SERVICE TEST PLAN

FOR

C/KC-135

HYDRAULIC ACTUATORS

REVISION A

November 12, 2004

Prepared For
Oklahoma City Air Logistics Center
Aircraft and Accessories Division
Tinker Air Force Base, Oklahoma 73135

Under Purchase Order 42042SM

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
ALC	Air Logistics Center
DQTP	Delta Qualification Test Procedure
HVOF	High Velocity Oxygen Fuel
IAW	In Accordance With
LGE	Aircraft and Accessories Division
OC-ALC	Oklahoma City Air Logistics Center
OO-ALC	Ogden Air Logistics Center
PDM	Programmed Depot Maintenance
P/N	Part Number
POC	Point of Contact
QA	Quality Assurance
TO	Technical Order
USAF	United States Air Force

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SECTION 1

INTRODUCTION

1.1 PURPOSE

The purpose of this service test plan is to define the tests that will be used to qualify newly coated hydraulic actuators used on United States Air Force (USAF) C/KC-135 aircraft. This service test plan will be used in conjunction with the Delta-Qualification Test Procedures (DQTP) to verify the performance and reliability of the actuators. The C/KC-135 service test plan will be implemented after completion of qualification testing or qualification by similarity.

1.2 BACKGROUND

In pursuit of identifying and qualifying suitable alternatives to engineering hard chrome, the Oklahoma City Air Logistics Center's Avionics and Accessories Division of the Logistics Management Directorate (OC-ALC/LGE) has identified four candidate hydraulic actuators on C/KC-135 aircraft that utilize electroplated chrome as a wear coating on the actuator assemblies. Two of these actuators will be delta-qualified and two actuators will be qualified by similarity. These actuators are identified in the table below.

Table 1 – Actuator Identification

	Actuator Nomenclature	Actuator Part Number	Qualification Method
1	Aileron Control Surface Snubber Assembly	5-88763-10	Delta-Qualification Testing
2	Ruddevator Boost Assembly	65-6750-1	Similarity (1)
3	Main Landing Gear Actuator Assembly	5-84046-6	Delta-Qualification Testing
4	Main Landing Gear Door Actuator Assembly	5-84045-9	Similarity (3)

The current chrome electroplating process has been proven to be a significant health hazard, and it is anticipated that future Government regulation will make the use of electroplated chrome application cost prohibitive. Therefore, efforts to reduce the volume of electroplated chrome application are in progress. This service test plan discusses the organizations and procedures that will be used in this service test plan to measure the performance of the actuators undergoing evaluation.

SECTION 2

APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

TO 9H8-22-6-3	Aileron Control Surface Snubber Assemblies Overhaul Instructions
TO 9H8-22-6-4	Aileron Control Surface Snubber Assemblies Illustrated Parts Breakdown
TO 6A1-2-9-3	Ruddevator Boost Assembly Overhaul Instructions
TO 6A1-2-9-4	Ruddevator Boost Assembly Illustrated Parts Breakdown
TO 9H2-2-30-3	Main Landing Gear Door Actuator Assemblies Overhaul Instructions
TO 9H2-2-30-4	Main Landing Gear Door Actuator Assemblies Illustrated Parts Breakdown
TO 9H2-2-34-3	Main Landing Gear Actuator Assemblies Overhaul Instructions
TO 9H2-2-34-4	Main Landing Gear Actuator Assemblies Illustrated Parts Breakdown
TO 9H8-22-9-3	Elevator Control Surface Snubber Assemblies Overhaul Instructions
TO 9H8-22-9-4	Elevator Control Surface Snubber Assemblies Illustrated Parts Breakdown
TO 9H13-4-3	Rudder Flutter Damper Assembly Overhaul Instructions
TO 9H13-4-4	Rudder Flutter Damper Assembly Illustrated Parts Breakdown
TO 1C-135-2-6	Air Refueling System Maintenance Instructions
TO 1C-135-2-7	Landing Gear Maintenance Instructions
TO 1C-135-2-8	Flight Controls Maintenance Instructions
TO 1C-135-2-13	Hydraulic Pressure Supply System Maintenance Instructions
TO 1C-135-2-2	Maintenance Instructions, Ground Handling
TO 1C-135-6CF-1	Acceptance and/or Functional Check Flight Procedures Manual
TO 1C-135A-6	Aircraft Scheduled Inspection and Maintenance Requirements

SECTION 3

SERVICE TEST PLAN

3.1 SERVICE TEST OBJECTIVES

The objective of this service test plan is to verify the performance and reliability of the hydraulic actuators listed in Table 1 for use on USAF C/KC-135 aircraft. This service test plan will verify that the actuators undergoing evaluation cause no degradation of aircraft capability or hydraulic system performance in an operational environment. This service test plan will be implemented after completion of qualification testing or qualification by similarity.

3.2 SCOPE OF SERVICE TEST PLAN

The scope of this actuator service test plan will include the following activities:

- Ogden Air Logistics Center (OO-ALC) inducts actuator for overhaul.
- OO-ALC disassembles the actuator and ships the chrome plated parts to ARINC for coating.
- ARINC subcontracts high velocity oxygen fuel (HVOF) coating application for chrome plated parts.
- ARINC ships newly coated parts to OO-ALC.
- ARINC provides new seals for newly coated mating surfaces, as required.
- ARINC observes and assists OC-ALC/LGER and OO-ALC with assembly of new seals, as required.
- OO-ALC completes the overhaul of the actuator and completes functional testing.
- OO-ALC prepares the actuator for shipment to ARINC.
- ARINC ships the actuator to the test site.
- OC-ALC/LGER and ARINC observe installation of actuator undergoing evaluation on aircraft.
- OC-ALC/LGER and ARINC evaluate actuator performance on a monthly, bi-annual, or annual basis, depending on aircraft location.
- OO-ALC disassembles actuators that have completed testing or have been removed due to failure. OC-ALC/LGER and ARINC monitor or witness these actions.
- OO-ALC, OC-ALC/LGERC, and ARINC perform detailed inspection of disassembled parts.
- ARINC prepares a report to document findings.
- OC-ALC/LGER revises technical data and engineering drawings, as required.

3.2.1 Install and Ground Evaluation

With OC-ALC/LGER and ARINC observation, USAF ground maintenance personnel will perform, certify, and document the initial installation of the actuators undergoing evaluation. After the initial maintenance evaluations are completed, ground maintenance crews will perform all required inspections, and

operate the test actuator as stated in ground maintenance TOs. If inspection and operation of actuators satisfy the functional ground evaluations, the flight phase can proceed.

3.2.2 Flight Evaluation

To determine if the actuators undergoing evaluation meet or exceed current aircraft flight requirements, observations will be made by OC-ALC/LGER and ARINC personnel on a monthly, bi-annual, or annual basis. This observation will involve examining the actuator on the aircraft and discussing any performance issues with ground maintenance and flight crews. All data gathered will be presented in a final report documenting the findings from the service test.

3.2.3 Other

There will be no deployment restrictions placed on any of the aircraft at any of the sites during the evaluation period. The evaluation aircraft will be returned to their original actuator configuration after completion of the service test or upon the failure of an actuator undergoing evaluation.

Two actuators of each part number (P/N) shall be service tested, although only one actuator of each P/N may be installed on the same aircraft. Multiple P/N actuators can be tested on the same aircraft if no degradation of aircraft capability results. The evaluation period for the installed actuators shall be at least 24 months. Should any of the aircraft be grounded or not scheduled to fly for 30 days or more (e.g. programmed depot maintenance (PDM)), the actuator undergoing evaluation must be removed and installed on an aircraft that will be in service. Prior to moving the actuator undergoing evaluation, contact Mr. Jerry Zimmerman of OC-ALC/LGER, Mr. Matt Reynolds of ARINC, or Ms. Amber Drennen of ARINC using contact information provided in Section 6.

3.3 SERVICE TEST PLAN SITES

Primary evaluation sites are suggested below, in order of preference, because of the high number of flying hours, diverse environmental flight conditions, low possibility of deployment, and increased support available for the service test. Since the offices of OC-ALC/LGER and ARINC are located in Oklahoma City, proximity to Oklahoma City (e.g., 507 ARW at Tinker) would aid in minimizing travel costs and response times during initial installations and periodic inspections.

