FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0406 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/09/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:LO2 BLEED DISCONNECT, 1.5 INCH (ORB)	MC276-0004-0001
	UNITED SPACE ALLIANCE - NSLD	74338000-101
LRU	: LO2 BLEED DISCONNECT, 1.5 INCH (GND)	MC276-0004-0002
	UNITED SPACE ALLIANCE - NSLD	74353000-101

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
DISCONNECT, LO2 BLEED, 1.5 INCH, SELF SEALING, FLIGHT AND GROUND HALF.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY FAIRCHILD CONTROLS BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PD13

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE DISCONNECT PROVIDES A PATH FOR LO2 TO BLEED OVERBOARD FROM THE LO2 OVERBOARD BLEED VALVE (PV19) IN TO THE GROUND VENT SYSTEM. LO2 IS BLED OVERBOARD TO MAINTAIN PROPER SSME CRYOGENIC START CONDITIONS. THE POGO ACCUMULATOR RETURN LINE IS ALSO FLUSHED PRIOR TO ENGINE START THROUGH THIS DISCONNECT. PRIOR TO LIFTOFF THE DISCONNECT IS ISOLATED FROM THE LO2 SYSTEM BY CLOSING THE LO2 OVERBOARD BLEED VALVE (PV19) AT T-9.4 SECONDS. THE DESIGN INCORPORATES A POPPET TO PREVENT FLOW OF LO2 OVERBOARD AFTER T-0 UMBILICAL DISENGAGEMENT AND LIFTOFF.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: LO2 BLEED DISCONNECT, 1.5 INCH ORB (PD13) **CRITICALITY OF THIS**
ITEM NAME: LO2 BLEED DISCONNECT, 1.5 INCH ORB (PD13) **FAILURE MODE:** 1/1

FAILURE MODE:
EXTERNAL LEAKAGE (ORBITER/GROUND UMBILICAL INTERFACE) DURING LO2 BLEED OPERATION OF PROPELLANT LOADING.

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:
CONTAMINATION, INTERFACE SEAL/SEALING SURFACES DAMAGE, IMPROPER ALIGNMENT, INSUFFICIENT BELLOWS SPRING LOAD

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:
RESULTS IN EXTERNAL LEAKAGE OF LO2. GN2 PURGES AT THE T-0 AND MLP HOOD WILL DISSIPATE SOME OF THE PROPELLANT. THERE IS NO HAZARDOUS GAS DETECTION SYSTEM (HGDS) ON THE LO2 TSM/T-0 UMBILICAL. POSSIBLE DAMAGE TO TPS AND SURROUNDING STRUCTURE FOR LO2 LEAKAGE. DURING LOADING, LO2 WILL DUMP INTO

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THE T-0 UMBILICAL. FIRE/EXPLOSION HAZARD TO THE EXTERIOR OF THE VEHICLE. GROSS LEAKAGE MAY BE DETECTABLE USING MONITORING TV CAMERAS.

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE MATED FLIGHT HALF AND GROUND HALF ARE DESIGNED FOR 100 PSIG OPERATING, 200 PSIG PROOF, AND 400 PSIG BURST. THE FLIGHT HALF BODY IS CAST A357 OR MACHINED A367 ALUMINUM; THE GROUND HALF BODY IS MACHINED 6061 ALUMINUM. THE GROUND HALF BELLOWS (TWO PLY) IS MANUFACTURED FROM INCONEL. THE FLIGHT HALF/GROUND HALF INTERFACE SEAL IS MADE OF SP-21 VESPEL. THE GROUND HALF SPHERICAL SEAT IS MADE FROM 304L CRES.

STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION; FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE. THE DISCONNECT ASSEMBLY (INCLUDING THE BELLOWS) HAS BEEN SUBJECTED TO A FLOW INDUCED VIBRATION TEST FOR THE CENTAUR PROGRAM AT FLOW RATES THAT EXCEED SHUTTLE REQUIREMENTS. THE VALVE WAS DESIGNED AND TESTED FOR 2,000 CYCLES (OVER 100 MISSIONS) UNDER BOTH CRYOGENIC AND AMBIENT CONDITIONS. AMBIENT PROOF AND LEAKAGE TESTS ARE PERFORMED DURING ATP.

IMPROPER MATING OF THE LO2 BLEED DISCONNECT IS NOT LIKELY SINCE THE MATED DISCONNECT IS DESIGNED FOR LIMITED MISALIGNMENT. ALSO THE GROUND HALF DISCONNECT IN THE T-0 UMBILICAL CARRIER AND THE AIRBORNE HALF DISCONNECT IN THE AIRBORNE UMBILICAL PANEL WERE ASSEMBLED UTILIZING THE SAME TOOLING FIXTURE. WHEN THE T-0 UMBILICAL CARRIER IS MATED TO THE AIRBORNE PANEL, CORRESPONDING ALIGNMENT TOOLING HOLES ARE USED TO VERIFY EXACT ALIGNMENT.

IN THE MATED CONDITION, THE GROUND HALF DISCONNECT BELLOWS ASSEMBLY PROVIDES A PRELOAD AT THE AIRBORNE INTERFACE SEAL. THE GROUND HALF

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DISCONNECT IS SHIMMED TO A PRESET DIMENSION TO PROVIDE A NOMINAL BELLOWS COMPRESSION. THE MATED DISCONNECT IS DESIGNED TO ALLOW FOR LIMITED RADIAL AND ANGULAR MISALIGNMENT.

THE LAUNCH FACILITY HAS DEDICATED, CONTINUOUS TV OBSERVATION OF THE UMBILICAL AREA THROUGHOUT BLEED OPERATION SO THAT MASSIVE LEAKAGE WOULD BE OBSERVED. A CONTINUAL GN2 PURGE IS MAINTAINED TO MINIMIZE ANY HAZARDOUS CONDITION.

SYSTEM CONTAMINATION IS MINIMIZED BY MAINTAINING THE CLEANLINESS TO LEVEL 800A, AND USE OF AN ET SCREEN, PREVALVE SCREENS, FACILITY DEBRIS PLATE AND FILTERS.

(B) TEST:
ATP

DISCONNECT DISENGAGED

ORBITER HALF

AMBIENT PROOF (520 PSIG)

AMBIENT HOUSING LEAKAGE (400 PSIG)

AMBIENT CLOSURE DEVICE LEAKAGE (20 & 400 PSIG)

GROUND HALF

AMBIENT PROOF (200 PSIG)

AMBIENT HOUSING LEAKAGE (100 PSIG)

AMBIENT CLOSURE DEVICE LEAKAGE (100 PSIG)

DISCONNECT ENGAGED (WITH RADIAL AND ANGULAR MISALIGNMENT AT MINIMUM AND MAXIMUM BELLOWS COMPRESSION)

PROOF PRESSURE (200 PSIG)

AMBIENT EXTERNAL LEAKAGE (25 & 100 PSIG)

CRYO (-255 DEG F) EXTERNAL LEAKAGE (100 PSIG)

ENGAGE - DISENGAGE CYCLE

CERTIFICATION

DURING ALL MATED TESTS THE ORBITER HALF IS RIGIDLY MOUNTED AND THE GROUND HALF IS MOUNTED WITH RADIAL AND ANGULAR MISALIGNMENT.

CRYO LEAKAGE (-400 DEG F)

MATED: 100 PSIG
ORBITER HALF: 25 AND 100 PSIG
GROUND HALF: 25 AND 100 PSIG

AMBIENT LEAKAGE
MATED: 25 AND 100 PSIG
ORBITER HALF: 20 AND 400 PSIG
GROUND HALF: 25 AND 100 PSIG

AMBIENT EXTERNAL BODY LEAKAGE
ORBITER HALF: 400 PSIG
GROUND HALF: 100 PSIG

LIFE CYCLES
2000 CYCLES (10 SERIES):
199 CYCLES AT AMBIENT TEMPERATURE
ONE CYCLE AT CRYO TEMPERATURE (-255 DEG F)

VIBRATION
TRANSIENT SINUSOIDAL VIBRATION
ORBITER HALF: 5 TO 35 HZ AT ZERO PSIG AND AMBIENT TEMPERATURE

RANDOM VIBRATION IN EACH OF TWO AXES AT -280 DEG F
MATED: 40 PSIG, 9 MINUTES
ORBITER HALF: 80 PSIG, 52 MINUTES
GROUND HALF: 0 PSIG, 9 MINUTES

THERMAL CYCLE TEST: 3 CYCLES (+70 TO -280 TO +70 TO +350 DEG F)

SALT FOG, BENCH HANDLING SHOCK AND DESIGN SHOCK PER MIL-STD-810, SAND AND DUST TEST

FLOW CAPACITY TEST (8 TO 18.5 LBS/SEC)

BURST TEST
MATED: 400 PSIG
ORBITER HALF: 600 PSIG
GROUND HALF: 400 PSIG

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION

RAW MATERIALS, INCLUDING CHEMICAL AND MECHANICAL REQUIREMENTS, ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. INSPECTION VERIFIES CERTIFICATION OF ULTRASONIC INSPECTION OF BODY HOUSING FORGING.

CONTAMINATION CONTROL

CLEANING PROCEDURES AND CONTAMINATION CONTROL REQUIREMENTS ARE VERIFIED. CLEANLINESS TO LEVEL 800A (FLIGHT HALF) AND 400A (GROUND HALF) FOR THE DISCONNECT ASSEMBLY IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. ALL CRITICAL DIMENSIONS AND FINISHES ARE VERIFIED BY INSPECTION. SEALING SURFACE OF THE POPPET IS INSPECTED USING 10X MAGNIFICATION. DRAWING TORQUE REQUIREMENTS ARE VERIFIED. SEALS ARE VISUALLY EXAMINED, PRIOR TO INSTALLATION, FOR DAMAGE AND CLEANLINESS USING 10X MAGNIFICATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE. LOG OF CLEAN ROOM AND TOOL CALIBRATION IS REQUIRED AND VERIFIED. ALL SPRINGS ARE LOAD TESTED AND VERIFIED BY INSPECTION.

CRITICAL PROCESS

HEAT TREATMENT, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED. CHEMICAL FILM PROTECTANT AND DRY FILM LUBRICANT ARE VERIFIED.

NONDESTRUCTIVE EVALUATION

BODY HOUSING IS FLUORESCENT PENETRANT INSPECTED. WELDS ARE VISUALLY EXAMINED AND VERIFIED BY X-RAY AND DYE PENETRANT. BELLOWS ASSEMBLY IS PROOF PRESS TESTED AND LEAK CHECKED.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPPING IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
ATP

NUMEROUS CASES OF EXTERNAL LEAKAGE HAVE OCCURRED DURING ATP. CAUSES HAVE BEEN ATTRIBUTED TO MISHANDLING WHICH CAUSED DAMAGE TO THE INTERFACE SEATING/SEALING SURFACES (REF CARS AB5444, AB5445, AB5446, A6637, A7374, AD0115, AD0862, AD8028, AC0722, AC0899, AD0996, AD0459, AC7736, AD0156, AD0270, AND AD0575). PERSONNEL WERE CAUTIONED TO EXERCISE CAUTION IN HANDLING TO PREVENT DAMAGE.

ONE CASE OF LEAKAGE OCCURRED DURING ATP WHEREBY A REVISION TO THE INTERFACE SEAL DRAWING WAS MADE TO CLARIFY THE REQUIRED CONDITION OF THE SEALING EDGE (REF CAR A6491).

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EXTERNAL LEAKAGE WAS RECORDED DURING ATP AT THE SUPPLIER WHERE THE GROUND HALF BELLOWS SHIELD WAS RESTRAINING THE BELLOWS ACTION AND CAUSING THE LEAKAGE (REF CAR A6492). THE BELLOWS SHIELD DESIGN WAS REVISED TO ASSURE ADEQUATE CLEARANCE.

EXTERNAL LEAKAGE WAS DETECTED DURING ATP ON A DISCONNECT THAT HAD AN INSUFFICIENT SPRING RATE BELLOWS INSTALLED ON THE GROUND HALF. THE SUPPLIER INTENTIONALLY INSTALLED THE OUT OF SPEC BELLOWS ASSEMBLY IN AN ATTEMPT TO DETERMINE IF THAT BELLOWS ASSEMBLY WAS ACCEPTABLE. ALSO THE METHOD OF TESTING WAS INCORRECT VERSUS ACTUAL USAGE. THE TEST UNIT WAS CHILLED BOTH EXTERNALLY AND INTERNALLY (REF CAR AB0234). IN ACTUAL USE THE UNIT IS SUBJECTED TO ONLY INTERNAL EXPOSURE TO CRYOGENICS. THE BELLOWS WAS REPLACED WITH A CORRECT UNIT AND THE DISCONNECT SUCCESSFULLY PASSED ATP. THE TEST PROCEDURE WAS CHANGED TO INCORPORATE THE INTERNAL CHILLING.

AN EXTERNAL LEAK WAS OBSERVED AT THE SUPPLIER DURING ATP WHERE IT WAS DETERMINED THAT DAMAGE WAS BEING CAUSED TO THE INTERFACE SEAL UPON INSTALLATION/REMOVAL OF THE PROTECTIVE CAP (REF CAR A9805). THE CAP WAS REDESIGNED TO PREVENT INTERFERENCE BETWEEN THE CAP AND INTERFACE SEAL.

QUALIFICATION

AN EXTERNAL LEAKAGE PROBLEM OCCURRED DURING QUALIFICATION TESTING AT CRYOGENIC TEMPERATURES. INVESTIGATION REVEALED THAT THE TORQUE HAD RELAXED ON THE SEAL RETAINER FASTENERS (REF CAR AB3556). THE ASSEMBLY PROCEDURE WAS REVISED TO REQUIRE RETORQUING THE SEAL RETAINER FASTENERS AFTER 24 HOURS.

FIELD

ONE INSTANCE OF EXTERNAL LEAKAGE OCCURRED AT KSC WHEN THE INTERFACE SEAL LEAKED BECAUSE IT HAD NOT BEEN COINED (PREFORMED) (REF CAR AB4316). ALL SUBSEQUENT SEALS WERE COINED.

SEVERAL DAMAGED SEALS HAVE BEEN OBSERVED AT KSC (REF CARS AB3181, AB3182, AC7043, AND 07F003). PERSONNEL HAVE BEEN CAUTIONED TO EXERCISE CAUTION IN HANDLING TO PREVENT DAMAGE.

GENERAL SYSTEM CONTAMINATION

THIS FAILURE MODE HAS NOT OCCURRED ON THIS COMPONENT DUE TO CONTAMINATION. HOWEVER, GENERAL MPS SYSTEM CONTAMINATION HAS OCCURRED WHICH MAY LODGE ANYWHERE IN THE SYSTEM CAUSING THIS FAILURE MODE (REFERENCE THE FOLLOWING PARAGRAPHS).

CONTAMINATION FAILURES HAVE OCCURRED AT ALL PHASES OF MANUFACTURING AND PARTS REPLACEMENT. IN ALL CASES, STRICT ADHERENCE TO CLEANLINESS CONTROL PROCEDURES IS THE PRIMARY METHOD OF CONTAMINATION PREVENTION.

NUMEROUS LARGE PARTICLES OF BLACK RUBBER MATERIAL WERE FOUND DURING A POST FLIGHT EXAMINATION OF THE LH2 17 INCH DISCONNECT OF OV099 (FLIGHT 7,

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REFERENCE CAR AC9800). THE LO2 AND LH2 SYSTEMS OF ALL VEHICLES WERE EXAMINED. NO RUBBER WAS FOUND IN ANY OTHER VEHICLES. AFTER EXTENSIVE INVESTIGATION THE ORIGIN WAS NOT DETERMINED.

METAL SHAVINGS HAVE BEEN DISCOVERED IN LINES AND COMPONENTS, WHICH WAS MOST LIKELY GENERATED WHEN THEY WERE CUT OUT AND/OR REPLACED (REFERENCE CARS AC9868, A9654, AC2210, AB1706; DR AD2226). METHODS HAVE BEEN REVISED TO MINIMIZE PARTICLE GENERATION WHEN INSTALLING/REPLACING COMPONENTS, LINES, AND FITTINGS REQUIRING WELDED OR BRAZED JOINTS (PRODUCT QUALITY IMPROVEMENT COUNCIL). PERSONNEL HAVE BEEN CAUTIONED. ROCKWELL PROBLEM ACTION CENTER WILL CONTINUE TO MONITOR BRAZING/WELDING REWORK CONTAMINATION. PROCEDURES HAVE BEEN REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

A PIECE OF A BRAZING PREFORM LODGED IN A 2-WAY SOLENOID VALVE ON OV- 099 AT PALMDALE CAUSING A LEAKAGE FAILURE (REFERENCE CARS AC2111, AB2538). STEEL AND ALUMINUM PARTICLES CAUSED EXCESSIVE LEAKAGE ON THE 850 PSIG HELIUM RELIEF VALVE (REF CAR AC2229). FOR BOTH FAILURES CORRECTIVE ACTION WAS TO ADD SPECIAL PURGE PORTS TO THE MPS HELIUM PANEL ASSEMBLIES TO IMPROVE THE QUALITY OF FINAL CLOSEOUT BRAZES.

SEVERAL FOREIGN MATERIALS WERE INTRODUCED INTO THE MPS SYSTEM DURING MANUFACTURE AND PARTS REPLACEMENT. EXAMPLES ARE: GLASS CLOTH IN LINE TO PREVENT TRAVEL OF CHIPS DOWN LINE; POLYSTYRENE OBJECT TO HOLD VALVE POPPET OPEN WHILE PURGING; COTTON SWAB MATERIAL AND GLASS BEADS FROM CLEANING OPERATION; MISCELLANEOUS PLASTIC; FOAM; AND TAPE (REFERENCE CARS AB4751, AC2217, AC6768, AC9868, MPS3A0005, AC7912, AB0530). MATERIALS WERE REMOVED AND PERSONNEL WERE CAUTIONED. A HIGH FLOW DELTA P TEST AT PALMDALE WAS ADDED TO VERIFY THAT LINES WERE NOT PLUGGED. GRIT BLASTING (GLASS BEADS AND SAND USED TO CLEAN A LINE) IS NO LONGER PERFORMED. PROCEDURES HAVE BEEN REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

ONE PIECE OF WIRE WAS FOUND IN THE INTERNAL RELIEF VALVE OF THE LO2 PREVALVE ON OV103 (REFERENCE CAR AC9101). THE SOURCE OF THE CONTAMINATION WAS NEVER FOUND, BUT IT WAS BELIEVED TO BE FROM THE ET. OTHER CONTAMINATION HAS BEEN FOUND ON THE FEEDLINE SCREENS, SUCH AS AN UNIDENTIFIED ROUND OBJECT AND VARIOUS METALLIC PARTICLES (REFERENCE CARS AB0529 AND AB0530). SOURCE OF CONTAMINATION WAS UNDETERMINED. BORESCOPE EXAMINATIONS ARE CONDUCTED ON ALL FEEDLINE SCREENS EVERY FIFTH FLIGHT TO VERIFY CLEANLINESS. CONTAMINATION WAS REMOVED WHEN POSSIBLE.

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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FLIGHT:
NO CREW ACTION CAN BE TAKEN.

GROUND:
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	: MIKE FISCHER	: /S/ MIKE FISCHER
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS