

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

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

PART DATA

	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

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.

PAGE: 2

PRINT DATE: 09/27/89

SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 04-1A-0101-14

SUBSYSTEM: ELECTRICAL POWER GENERATION: FUEL CELL REVISION# 2 09/26/89
LRU :FUEL CELL POWERPLANT
ITEM NAME: FUEL CELL POWERPLANT CRITICALITY OF THIS FAILURE MODE:1R3

FAILURE MODE:
WATER PURITY SENSOR FAILS LOW (OFF).

MISSION PHASE:
PL PRELAUNCH
LO LIFT-OFF
OO CN-ORBIT
DO DE-ORBIT
LS LANDING SAFING

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

CAUSE:
INTERNAL CIRCUIT FAILURE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)

B)
FAILURE GIVES LOW PH (NORMAL) INDICATION - FAILURE NOT DETECTABLE.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
NO EFFECT - LOSS OF REDUNDANCY.

SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 04-1A-0101-14

(B) INTERFACING SUBSYSTEM(S):

NO EFFECT FIRST FAILURE. SECOND FAILURE WILL RESULT IN THE LOSS OF VISIBILITY INTO FLOODING (REFERENCE CIL 04-1A-0101-3).

(C) MISSION:

SAME AS (B).

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

SAME AS (B).

(E) FUNCTIONAL CRITICALITY EFFECTS:

SAME AS (B).

 - DISPOSITION RATIONALE -

■ (A) DESIGN:

THE WATER PURITY SENSOR AND SIGNAL CONDITIONING ASSEMBLY MEASURES THE ELECTRICAL CONDUCTIVITY OF FCP PRODUCT WATER TO DETECT THE PRESENCE OF KOH ELECTROLYTE (FMEA 04-1A-0101-3). IT PROVIDES AN EVENT OUTPUT SIGNAL (5 VDC) FOR CREW AND GROUND ALERT. THE DEVICE SAMPLES THE ENTIRE FUEL CELL WATER OUTPUT AND, THROUGH A TEMPERATURE COMPENSATED RESISTANCE BRIDGE NETWORK, SENSES CHANGES IN THE WATER CONDUCTIVITY. VALUES GREATER THAN A PREDETERMINED VALUE (EQUIVALENT TO PH 9.5-10 KOH CONTAMINATED WATER) PRODUCE THE 5 VDC OUTPUT.

THE SENSOR CONSISTS OF A PAIR OF NICKEL ELECTRODES CONTAINED IN AN AMS 2468 ALUMINUM HOUSING AND SUPPORTED BY AN EPOXY RESIN HOLDER. THE HOUSING IS DESIGNED TO A BURST FACTOR OF 4 TIMES OPERATING PRESSURE. THE ELECTRONIC SIGNAL CONDITIONING CONSISTS OF DISCRETE OPPL COMPONENTS, DERATED FOR THERMAL AND ELECTRICAL STRESSES, MOUNTED ON PRINTED CIRCUIT BOARDS AND CONTAINED WITHIN A HERMETICALLY SEALED METAL CASE. SENSORS ARE CONNECTED TO THE ELECTRONICS THROUGH A GLASS BEAD FEED-THRU. INPUT POWER AND OUTPUT SIGNAL PASS THROUGH GLASS BEAD ELECTRICAL CONNECTORS.

EACH OF THE ORBITER FUEL CELLS CONTAINS ITS OWN WATER PURITY SENSOR ASSEMBLY, AND A COMMON SENSOR ASSEMBLY IS LOCATED IN THE VEHICLE WATER DELIVERY SYSTEM. EACH FUEL CELL SENSOR ASSEMBLY IS SUPPLIED 115 VAC SINGLE PHASE POWER FROM A SEPARATE VEHICLE INVERTER. THE COMMON SENSOR ASSEMBLY IS POWERED FROM THE SAME INVERTER SYSTEM AS THE FUEL CELL 2 SENSOR, BUT FROM A DIFFERENT PHASE. ALL OUTPUTS ARE PROCESSED BY DIFFERENT MOMS.

■ (B) TEST:

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

SHUTTLE CRITICAL ITEMS LIST - ORBITER NUMBER: 04-1A-0101-14

DEVELOPMENT PROGRAM. 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, 10,000 FLEXURE FATIGUE CYCLES. 4133 HOURS OF OPERATION DEMONSTRATED DURING FUEL CELL DEVELOPMENT PROGRAM.

ATP VERIFIES LEAKAGE INTEGRITY, SENSOR RESISTANCE, TEMPERATURE COMPENSATION AND ACTUATION POINT, CIRCUIT ISOLATION, POWER CONSUMPTION, INSULATION RESISTANCE, DIELECTRIC WITHSTANDING VOLTAGE (HIGH POTENTIAL), PROPER GROUND AND BONDING FUNCTIONS.

OMRSD: GROUND CHECKS VERIFY THE SENSORS BETWEEN FLIGHTS. A POTASSIUM BICARBONATE/WATER SOLUTION IS USED TO VERIFY SENSOR FUNCTION AND SIGNAL PATH CONTINUITY.

(C) INSPECTION:

RECEIVING INSPECTION

INCOMING MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

ALL PRINTED BOARDS ARE VERIFIED TO BE CLEANED WITH ETHYL ALCOHOL. THE INTERNAL FLUID AREAS ARE VERIFIED TO MAINTAIN CLEANLINESS 500A. FLUSHING OF THE INNER ELECTRODE ASSEMBLY WITH REAGENT GRADE ACETONE IS VERIFIED.

ASSEMBLY/INSTALLATION

MECHANICAL HARDWARE DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. ELECTRICAL PARTS ARE VISUALLY INSPECTED. ETCHED WIRES ARE VERIFIED BY INSPECTION. LUBRICATION OF O-RING WITH SILICONE COMPOUND IS VERIFIED BY INSPECTION. SENSOR CELL COATED WITH MIXED EPOXY FOR PROTECTION. SENSOR COATING IS VERIFIED.

NONDESTRUCTIVE EVALUATION

METALLURGICAL JOINTS ARE VERIFIED BY RADIOGRAPHIC INSPECTION. HELIUM LEAKAGE CHECK IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

ELECTRON BEAM WELDING, BRAZING, AND HEAT TREATMENT ARE VERIFIED BY INSPECTION. WIRE CRIMPING, SOLDERING, AND CLASS C ELECTRICAL BONDING ARE VERIFIED.

TESTING

ATP IS VERIFIED BY INSPECTION. THIS INCLUDES THE PROOF PRESSURE TEST AND THE INSULATION RESISTANCE TEST.

HANDLING/PACKAGING

PROTECTIVE CAPS AND PACKAGING FOR SHIPMENT ARE VERIFIED BY INSPECTION.

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■ (D) FAILURE HISTORY:

CAR NO. AC7554 SUPPLIER, PRE ATP

WATER PURITY SENSOR EXHIBITED AN INTERNAL LEAK TO SENSOR. THE INTERNAL LEAKAGE WAS A RESULT OF INADEQUATE SENSOR BONDING TECHNIQUE AND MISMATCH BETWEEN PROOF PRESSURE AND FCP ATP REQUIREMENTS. CORRECTIVE ACTION INCLUDED A SENSOR BONDING TECHNIQUE IMPROVEMENT AND A PROOF PRESSURE INCREASE TO MATCH FCP ATP.

CAR NO. AD4962 SUPPLIER, ATP

WATER PURITY SENSOR EXHIBITED AN INTERNAL LEAK TO SENSOR. A HISTORICAL REVIEW SHOWED THAT THE WATER PURITY SENSOR WAS ORIGINALLY BUILT IN THE SAME TIME PERIOD AS TWO UNITS WITH CAVITY LEAKAGE. BECAUSE BEHAVIOR UNDER PRESSURE TEST CONDITIONS IS IDENTICAL, IT WAS CONCLUDED THAT THE SAME BONDING TECHNIQUE WAS USED. THE CAUSE FOR THE WATER PURITY SENSOR LEAK INTERNAL TO SENSOR WAS DUE TO OUTER ELECTRODE HERMETIC SEAL INADEQUATE BONDING TECHNIQUE, COMPOUNDED BY INADEQUATE ATP LEAK TEST. CORRECTIVE ACTION INCLUDED A MODIFIED BONDING TECHNIQUE AND AN ACCEPTANCE TEST PERFORMED AT HIGHER PRESSURE.

(E) OPERATIONAL USE:

FUEL CELL 1 (2,3) PH: FLOODING WOULD BE DETECTED BY THE COMMON PH SENSOR. THE FUEL CELL SUBSTACK DELTA VOLTAGES (CPM) WOULD BE MONITORED TO DETERMINE WHICH FUEL CELL IS FLOODING.

- APPROVALS -

RELIABILITY ENGINEERING: G. M. PIKUS
DESIGN ENGINEERING : J. F. WILLIAMS
QUALITY ENGINEERING : J. COURSEN
NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

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