- Air Force Training Base
- Air National Guard or Air Force Reserve Base
- Operational Air Force Base

3.4 ORGANIZATION AND PERSONNEL RESPONSIBILITIES

Responsibilities are divided between OO-ALC, the using command (Air Mobility Command (AMC)), OC-ALC/LGER, and ARINC

3.4.1 Evaluation Project Management

Ground and flight evaluation information will be collected by ARINC from ground maintenance and flight crew personnel. Information collected will be delivered as an attachment to the monthly status reports to Mr. Jerry Zimmerman of OC-ALC/LGER.

3.4.2 OO-ALC Responsibilities

- Disassemble test actuators IAW instructions in work order
- Forward disassembled parts for chrome replacement IAW instructions in work order
- Overhaul and assemble newly coated parts in actuator.
- Identify actuator as service test actuator in accordance with (IAW) Section 3.6, Test Actuators.

3.4.3 AMC Responsibilities

- Provide aircraft.
- Provide aircraft logistic and support arrangements.
- Provide copies of all aircraft maintenance records, AFTO Form 781A.
- Provide ground maintenance personnel for installations, removals, evaluations, shipping, and documentation.
  - Perform removal of the aircraft's existing actuators.
  - Perform the installation of actuators undergoing evaluation.
  - Document installation and removal dates.
  - Remove actuator undergoing evaluation at conclusion of service test or after actuator failure.
  - Install aircraft's original actuator at project conclusion or after actuator failure.
  - At conclusion of testing or after actuator failure, contact Mr. Jerry Zimmerman of OC-ALC/LGER, Mr. Matt Reynolds of ARINC, or Ms. Amber Drennen of ARINC using contact information provided in Section 6.

3.4.4 ARINC Responsibilities

- Subcontract for the HVOF coating of the chrome plated parts.
- Supply new seals for newly coated parts, as required.
- Observe and assist OO-ALC with installation of new seals.

- Support initial ground, initial operational flight, pre-flight, and post-flight briefings.
- Document installation and removal dates.
- Document the results of ground and flight crew evaluations.
- Ensure flight crew and ground maintenance personnel know where and to whom to send actuators in case of failure.
- Receive actuators from evaluation sites and disposition as appropriate.
- Provide report to document all findings.
- Revise TOs and engineering drawings, as required.

3.4.5 OC-ALC/LGER Responsibilities

- Overall program management.

3.5 SAFETY REQUIREMENTS

3.5.1 Ground Safety

Follow established safety procedures and precautions found in applicable TOs, regulations, and local operating procedures.

3.5.2 Flight Safety

Follow established safety procedures and precautions found in applicable TOs regulations and local operating procedures.

3.6 TEST ACTUATORS

Table 2 – Test Actuators

	Actuator Nomenclature	Actuator Part Number	Qualification Method	Number to be Tested
1	Aileron Control Surface Snubber Assembly	5-88763-10	Delta-Qualification Testing	2
2	Ruddevator Boost Assembly	65-6750-1	Similarity (1)	2
3	Main Landing Gear Actuator Assembly	5-84046-6	Delta-Qualification Testing	2
4	Main Landing Gear Door Actuator Assembly	5-84045-9	Similarity (3)	2

3.6.1 Actuator Identification

To identify these assemblies as test items, they shall be tagged with special identification plates or external stencils or other markings. These plates will include all contact information and shipping information as provided in Section 6. In addition to the identification plates, the outside diameter of the main cylinder

housing shall be painted with bright orange stripes, per TO 1-1-8, using color FED-STD-595/38903.

3.6.2 Aileron Control Surface Snubber Assembly P/N 5-88763-10

Each inboard aileron is equipped with a snubber actuator (5-88763-10) mounted near its outboard end. These units are attached to the wing and aileron structure. The primary function of the snubber is to protect the aileron from wind damage when the aircraft is parked on the ground. The snubber also dampens the motion of the surface throughout its entire range and limits the maximum rate of rotation to 50° per second. The snubber consists of a cylinder, piston, and oil reservoir contained within the unit. As the aileron approaches its extreme position, the piston in the snubber enters a small chamber and cuts off free flow of hydraulic oil from the chamber. Further motion of the piston forces the oil trapped in the chamber to pass through small orifices in the sides of the chamber. This restricts the movement of the piston and slows down the action of the aileron to prevent damage caused by sudden bottoming. This snubber has been subjected to endurance and temperature extreme qualification testing.

