ADS-43A-HDBK

AERONAUTICAL DESIGN STANDARD HANDBOOK

QUALIFICATION REQUIREMENTS AND IDENTIFICATION OF CRITICAL CHARACTERISTICS FOR AIRCRAFT ENGINE COMPONENTS

UNITED STATES ARMY AVIATION AND TROOP COMMAND

ST.LOUIS, MISSOURI

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APPROVED: ______________________

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SECTION 1

GENERAL QUALIFICATION REQUIREMENTS

FOR

AIRCRAFT ENGINE COMPONENTS

1.1 INTRODUCTION

1.1.1 Purpose

Public Law 100-456, section 805b, requires that alternate sources comply with the same qualification requirements as those of the original source.

> "In procuring any spare or repair part that is critical to the operation of an aircraft or ship, the Secretary of Defense should require the contractor supplying such part to provide a part that meets all appropriate qualification and contractual quality requirements as may be specified and made available to prospective offerors. In establishing the appropriate qualification requirements, the Secretary of Defense should utilize those requirements, if available, which were used to qualify the original production part, unless the Secretary of Defense determines in writing that any or all such requirements are unnecessary."

Potential alternate manufacturing sources of aircraft engine parts, components, or assemblies are required to provide substantiation that the specific item offered meets or exceeds the identical item furnished by the original manufacturer in terms of service life, strength, durability, form, fit, and function. The substantiation requirements for alternate manufacturing source approval are included in this document. Candidates for alternate source approval are required to submit to Army Aviation and Troop Command (USAATCOM), Engineering Directorate a plan designed to meet the substantiation requirements. The USAATCOM Engineering Directorate will review the plan to insure that the proposed testing is sufficient to determine that the item to be manufactured will be equivalent to the original. The Engineering Test Table (ETT) in the Flight Safety Parts Information System (FSPIS) lists the testing that is normally required for alternate sources which use material, castings, forging, and process sources approved by the prime contractor or government for the item in question. Flight Safety Parts (FSP) and critical characteristics are identified. A potential alternate manufacturing source requesting approval is required to submit written substantiating data on a part, component, or assembly to become a qualified vendor. This data should include, but not limited to, the candidates capability to manufacture the item, a manufacturing plan (including sources for forging, castings, etc.), and a test plan to satisfy engineering test requirements. After USAATCOM engineering examines the data and determines that the alternate source is capable of manufacturing the item in accordance with all of the existing requirements, the alternate source will be added to the Potential Suppliers List. Should the alternate source bid successfully, all quality assurance requirements, qualification tests, and engineering tests must be completed prior to delivery of parts to the procuring agency. At the discretion of USAATCOM engineering, previous suppliers who have not completed the engineering test may be required to do so prior to the delivery of additional parts.

1.1.2 Implementation

This document should be used in conjunction with the Spares Technical Data Package (STDP) for a particular part to specify the substantiation requirements a component or assembly must comply with. The guidance contained in this publication, in conjunction with the TDP, will be utilized in place of any qualification document issued by the prime design control contractor or the original manufacturer and referenced on a part, component, or assembly drawing(s). Significant differences between this document and other applicable qualification documents should be brought to USAATCOM engineering's attention for resolution. The First Article Test (FAT) item, and all production parts, components, or assemblies must, of course, remain subject to all contract requirements. Note also that reverse engineering of FSP is prohibited by ATCOM policy. Waivers, deviations, plans, and reports required by this document should be approved by USAATCOM engineering in writing in order fulfill substantiation requirements.

1.1.3 Use of Alternate Suppliers/Processors

Use of suppliers or processors (subcontractors) that are not approved sources for material, forging, castings, or processing may require additional substantiation testing and/or engine qualification test. Public Law 100-456 requirements also apply to subcontractors as defined above. Proposals from these sources must be reviewed by USAATCOM engineering for approval.

1.1.4 Definitions

Alternate Manufacturing Source - A source for a part, component, or assembly who was not originally approved to manufacture such a part, component, or assembly but is now approved.

Assembly - A combination of parts and/or components which constitute an identifiable functional constituent of a larger assemblage, or can perform a specific function on its own.

Component - Usually made up of two or more parts which can be further subdivided but cannot perform a specific function without the aid of other components.

Critical Characteristics - any feature throughout the life cycle of a FSP such as dimension, tolerance, finish, material; assembly, manufacturing or inspection process; operation, software, field maintenance, or depot overhaul requirements, which, if nonconforming, missing, or degraded could cause the failure or malfunction of the FSP. Critical characteristics produced during the manufacturing process are termed "manufacturing critical characteristics." Critical characteristics which are not introduced during the manufacture of a part but are critical in terms of assembly/installation, for example proper fastener torque, are termed "installation critical characteristics."

Engineering Tests - Tests conducted to assure that parts, components, or assemblies installed in engines will perform satisfactorily (i.e. endurance tests, interchangeability tests, environmental tests, etc.).

First Article Test - Test and evaluation of initial production samples for conformance with specified contract requirements before or, in the initial stage of production.

Flight Safety Part - Any part, assembly, or installation containing a critical characteristic whose failure, malfunction, or absence could cause an uncommanded engine shutdown, and/or catastrophic engine failure resulting in loss or serious damage to an aircraft and/or serious injury or death to the occupants. NOTE: Refer to MIL-STD-882B for further explanation or aircraft and personal safety hazard severity categories.

Part - An essential portion or integral element which cannot be easily further subdivided.

Prime Design Contractor - The original end item (i.e. engine) designer and/or manufacturer who, under Government auspices, selected various subcontractors to furnish parts and components for the total engine assembly.

Qualification Requirements - A requirement for testing or other quality assurance demonstration that must be completed by an offeror. Qualification testing performed either as a "Prequalification Test" prior to contract award, or as an "Engineering Test" at the time of First Article Testing (FAT), should be performed as directed by USAATCOM engineering at the time of solicitation.

Source Controlled Drawings - Drawings which list such data as physical envelope, materials, operating environment, and design parameters. Each part number is normally a different configuration or design, which will perform the functions specified on the drawing. The drawings also list the manufacturing source that is qualified to produce each design.

1.2 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. In the event of a conflict between the documents referenced below and the contents of this specification, the contents of this specification must prevail. In other paragraphs of this specification only the basic document number is stated. The revisions and changes for the applicable documents are identified only in this paragraph.

Other applicable documents listed elsewhere in this document:

ATCOM Reg 702-7, Flight Safety Parts Program Management
AMC 702-32, Critical Safety Items Program
Federal Acquisition Regulation, Part 6 and Subpart 9.2

MIL-I-45208, Inspection Requirements (or as specified in the contract)
AV-E-8593D, Engines, Aircraft, Turboshaft and Turboprop, General Specifications for.
Federal Test Method Standard No. 15 1 Metal, Test Methods of
NISO 239.18.199X Scientific and Technical Reports, Elements, Organization and Design (or as specified in the contract)
MIL-STD-8 1 OC, Environmental Test Methods and Engineering Guidelines
ATCOM QE-STD-1 Flight Safety Parts Quality Systems Requirements
ATCOM Competition Advocates Shopping List (CASL)
ET-STD 1 Engineering Test Requirements for New Sources
MIL-STD-498C Software Development and Documentation

1.3 GENERAL REQUIREMENTS

1.3.1 General

The ETTs, in the FSPIS, provides lists of engine parts, components, and assemblies with the qualification requirements an alternate source must meet before that source can be approved to manufacture the component. Production components must be manufactured by the alternate source using the same facilities, equipment, and procedures that were used to manufacture the substantiation test articles (see paragraph 1.3.6). Requirements listed for assemblies include all requirements listed for parts and components used in that assembly. The alternate source must certify they have a quality program established which meets the requirements of MIL-I-45208 or a comparable higher-level non-government quality system before qualification testing may commence. (Mandatory 100% inspection in accordance with MIL-Q-9858A requires a waiver.) This certification should be submitted as part of the inspection report.

1.3.2 Source Control Drawings

Source Control Drawings (SCD) list those sources that are qualified to produce that particular component. The alternate source must satisfy all requirements specified by the SCD, any associated procurement specification, and requirements specified herein in order to be approved. Any duplication of requirements may be ignored. A test plan for substantiating compliance with SCD requirements must be submitted to USAATCOM engineering for approval prior to testing. The required Design Qualification Testing must be performed as a "Pre-qualification Test" since each vendor provides an entirely different design.

1.3.3 Dimensional Substantiation

All drawing dimensions, limits, and tolerances must be adhered to. All components listed in the attachments and used for testing in accordance with this document must require substantiation of all drawing dimensional requirements. The results of this dimensional substantiation should be included in the inspection report and submitted to USAATCOM engineering for approval (see paragraph 1.3 .8).

1.3.4 Material Substantiation

Components must only be fabricated from the material(s) specified. Castings and forging must only be procured from sources which have been previously approved by the prime contractor or USAATCOM engineering for each specific part or component. Other material used will be in accordance with all applicable procurement specifications. Substantiation of compliance with these requirements is required for all components listed in the ETT in the FSPIS. To access the FSPIS, see the FSPIS User's Guide or contact AMSAT-R-EBS. This substantiation should be included in the inspection report and submitted to the procuring service for approval (see paragraph 1.3.8).

1.3.5 Process Substantiation

The service life of engine components, particularly high speed rotating parts, is greatly affected by the processes performed during the manufacture of these parts. It is imperative that all processes are performed in a manner virtually identical to that established during the development of these components. All processes used in the fabrication of engine components must be performed by sources which have been previously approved by the prime contractor or USAATCOM engineering for each specific part or component. Other processors may be approved by the prime contractor or USAATCOM engineering upon request or, if the need arises. This includes heat treat, shot peen, finishes, forming, welding, coatings, plating, and all other processes used to manufacture the part. The component must also be subjected to all inspections (e.g., Nondestructive Inspection (NDI)) required by the drawing. Verification of compliance with process requirements and documentation of all inspection results is required for all components listed in the ETT in the FSPIS. Engine low cycle fatigue (LCF) spin pit testing may be required to substantiate parts lives in some cases. These should be included in an inspection report and submitted to USAATCOM engineering for approval (see paragraph 1.3.8). No new sources for processing engine parts will be approved until they have met all of the above requirements.

1.3.6 Manufacturing Process Control

A manufacturing and quality control process sheet listing the sequence of operations, operation descriptions, parameters, inspection stations and criteria, and specific equipment used to produce the component should be included in the inspection report and submitted to USAATCOM engineering (see paragraph 1.3.8). Upon acceptance of FAT for the component by USAATCOM engineering the process sheet including all changes made during the substantiation effort must be classified as “frozen planning.” Any proposed changes to the frozen planning must be submitted to USAATCOM engineering for approval.

1.3.7 Flight Safety Parts

Drawings of components and assemblies that are classified as FSP containing critical characteristics and are identified in the ETT in the FSPIS, may have additional requirements as specified in ATCOM Reg 702-7 and the STDP. Substantiation of conformance of all FSP critical characteristics to drawing requirements, specifications, acceptance test procedures, and detailed plans for the 100% inspection of critical characteristics, or a previously approved statistical substitute, should be included in the inspection report and submitted to USAATCOM engineering for approval.

1.3.8 Approval to Conduct Testing

Alternate sources must not commence qualification testing until an inspection report substantiating that all requirements of this section have been met, has been submitted to and approved by USAATCOM engineering. Upon receipt of approval, the alternate source may begin testing. The test plan may be submitted as part of the inspection report. Standard required tests are detailed in subsequent sections of this specification.

1.3.9 Parts Not Requiring Qualification Testing

Certain engine parts, components, and assemblies do not require qualification testing. Alternate sources of these items must be approved by having met the requirements provided in the CASL and STDP and by receipt and approval of documentation of compliance with the above requirements from USAATCOM engineering. With the exception of FSP, manufacturing process sheets are not required for these items. These requirements may be substantiated as part of the FAT.

1.4 TEST REQUIREMENTS

1.4.1 General

Certain components listed in the ETT require qualification testing in addition to substantiation of the dimensional and metallurgical requirements. The inspection report must be approved by USAATCOM engineering before testing commences. The alternate source must submit a test plan detailing the proposed test procedure(s), pass/fail criteria, testing and measuring equipment to be used, test location and dates, test article inspection plans, and test quality assurance provisions to USAATCOM engineering. Qualification testing can commence only after this test plan is approved. Required testing includes endurance, operational, interchangeability, and fatigue testing and is described in Section 2. Other tests, at the discretion of the USAATCOM engineering, may be added as part of the qualification requirements. Approval of the alternate source should be contingent upon successful completion of the applicable test(s) conducted in accordance with the approved test plan, examination of the component by USAATCOM engineering, and upon receipt and approval by USAATCOM engineering of a test report and inspection report which documents all testing and results. Test plans must be in accordance with contract requirements, and test reports in accordance with NISO Z39.18.199X, or per contract.

1.4.2 Environmental Testing

Components may require environmental tests as specified in the Engine Model Specification, AV-E-8593, or as determined by USAATCOM engineering. A new source for such components may also be required to demonstrate that the component does not alter engine operations. Such tests may include high and low air temperatures or high altitudes.

1.5 APPROVAL OF TEST RESULTS

1.5.1 Test Component Evaluation

Immediately upon completion of each qualification test USAATCOM engineering will examine the test components (i.e., “dirty” inspection). Test components will be evaluated on the basis of a comparison between the condition (e.g., wear, cracks, fretting) exhibited by the test article and that found on previously qualified components. Results of pre-test and post-test component calibration (if required) will be evaluated. The USAATCOM Engineering Directorate will provide written descriptions of all test article deficiencies through the contracting officer to the alternate source after this inspection. These inspection findings should be addressed by the alternate source and submitted as part of the formal test report. The test components should then be subjected to a “clean” inspection in accordance with drawing requirements, except removal of protective finishes is not required. The test report must include documentation of all testing and inspection results.

1.5.2 Rejection and Retest

When an engine part, assembly, or component listed in the ETT fails any of the qualification requirements, the item must be rejected. All failures, whether by noncompliance of hardware (dimensional or metallurgical) or failure during testing, and proposed modifications to both parts and testing procedure must be documented and submitted to USAATCOM engineering before testing can be resumed. Rejected engine parts, assemblies, or components must be replaced or reworked as specified by USAATCOM engineering to correct the deficiency, after which part or all applicable test(s) will be repeated, depending on the nature and severity of the failure.

1.5.3 Alternate Source Approval

An alternate source is approved only for the manufacture of the component specified. A prospective vendor must be referred to the CASL for qualification by similarity guidance.

1.5.4 Changes in Approved Sources/Processes

Any change in manufacturing location, such as to another plant of an individual vendor; a change in material processes or subvendors who perform a process; a change in material, casting, or forging suppliers; a change in manufacturing planning from the approved planning process; or a change in machining procedures which may affect component strength or durability may require retesting based upon a proposal from the alternate source and approval from USAATCOM engineering. Refer to CASL procedures for additional information.

SECTION 2

QUALIFICATION REQUIREMENTS

AND

IDENTIFICATION OF CRITICAL CHARACTERISTICS

FOR

AIRCRAFT ENGINE COMPONENTS

2.1 INTRODUCTION

Section 2 identifies critical characteristics for parts identified as FSP. It also identifies standard test requirements for substantiation of alternate source parts. Parts lists for each of the three (3) engine models covered by this document are listed in the ETT in the FSPIS. Different series of an engine in the Army inventory (i.e. 700, 701, 701C etc.), are listed separately. Source controlled parts and FSP are highlighted. Required qualification tests are identified for each part and are coded alphabetically as shown in subsection 2.3 of Section 2. The USAATCOM Engineering Directorate has the option to waive certain required tests upon request if the prospective vendor can show evidence that the test is not necessary or that he has already successfully conducted the test on an equivalent part. The USAATCOM Engineering Directorate reserves the right to specify additional engine and component qualification test requirements of AV-E-8593, paragraph 4.6, which addresses potential failure modes, based on design experience, service experience, or absence of complete manufacturing data.

The parts lists in the ETT show the following:

A. If part is source controlled.
B. If part is FSP.
C. Tests required for alternate source qualification.
D. Critical characteristics.

Generic critical characteristics will apply to those parts not listed (See 2.2.5).

2.2 CRITICAL CHARACTERISTICS

A critical characteristic is defined in paragraph 1.1.4.

All critical characteristics require 100% inspection. The only exception is where the required inspection procedure renders the part unusable. When this occurs, the vendor will propose a sampling procedure to USAATCOM engineering for approval. Statistical methods may be utilized in lieu of 100% inspection of nondestructively inspectable critical characteristics with the approval of the local Government Quality Assurance Representative and the PCO of USAATCOM Quality Engineering Division. All statistical methods must be approved in writing prior to implementation.

All FSP have critical characteristics which are identified on the applicable drawings. Without these drawings, critical characteristics cannot be properly identified. Reverse engineering of FSP or components of assemblies which are FSP is not permitted.

2.2.1 Materials

All FSP materials must be traceable to the original foundry melt with traceability maintained throughout manufacturing and processing to the finished part. Serialization of all parts therefore must be established and maintained, unless waived by USAATCOM engineering. Records will be made available to USAATCOM engineering on demand and should be maintained for five (5) years unless otherwise specified.

Typical generic material critical characteristics are as follows:

A. Composition
B. Grain size
C. Forging flow lines
D. Case hardness
E. Core hardness
F. Finish
G. Class 1A castings
H. Class of weld

2.2.1.1 Justification for Materials Critical Characteristics

The prospective vendor will inspect and test all ferrous and non-ferrous metallic materials in accordance with Federal Test Method Standard No. 15 1. If the material has been certified by the supplier, it must be verified in accordance with the prospective vendor's approved quality assurance plan. When material is inspected by melts, heats, or lots, the supplier or vendor must so arrange his working, handling, and marking of the material to maintain its proper identity. Such procedures must be made available to USAATCOM engineering upon request. When doubt exists as to the identity of any portion of the material, it is incumbent on the supplier or vendor to properly establish such identity of that portion or the lot will be rejected.

The material composition and grain size will be exactly as specified on the drawing. Alternate materials may be used only if listed on the drawing. Materials will be certified by the supplier and verified by the vendors quality assurance office. Forging will be procured only from approved vendors. Since strength and fatigue properties are affected by flow line direction, flow line direction will be as specified on the drawing. Case and core hardness are also critical to strength, wear, and fatigue properties of material. Therefore, case and core hardness must be as specified on the drawing. Finish specifications must be closely followed to allow for good fit and to reduce the possibility of crack initiation. Class 1A aircraft quality castings are required for all FSP and must be procured only from approved vendors. Castings must be certified by the supplier and verified by the vendors quality assurance office. Classes of welds will be as specified on the drawing. Stress relief procedures will be rigidly followed to reduce the possibility of crack initiation in welded areas.

2.2.2 Manufacturing

Manufacturing includes all of the tasks associated with converting raw material, such as forging, castings, extrusions, millstock, powdered metallurgy, etc., into a finished part. Some generic critical characteristics in manufacturing include the following:

A. Dimensions
B. Tolerances
C. Master tooling
   1. Master gears
   2. Master comparator charts
D. Machining
E. Grinding
F. Honing
G. Balancing

2.2.2.1 Justification for Manufacturing Critical Characteristics

a. The dimensions of a part or component are variables that can be expressed as mass, density, length, area, volume, finish, or angle. In some cases, when dealing with an assembly, moment or torque of a fastener is important. If any dimension is called out as a critical characteristic, it must be measured or verified on each part. For assemblies requiring interference or press fits, the dimensions of these parts cannot be verified after assembly, and must be measured before assembly.

b. Allowable tolerances must be observed. Any requests for deviations must be dispositioned by a Material Review Board (MRB) and approved by USAATCOM engineering. Otherwise, by definition, any deviation from a critical dimensional tolerance on a critical part will be cause for rejection, unless the part can be reworked to print.

c. The intersection of bores for support of spiral bevel gears is a point in space. This makes verification of bore intersection accuracy very difficult. An automatic coordinate measuring machine can be used for this and other critical measurements. Other less accurate methods may be used if approved by USAATCOM engineering. Accurate measurement of bevel gear tooth surfaces can only be accomplished by a high quality coordinate measuring machine. Tooth patterns can be assessed by use of a marking dye or paste. This is a less accurate but acceptable method once a gear set has been tested and a pattern baseline established. Master gears traceable to Grand or Gold Master Gears are required to measure tooth contact pattern on spiral bevel gears.

d. Gear cases are usually line bored to insure parallel axes of gear shafts for spur or helical gear trains. Engine frame assemblies generally support main shaft bearings where the bores or support pads for bearing supports must be accurately located. Verification of bore centers can be determined manually or with an automated coordinate measuring machine. Reference pads are sometimes machined onto a frame assembly to assist in accurate measurements.

e. Engine main shafts must be carefully measured to determine proper location and size of bearing journals, radii of transition points, and location and proper configuration of splines. Hollow main shafts must be carefully measured and inspected internally as well as externally. Finish specifications are equally critical both inside and outside of shafts to reduce the possibility of fatigue crack initiation.

f. Carbon radial or face seals are common in turbine engine dynamic sealing applications. Both the carbon seal and seal contact surfaces require very fine finishes usually expressed in terms of within two to three helium light bands. Measurement of such fine surface finishes requires specialized equipment capable of generating helium light and polarization to show interference fringing on the polished surface. Labyrinth seals usually are air seals with multiple knife edges running on some type of relatively soft coating. These seals are allowed to interfere with each other to “wear in.” Concentricity is important for good sealing. The labyrinth knife edges are sloped toward the pressure side to aid in sealing, and have a small radius (sharp) edge. Labyrinth seals will be marked or otherwise designed to prevent reverse installation. Under some circumstances, such markings could be a critical characteristic because excessive air leakage due to improper installation could adversely effect engine performance. Accessory drive seals are usually radial lip seals fabricated from a molded elastomer. Carbon seals are also used in accessory drives where the shaft speeds are very high. Elastomeric seal wear surfaces, although not as critical as carbon seals, must also have good surface finishes with outer diameters controlled for proper seal lip pressure.

g. Bearing raceways and rolling elements are polished to very fine finishes, usually less than 6 microinches arithmetic average (AA). Bearing ring and raceway dimensions are closely controlled such that mounted internal bearing clearances are in accordance with design specifications. Because of high rotational speeds, balance of the cage and rotating elements must be closely controlled. This requires careful selection of a set of elements and close control of cage dimensions. Internal unbalance can lead to bearing instability and failure. Bearings or bearing sets are usually designed to be loaded in one direction only and therefore must be marked for proper installation. Markings such as this could be construed as a critical characteristic because reverse installation could result in a short bearing life or engine failure.

h. Compressor and turbine blades are aerodynamically shaped and controlled dimensionally in the engineering drawings augmented by Master Comparator Charts (MCC) or electronic data generated by Computer Aided Design (CAD). The critical dimensions are the close tolerances of the blade root dovetail or fir tree and the aerodynamic shape, angle, and twist of the blade. The dovetail and fir tree retention is critical from a safety standpoint, and the aerodynamic shape is critical to engine performance. The specific critical dimensions are identified in the manufacturing drawings and/or the STDP.

The manufacturing contractor will be furnished an MCC by USAATCOM engineering or must have a MCC certified and serialized by a source approved by USAATCOM engineering. This MCC must be available for the First Article Inspection. The MCC is used in conjunction with an optical comparator which projects a magnified image of the part profile which is then compared directly with the MCC. The MCC shows, in blown-up form, the allowable tolerances for the blade airfoil or fir tree shape. The size of the MCC image and the magnification and screen size of the optical comparator are normally specified by USAATCOM engineering.

The compressor or turbine disks that retain the blades are dimensionally controlled by engineering drawings augmented by MCC or CAD. The fir trees and dovetails that retain the blade are made to close tolerances. The internal or external bearing or centering journals, splines, and curvic couplings are dimensionally critical. The heat treat, shot peening, machining feeds/speeds, surface finish and other processes may be critical to parts lives. The structural integrity, balance, and performance of these rotating parts make some dimensions critical. The specific critical dimensions are identified on the manufacturing drawings and/or the STDP.

Blisks, which combine disks and blades into an integral one-piece cast unit, are dimensionally controlled by drawings, MCC and/or CAD. In the case of a cast piece, the technical expertise is in the design and manufacturing of the die/pattern. However, the finished casting must be checked for critical characteristics. The structural integrity of the blisk, the aerodynamics of the blade, the close tolerances of bearing or centering journals and curvic couplings, and the rotating balance of the blisk make some dimensions critical. The specific critical dimensions are identified in the manufacturing drawing or the STDP.

Low cycle fatigue is a life limiting factor for the compressor, impeller, turbine disks, cooling or sealing plates, and certain other parts. Some of the factors which contribute to reducing low cycle fatigue life are material properties, material processing, surface finishes, marking components, radii, fillets and comer relief, and other anomalies. It is essential that all identifiable contributors to low cycle fatigue life reduction be eliminated to the greatest extent possible.

i. Oil jets are designed to be installed in only one position. To provide an exact aiming point for the jet, the jet hole drill angle is critical and maintained at close tolerance. All oil jets must be flow tested for proper oil quantities at system pressure, proper targeting, and proper spray pattern. A complete dimensional inspection is also required.

j. Deviations from drawing dimensions and tolerances, considered critical characteristics, will not be permitted for FSP. In some cases, final dimensions are affected by heat treating, plating, or other processes. Therefore, the vendor must make allowances to arrive at the correct dimension. Master tooling requirements are specified on the drawings for compressor blades and vanes, turbine blade and vane, airfoils, castings, forging, spiral bevel gears, and some compound curvature parts. This master tooling must be traceable to the original master in order to provide part interchangeability. Machining practices must be of the highest quality to insure proper form, fit, and function. Grinding, honing, or polishing procedures must also be of the highest quality. Checks for abusive grinding must be conducted on each part to prevent the possibility of surface cracking, leading to failure. Finish requirements must be equal to, or better than those specified on the drawings.

k. All high speed rotating components require balancing. In some cases, shafts rotate at speeds above the first critical speed and sometimes above the third critical speed. Usually damping is required while transversing critical speed points and any steady state operating speed, including idle, must be removed from any critical speed by at least 20%. Bladed disks require careful blade weighing and selection such that blades on opposite sides of the disc are within prescribed weight tolerances. Balance must be within blueprint requirements. The type of balancing machine selected by a prospective vendor must be approved by USAATCOM engineering. High speed gears must also be dynamically balanced. Any response frequency within 20% of any gear steady state operating speed, or multiple thereof, can indicate a potential hazardous condition leading to gear failure.

l. In order to provide concentricity for mating parts, surfaces called centering journals are machined on each part. These diameters are closely controlled such that fits, when mated, are snug to very tight. Both male and female parts require close adherence to tolerances for runout, diameter and concentricity such that, when mated, the assembly is in perfect alignment for proper engine function.

m. All digital engine controls will be subjected to full electromagnetic environmental effects testing to verify that the controls, and ultimately the engine, will operate to specifications in the Army's worldwide electromagnetic environment. All electronic controls will also be subjected to full environmental qualification testing per the Engine Model Specification or MIL-STD-8 1 OC, software validation and verification testing per the engine model or component specification, MIL-STD-498C or RTCA-DO 178, and system operational and endurance testing per the engine or component model specification or AV-E-8593D. Input and output signals will be checked for each digital control before mating to the engine. The dimensions, tolerance, and finish are necessary requirements for parts used in the fuel controls, valves, fuel nozzles, and pumps to ensure correct operation, such as flow rate on demand, operating pressure, leak rate, and back pressure where applicable.

n. Chip detectors, temperature sensors, pressure sensors, speed sensors, wiring harnesses, and torque measuring devices are used to provide engine condition information to the digital engine controls, hydromechanical fuel control units, and the airframe. These components are subject to performance and calibration tests, electromagnetic susceptibility test, system operational tests, and environmental tests in accordance with AV-E-8593D.

2.2.3 Processes

Processes include all of the operations, treatments, finishes, etc. which take place before, during, and after manufacturing and are essential in completing the part to drawing and specification requirements. Processes are described by a process specification. Military or industry specifications may be used which covers the process in question. Some of the processes include the following:

A. Casting
B. Forging
C. Extruding
D. Welding
E. Brazing
F. Soldering
G. Riveting
H. Swaging
I. Heat Treating
J. Annealing
K. Shot or Glass Peening
L. Cleaning
M. Plating
N. Coating
0. Painting
P. Bonding
Q. Software Conformation and Documentation
R. Pressure Tests
S. Flow Rate Tests
T. Insulation Resistance Tests
U. Continuity Resistance Tests
V. Electronic Component Bum In or Screening
W. Component Acceptance Testing

2.2.3.1 Justification for Process Critical Characteristics

Process critical characteristics define design compliance for all parts, and are critical for the application of a part in its intended use. Metallurgical processes, such as casting, forging or welding, determine the strength and acceptability of metallic parts, while electrical processes, such as soldering, bonding or insulation resistance, determine acceptability of electronic and electrical assemblies or components. Other processes are critical for operational environment reasons, such as anodizing, coating or painting. Deviation from critical processes is NOT allowed without the specific approval of USA ATCOM engineering.

2.2.4 Inspection Methods

Inspection methods may include both destructive or non-destructive. Generally, the destructive methods are used before the raw material is worked or processed. Non-destructive methods can be used before, during, or after manufacture of the part or, assembly. Inspection methods are used to inspect and verify that the critical characteristics are as required. Refer to “Code B Testing” for applicable test documents.

Destructive Inspection Methods Include the Following:

A. Chemical Analysis
B. Spectrochemical Analysis
C. Tensile Test
D. Charpy Impact Test
E. Cold Bending Test
F. Peel Strength of Brazed or Bonded Joints
G. Acid Etch for Grain Structure
H. Case Depth Inspection

Non-Destructive Inspection Methods Include the Following:

I. Electromagnetic Testing
J. X-Ray Testing (Radiography)
K. Liquid Penetrant Testing
L. Magnetic Particle Testing
M. Ultrasonic Testing
N. Coordinate Measuring Machine
0. Microscopic Test for Coating Thickness
P. Profilometers (Comparison Tester)
Q. Brine11 or Rockwell Hardness Testing
R. Pressure Flow or Leakage Testing
S. Nital Etch

T. Visual
U. Electrical Inspection

2.2.4.1 Justification for Inspection Methods Critical Characteristics

Destructive and /or Non-Destructive inspection methods may be required for some parts. Normally, destructive inspections are done on coupons or part segments which are cast or forged from the same material heat lot. These inspections are typically accomplished by the casting or forging vendor who then certifies that lot. In some cases, 100% ultrasonic or radiographic tests are required and records kept for future reference.

Non-Destructive inspection methods are often 100% for flight safety critical parts and will be accomplished as specified on the applicable drawings. Each required inspection is to verify that some critical characteristic has been met, i.e., no defects in material, processing, manufacturing, or deviations from dimensional requirements.

Electrical Inspection. For controls and associated components to be approved for operation on the engine, they must pass the required specifications for their ability to: monitor engine functions, process the functions, control the engine, process the prescribed signals to the cockpit, and store signals for future use; under severe conditions of altitude, humidity, temperature, electromagnetic compatibility (EMC), shock, and vibration as per specifications listed in the index. The data received and transmitted by the controls and components will be required to monitor engine and environmental functions and combine this data to control the engine and present information to the cockpit for reliable and safe control of the aircraft at all times. The control components must be compatible with received and transmitted electromagnetic energy so there will be no interference with control and monitoring functions of the engine.

2.2.5 Typical Critical Characteristics (Baseline)

The following are typical critical characteristics for engine components which must be considered baseline. Other critical characteristics may be added by USAATCOM engineering or, as prompted by field service experience.

2.2.5.1 Gears

Nital Etch Inspection, if required on drawing.
Inspection for white layer, when called out on drawing.
Magnetic Particle Inspection.
Master Tooling for Bevel Gears.
Balancing, if called out on Drawing.
Bearing and Centering Journals - Runout, Diameter, and Concentricity.

2.2.5.2 Bearings

Magnetic Particle Inspection for Rings and Steel Cages.
Fluorescent Penetrant Inspection for Non-Ferrous and Non-Magnetic Materials.
Nital Etch Inspection for Rings and Elements.
Balance of Cage, when called out on drawing.
Bore Diameter for Main Shaft Bearings.

2.2.5.3 Shafts

Magnetic Particle Inspection or Fluorescent Penetrant Inspection.
Ultrasonic Inspection, if required.
Nital Etch Inspection.
Balancing, when called out on drawing.
Bearing and Centering Journal(s) Runout, Diameter, and Concentricity.

2.2.5.4 Splines

Magnetic Particle Inspection or Fluorescent Penetrant Inspection.
Nital Etch Inspection.

