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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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:
FAILS TO OPEN/REMAIN OPEN POST MECO, PRE DUMP.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:
FAILS TO OPEN - BINDING, PIECE PART STRUCTURAL FAILURE, ACTUATOR FILTER CLOGGING

FAILS TO REMAIN OPEN - PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES
RTLS RETURN TO LAUNCH SITE
TAL TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN
A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)

B)
FAILS B SCREEN BECAUSE VALVE WOULD INDICATE OPEN AND LINKAGE FAILURE WOULD CAUSE VALVE TO BE CLOSED.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
NO EFFECT FOR NOMINAL MISSION. LH2 MANIFOLD PRESSURE WILL NOT RISE TO RELIEF PRESSURE BEFORE DUMP START.

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ENOUGH RESIDUALS REMAIN IN THE LH2 MANIFOLD DURING AN RTLS/TAL ABORT TO CAUSE THE LH2 MANIFOLD PRESSURE TO RISE TO RELIEF PRESSURE. FAILURE RESULTS IN A LACK OF RELIEF CAPABILITY. POSSIBLE RUPTURE OF THE LH2 MANIFOLD CAUSING LH2 LEAKAGE INTO THE AFT COMPARTMENT, OVERPRESSURIZATION, AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL COMPONENTS DUE TO CRYOGENIC EXPOSURE.

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

(C) MISSION:
NO EFFECT FOR NOMINAL MISSION. POSSIBLE LOSS OF CREW/VEHICLE DURING RTLS/TAL ABORT.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
CASE 1:
1R/3 3 SUCCESS PATHS. TIME FRAME - LH2 DUMP/VACUUM INERT.

1) RELIEF SHUTOFF VALVE (PV8) FAILS TO OPEN/REMAIN OPEN.
2) OUTBOARD FILL & DRAIN VALVE (PV11) FAILS TO OPEN/REMAIN OPEN.
3) EITHER RTLS DUMP VALVE (PV17, 18) FAILS TO OPEN. RTLS DUMP VALVES ARE OPENED FOLLOWING MECO FOR 110 SECONDS, BUT CAN BE OPENED BY THE CREW IF MANIFOLD PRESSURE APPROACHES RELIEF PRESSURES. EFFECTIVE FOR OI-29 AND SUBS THE RTLS DUMP VALVES WILL BE USED FOR LH2 VACUUM INERTING.

RESULTS IN LACK OF RELIEF CAPABILITY. POSSIBLE RUPTURE OF THE LH2 MANIFOLD CAUSING LH2 LEAKAGE INTO AFT COMPARTMENT, OVERPRESSURIZATION, AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

-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. WHEN ACTUATION PRESSURE IS APPLIED TO THE ACTUATOR THE BELLOWS IS COMPRESSED, CAUSING THE

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BELLOWS GUIDE AND MECHANICAL LINKAGE TO ROTATE THE FLAPPER TO THE VALVE CLOSED POSITION. VALVE INLET PRESSURE ASSISTS IN HOLDING THE FLAPPER TO THE VALVE SEAT.

FAILURE TO RETURN TO, OR REMAIN IN, THE OPEN POSITION INDICATES THE SPRING (BELLOWS) FORCE HAS BEEN REMOVED FROM THE FLAPPER. THIS COULD BE CAUSED BY STRUCTURAL FAILURE OF ANY OF THE FOLLOWING: FLAPPER ARM, FLAPPER LINK, EITHER OF THE TWO LINK PINS, BELLOWS GUIDE OR THE BELLOWS. STRESS ANALYSES OF THESE COMPONENTS INDICATE THE VALVE HAS A POSITIVE MARGIN OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS.

THE FLAPPER VALVE IS OPERATED BY THE BELLOWS THROUGH A PINNED LINKAGE CONSISTING OF A FLAPPER ARM, A LINK, AND A BELLOWS GUIDE WELDED TO THE BELLOWS. THE FLAPPER ARM IS MADE FROM COPPER-BERYLLIUM #172 AND HEAT TREATED TO CONDITION HT. THE FLAPPER LINK IS OF 2219-T87 AL AND IS .278 INCHES THICK. THE PINS ARE A286 CRES AND HAVE A 0.2475 INCH DIAMETER. THE BELLOWS GUIDE IS MACHINED FROM 304L CRES, WHICH IS SUBSEQUENTLY ANNEALED. THE BELLOWS IS FORMED FROM TWO PLYS OF 0.01 INCH INCONEL 718 AND IS HEAT TREATED AFTER FORMING. IT IS DESIGNED FOR 10,000 CYCLES; 5 TIMES GREATER THAN THE VALVE SPECIFICATION REQUIREMENT. THE BELLOWS ASSEMBLY ACCEPTANCE TESTING INCLUDES PROOF PRESSURE, LEAKAGE, AND CYCLING.

FAILURE TO RETURN TO THE OPEN POSITION COULD BE CAUSED BY BINDING AT ANY OF THE PINNED CONNECTIONS WITHIN THE FLAPPER LINKAGE (FLAPPER ARM TO FLAPPER LINK, FLAPPER LINK TO BELLOWS GUIDE, AND FLAPPER ARM TO CYLINDER CLEVIS). THE FLAPPER ARM, FLAPPER LINK, AND CLEVIS CYLINDER ARE ALL TREATED WITH A DRY LUBRICANT TO PREVENT BINDING. BINDING OF THE SLIDING CONTACT SURFACES BETWEEN THE CYLINDER CLEVIS AND BELLOWS GUIDE IS PRECLUDED BY TEFLON GUIDE RINGS.

THE ACTUATOR INLET PORT IS EQUIPPED WITH A FILTER TO PREVENT ACTUATOR CONTAMINATION.

(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

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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
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.

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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

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.

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(D) FAILURE HISTORY:
DURING QUALIFICATION TEST, VALVE OPENING RESPONSE TIME WAS 1.55 SECONDS, SHOULD BE 1.5 SECONDS (REF CAR A5547). CORRECTIVE ACTION WAS TO CHANGE THE OPENING RESPONSE TIME (CRYO TEMPERATURE ONLY) FOR THE HYDROGEN UNIT TO 2.5 SECONDS. NO HARDWARE SHIPPED WAS AFFECTED.

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: LH2 MANIFOLD PRESSURE IS ON CAUTION AND WARNING. CREW CAN OPEN MPS RTLS DUMP VALVES (PV17, PV18) ON GROUND COMMAND.

- 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