PRINT DATE: 11/21/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 04-2-S17C-IM-X

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SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

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		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU	:	AUXILIARY POWER UNIT (APU) SUNDSTRAND	MC201-0001-04XX X742211X
■ SRU	:	THERMOSTAT SUNDSTRAND DATA CONTROLS	5908109 975-0478-003

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
THERMOSTAT, OVERTEMPERATURE, APU FUEL PUMP/VALVE (GGVM)/FUEL LINES (~~FEED~~, BYPASS, REFERENCE)
SUPPLY

■ QUANTITY OF LIKE ITEMS: 6
1 FOR HEATER ELEMENT A
AND ONE FOR HEATER ELEMENT B, 2 PER APU

■ FUNCTION:
TO PROVIDE A CLOSED ELECTRICAL CIRCUIT AT A MINIMUM OF 120 DEG F AND AN OPEN CIRCUIT AT A MAXIMUM OF 140 DEG F. DIFFERENTIAL BETWEEN OPENING AND CLOSING TEMPERATURE IS REQUIRED TO BE AT LEAST 7 DEG F. EACH OVERTEMPERATURE THERMOSTAT (~~S17C/S17D~~) CONTROLS ONE OF THE REDUNDANT ELEMENTS (HEATER A/HEATER B) OF THE APU FUEL PUMP, GGVM AND FUEL LINE HEATERS (REFERENCE FMEA 04-2-HR17) IN THE EVENT THAT THE CONTROL THERMOSTAT (~~S17A/S17B~~) FAILS CLOSED.

SX7A/SX7B SX7C/SX7D

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE NUMBER: 04-2-S17C-IM-02

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SUBSYSTEM: AUXILIARY POWER UNIT (APU)
LRU :AUXILIARY POWER UNIT (APU)
ITEM NAME: THERMOSTAT

CRITICALITY OF THIS FAILURE MODE:1R3

■ FAILURE MODE:
FAILS TO OPEN (FAILS CLOSED).

MISSION PHASE:
PL PRELAUNCH
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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

■ CAUSE:
INTERNAL PIECE-PART FAILURE, VIBRATION, BIMETAL DISC CRACK OR FATIGUE, LOSS OF HERMETIC SEAL, CONTAMINATION.

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) PASS
■ B) FAIL
■ C) FAIL

PASS/FAIL RATIONALE:
■ A)
THERMOSTAT OPENING CAN BE VERIFIED DURING TURNAROUND.

■ B)
OVERTEMPERATURE THERMOSTAT FAILURE NOT DETECTABLE UNTIL CONTROL THERMOSTAT FAILS CLOSED.

■ C)
VIBRATION OF THE ~~MOUNTING~~ LINES ON THE APU COULD CAUSE FAILURE OF ~~CONTROL AND~~ OVERTEMPERATURE THERMOSTATS ON BOTH HEATER SYSTEMS A AND B.

■ MASTER MEAS. LIST NUMBERS: V46T0X12A
: V46T0X28A

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE NUMBER: 04-2-517C-IM-02

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: V46T0~~X71A~~ 1X71A
: V46T0~~X72A~~ 1X72A
: V46T0X92A

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
NO EFFECT ON APU OPERATION. LOSS OF HEATER REDUNDANCY IF CONTROL THERMOSTAT (~~S17A/S17B~~ S1X7A/S1X7B) FAILS.

■ (B) INTERFACING SUBSYSTEM(S):
NO EFFECT

■ (C) MISSION:
NO EFFECT AS OVERTEMPERATURE THERMOSTAT FAILURE IS NOT DETECTABLE.

■ (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT UNLESS FUEL LINE OVERHEATS AND FUEL IGNITES. POSSIBLE LOSS OF CREW/VEHICLE.

■ (E) FUNCTIONAL CRITICALITY EFFECTS:
1ST FAILURE - OVERTEMPERATURE THERMOSTAT FAILED CLOSED HAS NO EFFECT.
2ND FAILURE - FAILURE OF CONTROL THERMOSTAT (OPEN OR CLOSED) WILL BE DETECTED BY FDA AND RESULT IN CREW SELECTING THE REDUNDANT HEATER SYSTEM.
3RD FAILURE - FAILURE OF THE REDUNDANT SYSTEM OR COCKPIT SWITCH CAN CAUSE FAILED ON HEATER OR FAILED OFF HEATER. FAILED ON HEATER WOULD RESULT IN FUEL IGNITION IF HEATER POWER IS NOT REMOVED. FAILED OFF HEATER CAN CAUSE FUEL FREEZING AND LINE RUPTURE (HYDRAZINE LEAKAGE) UPON THAWING.

- DISPOSITION RATIONALE -

■ (A) DESIGN:
THE ELECTRICAL SYSTEM IS DESIGNED WITH (3) DRIVERS THROUGH (RPC) TO TURN HEATERS ON OR OFF. A (3) POLE SWITCH WHICH HAS (1) POLE TO EACH DRIVER WHICH ENERGIZES THE CIRCUIT. ANY ONE DRIVER FAILED OFF WILL TURN OFF A HEATER; ONE DRIVER FAILING ON WILL NOT DELIVER POWER TO THE HEATER.

SWITCH IS DESIGNED TO MEET THE REQUIREMENTS OF MIL-S-24236, IT IS AN ALL WELDED CONSTRUCTION, CORROSION RESISTANT, SIMPLE, SNAP-ACTING THERMAL SWITCH, HERMETICALLY SEALED WITH DRY NITROGEN, IT IS RATED AT 5 AMPS, BUT CARRIES MILLIAMPS.

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■ (B) TEST:
PART ACCEPTANCE TEST INCLUDES CONTACT RESISTANCE, SEAL TEST, CREEP, AND 250 CYCLE RUN-IN.

IT IS QUALIFIED BY SIMILARITY TO LIKE MIL-S-24236 SWITCHES BUILT BY SUNDSTRAND DATA CONTROL. THE SWITCH WAS QUALIFICATION TESTED.
LCC: NOT DETECTABLE UNLESS CONTROL THERMOSTAT FAILS CLOSED. MAY NOT BE DETE IN ANY CO DURING CRYO LO DUE TO LOW TEMPER
OMRSD: APU 1/2/3 HEATER TEST BY COCKPIT COMMAND VERIFIES THERMOSTATS FOR FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER ANY TIME THE LINE, INSULATION, OR HEATER IS DISTURBED.

OVERTEMPERATURE THERMOSTAT (either SYSTEM) IS VERIFIED FUNCTIONAL FOR FIRST FLIGHT AND EVERY FIFTH FLIGHT THEREAFTER. A AND B CONTROL THERMOSTATS/HEATER SYSTEMS ARE VERIFIED OPERATIONAL IN-FLIGHT EVERY FLIGHT. (BOTH)

(SYSTEMS

■ (C) INSPECTION:
RECEIVING INSPECTION:
RAW MATERIALS ARE CERTIFIED AND VERIFIED BY INSPECTION. 1ST AND 20TH RECEIVED SHIPMENTS ARE VERIFIED BY OUT-PLANT ANALYSIS. OTHER SHIPMENTS ARE ACCEPTED ON VENDOR-SUPPLIED CERTIFICATION.

CONTAMINATION CONTROL:
ALL CLEANING OPERATIONS ARE PERFORMED AND INSPECTED PER DOCUMENTED CLEANLINESS REQUIREMENT PROCEDURES. MICROPARTICLE ANALYSIS PERFORMED ON A SAMPLE. PRECAP INSPECTION IS PERFORMED FOR EVERY UNIT.

ASSEMBLY/INSTALLATION:
ALL MANDATORY INSPECTION POINTS FOR MANUFACTURING OPERATIONS ARE VERIFIED AND DOCUMENTED.

NONDESTRUCTIVE EVALUATION:
GROSS LEAK CHECK IS DONE IN FC43 FLUORINERT AND IS VERIFIED BY QUALITY ASSURANCE INSPECTION FOR EVERY UNIT. PARTICLE NOISE IMPACT DETECTION (PIND) TESTING IS PERFORMED AT THE LOWER MODULE ASSEMBLY LEVEL (NOT ATP) FOR EVERY UNIT.

CRITICAL PROCESSES:
VERIFICATION OF CASE WELD IS DONE BY HELIUM LEAK CHECK FOR EVERY UNIT.

TESTING:
TEST EQUIPMENT CALIBRATION IS PER MIL-STD-45662. BURN-IN CYCLING AND ATP ARE PERFORMED AND VERIFIED FOR EVERY UNIT BY INSPECTION.

HANDLING/PACKAGING:
HANDLING, PACKAGING, STORAGE, AND SHIPPING PROCEDURES ARE VERIFIED BY PERIODIC SYSTEM AUDITS.

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■ (D) FAILURE HISTORY:
CAR 34RF11:
BASELINE APU IN-FLIGHT VIBRATION LEVELS EXCEED SWITCH DESIGN LIMITS AND HAVE RESULTED IN FAILED ON CONDITION, BUT IT COULD ALSO LEAD TO A FAILED OFF CONDITION.

CORRECTIVE ACTION: A STUDY TO REPLACE THESE SWITCHES ON THE IAPU WITH A VIBRATION INSENSITIVE DEVICE IS IN WORK.

■ (E) OPERATIONAL USE:
MANUALLY SWITCH TO ALTERNATE HEATER IF CONTROL THERMOSTAT AND OVERTEMP THERMOSTAT FAIL. IF ALTERNATE HEATER FAILS ON, CREW MUST REMOVE POWER FROM HEATER THEN MANUALLY CYCLE HEATER (IF POSSIBLE). IF ALTERNATE HEATER FAILS OFF, CREW MUST ORIENT VEHICLE TO PREVENT FUEL FREEZING.

- APPROVALS -

RELIABILITY ENGINEERING	D. R. ATAPATTU	
DESIGN ENGINEERING	J. R. MUNROE	
QUALITY MANAGER	O. J. BUTTNER	
NASA RELIABILITY		
NASA SUBSYSTEM MANAGER		
NASA QUALITY ASSURANCE		