

1) CIL ITEM : B400-10
 2) PNEA CODE : B400
 3) COMPONENT : HPOTP
 4) PART NUMBER : RS0D7701
 5) SYSTEM/SUBSYSTEM : PUMPS/BHXK
 6) FAILURE MODE : ENERGY LOSS IN MAIN PUMP DIFFUSER

7) PREPARED : SSNE RELIABILITY
 8) APPROVED :
 9) DATE : 06-01-95
 10) REVISION/CHANGE : -002/D
 11) EFFECTIVITY : -761
 12) HAZARD REFERENCE : SEE LISTINGS BELOW
 13) CCBD # : me3-a-3275

| PHASE | FAILURE DESCRIPTION/EFFECT | CRITICALITY |
|-------|---|--|
| S | <p>ENERGY LOSS REDUCES PUMP DISCHARGE PRESSURE AND FLOW, RESULTING IN REDUCED ENGINE THRUST. REDUCED TURBOPUMP OUTPUT RESULTS IN REDUCED ENGINE THRUST. THIS IS SENSED BY THE CONTROLLER, WHICH INCREASES OXIDIZER PREBURNER FLOW. EXCESS TURBINE DISCHARGE TEMPERATURE WILL CAUSE REDLINE SHUTDOWN. MISSION ABORT IF DETECTED BY REDLINE. LOSS OF VEHICLE DUE TO HPOTP TURBINE OR HEAT EXCHANGER FAILURE MAY RESULT IF NOT DETECTED.</p> <p>REDUNDANCY SCREENS: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: PASS. REDUNDANT HARDWARE ITEMS ARE CAPABLE OF CHECKOUT DURING NORMAL GROUND TURNAROUND. B: PASS. LOSS OF A REDUNDANT HARDWARE ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.</p> | <p>IR HAZARD REF: ME-CIS,M.</p> |
| N | <p>ENERGY LOSS REDUCES PUMP DISCHARGE PRESSURE AND FLOW, RESULTING IN REDUCED ENGINE THRUST. REDUCED TURBOPUMP OUTPUT RESULTS IN REDUCED ENGINE THRUST. THIS IS SENSED BY THE CONTROLLER, WHICH INCREASES OXIDIZER PREBURNER FLOW. EXCESS TURBINE DISCHARGE TEMPERATURE WILL CAUSE REDLINE SHUTDOWN. MISSION ABORT IF DETECTED BY REDLINE. LOSS OF VEHICLE DUE TO HPOTP TURBINE OR HEAT EXCHANGER FAILURE MAY RESULT IF NOT DETECTED.</p> <p>REDUNDANCY SCREENS: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: PASS. REDUNDANT HARDWARE ITEMS ARE CAPABLE OF CHECKOUT DURING NORMAL GROUND TURNAROUND. B: PASS. LOSS OF A REDUNDANT HARDWARE ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.</p> | <p>IR HAZARD REF: ME-CIS,M.</p> |

| CIL ITEM: B400-10 | DESIGN | | DOCUMENT REF. |
|-------------------|---|---|--|
| FAILURE CAUSE A: | FRACTURE, DISTORTION OF DIFFUSER VANE | | |
| | <p>THE DIFFUSER VANES DIRECT THE IMPELLER DISCHARGE FLOW INTO THE VOLUTE SCROLL FOR PROPER DYNAMIC HEAD RECOVERY. THE VANES ARE MANUFACTURED UTILIZING AN INCONEL 718 FORGING BY AN EDM PROCESS (1). A CREW MILL OPERATION IS ACCOMPLISHED AFTER EDM TO REMOVE THE RECAST LAYER. THE ALLOY IS SOLUTION HEAT TREATED AND AGE-HARDENED (1). INCONEL 718 WAS SELECTED FOR ITS STRENGTH, WHILE RETAINING DUCTILITY AT CRYOGENIC TEMPERATURES (2). THE ALLOY IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING, AND IS LOX COMPATIBLE (2). EACH HOUSING IS PROOF PRESSURE TESTED PRIOR TO USE, AND THE VANES ARE SHOT-PEENED TO INCREASE FATIGUE RESISTANCE (1). THE VANE LEADING EDGES ARE CUI-BACKED TO INCREASE CROSS SECTIONAL AREA FOR ADDITIONAL STRUCTURAL MARGIN. SYSTEM CONTAMINATION IS CONTROLLED BY THE VEHICLE CLEANLINESS REQUIREMENTS (3) WHICH MINIMIZE POTENTIAL DAMAGE FROM CONTAMINATION IMPACT. THE HOUSING VOLUTE PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NOE FLAW GROWTH SINCE IT IS NOT A FRACTURE CRITICAL PART AND THE MAIN HOUSING WHICH WAS CLEARED BY RISK ASSESSMENT (4). THE HOUSING MEETS CEI REQUIREMENTS FOR HIGH CYCLE AND LOW CYCLE FATIGUE LIFE (5). THE MINIMUM FACTORS OF SAFETY FOR THE HOUSING MEET CEI REQUIREMENTS (6). THE MAIN HOUSING HAS COMPLETED DESIGN VERIFICATION TESTING FOR PROOF PRESSURE-STRESS DISTRIBUTION (7). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (8). REUSE OF PARTS DURING OVERHAUL ARE CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (9).</p> | <p>(1) RS007732 (2) R58-8578-11 (3) ICD 13H15000 (4) NASA TASK 117 (5) RL00532, CP320R00038 (6) R58-8546-16, CP320R00038 (7) R58-403-58 (8) CP406R0008 3.2.3:5.2 (9) RL00874</p> | |
| CIL ITEM: B400-10 | INSPECTION AND TEST | | |
| POSSIBLE CAUSES | SIGNIFICANT CHARACTERISTICS | INSPECTION(S)/TEST(S) | DOCUMENT REF. |
| FAILURE CAUSE A: | RS007729 - MAIN HOUSING RS007732 - HOUSING VOLUTE | | RS007729 RS007732 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. | R80170-953 R80170-954 |
| | | VOLUTE FORGING IS ULTRASONIC AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS. | RA0115-012 RA0115-116 |
| | | RECAST LAYER REMOVAL IS VERIFIED PER DRAWING REQUIREMENTS. | RS007732 |
| | HEAT TREAT | HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. | RA0611-020 R80170-153 R80170-154 |

| CIL ITEM: B400-10 | | INSPECTION AND TEST | |
|-------------------|-----------------------------|--|---|
| POSSIBLE CAUSES | SIGNIFICANT CHARACTERISTICS | INSPECTION(S)/TEST(S) | DOCUMENT REF. |
| B-247 | ASSEMBLY INTEGRITY | A PENETRANT INSPECTION IS PERFORMED ON THE HOUSING BEFORE AND AFTER PROOF PRESSURE TESTING PER DRAWING AND SPECIFICATION REQUIREMENTS. | RL00387 RA0115-116 |
| | | MAIN HOUSING WELDS 22 & 24 ARE MASS SPECTROMETER LEAK CHECKED PER SPECIFICATION REQUIREMENTS. | RA0115-116 |
| | | VANE FILLET RADIUS OF THE VOLUTE ARE INSPECTED PER DRAWING REQUIREMENTS. | RS007732 |
| | | THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE, PER OVERHAUL CLASSIFICATION. | RL00874 RA0115-116 |
| | CLEARLINESS OF COMPONENTS | COMPONENTS ARE VERIFIED CLEANED TO OXYGEN SERVICE PER SPECIFICATION REQUIREMENTS. | RL10001 |
| | ASSEMBLY INTEGRITY | OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M INSPECTIONS. | RL00050-04 RL00056-06 RL00056-07 RL00461 |
| | | TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT. | OMRSD V41890.040 |
| | | DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST) | MSFC PLM 1228 |

FAILURE HISTORY: COMPREHENSIVE FAILURE HISTORY DATA IS MAINTAINED IN THE PROBLEM REPORTING DATABASE (PRMS/PRACA).
 REFERENCE: NASA LETTER SA21/88/308 AND ROCKEFORTE LETTER BRRC09761.

OPERATIONAL USE: NOT APPLICABLE.

TABLE 8400. HIGH PRESSURE OXIDIZER TURBOPUMP
FREA/CIL WELD JOINTS

| COMPONENT | BASIC PART NO. | WELD NO. | WELD TYPE | CLASS | ROOT SIDE NOT ACCESS | CRITICAL INITIAL | | COMMENTS |
|---------------|-------------------|----------|--------------|-------|----------------------------|----------------------|-------------------|----------|
| | | | | | | FLAW SIZE NOT HCF | DETECTABLE LCF | |
| MAIN HOUSING | RS007729 | 1,2 | EBW | I | X | X | | |
| MAIN HOUSING | RS007729 | 3 | EBW | I | | X | | |
| MAIN HOUSING | RS007729 | 9,10 | GTAW | II | X | X | X | |
| MAIN HOUSING | RS007729 | 11,12 | GTAW | I | | X | | |
| MAIN HOUSING | RS007729 | 13 | EBW | I | X | X | | |
| MAIN HOUSING | RS007729 | 14-17,16 | GTAW | II | X | | | |
| MAIN HOUSING | RS007729 | 18,19 | GTAW | II | X | I | X | |
| MAIN HOUSING | RS007729 | 21,23 | GTAW | II | X | | | |
| MAIN HOUSING | RS007729 | 22,24 | GTAW | II | X | | | |
| MAIN HOUSING | RS007729 | 44,53-59 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 45 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 48 | GTAW | I | X | X | | X |
| MAIN HOUSING | RS007729 | 49 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 50 | GTAW | I | | | | |
| MAIN HOUSING | RS007729 | 51,52 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 54 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 55,56 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 61 | GTAW | I | | | | |
| MAIN HOUSING | RS007729 | 62 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 63 | GTAW | I | | | | |
| MAIN HOUSING | RS007729 | 64 | GTAW | I | X | X | | |
| MAIN HOUSING | RS007729 | 65 | GTAW | I | X | | | |
| MAIN HOUSING | RS007729 | 66-70 | GTAW | II | X | | | |
| INLET HOUSING | RS007732 | 4 | GTAW | I | | | I | |
| INLET HOUSING | RS007732 | 8,9 | GTAW | I | | | I | |
| VOLUTE | RS007732 | 10,15 | GTAW | I | X | I | | |
| VOLUTE | RS007732 | 20,21 | GTAW | I | | | | |
| VOLUTE | RS007732 | 22,23 | GTAW | I | | | | |
| VOLUTE | RS007732 | 24,27 | GTAW | I | | X | | X |
| VOLUTE | RS007732 | 25,26 | GTAW | I | | | | |
| FLANGE | RS007736 | 1,2 | GTAW | II | X | | | |
| FLANGE | RS007736 | 3,26 | GTAW | II | X | | | |

B-409

RSS-8740-11

TABLE 1400. HIGH PRESSURE OXIDIZER TURBOPUMP
FREA/CIL WELD JOINTS

| COMPONENT | BASIC PART NO. | WELD NO. | WELD TYPE | CLASS | ROOT | CRITICAL INITIAL | | COMMENTS |
|---------------------|-------------------|----------|--------------|-------|--------------------|----------------------|-------------------|----------|
| | | | | | SIDE NOT ACCESS | FLAW SIZE NOT HCF | DETECTABLE LCF | |
| FLANGE | RS007736 | 6,7 | GTAW | II | X | | | |
| FLANGE | RS007736 | 9-12,17 | GTAW | II | X | | | |
| FLANGE | RS007736 | 13-16 | GTAW | II | X | | | |
| FLANGE | RS007736 | 18,20 | GTAW | I | X | | | |
| FLANGE | RS007736 | 19,21 | GTAW | II | X | | | |
| FLANGE | RS007736 | 22 | EBW | I | X | | | |
| FLANGE | RS007736 | 23 | GTAW | II | | | | |
| FLANGE | RS007736 | 24 | GTAW | II | X | | | |
| FLANGE | RS007736 | 26 | GTAW | II | X | | | |
| BELLOWS | RS007740 | 1,2,5,9 | GTAW | I | | X | | |
| BELLOWS | RS007740 | 3,4 | EBW | I | | | | |
| HOUSING | RS007746 | 1,2 | GTAW | I | X | | X | |
| HOUSING | RS007746 | 3 | GTAW | I | X | | | |
| HOUSING | RS007746 | 4 | GTAW | II | X | | | |
| HOUSING | RS007746 | 5 | GTAW | II | X | | X | |
| HOUSING | RS007746 | 6-17 | GTAW | II | X | | X | |
| HOUSING | RS007746 | 18-29 | GTAW | II | X | | X | |
| HOUSING | RS007746 | 30-41 | GTAW | II | | X | | X |
| BELLOWS | RS007748 | 1 | EBW | I | | | | |
| BELLOWS | RS007748 | 2 | GTAW | I | X | | | |
| BELLOWS | RS007749 | 1-4 | GTAW | I | | | | |
| BELLOWS | RS007749 | 5,6 | EBW | I | | | | |
| BELLOWS | RS007749 | 11 | EBW | I | | | | |
| BELLOWS | RS007749 | 12 | EBW | I | | | | |
| BELLOWS | RS007751 | 3 | EBW | I | X | | | |
| BELLOWS | RS007751 | 4 | EBW | I | X | X | | X |
| BELLOWS | RS007751 | 8 | GTAW | I | X | X | | |
| SECOND STAGE NOZZLE | RS007752 | 1,2 | EBW | I | X | | | |
| SECOND STAGE NOZZLE | RS007752 | 1 | GTAW | I | X | X | | X |
| JET RING | RS007757 | 1 | GTAW | I | X | X | | X |
| FAIRING | RS007774 | 1-12 | GTAW | I | | X | | |
| FAIRING | RS007774 | 13-24 | GTAW | I | | X | | |

B - 410

RSS-8740-11

TABLE B100. HIGH PRESSURE OXIDIZER TURBOPUMP
FMEAS/CIL WELD JOINTS

| COMPONENT | BASIC PART NO. | WELD NO. | WELD TYPE | CLASS | ROOT SIDE NOT ACCESS | CRITICAL INITIAL | | COMMENTS |
|-----------|----------------|-------------------|-----------|-------|----------------------|------------------------------|--------------------|----------|
| | | | | | | FLAW SIZE NOT DEFECTABLE REF | NOT DEFECTABLE LCF | |
| FAIRING | RS007774 | 25-36 | BTAW | I | | | | X |
| FAIRING | RS007774 | 74 | BTAW | I | | | | |
| FAIRING | RS007774 | 75,76 | BTAW | II | X | | | |
| STRUT | RS007779 | 23-44, 143-164 | BTAW | II | X | | | |
| STRUT | RS007779 | 45-66, 165-186 | BTAW | II | X | | | |
| STRUT | RS007779 | 67 | BTAW | II | X | | | |
| STRUT | RS007779 | 69,70 | EDW | II | X | | | |
| STRUT | RS007779 | 71 | EDW | II | | | | |
| STRUT | RS007779 | 72 | EDW | II | | | | |
| STRUT | RS007779 | 73-94 | EDW | II | | | | |
| STRUT | RS007779 | 95,96 | EDW | II | X | | | |
| SHIELD | RS007781 | 1,11 | BTAW | II | | | | |
| SHIELD | RS007781 | 2,3,4 | BTAW | II | | | | |
| SEAL | RS006848 | 1 PLC | BTAW | I | | | | |
| SEAL | RS006857 | 1 PLC | BTAW | I | | X | | X |

B-411

RSS-8740-11