PRINT DATE: 06/07/99

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: 03-2F-131310 -X

SUBSYSTEM NAME: FORWARD REACTION CONTROL SYSTEM (RCS)
REVISION: 2 07/15/98

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
LRU	: THRUSTER, VERNIER	MC467-0029 235002, 235003

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VERNIER THRUSTER ASSEMBLY - 25 POUND THRUST LEVEL (F5L,F5R).

REFERENCE DESIGNATORS: F5L
F5R

QUANTITY OF LIKE ITEMS: 2
ONE PER SIDE (SIDE FIRING)

FUNCTION:
LEFT AND RIGHT YAW (+/- Y AXIS) THRUSTERS ARE PROVIDED IN THE FWD MODULE TO PROVIDE PRECISE LOW LEVEL PULSING FOR ATTITUDE HOLD. THRUSTERS ALSO PROVIDE SOME PITCH (Z AXIS-DOWN FIRING) CAPABILITY. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESSURE/TEMPERATURE TRANSDUCER.

PRELIMINARY

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: 03-2F-131310- 01

REVISION#: 1 07/15/98

SUBSYSTEM NAME: FORWARD REACTION CONTROL SYSTEM (RCS)
LRU: THRUSTER, VERNIER **CRITICALITY OF THIS**
ITEM NAME: THRUSTER, VERNIER **FAILURE MODE:** 2/2

FAILURE MODE:
LOSS OF OUTPUT, INLET VALVES/BLOCKED INJECTOR/STAND-OFF'S

MISSION PHASE: OO ON-ORBIT

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

CAUSE:
CONTAMINATION, PIECE PART STRUCTURAL FAILURE, IMPROPER SOLENOID ACTUATION, VIBRATION, HEATER FAILURE OR PRESSURE OR TEMP TRANSDUCER FAILURE, CORROSION, SHOCK, ELECTRICAL FAILURE AND GAS INGESTION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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LOSS OF FUNCTION (VERNIER THRUSTERS)-LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL.

(B) INTERFACING SUBSYSTEM(S):
NO EFFECT

(C) MISSION:
MISSION MODIFICATION MAY BE REQUIRED. MISSION MODIFICATION MAY BE REQUIRED. LOSS OF VERNIER THRUSTER DURING ISS REBOOST IS A CONCERN AND NEEDS TO BE ADDRESSED.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
NO EFFECT.

-DISPOSITION RATIONALE-

(A) DESIGN:
25 MICRON FILTRATION & HEATERS PROVIDED TO LIMIT CONTAM & PREVENT FREEZING.

(B) TEST:
THE QUALIFICATION TEST PROGRAM INCLUDED ROUGH HANDLING, VIBRATION (34 MIN/AXIS), FORWARD AND REVERSE INTERNAL LEAKAGE, EXTERNAL LEAKAGE, ABNORMAL OPERATION, ACCELERATED LIFE DUTY CYCLE, PROPELLANT COMPATIBILITY, BURST, HEATER OUT IGNITION, NOZZLE THERMAL TRANSIENT, MISSION DUTY CYCLE.

THE VERNIER THRUSTER INTERNATIONAL SPACE STATION (ISS) REBOOST TESTING WAS COMPLETED SUCCESSFULLY WITHOUT ANY DAMAGE TO THE THRUSTER. A TOTAL OF SEVEN REBOOST PROFILES WERE PERFORMED SUCCESSFULLY WITHOUT ANY SUBSTANTIAL CHAMBER DEGRADATION OR STANDOFF EROSION. THE THRUSTER DID NOT EXHIBIT ANY SIGNIFICANT PERFORMANCE CHANGES RESULTING FROM THE REBOOST TESTING. SHORT ON TIMES COUPLED WITH SHORT OFF TIMES RESULTED IN THE HIGHEST HEATING TO THE THRUSTER COMPONENTS. THE REBOOST TESTING DEMONSTRATED THE CAPABILITY OF THE VERNIER THRUSTER TO SUCCESSFULLY

PERFORM A ONE HOUR REBOOST FIRING PROFILE WITHOUT ANY COMPROMISE TO THE HARDWARE UNDER WORSE CASE CONDITIONS.

ACCEPTANCE TESTING INCLUDES PROOF PRESSURE OF THE NOZZLE (150 PSIG), EXTERNAL LEAKAGE, CLEANLINESS, THRUSTER PERFORMANCE. QUAL TEST UTILIZED THREE UNITS.

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH THE OMRSD. THE OMRSD DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE IF THERE IS ANY DISCREPANCY BETWEEN THE GROUND TESTING DATA PROVIDED BELOW AND THE OMRSD, THE OMRSD IS THE MORE ACCURATE SOURCE OF THE DATA.