3.6.3 Ruddevator Boost Assembly P/N 65-6750-1

The ruddevator boost assembly (65-6750-1) will be qualified by similarity to the snubber and the C-130 rudder booster cylinder. The ruddevator assembly has very similar designs to the aileron snubber assembly and the delta-qualified C-130 rudder actuator assembly and, therefore, will be qualified by similarity. The ruddevator boost assembly is used to provide hydraulic power to the refueling boom ruddevator control system. This system is used to aerodynamically position the refueling boom during flight. The ruddevators are controlled from the refueling boom operator compartment and serve as both rudder and elevators.

3.6.4 Main Landing Gear Actuator Assembly P/N 5-84046-6

The main landing gear actuator assembly (5-84046-6) is used to extend and retract the main landing gear. It is attached at the piston rod end to an arm of the main gear trunnion and at the cylinder end to the actuator beam assembly. The outboard end of the actuator beam is attached to another arm on the trunnion. When the actuator is pressurized, the resulting forces, acting in opposite directions along the piston rod and actuator beam, work together to rotate the trunnion in the same direction. The actuator uses a spring-loaded sliding valve snubbing assembly to restrict the rate of extension and retraction of the gear as it approaches the down and up locked positions. This main landing gear actuator has been subjected to endurance and temperature extreme qualification testing.

3.6.5 Main Landing Gear Door Actuator Assembly P/N 5-84045-9

The main landing gear door actuator assembly (5-84045-9) will be qualified by

similarity to the main landing gear actuator assembly and the A-10 aileron actuator assembly. The MLG door assembly has very similar functionality, duty cycle, environmental conditions, and material to the MLG assembly as well as similar in size to the delta-qualified A-10 aileron assembly; therefore, will be qualified by similarity to these two actuators. This additional part number will be included in this service tests. The main landing gear door is located at the forward inboard corner of each wheel well. The actuator is trunnion-mounted and jig-located to the upper keel beam web. The actuator rod end contains a self-aligning bearing and is attached to a nonadjustable actuator beam pivoted on the keel beam. The actuator extends to open the doors and retracts to close the doors. Either cycle is completed within 2 seconds with the actuator bottoming at each end of actuation.

SECTION 4

PERFORMANCE EVALUATION

This section describes the required steps for evaluating a test actuator.

4.1 REMOVAL OF ACTUATORS

USAF personnel will remove the original actuators IAW applicable TOs.

4.2 INSTALLATION OF ACTUATORS

USAF personnel will install the actuators IAW applicable TOs.

4.3 QUALITY ACCEPTANCE AND RELEASE FOR GROUND AND FLIGHT OPERATIONS

The purpose of the initial quality acceptance performed by USAF personnel is to certify the installation of the test actuators. This certification, performed by USAF Quality Assurance (QA) personnel, confirms that all installation steps were performed IAW applicable TOs and the installed actuators meet aircraft performance requirements.

4.4 GROUND OPERATION EVALUATION (As Required)

The ground check will be performed by USAF personnel. These personnel will verify that the actuators undergoing evaluation perform IAW ground operation requirements, as specified in applicable TOs. Data will be recorded, as required, and collected by OC-ALC/LGER and ARINC personnel.

4.5 FLIGHT OPERATION EVALUATION

The initial flight, performed by a standard contingent of flight crew personnel, verifies service test actuators satisfy flight operation requirements. Performance of the operational flight will be IAW the applicable TOs. Data will be recorded, as required, and collected by OC-ALC/LGER and ARINC personnel.

4.6 CERTIFICATION FOR CONTINUATION OF OPERATION

QA personnel will verify that the aircraft with service test actuators installed meets all aircraft ground and flight operation requirements (See TOs 1C-135-2-6, 1C-135-2-7, 1C-135-2-8, and 1C-135-6CF-1). After QA certification, the aircraft will be released for normal operation and further performance observations. Ground and flight observations will be conducted continuously, within normal operations, to determine the actuators' performance throughout the evaluation period. These observations will be the normal observations performed during ground maintenance, flight preparation, and flight.

Degradation of aircraft performance, caused by the actuators, will be discussed with OC-ALC/LGER.

4.7 FLIGHT EVALUATION

Continuous recorded operational flight evaluations are not required as the actuators will not affect normal operation.

4.8 INTERUPTION OF ACTUATOR EVALUATION

The evaluation of test actuators will stop for any of the following reasons:

- Actuator Failure – A failed actuator constitutes an end of evaluation for that actuator.

- End of Service Test Period – The end of the service test period is determined by the time allotted for the actuator to be installed on the aircraft. Upon notification that the period is over, the actuator will be removed from the aircraft.

- Service Test Interruption – An evaluation interruption occurs when an aircraft with an actuator undergoing testing is grounded or not scheduled to fly for 30 days.

Should any of the above occur, contact Mr. Jerry Zimmerman of OC-ALC/LGER, Mr. Matt Reynolds of ARINC, or Ms. Amber Drennen of ARINC using contact information provided in Section 6.

4.9 REMOVAL OF ACTUATORS

USAF personnel will remove the service test actuators IAW with applicable TOs.

4.10 INSTALLATION OF ORIGINAL ACTUATORS

USAF personnel will install original actuators and associated items IAW applicable TOs.

4.11 POST EVALUATION INSPECTION OF AIRCRAFT

Following the reinstallation of the original actuators, the aircraft will be inspected by USAF personnel and certified to original configuration.

4.12 SHIPPING OF ACTUATORS

At the completion of the evaluation period or in the event of an actuator failure, the actuator will be packaged and shipped by USAF personnel using the shipping instructions provided in Section 6.

SECTION 5

ACTUATOR FAILURE

5.1 FAILURE CRITERIA AND ACTIVITIES

The inability of the service test actuator to produce the required actions at any time during the evaluation period constitutes a failure. Additionally, any unacceptable conditions caused directly by the operation of the actuator will be recorded and Mr. Jerry Zimmerman of OC-ALC/LGER, Mr. Matt Reynolds of ARINC, or Ms. Amber Drennen of ARINC will be notified for further guidance.

5.2 FAILURE REPORTING

Upon the failure of any test actuator, the point of contact (POC) given above will be notified. If an actuator fails, the actuator will be removed and the original actuator will be installed IAW applicable TOs.

SECTION 6

POST EVALUATION PERIOD ACTIVITIES

6.1 REMOVAL OF ACTUATOR

Test actuators will be removed upon actuator failure, evaluation cessation on specific aircraft, or completion of evaluation period.

6.2 INSTALLATION OF ORIGINAL ACTUATORS

Installation of original actuators will be accomplished upon removal of test actuators.

6.3 CONTACT INFORMATION

- Mr. Jerry Zimmerman, OC-ALC/LGER
  DSN 336-3948
  405-736-3948
  Jerry.Zimmerman@tinker.af.mil
- Mr. Allen Arthur, OC-ALC/LGER
  DSN 336-2921
  405-739-2921
  Allen.Arthur@tinker.af.mil
- Mr. Matt Reynolds, ARINC
  405-605-7086
  mreynold@arinc.com
- Ms. Amber Drennen, ARINC
  405-605-7238
  adrennen@arinc.com

6.4 SHIPMENT OF ACTUATORS

6.4.1 Packaging

The packaging of the actuators will be accomplished as follows:

- Do not flush the actuators with preservative. Seal all openings with closures per MIL-C-5501. Using appropriate packing material and shipping container, pack and place the actuator into the container.
- Close and secure container for shipping.
- Identify the contents of the container with approved identification and inventory labels.

6.4.2 Shipping Instructions

Actuators will be shipped as follows:

- Prior to shipping the actuators, contact one of the personnel listed above.
- Ship the actuator to the following address:

  ARINC
  ATTN: Matt Reynolds/Amber Drennen
  6400 S.E. 59th Street
  Oklahoma City, OK 73135

- The actuators will be forwarded to the next evaluation site or appropriate Air Logistics Center (ALC) for wear or failure analysis.

6.5 ACTUATOR WEAR AND FAILURE ANALYSIS

OO-ALC will collect residual fluid in actuators and perform post service evaluation test, disassembly, and critical wear measurements as instructed in work orders. If actuator failure has occurred, OO-ALC will perform and document a failure analysis. OC-ALC/LGER and ARINC will witness critical wear measurements and failed actuator analysis on a non-interference basis.

6.6 ARINC REPORTING

During and following the evaluation period, ARINC is required to provide Mr. Jerry Zimmerman of OC-ALC/LGER the following deliverables:

- Monthly Status Reports
- Reports of significant events or contacts (via e-mail)
- Service Test Plan Actuator Final Reports
- Trip Reports, as required.