FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0501 -X

SUBSYSTEM NAME: MAIN PROPULSION
REVISION: 1 08/09/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:GH2/GO2 1" REPRESS DISCONNECT (ORB) UNITED SPACE ALLIANCE - NSLD	MC276-0003-0007
LRU	:GH2/GO2 1" REPRESS DISCONNECT (GND) UNITED SPACE ALLIANCE - NSLD	MC276-0003-0008

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
DISCONNECT, PREPRESSURIZATION ONE INCH, SELF SEALING, GH2/GO2 SYSTEM.

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

REFERENCE DESIGNATORS: PD10
PD9

QUANTITY OF LIKE ITEMS: 2
ONE GH2, ONE GO2

FUNCTION:
CONNECTS WITH GSE TO PROVIDE HELIUM FOR PROPELLANT TANK PRESSURIZATION AND ANTI-ICING PURGE. ACTS AS REDUNDANT CLOSURE DEVICE WITH PREPRESSURIZATION CHECK VALVE (CV17/CV16) AFTER FLOW CESSATION TO PREVENT OVERBOARD LOSS OF ET PRESSURANT THROUGH ORBITER PLUMBING. THE PRESSURE ACTUATED POPPET IN THE DISCONNECT REQUIRES A DELTA P TO OPEN.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0501-01

REVISION#: 1 08/09/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: GH2/GO2 1" REPRESS DISC ORB (PD9, 10) **CRITICALITY OF THIS**
ITEM NAME: GH2/GO2 1" REPRESS DISC ORB (PD9, 10) **FAILURE MODE:** 1R2

FAILURE MODE:
FAILS TO CLOSE/FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE UPON T-0 UMBILICAL SEPARATION.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:
FAILS TO CLOSE - BINDING, CONTAMINATION, PIECE PART STRUCTURAL FAILURE

FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE - PIECE PART STRUCTURAL FAILURE OF THE POPPET, SWIVEL SEAL OR POPPET SEAL DAMAGE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) N/A
C) FAIL

PASS/FAIL RATIONALE:
A)

B)
DISCONNECT IS STANDBY REDUNDANT TO THE PREPRESS CHECK VALVE. FAILURE IS NOT DETECTABLE BECAUSE THERE IS NO INSTRUMENTATION BETWEEN CHECK VALVE AND DISCONNECT.

C)
FAILS C SCREEN BECAUSE CONTAMINATION COULD CAUSE CHECK VALVE AND DISCONNECT TO FAIL OPEN.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
NO EFFECT. BACKUP CHECK VALVE LOCATED UPSTREAM WILL PREVENT OVERBOARD LEAKAGE.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL **FAILURE MODE NUMBER: 03-1-0501-01**

(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/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.

1) GH2/GO2 PREPRESS DISCONNECT (PD10/PD9) FAILS TO CLOSE/REMAIN CLOSED/INTERNAL LEAKAGE.
2) PREPRESS CHECK VALVE (CV17/CV16) FAILS TO CLOSE/REMAIN CLOSED/INTERNAL LEAKAGE.

GH2/GO2 WILL VENT OVERBOARD. THE GH2 FLOW CONTROL VALVES WILL CYCLE TO THE HIGH FLOW POSITION IN AN ATTEMPT TO MAINTAIN ET ULLAGE PRESSURE.

LOSS OF ET LH2/LO2 ULLAGE PRESSURE MAY RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS.

ON THE H2 SYSTEM, LOW NPSP MAY RESULT IN PREMATURE SSME SHUTDOWN.

MASS OF LO2 AND VEHICLE ACCELERATION SHOULD BE SUFFICIENT TO MAINTAIN PROPER ENGINE NPSP, MAY RESULT IN LOW NPSP LATE IN POWERED FLIGHT.

GH2/GO2 LEAKAGE OVERBOARD COULD CAUSE FIRE AND EXPLOSIVE HAZARD EXTERNAL TO THE VEHICLE DURING ASCENT.

POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE ORBITER AND GROUND HALF HOUSINGS ARE MADE OF INCONEL 718. THE FLIGHT AND GROUND DISCONNECT HALVES INCORPORATE A SWIVEL WHICH ACTS AS A SELF-ALIGNING DEVICE FOR PROPER ENGAGEMENT. THE SWIVEL IS PROTECTED AGAINST LEAKAGE (EXTERNAL TO THE VEHICLE) WITH A RACO SEAL. THE FLIGHT HALF HAS A FLOW-ACTUATED POPPET WITH A VESPEL SEAL. THE GROUND HALF DISCONNECT IS OPENED UPON ENGAGEMENT WITH THE FLIGHT HALF AND IT HAS A POPPET SEAL MADE OF VESPEL.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL **FAILURE MODE NUMBER: 03-1-0501-01**

STRUCTURAL FAILURE OF THE SWIVEL, POPPET, POPPET GUIDE, SEAL RETAINER (ALL OF A286 CRES) OR THE SEAL (VESPEL) MAY CAUSE THE FLIGHT HALF TO FAIL TO CLOSE. FAILURE TO REMAIN CLOSED COULD BE CAUSED BY STRUCTURAL FAILURE OF THE POPPET SPRING WHICH MAY RESULT IN FAILURE TO REMAIN CLOSED FOR LOW OR NO FLOW CONDITIONS. THE SPRING IS MADE FROM 0.070 INCH DIAMETER ELGILOY WIRE, HAS A SPRING RATE OF 13.75 LB/INCH, AND EXERTS A FORCE OF 19 POUNDS IN THE INSTALLED CONDITION. STRUCTURAL ANALYSIS, PERFORMED BY THE DISCONNECT SUPPLIER, INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF DISCONNECT OPERATION. FRACTURE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES THE ORBITER LIFE OF 100 MISSIONS.

THE DISCONNECT IS DESIGNED TO PREVENT FAILURE TO CLOSE DUE TO BINDING BY THE APPLICATION OF A DRY LUBRICANT (TIOLUBE) TO ALL SLIDING SURFACES. ALSO THE POPPET STEM IS GUIDED FOR OVER 65% OF ITS LENGTH.

FAILURE TO CLOSE DUE TO CONTAMINATION IS AVOIDED BY THE FILTRATION OF THE FACILITY SUPPLIED GASSES TO 25 MICRONS ABSOLUTE IN THE GROUND SYSTEM. THAT SAME SYSTEM IS MAINTAINED TO THE 300A CLEANLINESS LEVEL OF KSC SPEC -123.

LEAKAGE IN BOTH HALVES IS PREVENTED BY THE USE OF VESPEL SEALS SEATED AGAINST A286 CRES SEATS (SURFACE FINISH OF 16 MICRO-INCH).

(B) TEST:
ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE
- DEMATED
  - FLIGHT HALF: 1,900 PSIG
  - GROUND HALF: 9,000 PSIG
- MATED: 1,900 PSIG

OPERATION TEST
- MATE, PRESSURIZE TO 950 PSIG WITH GHE, AND MEASURE EXTERNAL LEAKAGE
  - (200 SCIM MAX)
  - CRACK/RESEAT PRESSURE (15 PSID MIN)
- DEMATE

EXTERNAL LEAKAGE
- DEMATED
  - FLIGHT HALF
    - 1 SCIM AT 5 PSIG
    - 10 SCIM AT 950 PSIG
  - GROUND HALF
    - 200 SCIM AT 950 PSIG
- MATED: 200 SCIM AT 950 PSIG

CERTIFICATION

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL **FAILURE MODE NUMBER: 03-1-0501-01**

SHOCK PER MIL-STD-810
DESIGN
BENCH HANDLING
AT COMPLETION PERFORM OPERATION AND EXTERNAL LEAKAGE TESTS

FLOW CAPACITY (MATED)
675 PSIG INLET, 1.27 LBM/SEC GN2, 18 TO 23 PSID

VIBRATION
RANDOM (TWO AXES)
9 MIN. IN EACH AXIS, MATED
52 MIN. IN EACH AXIS, FLIGHT HALF
9 MIN. IN EACH AXIS, GROUND HALF
TRANSIENT (TWO AXES)
5 TO 35 HERTZ ±0.25 G IN EACH AXIS
BEFORE/AFTER PERFORM OPERATION AND EXTERNAL LEAKAGE TESTS

THERMAL CYCLE (5 CYCLES EACH)
FLIGHT HALF: +70°F TO -250°F; PRESSURIZE TO 600 PSIG; -250°F TO +70°F TO +190°F; VENT; +190°F TO +70°F
GROUND HALF: PRESSURIZE TO 2,000 PSIG; +70°F TO -250°F; PRESSURIZE TO 4,500 PSIG; VENT; -250°F TO +70°F
AT CONCLUSION, PERFORM OPERATION & EXTERNAL LEAKAGE TESTS

LIFE TEST
LOW TEMPERATURE (-250°F): 100 CYCLES
MATE, PRESSURIZE TO 950 PSIG, DEMATE, VENT
AMBIENT: 1,900 CYCLES
MATE, PRESSURIZE TO 950 PSIG, VENT, DEMATE
AFTER EACH 500 CYCLES, PERFORM EXTERNAL LEAKAGE TEST AND HIGH TEMPERATURE EXTERNAL LEAKAGE TEST

HIGH TEMPERATURE EXTERNAL LEAKAGE TEST
MATED: PRESSURIZE TO 950 PSIG WITH +165°F GHE; 200 SCIM MAX
FLIGHT HALF: HEAT TO +190°F, PRESSURIZE TO 950 PSIG; 20 SCIM MAX

BURST
3,800 PSIG MATED
3,800 PSIG FLIGHT HALF
18,000 PSIG GROUND HALF

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

(C) INSPECTION:
RECEIVING INSPECTION
INCOMING COMPONENTS AND MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIALS AND PROCESSES CERTIFICATION.