OMRSD PERFORMS THE FOLLOWING: INSTRUMENTATION ELECTRICAL VERIFICATION FOR THE MOD/POD THE FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER. THRUSTER VALVE ELECTRO/MECHANICAL FUNCTIONAL TESTING THE FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER. A REDUNDANT CIRCUIT VERIFICATION TEST THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER. INTERFACE VERIFICATION BETWEEN THE ORBITER AND MOD/POD ON A CONTINGENCY BASIS. THRUSTER INSPECTION THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER. THRUSTER INSPECTION AFTER USING PRESSURE PLUGS. THRUSTER VALVE TRICKLE CURRENT TESTS EVERY MISSION. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER.

(C) INSPECTION:
RECEIVING INSPECTION
INSPECTION VERIFIES RAW MATERIAL AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL
CLEANLINESS TO LEVEL 200 FOR MMH AND 200A FOR NTO IS VERIFIED BY INSPECTION. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
FINAL INSPECTION OF ALL DIMENSIONS IS VERIFIED. INJECTOR COOLANT HOLES ARE OPEN AFTER EXCESS WELD BEAD REMOVAL IS VERIFIED BY INSPECTION. SURFACE FINISH IS VERIFIED BY INSPECTION. THRUSTER VALVES ARE VISUALLY AND DIMENSIONALLY INSPECTED DURING FABRICATION. MANUFACTURING, ASSEMBLY, AND INSTALLATION PROCEDURES ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
FUSED DISILICIDE COATING THICKNESS IS VERIFIED BY EDDY CURRENT INLET VALVE CLOSURE WELDS ARE ULTRASONIC INSPECTED. OTHER STRUCTURAL WELDS, UNLESS OTHERWISE CALLED OUT, ARE RADIOGRAPHIC INSPECTED AND ARE EITHER PENETRANT OR MAGNETIC PARTICLE INSPECTED.

CRITICAL PROCESSES
WELDING, SOLDERING AND APPLICATION OF DISILICIDE COATING IS VERIFIED BY INSPECTION. TEST SPECIMENS OF THE COATING ARE INSPECTED AND TESTED PER MPS-0545 REQUIREMENTS. THE COATED ASSEMBLIES ARE ALSO HEATED TO 2500 DEG F TO VERIFY COATING INTEGRITY. THE SURFACE IS THEN INSPECTED WITH A

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BORESCOPE AND A VIDEO TAPE RECORD IS MADE OF THE COATING CONDITION. WELDS (INCLUDING RESISTANCE WELDS PER MPS 1600, TACK WELDS AND STRUCTURAL WELDS) ARE VISUALLY INSPECTED TO SPECIFICATION REQUIREMENTS.

TESTING
ATP IS WITNESSED AND VERIFIED BY INSPECTION. WATER FLOW TESTS, PER INTERNAL TEST PROCEDURE, VERIFIES BY INSPECTION NO OCCLUDED PASSAGES. TEST FIRING WITH HEAT SENSORS VERIFY BY INSPECTION THAT THERE ARE NO HOT SPOTS. ELECTRICAL COMPONENTS ARE TESTED FOR INSULATION RESISTANCE AND DIELECTRIC STRENGTH AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING AND STORAGE ENVIRONMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE. THE FAILURE HISTORY DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE

NO LOSS OF OUTPUT FAILURE HISTORY. THERE WERE FAILURES THAT HAVE RESULTED IN THRUSTER DESELECTION.

TWO THRUSTERS EXHIBITED ERRONEOUS LEAK DETECTOR OUTPUTS ON OV102. CAUSE WAS THERMAL CONTACT RESISTANCE BETWEEN SENSOR AND INJECTOR. CORRECTIVE ACTION WAS TO ADD THERMAL GREASE. REF CAR 03F043.

(E) OPERATIONAL USE:
IN THE EVENT OF THE LOSS OF VERNIER THRUSTER CAPABILITY, THE PRIMARY THRUSTERS CAN BE USED FOR THE VERNIER FUNCTION. SOME MISSION OBJECTIVES MAY NOT BE MET DUE TO INCREASED RATE OF PROPELLANT CONSUMPTION ON PRIMARY THRUSTERS

- APPROVALS -

PAE MANAGER	:D.F.MIKULA	D.F. Mikula 22 JUL 98
PRODUCT ASSURANCE ENGR	:L.X.DANG	
DESIGN ENGINEERING	: L. TOAPANTA	7/15/98
BOEING SUBSYSTEM MANAGER	: D. PERRY	7/20/98
NASA MOD	: B. LUNNEY	8/18/98