

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0201 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 08/09/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:GHE 1" SUPPLY FILL DISCONNECT (ORB) UNITED SPACE ALLIANCE - NSLD	MC276-0003-0006 74332000-109
LRU	:GHE 1" SUPPLY FILL DISCONNECT (GND) UNITED SPACE ALLIANCE - NSLD	MC276-0003-0008 74343000-103

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

DISCONNECT, HELIUM FILL, 1 INCH SELF SEALING WITH REVERSE FLOW CHECK VALVE.

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

REFERENCE DESIGNATORS: PD8

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

CONNECTS WITH GSE TO PROVIDE THE FLOW PATH FOR FILLING THE FLIGHT HELIUM SUPPLY TANKS. ACTS AS A REDUNDANT CLOSURE DEVICE WITH HELIUM SYSTEM CHECK VALVES (CV1,2,3,4) AFTER FLOW CESSATION TO PREVENT OVERBOARD LOSS OF HELIUM SUPPLIES. PRESSURE ACTUATED POPPET IN DISCONNECT REQUIRES A DELTA P TO OPEN.

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: GHE 1" SUPPLY FILL DISCONNECT (ORB/GND)

CRITICALITY OF THIS

ITEM NAME: GHE 1" SUPPLY FILL DISCONNECT (ORB/GND)

FAILURE MODE: 1R3

FAILURE MODE:

FAILS TO CLOSE/FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE UPON DISCONNECTION

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 HELIUM SUPPLY CHECK VALVES. FAILURE IS NOT DETECTABLE BECAUSE THERE IS NO INSTRUMENTATION BETWEEN CHECK VALVES AND DISCONNECT.

C)

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

- FAILURE EFFECTS -

(A) SUBSYSTEM:

NO EFFECT. BACKUP CHECK VALVES (CV1,2,3,4) WOULD PREVENT OVERBOARD LEAKAGE.

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(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

SAME AS A.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) HELIUM DISCONNECT FAILS TO CLOSE/CHECK.
- 2) ONE OF THREE SSME GHE SUPPLY CHECK VALVES (CV1,2,3) FAILS TO CHECK. IF LEAK OCCURS EARLY IN ASCENT CREW WILL BE DIRECTED TO OPEN SSME INTERCONNECT "IN" VALVE SUPPLYING ENGINE WITH GHE FROM THE PNEUMATIC SUPPLY IN AN ATTEMPT TO EXTEND ENGINE RUN TIME. A SSME CAN SHUTDOWN SAFELY UNDER REDLINE MODE WITH VEHICLE ACCELERATION. IF LEAK OCCURS LATE IN ASCENT AND THE SSME GHE SUPPLY IS BELOW 2000 PSIA AT MECO, VEHICLE SOFTWARE WILL OPEN THE SSME INTERCONNECT "IN" VALVE TO SUPPLY THE ENGINE ZERO-G SHUTDOWN PURGES FROM THE PNEUMATIC SUPPLY.
- 3) SSME INTERCONNECT "IN" VALVE FAILS TO OPEN WHEN COMMANDED BY SOFTWARE RESULTING IN ZERO-G SHUTDOWN WITHOUT SUFFICIENT GHE SUPPLY FOR SHUTDOWN PURGES.

RESULTS IN INSUFFICIENT HELIUM SUPPLY TO THE AFFECTED ENGINE AT MECO. INTERRUPTION OF GHE INJECT FLOW TO THE LO2 TURBOPUMP MAY RESULT IN HPOTP TURBINE OVERSPEED AND UNCONTAINED ENGINE FAILURE.

POSSIBLE LOSS OF CREW/VEHICLE.

DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)): 1R2

(F) RATIONALE FOR CRITICALITY DOWNGRADE:

SAME AS E.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE DISCONNECT IS COMPRISED OF TWO HALVES: THE FLIGHT (ORBITER) HALF AND THE GROUND HALF. THE FLIGHT HALF IS A CHECK VALVE REQUIRING 15 PSID (GROUND TO ORBITER) MINIMUM CRACKING PRESSURE. THE NORMALLY CLOSED GROUND HALF

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DISCONNECT IS OPENED MECHANICALLY UPON ENGAGEMENT WITH THE FLIGHT HALF. THE FLIGHT AND GROUND DISCONNECT HALVES INCORPORATE A SWIVEL WHICH ACTS AS A SELF-ALIGNING DEVICE FOR PROPER ENGAGEMENT (THE TWO HALVES CAN ACCOMMODATE 0.062-INCH RADIAL AND 0.5 DEGREE MISALIGNMENT).

