

SRB CRITICAL ITEMS LIST

SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Feedback Linkages,  
Part of Servoactuator

PART NO.: A39264-1 (Feedback Arms Assembly), A07996 (Compression Spring), A22475 (Feedback Link), 093-78893 (Pin, Flanged) A05843-2 (Bellcrank and Roller Assembly), A24535 (Cam) FM CODE: A03

ITEM CODE: 20-02-08 REVISION: Basic

CRITICALITY CATEGORY: 1 REACTION TIME: Seconds

NO. REQUIRED: 2 (one per actuator) DATE: March 1, 2002

CRITICAL PHASES: Boost SUPERCEDES: March 1, 1993

FMEA PAGE NO.: A-213 ANALYST: K. Schroeder/S. Finnegan

SHEET 1 OF 6 APPROVED: S. Parvathaneni

CN 044

FAILURE MODE AND CAUSES: Failure of mechanical feedback to four servovalves caused by:

- o Broken feedback arms assembly
- o Broken or damaged link or attachment pins
- o Broken bellcrank
- o Damaged cam
- o Broken spring

FAILURE EFFECT SUMMARY: All four actuator servovalves will be isolated leading to actuator going hardover. Loss of Thrust Vector Control will lead to loss of vehicle, mission and crew.

RATIONALE FOR RETENTION:

A. DESIGN

- o Material selection is in compliance with MSFC-SPEC-522A. (All Failure Causes)
- o The servoactuator feedback linkages are designed to withstand, without damage or impairment of performance, the transmitted induced environments specified in USA SRBE 10SPC-0055, including nozzle induced vibration, exposure to the transmitted shocks, the aft skirt and nozzle induced shocks

(including ordnance, SRB parachute deployment and SRB water landing) and water entry loads. (All Failure Causes)

- o The feedback linkages are designed to a service life of (per 10SPC-0055): (All Failure Causes)
  - 200,000 cycles,  $\pm 0.01$  inch displacement at 10.0 Hz.
  - 200,000 cycles,  $\pm 0.25$  inch displacement at 10.0 Hz
  - 4,000 cycles,  $\pm 1.0$  inch displacement at 0.25 Hz
  - 400 cycles,  $\pm 6.0$  inch displacement at 0.1 Hz
- o The feedback arms assembly lower and upper arms are made of 6061-T6, T651, T6510 or T6511 aluminum alloy and chromic acid anodized. The feedback arms joint pin is made from A286 CRES. All five assembly ball bearings are heat treated. The ball bearings are lubricated and sealed by the bearing vendor. The feedback arms are traceable by lot number. (Broken Feedback Arms Assembly, Broken Spring)
- o The feedback arms support bracket is made from 6061-T6 or T651 aluminum alloy and is chromic acid anodized. The feedback, arm is shimmed to remove axial play at the joint. The feedback arms assembly is traceable by the support bracket serial number. (Broken or Damaged Link or Attachment Pins)
- o The feedback cam is made from A286 CRES and is passivated. The conically shaped cam is installed in the retract side of the main piston, supported by bearings at either end and shimmed to minimize end-play. The bearings permit 360 degree rotation of the piston without affecting operation of the mechanical position feedback mechanism. The cam is machined with integral shoulders at the outside diameter. The shoulders provide mechanical support within the piston rod inside diameter to minimize cam shift and resolution actuator piston shift in the event of a cam failure. (Damaged Cam)
- o The feedback arm rollers are held against the cam by four parallel springs contained by spring seats in the lower and upper arms. The springs are made from 17-7PH CRES, heat treated to condition CH900. The springs are traceable by lot number. (Broken Spring)
- o The feedback link is made of Aluminum Alloy 6061-T6, T651, T6510 or T6511 material and chromic acid anodized. The attach surfaces are finished to a surface finish of 32 rms. The attachment pins are made of 17-4 PH CRES and heat treated. The link and pins are traceable by lot number. (Broken or Damaged Link or Attachment Pins)
- o The bellcrank is a one piece construction from Aluminum Alloy 6061-T6, T651 or T6511 material and chromic acid anodized. The bellcrank roller is made from 17-4 PH CRES and heat treated to condition H1025. The roller is attached to the bellcrank by a swaged pin made of A286 CRES material and passivated. The bellcrank assembly is traceable by lot number. (Broken Bellcrank)

- o Fracture Mechanics Analysis was conducted per Fracture Mechanics Report for SRB TVC servoactuator, Battelle Laboratories, 4-30-78. (All Failure Causes except Broken Spring)
- o The feedback linkages, as part of the servoactuator, were 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 MR A-2406. This procedure includes: (All Failure Causes)
  - System Stability
  - Static Performance
  - Failure Response
  - Dynamic Acceptance Tests, Actuator Assembly
- 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. (All Failure Causes)

### KSC RELATED TESTING

- o Functional operation of the actuators is performed during hotfire per 10REQ-0021, para. 2.3.16.3. (All Failure Causes)
- o Actuator null, linearity and polarity and servovalve redundancy verification tests are performed per 10REQ-0021, para. 2.3.14. (All Failure Causes)
- 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 Null and Ramp 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 by OMRSD File II, Vol. 1, Requirement Number S00FS0.030 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 Acceptance tests are witnessed by USA SRBE PQAR per USA SRBE SIP 1127. (All Failure Causes)
- o USA SRBE PQAR verifies material certifications per USA SRBE SIP 1127. (All Failure Causes)
- 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 upper and lower feedback arms are etched and penetrant inspected per EP2067. (Broken Feedback Arms Assembly)
- o The feedback arms' assembly support bracket is etched and penetrant inspected per EP2067. (Broken Feedback Arms Assembly)
- o The feedback link is etched and penetrant inspected per EP2067. (Broken Feedback Arms Assembly)
- o The bellcrank is etched and penetrant inspected per EP2067. (Broken Bellcrank)
- o The feedback cam raw material is ultrasonically inspected per MIL-I-8950, Class A. The cam is etched and penetrant inspected per EP2067. (Damaged Cam)

- 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 repairs are processed by the cognizant Material Review Board.
  - Reassembly per the same procedures and controls as new hardware.
- o Critical Processes/Inspections:
  - Anodizing, Upper Feedback Arm, Lower Feedback Arm, Arms Support Bracket, Feedback Link, Bellcrank, per EP3203.
  - Heat Treat, Ball Bearings per MIL-H-6875, Cam Roller per EP3202, Feedback Arms Springs per EP3389, and Attach Pins, Bellcrank Roller per EP3233.
  - Chrome Plating, Pin roller Cam follower per QQ-C-320, Class 2.
  - Passivation, Cam Following Rollers, Feedback Cam per EP 3204.
  - Stress Relief Cam Follower, per EP 3211.
  - Penetrant Inspection, Upper Feedback Arm, Lower Feedback Arm, Support Bracket, Feedback Link, Bellcrank, Feedback Cam per EP2067
  - Ultrasonic Inspection, Feedback Cam Material per MIL-I-8950, Class A.

#### KSC RELATED INSPECTIONS

- o Proper function of TVC system is demonstrated during hotfire per 10REQ-0021, para. 2.3.16. (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 Number S00000.670 and .680 respectively. (All Failure Causes)
- o Both SRB actuator frequency response and step response tests are verified per OMRSD File II, Vol. 1 Requirement Numbers S0000.720 and .750 respectively. (All Failure Causes)

D. FAILURE HISTORY

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

E. OPERATIONAL USE

- o Not applicable to this failure mode.