FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: M8-1SS-BM002-X
(APPLIES ONLY TO THE ORBITER "SOFT" MECHANISM.)

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 DEC, 1996

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	STRUCTURAL LATCH MECHANISM RSC-ENERGIA	33U.6365.010-07 33U.6365.010-07
SRU	:	PYROTECHNIC BOLT RSC-ENERGIA	MC621-0087-0020 MC621-0087-0020

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
PYROTECHNIC BOLT

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 24
TWENTY-FOUR (1 FOR EACH ACTIVE/PASSIVE HOOK ON 12 ORBITER DOCKING MECHANISM STRUCTURAL HOOK ASSEMBLIES)

FUNCTION:
UPON RECEIVING AN ELECTRICAL COMMAND FROM THE PFCU THE AFFECTED PYRO BOLTS DETONATE AND SEVER TO ALLOW THE RELEASE OF THEIR RESPECTIVE ACTIVE OR PASSIVE STRUCTURAL HOOKS. THE PYRO RELEASE OF 12 ORBITER ACTIVE HOOKS PROVIDES POSITIVE SEPARATION BETWEEN THE ISSA AND THE ORBITER. (THE PYRO BOLTS ON THE 12 ORBITER PASSIVE HOOKS ARE USED DURING CONTINGENCIES ONLY. THE ISSA -7000 ACTIVE MECHANISM AND -8000 PASSIVE MECHANISMS DO NOT CONTAIN PYRO BOLTS.)

SERVICE IN BETWEEN FLIGHT AND MAINTENANCE CONTROL:
SERVICEABILITY CONTOL (ELECTRICAL CHECK).

MAINTAINABILITY
REPAIR METHOD - NONE (REPAIRING IN MANUFACTURING CONDITIONS ONLY).

REFERENCE DOCUMENTS:
LD34.440.024
33U.4645.011-05-002
33U.6121.038-07
33U.6201.008-09
33U.6365.010-07
33U.6366.007-02
33U.6366.008-02
33U.6366.009-02
33U.6366.010-02

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: M6-1SS-BM002- 01
(APPLIES ONLY TO THE ORBITER "SOFT" MECHANISM)

REVISION# 1 DEC, 1996

SUBSYSTEM NAME: MECHANICAL - ED5
LRU: STRUCTURAL LATCH MECHANISM
ITEM NAME: BOLT, PYROTECHNIC

CRITICALITY OF THIS FAILURE MODE: 1R3

FAILURE MODE:
PREMATURE FRACTURE

MISSION PHASE:
OO ON-ORBIT

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

CAUSE:
STRAY VOLTAGES, STATIC ELECTRICITY, RF RADIATION, EXTREME TEMPERATURES, IMPROPER MACHINING OF FRACTURE AREA, EXCESSIVE LOADS, MECHANICAL SHOCK

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

CRITICALITY 1R2 DURING INTACT ABORT ONLY (AVIONICS ONLY)? N/A

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

PASS/FAIL RATIONALE:
A)
N/A - PYROTECHNIC DEVICES ARE NOT CHECKED DURING GROUND OPERATIONS.

B)
N/A - PYROTECHNIC DEVICES ARE NOT CHECKED IN-FLIGHT.

C)
FAILS REDUNDANCY SCREEN "C" SINCE AN INADVERTENT FIRE COMMAND, EXTREME TEMPERATURES, OR STRAY/STATIC ELECTRICITY/RF RADIATION CAN ACTUATE MORE THAN ONE PYROTECHNIC RELEASE DEVICE. ALL WORKAROUNDS WOULD ALSO BE LOST WITH THIS EVENT - PREMATURE FIRING OF PYRO BOLTS ON ISSA MAY RENDER IT'S STRUCTURAL HOOKS UNUSABLE AND RAPID DECOMPRESSION DUE TO INADVERTENT FIRING OF ALL PYRO'S WOULD PRECLUDE CLOSING THE HATCHES TO ISOLATE LEAKAGE.

METHOD OF FAULT DETECTION:
PHYSICAL OBSERVATION - LEAKAGE THROUGH INTERFACE. CREW COULD POTENTIALLY HEAR A PREMATURE FIRING OF A PYRO.

REMARKS/RECOMMENDATIONS:

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UNDER NOMINAL OPERATIONS ONLY TWELVE ORBITER ACTIVE MECHANISM HOOKS ARE CLOSED.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
INADVERTENT OPENING OF A CLOSED ACTIVE HOOK OR SEPARATION OF A PASSIVE HOOK.

(B) INTERFACING SUBSYSTEM(S):
NO EFFECT FIRST FAILURE. POSSIBLE LOSS OF PRESSURE IN ORBITER HABITABLE AREAS FOLLOWING PREMATURE FRACTURING OF SECOND PYRO BOLT.

(C) MISSION:
POSSIBLE CREW DECISION TO ABORT MISSION IF AN INADVERTENT FRACTURING OF A PYRO BOLT OCCURS PRIOR TO COMPLETION OF MISSION OBJECTIVES. PYRO BOLT FRACTURING MAY PRECLUDE SUBSEQUENT DOCKINGS.

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT FIRST FAILURE. CREW SAFETY JEOPARDIZED FOLLOWING SECOND INADVERTENT PRYO BOLT FRACTURE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST PREMATURE PYRO BOLT FRACTURE - ONE ORBITER DOCKING MECHANISM STRUCTURAL HOOK IS NOT LATCHED. NO EFFECT, PRESSURE MAINTAINED WITH 11 HOOKS CLOSED.
SECOND PREMATURE PYRO BOLT FRACTURE - WORST CASE, TWO ADJACENT STRUCTURAL HOOKS ARE NOT LATCHED RESULTING IN ONLY 10 CLOSED HOOKS. DYNAMIC MOVEMENT BETWEEN ORBITER AND ISSA COULD BREAK THE SEAL BETWEEN BOTH MECHANISMS RESULTING IN LOSS OF HABITABLE PRESSURE THROUGH THIS INTERFACE. DURING IVA, ORBITER AND ISSA CREW SAFETY IS JEOPARDIZED WITH LOSS OF HABITABLE VOLUME.

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

(F) RATIONALE FOR CRITICALITY CATEGORY DOWNGRADE:
THIRD FAILURE (FAILURE TO CLOSE TWELVE ISSA STRUCTURAL HOOKS) - UNABLE TO SEAL INTERFACE. CONTINUOUS LOSS OF HABITABLE PRESSURE TO OUTSIDE ATMOSPHERE.
FOURTH FAILURE (UNABLE TO CLOSE APPROPRIATE HATCHES) - INABILITY TO ISOLATE LEAKAGE. POSSIBLE LOSS OF CREW AND VEHICLE WITH LOSS OF HABITABLE PRESSURE.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: HOURS TO DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: SECONDS

TIME FROM DETECTION TO COMPLETED CORRECTIVE ACTION: SECONDS TO MINUTES

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IS TIME REQUIRED TO IMPLEMENT CORRECTIVE ACTION LESS THAN TIME TO EFFECT?
YES

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
CREW HAS AMPLE TIME TO UTILIZE ISSA'S TWELVE STRUCTURAL HOOKS TO TIGHTEN THE INTERFACE OR CLOSE APPROPRIATE HATCH(S) TO ISOLATE LEAKAGE FROM THE CREW CABIN BEFORE PROBLEM BECAME CATASTROPHIC TO CREW/VEHICLE SAFETY.

HAZARDS REPORT NUMBER(S): ORBI 511

HAZARD(S) DESCRIPTION:
LOSS OF PRESSURE IN HABITABLE VOLUME.

-DISPOSITION RATIONALE-

(A) DESIGN:
FIRING CIRCUITRY CONSISTS OF TWISTED SHIELDED CABLES FOR BOTH EMI AND RF PROTECTION. THE PFCU CONTAINS BLEED-OFF RESISTORS WHICH GROUND OUT ANY ELECTROSTATIC CHARGE BUILDUP WITHIN THE ADPA. SERIES SWITCHES, SWITCH GUARDS, AND PULLED CIRCUIT BREAKERS PROVIDE PROTECTION AGAINST AN ERRONEOUS PYRO FIRING COMMAND. SPRING RATE OF BELLEVILLE WASHERS ARE VERIFIED BEFORE BEING INSTALLED ON PASSIVE HOOK. THE PYRO BOLT MATERIAL USED HAS A SAFETY FACTOR GREATER THAN 1.4 TIMES THE LIMIT LOAD.

THERMAL ANALYSIS HAD INDICATED THAT THE TEMPERATURE AT THE DOCKING MECHANISM WILL NEVER BE HIGH ENOUGH TO CAUSE AUTO-IGNITION OF THE PYROS BECAUSE THE ATTITUDE OF THE ORBITER IS CONSTANTLY CHANGING, IN RESPECT TO THE ISSA, DURING THE DOCKING PROCESS.

DEFLECTION ANALYSIS HAS INDICATED THAT THE ORBITER/ISSA DOCKING MECHANISM INTERFACE CAN BE INITIALLY SEALED FOR PRESSURIZATION WITH 10 ADJACENT ORBITER HOOKS CLOSED. HOWEVER, WITH THESE 10 HOOKS CLOSED DYNAMIC MOVEMENT BETWEEN THE VEHICLES COULD CREATE A GAP BETWEEN THE DOCKING MECHANISM AND SEAL, RESULTING IN LOSS OF PRESSURE THROUGH THIS INTERFACE. LEAK ANALYSIS HAD INDICATED THAT UNDER WORST CASE CONDITIONS A LEAK RATE OF 262 SCFM COULD OCCUR WHICH EXCEEDS THE 43.3 SCFM AIR MAKEUP CAPABILITY OF THE ORBITER AIR REVITALIZATION SYSTEM.

THE ELECTROEXPLOSIVE SYSTEM IS DESIGNED TO LIMIT THE POWER PRODUCED AT EACH PYROTECHNIC BOLT BY THE ELECTROMAGNETIC ENVIRONMENT ACTING ON THE SUBSYSTEM TO A LEVEL AT LEAST 20 DB BELOW THE MAXIMUM PIN-TO-PIN DC NO FIRE LEVEL OF THE PYROTECHNIC BOLT.

(B) TEST:
REFER TO "APPENDIX B" FOR DETAILS OF THE FOLLOWING QUALIFICATION TESTS OF THE DOCKING MECHANISMS RELATIVE TO THIS FAILURE MODE.

QUALIFICATION TESTS:
1. PYROTECHNIC SHOCK TEST

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REFER TO "APPENDIX C" FOR DETAILS OF THE FOLLOWING ACCEPTANCE AND QUALIFICATION TESTS OF PYROTECHNIC DEVICES RELATIVE TO THIS FAILURE MODE.

ACCEPTANCE TESTS:
(1) X-RAY
(2) BRIDGEWIRE RESISTANCE
(3) ELECTROSTATIC DISCHARGE
(4) INSULATION RESISTANCE

QUALIFICATION TESTS:
(1) ELEVATED TEMPERATURES
(2) BREAKING STRENGTH
(3) 6-FOOT DROP
(4) DC SENSITIVITY
(5) SHOCK
(6) BRIDGEWIRE RESISTANCE
(7) INSULATION RESISTANCE

QUALIFICATION TESTS (ADPA): THE FOLLOWING TESTS WAS PERFORMED ON THE MIR ADPA QUALIFICATION UNIT:

(1) RADIO FREQUENCY SAFETY - RADIATION TESTS WERE PERFORMED ON THE MIR/SHUTTLE DOCKING QUALIFICATION UNIT AT POWER LEVELS 20DB ABOVE THE ORBITER PAYLOAD BAY LIMITS. RADIATED RF POWER LEVELS WERE AS FOLLOWS: 11 VOLTS/M FOR FREQUENCY RANGE OF 1.5 TO ABOUT 11.5 MHZ; THEN INCREASES TO 13 VOLTS/M AT 11.5 MHZ; THEN INCREASES AT A CONSTANT RATE BETWEEN 13 AND 200 VOLTS/M BETWEEN 11.5 AND 1000 MHZ; AND REMAINS CONSTANT AT 200 VOLTS/M UNTIL A FREQUENCY OF 18,000 MHZ. THE RF RADIATION FIELD IS A CONTINUOUS WAVE SIGNAL. THIS TEST IS PERFORMED AT TWO WORST CASE POSITIONS WHERE EXPOSED PYRO BOLTS AND/OR WIRING ARE LOCATED. AT EACH TEST FREQUENCY THERE IS ABOUT 20 SECONDS OF DWELL TIME AND 20 SECONDS OF COOLING TIME.

(C) INSPECTION:
VISUAL INSPECTION
100% OF ALL PYRO BODIES ARE VISUALLY INSPECTED AND DOCUMENTEF FOR ABSENCE OF MECHANICAL DAMAGE AND CORROSION BY RSC-ENERGIA.

CRITICAL PROCESSES
HEAT TREATMENT PROPERTIES VERIFIED ON TEST SAMPLES ARE INSPECTED AND DOCUMENTED BY RSC-ENERGIA.

NON-DESTRUCTIVE EVALUATION
(1) X-RAY EVALUATION IS PERFORMED ON 100% OF THE FLIGHT UNITS AND COMPONENT QUAL TEST UNITS (SERIES II), BY RI, TO VERIFY CONSISTENCY OF PRODUCTION QUALITY BETWEEN UNITS TO ENSURE PROPER RELATIVE THICKNESS OF THE CROSS SECTION.
(2) NEUTRON RADIOGRAPHY TEST IS PERFORMED AND DOCUMENTED BY RSC-ENERGIA ON A 100% BASIS TO VERIFY THAT THE PYROTECHNIC CHARGE COMPONENTS ARE PRESENT AND PROPERLY ORIENTED.
(3) DIMENSIONAL CHECKS ARE PERFORMED BY RSC-ENERGIA ON A 100% BASIS TO VERIFY COMPLIANCE WITH DRAWING REQUIREMENTS.

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NUMBER: M8-1SS-9M002- 01
(APPLIES ONLY TO THE ORBITER "SOFT") MECHANISM)

ASSEMBLY/INSTALLATION
ASSEMBLY/INSTALLATION IS INSPECTED AND DOCUMENTED BY RSC-ENERGIA.

TESTING
QTP/ATP ARE INSPECTED AND DOCUMENTED BY RSC-ENERGIA WITH LIMITED PARTICIPATION FROM RI.

HANDLING/PACKAGING
HANDLING/PACKAGING PROCEDURES AND REQUIREMENT FOR SHIPMENT ARE INSPECTED AND DOCUMENTED BY RSC-ENERGIA.

(D) FAILURE HISTORY:
DATA ON TEST FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING OF ODS DOCKING MECHANISMS CAN BE FOUND IN PRACA DATA BASE.

(E) OPERATIONAL USE:
IF PREMATURE FRACTURING OF PYRO BOLTS RESULTS IN SLOW PRESSURE LEAKAGE, GIVEN SUFFICIENT TIME, CREW COULD CLOSE THE APPROPRIATE HATCHES TO ISOLATE LEAKAGE. CREW COULD CLOSE SIX OR TWELVE ISSA PASSIVE MECHANISM HOOKS TO SEAL INTERFACE.

- APPROVALS -

PRODUCT ASSURANCE ENGR.	: M. NIKOLAYEVA	:
DESIGN ENGINEER	: V. BERCUT	:
NASA SS/MA	:	:
NASA SUBSYSTEM MANAGER	:	:
JSC MOD	:	: