

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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SUBSYSTEM NAME: MAIN PROPULSION

LRU: VALVE, FLOW CONTROL (ON GH2)

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

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE.

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 SEAL

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:

GH2 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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GH2 FLOW CONTROL VALVES WILL OPEN IN AN ATTEMPT TO MAINTAIN ULLAGE PRESSURE. LOSS OF ET LH2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE UNCONTAINED SSME SHUTDOWN DUE TO LOW LH2 NPSP.

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 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 A286 CRES VALVE BODY AND 21-6-9 CRES INLET AND OUTLET TUBES HAVE DESIGN FACTORS OF SAFETY FOR INTERNAL PRESSURE OF 2.0 PROOF AND 4.0 BURST. THE THREADED SOLENOID-TO-HOUSING INTERFACE (TORQUED TO 60 TO 80 FT-LBS) CONTAINS A SINGLE BUNA-N O-RING SEAL PREVENTING EXTERNAL LEAKAGE. BACKOUT OF THE THREADED INTERFACE IS PREVENTED BY A 304 CRES CLAMP AND BOLT ASSEMBLY THROUGH THE FLANGE. AN INTERNAL SEAL (NICKEL FLASHED, GOLD PLATED A286 CRES K-MINI SEAL) PREVENTS INTERNAL LEAKAGE FROM THE HIGH PRESSURE SIDE OF THE VALVE TO THE LOW PRESSURE SIDE. THE O-RING SEAL IS A BACKUP TO THE K-MINI SEAL FOR THE HIGH PRESSURE EXTERNAL LEAKAGE AND IS A SINGLE BARRIER SEAL FOR THE LOW PRESSURE EXTERNAL LEAKAGE. THE PRIMARY SEAL IS DESIGNED FOR LEAKAGE NOT TO EXCEED 4 SCCM OF GH2 AT 4,500 PSIA (MAX OPERATING PRESSURE IS 4,100 PSIA).

THE INLET TUBE IS THREADED INTO THE VALVE BODY, TORQUED TO 65 FT-LBS, SEAL WELDED, AND REINFORCED WITH AN EXTERNAL WELDED COLLAR. THE OUTLET TUBE IS

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THREADED TO THE BODY HAND TIGHT, THEN SEAL WELDED. THE VALVE WAS SUCCESSFULLY BURST TESTED (19,340 PSIA) DURING CERTIFICATION TESTING.

**(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)

OPERATIONAL CYCLES

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

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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
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

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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:

DURING QUALIFICATION VIBRATION TESTING, A CRACK OCCURRED AT THE SEAL WELD OF
THE INLET TUBE AFTER TWO HOURS OF VIBRATION IN THE FIRST (Y) AXIS. AFTER REPAIR,
THE WELD FAILED AGAIN AFTER 26 MINUTES OF VIBRATION IN THE Y-AXIS. THE INLET TUBE
IS THREADED INTO THE VALVE BODY AND TORQUED TO 55 FT-LBS PRIOR TO WELDING.
THE INSTALLATION TORQUE WAS INCREASED TO 65 FT-LBS BUT THE JOINT FAILED AGAIN
DURING VIBRATION. IT WAS DETERMINED THAT WELDING CAUSED LOSS OF THREAD
PRELOAD FROM TORQUING. A REINFORCING COLLAR WAS INSTALLED WHICH FITS OVER
THE INLET TUBE JOINT. THIS COLLAR IS WELDED TO THE VALVE BODY ON ONE SIDE AND
TO THE INLET TUBE ON THE OTHER SIDE. THE VALVE, WITH THIS COLLAR, SUBSEQUENTLY
PASSED ALL VIBRATION TESTING (CAR AC3590).

DURING DEVELOPMENT TESTING AT THE SUPPLIER, K-MINI SEAL LEAKAGE ON A SPECIAL
GO2 FCV TEST HOUSING OCCURRED (REFERENCE CAR AD3154). THE FAILURE WAS
ATTRIBUTED TO CONTAMINATION DURING THE NICKEL FLASHING/GOLD PLATING PROCESS
OF THE K-SEAL CAUSING THE PLATING TO DELAMINATE. 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.

PREVIOUS CONFIGURATION FAILURE HISTORY

LEAKAGE THROUGH ORIFICE SEALS (REF CAR AC5875) WAS CORRECTED BY LAPPING THE
SEALING SURFACE. EXCESSIVE INLET TUBING/HOUSING INTERFACE LEAKAGE WAS NOTED
(REF CAR AC6924) DUE TO A SEAL WELD FAILURE. A SUPPORT WAS ADDED UPSTREAM
OF THE WELD. AN INLET TUBE WELD WAS FOUND TO BE CRACKED (REF CAR 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. A SIMILAR FAILURE OCCURRED (REF CAR AB3081) BUT A REDESIGN WAS
NECESSARY BECAUSE THE SEAL WELD COULD NOT WITHSTAND THE EXTENDED
VIBRATION LOADS.

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EXCESSIVE LEAKAGE HAS OCCURRED DURING PROOF TEST OPERATIONS (REF CAR AC6082, AC6921; DR AC6767, AC 6922, AC6968, AC6969, AC 7413). THIS LEAKAGE WAS DETERMINED TO BE FROM THE ORIFICE SEALING SURFACES. THE SEALING SURFACES OF THE ORIFICES WERE LAPPED TO THE REQUIRED FINISH. A MIP WAS IMPOSED AND 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 (REF CAR AC7283) AND 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 HOUSING WAS THICKNESS OF 0.030" AT THE DRILLED HOLE.

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

DURING A LEAK CHECK ON OV-102 AT KSC AN ORIFICE LEAK WAS FOUND (REF 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:

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.

- 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