FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER: M8-1SS-BM010-X
(DOESN'T APPLY TO PMA2/3 PASSIVE MECHANISM)

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 DEC, 1996

| | | PART NAME<br>VENDOR NAME | PART NUMBER<br>VENDOR NUMBER |
|---|---|---|---|
| LRU | : | DOCKING MECHANISM ASSEMBLY<br>RSC-ENERGIA | 33U.6316.003-09 ("SOFT")<br>33U.6316.003-05-001-01(PMA1) |
| SRU | : | ASSEMBLY, DIFFERENTIAL<br>RSC-ENERGIA | 33U.6321.004-09 ("SOFT")<br>33U.6321.004-05 (PMA1) |

## PART DATA

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**
MAIN DIFFERENTIAL ASSEMBLY

**REFERENCE DESIGNATORS:**

**QUANTITY OF LIKE ITEMS:** 1
ONE

**FUNCTION:**
THE DIFFERENTIAL ASSEMBLY IS THE PRIMARY COMPONENT IN THE KINEMATIC CHAIN AND PERFORMS THE FOLLOWING FUNCTIONS: (1) ENSURES DEPENDENT MOVEMENT OF EACH BALLNUT PAIR; (2) LOCKS BALLNUT PAIRS TO LIMIT THEIR MOVEMENT RELATIVE TO EACH OTHER (FIXATOR); (3) ENABLES EXTENSION AND RETRACTION OF THE DOCKING RING BY THE EXTEND/RETRACT ACTUATOR; (4) PROVIDES FORCED SUMMED INPUTS TO THE FRICTIONAL BRAKE; AND (5) PROVIDES CENTERING OF RING IN PITCH AND YAW DIRECTIONS (SPRING MECHANISMS). CONTAINED IN THE DIFFERENTIAL ASSEMBLY ARE THE "RING INITIAL POSITION" SENSOR AND "RING FORWARD POSITION" SENSOR. EACH IS DESCRIBED BELOW:

RING INITIAL POSITION SENSOR - ONCE THE DOCKING RING REACHES IT'S INITIAL POSITION, ABOUT 400 MM - FOR THE "SOFT" MECHANISM, /332 MM - FOR THE PMA1 MECHANISM FROM ITS FULLY RETRACTED POSITION, A SENSOR DRIVEN FROM THE FINAL SUMMING GEAR STAGE OF THE DIFFERENTIAL ASSEMBLY SENDS REDUNDANT SIGNALS TO THE DSCU. THESE SIGNALS ARE USED TO AUTOMATICALLY TURN OFF THE EXTEND/RETRACT ACTUATOR AT THE POINT WHERE INITIAL POSITION OF THE RING IS ACHIEVED AND IS USED TO ILLUMINATE THE "RING INITIAL POSITION" INDICATOR LIGHT ON THE DOCKING CONTROL PANEL. RING INITIAL POSITION IS ALSO DOWNLINKED FOR GROUND CREW MONITORING.

RING FORWARD POSITION SENSOR - A SECOND SENSOR DRIVEN FROM THE FINAL SUMMING GEAR STAGE OF THE DIFFERENTIAL ASSEMBLY SENSES WHEN THE DOCKING RING IS FULLY EXTENDED AND SENDS REDUNDANT SIGNALS TO THE DSCU TO TURN OFF THE EXTEND/RETRACT ACTUATOR, CONTINUE AUTOMATIC DOCKING SEQUENCE (RETRACT RING) (FOR THE PMA1 MECHANISM. FOR THE "SOFT"

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MECHANISM, , THE RING RETRACTION IS CARRIED BY THE OPERATOR' COMMAND), AND TO ILLUMINATE THE "RING FORWARD POSITION" INDICATOR LIGHT ON THE DOCKING CONTROL PANEL. RING FORWARD POSITION IS DOWNLINKED FOR GROUND MONITORING.

**SERVICE IN BETWEEN FLIGHT AND MAINTENANCE CONTROL:**
VISUAL INSPECTION, SERVICEABILITY CONTOL, DOCKING WITH CALIBRATING DOCKING MECHANISM.

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

**REFERENCE DOCUMENTS:** 33U.6321.004-09 ("SOFT")
33U.6321.004-05 (PMA1)
33U.6316.003-09 ("SOFT")
33U.6316.003-05-001-01 (PMA1)

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: M8-1SS-BM010- 02
(DOESN'T APPLY TO PMA2/3
PASSIVE MECHANISM)

REVISION# 1 DEC, 1996

SUBSYSTEM NAME: MECHANICAL - EDS
LRU: DOCKING MECHANISM ASSEMBLY
ITEM NAME: ASSEMBLY, MAIN DIFFERENTIAL

CRITICALITY OF THIS FAILURE MODE: 1R2

FAILURE MODE:
BROKEN

MISSION PHASE:
OO ON-ORBIT

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

CAUSE:
UNIVERSAL JOINT FAILURE, STRUCTURAL FAILURE DUE TO MECHANICAL/THERMAL SHOCK OR MANUFACTURE/MATERIAL DEFECT, BROKEN GEAR

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

REDUNDANCY SCREEN A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

METHOD OF FAULT DETECTION:
INSTRUMENTATION - THE CORRESPONDING DOCKING RING INDICATORS ON THE DOCKING CONTROL PANEL WILL ILLUMINATE TO INDICATE RING POSITION AND ALIGNMENT. VISUAL OBSERVATION - INABILITY TO MOVE THE DOCKING RING; POTENTIAL MOMENT CREATED BETWEEN VEHICLES.

REMARKS/RECOMMENDATIONS:
A BROKEN DIFFERENTIAL IS CONSIDERED TO BE VERY REMOTE. ALL COMPONENTS HAVE SAFETY FACTOR > 1.4.

- FAILURE EFFECTS -

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE NUMBER: M8-1SS-BM010- 02 (DOESN'T APPLY TO PMA2/3 PASSIVE MECHANISM)

(A) SUBSYSTEM:
ELEMENTS OF THE KINEMATIC CHAIN ARE DISCONNECTED RESULTING IN THE INABILITY OF DOCKING MECHANISM TO SUSTAIN A LOAD. LOSS OF CAPABILITY TO EXTEND OR RETRACT DOCKING RING.

(B) INTERFACING SUBSYSTEM(S):
POTENTIAL DAMAGE TO ORBITER/PMA1 STRUCTURE IF ORBITER(PMA1)/ISS COLLIDE DUE TO THIS FAILURE AND WORKAROUND IS NOT IMPLEMENTED.

(C) MISSION:
LOSS OF ORBITER(PMA1)/ISS DOCKING CAPABILITIES FOLLOWING BREAK IN DIFFERENTIAL CHAIN. THE INABILITY TO DOCK WILL RESULT IN LOSS OF ORBITER(PMA1)/ISS MISSION OBJECTIVES.

(D) CREW, VEHICLE, AND ELEMENT(S):
A BROKEN DIFFERENTIAL WILL ALLOW THE DOCKING RING TO COLLAPSE DURING CAPTURE POTENTIALLY CAUSING A MOMENT BETWEEN ORBITER/PMA1 AND ISS.

(E) FUNCTIONAL CRITICALITY EFFECTS:
N/A

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

(F) RATIONALE FOR CRITICALITY CATEGORY DOWNGRADE:
SECOND FAILURE - INABILITY TO OPEN CAPTURE LATCHES OR PERFORM SEPARATION (NOMINAL UNDOCKING IS NOT PLANNED TO PMA1 ASSEMBLY). INABILITY TO CIRCUMVENT THE MOMENT CREATED BETWEEN ORBITER/PMA1 AND ISS. POTENTIAL COLLISION BETWEEN BOTH VEHICLES RESULTING IN POSSIBLE LOSS OF CREW AND VEHICLE.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: MINUTES

TIME FROM FAILURE OCCURRENCE TO DETECTION: SECONDS

TIME FROM DETECTION TO COMPLETED CORRECTIVE ACTION: SECONDS

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 OPEN CAPTURE LATCHES (NOMINAL UNDOCKING IS NOT PLANNED TO PMA1 ASSEMBLY) AND FIRE RCS JETS (APPLIES ONLY TO THE ORBITER) TO AVOID A POTENTIAL COLLISION BETWEEN ORBITER/PMA1 AND ISS.

HAZARDS REPORT NUMBER(S): ORBI 402B

HAZARD(S) DESCRIPTION:
UNCONTROLLED/INADVERTENT COLLISION BETWEEN ORBITER/PMA1 AND ISS.

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-DISPOSITION RATIONALE-

(A) DESIGN:
A BROKEN DIFFERENTIAL IS CONSIDERED VERY REMOTE. COMPONENTS OF THE DIFFERENTIAL CHAIN ARE MADE OF STAINLESS STEEL. SPRING MECHANISMS ARE USED TO REDUCE SPACING BETWEEN GEARS TO PREVENT TEETH BREAKAGE DURING PERIODS OF HIGH LOADS. THE DIFFERENTIAL IS ENCLOSED TO REDUCE THE POTENTIAL FOR STRUCTURAL IMPACT DAMAGE.

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

DOCKING MECHANISM ACCEPTANCE TESTS:
1. VIBRATION TEST
2. GUIDE RING FUNCTIONAL PERFORMANCE TEST
3. AXIAL STIFFNESS IN INITIAL POSITION LOADS TEST
4. RETRACTION FORCE LOAD TEST
5. RESTRAINING FORCE LOAD TEST
6. TRANSLATION CAPABILITY TEST - $Y_T$ & $Z_T$ AXES
7. ROTATIONAL CAPABILITY LOADS TEST - $Y_T$ & $Z_T$ AXES
8. ROTATIONAL CAPABILITY LOADS TEST - $X_T$ AXIS
9. THERMAL VACUUM TEST

DOCKING MECHANISM QUALIFICATION TESTS:
1. TRANSPORTABILITY STRENGTH TEST
2. VIBRATION TEST
3. SHOCK-BASIC DESIGN TEST
4. THERMAL VACUUM TEST
5. SIX-DEGREE-OF-FREEDOM TEST
6. SERVICE LIFE TEST
7. EXTEND/RETRACT MECHANISM LIMIT LOAD TEST
8. EXTEND/RETRACT MECHANISM ULTIMATE LOAD TEST
9. DISASSEMBLY INSPECTION

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

(C) INSPECTION:
RECEIVING INSPECTION
COMPONENTS ARE SUBJECTED TO A 100% RECEIVING INSPECTION PRIOR TO INSTALLATION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROVISIONS AND CONTAMINATION CONTROL VERIFIED BY INSPECTION. CHECK OF ROOM CLEANLINESS; PARTS WASHING AND OTHER OPERATIONS OF THE TECHNOLOGICAL PROCESS WHICH PROVIDES CLEANLINESS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE NUMBER: M8-1SS-BM010- 02 (DOESN'T APPLY TO PMA2/3 PASSIVE MECHANISM)**

ANODIZING, HEAT TREATING, AND CHEMICAL PLATING VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
TORQUE, ADJUSTMENTS AND TOLERANCES ACCORDING TO TECHNICAL REQUIREMENTS OF THE DRAWINGS ARE VERIFIED BY INSPECTION.

TESTING
ATP/QTP/OMRSD TESTING VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING/PACKAGING PROCEDURES AND REQUIREMENT FOR SHIPMENT VERIFIED BY INSPECTION.

**(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:**
CREW COULD OPEN CAPTURE LATCHES AND FIRE APPROPRIATE ORBITER RCS JETS TO PERFORM SEPARATION IN THE EVENT A BROKEN DIFFERENTIAL RESULTS IN A MOMENT BETWEEN ORBITER AND ISS.

**- APPROVALS -**

| | | | |
|---|---|---|---|
| PRODUCT ASSURANCE ENGR. | : | M. NIKOLAYEVA | : |
| DESIGN ENGINEER | : | E. BOBROV | : |
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