

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0311 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 4 08/01/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LO2 OUTBOARD 8" FILL/DRAIN VALVE (PV9) UNITED SPACE ALLIANCE - NSLD	MC284-0397-0029 74328000-155

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LO2 OUTBOARD FILL VALVE, 8 INCH, PNEUMATICALLY OPERATED.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY FAIRCHILD CONTROLS BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PV9

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE OUTBOARD VALVE, ALONG WITH THE INBOARD FILL AND DRAIN VALVE (PV10), PROVIDES A REDUNDANT MEANS OF CONTAINING PROPELLANT IN THE FEED SYSTEM. THE VALVE IS MOUNTED ON THE FILL AND DRAIN DISCONNECT AND IS CLOSED PRIOR TO ENGINE START. BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION AND ARE OPENED FOR MPS VACUUM INERT TO VENT LO2 RESIDUALS. BOTH VALVES ARE OPEN FOR LO2 DUMP IN RTLS AND TAL ABORTS. THE OUTBOARD VALVE IS CLOSED FOR REENTRY MANIFOLD REPRESSURIZATION. INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS. THE VALVE ALSO INCORPORATES A RELIEF VALVE, RELIEVING INTO THE FILL LINE.

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ERRONEOUS INDICATION. VALVE OPEN, CLOSED POSITION INDICATION ON.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN	A) PASS
	B) FAIL
	C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS SCREEN B BECAUSE OF VALVE PIECE PART STRUCTURAL FAILURE AND/OR POSITION INDICATOR HAS SUFFICIENT DEADBAND TO ALLOW A CLOSED INDICATION WHEN THE VALVE HAS NOT FULLY CLOSED.

C)

- FAILURE EFFECTS -**(A) SUBSYSTEM:**

LOSS OF REDUNDANCY FOR PREVENTION OF OVERBOARD LEAKAGE. FOR RTLS AND TAL ABORT REENTRIES, VALVE FAILURE TO CLOSE FOLLOWING DUMP/INERT WILL RESULT IN LOSS OF GHE SUPPLY DURING MANIFOLD REPRESS BECAUSE THE INBOARD VALVE REMAINS OPEN. THIS RESULTS IN LOSS OF THE AFT COMPARTMENT PURGE. LOSS OF AFT COMPARTMENT PURGE IS NOT CRITICAL FOR A NOMINAL LH2 DUMP DURING RTLS/TAL

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(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

FAILURE WILL NOT RESULT IN A LAUNCH SCRUB SINCE THE LCC REQUIREMENT FOR THE OUTBOARD FILL AND DRAIN VALVE CLOSED INDICATION WILL BE SATISFIED. LOSS OF GHE SUPPLY HAS NO EFFECT FOR NOMINAL, AOA, AND ATO MISSIONS (RESULTS IN POSSIBLE SYSTEM CONTAMINATION DURING ENTRY).

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

SAME AS A.

(E) FUNCTIONAL CRITICALITY EFFECTS:

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

- 1) OUTBOARD FILL & DRAIN (PV9) IS OPEN, INDICATES CLOSED.
- 2) INBOARD FILL & DRAIN (PV10) FAILS TO REMAIN CLOSED.

LO2 WILL DUMP OVERBOARD RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE SHUTDOWN. FIRE/EXPLOSIVE HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF ET MINIMUM STRUCTURAL REQUIREMENTS DUE TO REDUCED ULLAGE PRESSURE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THIS FAILURE MODE CAN OCCUR WITH AN ACTUATOR SHAFT RUPTURE, STRIPPING/SHEARING OF THE ACTUATOR SHAFT SPLINE OR FAILURE OF THE VALVE SHAFT/DRIVER KEY. THE VALVE MAIN SHAFT IS MADE OF INCONEL 718, THE ACTUATOR MAIN PINION SHAFT IS OF BERYLLIUM-COPPER ALLOY 172 AND THE KEY OF A286 CRES. BASED UPON AN ANALYSIS PERFORMED BY THE VALVE MANUFACTURER, A POSITIVE MARGIN OF SAFETY EXISTS FOR THE ACTUATOR POWER TRAIN, FROM THE POSITION INDICATION CAM TO AND INCLUDING THE ACTUATOR VALVE INTERFACE SPLINE, FOR ALL RANGES OF ACTUATOR PRESSURES. THE WEAK LINK IN THE VALVE/ACTUATOR MECHANISM IS THE VALVE SHAFT/DRIVER KEY. THE ACTUATOR PROVIDES ENOUGH FORCE AT FULL ACTUATION PRESSURE TO APPLY A SHEARING LOAD TO THE KEY. A SEIZURE OF THE VALVE MAIN BLADE OR DRIVER MECHANISM WILL RESULT IN THE ACTUATOR LOAD BEING APPLIED TO SHEAR THE KEY AND CAN RESULT IN ACTUATOR FREE TRAVEL.

