FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER:M8-1SS-E046 -X

SUBSYSTEM NAME: ECLSS - EMU OXYGEN RECHARGE SYSTEM
REVISION: 1 10/22/97

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:LINES & FITTINGS	M072-643401
LRU	:LINES & FITTINGS	M072-643403
LRU	:LINES & FITTINGS	V828-643050
SRU	:LINES & FITTINGS MULTIPLE SOURCES	MULTIPLE P/N'S

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
EMU OXYGEN RECHARGE LINES, FEEDTHRU'S, AND FITTINGS

QUANTITY OF LIKE ITEMS: 1
ONE SET PER SUBSYSTEM

FUNCTION:
THREE FUNCTIONS ARE INCLUDED IN THIS FMEA: (1) PROVIDES A SINGLE SUPPLY PATH OF OXYGEN FROM A MID DECK CONNECTION TO THE EXTERNAL AIRLOCK EMU ECLSS PANEL INTERFACE; (2) WITHIN THE ECLSS PANEL THE OXYGEN LINE SPLITS INTO TWO PATHS TO SUPPLY OXYGEN TO BOTH EMU INTERFACE MECHANICAL FITTINGS; AND (3) PROVIDES A SINGLE PATH OF OXYGEN FROM A TEE IN THE SINGLE EMU O2 LINE TO THE EXTERNALLY MOUNTED EVA MANUAL O2 SHUTOFF VALVE IN THE O2 TRANSFER LINE TO SPACE STATION.

REFERENCE DOCUMENTS:
VS28-643001
V828-643050
V828-643051
M072-643403
M072-643416

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: M8-1SS-E046-01

REVISION#: 0 04/08/97

SUBSYSTEM NAME: ECLSS - EMU OXYGEN RECHARGE SYSTEM
LRU: EMU OXYGEN SUPPLY LINES CRITICALITY OF THIS
ITEM NAME: LINES, FEEDTHRU'S, & FITTINGS FAILURE MODE: 1R2

FAILURE MODE:
EXTERNAL LEAKAGE (GROSS)

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

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

CAUSE:
CORROSION, MECHANICAL SHOCK, EXCESSIVE VIBRATION, MATERIAL DEFECT, FATIGUE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN
A) PASS
B) N/A
C) PASS

PASS/FAIL RATIONALE:
A)

B)
N/A - REDUNDANCY IS IN STANDBY UNTIL REQUIRED

C)

METHOD OF FAULT DETECTION:
INSTRUMENTATION - REDUCED OR LOSS OF EMU OXYGEN PRESSURE INDICATION ON THE AW82D PANEL PRESSURE GAUGE. LEAKAGE OCCURRING UPSTREAM OF A CLOSED OXYGEN SHUTOFF VALVE COULD BE DETECTED BY A DROP IN ORBITER OXYGEN PRESSURE.

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REMARKS/RECOMMENDATIONS:
A SINGLE PATH PROVIDES OXYGEN TO THE ECLSS PANEL . WITHIN THE ECLSS PANEL DUAL OXYGEN SUPPLY PATHS ARE PROVIDED TO SERVICE THE EMU'S. EACH EMU CONTAINS TWO PRIMARY AND TWO SECONDARY TANKS ALL OF WHICH ARE FILLED PRIOR TO LAUNCH. WORST CASE SCENARIO IS WHEN OXYGEN LEAKAGE OCCURS UPSTREAM OF THE ECLSS PANEL EMU OXYGEN CONTROL VALVES AND PRIOR TO FILLING AFFECTED EMU. CLOSING ORBITER EMERGENCY OXYGEN VALVING TO TERMINATE LEAKAGE IS A CRITICALITY 1/1 CONDITION.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
WORST CASE. EMU OXYGEN SUPPLY IS DIVERTED BEFORE IT REACHES THE ECLSS PANEL.

(B) INTERFACING SUBSYSTEM(S):
INCREASED USE OF OXYGEN. POSSIBLE HIGH OXYGEN PRESSURE IN CREW CABIN OR EXTERNAL AIRLOCK IF LEAK IS NOT ISOLATED. POSSIBLE FLAMMABILITY VIOLATION. POTENTIAL LOSS OF EMERGENCY O2 SYSTEM DUE TO EXCESSIVE OXYGEN LEAKAGE.

(C) MISSION:
CREW DECISION TO ABORT MISSION WOULD RESULT IN LOSS OF MISSION OBJECTIVES. LES/AIRLOCK O2 SUPPORT HAS BEEN LOST IF LEAKAGE IS SIGNIFICANT. CABIN O2 MAKEUP CAPABILITY IS STILL AVAILABLE.

(D) CREW, VEHICLE, AND ELEMENT(S):
GROSS EXTERNAL LEAKAGE COULD RESULT IN INADEQUATE O2 SUPPLY TO LES STATIONS AND SPACE STATION. LOSS OF LES SUPPORT CAPABILITY MAY RESULT IN LOSS OF CREW IF UNCONTROLLED LEAK RATE PROHIBITS LES SYSTEM PRESSURIZATION AND LES IS REQUIRED. LOSS OF O2 TO EMU'S COULD RESULT IN LOSS OF CAPABILITY TO PERFORM CONTINGENCY EVA.

(E) FUNCTIONAL CRITICALITY EFFECTS:
LOSS OF EMERGENCY OXYGEN SYSTEM
(1A) FIRST FAILURE (EXTERNAL LEAKAGE OF LINES, FITTINGS, & QUICK DISCONNECTS) - OXYGEN IS DIVERTED OUT LEAKY LINE/FITTING/QD RESULTING IN AN INADEQUATE O2 SUPPLY TO LES STATIONS.
(2A) SECOND FAILURE (FAILURE THAT REQUIRED THE LES TO BE USED) - LOSS OF ORBITER OXYGEN SUPPLY RESULTING IN POTENTIAL LOSS OF CREW AND VEHICLE. - CRITICALITY 1R2 CONDITION.

INABILITY TO PERFORM CONTINGENCY EVA
(1B) FIRST FAILURE (EXTERNAL LEAKAGE OF LINES, FITTINGS, & QUICK DISCONNECTS) - OXYGEN IS DIVERTED AWAY FROM EMU PANEL. LOSS OF O2 TO EMU'S COULD RESULT IN LOSS OF EVA CAPABILITIES IF EMU O2 TANKS ARE EMPTY. CREW DECISION

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TO ABORT MISSION WOULD RESULT IN LOSS OF MISSION OBJECTIVES - CRITICALITY 2/2 CONDITION.
(2B) SECOND FAILURE (FAILURE NECESSITATING AN EVA TO PREVENT A POTENTIAL CATASTROPHIC SITUATION) - INABILITY TO PERFORM A CONTINGENCY EVA TO CORRECT A CRIT 1 CONDITION COULD RESULT IN LOSS OF CREW AND VEHICLE - CRITICALITY 1R2 CONDITION.

DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)): 1R2

(F) RATIONALE FOR CRITICALITY DOWNGRADE:
LOSS OF EMERGENCY OXYGEN SYSTEM
(3A) THIRD FAILURE (INABILITY TO ISOLATE EXTERNAL LEAKAGE) - GROSS EXTERNAL LEAKAGE RESULTS IN INADEQUATE O2 SUPPLY TO LES STATIONS. LOSS OF LES SUPPORT CAPABILITY MAY RESULT IN LOSS OF CREW IF LEAK RATE PROHIBITS LES SYSTEM PRESSURIZATION AND LES IS REQUIRED. NOTE - IN AN 8.0 PSIA HOLE IN CABIN CONTINGENCY MODE, AN EXTERNAL LEAK ALLOWING FLOW INTO THE CABIN MAY NOT BE CATASTROPHIC SINCE THERE IS A POSSIBILITY OF SAFELY BREATHING CABIN AIR, INTO WHICH THE O2 IS LEAKING, BY RAISING LES VISOR. WORST CASE FAILURE WOULD BE IN CASE OF CONTAMINATED CABIN ATMOSPHERE, WHEN LEAKAGE PREVENTS ADEQUATE FLOW TO LES STATIONS AND CABIN AIR MAY NOT BE SAFE FOR BREATHING. - CRITICALITY 1R3 CONDITION.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: SECONDS

TIME FROM DETECTION TO COMPLETED CORRECTING ACTION: N/A

IS TIME REQUIRED TO IMPLEMENT CORRECTING ACTION LESS THAN TIME TO EFFECT?
NO

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
THERE IS NO CORRECTIVE ACTION IF CREW DECIDES TO ABORT THE MISSION AS THE RESULT OF THIS FAILURE.

HAZARD REPORT NUMBER(S): FF-09, ORBI 270, ORBI 299

HAZARD(S) DESCRIPTION:
INABILITY TO SAFELY PERFORM EVA (FF-09), INABILITY TO SUPPLY O2 TO CABIN/CREW (ORBI 270), FLAMMABILITY THREAT IN CABIN DUE TO O2 LEAKAGE FROM ARS OR OTHER SYSTEMS (ORBI 299)

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: M6-1SS-E046-01

-DISPOSITION RATIONALE-

(A) DESIGN:
A RIGID LINE EXTENDS FROM THE MID DECK THROUGH A 576 BULKHEAD FEEDTHRU TO THE MFG BREAK. A FLEX LINE EXTENDS FROM A MECHANICAL FITTING LOCATED AT THE MFG BREAK THROUGH AN EXTERNAL AIRLOCK FEEDTHRU TO THE ECLSS PANEL. WITHIN THE ECLSS PANEL, TWO RIGID LINES EXTEND FROM A TEE TO AN OXYGEN CONTROL VALVE AND FROM EACH OXYGEN CONTROL VALVE TO AN EMU FITTING/QUICK DISCONNECT. ANOTHER RIGID LINE EXTENDS FROM A TEE IN THE ECLSS PANEL EMU O2 LINE TO THE EVA MANUAL O2 SHUTOFF VALVE LOCATED EXTERNALLY TO THE EXTERNAL AIRLOCK.

LINES, FEEDTHRU'S, AND FITTINGS ARE SIMILAR TO THOSE CURRENTLY USED ON THE ORBITER AND EXTENSIVE FLIGHT EXPERIENCE TO DATE PROVIDES CONFIDENCE IN THEIR DESIGN INTEGRITY.

RIGID LINES ARE FABRICATED OF 21-6-9 STAINLESS STEEL WITH A THICKNESS OF 0.016 INCH. FITTINGS ARE DYNATUBES MADE OF 17-4 PH STAINLESS STEEL AND ARE BRAZED INTO THE SYSTEM. 21-6-9 STAINLESS STEEL HAS GOOD CORROSION RESISTANCE, HIGH MECHANICAL PROPERTIES, GOOD IMPACT STRENGTH, AND HIGH STRENGTH TO WEIGHT RATIO. 17-4 PH CONDITION A CRES IS PRECIPITATION HARDENED CORROSION RESISTANT STEEL WHICH HAS A HIGH STRENGTH TO WEIGHT RATIO. BOTH MATERIALS ARE COMPATIBLE WITH GO2. ALL COMPONENTS HAVE A SAFETY FACTOR GREATER THAN FOUR.

FLEXIBLE LINES ARE MADE OF 321 CRES AND 17-4 PH CRES RESPECTIVELY. BOTH OF THESE STAINLESS STEELS ARE CORROSION RESISTANCE AND O2 COMPATIBLE. THE LINE ASSEMBLIES ARE A COMBINATION OF HARDLINE AND FLEX JOINTS WHICH PERMIT CONTROLLED FLEXURES IN THE X, Y, AND Z DIRECTIONS. THE LINE ASSEMBLY, WHILE AT OPERATING PRESSURE AND TEMPERATURE, CAN WITHSTAND 800 FLEXURE CYCLES IN EACH OF THE THREE ORTHOGONAL AXES WITHOUT LEAKAGE, IMPAIRMENT OR DEGRADATION OF PERFORMANCE.

(B) TEST:
ODS HARDWARE CERTIFIED BY SIMILARITY TO EXISTING ORBITER HARDWARE. ORBITER HARDWARE QUALIFICATION TESTING OF RIGID AND FLEXIBLE LINES IS AS FOLLOWS:
(1) RIGID LINES - PRETEST PROOF (2X OPERATING PRESSURE) AND EXTERNAL LEAK TEST (1 X 10 EXP -6 SCCS HE MAX). BURST TEST (BURST AT GREATER THAN OR EQUAL TO 4X OPERATING PRESSURE). IMPULSE FATIGUE TEST (TWO HUNDRED THOUSAND CYCLES OF IMPULSE WAVES). FLEXURE FATIGUE TEST (TEN MILLION CYCLES OF FLEXURE). RANDOM VIBRATION. POST TEST LEAK TEST (1 X 10 EXP -6 SCCS HE MAX). DYNATUBE COUPLINGS ARE AUTHORIZED BY RI SPEC MF0004-0100 "MECHANICAL - ORBITER PROJECT PARTS LIST".
(2) FLEXIBLE LINES - VIBRATION TESTING INCLUDES 48 MINUTES OF RANDOM VIBRATION IN EACH OF THE THREE ORTHOGONAL AXES OVER A FREQUENCY RANGE OF 20 TO 2000 HZ AT THE FOLLOWING INTENSITIES: 20 TO 150 HZ, 6 DB/OCTAVE RISE; 150 TO 900 HZ, CONSTANT AT 0.09 G**2/HZ; AND 900 TO 2000 HZ, 9 DB/OCTAVE DECREASE. FOLLOWING VIBRATION LINES SUBJECTED TO A PROOF PRESSURE TEST. DESIGN SHOCK: THREE SHOCK PULSES IN EACH DIRECTION OF THREE ORTHOGONAL AXES, EACH PULSE HAVING AN AMPLITUDE OF 20 G, A DURATION OF 11 MS, AND

APPROXIMATED A TERMINAL PEAK SAWTOOTH SHAPE. TRANSIENT SHOCK TEST: WHILE PRESSURIZED LINES SUBJECTED TO ONE SINUSOIDAL SWEEP IN THREE ORTHOGONAL AXES OVER FREQUENCY RANGE OF 5 TO 35 HZ AT A SWEEP RATE OF ONE OCTAVE PER MINUTE AT AN APPLIED ACCELERATION OF 0.25G PEAK. BURST PRESSURE: CRYO O2 - 4200 PSIG, AUX O2 - 5000 PSIG.

ACCEPTANCE TEST (ORBITER O2 FLEXIBLE LINES) - CRYO O2: FLOW RATE OF 10 LB/HR. PROOF PRESSURE AT 2100 PSIG. AUXILIARY O2: FLOW 150 LB/HR, PROOF PRESSURE AT 2500 PSIG. MAX PRESSURE DROP AT OPERATING PRESSURE: CRYO O2 - 0.08 PSI, AUX O2 - 4.62 PSI.

IN-VEHICLE TESTING (ORBITER O2 RIGID/FLEX LINES, FEEDTHRU'S, FITTINGS) - O2 LINES ARE OVERPRESSURED (1070 - 1255 PSIG) AND LEAK TESTING IS PERFORMED AT 925 - 950 PSIG, 1 X 10 EXP-7 SCCM MAX LEAKAGE.

IN-PROCESS AND ACCEPTANCE TEST (EMU OXYGEN RECHARGE SYSTEM) - (A) OVERPRESSURE TEST: WITH COMPONENTS INSTALLED & OPEN, EMU OXYGEN RECHARGE SYSTEM PRESSURIZED BETWEEN 1295 AND 1345 PSIG AND HELD FOR A MINIMUM OF 5 MINUTES. LINES, FITTINGS, AND FEEDTHROUGHS VERIFIED NOT TO RUPTURE. AND (B) JOINT LEAK CHECK: EMU OXYGEN RECHARGE SYSTEM PRESSURIZED BETWEEN 925 AND 950 PSIG WITH GHE. LEAK RATES VERIFIED NOT TO EXCEED 1 X 10-7 SCCS INDICATED OR 1 X 10-4 SCCS ACTUAL PER MF0001-003. GROSS LEAKAGE NOT TO EXCEED 10 SCCM.

OMRSD - TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
RAW MATERIAL AND PROCESS CERTIFICATIONS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROVISIONS AND CONTAMINATION CONTROL PLAN ARE VERIFIED BY INSPECTION. CLEANLINESS LEVEL 200A PER MA0110-301 PRIOR TO AND DURING OPERATIONS, 100 ML RINSE TEST VERIFIED BY INSPECTION. ELECTROPOLISHING ON EXTERNAL SURFACES PRIOR TO WELDING IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
FABRICATION OF PARTS/COMPONENTS PER DRAWING VERIFIED BY INSPECTION. DIMENSIONS AND TORQUES ARE VERIFIED BY INSPECTION. MANUFACTURING PROCESSES, INSTALLATION AND ASSEMBLY ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
RADIOGRAPHIC INSPECTION OF INDUCTION BRAZES VERIFIED BY INSPECTION. FLUORESCENT PENETRANT INSPECTION PER MIL-I-6866 PERFORMED AND VERIFIED BY INSPECTION.

CRITICAL PROCESSES
PARTS PASSIVATION AND ELECTRICAL BONDING APPLICATION VERIFIED BY INSPECTION. JOINT/TUBE BRAZING IS VERIFIED BY RADIOGRAPHIC INSPECTION.

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INERT ARC WELD APPLICATION IN ACCORDANCE WITH MA0107-3 VERIFIED BY INSPECTION.

TESTING
ATP/QTP/OMRSD TESTING 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 PRACA DATA BASE.

(E) OPERATIONAL USE:
CREW COULD CLOSE OXYGEN SHUTOFF VALVE LOCATED IN THE MID DECK IF LEAKAGE IS DOWNSTREAM OF THIS VALVE OR CLOSE AFFECTED ORBITER OXYGEN VALVE TO STOP LEAKAGE IF LEAKAGE IS UPSTREAM OF THIS VALVE. IF REQUIRED, CREW COULD THEN UTILIZE AN EMU THAT CONTAINS A SUFFICIENT AMOUNT OF OXYGEN TO PERFORM AN EVA.

- APPROVALS -

SS & PAE	:	M. W. GUENTHER	:
PAE MANAGER	:	C. A. ALLISON	:
DESIGN ENGINEER	:	K. J. KELLY	:
NASA SS/MA	:		: 2-17-97
NASA SUBSYSTEM MANAGER	:		: 2-17-98
JSC MOD	:		: