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.

PRINT DATE: 03/22/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE NUMBER: 04-2-GTII-11

REVISION# 3 03/22/91 R

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

CRITICALITY OF THIS FAILURE MODE: 1R2

■ FAILURE MODE:
LOSS OF OUTPUT, (INCLUDING REDUCED OR DEGRADED OUTPUT).

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:
BEARING SEIZURE, GEAR JAMMED, SHAFT SHEAR, IMPROPER LUBE QUANTITY (EITHER OVERFILL OR LOSS OF OIL), WSB FAILURE (LOSS OF COOLING), HYDRAZINE LEAKAGE INTO GEARBOX, PLUGGING OF LUBE JETS, LOSS OF PRESSURANT, FAILURE OF ACCUMULATOR, PUMP FAILURE

■ 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)

SHOULD BE COMPLETED

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- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
LOSS OF ONE APU SYSTEM. LOSS OF SHAFT POWER TO FUEL AND/OR LUBE OIL PUMP.

■ (B) INTERFACING SUBSYSTEM(S):
LOSS OF SHAFT POWER TO ONE HYDRAULIC PUMP.

■ (C) MISSION:
ASCENT-ABORT OR ABORT DECISION, TIME DEPENDENT.

■ (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:
POSSIBLE LOSS OF VEHICLE IF TWO OUT OF THREE APU'S LOST.

- DISPOSITION RATIONALE -

■ (A) DESIGN:
LUBE SYSTEM HAS 40-MICRON FILTER WITH 2 GRAMS AC COARSE DUST CAPABILITY. A FILTER BYPASS VALVE WILL OPEN IN THE EVENT THE FILTER GETS CLOGGED. THE FILTER PREVENTS THE COOLING AND LUBRICATING ORIFICES FROM BEING CONTAMINATED. GEARSHAFT/INSEPARABLE ASSEMBLY MS=2.20 ULTIMATE. BEARING CLEARANCE .00054/.00137 OVER -65/300 DEG F. LUBE OIL TEMP IS MONITORED. GEAR BOX BEARING TEMP IS MONITORED. S70-0606 LUBE OIL SERVICING UNIT HAS 25-MICRON FILTER. BASELINE APU GEAR BOX HAS MAGNETIC CHIP DETECTOR. GEAR BOX PRESSURIZATION WITH GN2 IS ACTIVATED AUTOMATICALLY TO ENSURE THAT THE LUBE PUMP INLET PRESSURE IS SUFFICIENT FOR PROPER OPERATION. AN ACCUMULATOR ACTS AS A VARIABLE VOLUME RESERVOIR.

■ (B) TEST:
ATP FUNCTIONAL VERIFICATION.

GEARBOX QUALIFICATION FOR ORBITAL FLIGHT AS PART OF APU.

CERTIFICATION TESTS CONDUCTED WERE - 27 MISSION DUTY CYCLES, THERMAL VACUUM, BENCH SHOCK, FOR A TOTAL OF 41.7 HR OPERATION INCLUDING VIBRATION FOR BASELINE APU.

Loss of one APU during powered flight will result in the associated SSME going into hydraulic lock-up and could result in loss of orbit capability or be catastrophic (with additional SSME valve failure). (Ref. Flight Rule 10-13)

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IMPROVED APU QUALIFICATION TEST GEAR BOX SUCCESSFULLY COMPLETED 75 HOURS RUNTIME. 100+ HOURS OF DEVELOPMENT TESTS CONDUCTED SUCCESSFULLY.

OMRSD: GEAR BOX PERFORMANCE IS VERIFIED DURING T-5 MIN RUN EVERY FLOW.

■ (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.

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■ (D) FAILURE HISTORY:
AD6298
SPURGEAR SHAFT BROKE ON ONE APU DEVELOPMENT TEST AT 493 HOURS RUNTIME ON SHAFT. SHAFT WAS NOT PRODUCTION HARDWARE CONFIGURATION. THE SHAFT DESIGN HAD BEEN REVISED FOR ALL BASELINE AND IMPROVED APUS IN THE AREA OF FAILURE DUE TO EARLY SIMILAR FAILURE. THIS PART DID NOT HAVE THIS DESIGN REVISION.

■ (E) OPERATIONAL USE: LOSS OF ONE APU WILL RESULT IN SWITCHING TO HIGH S AND INH ON OTHE ~~SHUT DOWN APU. OTHERWISE, IF APU SHUTS DOWN, REMAINING APU'S GO TO HIGH SPEED AND AUTOMATIC SHUTDOWN IS INHIBITED TO PRECLUDE INADVERTENT SHUTDOWNS.~~ APUs DEPENDING ON

- APPROVALS -

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