

SRB CRITICAL ITEMS LIST

SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Solenoid Isolation Valve Assembly,
Part of Servoactuator

PART NO.: A05745 (Solenoid Valve Assembly), A05364-1J (Bush-
ing, Spool and Sleeve Assembly), A07720 (Spring, Compression),
A07820 (Coil) FM CODE: A03

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 31, 1999

FMEA PAGE NO.: A-188 ANALYST: K. Schroeder/S. Finnegan

SHEET 1 OF 8 APPROVED: S. Parvathaneni

CN 044

FAILURE MODE AND CAUSES: One or more isolation valves fail to isolate when required including failure of two*, three, or four associated servovalves caused by:

- o Coil open or shorted
- o Jammed armature
- o Spool seized due to contamination
- o Broken or shorted wiring or connector
- o Pilot valve filter clogged
- o Supply pressure passage to solenoid blocked by contaminant
- o Supply pressure blocked from spool end area by contaminant

FAILURE EFFECT SUMMARY: Loss of capability to isolate failed servovalves leading to loss of actuator control 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. Operation is not affected until four paths are lost.

*NOTE: Failure of two servovalves is critical if both servovalves are hardover in the same direction. If the servovalves are failed hardover in the opposite direction, it is not critical for two failed servovalves.

REDUNDANCY SCREENS AND MEASUREMENTS:

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

- o Pass - Redundancy is verified by delta pressure measurements B58P1311A through B58P1318A; isolation valve command measurements V79X5100X, V79X5101X, V79X5105X, V79X5106X, V79X5110X, V79X5111X, V79X5115X, V79X5116X, and by actuator position measurements B58H1150C and B58H1151C.

- o Fail - Fluid contamination.

RATIONALE FOR RETENTION:

A. DESIGN

- o The Solenoid Isolation Valve 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. (All Failure Causes)
- o Solenoid coil wires are varnish insulated, vacuum impregnated, glass yarn wrapped, epoxy coated and are designed to withstand, continuously, an applied voltage up to 32.0 vdc. The minimum coil circuit insulation resistance is 50 megohms measured at 500 vdc. The coil and associated wiring insulation and connector are designed to a dielectric strength requirement of 500 microamp maximum leakage when tested at 500V rms, 60 Hz. (Coil Open or Shorted, Broken or Shorted Wiring or Connector)
- o For protection and forming, the coil is wound on a form made of diallyl-pthalate material. (Coil Open or Shorted)
- o The coil lead wires soldering meets the requirements of NHB 5300.4(3A-1) or 5300.4(3A-2) and potted to coil form. The lead wires are nickel plated copper conductor Teflon insulated rated at 600 Vdc at 200°C. To prevent damage, lead wires are covered with heat shrink tubing and are routed and supported between the coil and the connector. (Broken Shorted Wiring or Connector)
- o Electrical connectors are sealed, underwater types that have been qualified for SRB applications. (Broken or Shorted Wiring or Connector)
- o The armature to armature guide clearance is 0.00075 inches which is at least 4.5 times larger than filter entrapment capability. The guide and armature surfaces are finished to 16 rms. (Jammed Armature Spool Seized due to Contamination)
- o The armature return spring is made of 17-7PH CRES heat treated to condition CH900, passivated and demagnetized. (Jammed Armature)
- o The valve seat is protected by a 304 CRES filter rated at 100 microns and backed by a 160 micron screen. Further contamination protection is provided by a 44 micron downstream filter made of 316 CRES. fluid is supplied via the 5 micron absolute input system filter and the 10 micron (15 micron absolute) servovalve inlet filter. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage to Solenoid Blocked by Contaminant, Pilot Valve Filter Clogged, Spool Seized due to Contamination)

- 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 per Moog QAP 803-001-100. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage to Solenoid Blocked by Contaminant, Pilot Valve Filter Clogged, Spool Seized due to Contamination)
- o A spool-to-bushing diametrical clearance of 100 to 170 microinches is thirty times larger than maximum filter entrapment capability. (Spool Seized due to Contamination)
- o Supply pressure passages to solenoid are 0.093" in diameter which is approximately 23 times larger than 100 microns (230 times larger than the 10 micron absolute filter).
- o 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 per 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. (Spool Seized due to Contamination, Pilot Valve Filter Clogged, Supply Pressure Passage to Solenoid Blocked by Contaminant, Supply Pressure Block from Spool End Area by Contaminant)

- 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- o Hydraulic fluid is sampled for purity and particulate count prior to introduction to on-board Hydraulic circuits per 10REQ-0021, para. 2.3.2.6. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- o Actuator null, linearity and polarity and 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 B42HP0.010. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- 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 S00000.680. (Individual Channel Null and Ramp Test). (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 actuator ATP per 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- o USA SRBE PQAR verifies material certifications per USA SRBE SIP 1127. (Coil Open or Shorted)
- o USA SRBE PQAR verifies traceability records per USA SRBE SIP 1127. (All Failure Causes)
- o USA SRBE PQAR verifies assembly operations per USA SRBE SIP 1127. (All Failure Causes)
- o The pressure orifice assembly disc filter is inspected for loose particles at 20 times magnification per Moog Standard Receiving Inspection Manual 810-001-100. (Pilot Valve Filter Clogged)
- o The downstream filter is inspected for loose particles at 10 times magnification per Moog Standard Receiving Inspection Manual 810-001-100. (Supply Pressure Blocked from Spool End Area by Contaminant)
- o The solenoid valve housing raw material is ultrasonically inspected per MIL-I-8985, Class A. The housing is penetrant inspected per EP2067. (Supply Pressure Blocked from Spool End Area by Contaminant, Jammed Armature)
- o The solenoid valve cover is penetrant inspected per EP2067. (Coil Open or Shorted)
- o The bushing and spool are magnetic particle inspected per ASTM E1444. (Spool Seized due to Contamination)

- 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
 -
 - 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. CN 044
- 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:
 - Ultrasonic Inspection, Housing, per MIL-I-8950, Class A.
 - Penetrant Inspection, Housing, Cover, per EP 2067
 - Magnetic Particle Inspection, Bushing, Spool, per ASTM E1444
 - Demagnetization, Return Spring, per A07720
 - Material treatments for armature return spring, heat treat per EP 3389, Passivation per EP 3204 and demagnetization per 110-46639.
 - Soldering inspection, for coil per 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)

- 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- 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. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)
- o Both SRB individual channel null test and actuator individual channel ramp tests are performed per OMRSD File II, Vol. 1 Requirement Numbers S00000.670 and .680 respectively. (Supply Pressure Blocked from Spool End Area by Contaminant, Supply Pressure Passage of Solenoid Blocked by Contaminant, Spool Seized due to Contamination, Pilot Valve Filter Clogged)

D. FAILURE HISTORY

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

E. OPERATIONAL USE

- Not applicable to this failure mode.

THIS PAGE INTENTIONALLY LEFT BLANK.