

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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CLOGGED FLOWPATH (SEAT/POPPET).

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

CONTAMINATION FROM AN UPSTREAM ENGINE COMPONENT STRUCTURAL FAILURE OR FROM GROUND PREPRESSURIZATION GHE.

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 POSSIBLE BACKFLOW OF CONTAMINATION INTO THE FCVS DURING GHE PREPRESSURIZATION OR GROUND 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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DURING RTLS/TAL ABORTS, AN ENGINE OUT RESULTS IN LOSS OF ONE FCV PRESSURIZATION LEG. AT 104% RPL, A NO FLOW PRESSURIZATION SYSTEM FAILURE ON ONE OF THE REMAINING ENGINES WILL CAUSE THE ET LH2 ULLAGE PRESSURE TO FALL BELOW THE REQUIRED CONTROL BAND (32 - 34 PSIG) DURING MAIN ENGINE OPERATION. POSSIBLE VIOLATION OF TANK MINIMUM STRUCTURAL REQUIREMENTS AND NPSP. POSSIBLE UNCONTAINED SSME SHUTDOWN.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

FOR RTLS/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 - ENGINE OPERATION.

- 1) A SINGLE FCV CLOGS. CREW THROTTLES MAIN ENGINES TO MAINTAIN NPSP TO ACHIEVE SAFE MECO.
- 2) EITHER OF THE REMAINING TWO FCV'S FAILING TO STROKE TO HIGH FLOW POSITION OR LOSS OF GH2 PRESSURANT FROM EITHER OF THE REMAINING TWO ENGINES.

RESULTS IN INSUFFICIENT PRESSURIZATION GASES TO MAINTAIN LH2 ULLAGE PRESSURE IN THE REQUIRED FLIGHT CONTROL BAND (32 -34 PSIA). POSSIBLE VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS AND UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP.

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.

THE ONLY FLOW PATH IN THE VALVE THAT COULD BECOME CONSTRICTED AND REDUCE OR BLOCK FLOW IS THE ANNULAR ORIFICE AREA BETWEEN THE POPPET AND THE SEAT. THE RADIAL CLEARANCE IS 830 MICRONS IN THE HIGH FLOW POSITION AND 120 MICRONS IN

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THE LOW FLOW POSITION. IN ORDER TO BECOME CLOGGED FROM UPSTREAM DEBRIS, THE DEBRIS WOULD HAVE TO CONSIST OF ENOUGH PARTICLES OF LARGER THAN 830 MICRONS TO COMPLETELY CLOG THE ANNULAR ORIFICE AREA. ANY DEBRIS BETWEEN 120 AND 830 MICRONS TRAPPED IN THIS AREA DURING LOW FLOW CONDITIONS COULD BE RELEASED BY CYCLING THE VALVE.

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

(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
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)

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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

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

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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 HAD NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

PREVIOUS CONFIGURATION FAILURE HISTORY:

AT THE SUPPLIER, CONTAMINATION WAS FOUND IN EARLY CONFIGURATIONS OF THIS VALVE (DR AB8522, AC7921, AC7922, AC8405). THIS CONTAMINATION WAS ATTRIBUTED TO TEST EQUIPMENT. TEST EQUIPMENT CLEANING PROCEDURES WERE CHANGED AND A PARTICLE COUNT WAS INITIATED PRIOR TO VALVE INSTALLATION ON THE TEST STAND.

GENERAL SYSTEM CONTAMINATION

THIS FAILURE MODE HAS OCCURRED ON THE PREVIOUS CONFIGURATION OF THIS COMPONENT DUE TO CONTAMINATION. ADDITIONALLY, 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.

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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.

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.

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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	: 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