

## 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)

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(DOESN'T APPLY TO PMA2/3  
PASSIVE MECHANISM)

REVISION# 2 JAN, 1997

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

CRITICALITY OF THIS  
FAILURE MODE: 2R3("SOFT")  
2/2(PMA1)

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FAILURE MODE:  
FAILS TO ABSORB SHOCK

MISSION PHASE:  
OO ON-ORBIT

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

CAUSE:  
HIGH SLIP FORCE ON FRICTIONAL BRAKE - PARTICULATE CONTAMINATION, CORROSION,  
EXCESSIVE TIGHTENING OF SHAFT NUT

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

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REDUNDANCY SCREEN  
(FOR THE "SOFT" MECH.) A) PASS  
B) FAIL  
C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS SCREEN B SINCE A FAILURE OF THE FRICTIONAL BRAKE TO SLIP WHEN REQUIRED  
IS NOT DETECTED UNTIL THE LOW LEVEL SLIP CLUTCH IS LOCKED OUT.

C)

REDUNDANCY SCREEN  
(FOR THE PMA1 MECH.) A) N/A  
B) N/A  
C) N/A

PASS/FAIL RATIONALE:

A)

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N/A

B)  
N/AC)  
N/A**METHOD OF FAULT DETECTION:**

NONE PRIOR TO CAPTURE. DURING CAPTURE, FOLLOWING AN INADVERTENT ACTIVATION OF THE LOW LEVEL SLIP CLUTCH LOCKING DEVICE (APPLIES ONLY TO THE "SOFT" MECHANISM), A FAILURE OF THE FRICTIONAL BRAKE COULD BE DETECTED THROUGH PHYSICAL OBSERVATION - EXCESSIVE MECHANICAL SHOCKS.

**REMARKS/RECOMMENDATIONS:**

A FAILURE OF THE FRICTIONAL BRAKE TO SLIP IS CONSIDERED VERY REMOTE. THE IMPACT OF THE EXCESSIVE LOADS SHOULD OVERCOME THE BINDING BETWEEN RINGS DUE TO CONTAMINATION OR CORROSION. THIS FRICTIONAL BRAKE IS ONLY UTILIZED DURING THE INITIAL 2A ISS MISSION.

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

**PMA1 MECHANISM - POSSIBLE EXCESSIVE LOADS ON PMA1 AND ISS DOCKING MECHANISMS DURING CAPTURE**

**"SOFT" MECHANISM - NO INITIAL EFFECT. POSSIBLE EXCESSIVE LOADS ON ORBITER "SOFT" AND ISS DOCKING MECHANISMS DURING CAPTURE, FOLLOWING AN INADVERTENT ACTIVATION OF THE LOW LEVEL SLIP CLUTCH LOCKING DEVICE.**

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

NONE FOR FIRST FAILURE (FOR THE "SOFT" MECHANISM). SECOND FAILURE (FIRST - FOR THE PMA1 MECHANISM) - IF DOCKING LOADS ARE EXCESSIVE, ENERGY ASSOCIATED WITH THESE LOADS COULD PROPAGATE TO ORBITER/PMA1 AND ISS DOCKING MECHANISMS. ELEMENTS IN BOTH DOCKING MECHANISMS COULD BE OVERLOADED.

**(C) MISSION:**

NONE FOR FIRST FAILURE (FOR THE "SOFT" MECHANISM). SECOND FAILURE (FIRST - FOR THE PMA1 MECHANISM) - EXCESSIVE LOADS INCURRED DURING CONTACT COULD PRECLUDE DOCKING AND SUBSEQUENT LOSE ORBITER(PMA1)/ISS MISSION OBJECTIVES.

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

NO EFFECT ON CREW OR VEHICLE. POTENTIAL DAMAGE TO ORBITER/PMA1 AND ISS DOCKING MECHANISMS (FOLLOWING SECOND FAILURE FOR THE "SOFT" MECHANISM).

**(E) FUNCTIONAL CRITICALITY EFFECTS****FOR THE "SOFT" MECHANISM:**

FIRST FAILURE (EXTEND/RETRACT ACTUATOR FAILS TO ABSORB SHOCK - NO EFFECT SINCE LOW LEVEL SLIP CLUTCH WILL ABSORB DOCKING LOADS.

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SECOND FAILURE (LOW LEVEL SLIP CLUTCH LOCKING DEVICE INADVERTENTLY LOCKS) - EXCESSIVE LOADS INCURRED DURING CONTACT COULD PRECLUDE CAPTURE OR CAUSE DAMAGE TO ORBITER AND ISS DOCKING MECHANISMS RESULTING IN THE INABILITY TO EXTEND OR RETRACT DOCKING RING. THE INABILITY TO CAPTURE OR MOVE RING TO MATE BOTH MECHANISMS WILL RESULT IN LOSS OF DOCKING AND SUBSEQUENT LOSS OF ORBITER/ISS MISSION OBJECTIVES.

FOR THE PMA1 MECHANISM: 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: SECONDS TO MINUTES

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:

THERE IS NO CORRECTIVE ACTION TO RESTORE RING MOVEMENT FOLLOWING THIS FAILURE OF THE EXTEND/RETRACT ACTUATOR.

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:

A FAILURE OF THE FRICTIONAL BRAKE TO SLIP IS CONSIDERED VERY REMOTE. THE IMPACT OF THE EXCESSIVE LOADS SHOULD OVERCOME THE BINDING BETWEEN RINGS DUE TO CONTAMINATION OR CORROSION. THE FRICTIONAL BRAKE IS COMPLETELY ENCASED AND SEALED, WITH LINERS AT THE STATIONARY POINT AROUND THE ACTUATOR ARMATURE TO PREVENT THE INTRODUCTION OF OUTSIDE CONTAMINATION. DUST TRAPS ARE PROVIDED TO TRAP PARTICLES CAUSED BY FRICTIONAL WEAR. THE FRICTIONAL BRAKE IS DESIGNED TO SLIP WHEN THE LOADS BETWEEN BOTH DOCKING MECHANISMS EXCEEDS 1000 KG. THE FRICTIONAL BRAKE IS UTILIZED TO PREVENT EXCESSIVE LOADS FROM PROPAGATING TO THE ISS.

LOAD ANALYSIS HAS SHOWN THAT THE MAXIMUM AXIAL TENSION LOAD INCURRED AS THE RESULT OF THE EXTEND/RETRACT ACTUATOR FAILING TO ABSORB SHOCK (FRICTIONAL BRAKE FAILS TO SLIP) DURING CAPTURE IS 3203 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

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DAMAGED IN SUCH A WAY AS TO PREVENT IT FROM BEING ACTUATED OPEN DUE TO THIS 3203 KGF TENSION AXIAL LOAD. THIS AXIAL LOAD WILL NOT EXCEED EXTERNAL AIRLOCK /ORBITER STRUCTURAL LIMITS.

**(B) TEST:**

THE FRICTIONAL BRAKE WAS TESTED AT THE COMPONENT LEVEL AND FOUND TO SLIP WHEN AXIAL LOADS WERE BETWEEN 1000 KGF AND 1100 KGF.

THE FRICTIONAL BRAKE IS PART OF THE EXTEND/RETRACT ACTUATOR DRIVE CHAIN. SINCE THIS FAILURE MODE RESULTS FROM A FAILED FRICTIONAL BRAKE, VERIFICATION OF PROPER FRICTIONAL BRAKE AND ACTUATOR OPERATION (IN RESPECT TO THIS FAILURE MODE) IS PROVIDED BY THE FOLLOWING QUALIFICATION TEST. IN ALL CASES THE FRICTIONAL BRAKE HAD SLIPPED WHEN AXIAL LOADS WERE BETWEEN 1000 KGF AND 1100 KGF:

APDS SERVICEABILITY TEST IN A SIX-DEGREE-OF-FREEDOM DYNAMIC TEST  
(REFER TO 'APPENDIX B' FOR DETAILS.)

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**

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:**

NONE

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**PASSIVE MECHANISM)**

**- APPROVALS -**

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NASA SS/MA :  
NASA SUBSYSTEM MANAGER :  
JSC MOD :

*[Handwritten signatures and initials over horizontal lines]*