

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**  
**NUMBER: 02-2B-A01-SW -X**

**SUBSYSTEM NAME: FLIGHT CONTROL - TVC ACTUATOR**

**REVISION: 2      07/18/94**

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**PART DATA**

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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: SSME TVC ACTUATOR	MC621-0015
SRU	: SWITCHING VALVE MOOG	A39300

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**QUANTITY OF LIKE ITEMS: 6**  
**ONE PER ACTUATOR**

**FUNCTION:**

AUTOMATICALLY PROVIDES POWER FROM EITHER OF TWO HYDRAULIC SYSTEMS. THE VALVE SENSES AN ACTIVE SYSTEM LOSS AND AUTOMATICALLY SWITCHES TO THE STANDBY SYSTEM. THE VALVE WILL RESET IF THE FAILED SYSTEM REGAINS ITS PROPER PRESSURE LEVEL. VALVE SPOOL POSITION IS PROVIDED.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE**  
**NUMBER: 02-2B-A01-SW-05**

REVISION# 2 07/18/94

SUBSYSTEM NAME: FLIGHT CONTROL - TVC ACTUATOR

LRU: SSME TVC ACTUATOR

ITEM NAME: SWITCHING VALVE

CRITICALITY OF THIS  
FAILURE MODE: 1/1

**FAILURE MODE:**  
JAMS IN INTERMEDIATE POSITION

**MISSION PHASE:**

PL PRELAUNCH  
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

**CAUSE:**  
CONTAMINATION, JAMMED

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) N/A  
B) N/A  
C) N/A

**PASS/FAIL RATIONALE:**

A)  
B)  
C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**  
LOSS OF ELEVON ACTUATOR.

**(B) INTERFACING SUBSYSTEM(S):**  
SSME

**(C) MISSION:**  
POSSIBLE LOSS OF MISSION  
PRE-LAUNCH - LAUNCH SCRUB IF FAILURE OCCURS DURING APU START SEQUENCE.  
GIMBALING CHECKOUT WILL SCREEN FOR ANY FAILURES THAT OCCUR DURING  
SWITCHING VALVE ACTIVITY DURING APU START SEQUENCE. IF ENGINE #1  
PITCH IS NEAR THE POSITIVE STOP AND NOT RESPONDING DUE TO SWITCHING

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VALVE JAMMED IN INTERMEDIATE POSITION, THE POSSIBILITY EXISTS FOR ENGINE CONTACT DURING PROFILE. SHOULD ENGINE COLLISION OCCUR, THERE IS A POSSIBILITY OF DAMAGE AND A RELEASE OF HYDROGEN AND SUBSEQUENT FIRE/EXPLOSION.

ASCENT - IF AN ACTUATOR IS STALLED BY A JAMMED SWITCHING VALVE AND FLIGHT CONTROL MOVEMENT IS REQUIRED TO MAKE A FLIGHT ATTITUDE CORRECTION, THEN A POSSIBLE LOSS OF VEHICLE MAY OCCUR.

DESCENT - A STALLED ACTUATOR MAY PREVENT THE SSME'S FROM BEING RESTORED FOR ENTRY AND REPOSITION FOR DRAG CHUTE DEPLOYMENT AND HARDWARE MAY BE DAMAGED.

**(D) CREW, VEHICLE, AND ELEMENT(S):**  
SAME AS (C)

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
LOSS OF CREW/VEHICLE FOR FIRST FAILURE. IF CONTAMINATION IS PRESENT, SPOOL CAN JAM IN AN INTERMEDIATE POSITION AND BLOCK SUPPLY OR RETURN PORTS. LOSS OF SUPPLY PRESSURE TO AND RETURN FROM A TVC ACTUATOR CAN RESULT IN LOSS OF VEHICLE CONTROL ON ASCENT.

MPS ENGINE TVC ACTUATORS PROFILE CHECK WILL ASCERTAIN CORRECT POSITION OF SWITCHING VALVES PRIOR TO LAUNCH.

LOSS OF CREW/VEHICLE IF SWITCHING VALVE BLOCKS PRESSURE AND RETURN PORTS AFTER LOSS OF AN APU OR LOSS OF A HYDRAULIC SYSTEM (1R2).

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**  
SPOOL AND SLEEVE ARE 440C MATERIAL, HARDENED AND LAPPED FOR A MATCHED SET. SPOOL IS GROOVED TO CLEAR SILTING. EACH HYDRAULIC SYSTEM HAS A 5 MICRON FILTER UPSTREAM OF ACTUATOR THAT PROTECTS THE SWITCHING VALVE FROM CONTAMINATION. FORCE DEVELOPED ON SWITCHING VALVE SPOOL IS IN EXCESS OF 500 POUNDS TO CLEAR CONTAMINATION.

**(B) TEST:**  
**QUALIFICATION:**  
20,000 SWITCHING CYCLES PERFORMED. ACTUATOR WAS VIBRATED TO FLIGHT LEVELS. ACTUATOR WAS STABILIZED AT -65 DEG F FOR 3 HOURS AND THEN THE TEMPERATURE WAS RAISED TO OPERATING TEMPERATURE OF 60 DEG F AND FURTHER TESTING WAS CONDUCTED WITHIN THE OPERATING RANGE OF 60 DEG F TO 230 DEG F. 100,000 PRESSURE IMPULSE CYCLES AT EACH SUPPLY AND RETURN PORT, AT 230 DEGREES F. SUPPLY PORTS WERE CYCLED FROM 3,000 PSIG TO 4,500 PSIG TO 1,500 PSIG, BACK TO 3,000 PSIG EACH CYCLE; RETURN PORTS, FROM 750 PSIG TO 1,500 PSIG TO 0 PSIG, BACK TO 750 PSIG. VERIFIED THAT ALL PARTS WERE WITHIN ACCEPTABLE LIMITS DURING DISASSEMBLY AND INSPECTION AT COMPLETION OF QUALIFICATION.

**ACCEPTANCE:**  
FOUR SWITCHING VALVE CYCLES AT HIGH (MAIN PUMP) AND LOW (CIRCULATION PUMP) PRESSURES. PERFORMANCE TESTS VERIFIES SWITCHING VALVE IS OPERATIONAL.

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FLUID FROM ACTUATOR IS VERIFIED TO MEET CLEANLINESS LEVEL 190 PER MA01 10-301.

OMRSD:  
ACTUATOR SWITCHING VALVE CHECK, PERFORMED PRIOR TO EACH MISSION.  
HYDRAULIC FLUID SAMPLES ARE TAKEN AFTER EVERY FLIGHT AND VERIFIED TO BE WITHIN SPECIFIED CLEANLINESS LEVELS.

**(C) INSPECTION:**  
RECEIVING INSPECTION  
RAW MATERIAL VERIFICATION ARE VERIFIED. SPECIAL MATERIAL REQUIREMENTS ARE IDENTIFIED IN CERTIFICATIONS.

NONDESTRUCTIVE EVALUATION  
PIECE PARTS EVALUATED BY SELECTED PENETRANT, MAGNETIC PARTICLE, ULTRASONIC, AND RADIOGRAPHIC INSPECTIONS.

SPECIAL PROCESSES  
CRITICAL/CLOSE TOLERANCE DIMENSIONS AND FINISHES ARE 100 PERCENT INSPECTED FOLLOWING MACHINING.

CONTAMINATION CONTROL  
ASSEMBLY AREA CLEANLINESS IS VERIFIED BY CONTAMINATION CONTROL PLAN. COMPONENTS ARE PRECLEANED PRIOR TO ASSEMBLY. PARTS AND TOOLS/AIDS ARE CLEANED PRIOR TO ASSEMBLY. END ITEM FLUID SAMPLE IS VERIFIED PRIOR TO ACTUATOR DELIVERY.

TESTING  
ROCKWELL DESIGN AND QUALITY PERSONNEL, WITH NASA PARTICIPATION, CONDUCT A DETAILED ACCEPTANCE REVIEW OF THE HARDWARE AT THE VENDOR'S FACILITY, PRIOR TO THE SHIPMENT OF EACH END ITEM COVERED BY CONTROL PLAN. ATP VERIFICATION IS MIP FOR RI QA REPRESENTATIVE.

**(D) FAILURE HISTORY:**  
THERE IS NO HISTORY OF FAILURE FOR THIS FAILURE MODE.

**(E) OPERATIONAL USE:**  
NONE.

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**- APPROVALS -**

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EDITORIALLY APPROVED : RI  
EDITORIALLY APPROVED : JSC  
TECHNICAL APPROVAL : VIA CR

*[Signature]*  
*Michael C. [Signature]* August 3, 1994  
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