FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0301 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 4 08/04/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: LH2 8" INBOARD FILL/DRAIN VALVE UNITED SPACE ALLIANCE - NSLD	MC284-0397-0031 74328000-159

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
FILL VALVE, INBOARD LH2, 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: PV12

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE VALVE, ALONG WITH LH2 TOPPING VALVE (PV13) AND THE OUTBOARD FILL AND DRAIN VALVE (PV11), 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. IT IS REQUIRED TO BE CLOSED FOR PROPELLANT TOPPING/REPLENISHMENT OPERATIONS. BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION. POST MECO, THE INBOARD & OUTBOARD FILL VALVES ARE SOFTWARE COMMANDED OPEN FOR DUMP OF RESIDUAL LH2. FOR A NOMINAL MISSION THE INBOARD VALVE REMAINS OPEN AFTER INERTING THROUGH REENTRY AND LANDING. FOR AN RTLS/TAL THE INBOARD VALVE IS COMMANDED CLOSED AFTER 20 SECONDS (OI-23). VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT VALVE SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS. THE VALVE ALSO INCORPORATES A RELIEF VALVE, RELIEVING FROM THE FILL LINE INTO THE MANIFOLD; AND A PORT FOR INSTALLATION OF LH2 RELIEF SHUTOFF ISOLATION VALVE (PV8).

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LH2 INBOARD 8" FILL AND DRAIN VALVE (PV12) **CRITICALITY OF THIS**
ITEM NAME: LH2 INBOARD 8" FILL AND DRAIN VALVE (PV12) **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.

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

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(C) MISSION:
NO EFFECT. VALVE IS COMMANDED AND VERIFIED CLOSED AT LH2 REDUCED FAST FILL (ONE TIME VERIFICATION). THE GROUND LCC VERIFIES THAT THE CLOSED POWER INDICATION IS ON AND OPEN POWER INDICATION IS OFF FROM REDUCED FAST FILL TO T-31 SECONDS.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/3 3 SUCCESS PATHS. TIME FRAME - PRELAUNCH/ASCENT.
1) LH2 INBOARD FILL/DRAIN VALVE (PV12) CLOSED POSITION SWITCH FAILS ON.
2) VALVE THEN FAILS TO CLOSE OR REMAIN CLOSED. LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE.
3) LH2 OUTBOARD FILL/DRAIN VALVE (PV11) HAS ERRONEOUS INDICATION (VALVE OPEN, CLOSED POSITION SWITCH ON) DURING TERMINAL COUNT OR FAILS TO REMAIN CLOSED/LEAKAGE DURING ASCENT.

FAILURES RESULT IN LOSS OF LH2 DURING TSM DRAIN AFTER TERMINATION OF REPLENISH. IF LEAKAGE RATE IS EXCESSIVE, MAY RESULT IN A VIOLATION OF ET PRE-PRESSURIZATION LCC.

IF THE PREPRESS LCC IS NOT VIOLATED, LH2 WILL BE LOST OVERBOARD WHEN THE T-0 UMBILICAL SEPARATES, POSSIBLY RESULTING IN A PREMATURE MECO WITHOUT INTACT ABORT CAPABILITY. FIRE/EXPLOSIVE HAZARD EXTERNAL TO THE VEHICLE. POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO PUMP CAVITATION. 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 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.

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EACH SWITCH IS SCREENED AT CRYOGENIC TEMPERATURE BEFORE INSTALLATION TO VERIFY PERFORMANCE CHARACTERISTICS. NEWLY MANUFACTURED SWITCHES ARE SUBJECTED TO PARTICLE IMPACT NOISE DETECTION TEST (PIND). VEHICLE IMPLEMENTATION IS ON AN ATTRITION BASIS.

(B) TEST:
ATP

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 AND 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 AND CRYO PROOF WITH VALVE OPEN AND CLOSED - 143 PSIG

AMBIENT AND CRYO EXTERNAL LEAKAGE OF VALVE BODY (110 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 110 PSID ACROSS THE SEAL

AMBIENT AND CRYO VALVE INTERNAL LEAKAGE (INLET-TO-OUTLET WITH 15 PSID, OUTLET-TO-INLET WITH 110 PSID)

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

POST TEST EXAMINATION

CERTIFICATION

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STRUCTURAL LOAD AT CRYO TEMPS (-400 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), CRACK AND RESEAT, AND, EXTERNAL LEAKAGE (BODY AND ACTUATOR) TESTS. REPEAT WITH THE VALVE IN COMPRESSION.

VALVE LIFE CYCLING:

2400 AMBIENT TEMPERATURE CYCLES 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 110 PSIG WITH GN2

2400 CRYO TEMPERATURE (-400 DEG F) CYCLES WITH 50 - 60 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 110 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 (-400 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:

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 -
(AT 110 PSIG AND -250 DEG F) IN EACH AXIS

RANDOM VIBRATION TESTS -
13.3 HRS IN EACH OF THREE AXES WITH VALVE CLOSED AND AT -250 DEG F MAXIMUM. HALF OF THE TIME THE VALVE INTERNAL PRESSURE IS 110 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:
AMBIENT - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES. CRYO - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES. ELECTRICAL CHARACTERISTICS; POSITION INDICATION.

BURST: 165 PSIG VALVE OPEN 165 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 400. 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:
DURING QUALIFICATION TESTING, THE VALVE FAILED THE ELECTRICAL BONDING TEST (REFERENCE CAR AC5411). INVESTIGATION REVEALED THAT THE INDICATOR ASSEMBLY HAD A HIGH RESISTANCE BETWEEN THE GROUND LUG AND THE PLATE. A WASHER WAS

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INSTALLED BETWEEN THE LUG AND THE PLATE INSTEAD OF BETWEEN THE NUT AND THE LUG. THE MASTER ROUTE SHEET (MRS) FOR THE INDICATOR WAS REVISED TO CLARIFY THE PROPER SEQUENCE FOR INSTALLING THE GROUND LUG. THE ASSEMBLY INSPECTION CHECK LIST REFLECTS THE CHANGE OF THE MRS.

FOLLOWING THE COMPLETION OF THE RANDOM VIBRATION IN THE Y-AXIS ON TWO VALVES (ANTI-SLAM CONFIGURATION), THE OPEN POSITION INDICATION REMAINED "ON" IRRESPECTIVE OF THE VALVE POSITION (REFERENCE CAR AC5144). THE FAILURES OCCURRED WHEN THE SWITCH MOUNTING PLATE RESONANCE WAS INITIATED, CAUSING THE PLATE TO IMPACT AGAINST THE ACTUATOR MOUNTING BASE. THE SWITCH MOUNTING PLATE WAS REDESIGNED WITH AN INCREASED THICKNESS AND THE CSK SCREWS WERE REPLACED WITH FILLISTER HEAD SCREWS AND WASHERS. ALL DELIVERED VALVES WERE RETROFITTED BY REPLACING THE SWITCH ASSEMBLIES AND NEW PART NUMBERS WERE ASSIGNED.

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:
ASCENT - NO CREW ACTION CAN BE TAKEN.

GROUND – ORBITER/GROUND PRESSURES AND TEMPERATURES MAY INDICATE AN INBOARD FILL/DRAIN VALVE FAILED OPEN AT REDUCED FAST-FILL. EXCESSIVE PRE-PRESSURIZATION CYCLES MAY INDICATE LEAKAGE PAST INBOARD FILL/DRAIN VALVE.

- 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	: WILLIAM LANE	: /S/ WILLIAM LANE
USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS