

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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SUBSYSTEM NAME: MAIN PROPULSION

LRU: VALVE, FLOW CONTROL (GO2)

CRITICALITY OF THIS

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

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE OF THE VALVE BODY.

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

FATIGUE, MATERIAL DEFECT, DAMAGED/DEFECTIVE JOINT SEALS

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:

GO2 AND/OR GHE LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. GHE LEAKAGE FROM ANTI-ICING PURGE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS) PRIOR TO T-9 MINUTES.

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DEPENDING ON LEAK RATE, ET ULLAGE PRESSURE MAY NOT BE MAINTAINED. LOSS OF ET LO2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE LOSS OF ADJACENT CRITICAL COMPONENTS DUE TO IMPINGEMENT OF HIGH PRESSURE GAS. POSSIBLE UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP LATE IN ENGINE OPERATION.

ALSO RESULTS IN POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE.

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

(C) MISSION:
ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-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 INCONEL VALVE BODY HAS DESIGN FACTORS OF SAFETY FOR INTERNAL PRESSURE OF 2.0 PROOF AND 4.0 BURST. THE VALVE WILL REMAIN FUNCTIONAL AT TEMPERATURES UP TO 530 DEG F AND WILL BE STRUCTURALLY SOUND AT 710 DEG F. THE VALVE BODY-TO-BOLTED FLANGE AND BOLTED FLANGE-TO-SOLENOID INTERFACES EACH UTILIZE NICKEL FLASHED/GOLD PLATED INCONEL X-750 K-MINI PRIMARY AND SECONDARY SEALS. EACH INTERFACE INCORPORATES A LEAK DETECTION PORT TO MEASURE THE LEAKAGE ACROSS THE PRIMARY SEAL. EACH LEAK PORT IS SEALED WITH A K SEAL.

THE SEALS ARE DESIGNED FOR A TOTAL LEAKAGE NOT TO EXCEED 4 SCCM OF GO2 AT 4,600 PSIA (HIGH PRESSURE SIDE) AND 600 PSIA (LOW PRESSURE SIDE). THE SECONDARY

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SEALS ARE A BACKUP TO THE PRIMARY SEALS THROUGHOUT THE OPERATING TEMPERATURE AND PRESSURE RANGE. PRIMARY SEAL AND SECONDARY SEAL AMBIENT LEAKAGE IS CHECKED DURING ACCEPTANCE TESTING (600 PSI) AND ON THE VEHICLE (400 PSI). TOTAL VALVE EXTERNAL AMBIENT LEAKAGE IS ONLY CHECKED DURING ACCEPTANCE TESTING (600 PSI). THE CAPABILITY OF THIS SEAL DESIGN HAS BEEN DEMONSTRATED DURING CERTIFICATION LEAK TESTING WITH GO2 AT 530°F AND 4,600 PSIA.

THE INLET AND OUTLET TUBES ARE THREADED INTO THE VALVE BODY, TORQUED TO 35 - 40 FT-LBS, AND SEAL WELDED. THE INLET TUBE IS REINFORCED WITH AN EXTERNAL WELDED COLLAR. THE VALVE WAS SUCCESSFULLY BURST TESTED (19,340 PSIA) DURING CERTIFICATION TESTING.

(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

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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

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

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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 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 THE FOLLOWING FAILURE HISTORY:

DURING DEVELOPMENT TESTING AT THE SUPPLIER, K-MINI SEAL LEAKAGE ON A SPECIAL GO2 FCV TEST HOUSING OCCURRED (REFERENCE OPEN CAR AD3154). THE FAILURE WAS ATTRIBUTED TO CONTAMINATION DURING THE NICKEL FLASHING/GOLD PLATING PROCESS OF THE K-SEAL CAUSING THE PLATING TO DE LAMINATE. THE ENTIRE LOT OF SEALS HAS BEEN REMOVED FROM SERVICE. THE SUPPLIER IMPLEMENTED AN INSPECTION PROCEDURE TO EXAMINE THE K-SEAL UNDER 20X MAGNIFICATION FOR DEFECTS.

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AT KSC, THE ENGINE #2 GO2 FCV PRIMARY SEAL LEAKED 2.52 SCCM, SHOULD BE 2 SCCM (REFERENCE OPEN CAR KB0086). LEAKAGE REQUIREMENT WAS CHANGED TO 4 SCCM ON THE PRIMARY SEAL, 6 SCCM ON THE SECONDARY SEAL, AND 4 SCCM FOR THE TOTAL BODY. THIS REQUIREMENT WAS CHANGED BECAUSE THE 2 SCCM REQUIREMENT WAS CARRIED OVER FROM THE PREVIOUS DESIGN AND DID NOT ACCURATELY REFLECT THE CURRENT CONFIGURATION.

PREVIOUS CONFIGURATION FAILURE HISTORY

LEAKAGE THROUGH ORIFICE SEALS (CAR AC5875) WAS CORRECTED BY LAPPING THE SEALING SURFACE. EXCESSIVE INLET TUBING/HOUSING INTERFACE LEAKAGE WAS NOTED (CAR AC6924) DUE TO A SEAL WELD FAILURE. A LINE SUPPORT BRACKET WAS ADDED UPSTREAM OF THE WELD. AN INLET TUBE WELD WAS FOUND TO BE CRACKED (CAR'S A8648, A8531) BECAUSE THE TUBE HAD NOT BEEN PROPERLY TORQUED INTO THE THREADED HOUSING PORT PRIOR TO WELDING. THIS CONDITION WAS CORRECTED AND TESTING RESUMED. LATER, A SIMILAR FAILURE OCCURRED (CAR AB3081) DURING VIBRATION TESTING. THE VALVES INLET TUBE WAS REDESIGNED AND MATERIAL CHANGED TO 21-6-9 CRES TO PROVIDE MORE COMPATIBLE MATERIALS AT THE SEAL WELD.

EXCESSIVE LEAKAGE HAS OCCURRED DURING PROOF TEST OPERATIONS (CAR'S AC6082, AC6921 AND DR'S AC6767, AC6922, AC6968, AC6969, AC7413). THIS LEAKAGE WAS DETERMINED TO BE FROM THE ORIFICE SEALING SURFACES. THE SEALING SURFACES OF THE ORIFICES WERE LAPPED TO THE REQUIRED FINISH. A MANDATORY INSPECTION POINT WAS IMPOSED AND THE DRAWING WAS CHANGED TO REFLECT IMPROVED FLATNESS AND PERPENDICULARITY REQUIREMENTS. THE VALVES SUCCESSFULLY PASSED ATP.

LEAKAGE WAS DETECTED FROM A HOLE IN THE HOUSING BETWEEN THE TWO ORIFICES (CAR AC7283). THE HOLE WAS DETERMINED TO BE DUE TO A DRILL HOLE THAT HAD BROKEN THROUGH THE HOUSING FACE. THE HOUSING WAS REPLACED, RETESTED AND SUCCESSFULLY PASSED ATP. THE DRAWING WAS REVISED TO VERIFY THE HOUSING THICKNESS OF 0.030 INCH AT THE DRILLED HOLE.

LEAKAGE DUE TO AN INSUFFICIENT WELD WAS FOUND (DR AC5370). THIS IS AN ATP SCREENABLE CONDITION.

DURING A LEAK CHECK ON OV-102 AT KSC AN ORIFICE LEAK WAS FOUND (CAR AC6475). THE ORIFICE SEALING SURFACE WAS CLEANED AND LAPPED BUT THE SEALING SURFACE STILL APPEARED TO BE CORRODED. THIS PROBLEM WAS CORRECTED BY REQUIRING THAT ALL ORIFICES HAVE LUBRICANT BAKED ON AND BE LEAK CHECKED AT THE SUPPLIER.

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.

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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