

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0215 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 2 08/08/00**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	:LH2 4" DISCONNECT OPENING, 3-WAY SOLENOID VALVE, TYPE 2 UNITED SPACE ALLIANCE - NSLD	MC284-0404-0032, -0042  13111-5, -6

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, SOLENOID, NORMALLY CLOSED, 3-WAY, 1/4 INCH. LH2 RECIRCULATION DISCONNECT CONTROL. OPENING.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY WRIGHT COMPONENTS (NOW PERKIN ELMER) BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

**REFERENCE DESIGNATORS:** LV50**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

CONTROLS PNEUMATIC PRESSURE TO OPEN THE 4" LH2 RECIRCULATION DISCONNECT VALVE (PD3). THE OPEN SOLENOID (LV50) MUST DEACTUATE TO ALLOW THE DISCONNECT ACTUATOR TO VENT SO THE DISCONNECT CAN BE CLOSED. CLOSING SOLENOID (LV51) (REFERENCE FMEA/CIL 03-1-0216) MUST DEACTUATE TO ALLOW VALVE TO OPEN. THE DISCONNECT IS COMMANDED OPEN PRIOR TO ENGINE CONDITIONING AND COMMANDED CLOSED UPON ENGINE SHUTDOWN.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE****NUMBER: 03-1-0215-04****REVISION#:** 2 08/08/00**SUBSYSTEM NAME:** MAIN PROPULSION**LRU:** LH2 4" DISC OPEN SOLENOID VALVE (LV50)**CRITICALITY OF THIS****ITEM NAME:** LH2 4" DISC OPEN SOLENOID VALVE (LV50)**FAILURE MODE:** 1R2**FAILURE MODE:**

PREMATURE ACTUATION (RECIRCULATION DISCONNECT VALVE FAILS TO REMAIN CLOSED, REFERENCE FMEA/CIL 03-1-0405-06) CAUSING ACTUATOR OPENING SIDE TO PRESSURIZE FOR PREMATURE ENGINE SHUTDOWN.

**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, SEAL/SEAT DAMAGE

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES**

RTLS	RETURN TO LAUNCH SITE
PAD	PAD ABORT
TAL	TRANS-ATLANTIC LANDING
ATO	ABORT TO ORBIT
AOA	ABORT ONCE AROUND

**REDUNDANCY SCREEN**

A) PASS
B) PASS
C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

PASSES SCREEN B SINCE THE RECIRCULATION DISCONNECT VALVE (PD3) CLOSE POSITION SWITCH WILL NOT INDICATE "ON". SOLENOID VALVE DOES NOT HAVE POSITION INDICATORS.

C)

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**(A) SUBSYSTEM:**

RESULTS IN LOSS OF REDUNDANCY. FAILURE RESULTS IN APPLICATION OF ACTUATOR OPENING PRESSURE. OPENING PRESSURE IS NORMALLY APPLIED DURING LOADING, DETANKING, AND ENGINE OPERATION. CLOSING PRESSURE IS APPLIED AT MECO AND FOR ANY ENGINE OUT OCCURRENCE (INCLUDING PAD ABORT).

**(B) INTERFACING SUBSYSTEM(S):**

SAME AS A.

**(C) MISSION:**

NO EFFECT, VALVE WILL REMAIN CLOSED.

**(D) CREW, VEHICLE, AND ELEMENT(S):**

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

CASE 1:

1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) ENGINE SHUTDOWN WITH UNCONTAINED DAMAGE (ASSUMES ENGINE IS DAMAGED ONLY TO THE EXTENT THAT ISOLATION OF THE DAMAGE WILL SAVE THE SYSTEM).
- 2) PREMATURE ACTUATION OF DISCONNECT OPENING SOLENOID (LV50).

FOR OPEN SOLENOID FAILURES, DELTA PRESSURE ACROSS DISCONNECT FLAPPERS MAY NOT BE SUFFICIENT TO HOLD VALVE CLOSED AGAINST OPEN ACTUATOR BIAS. LH2 WILL LEAK INTO THE AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:

3/3. TIME FRAME - ORBITER/ET SEPARATION.

IF THE DISCONNECT WILL NOT CLOSE IN THE BACKUP MODE, IT WILL NOT CLOSE PNEUMATICALLY. THEREFORE, THE SOLENOIDS ARE NOT CONSIDERED REDUNDANT TO THE MECHANICAL BACKUP (REFERENCE FMEA/CIL 03-1-0405-06).

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

VALVE IS DESIGNED FOR A PRESSURE FACTOR OF SAFETY OF 2.0 PROOF, 4.0 BURST. THE CLOSURE DEVICE IS A 430 CRES BALL ACTING UPON EITHER OF TWO VESPEL SEATS. THE VALVE FEATURES A BALANCED LOAD ON THE BALL BY APPLYING INLET PRESSURE (750 PSIG NOMINAL) DIRECTLY TO THE BALL AT THE INLET SEAT AND INDIRECTLY (VIA A

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BELLOWS) THROUGH THE VENT SEAT. THE BELLOWS IS ASSISTED BY A SPRING, THE FORCE OF WHICH INSURES THE BALL IS HELD SECURELY AGAINST THE INLET SEAT WHEN THE SOLENOID IS DEENERGIZED. UPON BEING ENERGIZED THE SOLENOID DEVELOPS THE FORCE TO OVERCOME THE SPRING LOAD AND SEATS THE BALL ONTO THE VENT SEAT TO ALLOW HELIUM FLOW. TOTAL POPPET MOVEMENT (STROKE) IS LESS THAN 0.040 INCH.

PREMATURE ACTUATION, FROM THE MECHANICAL VIEW, MEANS APPLICATION OF A DIFFERENTIAL FORCE TO THE VALVE BALL TO CAUSE IT TO MOVE FROM THE INLET SEAT TO THE VENT SEAT. ON THE SOLENOID SIDE OF THE BALL, NO MECHANICAL FAILURES WOULD CAUSE PREMATURE ACTUATION. ON THE OTHER HAND, IF THE CLOSING FORCE OF THE BELLOWS/SPRING WERE REMOVED, INLET PRESSURE AND FLOW ACTING ON THE BALL WOULD DRIVE IT TO THE VENT SEAT, CAUSING PREMATURE ACTUATION.

THE FORCE TO HOLD THE BALL TO THE INLET SEAT, WHEN THE SOLENOID IS DEENERGIZED, IS PROVIDED BY THE BELLOWS ASSEMBLY AND SPRING THROUGH THE VALVE POPPET. IF THE BELLOWS FAILS, OR LEAKS TO THE POINT OF REDUCING THE BELLOWS INTERNAL PRESSURE TO LESS THAN THE VALVE INLET PRESSURE, THE LOAD BALANCING FEATURE IS ELIMINATED AND THE BALL WOULD MOVE TO THE VENT SEAT. THE BELLOWS IS MADE OF NICKEL-COBALT-COPPER AND IS PROOF PRESSURE TESTED AT 1550 PSIG PRIOR TO ASSEMBLY INTO THE VALVE. IF THE SPRING BREAKS, THE PRESSURIZED BELLOWS WOULD EXERT SUFFICIENT FORCE TO RETURN THE BALL TO THE INLET SEAT; HOWEVER, SEAT LEAKAGE MAY RESULT. THE SPRING IS MADE FROM 17-7PH CRES (ELGILOY) WIRE AND IS HEAT TREATED FOLLOWING FORMING. IT HAS A SPRING RATE OF 13.5 POUNDS/INCH AND EXERTS A FORCE OF 7.54 POUNDS IN ITS INSTALLED CONDITION.

PREMATURE ACTUATION DUE TO SEAT/SEAL DAMAGE IS VERY UNLIKELY. THIS PRESUMES FLOW PAST THE SEATED BALL AT A RATE SUFFICIENT TO PRESSURIZE THE ACTUATION PORT TO A PRESSURE OF 400 PSIA MINIMUM, WHILE THE VENT PORT IS OPEN. THE BALL IS OF 430 CRES AND THE SEAT IS OF VESPEL.

THE -0032, -0042 CONFIGURATION SOLENOID VALVES ARE IDENTICAL TO THE -0012 CONFIGURATION WITH THE EXCEPTION OF ADDING THE FILTER (10 MICRON NOMINAL, 25 MICRON ABSOLUTE) IN THE VENT PORT OF THE SOLENOID VALVE AND REDESIGN OF THE VENT PORT CHECK VALVE. THIS FILTER WAS ADDED TO PREVENT CONTAMINATION AND METALLIC PARTICLES GENERATED DURING THE REMOVAL OF THE VENT PORT CHECK VALVE DURING OMRSD LEAKAGE MEASUREMENTS FROM ENTERING THE SOLENOID VALVE.

THE VENT PORT CHECK VALVE WAS REDESIGNED TO PREVENT THE POPPET FROM BEING EJECTED DUE TO SHEARING OF THE RETAINING NUT THREAD. A PIN WAS ADDED TO THE CHECK VALVE HOUSING, WHICH RETAINS THE POPPET WITHIN THE CHECK VALVE HOUSING. A NEW ALUMINUM NUT, WHICH PROVIDE A MINIMUM ENGAGEMENT OF THREE THREADS, WAS UTILIZED TO INCREASE RELIABILITY.

**(B) TEST:**  
ATP

AMBIENT TEMPERATURE TESTS

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PROOF PRESSURE (1560 PSIG); EXTERNAL LEAKAGE (850 PSIG); ELECTRICAL CHARACTERISTICS AND RESPONSE; INTERNAL LEAKAGE (740 PSIG, ENERGIZED AND DEENERGIZED)

REDUCED TEMPERATURE TESTS (-160 DEG F)  
ELECTRICAL CHARACTERISTICS AND RESPONSE; INTERNAL LEAKAGE

ELECTRICAL BONDING TESTS

SOLENOID SUBASSEMBLY TESTS  
ELECTRICAL CHARACTERISTICS; ENCLOSURE LEAKAGE (ONE ATMOSPHERE)

CERTIFICATION

TWO UNITS -

PORT AND FITTING TORQUE

SALT FOG EXPOSURE FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS

AMBIENT VIBRATION TESTS: TOTAL 13.1 HOURS BOTH AXES FOR TWO VIBRATION LEVELS PLUS TRANSIENT VIBRATION SWEEP - RUN WITH ONE SPECIMEN ENERGIZED AND ONE DEENERGIZED - FOLLOWED BY ELECTRICAL CHARACTERISTICS AND LEAKAGE CHECKS

HANDLING SHOCK TEST

ENERGIZED AND DEENERGIZED FLOW TESTS

FIFTY HOUR CONTINUOUS CURRENT TEST AT 130 DEG F

AMBIENT TEMPERATURE ENDURANCE (4500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS); 130 DEG F ENDURANCE (500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS); OPERATION CYCLES (REPEATED 20 TIMES); REPEAT OF AMBIENT TEMPERATURE ENDURANCE ; -160 DEG F ENDURANCE (500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS).

DISASSEMBLY AND INSPECTION

BURST PRESSURE (3400 PSIG)

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 PROCESSES CERTIFICATION. BODY HOUSING BAR STOCK IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL

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CLEANLINESS LEVEL VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

10X MAGNIFICATION EXAMINATION OF ALL DETAIL PARTS FOR BURRS, DAMAGE AND CORROSION IS MADE PRIOR TO ASSEMBLY. ALL DETAIL PARTS ARE INSPECTED FOR DIMENSIONS. CRITICAL SURFACE FINISHES ARE INSPECTED USING A COMPARATOR AT 10X MAGNIFICATION. OTHER SURFACE FINISHES ARE INSPECTED AND VERIFIED WITH A PROFILOMETER. TORQUES ARE VERIFIED TO BE IN ACCORDANCE WITH DRAWING REQUIREMENTS. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

**CRITICAL PROCESS**

WELDING, HEAT TREATMENT AND PARTS PASSIVATION VERIFIED BY INSPECTION. POTTING OF SOLDER CUPS, ELECTRICAL WIRE STRIPPING, AND SOLDERING OF CONNECTORS ARE VERIFIED BY INSPECTION. CHROME PLATING AND DRY FILM LUBRICATION ARE VERIFIED BY INSPECTION.

**NONDESTRUCTIVE EVALUATION**

WELDS VISUALLY EXAMINED & VERIFIED BY X-RAY AND DYE PENETRANT INSPECTIONS. THE SOLENOID ASSEMBLY IS SUBJECTED TO LEAKAGE VERIFICATION USING RADIOACTIVE TRACER TECHNIQUES. SOME VALVE BODIES WERE SUBJECTED TO 10X MAGNIFICATION INSPECTION ONLY. OTHER VALVE BODIES WERE SUBJECTED TO EDDY CURRENT INSPECTION, IN ADDITION TO 10X MAGNIFICATION. THE REMAINING VALVE BODIES WERE SUBJECTED TO 10X MAGNIFICATION, ETCH AND DYE PENETRANT INSPECTIONS. REFURBISHED VALVE BODIES WERE SUBJECTED TO 40X MAGNIFICATION INSPECTION. BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED.

**TESTING**

ATP VERIFIED BY INSPECTION.

**HANDLING/PACKAGING**

HANDLING, PACKAGING, STORAGE AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

LEAKAGE RESULTING FROM SEAL/SEAT DAMAGE (OR CONTAMINATION) HAS OCCURRED BUT HAS NOT BEEN OF SUFFICIENT MAGNITUDE TO CAUSE PREMATURE ACTUATION (REFERENCE FMEA/CIL 0291-1, SOLENOID EXTERNAL LEAKAGE THROUGH VENT PORT).

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:**

NO CREW ACTION CAN BE TAKEN.

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**- 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	: DAVE NEARY	:/S/ DAVE NEARY
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	: ERICH BASS	:/S/ ERICH BASS