CONTAMINATION CONTROL
ALL PARTS AND ASSEMBLIES ARE MAINTAINED TO CLEANLINESS LEVEL 100A AS PER REQUIREMENTS. POST TEST DISCONNECT INLET AND OUTLET PROTECTION, TO MAINTAIN INTERNAL CLEANLINESS, IS VERIFIED BY INSPECTION. SEALS AND SEALING SURFACES PROTECTION ARE ALSO VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. TORQUES APPLIED TO COUPLINGS ARE VERIFIED PER DRAWING SPECIFICATIONS. PRIOR TO INSTALLATION, SEALS ARE VISUALLY EXAMINED FOR DAMAGE AND CLEANLINESS USING 10X MAGNIFICATION. SEALING SURFACE OF THE POPPET IS INSPECTED. THE CLEAN ROOM LOG AND TOOL CALIBRATION RECORDS ARE VERIFIED BY INSPECTION. INSPECTION POINTS ARE ESTABLISHED TO VERIFY ASSEMBLY PROCESSES.

CRITICAL PROCESSES
APPLICATION OF DRY FILM LUBRICANT TO PARTS IS VERIFIED BY INSPECTION. HEAT TREATMENT AND PART PASSIVATION ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
FLUORESCENT PENETRANT INSPECTION OF THE BODY HOUSING IS VERIFIED.

TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
INTERNAL LEAKAGE WAS DETECTED DURING ATP WHEN A REBUILT UNIT WITH NEW SEALS EXPERIENCED EXCESSIVE LEAKAGE (REFERENCE CAR AB1838). IT WAS DETERMINED THAT THE WEAR PATTERNS OF THE BUILT-UP DRY FILM LUBRICANT (TIO-LUBE) ON THE POPPET SEAT WERE INCONSISTENT WITH THE NEW SEALS SEALING AREA. THE EXCESSIVE DRY FILM LUBRICANT WAS REMOVED BY POLISHING.

EXTERNAL LEAKAGE WAS DETECTED DURING ATP DUE TO CONTAMINATION LODGED AT THE SWIVEL AND POPPET SEAL INTERFACE (REFERENCE CAR AB8396). THE MOST PROBABLE CAUSE WAS CONTAMINATION GENERATED DURING THE ASSEMBLY PROCESS. ASSEMBLY PERSONNEL WERE INSTRUCTED AND CAUTIONED ABOUT PROPER INSTALLATION TECHNIQUES.

AN AUDIBLE LEAK WAS DETECTED ON A DISCONNECT DURING ATP (REFERENCE CAR AB5095). THE CAUSE OF THE LEAK WAS A SWIVEL SEAL THAT HAD BEEN INSTALLED BACKWARDS. THE SEAL INSTALLATION WAS CORRECTED AND THE UNIT SUCCESSFULLY PASSED ATP. THE SUPPLIER CORRECTED THE MANUFACTURING ROUTE SHEET AND INSPECTION RECORDS WILL VERIFY PROPER INSTALLATION.

DURING ATP AT THE SUPPLIER, EXCESSIVE LEAKAGE WAS DETECTED (REFERENCE CAR AC8113). INVESTIGATION REVEALED A SCRATCH ACROSS THE FACE OF THE GROUND HALF SWIVEL SEAL. A SMALL PARTICLE OF CONTAMINATION PROBABLY BECAME LODGED

DURING ASSEMBLY. THE SEAL WAS REPLACED AND THE UNIT SUCCESSFULLY PASSED ATP.

LOW POPPET RESEAT PRESSURE WAS DETECTED DURING ATP (REFERENCE CAR AB8395). INVESTIGATION REVEALED AN INDENTATION ON THE POPPET SEAL SURFACE WHICH WOULD ALLOW LEAKAGE AND CAUSED THE LOW RESEAT PRESSURE. THE UNIT WAS REASSEMBLED WITH A NEW POPPET SEAL AND SUCCESSFULLY PASSED ATP. INSPECTION PERSONNEL WERE INSTRUCTED TO PERFORM THE VISUAL INSPECTION AT THE TIME OF ASSEMBLY, AS THE INSPECTION CHECKLIST CALLS OUT. ATP WILL DETECT THIS FAILURE.

GENERAL SYSTEM CONTAMINATION

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, 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 ARE BEING 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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL **FAILURE MODE NUMBER: 03-1-0501-01**

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 OV-103 (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:
IF THE LH2 NPSP DROPS BELOW THE PRE-FLIGHT ACCEPTED LEVELS (PER FLIGHT RULES), THE CREW WILL MANUALLY THROTTLE THE ENGINES TO KEEP THE NPSP HIGH ENOUGH TO PREVENT LH2 TURBOPUMP CAVITATION.

NO CREW ACTION CAN BE TAKEN FOR THE GO2 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