VALVE CLOSE POSITION INDICATES PRIOR TO FULL TRAVEL OF VALVE BLADE. VALVE BINDING (THAT OCCURS DURING FINAL CLOSURE MOTION) OR INTERNAL SYSTEM CONTAMINATION PREVENTING BLADE MOVEMENT WILL RESULT IN AN ERRONEOUS INDICATION. SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET

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SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER. BINDING IS GUARDED AGAINST BY THE USE OF NEEDLE AND COPPER-BERYLLIUM JOURNAL BEARINGS IN THE VALVE AND ROLLER AND VESPEL JOURNAL TYPES IN THE ACTUATOR; AND DRY FILM LUBRICANT COATING.

DURING THE CERTIFICATION TESTING THIS VALVE WAS CYCLED OPEN/CLOSED A TOTAL OF 5653 TIMES UNDER BOTH CRYOGENIC AND AMBIENT TEMPERATURE CONDITIONS AND AT BOTH NORMAL AND ACCELERATED (SLAM) CYCLE TIMES; THIS REPRESENTS OVER 100 MISSIONS.

(B) TEST:

ATP

ANTI-SLAM VALVES (BEFORE ASSEMBLY INTO THE ACTUATOR) - EXAMINATION OF PRODUCT; AMBIENT PROOF (1275 PSIG); AMBIENT AND CRYO FLOW; AMBIENT AND CRYO CRACKING PRESSURE; POST TEST EXAMINATION.

ACTUATOR (BEFORE ASSEMBLY ONTO THE FILL AND DRAIN VALVE) - EXAMINATION OF PRODUCT; POSITION INDICATION; AMBIENT PROOF (1275); ELECTRICAL CHARACTERISTICS; AMBIENT EXTERNAL LEAKAGE.

RELIEF VALVE ASSEMBLY (BEFORE INSTALLATION INTO THE FILL & DRAIN VALVE)- EXAMINATION OF THE PRODUCT; AMBIENT PROOF (340 PSIG); AMBIENT AND CRYO CRACK/RESEAT (15-50 PSID) AND INTERNAL LEAKAGE; POST TEST EXAMINATION.

FILL AND DRAIN VALVE ASSEMBLY -

EXAMINATION OF PRODUCT

ELECTRICAL BONDING

AMBIENT PROOF WITH VALVE OPEN (358 PSIG) AND CLOSED (275 PSID) APPLIED AT INBOARD SIDE

CRYO PROOF WITH VALVE OPEN (358 PSIG) AND CLOSED (358 PSID) APPLIED AT INBOARD SIDE

AMBIENT AND CRYO EXTERNAL LEAKAGE OF VALVE BODY (270 PSIG)

CRYO EXTERNAL LEAKAGE OF ACTUATOR (740 PSIG)

AMBIENT AND CRYO RESPONSE TIME (NORMAL AT 400 AND 740 PSIG ACTUATOR PRESSURE, AND SLAM AT 740 PSIG)

AMBIENT AND CRYO ACTUATOR LEAKAGE FROM PORT TO PORT

AMBIENT AND CRYO VALVE SHAFT SEAL (PRIMARY AND SECONDARY) LEAKAGE WITH 270 PSID ACROSS THE SEAL

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AMBIENT AND CRYO VALVE INTERNAL LEAKAGE (INLET-TO-OUTLET WITH 15 PSID, OUTLET-TO-INLET WITH 270 PSID)

AMBIENT AND CRYO RELIEF VALVE CRACK AND RESEAT (15 TO 50 PSID)

POST TEST EXAMINATION

CERTIFICATION

STRUCTURAL LOAD AT CRYO TEMPS (-300 DEG F) (AXIAL, SHEAR, TORSION, BENDING) WITH THE VALVE IN TENSION, PERFORM VALVE RESPONSE TIME (NOMINAL AND SLAM) ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), RELIEF VALVE CRACK AND RESEAT, AND EXTERNAL LEAKAGE (BODY AND ACTUATOR) TESTS. REPEAT WITH THE VALVE IN COMPRESSION.

