

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE

NUMBER: 03-1-0515 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1

09/09/96

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : SIGNAL CONDITIONER PACIFIC SCIENTIFIC HTL K-WEST DIV.	MC476-0148-0005

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

SIGNAL CONDITIONER, ULLAGE PRESSURE, GO2/GH2

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1
ONE ASSY

FUNCTION:

EACH ULLAGE PRESSURE SIGNAL CONDITIONER (LOCATED IN AFT AVIONICS BAY 4, 5, OR 6) POWERS/MONITORS ONE PAIR OF GO2 AND GH2 ET ULLAGE PRESSURE TRANSDUCERS AND CONTROLS ONE GH2 FLOW CONTROL VALVE (FCV). THE SIGNAL CONDITIONERS TO THE GO2 FLOW CONTROL VALVES HAVE BEEN DISCONNECTED FOR THE FIXED ORIFICE CONFIGURATION. THE SIGNAL CONDITIONER GENERATES FCV CLOSE COMMANDS TO MAINTAIN ET ULLAGE PRESSURE WITHIN A REQUIRED RANGE. ADDITIONALLY, THE SIGNAL CONDITIONERS PROVIDE 0 TO 5 VDC ANALOG SIGNALS FOR GROUND CONTROL OF ET ULLAGE PRESSURE DURING PROPELLANT LOADING, TELEMETRY, AND COCKPIT ULLAGE PRESSURE DISPLAY/CAUTION AND WARNING.

A COCKPIT SWITCH ALLOWS THE CREW TO OVERRIDE GH2 FCV CLOSE COMMANDS FROM THE SIGNAL CONDITIONERS, CAUSING ALL GH2 FCVS TO OPERATE AT HIGH FLOW.

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SUBSYSTEM NAME: MAIN PROPELLSION

LRU: SIGNAL CONDITIONER

ITEM NAME: SIGNAL CONDITIONER

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

LOSS OF CLOSE COMMAND TO GH2 FLOW CONTROL VALVE. (FCV OPEN - HIGH FLOW)

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

ELECTRICAL CIRCUIT FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS RETURN TO LAUNCH SITE

TAL TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN A) PASS
 B) PASS
 C) PASS

PASS/FAIL RATIONALE:

A)

B)

PASSES B SCREEN BECAUSE COMMAND STATUS CAN BE DETERMINED BY FCV CLOSE SOLENOID POWER INSTRUMENTATION

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LOSS OF COMMAND SIGNAL TO ONE GH2 FCV CAUSING IT TO OPEN/REMAIN OPEN.

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(B) INTERFACING SUBSYSTEM(S):

FOR NOMINAL MISSIONS NO EFFECT. REDUNDANT GH2 FCVS WOULD COMPENSATE TO MAINTAIN ULLAGE PRESSURE.

FOR RTLS AND TAL ABORTS, AN ENGINE OUT RESULTS IN THE LOSS OF ONE FCV PRESSURIZATION LEG. A SUBSEQUENT FCV FAILING OPEN ON EITHER OF THE REMAINING OPERATING ENGINE SYSTEMS RESULTS IN VENTING OF GH2 AT LOW ALTITUDE. POSSIBLE VIOLATION OF TANK MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE FIRE/EXPLOSION HAZARD EXTERNAL TO THE VEHICLE.

FOR GH2 SYSTEM, FCV CLOSE COMMANDS ARE VERIFIED ON BY LCC FROM PRE PRESSURIZATION TO T-31 SECONDS

(C) MISSION:

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION

FOR RTLS AND TAL ABORTS, POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS (C).

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/2 2 SUCCESS PATHS. TIME FRAME - ENGINE OPERATION

- 1) SIGNAL CONDITIONER FAILURE RESULTING IN LOSS OF CLOSE COMMAND TO ONE GH2 FCV CAUSING IT TO OPEN/REMAIN OPEN.
- 2) ONE OF THE FOLLOWING FAILURES ON A PARALLEL GH2 PRESSURIZATION LEG
 - ET ULLAGE PRESSURE TRANSDUCER FAILURE
 - LOSS OF A SECOND SIGNAL CONDITIONER
 - LOSS OF FCV CLOSE COMMAND HYBRID DRIVER
 - FCV FAILS IN THE HIGH FLOW POSITION

RESULTS IN EXCESSIVE GH2 ULLAGE PRESSURE CAUSING ET VENT VALVE TO RELIEVE EXCESS PRESSURE. POTENTIAL FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF THE ET MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS.

POSSIBLE LOSS OF CREW/VEHICLE

-DISPOSITION RATIONALE-

(A) DESIGN:

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THE ULLAGE PRESSURE SIGNAL CONDITIONER HAS TWO PHYSICALLY AND ELECTRICALLY ISOLATED MODULES MOUNTED ON A 6061-T6 ALUMINUM FRAME. ONE FOR GO2 AND ONE FOR GH2. EACH MODULE CONTAINS A POWER SUPPLY, SIGNAL CONDITIONER, CHECKOUT CIRCUIT, AND FCV COMMAND CIRCUIT IN A 6061-T6 BLACK ANODIZED ALUMINUM HOUSING. DYNAMIC DAMPENING OF THE INTERNALLY MOUNTED COMPONENTS IS ACHIEVED BY ENCAPSULATION IN GLASS RESIN EPOXY. THE COMPONENTS ARE MOUNTED ON SEMI-RIGID NICKEL RIBBONS AND ARE HELD IN PLACE BY THE ENCAPSULANT. THE NICKEL RIBBONS ARE CONNECTED TO AN ELECTRICAL INTERFACE CONNECTOR. EACH MODULE IS THEN EXTERNALLY SEALED AFTER CHECKOUT WITH EPOXY SEALANT TO PROVIDE AN ENVIRONMENTAL SEAL.

EACH MODULE CONTAINS AN ELECTRICAL INTERFACE CONNECTOR, WHICH IS HERMETICALLY SEALED AND SOLDERED. THE CONNECTOR IS BUILT TO THE MSFC 40M SPECIFICATIONS FOR SPACE VEHICLES. ALL ELECTRONIC COMPONENTS WERE SELECTED SO THAT THEIR USAGE MEETS THE SHUTTLE DERATING REQUIREMENTS.

CHECKOUT COMMANDS FROM THE GROUND MDM ARE DISTRIBUTED THROUGH OPTICAL ISOLATION CIRCUITS IN EACH MODULE.

FCV CLOSE COMMANDS ARE CONTROLLED ON THE BASIS OF EXCITATION TO TRANSDUCER FEEDBACK VOLTAGE RATIO, REDUCING THE EFFECTS OF EXCITATION VOLTAGE SHIFTS.

EXCITATION POWER TO THE ET ULLAGE PRESSURE TRANSDUCER IS LIMITED TO 10 MA BY CURRENT LIMITING CIRCUITRY TO MAINTAIN A SAFE CONFIGURATION IN CASE OF AN EXTERNAL SHORT CIRCUIT.

SYSTEM

SEPARATE CABLE HARNESSSES ARE USED ON THE ORBITER FOR EACH SIGNAL CONDITIONER (EACH POWERED BY A SEPARATE ORBITER MAIN BUS). THE OUTPUTS ARE FED TO SEPARATE MDMS AND VALVE LOAD DRIVERS TO MAINTAIN SIGNAL ISOLATION. TWO CABLE HARNESSSES ARE USED ON THE EXTERNAL TANK (ET) FOR CONNECTION TO THE ET TRANSDUCERS. ET AND ORBITER CABLES TO THE TRANSDUCERS ARE SHIELDED WITH A SINGLE GROUND CONNECTION AT THE SIGNAL CONDITIONER TO MINIMIZE RF NOISE PROBLEMS. THE ET MAINTAINS AN EXTRA OUTER SHIELD FOR LIGHTNING PROTECTION WITH MULTIPLE POINT GROUNDS. ET TRANSDUCER FAILURE MODES ARE DOCUMENTED BY THE ET PROJECT.