STRUCTURAL FAILURE OF ANY OF THE FOLLOWING PARTS MAY CAUSE THE FLIGHT HALF TO FAIL TO CLOSE: SWIVEL, POPPET, POPPET GUIDE, SEAL RETAINER (ALL OF A286 CRES), AND THE SEAL (VESPEL). DESIGN FACTORS OF SAFETY ARE: PROOF - 1.5 (6,750 PSIG) FLIGHT HALF, 2.0 (9,000 PSIG) GROUND HALF; BURST - 2.4 (10,800 PSIG) FLIGHT HALF, 4.0 (18,000 PSIG) BURST. STRUCTURAL ANALYSIS, PERFORMED BY THE DISCONNECT SUPPLIER, INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF DISCONNECT OPERATION, AND 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 (TIO-LUBE) TO ALL SLIDING SURFACES. ALSO THE POPPET STEM IS GUIDED FOR OVER 65% OF ITS LENGTH.

CONTAMINATION IS MINIMIZED BY THE USE OF MULTI-FILTERED HELIUM. GROUND SUPPLIED HELIUM (EITHER THROUGH THE T-0 UMBILICAL OR THE TEST POINT COUPLINGS) IS FILTERED TO 25 MICRONS ABSOLUTE.

FAILURE TO REMAIN CLOSED COULD BE CAUSED BY ANY OF THE STRUCTURAL FAILURES DESCRIBED ABOVE FOR THE FAILS-TO-CLOSE CASE. STRUCTURAL FAILURE OF THE POPPET SPRING MAY RESULT IN FAILURE TO REMAIN CLOSED FOR LOW OR NO FLOW CONDITIONS. THAT SPRING IS OF 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.

INTERNAL LEAKAGE IN BOTH HALVES IS PREVENTED BY THE USE OF VESPEL SEALS SEATING ONTO 16 MICRO-INCH SURFACE FINISHED A286 CRES SEATS.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE
DEMATED
FLIGHT HALF - 6,750 PSIG
GROUND HALF - 9,000 PSIG
MATED - 6,750 PSIG

OPERATION TEST

MATE
EXTERNAL LEAKAGE AT 4500 PSIG - 200 SCIM MAX
ENGAGING PRESSURE - 75 PSIG MAX
CRACK/RESEAT PRESSURE - 15 PSID MIN
DEMATE

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EXTERNAL LEAKAGE

DEMATED

FLIGHT HALF

1 SCIM @ 5 PSIG

5 SCIM @ 4,500 PSIG

GROUND HALF

200 SCIM @ 4,500 PSIG

MATED - 200 SCIM @ 4,500 PSIG

CERTIFICATION

HIGH TEMPERATURE EXTERNAL LEAKAGE TEST MATED:

PRESSURIZE TO 4,500 PSIG WITH +165°F GHE; 200 SCIMS MAX.

FLIGHT HALF: HEAT DISCONNECT TO +190°F,

PRESSURIZE TO 4,500 PSIG; 20 SCIMS MAX.

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

SALT FOG PER MIL-STD-810

AT COMPLETION PERFORM OPERATION & EXTERNAL LEAKAGE TESTS

SHOCK PER MIL-STD-810

DESIGN

BENCH HANDLING

AT COMPLETION PERFORM OPERATION & EXTERNAL LEAKAGE TESTS

THERMAL CYCLE - 5 CYCLES EACH

FLIGHT HALF: PRESSURIZE TO 2,000 PSIG; +70°F TO -250°F; PRESSURIZE TO 4,500 PSIG; -

250°F TO +70°F TO +190°F; REDUCE PRESSURE TO 2,000 PSIG; 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

FLOW CAPACITY - MATED

4,110 PSIG INLET, 0.1 LBM/SEC GHE, 18 TO 20 PSID

LIFE TEST

CRYO (-250°F): 100 CYCLES

AMBIENT: 1,900 CYCLES

CYCLE: MATE, PRESSURIZE TO 4,500 PSIG, VENT, DEMATE

AFTER EACH 500 CYCLES, PERFORM EXTERNAL LEAKAGE TEST AND HIGH TEMPERATURE EXTERNAL LEAKAGE TEST

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BURST

10,800 PSIG MATED

10,800 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. PROTECTION OF POPPET SEALING SURFACE IS INSPECTED. 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.

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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 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 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.

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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:

CREW WILL PERFORM LEAK ISOLATION PROCEDURE, EVENTUALLY INTERCONNECTING THE PNEUMATIC SUPPLY TO EXTEND ENGINE RUN TIME. IF THE LEAK RATE IS SUCH THAT MECO OCCURS PRIOR TO DEPLETION OF THE PNEUMATIC SUPPLY, UNCONTAINED ENGINE FAILURE WILL BE AVOIDED. IF IT IS DETERMINED THAT THE LEAKING ENGINE SHUTDOWN WILL OCCUR UNDER A ZERO-G CONDITION AND AT A PRESSURE LESS THAN 1150 PSIA, THE CREW WILL MANUALLY SHUTDOWN THE AFFECTED ENGINE AT MECO-30 SECONDS IN ORDER TO ENSURE ENGINE SHUTDOWN UNDER VEHICLE ACCELERATION.

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- 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