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PRINT DATE: 09/04/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 04-2-CONTL2-14-X

5050271X
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SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

REVISION : 3 09/04/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU :	APU CONTROLLER SUNDSTRAND	MC201-0001-1005 753831

PART DATA

- EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
HIGH SPEED CONTROL (ELECTRONIC CONTROL CIRCUIT) FOR THE GGVM SHUTOFF (N.C.) VALVE
- QUANTITY OF LIKE ITEMS: 4
FOUR CONTROL CIRCUITS PER APU CONTROLLER, 1 CONTROLLER PER APU
- FUNCTION:
 - (1) PROVIDES AN OUTPUT SIGNAL TO OPEN THE GGVM SHUTOFF (N.C.) VALVE ~~(LV13)~~ IN RESPONSE TO A "START/RUN" COMMAND.
 - (2) PROVIDES AN OUTPUT SIGNAL TO ^{CYCLE} OPEN THE NORMALLY CLOSED GGVM SHUTOFF VALVE TO MAINTAIN TURBINE - HIGH (113%) SPEED WITHIN PLUS OR MINUS 8% WHEN HIGH SPEED IS SELECTED BY CREW.

(50V#6LV17)

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REVISION# 3 10/21/91 RR

SUBSYSTEM: AUXILIARY POWER UNIT (APU)
LRU : APU CONTROLLER
ITEM NAME: APU CONTROLLER

CRITICALITY OF THIS
FAILURE MODE: 1R2

■ FAILURE MODE:

PREMATURE OUTPUT, CAUSING INADVERTENT APU RESTART (PRODUCES A SIGNAL TO OPEN GGVM SHUTOFF VALVE AFTER AN APU SHUTDOWN OR DURING A PLANNED HOT RESTART PRIOR TO COMPLETION OF THE 209 SECOND MANUAL GG INJECTOR COOLING)

PLANNED

MISSION PHASE:

PL PRELAUNCH
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT
LS LANDING SAFING

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

- CAUSE:
WIRE-TO-WIRE POWER SHORT, TWO INTERNAL CONTROLLER PIECE-PART FAILURES

- 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 -

- (A) SUBSYSTEM:
NO EFFECT AFTER FIRST FAILURE. SECOND FAILURE CAN RESULT IN HYDRAZINE DETONATION DUE TO UNCOOLED HOT INJECTOR FUEL PASSAGES. IF MINOR DETONATION OCCURS, THE INJECTOR MAY BE DAMAGED, CAUSING ROUGH COMBUSTION. IF MAJOR DETONATION OCCURS, APU IS LOST WITH POSSIBLE FUEL SYSTEM RUPTURE.
- (B) INTERFACING SUBSYSTEM(S):
LOSS OF ONE HYDRAULIC SYSTEM. POSSIBLE LOSS OF ADJACENT HARDWARE DUE TO APU DETONATION.
- (C) MISSION:
LOSS OF MISSION IF FAILURE OCCURS FOLLOWING ASCENT.
- (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT AFTER FIRST FAILURE. POSSIBLE LOSS OF CREW/VEHICLE DUE TO RAW FUEL IN AFT ~~(FIRE)~~ AND/OR HYDRAZINE DETONATION AFTER SECOND FAILURE. BOTH CONTROLLER FAILURES MUST OCCUR BEFORE CREW CLOSES FUEL ISOLATION VALVES OR SHUTS OFF CONTROLLER POWER. CLOSURE OF FUEL ISOLATION VALVES OR SHUTTING OFF CONTROLLER POWER INHIBITS THIS FAILURE MODE.
- (E) FUNCTIONAL CRITICALITY EFFECTS:
TWO CONTROLLER PART FAILURES (VALVE DRIVER SWITCHES OR SPEED CONTROLLER CIRCUIT) OR WIRE-TO-WIRE POWER SHORTS (TWO FAILURES) REQUIRED FOR THIS FAILURE MODE. SINGLE FAILURE OF SWITCH (REF CIL 05-6N-2035-2) CAN RESULT IN THIS FAILURE MODE.

delete period

- DISPOSITION RATIONALE -

- (A) DESIGN:
FOUR SEPARATE SPEED CONTROL CIRCUITS FEED INTO A PARALLEL/SERIES COMBINATION OF VALVE DRIVER SWITCHES (FET). ELECTRICAL COMPONENTS ARE REQUIRED TO BE QUALIFIED, PROPERLY DERATED, AND APPLIED PER MC201-0001, PARAGRAPH 3.3.2.2. ELECTRICAL PARTS SELECTED FROM ~~MF0004-400 (OPPL) 8~~ PLUS. *OPPL*

CONFORMAL COATING PER SUNOSTRAND SPEC CP 17.32-01. CLEANLINESS PER MA0110-301. CONTROLLER VIBRATION DAMPED AT MOUNTING.

