

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0301 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 4 08/04/00

PART DATA

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

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

FILL VALVE, INBOARD LH2, 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: PV12

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE VALVE, ALONG WITH LH2 TOPPING VALVE (PV13) AND THE OUTBOARD FILL AND DRAIN VALVE (PV11), PROVIDES A REDUNDANT MEANS OF CONTAINING PROPELLANT IN THE FEED SYSTEM. THE VALVE IS MOUNTED ON THE FEED LINE MANIFOLD TO ISOLATE THE FILL LINE FROM THE FEED SYSTEM. IT IS REQUIRED TO BE CLOSED FOR PROPELLANT TOPPING/REPLENISHMENT OPERATIONS. BOTH THE INBOARD AND OUTBOARD VALVES REMAIN CLOSED DURING ENGINE OPERATION. POST MECO, THE INBOARD & OUTBOARD FILL VALVES ARE SOFTWARE COMMANDED OPEN FOR DUMP OF RESIDUAL LH2. FOR A NOMINAL MISSION THE INBOARD VALVE REMAINS OPEN AFTER INERTING THROUGH REENTRY AND LANDING. FOR AN RTLS/TAL THE INBOARD VALVE IS COMMANDED CLOSED AFTER 20 SECONDS (OI-23). VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT VALVE SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS. THE VALVE ALSO INCORPORATES A RELIEF VALVE, RELIEVING FROM THE FILL LINE INTO THE MANIFOLD; AND A PORT FOR INSTALLATION OF LH2 RELIEF SHUTOFF ISOLATION VALVE (PV8).

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REVISION#: 2 08/04/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 INBOARD 8" FILL AND DRAIN VALVE (PV12)

CRITICALITY OF THIS

ITEM NAME: LH2 INBOARD 8" FILL AND DRAIN VALVE (PV12)

FAILURE MODE: 1R2

FAILURE MODE:

RELIEF VALVE REVERSE LEAKAGE/FAILS TO RESEAT DURING ASCENT.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

REVERSE LEAKAGE - PIECE PART STRUCTURAL FAILURE. FAILS TO RESEAT - 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 B SCREEN SINCE RELIEF VALVE LEAKAGE IS UNDETECTABLE IN FLIGHT (NO INSTRUMENTATION IN THE FILL & DRAIN LINE).

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LH2 WILL ENTER FILL LINE. THE FILL LINE CAN WITHSTAND ACCELERATION LOADS WITH LH2 PRESENT. THE ENGINES ARE NOT AFFECTED BY LEAKAGE THROUGH THE RELIEF VALVE INTO THE FEED SYSTEM.

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(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

NO EFFECT ON MISSION OR CREW/VEHICLE.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

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

- 1) INBOARD FILL & DRAIN (PV12) RELIEF VALVE LEAKS
- 2) OUTBOARD FILL & DRAIN (PV11) RELIEF VALVE AND/OR BLADE LEAKS OR FAILS TO REMAIN CLOSED

LH2 WILL DUMP OVERBOARD. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE.
POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

DURING CERTIFICATION TESTING THE RELIEF VALVE WAS CYCLED 5000 TIMES (2500 EACH AT AMBIENT AND CRYOGENIC TEMPERATURES). LEAKAGE IN BOTH DIRECTIONS WAS MEASURED AFTER EACH 500 CYCLES. THE WORST CASE WAS 63 SCIMS OF GHE IN THE REVERSE DIRECTION - WELL WITHIN SPEC. RELIEF VALVE LEAKAGE WILL NOT CAUSE EARLY FUEL DEPLETION SINCE LEAKAGE OVERBOARD WILL BE LESS THAN 90 GALLONS. THE RELIEF VALVE IS OF SIMPLE DESIGN CONSISTING OF ONLY SEVEN PARTS. A SPHERICAL (BALL) POPPET IS SPRING LOADED ONTO A KEEL-F SEAT AND IS CLOSELY GUIDED THROUGHOUT ITS SHORT STROKE. TO FURTHER PREVENT BINDING, ALL SURFACES IN CONTACT WITH THE ALUMINUM-OXIDE POPPET ARE HARD ANODIZED 6061-T651.

(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.

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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

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).

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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 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

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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:
THE RELIEF VALVE EXPERIENCED LEAKAGE (CAR AB3307) DURING QUALIFICATION TESTING DUE TO INSUFFICIENT CLEARANCE BETWEEN SPRING GUIDE AND BODY. THIS WAS CORRECTED BY MINOR DIMENSIONAL CHANGES TO THE CHAMFER ON THE SPRING GUIDE AND INCREASING THE BODY DIAMETER PERMITTING PROPER BALL SEATING.

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

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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