

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0504 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 07/27/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: GH2 ET TANK PRESSURIZATION FLOW CONTROL VALVES	MC280-0017-1301
	VACCO INDUSTRIES	80410-1301

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, FLOW CONTROL, SOLENOID, GH2 PRESSURANT, NORMALLY HIGH FLOW (0.625 INCH DIA INLET, 1.0 INCH DIA OUTLET).

REFERENCE DESIGNATORS: LV56
LV57
LV58

QUANTITY OF LIKE ITEMS: 3

FUNCTION:

THREE FLOW CONTROL VALVES (ONE PER SSME SYSTEM) CONTROL THE FLOW OF PRESSURIZATION GAS FROM THE ENGINES TO THE HYDROGEN TANK TO MAINTAIN ULLAGE PRESSURE FOR TANK STRUCTURAL STABILITY AND SSME NPSP. THE UNPOWERED SOLENOID VALVE POSITION IS HIGH FLOW. VALVE POSITION (HIGH FLOW-70%/LOW FLOW-31%) IS CONTROLLED BY STIMULI FROM THE ORBITER MOUNTED SIGNAL CONDITIONERS. SIGNAL CONDITIONER INPUT COMES FROM ET MOUNTED ULLAGE PRESSURE TRANSDUCERS. A SINGLE COCKPIT SWITCH ALLOWS THE CREW TO REMOVE POWER FROM THE SOLENOIDS RESULTING IN ALL THREE VALVES OPERATING IN THE HIGH FLOW POSITION.

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LRU: VALVE, FLOW CONTROL (ON GH2)

ITEM NAME: GH2 FLOW CONTROL VALVES (LV56, 57, 58)

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

FAILS TO STROKE TO LOW FLOW POSITION DURING ENGINE OPERATION.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

BINDING, ELECTRICAL SOLENOID FAILURE, PIECE PART STRUCTURAL FAILURE, CONTAMINATION, MARGINAL POPPET FORCE BALANCE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTL	RETURN TO LAUNCH SITE
TAL	TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN

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

PASS/FAIL RATIONALE:

A)

FAILS A SCREEN BECAUSE CHECKOUT WOULD INVOLVE INVASIVE TESTING (FORCE BALANCE TESTING REQUIRES FLOW THROUGH VERIFICATION).

B)

C)

FAILS C SCREEN BECAUSE OF BACKFLOW OF CONTAMINATION INTO AN FCV DURING HE PREPRESS AND ANTI-ICING PURGE.

- FAILURE EFFECTS -

(A) SUBSYSTEM:

FOR NOMINAL MISSIONS, NO EFFECT. REDUNDANT FLOW CONTROL VALVES (FCVS) WOULD COMPENSATE TO MAINTAIN ULLAGE PRESSURE AND NPSP.

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FOR RTLS AND TAL ABORT, AN ENGINE OUT RESULTS IN THE LOSS OF ONE FCV PRESSURIZATION LEG. A SUBSEQUENT FCV FAILING HIGH ON EITHER OF THE REMAINING OPERATING ENGINE SYSTEMS RESULTS IN VENTING OF GH2 AT LOW ALTITUDE. POSSIBLE VIOLATION OF TANK MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE FIRE/EXPLOSION HAZARD EXTERNAL TO THE VEHICLE.

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

(C) MISSION:
FOR RTLS AND TAL ABORTS, POSSIBLE LOSS OF CREW/VEHICLE.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/2 2 SUCCESS PATHS. TIME FRAME - SSME START THROUGH SRB SEP.

- 1) A SINGLE FCV FAILS TO STROKE TO LOW FLOW POSITION.
- 2) ONE OF THE FOLLOWING FAILURES ON A PARALLEL GH2 PRESSURIZATION LEG CAUSING A SECOND FCV TO OPEN/REMAIN OPEN:
 - A SECOND HDC FAILS TO CONDUCT
 - ET ULLAGE PRESSURE TRANSDUCER FAILURE
 - LOSS OF A SIGNAL CONDITIONER
 - FCV FAILS IN THE HIGH FLOW POSITION
 - CONTACT-TO-CONTACT SHORT IN THE LH2 ULLAGE PRESSURE TOGGLE SWITCH INHIBIT CIRCUIT TO THE FCV CLOSE COMMAND HYBRID DRIVER

RESULTS IN EXCESSIVE GH2 ULLAGE PRESSURE CAUSING ET VENT VALVE TO RELIEVE EXCESS PRESSURE. POTENTIAL FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF THE ET MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS.

POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE VALVE IS A SINGLE FLOW PATH, DUAL POSITION TYPE. IT IS SHIMMED TO ALLOW FLOW AT THE REQUIRED HIGH AND LOW FLOW SETTINGS. IT IS SPRING LOADED TO THE HIGH FLOW POSITION AND SOLENOID ACTUATED TO THE LOW FLOW POSITION. A LABYRINTH-DESIGN SEAL REDUCES THE POTENTIAL FOR MARGINAL POPPET FORCE BALANCE BY MINIMIZING ACTUATION FORCE REQUIRED FROM THE SOLENOID.

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BINDING COULD OCCUR DUE TO CONTAMINATION OR GALLING BETWEEN THE POPPET SEAL (NITRIDED INCONEL) AND THE SLEEVE (440A CRES) OR BETWEEN THE ARMATURE (GOLD PLATED 430F CRES) AND THE SOLENOID FLANGE (430F CRES). THE POPPET SEAL IS NITRIDED AND THE ARMATURE IS GOLD PLATED TO PREVENT GALLING. CLEARANCE BETWEEN THE ARMATURE AND FLANGE IS 0.0005 INCH AND CLEARANCE BETWEEN THE SEAL AND SLEEVE IS 0.0004 INCH. NO FAILURE OF THIS TYPE HAS OCCURRED DURING PARTICLE IMPACT TESTING IN WHICH 10 MG OF CONTAMINANT WAS INJECTED DURING EACH TEST.

ELECTRICAL FAILURE OF THE COIL ASSEMBLY WILL PREVENT ACTUATION TO LOW FLOW POSITION. THE COIL IS MADE OF HIGH TEMPERATURE WIRE WINDINGS WITH TWO-PLY INSULATION AND LEAD WIRES SOLDERED USING HIGH-TEMPERATURE SILVER SOLDER. THE LEAD WIRES, AFTER SOLDERING, ARE POTTED TO PREVENT FATIGUE FAILURES RESULTING FROM VIBRATION. THE OUTER CONTAINER IS WELDED TO THE CONNECTOR FLANGE AND INSPECTED USING RADIOACTIVE TRACER GAS (RADIFLOW).

STRUCTURAL FAILURE OF THE ARMATURE SHAFT (A286 CRES) OR 440A OR 440C CRES POPPET WILL REMOVE SOLENOID CLOSING FORCE. AERODYNAMIC FORCES WOULD THEN MOVE THE RELEASED POPPET TO THE HIGH FLOW POSITION. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION. FRACTURE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

SYSTEM CONTAMINATION IS MINIMIZED BY AN ET SCREEN, A PREVALVE SCREEN, A GSE DEBRIS PLATE, A GSE FILTER AND A GH2 FILTERS INSTALLED IN THE PRE-PRESSURIZATION AND EACH IN ENGINE LEG.

(B) TEST:

ATP

EXAMINATION OF PRODUCT

AMBIENT TESTS (GN2)

PROOF PRESSURE: VALVE HOUSING (9440 PSIA, TEMPERATURE CORRECTED)
TOTAL EXTERNAL LEAKAGE (800 PSIA)

ELECTRICAL CHARACTERISTICS

INSULATION RESISTANCE
BONDING
DIELECTRIC STRENGTH
COIL RESISTANCE
COIL TEMPERATURE TEST

FLOW CALIBRATION VERIFICATION (GH2 AT 80 DEG F)

HI FLOW POSITION
INLET PRESSURE: 3300 PSIA
OUTLET PRESSURE: 800 PSIA MAXIMUM
LOW FLOW POSITION
INLET PRESSURE: 3300 PSIA

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OUTLET PRESSURE: 800 PSIA MAXIMUM

FUNCTIONAL TEST

DEMONSTRATION DUTY CYCLE
INLET PRESSURE: 4,250 PSIA
PURGE FLOW TEMPERATURE: -130 DEG F
PERFORMANCE VERIFICATION (ELECTRICAL)

CERTIFICATION

FUNCTIONAL TESTS

DEMONSTRATION DUTY CYCLE
12 SETS OF INITIAL CONDITIONS:
GH2 AT -70 DEG F, +80 DEG F, +210 DEG F
1500 PSIA, 2500 PSIA, 3500 PSIA, 4500 PSIA
(EACH PRESSURE AT ALL THREE TEMPERATURES)

LIFE TESTS (10,000 CYCLES INCLUDING ATP AND QUALIFICATION TESTS)

OPERATIONAL CYCLES

INLET PRESSURE: 25 AND 3600 PSIA
INLET TEMPERATURE: 80 DEG F
PERFORMANCE VERIFICATION (ELECTRICAL AND FLOW)

AMBIENT CYCLES (5000 CYCLES)

INLET PRESSURE: 25 PSIA
INLET TEMPERATURE: AMBIENT
PERFORMANCE VERIFICATION (ELECTRICAL AND FLOW)

AT COMPLETION OF AMBIENT CYCLE TEST REPEAT PERFORMANCE
VERIFICATION (ELECTRICAL) AND ELECTRICAL CHARACTERISTICS TEST

SOLENOID POWERED LIFE TEST

50 HOURS MINIMUM
INLET PRESSURE: 25 PSIA
VALVE BODY TEMPERATURE: +140 DEG F
ELECTRICAL POWER: +32 VOLTS DC

VIBRATION

TRANSIENT: 5 TO 35 HZ AT +/- 0.25 GS
RANDOM: 13.3 HOURS IN EACH OF THREE AXES AT 600 PSIG GHE AT
AMBIENT TEMPERATURE

DESIGN SHOCK (PER MIL-STD-810)

THERMAL SHOCK (100 CYCLES)

BODY TEMPERATURE: AMBIENT
INLET PRESSURE: 4500 PSIA
INLET TEMPERATURE: +70 DEG F TO -160 DEG F TO +80 DEG F

BURST TEST

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19,340 PSIA AT 300 DEG F

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

(C) INSPECTION:

RECEIVING INSPECTION
ALL INCOMING MATERIALS ARE INSPECTED FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL
ASSEMBLIES ARE MAINTAINED TO CLEANLINESS LEVEL 400 FOR HYDROGEN. CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ALL PARTS ARE CLEANED PRIOR TO ASSEMBLY. DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE ESTABLISHED TO VERIFY ASSEMBLY PROCEDURES. TORQUE REQUIREMENTS AND ELECTROCHEMICAL ETCH MARKINGS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
WELDING, INCLUDING SECTIONING WELD SAMPLES, AND SOLDERING ARE VERIFIED BY INSPECTION. ALL SOLDER JOINTS, INSULATED WITH HEAT SHRINK SLEAVINGS, ARE VERIFIED PER APPLICABLE REQUIREMENTS AND POTTED TO PROVIDE STABILITY. ELECTRO POLISHING AND PASSIVATION ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
WELDS ARE VISUALLY EXAMINED AND VERIFIED BY X-RAY AND DYE PENETRANT INSPECTION. RADIFLOW INSPECTION IS PERFORMED ON SOLENOID ASSEMBLY.

TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THE ORIGINAL GH2 FLOW CONTROL VALVE CONFIGURATION (MC280-0017-0015) HAD SUBSTANTIAL GROUND AND FLIGHT FAILURE HISTORY. AS A RESULT, THE VALVE HAS BEEN COMPLETELY REDESIGNED TO A NEW CONFIGURATION (-0361) WHICH HAS BEEN USED SINCE STS-41D. THE REDESIGNED VALVE HAS THE FOLLOWING FAILURE HISTORY:

THREE MC280-0017-0315 (-0361) HYDROGEN FLOW CONTROL VALVES EXCEEDED THE MAXIMUM FLOW RATE AND OUTLET PRESSURE (CAR AC5478) DURING ATP. THE VALVES WERE DISASSEMBLED AND RESHIMMED TO REDUCE THE POPPET OPENING IN THE HIGH FLOW POSITION. AFTER RESHIMMING, THE VALVES WERE WELL WITHIN THE FLOW SPECIFICATIONS. FUTURE VALVES WILL BE FLOW TESTED IN A PRE-ACCEPTANCE TEST AND RESHIMMED AS REQUIRED PRIOR TO FORMAL ATP.

PREVIOUS CONFIGURATION FAILURE HISTORY

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DURING QUAL POWERED LIFE TESTING, A FAILURE OCCURRED IN WHICH THE COIL WAS SHORTED INTERNALLY (REF DR A9928). THIS FAILURE WAS DUE TO OVER TEMPERATURE EXPOSURE THAT OCCURRED EARLIER DUE TO AN ENVIRONMENTAL CHAMBER MALFUNCTION. THIS WAS A TEST ORIENTED FAILURE AND NO FURTHER ACTION WAS TAKEN.

DURING ATP THE VALVES FAILED TO CYCLE BECAUSE OF OVERTESTING (REF CAR A5237, A5238, A5239, A5240, A5241, A5242). HIGH PRESSURE GN2 FLOW TESTS WERE ELIMINATED FROM THE TEST PLAN AND PRODUCTION UNITS WERE NOT SUBJECTED TO THIS CONDITION.

SEVERAL FAILURES TO CYCLE OCCURRED DUE TO POPPET FORCE IMBALANCE. A POPPET REDESIGN WAS INITIATED (REF CAR AC5936) TO OVERCOME THE IMBALANCE. THE SPRING WAS GROUND (REF CAR AC6045, DR AC8051) TO REDUCE THE OPENING LOAD. THESE VALVES THEN SUCCESSFULLY PASSED ATP.

FAILURE TO PULL IN CLOSED OCCURRED DUE TO CONTAMINATION (REF DR AC7922) AND DUE TO A RELIEF HOLE BORED OFF CENTER (REF DR AC8093). SYSTEM CLEANLINESS AND CONCENTRICITY OF RELIEF VALVE HOLES ARE NOW VERIFIED.

SEVERAL UNITS FAILED FLOW TESTING (REF DR AC4807, AC5760) SO THEY WERE RE-CALIBRATED BY OUTFITTING WITH NEW ORIFICES.

HESITATION HAS OCCURRED THAT IS AN ATP SCREENABLE FAILURE (REF CAR AC7366; DR AC7848, AC8245). AFTER REWORK, UNITS PASSED ATP. THE HOUSING DRAWINGS WERE REVISED DUE TO A CHANGE IN THE SHOULDER THICKNESS DIMENSION.

SLOW RESPONSE TIME HAS OCCURRED (REF DR AC8405, AC8298). UPON DISASSEMBLY A PIECE OF AN "O" RING WAS FOUND LODGED INSIDE THE VALVE ASSEMBLY WHICH ORIGINATED FROM THE TEST FIXTURE. THE UNIT WAS CLEANED AND RETESTED AND PASSED ATP.

FAILURES HAVE OCCURRED WHERE THE LOW FLOWRATE WAS NOT ACHIEVED (REF CAR AC0171, AC5459, AC5467, AC5477, AC9700; DR AC9573). ORIFICES WERE CHANGED, POPPET SLEEVE ASSEMBLY WAS REDESIGNED, A WAIVER WAS INITIATED, AND THE VALVE WAS REDESIGNED.

DURING ATP A UNIT FAILED DIELECTRIC STRENGTH TEST DUE TO CONTAMINATION ON THE BACK OF THE CONNECTOR PRIOR TO POTTING. THE PROCUREMENT SPEC. WAS REVISED AND THE VALVE WAS REWORKED AND SUCCESSFULLY PASSED ATP (REF CAR A5476). A UNIT FAILED INSULATION RESISTANCE TESTING (REF CAR A9667). THIS FAILURE WAS DUE TO A DECREASE IN INSULATION RESISTANCE OF THE POTTING COMPOUND WHEN SUBJECT TO HEATING. THE POTTING COMPOUND WAS CHANGED AND THE VALVE WAS REWORKED AND SENT THROUGH ATP AGAIN.

GENERAL SYSTEM CONTAMINATION

GENERAL MPS SYSTEM CONTAMINATION HAS OCCURRED WHICH MAY LODGE ANYWHERE IN THE SYSTEM CAUSING THIS FAILURE MODE (REFERENCE THE FOLLOWING PARAGRAPHS).

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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. 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.

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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:
NO CREW ACTION CAN BE TAKEN.

- 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	: CHARLES EBERHART	:/S/ CHARLES EBERHART
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MICHAEL SNYDER	:/S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	:/S/ BILL PRINCE