

SRB CRITICAL ITEMS LIST

SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Servovalve Assembly,  
Part of Servoactuator

PART NO.: A07468-3

FM CODE: A04

ITEM CODE: 20-02-04

REVISION: Basic

CRITICALITY CATEGORY: 1R

REACTION TIME: Seconds

NO. REQUIRED: 8 (4 per actuator)

DATE: March 1, 2002

CRITICAL PHASES: Boost

SUPERCEDES: March 31, 1999

FMEA PAGE NO.: A-196

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SHEET 1 OF 7

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FAILURE MODE AND CAUSES: Loss of output from three or four servovalves caused by:

- o Both nozzles or drain orifices clogged by contamination
- o Coil or electrical filter is open or shorted
- o Damaged electrical connector
- o Clogged fluid filter

FAILURE EFFECT SUMMARY: Loss of three or four servovalves leading to inadequate control or to the actuator going hardover. Loss of Thrust Vector Control will lead to vehicle breakup and loss of mission and crew. Three success paths remain after the first failure.

REDUNDANCY SCREENS AND MEASUREMENTS:

- o Pass - ATP is conducted on all units, redundancy is verified during ATP.
- o Pass - Abnormal outputs are detectable from delta pressure measurements B58P1311A through B58P1318A, by actuator position measurements B58H1150C and B58H1151C, and by isolation valve command measurements V79X5100X, V79X5101X, V79X5105X, V79X5106X, V79X5110X, V79X5111X, V79X5115X and V795116X.
- o Fail - Fluid contamination.

## RATIONALE FOR RETENTION:

## A. DESIGN

- o The Servovalve Assembly is designed and qualified in accordance with the end item specification 10SPC-0055. (All Failure Causes)
- o Material selection is in compliance with MSFC-SPEC-522A. (All Failure Causes)
- o All servovalve piece-parts, subassemblies and assemblies are cleaned and assembly operations are performed in a controlled environment conforming to Class 100,000 clean room conditions. The Moog clean room is certified per Moog QAP 803-001-100. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o The servovalve first stage orifices are protected by a 20 micron, 35 micron absolute filter. Further contamination protection is provided by the 5 micron absolute system filter and the servovalve inlet filter (10 micron nominal, 15 micron absolute). (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o The servovalve inlet filter is designed for a twenty mission service life. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Sampling valve ports are provided on the servoactuator for sampling the hydraulic fluid at the primary inlet and at the return. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Servovalve torque motor coils are designed with insulated wiring with mutual insulation resistance of 50 megohms minimum, with 500 vdc test potential applied and a dielectric strength capable of withstanding  $500 \pm 50$  volts RMS, 60 Hz between insulated turns without breaking down or a current leakage of not more than 500 microamperes between actuator housing or coil turns. (Coil or Electrical Filter is Open or Shorted)
- o The torque motor coils are designed for continuous operation at 100 to 140 milliamperes. The operational (orbiter) command currents are limited to  $\pm 55$  ma per ICD-2-14001. In addition, software (orbiter limits on actuator commands are imposed which are equivalent to 20 ma from T -20 minutes to T + 2.5 seconds and 44.9 ma from T + 2.5 seconds to separation. (Coil or Electrical Filter is Open or Shorted)
- o The electrical filter ceramic capacitors are rated at 50 VDC. The resistors are wirewound with a power rating of 2 watts at 25°C and a temperature coefficient of  $0 \pm 20$  PPM/°C. The capacitors and resistors are lot traceable with identification data included in each shipment. The filter elements are potted within a housing made of 304 or 302 CRES material to prevent filter element damage or shorting. (Coil or Electrical Filter is Open or Shorted)

- o Torque motor coil lead wires are teflon insulated. Conductors rated for 600 VAC and 200°C. The lead wires are covered with heat shrink tubing and are routed and supported between the coil housing and the connector. (Coil or Electrical Filter is Open or Shorted, Damaged Electrical Connector)
- o Soldering meets the requirements of NASA NHB 5300.4(3A-1) or NHB 5300.4(3A-2). (Coil or Electrical Filter is Open or Shorted, Damaged Electrical Connector)
- o External connectors are sealed, underwater type that have been qualified for SRB application. Metal protective caps are provided for installation on the connectors at all times except when access is required for test and flight cable installation. Lubricants, compatible with connector O-ring seals, are provided to facilitate connector installation and mating. (Damaged Electrical Connector)
- o The servoactuator (including servovalves) is designed to a service life of 200,000 cycles with  $\pm 0.10$  inch displacement at 10.0 Hz; 200,000 cycles with  $\pm 0.25$  inch displacement at 10.0 Hz; 4,000 cycle with  $\pm 1.0$  inch displacement at 0.25 Hz and 400 cycles with  $\pm 6.0$  inches displacement at 0.1 Hz. (All Failure Causes)
- o The servovalve assembly, as part of the servoactuator, was subjected to qualification testing which verified the design requirements, including a burst pressure conducted at Moog. The test results are reported in Qualification Test Report MSFC-RPT-900. The Moog conducted burst pressure testing results are reported in Moog Report No. MR T-2980. Two units were subjected to qualification testing. After completion of the MSFC/Moog conducted testing, the two units were torn down and inspected. There was no evidence of wear, damage or other anomalies as reported in Moog disassembly and inspection analysis reports, MR M-2982 and MR M-2983. (All Failure Causes)

## B. TESTING

### VENDOR RELATED TESTING

- o Servoactuator Acceptance Tests are performed per Moog Report No. MR A-2406. This procedure includes: (All Failure Causes)
  - Servovalve Torque Motor Coils
  - Command Current Limiting Response
  - Servovalve Pressure Gain
  - Failure Response
  - Dynamic Acceptance Tests
  - Cleanliness
  - Coil Dielectric Strength Tests
  - Coil Insulation Resistance Test
  - Examination of Product
- o A two minute flushing procedure is performed when a hydraulic line is removed or reinstalled per Moog ATP MR A-2406. (Both Nozzles or Drain Orifices Clogged By Contamination, Clogged fluid Filter)

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- o Refurbished servoactuators are tested as follows:
  - End Item Acceptance Test per Moog MR A-2406. This is the same ATP as new hardware except some component level tests are not required when teardown does not affect the validity of the previous component test. These component tests are Power Valve Pressure Gain, Transient Load Relief Valve and Servo Valve Differential Pressure Transducers. (All Failure Causes)

#### KSC RELATED TESTING

- o Helium is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board circuits per 10REQ-0021, para. 2.3.2.5. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Hydraulic fluid is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board hydraulic circuits per 10REQ-0021, para. 2.3.2.6. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Effluent hydraulic fluid is verified for moisture content and cleanliness (water content and particulate count) from the rock actuator, the tilt reservoir, the rock reservoir and the tilt actuator per 10REQ-0021, para. 2.3.12.3. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Actuator response to predefined input commands during hotfire, per 10REQ-0021, paras. 2.3.16.3 and 2.3.16.4. (All Failure Causes)
- o Actuator null, linearity and polarity and servo valve redundancy verification tests are performed per 10REQ-0021, para. 2.3.14. (All Failure Causes)
- o Hydraulic fluid is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board hydraulic circuits during prelaunch operations per OMRSD File V, Vol. 1 Requirement Number B42HPO.010. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Ascent Thrust Vector Control/SRB-TVC system response to predefined input commands per OMRSD File II, Vol. 1 Requirement Number S00000.650. (Gain Test). (All Failure Causes)
- o Dynamic operation of the Ascent Thrust Vector Control/SRB-TVC System Failure Detection and Isolation Circuitry per OMRSD File II, Vol. 1 Requirement Numbers S00000.670 and .680. (Individual Channel Test). (All Failure Causes)

- o Frequency response (gain and phase) and step response of the Ascent Thrust Vector Control/SRB-TVC system per OMRSD File II, Vol. 1 Requirement Numbers S00000.720 and .750 respectively. (All Failure Causes)
- o Gimbal test performed after SRB HPU start under control of automated software in GLS and RSLs verifies actuator performance by monitoring actuator position, servovalve differential pressure, isolation valve events and APU turbine speed (related to actuator pressure switch). Pass/fail criteria for automated portions of terminal countdown are controlled per OMRSD File II, Vol. 1, requirement number S00FSO.030 and launch commit criteria. This is the last test that verifies actuator performance. (All Failure Causes)

The above referenced OMRSD testing is performed every flight.

C. INSPECTION

VENDOR RELATED INSPECTIONS

- o USA SRBE PQAR witnesses final servoactuator ATP according to USA SRBE SIP 1127. (All Failure Causes)
- o USA SRBE PQAR verifies hydraulic fluid is inspected for contamination before loading according to USA SRBE SIP 1127. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o USA SRBE verifies all material certifications in accordance with USA SRBE SIP 1127. (All Failure Causes)
- o USA SRBE PQAR performs visual inspection of unit paying special attention to connector pins per USA SRBE SIP 1127. (All Failure Causes)
- o During refurbishment and prior to reuse, the servoactuator is disassembled, cleaned, inspected and tested to ensure proper performance per 10SPC-0131. Preliminary evaluation includes: (All Failure Causes)
  - Clean and inspect external surfaces
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  - Disassembly as required to inspect the body/cylinder interface and bushing, spool and sleeve assemblies of the: selector valve, lock valve, servovalves and power valve for evidence of seawater contamination.
- o Extent of repair is determined from this evaluation and accomplished per the following general requirements: (All Failure Causes)
  - Total disassembly is required if any wetted hydraulic surface discloses seawater contamination.

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- All nonhermetic electrical/electronic parts which have been exposed to seawater are replaced.
  - All repairs are processed by the cognizant Material Review Board.
  - All seals which have been removed from the installed position or exposed to seawater contamination are replaced.
  - All hydraulic surfaces that have been exposed to seawater contamination are recleaned per Moog Documents 800-000-100, supplement 32 and MR-Q-6428.
  - Reassembly per the same procedures and controls as new hardware.
- o Critical Processes/Inspections:
- Soldering per QQ-S-571 and NHB5300.4(3A-1) or NHB 5300.4(3A-2)

#### KSC RELATED INSPECTIONS

- o Helium cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board circuits per 10REQ-0021, para. 2.3.2.5. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Hydraulic fluid cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board hydraulic circuits per 10REQ-0021, 2.3.2.6. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o The moisture content and cleanliness (water content and particulate count) of the effluent hydraulic fluid from the rock actuator, the tilt reservoir, the rock reservoir and the tilt actuator are verified per 10REQ-0021, para. 2.3.12.3. (Clogged fluid Filter, Both Nozzles or Drain Orifices Clogged by Contamination)
- o Proper function of TVC system is demonstrated during hotfire operations per 10REQ-0021, para. 2.3.16. (All Failure Causes)
- o Hydraulic fluid cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board Hydraulic circuits during prelaunch operations per OMRSD File V, Vol. 1, Requirement Number B42HP0.010.(All Failure Causes)
- o SRB TVC actuator positioning test is verified per OMRSD File II, Vol. 1 Requirement Number S00000.650. (All Failure Causes)
- o Both SRB individual channel null test and actuator individual channel ramp test are verified per OMRSD File II, Vol. 1 Requirement Numbers S00000.670 and .680 respectively. (All Failure Causes)
- o Both SRB actuator frequency response and step response are verified per OMRSD File II, Vol. 1 Requirement Numbers S00000.720 and .750 respectively. (All Failure Causes)

D. FAILURE HISTORY

- o Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- Not applicable to this failure mode.