SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Pressure Switching Valve Assembly, Part of Servoactuator

PART NO.: A22089 (Switch, Pressure), A20434-3 (Connector, Electrical)

FM CODE: A05

ITEM CODE: 20-02-01

REVISION: 3

CRITICALITY CATEGORY: 1R

REACTION TIME: Seconds

NO. REQUIRED: 2 (one per actuator)

DATE: March 1, 2002

CRITICAL PHASES: Boost

SUPERCEDES: March 31, 1999

FMEA PAGE NO.: A-182

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FAILURE MODE AND CAUSES: Unwanted or continuous output of the pressure operated switch to APU controller caused by:

- o Switch contacts shorted
- o Shorted wiring or connector
- o Defective switch return mechanism
- o Plunger jammed due to contamination
- o Improper adjustment

FAILURE EFFECT SUMMARY: Loss of capability to command the redundant APU to operate at one hundred ten percent speed if required. Degraded Thrust Vector Control performance will result in vehicle breakup and loss of mission and crew. One success path remains after the first failure. Operation is not affected until both paths are lost.

REDUNDANCY SCREENS AND MEASUREMENTS:

- o Pass - ATP is conducted on all units. Operation is verified during ATP.

- o Pass - Unwanted or continuous output is detectable by actuator primary pressure OK measurements B58X1859X and B58X1860X, by APU turbine speed measurements B46R1406C through B46R1409C and hydraulic supply pressure measurements B58P1303C and B58P1304C.

- o Fail - Fluid contamination

RATIONALE FOR RETENTION:

A. DESIGN

- The Pressure Switching 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. (All Failure Causes)

- The pressure switch monitors primary supply pressure when the switching valve is in the primary position. The pressure switch monitors primary return pressure when the switching valve is in the secondary position. (All Failure Causes)

- The switch is designed to close with an increasing pressure at 2300-2600 psig and to open with a decreasing pressure at 1900-2200 psig. The unit is rated for an operating pressure of 3250 psig., a proof pressure of 4875 psig, and a burst pressure of 8125 psig. The switch is capable of withstanding 100,000 pressure cycles between 200 and 4000 psig. (All Failure causes)

- Switch contacts and return mechanism are designed and constructed to resist vibration and shock and to function normally after 1000 switching cycles at the operating currents of .10 amp. Since the contacts operate at 28VDC, the possibility of shorting due to arcing is minimal. (Switch Contacts Shorted, Defective Switch Return Mechanism, Improper Adjustment)

- Conductors are AWG 24, nickel plated copper. Soldering meets the requirements of NASA NHB 5300.4 (3A-1) or NHB 5300.4(3A-2). Lead wires are supported and routed directly to a separate external connector located on the cover of the servoactuator. The electrical connector is a sealed, underwater type that has been qualified for SRB applications. The insulation resistance at 500 VDC under any combination of environmental conditions exceeds 50 megohms. The pressure switch will withstand the application of 500 volts RMS between lead wires and case without breakdown or leakage exceeding 500 microamps. (Shorted Wiring or Connector, Switch Contacts Shorted)

- The manufacturer adjusts the pressure switch for specified closing and opening pressure and for proper contact pressure and travel prior to sealing the component. Adjustments are verified by testing the component. (Improper Adjustment, Defective Switch Return Mechanism)

- The pressure switching valve switches from primary position to secondary position when primary supply pressure decays to a range of 1900 to 2200 psig. Switching back from secondary to primary position occurs within a range of 2300 to 2600 psig. Switching initiation has a hydromechanical time delay of 50 milliseconds, with mechanical switching of the spool required to be completed within 100 milliseconds. (Improper Adjustment, Defective Switch Return Mechanism)

o The pressure switching 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 Moog conducts tests on each pressure switch received from the manufacturer per QAP 801-001-100. (All Failure Causes)

o The Pressure Switching Valve Assembly (with pressure switch) installed in the servoactuator is subjected to acceptance testing in accordance with Moog Report MR A-2406. These tests include: (All Failure Causes)

- Proof Pressure Tests
- Switching Valve Performance Tests
- Cleanliness
- Dielectric Strength Test
- Insulation Resistance Test
- Examination of Product includes Connectors

o Refurbished servoactuators are tested as follows: (All Failure Causes)

- Proof Load Test per Moog EI -1037.

- 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.

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. (Plunger Jammed due to 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. (Plunger Jammed due to Contamination)

o Effluent hydraulic fluid is verified for moisture content and composition (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. (Plunger Jammed due to Contamination)

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

- Actuator null, linearity and polarity and servovalve 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. (Plunger Jammed due to Contamination)

- 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)

- 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)

- 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. (Frt/Step Response Test). (All Failure Causes)

- 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 numbers S00FSO.030 and S00FRO.070 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

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

- o USA SRBE PQAR verifies that hydraulic fluid is inspected for contamination before servoactuator is loaded per USA SRBE SIP 1127. (Plunger Jammed due to Contamination)

- o USA SRBE PQAR verifies vendor materials certification and assures vendor buy off of dimensions and cleaning per USA SRBE SIP 1127. (Defective Switch Return Mechanism, Improper Adjustment)

- 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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  - 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:

  - None

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. (Plunger Jammed due to Contamination)

- 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. (Plunger Jammed due to 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. (Plunger Jammed due to Contamination)

- o Proper function of TVC system is demonstrated, both electrically and mechanically, during hotfire using hydrazine as power source 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. (Plunger Jammed due to Contamination)

- o SRB TVC actuator positioning test is performed per OMRSD File II, Vol. 1 Requirement Number S00000.650. (Plunger Jammed due to Contamination)

- o Both SRB individual channel null test and actuator individual channel ramp tests are performed per OMRSD File II, Vol. 1 Requirement Number S00000.670 and .680 respectively. (Plunger Jammed due to Contamination)

- o Both SRB actuator frequency response and step response tests are verified per OMRSD File II, Vol. 1 Requirement Numbers S00000.720 and .750 respectively. (Plunger Jammed due to Contamination)

D. FAILURE HISTORY

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

E. OPERATIONAL USE

- Not applicable to this failure mode.