

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0291 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 07/27/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:GHE 3-WAY SOLENOID VALVE, NC TYPE 2 UNITED SPACE ALLIANCE - NSLD	MC284-0404-0032, -0042 13111-5, -6
LRU	:GHE 3-WAY SOLENOID VALVE, NC TYPE 1 UNITED SPACE ALLIANCE - NSLD	MC284-0404-0041, -0051 13110-6, -7

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

THREE-WAY SOLENOID VALVE, NORMALLY CLOSED. BOTH 1/4 AND 3/8 INCH. FOR ALL VALVE ACTUATION CONTROL UPSTREAM OF HELIUM PNEUMATIC CHECK VALVE, CV9.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY WRIGHT COMPONENTS (NOW PERKIN ELMER) BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: LV28
LV29
LV30
LV31
LV32
LV33
LV34
LV35
LV36
LV39
LV77
LV78

QUANTITY OF LIKE ITEMS: 12
VALVES UPSTREAM OF CHECK VALVE, CV9.

FUNCTION:

EACH SOLENOID CONTROLS PNEUMATIC PRESSURE TO OPEN OR CLOSE ITS CORRESPONDING ACTUATOR/VALVE. THE VALVES OPERATED BY THESE SOLENOIDS ARE:

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LO2 OUTBOARD FILL & DRAIN VALVE (LV28,29),
LO2 INBOARD FILL & DRAIN VALVE (LV30,31),
LH2 OUTBOARD FILL & DRAIN VALVE (LV32,33),
LH2 INBOARD FILL & DRAIN VALVE (LV34,35),
LH2 RECIRCULATION VALVES (LV36),
LH2 TOPPING VALVE (LV39),
LO2 POGO/RECIRCULATION VALVES (LV77,78)

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: GHE 3-WAY SOLENOID VALVE, NC

ITEM NAME: GHE 3-WAY SOL VALVES, REGULATOR LEG

CRITICALITY OF THIS

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 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:

MAY RESULT IN AFT COMPARTMENT OVERPRESS AND POSSIBLE LOSS OF CREW/VEHICLE.

LEAKAGE MAY PREVENT THE:

CLOSING AND/OR OPENING OF THE LO2 INBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0310),

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CLOSING AND/OR OPENING OF THE LO2 OUTBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0311),

CLOSING AND/OR OPENING OF THE LH2 INBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0301),

CLOSING AND/OR OPENING OF THE LH2 OUTBOARD FILL & DRAIN VALVE (REFERENCE FMEA/CIL 03-1-0302),

OPERATION OF THE LH2 RECIRCULATION VALVE (REFERENCE FMEA/CIL 03-1-0403),

OPENING OF THE LH2 TOPPING VALVE (REFERENCE FMEA/CIL 03-1-0304),

OPERATION OF THE LO2 POGO ACCUMULATOR RECIRCULATION VALVES (REFERENCE FMEA/CIL 03-1-0453).

(B) INTERFACING SUBSYSTEM(S):

SOLENOIDS ARE LOCATED ON HELIUM PNEUMATIC LEG UPSTREAM OF CHECK VALVE CV9 (NON-ACCUMULATOR LEG). RESULTS IN DEPLETION OF THE MPS VALVE ACTUATION HELIUM SUPPLY. AT MECO THE ENGINE NUMBER TWO HELIUM SUPPLY IS SWITCHED INTO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY BE SUFFICIENT FOR VALVE ACTUATION. HELIUM REMAINING DOWNSTREAM OF CV9 (ACCUMULATOR LEG) IS SUFFICIENT TO CLOSE LO2 PREVALVES AT MECO. RESULTS IN LACK OF AFT COMPARTMENT PURGE DURING REENTRY. LEAKAGE MAY BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

(C) MISSION:

ON GROUND, POSSIBLE VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB. LOSS OF HELIUM SUPPLY GAS HAS NO EFFECT (RESULTS IN POSSIBLE SYSTEM CONTAMINATION DURING ENTRY).

(D) CREW, VEHICLE, AND ELEMENT(S):

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) VENT PORT LEAKAGE OF A THREE WAY SOLENOID UPSTREAM OF CHECK VALVE CV9.
- 2) FAILURE OF CV9 TO CHECK/REMAIN CLOSED.

RESULTS IN INABILITY TO CLOSE LO2 PREVALVES AT MECO DUE TO LOSS OF HELIUM SUPPLY (BOTH ACCUMULATOR AND NON ACCUMULATOR LEGS). FAILURE OF THE PREVALVES TO CLOSE CAUSES THE INABILITY TO MAINTAIN INJECTED HELIUM AND LO2 PRESSURE TO THE HPOTP TO PREVENT PUMP OVERSPEED AND CAVITATION AT MECO. MAY RESULT IN UNCONTAINED ENGINE DAMAGE, AFT COMPARTMENT OVERPRESS, AND FIRE/EXPLOSIVE HAZARD. AT MECO THE ENGINE NUMBER TWO HELIUM SUPPLY IS

