

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 03-3-4001-X

SUBSYSTEM NAME: ORBITAL MANEUVERING SYSTEM (OMS)

REVISION : 2 03/16/90

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU :	VALVE ASSEMBLY, BI-PROP, ENG AEROJET	1186700 SAME

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE ASSEMBLY, ENGINE, BI-PROPELLANT, PNEUMATIC ACTUATED (NORMALLY CLOSED). (INCLUDES CONTROL VALVE, PNEUMATIC ACTUATOR, RACK AND PINION GEAR ASSEMBLY, RELIEF VALVE.)

QUANTITY OF LIKE ITEMS: 2
ONE PER ENGINE

FUNCTION:
VALVE IS USED TO INITIATE ENGINE FIRING THRU GPC COMMAND TO ENGINE CONTROL PNEUMATIC VALVE. OX LEAD TO THE COMBUSTION CHAMBER IS PROVIDED. VALVE IS PNEUMATICALLY OPERATED THRU ACTUATOR, RACK AND PINION ASSEMBLY WITH ENGINE ARMING VALVE IN OPEN POSITION PRIOR TO FIRING AND ENGINE CONTROL VALVE OPENING UPON FIRING COMMAND TO PRESSURIZE ACTUATOR. SERIES VALVE ELEMENTS PROVIDE REDUNDANT SEALING. EACH VALVE ASSEMBLY CONSISTS OF AN ACTUATOR ASSEMBLY, UPSTREAM BALL, DOWNSTREAM BALL AND POSITION INDICATION. THE RACK AND PINION ASSEMBLY OPERATES A SET OF FUEL AND OXIDIZER VALVE ELEMENTS SIMULTANEOUSLY. THE ACTUATOR FORCE IS PROVIDED BY AN ACTUATOR SUPPLIED WITH NITROGEN FROM THE GN2 TANK.

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SUBSYSTEM: ORBITAL MANEUVERING SYSTEM (OMS) REVISION# 2 03/16/90
LRU :VALVE ASSEMBLY, BI-PROP, ENG CRITICALITY OF THIS
ITEM NAME: VALVE ASSEMBLY, BI-PROP, ENG FAILURE MODE:1R2

FAILURE MODE:
FAILS PARTIALLY OPEN/CLOSE, FAILS OUT OF TOLERANCE (TIMING).

MISSION PHASE:
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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

CAUSE:
CONTROL VALVE (CLOSING OR OPENING TIMING TRIM ORIFICE CONTAMINATED OR
PLUGGED, IMPROPER SIZE ORIFICE, VENT CHECK VALVE STUCK/RESTRICTED);
ACTUATOR (CONTAMINATION, CORROSION, IMPROPER MATERIAL OR DEFECT, WEAR
OR SCORED CYLINDER WALL, BROKEN RETURN SPRING, PISTON/SPRING SEIZED,
JAMMED OR COCKED, IMPROPER CLEARANCE, GALLING OF INTERFACE, BREAKING OF
GEAR TEETH); VIBRATION.

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

REDUNDANCY SCREEN A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)
B)
C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF REDUNDANCY (LOSS OF ONE ENGINE).

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(B) INTERFACING SUBSYSTEM(S):
LOSS OF REDUNDANCY.

(C) MISSION:
POSSIBLE EARLY MISSION TERMINATION. REDLINE ADDITIONAL PROPELLANT FOR RCS BACKUP DEORBIT. NEXT PLS DEORBIT IF SUFFICIENT PROPELLANT NOT AVAILABLE.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT - CRITICALITY 1 FOR ABORT - ONE ENGINE CANNOT DEplete PROPELLANT WITHIN TIME REQUIRED. REDUCED FLOWRATE DURING DUMP COULD CAUSE LANDING WEIGHT, C.G. PROBLEMS.

- (E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE. FAILURE OF OTHER ENGINE (AND INADEQUATE PROPELLANT FOR RCS DEORBIT) COULD RESULT IN INABILITY TO DEORBIT. UNABLE TO VERIFY VALVE TIMING WITH FLIGHT INSTRUMENTATION.

- DISPOSITION RATIONALE -

(A) DESIGN:
FACTOR OF SAFETY FOR BALL VALVE IS 1.5. FACTOR OF SAFETY FOR CONTROL VALVE IS 2.4. FACTOR OF SAFETY FOR ACTUATOR IS 2.4. EACH ENGINE PRESSURIZATION VALVE AND EACH CONTROL VALVE IN THE TWO ENGINE SUBSYSTEMS CONTAIN DUAL COILS UTILIZING SEPARATE POWER SOURCES WHICH PROVIDE ELECTRICAL REDUNDANCY FOR BI-PROP VALVE ACTUATION. A 100-MICRON PROPELLANT INLET FILTER IS UTILIZED TO LIMIT THE POTENTIAL FOR CONTAMINATION THAT COULD CAUSE JAMMING OF MOVING PARTS. AN 18 MICRON FILTER IS PROVIDED TO LIMIT THE POSSIBILITY OF CONTAMINANT CAUSING JAMMING OF MOVING PARTS OR PLUGGING OPENING ORIFICES OF THE CONTROL VALVE OR ACTUATOR. FRACTURE MECHANICS ANALYSIS BY THE SUPPLIER INDICATES INFINITE ACTUATOR LIFE. ANALYSIS INDICATES THAT ALL PARTS OF THE ACTUATION SYSTEM ARE CAPABLE OF WITHSTANDING MAX ANTICIPATED LOADS. REDUNDANT ENGINE SYSTEMS ARE PROVIDED EITHER OF WHICH IS ADEQUATE FOR DEORBIT. A FACTOR OF TWO FOR ACTUATOR FORCE IS PROVIDED FOR VALVE OPENING.

- (B) TEST:
QUALIFICATION TEST
THERMAL CYCLE (-23 TO +150 DEG F). LEAK AND FUNCTIONAL TESTS THROUGHOUT TEMPERATURE RANGE. BI-PROP VALVE ENDURANCE (200 DRY, 2200 WET CYCLES). ACTUATOR ENDURANCE TESTS (2400 PRESSURE CYCLES). BENCH HANDLING SHOCK TEST. POST TEST ACCEPTANCE. BURST OF BALL VALVE HOUSING (825 PSI DESIGN), BURST OF ACTUATOR AND CONTROL VALVE (1080 PSI DESIGN), VIBRATION AT ENGINE LEVEL. ALSO QUALIFIED AS PART OF ENGINE

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ASSEMBLY 138 TESTS DURING ENGINE QUAL, 498 TESTS AT POD LEVEL AT WSTF.

ACCEPTANCE TEST

EXAMINATION OF PRODUCT, WELD INSPECTION, PROOF PRESSURE, INTERNAL AND EXTERNAL LEAKAGE AND FUNCTIONAL TESTS. CONTROL VALVE ELECTRICAL CHECKS, PULL-IN AND DROP-OUT VOLTAGE (EACH COIL AND BOTH COILS), CLEANLINESS, RADIOGRAPHIC INSPECTION, FLUORESCENT INSPECTION.

GROUND TURNAROUND

- V43CA0.050 PERFORMS ENGINE PNEUMATIC ELECTRICAL VERIFICATION FOR FIRST FLIGHT AND CONTINGENCY.
- V43CA0.070 PERFORMS REDUNDANT CIRCUIT VERIFICATION (ORBITER/POD) FOR FIRST AND EVERY 5TH FLIGHT.
- V43CA0.075 PERFORMS ELECTRICAL INTERFACE VERIFICATION ORBITER/POD ON A CONTINGENCY BASIS.
- V43CA0.080 PERFORMS INSTRUMENTATION VERIFICATION EACH FLIGHT.
- V43CB0.170 PERFORMS BALL VALVE FUNCTIONAL TESTS BEFORE FIRST FLIGHT AND CONTINGENCY.
- V43CB0.185 PERFORMS GN2 CONTROL VALVE LEAK CHECK AT LOW PRESSURE EVERY FIFTH FLIGHT
- V43CB0.186 PERFORMS GN2 ACTUATOR PISTON LEAK CHECK AT LOW PRESSURE EVERY FIFTH FLIGHT.
- V43CB0.190 PERFORMS GN2 FILL/VENT VALVE LEAK CHECK FOR FIRST FLIGHT AND EVERY 5TH FLIGHT.
- V43CB0.191 PERFORMS GN2 ISOLATION VALVE LEAK CHECK FOR FIRST FLIGHT AND EVERY 5TH FLIGHT.
- V43CB0.192 PERFORMS GN2 REGULATOR LEAK/FUNCTIONAL TEST FOR FIRST FLIGHT AN EVERY 5TH FLIGHT.
- V43CB0.195 PERFORMS GN2 CONTROL VALVE HIGH PRESSURE LEAK CHECK FIRST FLIGHT AND CONTINGENCY.
- V43CB0.196 PERFORMS GN2 ACTUATOR PISTON LEAK CHECK FIRST FLIGHT AND CONTINGENCY.
- V43CB0.280 PERFORMS PNEUMATIC SYSTEM PRESSURE DECAY TEST EACH FLIGHT.
- V43CE0.050 PERFORMS BI-PROP VALVE DRAIN AND PURGE EVERY FLIGHT.
- V43CE0.100 PERFORMS CONTROL VALVE/GN2 ISO VALVE COIL POWER REDUNDANCY VERIFICATION EACH FLIGHT.

BALL VALVE PERFORMANCE (CYCLE TIME AND % OPEN) MONITORED IN FLIGHT (TO EXTENT ALLOWED BY SAMPLE RATE).

GN2 PRESSURE MONITORED IN FLIGHT FOR INDICATION OF LEAKAGE.

(C) INSPECTION:

RECEIVING INSPECTION

MATERIALS AND PROCESSES CERTIFICATION ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

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CLEANLINESS TO LEVEL 200 FOR MMH AND 200 A FOR NTO 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. VISUAL AND DIMENSIONAL INSPECTION OF BODY AND BALL IS PERFORMED DURING FABRICATION. THE SURFACE FINISH OF THE BALL IS VERIFIED BY INSPECTION. VISUAL, DIMENSIONAL AND LUBRICANT INSPECTION OF RACK IS VERIFIED BY INSPECTION. VISUAL, DIMENSIONAL, PITCH RUN-OUT AND SURFACE FINISH INSPECTION OF PINION IS VERIFIED BY INSPECTION. VISUAL, DIMENSIONAL AND SOLDERING AT 10X MAGNIFICATION FOR LINEAR POSITIONING TRANSDUCER IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

THE WELDING PROCESS AND VERIFICATION THAT WELDS MEET SPECIFICATION REQUIREMENTS ARE VERIFIED BY INSPECTION. SOLDER JOINTS AND PROCESSES ARE VERIFIED BY INSPECTION

NONDESTRUCTIVE EVALUATION

PENETRANT AND RADIOGRAPHIC INSPECTION OF WELDS ARE VERIFIED BY INSPECTION. PENETRANT INSPECTION OF BALL AND CONTROL VALVE BODY AFTER ETCHING AND PRIOR TO FINISH IS VERIFIED BY INSPECTION. MAGNETIC PARTICLE AND PENETRANT INSPECTION OF RACK IS VERIFIED BY INSPECTION. PENETRANT INSPECTION OF PINION IS VERIFIED BY INSPECTION.

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. INSULATION RESISTANCE OF LINEAR POSITIONING TRANSDUCER IS VERIFIED BY INSPECTION. MICRO-ETCH OF ROUGH CUT BODY FOR CRYSTAL STRUCTURE IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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

(D) FAILURE HISTORY:

NONE

(E) OPERATIONAL USE:

ISOLATE FAILED ENGINE. COMPLETE MISSION REQUIREMENTS USING CROSSFEED FOR PROPELLANT UTILIZATION. REDLINE ADDITIONAL PROPELLANT FOR RCS BACKUP DEORBIT. POSSIBLE MISSION IMPACT (DECREASED PROPELLANT AVAILABLE FROM OMS TO RCS THROUGH INTERCONNECT FOR ON-ORBIT OPERATIONS). NEXT PLS DEORBIT IF PROPELLANT FOR RCS BACKUP NOT AVAILABLE.

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- APPROVALS -

RELIABILITY ENGINEERING: J. N. HART
DESIGN ENGINEERING : D. W. CARLSON
QUALITY ENGINEERING : O. J. BUTTNER
NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

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: D. W. Carlson
: O. J. Buttner 4/12/90
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