

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0402 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 07/10/00**PART DATA**

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LH2 PREVALVE UNITED SPACE ALLIANCE-NSLD	MC284-0396-0008,-0010 73325000-117,-121

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, PRE, LH2 12 INCH PNEUMATICALLY OPERATED. INCORPORATES REVERSE FLOW RELIEF VALVE.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY FAIRCHILD COMPONENTS (NOW ORBITAL SCIENCES CORP.) BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PV4
PV5
PV6

QUANTITY OF LIKE ITEMS: 3

FUNCTION:

VALVE OPEN DURING CHILLDOWN AND INITIAL PHASES OF LOADING. MUST CLOSE FOR RECIRC OPERATION. REQ'D TO REMAIN OPEN FOR ENGINE OPERATION. ELECTRICAL CIRCUITRY LOCKOUT PREVENTS PREVALVE CLOSURE UNTIL THRUST CHAMBER PRESSURE DECAYS TO 30% LEVEL (30% PC LOCKOUT IS REMOVED DURING MECO). USED AS AN ISOLATION VALVE TO PROPELLANT FEED SYSTEM FOR A SHUTDOWN/FAILED SSME. VALVE IS REOPENED FOR DUMPS AND LEFT OPEN FOR RE/ENTRY. VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT VALVE SLAMMING DURING IMPROPER OPEN/CLOSE OPERATIONS. VALVE RELIEF SYSTEMS INCLUDE VISOR LIFTOFF AND A BYPASS RELIEF VALVE.

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LOSS OF POSITION INDICATION - OPEN POSITION INDICATION FAILS ON (LCC DECEPTION).

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:

POSITION SWITCH PIECE PART FAILURE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN	A) PASS
	B) FAIL
	C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS B SCREEN SINCE FAILURE INDICATION CANNOT BE READILY DISTINGUISHED FROM EXPECTED OUTPUT DURING LCC PERIOD.

C)

- FAILURE EFFECTS -**(A) SUBSYSTEM:**

NO EFFECT. CAPABILITY OF VALVE TO CONTROL FLUID FLOW IS NOT AFFECTED.

LCC VERIFIES THAT BOTH OPEN POSITION SWITCHES ARE OFF FROM INITIATION OF LH2 RECIRCULATION TO T-31 SECONDS. RSLs COMMANDS VALVE OPEN AT T- 9.5 SECONDS AND VERIFIES ONE OF TWO SWITCHES ARE ON AT T-7 SECONDS.

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(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
FIRST FAILURE - NO EFFECT.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/2, 2 SUCCESS PATHS. TIME FRAME - ENGINE START.
1) LH2 PREVALVE OPEN POSITION SWITCH FAILS ON AFTER T-31 SECONDS.
2) LH2 PREVALVE FAILS CLOSED.

POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO LACK OF LH2 DURING ENGINE START.
POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE
LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
TWO VALVE POSITION INDICATION MICROSWITCHES ARE PROVIDED TO MONITOR VALVE OPEN AND CLOSED POSITIONS. THE HERMETICALLY SEALED, CAM OPERATED MECHANICAL MICROSWITCHES ARE MOUNTED AND SECURED TO PLATES WITH TWO SCREWS. TWO SEPARATE TRIP LEVERS ON THE PLATES RIDE ON A CAM CONNECTED TO THE VALVE CLOSURE DEVICE SHAFT. THESE TRIP LEVERS ACTUATE THE MICROSWITCH EXTERNAL SPRING ARMS WHICH IN TURN ACTUATE THE SWITCH INTERNAL ELECTRICALLY CONDUCTING METALLIC SPRINGS WITH ELECTRICAL CONTACTS. THESE SPRINGS ARE ATTACHED TO TERMINAL POSTS WHICH ARE EXTERNALLY SOLDERED TO LEAD WIRES. THE EXTERNAL SWITCH SPRING ARMS MOVE A MINIMUM OF 0.0015 INCH BETWEEN THE ACTUATED AND DEACTUATED POSITIONS.

EACH SWITCH IS SCREENED AT CRYOGENIC TEMPERATURE BEFORE INSTALLATION TO VERIFY PERFORMANCE CHARACTERISTICS. NEWLY MANUFACTURED SWITCHES ARE SUBJECTED TO A PARTICLE IMPACT NOISE DETECTION TEST (PIND). PIND TESTED SWITCHES WILL BE IMPLEMENTED ON AN ATTRITION BASIS.

(B) TEST:
ATP

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ACTUATOR - AMBIENT PROOF (1275 PSIG); CRYO PROOF OF ACTUATOR FLANGE AND SHAFT SEALS (358 PSID); POSITION INDICATION; ELECTRICAL CHARACTERISTICS; AMBIENT AND CRYO RESPONSE TIME (NORMAL AND SLAM) AT 400 AND 740 PSIG ACTUATION PRESSURE; AMBIENT AND CRYO LEAKAGE (FROM PORT TO PORT); AMBIENT AND CRYO SHAFT SEAL LEAKAGE (PRIMARY AND SECONDARY) WITH 220 PSID ACROSS SEAL; AMBIENT AND CRYO EXTERNAL LEAKAGE.

RELIEF VALVE ASSEMBLY - AMBIENT PROOF (299 PSIG), AMBIENT AND CRYO CRACK AND RESEAT (15-50 PSID).

PREVALVE ASSEMBLY - POSITION INDICATION; ELECTRICAL CHARACTERISTICS; VALVE HOUSING AND VISOR AMBIENT PROOF (85 PSIG); VALVE HOUSING AND VISOR CRYO PROOF (143 PSID); ACTUATOR AMBIENT PROOF (1275 PSIG); AMBIENT AND CRYO EXTERNAL LEAKAGE (WITH VALVE BODY AT 60 PSIG AND ACTUATOR AT 740 PSIG); AMBIENT AND CRYO RESPONSE TIME AT 400 AND 740 PSIG ACTUATION PRESSURE; AMBIENT AND CRYO ACTUATOR LEAKAGE FROM PORT TO PORT; AMBIENT AND CRYO VALVE SHAFT SEAL (PRIMARY AND SECONDARY) LEAKAGE WITH 60 PSID ACROSS THE SEAL; AMBIENT AND CRYO VISOR LEAKAGE (INLET-TO-OUTLET WITH 50 PSID, OUTLET-TO-INLET WITH 5 PSID AMBIENT AND 15 PSID CRYO); AMBIENT RELIEF VALVE CRACK (6.7 TO 50 PSID) AND RESEAT (5 TO 50 PSID) WITH ACTUATOR CLOSE PRESSURE ON; CRYO RELIEF VALVE CRACK AND RESEAT (15 TO 50 PSID) WITH ACTUATOR CLOSE PRESSURE ON; AMBIENT VISOR LIFT-OFF (15 PSID MAX) WITH ACTUATOR VENTED.

CERTIFICATION

STRUCTURAL LOAD AT CRYO TEMPS (-400 DEG F) (AXIAL, SHEAR, TORSION, BENDING).

LIFE CYCLING (3050 AMBIENT CYCLES, 2050 CRYO CYCLES. ACTUATOR RECEIVED ADDITIONAL 300 AMBIENT AND 200 CRYO SLAM CYCLES); RELIEF VALVE LIFE (500 CYCLES AMBIENT, 500 CYCLES CRYO); ANTI-SLAM VALVE LIFE (2700 CYCLES AMBIENT, 1800 CYCLES CRYO).

THREE THERMAL CYCLES (70 DEG F TO -400 DEG F TO +200 DEG F TO 70 DEG F).

TRANSIENT SINUSOIDAL VIBRATION (AT 50 PSIG AND -250 DEG F); RANDOM VIBRATION (13.3 HRS IN EACH OF THREE AXES WITH VALVE OPEN AND AT 50 PSIG/LESS THAN -250 DEG F. OPEN PRESSURE WAS REMOVED DURING A PORTION OF THE TEST; SUBSEQUENTLY REPEATED TO CERTIFY THE ANTI-SLAM ACTUATOR). DESIGN SHOCK (18 SHOCKS OF 15G EACH - THREE IN EACH DIRECTION OF THREE AXES, ALL WITH VALVE OPEN AND ACTUATOR VENTED; REPEATED TO CERTIFY THE ANTI-SLAM ACTUATOR).

AMBIENT AND CRYO FUNCTIONAL, INTERNAL AND EXTERNAL LEAKAGE PERFORMANCE.

BURST (165 PSIG VALVE BODY, 1700 PSIG ACTUATOR).

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

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RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

VALVE IS CLEANED TO LEVEL 400 AND THE ACTUATOR IS CLEANED TO 400A.

ASSEMBLY/INSTALLATION

ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. LOG OF CLEAN ROOM AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. MICROSCOPIC EXAMINATION OF ALL DETAIL PARTS ARE MADE PRIOR TO ASSEMBLY. TORQUE REQUIREMENTS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURES.

CRITICAL PROCESSES

CRITICAL DIMENSIONS AND SURFACE FINISHES EXAMINED FROM 3X TO 7X MAGNIFICATION FOR MATERIAL DEFECTS.

NONDESTRUCTIVE EVALUATION

FLOW LINER WELD VISUALLY EXAMINED. THE VALVE BODY, PRIOR TO FINAL MACHINING, IS SUBJECTED TO DYE PENETRANT INSPECTION. REQUIREMENTS FOR DETAIL PARTS PENETRANT INSPECTION ARE BASED UPON CONFIGURATION MATERIAL, AND MANUFACTURING PROCESSES.

TESTING

ACCEPTANCE TEST PROCEDURES VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR CLEANLINESS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

DURING MPTA STATIC FIRING #1, THE ENGINE 2 LH2 PREVALVE CLOSED SWITCH INDICATED ON WHEN THE VALVE WAS OPEN (REFERENCE CAR AB0317). THE SWITCH WAS FOUND TO BE SENSITIVE TO CERTAIN CRYOGENIC TEMPERATURES. INSULATION WAS REMOVED FROM THE ACTUATOR TO PROVIDE A WARMER ENVIRONMENT FOR THE SWITCHES. THE INSULATION CHANGE WAS EFFECTIVE ON OV-102 AND SUBS.

LH2 PREVALVE CLOSED SWITCH INDICATIONS HAVE BEEN LOST MULTIPLE TIMES AFTER THE VALVE WAS CLOSED AT MECO. FAILURE INVESTIGATION ATTRIBUTED THE LOSS OF THE CLOSED INDICATION TO PREVALVE VISOR RELIEF OF DOWNSTREAM PRESSURE INTO THE MANIFOLD. AS THE VISOR LIFTS OFF ITS SEAT, THE MAIN SHAFT ROTATES, AND DEPENDING ON TOLERANCES, MAY DEACTUATE THE CLOSED SWITCH. THIS IS NOT CONSIDERED A FAILURE CONDITION.

DURING STS-51B (OV-099), THE LO2 PREVALVE OPEN SWITCH DID NOT INDICATE ON DURING THE MPS DUMP ALTHOUGH THE CLOSED INDICATION WAS OFF (REFERENCE CAR 24F016). THE MALFUNCTION WAS AN ISOLATED CASE AND COULD NOT BE REPRODUCED AT THE SUPPLIER. A NEW SWITCH WAS INSTALLED AND SUBSEQUENTLY PASSED ATP.

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

(E) OPERATIONAL USE:

FLIGHT: N/A

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: STUART KOBATA	: /S/ STUART KOBATA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: JEFFREY L. MUSLER	: /S/ JEFFREY L. MUSLER
USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	: /S/ BILL PRINCE