(B) TEST:

ATP

EXAMINATION OF PRODUCT

INSULATION RESISTANCE
50 VOLTS DC

DIELECTRIC STRENGTH
250 VRMS (60 HZ)

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THERMAL CYCLE

+20 DEG F TO -40 DEG F TO +140 DEG F TO +70 DEG F
60 MINUTES AT EACH TEMPERATURE

RANDOM VIBRATION

30 SECONDS FOR EACH OF 3 AXES

EXTERNAL LEAKAGE

NOT GREATER THAN 1×10^{-4} SCCS OF HELIUM

PERFORMANCE TESTS

CERTIFICATION (3 UNITS)

VIBRATION

48 MINUTES FOR EACH OF 3 AXES.

EXTERNAL LEAKAGE

NOT GREATER THAN 1×10^{-4} SCCS OF HELIUM

SHOCK

PER MIL-STD-810
BENCH HANDLING
DESIGN

LIGHTNING

PER MF0004-002.

EMC

PER MF0004-002 AND MIL-STD-462

THERMAL CYCLE

10 CYCLES +70 TO +105 TO -65 TO -165 TO +70 DEG F
60 MINUTES AT EACH TEMPERATURE

THERMAL VACUUM

6 HOURS AT 1×10^{-6} TORR
TEMPERATURE 160 DEG F

PERFORMANCE TESTS

OPERATING LIFE

1000 HOURS OF CYCLING
CYCLE PERIOD: 6 HOURS (POWER ON FOR 3 HOURS, OFF FOR 3 HOURS)
DURING THE POWER ON PHASE THE ON/OFF COMMAND IS CYCLED EVERY 5
SECONDS

POST TEST INSPECTION

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH
OMRSD.

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(C) INSPECTION:

RECEIVING INSPECTION

INCOMING PARTS ARE VERIFIED FOR MATERIAL, PHYSICAL CHARACTERISTICS, AND PROCESS CERTIFICATIONS. RECEIVING RECORDS ARE MAINTAINED FOR VERIFICATION.

CONTAMINATION CONTROL

PROPER CLEANLINESS IN ACCORDANCE WITH ASSEMBLY AND TEST REQUIREMENTS IS INSPECTED AND VERIFIED.

ASSEMBLY/INSTALLATION

ALL SOLDER AND WELD JOINTS COATED WITH 2850/CAT9 EPOXY ARE INSPECTED. INSPECTION VERIFIES ALL MODULES FILLED WITH XR-5068 ENCAPSULANT AND CURE TIME OF 2 HOURS AT 160 DEG F. TIGHTENED SCREWS AND TORQUE ARE CHECKED TO PRECLUDE STRIPPED SCREWS AND ENSURE PROPER MOUNTING. ALL EXTERIOR SURFACES OF HOUSING AND COVER MACHINED TO 63 RMS ARE CHECKED. GAP BETWEEN COVER AND CASE SEALED WITH 2850/CAT9 AND CURE TIME ARE MONITORED. MANDATORY INSPECTION POINTS ARE INCLUDED IN ASSEMBLY PROCESS.

CRITICAL PROCESSES

CONFORMAL COATING ON PWB ARE VERIFIED BY INSPECTION. ADHESIVE BONDING OF TYPE GE GLASS EPOXY BOARD TO PWB SURFACE IS CHECKED. WIRE WELDING AND LEAD SOLDERING OF COMPONENTS ARE INSPECTED IN ACCORDANCE WITH APPLICABLE REQUIREMENTS. ASSEMBLY POTTING IS VERIFIED.

NONDESTRUCTIVE EVALUATION

NOT APPLICABLE

TESTING

ATP, INCLUDING PERFORMANCE TEST, IS VERIFIED BY INSPECTION

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

THERE HAVE BEEN NO FLIGHT OR FIELD FAILURES OF THIS CONFIGURATION SIGNAL CONDITIONER FOR LOSS OF CLOSE COMMAND IN THE HISTORY OF THE PROGRAM.

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. THE FAILURE HISTORY DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE.

