

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

NUMBER: 03-1-0262 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 07/25/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: HIGH PRESSURE TWO WAY SOLENOID VALVE, NC TYPE 1	MC284-0403-0021
	UNITED SPACE ALLIANCE - NSLD	12199-5

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

TWO WAY, PILOTED SOLENOID VALVE, HELIUM SUPPLY INTERCONNECT "OUT", NORMALLY CLOSED, 0.375 INCH DIAMETER.

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:** LV60  
LV62  
LV64

**QUANTITY OF LIKE ITEMS:** 3  
ONE PER ENGINE HE SUPPLY

**FUNCTION:**

PROVIDES CONTROL OF THE FLOW PATH OF HELIUM FROM A PARTICULAR ENGINE HELIUM SUPPLY SYSTEM TO EITHER THE PNEUMATIC HELIUM SYSTEM OR ANOTHER ENGINE HELIUM SUPPLY SYSTEM. THE ENGINE 1 AND 3 VALVES ARE OPENED AT MECO PLUS 20 SECONDS TO ALLOW THEIR HELIUM SUPPLIES TO SUPPLEMENT THE PNEUMATIC AND ENGINE 2 HELIUM SUPPLIES DURING THE MPS DUMP SEQUENCES. THE SAME VALVES ARE ALSO OPENED DURING ENTRY TO SUPPLEMENT THE ENGINE 2 AND PNEUMATIC HELIUM SUPPLIES FOR MPS ENTRY REPRESSURIZATION AND AFT COMPARTMENT/OMS POD PURGE.

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**SUBSYSTEM NAME: MAIN PROPULSION**

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

**CRITICALITY OF THIS**

**ITEM NAME: SSME GHE SUPPLY I/C OUT VALVE (LV60, 62, 64)**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

RUPTURE/LEAKAGE OF THE 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, SEAL DAMAGE/DEFECT.

**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:**

DURING ASCENT, HELIUM SUPPLY TO ONE ENGINE 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

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RESULT IN OVERPRESSURIZATION OF THE 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:**  
ON GROUND, POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

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

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
NONE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**  
THE VALVE IS A PILOT OPERATED SOLENOID VALVE CONTROLLING THE APPLICATION OF VALVE INLET PRESSURE TO THE POPPET. THE POPPET IS PART OF A RING ASSEMBLY (PISTON) THAT IS SPRING LOADED TO THE CLOSED POSITION. THE VALVE INLET PRESSURE IS ALWAYS EXERTING AN OPENING FORCE ON THE PISTON. WHEN THE SOLENOID IS DEENERGIZED, THE PILOT VALVE DIRECTS THE INLET PRESSURE TO THE CLOSING SIDE OF THE POPPET, UNBALANCING THE FORCE FROM THE INLET SIDE. THIS ALLOWS THE SPRING FORCE PLUS THE PRESSURE-AREA DIFFERENTIAL FORCE TO HOLD THE VALVE CLOSED. WHEN THE SOLENOID IS ENERGIZED, THE PILOT VALVE VENTS THE PRESSURE AT THE CLOSING SIDE OF THE PISTON TO AMBIENT. THIS ALLOWS THE INLET PRESSURE TO OVERCOME THE VALVE SPRING FORCE AND OPEN THE VALVE.

THE PILOT VALVE UTILIZES A 430 CRES BALL AS A CLOSURE DEVICE SEALING AGAINST EITHER OF TWO 17-4PH CRES SEATS. IN THE DEENERGIZED STATE, THE BALL IS HELD AGAINST THE CLOSING SEAT BY A SPRING ACTIVATED PUSHROD. WHEN ENERGIZED, THE SOLENOID (PLUNGER) FORCE OVERCOMES THE SPRING FORCE AND TRANSLATES THE PUSHROD AND BALL AND HOLDS THE BALL AGAINST THE OPENING SEAT. TOTAL BALL MOVEMENT (STROKE) IS LESS THAN 0.05 INCH.

THE VALVE IS DESIGNED AND VERIFIED TO PRESSURE FACTORS OF SAFETY OF 2.0 PROOF AND 4.0 BURST. THE 304L CRES VALVE BODY AND THE ARMCO NITRONIC 40 CONNECTION TUBES ARE MACHINED PARTS. BOTH THE BODY AND THE TUBES ARE PASSIVATED

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FOLLOWING MACHINING. THE TUBES ARE ELECTRON BEAM WELDED TO THE BODY. THE WELDS ARE X-RAY AND DYE PENETRANT INSPECTED.

EXTERNAL LEAKAGE IS PREVENTED BY ISOLATING THE HIGH PRESSURE AND VENTED SECTION OF THE VALVE FROM ONE ANOTHER BY USE OF SILVER PLATED, INCONEL "V" SEALS.

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

EXAMINATION OF PRODUCT

AMBIENT TEMPERATURE TESTS:

PROOF PRESSURE (9000 PSIG)  
EXTERNAL LEAKAGE (4500 PSIG)  
INTERNAL LEAKAGE (4500 PSID, ENERGIZED AND DEENERGIZED)  
CHECK VALVE LEAKAGE (15 PSID)  
ELECTRICAL CHARACTERISTICS  
(PULL-IN/DROPOUT VOLTAGE, CURRENT SIGNATURE)  
VALVE RESPONSE TIMES (4500 PSIG)

REDUCED TEMPERATURE TESTS (-160 DEG F):

INTERNAL LEAKAGE (4500 PSID, ENERGIZED AND DEENERGIZED)  
ELECTRICAL CHARACTERISTICS (PULL-IN/DROPOUT VOLTAGE)  
VALVE RESPONSE TIMES (4500 PSIG)

ELECTRICAL TESTS:

ELECTRICAL BONDING  
DIELECTRIC WITHSTANDING VOLTAGE  
INSULATION RESISTANCE

SOLENOID SUBASSEMBLY TESTS:

ELECTRICAL CHARACTERISTICS  
ENCLOSURE LEAKAGE (1 ATMOSPHERE DIFFERENTIAL)

CERTIFICATION

SALT FOG TEST (1 UNIT)

PER MIL-STD-810

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AMBIENT PERFORMANCE TEST  
ELECTRICAL CHARACTERISTIC  
VALVE RESPONSE

SHOCK (1 UNIT)

PER MIL-STD-810  
BENCH HANDLING  
DESIGN

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)

VIBRATION (2 UNITS)

TRANSIENT: 5 TO 35 HZ

RANDOM (AMBIENT HELIUM):  
INLET PRESSURE: 4500 PSIG  
108 MINUTES FOR EACH OF 2 AXES  
15 MINUTES ENERGIZED  
15 MINUTES VALVE CYCLE (1 CYCLE/MINUTE)  
78 MINUTES DEENERGIZED

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

THERMAL VACUUM AND ENDURANCE TEST (2 UNITS)

9000 CYCLES: 4500 PSIG, AMBIENT HELIUM  
500 CYCLES: 4500 PSIG, +130 DEG F HELIUM  
500 CYCLES: 4500 PSIG, -160 DEG F HELIUM

OPERATIONAL CYCLE TEST  
3 CYCLES PERFORMED DURING EXPOSURE TO FOLLOWING CONDITIONS:  
VALVE ENERGIZED/DEENERGIZED  
INLET PRESSURE: 4000 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

FLOW TEST (1 UNIT)

DIFFERENTIAL PRESSURE TEST

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INLET PRESSURE: 950 PSIG  
FLOW RATES: 0.06 TO 0.10 LBS/SEC  
PRESSURE DROP NOT TO EXCEED 50 PSID

HIGH FLOW CLOSURE TEST  
3 CYCLES:  
INLET PRESSURE: 4500 PSIG  
FLOW RATE: 1 LBS/SEC  
CYCLE VALVE CLOSED AND VERIFY CLOSURE BY LEAKAGE TEST

BURST TEST (1 UNITS)  
18,000 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

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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 SCREENED 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:**

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	: 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