

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0244 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 2 11/06/00**PART DATA**

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LO2 OVERBOARD BLEED VALVE CLOSE SOLENOID	MC284-0404-0032, -0042
	UNITED SPACE ALLIANCE - NSLD	13111-5

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, SOLENOID, NORMALLY CLOSED, 3 WAY, 1/4 INCH, LO2 OVERBOARD BLEED VALVE CONTROL, CLOSING.

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: LV76**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

THE SOLENOID VALVE CONTROLS PNEUMATIC PRESSURE TO CLOSE THE NORMALLY OPEN LO2 OVERBOARD BLEED VALVE (PV19). ENERGIZING THE SOLENOID PROVIDES HELIUM PRESSURE TO CLOSE THE BLEED VALVE. DE-ENERGIZING THE SOLENOID VALVE PROVIDES A VENT FOR THE HELIUM FROM THE BLEED VALVE ACTUATOR, ALLOWING THE BLEED VALVE TO OPEN BY SPRING FORCE.

THE OVERBOARD BLEED VALVE IS CLOSED APPROXIMATELY 9 SECONDS BEFORE LIFTOFF AND IS REQUIRED CLOSED BY LCC. CLOSING PRESSURE IS MAINTAINED DURING ASCENT. FOR NOMINAL, ATO, AND AOA MISSIONS THE VALVE IS OPENED AT COMPLETION OF DUMP. FOR RTLS/TAL ABORTS THE VALVE REMAINS CLOSED UNTIL THE END OF THE 650 SECOND BLOWDOWN PURGE. THE VALVE INCORPORATES TWO REDUNDANT CLOSED POSITION INDICATORS AND A SINGLE OPEN INDICATOR.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0244-05

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: LO2 OVERBOARD BLEED VLV CLOSE SOLENOID

CRITICALITY OF THIS

ITEM NAME: LO2 OVERBOARD BLEED VLV CLOSE SOLENOID

FAILURE MODE: 1R2

FAILURE MODE:

PREMATURE ACTUATION (BLEED VALVE FAILS TO REMAIN OPEN, REFERENCE FMEA/CIL 03-1-0452-01) CAUSING CLOSING PRESSURE TO BE APPLIED TO THE VALVE ACTUATOR

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:

PIECE PART STRUCTURAL FAILURE, SEAL/SEAT DAMAGE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

- A) PASS
- B) PASS
- C) PASS

PASS/FAIL RATIONALE:

A)

B)

PASSES B SCREEN SINCE THE LO2 OVERBOARD BLEED VALVE (PV19) OPEN POSITION SWITCH WILL NOT INDICATE "ON". SOLENOID VALVE DOES NOT HAVE POSITION INDICATOR.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

RESULTS IN CLOSURE OF LO2 OVERBOARD BLEED VALVE (PV19).

CASE 1: NO EFFECT FIRST FAILURE. LOSS OF REDUNDANCY TO PREVENT LO2 GEYSERING FOLLOWING FRF OR TANKING TEST (PLANNED DETANK).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0244-05**

CASE 2: NO EFFECT FIRST FAILURE. LOSS OF REDUNDANCY TO PREVENT LO2 GEYSERING FOLLOWING A SCRUB (UNPLANNED DETANK). FAILURE DURING LOADING RESULTS IN THE INABILITY TO MEET SSME START CONDITIONS.

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

(C) MISSION:
CASE 1: NO EFFECT FIRST FAILURE.

CASE 2: RESULTS IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/3 3 SUCCESS PATHS. TIME FRAME - DETANK FOLLOWING FRF OR TANKING TEST.

- 1) PREMATURE ACTUATION OF LO2 OVERBOARD BLEED CLOSING SOLENOID VALVE (LV76).
- 2) INBOARD OR OUTBOARD FILL & DRAIN VALVES (PV9,10) FAIL TO OPEN/REMAIN OPEN.
- 3) ONE OF THREE PREVALVES (PV1,2,3) OR ONE OF TWO LO2 POGO VALVES (PV20,21) FAILS TO CLOSE/REMAIN CLOSED OR HELIUM INJECT FAILS TO RESUME/CONTINUE.

TO PREVENT GEYSERING, PREVALVE CLOSURE IS REQUIRED TO LIMIT HEAT SOAKBACK FROM THE MAIN ENGINES INTO THE FEED SYSTEM. FOR PREVALVE FAILURE TO CLOSE, HELIUM INJECTION IS NOT SUFFICIENT TO PREVENT GEYSERING AND OVERBOARD BLEED OR LO2 DRAIN MUST BE INITIATED WITHIN OMRSD REQUIREMENTS.

GEYSERING MAY RESULT IN FEEDLINE RUPTURE, EXTERNAL LEAKAGE OF LO2, AND POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF VEHICLE.