THE OPPL CALLS FOR GLASSIVATION FOR INTEGRATED CIRCUIT DIE, SINGLE SEAL FOR TANTALUM WET SLUG CAPACITORS, ETC. DERATING OF EEE PARTS IS

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EXPANDED BEYOND THE SIMPLISTIC (75% X RATED) REQUIREMENTS OF THE CONTRACT.

■ (B) TEST:

CONTROLLER IS FUNCTIONALLY TESTED DURING ATP. CONTROLLER IS SUBJECTED TO AVT. CONTROLLER IS THERMAL TESTED DURING ATP - RANGE 70 DEG F, 130 DEG F, 30 DEG F.

CONTROLLER IS QUALIFIED FOR QAVT, EMI, THERMAL VACUUM (-65 DEG F TO 165 DEG F, 80 K FT FOR 10 CYCLES), HUMIDITY AND FLIGHT VIBRATION.

ALL EEE PARTS ARE SUBJECTED TO SCREENING AND BOX LEVEL BURN-IN TESTS TO DETECT MARGINAL PARTS AND TO CAUSE INFANT MORTALITY FAILURES.

CMRSD: CONTROLLER/CCU TESTS ARE PERFORMED ON EACH CONTROLLER EVERY FLOW DURING GROUND TURNAROUND TO VERIFY ALL FOUR SPEED CONTROL CIRCUITS AND NO GROUND SHORTS.

■ (C) INSPECTION:

RECEIVING INSPECTION

VISUAL AND DIMENSIONAL INSPECTIONS ARE PERFORMED ON ALL INCOMING PARTS. MATERIAL AND PROCESSES CERTIFICATIONS ARE VERIFIED.

CONTAMINATION CONTROL

CLEANLINESS IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, ASSEMBLY, AND INSTALLATION REQUIREMENTS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

SOLDERING TO NH8 5300.4(3A) IS VERIFIED BY INSPECTION.

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ATP IS WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE, AND SHIPPING PROCEDURES ARE VERIFIED.

■ (D) FAILURE HISTORY:

TWO INSTANCES OF APU HOT RESTART HAVE BEEN RECORDED IN THE PROBLEM RESOLUTION AND CORRECTIVE ACTION (PRACA) SYSTEM. BOTH RESULTED IN HYDRAZINE DETONATION WITH GAS GENERATOR INJECTOR TUBE AND GAS GENERATOR VALVE MODULE DAMAGE.

BOTH OCCURRED IN TEST STANDS, AND NEITHER WAS AN INADVERTENT RESTART.

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HOWEVER, THESE INSTANCES ARE MENTIONED HERE BECAUSE THEY SHOW THE EFFECTS OF A HOT RESTART.

THE FIRST (CAR AB0284) OCCURRENCE WAS AT JSC ON 3/24/78 AS A PART OF DEVELOPMENT TESTING. CORRECTIVE ACTION INCLUDED CHANGING MISSION RULES TO OPERATE APUS CONTINUOUSLY THROUGHOUT AOA (ABORT ONCE AROUND), AND THUS MAKES A HOT RESTART UNNECESSARY.

AT THE TIME, THE APU INJECTOR TEMPERATURE LIMIT FOR HOT RESTART WAS ALSO REVISED TO A TEMPERATURE OF 450 DEG F. IN ADDITION, A FEASIBILITY STUDY OF ACTIVE WATER COOLING OF THE GAS GENERATOR TO GIVE THE APU AN UNRESTRICTED HOT RESTART CAPABILITY WAS AUTHORIZED.

THE SECOND INSTANCE (CAR AB4205) OCCURRED AT JSC ON 6/5/79 AS A PART OF PREQUALIFICATION TESTING. CORRECTIVE ACTION AUTHORIZED THE ADDITION OF AN ACTIVE WATER COOLING SYSTEM TO COOL BOTH THE FUEL PUMP AND THE GAS GENERATOR VALVE MODULE AFTER SHUTDOWN.

- (E) OPERATIONAL USE:
CLOSE TANK ISOLATION VALVE, THEN SHUT OFF CONTROLLER POWER.

- APPROVALS -

RELIABILITY ENGINEERING:	D. R. ATAPATTU	: <i>[Signature]</i>
DESIGN ENGINEERING	: D. J. ZWICK	: <i>[Signature]</i>
QUALITY ENGINEERING	: W. R. HIGGINS	: <i>[Signature]</i> 1/11/91
NASA RELIABILITY	:	: <i>[Signature]</i> 1/21/92
NASA SUBSYSTEM MANAGER	:	: <i>[Signature]</i> 1-24-92
NASA QUALITY ASSURANCE	:	: <i>[Signature]</i> 1/21/91

FUEL