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PRINT DATE: 04/10/90

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 03-1-0310-X

1258

SUBSYSTEM NAME: MAIN PROPULSION

REVISION : 1 04/10/90

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	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU :	VALVE, FILL, 3 IN.	MC294-3297-0020
■	FAIRCHILD CONTROL SYSTEMS	74326000-145

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PART DATA

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- EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
FILL INBOARD LO2 VALVE, 3 INCH, PNEUMATICALLY OPERATED, INCLUDES A RELIEF VALVE.
- REFERENCE DESIGNATORS: PV10
- QUANTITY OF LIKE ITEMS: 1  
ONE LO2
- FUNCTION:  
PROVIDES A MEANS OF LOADING AND DRAINING THE ET THROUGH THE PROPELLANT FEED SYSTEM. THE VALVE, ALONG WITH THE OUTBOARD FILL AND DRAIN VALVE (PV9), 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. THE VALVE IS CLOSED AFTER LOADING IN ORDER TO DRAIN THE FILL LINE (PRIOR TO CLOSING THE OUTBOARD FILL & DRAIN VALVE). 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 INBOARD VALVE REMAINS OPEN AFTER DUMP/INERT, THROUGH REENTRY AND LANDING. THE VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS. THE VALVE INCORPORATES A RELIEF VALVE, RELIEVING FROM THE FILL LINE INTO THE MANIFOLD; AND A PORT FOR INSTALLATION OF LO2 RELIEF SHUTOFF ISOLATION VALVE (PV7).

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SUBSYSTEM: MAIN PROPULSION  
LRU : VALVE, FILL, 8 IN.  
ITEM NAME: VALVE, FILL, 8 IN.

CRITICALITY OF THIS  
FAILURE MODE: 1/1

- FAILURE MODE:  
FAILS TO RELIEVE LO2 FILL LINE BOILOFF INTO FEED MANIFOLD.

MISSION PHASE:  
LO LIFT-OFF

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

- CAUSE:  
BINDING.

- 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:  
RESULTS IN POSSIBLE OVERPRESSURIZATION AND RUPTURE OF THE FILL LINE  
DUE TO PRESENCE OF GO2 RESIDUALS FROM DRAINBACK. POSSIBLE  
OVERPRESSURIZATION OF AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. BLADE  
LIFTOFF FROM THE VALVE SEAT MAY ALLOW RELIEF INTO THE MANIFOLD, BUT  
THIS FUNCTION IS NOT A DESIGN REQUIREMENT AND HAS NOT BEEN CERTIFIED.
- (B) INTERFACING SUBSYSTEM(S):  
SAME AS A.

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- (C) MISSION:  
POSSIBLE LOSS OF CREW/VEHICLE.
- (D) CREW, VEHICLE, AND ELEMENT(S):  
SAME AS C.
- (E) FUNCTIONAL CRITICALITY EFFECTS:  
1R/2, 2 SUCCESS PATHS. TIME FRAME-OTBD F/D VALVE CLOSURE TO DUMP.  
1) INBOARD FILL AND DRAIN VALVE (PV10) FAILS TO RELIEVE.  
2) INBOARD FILL AND DRAIN VALVE (PV10) LEAKS EXCESSIVELY.

RESULTS IN LO2 LEAKAGE INTO FILL LINE. SUBSEQUENT FAILURE OF THE RELIEF VALVE MAY CAUSE OVERPRESSURIZATION AND RUPTURE OF THE LINE. POSSIBLE FIRE/EXPLOSION HAZARD IN AFT COMPARTMENT. POSSIBLE LOSS OF GHE SUPPLY DURING MANIFOLD REPRESSURIZATION RESULTING IN LOSS OF AFT COMPARTMENT PURGE (RTL5 AND TAL ABORT CRITICAL). POSSIBLE LOSS OF CREW/VEHICLE.

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- DISPOSITION RATIONALE -  
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- (A) DESIGN:  
THE RELIEF VALVE WAS CYCLED 5000 TIMES (2500 EACH AT AMBIENT AND CRYOGENIC TEMPERATURES) DURING CERTIFICATION TESTING. THE MAIN VALVE BLADE (CLOSURE) LIFTS OFF FROM ITS SEAT AT 70 PSID AS WAS DETERMINED IN CERTIFICATION TESTING OF THE LO2 VALVE. THE RELIEF VALVE IS OF SIMPLE DESIGN CONSISTING OF SEVEN PARTS. A SPHERICAL POPPET IS SPRING LOADED ONTO A KEL-F SEAT AND IS CLOSELY GUIDED THROUGHOUT ITS SHORT STROKE. TO FURTHER PREVENT BINDING, ALL SURFACES WITHIN THE RELIEF VALVE THAT ARE IN CONTACT WITH THE ALUMINUM OXIDE POPPET ARE HARD ANODIZED 6061-T651. CONTAMINATION IS MORE LIKELY TO PREVENT CLOSURE RATHER THAN PREVENT OPENING.
- (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

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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

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

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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 G02

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 -  
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

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DESIGN SHOCK POST TEST:

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

1275

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

GROUND TURNAROUND TEST

V41BHO.030 PV10,12 RELIEF VALVE FUNCTIONAL (EVERY FIFTH FLIGHT)

■ (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 300A. 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:

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR

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FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

- (E) OPERATIONAL USE:  
NO CREW ACTION CAN BE TAKEN.

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- APPROVALS -  
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RELIABILITY ENGINEERING:	K. ANVARI	:	<u>OK</u>	<u>5-7-90</u>
DESIGN ENGINEERING	: H. P. SAFFORD	:	<u>HPB</u>	<u>4-25-90</u>
QUALITY ENGINEERING	: O. J. BUTTNER	:	<u>DRS</u>	<u>5/1/90</u>
NASA RELIABILITY	:	:	<u>J. Buttner</u>	<u>10/1/90</u>
NASA SUBSYSTEM MANAGER:	:	:	<u>J. Buttner</u>	<u>10/1/90</u>
NASA QUALITY ASSURANCE:	:	:	<u>M. J. H.</u>	<u>7/20/90</u>