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 / **VENDOR NAME**	**PART NUMBER** / **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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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 PREVALVE (PV4,PV5,PV6) **CRITICALITY OF THIS**
ITEM NAME: LH2 PREVALVE (PV4,PV5,PV6) **FAILURE MODE:** 1/1

FAILURE MODE:
FAILS TO REMAIN OPEN DURING ENGINE OPERATION.

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

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

CAUSE:
PIECE PART STRUCTURAL FAILURE.

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:
STOPS FUEL FLOW TO ONE SSME RESULTING IN A LO2 RICH ENGINE SHUTDOWN, PUMP CAVITATION & OVERSPEED. RESULTS IN UNCONTAINED ENGINE DAMAGE. POSSIBLE LINE RUPTURE DUE TO WATER HAMMER EFFECT (LINE PRESSURE EXCEEDS 150 PSI). POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE VALVE VISOR FRACTURE AND INGESTION INTO ENGINE (ENGINE INLET SCREENS MAY NOT CONTAIN PARTS OF THIS SIZE).

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE. VALVE FAILURE DURING CHILLDOWN AND INITIAL PHASES OF LOADING HAS NO EFFECT, POSSIBLE LAUNCH SCRUB.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:

-DISPOSITION RATIONALE-

(A) DESIGN:
DURING THE BOOST PHASE, THE PREVALVE IS MAINTAINED IN THE OPEN POSITION BY CONTINUOUS OPEN ACTUATION PRESSURE APPLIED TO THE ACTUATOR, AND THE CLOSING PRESSURE VENTED. IN ADDITION, THE VALVE VISOR IS HELD IN THE OPEN POSITION BY TWO MECHANICAL DETENTS. IF THE PNEUMATIC SYSTEM (OPEN COMMAND) WERE TO BE COMPLETELY VENTED, THE DETENTS WOULD BE SUFFICIENT TO RESTRAIN THE VISOR IN THE OPEN POSITION. A FULL FLOW LN2 DETENT VERIFICATION TEST HAS BEEN SUCCESSFULLY PERFORMED. DURING QUAL TESTING THE VALVE WAS VIBRATED IN ALL THREE AXES, WITH BOTH ACTUATOR PORTS VENTED, AND THE DETENTS HELD THE VISOR IN THE OPEN POSITION. THE VALVE DESIGN IS SUCH THAT THE VISOR IS COMPLETELY OUT OF THE FLOW STREAM WHEN IN THE OPEN POSITION; IT RESTS BEHIND A FLOW LINER.

(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.

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.

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

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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 VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR CLEANLINESS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
HAVE EXPERIENCED VALVE DAMAGE INTERNALLY IN OLDER CONFIGURATION OF THE VALVE (CRACK IN FLOW LINER, CAR A9981, AND MAIN SEAL FRACTURE, CAR AB6078) FROM INCORRECT OPERATION OF THE VALVE (VALVE ACTUATION WITHOUT SNUBBING PRESSURE IN ACTUATOR CAUSES SLAMMING OF THE VALVE). AN ANTI-SLAM MECHANISM HAS BEEN INSTALLED TO PREVENT VALVE DAMAGE DUE TO SLAMMING.

DURING INSPECTIONS, DETENT ROLLERS HAVE BEEN FOUND WITH UNEVEN WEAR. THE ROLLERS HAVE BEEN REWORKED/REPLACED WITH SPECIAL CONTOURED ROLLERS TO MATCH THE VISOR. THE OMRSD SPECIFIES PERIODIC SCREEN INSPECTION TO DETECT CONTAMINANTS GENERATED BY THE ROLLERS.

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

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USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	: /S/ BILL PRINCE