

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : MAIN PROPULSION FMEA NO 03-1 -0414 -1 REV: 03/17/8

ASSEMBLY : FAIRCHILD CONTROL CRIT. FUNC: :
 P/N RI : MC284-0406-0002 CRIT. HDW: :
 P/N VENDOR: VEHICLE 102 103 104
 QUANTITY : 1 EFFECTIVITY: X X X
 : ONE LO2 PHASE(S): PL LO X OO DO LS

PREPARED BY: DES J E OSLUND REL L H FINEBERG QE E M GUTIERREZ
 REDUNDANCY SCREEN: A- B- C-
 APPROVED BY: DES HPBafford APPROVED BY (NASA):
 REL LASCOE, JH SSM Phillips, JH
 QE R. Williams QE Swain

ITEM:
 VALVE, ONE INCH LO2 FEEDLINE RELIEF SHUTOFF, PNEUMATICALLY ACTUATED
 CLOSED, NORMALLY OPEN (PV7)

FUNCTION:
 ISOLATES THE LO2 PROPELLANT FEED SYSTEM FROM THE FEEDLINE RELIEF SYSTEM
 MAINTAINED CLOSED FROM START OF PROPELLANT LOADING UNTIL MECO. VALVE IS
 MOUNTED ON THE INBOARD FILL & DRAIN VALVE BODY.

FAILURE MODE:
 FAILS TO OPEN/REMAIN OPEN POST MECO, PRE DUMP.

CAUSE(S):
 FAILS TO OPEN - BINDING, PIECE PART STRUCTURAL FAILURE, ACTUATOR FILTER
 CLOGGING.

FAILS TO REMAIN OPEN - PIECE PART STRUCTURAL FAILURE.

EFFECT(S): ON
 (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:

(A, B) RESULTS IN LACK OF RELIEF CAPABILITY PRIOR TO DUMP. POSSIBLE
 RUPTURE OF THE LO2 MANIFOLD CAUSING LO2 LEAKAGE INTO AFT COMPARTMENT,
 OVERPRESSURIZATION, AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF ADJACE
 CRITICAL COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF
 CREW/VEHICLE.

A VENT PATH EXISTS (APPROXIMATELY 4 SCFM PER BLEED CHECK VALVE) THROUGH
 THE POGO SYSTEM TO THE SSME HPOT SEAL AND RELEASED OVERBOARD. THIS VEN
 PATH IS NOT CONSIDERED SUFFICIENT TO RELIEVE THE LO2 MANIFOLD IF THE
 MANIFOLD RELIEF SYSTEM FAILS.

(C, D) POSSIBLE LOSS OF CREW/VEHICLE.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0414 -1

REV:03/17/88

(E) FUNCTIONAL CRITICALITY EFFECTS:

LR/3, 5 SUCCESS PATHS. TIME FRAME - LO2 DUMP/INERT.

1,2,3) ALL THREE LO2 PREVALVES (PV1,2,3) FAIL TO OPEN/REMAIN OPEN.

4) EITHER OUTBOARD OR INBOARD FILL & DRAIN VALVE (PV9,10) FAIL TO OPEN/REMAIN OPEN.

5) RELIEF SHUTOFF VALVE (PV7) FAILS TO REMAIN OPEN.

RESULTS IN RUPTURE OF THE 17 INCH FEEDLINE/MANIFOLD DUE TO EXPANDING LO2 RESIDUALS AFTER DUMP. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

DISPOSITION & RATIONALE

(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E)OPERATIONAL USE:

(A) DESIGN

VALVE

THE VALVE IS A NORMALLY OPEN, FLAPPER-TYPE SHUTOFF VALVE, WITH A PNEUMATIC ACTUATOR. IT IS SPRING LOADED TO THE OPEN POSITION BY A BELLOWS WITHIN THE ACTUATOR. IN THE ACTUATOR-VENTED CONDITION THE BELLOWS SPRING FORCE IS TRANSMITTED TO THE VALVE FLAPPER VIA A BELLOWS GUIDE (SHAFT) AND MECHANICAL LINKAGE TO ROTATE THE FLAPPER AWAY FROM THE VALVE SEAT. WHEN ACTUATION PRESSURE IS APPLIED TO THE ACTUATOR THE BELLOWS IS COMPRESSED, CAUSING THE BELLOWS GUIDE AND MECHANICAL LINKAGE TO ROTATE THE FLAPPER TO THE VALVE CLOSED POSITION. VALVE INLET PRESSURE ASSISTS IN HOLDING THE FLAPPER TO THE VALVE SEAT.

FAILURE TO RETURN TO, OR REMAIN IN, THE OPEN POSITION INDICATES THE SPRING (BELLOWS) FORCE HAS BEEN REMOVED FROM THE FLAPPER. THIS COULD BE CAUSED BY STRUCTURAL FAILURE OF ANY OF THE FOLLOWING: FLAPPER ARM, FLAPPER LINK, EITHER OF THE TWO LINK PINS, BELLOWS GUIDE OR THE BELLOWS. STRESS ANALYSES OF THESE COMPONENTS INDICATE THE VALVE HAS A POSITIVE MARGIN OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS.

THE FLAPPER VALVE IS OPERATED BY THE BELLOWS THROUGH A PINNED LINKAGE CONSISTING OF A FLAPPER ARM, A LINK, AND A BELLOWS GUIDE WELDED TO THE BELLOWS. THE FLAPPER ARM IS MADE FROM COPPER-BERYLLIUM #172 AND HEAT TREATED TO CONDITION HT. THE FLAPPER LINK IS OF 2219-T87 AL AND IS .278 INCHES THICK. THE PINS ARE A286 CRES AND HAVE A 0.2475 INCH DIAMETER. THE BELLOWS GUIDE IS MACHINED FROM 304L CRES, WHICH IS SUBSEQUENTLY ANNEALED. THE BELLOWS IS FORMED FROM TWO PLYS OF 0.01 INCH INCONEL 718 AND IS HEAT TREATED AFTER FORMING. IT IS DESIGNED FOR 10,000 CYCLES; 5 TIMES GREATER THAN THE VALVE SPECIFICATION REQUIREMENT. THE BELLOWS ASSEMBLY ACCEPTANCE TESTING INCLUDES PROOF PRESSURE, LEAKAGE, AND CYCLING.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0414 -1

REV:03/17/

FAILURE TO RETURN TO THE OPEN POSITION COULD BE CAUSED BY BINDING AT ANY OF THE PINNED CONNECTIONS WITHIN THE FLAPPER LINKAGE (FLAPPER ARM TO FLAPPER LINK, FLAPPER LINK TO BELLOWS GUIDE, AND FLAPPER ARM TO CYLINDER CLEVIS). THE FLAPPER ARM, FLAPPER LINK, AND CLEVIS CYLINDER ARE ALL TREATED WITH A DRY LUBRICANT TO PREVENT BINDING. BINDING OF THE SLIDING CONTACT SURFACES BETWEEN THE CYLINDER CLEVIS AND BELLOWS GUIDE IS PRECLUDED BY TEFLON GUIDE RINGS.

THE ACTUATOR INLET PORT IS EQUIPPED WITH A FILTER TO PREVENT ACTUATOR CONTAMINATION.

SYSTEM

PRESENT SYSTEM CONFIGURATION ALLOWS 12 INCH FEEDLINE VENTING THROUGH SSP HPOT SEALS. PRESENT DUMP SEQUENCE PREVENTS EXCESSIVE MANIFOLD PRESSURE BUILDUP. FLIGHT AND GROUND TEST EXPERIENCE HAS SHOWN THAT MANIFOLD PRESSURE DOES NOT INCREASE TO MINIMUM RELIEF VALVE CRACKING PRESSURE FOR NOMINAL OPERATION.

(B) TEST

ATP

AMBIENT AND CRYO (-300 DEG F) PROOF
VALVE BODY - 413 PSIG WITH VALVE BOTH OPEN AND CLOSED
ACTUATOR - 1275 PSIG

VALVE RESPONSE TIMES

AMBIENT - VALVE PRESSURIZED TO 5 PSIG; ACTUATOR PRESSURIZED TO 780 AND 400 PSIG (OPEN AND CLOSED).

CRYO (-300 DEG F) -

OPENING: VALVE PRESSURIZED TO 180 AND 20 PSIG; ACTUATOR 780 PSIG
CLOSING: VALVE PRESSURIZED TO 0 AND 220 PSIG; ACTUATOR 780 AND 400 PSIG

EXTERNAL LEAKAGE

AMBIENT AND CRYO (-300 DEG F) - VALVE BODY @ 50 AND 200 PSIG GHe,
VALVE OPEN; ACTUATOR @ 780 PSIG GHe

INTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F)

INLET TO OUTLET @ 50 AND 200 PSIG GHe, VALVE CLOSED

POSITION INDICATION - VERIFICATION OF OPERATION (AMBIENT ONLY)

ELECTRICAL TESTS

ELECTRICAL BONDING; DIELECTRIC; INSULATION RESISTANCE

CERTIFICATION (TWO UNITS CERTIFIED)

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0414 -1

REV:03/17/88

VALVE RESPONSE TIMES

AMBIENT - VALVE PRESSURIZED TO 5 PSIG; ACTUATOR PRESSURIZED TO 780 AND 400 PSIG (OPEN AND CLOSED).

CRYO (-300 DEG F)

OPENING: VALVE PRESSURIZED TO 180 AND 20 PSIG; ACTUATOR 780 PSIG

CLOSING: VALVE PRESSURIZED TO 0 AND 220 PSIG; ACTUATOR 780 AND 400 PSIG

CRYO (-400 DEG F)

OPENING: VALVE PRESSURIZED TO 30 PSIG; ACTUATOR 780 PSIG

CLOSING: VALVE PRESSURIZED TO 0 AND 60 PSIG; ACTUATOR 780 AND 400 PSIG

EXTERNAL LEAKAGE

AMBIENT - VALVE BODY @ 50 AND 200 PSIG GHe, VALVE OPEN; ACTUATOR @ 780 PSIG GHe

CRYO (-300 DEG F) - VALVE BODY @ 50 AND 200 PSIG GHe, VALVE OPEN; ACTUATOR @ 780 PSIG GHe

CRYO (-400 DEG F) - VALVE BODY @ 50 PSIG GHe, VALVE OPEN; ACTUATOR @ 780 PSIG GHe

INTERNAL LEAKAGE

AMBIENT AND CRYO (-300 DEG F) - INLET TO OUTLET @ 50 AND 200 PSIG GHe, VALVE CLOSED

CRYO (-400 DEG F) - INLET TO OUTLET @ 50 PSIG GHe, VALVE CLOSED

LIFE TEST

CRYO (-400 DEG F) - 250 CYCLES AT 200 PSIG AND 250 CYCLES AT 50 PSIG FOLLOWED BY A CRYO (-400 DEG F) LEAKAGE TEST

AMBIENT - 1500 CYCLES @ 5 PSIG. AFTER EACH 500 CYCLES PERFORM AMBIENT LEAK TESTS.

VIBRATION

TRANSIENT - (5 - 35 HZ) IN EACH OF THREE AXES, WITH VALVE CLOSED

RANDOM - (13.3 HOURS IN EACH OF THREE AXES WHILE PRESSURIZED TO 200 PSIG, AT -300 DEG F, AND WITH THE VALVE CLOSED. FOLLOWING EACH

AXIS TEST, PERFORM CRYO (-300 DEG F) VALVE RESPONSE TIMES TEST, AND CRYO (-300 DEG F) LEAKAGE TESTS (EXCEPT ACTUATOR).

DESIGN SHOCK (18 SHOCKS OF 15G EACH) - THREE IN EACH DIRECTION OF THREE AXES). UPON COMPLETION PERFORM AMBIENT VALVE RESPONSE TIMES TEST, AND AMBIENT LEAKAGE TESTS.

THERMAL CYCLE TEST - +70 DEG F TO -400 DEG F TO +70 DEG F TO +275 DEG F TO +150 DEG F TO +70 DEG F PERFORMED THREE TIMES FOLLOWED BY AMBIENT VALVE RESPONSE TIMES TEST, AMBIENT LEAKAGE TESTS, AND ELECTRICAL INSULATION TEST.

ELECTRICAL BONDING (ONE UNIT ONLY)

BURST TEST (ONE UNIT ONLY) -.550 PSIG VALVE BODY, 3400 PSIG ACTUATOR

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0414 -1

REV:03/17/

OMRSD

V41AYO.010 LO2 PROPELLANT VALVE EXTERNAL LEAK TEST (15)
V41AYO.130 LO2 PROPELLANT SYSTEM DECAY CHECK (EVERY FLIGHT)
V41AYO.221 HELIUM SIGNATURE LEAK CHECK (EVERY FLIGHT)
V41BIO.070 PV7 RELIEF SHUTOFF VALVE RESPONSE TIME (EVERY FLIGHT)
V41BIO.230 INFLIGHT VALVE RESPONSE (POST FLIGHT DATA ANALYSIS)

(C) INSPECTION

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. BODY HOUSING FORGING IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 400A IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. LOG OF CLEAN ROOM AND TOOL CALIBRATION IS VERIFIED BY INSPECTION. DRAWING TORQUE AND SURFACE FINISH REQUIREMENTS ARE VERIFIED. COMPONENTS ARE VISUALLY AND DIMENSIONALLY INSPECTED DURING FABRICATION. SEALS ARE VISUALLY EXAMINE FOR DAMAGE AND CLEANLINESS PRIOR TO INSTALLATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED. DRY FIL LUBRICANT APPLICATION IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

ULTRASONIC INSPECTION OF BODY HOUSING IS VERIFIED. WELDS ARE DYE PENETRANT INSPECTED.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING AND PACKAGING FOR SHIPMENT ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

DURING QUALIFICATION TEST, VALVE OPENING RESPONSE TIME WAS 1.55 SECONDS. SHOULD BE 1.5 SECONDS (REF CAR A5547). CORRECTIVE ACTION WAS TO CHANGE THE OPENING RESPONSE TIME (CRYO TEMPERATURE ONLY) FOR THE HYDROGEN UNIT TO 2.5 SECONDS. NO HARDWARE SHIPPED WAS AFFECTED. NO FURTHER INCIDENTS HAVE OCCURED.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0414 -1

REV:03/17/88

(E) OPERATIONAL USE

LO2 MANIFOLD PRESSURE IS ON CAUTION AND WARNING.

POST MECO/PRE DUMP: START MPS PROPELLANT DUMP AS SOON AS POSSIBLE.

POST DUMP: OPEN THE LO2 FILL/DRAIN VALVES.