2.2.5.5 Threaded Components

Magnetic Particle or Fluorescent Penetrant Inspection.
Nital Etch Inspection, if called out on drawing.
Flatness or Squared, if called out on drawing

2.2.5.6 Disks

Master Comparator Chart for Dovetail or Fir Tree Slots.
Contour Limits must be met on all surfaces on both sides of Dovetail or Fir Tree Slot simultaneously.
Centering Journal(s) Runout, Diameter, and Concentricity.
Magnetic Particle or Fluorescent Penetrant Inspection.

2.2.5.7 Compressor and Turbine Blades

Master Comparator Charts for Blade Airfoils.
Master Comparator Charts for Blade Dovetails or Fir Trees
Contour Limits must be met on all surfaces on both sides of Dovetail or Fir Tree simultaneously (Measurement over Pins).
Magnetic Particle or Fluorescent Penetrant Inspection.
Air and/or Water Flow Checks, if called out on drawing.

2.2.5.8 Compressor Blisks/Disks

Master Comparator Charts or equivalent for Airfoils as approved by USAATCOM engineering.
Magnetic Particle or Fluorescent Penetrant Inspection.

2.2.5.9 Turbine Nozzles

Magnetic Particle or Fluorescent Penetrant Inspection.

2.2.5.10 Impellers

Magnetic Particle or Fluorescent Penetrant Inspection.
Balancing, if called out on drawing.
Centering Journal(s) Runout, Diameter, and Concentricity.

2.2.5.11 Turbine Spacers

Magnetic Particle or Fluorescent Penetrant Inspection.
Balancing, if called out on drawing.
Centering Journal(s) Runout, Diameter, and Concentricity.

2.2.5.12 Turbine Cooling Plates

Magnetic Particle or Fluorescent Penetrant Inspection.
Centering Journal(s) Runout, Diameter, and Concentricity.

2.2.5.13 Locking Rings

Magnetic Particle Inspection or Fluorescent Penetrant Inspection.

2.2.5.14 Oil Jets

Flow Check Through Target Gage.
Pressure Test

2.2.5.15 Diffusers

Magnetic Particle or Fluorescent Penetrant Inspection
Radiographic Inspections, if called out on drawing.
Pressure Test, if called out on drawing.

Throat Opening Dimensions and Vane Orientation.

2.2.5.16 Compressor Stator Vanes

Fluorescent Penetrant Inspection of Brazed Joints.

2.2.5.17 Metal Tubing

Minimum Internal Diameter.
Pressure Test.
Magnetic or Fluorescent Particle on Welded or Brazed Joints, if called out on drawing.
Braze Filler Material Requirements, if called out on drawing.

2.2.5.18 Pumps (Oil and Fuel)

Shaft Spline Measurement Reference.
Pressure Tests.

2.2.5.19 Oil Coolers

Fluorescent Penetrant Inspection.
Radiographic Inspection, if called out on drawing.
Fuel Side Proof Pressure Test, if called out on drawing.
Oil Side Proof Pressure Test, if called out on drawing.

2.2.5.20 Controls Electronic

Input/Output Signal Processing
Vibration
Temperature Cycling
Electromagnetic Compatibility
Functional Test

2.2.5.21 Fuel Controls (HMU)

Environmental (Altitude, Fuel Temperature)
Vibration
Fuel Pressure
Functional Test

2.2.5.22 Filters (Oil and Fuel)

Pressure Tests

Bypass Indication

2.2.5.23 Valves (Hydraulic and Pneumatic)

Pressures (Flow Rate, Leakage, Back Pressure)
Solenoid Min. and Max. Operating Voltage
Solenoid Insulation Resistance
Solenoid Coil Resistance

2.2.5.24 Wiring Harness

Insulation Resistance (Megger)
Continuity Tests

2.2.5.25 Thermocouple Assembly

Insulation Resistance
Temperature Calibration
Dimensional Inspection

2.2.5.26 Fuel Manifold

Pressure Tests
Magnetic or Fluorescent Particle on Welded or Brazed Joints, if called on in drawing.
Electrical Resistance

2.2.5.27 Ignition System

Insulation Resistance
Voltage Operation Range
Power Delivered

2.2.5.28 Fuel Nozzle

Flow Rate and Pressure Test at various Engine Requirements
Spray Characteristics as related to Droplet Size, Cone angle, Pattern, and Penetration.

2.2.5.29 Heat Exchangers

Pressure Tests
Magnetic or Fluorescent Particle on Welded or Brazed Joints, if called out on drawing.

2.2.5.30 Alternators

Insulation Resistance
Shaft Spline Measurement Reference
Output Power Characteristics

2.2.5.3 1 Pickups (Speed)

Insulation Resistance
Continuity Tests
Environmental Sealing

2.2.5.32 Sensors (Temp and Pressure)

Insulation Resistance
Continuity Tests
Signal/Accuracy
Environmental Sealing

2.2.5.33 Torquemeter

Insulation Resistance
Continuity Tests
Signal/Accuracy

2.2.5.34 Springs

Modulus Over Operating Range

2.3 TEST DESCRIPTION

Code A. High Cycle Fatigue Tests

High cycle fatigue testing may be required to qualify some parts due to the critical nature of the part, high numbers of load cycles imposed on the part, and/or sensitivity of the part to manufacturing or finishing process. Blades, wheels, shafts, and gears are some examples of such parts. The preferred method of fatigue testing is the S-N technique, since service lives can be determined from S-N data for any load condition. The procedures for S-N testing are well documented and therefore are not repeated. Variables which significantly influence the test results, number of specimens, methods of applying loads, data scatter limits, etc. must be approved by USAATCOM engineering. Fatigue test specimens must be of production configuration and quality. The number of specimens to be tested will be proposed by the contractor and approved by USAATCOM engineering. However, a minimum of two specimens are required.

A test plan will be submitted in accordance with paragraph 1.4.1.

High Cycle Fatigue (HCF) Life

All parts of the engine must have the following minimum high cycle fatigue life:

a. Steel parts: 10 million cycles

b. Non ferrous alloy parts: 30 million cycles

HCF testing is accomplished as a part of the engine endurance test.

Code B. Seal Tests

This section documents the alternate source qualification requirements for main shaft carbon face seals, bore rubbing circumferential seals, and elastomeric lip seals.

B1. Carbon radial or face seals are common in turbine engine dynamic sealing applications. Both the carbon seal and seal contact surfaces require very fine finishes, usually expressed in terms of within two to three helium light bands. Carbon seals require both a rig and an engine test.

B2. Bellows type seals require a resonance frequency test to ensure that the bellows spring does not have a natural frequency that will be excited during engine operation. If the bellows design incorporates a damper, this test may be waived by USAATCOM engineering.

B3. Elastomeric lip seals may be qualified by engine testing, accessory gearbox bench testing or seal rig testing. Between 150-300 hours of test time is needed to substantiate some elastomeric lip seals. The prospective vendor must submit a test plan, in accordance with paragraph 1.4.1, to USAATCOM engineering for approval.

B4. Labyrinth type seals are used because of demonstrated performance and reliability at high rubbing speeds. Labyrinth seal break-in occurs during first engine run-ups and performance stabilizes without further wear. Labyrinth seal testing is required because of the consequences of an improperly manufactured seal or wear surface. Labyrinth seal "tightness" serves to minimize the amount of air used to protect sumps from local high temperatures, maintain proper pressure levels for thrust balance, and to minimize performance penalties due to leakage. Seal performance and endurance must be demonstrated by test. All labyrinth seals must undergo the following testing, as a minimum:

One sample (both rotor and stator) 150 hours engine endurance testing with no significant discrepancies following the test.

B5. Rig Testing:

Rig testing is required for qualification of all alternate seals. A minimum of 50 hours test time is needed to ensure that wear rate can be determined and leakage measurements after wear-in are within specification limits. The rig test (i.e. speeds, temperature, oil, and air flow) must be conducted under engine operating conditions. Rig testing is conducted to determine oil leakage rate and wear-in time. A test plan must be submitted in accordance with paragraph 1.4.1.

B6. Engine Testing:

Engine testing is required to qualify alternate sources for main shaft carbon seals. Rig tests cannot completely simulate the thermal and vibration environment of an engine. The amount of test time required will vary depending on the thermal environment of the seal, the operating speed and pressure (PV), and its past history. Number of seals tested will vary depending on these same parameters. The following table shows the high and low end range for engine testing.

	HIGH SEVERITY APPLICATION	LOW SEVERITY APPLICATION
Number of samples	3	2
Total time (Hours)	500 - 1000	300 - 500
Minimum time for 1 seal (Hours)	300 - 500	150 - 300

The seal will be considered in a high severity application if any one of the following parameters is exceeded:

PV > 300,000 psi-ft/min.

Temperature >	450 degrees F
Pressure >	40 psi
Surface Speed >	375 ft/sec

Engine testing will be conducted to the engine specification endurance test (see code E) or, an alternate test of equivalent severity as approved by USAATCOM engineering. All seals must be 100% inspected before and after endurance testing. All pre-test and post-test deficiencies must be documented for USAATCOM engineering review. See Appendix for engine test time needed to qualify seal positions for each engine.

B7. In lieu of testing described above, a source may be approved for some seals if the following conditions are met:

a. The seal successfully completes a 150 hour qualification test.

b. Following completion of the 150 hour qualification test, the seal successfully completes the leakage test and all serviceability checks per the Depot Maintenance Work Requirement (DMWR).

c. The proposed vendor provides access to both the proposed vendor's detail drawings and the prime manufacturer's detail part drawings.

d. The vendor provides engineering analysis and prime manufacturer engineering analysis to assess part design.

Code C. Bearing Tests

C1 Ball and roller bearings supporting the main engine shafts normally have multiple sources qualified during engine development testing. These are high speed, high technology bearings which require extreme quality control measures during each manufacturing step. The qualification testing consists of three (3) bearings successfully accumulating 1000 hours of engine endurance testing (see code E), with one bearing having a minimum of 500 hours.

C2 Accessory drive bearings usually are not required to undergo the loads and speeds of engine main shaft support bearings. The latter would be required to be tested in the same manner as engine main shaft bearings. Bearings in the accessory gearbox can be tested as part of an engine endurance test or, as part of an accessory gearbox bench test. The amount of time required for qualification would be a minimum of 150 hours on each of two bearings. Since many accessory drive bearing sets are identical, usually only one 150 hour test would be required to meet this requirement as determined by USAATCOM engineering.

C3 Engine output shaft reduction drive support bearings such as those designed to drive a propeller, are required to undergo the same qualification testing previously outlined for the engine main shaft bearings. This would consist of successful completion of 500 hours of endurance testing on one assembly since identical bearings support each of three or more cluster gears. A gearbox bench test may be used in lieu of an engine endurance test as long as the loads, speeds, temperatures, and shaft moments are equivalent to those experienced during an engine endurance test. The prospective vendor must propose a test procedure for approval by USAATCOM engineering before testing is started.

All bearings must be 100% inspected before and after endurance testing. All pre-test and post-test deficiencies must be documented for USAATCOM engineering review.