CASE 2:

1R/2 2 SUCCESS PATHS. TIME FRAME - PROPELLANT LOADING.

- 1) PREMATURE ACTUATION OF LO2 OVERBOARD BLEED CLOSING SOLENOID VALVE (LV76).
- 2) ONE OF THREE PREVALVES (PV1,2,3) OR ONE OF TWO LO2 POGO VALVES (PV20,21) FAILS TO CLOSE/REMAIN CLOSED OR HELIUM INJECT FAILS TO CONTINUE.

TO PREVENT GEYSERING, PREVALVE CLOSURE IS REQUIRED TO LIMIT HEAT SOAKBACK FROM THE MAIN ENGINES INTO THE FEED SYSTEM. FOR PREVALVE FAILURE TO CLOSE,

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0244-05**

HELIUM INJECTION IS NOT SUFFICIENT TO PREVENT GEYSERING AND OVERBOARD BLEED MUST BE INITIATED WITHIN 2 MINUTES OR FILL/DRAIN DETANK MUST BE INITIATED WITHIN 12 MINUTES. FOR UNPLANNED DETANK, OPENING THE FILL AND DRAIN VALVES TO BEGIN DRAIN CANNOT BE COUNTED AS A SUCCESS PATH SINCE IT REQUIRES A CREW AND/OR GROUND ACTION.

GEYSERING MAY RESULT IN FEEDLINE RUPTURE, EXTERNAL LEAKAGE OF LO2, AND POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF 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 ACTUATION, FROM THE MECHANICAL VIEW, MEANS APPLICATION OF A DIFFERENTIAL FORCE TO THE VALVE BALL TO CAUSE IT TO MOVE FROM THE INLET SEAT TO THE VENT SEAT. ON THE SOLENOID SIDE OF THE BALL, NO MECHANICAL FAILURES WOULD CAUSE PREMATURE ACTUATION. ON THE OTHER HAND, IF THE CLOSING FORCE OF THE BELLOWS/SPRING WERE REMOVED, INLET PRESSURE AND FLOW ACTING ON THE BALL WOULD DRIVE IT TO THE VENT SEAT, CAUSING PREMATURE ACTUATION.

THE FORCE TO HOLD THE BALL TO THE INLET SEAT, WHEN THE SOLENOID IS DEENERGIZED, IS PROVIDED BY THE BELLOWS ASSEMBLY AND SPRING THROUGH THE VALVE POPPET. IF THE BELLOWS FAILS, OR LEAKS TO THE POINT OF REDUCING THE BELLOWS INTERNAL PRESSURE TO LESS THAN THE VALVE INLET PRESSURE, THE LOAD BALANCING FEATURE IS ELIMINATED AND THE BALL WOULD MOVE TO THE VENT SEAT. THE BELLOWS IS MADE OF NICKEL-COBALT-COPPER AND IS PROOF PRESSURE TESTED AT 1550 PSIG PRIOR TO ASSEMBLY INTO THE VALVE. IF THE SPRING BREAKS, THE PRESSURIZED BELLOWS WOULD EXERT SUFFICIENT FORCE TO RETURN THE BALL TO THE INLET SEAT; HOWEVER, SEAT LEAKAGE MAY RESULT. THE SPRING IS MADE FROM 17-7PH CRES (ELGILOY) WIRE AND IS HEAT TREATED FOLLOWING FORMING. IT HAS A SPRING RATE OF 13.5 POUNDS/INCH AND EXERTS A FORCE OF 7.54 POUNDS IN ITS INSTALLED CONDITION.

PREMATURE ACTUATION DUE TO SEAT/SEAL DAMAGE IS VERY UNLIKELY. THIS PRESUMES FLOW PAST THE SEATED BALL AT A RATE SUFFICIENT TO PRESSURIZE THE ACTUATION

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0244-05**

PORT TO A PRESSURE OF 400 PSIA MINIMUM, WHILE THE VENT PORT IS OPEN. THE BALL IS OF 430 CRES AND THE SEAT IS OF VESPEL.

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); ELECTRICAL CHARACTERISTICS AND RESPONSE; INTERNAL LEAKAGE (740 PSIG, ENERGIZED AND DEENERGIZED)

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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0244-05**

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

HANDLING SHOCK TEST

ENERGIZED AND DEENERGIZED FLOW TESTS

FIFTY HOUR CONTINUOUS CURRENT TEST AT 130 DEG F

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.

(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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0244-05**

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:

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:

FLIGHT: N/A

GROUND: GROUND WILL INITIATE DRAIN UPON FAILURE LO2 BLEED DISCONNECT OR LO2 POGO VALVE. GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

- 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