

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE  
NUMBER: 02-2B-A01-SP-X

SUBSYSTEM NAME: FLIGHT CONTROL MECHANISM -TVC ACTUATOR

REVISION: 0 03/25/94

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: TVC ACTUATOR	MC-621-0015
SRU	: SEC DIFF PRESSURE TRANSDUCER MOOG INC.	A24010

## PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
SECONDARY DIFFERENTIAL PRESSURE TRANSDUCER

REFERENCE DESIGNATORS: 50V58PV1  
50V58PV2  
50V58PV3  
50V58PV4  
50V58PV5  
50V58PV6

QUANTITY OF LIKE ITEMS: 24  
4 TRANSDUCERS PER ACTUATOR

## TYPICAL:

TOP PITCH --- 50V58PV1	YAW --- 50V58PV2
PITCH --- 50V58PV3	YAW --- 50V58PV4
PITCH --- 50V58PV5	YAW --- 50V58PV6

## FUNCTION:

THE TVC ACTUATORS (6) PROVIDE FORCE & CONTROL FOR POSITIONING THE SPACE SHUTTLE MAIN ENGINES.

THE TVC ACTUATOR SECONDARY DIFFERENTIAL PRESSURE TRANSDUCER SERVES TWO PURPOSES (1) FDI - AUTOBYPASS IF PRESSURE EXCEEDS 2025 PSID (TRIP LEVEL) AND (2) EQUALIZATION- BLANCES PRESSURE VARIANCES BETWEEN 4 CHANNELS. THESE SIGNALS PROVIDE A CLOSED LOOP OPERATION THROUGH INTERFACE WITH THE AVIONIC FLIGHT CONTROL SYSTEM.

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REVISION# 1 08/11/94

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LRU: TVC ACTUATOR  
ITEM NAME: SEC DIFF PRESSURE TRANSDUCER

CRITICALITY OF THIS  
FAILURE MODE: 1R2

FAILURE MODE:  
TRANSDUCER STUCK AT PRESSURE ABOVE EQUALIZATION DEADBAND AND BELOW  
TRIP (BYPASS) LEVEL.

MISSION PHASE:  
LO LIFT-OFF

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

CAUSE:  
STRUCTURE FAILURE, PARTICLE CONTAMINATION, GALLING, CORE DEBONDING

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS  
B) FAIL  
C) PASS

PASS/FAIL RATIONALE:  
A)

B)  
FAILS "B" SCREEN BECAUSE FAILURE MODE CAN MASK CHANNEL FAILURE, WHICH  
CONSISTS OF THE POSSIBILITY OF THE TRANSDUCER BECOMING STUCK AT A  
PRESSURE ABOVE EQUALIZATION DEADBAND AND BELOW TRIP (BYPASS) LEVEL. THIS  
RESULTS IN THE EQUALIZATION LOGIC DRIVING THE SECONDARY DELTA PRESSURE  
OUTPUT IN THE OPPOSITE DIRECTION. THE NEXT HARDOVER FAILURE IN THE SAME  
DIRECTION WILL CREATE A TWO ON TWO FORCE FIGHT AND LOSS OF ACTUATOR.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:  
NONE

(B) INTERFACING SUBSYSTEM(S):  
THIS FAILURE MODE CAN PROVIDE ERRONEOUS OUTPUT TO THE AVIONICS  
SUBSYSTEM.

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**(C) MISSION:**

FAILURE CAN RESULT IN MINIMUM DURATION FLIGHT(MDF)

**(D) CREW, VEHICLE, AND ELEMENT(S):**

NO EFFECT FOR ONE FAILURE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

FUNCTIONAL CRITICALITY EFFECTS- POSSIBLE LOSS OF CREW/VEHICLE AFTER SECOND UNDETECTED FAILURE. LOSS OF FUNCTION CAN RESULT IN LOSS OF VEHICLE CONTROL.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE TRANSDUCER PISTON IS MADE FROM 316 CRES, CHROME PLATED ON BEARING SURFACES TO PREVENT GALLING. HYDRAULIC FLUID ENTERING THE TRANSDUCER IS FILTERED BY A ( 5 MICRON ) HYDRAULIC SYSTEM FILTER TO PREVENT STICTION, DUE TO PARTICLE CONTAMINATION. ALL PARTS ARE CLEANED PRIOR TO ASSEMBLY.

**(B) TEST:**

**QUALIFICATION:**

ENDURANCE CYCLING- 400 MISSION DUTY CYCLES UNDER LOAD AT MAXIMUM TEMPERATURE OF 250 DEGREES F. ACTUATOR WAS VIBRATED AT FLIGHT LEVELS AND TESTED AT -65 AND 250 DEGREES F. 100,000 PRESSURE IMPULSE CYCLES AT EACH SUPPLY AND RETURN PORT, AT 225 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. PERFORMANCE RECORD TESTS CONDUCTED AT 35 AND 225 DEGREES F FOLLOWING ENDURANCE TESTING. VERIFIED THAT ALL PARTS WERE WITHIN ACCEPTABLE LIMITS DURING DISASSEMBLY AND INSPECTION AT COMPLETION OF QUALIFICATION.

**ACCEPTANCE:**

PERFORMANCE TESTS VERIFY DIFFERENTIAL PRESSURE TRANSDUCERS ARE OPERATIONAL.

**GROUND TURNAROUND TEST**

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION- RAW MATERIAL CERTIFICATIONS ARE VERIFIED. SPECIAL MATERIAL REQUIREMENTS ARE IDENTIFIED IN CERTIFICATIONS. END FITTING IS MANUFACTURED BY MOOG AND SUPPLIED TO TRANSDUCER VENDOR.

**NONDESTRUCTIVE EVALUATION: NONE PERFORMED**

**CRITICAL PROCESSES-VENDOR'S SOLDERING AND TIG WELDING PROCESSES ARE CONTROLLED BY MOOG. ALSO CLEANING AND BONDING PROCESSES ARE CONTROLLED BY MOOG.**

**SPECIAL PROCESSES-TRANSDUCER VENDOR COIL DESIGN AND MANUFACTURING PLANNERS ARE CONTROLLED BY MOOG.**

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ASSEMBLY/INSTALLATION-SAFETY WIRING AND TORQUING OPERATIONS ARE PERFORMED AND VERIFIED BY MANDATORY INSPECTIONS. SPECIALLY DESIGNED ASSEMBLY TOOLS/FIXTURES ARE REQUIRED BY ASSEMBLY DOCUMENTATION. CRIMP CONNECTIONS OF TRANSDUCER LEADS TO ELECTRICAL CONNECTORS ARE PERFORMED BY SPECIALLY TRAINED/CERTIFIED TECHNICIAN.

TESTING-ATP WITNESSED BY ROCKWELL QUALITY AND DCAS. TRANSDUCER ATP PERFORMED AT COMPONENT LEVEL AND AT ACTUATOR LEVEL. 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.

(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

PER STANDARD FCS CHANNEL MANAGEMENT (FLIGHT RULE 8-52), FAILED AND UNBYPASSED PORTS WILL BE ISOLATED WITH CREW ACTION TO TURN OFF THE AFFECTED FCS CHANNEL.

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- APPROVALS -

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EDITORIALLY APPROVED : RI  
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