

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ORBITAL MANEUVER FMEA NO 03-3 -4004 -1 REV: 3/30/88

ASSEMBLY : ENGINE SUBSYSTEM		CRIT. FUNC:	1	
P/N RI : MC621-0009		CRIT. HDW:	1	
P/N VENDOR: 1186262	VEHICLE	102	103	104
QUANTITY : 2	EFFECTIVITY:	X	X	X
: 1 FOR EACH ENG SUB-SYS	PHASE(S):	PL	LO X	OO X DO X LS

PREPARED BY:		REDUNDANCY SCREEN:	A-	B-	C-
DES	V F ROZKOS	APPROVED BY:	APPROVED BY (NASA):		
REL	C M AKERS	DES	SSM	<i>[Signature]</i>	
QE	W J SMITH	REL	REL	<i>[Signature]</i>	
		QE	QE	<i>[Signature]</i>	

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 304 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:
 STRUCTURAL FAILURE, BURN THROUGH.

CAUSE(S):
 MATERIAL DEFECT, PRE-EXISTING LEAK PATH, EXTREME COMBUSTION TEMPERATURE, PLUGGED ORIFICES, (RUPTURED FILTER ALLOWS CONTAMINATION TO REACH INJECTOR), SPRAY PATTERN INCORRECT, INADEQUATE COOLING, INTERMANIFOLD PROPELLANT LEAKAGE, MANIFOLD PROPELLANT DETONATIONS, COMBUSTION INSTABILITY, HARD START (INCORRECT BI-PROP VALVE TIMING).

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

(A) LOSS OF FUNCTION - INJECTOR DAMAGE LEADING TO LOSS OF ONE ENGINE.

(B) LOSS OF REDUNDANCY.

(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 FIRE OR EXPLOSIVE HAZARD.
POSSIBLE TPS, POD STRUCTURE AND/OR 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

441 BOMB TESTS WERE CONDUCTED ON INJECTOR AND THRUST CHAMBER ASSEMBLIES AS PART OF THE CERTIFICATION OF THE ENGINE FOR COMBUSTION STABILITY. VIBRATION TESTS AT ENGINE LEVEL. HOT-FIRE TEST PROGRAM - VERIFICATION OF PERFORMANCE WITHIN SPEC ENVELOPE. TCA LEVEL - 760 FIRINGS - 13251 SEC DURATION, 20 BOMB STABILITY TESTS. ENGINE LEVEL - 498 FIRINGS, 14831 SEC DURATION. DEFINITION OF PERFORMANCE UNDER ABNORMAL CONDITIONS - EFFECT OF PROPULSION SYSTEM FAILURES, PROPULSION SYSTEM OPERATION IN CONTINGENCY MODES.

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 USING A BORESCOPE IS REQUIRED PRIOR TO EACH MISSION.

V43CBO.275 PERFORMS PRESSURE DECAY TEST DOWNSTREAM OF ENGINE VALVE EVERY 5TH FLIGHT.

V43CEO.010 PERFORMS ENGINE TRICKLE PURGE/THROAT PLUG EVERY FLIGHT.

V43CEO.030 PERFORMS SUBSYSTEM INSPECTION EVERY 5TH FLIGHT.

V43CEO.050 PERFORMS BI-PROP VALVE DRAIN AND PURGE EVERY FLIGHT.

V43CEO.090 PERFORMS PROPELLANT SAMPLING 2ND 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 PROPELLANT VALVE CAVITIES, A GN2 TRICKLE PURGE IS MAINTAINED AND A THROAT PLUG IS INSTALLED IN CHAMBER THROAT TO KEEP PROPELLANT VAPORS AND MOISTURE OUT OF INJECTOR MANIFOLDS AND PREVENT SALT, PROPELLANT NITRATES AND CORROSION FROM DEVELOPING IN INJECTOR.

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(C) INSPECTION

RECEIVING INSPECTION

MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION.

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 SHADOWGRAPH ARE 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

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 ORIGINAL LIFE GOAL FOR THE INJECTOR (1000 STARTS) WAS REDUCED TO 400 STARTS (MEETS ANTICIPATED MISSION REQUIREMENTS).

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.

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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.

(E) OPERATIONAL USE

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 BACK-UP NOT AVAILABLE. POSSIBLE MISSION IMPACT. DECREASED PROPELLANT AVAILABLE FROM OMS TO RCS THROUGH INTERCONNECT FOR ON-ORBIT OPERATION.