

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

NUMBER: 03-1-0606 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 07/26/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	:LOW PRESSURE 2-WAY SOLENOID VALVE, NC	MC284-0403-0013, -0023
	UNITED SPACE ALLIANCE - NSLD	12201-2/-3

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, 2-WAY, DIRECT ACTING SOLENOID, LH2 MANIFOLD REPRESSURIZATION, NORMALLY CLOSED (0.5 INCH).

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:** LV42  
LV43

**QUANTITY OF LIKE ITEMS:** 2

**FUNCTION:**

TWO VALVES IN SERIES ISOLATE PNEUMATIC SYSTEM HELIUM PRESSURE (750 PSIA) FROM THE 20 PSIG REGULATOR (PR6). THE TWO VALVES ARE OPENED TO PROVIDE A FLOW PATH TO THE REGULATOR FOR PRESSURIZING THE LH2 MANIFOLD AND IN REPRESSURIZING THE LH2/GH2 SYSTEMS FOR ENTRY.

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: VALVE, SOLENOID, NC 2W**

**CRITICALITY OF THIS**

**ITEM NAME: LH2 MANIFOLD REPRESS SOL VALVE (LV42, 43)**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

RUPTURE/LEAKAGE.

**MISSION PHASE:**

LO LIFT-OFF  
DO DE-ORBIT

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

**CAUSE:**

MATERIAL DEFECT, FATIGUE, DAMAGED/DEFECTIVE SEAL.

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

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**REDUNDANCY SCREEN**

A) N/A  
B) N/A  
C) N/A

**PASS/FAIL RATIONALE:**

A)

B)

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

FOR RUPTURE OF LV42 DURING ASCENT, PNEUMATIC HELIUM SUPPLY WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT. RESULTS IN LOSS OF HELIUM FROM THE PNEUMATIC HELIUM SUPPLY.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY

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RESULT IN OVERPRESSURIZATION OF AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

PRIOR TO T-9 MINUTES, EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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

**(C) MISSION:**  
POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

**(D) CREW, VEHICLE, AND ELEMENT(S):**  
POSSIBLE LOSS OF CREW/VEHICLE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT, DEORBIT.  
1) LV43 RUPTURES/EXTERNAL LEAKAGE.  
2) LV42 FAILS TO REMAIN CLOSED.

DURING ASCENT, THE PNEUMATIC HELIUM SUPPLY WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY RESULT IN OVERPRESSURIZATION OF AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**  
THE SOLENOID VALVE IS A NORMALLY CLOSED, DIRECT-ACTING VALVE. WHEN DE-ENERGIZED, THE VALVE POPPET IS HELD AGAINST THE VALVE SEAT BY A SPRING AND A BELLOWS, EITHER OF WHICH CAN MAINTAIN THE CLOSED POSITION. THE BELLOWS ASSEMBLY INTERIOR IS EXPOSED TO OUTLET PRESSURE BY VENT HOLES THROUGH THE POPPET, PROVIDING A FORCE BALANCE WHICH ALLOWS THE SOLENOID, WHEN ENERGIZED, TO DEVELOP SUFFICIENT FORCE TO OPEN THE VALVE.

THE VALVE IS DESIGNED FOR A PRESSURE FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST. THE VALVE BODY IS MACHINED FROM 6061-T651 ALUMINUM ALLOY. THE SOLENOID COIL AND SPOOL ASSEMBLIES ARE EB WELDED AND CONSISTS OF 430 AND 304L CRES

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COMPONENTS. THE SPOOL ASSEMBLY IS PRESSURE AND LEAK- TESTED AT 1550 PSIG PRIOR TO FINAL ASSEMBLY OF THE SOLENOID COIL ASSEMBLY.

THE VALVE HAS A DESIGN LIFE OF 100 MISSIONS. DURING CERTIFICATION TESTING THESE DESIGN LIMITS WERE DEMONSTRATED FOR THE EQUIVALENT OF 100 MISSIONS ON TWO UNITS BY BURST PRESSURE TESTING AT 3300 PSIG (WITHOUT EVIDENCE OF RUPTURE OR PERMANENT DEFORMATION) AND VIBRATING AND CYCLING THE UNITS UNDER WORST CASE CONDITIONS.

EXTERNAL LEAKAGE IS CONTROLLED BY SEALING THE HIGH PRESSURE AND VENTED PORTIONS OF THE VALVE FROM ONE ANOTHER BY USE OF SOFT SILVER PLATED, INCONEL "V" SEALS.

**(B) TEST:**  
ATP

EXAMINATION OF PRODUCT

AMBIENT TEMPERATURE TESTS:

- PROOF PRESSURE (1550 PSIG)
- EXTERNAL LEAKAGE (850 PSIG)
- INTERNAL LEAKAGE  
(INLET-TO-OUTLET AT 825 PSID AND OUTLET-TO-INLET AT 150 PSID)
- ELECTRICAL CHARACTERISTICS  
(PULL-IN/DROPOUT VOLTAGE, CURRENT SIGNATURE AT 850 PSIG)
- VALVE RESPONSE TIMES (850 PSIG)
- REVERSE PRESSURE VALVE RESPONSE TIMES (150 PSIG)

REDUCED TEMPERATURE TESTS (-160 DEG F)

- INTERNAL LEAKAGE  
(INLET-TO-OUTLET AT 825 PSID AND OUTLET-TO-INLET AT 150 PSID)
- ELECTRICAL CHARACTERISTICS  
(PULL-IN/DROPOUT VOLTAGE AT 850 PSIG)
- VALVE RESPONSE TIMES (850 PSIG)
- REVERSE PRESSURE VALVE RESPONSE TIMES (150 PSIG)

ELECTRICAL TESTS

- ELECTRICAL BONDING
- DIELECTRIC WITHSTANDING VOLTAGE
- INSULATION RESISTANCE

CERTIFICATION

- PORT AND FITTING TORQUE (2 UNITS)  
(TWICE NORMAL INSTALLATION TORQUE)

- SALT FOG TEST (1 UNIT)  
PER MIL-STD-810

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SHOCK

PER MIL-STD-810  
BENCH HANDLING  
DESIGN

VIBRATION (2 UNITS)

TRANSIENT: 5 TO 35 HZ

RANDOM:

ONE UNITS TESTED ENERGIZED AND FLOWING 100 SCIM, SECOND UNIT TESTED  
DEENERGIZED

INLET PRESSURE: 750 PSIG AMBIENT HELIUM  
13.3 HOURS FOR EACH OF 2 AXES

PANEL MOUNTED (2 UNITS)

INLET PRESSURE: 750 PSIG AMBIENT HELIUM  
13.3 HOURS FOR EACH OF 3 AXES

ELECTRICAL CHARACTERISTICS, VALVE RESPONSE, AND INTERNAL LEAKAGE  
AFTER EACH AXIS

FLOW TEST

DIFFERENTIAL PRESSURE TEST (1 UNIT)

INLET PRESSURE: 525 PSIG AMBIENT HELIUM  
FLOW RATES: 0.15 TO 0.25 LBS/SEC  
PRESSURE DROP NOT TO EXCEED 125 PSID

HIGH FLOW CLOSURE TEST (1 UNIT)

3 CYCLES:  
INLET PRESSURE: 850 PSIG AMBIENT HELIUM  
FLOW RATE: 0.3 LB/SEC  
CYCLE VALVE CLOSED AND VERIFY BY LEAKAGE TEST

CONTINUOUS CURRENT TEST (2 UNITS)

50 HOURS WITH SOLENOID ENERGIZED  
TEMPERATURE: +130 DEG F SURROUNDING ENVIRONMENT  
INSULATION RESISTANCE TEST (+130 DEG F MAINTAINED)  
INSULATION RESISTANCE TEST (AMBIENT TEMPERATURE)

THERMAL VACUUM AND ENDURANCE TEST (2 UNITS)

9000 CYCLES: 850 PSIG, AMBIENT HELIUM  
500 CYCLES: 850 PSIG, +130 DEG F HELIUM  
500 CYCLES: 850 PSIG, -160 DEG F HELIUM

OPERATIONAL CYCLE TEST

3 CYCLES PERFORMED DURING EXPOSURE TO FOLLOWING CONDITIONS:

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VALVE ENERGIZED/DEENERGIZED  
INLET PRESSURE: 750 TO 200 PSIG  
TEMPERATURE: +130 TO +250 DEG F HELIUM  
SURROUNDING TEMPERATURE: AMBIENT TO +275 DEG F  
SURROUNDING ENVIRONMENT: AMBIENT TO VACUUM

ELECTRICAL CHARACTERISTICS AND INTERNAL LEAKAGE AFTER EACH SET OF CYCLES AT APPROPRIATE TEMPERATURE CONDITIONS

BURST TEST (1 UNIT)  
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  
CLEANLINESS LEVEL IS VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION  
ALL DETAIL PARTS AND ASSEMBLIES ARE EXAMINED FOR BURRS, DAMAGE AND CORROSION (AT 10X MAGNIFICATION) AND INSPECTED FOR CORRECT DIMENSIONS PRIOR TO ASSEMBLY. 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. BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESS  
THE FOLLOWING ARE VERIFIED BY INSPECTION:

WELDING  
HEAT TREATMENT  
PARTS PASSIVATION  
POTTING OF SOLDER CUPS  
ELECTRICAL WIRE STRIPPING  
DRY FILM LUBRICATION  
CHROME PLATING

NONDESTRUCTIVE EVALUATION  
ALL WELDS ARE VISUALLY EXAMINED AND VERIFIED BY X-RAY OR 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

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CURRENT INSPECTION, IN ADDITION TO 10X MAGNIFICATION. REFURBISHED VALVE BODIES ARE SUBJECTED TO 40X MAGNIFICATION INSPECTION.

TESTING  
ATP VERIFIED BY INSPECTION.

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

**(D) FAILURE HISTORY:**

DURING QUALIFICATION, THE "V" SEAL WAS NOT SEALING PROPERLY (REFERENCE CAR A9476). THE THICKNESS OF SILVER PLATE WAS INCREASED TO 0.003 EFFECTIVE NEXT PRODUCTION ORDERS AND REPAIR.

DURING ATP, THE UNIT WAS FOUND TO BE LEAKING ACROSS A DAMAGED "V" SEAL (REFERENCE CAR AC5633). THE SEAL WAS REPLACED AND PERSONNEL WERE CAUTIONED TO USE UTMOST CARE DURING VALVE ASSEMBLY. INSPECTION PERSONNEL WERE INSTRUCTED TO PERFORM A COMPLETE PRETEST PRIOR TO ACCEPTANCE TESTING.

AT DOWNEY, THE "V" SEAL WAS MISSING (REFERENCE CAR AC7257). THIS WAS FOUND DURING PANEL LEAK CHECK. THE ASSEMBLY PROCEDURE WAS CHANGED TO VERIFY "V" SEAL INSTALLATION.

AT DOWNEY TWO VALVES WERE FOUND WITH SAFETY WIRE MISSING FROM THE SOLENOID MOUNTING SCREWS (REFERENCE CARS AC6776, AC6777). SUPPLIER ADDED MANDATORY INSPECTION BUY-OFF TO ASCERTAIN THAT SAFETY WIRE IS INSTALLED.

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:**

PNEUMATIC ACTUATION HELIUM BOTTLE PRESSURE IS ON A DEDICATED DISPLAY IN COCKPIT. CREW ACTION IS TO FOLLOW NORMAL LEAK ISOLATION PROCEDURE. PRIOR TO MECO, ISOLATION VALVES (LV7, LV8) WILL BE REOPENED AND THE LEFT ENGINE HELIUM CROSSOVER VALVE (LV10) WILL BE OPENED.

PNEUMATIC TANK, REGULATOR, AND ACCUMULATOR PRESSURE ARE ON S/M ALERT FDA SYSTEM AND THE BFS SYSTEM SUMMARY DISPLAY. THIS ALLOWS THE FLIGHT CREW TO RESPOND TO A PNEUMATIC HELIUM SYSTEM LEAK INDEPENDENT OF GROUND CONTROL.

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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

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DESIGN ENGINEERING	: DAVE NEARY	:/S/ DAVE NEARY
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MICHAEL SNYDER	:/S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	:/S/ BILL PRINCE