

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.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE**NUMBER: 03-1-0402-07****REVISION#:** 1 07/10/00**SUBSYSTEM NAME:** MAIN PROPULSION**LRU:** LH2 PREVALVE (PV4, PV5, PV6)**ITEM NAME:** LH2 PREVALVE (PV4, PV5, PV6)**CRITICALITY OF THIS****FAILURE MODE:** 1/1**FAILURE MODE:**

ERRONEOUS INDICATION. VALVE FAILED TO OPEN, BUT OPEN INDICATION IS ON.

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:

PIECE PART STRUCTURAL FAILURE OF THE ACTUATOR/VALVE LINKAGE.

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:**

FAILURE OF THE PREVALVE TO OPEN DUE TO ACTUATOR/VALVE LINKAGE FAILURE CAUSING ACTUATOR TO INDICATE OPEN WHILE VALVE IS ACTUALLY CLOSED. POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO LACK OF LH2 DURING ENGINE START. OCCURRENCE OF FAILURE IS DURING TERMINATION OF LH2 RECIRCULATION WHEN THE LH2 PREVALVE IS COMMANDED OPEN. WITH BOTH A PREVALVE AND RECIRCULATION VALVE CLOSED, ENGINE START CONDITIONS CAN STILL BE ACHIEVED (ENGINE INLET CONDITIONS WOULD BE WITHIN LCC LIMITS).

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NUMBER: 03-1-0402-07**

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:

DURING THE QUAL TEST PROGRAM THIS VALVE WAS CYCLED OPEN/CLOSE 5,204 TIMES UNDER BOTH CRYOGENIC AND AMBIENT TEMPERATURE CONDITIONS AND AT BOTH NORMAL AND ACCELERATED (SLAM) CYCLE TIMES; THIS REPRESENTS OVER 100 MISSIONS. THE MAIN VALVE SHAFT, THE DRIVE CYLINDER AND THE ACTUATOR SHAFT ARE OF CRES. THE ACTUATOR PINION GEAR (WHICH CONTAINS THE POSITION SWITCH ACTUATING PINS) IS OF COPPER BERYLLIUM. THE PINION GEAR IS SPLINED TO THE ACTUATOR SHAFT. FOR THE VALVE TO REMAIN CLOSED, BUT THE POSITION SWITCHES TO INDICATE OPEN, REQUIRES FRACTURE OF THE ACTUATOR SHAFT (BETWEEN THE PINION GEAR AND THE SPLINES), OR FAILURE OF THE ACTUATOR SHAFT/DRIVE CYLINDER SPLINE, OR FAILURE OF THE MAIN VALVE SHAFT/DRIVE CYLINDER SPLINE, OR FRACTURE OF EITHER THE DRIVE CYLINDER OR THE MAIN VALVE SHAFT. BASED UPON AN ANALYSIS PERFORMED BY THE VALVE MANUFACTURER, A POSITIVE MARGIN OF SAFETY EXISTS FOR THE ENTIRE POWER TRAIN, FROM THE ACTUATOR PINION TO THE MAIN VALVE, FOR ALL RANGES OF ACTUATOR PRESSURES.

(B) TEST:

ATP

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0402-07**

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:

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.

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

CRITICAL PROCESSES

HEAT TREATMENT AND DRY FILM LUBE APPLICATION ARE VERIFIED BY INSPECTION.

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:

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:

NO CREW ACTION CAN BE TAKEN.

- 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