

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0452 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/06/00

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : VALVE, BALL (TYPE 5) VACCO INDUSTRIES	MC284-0395-0055 1442-511

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LO2 OVERBOARD BLEED VALVE (PV19), 1.5 INCH DIAMETER, NORMALLY OPEN, PNEUMATICALLY ACTUATED CLOSED. RELIEVES TO INBOARD SIDE OF VALVE.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY VACCO INDUSTRIES (EATON). THE UNITED SPACE ALLIANCE-NSLD IS A CERTIFIED REPAIR DEPOT BUT HAS NOT YET BEEN CERTIFIED AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PV19

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

CONTROLS OVERBOARD BLEED FLOW (DURING LOADING) THROUGH LO2 BLEED DISCONNECT (PD13) TO MAINTAIN PROPER CRYOGENIC START CONDITIONS FOR LO2 ENGINE FEED. VALVE IS REDUNDANT TO THE LO2 BLEED DISCONNECT TO PREVENT OVERBOARD LOSS OF LO2 DURING ASCENT. PROVIDES RELIEF FEATURE FOR LO2 TRAPPED BETWEEN BLEED VALVE (PV19) AND LO2 BLEED DISCONNECT (PD13). THE VALVE IS CLOSED APPROXIMATELY 9 SECONDS BEFORE LIFTOFF AND IS REQUIRED CLOSED BY LCC. FOR NOMINAL, ATO, AND AOA MISSIONS THE VALVE IS OPENED AT COMPLETION OF DUMP. FOR RTLS/TAL ABORTS THE VALVE REMAINS CLOSED UNTIL THE END OF THE 650 SECOND BLOWDOWN PURGE. THE VALVE INCORPORATES TWO REDUNDANT CLOSED POSITION INDICATORS AND A SINGLE OPEN INDICATOR.

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NUMBER: 03-1-0452-05

REVISION#: 1 09/20/01

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LO2 OVERBOARD BLEED VALVE, PV19

ITEM NAME: LO2 OVERBOARD BLEED VALVE, PV19

CRITICALITY OF THIS

FAILURE MODE: 1R3

FAILURE MODE:

ERRONEOUS INDICATION (VALVE CLOSED, OPEN INDICATION ON)

MISSION PHASE:

PL PRE-LAUNCH

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 B SCREEN SINCE ERRONEOUS INDICATION MATCHES EXPECTED STATE

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

RESULTS IN INTERRUPTION OF LO2 OVERBOARD BLEED AND FAILURE TO MAINTAIN SSME START BOX CONDITIONS. LO2 MANIFOLD TEMPERATURE MEASUREMENTS (V41T1527A AND V41T1528A) WILL DETECT ANOMALOUS CONDITIONS IN LO2 MANIFOLD AND RESULT IN LAUNCH SCRUB.

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(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

RESULTS IN LAUNCH SCRUB.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/3 3 SUCCESS PATHS. TIME FRAME - LIFTOFF

- 1) ERRONEOUS INDICATION, VALVE FAILED CLOSED, OPEN INDICATOR ON RESULTING IN INTERRUPTION OF LO2 OVERBOARD BLEED. RESULTS IN FAILURE TO MAINTAIN LO2 INLET CONDITIONS ONCE LO2 REPLENISH IS TERMINATED.
- 2,3) BOTH LO2 MANIFOLD TEMPERATURE TRANSDUCERS (V41T1527A AND V41T1528A) FAIL WITHIN LCC LIMITS.

RESULTS IN POSSIBLE LO2 GEYSER FORMATION DURING TERMINAL COUNT. GEYSERING MAY RESULT IN FEEDLINE RUPTURE, EXTERNAL LEAKAGE OF LO2, AND POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF VEHICLE.

CASE 2

1R/3 4 SUCCESS PATHS. TIME FRAME - DETANK FOLLOWING FRF, TANKING TEST OR PAD ABORT

- 1) ONE OF THREE PREVALVES (PV1,2,3) OR ONE OF TWO POGO RECIRCULATION VALVES (PV20, 21) FAIL TO CLOSE/REMAIN CLOSED AND OR HELIUM INJECT FAILS TO RESUME/CONTINUE.
- 2) ERRONEOUS INDICATION, VALVE FAILED CLOSED, OPEN INDICATOR ON RESULTING IN INTERRUPTION OF LO2 OVERBOARD BLEED. RESULTS IN FAILURE TO MAINTAIN LO2 INLET CONDITIONS DURING LO2 DRAINBACK.
- 2,3) BOTH LO2 MANIFOLD TEMPERATURE TRANSDUCERS (V41T1527A AND V41T1528A) FAIL WITHIN LCC LIMITS.

AFTER A PAD ABORT, PREVALVE CLOSURE IS REQUIRED TO LIMIT HEAT SOAKBACK FROM THE MAIN ENGINES INTO THE FEED SYSTEM AND PREVENT LO2 GEYSERING. FOR PREVALVE FAILURE TO CLOSE, HELIUM INJECTION IS NOT SUFFICIENT TO PREVENT GEYSERING AND OVERBOARD BLEED OR LO2 DRAIN MUST BE INITIATED WITHIN OMRSD REQUIREMENTS.

GEYSERING MAY RESULT IN FEEDLINE RUPTURE, EXTERNAL LEAKAGE OF LO2, AND POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF VEHICLE.

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-DISPOSITION RATIONALE-

(A) DESIGN:

THE VALVE ACTUATOR IS SPRING LOADED TO THE OPEN POSITION. THE ACTUATOR PISTON DRIVES A SPRING LOADED RACK WHICH, IN TURN, DRIVES A PINION GEAR SHAFT WHICH ROTATES THE VALVE BALL CLOSURE DEVICE. THE SPRING IS MANUFACTURED FROM 0.177 INCH DIAMETER ELGILOY WIRE AND HAS A SPRING RATE OF 96 POUNDS PER INCH. IN THE INSTALLED POSITION, WITH THE ACTUATOR VENTED, THE SPRING EXERTS A FORCE OF 275 POUNDS. IF THE SPRING SHOULD BREAK WITH THE VALVE OPEN, THE INTERNAL FRICTION OF THE ACTUATOR AND VALVE WOULD PREVENT THE VALVE FROM DRIFTING OUT OF THE OPEN POSITION.

THE RACK AND PINION ARE OF INCONEL 718 AND THE PINION GEAR/SHAFT IS MACHINED FROM A SINGLE PIECE OF STOCK. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION; FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

THE ACTUATOR AND VALVE BEARINGS ARE OF EITHER VESPEL OR FLUOROGOLD AND ARE DESIGNED SO THAT THEY WILL TURN WITHIN THEIR HOUSING IN THE EVENT OF SHAFT/BEARING SEIZURE/BINDING. TO PREVENT BINDING IN THE ACTUATOR, THE RACK IS GUIDED ON EACH END BY A FLUOROGOLD GUIDE RING. THE CHROME PLATED PISTON SLIDES THROUGH RETAINERS TREATED WITH A DRY FILM LUBRICANT. THE ACTUATOR PISTON SEAL DESIGN USES A KEL-F STATIC SEAL AGAINST THE MOVING, CHROME-PLATED PISTON.

TO CONTROL CONTAMINATION, A 10 MICRON FILTER IS DESIGNED INTO THE ACTUATOR PRESSURIZATION PORT.

(B) TEST:

ATP

EXAMINATION OF PRODUCT

AMBIENT PROOF

VALVE BODY - 600 PSIG VALVE OPEN; 600 PSIG VALVE CLOSED.
ACTUATOR - 1700 PSIG.

VALVE RESPONSE TIMES

AMBIENT AND CRYO (-300 DEG F) VALVE PRESSURIZED TO 105 PSIG
ACTUATOR PRESSURIZED TO 740 AND 500 PSIG

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

VALVE BODY @ 220 PSIG
SHAFT SEAL @ 220 PSIG
ACTUATOR @ 740 PSIG

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RELIEF FUNCTION (OUTLET-TO-INLET)
CRACK/RESEAT CRYO (-300 DEG F, 15-40 PSID)

INTERNAL LEAKAGE
INLET-TO-OUTLET @ 220 PSIG

POSITION INDICATION: VERIFICATION OF OPERATION

ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE, DIELECTRIC STRENGTH AND RESISTANCE.

CERTIFICATION

VALVE RESPONSE TIMES
AMBIENT AND CRYO (-300 DEG F) - VALVE PRESSURIZED TO 105 PSIG
ACTUATOR PRESSURIZED TO 740 AND 500 PSIG

EXTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F)
VALVE BODY @ 220 PSIG
SHAFT SEAL @ 220 PSIG
ACTUATOR @ 740 PSIG

LIFE
CRYO (500 CYCLES @ -300 DEG F FOLLOWED BY CRYO LEAKAGE TESTS)
AMBIENT (1500 CYCLES. AFTER EACH 500 CYCLES PERFORM AMBIENT LEAKAGE TESTS AND AMBIENT CRACK/RESEAT TESTS).

VIBRATION
TRANSIENT VIBRATION - (5 TO 35 HZ) PRIOR TO EACH AXIS OF RANDOM VIBRATION TEST.

RANDOM VIBRATION - (13.3 HOURS IN EACH OF THREE AXES WHILE PRESSURIZED TO 105 PSIG AND AT -300 DEG F.

PRIOR TO EACH AXIS TEST, PERFORM CRYO VALVE RESPONSE TIMES TEST. FOLLOWING EACH AXIS TEST, PERFORM CRYO VALVE RESPONSE TIMES TEST, CRYO LEAKAGE TESTS, AND CRYO CRACK/RESEAT TESTS. AFTER TEST UNIT HAS WARMED, PERFORM ELECTRICAL CHARACTERISTICS TESTS, AMBIENT VALVE RESPONSE TIMES TEST, AMBIENT LEAKAGE TESTS, AND AMBIENT CRACK/RESEAT TESTS).

THERMAL CYCLE TEST (+70 DEG F TO -300 DEG F, TO +70 DEG F, TO +275 DEG F, TO +150 DEG F, TO AMBIENT) BY SIMILARITY TO TYPE II VALVES (LO2 POGO VALVE).

ELECTRICAL CHARACTERISTICS TESTS AND ELECTRICAL BONDING TEST

DESIGN SHOCK - BY SIMILARITY TO THE TYPE I (RECIRC AND TOPPING VALVES) AND III VALVES (INBOARD RTLS DUMP AND HI POINT BLEED VALVE).

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BURST TEST

VALVE BODY @ 800 PSIG
ACTUATOR @ 3400 PSIG

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIAL VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. TEST REPORTS REQUIRED ON CAST MATERIAL. COMPLETION OF HOT ISO STATIC PRESSING (HIP) PROCESS IS VERIFIED. CAST HOUSING (ROUGH MACHINED) IS INSPECTED FOR POROSITY.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. THE INTERNAL WETTED SURFACES ARE CLEANED TO LEVEL 400A AND VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL DETAIL PARTS ARE INSPECTED FOR CRITICAL DIMENSIONS, SURFACE FINISH, BURRS, DAMAGE, AND CORROSION. CRITICAL POPPET AND SLEEVE SURFACES ARE LAPPED AND INSPECTED WITH 40X MAGNIFICATION. TORQUES ARE VERIFIED TO BE IN ACCORDANCE WITH DRAWING REQUIREMENTS. PRIOR TO INSTALLATION, SEALS ARE VISUALLY EXAMINED WITH 10X MAGNIFICATION FOR DAMAGE AND CLEANLINESS. ALL SPRINGS ARE LOT TRACEABLE AND LOAD TESTED AT THE PIECE PART LEVEL. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT OF THE VALVE BALL AFTER MACHINING IS VERIFIED. PART PASSIVATION AND HARD ANODIZING ARE VERIFIED. CERTIFICATION OF WELDING, POTTING, AND SOLDERING IS VERIFIED. PAINTING (ON BODY), ELECTRICAL BONDING, AND DRY FILM LUBRICANT ARE VERIFIED BY INSPECTION. ALL CASTINGS ARE SUBJECTED TO A HIP PROCESS.

NONDESTRUCTIVE EVALUATION

PRIOR TO FINAL MACHINING, THE HOUSING IS X-RAYED, ETCH AND DYE PENETRANT INSPECTED, AND LEAK CHECKED AT PROOF PRESSURE. ALL WELDS ON THE ELECTRICAL CONNECTOR ARE DYE PENETRANT INSPECTED AND VERIFIED BY INSPECTION.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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HANDLING, PACKAGING, STORAGE, AND SHIPPING REQUIREMENTS ARE 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:

FLIGHT: N/A

GROUND: GROUND WILL INITIATE DRAIN UPON FAILURE OF LO2 OVERBOARD BLEED VALVE/DISCONNECT, LO2 PREVALVE OR LO2 POGO VALVE. GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

- 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	: EARL HIRAKAWA	:/S/ EARL HIRAKAWA
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	:/S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS