PRINT DATE: 06/21/97

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: M5-6MB-2301-G -X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC
REVISION: 9 04/16/96

PART DATA

	PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
LRU	: H2/O2 CONTROL BOXES	V070-764470
SRU	: CURRENT LEVEL DETECTOR	MC431-0137-0001

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CURRENT LEVEL DETECTOR - "SHORT TO STRUCTURE" PROTECTION CIRCUIT FOR LO2 TANKS 1 THRU 9 HEATERS

REFERENCE DESIGNATORS:
40V76A141CLD1
40V76A141CLD2
40V76A141CLD3
40V76A141CLD4
40V76A142CLD1
40V76A142CLD2
40V76A142CLD3
40V76A142CLD4
40V76A143CLD1
40V76A143CLD2
40V76A143CLD3
40V76A143CLD4
40V75A144CLD1
40V76A144CLD2
40V76A144CLD3
40V76A144CLD4
40V76A217CLD1
40V76A217CLD2
40V76A217CLD3
40V76A217CLD4
40V76A218A1CLD1
40V76A218A1CLD2
40V76A218A1CLD3
40V76A218A1CLD4
40V76A218A2CLD1
40V76A218A2CLD2
40V76A218A2CLD3
40V75A218A2CLD4
40V76A218A3CLD1

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40V76A218A3CLD2
40V76A218A3CLD3
40V76A218A3CLD4
40V76A218A4CLD1
40V76A218A4CLD2
40V76A218A4CLD3
40V76A218A4CLD4

QUANTITY OF LIKE ITEMS:
FOUR PER H2/O2 CONTROL BOX

FUNCTION:
PROVIDES FOR DETECTION OF DIFFERENTIAL CURRENT CONDITIONS IN THE LO2 TANK HEATER CIRCUIT, AND PROVIDES A TRIP SIGNAL TO THE LATCHING HYBRID DRIVER CONTROLLER TO INITIATE SHUTDOWN OF THE AFFECTED LO2 TANK HEATERS.

- APPROVALS -

PRODUCT ASSURANCE ENGR : J. NGUYEN
DESIGN ENGINEERING : T. D. NGUYEN
Editorially Approved JSC

J. Nguyen 7/2/97
7/2/97
9-12-96

PRINT DATE: 09/05/92

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

REVISION# 9 09/09/92

SUBSYSTEM: ELECTRICAL POWER GENERATION - CRYO, GENERIC
LRU H2/O2 CONTROL BOXES
ITEM NAME: CURRENT LEVEL DETECTORS

CRITICALITY OF THIS FAILURE MODE: 1R3

FAILURE MODE:
LOSS OF OUTPUT

MISSION PHASE:
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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

CAUSE:
PIECE PART FAILURE, CONTAMINATION, VIBRATION, MECHANICAL SHOCK, THERMAL STRESS, PROCESSING ANOMALY

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)

B)
REDUNDANCY SCREEN "B" FAILS BECAUSE THE OUTPUT OF THE CURRENT LEVEL DETECTOR IS NOT MONITORED IN FLIGHT EXCEPT WHEN THE DAILY CURRENT LEVEL DETECTOR TEST IS PERFORMED.

C)

PRINT DATE: 09/09/92

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: MS-6MB-2301-G-01

- FAILURE EFFECTS -

(A) SUBSYSTEM:
DEGRADATION OF REDUNDANCY IN DETECTING A DIFFERENTIAL HEATER CURRENT.

(B) INTERFACING SUBSYSTEM(S):
DEGRADATION OF REDUNDANT PROTECTION AGAINST LO2 TANK HEATER ELEMENT SHORTING TO STRUCTURE.

(C) MISSION:
NO EFFECT - FIRST FAILURE

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT - FIRST FAILURE

(E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE DUE TO THE FOLLOWING SCENARIO: 1) LOSS OF OUTPUT OF CURRENT LEVEL DETECTOR (CLD), 2) SECOND SERIES REDUNDANT CLD FAILS, 3) LO2 TANK HEATER SHORTS THROUGH ONE OF ITS LAYERS OF INSULATION, AND 4) SAME LO2 TANK HEATER SHORTS TO STRUCTURE THROUGH ITS SECOND LAYER OF INSULATION, POSSIBLY INDUCING LOCALIZED HOT SPOTS, RESULTING IN POSSIBLE LO2 TANK RUPTURE/EXPLOSION.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