Code D. Gear Tests

Bevel gear, most spur gears, helical gear accessory, planetary sets, and associated components must be subjected to an interchangeability test. Components manufactured by the alternate source must be interchanged with components manufactured by an approved source to insure complete interchangeability between components. The exact parts to be interchanged, depending on the engine configuration, must be proposed by the candidate alternate source and approved by USAATCOM engineering. Components must be assembled in the appropriate gearbox or speed reduction assembly, subjected to an acceptance test for a total test time of five (5) hours. This test may be waived if the component can be interchanged successfully during endurance testing. This test is required only for those components specified in the ETT.

In addition to the Interchangeability Tests of this Section, all spur, helical, and bevel gears manufactured by a new potential vendor must be endurance tested. This consists of a 150 hour qualification test at rated load and speed. This test may be conducted as part of an engine 150 hour endurance test (see code E), or as 150 hour gearbox bench test. All material, quality, and drawing requirements must be met. Spiral bevel gears require working master gears traceable to the Grand or Gold Masters. Gleason Summaries for the specific gear to be manufactured must be made available to the procuring service upon request. A qualification test is needed for gears to ensure that residual stress in the gear blank, introduced during carbonizing and/or machining operations, are properly reduced through heat treatment.

All gears must be 100% inspected before endurance testing. Post-test inspection will consist of the following: Three teeth, spaced at 120 degrees, will be inspected for lead and profile. The lead is to be checked at three places; one in the mid addendum, one at the pitch diameter, and one at the mid dedendum. The profile must also be checked at three places; one at each edge of face (1/8" in from edge) and one at mid face. This post-test data will be compared to the pre-test gear inspection data to assess gear wear above normal "break-in" wear. All pre-test and post-test deficiencies must be documented for USAATCOM engineering review.

Code E. Endurance Tests

Engine endurance testing is required to quality engine parts manufactured by potential vendors. The endurance test procedure should be tailored from the Engine Model Specification or AV-E-8593D, paragraph 4.6.1.3. The endurance test procedure requires approval of USAATCOM engineering prior to testing.

The following codes describe the test length in hours and additional qualification requirements necessary to substantiate alternate vendor designs. These same codes are listed in the ETT by the part number and nomenclature for each engine system.

ENDURANCE TESTING CODES

CODE	HOURS	ADDITIONAL QUALIFICATION REQUIREMENTS
E1	150	Laboratory analysis of material and processes as defined by drawing(s) plus fatigue testing of free standing compressor blades, turbine blades, and vanes. Test pieces must be 100% dimensionally inspected plus any applicable inspection or test required by drawing(s) and referenced design requirements.
E2	150	100% test piece dimensional inspection plus required inspections from drawing notes and referenced design requirements.
E3	300	Laboratory analysis of material and processes as

		defined by drawing(s) plus fatigue testing of free standing compressor blades, turbine blades, and vanes. A 100% test piece dimensional inspection plus any applicable inspection or test required by drawing(s) and referenced design requirements.
E4	300	100% test piece dimensional inspection plus required inspections from drawing notes and referenced design requirements.

The engine completing the endurance test must be disassembled for examination of tested part(s). Prior to cleaning, the engine parts must be given a "dirty inspection" for evidence of leakage, oil coking, unusual heat patterns, and abnormal conditions. The "dirty inspection" should be completed before any parts are cleaned. The engine parts should then be cleaned and a "clean inspection" should be performed. Engine part measurements must be taken as necessary to determine excessive wear and distortion. These measurements must be compared with the engine manufacturer's drawing dimensions and tolerances and, with similar hardware, will be within usable limits and have no evidence of impending failure. Inspection techniques may also include but, not be limited to: magnetic particle, fluorescent penetrate, x-ray, and ultrasonic. During the "clean inspection" a visual examination and condition assessment must be conducted. Upon completion of the clean inspection, USAATCOM engineering must be provided all results of non-destructive tests. The USAATCOM Engineering Directorate should be notified of the inspection start date at least 7 days prior to each inspection.

Code F. Low Cycle Fatigue (LCF) Test

A LCF test is sometimes necessary to qualify alternate source critical rotating engine components, such as turbine disks or compressor blisks. This step is necessary to ensure the alternate source's manufacturing processes do not degrade component life. The LCF test can be accomplished in either a full engine test or a rig test where the critical components are rotated in a spin pit independently of the engine. A rig test is the preferred method of qualification due to the high cost of engine testing. The specific type of LCF test necessary to qualify a component will be determined by USAATCOM engineering.

LCF Test (Spin Pit)

In the spin pit test, components are attached to a rotating shaft and mechanically cycled from low speed to high speed. Critical engine stress (thermal and mechanical) need to be calculated using finite element methods and must be repeated as closely as possible in the spin pit. Care must be taken to ensure that the critical stress sites in the pit do not differ from those in the engine. The detailed procedure for calculating number of required test cycles, the number of components to be tested, and the maximum test speed (rpm) is complex and varied depending on component design and application. This information must be obtained from USAATCOM engineering.

The LCF test cycle will be as follows:

Start cycle
Accelerate to maximum rpm required in test
Stabilize at maximum rpm
Decelerate to 5,000 rpm or less
Repeat

After every 15,000 cycles, or as directed by USAATCOM engineering, the component will be removed from the pit and inspected for cracks. Additional inspections will occur at an indication of an anomaly. Successful accomplishment of the test will be based on completion of the required number of cycles without the occurrence of a crack of detectable size.

LCF Test (Engine)

The number of cycles required for this test will be directed by USAATCOM engineering. Prior to the test, the engine control will be adjusted to provide the maximum allowable acceleration fuel flow schedules and maximum allowable starting fuel flow schedules. Deceleration fuel flow schedules will be preset to provide maximum thermal shock. The customer bleed air will be set with a fixed orifice to provide maximum permissible bleed air flow. The accessory pads will be loaded to provide maximum continuous loads.

The LCF Test cycle will be as follows:

Approximate Total Time (Minutes)	Approximate Schedule time (Minutes)	Event

0.5	0.5	Start engine
2.5	2.0	Run at idle
2.6	0.1	Accelerate to max power
5.1	2.5	Run at maximum power
5.2	0.1	Decelerate to idle
8.2	3.0	Run at idle
8.3	0.1	Accelerate to maximum continuous power
10.8	2.5	Run at maximum continuous power
10.9	0.1	Decelerate to idle
12.9	2.0	Run at idle
15.0	2.1	Shutdown and cool down

Following completion of the prescribed numbers of cycles, using the above schedule, the engine will be disassembled and the test part(s) inspected for evidence of cracking. Successful accomplishment of the test will be based on completion of the required number of cycles without the occurrence of a crack of detectable size.

Code G. Engine Performance Tests

System Check: Conduct a back-to-back engine test to acceptance test procedure. First use a qualified stator assembly to establish a baseline performance, i.e., shp, sfc, Ng (corrected), etc. Establish an adequate surge margin by doing a surge margin check listed in the overhaul acceptance test specification. If the acceptance test procedure does not contain an appropriate surge check, USAATCOM engineering will provide a procedure to accomplish a surge check. Install qualification hardware and redo acceptance test to establish new performance parameters. Acceptance testing will establish a load line to determine if the surge margin is above or below minimum. The primary concern is reduced surge margin. Acceptance of performance parameters will be based upon direction and magnitude of difference. If surge margin check indicates problems (surges), the following can be conducted:

Surge Line Determination

a. Run back-to-back compressor rig test or,

b. Inflow bleed engine test (integration effects included).

Note: Maximize the load line reduction to maintain surge margin, if required.

If a review of the performance data indicates the possibility of air flow reduction at constant pressure ratio, then additional testing must be conducted to determine if the air flow at maximum allowable gas generator speed has been impacted. This testing will have to be conducted at low ambient temperatures (tl < 0 degrees F) to reach the maximum referred gas generator speed. Special arrangements have to be made to conduct the testing at low ambient temperatures.

Code H. Special Tests

Special testing is required to qualify this type of component due to service experience, design experience, or absence of complete manufacturing data. Contact USAATCOM engineering for specific direction on alternate source qualification requirements for these parts.

Code I. Electronic Control Testing

Testing of the electronic control will be as directed by USAATCOM engineering. A digital device will require input/output check to determine if the signal processor has the required software to process the input to give the correct output, and that electromagnetic compatibility requirements have been met. The control will require tests to determine if the input signals are processed to give the correct out signal. Burn-in (stress screening) testing may also be required.

Code J. Fuel Control Testing

Testing of the fuel control is required to determine if the control will supply the correct fuel flow under different conditions of altitude, inlet fuel pressure, and temperature. Contaminated fuel and pump cavitation tests may also be required. Procedure should be as directed by USAATCOM engineering.

Code K. Valve Assembly (Hydraulic and Pneumatic)

Valves require testing to determine that they meet the required flow rate, critical diameter, leakage and back pressure, and if solenoid operated, the minimum and maximum operating voltage.

Code L. Wiring Harness

All wiring harness will require continuity and insulation resistance tests.

Code M. Thermocouple Assembly

All thermocouple assemblies require insulation resistance, temperature calibration, and dimensional tests before use. Electrical resistance may be limited to a specific value.

Code N. Electrical Tests

The vendor must inspect and test all controls and electrical components per the electrical requirements of the Engine Model Specification, the component specifications, or the applicable portion of the following specifications:

ADS-37A-PRF	Aeronautical Design Standard Electromagnetic Environmental Effects (E3) Management, Design, and Test Requirements
MIL-STD-498C	Software Development and Documentation
MIL-STD-461 C	Electromagnetic Emission and Susceptibility Requirements for the control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference (Notice 3) Characteristics, Measurement of
SAE AE4L	Protection of Aircraft Electrical/Electronic Systems Against the indirect effects of lightning
MIL-STD-704D	Aircraft Electrical Power Characteristics
MIL-W-5088	Wiring, Aerospace Vehicle
MIL-STD-454	Standard General Requirements for Electronic Equipment
DOD-STD-1795	Lightning Protection of Aerospace Vehicles

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-STD-1553	Digital Time Division Command/Response Multiplex/Data Bus
MIL-STD-1773	Fiber Optics Mechanization of an Aircraft Internal Time Division/Response Multiplex Data Bus
MIL-C-38999	Connector, Electrical Circular Miniature, High Density Quick Disconnect (Bayonet, Threaded and Breech Coupling) Environment Resistance, Removal Crimp, and Hermetic Solder Contacts, General Spec for,

Code 0. Fuel Nozzles

Spray characterization: Nozzles designed with same flow and pressure may produce dissimilar spray characteristics due to several factors such as different internal geometry. It must be demonstrated that the alternate design has the same characteristics as the qualified design. Some of the characteristics require the use of the nozzle/swirler combination.

Combustor Rig: Combustor rig testing is required because slight or minor differences in spray characteristics can produce major shifts in PTF or radial profile numbers. Adverse shifts can cause severe hot section distress/failure. Exit profiles cannot be measured by engine test. Any adverse profiles must be identified in a rig to avoid engine damage. The rig will provide a first look at ignition characteristics in a system level unit. Combustor rig provides partial simulation of fuel nozzle operation environment and will identify any major flame stability problems. The use of the combustor rig to identify major flame stability problems is economically prudent when compared to the use of an engine altitude test to identify such problems.

2.3.1 Test Code Guidelines

COMPONENT	TEST CODE
ALTERNATORS	H, N
BEARING	C

BLISK	A, El, F, G
COMBUSTOR	E2
COMPRESSOR BLADE	A, El
CONTROLS ELECTRONIC	I, N, H
COOLING PLATE ***	E2, F
DIFFUSER ***	E2, G
DISC	E2, F
FRAME	E2
FUEL CONTROL, MECHANICAL	J, H
FUEL MANIFOLD	H
FUEL NOZZLE	E4, O
GEAR	D
GEARBOX	E2
HEAT EXCHANGER	H
HOUSING/CASE	NONE
IGNITION SYSTEM	H, N
IMPELLER	El, F, G
LOCKING RING	NONE
NOZZLE *	El
OIL COOLER	H
OIL JET	NONE
OIL PUMP	H
PICKUPS (SPEED AND ETC.)	H, N
PUMPS (OIL AND FUEL)	H
SEAL	B
SENSORS (TEMPERATURE & PRESSURE)	H, N
SHAFT	E2
SHROUD **	E2
SPACER	NONE
SPRINGS	H
STATOR/VANE	A, El, G
THERMOCOUPLE ASSEMBLY	M, N
THREADED COMPONENT	NONE
TORQUEMETER	H, N
TUBING	NONE
TURBINE BLADE	El
VALVES	K
WIRING HARNESS	L, N

* Test can be waived if coating source is approved.

** Test can be waived if component is not brazed or coated.

*** If an engine LCF test is performed (Code F), an engine endurance test (Code E), is not required for these components.

For all components the castings or forging source must be an USAATCOM engineering approved source.

For all new sources a form, fit and function acceptance test is necessary.

QUALIFICATION REQUIREMENTS FOR MAIN SHAFT CARBON FACE/CIRCUMFERENTIAL SEALS FOR THE T53-L13

P/N	RIG TEST	ENGINE TEST	RATIONALE
1-300-W Forward Comp Shaft on 1 Seal (Face)	50 Hours Minimum	300 Hrs. Total 150 Hrs Minimum. 2 Samples	This seal is considered a low severity seal according to guidelines, because of the temperature and low surface speed (150 degrees F, 3 18 ft/s).
l-300-173 Aft Comp Shaft (Fwd) (Circumferential)	50 Hours Minimum	750 Hrs Total, 400 Hrs Minimum on 1 Seal 3 Samples	This seal is considered a high severity seal according to guidelines, because of its high temperature and surface speeds (715 degrees F, 364 ft/s).
l-300-336	50 Hours Minimum	500 Hrs Total, 300 Hrs Minimum 3 Samples	This seal is considered a high severity seal according to guidelines, but is rated at the low end of the high severity range because of its exposure to high temperatures, but low surface speed (650 degrees F, 287 ft/s).
l-300-616 Aft Comp Shaft (Aft) (Circumferential)	50 Hours Minimum	700 Hrs Total, 300 Hrs Minimum 3 Samples	This seal is considered a high severity seal according to guidelines, because of its exposure to high temperature and high surface speed (735

			degrees F, 377 ft/s).
l-300-334 Output Shaft (Face)	50 Hours Minimum	300 Hrs Total, 150 Hrs Minimum on 1 Seal 2 Samples	This seal is considered a low severity seal according to guidelines, and is rated at the low end of the low severity range because of the low temperature and surface speed value)

QUALIFICATION REQUIREMENTS FOR MAIN SHAFT CARBON FACE/CIRCUMFERENTIAL SEAL FOR THE T55 ENGINE.

P/N	RIG TEST	ENGINE TEST	RATIONALE
2-101-731 Forward Comp Shaft (Circumferential)	50 Hours Minimum	500 Hrs Total, 300 Hrs minimum on 1 Seal	This seal is considered a low severity seal according to guidelines, but is rated at the top end of the low severity range because of high surface speed (338 ft/s).
2-300-323 Aft Comp Shaft (Circumferential)	50 Hours Minimum	750 Hrs Total, 400 Hrs Minimum on 1 Seal 3 Samples	This seal is considered a high severity seal according to guidelines, because of its high temperature and surface speeds (600 degrees F, 345 ft/s). This seal has a history of problems.
2-300-973	50 Hours minimum	500 Hrs. Total, 400 Hrs Minimum on 1 Seal	This seal is considered a high severity seal according to guidelines, because of its exposure to high temperature (600 degrees F).
2-300-387	50 Hours Minimum	1000 Hrs Total, 500 Hrs Minimum on 1 Seal	This seal is considered a high severity seal according to guidelines, but is rated at the top end of high severity because of its exposure to high temperature (900

		3 Samples	degrees F). This seal has a history of problems.
1-300-045 Output Shaft (Circumferential)	50 Hours Minimum	300 Hrs Total, 150 Hrs Minimum 2 Samples	This seal is considered a low severity seal according to guidelines, and is rated at the low end of the low severity range because of the low temperature and surface speed values (300 degrees F, 135 ft/s).

QUALIFICATION REQUIREMENTS FOR MAIN SHAFT CARBON CIRUMFERENTIAL SEALS FOR THE T700/701

P/N	RIG TEST	ENGINE TEST	RATIONALE
6039T37P01, 6053T48P01 No. 1 Forward A-Sump Circumferential Tandem Dual	50 Hours Minimum	500 Hrs Total, 300 Hrs Minimum on 1 Seal 2 Samples	This seal is considered a low severity seal with moderate temperature and low surface speed (370 degrees S and 258 ft/s).
5044T41P01, 5044T41PO2 No. 5 Forward C-Sump Circumferential Single	50 Hours Minimum	500 Hrs Total, 300 Hrs minimum on 1 Seal 3 Samples	This seal is considered a low severity seal with top of the low range temperature and low surface speed (425 degrees F and 192 ft/s).

SECTION 3

OVERHAUL and MAJOR REPAIR REQUIREMENTS

AND

IDENTIFICATION OF CRITICAL CHARACTERISTICS

FOR

AIRCRAFT ENGINE COMPONENTS

3.1 INTRODUCTION

Section 3 discusses critical characteristics for parts identified as FSP as applicable to the overhaul process. It also identifies the inspection(s) and test(s) for FSP at the time of engine overhaul. The applicable DMWR identify the FSP for each engine, as well as the required test and inspection procedures.

3.2 CRITICAL CHARACTERISTICS

A critical characteristic is defined in paragraph 1.1.4. All critical characteristics require 100% inspection, as specified in the applicable DMWR.

3.2.1 Materials

During the overhaul program, it is assumed that all of the material critical characteristics (i.e. material composition, grain size, traceability of raw material) were met during manufacture of the part. The material critical characteristics of concern during the overhaul process are cracks and hardness.

3.2.1.1 Justification for Material Critical Characteristics

Engine components, particularly hot section components, are prone to developing cracks. These cracks must be detected and evaluated in accordance with the DMWR to determine if the part is usable, requires rework, or must be replaced. Cracks are detected by magnetic particle inspection, fluorescent penetrant inspection, radiographic inspection, etc. Due to hot starts, engine over temperature conditions, and temperature cycles engine component material properties may be altered reducing the life of the part. Degraded parts are identified by the use of hardness tests. Parts are usable or must be replaced in accordance with criteria specified in the DMWR.

3.2.2 Dimensions

The dimensions of a part or component are variables which can be expressed as mass, density, length, area, volume, finish, or angle. In some cases, when dealing with an assembly, moment or torque of a fastener is important. If any dimension is called out as a critical characteristic, it must be verified on each part.

3.2.2.1 Justification for Dimensional Characteristics

Some dimensions that are critical at overhaul are: bore diameters in bearing housings, turbine disks; diameters of compressors sections, turbine shafts, blisks, turbine assemblies, etc.; torque for assembly of the compressor assembly, turbine assemblies, and gear boxes; excessive play in bearings, etc.

3.2.3 Assembly Procedure

Assembly procedures may require special tools, a prescribed sequence of assembly or controlled assembly methods (i.e. specific torque, specific lubrication requirements etc.).

3.2.3.1 Justification for Assembly Procedure Critical Characteristic

Some assembly procedures for turbine assemblies, controls, compressor assemblies, and gear boxes are critical characteristics. These may include installation of bearings, gears, turbine blades, balancing compressor and turbine assemblies, oil tubes, labyrinth seals, assembly and installation of carbon seals, compressor stators, turbine nozzles, etc.

3.2.4 Pressure Testing

Aircraft and engine fluid systems are pressure tested to determine that tanks, reservoirs, fluid lines, and other parts of the engine which contain fluid are capable of withstanding a specified pressure without rupture or leakage.

3.2.4.1 Justification for Pressure Testing Critical Characteristic

Fuel and oil leaks by any of the engine components are fire hazards and are therefore to be prevented. Pressure tests are conducted on all hoses and tubes, oil coolers, fuel heaters, fuel and oil filters, and other components which contain combustible fluids. Fuel controls, gear boxes etc., are checked for leakage during the Engine Acceptance Test.

3.2.5 Service Life

Some engine components (i.e. shafts, disks, turbine and compressor blades, etc.) are subject to repeated cyclic loads which could cause fatigue failures. For some a usable service life has been established.

3.2.5.1 Justification for Service Life Critical Characteristic

Service lives for certain engine components were established by tests conducted on the components and engineering evaluation of the test results. Use of the part beyond its established useful life could result in catastrophic engine failure. Therefore, it is important that accurate records be kept of the operating time accumulated on these components and components are removed from service when they reach their mandatory replacement times.

3.2.6 Engine Acceptance Test

The Engine Acceptance Test is conducted to insure the engine meets the performance requirements noted in the DMWR. These include power delivered under ambient conditions of temperature and pressure altitude, power turbine inlet temperature, fuel consumption, vibration limits, leakage of compressor air, fuel or oil leakage from anywhere on the engine, satisfactory performance of gear boxes, oil temperature within limit etc.

3.2.6.1 Justification for Engine Acceptance Test Critical Characteristic

The Engine Acceptance Test incorporates performance parameters for the engine assembly and a number of components which have no other identified critical characteristics. These include engine vibration, fuel, oil and air leaks, engine power output etc. To ensure that the engine will perform satisfactorily when installed in the aircraft, all of the above parameters must be met.

