

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

NUMBER: 03-1-0233 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 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, TYPE 2 NC UNITED SPACE ALLIANCE - NSLD	MC284-0403-0012, -0022  12200-2/-3

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, (LV26, 27), 2-WAY, DIRECT-ACTING SOLENOID, BLOWDOWN, NORMALLY CLOSED, 0.375 INCH DIA.

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:** LV26  
LV27

**QUANTITY OF LIKE ITEMS:** 2

**FUNCTION:**

SERIES REDUNDANT VALVES PROVIDE A HELIUM PURGE CAPABILITY INTO THE OMS PODS AND ET LH2 UMBILICAL/AFT COMPARTMENT DURING ENTRY TO PRECLUDE FLAMMABLE CONCENTRATIONS OF HAZARDOUS GASES FROM THE WAKE BEING INGESTED. ALSO USED TO BLOW DOWN THE HELIUM SYSTEM.

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**SUBSYSTEM NAME: MAIN PROPULSION**

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

**ITEM NAME: MPS GHE BLOWDOWN VALVE (LV26, 27)**

**CRITICALITY OF THIS**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

RUPTURE/LEAKAGE OF VALVE BODY.

**MISSION PHASE:**

- LO LIFT-OFF
- DO DE-ORBIT
- LS LANDING/SAFING

**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 INBOARD BLOWDOWN VALVE (LV26) RUPTURE DURING ASCENT, THE PNEUMATIC HELIUM SUPPLY WILL BE LOST. HELIUM PRESSURE WILL NOT BE AVAILABLE TO CLOSE THE PREVALVES AT MECO OR THE ET/ORBITER UMBILICAL DISCONNECTS PRIOR TO ET SEPARATION. DISCONNECTS WILL CLOSE IN MECHANICAL BACKUP MODE DURING UMBILICAL RETRACT. FAILURE TO CLOSE THE LO2 PREVALVES AT MECO WILL RESULT IN UNCONTAINED ENGINE DAMAGE. RESULTS IN THE INABILITY TO MAINTAIN INJECTED HELIUM AND LO2 PRESSURE AT THE SSME PUMP, RESULTING IN POSSIBLE PUMP

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OVERSPEED AND EXPLOSION. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSIVE HAZARD.

ENGINE HELIUM SUPPLY SYSTEM IS CONNECTED TO VALVE ACTUATION SUPPLY BY THE CROSSOVER VALVE (LV10) AT MECO BY SOFTWARE COMMAND. THE ADDITIONAL HELIUM SUPPLY MAY NOT ACTUATE LO2 PREVALVES CLOSED.

RESULTS IN LOSS OF PNEUMATIC AND LEFT ENGINE HELIUM SUPPLY IF THE FAILURE OCCURS AFTER THE LEFT ENGINE HELIUM CROSSOVER VALVE (LV10) OPENS AT MECO. LOSS OF PNEUMATIC AND ALL ENGINE HELIUM SUPPLIES IF FAILURE OCCURS WHILE THE ENGINE 1 AND 3 INTERCONNECT "OUT" VALVES (LV60, 64) AND LV10 ARE OPEN, BEGINNING AT 20 SECONDS AFTER MECO.

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

HELIUM WILL NOT BE AVAILABLE FOR AFT COMPARTMENT PURGE

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 THE AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

**(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 (FOR LV27), 2 SUCCESS PATHS. TIME FRAME - ASCENT, DEORBIT.

- 1) OUTBOARD BLOWDOWN VALVE (LV27) RUPTURES.
- 2) INBOARD BLOWDOWN VALVE (LV26) FAILS TO REMAIN CLOSED.

DURING ASCENT, THE PNEUMATIC HELIUM SUPPLY WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT. ADDITIONALLY, LOSS OF PNEUMATIC ACTUATION HELIUM RESULTS IN LO2 PREVALVE FAILING TO CLOSE AND INABILITY TO MAINTAIN INJECTED HELIUM AND LO2 PRESSURE TO THE HIGH PRESSURE OXYGEN TURBOPUMP TO PREVENT PUMP OVERSPEED AND CAVITATION AT MECO. RESULTS IN UNCONTAINED ENGINE DAMAGE, AFT COMPARTMENT OVERPRESSURIZATION, AND FIRE/EXPLOSION HAZARD. AT MECO, THE ENGINE 2 HELIUM SUPPLY IS SWITCHED IN TO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY ACTUATE THE LO2 PREVALVES CLOSED.

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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 THE 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 DEENERGIZED, 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 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)

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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)

SHOCK (PER MIL-STD-810)  
BENCH HANDLING  
DESIGN

VIBRATION (2 UNITS)

TRANSIENT: 5 TO 35 HZ

RANDOM: 13.3 HOURS FOR EACH OF 2 AXES  
INLET PRESSURE: 750 PSIG AMBIENT HELIUM  
ONE UNITS TESTED ENERGIZED AND FLOWING 100 SCIM, SECOND UNIT TESTED  
DEENERGIZED

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

FLOW TEST

DIFFERENTIAL PRESSURE TEST (1 UNIT)  
INLET PRESSURE: 605 PSIG AMBIENT HELIUM  
FLOW RATES: 0.015 TO 0.025 LBS/SEC  
PRESSURE DROP NOT TO EXCEED 5 PSID

LOW FLOW CLOSURE TEST (1 UNIT)  
3 CYCLES: INLET PRESSURE: 850 PSIG AMBIENT HELIUM  
FLOW RATE: 0.2 LB/SEC  
CYCLE VALVE CLOSED AND VERIFY BY LEAKAGE TEST

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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:  
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

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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 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:**

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