FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0310 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 08/02/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:LO2 INBOARD 8" FILL/DRAIN VALVE (PV10) UNITED SPACE ALLIANCE - NSLD	MC284-0397-0030 74328000-157

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
FILL INBOARD LO2 VALVE, 8 INCH, PNEUMATICALLY OPERATED, INCLUDES A RELIEF VALVE.

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: PV10

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE VALVE, ALONG WITH THE OUTBOARD FILL AND DRAIN VALVE (PV9), PROVIDES A REDUNDANT MEANS OF CONTAINING PROPELLANT IN THE FEED SYSTEM. THE VALVE IS MOUNTED ON THE FEED LINE MANIFOLD TO ISOLATE THE FILL LINE FROM THE FEED SYSTEM. THE VALVE IS CLOSED AFTER LOADING IN ORDER TO DRAIN THE FILL LINE (PRIOR TO CLOSING THE OUTBOARD FILL & DRAIN VALVE). BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION AND ARE OPENED FOR MPS VACUUM INERT TO VENT LO2 RESIDUALS. BOTH VALVES ARE OPEN FOR LO2 DUMP IN RTLS AND TAL ABORTS. THE INBOARD VALVE REMAINS OPEN AFTER DUMP/INERT, THROUGH REENTRY AND LANDING. THE VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS. THE VALVE INCORPORATES A RELIEF VALVE, RELIEVING FROM THE FILL LINE INTO THE MANIFOLD; AND A PORT FOR INSTALLATION OF LO2 RELIEF SHUTOFF ISOLATION VALVE (PV7).

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LO2 INBOARD 8" FILL AND DRAIN VALVE (PV10) **CRITICALITY OF THIS**
ITEM NAME: LO2 INBOARD 8" FILL AND DRAIN VALVE (PV10) **FAILURE MODE:** 1/1

FAILURE MODE:
FAILS TO REMAIN CLOSED 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:
RESULTS IN ASCENT WITH FILL LINE FULL OR PARTIALLY FULL OF LO2. POTENTIAL WATER HAMMER EFFECT OF APPROXIMATELY 700 PSI (AT 1-G). FAILURE RESULTS IN POSSIBLE RUPTURE OF THE LO2 FILL LINE, AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT FUNCTIONS DUE TO CRYO EXPOSURE.

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DISPLACED GAS MAY ENTER ENGINE CAUSING UNCONTAINED ENGINE DAMAGE AND POSSIBLE SHUTDOWN OF ONE OR MORE SSME(S).

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.
1) INBOARD FILL & DRAIN (PV10) FAILS TO REMAIN CLOSED.
2) OUTBOARD FILL & DRAIN (PV9) FAILS TO REMAIN CLOSED.

LO2 WILL DUMP OVERBOARD RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE CUTOFF. POSSIBLE FIRE HAZARD AT THE VEHICLE EXTERIOR. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS DUE TO REDUCED ULLAGE PRESSURE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
VALVE IS BI-STABLE - WILL REMAIN IN LAST COMMANDED POSITION. AN INTEGRAL PART OF THE COPPER-BERYLLIUM ACTUATOR SHAFT IS A CAM WITH DETENTS IN THE OPEN AND CLOSED POSITION. THE CAM IS FOLLOWED BY A BELLVILLE SPRING-LOADED DETENT ROLLER. THE SEVEN STACKED BELLVILLES ARE SHIMMED, UPON INSTALLATION, TO PRODUCE A FORCE OF 140 LBS BY THE ROLLER UPON THE CAM, WHEN IN EITHER THE OPEN OR CLOSED POSITION. TO LEAVE EITHER POSITION THE ROLLER MUST PASS OVER A 0.105 INCH HIGH SHOULDER ON THE CAM. LOADED TANK PRESSURE TENDS TO FORCE THE GATE INTO GATE SEAL CONTRIBUTING TO AN EFFECTIVE SEAL AND TO HOLDING THE GATE CLOSED.

THE VALVE IS DESIGNED FOR 5000 LIFE CYCLES AND WAS CYCLED OPEN/CLOSED 5,653 TIMES (OVER 100 MISSIONS) DURING CERTIFICATION TESTING. CYCLING WAS AT BOTH CRYOGENIC AND AMBIENT TEMPERATURES AND WITH BOTH NORMAL AND ACCELERATED (SLAM) CYCLE TIMES.

(B) TEST:
ATP

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ANTI-SLAM VALVES (BEFORE ASSEMBLY INTO THE ACTUATOR) - EXAMINATION OF PRODUCT; AMBIENT PROOF (1275 PSIG); AMBIENT AND CRYO FLOW; AMBIENT AND CRYO CRACKING PRESSURE; POST TEST EXAMINATION.

ACTUATOR (BEFORE ASSEMBLY ONTO THE FILL AND DRAIN VALVE) - EXAMINATION OF PRODUCT; POSITION INDICATION; AMBIENT PROOF (1275); ELECTRICAL CHARACTERISTICS; AMBIENT EXTERNAL LEAKAGE.

RELIEF VALVE ASSEMBLY (BEFORE INSTALLATION INTO THE FILL & DRAIN VALVE)- EXAMINATION OF THE PRODUCT; AMBIENT PROOF (340 PSIG); AMBIENT AND CRYO CRACK/RESEAT (15-50 PSID) AND INTERNAL LEAKAGE; POST TEST EXAMINATION.

FILL AND DRAIN VALVE ASSEMBLY -

EXAMINATION OF PRODUCT

ELECTRICAL BONDING

AMBIENT PROOF WITH VALVE OPEN (358 PSIG) AND CLOSED (275 PSID) APPLIED AT INBOARD SIDE

CRYO PROOF WITH VALVE OPEN (358 PSIG) AND CLOSED (358 PSID) APPLIED AT INBOARD SIDE

AMBIENT AND CRYO EXTERNAL LEAKAGE OF VALVE BODY (270 PSIG)

CRYO EXTERNAL LEAKAGE OF ACTUATOR (740 PSIG)

AMBIENT AND CRYO RESPONSE TIME (NORMAL AT 400 AND 740 PSIG ACTUATOR PRESSURE, AND SLAM AT 740 PSIG)

AMBIENT AND CRYO ACTUATOR LEAKAGE FROM PORT TO PORT

AMBIENT AND CRYO VALVE SHAFT SEAL (PRIMARY AND SECONDARY) LEAKAGE WITH 270 PSID ACROSS THE SEAL

AMBIENT AND CRYO VALVE INTERNAL LEAKAGE (INLET-TO-OUTLET WITH 15 PSID, OUTLET-TO-INLET WITH 270 PSID)

AMBIENT AND CRYO RELIEF VALVE CRACK AND RESEAT (15 TO 50 PSID)

POST TEST EXAMINATION

CERTIFICATION

STRUCTURAL LOAD AT CRYO TEMPS (-300 DEG F) (AXIAL, SHEAR, TORSION, BENDING) WITH THE VALVE IN TENSION, PERFORM VALVE RESPONSE TIME (NOMINAL AND SLAM) ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), RELIEF VALVE CRACK AND

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RESEAT, AND EXTERNAL LEAKAGE (BODY AND ACTUATOR) TESTS. REPEAT WITH THE VALVE IN COMPRESSION.

VALVE LIFE CYCLING:

2400 CYCLES AT AMBIENT TEMPERATURE WITH 5 PSIG INTERNAL PRESSURE (525 NORMAL CYCLES AND 1875 SLAM CYCLES)

100 AMBIENT CYCLES (50 NORMAL AND 50 SLAM CYCLES) WITH VALVE INLET VENTED TO ATMOSPHERE AND VALVE OUTLET CONNECTED TO A 4 CUBIC FOOT VOLUME PRESSURIZED TO 220 PSIG WITH GO2

2400 CRYO TEMPERATURE (-300 DEG F) CYCLES WITH 220 PSIG INTERNAL PRESSURE (1775 NORMAL CYCLES AND 625 SLAM CYCLES)

100 NORMAL CRYO CYCLES WITH THE VALVE INLET VENTED TO ATMOSPHERE AND THE OUTLET PRESSURIZED TO 220 PSIG

FOR THE FOREGOING LIFE TEST, PRIOR TO AND EVERY 100 CYCLES THEREAFTER, ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, AND VALVE INTERNAL LEAKAGE (OUTLET-TO-INLET) TESTS WERE PERFORMED.

RELIEF VALVE LIFE CYCLING :

2500 CYCLES AT CRYO (-300 DEG F) TEMP, 2500 CYCLES AT AMBIENT.

FOLLOWING EACH 500 CYCLES PERFORM FILL AND DRAIN VALVE INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), AND CRACK/RESEAT TESTS. POST CYCLE EXAMINATION.

VIBRATION:

PRE-VIBRATION TESTS -
VALVE RESPONSE TIME (NORMAL AND SLAM), ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), CRACK AND RESEAT, AND EXTERNAL LEAKAGE (BODY AND ACTUATOR)

TRANSIENT SINUSOIDAL VIBRATION -
270 PSIG AND -250 DEG F IN EACH AXIS

RANDOM VIBRATION TESTS -
13.3 HOURS IN EACH OF THREE AXES WITH VALVE CLOSED AND AT -250 DEG F MAXIMUM. HALF OF THE TIME THE VALVE INTERNAL PRESSURE IS 270 PSIG; THE OTHER HALF AT 5 PSIG. ONCE EACH HOUR, CLOSING PRESSURE IS REMOVED FROM THE ACTUATOR. ALSO BOTH CLOSING AND OPENING PRESSURES ARE APPLIED CONCURRENTLY TO THE ACTUATOR. IN BOTH CASES THE VALVE REMAINS CLOSED

DESIGN SHOCK: 18 SHOCKS OF 15G EACH - THREE IN EACH DIRECTION ALONG EACH OF THREE AXES, ALL WITH VALVE OPEN AND ACTUATOR VENTED

DESIGN SHOCK POST TEST:

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AMBIENT - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES
CRYO - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES
ELECTRICAL CHARACTERISTICS; POSITION INDICATION

BURST: 413 PSIG VALVE OPEN 413 PSIG ON OUTLET OF CLOSED VALVE, 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. BODY HOUSING FORGING IS ULTRASONICALLY AND PENETRANT INSPECTED.

CONTAMINATION CONTROL
PARTS ARE VERIFIED CLEAN TO LEVEL 800A. 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. ALL SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED. VISUAL (3X TO 7X) AND DIMENSIONAL INSPECTION OF VALVE BODY AND COMPONENTS ARE VERIFIED DURING ASSEMBLY. THREADED FASTENER TORQUES ARE VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES
HEAT TREATMENT AND DRY FILM LUBE APPLICATION ARE VERIFIED BY INSPECTION.

NON DESTRUCTIVE EVALUATION
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 SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

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