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PRINT DATE: 09/21/94

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE  
NUMBER: D4-2-CL03-X**

**SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)**

**REVISION: 3 09/21/94**

	<b>PART NAME VENDOR NAME</b>	<b>PART NUMBER VENDOR NUMBER</b>
LRU	: LINES AND FITTINGS	V070-465502
LRU	: LINES AND FITTINGS	V070-465523

**PART DATA**

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
LINES, FITTINGS, AND H<sub>2</sub>O SERVICE COUPLING (MDO1)**

**QUANTITY OF LIKE ITEMS: 1  
ONE**

**FUNCTION:**

TRANSFERS COOLING WATER FROM WATER TANK TO WATER VALVES. INJECTOR COOLING SYSTEM PREVENTS 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) SOOB SECTION 3.4.4.3.5  
NSTS 12820, FLIGHT RULE SECTION 10-3

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE  
NUMBER: 04-2-CL03-02**

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)      REVISION# 3      09/21/94  
LRU: LINES AND FITTINGS  
ITEM NAME: LINES AND FITTINGS      CRITICALITY OF THIS FAILURE MODE: 1R2

**FAILURE MODE:**  
RESTRICTED FLOW

**MISSION PHASE: PRELIMINARY**

LO      LIFT-OFF  
OO      ON-ORBIT  
         ENTRY

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

**CAUSE:**  
CORROSION, CONTAMINATION, PINCHED LINE

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

**REDUNDANCY SCREEN**

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

**PASS/FAIL RATIONALE:**

A)

B) "Injector cooling is addressed as an emergency system. Therefore, its functional criticality is 1R.  
Redundancy screens for this hardware is N/A as there is no redundant hardware

C) to perform this function."

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

NO EFFECT FOR NOMINAL MISSION. RESTRICTED/IMPROPER FLOW 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. APUS 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).

IN LINE COMMON TO ALL APUS.

**(B) INTERFACING SUBSYSTEM(S):**

NO EFFECT FOR NOMINAL MISSION. LOSS OF SHAFT POWER TO ASSOCIATED HYDRAULIC SYSTEM(S). IF HOT RESTART CANNOT BE PERFORMED

**(C) MISSION:**

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(FIRST FAILURE)

NO EFFECT FOR NOMINAL MISSION. PRECLUDES SAFE APU RESTART IN THE EVENT OF CONTINGENCY ABORT, OR SYSTEM-INDUCED ADA 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.

WITH INADEQUATE

**(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:**

LINES ARE 1/4-IN 304L CRES WITH 0.020-IN. WALL THICKNESS WITH BRAZED JOINTS AND VOI-SHAN SEALS AT VALVES AND FITTINGS. THE BRAZED CONSTRUCTION ELIMINATES JOINTS AND POSSIBLE LEAK PATHS. LESS THAN 100 PSI OPERATING PRESSURE.

FASTENING CLAMPS ALLOW FREEDOM OF MOVEMENT. TUBING BENDS ARE CONTROLLED BETWEEN FIXED POINTS TO FACILITATE INSTALLATION AND ACCOMMODATE VEHICLE GROWTH AND MOVEMENT. FLOW TO INJECTOR IS CONTROLLED BY 0.018-IN. ORIFICE.

**(B) TEST:**

INITIAL TUBING PROOF PRESSURE AT 1.5 TIMES OPERATING PRESSURE. SUBSYSTEM FUNCTIONAL AND LEAK TESTS AFTER INSTALLATION.

ROCKWELL PERFORMED TUBING CERTIFICATION TESTS PER ORBITER TUBING VERIFICATION PLAN (SD 75-SH-205). THIS TESTING INCLUDED WORST CASE USAGE, PRESSURE CYCLING, FATIGUE, AND OFF-LIMIT TESTING FOR LINES, JOINTS, AND PANELS. SYSTEM EVALUATION TESTS ON OV-101 AND AT SUNSTRAND ALLOWED EVALUATION OF THE INSTALLED-SYSTEM CONDITION.

**GROUND TURNAROUND TEST**

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSO.

**(C) INSPECTION:**

RECEIVING INSPECTION  
MATERIAL AND PROCESSES CERTIFICATIONS ARE VERIFIED.

**CONTAMINATION CONTROL**

CLEANLINESS TO LEVEL 100 IS VERIFIED BY INSPECTION. CORROSION PROTECTION REQUIREMENTS ARE VERIFIED BY INSPECTION.

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**ASSEMBLY/INSTALLATION**

MANUFACTURING, ASSEMBLY AND INSTALLATION REQUIREMENTS ARE VERIFIED BY INSPECTION. CLAMPS AND ATTACHING HARDWARE ARE VERIFIED BY INSPECTION. VISUAL INSPECTION FOR BURRS DURING MANUFACTURE IS PERFORMED. VISUAL INSPECTION OF TUBING SECTIONS DURING FABRICATION IS VERIFIED BY INSPECTION.

**NONDESTRUCTIVE EVALUATION**

RADIOGRAPHIC INSPECTION OF BRAZE JOINTS IS VERIFIED BY INSPECTION.

**CRITICAL PROCESSES**

BRAZING PER SPECIFICATION REQUIREMENTS IS VERIFIED BY INSPECTION.

**TESTING**

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

**HANDLING/PACKAGING**

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

**(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 -**

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PAE MANAGER : K. L. PRESTON  
 PRODUCT ASSURANCE ENGR : T. AI  
 DESIGN ENGINEERING : J. C. ROBINSON  
 NASA SSMA :  
 NASA SUBSYSTEM MANAGER :

*V. L. Preston 9/22/94*  
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*V. L. Preston 10/12/94*  
*J. C. Robinson 10-17-94*