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PAGE: 1 PRINT DATE: 11/21/91

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: 04-2-S17A-IM-X

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SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
REVISION : 3 11/21/91

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

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
THERMOSTAT, TEMPERATURE CONTROL, 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 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 (~~S17A/S17B~~) 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).

SX7A/SX7B

(ONE PER HEATER SYSTEM)

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

CRITICALITY OF THIS FAILURE MODE:1R2

■ FAILURE MODE:
FAILS TO CLOSE (FAILS OPEN)

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, DISC FATIGUE/WEAR AND RESULTING CONTAMINATION.

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
■ A)
THERMOSTAT CLOSING CAN BE VERIFIED DURING TURNAROUND OR CRYO LOADING.

■ B)
TEMP SENSORS ARE ON FOA. LOW LIMIT IS 60 DEG F, BYPASS LINE TEMPERATURE (V46T0X28A).

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

■ MASTER MEAS. LIST NUMBERS: V46T0X28A
: V46T0X12A

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S05C27C
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: ~~V46T0X71A~~ → V46T1X71A
: ~~V46T0X72A~~ → V46T1X72A
: V46T0X92A

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
NO EFFECT ON APU OPERATION. LOSS OF HEATER REDUNDANCY. POSSIBLE LOSS OF SINGLE APU IF FUEL FREEZES.

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

■ (C) MISSION:
LAUNCH SCRUB IF DETECTED. NO EFFECT UNLESS BOTH PRIMARY AND SECONDARY HEATERS FAIL, THEN ABORT.

■ (D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT UNTIL SECOND SYSTEM LOSS. POSSIBLE LOSS OF CREW/VEHICLE DUE TO FIRE/EXPLOSION IF FUEL FREEZES AND LINE RUPTURE OCCURS UPON THAWING.

■ (E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST FAILURE NO EFFECT - FAILURE OF HEATER SYSTEM WILL BE DETECTABLE BY FDA AND RESULT IN CREW SWITCHING TO REDUNDANT HEATER SYSTEM WITHIN THE NORMAL RESPONSE TIME OF 15 MINUTES. FAILURE OF REDUNDANT HEATER SYSTEM OR COCKPIT SWITCH WILL RESULT IN ORBITER ATTITUDE MANAGEMENT TO MAINTAIN SYSTEM THERMAL CONSTRAINTS WITHIN LIMITS (REF. FLIGHT RULE 10-167). FMEA/CIL GROUND RULES DO NOT ALLOW ATTITUDE MANAGEMENT TO BE CONSIDERED AS REDUNDANCY. THEREFORE, CRITICALITY IS 1R2.

- DISPOSITION RATIONALE -

■ (A) DESIGN:
THE ELECTRICAL SYSTEM IS DESIGNED WITH (3) DRIVERS THROUGH (RPC) TO TURN OFF THE HEATER. A (3) POLE SWITCH HAS (1) POLE TO EACH DRIVER WHICH ENERGIZES THE CIRCUIT. ANY ONE DRIVER TURNED OFF WILL TURN OFF A 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 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: FUNCTION VERIFIED DURING THE T-0 HOUR PERIOD. BOTH
OMRSD: APU 1/2/3 HEATER TEST BY COCKPIT COMMAND VERIFIES THERMOSTATS (SYSTEMS A
FOR FIRST FLIGHT AND ON A CONTINGENCY BASIS THEREAFTER ANY TIME THE
LINE, INSULATION, OR HEATER IS DISTURBED.
EITHER SYSTEM
CONTROL THERMOSTAT OPENING/CLOSING IS VERIFIED OPERATIONALLY EVERY
FLIGHT FOR SYSTEMS A AND B.

■ (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 A FAILED ON CONDITION, BUT IT COULD ALSO LEAD TO 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:
FAILURE OF THE HEATER SYSTEM IS DETECTABLE BY FDA AND REQUIRES THE CREW MANUALLY SWITCHING TO THE REDUNDANT HEATER SYSTEM. IF REDUNDANT HEATER SYSTEM FAIL THEN ATTITUDE MANAGEMENT IS REQUIRED.

- APPROVALS -

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DESIGN ENGINEERING : J. R. MUNROE :
QUALITY MANAGER : O. J. BUTTNER :
NASA RELIABILITY : Manager 1/24/92
NASA SUB SYSTEM MANAGER: 1-24-92
NASA QUALITY