FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: 04-2-GTII-X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
REVISION : 3 12/18/91

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	AUXILIARY POWER UNIT (APU) SUNDSTRAND	MC201-0001-02XX 729867XX/754949
LRU	:	AUXILIARY POWER UNIT (APU) SUNDSTRAND	MC201-0001-03XX 729867XX/754949A
LRU	:	AUXILIARY POWER UNIT (APU) SUNDSTRAND	MC201-0001-04XX X742211X
SRU	:	GEARBOX	726079 SAME
SRU	:	GEARBOX	742774

PART DATA

- QUANTITY OF LIKE ITEMS: 3
  ONE PER APU

- FUNCTION:
  TO TRANSFER ROTATIONAL POWER FROM HIGH SPEED TURBINE TO LOW SPEED HYDRAULIC, FUEL AND LUBE OIL PUMPS.

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NUMBER: 04-2-GT11-02

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

CRITICALITY OF THIS FAILURE MODE:1R2

■ FAILURE MODE:
LOSS OF GEARBOX INTERNAL GN2 PRESSURE

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:
SEAL FAILURE, GEARBOX STRUCTURAL FAILURE, EXTERNAL LEAK.

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) PASS
■ B) PASS
■ C) PASS

PASS/FAIL RATIONALE:
■ A)

■ B)

■ C)

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
POSSIBLE LOSS OF ONE APU SYSTEM. DUE TO LOSS OF LUBRICATION CAPABILITY OR LOSS OF LUBRICATION PRESSURIZATION CAUSED BY DEPLETION OF INTERNAL GAS PRESSURE.

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- (B) INTERFACING SUBSYSTEM(S):
  POSSIBLE 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 SECCND SYSTEM LOSS.

- (E) FUNCTIONAL CRITICALITY EFFECTS:
  POSSIBLE LOSS OF CREW/VEHICLE IF TWO OUT OF THREE APU'S LOST.

- DISPOSITION RATIONALE -

- (A) DESIGN:
  STATIC SEALS ARE DUPONT VITON (MIL-R-83248/I), EXCEPT THAT SEAL CAVITY DRAIN INTERFACE STATIC SEAL IS KALREZ. ROTATING SEALS ARE CARBON FACED BELLOWS TYPE LOCATED AT THE FUEL PUMP, HYDRAULIC PUMP AND TURBINE EXHAUST INTERFACES.

  APU MOUNTED GEARBOX REPRESSURIZATION SYSTEM (140 PSIA BOTTLE PRESS) IS SUFFICIENT TO PROVIDE PRESSURIZATION OF 4 PSIA MINIMUM DURING ON-ORBIT OPERATIONS TO PERMIT PROPER LUBE SYSTEM PERFORMANCE DURING START AND OPERATION. TURBINE BEARING TEMPERATURES AND LUBE OIL PRESSURE ARE MONITORED.

- (B) TEST:
  DEVELOPMENT TESTS HAVE DEMONSTRATED PROPER LUBE SYSTEM OPERATION AT APPROXIMATELY 2 PSIA.

  QUALIFIED AS PART OF APU. PRESSURE DECAY TEST (.2 PSIG/15 MIN) MONITORED FOR LUBE OIL LEAKS AFTER ATP FUNCTIONAL TEST.

  CERTIFICATION TESTS CONDUCTED WERE - 27 MISSION DUTY CYCLES FOR A TOTAL OF 41.7 HOURS OPERATION.

  OMRSD: GEARBOX PERFORMANCE VERIFIED DURING THE T-5 MINUTE RUN EVERY FLIGHT.

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

  CONTAMINATION CONTROL
  CLEANLINESS TO DRAWING REQUIREMENTS IS VERIFIED BY INSPECTION.

CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
MANUFACTURING, ASSEMBLY, AND INSTALLATION REQUIREMENTS ARE VERIFIED BY INSPECTION. GEAR DATA ARE VERIFIED BY INSPECTION. DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. BEARING AND SEAL INSTALLATION ARE VERIFIED BY INSPECTION. BEARINGS, SEALS, AND FLUID BOSSES PER MS33649 ARE VERIFIED BY INSPECTION. HELICAL COIL THREADS AND INSTALLATION ARE VERIFIED BY INSPECTION. FASTENER INSTALLATION, INCLUDING TORQUING AND SAFETY WIRING, IS VERIFIED BY INSPECTION. LUBRICATION IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
RADIOGRAPHIC INSPECTION OF INPUT HOUSING CASTING AND ULTRASONIC INSPECTION OF OUTPUT HOUSING HAND FORGING ARE VERIFIED BY INSPECTION. INSPECTION VERIFIES PENETRANT INSPECTION OF PARTS, INCLUDING HOUSING ASSEMBLIES AND HOUSING ASSEMBLY WELDS. MAGNETIC PARTICLE INSPECTION OF GEARS AND SHAFTS IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES
CASTING OF INPUT HOUSING AND HAND FORGING OF OUTPUT HOUSING ARE VERIFIED BY INSPECTION. WELDING IS VERIFIED BY INSPECTION. ANODIZATION AND CHEM FILM PROCESSES ARE VERIFIED BY INSPECTION. HEAT TREATING, INCLUDING CARBURIZATION, IS VERIFIED BY INSPECTION.

TESTING
MECHANICAL PROPERTIES OF INPUT HOUSING CASTING AND OUTPUT HOUSING HAND FORGING ARE VERIFIED BY INSPECTION. SURFACE TEMPER INSPECTION (NITAL ETCH) IS VERIFIED BY INSPECTION. ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE, AND SHIPPING PROCEDURES ARE VERIFIED BY INSPECTION.

■ (D) FAILURE HISTORY:
EIGHT TURBINE SEAL, 3 HYDRAULIC PUMP SEAL AND 4 FUEL PUMP SEAL LEAKAGE FAILURES HAVE OCCURRED. CAR'S AB6034, AB6126, AB6177, & AB6204 WERE ALL LEAKAGES REPORTED AGAINST APU QUAL UNIT S/N 202. CORRECTIVE ACTION WAS TO TOUCH LAP THE SEAL.

THE MINOR LEAKAGE REPORTED IN CAR'S AC3294 AND AC3315 WAS CORRECTED BY REMOVAL OF A RESTRICTING SHIM IN THE FUEL PUMP SEAL CAVITY.

CAR AC5786 HAD INCORRECT LEAKAGE REPORTED AGAINST IT AND CAR AC7314 WAS REPORTED AGAINST AN STS-9 UNIT THAT WAS SCRAPPED.

CAR'S AC8266, AC8406, & AC8878 WERE ATP FAILURES ON REFURBISHED APU'S.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
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CORRECTIVE ACTION WAS TO TOUCH LAP THE SEALS AND RE-ATP THEM.

CAR'S AD0712, AD0405, AD1342, AND AD1635 WERE ATP FAILURES. THESE SEALS WERE ALL FROM THE SAME LOT AND HAD TOO HIGH OF AN INTERFERENCE FIT BETWEEN THE CARBON INSERT AND THE CARRIER WHICH CAUSED AN "OUT-OF-FLAT" CONDITION ON THE SEALING SURFACE. THE SEAL WAS REDESIGNED TO DECREASE THE INTERFERENCE FIT AND ONE MORE THERMAL STABILIZATION CYCLE WAS ADDED AFTER MACHINING.

■ (E) OPERATIONAL USE:
SHUT DOWN APU BASED ON SYSTEM TEMPERATURE AND FLIGHT PHASE. IF APU SHUTS DOWN, REMAINING APU'S GO TO HIGH SPEED AND AUTOMATIC SHUTDOWN IS INHIBITED TO PRECLUDE INADVERTENT SHUTDOWNS.

- APPROVALS -

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