VALVE LIFE CYCLING:

2400 CYCLES AT AMBIENT TEMPERATURE WITH 5 PSIG INTERNAL PRESSURE (525 NORMAL CYCLES AND 1875 SLAM CYCLES)

100 AMBIENT CYCLES (50 NORMAL AND 50 SLAM CYCLES) WITH VALVE INLET VENTED TO ATMOSPHERE AND VALVE OUTLET CONNECTED TO A 4 CUBIC FOOT VOLUME PRESSURIZED TO 220 PSIG WITH GO2

2400 CRYO TEMPERATURE (-300 DEG F) CYCLES WITH 220 PSIG INTERNAL PRESSURE (1775 NORMAL CYCLES AND 625 SLAM CYCLES)

100 NORMAL CRYO CYCLES WITH THE VALVE INLET VENTED TO ATMOSPHERE AND THE OUTLET PRESSURIZED TO 220 PSIG

FOR THE FOREGOING LIFE TEST, PRIOR TO AND EVERY 100 CYCLES THEREAFTER, ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, AND VALVE INTERNAL LEAKAGE (OUTLET-TO-INLET) TESTS WERE PERFORMED.

RELIEF VALVE LIFE CYCLING :

2500 CYCLES AT CRYO (-300 DEG F) TEMP, 2500 CYCLES AT AMBIENT.

FOLLOWING EACH 500 CYCLES PERFORM FILL AND DRAIN VALVE INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), AND CRACK/RESEAT TESTS. POST CYCLE EXAMINATION.

VIBRATION:

PRE-VIBRATION TESTS -

VALVE RESPONSE TIME (NORMAL AND SLAM), ACTUATOR INTERNAL LEAKAGE, PRIMARY AND SECONDARY SHAFT SEAL LEAKAGE, INTERNAL LEAKAGE (OUTLET-TO-INLET AND INLET-TO-OUTLET), CRACK AND RESEAT, AND EXTERNAL LEAKAGE (BODY AND ACTUATOR)

TRANSIENT SINUSOIDAL VIBRATION -

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270 PSIG AND -250 DEG F IN EACH AXIS

RANDOM VIBRATION TESTS -

13.3 HOURS IN EACH OF THREE AXES WITH VALVE CLOSED AND AT -250 DEG F MAXIMUM. HALF OF THE TIME THE VALVE INTERNAL PRESSURE IS 270 PSIG; THE OTHER HALF AT 5 PSIG. ONCE EACH HOUR, CLOSING PRESSURE IS REMOVED FROM THE ACTUATOR. ALSO BOTH CLOSING AND OPENING PRESSURES ARE APPLIED CONCURRENTLY TO THE ACTUATOR. IN BOTH CASES THE VALVE REMAINS CLOSED

DESIGN SHOCK: 18 SHOCKS OF 15G EACH - THREE IN EACH DIRECTION ALONG EACH OF THREE AXES, ALL WITH VALVE OPEN AND ACTUATOR VENTED

DESIGN SHOCK POST TEST:

AMBIENT - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES CRYO - VALVE RESPONSE, INTERNAL AND EXTERNAL LEAKAGES ELECTRICAL CHARACTERISTICS; POSITION INDICATION

BURST: 413 PSIG VALVE OPEN 413 PSIG ON OUTLET OF CLOSED VALVE, 1700 PSIG ACTUATOR

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 PROCESS CERTIFICATION. BODY HOUSING FORGING IS ULTRASONICALLY AND PENETRANT INSPECTED.

CONTAMINATION CONTROL

PARTS ARE VERIFIED CLEAN TO LEVEL 800A. THE ACTUATOR IS CLEANED TO 400A.

ASSEMBLY/INSTALLATION

ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. LOG OF CLEAN ROOM AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ALL SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED. VISUAL (3X TO 7X) AND DIMENSIONAL INSPECTION OF VALVE BODY AND COMPONENTS ARE VERIFIED DURING ASSEMBLY. THREADED FASTENER TORQUES ARE VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT AND DRY FILM LUBE APPLICATION ARE VERIFIED BY INSPECTION.

NON DESTRUCTIVE EVALUATION VALVE BODY, PRIOR TO FINAL MACHINING, IS SUBJECTED TO DYE PENETRANT INSPECTION. REQUIREMENTS FOR DETAIL PARTS PENETRANT INSPECTION ARE BASED UPON CONFIGURATION, MATERIAL, AND MANUFACTURING PROCESSES.

TESTING

ACCEPTANCE TEST VERIFIED BY INSPECTION.

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HANDLING/PACKAGING
PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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:

ON GROUND CALL, CREW CAN CLOSE INBOARD FILL AND DRAIN VALVE (PV10), IF DETECTABLE AND TIME PERMITS.

- 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	: STUART KOBATA	: /S/ STUART KOBATA
MPS SUBSYSTEM MGR.	: TIMOTHY REITH	: /S/ TIMOTHY REITH
MOD	: WILLIAM LANE	: /S/ WILLIAM LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	: /S/ BILL PRINCE