

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0432 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1

08/09/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LH2 HI POINT BLEED DISCONNECT, 1.5 INCH (GND) UNITED SPACE ALLIANCE - NSLD	MC276-0004-0002
LRU	:LH2 HI POINT BLEED DISCONNECT, 1.5 INCH (ORB) UNITED SPACE ALLIANCE - NSLD	MC276-0004-0003

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

DISCONNECT, HIGH POINT 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: PD17**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

THE DISCONNECT PROVIDES A PATH FOR GH2 TO BLEED OVERBOARD FROM THE HIGH POINT BLEED VALVE (PV22) INTO THE GROUND VENT SYSTEM. BLEED FLOW STARTS AT SLOW FILL AND TERMINATES AT HIGH POINT BLEED VALVE CLOSURE (T-26 SECONDS) ISOLATING THE DISCONNECT FROM THE FEED SYSTEM. DURING T-0 UMBILICAL DISENGAGEMENT, THE DISCONNECT POPPETS CLOSE, PROVIDING A REDUNDANT INHIBIT AGAINST OVERBOARD FLOW (FLIGHT FLOW) AND ISOLATING THE GROUND VENT SYSTEM (GROUND HALF).

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 HI POINT BLEED DISC, 1.5 INCH (ORB)

ITEM NAME: LH2 HI POINT BLEED DISC, 1.5 INCH (ORB)

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

EXTERNAL LEAKAGE (ORBITER/GROUND UMBILICAL INTERFACE) DURING HIGH POINT BLEED OPERATION OF PROPELLANT LOADING.

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:

INTERFACE SEAL/SEALING SURFACE DAMAGE, IMPROPER ALIGNMENT, INSUFFICIENT BELLOWS SPRING LOAD, CONTAMINATION

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:

LEAKAGE OF GH2/LH2 CREATES A HAZARDOUS CONDITION EXTERNAL TO THE VEHICLE IN THE AREA OF THE DISCONNECT. GROUND SUPPLIED HELIUM PURGE IN THE T-0 UMBILICAL MAY LOWER GH2 CONCENTRATION, BUT THE FIRE/EXPLOSION HAZARD IS STILL PRESENT. POSSIBLE DAMAGE TO TPS AND SURROUNDING STRUCTURE. LEAKAGE MAY BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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(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 LH2 HIGH POINT 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 DISCONNECT IS SHIMMED TO A PRESET DIMENSION TO PROVIDE A NOMINAL BELLOWS

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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 HIGH POINT BLEED OPERATION SO THAT MASSIVE LEAKAGE WOULD BE OBSERVED. THIS UMBILICAL AREA IS ALSO MONITORED FOR LH2 LEAKAGE BY A HAZARDOUS GAS DETECTION SYSTEM AND OBSERVED WITH ULTRAVIOLET DETECTORS FOR FIRE DETECTION. THE UMBILICAL PLATE PURGE IS ADEQUATE TO SAFELY DILUTE A 5800 SCIM H2 LEAK.

SYSTEM CONTAMINATION IS MINIMIZED BY MAINTAINING THE CLEANLINESS TO LEVEL 400, 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.

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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

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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 CLEANING

PROCEDURES AND CONTAMINATION CONTROL REQUIREMENTS ARE VERIFIED BY INSPECTION. CLEANLINESS TO LEVEL 400A 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.

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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).

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 WERE 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, AND AC7043). PERSONNEL HAVE BEEN CAUTIONED TO EXERCISE CAUTION IN HANDLING TO PREVENT DAMAGE.

LEAKAGE EXCEEDING 4% (HYDROGEN CONCENTRATION) WAS DETECTED AT THE LH2 BLEED DISCONNECT DURING LOADING OPERATIONS OF STS-7 (REFERENCE CAR 07F003). BOTH THE GROUND HALF DISCONNECT AND THE FLIGHT HALF INTERFACE SEAL WAS REMOVED AND RETURNED TO ROCKWELL DOWNEY. THE FAILURE COULD NOT BE REPEATED AT NOMINAL AND MAXIMUM ADVERSE TOLERANCE CONDITIONS OF ENGAGEMENT. CAUSE IS BELIEVED TO BE DUE TO CONTAMINATION AT THE INTERFACE SEAL AREA AND/OR ABNORMAL DISCONNECT MATING ENGAGEMENT. THE INTEGRITY OF THE INTERFACE SEAL WILL BE VERIFIED PRIOR TO EACH FLIGHT. SPECIAL CARE WILL BE

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TAKEN DURING THE SEAL COINING AND MATING PROCESSES. THE POPPET SEAL TORQUE WILL BE REVERIFIED WHENEVER THE INTERFACE SEAL IS REPLACED.

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 ARE BEING 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 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 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.

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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:

FLIGHT:
NO CREW ACTION REQUIRED.

GROUND:
GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN 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