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.

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: 03-2F-131310- 02

REVISION#: 2 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:
VALVE FAILS OPEN, VALVE FAILS TO CLOSE, VALVE LEAKAGE

MISSION PHASE: OO ON-ORBIT

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

CAUSE:
CONTAMINATION, PIECE PART STRUCTURAL FAILURE, VIBRATION, MATERIAL DEFECT, ELECTRICAL FAILURE, CORROSION, SEAL WEAR, IMPROPER SOLENOID ACTUATION

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:
LOSS OF SOME PROPELLANTS. LOSS OF FUNCTION (VERNIER THRUSTERS) - LOSS OF SINGLE DOWN FIRING VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL.

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: 03-2F-131310- 02

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

(C) MISSION:
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 CONTAMINATION AND TO 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

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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: THRUSTER VALVE MECHANICAL FUNCTIONAL TESTING THE FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS THRUSTER INSPECTION THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER USING A FLASHLIGHT AND MIRROR. THRUSTER INSPECTION EVERY FLIGHT INTERVAL USING A BORESCOPE. 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 PREPARATION ON A CONTINGENCY BASIS. INSTALLATION OF PROTECTIVE COVERS THE SECOND FLIGHT AND EVERY FLIGHT THEREAFTER. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS.

(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 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

MOST VALVE LEAKAGE FAILURES WERE DUE TO CONTAMINATION. CORRECTIVE ACTION WAS TO CONTINUE IMPROVING CLEANLINESS CONTROLS. ONE FAILURE WAS DUE TO CONTAMINATION BUILD-UP.

(E) OPERATIONAL USE:
CLOSE UPSTREAM MANIFOLD ISOLATION VALVE. THE TANK ISOLATION VALVE IS A BACKUP TO THE MANIFOLD ISOLATION VALVE.

IN THE EVENT OF THE LOSS OF VERNIER THRUSTER CAPABILITY, THE PRIMARY THRUSTERS CAN BE USED FOR MOST VERNIER FUNCTIONS. 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