

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0519 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 07/26/00**PART DATA**

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : GO2 ET TANK PRESSURIZATION FLOW CONTROL VALVES	MC280-0017-1447, -2492
VACCO INDUSTRIES	84400-2492

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, FLOW CONTROL, SOLENOID, GO2 PRESSURANT, NORMALLY HIGH FLOW (0.625 INCH DIA INLET 1.0 INCH DIA OUTLET) (LV53, 54, 55).

REFERENCE DESIGNATORS: LV53
LV54
LV55

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 OXYGEN TANK TO MAINTAIN ULLAGE PRESSURE FOR TANK STRUCTURAL STABILITY AND SSME NPSP.

FOR ACTIVE CONFIGURATION VALVES (-1447) THE UNPOWERED SOLENOID VALVE POSITION IS HIGH FLOW. VALVE POSITION (HIGH FLOW / LOW FLOW) IS CONTROLLED BY STIMULI FROM THE ORBITER MOUNTED SIGNAL CONDITIONERS. SIGNAL CONDITIONER INPUT COMES FROM ET MOUNTED ULLAGE PRESSURE TRANSDUCERS.

FOR FIXED ORIFICE VALVES (-2492) THE VALVES ARE SHIMMED TO A FIXED FLOW SETTING (78% FLOW) AND THE SIGNAL CONDITIONER IS DISCONNECTED FROM THE VALVE SOLENOIDS.

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LRU: VALVE, FLOW CONTROL (GO2)

ITEM NAME: GO2 FLOW CONTROL VALVES (LV53, 54, 55)

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

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 DURING GROUND GHE PREPRESS.

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:

THIS FAILURE MODE APPLIES TO ACTIVE AND FIXED ORIFICE CONFIGURATION VALVES.

FOR NOMINAL MISSIONS LOSS OF ET LO2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. MASS OF LO2 AND VEHICLE

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ACCELERATION SHOULD BE SUFFICIENT TO MAINTAIN PROPER ENGINE NPSP, DELAYING UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP UNTIL LATE IN POWERED FLIGHT.

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 LO2 ULLAGE PRESSURE TO FALL BELOW THE REQUIRED CONTROL BAND (20-22 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:
POSSIBLE LOSS OF CREW/VEHICLE.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
SAME AS A.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE ACTIVE CONFIGURATION 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 FIXED ORIFICE CONFIGURATION HAS HAD THE POPPET SHIMMED TO A 78% FLOW SETTING AND THE SIGNAL CONDITIONER INPUTS DISCONNECTED FROM THE VALVE SOLENOIDS.

THE ONLY CONSTRICTED FLOW PATH IN THE VALVE IS THE ANNULAR ORIFICE AREA BETWEEN THE POPPET AND THE SEAT. THE RADIAL CLEARANCE IS 525 MICRONS IN THE HIGH FLOW POSITION AND 225 MICRONS IN THE LOW FLOW POSITION. IN ORDER TO BECOME CLOGGED, DEBRIS WOULD HAVE TO ORIGINATE DOWNSTREAM OF THE ANTI-FLOOD VALVE FILTER (100 MICRONS) AND CONSIST OF ENOUGH PARTICLES LARGER THAN 525 MICRONS TO COMPLETELY CLOG THE ANNULAR ORIFICE AREA. ANY DEBRIS BETWEEN 225 AND 525 MICRONS TRAPPED IN THIS AREA DURING LOW FLOW CONDITIONS COULD BE RELEASED BY CYCLING THE VALVE.

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IN ADDITION TO THE ANTI-FLOOD VALVE FILTER, SYSTEM CONTAMINATION IS FURTHER 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

PROOF PRESSURE: VALVE HOUSING (9,860 PSIA OF GN2, TEMP CORRECTED)
PRIMARY SEAL LEAKAGE (600 PSIA OF HELIUM)
SECONDARY SEAL LEAKAGE (400 PSIA OF HELIUM)
TOTAL EXTERNAL LEAKAGE (600 PSIA OF HELIUM)

ELECTRICAL CHARACTERISTICS

INSULATION RESISTANCE
BONDING
DIELECTRIC STRENGTH
COIL RESISTANCE
COIL TEMPERATURE TEST

FLOW CALIBRATION VERIFICATION (GO2 AT +380 DEG F)

HI FLOW POSITION
INLET PRESSURE: 3700 PSIA OR LESS
OUTLET PRESSURE: 600 PSIA MAXIMUM
LOW FLOW POSITION
INLET PRESSURE: 3700 PSIA
OUTLET PRESSURE: 600 PSIA MAXIMUM

FUNCTIONAL TEST

DEMONSTRATION DUTY CYCLE (720 SECONDS OF GO2 FLOW)
INLET PRESSURE (LOW FLOW): 3700 PSIA
GO2 FLOW TEMPERATURE: +380 DEG F
PERFORMANCE VERIFICATION (ELECTRICAL)

CERTIFICATION

FUNCTIONAL TESTS

DEMONSTRATION DUTY CYCLE (720 SECONDS OF GO2 FLOW)
12 SETS OF INITIAL CONDITIONS:
GO2 AT 260°F, 380°F, 530°F
1,500 PSIA, 2,500 PSIA, 3,500 PSIA, 4,500 PSIA
(ALL PRESSURES AT ALL THREE TEMPERATURES)
HIGH TEMPERATURE (4 DUTY CYCLES OF 600 SECONDS EACH)
GO2 AT 710°F
3,600 (LOW FLOW) TO 4,200 PSIA (HIGH FLOW)
ONE HUNDRED MISSION FLOW (51 DUTY CYCLES)
GO2 AT 380°F AND 3,700 PSIA

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SEAL LEAKAGE TESTS

PRIMARY SEAL (PERFORMED DURING OFF-LIMIT TEMPERATURE TEST)
SECONDARY SEAL
HELIUM AT AMBIENT
400 PSIA AT PRIMARY TEST PORT

LIFE TESTS

OPERATIONAL CYCLES (5000 CYCLES)
INLET PRESSURE: 4500 PSIA
INLET TEMPERATURE: +380 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

VIBRATION

RANDOM: 13.3 HOURS IN EACH OF THREE AXES PRESSURIZED WITH 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 +380 DEG F

PARTICLE IMPACT TEST

10 MG SAMPLE MIXTURE OF 5 TO 250 MICRON DIAMETER INCONEL, ALUMINUM, AND
CRES 21-6-9 PARTICLES 40 HIGH FLOW AND 40 LOW FLOW TESTS AT
TEMPERATURES OF 490°F AND 620°F (160 TESTS TOTAL).

BURST TEST

19,340 PSIA AT 300 DEG F

NOTE: CERTIFICATION TESTING OF THIS COMPONENT IS STILL IN PROCESS.

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

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ASSEMBLIES ARE MAINTAINED TO CLEANLINESS LEVEL 100A FOR OXYGEN. 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. ALL MATERIALS ARE EVALUATED FOR OXYGEN COMPATIBILITY.

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THE ORIGINAL GO2 FLOW CONTROL VALVE CONFIGURATION (MC280-0017-0028) HAS HAD SUBSTANTIAL GROUND AND FLIGHT FAILURE HISTORY. AS A RESULT OF CONCERNS OVER FRETTING, FORCE BALANCE PROBLEMS, AND SUSCEPTIBILITY TO IGNITION DUE TO PARTICLE IMPACT, THE VALVE HAS BEEN COMPLETELY REDESIGNED TO A NEW CONFIGURATION (-1447) WHICH WILL BE USED FOR STS-26 AND SUBS. 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).

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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