FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0437 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 07/17/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:LH2 MANIFOLD RELIEF SHUTOFF VALVE UNITED SPACE ALLIANCE - NSLD	MC284-0406-0002 74329000-103

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, ONE INCH LH2 FEEDLINE RELIEF SHUTOFF, PNEUMATICALLY ACTUATED CLOSED, NORMALLY OPEN.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY FAIRCHILD CONTROLS BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PV8

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
ISOLATES THE LH2 PROPELLANT FEED SYSTEM FROM THE FEEDLINE RELIEF SYSTEM. MAINTAINED CLOSED FROM START OF PROPELLANT LOADING UNTIL MECO. VALVE IS MOUNTED ON THE INBOARD FILL & DRAIN VALVE BODY.

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NUMBER: 03-1-0437-09

REVISION#: 1 07/17/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 MANIFOLD RELIEF SHUTOFF VALVE **CRITICALITY OF THIS**
ITEM NAME: LH2 MANIFOLD RELIEF SHUTOFF VALVE **FAILURE MODE:** 1/1

FAILURE MODE:
RUPTURE/LEAKAGE OF THE ACTUATOR DURING ASCENT.

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

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

CAUSE:
FATIGUE, MATERIAL DEFECT, DAMAGED/DEFECTIVE ACTUATOR SEALS

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:
LOSS OF APPLICATION OF ACTUATION PRESSURE TO THE LH2 SHUTOFF VALVE (PV8), CAUSING THE SHUTOFF VALVE TO OPEN. POSSIBLE DEPLETION OF VALVE ACTUATION PRESSURE, CAUSING FAILURE TO CLOSE LO2 PREVALVES AT MECO. RESULTS IN INABILITY TO MAINTAIN INJECTED HELIUM AND LO2 PRESSURE AT THE SSME PUMP, RESULTING IN POSSIBLE PUMP OVERSPEED AND EXPLOSION. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSIVE HAZARD.

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AT MECO THE ENGINE NUMBER TWO HELIUM SUPPLY IS SWITCHED INTO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY NOT ACTUATE THE LO2 PREVALVES CLOSED.

PRIOR TO T-9 MINUTES HELIUM LEAKAGE FROM ACTUATOR INTO THE AFT COMPARTMENT MAY BE DETECTED BY HGDS RESULTING IN VIOLATION OF LCC REQUIREMENT. PRIOR TO T-31 SECONDS VALVE FAILING TO REMAIN CLOSED DUE TO ACTUATOR LEAKAGE WILL BE DETECTED BY GLS RESULTING IN VIOLATION OF LCC REQUIREMENT.

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 THE HGDS AND/OR VALVE POSITION LCC REQUIREMENT WILL RESULT IN LAUNCH SCRUB.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE VALVE IS A NORMALLY OPEN, FLAPPER-TYPE SHUTOFF VALVE, WITH A PNEUMATIC ACTUATOR. IT IS SPRING LOADED TO THE OPEN POSITION BY A BELLOWS WITHIN THE ACTUATOR. IN THE ACTUATOR-VENTED CONDITION THE BELLOWS SPRING FORCE IS TRANSMITTED TO THE VALVE FLAPPER VIA A BELLOWS GUIDE (SHAFT) AND MECHANICAL LINKAGE TO ROTATE THE FLAPPER AWAY FROM THE VALVE SEAT AND OUT OF THE FLOW STREAM. WHEN ACTUATION PRESSURE IS APPLIED TO THE ACTUATOR THE BELLOWS IS COMPRESSED, CAUSING THE BELLOWS GUIDE AND MECHANICAL LINKAGE TO ROTATE THE FLAPPER TO THE VALVE CLOSED POSITION.

THE ACTUATOR HOUSING IS A356-T6 ALUMINUM ALLOY AND IS DESIGNED WITH A FACTOR OF SAFETY OF 1.5 PROOF, 4.0 BURST. STRESS ANALYSIS INDICATES THE ACTUATOR HAS A POSITIVE MARGIN OF SAFETY FOR ALL CONDITIONS OF OPERATION. ACTUATOR IS BURST TESTED TO 3400 PSIG WITHOUT RUPTURE.

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EXTERNAL VALVE LEAKAGE IS CONTROLLED AT THE ACTUATOR/VALVE INTERFACE BY A FACE SEAL (RACO TYPE WITH A 301 CRES SPRING JACKETED WITH FEP TEFLON) BETWEEN THE BELLOWS RETAINER AND THE VALVE HOUSING.

(B) TEST:
ATP

AMBIENT AND CRYO (-300 DEG F) PROOF
VALVE BODY - 413 PSIG WITH VALVE BOTH OPEN AND CLOSED
ACTUATOR - 1275 PSIG

VALVE RESPONSE TIMES
AMBIENT - VALVE PRESSURIZED TO 5 PSIG; ACTUATOR PRESSURIZED TO 780 AND 400 PSIG (OPEN AND CLOSED).
CRYO (-300 DEG F) -
OPENING: VALVE PRESSURIZED TO 180 AND 20 PSIG; ACTUATOR 780 PSIG
CLOSING: VALVE PRESSURIZED TO 0 AND 220 PSIG; ACTUATOR 780 AND 400 PSIG

EXTERNAL LEAKAGE
AMBIENT AND CRYO (-300 DEG F) - VALVE BODY @ 50 AND 200 PSIG GHE, VALVE OPEN; ACTUATOR @ 780 PSIG GHE

INTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F)
INLET TO OUTLET @ 50 AND 200 PSIG GHE, VALVE CLOSED

POSITION INDICATION - VERIFICATION OF OPERATION (AMBIENT ONLY)

ELECTRICAL TESTS
ELECTRICAL BONDING; DIELECTRIC; INSULATION RESISTANCE

CERTIFICATION (TWO UNITS CERTIFIED)

VALVE RESPONSE TIMES
AMBIENT - VALVE PRESSURIZED TO 5 PSIG; ACTUATOR PRESSURIZED TO 780 AND 400 PSIG (OPEN AND CLOSED).
CRYO (-300 DEG F)
OPENING: VALVE PRESSURIZED TO 180 AND 20 PSIG; ACTUATOR 780 PSIG
CLOSING: VALVE PRESSURIZED TO 0 AND 220 PSIG; ACTUATOR 780 AND 400 PSIG
CRYO (-400 DEG F)
OPENING: VALVE PRESSURIZED TO 30 PSIG; ACTUATOR 780 PSIG
CLOSING: VALVE PRESSURIZED TO 0 AND 60 PSIG; ACTUATOR 780 AND 400 PSIG

EXTERNAL LEAKAGE
AMBIENT - VALVE BODY @ 50 AND 200 PSIG GHE, VALVE OPEN; ACTUATOR @ 780 PSIG GHE

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CRYO (-300 DEG F) - VALVE BODY @ 50 AND 200 PSIG GHE, VALVE OPEN; ACTUATOR @ 780 PSIG GHE
CRYO (-400 DEG F) - VALVE BODY @ 50 PSIG GHE, VALVE OPEN; ACTUATOR @ 780 PSIG GHE

INTERNAL LEAKAGE
AMBIENT AND CRYO (-300 DEG F) - INLET TO OUTLET @ 50 AND 200 PSIG GHE, VALVE CLOSED
CRYO (-400 DEG F) - INLET TO OUTLET @ 50 PSIG GHE, VALVE CLOSED

LIFE TEST
CRYO (-400 DEG F) - 250 CYCLES AT 200 PSIG AND 250 CYCLES AT 50 PSIG FOLLOWED BY A CRYO (-400 DEG F) LEAKAGE TEST
AMBIENT - 1500 CYCLES @ 5 PSIG. AFTER EACH 500 CYCLES PERFORM AMBIENT LEAK TESTS.

