Tail Rotor Hydraulic Servo Examination

NTSB Accident # CHI02FA174

Part Number: AC67032

Serial Number: QJ272

On September 10, 2002, the tail rotor servo from the aforementioned accident was examined at the Hawker Pacific Aerospace facility in Sun Valley, California. Preston Hicks (NTSB, SWR-A), Nicole Charnon (NTSB, SWR-A), Jim Carver (Eurocopter), Dan Woods (Rocky Mountain Helicopters), Brendan Darling (Hawker Pacific Aerospace), and Dean Meloni (Hawker Pacific Aerospace) attended the examination. The examination was conducted by a Hawker Pacific Aerospace technician.

The servo was removed from the mailing package and was examined. The control cable connector bearing, anchor bearing and compensator bearing were in place and moved freely. The pressure/return manifold, control cable linkage, and compensator linkage were removed to facilitate attachment to the test bench. Upon removal of the pressure/return manifold, the banjo bolts were removed. Two of the orifices in the return port banjo bolt contained dark debris. The debris noted was not large enough to block any of orifices entirely. The debris was left in place and packaged for the NTSB IIC's examination. The remaining hydraulic fluid in the servo was drained from the unit and collected in a sample jar for further examination. The pressure port filter was examined and appeared to be clean and clear of debris. The removed pressure/return manifold was flushed with hydraulic fluid and a small piece of light colored debris was found and sealed in a plastic bag.

The servo was placed on the test bench and hydraulic fluid was cycled through the servo and collected for debris testing. The component maintenance manual was referenced for the testing of the servo. The results of the tests indicated that the servo performed within specifications with the exception of the Permanent Flow Test, which resulted in excessive flow in the mid-stroke, the fully extended, and the fully retracted positions. The test sheet is attached to this report.

The servo was then disassembled and examined. The shuttle valve, spring, and split rings were intact and in place. All of the o-rings, scraper rings, and seals were

found in place and intact. The pilot valve was removed and no uneven wear marks or unusual scraping was noted. The servo piston was intact and did not display any unusual scrapes or wear marks.

The hydraulic fluid samples were sent to a local test facility for examination.

Nicole L. Charnon
Air Safety Investigator
NTSB; SWRA

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SERVO COMMANDE
(SERVO CONTROL)

REV 11 22 SEP 1995

TESTING AND FAULT ISOLATION

1. Test Equipment and Materials

NOTE: Equivalent substitutes may be used for listed items. Refer to Special Tools, Fixtures and Equipment for equipment identity.

A. Test Equipment

Tool List Item No.	Description		Remarks
12	Master Test Ram		For testing of servo unit assembly
	Hydraulic pump Switch Gear Test Gear	Locally Supplied	Minimum delivery 23 litres (5 Imperial, 6 U.S. gallons) /minute For hydraulic pump

B. Test Materials

Hydraulic Fluid MIL-H-83282

C. Preparation of Test System

(1) Incorporate a hydraulic test system comprising a pump, switch gear and header tank into a suitable test rig. Make the necessary supply and return connections.

(2) Connect the pump switch gear to a suitable electrical supply.

D. General

(1) Filter the test fluid to NAS1638 Class 6 standard of cleanliness or better.

(2) Maintain the test fluid within the temperature range 25 to 45 degrees C. (77 to 113 degrees F.).

(3) Maintain absolute cleanliness in the test area.

(4) Fill the unit with test fluid them prime and bleed the test system and unit before carrying out each test.

(5) The test sequence may be varied to the operator's convenience.

(6) The serviceability of a suspect servo unit assembly can be determined by assembling the suspect servo unit to the master test ram (Item No. 12) and testing as detailed in para. 3.

2. Acceptance Tests

(1) If, on receipt from the manufacturer or on withdrawal from stores of a servo commande, it is desired to test the component then carry out the Bench/Shop Tests detailed in para. 3.A, F, G and H.

3. Bench/Shop Tests

A. Leakage Test (Dynamic) ✓ WITHIN LIMITS

(1) Throughout tests A to K inclusive, periodically check the servo commande for external leakage. The maximum permitted leakage for new units is one drop over each 100 extend/retract operations. The maximum permitted leakage for in-service units is two drops over each 25 extend/retract operations.

B. Stroke Test ✓ WITHIN LIMITS

(1) Secure the servo commande horizontally in a suitable test rig.

(2) Connect the test rig hoses ensuring the pressure supply is connected to the unit supply port P and the return line is connected to the unit return port R.

(3) Apply a supply pressure of 40 bars (580 lbf/in^2).

(4) Move the lever on the unit to extend and retract the ram body over its full range and check that the stroke is 134 to 136 mm (5.275 to 5.354 in.).

(5) Release the supply pressure. 5.340

C. Load Test ✓ WITHIN LIMITS

(1) Mount the unit as detailed in para. B. (1) and (2).

(2) Apply a supply pressure of 40 bars (580 lbf/in^2).

(3) Move the lever to fully extend the unit.

(4) Apply a load to the unit ram and check that the load supported by the unit exceeds 180 daN (405 lbf) and that the unit does not retract under this load.

(5) Release the ram load and supply pressure.

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D. Distributor Test

(1) Mount the unit as detailed in para.B (1) and (2).

(2) Check the stroke of the lever by ensuring lever movement is 1,08 to 1,44 mm (0.043 to 0.058 in.) either side of the 'null' zero position. ✓ WITHIN LIMITS

(3) Insert a suitable rigging pin with a diameter of 5,97 to 5,99 mm (0.2350 to 0.2358 in.) through the rigging pin hole to immobilize the lever. ✓ WITHIN LIMITS

(4) Apply a supply pressure of 40 bars (580 lbf/in²) and check that the unit does not creep more than 2 mm (0.079 in)/second in either direction. ✓ WITHIN LIMITS

(5) Remove the rigging pin and with the supply pressure of 40 bars (580 lbf/in²) applied, check that the dead travel of the lever does not exceed 0,15 mm (0.006 in.) either side of the 'null' position. ✓ .001 EXTENDED .003 RETRACTED

(6) Operate the unit several times in each direction but do not allow the unit body to strike the piston rod at the end of each stroke. Cease operating with the servo valve in mid position and the unit body approximately 5 mm (0.20 in.) from one end of its full stroke.

(7) Immediately attach a suitable gauge to the lever and check that the force required to operate the unit does not exceed 6 N (1.35 lbf.). ✓ 0.5 EXTENDED 0.6 RETRACTED

(8) Repeat operation (6) but cease operating with the unit body approximately 5 mm (0.20 in.) from the other end of its full stroke. Repeat operation (7). ✓

(9) Repeat operations (6), (7) and (8) but during each test leave the unit static for five minutes before checking the force required to operate the unit (operation (7)). ✓ 0.7 EXTENDED 0.75 RETRACTED

(10) Release the supply pressure.

E. Permanent Flow Test

(1) Secure the unit in the test rig.

(2) Connect the test rig pressure supply to the unit supply port P. Connect a suitable flowmeter to the unit return port R.

(3) Apply a supply pressure of 40 bars (580 lbf/in²) ensuring that no load is exerted on the unit.

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(4) Operate the unit to set the piston in the mid stroke position and the spool in the mid position (closed). Check the flow indicated by the flowmeter which shall not exceed 100 cc/min.

150

(5) Operate the unit to set the piston against the 'fully extended' stop and the spool fully open. Check the flow indicated by the flowmeter which shall not exceed 100 cc/min.

175

(6) Operate the unit to set the piston against the 'fully retracted' stop and the spool fully open. Check the flow indicated by the flowmeter which shall not exceed 100 cc/min.

160

(7) Release the supply pressure.

F. By-Pass Valve Operation Test

(1) Mount the unit as detailed in para.E (1) and (2).

(2) Apply a supply pressure of 40 bars (580 lbf/in²).

(3) Oscillate the lever and at the same time slowly reduce the supply pressure. Check that the by-pass valve is fully open (resistance is applied to lever) at a pressure of not less than 6 bars (87 lbf/in²). ✓ 100

(4) Reduce supply pressure to zero.

(5) Progressively re-apply the supply pressure to 40 bars (580 lbf/in²) while oscillating the lever. Check that the by-pass valve is fully closed (resistance to lever movement ceases) at a pressure not exceeding 12 bars (175 lbf/in²). ✓ 120

(6) Reduce supply pressure to zero.

(7) Immobilize the lever.

(8) Slowly increase the supply pressure and check the instantaneous flow indicated by the flowmeter as the by-pass valve closes. This flow shall not exceed 700 cc/min.

✓ 200

(9) Release the supply pressure.

G. Speed Test Hydraulic Mode

(1) Mount the unit as detailed in para.B (1) and (2).

(2) Apply a supply pressure of 40 bars (580 lbf/in²) ensuring no opposing load is exerted on the unit.

(3) Fully extend and retract the unit several times and check that the speed of the unit extending and retracting is between 100 and 120 mm/sec. ensuring speed dissymmetry does not exceed 15% of the faster speed.

✓ WITHIN LIMITS

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(4) Release supply pressure.

H. Speed Test Mechanical Mode

(1) Mount the unit as detailed in para. B (1) and (2).

(2) Suspend a load of 15 daN (33.75 lbf) to the lever.

(3) Support the load and move the unit body to the fully retracted position.

(4) Release the hold on the unit body and allow it to travel under the influence of the suspended load, checking that the speed of the unit over its full travel is a minimum of 80 mm/sec. ✓ WITHIN LIMITS

NOTE: Tests J and K are only applicable after any part of the Servo Valve Assembly (25) is disturbed or disassembled.

J. Stability Test

(1) Mount the unit in the test rig secured in a fixture representing an anchorage stiffness of 1600 daN/mm (40.8 ton/in). Connect the test rig hoses as detailed in para.B (2).

(2) Apply a load of 19,6 daN (44.1 lbf) to the ram output end.

(3) Apply a supply pressure of 40 bars (580 lbf/in^2).

(4) Use a simulated pilot's control on the test rig, operate the lever as detailed in the following operations (a) to (e) and check there is no chattering, self induced vibration or other phenomenon.

(a) Move the lever backwards and forwards over a long stroke, but not striking the stops, at least ten times in each direction at a fast speed of operation.

(b) Repeat the operation (a) at a slow speed of operation.

(c) Move the lever backwards and forwards over a short stroke at least ten times in each direction at a fast speed of operation.

(d) Repeat operation (c) at a slow speed of operation.

(e) Repeat operation (a) moving the lever fully against the rig mechanical stops at the end of each stroke.

(5) Release the supply pressure. ✓ SMOOTH, NO CHATTER OR VIBRATIONS NOTED

K. Efficiency Test

(1) Mount the unit as detailed in para. B (1) and (2).

(2) Apply a supply pressure of 40 bars (580 lbf/in^2) ensuring no load is exerted at the output end.

(3) Apply a sinusoidal lever movement of amplitude ± 0,35 mm (±0.014 in.) at 1 Hz. ✓ 0.24

(4) Check that the movement of the output end of the unit has a minimum amplitude of 70% of lever movement, i.e. a minimum movement of 0,245 mm (0.010 in.) in either direction. ✓ 0.12 - 0.13

(5) Release a supply pressure.

L. Leakage Test (Static)

(1) Secure the unit in the test rig.

(2) Connect the test rig pressure supply to the unit supply port P. Fit a pressure blank to the unit return port R.

(3) Apply a supply pressure of 40 bars (580 lbf/in^2).

(4) Check the unit for external leakage over a period of one minute in each of the fully extended, fully retracted and mid stroke positions. External leakage is not permitted.

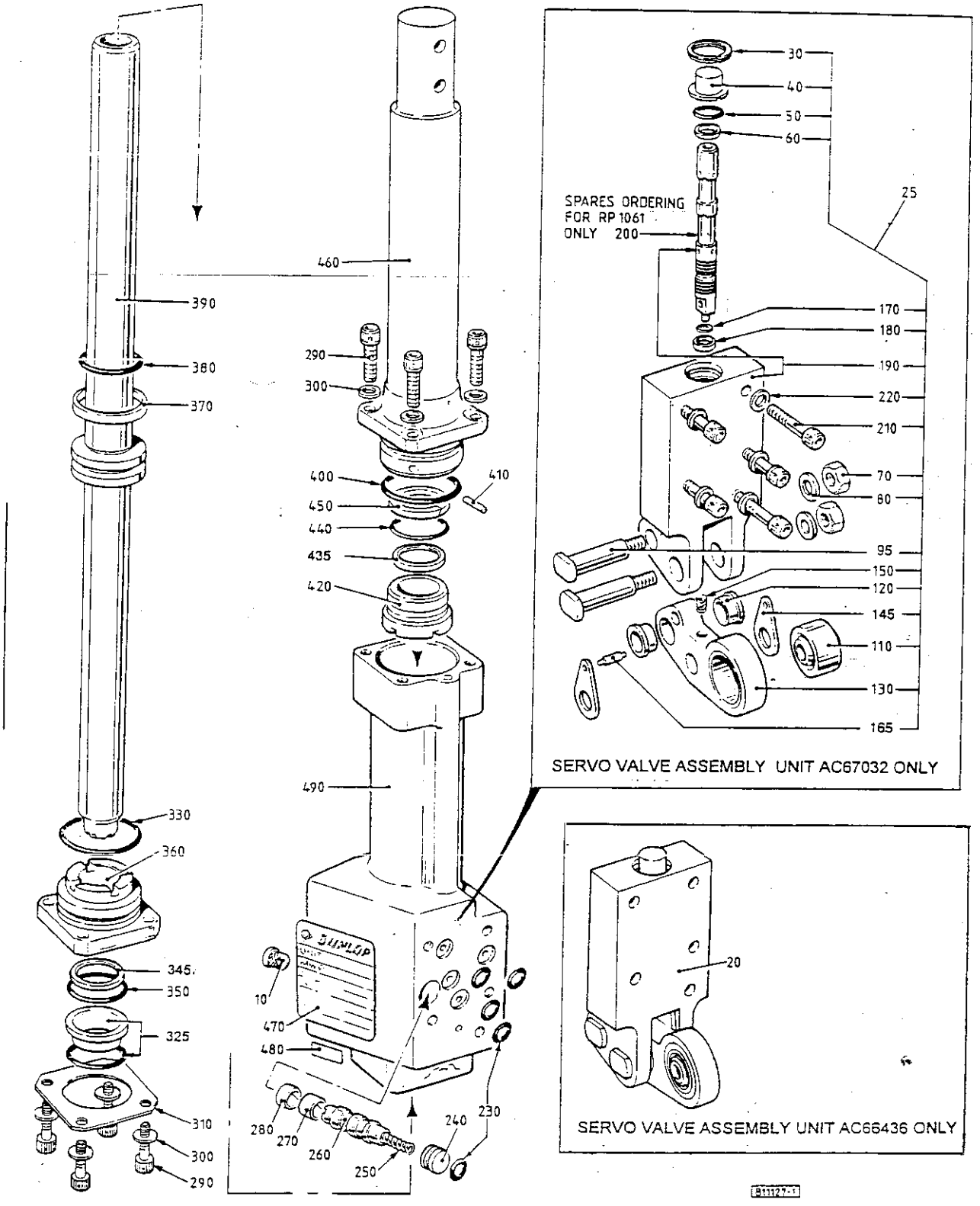
(5) Release supply pressure.

(6) Disconnect test rig pressure supply and fit a pressure blank to unit supply port P. Remove pressure blank from unit return port R. Connect test rig pressure supply to unit return port R.

(7) Apply a supply pressure of 0,2 bars (2.9 lbf/in^2) to the unit return port R and maintain the pressure for 10 hours in both chambers of the ram.

(8) Check the unit for external leakage after 10 hours. External leakage is not permitted.

(9) Release supply pressure.



Servo Commande
Figure-1

ILLUSTRATED PARTS LIST

Fig Item	Part Number	Airline Part Number	1 2 3 4 5 6 7 Nomenclature	EFF Code	Units Per Assy
1-1A	AC66436		SERVO COMMANDE	A	RF
1-1B	AC67032		SERVO COMMANDE MOD C2011	B	RF
10	ACO42963		. FILTER ASSEMBLY	AB	1
* 20	ACM28687		. VALVE ASSEMBLY SERVO PRE-MOD C2011	A	1
* 25	ACM29029		. VALVE ASSEMBLY SERVO MOD C2011	B	1
30	RR56S		. . RING RETAINING DSR2717-4	B	1
40	ACO42955		. . CAP END	B	1
50	DAS2475-1010		. . RING SEAL	B	1
60	S50992-1188-99		. . RING WIPER (U2533) DSR4263-1007	B	1
70	DAS2480-1006		. . NUT	B	2
80	ACO43543		. . WASHER	B	2
*- 90	ACO43241		. . PIN HINGE PRE MOD C2673	A	2
* 95	ACO46747		. . PIN HINGE MOD C2673	B	2
*- 100	ACO43208		. . LEVER ASSEMBLY	B	1
110	KN6E		. . . BEARING ADR FRANCE DSR1253-1002	B	1
120	ACO43171		. . . BUSH	B	2
130	ACO43202		. . . LEVER	B	1
-140	ACO43173		. . PLATE LINK PRE MOD C2673	A	2
145	ACO46746		. . PLATE LINK MOD C2673	B	2
150	ACO43242		. . SPRING	B	1
-160	ACO43170		. . PIN LINK PRE MOD C2673	A	1
165	ACO46748		. . PIN LINK MOD C2673	B	1
170	DAS2475-1005		. . RING SEAL	B	1
180	S50993-1308-99		. . RING WIPER (U2533) DSR58876-1002	B	1
* 190	ACO43964		. . VALVE ASSEMBLY MOD C2011	B	1
* 200	ACO43960		. . . SPOOL ASSEMBLY MOD C2011	B	1
210	DAS54153-1210		. SCREW SKT HD CAP SELF LOCKING M5 X 30 mm long MOD C10950(0)	AB	5
210A	EDS1000-1210		. SCREW SKT HD CAP SELF LOCKING M5 X 30 mm long OPT TO ITEM 210	AB	5
220	DSR60504-1003		. WASHER PLAIN STEEL CAD PLATED 10 mm o/d X 5,3 mm i/d X 1 mm thick conforms to LN9025	AB	5
230	DAS2475-1008		. RING SEAL.	AB	1
240	ACO43001		. STOP SHUTTLE	AB	1
250	ACO43034		. SPRING	AB	1
260	ACM28647		. SHUTTLE	AB	1
270	ACO43115		. RING SPLIT	AB	1
280	ACO43009		. RING SPLIT	AB	1

- Item not illustrated
* Vital Parts

ILLUSTRATED PARTS LIST

Fig Item	Part Number	Airline Part Number	1 2 3 4 5 6 7 Nomenclature	EFF Code	Units Per Assy
290	DAS54153-1206		. SCREW SKT.HD. CAP SELF LOCKING M5 X 16 mm long MOD C10950(0)	AB	8
290A	EDS1000-1206		. SCREW SKT.HD. CAP SELF LOCKING M5 X 16 mm long OPT TO ITEM 290	AB	8
300	DSR60504-1003		. WASHER PLAIN STEEL CAD PLATED 10 mm o/d x 5,3 mm i/d x 1 mm thick conforms to LN9025	AB	8
310	ACO44418		. PLATE RETAINING MOD C2120	AB	1
-320	S50039-1209-5		. EXCLUDER ASSY PRE MOD C2751 DSR58879-1009 (U2533)	AB	1
325	ACO47024		. EXCLUDER RING MOD C2751	AB	1
330	DAS2478-1013		. RING SEAL	AB	1
-340	S50992-1192-99		. RING WIPER PRE MOD C2751 DSR58877-1015 (U2533)	AB	1
345	ACO47025		. STEP SEAL MOD C2751	AB	1
350	DAS2477-1002		. RING SEAL	AB	1
-359	ACM28590		. BEARING PRE-MOD C2120	AB	1
360	ACM29386		. BEARING MOD C2120	AB	1
370	S50993-1322-99		. RING WIPER (U2533) DSR58876-1015	AB	1
380	DAS2475-1020		. RING SEAL	AB	1
* 390	ACM28677		. ROD PISTON MOD C2618	AB	1
400	DAS2478-1013		. RING SEAL	AB	1
410	DSR57926-1806		. PIN SPIROL STD DUTY 3 mm Dia x 14 mm (K3297)	AB	1
420	ACO42965		. BEARING	AB	1
-430	S50992-1192-99		. RING WIPER PRE MOD C2751 DSR58877-1015 (U2533)	AB	1
435	ACO47025		. STEP SEAL MOD C2751	AB	1
440	DAS2477-1002		. RING SEAL	AB	1
450	ACO42952		. RING BACK-UP	AB	1
* 460	ACM28679		. PIECE EXTENSION	AB	1
470	DAS2133-26		. LABEL SELF ADHESIVE	AB	1
480	DAS2366-19		. LABEL SELF ADHESIVE	AB	1
*490	AC66375		. BODY ASSEMBLY RAM MOD C2781	AB	1
			TRANSIT AND STORAGE ITEMS		
-500	DAS2426-01AA		. PLUG PROTECTION	AB	2
-510	DAS2427-03A		. SEAL RUBBER	AB	2

- Item not illustrated
* Vital Parts

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