

## FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL HARDWARE

NUMBER: M8-1SS-BM014-X  
 (DOESN'T APPLY TO PMA2/3  
 PASSIVE MECHANISM)

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 DEC, 1996

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: DIFFERENTIAL ASSEMBLY RSC-ENERGIA	33U.6321.004-09 ("SOFT") 33U.6321.004-05 (PMA1)
SRU	: ACTUATOR, EXTEND/RETRACT RSC-ENERGIA	33U.6121.035-09 ("SOFT") 33U.6121.035-05-001 (PMA1)

## PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
 EXTEND/RETRACT ACTUATOR

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1  
 ONE

## FUNCTION:

PROVIDES THE ENERGY NECESSARY TO EXTEND AND RETRACT THE ORBITER/PMA1 DOCKING RING. CONTAINED IN THE ACTUATOR IS A FRICTIONAL BRAKE WHICH IS ONLY UTILIZED DURING A "HARD" DOCKING SINCE THE LOW LEVEL SLIP CLUTCH WILL LOCK OUT THIS DEVICE DURING A "SOFT" DOCKING. CURRENTLY, ONLY THE FIRST ISS MISSION (MISSION 2A ) WILL UTILIZE A HARD DOCKING. THE FRICTIONAL BRAKE IS LOCATED ON THE SHAFT OF THE EXTEND/RETRACT ACTUATOR AND LIMITS DOCKING LOADS AND DISSIPATES ENERGY. DURING MATING WHEN LOADS ON THE ACTUATOR ARMATURE ARE HIGH, THE BRAKE ABSORBS THE AXIAL KINETIC ENERGY ASSOCIATED WITH THE RELATIVE CLOSING VELOCITY BY SLIPPING. BRAKE SLIPPAGE ALSO OCCURS DURING RING RETRACTION WHEN THE RING HAS BOTTOMED OUT.

## SERVICE IN BETWEEN FLIGHT AND MAINTENANCE CONTROL:

SERVICEABILITY CONTROL, DOCKING WITH CALIBRATING DOCKING MECHANISM.

## MAINTAINABILITY

REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.6121.035-09 ("SOFT")  
 33U.6121.035-05-001 (PMA1)  
 33U.6321.004-09 ("SOFT")  
 33U.6321.004-05 (PMA1)

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
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REVISION# 1 DEC, 1996

SUBSYSTEM NAME: MECHANICAL - EDS  
 LRU: DIFFERENTIAL ASSEMBLY  
 ITEM NAME: ACTUATOR, EXTEND/RETRACT

CRITICALITY OF THIS  
 FAILURE MODE: 2/2

FAILURE MODE:  
 FAILS TO TRANSFER TORQUE LOADS

MISSION PHASE:  
 OO ON-ORBIT

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

CAUSE:  
 ACTUATOR FAILURE - GEAR/SHAFT/KEY FAILURE BETWEEN NO-BACK & DIFFERENTIAL  
 DUE TO MECHANICAL/THERMAL SHOCK, MANUFACTURE/MATERIAL DEFECT, OR STRESS  
 CORROSION

LOW SLIP FORCE ON FRICTIONAL BRAKE - SHAFT/MULTIPLE RING FAILURES DUE TO  
 MECHANICAL/THERMAL SHOCK OR MANUFACTURE/MATERIAL DEFECT, EXCESSIVE  
 LOADS, MULTIPLE BROKEN SPRINGS, LOOSE SHAFT NUT, OIL CONTAMINATION

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) N/A

PASS/FAIL RATIONALE:

A)  
 N/A

B)  
 N/A

C)  
 N/A

METHOD OF FAULT DETECTION:  
 VISUAL OBSERVATION - RING FAILS TO EXTEND OR RETRACT. INSTRUMENTATION -  
 APPROPRIATE INDICATORS ON THE DOCKING CONTROL PANEL WILL INDICATE POSITION  
 OF RING AT TIME OF FAILURE. WITH ACTUATOR DISCONNECTED FROM THE KINEMATIC  
 CHAIN THE ORBITER/PMA1 DOCKING RING CAN BE MANUALLY RETRACTED BY PUSHING  
 ON THE RING.

REMARKS/RECOMMENDATIONS:

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STRUCTURAL FAILURE OF EXTEND/RETRACT ACTUATOR ARMATURE/SHAFT IS CONSIDERED VERY REMOTE. ALL ACTUATOR COMPONENTS HAVE A SAFETY FACTOR > 1.4.

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

EXTEND/RETRACT ACTUATOR IS DISCONNECTED FROM THE REMAINING ELEMENTS IN THE KINEMATIC CHAIN. INABILITY OF DOCKING MECHANISM TO SUSTAIN A LOAD RESULTING IN A COLLAPSE OF THE DOCKING RING DURING CAPTURE. DOCKING LOADS ARE EXCESSIVE GIVEN THIS FAILURE. DAMAGE TO EXTEND/RETRACT ACTUATOR AS THE RESULT OF THESE EXCESSIVE LOADS COULD RESULT IN LOSS OF CAPABILITY TO EXTEND OR RETRACT THE RING TO COMPLETE DOCKING.

**(B) INTERFACING SUBSYSTEM(S):**

EXCESSIVE LOADS INCURRED DURING DOCKING AS THE RESULT OF THE EXTEND/RETRACT ACTUATOR FAILING TO TRANSFER TORQUE LOADS COULD PROPAGATE TO EXTERNAL AIRLOCK AND ORBITER/PMA1 STRUCTURE.

**(C) MISSION:**

DOCKING BETWEEN ORBITER/PMA1 AND ISS IS IMPOSSIBLE IF RING CANNOT BE EXTENDED OR RETRACTED. EXTENSIVE DAMAGE TO EITHER DOCKING MECHANISM AS THE RESULT OF THIS FAILURE COULD FURTHER IMPEDE THE DOCKING PROCESS. WORST CASE, LOSS OF ORBITER(PMA1)/ISS MISSION OBJECTIVES.

**(D) CREW, VEHICLE, AND ELEMENT(S):**

THE INABILITY OF THE DOCKING RING TO SUSTAIN LOADS AS THE RESULT OF THIS FAILURE COULD ALLOW THE RING TO COLLAPSE DURING CAPTURE, POTENTIALLY CAUSING EXTENSIVE DAMAGE TO ORBITER/PMA1 AND ISS DOCKING MECHANISMS.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

N/A

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

**(F) RATIONALE FOR CRITICALITY CATEGORY DOWNGRADE:**

N/A (THERE ARE NO WORKAROUNDS TO CIRCUMVENT THIS FAILURE.)

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**- TIME FRAME -**

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TIME FROM FAILURE TO CRITICAL EFFECT: HOURS TO DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: MINUTES TO HOURS

TIME FROM DETECTION TO COMPLETED CORRECTIVE ACTION: N/A

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

N/A

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:

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THERE IS NO CORRECTIVE ACTION TO CIRCUMVENT THIS FAILURE. A FAILURE OF THE EXTEND/RETRACT ACTUATOR TO TRANSFER TORQUE LOADS MAY NOT BE DETECTABLE UNTIL AFTER CAPTURE, AT WHICH TIME THE RESULTING HIGH LOADS COULD DAMAGE BOTH ORBITER/PMA1 AND ISS DOCKING MECHANISMS TO THE POINT OF PRECLUDING DOCKING.

**HAZARDS REPORT NUMBER(S): ORBI 402B****HAZARD(S) DESCRIPTION:****DAMAGE TO BOTH ORBITER/PMA1 AND ISS DOCKING MECHANISMS.**

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

STRUCTURAL FAILURE OF EXTEND/RETRACT ACTUATOR ARMATURE/SHAFT IS CONSIDERED VERY REMOTE. FRICTIONAL BRAKE IS MADE UP OF TWENTY SOLID RINGS. EACH RING IS MADE OF STEEL WITH A THICKNESS OF 1.5 MM AND IMPREGNATED WITH A SUBSTANCE THAT PROVIDES HIGH FRICTION. TEN RINGS ARE ATTACHED TO THE HOUSING WHICH IS MOUNTED TO THE SHAFT THAT DRIVES THE KINEMATIC CHAIN AND TEN ARE ATTACHED TO THE ARMATURE OF THE ACTUATOR. THESE RINGS ARE POSITIONED SIDE BY SIDE WITH EVERY OTHER RING ATTACHED TO THE SAME POINT (KINEMATIC SHAFT AND ACTUATOR ARMATURE). SIX SPRINGS FORCE THESE RINGS TOGETHER TO PROVIDE MAXIMUM FRICTION BETWEEN THEM. A SINGLE NUT IS SAFETY WIRED AT THE END OF THE ARMATURE TO HOLD ALL SIX COMPRESSED SPRINGS INTO PLACE.

LOAD ANALYSIS HAS SHOWN THAT THE MAXIMUM AXIAL TENSION LOAD INCURRED AS THE RESULT OF THE EXTEND/RETRACT ACTUATOR FAILING TO TRANSFER TORQUE LOADS (BROKEN CLUTCH/BRAKE) DURING CAPTURE IS 3559 KGF ALONG THE Z-AXIS WHICH IS NOT HIGH ENOUGH TO CAUSE A CAPTURE LATCH TO DISENGAGE. (ANALYSIS HAS SHOWN THAT AN AXIAL LOAD OF 3698 KGF IS REQUIRED TO DISENGAGE A CAPTURE LATCH.) STRESS ANALYSIS HAS INDICATED THAT THE CAPTURE LATCH WILL NOT BE DAMAGED IN SUCH A WAY AS TO PREVENT IT FROM BEING ACTUATED OPEN DUE TO THIS 3559 KGF TENSION AXIAL LOAD. THIS AXIAL LOAD WILL NOT EXCEED EXTERNAL AIRLOCK /ORBITER STRUCTURAL LIMITS.

**(B) TEST:**

THE FRICTIONAL BRAKE IS PART OF THE EXTEND/RETRACT ACTUATOR DRIVE CHAIN. SINCE THIS FAILURE MODE WOULD CREATE A BREAK IN THAT DRIVE CHAIN, VERIFICATION OF PROPER FRICTIONAL BRAKE AND ACTUATOR OPERATION (IN RESPECT TO THIS FAILURE MODE) IS PROVIDED BY THE FOLLOWING ACCEPTANCE AND QUAL TESTING OF THE ACTUATOR. (REFER TO "APPENDIX B" FOR DETAILS.)

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**DOCKING MECHANISM ACCEPTANCE TESTS:**

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

EXTEND/RETRACTION ACTUATOR AND FRICTIONAL BRAKE 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 WHICH PROVIDES CLEANLINESS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

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

ASSEMBLY/INSTALLATION

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

TESTING

ATP/OTP/OMRSD TESTING VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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

**(D) FAILURE HISTORY:**

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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:**  
 NONE. CREW WOULD OPEN CAPTURE LATCHES AND FIRE ORBITER RCS JETS TO ENABLE SEPARATION.

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- APPROVALS -

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PRODUCT ASSURANCE ENGR. :  
 DESIGN ENGINEER :  
 NASA SS/MA :  
 NASA SUBSYSTEM MANAGER :  
 JSC MOD :

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*[Handwritten signatures and initials over approval lines]*