- DISPOSITION RATIONALE -

(A) DESIGN

FUNCTIONAL DESCRIPTION

THE CURRENT LEVEL DETECTOR (CLD) IS A CURRENT TRANSDUCER THAT MEASURES THE RESULTANT DC CURRENT OF ONE OR MORE LINES AND PROVIDES A LOW LEVEL (LOGIC "0") OUTPUT VOLTAGE WHEN THE INPUT PASS-THRU CURRENT THROUGH THE TOROID ASSEMBLY IS BELOW THE TRIP POINT AND A HIGH LEVEL (LOGIC "1") WHEN THE PASS-THRU CURRENT IS ABOVE THE TRIP POINT. IF AN ELECTRICAL FAULT TO STRUCTURE OCCURS IN A HEATER CIRCUIT AND THE TRIP POINT IS EXCEEDED, THE AFFECTED CLD PAIR WILL PROVIDE A LOGIC "1" SIGNAL TO THE CIRCUITS CONTROLLING THE HEATERS TO REMOVE THE CURRENT FEEDING THE FAULT.

PHYSICAL DESCRIPTION

TWO PAIRS OF CLD'S ARE INSTALLED WITHIN EACH CRYO HEATER CONTROL ASSEMBLY (OR H2/O2 CONTROL BOX) WHERE EACH PAIR OF CLD'S SENSES DIFFERENTIAL CURRENT FLOWING IN THE PRSD LO2 TANK HEATER CIRCUITS "A" OR "B". THERE ARE ONLY THREE ELECTRICAL INTERFACE CONNECTIONS PER CLD. EACH UNIT IS MANUFACTURED USING PRINTED CIRCUIT BOARD WIRING, ALL PROPERLY DERATED SOLID STATE QUALIFIED PARTS, ALUMINUM NICKEL-PLATED EPOXY-COATED ENCLOSURE, EXPLOSION PROOF DESIGN WHERE THE SURFACE TEMPERATURE OF THE CASE AND INTERNAL COMPONENTS SHALL NOT EXCEED 352 DEGREE F, ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY REQUIREMENTS FOR CLASS ID EQUIPMENT, WEIGHT OF 11.5 OZ (MAXIMUM), AND THE ENTIRE UNIT IS FILLED WITH A SILICONE-RUBBER POTTING COMPOUND FOR MOISTURE PREVENTION AND SHOCK AND VIBRATION ABSORPTION.

THE CERTIFIED PART NUMBER IS MC431-0137-0001.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

(B) TEST

QUALIFICATION/CERTIFICATION

CERTIFICATION TESTING AND ANALYSIS ARE COMPLETED AND APPROVED. QUALIFICATION TESTS INCLUDED THE FOLLOWING:

CAUSES			
a Piece part failure		d Mechanical shock	
b Contamination		e Processing anomaly	
c Vibration		f Thermal stress	

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
ACCEPTANCE	X	X			X	X
CORROSION (5 PERCENT SALT FOG, 48 HOURS)		X			X	
HUMIDITY		X			X	
THERMAL VACUUM (20 TO 130 DEG F AT MOUNT, 10-6 TORR, 5 CYCLES, 120 HRS)	X				X	X
TEMPERATURE, AMBIENT - NONOPERATIONAL (-65 DEG F MIN, 165 DEG F MAX)						X
RANDOM VIBRATION (0.04g2/HZ TO 0.15g2/HZ, 48 MIN PER AXIS)	X		X		X	
DESIGN SHOCK (20g IN EACH OF 3 AXIS)				X		
ELECTROMAGNETIC COMPATIBILITY	X				X	
EXPLOSIVE ATMOSPHERE	X					
OPERATIONAL LIFE (5,000 ON/OFF CYCLES, 40,000 HRS)	X				X	
DIELECTRIC WITHSTANDING VOLTAGE (DWV, AT 1000 VRMS, 60 HZ)		X			X	
INSULATION RESISTANCE (2 MEGOHMS, 500 VDC)		X			X	
FUNCTIONAL AND PERFORMANCE EXAMINATION	X	X			X	

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FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

ACCEPTANCE AND SCREENING

ALL PRODUCTION UNITS ARE SUBJECTED TO A 100% ACCEPTANCE TESTING WHICH INCLUDE THE FOLLOWING:

CAUSES

a	Piece part failure	d	Mechanical shock
b	Contamination	e	Processing anomaly
c	Vibration	f	Thermal stress

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
VISUAL AND MECHANICAL EXAMINATION	X	X			X	
FUNCTIONAL AND PERFORMANCE (ABBREVIATED)	X				X	
THERMAL (ATT)					X	X
DIELECTRIC WITHSTANDING VOLTAGE		X			X	
INSULATION RESISTANCE		X			X	
FUNCTIONAL AND PERFORMANCE	X				X	
POWER CONSUMPTION						
SENSE CURRENT						
SHORT-CIRCUIT PROTECTION						
OUTPUT ISOLATION						
OUTPUT LEVEL						
TRIP LEVEL						
RESPONSE						
VISUAL AND MECHANICAL EXAMINATION (FINAL)	X				X	

TEST

THE OPERATION OF THE CURRENT LEVEL DETECTOR IS VERIFIED IN FLIGHT DURING LO2 TANK HEATER CURRENT LEVEL SENSOR TESTS,

(TANKS 1-5) PERFORM GROUND TURNAROUND TEST WHEN VALID VERIFICATION IS UNOBTAINABLE IN FLIGHT.

(TANKS 6-9) TESTS PERFORMED PRIOR TO FIRST EDO FLIGHT, WHEN VALID VERIFICATION IS UNOBTAINABLE IN FLIGHT, OR AFTER LRU REPLACEMENT.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

(C) INSPECTION

RECEIVING INSPECTION (FAILURE CAUSE a,b,e)

RECEIVING INSPECTION VERIFIES ALL INCOMING PARTS AND MATERIALS, INCLUDING PERFORMANCE OF VISUAL AND DIMENSIONAL EXAMINATIONS, IN ACCORDANCE WITH REQUIREMENTS. CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL (FAILURE CAUSE b)

A CONTROLLED WORK AREA IS UTILIZED FOR ASSEMBLY AND TEST. QUALITY CONTROL (QC) VERIFIES PROPER MAINTENANCE OF CLEANLINESS CONTROL.

ASSEMBLY/INSTALLATION (FAILURE CAUSE a,b,e)

DETAILED INSPECTION PERFORMED ON ALL PARTS PRIOR TO NEXT ASSEMBLY. SOLDERING AND ELECTRICAL TERMINATIONS VERIFIED BY INSPECTION. CORROSION PROTECTION PROVISIONS VERIFIED BY INSPECTION.

CRITICAL PROCESSES (FAILURE CAUSE a,b,e)

ALL CRITICAL PROCESSES AND CERTIFICATIONS, INCLUDING SOLDERING, ARE MONITORED AND VERIFIED BY INSPECTION.

TESTING (FAILURE CAUSE a,b,e,f)

ACCEPTANCE TESTS, INCLUDING PHYSICAL, THERMAL, INSULATION RESISTANCE, DIELECTRIC STRENGTH, FUNCTIONAL AND PERFORMANCE ARE OBSERVED AND VERIFIED BY QC.

HANDLING/PACKAGING (FAILURE CAUSE a,b,c,d)

PART PRESERVATION, PACKAGING AND PROTECTION IS VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2302-G-01

(D) FAILURE HISTORY

FAILURE MODE: LOSS OF OUTPUT

CAR AC4799
WHILE PERFORMING THE OV-099 EGRESS SWITCH LIST, THE CRYO HEATER LO2 TANK SENSOR CIRCUIT BREAKER WOULD NOT REMAIN IN THE CLOSED OR SET POSITION. ANALYSIS ISOLATED THE PROBLEM TO A NEAR SHORT CIRCUIT BETWEEN TERMINALS 1 AND 3 OF A CLD CAUSED BY A FILTER CAPACITOR INSTALLED BACKWARDS; AN ASSOCIATED RESISTOR HAD OVERHEATED AND BURNED A HOLE IN THE PRINTED CIRCUIT BOARD. THIS CONDITION WAS ATTRIBUTED TO AN ISOLATED WORKMANSHIP ESCAPE AND HAS BEEN CALLED TO THE ATTENTION OF THE MANUFACTURING AND INSPECTION PERSONNEL.

FAILURE MODE: INADVERTENT OUTPUT

CAR AB8427
DURING FUNCTIONAL TEST OF THE NEXT LEVEL OF ASSEMBLY (CRYO HEATER CONTROL ASSEMELY - H2/O2 CONTROL BOX), ALL FOUR CLD'S PROVIDED AN OUTPUT OF 28 VDC WHEN NO CURRENT WAS FLOWING THROUGH THE LINES OF THE SENSING COIL; THE OUTPUT SHOULD HAVE BEEN ZERO. ADDITIONAL EVALUATION DISCLOSED THAT THIS OUTPUT VOLTAGE, AFTER ONE TO TWO SECONDS FROM INITIAL POWER APPLICATION, DECREASED APPROXIMATELY TWO VOLTS. ANALYSIS OF THE CLD'S REVEALED ELECTRICALLY OPEN OR DEGRADED RESISTORS AND OPEN DIODES WHICH INDICATED THAT A TRANSIENT POTENTIAL BETWEEN THE COMMON SIGNAL RETURN AND THE CHASSIS GROUND COULD HAVE CREATED THE DAMAGE. THIS ELECTRICAL OVERSTRESS OCCURRED DURING THE BEECH AIRCRAFT CRYO SYSTEM CONFIGURATION TESTS. PROBLEMS OCCURRED IN THE CONTROL PRESSURE CONDITIONER (CPC) WITHIN THE CRYO HEATER CONTROL ASSEMBLY DURING THE THERMAL-VACUUM TEST. POWER GLITCHES WERE EXPERIENCED AND THE CPC WAS ELECTRICALLY OVERSTRESSED. ALL AVAILABLE EVIDENCE INDICATES THAT THE CLD'S WERE SUBJECTED TO AN UNKNOWN TRANSIENT DURING THE BEECH CRYO SYSTEM THERMAL-VACUUM TEST.

SINCE THE BEECH TEST WAS A ONE TIME TEST, NO CORRECTIVE ACTION WAS CONSIDERED NECESSARY SINCE IT WAS A SYSTEM FAILURE RATHER THAN A FAILURE OF THE CLD. ALL FLIGHT HARDWARE HAS OR WILL HAVE PASSED A FORMAL ACCEPTANCE TEST PRIOR TO DELIVERY FOR ORBITER USAGE.

PRINT DATE: 09/09/92

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M5-6MB-2301-G-01

CAR AD8290
WHILE PERFORMING FUNCTIONAL TEST IN DOWNEY ON THE CRYO HEATER CONTROL ASSEMBLY, THE CLD GAVE A STEADY OUTPUT AT PIN NO. 2 WHEN IT SHOULD ONLY GIVE A MOMENTARY OUTPUT. FAILURE ANALYSIS BY THE SUPPLIER, AMERICAN AEROSPACE CONTROLS (AAC) DISCLOSED A DEFECTIVE SOLDER JOINT AT THE COLLECTOR OF THE Q5 TRANSISTOR. THE JOINT WAS REFLOWED AND THE CLD OPERATED AS REQUIRED. IT WAS BELIEVED THAT THE DEFECTIVE SOLDER JOINT WAS CAUSED BY AN OPERATOR IMPROPERLY FORMING THE LEAD IN CONJUNCTION WITH EXCESSIVE HEAT BEING APPLIED. THIS IS THE FIRST OCCURRENCE OF THIS TYPE OF FAILURE AND IT IS BELIEVED TO BE AN ISOLATED INCIDENT AND NOT A GENERIC PROBLEM. THE CLD'S INSTALLED ON THE ORBITERS HAVE OR WILL HAVE SUCCESSFULLY PASSED THEIR ACCEPTANCE TESTS AT THE NEXT HIGHER ASSEMBLY LEVEL ALONG WITH THE SUBSYSTEM AND COMBINED SYSTEMS CHECKOUT TESTS.

(E) OPERATIONAL USE
WHEN THE CLD FAILS ITS DAILY TEST, THE AFFECTED TANK HEATERS WILL BE DISABLED.

- APPROVALS -

PRODUCT ASSURANCE MGR	T. J. EAVENSON	T. J. Eavenson 9/14/92
PRODUCT ASSURANCE ENG	T. K. KIMURA	T. K. Kimura 9/14/92
DESIGN ENG TEAM LEADER	G. M. ANDERSON	G. M. Anderson 9.15.92
DESIGN ENGINEERING	T. D. NGUYEN	T. D. Nguyen 9/15/92
NASA RELIABILITY		12/14/92
NASA SUBSYSTEM MANAGER		12/16/92
NASA EPD&C RELIABILITY		12/14/92
NASA QUALITY ASSURANCE		RFKO
NASA EPD&C SUBSYS MGR		12/14/92