

## 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  
ITEM NAME: VALVE ASSEMBLY, BI-PROP, ENG CRITICALITY OF THIS FAILURE MODE:1R2

FAILURE MODE:  
EXTERNAL LEAKAGE (BI-PROP VALVE, PRESSURE RELIEF VALVE)

MISSION PHASE:  
PL PRELAUNCH  
LO LIFT-OFF  
OO ON-ORBIT  
DO DE-ORBIT  
LS LANDING SAFING

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

CAUSE:  
RELIEF VALVE BETWEEN SERIES ELEMENTS FAILS CLOSED OR OPEN, RELIEF VALVE  
POPPET BINDS IN GUIDE OR DOES NOT SEAT AS REQUIRED, STRESS CORROSION,  
CONTAMINATION/PROPELLANT RESIDUE, VIBRATION, SHOCK, SPRING BREAKS OR  
COCKS, SEAT CRACKS. BALL SEAL COLD FLOW.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS  
B) FAIL  
C) PASS

PASS/FAIL RATIONALE:

- A)
- B)
- C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:  
LOSS OF REDUNDANCY (LEAK OF ONE OF SERIES VALVE ELEMENTS).

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(B) INTERFACING SUBSYSTEM(S):  
NO EFFECT

(C) MISSION:  
NO EFFECT.

(D) CREW, VEHICLE, AND ELEMENT(S):  
NO EFFECT.

(E) FUNCTIONAL CRITICALITY EFFECTS:  
POSSIBLE LOSS OF CREW/VEHICLE. LEAKING PROPELLANT MAY FREEZE DOWNSTREAM OF VALVE AND/OR IN REGENERATIVE COOLING CHANNELS. FROZEN PROPELLANT RESIDUE MAY CAUSE HARD START OR COMBUSTION CHAMBER DAMAGE. NO INSTRUMENTATION AVAILABLE FOR DETECTION OF INITIAL FAILURE.

- DISPOSITION RATIONALE -

(A) DESIGN:  
FACTOR OF SAFETY FOR BALL VALVE IS 1.5. PROPELLANT COMPATIBLE MATERIALS ARE USED. ONE SERIES BI-PROP ELEMENT IS DOWNSTREAM OF RELIEF VALVE AND PROVIDES REDUNDANCY FOR LEAKAGE MODE. A 100 MICRON PROPELLANT INLET FILTER AND 18 MICRON FILTER AT THE RELIEF VALVE INLET LIMIT POTENTIAL FOR CONTAMINATION. CRES 304 RELIEF VALVE BODY/ELECTROLYZED CHROME POPPET MINIMIZES GALLING POTENTIAL. BI-PROP VALVE "LIFT-OFF" BALL SEAL DESIGN MINIMIZES SEAL WEAR.

(B) TEST:  
QUALIFICATION TESTS  
2000 WET CYCLES AND 220 DRY CYCLES AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM WAS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. BURST TESTS SHOWED THAT FAILURE OCCURRED TO THE UPSTREAM FUEL BALL AT 3925 PSI RATHER THAN STRUCTURAL FAILURE OF THE HOUSING. THE OXIDIZER VALVE UPSTREAM STATIC SEAL FAILED AT 4000 PSI. QUAL TESTS INCLUDED 100 PRESSURE RELIEF CYCLES AND WERE CONDUCTED ON 4 UNITS. ALSO USED DURING ENGINE AND POD QUAL TESTS.

ACCEPTANCE TESTS  
VISUAL INSPECTION, CRACK AND RESEAT, FLOW CALIBRATION, CLEANLINESS VERIFICATION, PROOF PRESSURE, LEAKAGE, OPERATION AND FLOW TESTS ARE PERFORMED DURING ATP. LEAKAGE AND OPERATION TESTS ARE ALSO CONDUCTED AS PART OF PRE/POST FLIGHT CHECKOUT.

GROUND TURNAROUND  
V43C80.180 PERFORMS BALL VALVE LEAK CHECK FOR FIRST FLIGHT AND EVERY

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5TH FLIGHT.

V43CBO.182 PERFORMS BALL VALVE CAVITY RELIEF VALVE FUNCTIONAL TEST FOR FIRST FLIGHT AND EVERY 5TH FLIGHT.

V43CBO.240 TOXIC VAPOR LEAK CHECK OF PROP FEED SYSTEM FIRST FLIGHT AND CONTINGENCY ONLY.

V43CEO.010 PERFORMS TRICKLE PURGE/THROAT PLUG TEST EACH FLIGHT.

V43CEO.020 PERFORMS ENGINE POST FLIGHT INSPECTION EACH FLIGHT.

V43CEO.050 PERFORMS BI-PROP VALVE DRAIN AND PURGE EACH FLIGHT.

V43CEO.090 PERFORMS PROPELLANT SAMPLE FOR SECOND FLIGHT AND CONTINGENCY.

V43CEO.120 PERFORMS STATIC AIR SAMPLE OF POD THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER.

## (C) INSPECTION:

RECEIVING INSPECTION

MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PLAN APPROVED BY QUALITY ENGINEERING.

CLEANLINESS TO LEVEL 200 FOR MMH AND 200A FOR NTO AND CORROSION

PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, ASSEMBLY AND INSTALLATION OPERATIONS ARE MANDATORY INSPECTION POINTS AND ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. INSPECTION FOR PROPER ELECTRICAL TERMINATIONS IS VERIFIED BY INSPECTION. PARTS PROTECTION IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

PENETRANT AND RADIOGRAPHIC INSPECTION OF WELDS ARE VERIFIED BY INSPECTION. INSPECTION FOR SURFACE AND SUBSURFACE DEFECTS IS 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.

CRITICAL PROCESSES

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

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. SPECIAL MEASUREMENT STANDARDS, EQUIPMENT AND MATERIAL CONFORMANCE TO CONTRACT REQUIREMENTS IS VERIFIED BY INSPECTION.

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HANDLING/PACKAGING

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

(D) FAILURE HISTORY:

MINOR LEAKAGE PROBLEMS HAVE BEEN OBSERVED DURING SUPPLIER ACCEPTANCE TEST DUE TO ASSEMBLY DAMAGE OR CONTAMINATION; AND FOLLOWING FLIGHT USAGE DUE TO CONTAMINATION OR PROPELLANT RESIDUE.

CAR AB0906, AB0908, AB4031. THESE FAILURES RECORD SHAFT SEAL LEAKAGE DURING SUPPLIER TEST DUE TO TEFLON PARTICLES FROM EXCESS DRY FILM LUBE. TRAINING IN PROPER ASSEMBLY AND LUBRICANT APPLICATION WAS PROVIDED FOR THE TECHNICIANS.

CAR AB4001, AB7589. THESE FAILURES RECORD INSTANCES OF SHAFT SEAL LEAK DURING SUPPLIER TEST DUE TO TEFLON PARTICLES FROM THE DRY FILM LUBE. DESIGN AND PROCESS CHANGES INCLUDED PINION SHAFT FINISH, RUN-IN PRIOR TO ASSEMBLY, SEAL AND SEAL SPRING INSPECTIONS.

CAR AB1640 RECORDS BALL SEAL LEAKAGE DURING ATP DUE TO A FLAT SPOT ON THE SEAL. ADDITIONAL INSPECTION AND INCREASE IN ALLOWABLE LEAK RATE WERE INCORPORATED.

CAR AC3032 RECORDS BALL SEAL LEAKAGE DURING SUPPLIER TEST DUE TO INCORRECT INSTALLATION OF THE SEAL CARTRIDGE. INSPECTION SUPERVISION SIGN-OFF WAS ADDED FOR ASSEMBLY.

CAR AB6471 RECORDS BALL SEAL LEAKAGE DURING SUPPLIER QUALIFICATION TEST DUE TO A SCRATCHED BALL AND SEAL ATTRIBUTED TO ASSEMBLY DAMAGE AND/OR CONTAMINATION. CORRECTIVE ACTION INCLUDED FORMATION OF A CONTAMINATION CONTROL TEAM, ADDITIONAL TEST FACILITY FILTERS, VERIFICATION OF FILTER AND PROPELLANT LINE, PROPELLANT SAMPLE CHECK SHEET, AND THE USE OF PROTECTIVE CLOSURES DURING ASSEMBLY.

CAR A00747 RECORDS BALL SEAL LEAKAGE ATTRIBUTED TO CONTAMINATION AND PROPELLANT RESIDUE FOLLOWING FLIGHT USAGE. THE ENGINE HAD BEEN IN STORAGE AND TRANSIT FOR AN EXTENDED TIME PERIOD. THE RESIDUE FORMATION IS A RESULT OF ATMOSPHERIC REACTION WITH RESIDUAL PROPELLANT. THE RESIDUE IS SOLUBLE IN PROPELLANT AND IS NOT EXPECTED TO HAVE ANY SIGNIFICANT EFFECT ON THE BALL VALVE. THIS FAILURE INVESTIGATION IS ON-GOING. POST FLIGHT PURGES WILL LIMIT RECURRENCE OF THIS TYPE OF CONDITION.

(E) OPERATIONAL USE:

NO ACTION FOR FIRST FAILURE (NOT DETECTABLE). FOR FAILURE OF RELIEF VALVE AND DOWNSTREAM BALL SEAL ELEMENT. THE AFFECTED ENGINE WILL NOT BE

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

- APPROVALS -

RELIABILITY ENGINEERING: J. N. HART  
DESIGN ENGINEERING : V. F. ROZNOS  
QUALITY ENGINEERING : W. J. SMITH  
NASA RELIABILITY :  
NASA SUBSYSTEM MANAGER :  
NASA QUALITY ASSURANCE :

: JNH  
: VFR  
: WJS  
: 4/2/90  
: 8-25-90