

SRB CRITICAL ITEMS LIST

SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Dynamic Pressure Feedback Assembly,  
Part of Servoactuator

PART NO.: A39350-2 (DPF Assembly), FM CODE: A02  
A21953-15 (Nozzle Assembly),  
073-63886-4 (Union),  
A21156-006MS (Seal, External Groove)

ITEM CODE: 20-02-05 REVISION: Basic

CRITICALITY CATEGORY: 1R REACTION TIME: Seconds

NO. REQUIRED: 8 (4 per actuator) DATE: March 1, 2002

CRITICAL PHASES: Boost SUPERCEDES: March 1, 1996

FMEA PAGE NO.: A-199 ANALYST: K. Schroeder/S. Finnegan

SHEET 1 OF 5 APPROVED: S. Parvathaneni

CN 044

FAILURE MODE AND CAUSES: Loss of or reduced output (three or four DPF assemblies) caused by:

- o Piston friction
- o Piston seizure due to improper clearance or contamination
- o Broken spring or damaged spring seat
- o Internal leakage due to wear or damaged piston/bushing
- o One or two DPF nozzles plugged by contaminant
- o Broken or damaged transfer tube or seals

FAILURE EFFECT SUMMARY: Loss of capability to stabilize the servoactuator. 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 - Redundancy is verified during vendor acceptance test.
- o Fail - Failure of DPF assemblies is not detectable until at least three assemblies fail.
- o Fail - Fluid contamination.

CN 044

## RATIONALE FOR RETENTION:

## A. DESIGN

- o The Dynamic Pressure Feedback Assembly is designed and qualified in accordance with end item specification 10SPC-0055. (All Failure Causes)
- o Material selection is in compliance with MSFC-SPEC 522A. (Broken Armature Return Spring, Defective Spool Return Spring)
- o The valve seat is protected from contamination by a 304 CRES screen in the pressure orifice assembly. The screen is rated at 100 microns (nominal) and is backed by a 160 micron (nominal) screen. Additional protection against contamination is provided by the 5 micron absolute filter in each of the input hydraulic systems and the 10 micron, 15 micron absolute servovalve inlet filter assembly in the actuator. Further contamination protection is provided by a down stream filter made of 316 CRES with 44 micron (nominal) entrapment capability. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)
- o Servoactuator piece parts, subassemblies and assemblies are cleaned and assembled in a controlled environment conforming to Class 100,000 clean room. The Moog clean room is certified in accordance with Moog QAP 803-001-100. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)
- o The piston body is made of 440C CRES, heat treated per EP 3202 and stress relieved. The piston body is machined to .001 of an inch tolerance and grooved for packing ring with a surface finish of 32 rms. The piston ends are machined to plus zero tolerance and minus 50 microinch diametral clearance with a surface finish of 5 rms. (All Failure Causes)
- o The body assembly is 6061-T6, T651, T6510 or T6511 material, chromic acid anodized and hard anodized to .0010-0020 inches thickness with no breaks allowed in the hard anodize. (All Failure Causes)
- o The centering springs are made of 17-7 PH CRES, heat treated, penetrant inspected and demagnetized after final manufacturing operation and traceable by lot number. (All Failure Causes)
- o Four pivots are provided, one at each of two centering spring assembly seats and two at piston to spring assembly interfaces, to decouple piston/spring lateral motions and reduce friction. (All Failure Causes)
- o Control ports are .047 inches in diameter which is sufficient size to tolerate, without malfunction, the maximum influent contamination levels specified in USA SRBE 10SPC-0055. (One or Two DPF Nozzles Plugged by Contaminant)
- o The seals material is Nitrile (buna N) rubber and back up ring material is teflon. (Internal Leakage Due to Wear or Damaged Piston/Bushing)

- o The Dynamic Pressure Feedback Assembly, as part of the servoactuator, was subjected to qualification testing which verified the design requirements, including a qualification burst pressure test 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 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, with a specific test for the Dynamic Pressure Feedback Assembly's redundancy that is included in the dynamic performance tests. Additionally, ATP includes: (All Failure Causes)
  - Proof test
  - Dynamics
  - Cleanliness
- o Moog ATP MR A-2406 requires a two minute flushing procedure when a hydraulic line is removed or reinstalled. (One or Two DPF Nozzles Plugged by Contaminant, Piston Seized Due to Improper Clearance or Contamination)
- o Refurbished servoactuators are tested as follows: (All Failure Causes)
  - End item acceptance test per Moog MR A-2406. This is the same acceptance test as new actuators. However, no specific tests are included in the ATP to verify acceptable performance of the dynamic pressure feedback (DPF) module at the actuator level. "In-process" component tests are performed on the DPF module to verify component performance on refurbished hardware only if total disassembly is required - as evidenced by salt water in hydraulics.

CN 044

### 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. (One or Two DPF Nozzles Plugged 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. (One or Two DPF Nozzles Plugged 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. (One or Two DPF Nozzles Plugged by Contaminant, Piston Seizure Due to Improper Clearance or Contamination)

- 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 B42HP0.010. (One or Two DPF Nozzles Plugged by Contaminant, Piston Seizure Due to Improper Clearance or Contamination)

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 actuator loading per USA SRBE SIP 1127. (One to Two DPF Nozzles Plugged by Contaminant)
- o USA SRBE PQAR verifies material certifications per USA SRBE SIP 1127. (All Failure Causes)
- o The body assembly raw material is ultrasonic inspected per MIL-I-8950, Class A, penetrant inspected per EP 2067. (Broken or Damaged Transfer Tube or Seals, Internal Leakage Due to Wear or Damaged Piston/Bushing)
- o The piston is magnetic particle inspected per ASTM E1444. (Piston Friction)
- 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
  - Check main piston runout
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  - CN 044
  - 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.
  - 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 process/Inspections:
  - Heat Treat, Piston, per EP 3202
  - Heat Treat, Spring, per EP 3389
  - Stress Relief, Piston, per EP 3211
  - Magnetic Particle Inspection, Piston, per ASTM E1444
  - Anodizing, Body, per EP 3203
  - Ultrasonic Inspection, Body, per MIL-I-8950, Class A
  - Penetrant Inspection, Body, per EP 2607
  - Penetrant Inspection, Spring, per MIL-I-6866
  - Shot Peening, Spring, per AMS 2430
  - Demagnetization, Spring, per A05684

#### 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.(One or Two DPF Nozzles Plugged by Contaminant)
- o Hydraulic fluid cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board hydraulic circuits per 10REQ-0021, para. 2.3.2.6. (Piston Seizure Due to Improper Clearance or Contamination, One or Two DPF Nozzles Plugged by Contaminant)
- 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. (Piston Seizure Due to Improper Clearance or Contamination, One or Two DPF Nozzles Plugged by Contamination)
- 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. (One or Two DPF Nozzles Plugged by Contaminant, Piston Seizure Due to Improper Clearance or Contamination)

#### D. FAILURE HISTORY

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

#### E. OPERATIONAL USE

- o Not applicable to this failure mode.