SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: Structure and Housings, Part of Servoactuator

PART NO.: A22933-3 (Rod End and Bearing Assembly), A07431-2 (Tailstock and Bearing Assembly), 10208-0003-001 (Stud/Clevis Pin)

FM CODE: A01

ITEM CODE: 20-02-07

REVISION: Basic

CRITICALITY CATEGORY: 1

REACTION TIME: Seconds

NO. REQUIRED: 2 Sets (one per actuator)

DATE: March 1, 2002

CRITICAL PHASES: Boost

SUPERCEDES: March 1, 1993

FMEA PAGE NO.: A-206

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SHEET 1 OF 5

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FAILURE MODE AND CAUSES: Structural failure of rod end and bearing assembly, tailstock and bearing assembly, or clevis pin(s) caused by:

- Defective material
- Manufacturing defects
- Fatigue

FAILURE EFFECT SUMMARY: Loss of actuator control and possible damage to SRB and SRM nozzle. Loss of Thrust Vector Control (TVC) will lead to vehicle breakup and loss of mission and crew.

RATIONALE FOR RETENTION:

A. DESIGN

- The Structure and Housings are 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)

- Rod end material is Inconel 718, grade A forging, solution heat treated after forging, heat treated after rough machining, and is traceable by serial number. (All Failure Causes)

- Clevis pin is made of Inconel 718, ultrasonically inspected, finished clevis pin is Eddy current inspected. Pin materials, overall dimensions

and nozzle clevis configurations are controlled by interface control document (ICD-3-44003). (All Failure Causes)

- o Spherical ball of the rod end and tailstock bearings is made of Inconel 718, solution heat treated, age hardened after machining, chrome plated and hydrogen embrittlement relieved, penetrant inspected before assembly, radial load limit is 175,000 pounds, along axis of bore 24,000 pounds and traceable by serial number. (All Failure Causes)

- o Outer race of the rod end and tailstock bearings is made of A-286 CRES, solution heat treated, age hardened after machining, penetrant inspected before assembly, liner is made of teflon, radial load limit is 175,000 pounds, along axis of bore 24,000 pounds and traceable by serial number. (All Failure Causes)

- o Tailstock material is 6AL-4V titanium alloy, annealed before machining, with a yield strength 120,000 psi, tensile strength 130,000 psi minimum and traceable by serial number. (All Failure Causes)

- o Fracture Mechanics Analysis was conducted per Fracture Mechanics Report for SRB TVC Servoactuator, Battelle Laboratories, 4-30-78. (All Failure Causes)

- o The rod end and tailstock, 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 Servoactuator acceptance tests are performed per Moog Report MR A-2406. This procedure includes: (All Failure Causes)

  - Proof Pressure
  - Examination of Product

- 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.

o Actuator rod end and tailstock bearings are tested for backlash during the refurbishment cycle per 10SPC-0131. (All Failure Causes)

KSC RELATED TESTING

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

o The above referenced OMRSD testing is performed every flight.

C. INSPECTION

VENDOR RELATED INSPECTIONS

o Servoactuator acceptance tests are witnessed by USA SRBE PQAR per USA SRBE SIP 1127. (All Failure Causes)

o USA SRBE PQAR performs final visual inspection of servoactuator per USA SRBE SIP 1127. (Manufacturing Defects)

o USA SRBE PQAR verifies material certifications of servoactuator per USA SRBE SIP 1127. (Defective Material)

o USA SRBE PQAR verifies traceability records per USA SRBE SIP 1127. (Defective Material)

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.

- Clevis pin is inspected for scratches, corrosion and thread damage and refurbished per 10SPC-0131.

o Critical Processes/Inspections:

- Solution Heat Treat, Rod End, Tailstock, Rod End Ball, Tailstock Ball, Rod End Race, Tailstock Race, per AMS 5664, 5662 and 5373.

- Heat Treat, Rod End, Tailstock, Rod End Ball, Tailstock Ball, Tailstock Race, per MIL-T-9047, AMS 5662 and 5373.

- Age Hardening, Rod End, Rod End Ball, Rod End Race, Tailstock, Tail- stock Ball, Tailstock Race and Stud per AMS 5664, 5662 and 5373.

- Penetrant Inspection, Rod End, Rod End Ball, Rod End Race, Tail- stock, Tailstock Ball, Tailstock Race, per EP2067 or MIL-I-6866.

- Passivation, Rod End Race, per EP3204.

- Embrittlement Relief, Rod End Ball, Tailstock Ball, per QQ-C-320, Class 2D.

- Ultrasonic Inspection, Clevis Pin, per MIL-I-8950B, Class A.

- Eddy Current Inspection, Clevis Pin, per ASTM-E426.

KSC RELATED INSPECTIONS

o Torque/lockwire verification is performed during installation of actuator attachment studs, washer and nut per assembly drawing 10REQ-0021, para. 2.1.4 and per OMRSD File V, Vol. 1, Requirement Numbers B42GEN.010 and .020. (Manufacturing Defects)

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. (All Failure Causes)

D. FAILURE HISTORY

- Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- Not applicable to this failure mode.