

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0302 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 08/02/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LH2 OUTBOARD 8" FILL/DRAIN VALVE UNITED SPACE ALLIANCE - NSLD	MC284-0397-0031 74328000-159

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LH2 OUTBOARD FILL VALVE, 8 INCH. PNEUMATICALLY OPERATED, INCLUDES A RELIEF VALVE.

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: PV11

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE OUTBOARD VALVE PREVENTS OVERBOARD LOSS OF PROPELLANT DUE TO LEAKAGE FROM THE LH2 INBOARD FILL & DRAIN VALVE (PV12) AND/OR THE LH2 TOPPING VALVE (PV13). THE VALVE IS MOUNTED ON THE FILL AND DRAIN DISCONNECT AND REMAINS OPEN FROM START OF LOADING OPERATIONS TO COMPLETION OF TSM DRAIN (APPROXIMATELY T - 48 SEC). BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION. POST MECO, THE VALVES ARE OPENED BY SOFTWARE COMMAND TO DUMP LH2. THE OUTBOARD VALVE IS SUBSEQUENTLY OPENED BY SOFTWARE TO VENT LH2 RESIDUALS DURING THE FIRST VACUUM INERT. THE OUTBOARD VALVE IS ADDITIONALLY OPENED MANUALLY DURING THE SECOND VACUUM INERT. (EFFECTIVE FOR OI-29 AND SUBS, THE FILL/DRAIN VALVES WILL NO LONGER BE USED FOR VACUUM INERTS. VACUUM INERT WILL BE ACCOMPLISHED VIA THE RTLS DUMP VALVES, PV17 & PV18). THE OUTBOARD VALVE IS CLOSED PRIOR TO ENTRY FOR 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.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0302-03

REVISION#: 2 08/02/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 OUTBOARD 8" FILL/DRAIN VALVE (PV11)

CRITICALITY OF THIS

ITEM NAME: LH2 OUTBOARD 8" FILL/DRAIN VALVE (PV11)

FAILURE MODE: 1R2

FAILURE MODE:

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 AN ERRONEOUS INDICATION WHEN VALVE HAS NOT FULLY CYCLED.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LOSS OF REDUNDANCY FOR PREVENTION OF OVERBOARD LEAKAGE. FOR RTLS/TAL ABORTS, LH2 INBOARD VALVE IS CLOSED PRIOR TO MANIFOLD REPRESS. REPRESS REGULATOR WILL LOCK UP PRESSURE IN LH2 MANIFOLD AND LIMIT HELIUM LOSS. DURING ENTRY, THE FILL AND DRAIN LINE, TOPPING/RECIRCULATION SYSTEM WILL BE EXPOSED TO ATMOSPHERE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0302-03**

(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.

(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 (PV11) OPEN BUT INDICATES CLOSED.
- 2) INBOARD FILL & DRAIN (PV12) FAILS TO REMAIN CLOSED OR TOPPING VALVE (PV13) FAILS TO REMAIN CLOSED.

LH2 WILL DUMP OVERBOARD RESULTING IN LOSS OF PROPELLANT AND PREMATURE ENGINE SHUTDOWN. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO PUMP CAVITATION. 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 OF INCONEL 718, THE ACTUATOR MAIN PINION SHAFT 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 SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER. BINDING IS GUARDED AGAINST BY THE

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0302-03**

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 5256 TIMES UNDER BOTH CRYOGENIC AND AMBIENT TEMPERATURE CONDITIONS AND AT BOTH NORMAL AND ACCELERATED (SLAM) CYCLE TIMES; THIS REPRESENTS OVER 100 MISSIONS. NO FAILURES OF THIS TYPE OCCURRED.

(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 AND 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 AND CRYO PROOF WITH VALVE OPEN AND CLOSED - 143 PSIG

AMBIENT AND CRYO EXTERNAL LEAKAGE OF VALVE BODY (110 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 110 PSID ACROSS THE SEAL

AMBIENT AND CRYO VALVE INTERNAL LEAKAGE (INLET-TO-OUTLET WITH 15 PSID, OUTLET-TO-INLET WITH 110 PSID)

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

POST TEST EXAMINATION

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0302-03**

CERTIFICATION

STRUCTURAL LOAD AT CRYO TEMPS (-400 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), CRACK AND RESEAT, AND, EXTERNAL LEAKAGE (BODY AND ACTUATOR) TESTS. REPEAT WITH THE VALVE IN COMPRESSION.

VALVE LIFE CYCLING:

2400 AMBIENT TEMPERATURE CYCLES 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 110 PSIG WITH GN2

2400 CRYO TEMPERATURE (-400 DEG F) CYCLES WITH 50 - 60 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 110 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 (-400 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 -
(AT 110 PSIG AND -250 DEG F) IN EACH AXIS

RANDOM VIBRATION TESTS -

13.3 HRS IN EACH OF THREE AXES WITH VALVE CLOSED AND AT -250 DEG F MAXIMUM. HALF OF THE TIME THE VALVE INTERNAL PRESSURE IS 110 PSIG; THE OTHER HALF AT 5 PSIG. ONCE EACH HOUR, CLOSING PRESSURE IS REMOVED FROM THE ACTUATOR. ALSO

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0302-03**

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: 165 PSIG VALVE OPEN 165 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 400. 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.

HANDLING/PACKAGING PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0302-03**

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	: STUART KOBATA	: /S/ STUART KOBATA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: WILLIAM LANE	: /S/ WILLIAM LANE
USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS