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PRINT DATE: 11/22/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 04-2-GG11-1M-X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

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	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU :	AUXILIARY POWER UNIT (APU)	MC201-0001-04XX
■	SUNSTRAND	X742211X
■ SRU :	GAS GENERATOR	5905135
■		SAME

PART DATA

- EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
GAS GENERATOR, CATALYTIC DECOMPOSITION CHAMBER
- QUANTITY OF LIKE ITEMS: 3  
ONE PER APU
- FUNCTION:  
TO CATALYTICALLY DECOMPOSE FUEL AND PORT HOT GAS TO TURBINE INLET.

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SUBSYSTEM: AUXILIARY POWER UNIT (APU)  
LRU :AUXILIARY POWER UNIT (APU)  
ITEM NAME: GAS GENERATOR

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CRITICALITY OF THIS  
FAILURE MODE: R2

- FAILURE MODE:  
FAILS TO FUNCTION, (FAILS TO DECOMPOSE)

MISSION PHASE:

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

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

- CAUSE:  
CATALYST DEGRADES, WATER, SALT FOG ENTERING THROUGH EXHAUST DUCT,  
IMPURITIES IN THE FUEL, VIBRATION, LOSS OF CATALYST, INTERNAL PIECE  
PART FAILURE WITHIN GAS GENERATOR, FAILURE OF SPRING MECHANISM TO  
TAKEUP CATALYST LOSS.

- CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES  
AOA ABORT ONCE AROUND  
ATO ABORT TO ORBIT  
RTLs RETURN TO LAUNCH SITE  
TAL TRANS ATLANTIC ABORT

- 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 ONE APU SYSTEM. TURBINE UNDERSPEEDS AND SHUTS DOWN OR FAILS TO RESTART.
  - (B) INTERFACING SUBSYSTEM(S):  
 LOSS OF SHAFT POWER TO ONE HYDRAULIC PUMP.
  - (C) MISSION:  
 ABORT DECISION IS REQUIRED IF FAILURE OCCURS PRIOR TO ENTRY COMMITMENT.
  - (D) CREW, VEHICLE, AND ELEMENT(S):  
 NO EFFECT UNTIL SECOND SYSTEM LOSS. CRITICALITY 1 FOR SSME INDUCED RTLS, ATO, AOA, OR TAL DUE TO THE POSSIBLE ADDITIONAL LOSS OF ASSOCIATED APU/HYD AND MAIN ENGINE.
  - (E) FUNCTIONAL CRITICALITY EFFECTS:  
 1ST FAILURE - LOSS OF 1 APU.  
~~POSSIBLE LOSS CREW/VEHICLE IF TWO OUT OF THREE APUS LOST~~
- 2ND FAILURE - LOSS OF ADDITIONAL APU/HYD SYSTEM RESULTS IN POSSIBLE LOSS OF CREW OR VEHICLE.*

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 - DISPOSITION RATIONALE -  
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- (A) DESIGN:  
 IMPROVED DESIGN HAS CIRCUMFERENTIAL SPRING ALLOWING FOR CATALYST TAKEUP TO REDUCE VOIDS AND PROLONG LIFE.  
  
 PRIOR TO APU START, PREHEATING OF GAS GENERATOR IS PERFORMED TO PROLONG GAS GENERATOR LIFE.  
  
 UPSTREAM FILTER, 25-MICRON ABSOLUTE. APU FUEL SYSTEM AND APU ASSEMBLY CLEANLINESS CONTROLLED TO MA0110-301 (LEVEL 100).
- (B) TEST:  
 ACCEPTANCE FUNCTIONAL TEST VERIFIES INTEGRITY OF CATALYTIC BED PRIOR TO ASSEMBLY. APU ATP VERIFIES FUNCTIONAL INTEGRITY AFTER ASSEMBLY BY MONITORING FUEL CONSUMPTION, EXHAUST TEMP/PRESS AND CHAMBER PRESSURE.  
  
 IAPU QUALIFICATION COMPLETED SUCCESSFULLY (75 HRS ON QUAL I). FOUR (4) PRODUCTION SSG'S WITH CHROMIZED INJECTOR LIFE TESTED SUCCESSFULLY DURING DEVELOPMENT. TWO UNITS EXCEEDED 75 HOURS (90 HOURS MAXIMUM). QUAL II TESTING (75 HOURS) TO BE PERFORMED.  
  
 QUALIFICATION TEST WAS CONDUCTED ON BASELINE APU WITH WATER INJECTED

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INTO THE EXHAUST DUCT AFTER SHUTDOWN TO DEMONSTRATE THAT RAIN INTO EXHAUST WILL NOT DEGRADE APU PERFORMANCE.

~~LESS~~  
BMSD: GG PERFORMANCE IS VERIFIED DURING <sup>APU CONFIDENCE RUN FOLLOWING EVERY 10TH</sup> ~~7-5 MIN RUN EVERY FLOW AND~~  
~~DURING ENTRY FROM TAEM TO TOUCHDOWN WHILE IAPU IS UNDER LOAD.~~  
HYDRAULIC LOAD TEST PERFORMED EVERY 5TH FLIGHT TO DETERMINE HEALTH OF GAS GENERATOR.

*IF OMSD: CONFIDENCE RUN FOLLOWING AND INSTALLATION*

- (C) INSPECTION:  
RECEIVING INSPECTION  
MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL  
CLEANLINESS TO LEVEL 100 IS VERIFIED BY INSPECTION. FLUID SAMPLES ARE INSPECTED FOR CONTAMINATION. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION  
TORQUING IS VERIFIED BY INSPECTION. MANUFACTURING, ASSEMBLY, AND INSTALLATION PROVISIONS ARE VERIFIED BY INSPECTION. INJECTOR STEM AND O-RINGS ARE VERIFIED CLEAN BY INSPECTION. DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION  
PENETRANT INSPECTION FOR SURFACE DEFECTS IS VERIFIED BY INSPECTION. HOUSING WELDS ARE INSPECTED USING 10X MAGNIFICATION.

CRITICAL PROCESSES  
WELDING PER SPECIFICATION REQUIREMENTS 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 BY INSPECTION.

- (D) FAILURE HISTORY:  
CAR AD6827 - SPRING GAS GENERATOR 6003 INDICATED ROUGHNESS (OVER 150 PSIA PEAK-TO-PEAK) FOLLOWING 2 HOURS OF RUNTIME. THE UNIT WAS USED FOR TOTAL OF 23.7 HOURS IN WHICH TIME THE ROUGHNESS PEAKED AT 250 PSI. THE ROUGHNESS PEAK LIMIT IS 300 PSI. ANALYSIS REVEALED THAT THE COMPRESSION BAND WAS JAMMED AND THE SPRING MECHANISM FAILED TO TAKE-UP FULLY. CORRECTIVE ACTION - MANUFACTURING PROCESS CHANGED TO USE CUSTOM FITTED TOOLING WHEN BUILDING EACH UNIT. ALL PRODUCTION UNITS WERE BUILT AFTER THIS CORRECTIVE ACTION.

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LIFE TESTING OF SPRING GAS GENERATOR WITH CHROMIZED INJECTORS HAS RESULTED IN UNIT 6003 REACHING END OF LIFE AT 66 HOURS. HOWEVER, THIS UNIT WAS OVERTESTED WITH 221 STARTS (EXPECTED NUMBER OF STARTS IS 120). OTHER UNITS (6002 AND 6019) HAVE EXCEEDED 75 HOURS AND 120 STARTS SUCCESSFULLY.

■ (E) OPERATIONAL USE:

IF APU SHUTS DOWN, REMAINING APU'S GO TO HIGH SPEED AND AUTOMATIC SHUTDOWN IS INHIBITED TO PRECLUDE INADVERTENT SHUTDOWNS DEPENDING ON MISSION PHASE.

IF EXCESSIVE  
CHAMBER PRESSURE  
SPIKING IS OBS  
SHUT DOWN APU  
CLOSE ISOLATE  
VALVE

- APPROVALS -

RELIABILITY ENGINEERING: D. R. ATAPATTU  
DESIGN ENGINEERING : J. R. MUNROE  
QUALITY MANAGER : O. J. BUTTNER  
NASA RELIABILITY :  
NASA SUBSYSTEM MANAGER :  
NASA QUALITY ASSURANCE :

*[Handwritten signatures and dates]*  
1-24-92