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PRINT DATE: 09/21/94

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CRITICAL HARDWARE  
NUMBER: 04-2-CTK01-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	: TANK, WATER	ME282-0100-0001
LRU	: COUPLING	ME276-0032-0009

**PART DATA**

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
WATER TANK AND TEST POINT COUPLING, GN<sub>2</sub> (MDO<sub>2</sub>)**

**QUANTITY OF LIKE ITEMS: 1  
ONE**

**FUNCTION:**

STORES/PROVIDES COOLING WATER FOR APU INJECTOR COOLING SYSTEM. TANK USES PRESSURIZED DIAPHRAM TO PROVIDE WATER TO CONTROL 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 209 SECONDS, CREW MUST CYCLE APU OPERATE SWITCH TO 'START/RUN' POSITION IMMEDIATELY TO PREVENT REHEATING OF INJECTOR BRANCH PASSAGES. COOLING PERIOD

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-21-22,  
NSTS-00034, (VOL I) SODB SECTION 3.4.4.3.5  
NSTS 12020, FLIGHT RULE SECTION 10-3**

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE  
NUMBER: 04-2-CTK01-01**

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

**FAILURE MODE:**  
BLADDER LEAK

**MISSION PHASE:** PRELIMINARY

LO      LIFT-OFF  
OO      ON-ORBIT  
         ENTRY

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

**CAUSE:**  
CONTAMINATION, EXCESSIVE PRESSURE, MATERIAL DEFECT, EXCESS REVERSE PRESSURIZATION

**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 to perform this function."

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

NO EFFECT FOR NOMINAL MISSION. GROSS WATER LEAKAGE 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. APU'S CANNOT BE SAFELY RESTARTED WITHOUT WATER COOLING UNTIL GG INJECTOR OR BED TEMPERATURE (V46TOX74A OR V46TOX22A) FALLS BELOW 415 DEG F (APPROXIMATELY 4 HOURS AFTER SHUTDOWN).

**(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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(1ST FAILURE)

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.

IN ADEQUATE

**(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.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

TANK USED ON SCATHA PROGRAM AS A FUEL TANK AT WORKING PRESSURE 400 PSIG AND SAFETY FACTOR OF 4 FOR BURST WITH FRACTURE MECHANICS CONTROL. DIAPHRAGM IS AF-E-332 MOLDED ETHYLENE PROPYLENE RUBBER, THE SAME AS USED IN APU FUEL TANK (REFERENCE FMEA 04-2-TK11-12).

**(B) TEST:**

BLADDER IS LEAK CHECKED AT 5 AND 100 PSID DURING ATP.

DURING QUALIFICATION TEST, BLADDER SUCCESSFULLY PASSED LEAK CHECK AFTER 100 EXPULSION CYCLES. TANK WAS VIBRATED TO 26.8 G RMS AND WITH SHOCK TESTING FOR SCATHA PROGRAM, WHICH ARE TO HIGHER REQUIREMENTS THAN FOR ORBITER.

**GROUND TURNAROUND TEST:**

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:****RECEIVING INSPECTION**

MATERIALS AND PROCESSES CERTIFICATIONS ARE VERIFIED BY INSPECTION. ELASTOMER COMPONENTS ARE VERIFIED BY INSPECTION.

**CONTAMINATION CONTROL**

MOLD CLEANLINESS IS VERIFIED BY INSPECTION. CLEANLINESS TO LEVEL 100 IS VERIFIED BY INSPECTION. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. MANUFACTURING, ASSEMBLY, AND INSTALLATION PROVISIONS ARE VERIFIED BY INSPECTION. DIAPHRAGM FABRICATION IS VERIFIED BY INSPECTION.

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**NONDESTRUCTIVE EVALUATION**  
BACKLIGHTING AND X-RAY OF DIAPHRAGM IS VERIFIED BY INSPECTION. PENETRANT AND RADIOGRAPHIC INSPECTIONS OF WELDS ARE VERIFIED BY INSPECTION. PENETRANT INSPECTION IS PERFORMED AFTER FORMING VESSEL IS VERIFIED BY INSPECTION.

**CRITICAL PROCESSES**  
WELDING PER SPECIFICATION REQUIREMENTS IS VERIFIED BY INSPECTION.

**TESTING**  
PRESSURE TEST OF DIAPHRAGM PRIOR TO INSTALLATION INTO TANK HEMISPHERE IS VERIFIED BY INSPECTION. 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 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

**- APPROVALS -**

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

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*T. AI*  
*J. C. Robinson 09/21/94*  
*R. W. Young 10-17-94*