

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

NUMBER: 03-1-0245 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 3 11/07/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: VALVE SOLENOID, NC 3W, TYPE 2 UNITED SPACE ALLIANCE - NSLD	MC284-0404-0032,-0042 13111-3

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, SOLENOID, NORMALLY CLOSED, 3-WAY, 1/4 INCH. LH2 RTLS DUMP VALVE CONTROL. OPENING (LV72,73).

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:**

QUANTITY OF LIKE ITEMS: 2

**FUNCTION:**

THE SOLENOID VALVES CONTROL PNEUMATIC PRESSURE TO OPEN THE LH2 RTLS DUMP VALVES (PV17, PV18). THE SOLENOID VALVES (LV77, LV78) MUST ENERGIZE IN ORDER TO PROVIDE ACTUATION PRESSURE TO OPEN THE SERIES REDUNDANT RTLS DUMP VALVES. THE OPEN SOLENOIDS MUST DEACTUATE TO VENT SO THE DUMP VALVES CAN CLOSE.

TWO SERIES REDUNDANT RTLS DUMP VALVES PROVIDE A PATH TO DUMP LH2 OVERBOARD FROM THE LH2 FEEDLINE MANIFOLD. FOR NOMINAL, ATO AND AOA MISSIONS THE VALVES ARE SOFTWARE COMMANDED OPEN AT MECO+11 SECONDS AND CLOSED AT DUMP STOP. THE VALVES ARE THEN RE-OPENED FOR ENTRY TO PERFORM A FINAL VACUUM INERT PRIOR TO ENTRY. FOR RTLS AND TAL MISSIONS, THE VALVES ARE OPENED NOMINALLY AND THEN REMAIN OPEN UNTIL ENTRY AT VREL=5300 FT/SEC. THE RTLS INBOARD VALVE, PV17, PROVIDES A RELIEF FEATURE FOR LH2 TRAPPED BETWEEN THE INBOARD AND OUTBOARD, PV18, VALVES.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- NON-CIL FAILURE MODE****NUMBER: 03-1-0245-04****REVISION#:** 2 11/07/00**SUBSYSTEM NAME:** MAIN PROPULSION**LRU:** LH2 RTLS DUMP VALVE OP SOLENOIDS, PV17, 18**CRITICALITY OF THIS****ITEM NAME:** LH2 RTLS DUMP VALVE OP SOLENOIDS, PV17, 18**FAILURE MODE:** 1R3**FAILURE MODE:**

PREMATURE DEACTUATION (RTLS DUMP VALVE FAILS TO REMAIN OPEN, REFERENCE FMEA/CIL 03-1-0651-03) CAUSING ACTUATOR OPEN SIDE TO VENT FOLLOWING MECO

**MISSION PHASE:** LO LIFT-OFF

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:**

PIECE PART STRUCTURAL FAILURE, ELECTRICAL SOLENOID FAILURE

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

<b>REDUNDANCY SCREEN</b>	A) PASS
	B) PASS
	C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

PASSES B SCREEN SINCE FAILURE OF EITHER RTLS DUMP VALVE TO REMAIN OPEN IS DETECTABLE BY MONITORING LH2 MANIFOLD PRESSURE INCREASE. RELIEF VALVE WILL CYCLE SEVERAL TIMES PRIOR TO INITIATION OF NOMINAL PROPELLANT DUMP.

C)

**- FAILURE EFFECTS -****(A) SUBSYSTEM:**

PREMATURE DEACTUATION OF EITHER SOLENOID VALVE CAUSES THE CORRESPONDING RTLS DUMP VALVE TO FAIL TO REMAIN OPEN (FROM MECO + 11 TO MECO + 240 SECONDS). THIS PREVENTS DUMPING LH2 THROUGH THE RTLS LINE WHICH RESULTS IN LOSS OF REDUNDANCY TO RELIEVE LH2. RTLS DUMP VALVE IS REDUNDANT TO THE RELIEF VALVE SINCE RELIEF VALVE CYCLING IS NOT EXPECTED.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE  
NUMBER: 03-1-0245-04**

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

SAME AS A.

**(C) MISSION:**

NO EFFECT.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

1R/3 3 SUCCESS PATHS. TIME FRAME - POST MECO, PRE DUMP.

- 1) PREMATURE DEACTUATION OF EITHER RTLS DUMP VALVE OPENING SOLENOID (LV72 OR 73).
- 2) LH2 MANIFOLD RELIEF SYSTEM FAILS TO RELIEVE.
- 3) LH2 MANIFOLD PRESSURE TRANSDUCER FAILS OR LH2 OUTBOARD FILL/DRAIN VALVE (PV11) FAILS CLOSED. DEFEATS VEHICLE SOFTWARE CHECK OF LH2 MANIFOLD PRESSURE EXCEEDING 60 PSIA AND INITIATION OF LH2 DUMP.

RESULTS IN LACK OF RELIEF CAPABILITY. POSSIBLE RUPTURE OF THE LH2 MANIFOLD CAUSING LH2 LEAKAGE INTO THE AFT COMPARTMENT, OVERPRESSURIZATION, AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

---

**-DISPOSITION RATIONALE-**

---

**(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 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 DEACTUATION MEANS THE FORCE HOLDING THE VALVE BALL TO THE VENT SEAT HAS BEEN REMOVED. MECHANICALLY, THE ONLY VALVE PARTS INVOLVED ARE THE SOLENOID PLUNGER, THE SOLENOID STOP, AND TWO PUSHRODS. THE PLUNGER AND STOP ARE MASSIVE BY COMPARISON TO THE PUSHRODS, AND ARE BOTH OF 430 CRES. THE PUSHRODS ARE ALIGNED IN SERIES WITHIN THE STOP. THE PUSHRODS ARE MADE OF CRES AND CARRY ONLY AXIAL LOADS. IF THE RODS WERE TO FAIL STRUCTURALLY, THEY WOULD CONTINUE TO PERFORM THEIR FUNCTION BECAUSE THEY ARE TOTALLY

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE  
NUMBER: 03-1-0245-04**

CONTAINED IN THE STOP (THE ROD O.D. IS 0.125 INCH AND THE STOP I.D. IS 0.126 INCH). THE ROD, IN CONTACT WITH THE BALL, IS GUIDED BY THE SOLENOID STOP FOR OVER 28% OF ITS LENGTH.

THE ONLY OTHER APPARENT WAY TO ACHIEVE PREMATURE DEACTUATION WOULD BE BY STRUCTURAL DAMAGE SUCH THAT A LEAK WOULD BE CREATED OF SUFFICIENT CAPACITY TO VENT THE VALVE ACTUATION PORT THROUGH THE VENT PORT. WITH THE POSSIBLE EXCEPTION OF BALL DISINTEGRATION, NO INTERNAL STRUCTURAL FAILURE WILL CAUSE PREMATURE DEACTUATION BECAUSE THE FAILURE POINT IS DOWNSTREAM OF THE ACTUATION PORT.

IF A VALVE COMPONENT SHOULD FAIL STRUCTURALLY, IT WOULD NOT DISINTEGRATE AND DISAPPEAR. THE FAILURE WOULD CREATE A FLOW PATH FROM THE HIGH PRESSURE SIDE OF THE VALVE TO THE VENT AND SOMEWHERE IN THAT PATH THE FLOW WILL CHOKE. UPSTREAM OF THAT CHOKING POINT (INCLUDING THE ACTUATION PORT), THE PRESSURE WILL REMAIN ABOVE 400 PSIA. THIS RATIONALE ALSO APPLIES TO SEAT AND SEAL DAMAGE. THE BALL IS MADE FROM 430 CRES.

THE SOLENOID STRUCTURE IS CONSTRUCTED OF CRES AND IS EB WELDED. THE COIL IS VACUUM IMPREGNATED (POTTED). THE UNIT IS PRESSURE AND LEAK TESTED AT THE MAJOR ASSEMBLY POINTS.

THE -0022 CONFIGURATION WAS ADDED DUE TO A BELLOWS ASSEMBLY DESIGN CHANGE (P/N 24340 TO P/N 24340-1) TO ELIMINATE THE "SQUIRMED" CONDITION WHICH SOME OF THE ORIGINAL BELLOWS ASSEMBLIES EXPERIENCED DURING PROOF PRESSURE TESTING AT ATP. THE DESIGN CHANGE WAS MADE TO STRENGTHEN THE BELLOWS. BECAUSE THE DAMAGE OCCURRED DURING ATP, VALVES ALREADY IN THE FLEET (-0012 CONFIGURATION) WERE X-RAY TESTED AND ONLY VALVES WHICH HAD SQUIRMED BELLOWS WERE UPGRADED TO THE -0022 CONFIGURATION.

THE -0032 AND -0042 CONFIGURATION SOLENOID VALVES ARE IDENTICAL TO THE -0012 AND -0022 CONFIGURATION SOLENOID VALVES (RESPECTIVELY) WITH THE EXCEPTIONS 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 (P/N 11107-5) WAS REDESIGNED (P/N 11107-7) 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 PROVIDES A MINIMUM ENGAGEMENT OF THREE THREADS, WAS UTILIZED TO INCREASE RELIABILITY.

**(B) TEST:**  
ATP

AMBIENT TEMPERATURE TESTS  
PROOF PRESSURE: 1560 PSIG  
EXTERNAL LEAKAGE: 850 PSIG

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE  
NUMBER: 03-1-0245-04**

INTERNAL LEAKAGE: 740 PSIG, ENERGIZED AND DEENERGIZED  
ELECTRICAL CHARACTERISTICS AND RESPONSE

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

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

SHOCK  
HANDLING

FLOW  
ENERGIZED  
DEENERGIZED

ELECTRICAL  
FIFTY HOUR CONTINUOUS CURRENT TEST AT 130 DEG F

LIFE 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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE  
NUMBER: 03-1-0245-04**

**(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 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:**

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE. 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).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE  
NUMBER: 03-1-0245-04**

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 ADDITIONAL CREW ACTION CAN BE TAKEN.

---

**- 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