SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 03-2F-I21312-X

SUBSYSTEM NAME: FORWARD REACTION CONTROL SYSTEM (RCS)

REVISION : 2 12/12/89

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	THRUSTER, PRIMARY	MC457-0028
SRU	:	THRUSTER CHAMBER	235148
SRU	:	THRUSTER CHAMBER	235150

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
THRUST CHAMBER, FROM THRUSTER VALVE MOUNTING PLATE TO NOZZLE EXTENSION (COATED COLUMBIUM)

QUANTITY OF LIKE ITEMS: 14
ONE PER THRUSTER

FUNCTION:
TO CONTAIN HYPERGOLIC REACTION OF PROPELLANTS AND DIRECT COMBUSTION PRODUCTS THROUGH NOZZLE & EXTENSION TO PROVIDE IMPULSE TO VEHICLE. THE CHAMBER IS CONSTRUCTED OF C-103 COLUMBIUM WITH R-512 A OXIDATION RESISTANT COATING AND UTILIZES FILM COOLING. THE CHAMBER PRESSURE IS 152 PSI AND IS DESIGNED TO PRODUCE A THRUST OF 870 LBS VACUUM AT A NOMINAL STEADY STATE SPECIFIC IMPULSE OF 280 SECONDS. (NOTE - INJECTOR PERFORMANCE DEGRADATION DELETED-FMEA NO. 221311-1 - AND INCLUDED IN THIS FMEA AS A FAILURE CAUSE PER NASA DIRECTION).

SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 03-2F-121312-01

REVISION# 2 12/12/89

SUBSYSTEM: FORWARD REACTION CONTROL SYSTEM (RCS)
LRU :THRUSTER, PRIMARY
ITEM NAME: THRUSTER CHAMBER

CRITICALITY OF THIS FAILURE MODE:1/1

FAILURE MODE:
HOT GAS LEAKAGE, BURN THROUGH

MISSION PHASE:
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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

CAUSE:
THERMAL CYCLING/STRESS FATIGUE, INJECTOR FRACTURE, VIB, GAS INGESTION, COMBUSTION INSTABILITY, SHOCK, BLOCKED INJ ORIFICES, HIGH TEMPERATURE/ LOCALIZED HOT SPOTS/INADEQUATE COOLING, VALVE LEAKAGE, NOZZLE RESTRICTION, SEAL LEAKAGE, PRESSURE TRANSDUCER TUBE FRACTURE

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 REDUNDANCY-POSS LOSS OF 3 THRUSTERS IF MANIFOLD ISOL VALVE MUST BE CLOSED. POSSIBLE PRESSURIZED LINE OR TANK RUPTURE DUE TO HOT GAS IMPINGEMENT. LEAKAGE OF HOT GAS IN TO AFT COMPARTMENT.

(B) INTERFACING SUBSYSTEM(S):
INCREASED GN&C AND USE OF ALTERNATE THRUSTERS. POSSIBLE DAMAGE TO TPS.

POSSIBLE DAMAGE TO POD DUE TO OVERPRESSURIZATION.

(C) MISSION:
MISSION MODIFICATION/ABORT DECISION IF FAILURE CAUSES DAMAGE PROPAGATION.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE. BURN THROUGH MAY CAUSE HIGH TEMP DAMAGE TO SURROUNDING STRUCTURE AND ADJACENT THRUSTERS RESULTING IN POSSIBLE ENTRY HAZARD IF TPS IS DAMAGED. OVERPRESSURIZATION OF POD MAY OCCUR.

(E) FUNCTIONAL CRITICALITY EFFECTS:

- DISPOSITION RATIONALE -

(A) DESIGN:
THE THRUSTER INSTABILITY PROTECTION SYSTEM WILL SHUT DOWN THRUSTER DUE TO BURN THROUGH RESULTING FROM INSTABILITY. INTERMETALLIC DIFFUSION. LAYER FORMS AN INTEGRAL BOND BETWEEN THE DISILICIDE COATING AND THE PARENT COLUMBIUM MATERIAL AND TENDS TO RESIST SHOCK LOADING.

