If parts examined per Table I are obviously in compliance, no further inspection effort is required. If the visual check indicates parts are marginal, a verification test per paragraph 6 must be performed.

5.3 Preservation and Handling of Detail Parts Following Inspection: Cleaned parts shall be protected to the extent selected in Table II to assure a proper level of cleanliness at final assembly.

Table II

Preservation Level Code	Preservation
P1	No preservation required.
P2	Apply corrosion inhibiting compound to exposed surfaces as required. All exposed surfaces shall have been previously treated with a suitable fingerprint neutralizer prior to application of corrosion inhibiting compound. Application of the corrosion inhibiting compound shall be in such a manner as to displace the fingerprint neutralizer. This level is intended for parts to be immediately assembled where long term storage is not a consideration.

5.3 (Continued):

Table II
(Continued)

Preservation Level Code	Preservation
P3	Apply corrosion inhibiting compound to exposed surfaces as required. All exposed surfaces shall have been previously treated with a suitable fingerprint neutralizer prior to application of a corrosion inhibiting compound. Application of the corrosion inhibiting compound shall be in such a manner as to displace the fingerprint neutralizer. Enclose part in polyethylene or equivalent vapor barrier bag and seal bag.
P4	Cap and plug all openings to retain residual test fluids, apply corrosion inhibiting compound to exposed surfaces. All exposed surfaces shall have been previously treated with a suitable fingerprint neutralizer prior to application of the corrosion inhibiting compound. Application of corrosion inhibiting compound shall be in such a manner as to displace the fingerprint neutralizer. Enclose part in a polyethylene or equivalent type bag and seal bag.
P5	Apply corrosion inhibiting compound and encapsulate in a sealed, dehumidified container. All exposed surfaces shall have been previously treated with a suitable fingerprint neutralizer prior to application of the corrosion inhibiting compound. Application of corrosion inhibiting compound shall be in such a manner as to displace the fingerprint neutralizer.
P6	Enclose part in vapor barrier bag and seal bag.
P7	Apply preservative specified on the drawing to exposed surfaces and enclose in a vapor barrier bag and seal bag.
P8	Enclose part in a vapor barrier bag seal bag, and place in an enclosed, rigid, individual container.

5.3.1 Throughout manufacture and specifically following final inspection, all parts should be handled, stored, and transported in such manner and by such means to preclude contamination of, or damage to, final surfaces until used on the assembly floor. All corrosion inhibiting compounds and fingerprint neutralizers must be under strict control so that cleanliness is measured and controlled so as to be as good as the ACL of the actual component. Acceptable corrosion inhibiting compounds and fingerprint neutralizers suggested are MIL-C-15074 and MIL-C-16173.

5.3.2 Detail parts requiring a protection level of P6, P7, and P8 require a vapor barrier bag and a seal bag. The barrier bag suggested is made of a transparent, thermoplastic, nylon film. The barrier bag must be cleaned immediately before sealing by purging with prefiltered dry nitrogen. The second or sealing bag shall be made of a transparent, thermoplastic, polyethylene film.

5.4 Assembly: Detail parts shall be assembled in a controlled environment to insure the required cleanliness of the final assembly. Specific installations may, of necessity, vary in design. The selection of an area may be made from the levels specified in:

FED-STD-209 Clean Room and Work Station Requirements, Controlled Environment

Particular attention must be paid to containers for holding parts and assembly tools in the controlled environment. They must never be contaminated in excess of the level specified for the cleanest detail part requirement and must be periodically inspected for conformance.

It must be recognized that the actual assembly processes can generate contamination. Even with relatively clean parts and tools and normal aerospace assembly practices, contamination can be generated during assembly. A final assembly cleaning operation such as flushing is therefore required.

5.5 Flushing After Final Assembly: An additional degree of cleanliness will be gained by flushing partially assembled fuel system components prior to final closure. In general, it is recommended that the partially assembled unit be positioned with the open face or feature down in a compartment of a flushing rig. Be sure that electrical components, which operate dry, are protected from exposure to the flushing fluid. The unit is then flushed with an upward stream of pressurized MIL-C-7024C Type II calibrating fluid①. External areas of the component should be flushed with a horizontal stream of the same calibrating fluid. Following flushing, drain the flushing fluid. This procedure must be repeated if components are later opened for repair or adjustment in the controlled environment. Proper quality

①This is the typical hydrocarbon fuel system calibrating fluid. In some applications, other fluids may be used at the discretion of the customer such as P-D-680 Type II.

5.5 (Continued):

precautions must be taken to periodically check the fluid in the flushing rig to assure cleanliness. The RCL of the flushing fluid is expected to have not more than 10% of the particle count specified for the level of the ACL of the actual component.

5.6 Calibration and Acceptance Tests: All fuel system components requiring calibration and acceptance testing must have a proper level of fluid filtration and quality control provisons for periodically checking the contamination level of the rig test fluid. As in the case of flushing procedures, the RCL of test fluid must be not more than 10% of the level of the ACL of the component undergoing test.

5.7 Preparation for Shipment: Fuel system components must be protected from contamination following any final test operation. Proper enclosures should be utilized. All shipping closures, caps, etc., should be under the same quality control provisions as specified for the detail parts and controlled assembly environment. A moisture proof, sealed container, or bag, is recommended to enclose the component prior to placement in the final shipping container.

6. TEST PROCEDURES FOR VERIFICATION OF LEVEL OF CLEANLINESS: Recognizing that there are many different types of fuel system components, it is necessary to define procedures which have the broadest possible application and produce repeatable results. The first differentiation to be considered is static versus dynamic components. Any component with rotating or reciprocating parts such as valves, servos, motors and transducers should be considered a dynamic component. As in hydraulics, hoses are considered dynamic parts. Any component which does not fit any of the requirements to make it dynamic shall be considered static. Generally speaking, it should be required to run a simple "slosh" test of a static component, while a dynamic component should be flowed while being functionally exercised. Recognizing that electrical interface devices may have a wet section and a dry section, it is recommended that for purposes of this procedure the wet and dry sections be isolated from one another and only the wet section be evaluated. For purposes of consistency, the fluid recommended for use in the procedure should be MIL-C-7024C, Type II. It should follow the RCL rule for cleanliness which is that the RCL permits not more than 10% of the level specified for the ACL for the component.

6.1 Methods to Obtain Fluid Samples: Two methods of obtaining fluid samples will be described. For static systems, the simple slosh test of paragraph 6.1.1 should suffice. For dynamic systems, which require exercising of moving parts, paragraph 6.1.2 applies.

6.1.1 Static Components: Fill the component from one-third (1/3) to one-half (1/2) full with clean fluid and seal the component. Seal all ports with clean closures and agitate the component mechanically. The plan for agitation, vibration, or shock shall be specified by the user. Fluid samples from very large static components should be removed using the method of ANSI Standard No. B93.44 (1978).