PRINT DATE: 03/30/98

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: 04-2-TR12 -X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

REVISION: 4 03/26/98

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: AUXILIARY POWER UNIT (APU)	MC201-0001-06XX
	SUNDSTRAND	729867XX/754949
SRU	:CONTAINMENT RING	716589
	SUNDSTRAND	SAME
SRU	:TURBINE WHEEL	752370
	SUNDSTRAND	SAME

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
TURBINE WHEEL AND CONTAINMENT RING

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
ONE PER APU

FUNCTION:
TO PROVIDE ENERGY CONVERSION FROM HOT GAS TO DRIVE APU GEARBOX.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 04-2-TR12-01

REVISION#: 4 03/26/98

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
LRU: AUXILIARY POWER UNIT (APU) **CRITICALITY OF THIS**
ITEM NAME: TURBINE WHEEL **FAILURE MODE:** 1/1

FAILURE MODE:
TURBINE WHEEL FRACTURES/BREAKS APART AND CONTAINMENT RING FAILS TO CONTAIN.

MISSION PHASE:

PL	PRE-LAUNCH
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:
FAILURE DUE TO LOSS OF OIL OR GEARBOX GN2 PRESSURE, STRUCTURAL FAILURE OF THE TURBINE WHEEL DUE TO MATERIAL DEFECT IN DISK, BLADES, OR SHROUD.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF ONE APU SYSTEM.

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(B) INTERFACING SUBSYSTEM(S):
POSSIBLE LOSS OF ADJACENT EQUIPMENT DUE TO RUPTURE OF FUEL LINES AND ESCAPING HOT GASES MAY CAUSE FIRE. LOSS OF SHAFT POWER TO ONE HYDRAULIC PUMP.

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

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW AND VEHICLE IF FIRE AND/OR EXPLOSION OCCURS; OTHERWISE NO EFFECT UNTIL SECOND SYSTEM LOST, THEN POSSIBLE CREW/VEHICLE LOSS.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE

-DISPOSITION RATIONALE-

(A) DESIGN:
TURBINE WHEEL AND BLADES ARE FABRICATED FROM FORGED RENE 41 MATERIAL. RENE 41 YIELD STRENGTH IS 109 KSI AT 1200 DEG F AND HAS EXCELLENT RESISTANCE TO NITRIDING. RENE 41 IS A PROVEN MATERIAL FOR TURBINE WHEEL USE. TURBINE WHEEL HAS A MS+=.16 AT 93,600 RPM (130%) SPEED (NOMINAL DISK PROFILE, MINIMUM ULTIMATE STRENGTH 148 KSI @ 1200 DEG F). FRACTURE MECHANICS ANALYSIS OF TURBINE DISK SHOWS >4X LIFE (>200 MISSIONS) WITH A DETECTABLE FLAW SIZE OF .094" (SPECIAL LEVEL PENETRANT NDE). BLADE/SHROUD CONFIGURATION HAS BEEN MODIFIED, IN COMPARISON TO PREVIOUS DESIGN, TO ELIMINATE BLADE CRACKING. ORBITER APU TURBINE WHEEL IS SIMILAR IN DESIGN TO THE SRB HPU (BLADE/SHROUD CONFIGURATION IS PRIMARY DIFFERENCE).

TURBINE WHEEL ROTATIONAL SPEED IS 72,000 RPM AT 100% SPEED. AUTOMATIC SHUTDOWN IS INITIATED AT OVERSPEED SIGNAL WHEN SPEED REACHES 92,880 RPM AT 129% SPEED. THE BLADE AIRFOILS ARE OF SUPERSONIC DESIGN WHICH ARE SHROUDED TO MAXIMIZE OPERATING LIFE AND PERFORMANCE. THE CONTAINMENT RING IS INTENDED TO CONTAIN TURBINE FRAGMENTS.

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TURBINE ASSEMBLY IS DYNAMICALLY BALANCED IN TWO PLANES WITHIN 0.001 IN-OZ. ASSEMBLY USES ANGULAR CONTACT BALL BEARINGS (ABEC CLASS 5), MADE FROM M-50 TOOL STEEL. SPUR GEAR (PINION) IS AMS 6487 STEEL WITH NITRIDED TOOTH AND ROOT PROFILE.

(B) TEST:
EACH APU IS SUBJECTED TO ATP FUNCTIONAL TEST. THE TURBINE WHEEL (P/N 75230) IS INTENDED TO BE CERTIFIED FOR 75 HOURS. CURRENTLY THE CERTIFICATION IS FOR 20 HOURS WITH NO LIMIT ON STARTS OR HIGH SPEED RUNTIME. OVER 165 HOURS (240 PLUS STARTS) HAVE BEEN SUCCESSFULLY DEMONSTRATED DURING DEVELOPMENT, QUALIFICATION AND FLIGHT USING 7 DIFFERENT TURBINE WHEELS. ONE WHEEL HAS ACCUMULATED 90.7 HOURS, WITH A SECOND IN THE 45 HOUR RANGE.

OMRSD: NONE. THE TURBINE ASSEMBLY IS INTERNAL TO THE APU AND DIRECT OMRSD TESTING WOULD REQUIRE DISASSEMBLY OF THE APU WHICH IS INVASIVE AND ILLOGICAL.

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

CONTAMINATION CONTROL
CLEANLINESS PER REQUIREMENTS IS VERIFIED BY INSPECTION. CORROSION PROTECTION REQUIREMENTS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
MANUFACTURING, ASSEMBLY AND INSTALLATION REQUIREMENTS ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION/TEST.

NONDESTRUCTIVE EVALUATION
TURBINE FORGING PENETRANT AND ULTRASONICALLY INSPECTED. SHAFT/DISK TIG WELD RADIOGRAPHICALLY INSPECTED. SHROUD ELECTRON BEAM WELD IS ULTRASONIC AND PENETRANT INSPECTED, BOTH PRIOR TO AND FOLLOWING HEAT TREAT. FINISH MACHINED TURBINE WHEEL ASSEMBLY IS PENETRANT INSPECTED; TURBINE DISK IS INSPECTED USING SPECIAL LEVEL PENETRANT TECHNIQUES (.050" THRESHOLD DETECTION LEVEL). TURBINE BLADES ARE INSPECTED UNDER MAGNIFICATION USING PENETRANT.

CRITICAL PROCESSES
INSPECTION AND/OR TEST VERIFIES FORGING, TIG AND ELECTRON BEAM WELDING, ELECTRO-CHEMICAL MACHINING, HEAT TREATMENT AND SPUR GEAR NITRIDING.

TESTING
ATP IS WITNESSED AND VERIFIED BY INSPECTION.

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

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(D) FAILURE HISTORY:
REFER TO PROBLEM REPORTING AND CORRECTIVE ACTION (PRACA) FAILURE HISTORY DATABASE.

(E) OPERATIONAL USE:
NONE

- APPROVALS -

BOEING DESIGN	: STAN BARAUSKAS	: Stan Barauskas 3/30/98
BOEING S-SYSTEM MGR	: TIBOR FARKAS	: 3/30/98
BOEING SS&PAE MGR	: POLLY STENGER	: 3/30/98
BOEING SAFETY ENG	: GOPAL RAO	: 3/30/98
BOEING RELIABILITY	: DAN HUNTER	: 3/30/98
NASA -JSC MOD	: MEL FRIANT	: 4/1/98
NASA-JSC DCE REP	: BRAD IRLBECK	: 4/1/98
JSC SS&MA	: DAVID BEAUCH	: David Beauch 4/1/98
USA ORBITER ELEMENT	: MIKE BURKHARDT	: 4/1/98