3.2.7 Processes

Processes include all of the operations, treatments, finishes, etc. which take place before, during and after overhaul of the engine. Processes are described in the DMWR, government technical publications, and industry technical publications. Processes used during engine overhaul include the following:

A. Welding
B. Soldering
C. Riveting
D. Swaging
E. Cleaning
F. Plating
G. Painting
H. Bonding
I. Pressure Test
K. Flow Rate Test
L. Insulation Resistance Test
M. Resistance Test
N. Megger Test
0. Continuity Resistance Test
P. Software Conformation

3.2.7.1 Justification for Process Critical Characteristics

The organization responsible for overhauling the engine must inspect and test all ferrous and non-ferrous materials as specified in the DMWR. Classes of welds must be as specified. Stress relief procedures must be rigidly followed to reduce the possibility of cracks. Braze joints must be done and inspected in accordance with applicable documents to insure there are no more than the allowable voids in the joint. Good solder joints are required for good electrical continuity and for complete sealing against moisture or fluids. The soldered surfaces must be completely wetted with smooth beads and fillets. If used, rivets must be set properly with good contact between faying surfaces. Inspection is primarily visual for absence of cracks, strain lines, buckling or warping, and for the presence of adhesive or sealer, where required. Swaged joints must be free of cracks or strain lines and have the proper flare. Swaging is used primarily on cables, metal lines, or flexible hose fittings, and may be critical in application. Annealing may be required to reduce the stresses in welded parts. Cleaning of a part or assembly is an important prerequisite for application of coatings, painting, or bonding. This is a critical step to achieve good results for what ever process follows. The correct procedures for plating, painting, and bonding, and the associated inspection criteria are covered in the DMWR. Software confirmation is necessary to determine that the required instructions are in the non-volatile memory for processing the digital control system when it is operating. Pressure tests are required on filters, pumps, and valves to test for flow rates and back pressure leakage. These tests will determine that the components are assembled correctly. Electrical tests for resistance, continuity, and proper function will be required for all wiring harnesses, ignition system components, solenoid coils, alternators, pickups, sensors, and torque pick up coils. Any process or procedure intended to restore a critical characteristic should be approved by USAATCOM engineering prior to use in the overhaul program.

3.2.8 Inspection Methods

During the overhaul process, various inspection methods are used to insure that the critical characteristics of engine parts and components have not been degraded. The following are some of the inspection methods used during engine overhaul:

A. Electromagnetic Testing
B. X-ray Testing (Radiography)
C. Liquid Penetrant Testing
D. Magnetic Particle Testing
E. Ultrasonic Testing
G. Brine11 or Rockwell Hardness Testing
H. Pressure Flow or Leakage Testing
I. Visual
K. Electrical Inspection
L. Dimensional Inspection

3.2.8.1 Justification for Inspection Methods Critical Characteristics

For certain parts and components, 100% inspection by one or more of the above methods is required during the overhaul process to ensure that the critical characteristics have not been compromised. Visual and dimensional inspections are required on almost all engine parts. Electrical inspections are required on all electrical components. Evaluation of some electrical components, i.e. the electronic engine control, require special test equipment to insure proper performance of the unit.

3.2.9 Typical Critical Characteristics (Baseline)

The following are typical critical characteristics for engine components which must be considered baseline for engine overhaul. Other critical characteristics may be added by USAATCOM engineering or as prompted by field service experience.

2.9.1 Gears

Nital Etch Inspection, if required in DMWR.
Magnetic Particle Inspection.
Balancing, if called out in DMWR.
Bearing and Centering Journals - Runout, Diameter, and Concentricity
Visual for Fretting, Corrosion, etc.

3.2.9.2 Bearings

Bore Diameter for Main Shaft Bearings.
Visual Inspection for Spalling, Corrosion, and Damage.

3.2.9.3 Shafts

Magnetic Particle Inspection or Fluorescent Penetrant Inspection.
Ultrasonic Inspection, if required in DMWR.
Nital Etch Inspection.
Balancing when called out in DMWR.
Bearing and Centering Journal(s) Runout, Diameter and Concentricity.
Service Life Limits

3.2.9.4 Splines

Magnetic Particle Inspection or Fluorescent Penetrant Inspection.
Nital Etch Inspection.

3.2.9.5 Threaded Components

Magnetic Particle Inspection or Fluorescent Penetrant Inspection, if called out in DMWR.
Nital Etch Inspection, if called out in DMWR.
Visual Inspection for Galling, Corrosion, etc.

3.2.9.6 Disks

Centering Journal(s) Runout, Diameter, and Concentricity.
Magnetic Particle or Fluorescent Penetrant Inspection.
Service Life Limits

3.2.9.7 Compressor and Turbine Blades

Contour limits must be met on all surfaces on both sides of dovetail or fir tree simultaneously (measurement over pins).
Magnetic Particle or Fluorescent Penetrant Inspection.
Air and/or Water Flow Checks, if called out in DMWR
Service Life Limits

3.2.9.8 Blisks

Magnetic Particle or Fluorescent Penetrant Inspection.
Service Life Limits

3.2.9.9 Turbine Nozzles

Magnetic Particle or Fluorescent Penetrant Inspection.

3.2.9.10 Impellers

Magnetic Particle or Fluorescent Penetrant Inspection.
Balancing, if called out in DMWR.
Centering Journal(s) Runout, Diameter and Concentricity.
Service Life Limits

3.2.9.11 Turbine Spacers

Magnetic Particle or Fluorescent Penetrant Inspection.
Balancing, if called out in DMWR.
Centering Journal(s), Runout, Diameter and Concentricity.

3.2.9.12 Turbine Cooling Plates

Magnetic Particle or Fluorescent Penetrant Inspection.
Centering Journal(s) Runout, Diameter and Concentricity.
Service Life

3.2.9.13 Locking Rings

Magnetic Particle or Fluorescent Penetrant Inspection.

3.2.9.14 Oil Jets

Flow Check through Target Gage.
Pressure Test
Visual Inspection for Damage or Corrosion.

3.2.9.15 Diffusers

Magnetic Particle or Fluorescent Penetrant Inspection
Radiographic Inspections, if called out in DMWR.
Pressure Test, if called out in DMWR.
Throat Opening Dimensions and Damage to Vanes.

3.2.9.16 Compressor Stator Vanes

Fluorescent Penetrant Inspection of Brazed Joints.
Visual Inspection for Erosion and other Damage.

3.2.9.17 Metal Tubing

Pressure Test
Magnetic or Fluorescent Particle on Welded or Brazed Joints, if called out in DMWR.

3.2.9.18 Pumps (Oil and Fuel)

Shaft Spline Measurement Reference.
Pressure Tests.

3.2.9.19 Oil Coolers

Fluorescent Penetrant Inspection.
Radiographic Inspection, if called out in DMWR.
Fuel Side Proof Pressure Test, if called out in DMWR.

Oil Side Proof Pressure Test, if called out in DMWR.

3.2.9.20 Controls Electronic

Input/Output Signal Processing
Temperature Cycling

3.2.9.21 Fuel Controls (HMU)

Fuel Pressure
Fuel Flow on Demand Schedule

3.2.9.22 Filters (Oil and Fuel)

Pressure Tests
Bypass Indication

3.2.9.23 Valves (Hydraulic and Pneumatic)

Pressures (Flow Rate, Leakage, Back Pressure)
Solenoid Min and Max Operating Voltage
Solenoid Insulation Resistance
Solenoid Coil Resistance

3.2.9.24 Wiring Harness

Insulation Resistance
Continuity Tests

3.2.9.25 Thermocouple Assembly

Insulation Resistance
Temperature Calibration - Jet Cal Test
Visual Inspection for Damage

3.2.9.26 Fuel Manifold

Pressure Tests
Magnetic Particle or Fluorescent Penetrant on Welded or Brazed Joints
Electrical Resistance

3.2.9.27 Ignition System

Insulation Resistance
Voltage Operation Range
Power Delivered

3.2.9.28 Fuel Nozzle

Flow Rate and Pressure Test at various Engine Requirements
Spray characteristics as related to Droplet Size, Cone Angle, Pattern, and Penetration
Visual Inspection for Damage

3.2.9.29 Heat Exchangers

Pressure Tests
Magnetic or Fluorescent Particle on Welded or Brazed Joints, if called out in DMWR

3.2.9.30 Alternators

Insulation Resistance
Shaft Spline Measurement Reference
Output Power Characteristics

3.2.9.31 Pickups (Speed and etc.)

Insulation Resistance
Continuity Tests
Visual Inspection for Damage

3.2.9.32 Sensors (Temp and Pressure)

Insulation Resistance
Continuity Tests
Signal/Accuracy
Visual Inspection for Damage

3.2.9.33 Torquemeter

Insulation Resistance
Continuity Tests
Signal/Accuracy
Visual Inspection for Damage

3.2.9.34 Springs

Dimensional Inspection for Length
Visual Inspection for Damage/Corrosion

3.3 TEST DESCRIPTION

The engine will be subjected to an acceptance test in accordance with the applicable DMWR after completion of the inspections and assembly of parts and components during the overhaul program. An engine test stand, which has the capability for determining engine output power, specific fuel consumption, turbine inlet temperature, compressor discharge pressure, simulate various altitudes and temperatures etc., is required for this test. During the acceptance test, the engine is checked for compliance with all DMWR requirements i.e., performance, fuel consumption, turbine inlet temperature, compressor discharge pressure, vibration etc. The engine is also checked for fluid and air leaks. Any discrepancies must be corrected in accordance with instructions in the DMWR before the engine is delivered to the user.

SECTION 4

AVIATION UNIT AND INTERMEDIATE MAINTENANCE REQUIREMENTS

AND

IDENTIFICATION OF CRITICAL CHARACTERISTICS

FOR

AIRCRAFT ENGINE COMPONENTS

4.1 INTRODUCTION

Section 4 discusses critical characteristics for parts identified as FSP as applicable to the maintenance process. It also identifies the inspection(s) and test(s) for FSP at the time of engine maintenance. The applicable Aviation Unit and Intermediate Maintenance Manuals (TM's) identify the FSP for each engine, as well as the required test and inspection procedures.

4.2 CRITICAL CHARACTERISTICS

All critical characteristics defined in paragraph 1.1.4 require 100% inspection, as specified in the applicable technical manual.

4.2.1 Materials

It is assumed that all of the material critical characteristics (i.e. material composition, grain size, material source) were met during manufacture of the part. The material critical characteristics of concern during the maintenance process are hidden defects, cracks, oxidation, dents, scratches, gouges etc.

4.2.1.1 Justification for Material Critical Characteristics

Turbine engine components are prone to developing cracks. These cracks must be detected and evaluated in accordance with the TM to determine if the part is usable as is, requires rework, or must be replaced. Cracks are detected by appropriate inspection. Due to thermal and mechanical cycling, engine components may be degraded. Parts suspected of being subjected to hot starts or over temperature conditions are to be removed from service for further evaluation at depot. Parts are usable or must be replaced in accordance with criteria specified in the TM.

4.2.2 Dimensions

The dimensions of a part or component are variables which can be expressed as length, area, finish, or angle. In some cases, when dealing with an assembly, moment or torque of a fastener is important. If any dimension is called out as a critical characteristic, it must be verified on each part.

4.2.2.1 Justification for Dimensional Characteristics

Some dimensions that are critical during maintenance are torque for installation of the compressor housing assembly, turbine assemblies, and gear boxes, dimensions of cracks and damaged areas, etc. Damage which exceeds the specified dimensional limits could result in premature failure of the part.

