

SERVICE TEST PLAN
FOR
A-10
HYDRAULIC ACTUATORS

May 28, 2004

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

Under Purchase Order 42042SM

Prepared by

ARINC Engineering Services, LLC
6400 South East 59th Street
Oklahoma City, Oklahoma 73135

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 28 MAY 2004		2. REPORT TYPE		3. DATES COVERED 00-00-2004 to 00-00-2004	
4. TITLE AND SUBTITLE Service Test Plan for A-10 Hydraulic Actuators				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) ARINC Engineering Services, LLC, 6400 South East 59th Street, Oklahoma City, OK, 73135				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 17	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

2004 ARINC Incorporated

This material may be reproduced by or for the
U.S. Government pursuant to the copyright license
under DFAR Clause 252.227-7013 (1995)

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

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS	iii
SECTION 1.....	1
INTRODUCTION.....	1
1.1 PURPOSE	1
1.2 BACKGROUND	1
SECTION 2.....	2
APPLICABLE DOCUMENTS.....	2
2.1 GOVERNMENT DOCUMENTS	2
SECTION 3.....	3
SERVICE TEST PLAN.....	3
3.1 SERVICE TEST OBJECTIVES	3
3.2 SCOPE OF SERVICE TEST PLAN.....	3
3.2.1 Install and Ground Evaluation	3
3.2.2 Flight Evaluation.....	4
3.2.3 Other	4
3.3 SERVICE TEST PLAN SITES	4
3.4 ORGANIZATION AND PERSONNEL RESPONSIBILITIES.....	5
3.4.1 Evaluation Project Management	5
3.4.2 OO-ALC Responsibilities	5
3.4.3 AMC Responsibilities	5
3.4.4 ARINC Responsibilities.....	5
3.4.5 OC-ALC/LGER Responsibilities.....	6
3.5 SAFETY REQUIREMENTS	6
3.5.1 Ground Safety	6
3.5.2 Flight Safety.....	6
3.6 TEST ACTUATORS	6
3.6.1 Actuator Identification	6
3.6.2 Aileron Actuator Hydraulic Assembly P/N 2730500-5, Rudder Actuator Hydraulic Assembly P/N 2730534-1, and Elevator Actuator Hydraulic Assembly P/N 2730551-5.	7
3.6.2.1 Qualification by Similarity	7
SECTION 4.....	8
PERFORMANCE EVALUATION.....	8
4.1 REMOVAL OF ACTUATORS	8
4.2 INSTALLATION OF ACTUATORS	8
4.3 QUALITY ACCEPTANCE AND RELEASE FOR GROUND AND FLIGHT OPERATIONS	8
4.4 GROUND OPERATION EVALUATION (As Required)	8
4.5 FLIGHT OPERATION EVALUATION.....	8
4.6 CERTIFICATION FOR CONTINUATION OF OPERATION.....	8
4.7 FLIGHT EVALUATION.....	9
4.8 INTERRUPTION OF ACTUATOR EVALUATION.....	9
4.9 REMOVAL OF ACTUATORS	9
4.10 INSTALLATION OF ORIGINAL ACTUATORS	9

4.11	POST EVALUATION INSPECTION OF AIRCRAFT	9
4.12	SHIPPING OF ACTUATORS.....	9
	SECTION 5.....	10
	ACTUATOR FAILURE.....	10
5.1	FAILURE CRITERIA AND ACTIVITIES	10
5.2	FAILURE REPORTING	10
	SECTION 6.....	11
	POST EVALUATION PERIOD ACTIVITIES.....	11
6.1	REMOVAL OF ACTUATOR	11
6.2	INSTALLATION OF ORIGINAL ACTUATORS	11
6.3	CONTACT INFORMATION.....	11
6.4	SHIPMENT OF ACTUATORS.....	11
6.4.1	Packaging.....	11
6.4.2	Shipping Instructions.....	12
6.5	ACTUATOR WEAR AND FAILURE ANALYSIS	12
6.6	ARINC REPORTING	12

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) A-10 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 A-10 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 a hydraulic actuator on the A-10 aircraft that utilizes electroplated chrome as a wear coating on the actuator assembly. This actuator will be delta-qualified while two other 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 Actuator Hydraulic	2730500-5	Delta-Qualification Testing
2	Rudder Actuator Hydraulic Flight Control System	2730534-1	Similarity to (1)
3	Elevator Actuator Hydraulic Flight Control System	2730551-5	Similarity to (1)

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 to measure the performance of the actuators undergoing evaluation.

SECTION 2

APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

TO 9H2-4-227-3	Aileron Actuator Hydraulic Overhaul Instructions with Illustrated Parts Breakdown
TO 9H2-4-228-3	Rudder Actuator Hydraulic Flight Control System Overhaul Instructions with Illustrated Parts Breakdown
TO 9H2-2-229-3	Elevator Actuator Hydraulic Flight Control System Overhaul Instructions with Illustrated Parts Breakdown
TO 1A-10A-1-2	Flight Manual USAF Series A-10A/OA-10A Aircraft
TO 1A-10A-2-27MS-1	Maintenance Support Manual, Flight Controls, A-10A
TO 1A-10A-6	Scheduled Inspection and Maintenance Requirements USAF Series A-10A/OA-10A Aircraft Serial Number 75-0582 and Subsequent

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 A-10 aircraft. This service test plan will verify that the actuators undergoing evaluation cause no degradation of aircraft capability or hydraulic system operation. This service test plan will also determine if these actuators will surpass the current actuator life. 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.
- 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 performs 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., Will Rogers Airport) 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
- Active 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 in accordance with (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 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 Actuator Hydraulic	2730500-5	Delta-Qualification Testing	2
2	Rudder Actuator Hydraulic Flight Control System	2730534-1	Similarity to (1)	2
3	Elevator Actuator Hydraulic Flight Control System	2730551-5	Similarity to (1)	2

3.6.1 Actuator Identification

To identify these assemblies as test items, they will be tagged with special identification plates. 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 will be painted with bright orange stripes, per TO 1-1-8, using color FED-STD-595/38903.

3.6.2 Aileron Actuator Hydraulic Assembly P/N 2730500-5, Rudder Actuator Hydraulic Assembly P/N 2730534-1, and Elevator Actuator Hydraulic Assembly P/N 2730551-5.

The aileron actuator hydraulic assembly consists of a primary and secondary piston rod. This actuator provides control movement to the aircraft aileron as directed by the pilot.

3.6.2.1 Qualification by Similarity

The rudder actuator hydraulic assembly (2730534-1) and elevator actuator hydraulic assembly (2730551-5) will be qualified by similarity to the aileron actuator hydraulic assembly. The rudder and elevator assemblies have very similar designs to the aileron actuator hydraulic assembly. These additional part numbers will be included in these service tests.

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

The AMC QA personnel will verify that the aircraft with service test actuators installed meets all aircraft ground and flight operation requirements. 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 these actuators will not affect normal operation.

4.8 INTERRUPTION 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 allotted 24 month time period that the actuator is 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 (as defined in the technical orders, referenced in Section 2.1) 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.