FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0436 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 07/27/00

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
LRU	: VALVE, RELIEF UNITED SPACE ALLIANCE - NSLD	MC284-0501-0002 5760074-101

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, RELIEF, 1 INCH, LH2 FEEDLINE MANIFOLD RELIEF.

REFERENCE DESIGNATORS: RV6

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
RELIEVES PRESSURE BUILDUP FROM LH2 MANIFOLD. THE VALVE INLET IS ISOLATED FROM THE FEED SYSTEM UNTIL MECO BY THE UPSTREAM FEEDLINE RELIEF SHUTOFF VALVE (PV8). THE RELIEF VALVE INCORPORATES A SENSE PORT WHICH SENSES THE LH2 MANIFOLD PRESSURE VIA A SENSE LINE. THE CRACKING AND RESEAT PRESSURES ARE BETWEEN 40 & 55 PSIG.

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NUMBER: 03-1-0436-04

REVISION#: 1 07/27/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: VALVE, RELIEF
ITEM NAME: LH2 FEEDLINE MANIFOLD RELIEF VALVE (RV6)

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
RUPTURE/EXTERNAL LEAKAGE OF RELIEF VALVE

INTERNAL CONTROL ASSEMBLIES - PILOT BELLOWS ASSEMBLY, PILOT POPPET SEAT/SEAL ASSEMBLY, MAIN POPPET BELLOWS ASSEMBLY AND PILOT POPPET ASSEMBLY

EXTERNAL ASSEMBLIES - VALVE BODY, PILOT ASSEMBLY HOUSING

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, FATIGUE, MATERIAL DEFECTS, PILOT SEAT ASSEMBLY STATIC SEAL DAMAGE

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:

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DURING LOADING, ASCENT, AND DUMP/INERT, LEAKAGE OF PILOT BELLOWS ASSEMBLY WILL ALLOW LH2/GH2 FROM MANIFOLD SENSE LINE TO ESCAPE FROM RELIEF VALVE REFERENCE PORT AND ENTER THE AFT COMPARTMENT. (VALVE INLET IS NOT EXPOSED TO LH2 UNTIL RELIEF SHUTOFF VALVE (PV8) IS OPENED AT MECO). POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. LEAKAGE INTO AFT COMPARTMENT DETECTABLE DURING PROPELLANT LOADING USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

LEAKAGE OF MAIN BELLOWS ASSEMBLY OR PILOT POPPET ASSEMBLY WILL ALLOW LH2/GH2 LEAKAGE OVERBOARD THROUGH THE MAIN RELIEF LINE. FIRE/EXPLOSION HAZARD EXTERIOR TO VEHICLE.

ALSO RESULTS IN POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE.

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

(C) MISSION:
ON GROUND, VIOLATION OF HGDS LCC REQUIREMENT WILL RESULT IN LAUNCH SCRUB (PILOT BELLOWS ASSEMBLY ONLY).

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE RELIEF VALVE CONSISTS OF TWO SECTIONS: A PRESSURE ACTUATED MAIN POPPET SECTION AND A PILOT SECTION WHICH SENSES MANIFOLD PRESSURE BY MEANS OF A SENSING LINE.

THE PILOT SECTION CONTROLS THE OPENING AND CLOSING OF THE MAIN POPPET BY ALLOWING THE MANIFOLD PRESSURE TO ENTER OR EXIT A CONTROL CHAMBER. WHEN THE MANIFOLD PRESSURE REACHES A PREDETERMINED PILOT SETTING, THE PILOT VENTS THE CHAMBER PRESSURE OVERBOARD ALLOWING THE PRESSURE DIFFERENTIAL ACROSS THE MAIN POPPET TO PUSH THE MAIN POPPET OPEN. ONCE THE MANIFOLD PRESSURE DROPS BELOW THE PILOT CONTROL SETTING, THE PILOT POPPET CLOSES, THE MANIFOLD PRESSURE ENTERS THE CONTROL CHAMBER, AND THE MAIN POPPET CLOSES.

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THE END CAP, THE PILOT HOUSING, AND THE MAIN BODY ARE CONSTRUCTED OF 6061-T651 ALUMINUM ALLOY. THE INTERMEDIATE HOUSING IS CONSTRUCTED OF 304L CRES. THE THERMAL ISOLATOR IS CONSTRUCTED OF VESPEL SP21. THE MAIN SEAT VALVE HOUSING IS CONSTRUCTED OF PH13-8MO CRES.

THERE ARE SIX EXTERNAL LEAK PATHS. THEY ARE SEALED USING SPRING LOADED FACE SEALS (SPRING IS INCONEL, JACKET IS TEFLON). THE VALVE BODY SEALING SURFACES HAVE 8 MICROINCH SURFACE FINISH.

THE VALVE IS DESIGNED FOR A STRUCTURAL FACTOR OF SAFETY OF 2.0 PROOF, 4.0 BURST. IT IS DESIGNED FOR 10,000 CYCLES (100 MISSION EQUIVALENT) AND TESTED THROUGH A TOTAL OF 5000 CYCLES UNDER CRYOGENIC AND AMBIENT TEMPERATURES.

THE FOLLOWING COMPONENTS MAY CAUSE FAILURE OF THE PILOT POPPET ASSEMBLY TO REMAIN CLOSED/LEAK DUE TO STRUCTURAL FAILURE: MACHINED SPRING, STOP SPRING, STOP, PUSH ROD, POPPET SPRING, POPPET, SEAT, SEAT RETAINER, SEAT ASSEMBLY SEAL, AND SEAT ASSEMBLY SEAL SPRING.

THE MACHINED SPRING CONTROLS THE CRACKING PRESSURE. IT IS OF INCONEL 718, HEAT TREATED AND PASSIVATED.

THE STOP SPRING PRELOADS THE PILOT STOP. IT IS A BELLEVILLE SPRING OF HEAT TREATED INCONEL 718.

THE STOP PRELOADS THE INSIDE DIAMETER OF THE STOP SPRING. THE STOP IS CRES PH 15-5, HEAT TREATED AND PASSIVATED.

THE PUSH ROD PRELOADS THE PILOT POPPET SPRING. THE PUSH ROD IS A286 CRES, HEAT TREATED AND PASSIVATED.

THE POPPET SPRING IS THE RETURN SPRING FOR THE POPPET. THE SPRING IS OF ELGILOY 54-71A AND HEAT TREATED.

THE POPPET IS THE FLOW CONTROL DEVICE FOR THE PILOT VALVE, IT IS CRES PH 13-8 MO, HEAT TREATED AND PASSIVATED.

THE SEAT IS TEFLON (TFE).

THE SEAT RETAINER RETAINS THE SEAT IN THE SEAT ASSEMBLY. IT IS OF 6051-T651 AL ALLOY. THE SEAT RETAINER IS TORQUED, STRESS RELIEVED, AND RETORQUED.

THE SEAT ASSEMBLY SEAL PREVENTS INTERNAL LEAKAGE FROM THE CAVITY BETWEEN THE SEAT ASSEMBLY AND THE HOUSING. THE "V" SEAL IS A TEFLON JACKETED INCONEL 718 SPRING.

THE SEAT ASSEMBLY SEAL SPRING PRELOADS THE SEAT ASSEMBLY AGAINST THE SEAT ASSY SEAL. IT IS A BELLEVELLE SPRING OF 302 CRES AND PASSIVATED.

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RUPTURE/LEAKAGE OF THE PILOT POPPET BELLOWS ASSEMBLY ALLOWS LEAKAGE FROM SENSE PORT TO PILOT REFERENCE PORT AND INTO THE AFT COMPARTMENT. RUPTURE/LEAKAGE OF THE MAIN BELLOWS ASSEMBLY ALLOWS LEAKAGE OVERBOARD THROUGH THE RELIEF VALVE.

THE PILOT BELLOWS (2 PLY) AND MAIN BELLOWS (3 PLY) ARE SIMILAR IN CONSTRUCTION AND OF THE SAME MATERIAL. BOTH BELLOWS ASSEMBLIES CONSIST OF 3 PARTS; THE FLANGE, A BELLOWS, AND A CAP; ALL OF INCONEL 625 AND PASSIVATED. THE SEAMS OF THE BELLOWS ARE FUSION WELDED (FULL PENETRATION). THE FLANGE AND CAP ARE FUSION WELDED TO THE BELLOWS. EACH BELLOWS ASSEMBLY IS TESTED FOR PROOF PRESSURE AND LEAKAGE BEFORE BEING ASSEMBLED INTO A RELIEF VALVE. THE MAIN BELLOWS ASSEMBLY IS THEN ELECTRON BEAM WELDED TO THE MIDDLE HOUSING ASSEMBLY. THE WELD IS DYE PENETRANT INSPECTED, PROOF PRESSURE TESTED, AND LEAK TESTED.

(B) TEST:
ATP

VISUAL INSPECTION
STROKE VERIFICATION OF MAIN POPPET (0.225 +/- 0.002 INCH)

AMBIENT TEST

PROOF PRESS: VALVE BODY, 110 PSIG INLET & SENSE PORT, 300 PSIG OUTLET

INTERNAL LEAKAGE:
1 TO 35 PSIG GHE AT INLET AND SENSE PORT
10 SCIM MAX AT OUTLET PORT

EXTERNAL LEAKAGE: 55 PSIG GHE; 5 SCIM MAX

CRACK/RESEAT: 40 TO 55 PSIG

REVERSE FLOW LEAKAGE:
10 PSID GHE OUTLET TO INLET
MAIN SEAT LEAKAGE 50 SCIM MAX
PILOT REVERSE LEAKAGE 1700 SCIM MAX.

CRYOGENIC TEST (GHE AT -300 DEG F):

CRACK/RESEAT: 40 TO 55 PSIG, VALVE BODY AMBIENT

EXTERNAL LEAKAGE: 55 PSIG, 10 SCIM MAX, VALVE BODY -100 DEG F

INTERNAL LEAKAGE: 35 PSIG, 10 SCIM MAX, VALVE BODY -100 DEG F

CERTIFICATION

LIFE TEST

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CRYO - 4500 CYCLES OPEN AND CLOSED USING LN2, VALVE CHECKED FOR INTERNAL LEAKAGE AFTER EACH 500 CYCLES, VALVE CHECKED FOR CRYO INTERNAL LEAKAGE AFTER EACH 1500 CYCLES.

AMBIENT - 500 CYCLES, VALVE INTERNAL LEAK CHECK EACH 50 CYCLES.

CRYO STEADY STATE FLOW TEST

SENSES PORT PRESS AT 65 PSIG GHE AT -412 DEG F
FLOW RATE OF 272 GPM LH2 AT 23 PSID

CRYO RESPONSE TEST

1.5 SEC TO INDICATE STEADY FLOW AFTER CRACKING WITH LH2

CRYO FUNCTIONAL TEST USING LH2

CRACKED AT 51 PSIG; RESEAT AT 44 PSIG

RANDOM VIBRATION 13.3 HOURS IN EACH OF THE THREE AXES

FIRST 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: AMBIENT

SECOND 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT TO +100 TO -100 TO AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: 35 PSIG GHE AT -425 DEG F

THIRD 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: 35 PSIG LN2

CRACK/RESEAT AND INTERNAL LEAKAGE PERFORMED AT COMPLETION OF EACH AXIS OF VIBRATION.

BENCH HANDLING AND DESIGN SHOCK PER MIL-STD-810
FOLLOWED BY AMBIENT CRACK/RESEAT AND INTERNAL LEAKAGE TESTS.

THERMAL CYCLE TEST (3 CYCLES)

VALVE AT 70 DEG F; SHOCKED WITH -300 DEG F FLUID FOR 20 MINUTES MIN; VALVE ALLOWED TO WARM UP TO 70 DEG F; VALVE HEATED TO 275 DEG F FOR 15 MINUTES. DURING THE 15 MINUTES THE VALVE WAS TESTED FOR AMBIENT CRACK/RESEAT PRESSURE.

ELECTRICAL BONDING

BURST TEST
220 PSIG ON SENSE AND INLET PORTS, 600 PSIG ON OUTLET PORT

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. PART PROTECTION COATING AND PLATING REQUIREMENTS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 400A (PROCUREMENT SPECIFICATION REQUIREMENT IS 400) VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL CRITICAL DIMENSIONS ARE VERIFIED BY INSPECTION. LOG OF CLEAN ROOM AND TOOL CALIBRATION IS VERIFIED BY INSPECTION. TORQUE PER DRAWING REQUIREMENTS AND SURFACE FINISH ARE VERIFIED BY INSPECTION. SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED BY INSPECTION. ALL SEALING SURFACES AND SEALS ARE VISUALLY EXAMINED BEFORE INSTALLATION USING 10X MAGNIFICATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE MANUFACTURING PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT, WELDING, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED. DRY FILM LUBRICANT APPLICATIONS ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

ALL WELDS ARE VISUALLY EXAMINED AND VERIFIED BY DYE PENETRANT. IN ADDITION, BELLOWS WELDS (EXCLUDING END FITTING WELDS) ARE X-RAYED.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPPING IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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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
NO CREW ACTION IS REQUIRED.

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	: CHARLES EBERHART	: /S/ CHARLES EBERHART
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: JEFF MUSLER	: /S/ JEFF MUSLER
USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS