SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Solenoid Isolation Valve Assembly,
Part of Servoactuator

PART NO.: A05745 (Solenoid Valve Assembly),
A05364-1J (Bushing, Spool and Sleeve Assembly),
A07720 (Spring, Compression)

FM CODE: A05

ITEM CODE: 20-02-03

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-190

ANALYST: K. Schroeder/S. Finnegan

SHEET 1 OF 6

APPROVED: S. Parvathaneni

CN 044

FAILURE MODE AND CAUSES: Valves isolate when not required (three or four servovalves) caused by:

- o Excessive leakage due to damaged or contaminated valve seat
- o Broken armature return spring
- o Defective spool return spring

FAILURE EFFECT SUMMARY: Loss of servovalve outputs leading to inadequate performance or to 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 - Redundancy can be verified by delta pressure measurements B58P1311A through B58P1318A. Actuator position measurements B58H1150C, B58H1151C and Isolation Valve command measurements A79X5100X, A79X5101X, A79X5105X, A79X5106X, A79X5110X, A79X5111X, A79X5115X and A79X5116X.

- o Fail - fluid contamination.

RATIONALE FOR RETENTION:

A. DESIGN

- The Solenoid Isolation Valve Assembly is designed and qualified in accordance with end item specification 10SPC-0055. (All Failure Causes)

- Material selection is in compliance with MSFC-SPEC-522A. (Broken Armature Return Spring, Defective Spool Return Spring)

- 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 downstream filter made of 316 CRES with 44 micron (nominal) entrapment capability. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- 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)

- The pressure orifice is made of AISI 52100 material and heat treated. The nozzle diameter is at least 11 orders of magnitude larger than filter trapping capability. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- The pressure orifice nozzle (valve seat) size is approximately one half the diameter of the solenoid ball, making a positive seal when the valve is closed. The solenoid ball is made of tungsten carbide (T.C. 44A, Grade Ten). The valve seat is surface finished to 16 rms. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- The armature return spring is designed and is enclosed in an end bore in the armature thus preventing bending or distortion. The armature return spring is made of 17-7PH CRES, heat treated to condition CH900, passivated and demagnetized. (Broken Armature Spring Return)

- The spool return spring (.064 dia. wire) is made from 17-7PH CRES, heat treated to condition CH900. (Defective Spool Return Spring)

- The solenoid isolation valve 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 Acceptance testing of Solenoid Isolation Valve Assemblies is performed after installation in the servoactuator in accordance with the Acceptance Test Procedure defined in Moog Report MR A-2406. These tests include: (All Failure Causes)

- Isolation Valves
- Pull-in, Drop-out current
- On-time Response
- Failure Response
- Second Failure
- Cleanliness
- Dielectric Strength
- Insulation Resistance
- Resistance
- Examination of Product

o A two minute flushing procedure is performed when a hydraulic line is removed or reinstalled per Moog report MR A-2406. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

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 Servovalve 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

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. (Excessive Leakage Due to Damage or Contaminated Valve Seat)

- 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- Actuator response to predefined input commands during hotfire per 10REQ-0021, paras. 2.3.16.3 and 2.3.16.4. (All Failure Causes)

- Actuator null, linearity and polarity and redundancy verification tests are performed per 10REQ-0021, para. 2.3.14. (All Failure Causes)

- 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- 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 Null and Ramp Test). (All Failure Causes)

The above referenced OMRSD testing is performed every flight.

C. INSPECTION

VENDOR RELATED INSPECTIONS

- USA SRBE PQAR witnesses final actuator ATP per USA SRBE SIP 1127. (All Failure Causes)

- USA SRBE PQAR verifies hydraulic fluid is inspected for contamination before actuator loading per USA SRBE SIP 1127. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- USA SRBE PQAR verifies material certifications per USA SRBE SIP 1127. (Broken Armature Return Spring, Defective Spool Return Spring)

- USA SRBE PQAR verifies traceability records per USA SRBE SIP 1127. (Broken Armature Return Spring, Defective Spool Return Spring)

- USA SRBE PQAR verifies assembly operations per USA SRBE SIP 1127. (All Failure Causes)

- The pressure orifice assembly disc filter is inspected for loose particles at twenty times magnification per Moog Standard Receiving Inspection Plan. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- o The downstream filter is inspected for loose particles at 10 times magnification per Moog Standard Receiving Inspection Plan. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- o The solenoid valve housing raw material is ultrasonically inspected per MIL-I-8950, Class A. The housing is penetrant inspected per EP 2067. (All Failure Causes)

- o The solenoid valve cover is penetrant inspected per EP 2067. (All Failure Causes)

- o The fitted bushing and spool are magnetic particle inspected per ASTM E1444. (All Failure Causes)

- o The dimensions of the solenoid valve ball and seat are inspected per Moog QAP 801-001-100. (All Failure Causes)

- o The dimensions of the armature return spring and the spool return spring are inspected per Moog Standard Receiving Inspection Plan. (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
  -

    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 Processes/Inspections:

  - Heat Treat, Pressure Orifice, per EP 1256
  - Heat Treat, Armature Return Spring, Spool Return Spring per EP 3389
  - Demagnetization, Armature Return Spring, Spool Return Spring, per 110-46639
  - Ultrasonic Inspection, Valve Housing, MIL-I-8950
  - Penetrant Inspection, Valve Housing, EP 2067
  - Magnetic Particle Inspection, Fitted Bushing and Spool, ASTM E1444

.

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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- 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. (Excessive Leakage Due to Damaged or Contaminated Valve Seat)

- o Both SRB individual channel null test and actuator individual channel ramp test are performed per OMRSD File II, Vol. 1 Requirement Numbers S00000.670 and .680 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.