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FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 04-2-S17A-IM-X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)

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	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU	AUXILIARY POWER UNIT (APU)	MC201-0001-04XX
■	SUNOSTRAND	X742211X
■ SRU	THERMOSTAT	59057
■	SUNOSTRAND DATA CONTROLS	975-0478-002
■ SRU	THERMOSTAT	59903
■	SUNOSTRAND DATA CONTROLS	975-0478-002

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
THERMOSTAT, TEMPERATURE CONTROL, APU FUEL PUMP/VALVE (GGVM)/FUEL LINES
(LEED, 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 73.5 DEG F AND
AN OPEN CIRCUIT AT A MAXIMUM OF 100 DEG F. DIFFERENTIAL BETWEEN
OPENING AND CLOSING TEMPERATURE IS REQUIRED TO BE AT LEAST 7 DEG F.
EACH THERMOSTAT (~~04-2-S17C~~) 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). THERE ARE OVERTEMPERATURE THERMOSTATS IN
SERIES WITH THE HEATERS (REFERENCE FMEA 04-2-S17C).

S X7A/S X7B

FOR
HEATER SYSTEM
(ONE HEATER SYSTEM)

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FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
 NUMBER: 04-2-S17A-IM-02

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

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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) PASS
- C) FAIL

PASS/FAIL RATIONALE:

- A)
 THERMOSTAT OPENING CAN BE VERIFIED DURING TURNAROUND.
- B)
 CONTROL THERMOSTAT FAILED CLOSED IS DETECTABLE. TEMPERATURE CONTROL
 BAND WILL SHIFT HIGHER FOR OVERTEMP THERMOSTAT CONTROL.
- C)
As a result
 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: V46TOX12A
 : V46TOX28A

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: V46TOX71A V46TIX71A
: V46TOX72A V46TIX72A
: V46TOX92A

- FAILURE EFFECTS -

- (A) SUBSYSTEM:
NO EFFECT ON APU OPERATION. LOSS OF HEATER REDUNDANCY IF OVERTEMP THERMOSTAT (S76/S7D) FAILS
- (B) INTERFACING SUBSYSTEM(S):
NO EFFECT
- (C) MISSION:
NONE.
- (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT UNLESS FUEL LINE OVERHEATS AND FUEL IGNITES AFTER A MINIMUM OF 3 FAILURES. POSSIBLE LOSS OF CREW/VEHICLE.
- (E) FUNCTIONAL CRITICALITY EFFECTS:
1ST FAILURE - CONTROL THERMOSTAT FAILED CLOSED WILL RESULT IN OVERTEMPERATURE THERMOSTAT REGULATING TEMPERATURE.
2ND FAILURE - FAILURE OF OVERTEMPERATURE 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 HEATER ON OR OFF. A (3) POLE SWITCH WHICH HAS (1) POLE TO EACH DRIVER WHICH ENERGIZES THE CIRCUIT. ANY ONE DRIVER 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 AND CARRIES MILLI AMPS

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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: FUNCTION VERIFIED DURING THE 6 HOUR PERIOD. *MAY NOT BE ABLE TO DETECT FAILED CLOSED THERMOSTAT DUE TO AFT COMMAND TEMPERATURE DURING CRYO LOADING.*
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.

^{EITHER}
A AND B CONTROL THERMOSTATS/HEATER SYSTEMS ARE VERIFIED OPERATIONAL IN-FLIGHT, EVERY FLIGHT.

■ (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.

