FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-2A-231310 -X

SUBSYSTEM NAME: AFT REACTION CONTROL SYSTEM (RCS)
REVISION: 3 07/15/98

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
SRU	: THRUSTER, VERNIER	MC467-0029

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 4
TWO PER POD
(1 DOWN FIRING)
(1 SIDE FIRING)

FUNCTION:
ONE PITCH (Z AXIS-DOWN FIRING) AND ONE YAW (+/- Y AXIS) VERNIER THRUSTER ARE PROVIDED IN EACH ARCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING AND ATTITUDE HOLD. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP TRANSDUCER.

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LRU:
ITEM NAME: THRUSTER, VERNIER
CRITICALITY OF THIS 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, 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:
LOSS OF FUNCTION (VERNIER THRUSTERS)-LOSS OF SINGLE DOWN FIRING VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL.

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(B) INTERFACING SUBSYSTEM(S):
NO EFFECT

(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:
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

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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. PROPELLANT SAMPLING THE SECOND FLIGHT AND ON A CONTINGENCY BASIS. REDUNDANT CIRCUIT VERIFICATION ORB/POD AND ORB/MOD EVERY FLIGHT. INTERFACE VERIFICATION ORB/POD AND ORB/MOD ON A CONTINGENCY BASIS. THRUSTER INSPECTION THE SECOND AND EVERY FLIGHT THEREAFTER USING A BORESCOPE. THRUSTER VALVE TRICKLE CURRENT TESTING IS PERFORMED EVERY FLIGHT.

(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 ARE VERIFIED BY INSPECTION. 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.

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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

CAR AC8897: VENIER THRUSTER (RSD, OV-099) OX VALVE SIGNATURE INDICATED THAT THE VALVE WAS NOT OPENING. FAILURE ANALYSIS REVEALED THE CAUSE TO BE HEAVY DEPOSITS OF METALLIC NITRATES RESULTING FROM FAILURE TO VACUUM PURGE THE VALVE OF N2O4 BEFORE WATER FLUSH DURING ATP. CORRECTIVE ACTION WAS TO IMPROVE THE PURGE AND DRY OPERATION AT THE SUPPLIER'S FACILITY.

CAR 03F043: THERE WERE FAILURES THAT HAVE RESULTED IN THRUSTER DESELECTION. TWO THRUSTERS EXHIBITED ERRONEOUS LEAK DETECTOR OUTPUTS ON OV-102. CAUSE WAS THERMAL CONTACT RESISTANCE BETWEEN SENSOR AND INJECTOR. CORRECTIVE ACTION WAS TO ADD THERMAL GREASE BETWEEN THE SENSOR PROBE AND INJECTOR. NO FAILURES OF THIS TYPE HAVE BEEN NOTED SINCE THE DESIGN CHANGE.

CAR AC5975: ONE INCIDENT REPORTED SLOW OPEN/CLOSE TIME DURING THE INITIAL TEST AFTER INSTALLATION OF LSD ON OV103. THE CAUSE WAS WHITE GREENISH MATERIAL BETWEEN THE COILS OF THE VALVE SPRING. THE CAUSE WAS IMPROPER HEAT TREAT DE-SCALING. CORRECTIVE ACTION WAS TO IMPROVE SPRING DE-SCALING PROCESS.

(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	
DESGIN ENGINEERING	: L. TOAPANTA	7/15/98
BOEING SUBSYSTEM MANAGER	: D. PERRY	7/20/98
JSC MOD	: B. LUNNEY	8/6/98