

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 03-3-2007-X

SUBSYSTEM NAME: ORBITAL MANEUVERING SYSTEM (OMS)

REVISION : 6 03/05/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU	VALVE, TANK ISOLATION, OX PARKER HANNIFIN	MC284-0430-0023/0047 5750029-103/106
■ LRU	VALVE, TANK ISOLATION, FUEL PARKER HANNIFIN	MC284-0430-0024/0048 5750030-103/106

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, TANK ISOLATION, A.C. MOTOR ACTUATED, 115/200 V, AC, 3-PHASE, 400 HZ, 1.0 AMP MAX (2-PHASE), 1.0 AMP (3 PHASE). (L7462, 464, 461, 463, 562, 564, 561, 563)

QUANTITY OF LIKE ITEMS: 8
4 PER POD (PARALLEL)

FUNCTION:

TWO PARALLEL REDUNDANT ISOLATION VALVES ARE USED PER TANK TO ISOLATE OMS PROPELLANT DURING OMS CROSS-FEED. THEY ARE ALSO USED TO PREVENT HELIUM INGESTION TO ENGINE AT PROPELLANT RUN OUT, TO ISOLATE LEAKS BY MANUAL SWITCH ACTUATION, AND ARE ALSO USED DURING GROUND OPERATIONS. FUEL AND OXIDIZER VALVE ARE OPERATED INDEPENDENTLY FOR C/O. THE ACTUATOR ASSEMBLY CONSISTS OF 115 V.A.C., 400 HZ, THREE PHASE MOTOR (CAPABLE OF 2-PHASE OPERATION) OPERATING THROUGH A PLANETARY GEAR TRAIN WITH MICROSWITCHING TO CONTROL MOTOR POWER. THE FLOW ASSEMBLY CONSISTS OF LIFT-OFF BALL VALVE ACTUATED THROUGH A ROTATING FINGER DRIVEN BY THE ACTUATOR. AN INTERNAL RELIEF DEVICE IS PROVIDED. THERMAL SWITCHES ON EACH AC PHASE INTERRUPT ELECTRICAL POWER WHEN VALVE HOUSING REACHES A TEMPERATURE OF 255 F.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 03-3-2007-02

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LRU : VALVE, TANK ISOLATION, OX
ITEM NAME: VALVE, TANK ISOLATION, FUEL

CRITICALITY OF THIS
FAILURE MODE: 1R2

- FAILURE MODE:
FAILS CLOSED, FAILS TO OPEN, FAILS TO REMAIN OPEN, RESTRICTED FLOW.

MISSION PHASE:

LD	LIFT-OFF
OO	ON-ORBIT
DO	DE-ORBIT

- VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
: 103	DISCOVERY
: 104	ATLANTIS
: 105	ENDEAVOUR

CAUSE:
ELECTRICAL OPEN, JAMMING OF BALLSHAFT OR CAMS, CORROSION, RESIDUE,
MATERIAL OR SPRING DEFECT, PREMATURE SIGNAL (FAILED V.P.I.) PLUGGED
INLET FILTER. TWO OF THREE THERMAL SWITCHES FAIL OPEN.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

- REDUNDANCY SCREEN A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF REDUNDANCY.

(B) INTERFACING SUBSYSTEM(S):
SAME AS (A)

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE

NUMBER: 03-3-2007-02

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ATTACHMENT

PAGE 60 OF 265

(C) MISSION:
NO EFFECT.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (C)

(E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE CREW/VEHICLE LOSS - FAILED CLOSED OF PARALLEL REDUNDANT VALVES
RESULTS IN INABILITY TO UTILIZE/DEplete PROPELLANT REQ'D FOR ORBIT &
POSSIBLE O.G. PROBLEM DUE TO WEIGHT OF REMAINING PROPELLANT.
RESTRICTED FLOW THROUGH ONE VALVE NOT DETECTABLE IN FLIGHT (BOTH VALVES
OPEN FOR ALL MANEUVERS).

