

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.

## FAILURE MODES EFFECTS ANALYSIS FMEA - CIL FAILURE MODE

NUMBER: 04-1A-0101-08

REVISION#: 1 03/25/96

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION: FUEL CELL

LRU: FUEL CELL POWERPLANT

CRITICALITY OF THIS

ITEM NAME: FUEL CELL POWERPLANT

FAILURE MODE: 1R2

FAILURE MODE:  
REGULATOR LEAKAGE  
GROSS VENTING

MISSION PHASE: LO LIFT-OFF  
DO DE-ORBIT

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

CAUSE:  
MECHANICAL SHOCK, VIBRATION, FATIGUE, CORROSION, CONTAMINATION.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS  
B) PASS  
C) PASS

PASS/FAIL RATIONALE:  
A)

B)

C)

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- FAILURE EFFECTS -

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(A) SUBSYSTEM:  
LOSS OF REDUNDANCY - FCP SHUTDOWN DUE TO GROSS VENTING WITH REGULATOR  
BEING UNABLE TO MAINTAIN SUFFICIENT OPERATING PRESSURE. CREW ACTION

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REQUIRED TO SHUT DOWN FCP IF INSUFFICIENT REACTANTS AVAILABLE TO COMPLETE MISSION.

**(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.  
(CAPABILITY EXISTS FOR SAFE RETURN ON 1 OF 3 FUEL CELLS.)

**(D) CREW, VEHICLE, AND ELEMENT(S):**  
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. LOSS OF SECOND FCP DURING DESCENT LOSES CREW/VEHICLE IF INSUFFICIENT TIME IS AVAILABLE FOR AN ELECTRICAL LOAD RECONFIGURATION RESULTING IN THE INABILITY OF THE SINGLE REMAINING FUEL CELL TO SUPPLY ADEQUATE ELECTRICAL POWER.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
SAME AS (D).

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**  
REGULATOR MATERIALS ARE COMPATIBLE WITH REACTANTS AND WILL NOT DEGRADE OVER THE LIFE OF THE FUEL CELL. THE ALUMINUM HOUSINGS ARE ANODIZED TO PREVENT CORROSION.

REGULATOR SUPPLY SYSTEM CAPABLE OF SUPPLYING OVER 2 TIMES FLOW REQUIRED FOR NORMAL FUEL CELL OPERATION.

REACTANTS ARE SUPPLIED TO THE FCP'S THROUGH A 25 MICRON ABSOLUTE FILTER.

REGULATOR HAS 10 MICRON INLET SCREEN TO PREVENT CONTAMINATION. DESIGN MINIMIZES SLIDING PARTS; ANEROID UTILIZES TEFLON SLEEVE TO PREVENT BINDING.

**(B) TEST:**

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THE PRESSURE REGULATOR IS LEAKAGE TESTED DURING THE COMPONENT PROOF AND LEAKAGE TEST. THE ATP VERIFIES PROPER REGULATOR FUNCTION AND FUEL CELL PERFORMANCE. PREFLIGHT AND POSTFLIGHT ANALYSIS DETERMINES ACCEPTABLE SYSTEM PERFORMANCE.

DEVELOPMENT VIBRATION TESTING GREATER THAN 10 TIMES EQUIVALENT DAMAGE OR EQUIVALENT ACCUMULATED ENERGY LEVELS EXPERIENCED DURING FLIGHT.

SIXTY MISSION EQUIVALENT QUALIFICATION VIBRATION TESTING PERFORMED AT FUEL CELL POWERPLANT LEVEL (OPERATING TEST). FUEL CELL COMPONENTS HAVE DEMONSTRATED ABILITY TO WITHSTAND VIBRATION LEVELS HIGHER THAN FLIGHT LEVELS (DEVELOPMENT TEST). 4133 HOURS OF OPERATION DEMONSTRATED DURING FUEL CELL DEVELOPMENT PROGRAM.

OMRSD: REACTANT FLOW TO STACK IS REQUIRED FOR FCP OPERATION. REACTANT CONSUMPTION IS MONITORED DURING PRELAUNCH OPERATIONS. TURNAROUND TESTS VERIFY NO REGULATOR VENTING.

**(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 ARE VERIFIED BY INSPECTION. ALL SOLDER CONNECTIONS ARE VISUALLY INSPECTED AT A MINIMUM OF 4X MAGNIFICATION IN ACCORDANCE WITH NHB 5300.4 (3A).

**NONDESTRUCTIVE EVALUATION**

ALL WELDS AND WELD REPAIRS REQUIRE 100% NONDESTRUCTIVE EVALUATION TESTING AS PER VISUAL (10X) AND X-RAY, IN ADDITION TO LEAK CHECK USING MASS SPECTROMETER WHICH IS VERIFIED BY INSPECTION.

**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.

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE.

(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 OR TWO FCP(S).

- APPROVALS -

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

*D.F. Mikula 29 MAR 96*  
*L. X. Dang 3/29/96*  
*Mustin, Lloyd 3-28-96*  
*SSMA 4/1/96 6/14/97*  
*Howard L. Walker 6/16/97*