SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ORBITAL MANEUVER FMEA NO 03-3 -4004 -2 REV: 3/30/88

ASSEMBLY :ENGINE SUBSYSTEM
P/N RI :MC621-0009
P/N VENDOR:1186262
QUANTITY :2
;1 FOR EACH ENG SUB-SYS
:

CRIT. FUNC: 1
CRIT. HDW: 1

VEHICLE EFFECTIVITY:	102	103	104
	X	X	X

PHASE(S): PL LO X OO X DO X LS

REDUNDANCY SCREEN: A- B- C-

PREPARED BY:		APPROVED BY:	APPROVED BY (NASA):
DES	V F ROZNOS	DES	SSM
REL	C M AKERS	REL	REL
QE	J M SMITH	QE	QE

ITEM:
INJECTOR BI-PROPELLANT, ROCKET ENGINE.

FUNCTION:
PROVIDES INJECTION OF LIQUID PROPELLANT INTO THE THRUST CHAMBER. TRANSVERSE LIKE ON LIKE DOUBLET ORIFICES WITH TANGENTIAL FANS AND SPRAY INJECTION ARE UTILIZED TO ACHIEVE A NOMINAL ISP OF 313. THE 304L S.S. INJECTOR IS FLAT FACED & UNBAFFLED. A TOTAL OF 12 DUAL ACOUSTIC TUNED CAVITIES ARE PLACED AROUND THE INJECTOR PERIMETER FOR FREQUENCY RESPONSE DAMPING & TO MAINTAIN COMBUSTION STABILITY.

FAILURE MODE:
FAILS OUT OF TOLERANCE, RESTRICTED FLOW.

CAUSE(S):
PLUGGED ORIFICES,BI-PROP VALVE FAILS PARTIALLY OPEN OR INCORRECT VALVE TIMING, BLOCKAGE OR RUPTURE OF ENGINE INLET FILTER, CONTAMINATION/ PROPELLANT COMBUSTION RESIDUE, LEAKING & FREEZING OF PROPELLANT, PROPELLANT REACTION WITH ATMOSPHERIC PRODUCTS.

EFFECT(S) ON:
(A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE

(A) FUNCTIONAL DEGRADATION - INADEQUATE CHAMBER COOLING. POSSIBLE COMBUSTION INSTABILITY, POSSIBLE CHAMBER BURN-THROUGH DUE TO INADEQUATE COOLING. POSSIBLE LOSS OF ENGINE.

(B) DEGRADATION OF INTERFACE FUNCTION - REDUCED THRUST, ISP, POSSIBLE LOSS OF ENGINE. DEFECTIVE ENGINE CAN BE SHUTDOWN AND DEORBIT ACCOMPLISHED WITH REMAINING ENGINE.

(C) POSSIBLE EARLY MISSION TERMINATION. REDLINE ADDITIONAL PROPELLANT FOR RCS BACKUP DEORBIT. NEXT PLS DEORBIT IF SUFFICIENT PROPELLANT NOT AVAILABLE.

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(D) POSSIBLE LOSS OF CREW/VEHICLE - POSSIBLE COMBUSTION INSTABILITY OR INADEQUATE CHAMBER COOLING CAUSING CHAMBER AND/OR POD/TPS/AFT FUSELAGE DAMAGE.

DISPOSITION & RATIONALE:
(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E)OPERATIONAL USE

(A) DESIGN
THE INJECTOR DESIGN FEATURES DIFFUSION BOND AND EB WELD OF FACE PLATE TO BODY PROVIDING REDUNDANCY BETWEEN FUEL AND OXIDIZER PASSAGES. ENGINE INLET FILTERS ARE PROVIDED. POST BURN PURGES ARE PERFORMED. COMPLETE THERMAL ANALYSIS AND STRESS ANALYSIS HAVE BEEN COMPLETED. REDUNDANT ENGINES ARE PROVIDED EITHER OF WHICH IS CAPABLE OF DE-ORBIT.

(B) TEST

QUALIFICATION TESTS
CHAMBER "BOMB" TESTS CONDUCTED. ENDURANCE (1500 FIRINGS), VIBRATION AT ENGINE LEVEL. ALSO QUALIFIED AS PART OF ENGINE ASSEMBLY, 138 FIRINGS DURING ENGINE QUAL, 498 FIRINGS AT POD LEVEL AT WSTF.

ACCEPTANCE TESTS
EXAMINATION OF PRODUCT. WELD INSPECTION. RADIOGRAPHIC AND FLUORESCENT INSPECTION. SPRAY PATTERN VERIFICATION AND FLOW TESTS.

GROUND TURNAROUND
VISUAL INSPECTION (V43CEO.020) OF INJECTOR FACE WITH BORESCOPE PRIOR TO EACH MISSION.
V43CBO.275 PERFORMS PRESSURE DECAY DOWNSTREAM OF ENGINE VALVE EVERY 5TH FLIGHT.
V43CEO.010 PERFORMS ENGINE TRICKLE PURGE/THROAT PLUG TEST EVERY FLIGHT.
V43CEO.030 PERFORMS INTERNAL POD INSPECTION EVERY 5 FLIGHTS.
V43CEO.050 PERFORMS BI-PROP VALVE DRAIN AND PURGE EVERY FLIGHT.
V43CEO.090 PERFORMS PROPELLANT SAMPLING SECOND FLIGHT.
V43CFO.010 PERFORMS PROPELLANT SERVICING TO FLIGHT LOAD AND VERIFIES CONFORMANCE TO SE-S-0073 EVERY FLIGHT.
V43CHO.010 PERFORMS WATER INTRUSION INSPECTION AFTER FIREX USAGE ON PAD.
FLIGHT DATA IS ANALYZED TO DETERMINE THE CAUSE OF ANY ANOMALOUS CONDITION. PROPELLANTS ARE DRAINED FROM BI-PROPELLANT VALVE CAVITIES, A GN2 TRICKLE PURGE IS MAINTAINED AND A THROAT PLUG IS INSTALLED IN THE CHAMBER THROAT TO KEEP PROPELLANT VAPORS AND MOISTURE OUT OF THE INJECTOR MANIFOLDS AND PREVENT SALTS, PROPELLANT NITRATES AND CORROSION FROM DEVELOPING IN THE INJECTOR.

(C) INSPECTION

RECEIVING INSPECTION
MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION.

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

ASSEMBLY/INSTALLATION
MANUFACTURING, ASSEMBLY AND INSTALLATION PROCEDURES ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
PENETRANT AND RADIOGRAPHIC INSPECTION OF WELDS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
INJECTOR PLATELET CHEM-MILL AND SHADOW GRAPH IS VERIFIED BY INSPECTION. THE WELDING PROCESS AND VERIFICATION THAT WELDS MEET SPECIFICATION REQUIREMENTS ARE VERIFIED BY INSPECTION.

TESTING
TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. CLAMPED PLATELET HYDROTEST FOR CORRECT SPRAY AND INTERSECTIONAL PATTERN IS VERIFIED BY INSPECTION. DIFFUSION BONDED PLATELET STACK HYDROTEST FOR CORRECT SPRAY AND INTERSECTIONAL PATTERN IS VERIFIED BY INSPECTION. TEST FIRING AND INSPECTION FOR HOT SPOTS IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY
NO FAILURES ASSOCIATED WITH THIS FAILURE MODE HAVE OCCURRED DURING OPERATIONAL USAGE.

TWO DEVELOPMENT INJECTORS DEVELOPED FACE CRACKS AFTER BEING FIRED OVER 500 TIMES. BOTH INJECTORS WERE FIRED AN ADDITIONAL 1000 TIMES WITH NO MEASURABLE EFFECT ON PERFORMANCE. NO CORRECTIVE ACTION WAS CONSIDERED NECESSARY. THE LIMITED LIFE REQUIREMENT FOR THE INJECTOR IS 27 MISSIONS.

THREE ENGINE ASSEMBLY INJECTORS SUSTAINED ORIFICE DEFORMATION DUE TO DETONATIONS IN THE INJECTOR MANIFOLDS DURING GROUND TEST PROGRAMS - ONE DURING DEVELOPMENT, ONE IN THE POD QUAL PROGRAM AND ONE DURING THE OPERATIONAL ENHANCEMENT PROGRAM.

CAR AC4020 INDICATES THAT THE CAUSE OF DAMAGE TO THE INJECTOR MANIFOLD WAS CAUSED BY A DETONATION DUE TO OMISSION OF THE POST FIRE PURGE AND THE PREVIOUS SHORT ENGINE FIRING. THIS ALLOWED RESIDUAL FUEL TO MIGRATE INTO THE OXIDIZER CHANNELS. THE TEST PROCEDURE WAS REVISED. DAMAGE DURING FLIGHT IS NOT ANTICIPATED SINCE POST FIRE PURGES ARE REQUIRED AND THE SPACE VACUUM WILL FURTHER LIMIT OCCURRENCE OF THIS CONDITION. DETAILED VISUAL INSPECTION OF THE INJECTOR IS PERFORMED AFTER EACH FLIGHT.

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(E) OPERATIONAL USE

INJECTOR (FUEL OUT) TEMPERATURE MONITORED; ENGINE SHUTDOWN IF TEMPERATURE EXCEEDS OPERATIONAL LIMITS. FAILURE MAY BE DIFFICULT TO DIAGNOSE. ISOLATE FAILED ENGINE AND COMPLETE MISSION REQUIREMENTS USING CROSSFEED FOR PROPELLANT UTILIZATION. REDLINE ADDITIONAL PROPELLANT FOR RCS BACKUP DEORBIT. NEXT PLS DEORBIT IF PROPELLANT FOR RCS BACKUP NOT AVAILABLE.