

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0246 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 3 07/26/00**PART DATA**

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LOW PRESSURE 2-WAY SOLENOID VALVE, TYPE 2 NC	MC284-0403-0012, -0022
	UNITED SPACE ALLIANCE-NSLD	12200-2/-3

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE , 2-WAY, DIRECT ACTING SOLENOID, LH2 RTLS REPRESSURIZATION, NORMALLY CLOSED, (0.5 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: LV74
LV75

QUANTITY OF LIKE ITEMS: 2

FUNCTION:

TWO HALVES IN SERIES ISOLATE PNEUMATIC SYSTEM HELIUM PRESSURE (750 PSIA) FROM THE LH2 FEED MANIFOLD. DURING A RTLS OR TAL MISSION, AFTER THE FEEDLINE RELIEF SHUT-OFF VALVE (PV8) IS OPENED, THE TWO VALVES ARE OPENED TO PROVIDE A FLOW PATH FOR HELIUM TO PRESSURIZE THE LH2 MANIFOLD AS AN AID IN DUMPING PROPELLANTS.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0246-03

REVISION#: 2 07/26/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LOW PRESSURE 2-WAY SOLENOID VALVE, NC

CRITICALITY OF THIS

ITEM NAME: RTLS REPRESS SOLENOID VALVE (LV74,75)

FAILURE MODE: 1/1

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

REDUNDANCY SCREEN

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

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

FOR RUPTURE OF LV74 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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

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

FOR RUPTURE/LEAKAGE OF LV74 OR LV75 DURING RTLS MANIFOLD REPRESSURIZATION, PNEUMATIC AND ENGINE HELIUM SUPPLIES WILL BE LOST (INTERCONNECT OUT VALVES ARE OPEN), PRECLUDING THE AFT COMPARTMENT PURGE.

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:
CASE 1:
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT, DEORBIT.
1) LV75 RUPTURES/EXTERNAL LEAKAGE.
2) LV74 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.

CASE 2:
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT (POST MECO).
1) LV75 RUPTURES/EXTERNAL LEAKAGE.
2) CHECK VALVE (CV30) FAILS TO CHECK.

AT MECO, THE LH2 FEEDLINE RELIEF ISOLATION VALVE (PV8) OPENS. HYDROGEN FROM THE LH2 MANIFOLD WILL LEAK THROUGH THE RUPTURE. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYOGENIC EXPOSURE, AFT FUSELAGE FIRE/EXPLOSION, AND OVERPRESSURIZATION HAZARD.

POSSIBLE LOSS OF CREW/VEHICLE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

CASE 3:

1R/3 3 SUCCESS PATHS. TIME FRAME - ENGINE OPERATION.

- 1) LV75 RUPTURES/EXTERNAL LEAKAGE.
- 2) CHECK VALVE (CV30) FAILS TO CHECK.
- 3) PV8 LH2 FEEDLINE RELIEF SHUTOFF VALVE FAILS TO REMAIN CLOSED.

HYDROGEN FROM THE LH2 MANIFOLD WILL LEAK THROUGH THE RUPTURE. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYOGENIC EXPOSURE, AFT FUSELAGE FIRE/EXPLOSION, AND OVERPRESSURIZATION HAZARD.

POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(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)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

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

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

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

FLOW TEST

DIFFERENTIAL PRESSURE TEST (1 UNIT)
INLET PRESSURE: 605 PSIG AMBIENT HELIUM

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

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

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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

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. 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 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 ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THERE HAVE BEEN NO FAILURES ASSOCIATED WITH THE RUPTURE FAILURE MODE.

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0246-03**

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.

- 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	: 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