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PRINT DATE: 09/21/94

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: 04-2-CLV13-X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

REVISION: 3 09/21/94

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	VALVE SOLENOID CARLETON CONTROLS	ME284-0552-0005 1809-001-68

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE SOLENOID, WATER

QUANTITY OF LIKE ITEMS: 3
THREE
ONE PER APU

FUNCTION:

CONTROLS FLOW OF COOLING WATER TO APU GAS GENERATOR (GG) TO LOWER INJECTOR TUBE BRANCH PASSAGE TEMPERATURES TO PREVENT HYDRAZINE DETONATION DURING APU HOT RESTART. GG INJECTOR COOLING MUST BE PERFORMED PRIOR TO APU START IF GG INJECTOR OR BED TEMPERATURE IS ABOVE 415 DEG F (DUE TO SOAKBACK) PER V46T0X74A OR V46T0X22A. CREW OPENS VALVE FOR 209 SECONDS (MINIMUM) WITH CONTROLLER POWER ON AND APU OPERATE SWITCH IN "INJECTOR COOL" POSITION. CREW MONITORS REAL-TIME DISPLAY TO CONFIRM INJECTOR TEMPERATURES ARE DECREASING. AT END OF COOLING PERIOD, CREW MUST CYCLE APU OPERATE SWITCH TO "START/RUN" POSITION IMMEDIATELY TO PREVENT REHEATING OF INJECTOR BRANCH PASSAGES.

INJECTOR COOLING CAN BE USED FOR BOTH PAD AND MISSION APU HOT RESTARTS (REFER TO THE FOLLOWING REFERENCE DOCUMENTS).

REFERENCE DOCUMENTS: NSTS-16007, LCC SECTIONS: APU-19, APU-20, APU-24-22,
NSTS-08934, (VOL I) SODB SECTION 3.4.4.3.5
NSTS 12820, FLIGHT RULE SECTION 10-3

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE
NUMBER: 04-2-CLV13-02**

REVISION# 3 09/21/94

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

LRU: VALVE SOLENOID

ITEM NAME: VALVE SOLENOID

CRITICALITY OF THIS
FAILURE MODE: 1R2

FAILURE MODE:
EXTERNAL LEAK, STUCK OPEN, INTERNAL LEAK

MISSION PHASE: PRELAUNCH

LO LIFT-OFF

OO ON-ORBIT

ENTR

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
CONTAMINATION, CORROSION, TRAPPED

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES
AOA ABORT ONCE AROUND

REDUNDANCY SCREEN

A) PASS	3
B) PASS	
C) PASS	FAIL

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

NO EFFECT FOR NOMINAL MISSION. GROSS WATER LEAKAGE RESULTS IN LOSS OF COOLING CAPABILITY TO ALL THREE APU'S. POSSIBLE HYDRAZINE DETONATION AT RESTART DUE TO EXCESSIVE GG BRANCH PASSAGE TEMPERATURE IF COOLING IS NOT AVAILABLE. APU'S CANNOT BE SAFELY RESTARTED WITHOUT WATER COOLING UNTIL GG INJECTOR OR BED TEMPERATURE (V46T0X74A OR V46T0X22A) FALLS BELOW 415 DEG F (APPROXIMATELY 4 HOURS AFTER SHUTDOWN).

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(B) INTERFACING SUBSYSTEM(S):
NO EFFECT FOR NOMINAL MISSION. LOSS OF SHAFT POWER TO ASSOCIATED HYDRAULIC SYSTEM(S).

(C) MISSION:
NO EFFECT FOR NOMINAL MISSION. PRECLUDES SAFE APU RESTART IN THE EVENT OF CONTINGENCY ABORT, OR SYSTEM-INDUCED AOA WITHIN FOUR HOURS OF APU SHUTDOWN. IF INJECTOR COOLING NOT AVAILABLE, ABORTS POSSIBLY DELAYED UNTIL GG INJECTOR TEMPERATURES FALL WITHIN SAFE RANGE.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT FOR NOMINAL MISSION. LOSS OF CREW/VEHICLE IF REENTRY IS ATTEMPTED WITHOUT HYDRAULIC POWER. POSSIBLE LOSS OF CREW/VEHICLE IN THE EVENT OF EMERGENCY SITUATION IF DEORBIT IS DELAYED. HAZARDOUS CONDITION EXISTS IF APU HOT RESTART IS ATTEMPTED WITHOUT INJECTOR COOLING.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NO EFFECT FOR NOMINAL MISSION. LOSS OF AEROSURFACE CONTROL, NOSE WHEEL STEERING (APU'S 1 & 2), BRAKING, AND LOSS OF LANDING GEAR DEPLOY (APU 1) REDUNDANCY UNTIL APU'S CAN BE STARTED. CRITICALITY 1 FOR SYSTEM-INDUCED ABORT-ONCE-AROUND IF APU'S ARE SHUT DOWN PRIOR TO INITIATION OF ABORT.

DISPOSITION RATIONALE

(A) DESIGN:
THE VALVE IS NORMALLY CLOSED. TWO POSITION SOLENOID VALVE, AND WOULD NOT BE OPENED UNLESS APU HAS TO START IN THE "INJECTOR COOL" POSITION TO ALLOW HOT RESTART; THEREFORE THE FAIL OPEN MODE IS REMOTE.

THE ENERGIZED SOLENOID COIL ASSEMBLY IS DESIGNED TO ELECTROMAGNETICALLY ATTRACT THE PLUNGER SLIDE (ARMATURE) WITH FORCES TO OVERCOME THE SEALED BELLOWS SPRING FORCE. THE BELLOWS IS MADE OF NICKEL AND PROVIDES A DYNAMIC INTERNAL SEAL IN CONJUNCTION WITH AN EPR (E515-8) STATIC SEAL. THE BELLOWS IS MECHANICALLY FITTED TO PLUNGER SLIDE TO ALLOW BELLOWS COMPRESSION WHEN THE SOLENOID IS ENERGIZED.

ALL METALS USED INSIDE VALVE WITH THE EXCEPTION OF THE BELLOWS, COIL WINDINGS, AND POWER LEADS ARE CONSTRUCTED OF CRES. MAXIMUM WORKING PRESSURE IS 140 PSIA, PROOF PRESSURE OF 155 PSIG AND BURST PRESSURE OF 200 PSIG.

VALVE IS PROTECTED BY INLET FILTER.

THE "INJECTOR COOL" POSITION OF THE COCKPIT SWITCH IS USED TO ENERGIZE EACH VALVE IN THE ORBITER.

(B) TEST:
ATP INCLUDES CLEANLINESS VERIFICATION, PROOF PRESSURE TO 155 PSIG, LEAK CHECKS AT 125 PSIG, FUNCTIONAL OPERATION, DIELECTRIC WITHSTANDING VOLTAGE (DWW), INSULATION RESISTANCE (IR), COIL RESISTANCE AND EXAMINATION OF PRODUCT.

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GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH
OMRSD

(C) INSPECTION:

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 300 IS VERIFIED BY INSPECTION. CORROSION PROTECTION IS
VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

POTTING AND TORQUING ARE VERIFIED BY INSPECTION. DIMENSIONAL INSPECTIONS
ARE PERFORMED AND VERIFIED BY INSPECTION. LUBRICANT APPLICATION ON SEAL
RING IS VERIFIED BY INSPECTION. SURFACE FINISHES ARE VERIFIED BY INSPECTION.
MANUFACTURING, ASSEMBLY, AND INSTALLATION PROCEDURES ARE VERIFIED BY
INSPECTION. BELLOWS FABRICATION IS VERIFIED BY INSPECTION. EB WELD IS
VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

VISUAL INSPECTION UNDER 10X MAGNIFICATION OF SEALING O-RING IS VERIFIED BY
INSPECTION.

CRITICAL PROCESSES

HEAT TREATMENT IS VERIFIED BY INSPECTION. SOLDERING REQUIREMENTS ARE
VERIFIED BY INSPECTION.

TESTING

TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ATP IS
WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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

(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND
OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE
FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

NONE

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- APPROVALS -

PAE MANAGER : K. L. PRESTON
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NASA SSMA :
NASA SUBSYSTEM MANAGER :

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J.C. Robinson
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W. Williams 10/12/94
10-17-94