

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL HARDWARE  
 NUMBER: 04-1A-0101 -X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION: FUEL CELL  
 REVISION: 3 03/27/96

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PART DATA

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	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: FUEL CELL POWERPLANT IFC	MC464-0115-3020 807100
LRU	: FUEL CELL POWERPLANT IFC	MC464-0115-3021 808100
LRU	: FUEL CELL POWERPLANT IFC	MC464-0115-3030 814100
LRU	: FUEL CELL POWERPLANT. IFC	MC464-0115-3031 815100

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EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
 FCP NO. 1, 2, 3

REFERENCE DESIGNATORS: 40V45A100  
 40V45A200  
 40V45A300

QUANTITY OF LIKE ITEMS:  
 TWO-RH  
 ONE-LH

FUNCTION:  
 THREE POWER SOURCES FOR MAIN ELECTRICAL POWER.

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**SUBSYSTEM NAME: ELECTRICAL POWER GENERATION: FUEL CELL**

**LRU: FUEL CELL POWERPLANT**

**CRITICALITY OF THIS**

**ITEM NAME: FUEL CELL POWERPLANT**

**FAILURE MODE: 1/1**

**FAILURE MODE:**

**EXTERNAL LEAKAGE OF OXYGEN/HYDROGEN LINES AND FITTINGS, ACCESSORY COMPONENTS AND/OR POWER SECTION.**

**MISSION PHASE: DO DE-ORBIT  
LS LANDING/SAFING**

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:  
MECHANICAL SHOCK, VIBRATION, FATIGUE, CORROSION, PRESSURE BUILDUP.**

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES**

**REDUNDANCY SCREEN**      A) N/A  
   B) N/A  
   C) N/A

**PASS/FAIL RATIONALE:**

A)

B)

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

**LOSS OF REDUNDANCY - LOSS OF FCP DUE TO LOSS OF REACTANT. CREW ACTION IS REQUIRED TO SHUT DOWN FCP FOR ISOLATION OF REACTANT LEAK IN FUEL CELL.**

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**(B) INTERFACING SUBSYSTEM(S):**

DEGRADATION OF INTERFACE FUNCTION - REDUCED ELECTRICAL POWER SUPPLY TO EPD&C.

**(C) MISSION:**

NO EFFECT AFTER LOSS OF ONE FUEL CELL. MINIMUM DURATION MISSION INVOKED. LOSS OF FUEL CELL REDUNDANCY. (CAPABILITY EXISTS FOR SAFE RETURN ON ONE OF THREE FUEL CELLS.)

**(D) CREW, VEHICLE, AND ELEMENT(S):**

UNDETECTED GROSS LEAKAGE (1.5 LB/HR OR GREATER) OF H<sub>2</sub> MAY RESULT IN EXPLOSIVE MIXTURE IN MIDBODY DURING ENTRY. NO EFFECT ON CREW OR VEHICLE AFTER LOSS OF ONE FCP. LOSS OF TWO FCP'S DURING ASCENT WILL RESULT IN LOSS OF CREW AND VEHICLE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

STAINLESS STEEL WELDED OR BRAZED CONSTRUCTION. MACHINED HOUSINGS, MECHANICAL O-RINGS AND GASKETS. STAINLESS STEEL PLUMBING WITH HIGH PRESSURE STAINLESS STEEL OR INCONEL FITTINGS IN PRESSURE CARRYING SYSTEMS. PROOF SAFETY FACTOR OF 2.0 AND ULTIMATE SAFETY FACTOR 4.0.

FCP DESIGNED TO WITHSTAND STATIC LOADS OF 25G. MOUNTING BRACKETS CAPABLE OF WITHSTANDING LOADS IN EXCESS OF 9G. PLUMBING INSTALLATION COMPATIBLE WITH 40-50G SHOCK LEVELS (STRESS ANALYSIS).

GROSS LEAKAGE DETECTABLE WITH REACTANT FLOWMETERS, TANK QUANTITIES AND PRESSURES. LEAKAGE CAN BE ISOLATED VIA REACTANT SHUT OFF VALVES. REACTANT COMPONENTS ARE COMPATIBLE WITH REACTANTS.

**(B) TEST:**

ALL COMPONENTS ARE PROOF TESTED TO TWICE MAXIMUM WORKING PRESSURE. ALL LINES AND COMPONENTS WITHSTOOD EXTENSIVE PRESSURE CYCLING DURING DEVELOPMENT PROGRAM.

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DEVELOPMENT VIBRATION TESTING GREATER THAN 10 TIMES EQUIVALENT DAMAGE OR ACCUMULATED ENERGY LEVELS EXPERIENCED IN FLIGHT. FLEXURE FATIGUE CERTIFICATION TESTING PERFORMED ON LINES: 200K IMPULSE FATIGUE CYCLES, 10,000K FLEXURE FATIGUE CYCLES. SIXTY MISSION EQUIVALENT QUALIFICATION VIBRATION TESTING PERFORMED AT FUEL CELL POWERPLANT LEVEL.

ATP PRESSURE DECAY TESTS VERIFY SYSTEMS LEAKAGE INTEGRITY.

TURNAROUND PRESSURE DECAY TESTING VERIFIES LEAKAGE INTEGRITY PRELAUNCH.

GROSS LEAKAGE IS DETECTABLE WITH REACTANT FLOWMETERS, TANK QUANTITIES, AND PRESSURES.

OMRSD: MIDBODY MONITORED PRELAUNCH FOR HAZARDOUS GAS. DURING TURNAROUND, FUNCTIONAL TESTS ARE MONITORED TO VERIFY PRESSURE AND FLOW RATES ARE WITHIN SPECIFIED LIMITS. REACTANT CONSUMPTION IS MONITORED DURING PRELAUNCH AND FLIGHT OPERATIONS. NORYL END PLATE INSULATORS CHECKED FOR H2 LEAKAGE EACH TURNAROUND.

**(C) INSPECTION:**

**RECEIVING INSPECTION**

DIMENSIONAL INSPECTIONS ARE PERFORMED AT RECEIVING, IN PROCESS, AND ACCEPTANCE SEQUENCES. MATERIAL LOT SAMPLES ARE FORWARDED TO A TEST LAB FOR CERTIFICATION ANALYSIS. WELD FILLER METAL IS CERTIFIED BY LAB TESTING AND MATERIAL CONTROL LAB SPECIFICATIONS.

**CONTAMINATION CONTROL**

DETAIL PARTS AND ASSEMBLIES ARE SOLVENT CLEANED PER APPROVED PROCEDURES AND DOUBLE BAGGED AS REQUIRED TO PREVENT CONTAMINATION. ASSEMBLY OPERATIONS ARE PERFORMED UNDER CONTROLLED CONDITIONS USING PROCEDURES WHICH MAINTAIN CLEANLINESS AND WHICH SPECIFY APPROPRIATE HANDLING PRECAUTIONS. CLEANLINESS OF OPERATING/TEST FLUIDS IS MAINTAINED THROUGH SAMPLING AND/OR FILTRATION. THE ASSEMBLED FUEL CELL UTILIZES CAPS OR CLOSURES ON ALL FLUID FITTINGS AND THE SHIPMENT/STORAGE OF THE FUEL CELL IS IN A NITROGEN PRESSURIZED METAL SHIPPING CONTAINER.

**ASSEMBLY/INSTALLATION**

ALL TORQUING OPERATIONS ARE VERIFIED BY QC. INLET/OUTLET ACCESS TUBES BRAZING PROCESS AND SEQUENCE IS VERIFIED BY INSPECTION. ALL SOLDER CONNECTIONS ARE VISUALLY INSPECTED AT A MINIMUM OF 4X MAGNIFICATION IN ACCORDANCE WITH NH8 5300.4 (3A).

NONDESTRUCTIVE EVALUATION RADIOGRAPHIC INSPECTION PERFORMED ON ALL WELDS AND WELD REPAIRS.

**TESTING**

FUNCTIONAL AND LEAKAGE REQUIREMENTS ARE VERIFIED DURING ACCEPTANCE TEST. RESULTS OF THE ATP ARE OBSERVED AND VERIFIED BY QC.

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**(D) FAILURE HISTORY:**

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

CAR NO. AC0409-010 SUPPLIER, ATP  
LOW LEVEL H2 LEAKAGE DETECTED AT THE NORYL END CELL INSULATOR PLATE INSPECTION VERIFIED THE LEAK TO BE CAUSED BY A CRACK APPROXIMATELY 0.12 INCHES LONG. THE INVESTIGATION CONCLUDED THE CAUSE TO BE A SURFACE IMPERFECTION AT A LOCAL AREA OF ORIENTED FIBERS WHICH INDUCED THE CRACK TO INITIATE AND PROPAGATE. CORRECTIVE ACTION INCLUDES: THE INSPECTION OF ALL INSULATOR/HEATER PLATES IN INVENTORY AND ON ORDER TO BE CONDUCTED AT BOTH THE SUPPLIER AND SUBCONTRACTOR TO SCREEN OUT PLATES WITH CRACKS. AND ALL PLATES TO BE PRESSURE TESTED AT ROOM TEMPERATURE AT 1.5 TIMES OPERATING PRESSURE FOR 10 CYCLES.

CAR NO. AC8062-010 SUPPLIER, PRE-ATP  
LOW LEVEL EXTERNAL LEAKAGE AT THE ACCESSORY END NORYL INSULATOR PLATE. INSPECTION VERIFIED THE LEAK TO BE CAUSED BY A CRACK APPROXIMATELY 0.16 INCHES LONG. THE INVESTIGATION CONCLUDED THE CAUSE TO BE A PARALLEL ORIENTATION OF THE GLASS FIBERS IN A SECTION WHICH CAUSED A WEAKNESS IN THE AREA, RESULTING IN THE FRACTURE. SINCE NO FAULT WAS FOUND IN THE MATERIAL (FIBER ORIENTATION BEING A RANDOM PROCESS OCCURRING DURING MOLDING OPERATIONS), NO CORRECTIVE ACTION WAS AVAILABLE AT THE MANUFACTURING LEVEL. ALTHOUGH THE PROBLEM WAS DETECTED PRE-ATP, THE OMRSD WAS REVISED TO INCLUDE A LEAK CHECK AT THE INSULATOR PLATE MANIFOLDS TO PREVENT THE PROBLEM FROM GOING UNDETECTED IN THE FIELD.

**(E) OPERATIONAL USE:**

CREW ACTION IS REQUIRED TO SHUTDOWN FCP. FCP SHUTDOWN PROCEDURE INCLUDES CLOSING THE REACTANT VALVES. ONBOARD PROCEDURES MANAGE POWER FOR LOSS OF ONE FCP.

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- APPROVALS -

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PAE MANAGER : D. F. MIKULA  
PRODUCT ASSURANCE ENGR : L. X. DANG  
DESIGN ENGINEERING : MUSTIN, LLOYD  
NASA SSMA :  
NASA SUBSYSTEM MANAGER :

*D.F. Mikula* 29-JAN-96  
*L.X. Dang* 31-14-96  
*Mustin, Lloyd* 3-28-96  
*Robert G. Keller* 2/1/97  
*Robert L. W. ...* 7/1/97