

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ORBITAL MANEUVER FMEA NO 03-3 -4005 -1 REV: 3/30/88

ASSEMBLY : ENGINE SUBSYSTEM CRIT. FUNC: 1
P/N RI : MC621-0009 CRIT. HDW: 1
P/N VENDOR: 1186335 VEHICLE 102 103 104
QUANTITY : 2 EFFECTIVITY: X X X
: 1 FOR EACH ENG SUBSYS PHASE(S): PL LO X OO X DO X LS

PREPARED BY: REDUNDANCY SCREEN: A- B- C-
DES V F ROZDOS APPROVED BY: NAME:
REL C M AKERS REL *[Signature]* SSM *[Signature]*
QE W J SMITH QE *[Signature]* REL *[Signature]* 10-26-88

ITEM:
THRUST CHAMBER, REGENERATIVE, COOLED, ROCKET ENGINE.

FUNCTION:
PROVIDES ENCLOSURE FOR COMBUSTION OF PROPELLANT AND EXPANSION AND
EXPULSION OF COMBUSTION GASES TO GENERATE THRUST. CHAMBER IS FUEL
REGENERATIVELY COOLED (120 CHANNELS) FABRICATED FROM A 304L S.S. LINER
AND ELECTRO FORMED NICKEL SHELL (REGEN JACKET CLOSEOUT). PC IS 131 PSIA.
GAS WALL TEMPERATURE IS 800 F (500 F EXT). CHAMBER THROAT IS 5.0 IN.
DIAMETER. BOLTED NOZZLE ATTACHMENT FLANGE WITH GRAFOIL SEAL IS
UTILIZED. NOZZLE EXTENSION FLANGE IS AT AN AREA RATIO OF 6 TO 1.

FAILURE MODE:
STRUCTURAL FAILURE, BURN THROUGH OR RUPTURE AT CHAMBER TO NOZZLE
EXTENSION FLANGE.

CAUSE(S):
EXCESS CHAMBER PRESS - LEAK PATH (GASKET FAILURE), INADEQUATE COOLING,
INCORRECT BOLT OR MATERIAL DEFICIENCY, WELD DEFECT, IMPROPER NOZZLE
INSTALLATION OR FLANGE IRREGULARITIES, DIMENSIONAL DISCREPANCY, HIGH
NOZZLE SIDE LOADS, GIMBAL ACTUATOR FAILURE DURING ASCENT ALLOWING NOZZLE
EXTENSION TO ROTATE INTO AIRSTREAM CREATING HIGH BENDING MOMENTS.

EFFECT(S) ON:
(A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE
(A) LOSS OF FUNCTION - LOSS OF ONE ENGINE.
(B) LOSS OF INTERFACE FUNCTION - POSSIBLE DAMAGE TO AFT RCS, TPS OR POD
STRUCTURE/AFT FUSELAGE DAMAGE.
(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 EXPLOSION FROM EXHAUST GASES DUMPING INTO POD.

DISPOSITION & RATIONALE:

(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E)OPERATIONAL USE

(A) DESIGN

DETAILED THERMAL AND STRESS ANALYSES PERFORMED. STRUCTURAL FACTOR OF SAFETY IS 1.4 MINIMUM. BOSF (BURN-OUT SAFETY FACTOR) IS 1.4 UNDER WORST CASE CONDITIONS OF OPERATIONS WITHIN SODE ENVELOPE. LIFE CYCLE DESIGN MARGIN IS 4.0. REDUNDANT ENGINES ARE PROVIDED. ENGINE INLET FILTERS ARE PROVIDED. POST-FIRE PURGES PERFORMED TO REMOVE RESIDUAL FUEL FROM REGEN JACKET AND INJECTOR.

(B) TEST

QUALIFICATION TESTS

VIBRATION TESTS AT ENGINE LEVEL. HOT-FIRE TEST PROGRAM - VERIFICATION OF PERFORMANCE WITHIN SPEC ENVELOPE. TCA LEVEL - 1216 FIRINGS, 6941 SEC DURATION, 20 BOMB STABILITY TESTS. ENGINE LEVEL - 760 FIRINGS - 13251 SEC DURATION. 12 THERMAL MARGIN OFF-LIMITS TESTS. SYSTEM 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

DETAILED VISUAL INSPECTION. WELD INSPECTIONS. INDIVIDUAL CHANNELS FLOWED & LEAK CHECKED. PROOF PRESSURE & LEAK TESTING OF CHAMBER, ELECTROFORMED NICKEL TO STAINLESS STEEL BOND AND WELDS. VERIFICATION OF HEAT-FLUX COMPATIBILITY BETWEEN INJECTOR AND CHAMBER. MINIMUM OF TWO 30-SECOND FIRINGS OF COMPLETE ENGINE ASSEMBLY FOR PERFORMANCE VERIFICATION. CLEANLINESS VERIFICATION.

GROUND TURNAROUND

V43CBO.211 PERFORMS LEAK CHECK OF OME CHAMBER/ NOZZLE JOINT FOR FIRST FLIGHT AND ON 5-FLIGHT INTERVALS.

V43CEO.010 DEFINES ENGINE PROTECTION REQUIREMENTS (THROAT PLUG AND TRICKLE PURGE); THROAT PLUG INSTALLATION OR TRICKLE PURGE INITIATION REQUIRED WITHIN 24 HOURS OF LANDING.

V43CEO.050 REQUIRES PURGE OF RESIDUAL PROPELLANT FROM BALL VALVE CAVITY WITHIN 14 DAYS OF LANDING.

V43CEO.020 DEFINES DETAILED VISUAL INSPECTION OF OME INJECTOR, ACOUSTIC CAVITIES, COMBUSTION CHAMBER WALL, AND NOZZLE; DOCUMENTATION IS REQUIRED FOR ANY ANOMALOUS INDICATIONS (PERFORMED EACH FLIGHT).

V43CEO.030 DEFINES DETAILED VISUAL INSPECTION OF ENGINE COMPONENTS WITH ENGINE BOX (REMOVAL OF HEAT SHIELD REQUIRED); REQUIREMENTS TO BE CARRIED OUT WHENEVER POD IS REMOVED (AT LEAST EVERY 5 FLIGHTS).

V43CBO.275 PERFORMS PERIODIC LEAK CHECK OF ENGINE PLUMBING DOWNSTREAM OF ENGINE BI-PROP VALVE EVERY FIVE FLIGHTS.

V43CEO.090 REQUIRES PROPELLANT SAMPLE (SE-S-0073) FOR SECOND FLIGHT AND ON A CONTINGENCY BASIS.

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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 200 A FOR NTO AND CORROSION PROTECTION PROVISION ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, ASSEMBLY AND INSTALLATION PROCEDURE ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. DIMENSIONAL INSPECTION OF THRUST CHAMBER AFTER MACHINING IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

NICKEL PLATING THICKNESS IS VERIFIED BY INSPECTION. THE WELDING PROCESS AND VERIFICATION THAT WELDS MEET SPECIFICATION REQUIREMENTS ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

PENETRANT AND RADIOGRAPHIC INSPECTION OF WELDS ARE VERIFIED BY INSPECTION. ULTRASONIC INSPECTION OF THRUST CHAMBER FORGING IS VERIFIED BY INSPECTION. CHAMBER PENETRANT INSPECTION IS VERIFIED BY INSPECTION.

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. CHAMBER LEAK TEST IS VERIFIED BY INSPECTION. CHAMBER FLOW CALIBRATION IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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

(D) FAILURE HISTORY

CAR AC7356 RECORDS TCA/NOZZLE FLANGE LEAKAGE, CAUSED BY NOZZLE FLANGE FLATNESS NOT BEING TO SPECIFICATION REQUIREMENT (SN115,116 117,118). THIS WAS DUE TO INADEQUATE INSPECTION DURING THE FABRICATION PROCESS. A TOOL WAS CONSTRUCTED TO FLATTEN FLANGES ON COMPLETED NOZZLES, PROCESSES AND PROCEDURES WERE REVISED FOR FUTURE BUILDS. INSTALLATION PROCEDURES WERE REVISED. ADDITIONAL LEAK CHECK TESTS AND INSPECTIONS WERE REQUIRED FOR FLIGHT ENGINES.

(E) OPERATIONAL USE

FAILURE MAY BE DIFFICULT TO DIAGNOSE. ISOLATE FAILED ENGINE AND COMPLETE MISSION REQUIREMENTS USING CROSSFEED FOR PROPELLANT UTILIZATION. REDLIN 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.

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