FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: 04-2-LV12-IM -X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
REVISION: BASIC 03/26/98

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: AUXILIARY POWER UNIT (APU) SUNDSTRAND	MC201-0001-06XX AND SUBS 763758
SRU	:GAS GENERATOR VALVE MODULE, SOLENOID SUNDSTRAND	5910215 SAME

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, PULSE CONTROL (PCV), DIRECT ACTING, 3 PORT, 2 POSITION, POPPET TYPE VALVE, NORMALLY OPEN, PRIMARY AND SECONDARY SPEED CONTROL

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
ONE PER APU

FUNCTION:
TO CONTROL APU TURBINE SPEED (AT 103% SPEED - "NORMAL" SPEED - OR 115% SECONDARY) BY PORTING FUEL TO EITHER THE GAS GENERATOR OR TO THE BYPASS TO THE FUEL PUMP INLET. NOTE: CANNOT FUNCTION AS SHUTOFF VALVE.

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: 04-2-LV12-IM-01

REVISION#: BASIC 03/26/98
SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
LRU: AUXILIARY POWER UNIT (APU) **CRITICALITY OF THIS**
ITEM NAME: PULSE CONTROL VALVE, SOLENOID **FAILURE MODE:** 1R2

FAILURE MODE:
FAILS IN THE ENERGIZED POSITION (OPEN TO BYPASS, CLOSED TO OUTLET)

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF
DO DE-ORBIT
LS LANDING/SAFING

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

CAUSE:
INTERNAL MECHANICAL FAILURE, CONTAMINATION OR CORROSION IN THE VALVE OR ARMATURE MECHANISM, SEAT CONTAMINATION, BYPASS SEAT/SEAL LEAKAGE, CONTROLLER LOGIC FAILURES, POPPET FAILS TO OPERATE, LOSS/PARTIAL LOSS OF "S" SPRING FORCE, POPPET DISCONNECTED FROM STEM, INTERNAL LEAKAGE, O-RING 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 LANDING

REDUNDANCY SCREEN
A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

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- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF ONE APU SYSTEM. APU FAILS TO START OR SHUTS DOWN (UNDERSPEED), ALSO POSSIBILITY OF FUEL OVERHEATING AND DECOMPOSING WITH MULTIPLE CONTROLLER FAILURES CAUSING SOLENOID COIL TO REMAIN POWERED, RESULTING IN RUPTURE OF VALVE WHILE APU IS NOT OPERATING.

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

(C) MISSION:
ABORT DECISION IS POSSIBLE IF FAILURE OCCURS DURING ASCENT (TIMING AND FLIGHT TRAJECTORY DEPENDENT).

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT IF FAILURE OCCURS PRIOR TO LIFT OFF OR UNTIL SECOND SYSTEM IS LOST. DUAL CONTROLLER VALVE DRIVER FAILURES (SHORT) PLUS A SECOND FAILURE OF AN RPC OR PANEL SWITCH WOULD PREVENT POWER FROM BEING REMOVED, RESULTING IN OVERHEATING/RUPTURE. POSSIBLE LOSS OF VEHICLE IF CONTROLLER POWER NOT REMOVED AFTER APU SHUTDOWN. CRITICALITY 1 FOR ANY NON-APU 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 ARE LOST.

-DISPOSITION RATIONALE-

(A) DESIGN:
VALVE IS PROTECTED BY 25-MICRON SYSTEM FILTER IN-LINE UPSTREAM AND FUEL PUMP 25-MICRON FILTER IN-LINE UPSTREAM. CORROSION-RESISTANT MATERIALS (17-7PH, 304L, MP35N, TITANIUM) ARE USED. NGGVM INCORPORATES THE FOLLOWING IMPROVEMENTS: 1. THE INSPECTABILITY OF CRITICAL WELDS, 2. INCREASED BARRIER THICKNESS BETWEEN THE COIL AND POPPET CHAMBER TO REDUCE STRESS, 3. ADOPTED A BOLTED DESIGN TO FACILITATE OVERHAUL AND REPAIR, 4. INCORPORATED A SEGMENTED COIL TO PRECLUDE FAILURE INDUCED OVERHEAT, 5. FRACTURE/CORROSION RESISTANT INTERNAL VALVE SEAT/POPPET MATERIAL, 6. ADDITIONAL EXPOSURE TESTS ON SELECTED MATERIALS HAVING LIMITED DATA.

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(B) TEST:
NGGVM PERFORMANCE IS VERIFIED DURING ACCEPTANCE TESTING AT THE VENDOR. ACCEPTANCE LEAKAGE TESTS ARE CONDUCTED AT BOTH VALVE AND APU LEVEL. CERTIFICATION TESTS CONDUCTED AT THE WHITE SANDS TEST FACILITY COMPLETED 33.8 HOURS IN 1996. APPROXIMATELY 30 HOURS ADDITIONAL TESTING TO BE PERFORMED IN 1997-99.

OMRSD: ELECTRICAL AND EXTERNAL LEAK CHECKS ARE PERFORMED ON THE ORBITER AFTER APU INSTALLATION. OPERATION IS THEN VERIFIED THROUGH A CONFIDENCE RUN PRIOR TO FLIGHT OF EACH NEWLY INSTALLED APU. FLIGHT DATA IS USED TO VERIFY NGGVM OPERATION EVERY FLOW AFTER THE FIRST FLIGHT. BETWEEN FLIGHTS, ELECTRICAL CONTINUITY AND CONTROLLER TESTS ARE PERFORMED TO VERIFY FLIGHT READINESS.

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

CONTAMINATION CONTROL
CLEANLINESS TO LEVEL 100 IS VERIFIED BY INSPECTION. FLUID SAMPLES ARE ANALYZED FOR CONTAMINATION AND 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. SOLENOID IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
PENETRANT INSPECTION OF WELDS AND ASSEMBLIES IS VERIFIED. RADIOGRAPHIC INSPECTION OR CROSS SECTION INSPECTION OF LOT SAMPLE PERFORMED ON WELDS. NDE PERFORMED FOR CRITICAL WELDS.

CRITICAL PROCESSES
WELDING PER SPECIFICATION REQUIREMENTS IS VERIFIED BY INSPECTION. WELDING PROCEDURES, EQUIPMENT AND SCHEDULES ARE REVIEWED/APPROVED BY THE APU CORE TEAM. DESTRUCTIVE INSPECTION OF CRITICAL WELDS FROM LOT SAMPLES OF PRODUCTION HARDWARE IS VERIFIED BY INSPECTION.

TESTING
CALIBRATION OF TOOLS AND TEST EQUIPMENT ARE VERIFIED BY INSPECTION. ATP IS WITNESSED AND VERIFIED BY INSPECTION

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

(D) FAILURE HISTORY:

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

(E) OPERATIONAL USE:
PRELAUNCH OCCURRENCE WILL CAUSE LAUNCH TO BE SCRUBBED. IF APU SHUTS DOWN DURING ASCENT, REMAINING APUS ARE COMMANDED TO HIGH SPEED AND AUTOMATIC SHUTDOWN IS INHIBITED TO PRECLUDE INADVERTENT SHUTDOWNS. IF AN APU SHUTS DOWN DURING DESCENT, REMAINING APUS ARE COMMANDED TO HIGH SPEED AT TAEM AND AUTO SHUTDOWN REMAINS ENABLED.

- 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 ENG	: DAN HUNTER	: 3/30/98
NASA-JSC MOD	: MEL FRIANT	: 4/1/98
NASA-JSC DCE REP	: BRAD IRLBECK	: 4/1/98
JSC SSCMA	: DAVID BEAUGH	: David Beaugh 4/1/98
USA ORBITER ELEMENT	: MIKE BURGHARDT	: M J. Burghardt 4/1/98