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SWITCHED INTO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY ACTUATE THE LO2 PREVALVES CLOSED. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE VALVE IS DESIGNED FOR A PRESSURE FACTOR OF SAFETY OF 2.0 PROOF, 4.0 BURST, AND FOR A 10,000 CYCLE LIFE. THE BODY IS MACHINED FROM 6061-T651 BAR STOCK. THE SEAL BETWEEN THE VALVE BODY AND THE SOLENOID IS A SILVER PLATED INCONEL V-SHAPED SEAL. THE OPEN SIDE OF THE "V" IS TO THE CENTER OF THE VALVE SO THAT THE INTERNAL PRESSURE WILL AUGMENT THE SEALING PROPERTIES OF THE SEAL. THE SOLENOID IS ATTACHED TO THE VALVE BODY BY FOUR SCREWS THAT ARE LOCK-WIRED IN PLACE.

THE -0031 CONFIGURATION WAS ADDED DUE TO A BELLOWS ASSEMBLY DESIGN CHANGE (P/N 24340 TO P/N 24340-1) TO ELIMINATE THE "SQUIRMED" CONDITION WHICH SOME OF THE ORIGINAL BELLOWS ASSEMBLIES EXPERIENCED DURING PROOF PRESSURE TESTING AT ATP. THE DESIGN CHANGE WAS MADE TO STRENGTHEN THE BELLOWS. BECAUSE THE DAMAGE OCCURRED DURING ATP, VALVES ALREADY IN THE FLEET (-0021 CONFIGURATION) WERE X-RAY TESTED AND ONLY VALVES WHICH HAD SQUIRMED BELLOWS WERE UPGRADED TO THE -0031 CONFIGURATION.

THE -0041 AND -0051 CONFIGURATION SOLENOID VALVES ARE IDENTICAL TO THE -0021 AND -0031 CONFIGURATION SOLENOID VALVES (RESPECTIVELY) WITH THE EXCEPTIONS OF ADDING THE FILTER (10 MICRON NOMINAL, 25 MICRON ABSOLUTE) IN THE VENT PORT OF THE SOLENOID VALVE AND REDESIGN OF THE VENT PORT CHECK VALVE. THIS FILTER WAS ADDED TO PREVENT CONTAMINATION AND METALLIC PARTICLES GENERATED DURING THE REMOVAL OF THE VENT PORT CHECK VALVE DURING OMRSD LEAKAGE MEASUREMENTS FROM ENTERING THE SOLENOID VALVE.

THE -0022 CONFIGURATION WAS ADDED DUE TO A BELLOWS ASSEMBLY DESIGN CHANGE (P/N 24340 TO P/N 24340-1) TO ELIMINATE THE "SQUIRMED" CONDITION WHICH SOME OF THE ORIGINAL BELLOWS ASSEMBLIES EXPERIENCED DURING PROOF PRESSURE TESTING AT ATP. THE DESIGN CHANGE WAS MADE TO STRENGTHEN THE BELLOWS. BECAUSE THE DAMAGE OCCURRED DURING ATP, VALVES ALREADY IN THE FLEET (-0012 CONFIGURATION) WERE X-RAY TESTED AND ONLY VALVES WHICH HAD SQUIRMED BELLOWS WERE UPGRADED TO THE -0022 CONFIGURATION.

THE -0032 AND -0042 CONFIGURATION SOLENOID VALVES ARE IDENTICAL TO THE -0012 AND -0022 CONFIGURATION SOLENOID VALVES (RESPECTIVELY) WITH THE EXCEPTIONS OF ADDING THE FILTER (10 MICRON NOMINAL, 25 MICRON ABSOLUTE) IN THE VENT PORT OF THE SOLENOID VALVE AND REDESIGN OF THE VENT PORT CHECK VALVE. THIS FILTER WAS ADDED TO PREVENT CONTAMINATION AND METALLIC PARTICLES GENERATED DURING THE REMOVAL OF THE VENT PORT CHECK VALVE DURING OMRSD LEAKAGE MEASUREMENTS FROM ENTERING THE SOLENOID VALVE.

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THE VENT PORT CHECK VALVE (P/N 11107-5) WAS REDESIGNED (P/N 11107-7) TO PREVENT THE POPPET FROM BEING EJECTED DUE TO SHEARING OF THE RETAINING NUT THREAD. A PIN WAS ADDED TO THE CHECK VALVE HOUSING, WHICH RETAINS THE POPPET WITHIN THE CHECK VALVE HOUSING. A NEW ALUMINUM NUT, WHICH PROVIDES A MINIMUM ENGAGEMENT OF THREE THREADS, WAS UTILIZED TO INCREASE RELIABILITY.

(B) TEST:
ATP

AMBIENT TEMPERATURE TESTS:
PROOF PRESSURE (1560 PSIG); EXTERNAL LEAKAGE (850 PSIG); ELECTRICAL CHARACTERISTICS AND RESPONSE; INTERNAL LEAKAGE (740 PSIG, ENERGIZED AND DEENERGIZED).

REDUCED TEMPERATURE TESTS (-160 DEG F):
ELECTRICAL CHARACTERISTICS AND RESPONSE; INTERNAL LEAKAGE.

ELECTRICAL BONDING TESTS.

SOLENOID SUBASSEMBLY TESTS:
ELECTRICAL CHARACTERISTICS; ENCLOSURE LEAKAGE (ONE ATMOSPHERE).

CERTIFICATION

TWO UNITS -

PORT AND FITTING TORQUE

SALT FOG EXPOSURE FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS

AMBIENT VIBRATION TESTS: TOTAL 13.1 HOURS BOTH AXES FOR TWO VIBRATION LEVELS PLUS TRANSIENT VIBRATION SWEEP - RUN WITH ONE SPECIMEN ENERGIZED AND ONE DEENERGIZED - FOLLOWED BY ELECTRICAL CHARACTERISTICS AND LEAKAGE CHECKS

HANDLING SHOCK TEST

ENERGIZED AND DEENERGIZED FLOW TESTS

FIFTY HOUR CONTINUOUS CURRENT TEST AT 130 DEG F

AMBIENT TEMPERATURE ENDURANCE (4500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS); 130 DEG F ENDURANCE (500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS); OPERATION CYCLES (REPEATED 20 TIMES); REPEAT OF AMBIENT TEMPERATURE ENDURANCE ; -160 DEG F ENDURANCE (500 CYCLES FOLLOWED BY ELECTRICAL AND LEAKAGE CHECKS)

DISASSEMBLY AND INSPECTION

BURST PRESSURE (3400 PSIG)

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

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESSES CERTIFICATION. BODY HOUSING BAR STOCK IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL

CLEANLINESS LEVEL VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. MICROSCOPIC EXAMINATION OF ALL DETAIL PARTS IS MADE PRIOR TO ASSEMBLY. ALL SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE. MECHANICAL SURFACE FINISH AT 125 RMS IS INSPECTED AND VERIFIED WITH A PROFILOMETER. SURFACE FINISHES SMOOTHER THAN 125 RMS ARE INSPECTED USING A COMPARATOR AT 10X MAGNIFICATION. ALL CRITICAL DIMENSIONS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESS

HEAT TREATMENT AND PARTS PASSIVATION VERIFIED BY INSPECTION. POTTING OF SOLDER CUPS, ELECTRICAL WIRE STRIPPING, AND SOLDERING OF CONNECTORS ARE VERIFIED BY INSPECTION. DRY FILM LUBRICATION APPLIED TO THE PLUNGER IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

WELDS VISUALLY EXAMINED & VERIFIED BY X -RAY, DYE PENETRANT, AND EDDY CURRENT. THE SOLENOID ASSEMBLY IS SUBJECTED TO LEAKAGE VERIFICATION USING RADIOACTIVE TRACER TECHNIQUES. THE VALVE BODY, PRIOR TO FINAL MACHINING, IS SUBJECTED TO ETCH AND DYE PENETRANT INSPECTION. BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

EXTERNAL LEAKAGE OCCURRED AT SUPPLIER DUE TO CRACKED HOUSINGS. THE PROBLEM WAS ISOLATED TO AN OVER HEAT-TREATED MATERIAL LOT (CAR AB9798). THE CORRECTIVE ACTION RESULTED IN SCRAPPING ALL HOUSINGS FABRICATED FROM THE LOT, IMPOSING A DYE PENETRANT INSPECTION PRIOR TO ANODIZING, AND ADDING EDDY CURRENT TEST.

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DURING ATP MINOR EXTERNAL LEAKAGE WAS CAUSED BY DEFORMED "V" SEALS (CAR AC4984). THE CORRECTIVE ACTION WAS TO SCRAP ALL SEALS FROM THAT LOT. THIS CONDITION IS ATP SCREENABLE.

DURING QUALIFICATION TESTING EXCESSIVE EXTERNAL LEAKAGE WAS OBSERVED ON TWO VALVES (CAR AD7990 AND A7991). DURING THE SALT FOG TESTING, THE UNITS WERE NOT PROPERLY RINSED AND CORROSION DETERIORATED THE SEALING SURFACES ADJACENT TO THE V SEALS. THIS TEST WAS MUCH MORE SEVERE THAN ANY NORMAL CONDITIONS. A PROTECTIVE PAINT SEAL WAS ADDED TO THE SOLENOID MOUNTING FLANGE FOR ALL UNITS.

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:

HELIUM BOTTLE PRESSURE IS ON DISPLAY IN COCKPIT. CREW ACTION CAN CLOSE ISOLATION VALVES DURING ASCENT. PRIOR TO MECO, ISOLATION VALVES (LV7,LV8) CAN BE REOPENED OR THE LEFT ENGINE LOW PRESSURE GHE CROSSOVER VALVE (LV10) CAN BE OPENED.

- 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	: DAVID NEARY	:/S/ DAVID NEARY
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	: ERICH BASS	:/S/ ERICH BASS