EARLY PRODUCTION UNITS

DURING ATP (-40 DEG F, 22 VOLT INPUT ANALOG OUTPUT ERROR TEST), THE MODULE DREW EXCESSIVE CURRENT (REFERENCE CAR AC0545). THE INTERMITTENT FAILURE WAS VERIFIED AT LOW TEMPERATURE AND WAS ATTRIBUTED TO A SHORT END

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EFFECT (LOSS OF OR ERRONEOUS FCV CLOSE COMMAND, ERRONEOUS PRESSURE INDICATION) DEPENDS ON LOCATION OF THE SHORT. WIRING COULD HAVE BEEN DISPLACED DURING ENCAPSULATION; TEMPERATURE VARIATIONS COULD THEN HAVE CAUSED STRESS ON THE WIRING RESULTING IN AN INTERMITTENT SHORT. CORRECTIVE ACTION WAS TO PERFORM A POST-ENCAPSULATION CONFIDENCE TEST WITH THERMAL CYCLING PRIOR TO ATP.

SEVERAL SIGNAL CONDITIONER CLOSE COMMAND OUTPUT TRANSISTORS WERE DAMAGED BY INADVERTENT EXTERNAL SHORT CIRCUITING DURING TEST, RESULTING IN LOSS OF THE FCV CLOSE COMMAND. THE -0005 CONFIGURATION SPECIFICALLY INCORPORATES SHORT CIRCUIT PROTECTION (ADDITIONAL RESISTORS) ON THE VALVE COMMAND CIRCUIT TO PREVENT SUCH OCCURRENCES (REFERENCE CARS D8F015, AC8144, A3032, A4605).

DURING ATP, THE SIGNAL CONDITIONER FAILED THE FREQUENCY RESPONSE TEST BY DRAWING EXCESSIVE CURRENT (REFERENCE CAR A5038). DURING REMOVAL OF THE UNIT FROM THE CASE AND SHIELD, A WELD CONNECTION ON ONE MODULE LOCATED ADJACENT TO THE MODULE DIVIDER SHIELD WAS FOUND TO BE MAKING INTERMITTENT CONTACT WITH THE DIVIDER SHIELD. THE MODULE INTERCONNECTING RIBBON HAD WORN THROUGH THE DIVIDER SHIELD INSULATION DUE TO INSUFFICIENT CLEARANCE BETWEEN THE DIVIDER SHIELD AND MODULES. END EFFECT OF THIS CONDITION (INADVERTENT FCV CLOSE COMMAND, ERRONEOUS PRESSURE INDICATION) DEPENDS ON LOCATION OF THE SHORT. CORRECTIVE ACTION WAS TO CONTROL THE LENGTH OF THE RIBBONS. FOR ASSEMBLED HARDWARE, THE ATP THERMAL CYCLE AND VIBRATION TESTS WERE CONSIDERED SUFFICIENT SCREENING TO INSURE DETECTION OF THE POTENTIAL PROBLEM.

SEVERAL SIGNAL CONDITIONER FAILURES (VARIOUS MODES) AT KSC WERE ATTRIBUTED TO MOISTURE RETAINED IN THE GLASS RESIN EPOXY ENCAPSULATION MATERIAL CAUSING MULTIPLE SHORT CIRCUITS WITHIN THE WELDED MODULES (REFERENCE CAR AC4420). ALL UNITS WERE REFURBISHED TO THE -0005 CONFIGURATION TO IMPROVE SEALING AND PRECLUDE INTERNAL MOISTURE. ADDITIONAL EPOXY SEALANT WAS ADDED BETWEEN THE COVER AND HOUSING. THE UNIT IS VACUUM BAKED AFTER THE ENCAPSULANT IS ADDED TO INSURE ABSENCE OF INTERNAL MOISTURE PRIOR TO SEALING OF THE FILL HOLE WITH EPOXY. THE UNIT IS THEN LEAK CHECKED, AND EPOXY IS APPLIED TO SEAL ELECTRICAL CONNECTOR SOLDER JOINT POROSITY IF REQUIRED.

(E) OPERATIONAL USE:

NO CREW ACTION CAN BE TAKEN.

- APPROVALS -

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