VIBRATION
TRANSIENT - (5 - 35 HZ) IN EACH OF THREE AXES, WITH VALVE CLOSED
RANDOM - (13.3 HOURS IN EACH OF THREE AXES WHILE PRESSURIZED TO 200 PSIG, AT -300 DEG F., AND WITH THE VALVE CLOSED. FOLLOWING EACH AXIS TEST, PERFORM CRYO (-300 DEG F) VALVE RESPONSE TIMES TEST, AND CRYO (- 300 DEG F) LEAKAGE TESTS (EXCEPT ACTUATOR).

DESIGN SHOCK (18 SHOCKS OF 15G EACH) - THREE IN EACH DIRECTION OF THREE AXES). UPON COMPLETION PERFORM AMBIENT VALVE RESPONSE TIMES TEST, AND AMBIENT LEAKAGE TESTS.

THERMAL CYCLE TEST - +70 DEG F TO -400 DEG F TO +70 DEG F TO +275 DEG F TO +150 DEG F TO +70 DEG F PERFORMED THREE TIMES FOLLOWED BY AMBIENT VALVE RESPONSE TIMES TEST, AMBIENT LEAKAGE TESTS, AND ELECTRICAL INSULATION TEST.

ELECTRICAL BONDING (ONE UNIT ONLY)

BURST TEST (ONE UNIT ONLY) - 550 PSIG VALVE BODY, 3400 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. BODY HOUSING FORGING IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL
CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 400A IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

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ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. LOG OF CLEAN ROOM AND TOOL CALIBRATION IS VERIFIED BY INSPECTION. DRAWING TORQUE AND SURFACE FINISH REQUIREMENTS ARE VERIFIED. COMPONENTS ARE VISUALLY AND DIMENSIONALLY INSPECTED DURING FABRICATION. SEALS ARE VISUALLY EXAMINED FOR DAMAGE AND CLEANLINESS PRIOR TO INSTALLATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES
HEAT TREATMENT, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED. DRY FILM LUBRICANT APPLICATION IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
ULTRASONIC INSPECTION OF BODY HOUSING IS VERIFIED. WELDS ARE DYE PENETRANT INSPECTED.

TESTING
ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING AND PACKAGING FOR SHIPMENT ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
DURING ATP, ACTUATOR SHAFT SEAL LEAKAGE WAS 13 SCIM (MAX ALLOWABLE IS 10 SCIM). TEARDOWN ANALYSIS REVEALED THE SHAFT SEAL TO HAVE BEEN DAMAGED EITHER PRIOR TO OR DURING INSTALLATION. ALSO, NUMEROUS PINHOLE LEAKS WERE FOUND IN THE ACTUATOR BODY. TWO OTHER ACTUATOR BODY HOUSINGS AT THE VENDOR WERE ALSO FOUND TO LEAK. THIS LEAKAGE IS A RESULT OF CAVITY SHRINKAGE AND DROSS INCLUSIONS NORMAL TO CASTINGS OF THIS MATERIAL. CORRECTIVE ACTION FOR PINHOLE LEAKS WAS TO ADD PROOF AND LEAK TEST AFTER MACHINING; PREVIOUSLY, CASTINGS WERE LEAK CHECKED ONLY PRIOR TO MACHINING. CORRECTIVE ACTION FOR DAMAGED SHAFT SEAL WAS TO ADD CAUTION IN HANDLING AND 10X MAGNIFICATION INSPECTION OF SEALS (REF CAR A4997). THIS FAILURE IS ATP SCREENABLE.

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:
HELIUM BOTTLE PRESSURE IS ON DISPLAY IN COCKPIT. CREW ACTION CAN CLOSE ISOLATION VALVES DURING ASCENT. PRIOR TO MECO ISOLATION VALVES (LV7,LV8) CAN BE REOPENED OR THE LEFT ENGINE LOW PRESSURE GHE CROSSOVER VALVE (LV10) CAN BE OPENED.

- APPROVALS -

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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	: HUGO MARTINEZ	: /S/ HUGO MARTINEZ