

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

NUMBER: 03-1-0451 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/09/00

**PART DATA**

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : VALVE, DUAL CHECK PARKER-HANNIFIN	MC284-0515-0005

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, DUAL CHECK, LO2 BLEED, 1 INCH DIAMETER.

**REFERENCE DESIGNATORS:** CV31  
CV33  
CV35

**QUANTITY OF LIKE ITEMS:** 3  
ONE PER ENGINE

**FUNCTION:**

PARALLEL FLAPPERS CONTAINED IN ONE CHECK VALVE ASSEMBLY PROVIDE A PATH FOR LO2 RECIRCULATION/BLEED AND POGO SUPPRESSION FLOW. PREVENTS REVERSE FLOW OF LO2 INTO THE SSME DURING START SEQUENCE AND IN THE EVENT OF AN ENGINE MALFUNCTION (PREMATURE SHUTDOWN). ONE CHECK VALVE ASSEMBLY IS PROVIDED FOR EACH ENGINE SYSTEM.

EACH CHECK VALVE ASSEMBLY HAS ONE 0.052 INCH ORIFICE TO PROVIDE A CONTROLLED (4 SCFM) GHE REPRESSURIZATION PURGE TO THE RESPECTIVE SSME DURING ENTRY (DUE TO THE EXCESSIVE LEAK RATE THROUGH THE ENGINE HPOT SEALS THE LO2 PREVALVES ARE MAINTAINED CLOSED TO PREVENT LOSS OF HELIUM SUPPLY).

POGO RECIRCULATION VALVES (PV20,21) ARE OPENED AT T-12.5 SECONDS TO CHILL DOWN POGO RETURN LINE UNTIL OVERBOARD BLEED VALVE (PV19) IS CLOSED AT T-9.4 SECONDS. THIS CHECKS (VALVE FLAPPERS CLOSE) BLEED FLOW FROM ENGINES UNTIL ENGINE START. ENGINE START SEQUENCE BEGINS AT T-6.6 SECONDS.

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**LRU: LO2 1" BLEED CHECK VALVE (CV31, 33, 35)**

**CRITICALITY OF THIS**

**ITEM NAME: LO2 1" BLEED CHECK VALVE (CV31, 33, 35)**

**FAILURE MODE: 1R2**

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**FAILURE MODE:**

FAILS TO CLOSE/REMAIN CLOSED (INTERNAL LEAKAGE OVER 4 SCFM).

**MISSION PHASE:**

PL PRE-LAUNCH  
LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

**CAUSE:**

FAILS TO CLOSE - PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION, SEAL/SEAT DAMAGE

FAILS TO REMAIN CLOSED - PIECE PART STRUCTURAL FAILURE

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES**

RTLS RETURN TO LAUNCH SITE  
TAL TRANS-ATLANTIC LANDING  
AOA ABORT ONCE AROUND  
ATO ABORT TO ORBIT

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**REDUNDANCY SCREEN**

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

**PASS/FAIL RATIONALE:**

A)

B)

FAILS B SCREEN BECAUSE THERE IS NO INSTRUMENTATION IN THE CHECK VALVE.

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

FAILURE CRITICAL FOR ALL ABORT MODES. PREVENTS ISOLATION OF THE POGO SYSTEM FROM A SHUTDOWN SSME WITH UNCONTAINED DAMAGE (ASSUMES ENGINE DAMAGED ONLY TO THE EXTENT THAT THE ISOLATION OF THE DAMAGE WILL SAVE THE SYSTEM). POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD DUE TO LO2 LEAKAGE. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. LOSS OF PROPELLANT CAUSING POSSIBLE PREMATURE ENGINE SHUTDOWN FOR THE REMAINING, OPERATING, SSMEs. POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE FOR ENTRY.

FOR PAD ABORTS, GN2 PURGE OF THE AFT COMPARTMENT MAY LOWER THE GO2 CONCENTRATION BUT FIRE/EXPLOSION HAZARD STILL PRESENT. LEAKAGE IN THE AFT COMPARTMENT IS DETECTABLE ON GROUND USING THE HAZARDOUS GAS DETECTION SYSTEM (HGDS).

FAILURE IS NOT APPLICABLE ON AN OPERATING ENGINE SINCE BLEED FLOW MAINTAINS THE CHECK VALVE OPEN.

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

SAME AS A.

**(C) MISSION:**

NO EFFECT NOMINAL MISSION. FOR ALL ABORTS, POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

1R2 2 SUCCESS PATHS. TIME FRAME - PREMATURE ENGINE SHUTDOWN (NOMINAL MISSIONS)

- 1) PREMATURE ENGINE SHUTDOWN WITH UNCONTAINED DAMAGE (ASSUMES ENGINE DAMAGED ONLY TO THE EXTENT THAT THE ISOLATION OF THE DAMAGE WILL SAVE THE SYSTEM).
- 2) LO2 BLEED CHECK VALVE (CV31,33, OR 35) FAILS TO CLOSE/REMAIN CLOSED.

RESULTS IN LO2/GO2 LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. LOSS OF PROPELLANT CAUSING POSSIBLE PREMATURE ENGINE SHUTDOWN FOR THE REMAINING, OPERATING, SSMEs. POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE LO2 CHECK VALVE HOUSING IS MADE FROM 321/304L CRES. PARALLEL FLAPPERS (TEFLON-COATED 304 CRES) ARE USED TO PROVIDE THE REVERSE FLOW CHECK CAPABILITY. A FLAPPER WEDGE IS USED TO KEEP THE FLAPPERS OPEN 30 DEGREES AND ALLOW THE FLOW FORCES TO CLOSE THE FLAPPERS BY THE HYDRODYNAMIC FORCES OF REVERSE FLOW. THE HINGE BOXES ARE TEFLON COATED TO PREVENT BINDING. THE FLAPPER CRACKING PRESSURE IS 0.5 PSID, WHICH IS LESS THAN THE SYSTEM PRESSURE ACTING TO OPEN THE FLAPPERS. THE ASSEMBLY INCLUDES A 0.052 INCH ORIFICE FOR REPRESSURIZATION/PURGING OPERATIONS.

THE DESIGN FACTORS OF SAFETY FOR PROOF IS 2 TIMES OPERATING PRESSURE (800 PSIG), AND 4 TIMES OPERATING PRESSURE (1600 PSIG) FOR BURST. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS; FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, PREVALVE SCREENS, A GSE DEBRIS PLATE, A GSE FILTER, AND MAINTAINING A CLEANLINESS LEVEL OF 800A.

**(B) TEST:**

ATP (ALL TESTS RUN AT AMBIENT TEMPERATURE)

PROOF

CLOSURE DEVICE PROOF PRESSURE (550 PSIG)  
BODY PROOF PRESSURE (800 PSIG)

LEAKAGE

INTERNAL LEAKAGE, REVERSE DIRECTION (10 AND 275 PSIG)  
EXTERNAL LEAKAGE (400 PSIG)

FUNCTIONAL

CRACKING (0.6 PSID MAX)  
RESEATING (0.1 PSID) PRESSURES

CERTIFICATION (LEAKAGE AND CRACK/RESEAT TESTS WERE PERFORMED BEFORE AND AFTER THE FOLLOWING TESTS.)

LEAKAGE

INTERNAL, REVERSE DIRECTION (10 AND 275 PSIG)  
EXTERNAL, (400 PSIG)

CRACKING/RESEAT

AMBIENT AND CRYOGENIC (0.6 PSID AND 0.1 PSID)

LIFE

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- 2000 CYCLES AT AMBIENT TEMPERATURE WITH AMBIENT FUNCTIONAL TESTS AFTER 1000 AND 2000 CYCLES
- 1000 CYCLES AT -320 DEG F FOLLOWED BY CRYOGENIC FUNCTIONAL TESTS
- 2000 CYCLES AT +130 DEG F FOLLOWED BY AMBIENT FUNCTIONAL TESTS

**THERMAL**

THREE THERMAL CYCLE TESTS (AMBIENT TO 275 DEG F TO AMBIENT) FOLLOWED BY AMBIENT FUNCTIONAL TESTS

**SHOCK**

BENCH HANDLING AND DESIGN SHOCK PER MIL-STD-810B

**VIBRATION**

RANDOM - 13.3 HOURS EACH AXIS (3) AT CRYOGENIC TEMPERATURES (-300 DEG F); 3.3 HOURS CLOSED AND 10 HOURS WITH FLOWING LIQUID NITROGEN; EACH AXIS TEST FOLLOWED BY CRYOGENIC FUNCTIONAL TEST

TRANSIENT - (5 TO 35 HZ AT + OR - .25G PEAK)

**PERFORMANCE - FLOW TESTS**

TWO FLAPPER

AMBIENT AND CRYOGENIC (-320 DEG F)

SINGLE FLAPPER

AMBIENT AND CRYOGENIC (-320 DEG F)

**BURST**

FLAPPER (1100 PSIG)

VALVE BODY (1600 PSIG)

**GROUND TURNAROUND TEST**

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION RAW MATERIALS ARE VERIFIED FOR MATERIAL PROCESS AND INSPECTION.

**CONTAMINATION CONTROL**

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 800A IS VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. THE INSIDE SURFACES OF THE VALVE ARE VISUALLY INSPECTED USING A BORESCOPE (10X MAGNIFICATION). ELECTROCHEM ETCH MARKING IS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

**CRITICAL PROCESSES**

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PROCESSES OF EB WELDING, HEAT TREATMENT, PASSIVATION, AND ELECTROPOLISH ARE VERIFIED BY INSPECTION. HELIUM LEAK TEST IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION  
X-RAY AND PENETRANT INSPECTION OF EB. WELDS ARE VERIFIED BY INSPECTION.

TESTING  
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING  
PACKAGING, HANDLING, AND TRANSPORTATION OF PRODUCT VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

THE VALVE EXPERIENCED INTERNAL LEAKAGE (INFLIGHT) DUE TO AN IMPROPERLY INSTALLED FLAPPER SPRING (REF CAR 03F035, STS-3). THIS CAUSED THE SPRING TO BREAK, RESULTING IN LOSS OF 50% OF FLAPPER CLOSING FORCE. CORRECTIVE ACTION WAS TO ADD A MANDATORY INSPECTION POINT AT THE SUPPLIER. ALL ORBITER INSTALLED VALVES WERE X-RAYED TO VERIFY PROPER SPRING INSTALLATION.

THE FOLLOWING THREE FAILURES (A7066, A9901, AND AB1550) OCCURRED ON THE SAME VALVE (MC284-0515-0001):

DURING ACCEPTANCE TESTING OF THE MPTA, THE DUAL CHECK VALVE EXHIBITED 3150 SCIM REVERSE LEAKAGE AT -320 DEG F, MAXIMUM ALLOWABLE IS 400 SCIM (REF CAR A7066). FAILURE WAS DUE TO FLAPPER/SEAT THERMAL DISTORTION DURING THE FINAL CLOSURE WELD OF THE BODY. CORRECTIVE ACTION WAS A DESIGN CHANGE TO UTILIZE A THREADED FLANGE TO MATE THE TWO HALVES OF THE BODY (NEW DASH # -0002). ALL INSTALLED AND PRODUCTION VALVES REFLECT THIS CHANGE EXCEPT MPTA.

DURING SYSTEM CHECKOUT OF THE MPTA, THE DUAL CHECK VALVE EXHIBITED 1288 SCIM REVERSE LEAKAGE AT 10 PSID, MAXIMUM ALLOWABLE IS 400 SCIM AT 10 PSID (REF CAR A9901). FAILURE WAS DUE TO METALLIC PARTICLE CONTAMINATION ON THE SEALING SURFACES OF THE TEFLON COATED FLAPPERS. CONTAMINATION WAS CREATED DURING THE PROCESS OF CUTTING OFF THE EXTENSION TUBE STUBS AT COMPLETION OF ATP AND DURING INSTALLATION OF THE CHECK VALVE ON THE MPTA. CORRECTIVE ACTION WAS TO REVISE THE ATP AS FOLLOWS: PERFORM INTERNAL LEAK TEST, VISUALLY EXAMINE THE VALVE FOLLOWING REMOVAL OF THE EXTENSION TUBES (FOR TEST USE ONLY), AND FLUSH VALVES AFTER ATP. A NEW FLIGHT CONFIGURATION (REF CAR A7066 ABOVE) WAS INSTALLED ON THE MPTA AS A REPLACEMENT WITH NO FURTHER PROBLEMS.

DURING ATP THE VALVE LEAKED INTERNALLY 200 SCIM AT 4 PSIG, MAX ALLOWABLE IS 5 SCIM (REF CAR AB1550). THE FAILURE OCCURRED FOLLOWING THE FUNCTIONAL PORTION OF THE ATP ON THE SAME VALVE AS ABOVE (REF CAR A9901). FAILURE WAS DUE TO CONTAMINATION ON THE SEALING SURFACES OF THE FLAPPERS, WHICH ENTERED THE VALVE DURING POST ATP TEST EXTENSION TUBE FITTING CUTOFF OPERATION. CORRECTIVE ACTION WAS TO CHANGE THE ATP TO FLUSH THE VALVE AT A HIGHER FLOW RATE.

THE VALVE LEAKED 500 SCIM (MAX ALLOWABLE 400 SCIM) DURING PREPARATION FOR QUAL TESTING OF THE REDESIGNED VALVE DESCRIBED IN CAR A7066 (-0002)

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CONFIGURATION). FAILURE WAS DUE TO CONTAMINATION, WHICH ENTERED THE VALVE DURING REMOVAL OF THE EXTENSION TUBE FITTINGS (FOR TEST USE ONLY). CORRECTIVE ACTION WAS TO PERFORM THE FOLLOWING AFTER EXTENSION TUBE REMOVAL AND PRIOR TO PACKAGING: FREON FLUSH AND PARTICLE COUNT; PERFORM INTERNAL LEAK CHECK; AND VISUALLY EXAMINE THE VALVE FOR CONTAMINATION. THIS CORRECTIVE ACTION WAS EFFECTIVE FOR ALL FLIGHT HARDWARE.

**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, 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 MONITORS BRAZING/WELDING REWORK CONTAMINATION PROBLEMS. 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

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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). THE SOURCE OF CONTAMINATION WAS UNDETERMINED. BORESCOPE EXAMINATIONS ARE CONDUCTED ON ALL FEEDLINE SCREENS EVERY FIFTH FLIGHT TO VERIFY CLEANLINESS. CONTAMINATION IS 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 CAN BE TAKEN.

GROUND:

GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

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**- APPROVALS -**

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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