A 75 MICRON FILTER IN THE VALVE INLET UPSTREAM OF INJECTOR HOLES WILL PRECLUDE ENTRY OF CONTAMINANTS. ACOUSTIC CAVITIES DAMPEN THE FREQUENCIES THAT EXCITE INSTABILITY. STRUCTURAL MARGINS (2.0 TO 4.0) MINIMIZE FAILURE EFFECT(s).

THE ENGINE IS DESIGNED TO WITHSTAND GAS INGESTION. BOUNDARY LAYER COOLANT HOLES ARE LOCATED AT PERIMETER OF THE INJECTOR FACE. FUEL IS SPRAYED ONTO THE COMBUSTION CHAMBER WALLS TO COOL THE SURFACE.

THRUSTER USAGE IS TRACKED BY THE LIMITED LIFE SPECIFICATION. REDUNDANT SEALS FOR VALVE MOUNTING.

(B) TEST:
THE QUAL TEST PROGRAM INCLUDED STABILITY TEST (PURGE AND PRIME AND BOMB), ROUGH HANDLING, VIBRATION (34 MIN/AXIS), NOZZLE THERMAL TRANSIENT, 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) AND THE VIBRO-ACOUSTIC TEST AT JSC (131 EQUIVALENT MISSIONS). QUAL TESTING FOR CERTIFICATION OF THE THRUSTER INSTABILITY PROTECTION SYSTEM WIRE WRAP WILL BE CONDUCTED.

ACCEPTANCE TESTING INCLUDES PROOF PRESSURE (INLET VALVE - 1500 PSIG, INJECTOR 525 PSIG, THRUST CHAMBER 525 PSIG, NOZZLE 150 PSIG, PC TRANSDUCER 3000 PSIG, THRUSTER ASSY 525 PSIG), INTERNAL LEAKAGE, THRUSTER PERFORMANCE, INSULATION RESISTANCE, PULL-IN VOLTAGE, CONTINUITY/RESISTANCE, EXTERNAL LEAKAGE, FLOW CALIBRATION, CLEANLINESS, VALVE TIMING/RESPONSE OF THE VALVES AND DIELECTRIC STRENGTH.

OMRSD PERFORMS THE FOLLOWING: A THRUSTER VISUAL AND BORESCOPE INSPECTION ON SECOND FLIGHT AND EVERY FLIGHT THEREAFTER. A PROPELLANT TANK ACQUISITION EVALUATION BY X-RAY EVERY 5 FLIGHTS AND AS A CONTINGENCY WHEN THE POD IS REMOVED AND THE PROPELLANT NOT DRAINED FROM THE TANKS. THRUST CHAMBER LEAKAGE TESTS AFTER THE 5TH AND EVERY 5TH MISSION THEREAFTER. THE PROPELLANT TANK ACQUISITION VERIFICATION EVERY TEN FLIGHTS ON LEAD TANKS AND ON A CONTINGENCY BASIS. THE THRUSTER INSPECTION AFTER USING PRESSURE PLUGS ON A CONTINGENCY BASIS. PROPELLANT LOADING EVERY FLIGHT. CONTROL OF COATING SURFACE PROTECTION: THRUSTER INSPECTION THE SECOND FLIGHT AND THEREAFTER USING A FLASHLIGHT AND MIRROR. THRUSTER INSPECTION ON A FIFTH FLIGHT INTERVAL USING A BORESCOPE.

(C) INSPECTION:
RECEIVING INSPECTION
RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIAL AND PHYSICAL PROPERTIES (RAW MATERIAL, ANNEALING).

ASSEMBLY/INSTALLATION
FINAL INSPECTION OF ALL DIMENSIONS IS VERIFIED.

NONDESTRUCTIVE EVALUATION
FUSED DISILICIDE COATING THICKNESS IS VERIFIED BY EDDY CURRENT. WELDS ARE RADIOGRAPHIC INSPECTED PER MPS-909 AND ARE ALSO EITHER MAGNETIC PARTICLE OR PENETRANT INSPECTED.

CRITICAL PROCESSES
WELDING PER MPS 1609 CLA OR MPS 1610 CLA 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.

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.

(D) FAILURE HISTORY:
CAR'S AD0159 KSC, AD1606 ATP, AD1705 ATP, AND AD0169:
COATING DAMAGE WAS REPORTED ON THREE THRUSTERS. INSTALLATION AND REMOVAL OF THE RCS THROAT PLUG CAUSED DAMAGE. CORRECTIVE ACTION - TO PRECLUDE DAMAGE WHEN INSTALLING THE THROAT PLUGS, THE OMRSD LIMITS THE PRESSURE APPLIED FOR TESTING. THE THRUSTERS ARE INSPECTED WITH BORESCOPE AFTER EACH USE OF THROAT PLUG AND AFTER EVERY FLIGHT FOR COATING DAMAGE.

ONE THRUSTER WITH MINOR COATING DAMAGE WAS FIRED TO DETERMINE IF THE ENGINE COULD GO ONE MISSION WITH THIS COATING DAMAGE. NO DEGRADATION OF COATING WAS OBSERVED IN THE AREA OF DAMAGE.

CAR AC5385:
20 INSTABILITIES HAVE OCCURRED ON 7 PROD AND 1 QUAL THRUSTERS DURING TESTING AT THE SUPPLIER'S FACILITY. INSTABILITIES LASTING LONGER THAN 2 SECONDS MAY RESULT IN BURN THROUGH OF THE COMBUSTION CHAMBER NEAR THE INJECTOR FACE.
CORRECTIVE ACTION - A PRIMARY THRUSTER INSTABILITY PROTECTION SYSTEM HAS BEEN INSTALLED PRIOR TO THE FIRST POST 51L FLIGHT ON ALL PRIMARY THRUSTERS. A POWER CABLE FOR ENGINE VALVES HAS BEEN WRAPPED AROUND THE CHAMBER AND BURN THROUGH WILL REMOVE POWER TO BOTH VALVES.

CAR AC4684:
CRACKS IN THE STRESS RELIEF GROOVE AREA OF THE ACOUSTIC CAVITIES AND THRUSTER SUPPORT HAVE BEEN OBSERVED. CORRECTIVE ACTION - HYDROFLUORIC ACID CLEANING PROCESS WAS ELIMINATED (REF EDCP-0178). THE ATP BAKEOUT TO REMOVE RESIDUAL PROCESSING FLUIDS IS CONSIDERED SUFFICIENT TO PREVENT METAL ATTACK AND SUBSEQUENT CRACKS.

CAR AD3272:
FOLLOWING FOUR SECONDS OF UNSTABLE OPERATION THE PC TRANSDUCER PRESSURE INDICATION DROPPED FROM 210 PSIA TO 30 PSIA IN APPROXIMATELY 7 SECONDS. THE PC TRANSDUCER INLET TUBE WAS OBSERVED TO BE FRACTURED ABOVE THE INJECTOR/TUBE WELD JOINT. THE FACTS AND CONCLUSIONS FROM THIS ANALYSIS WERE PRESENTED TO TSR ON APRIL 26, 1988 AND AT CCB ON MAY 10, 1988, AND WERE USED TO JUSTIFY THE CONTINUED USE OF THESE THRUSTERS WITH POTENTIAL PC TUBE BREAKAGE DURING THRUSTER INSTABILITY.

(E) OPERATIONAL USE:
NONE

- APPROVALS -

RELIABILITY ENGINEERING:	F.E. BARCENAS	: F. E. Barcenas
DESIGN ENGINEERING :	B. DIPONTI	: B. Diponti
QUALITY ENGINEERING :	M. SAVALA	: M. Savala 1/18/90
NASA RELIABILITY :		: [illegible] 2/22/90
NASA SUBSYSTEM MANAGER :		: [illegible]
NASA QUALITY ASSURANCE :		: [illegible] 2/13/90