

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL HARDWARE

NUMBER: 04-2-LV13-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) SUNSTRAND	MC201-0001-06XX AND SUBS 763758
SRU	GAS GENERATOR VALVE MODULE, SOLENOID SUNSTRAND	5910215 SAME

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

SOLENOID SHUTOFF VALVE, DIRECT ACTING, 3 PORT, 2 POSITION POPPET TYPE VALVE, NORMALLY CLOSED. HIGH SPEED CONTROL AND APU SHUTOFF.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
ONE PER APU

FUNCTION:

(1) TO CONTROL APU TURBINE WHEN "HIGH SPEED" (113%) HAS BEEN MANUALLY SELECTED OR WHEN PULSE CONTROL (PC) VALVE (LV12) FAILS OPEN.
(2) TO SHUT DOWN THE APU WHEN DE-ENERGIZED AND SHUTOFF FUEL FLOW TO MAINTAIN APU INLET PRESSURE FOR SUBSEQUENT APU START/OPERATION

FAILURE MODES EFFECTS ANALYSIS FMEA - CIL FAILURE MODE

NUMBER: 04-2-LV13-IM-01

REVISION#: BASIC 03/26/98

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

LRU: AUXILIARY POWER UNIT (APU)

ITEM NAME: SHUTOFF VALVE, SOLENOID

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

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

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:

INTERNAL MECHANICAL OR WELD FAILURE, CONTAMINATION OR CORROSION IN THE VALVE OR ARMATURE MECHANISM, SEAT/SEAL LEAKAGE, DUAL CONTROLLER LOGIC FAILURES, CONTAMINATION, CONTAMINATION IN ARMATURE/MAGNET GAP, LOSS/PARTIAL LOSS OF 'S' SPRING FORCE, O-RING FAILURE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS
 B) PASS
 C) PASS

PASS/FAIL RATIONALE:

A)

B)

DETECTABLE ONLY AT APU SHUTDOWN WHEN APU CONTINUES TO OPERATE AFTER SHUTDOWN IS COMMANDED OR IF CHAMBER PRESSURE DOES NOT FALL TO ZERO (OPERATING TRANSDUCER BIAS LEVEL) WHEN HIGH SPEED IS SELECTED.

C)

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

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- FAILURE EFFECTS -

(A) SUBSYSTEM:

LOSS OF HIGH SPEED CAPABILITY. LOSS OF OVERSPEED PROTECTION FOR CASE OF PCV FAILING OPEN. INABILITY TO SHUTDOWN APU USING NORMAL PROCEDURES. REQUIRES FIV CLOSURE FOR APU SHUTDOWN. THIS PROCEDURE RESULTS IN FUEL LINE EVACUATION DOWNSTREAM OF FIV AND POTENTIAL ADIABATIC COMPRESSION DETONATION (ABCD) WITH SUBSEQUENT FIV OPENING.

(B) INTERFACING SUBSYSTEM(S):

NONE WITHOUT ADDITIONAL FAILURE. POSSIBLE DAMAGE TO ADJACENT EQUIPEMENT FOR TURBINE OVERSPEED CASE.

(C) MISSION:

NONE WITHOUT ADDITIONAL FAILURE.

(D) CREW, VEHICLE, AND ELEMENT(S):

LOSS OF APU FOR FLIGHT OPERATIONS. POSSIBLE LOSS OF CREW/VEHICLE IF SECOND FAILURE CAUSES TURBINE OVERSPEED.

(E) FUNCTIONAL CRITICALITY EFFECTS:

POSSIBLE LOSS OF VEHICLE IF TWO OF THREE APUS ARE LOST.

-DISPOSITION RATIONALE-

(A) DESIGN:

VALVE PROTECTED BY 25-MICRON FILTER IN-LINE UPSTREAM AND FUEL PUMP 25-MICRON FILTER UPSTREAM. SHUTOFF VALVE IS CYCLED INFREQUENTLY. CORROSION RESISTANT MATERIALS (17-7PH, 304L, MP35N, TITANIUM) ARE USED. NGGVM INCORPORATES THE FOLLOWING: 1. THE INSPECTABILITY OF CRITICAL WELDS, 2. INCREASED BARRIER 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.

THE FUEL ISOLATION VALVES WILL BE AUTOMATICALLY CLOSED BY OVERSPEED SIGNAL FROM APU. A COMPUTER SIMULATION OF THE SAFETY SHUTDOWN CAPABILITY HAS INDICATED THAT WHEN THE LEAKAGE AREA OF THE PULSE CONTROL VALVE OUTLET IS OVER 25 PERCENT, IN COMBINATION WITH THE SHUTOFF VALVE BEING HELD OPEN OVER 95 PERCENT, ISOLATION VALVE CLOSURE AT OVERSPEED SIGNAL MAY NOT PREVENT OVERSPEED TO WHEEL BURST. THIS OCCURS ONLY WHEN THE HYDRAULIC PUMP IS UNDER LOW LOAD (APPROXIMATELY 10 HORSEPOWER).

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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. SOLENIOD 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 IS 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:

APU WILL CONTINUE OPERATE EVEN THOUGH IT IS COMMANDED OFF WITH THE APU OPERATE SWITCH (START/RUN TO OFF). THE APU WILL SHUTDOWN SAFELY WHEN THE FUEL ISOLATION VALVE (FIV) CLOSES AND FUEL IS EMPTIED DOWNSTREAM OF THE FIV. HOWEVER, APU IS LOST FOR THE REST OF THE MISSION DUE TO AN EVACUATED FUEL LINE DOWNSTREAM OF THE FIV. DURING DESCENT REMAINING APUS ARE COMMANDED TO HIGH SPEED AT TAEM AND AUTO SHUTDOWN REMAINS ENABLED.

- APPROVALS -

BOEING DESIGN	: STAN BARAUSKAS	: <i>Stan Barauskas 3/30/98</i>
BOEING S-SYSTEM MGR	: TIBOR FARKAS	: <i>Tibor Farkas 3/30/98</i>
BOEING SS&PAE MGR	: POLLY STENGER	: <i>Polly Stenger for 3/26/98</i>
BOEING SAFETY ENG	: GOPAL RAO	: <i>Gopal Rao 3/27/98</i>
BOEING RELIABILITY ENG	: DAN HUNTER	: <i>Dan Hunter 3/29/98</i>
NASA-JSC MOD	: MEL FRIANT	: <i>Mel Friant 4/1/98</i>
NASA-JSC DCE REP	: BRAD IRLBECK	: <i>Brad Irlbeck 4/1/98</i>
JSC SS&MA	: DAVID BEAUGH	: <i>David Beough 4/1/98</i>
USA ORBITER ELEMENT	: MIKE BURGHARDT	: <i>M. J. Burghardt 4/1/98</i>