4.2.3 Assembly Procedure

Assembly procedures may require special tools, a prescribed sequence of assembly, or controlled assembly methods (i.e. specific torque, specific lubrication requirements etc.).

4.2.3.1 Justification for Assembly Procedure Critical Characteristic

Some assembly procedures for installation of engine fuel and electronic controls, compressor housing assemblies, wiring , plumbing, and gear boxes are critical characteristics. These may include installation and rigging of fuel controls, installation of engine gear boxes, proper installation of wiring and plumbing controls, installation of compressor housing assemblies and blending of compressor or turbine blades,.

42.4 Pressure Testing

Aircraft and engine fluid systems are pressure tested to determine that tanks, reservoirs, fluid lines and other parts of the engine which contain fluid, are capable of withstanding a specified pressure without rupture or leakage.

4.2.4.1 Justification for Pressure Testing Critical Characteristic

Fuel and oil leaks by any of the engine components are fire hazards and are to be prevented. Pressure tests are conducted on all hoses, tubes, oil coolers, fuel heaters, fuel and oil filters, and other components which contain combustible fluids. Fuel controls, gear boxes etc. are checked for leakage during the Engine Acceptance Test.

4.2.5 Service Life

Some engine components (i.e. shafts, disks, cooling plates, etc.), are subject to repeated thermal and mechanical cycling which result in low cycle fatigue damage. Low cycle fatigue is the major contributor to establishing component life. To prevent reduction of low cycle fatigue life, the factors contributing to low cycle fatigue, i.e. material properties and processing, surface finishes etc., must be carefully controlled.

4.2.5.1 Justification for Service Life Critical Characteristic

Service lives for certain engine components were established by tests conducted on the components and engineering evaluation of the test results. Use of the part beyond its established useful life could result in catastrophic engine failure. Therefore, it is important that accurate records be kept of the operating time accumulated on these components and that the components are removed from service when they reach their service life limit. On the T700 engine, low cycle fatigue (full count), low cycle fatigue (‘partial count) and time temperature index are monitored to assist in tracking parts lives.

4.2.6 Engine Acceptance Test

The engine acceptance test is conducted to insure that the engine meets the performance requirements noted in the TM. These include power delivered under test conditions specified in the applicable TM, turbine temperature, fuel consumption, vibration limits, leakage of compressor air, fuel or oil leakage from anywhere on the engine, satisfactory performance of gear boxes, oil temperature within limit etc.

4.2.6.1 Justification for Engine Acceptance Test Critical Characteristic

The Engine Acceptance Test incorporates performance parameters for the engine assembly and a number of components which have no other identified critical characteristics. These include engine vibration, fuel, oil and air leaks, engine power output etc. To ensure that the engine will perform satisfactorily when installed in the aircraft, all of the above parameters must be met.

4.2.7 Processes

Processes include all of the operations, treatments, finishes, etc. which take place before, during, and after engine maintenance. Processes are described in the TM, government technical publications, and industry technical publications. Processes used during engine maintenance include the following:

A Welding
B Brazing
C. Soldering
D. Riveting
E Swaging
F. Cleaning
G. Painting
H. Bonding

4.2.7.1 Justification for Process Critical Characteristics

The organization responsible for maintaining the engine must inspect and test all ferrous and non-ferrous materials as specified in the TM. Welding consists of joining metal by applying heat, pressure or both, with or without filler material, by fusion and recrystallization across the joint interface. Welding can be accomplished by the fusion or resistance welding processes. Welds can be inspected by radiographic means, ultrasound, magnetic particle inspection, eddy current, penetrant inspection, and destructive testing. Brazing is similar to welding. Grade A braze joints must have not more than 20% of the faying surface unbrazed for aluminum, or 15% for all other metals. No single unbrazed area is to exceed 20% of the overlap area. Grade A joints are to be subjected to radiographic, ultrasonic, or dye penetrant inspections. Good solder joints are required for good electrical continuity and for complete sealing against moisture or fluids. The soldered surfaces must be completely wetted with smooth beads and fillets. If used, rivets must be set properly with good contact between faying surfaces. Inspection is primarily visual for absence of cracks, strain lines, buckling or warping, and for the presence of adhesive or sealer where required. Swaged joints must be free of cracks or strain lines and have the proper flare. Swaging is used primarily on cables, metal lines, or flexible hose fittings and may be critical in application. Cleaning of a part or assembly is an important prerequisite for application of coatings, painting, or bonding. This is a critical step to achieve good results for what ever process follows. The correct procedures for painting and bonding, and the associated inspection criteria are covered in the TM. Pressure tests are required on hoses and tubes to test for leakage. These tests will determine that the components are assembled correctly. Electrical tests for resistance, continuity, and proper function will be required for all wiring harnesses, ignition system components, solenoid coils, alternators, pickups, sensors, and torque pick up coils.

4.2.8 Inspection Methods

During the maintenance process, various inspection methods are used to insure that the critical characteristics of engine parts and components have not been degraded. The following are some of the inspection methods used during engine maintenance:

A. Liquid Penetrant Testing
B. Pressure or Leakage Testing
C. Visual
D. Electrical Inspection
E. Dimensional Inspection

4.2.8.1 Justification for Inspection Methods Critical Characteristics.

For certain parts and components, 100% inspection by one or more of the above methods is required during the maintenance process to insure that the critical characteristics have not been compromised. Liquid penetrant testing is used to locate cracks and other surface imperfections which may make the component unacceptable. Pressure tests are required on hoses and tubes to test for leakage. These tests will determine that the components are assembled correctly. Visual inspections are required on accessible engine parts. Electrical tests for resistance, continuity, and proper function will be required for all wiring harnesses, ignition system components, solenoid coils, alternators, pickups, sensors, and torque pick up coils. Evaluation of some electrical components, i.e. the electronic engine control, is accomplished during the engine acceptance test. Dimensional inspection is necessary to determine if the part meets the TM dimensional requirements.

4.2.9 Typical Critical Characteristics (Baseline)

The following are typical critical characteristics for engine components which must be considered baseline for engine maintenance. Other critical characteristics may be added by USAATCOM engineering or, as prompted by field service experience.

4.2.9.1 Gears

Bearing and Centering Journals - Runout, Diameter, and Concentricity
Visual for Fretting, Corrosion, etc.

4.2.9.2 Bearings

Bore Diameter for Main Shaft Bearings.
Visual Inspection for Spalling, Corrosion, and Damage.

4.2.9.3 Shafts

Fluorescent Penetrant Inspection
Bearing and Centering Journal(s) Runout, Diameter and Concentricity.
Service Life

4.2.9.4 Splines

Fluorescent Penetrant Inspection.
Visual Inspection.

4.2.9.5 Threaded Components

Fluorescent Penetrant Inspection, if called out in TM.
Visual Inspection for Galling, Corrosion, etc.

4.2.9.6 Compressor and Turbine Blades

Visual Inspection for Cracks and Damage.
Service Life

4.2.9.7 Blisks

Visual Inspection for Cracks and Damage.
Service Life

4.2.9.8 Turbine Nozzles

Visual Inspection for Cracks or Damage.

4.2.9.9 Impellers

Visual Inspection for Cracks or Damage.4.2.9.10 Compressor Stator Vanes

Visual Inspection for Erosion and other Damage.

4.2.9.11 Disks

Visual Inspection for Cracks and Damage
Service Life
Special nondestructive as required (ie, eddy current, ultrasound,etc.)

4.2.9.12 Turbine Cooling Plates

Visual Inspection
Service Life

4.2.9.13 Metal Tubing

Pressure Test
Visual Inspection for Damage

4.2.9.14 Oil Coolers

Visual Inspection for Damage.

4.2.9.15 Controls Electronic

Proper Operation During Acceptance Test

4.2.9.16 Fuel Controls (HMU)

Proper Operation During Acceptance Test

4.2.9.17 Filters (Oil and Fuel)

Bypass Indication

4.2.9.18 Valves (Hydraulic and Pneumatic)

Proper Operation During Acceptance Test

4.2.9.19 Wiring Harness

Insulation Resistance
Continuity Tests

4.2.9.20 Thermocouple Assembly

Proper Operation During Acceptance Test
Visual Inspection for Damage

4.2.9.2 1 Fuel Manifold

Pressure Tests
Visual Inspection for Damage

4.2.9.22 Ignition System

Visual Inspection for Damage
Proper Operation During Acceptance Test

4.2.9.23 Fuel Nozzle

Proper Operation During Acceptance Test
Visual Inspection for Damage

4.2.9.24 Heat Exchangers

Visual Inspection for Damage

4.2.9.25 Alternators

Proper Operation During Acceptance Test

4.2.9.26 Pickups (Speed and etc.)

Visual Inspection for Damage
Proper Operation During Acceptance Test

4.2.9.27 Sensors (Temp and Pressure)

Visual Inspection for Damage
Proper Operation During Acceptance Test

4.2.9.28 Torquemeter

Visual Inspection for Damage
Proper Operation During Acceptance Test

4.2.9.29 Springs

Dimensional Inspection for Length

4.3 TEST DESCRIPTION

The engine will be subjected to an acceptance test in accordance with the applicable TM after completion of inspections and assembly of parts and components during the maintenance program. All test points specified in the TM are to be met before the engine is returned to service. The engine must be checked for oil and fuel leaks during the acceptance test. All leaks are to be repaired before returning the engine to service.

Certification Board Record

Board Date: 07 MARCH 1997

Document identifier and title: MIL-PRF-63029(AV),MANUALS, TECHNICAL:

REQUIREMENTS FOR OPERATOR'S MANUALS AND CHECKLIST FOR AIRCRAFT

Rationale for certification:

Document meets the criteria defining a performance specification

Decision:

General Type	Decision (check)	Certification
specification		**Performance** XXX
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook		Handbook (non-mandatory use)
Alternative Action		

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Standardization Executive BARRY J. BASKETT AMSAT-R-E			Proponent AMSAT-I-MTC MR DONALD MCCABE

Certification Board Record

Board Date: 07 MARCH 1997

Document identifier and title: ADS-43A-HBDK(AV), AERONAUTICAL, DESIGN STANDARDS:

QUALIFICATION REQUIREMENTS AND IDENTIFICATION OF CRITICAL CHARACTERISTICS FOR AIRCRAFT ENGINE COMPONENTS

Rationaleforcertification:

Document meets the criteria defining a performance specification

Decision:

General Type	Decision (check)	Certification
specification		**Performance** XXX
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook		Handbook (non-mandatory use)
Alternative Action		

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Certification Board Record

Board Date:

Document identifier and title:

ADS-43A-HDBK, Qualification Requirements and Identification of Critical Characteristics for Aircraft Engine Components (Applicable Engine Series T53, T55, T700).

Rationale for certification:

The document meets the criteria defining a handbook, and contains the disclaimer that the document can not be mandatory in any solicitation.

Decision:

General Type	Decision (check)	Certification
Specification		Performance
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook	**x**	**Handbook (non-mandatory use)**
Alternative Action		

MEMBERS	Concur	Noncon cur	ADVISORS
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