PRINT DATE: 2/25/2003
DATE/SUPERCEDING: NONE

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- HARDWARE
NUMBER: M0-AG1-E03 -X

SUBSYSTEM NAME: REMOTELY OPERATED FLUID UMBILICAL (ROFU)
REVISION: 01/23/03

PART DATA

PART NAME **VENDOR NAME**	**PART NUMBER** **VENDOR NUMBER**
: ROFU	V847-544100-001
: LINE HEATER COX & CO	MC363-0038-0037/-0038 2767-37,-38

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
MC363-0038-0037 IS LINE HEATER ON PAYLOAD SUPPLY AND RETURN LINES. MC363-0038-0038 IS LINE HEATER ON ORBITER SUPPLY AND RETURN LINES. HEATERS ARE ELECTRICAL RESISTANCE TYPE.

REFERENCE DESIGNATORS:
40P848HR1
40P848HR2
40P847HR28
40P847HR29

QUANTITY OF LIKE ITEMS: 4
(TWO ON PAYLOAD SIDE, TWO ON ORBITER SIDE)

FUNCTION:
EACH LINE HEATER IS SPIRALLY WRAPPED AROUND A FLEX HOSE AND QD TO PREVENT FREEZING OF COOLANT DURING ORBITAL OPERATIONS. EACH LINE HEATER HAS REDUNDANT HEATING ELEMENTS. POWER DISSIPATION FOR EACH ELEMENT OF PAYLOAD LINE HEATERS IS 8.0 +/- 0.4 WATTS AT 14 VDC, AND FOR ORBITER LINE HEATER ELEMENT 35.2 +/- 1.7 WATTS AT 14 VDC. HEATER LENGTHS ARE 96.5 IN. AND 191 +/- 3.0 IN. RESPECTIVELY. THERMAL SWITCHES CONTROL HEATER ON/OFF CYCLES. BOTH ELEMENTS CAN BE ENERGIZED AT THE SAME TIME. PLUMBING IS THERMALLY INSULATED TO MINIMIZE ELECTRICAL POWER REQUIREMENTS.

FAILURE MODES EFFECTS ANALYSIS FMEA -- FAILURE MODE NUMBER: M0-AG1-E03- 02

REVISION#: 01/23/03

SUBSYSTEM NAME: REMOTELY OPERATED FLUID UMBILICAL (ROFU)
LRU: LINE HEATER **CRITICALITY OF THIS**
ITEM NAME: LINE HEATER **FAILURE MODE:** 2R3

FAILURE MODE:
LINE TO LINE SHORT

MISSION PHASE: OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
INSULATION BREAKDOWN, GROUND HANDLING

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)
CONTINUITY CHECK IN OPF WOULD DETECT FAILURE

B)
NO INSTRUMENTATION AVAILABLE TO PROVIDE HEATER CONDITION. IT REQUIRES TWO INSULATION FAILURES OF THE HEATER ELEMENT(S) TO RESULT IN A LINE TO LINE SHORT.

C)
NO SINGLE CREDIBLE EVENT CAN DAMAGE BOTH ELEMENTS OF HEATER

- FAILURE EFFECTS -

(A) SUBSYSTEM:
NO EFFECT - FIRST FAILURE. LOSS OF ELECTRICAL INSULATION PROPERTIES OF ONE HEATER ELEMENT OF THE AFFECTED LINE HEATER.

(B) INTERFACING SUBSYSTEM(S):

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- FAILURE MODE NUMBER: M0-AG1-E03- 02

NO EFFECT - FIRST FAILURE. LINE TO LINE FAILURE OF THE HEATER ELEMENTS WILL NOT OCCUR UNTIL THERE IS SECOND LOSS OF DIELECTRIC PROPERTIES OF THE HEATER ELEMENT OR THAT OF THE REDUNDANT HEATER ELEMENT.

(C) MISSION:
NO EFFECT- FIRST FAILURE. AFTER SECOND INSULATION FAILURE RESULTING IN LOSS OF NOMINAL HEATING CAPABILITY OF THE HEATING ELEMENT, THE REDUNDANT HEATER ELEMENT CAN BE ENREGIZED. LOSS OF MISSION OBJECTIVE IF PAYLOAD COOLING SYSTEM IS LOST AFTER FAILURE OF ALL HEATING CAPABILITY.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NO EFFECT ON CREW OR VEHICLE. ACCUMULATOR WILL PREVENT DAMAGE TO COOLING SYSTEM / HEAT EXCHANGER IF LINE FREEZES AND COOLANT EXPANDS. LOSS OF HEATING CAPABILITY (AFTER TWO HEATER INSULATION FAILURES) COULD RESULT IN LOCALIZED FREEZING OF A COOLANT LINE FLEX HOSE RESULTING IN POSSIBLE FLEX HOSE RUPTURE. ANALYSIS INDICATES THAT THE SMALL QUANTITY OF WATER [50 OR SO CUBIC INCHES (~ 4 CUPS)] THAT WOULD BE RELEASED DUE TO FLEX HOSE RUPTURE DOES NOT POSE A HAZARD TO THE ORBITER. (REF. ANALYSIS NO. GDS-FSSO-02-012, DATED DECEMBER 12, 02)

SUCCESS PATHS REMAINING AFTER FIRST FAILURE: 1

- TIME TO EFFECT -

REACTION TIME: IMMEDIATE

-DISPOSITION RATIONALE-

(A) DESIGN:
THE TWO ELEMENTS IN EACH LINE HEATER ARE COVERED WITH SILICONE RUBBER. THE MINIMUM THICKNESS OF INSULATION IS .01 INCH TO THE OUTER SURFACE, .005 INCH BETWEEN ADJACENT PARTS OF THE SAME CIRCUIT, .10 INCH BETWEEN TERMINALS OF REDUNDANT CIRCUITS AND .015 INCH BETWEEN REDUNDANT ELEMENTS. THE HEATER ELEMENTS ARE SPIRALLY WRAPPED AROUND THE FLEX HOSES AND QDS, AND OVERWRAPPED WITH AN MLI BLANKET. THIS TYPE OF HEATER IS EXTENSIVELY USED ON THE ORBITER VEHICLE AND IS RESISTANT TO DAMAGE BY HANDLING, INSTALLATION OR FLUID CONTACT.

(B) TEST:
ACCEPTANCE TESTS ON EACH LINE HEATER INCLUDE EXAMINATION OF PRODUCT; INSULATION RESISTANCE AT 500 VDC AFTER 1.5 HOURS AT 300°F; POWER DISSIPATION AT THE RATING VOLTAGE; AND RADIOGRAPHIC INSPECTION. QUALIFICATION TESTS ON SIMILAR LINE HEATERS INCLUDED SALT FOG, HUMIDITY, LIFE CYCLING, AND STATIC PULL TEST (14LB TENSION ON EACH LEAD WIRE FOR ONE MINUTE WITH MONITORING OF ELECTRICAL CONTINUITY).

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- FAILURE MODE NUMBER: M0-AG1-E03- 02

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS AND MATERIALS. CERTIFICATION RECORDS AND TEST REPORTS FOR MATERIALS AND PHYSICAL PROPERTIES ARE MAINTAINED.

CONTAMINATION CONTROL
CONTAMINATION CONTROL PROCESSES ARE VERIFIED BY INSPECTION. ALL MATERIALS ARE CLEANED TO ENSURE SURFACES OF PARTS ARE FREE OF DUST, OILS AND OTHER SURFACE CONTAMINATION.

TESTING
ACCEPTANCE TESTING, INCLUDING DIELECTRIC STRENGTH AND ELEMENT RESISTANCE, ARE VERIFIED BY CERTIFIED PERSONNEL.

HANDLING/PACKAGING
PARTS PROTECTION, HANDLING AND PACKAGING ARE VERIFIED BY INSPECTION TO APPLICABLE MIL-STD-794 REQUIREMENTS.

(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 DATA BASE.

(E) OPERATIONAL USE:
DURING UNDOCK MISSION PHASE, THERMAL CONDITIONING OF VEHICLE MAY BE POSSIBLE TO THAW FROZEN LINE OR TO PREVENT FREEZING.

- APPROVALS -

S&R ENGINEER	:A. NGUYEN	:/S/ ANH NGUYEN_____
CARGO/INTEG ITM	:J. CAPALENI	:/S/Bob Dueeasef or_____
DESIGN ENGINEER	:L.T. HARPER	:/S/ L. T. HARPER_____
SSM	:L. J. SALVADOR	:/S/ PHAM HOE FOR_____
NASA/DCE	:B. BROWN	:/S/ B. BROWN_____
MOD	:C. STEPHENSON	:/S/ C. STEPHENSON_____
SR&QA	:H. MALTBY	:/S/ HARRY MALTBY_____
USA/SAM	:R. SMITH	:/S/ R. SMITH_____
USA CARGO/INTG ELEMENT	:S. KUNKEL	:/S/ S. KUNKEL_____
USA ORBITER ELEMENT	S. LITTLE	:/S/ SUZANNE LITTLE_____