- DISPOSITION RATIONALE -

(A) DESIGN:

AC MOTOR VALVE IS 3-PHASE, 2 OF 3 WINDINGS ARE ADEQUATE FOR VALVE
FUNCTION. SERIES (HYBRID) RELAYS PROVIDE REDUNDANCY FOR ELECTRICAL
POWER SIGNAL. ADDITIONALLY, PARALLEL REDUNDANT VALVES ARE PROVIDED. A
400-MICRON FILTER IS UTILIZED ON THE INLET AND OUTLET TO LIMIT THE
POTENTIAL FOR CONTAMINATION CAUSED FAILURE OR JAMMING OF MOVING
PARTS. AN INTERNAL RELIEF DEVICE IS PROVIDED.

(B) TEST:

QUALIFICATION TEST

(4 UNITS), SHOCK, ENDURANCE (2500 CYCLES), THERMAL CYCLING (+20 TO
+150 DEG F), RANDOM VIBRATION, PROPELLANT EXPOSURE, SURGE PRESSURE,
BURST (2000 PSI). ALSO QUALIFIED AS PART OF POD ASSEMBLY -
VIBRO-Acoustic TESTING AT JSC (131 EQUIVALENT MISSIONS). HOT-FIRE
TEST PROGRAM AT WSTF-517 TESTS (24 EQUIVALENT MISSIONS). APPROX. 7
YRS PROPELLANT EXPOSURE.

ACCEPTANCE TEST

IN-PROCESS BELLOW LEAK TEST, THERMAL PROTECTION SWITCH ACTUATION,
PROOF AND EXTERNAL LEAKAGE, INTERNAL LEAKAGE, RELIEF VALVE FUNCTION,
ACCEPTANCE VIBRATION, ELECTRICAL PERFORMANCE, PRESSURE DROP,
INLET/OUTLET SCREEN RATING, CLEANLINESS.

GROUND TURNAROUND

V43CA0.045 PERFORMS FIRST FLIGHT ELECTRICAL VERIFICATION.

V43CA0.072 PERFORMS REDUNDANT ELECTRICAL CIRCUIT VERIFICATION EVERY
FLIGHT.

V43CA0.075 PERFORMS ELECTRICAL INTERFACE VERIFICATION ON A CONTINGENCY

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: 03-3-2007-02

BASIS.

- V43CF0.010 PERFORMS PROPELLANT SERVICING TO FLIGHT LOAD EVERY FLIGHT AND VERIFIES PROPELLANT CONFORMANCE TO SE-S-0073.
- SCCF30.295 PERFORMS FUNCTIONAL TEST OF CRITICALITY I VALVES PRE-LAUNCH.
- V43CB0.165 REQUIRES EACH-FLIGHT SNIFF TEST TO VERIFY NO PROPELLANT VAPOR IN VALVE ACTUATOR.

■ (C) INSPECTION:

RECEIVING INSPECTION

MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 200 FOR MMH AND 200 A FOR NTC AND CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, ASSEMBLY AND INSTALLATION PROCEDURES ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. ADDITIONAL INSPECTIONS HAVE BEEN ADDED FOR NEW VALVE BUILDS INCLUDING 100% INSPECTION OF BELLOWS WELD, WELD SAMPLES AT BEGINNING OF EACH SHIFT, AND INSPECTION OF EACH COLLAR AFTER TRIMMING. BELLOWS KRYTOX FILL VERIFICATION IS ALSO PERFORMED.

NONDESTRUCTIVE EVALUATION

CASTINGS ARE PENETRANT AND X-RAY INSPECTED ON THE DETAIL LEVEL. WELDS RECEIVE VARIOUS COMBINATIONS OF X-RAY, PENETRANT, VISUAL AND LEAK TEST. SOME WELDS SUCH AS BELLOWS END WELDS ARE NOT X-RAYED. BELLOWS END WELDS ARE LEAK TESTED AND VISUALLY EXAMINED. THE VALVE IS X-RAY INSPECTED AFTER PROOF PRESSURE TEST TO VERIFY THAT THE BELLOWS HAS NOT DEFORMED.

CRITICAL PROCESSES

THE WELDING PROCESS AND VERIFICATION THAT WELDS MEET SPECIFICATION REQUIREMENTS ARE VERIFIED BY INSPECTION. WELDING PER 2 EPS 5750023, SOLDERING PER NH85300.4 (3A) AND KRYTOX FILL PER 2 EPS 5750023 ARE VERIFIED BY INSPECTION.

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. THERMAL SWITCH ACTUATION IS VERIFIED AT PRE-ACCEPTANCE LEVEL (PRIOR TO ASSEMBLY INTO VALVE).

HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

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NUMBER: 03-3-2007-02

■ (D) FAILURE HISTORY:

THIS FAILURE HISTORY REFERS TO AND IS APPLICABLE TO BOTH THE OMS AND RCS. EIGHTEEN CASES OF VALVE FAIL TO FUNCTION DUE TO FAILED VALVE POSITION INDICATOR (VPI) SWITCHES (16 FLIGHT, 2 GROUND).

CAR 13F001 ADDRESSES LIMIT SWITCH FAILURES. THE CRITICAL TANK AND CROSSFEED/VALVE SWITCHES ARE BEING REPLACED WITH "PIND" TESTED SWITCHES DURING THE POST STS-51L STAND DOWN PERIOD. ACTUATORS WITH PIND-TESTED SWITCHES NOW IN PRODUCTION, PLAN CHANGEDOUT ON ATTRITION BASIS (EXCEPT VALVES CRITICAL FOR ABORT).

THIS FAILURE HISTORY REFERS TO AND IS APPLICABLE TO BOTH THE OMS AND RCS. A TOTAL OF 13 BELLOW FAILURES HAVE BEEN RECORDED TO DATE FOR OMS AND RCS.

- (1) 2 FAILURES WHICH HAVE NOT BEEN EVALUATED ARE RECORDED ON A03375.
- (2) 9 WERE DUE TO POROSITY (POROUS WELD AT END COLLAR, AND ARE RECORDED ON AC9013).
- (3) 4 WERE DUE TO COLLAPSED BELLOWS (DEFORMED BELLOWS CONVOLUTES) AND ARE RECORDED ON A00035 (INCLUDES 1 FAILURE FROM ITEM 2) ABOVE WHICH ALSO EXHIBITED POROSITY.

DEFORMATION OF THE BELLOWS HAS BEEN ATTRIBUTED TO INSUFFICIENT FILL OF THE BELLOWS WITH KRYTOX DURING ASSEMBLY. THE DEFORMATION OCCURS DURING SUBSEQUENT PROOF PRESSURE TESTING. THREE DELTA VERIFICATION TESTS WERE CONDUCTED ON VALVES WITH DEFORMED BELLOWS. ALL THREE VALVES DEVELOPED LEAKS (REF A01637) ACROSS THE BELLOWS DURING TEST. TWO VALVES COMPLETED 5 MISSIONS AND ONE VALVE COMPLETED 50 MISSIONS. THE LEAKAGE WAS LESS THAN 1×10^{-6} SCCS. HOWEVER THIS LEAK RATE CAN RESULT IN A NON-FUNCTIONING VALVE AFTER AN EXTENDED PROPELLANT EXPOSURE TIME IN THE ACTUATOR. THE ALLOWABLE LEAK RATE FOR THE BELLOWS HAS BEEN CHANGED TO 1×10^{-8} SCCS. IMPROVED PROCESSES AND PROCEDURES INCLUDING VERIFICATION OF PROPER FILL OF THE BELLOWS WITH KRYTOX HAVE BEEN IMPLEMENTED FOR FUTURE BUILDS. ALL INSTALLED VALVES WERE INSPECTED BY X-RAY FOR BELLOWS DEFORMATION. VALVES WITH UNACCEPTABLE BELLOWS WERE REPLACED. A SNIFF TEST OF ALL VALVE ACTUATORS IS ALSO REQUIRED FOR EACH FLIGHT.

■ (E) OPERATIONAL USE:

ATTEMPT TO OPEN VALVE BY USE OF MANUAL SWITCH. USE REDUNDANT VALVE TO PROVIDE FLOW PATH (VALVE IS NORMALLY OPEN). FOR TWO FAILURES, USE MIXED CROSSFEED DEORBIT BURN TO MINIMIZE Y CG OFFSET.

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- APPROVALS -

RELIABILITY ENGINEERING: J. N. HART
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NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

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