

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-2F-121310 -X

SUBSYSTEM NAME: FORWARD REACTION CONTROL SYSTEM (RCS)

REVISION: 2

12/12/89

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: THRUSTER, PRIMARY	MC467-0028
SRU	: VALVE, INLET	234175
SRU	: VALVE, INLET	234180

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

INLET VALVE, ENGINE PILOT OPERATED, SOLENOID DRIVEN (28 VOLTS DC) FLUID ACTIVATED.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 28

14 FUEL AND 14 OX

FUNCTION:

VALVES ARE USED TO INITIATE THRUSTER FIRING BY OPENING UPON GN&C COMMAND. AN OX AND FUEL VALVE ARE PROVIDED FOR EACH THRUSTER.

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LRU : THRUSTER, PRIMARY
ITEM NAME: VALVE, INLET CRITICALITY OF THIS FAILURE MODE: 1R3

FAILURE MODE:
FAILS OPEN, FAILS TO CLOSE, LEAKAGE

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

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

CAUSE:
CONTAMINATION, PIECE PART FAILURE, VIBRATION, MATERIAL DEFECT,
ELECTRICAL FAILURE, CORROSION, SEAL WEAR, SEAL DAMAGE DUE TO ZOTS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF PROPELLANTS. EVENTUAL LOSS OF UP TO FOUR THRUSTERS DUE TO
MANIFOLD ISOLATION.

(B) INTERFACING SUBSYSTEM(S):
INCREASED GN&C SWITCHING AND USAGE OF ALTERNATE THRUSTERS.

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(C) MISSION:
NO EFFECT

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE INABILITY TO PERFORM ET SEP DUE TO INSUFFICIENT THRUST CAPABILITY IN THE REQUIRED AXIS. LOSS OF ALL PROPELLANT MAY RESULT IF ISOLATION CANNOT BE ACCOMPLISHED WITH UPSTREAM TANK OR MANIFOLD ISOLATION VALVES. THRUSTERS CANNOT BE FIRED WHILE ON THE VEHICLE DURING GROUND CHECKOUT.

- DISPOSITION RATIONALE -

(A) DESIGN:
ALL MATERIALS COMPATIBLE WITH PROPELLANTS, DESIGNED TO OPERATE AT 175-350 PSIA, THE VALVE HAS IMPROVED SEALS; CONTAINS A 75 MICRON FILTER AT THE INLET, THE VALVE OPENS WITH AS LITTLE AS 18V DC AND IS PILOT OPERATED, HAS CYCLE LIFE OF 80000 CYCLES.

- (B) TEST:
THE QUALIFICATION TEST PROGRAM INCLUDED ROUGH HANDLING, VIBRATION (34 MIN/AXIS), FORWARD AND REVERSE INTERNAL LEAKAGE, EXTERNAL LEAKAGE, ABNORMAL OPERATION, BUBBLE INGESTION, ELECTROMAGNETIC INTERFERENCE, IGNITION OVERPRESSURE, BURST PRESSURE, SAFETY MARGIN, LIGHTNING, HEATER OUT IGNITION, ZOTS, MISSION DUTY CYCLES, ACCELERATED LIFE DUTY CYCLE, AND PROPELLANT COMPATIBILITY.

THE UNITS ALSO QUALIFIED AS PART OF THE HOT FIRE TEST PROGRAM AT WSTF (24 EQUIVALENT MISSION DUTY CYCLES AND APPROX 7 YEARS OF PROPELLANT EXPOSURE).

ACCEPTANCE TESTING INCLUDES PROOF PRESSURE (INLET VALVE - 1500 PSIG), INTERNAL LEAKAGE, THRUSTER PERFORMANCE, INSULATION RESISTANCE, PULL-IN VOLTAGE, CONTINUITY/RESISTANCE, EXTERNAL LEAKAGE, FLOW CALIBRATION, CLEANLINESS, RESPONSE OF THE VALVES AND DIELECTRIC STRENGTH.

OMRSD PERFORMS THE FOLLOWING: THRUSTER VALVE ELECTRO/MECHANICAL VERIFICATION THE FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS. THRUSTER VALVE LEAKAGE TESTS THE FIRST FLIGHT AND ON A CONTINGENCY BASIS. ~~TOXIC VAPOR LEAK CHECK OF PROPELLANT MANIFOLDS FIRST FLIGHT AND ON A CONTINGENCY BASIS. A STATIC AIR SAMPLE THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER AND ON CONTINGENCY.~~ PREPARATION FOR SHIPMENT OF THRUSTERS THE FIRST FLIGHT AND ON A CONTINGENCY BASIS. FERRY FLIGHT

SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 03-2F-121310-02.

PREPARATION ON A CONTINGENCY BASIS. - INSTALLATION OF PROTECTIVE COVERS THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER BASIS. THRUSTER INSPECTION THE SECOND FLIGHT AND THEREAFTER WITH FLASHLIGHT AND MIRROR. THRUSTER INSPECTION ON A FIFTH INTERVAL USING A BORESCOPE. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS. THE VALVE CANNOT BE CYCLED ON THE GROUND EXCEPT WHEN THE MANIFOLDS ARE DRY.

(C) INSPECTION:

RECEIVING INSPECTION

INSPECTION VERIFIES MATERIAL AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL

CLEANLINESS PER MPS 210 IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

FINAL INSPECTION OF ALL DIMENSIONS IS VERIFIED. INSPECTION VERIFIES THREADS ARE LUBRICATED WITH KRYTOX 143AC PER MPS 1103, APPENDIX 1. THE 235595 SEAT ASSEMBLY IS VISUALLY INSPECTED PER STD V234159.

NONDESTRUCTIVE EVALUATION

INSPECTION VERIFIES VALVE CLOSURE WELDS (VALVE/CAP WELD AND VALVE/SEAT WELD) ARE ULTRASONIC INSPECTED PER MPS-907, LEVEL AA, AFTER WELD AND AFTER MTS-1291 PARAGRAPH 4.4 (1500 PSIG PROOF). OTHER STRUCTURAL CLASS A WELDS ARE, UNLESS OTHERWISE CALLED OUT, RADIOGRAPHIC INSPECTED AND EITHER PENETRANT OR MAGNETIC PARTICLE INSPECTED.

CRITICAL PROCESSES

INSPECTION VERIFIES WELDING IS PER SPECIFICATION REQUIREMENTS, INCLUDING VALVE CLOSURE WELDS, PER MPS 1609, APPENDIX VI AND TACK WELDS PER MPS 1601, CLASS B, AND VISUALLY INSPECTS WELDS.

TESTING

VALVE ACCEPTANCE TESTING PER MTS1270 PART II PRIOR TO WELDING AND PER MTS1291 AFTER WELDING IS VERIFIED BY INSPECTION. VALVE IS LEAK TESTED PER THE REQUIREMENTS OF MPS 120 AND IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING PROCEDURES ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THERE HAVE BEEN APPROXIMATELY 170 OXIDIZER LEAKAGES REPORTED AND 89 FUEL LEAKAGES REPORTED. 24 OF THE OX LEAKS OCCURRED DURING ORBITER TURNAROUND, 3 DURING FLIGHT, 69 DURING QUAL AND 74 DURING ATP. 5 OF THESE FUEL LEAKS OCCURRED DURING TURNAROUND, 1 DURING FLIGHT, 31 DURING QUAL AND 51 DURING ATP. THE MAJORITY OF THESE FAILURES ARE SIMILAR TO BUT NOT WORSE THAN THOSE HIGHLIGHTED BELOW.

CAR ADD044;

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THRUSTER R2D ON OV102 EXHIBITED OXIDIZER VALVE LEAKAGE AFTER THE AA MOD. THE VALVE HAD BEEN INACTIVE FOR 18 MONTHS AND THE LEAKAGE COULD HAVE BEEN CAUSED BY REVERSE LEAKAGE DURING MANIFOLD EVACUATION OR FAILING TO MAINTAIN A PROPER PURGE, EITHER OF WHICH WOULD ALLOW AIR (MOISTURE) TO ENTER THE VALVE. THIS RESULTS IN IRON NITRATES AND LEAKAGE.

CORRECTIVE ACTION - IF PROPELLANT VALVES REMAIN WETTED WITH PROPELLANT, LEAKAGE DUE TO IRON NITRATES IS MINIMIZED. IN A NORMAL TURNAROUND THE SYSTEM REMAINS WET AND IF DRIED IT IS ONLY FOR A SHORT PERIOD OF TIME.

CAR'S 04F004, 06F009, 09F006 AND 23F003:

FOUR FLIGHT LEAKAGES WERE REPORTED. THEY WERE ANALYZED AND FOUND TO BE CAUSED BY PARTICLE CONTAMINATION.

CORRECTIVE ACTION - ACCEPTABLE FAILURE RATE FOR NUMBER OF THRUSTERS FLOWN (38 X NUMBER OF FLIGHTS). THESE LEAKAGES WERE MINOR AND NOT JEOPARDIZING TO THE MISSION.

CORRECTIVE ACTION WAS TO IMPROVE SPRING DE-SCALING PROCESS.

CAR'S AB9974, AC0367, AC1967, AC1970 AND ADD044:

THE ABOVE CAR'S REPORTED GROUND TURNAROUND LEAKAGES (BOTH LOW TEMPERATURE AND AMBIENT). CAUSES OF LEAKAGE WERE METALLIC NITRATES, LACK OF SEAL PROUD HEIGHT AND PARTICULATE CONTAMINATION. CORRECTIVE ACTION INCLUDED INCREASED SEAL PROUD (EDCP-0127), INCREASING THE HEATER SET POINTS TO TURN THE HEATER ON BETWEEN 66 AND 76 F (WAS 4 TO 55 F) FOR LOW TEMP LEAKAGES (MCR 5832), AND CONTINUE TO IMPROVE CLEANLINESS CONTROLS. IN ADDITION THE OMRSD AND PROPELLANT SPECS CONTROL IRON IN OXIDIZER (1 PPM PER SE-S-0073).

CAR A36237:

THERE HAVE BEEN TWO ZOTS INCIDENTS REPORTED BY THE SUPPLIER DURING QUAL TEST. CORRECTIVE ACTION FOR ZOTS IS TO MAINTAIN PROPELLANT TEMPERATURE ABOVE 70 DEGREES F. A FLIGHT-RULE LIMITS PROPELLANT BULK TEMPERATURE FOR ENTRY TO MINIMIZE ZOTS.

(E) OPERATIONAL USE:

CLOSE UPSTREAM MANIFOLD ISOLATION VALVE IF LEAK RATE DOES NOT SUPPORT ET SEPARATION. THE TANK ISOLATION VALVE IS A BACKUP TO THE MANIFOLD ISOLATION VALVE.

IF ALL REDUNDANCY IS LOST IN THE FRCS, PERFORM CONTINGENCY AFT ONLY ET SEPARATION.

IF ONLY ONE THRUSTER IS LOST, A NOMINAL ET SEPARATION CAN BE PERFORMED WITH REMAINING THRUSTERS.

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- APPROVALS -

RELIABILITY ENGINEERING:	F.E. BARCENAS	:	<i>[Signature]</i>
DESIGN ENGINEERING :	B. DIPONTI	:	<i>[Signature]</i>
QUALITY ENGINEERING :-	M. SAVALA	:	<i>[Signature]</i>
NASA RELIABILITY :		:	<i>[Signature]</i>
NASA SUBSYSTEM MANAGER :		:	<i>[Signature]</i>
NASA QUALITY ASSURANCE :		:	<i>[Signature]</i>