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: 03-1-0437-06

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:** 1R3

FAILURE MODE:
LOSS OF POSITION INDICATION - CLOSED POSITION INDICATION FAILS ON (LCC DECEPTION).

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

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 CLOSED POSITION SWITCH IS ON AT T-31 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:
CASE 1:
1R/3 3 SUCCESS PATHS. TIME FRAME - PRELAUNCH.
1) SHUTOFF VALVE (PV8) CLOSED POSITION SWITCH FAILS ON.
2) SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED.
3) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.

VALVE POSITION LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE.

LH2 WILL DUMP OVERBOARD RESULTING IN PROPELLANT LEAKAGE ON TO THE PAD SURFACE. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE AND ON THE PAD. FIRE AND/OR LEAKAGE MAY BE DETECTABLE USING TV CAMERAS AND FIRE DETECTOR SENSORS. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:
1R/3 3 SUCCESS PATHS. TIME FRAME - ASCENT (PRE MECO).
1) SHUTOFF VALVE (PV8) CLOSED POSITION SWITCH FAILS ON.
2) SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED.
3) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.

VALVE POSITION LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE.

LH2 WILL DUMP OVERBOARD RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE SHUTDOWN. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS DUE TO REDUCED ULLAGE PRESSURE. 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

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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. NEW SWITCHES ARE ALSO SUBJECTED TO A PARTICLE IMPACT NOISE DETECTION TEST (PIND) AND ARE BEING IMPLEMENTED ON AN ATTRITION BASIS.

(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

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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
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 PENETRANT INSPECTED. BODY HOUSING FORGING IS ULTRASONICALLY INSPECTED.

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

ASSEMBLY/INSTALLATION
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 VISUAL 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 OV-099 CHECKOUT, BOTH OPEN AND CLOSED INDICATIONS WERE ON WITH THE VALVE IN THE "OPEN" POSITION (REFERENCE CAR AC2296). TRAVEL OF THE SWITCH ACTUATION ARM WAS FOUND TO BE RESTRICTED DUE TO A HINGE POINT SHIFT. THIS PROBLEM HAD BEEN CORRECTED BY THE MICROSWITCH VENDOR ON LATER UNITS. VALVES UNDERGOING REFURBISHMENT WILL BE EQUIPPED WITH THE CORRECTED SWITCHES.

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: WHEN THE ULLAGE PRESSURE DROPS BELOW 28 PSI, THE CREW WILL OPEN THE LH2 FLOW CONTROL VALVE WITH THE COCKPIT SWITCH. WHEN THIS IS INEFFECTIVE AND THE NPSP DROPS BELOW A PREFLIGHT ACCEPTED VALUE, THE CREW WILL ABORT TO TAL OR ACLS.

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

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- 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	: HUGO MARTINEZ	: /S/ HUGO MARTINEZ