

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE  
NUMBER: M8-1MR-8M005-X**

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 9/1/95

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: MECH, BALLSCREW INTERCONNECTING NPO-ENERGIA	33U.6365.011-05 33U.6365.011-05
SRU	: ASSY, ELECTRO-MAGNETIC DAMPER NPO-ENERGIA	33U.6661.005 33U.6661.005

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**PART DATA**

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**  
GUIDE RING ELECTRO-MAGNETIC DAMPER ASSEMBLY

**REFERENCE DESIGNATORS:**

**QUANTITY OF LIKE ITEMS: 3**  
THREE (ONE PER BALLSCREW INTERCONNECTING MECH)

**FUNCTION:**  
AN ELECTRO-MAGNETIC DAMPER IS LOCATED WITHIN EACH BALLSCREW INTERCONNECTING MECHANISM BETWEEN EACH ROD OF THE BALLSCREW PAIR. IT IS MAINTAINED IN THE 'ON' POSITION AND DOES NOT REQUIRE EXTERNAL POWER TO ENGAGE OR DISENGAGE. THESE DAMPERS ARE USED TO DAMP OUT RELATIVE ROLL AND LATERAL ROTATIONAL VELOCITIES OF THE DOCKING RING.

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

**MAINTAINABILITY**  
REPAIR METHOD - REPLACEMENT.

**REFERENCE DOCUMENTS:** 33U.6661.005  
33U.6365.011-05



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**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE**

NUMBER: MB-1MR-8M008-01

REVISION# 1 8/1/95

SUBSYSTEM NAME: MECHANICAL - EDS

LRU: BALLSCREW INTERCONNECTING MECHANISM

ITEM NAME: ASSEMBLY, RING DAMPER

CRITICALITY OF THIS

FAILURE MODE: 2/2

**FAILURE MODE:**

JAMMING

**MISSION PHASE:**

OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 104 ATLANTIS

**CAUSE:**CONTAMINATION, STRUCTURAL FAILURE DUE TO MECHANICAL SHOCK, VIBRATION, OR  
MANUFACTURE/MATERIAL DEFECT

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:**A JAMMED RING DAMPER CAN BE DETECTED THROUGH VISUAL OBSERVATION  
FOLLOWING CAPTURE. TELEMETRY DATA ASSOCIATED WITH MOVEMENT OF THE RING  
(BALLSCREW MISALIGNMENT) IS AVAILABLE TO GROUND PERSONNEL FOR EVALUATION  
OF A JAMMED DAMPER.**- FAILURE EFFECTS -****(A) SUBSYSTEM:**A JAMMING OF ONE DAMPER WILL DISALLOW ROTATIONAL MOVEMENT OF ITS  
ASSOCIATED BALLSCREW PAIR. ROLL AND TRANSLATION MOVEMENT IS RESTRICTED  
AT ONE POINT ON THE DOCKING RING. CAPTURE AND RING ALIGNMENT MAY BE  
IMPAIRED WITH A SINGLE JAMMED RING DAMPER.RBC  
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## FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: MB-1MR-BM005-01

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

NO EFFECT ON INTERFACING ORBITER SUBSYSTEMS.

**(C) MISSION:**

WORST CASE, A SINGLE JAMMED DAMPER MAY PREVENT CAPTURE OR PREVENT RING ALIGNMENT FOR MATING OF ORBITER/MIR DOCKING MECHANISMS RESULTING IN LOSS OF DOCKING AND SUBSEQUENT LOSS OF ORBITER/MIR MISSION CAPABILITIES.

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

NO EFFECT ON CREW OR VEHICLE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

N/A

DESIGN CRITICALITY (PRIOR TO OPERATIONAL DOWNGRADE, DESCRIBED IN F): 2/2

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

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

**-DISPOSITION RATIONALE-****(A) DESIGN:**

DESIGN OF THE DAMPERS PROVIDES SUFFICIENT FREEPLAY BETWEEN SURFACES TO ALLOW FOR TEMPERATURE EXPANSION AND TO PREVENT JAMMING. THE DAMPING PORTION IS A MAGNETIC FIELD DEVICE. GRAPHITE LUBRICATION IS PROVIDED TO PREVENT MOVING SURFACES FROM STICKING.

**(B) TEST:****DOCKING MECHANISM ACCEPTANCE TESTS:**

1. VIBRORESISTENT TEST - APDS SUBJECTED TO THE FOLLOWING VIBRATION LEVELS FOR 2 MINUTES PER AXIS:

FREQUENCY (HZ)	SPECTORAL DENSITY ACCELERATION
FROM 20 TO 80	INCREASING 3DB OCTAVE TO 0.04G <sup>2</sup> /HZ
FROM 80 TO 350	PERMANENT 0.04G <sup>2</sup> /HZ
FROM 350 TO 2000	DECREASING 3DB OCTAVE WITH 0.04G <sup>2</sup> /HZ

SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

2. DOCKING MECHANISM CHECKOUT (STATIC) TEST - AFTER CAPTURE SETTLING FORCES OF THE DOCKING RING ARE MEASURED FOLLOWING APPLICATION OF VARIOUS LOAD FORCES. A JAMMED DAMPER COULD BE DETECTED AT THIS TIME.

3. THERMO VACUUM TEST - DOCKING OF THE MECHANISM IS THERMALLY CYCLED, UNDER LOAD CONDITIONS, FROM +20°C TO -50/-55°C TO +50/+55°C TO +20°C IN A VACUUM AT 10<sup>-4</sup> TO 10<sup>-5</sup> TORR. DWELL AT EACH TEMPERATURE AND BETWEEN OPERATIONS AT EACH TEMPERATURE IS A MINIMUM OF 60 MINUTES AFTER STABILIZATION. OPERATIONS INCLUDES PERFORMING DOCKING WHICH IS ACCOMPLISHED AT A SPEED OF 0.15M/SEC BETWEEN THE SIMULATOR AND MOVEABLE PLATFORM (CONTAINING THE DOCKING MECHANISM). PROPER

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OPERATION OF THESE DAMPERS IS VERIFIED DURING DOCKING FOR A TEMPERATURE RANGE OF -50°C/-55°C TO 50°C/55°C.

4. CONTROLLED DOCKING TEST - CONTROLLED DOCKING IS PERFORMED UNDER LOAD CONDITIONS. PROPER RING PERFORMANCE WILL VERIFY PROPER DAMPING OPERATIONS.

DOCKING MECHANISM QUALIFICATION TESTS:

1. TRANSPORTABILITY STRENGTH TEST - SHIPPING LOADS ARE SIMULATED ON A VIBRATING TABLE TO VERIFY THAT THE DOCKING MECHANISM WILL NOT BE DAMAGED DURING SHIPMENT. THIS TEST IS CONDUCTED UNDER THE CONDITIONS CONTAINED IN THE FOLLOWING TABLE.

VIBRATION ACCELER DIRECTION	VIBRATION ACCELER AMPLITUDE	FREQUENCY SUBBAND, HZ					TOTAL TEST DURATION	
		5-7	7-15	15-30	30-40	40-60	HR	MIN
ALONG X-AXIS	1.4	-	4	-	-	-	-	4
	1.2	76	93	32	61	39	5	7
ALONG Y-AXIS	1.1	-	4	-	-	-	-	4
	1.0	19	16	7	10	7	-	53
ALONG Z-AXIS	1.1	-	4	-	-	-	-	4
	1.0	32	40	18	28	16	2	10

SUBSEQUENT TO THIS TEST AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE AT WHICH TIME A JAMMED DAMPER WOULD BE DETECTED.

2. VIBRATION STRENGTH TEST - APDS SUBJECTED TO THE FOLLOWING VIBRATION LEVELS IN EACH AXIS FOR A 400 SECOND DURATION.

FREQUENCY (HZ)	SPECTORAL DENSITY ACCELERATION
FROM 20 TO 80	INCREASING, 3DB OCTAVE TO 0.067G <sup>2</sup> /HZ
FROM 80 TO 350	CONSTANT 0.067G <sup>2</sup> /HZ
FROM 350 TO 2000	DECREASING 3DB OCTAVE WITH 0.067G <sup>2</sup> /HZ

SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE AT WHICH TIME A JAMMED DAMPER WOULD BE DETECTED.

3. SHOCK AND SAWTOOTH LOADING STRENGTH TEST - DOCKING MECHANISM IS SUBJECTED TO 20G TERMINAL SAWTOOTH SHOCK PULSES IN EACH AXIS, 3 PULSES IN EACH DIRECTION FOR A TOTAL OF 6 PULSES/AXIS. AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE. A JAMMED DAMPER WOULD BE DETECTED AT THIS TIME.

4. APDS SERVICEABILITY TEST IN A SIX-DEGREE-OF-FREEDOM DYNAMIC TEST - THE SIX-DEGREE-OF-FREEDOM DYNAMIC TEST VERIFIES APDS DOCKING AND UNDOCKING OPERATIONS UNDER CLOSE-TO-FULL-SCALE CONDITIONS. STATIC MOTION OF ENTITIES IS SIMULATED UNDER SPECIFIC INERTIAL AND GEOMETRICAL PARAMETERS FOR VARIOUS INITIAL CONDITIONS FOR MIR/SHUTTLE DOCKING. A TOTAL OF 20 DOCKINGS IS PERFORMED. ABSORPTION OF ENERGY OF RELATIVE MOVEMENT DURING EACH DOCKING WILL DETECT A JAMMED DAMPER. SUBSEQUENT TO THIS TEST AN



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ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

5. COLD AND HEAT RESISTANCE TEST - DOCKING OF THE MECHANISM IS THERMALLY CYCLED FROM +20°C TO -50/-55°C TO +50/+55°C TO +20°C IN A VACUUM AT  $10^{-4}$  TO  $10^{-5}$  TORR. DWELL AT EACH TEMPERATURE AND BETWEEN OPERATIONS AT EACH TEMPERATURE IS A MINIMUM OF 60 MINUTES AFTER STABILIZATION. FIVE CYCLES WERE PERFORMED AGAINST THE GUIDE RING EXTEND AND FINAL POSITION MECHANICAL STOPS FOR 10 SECONDS EACH. DURING EACH DOCKING, AS SHOWN IN THE FOLLOWING TABLE, A JAMMED DAMPER WOULD BE DETECTED.

SEQ NO.	DOCKING RATE, M/S	SIMULATOR ROTATIONAL ANGLE		TEMP °C	VOLTAGE VOLTS	PRESS INTEGRITY CHECKOUT
		PITCH	ROLL			
1	0.10	0°	0°	25 +/-10	23	YES
2	0.10	0°	4°	25 +/-10	34	NO
3	0.12	4°	4°	25 +/-10	27	NO
4*	---	---	---	+60+/-5	---	YES
4	0.10	4°	0°	+50+/-5	27	YES
5*	---	---	---	-(60+/-5)	---	YES
5	0.10	4°	0°	-(30+/-5)	27	YES
6*	---	---	---	+60+/-5	---	YES
6	0.12	0°	4°	+50+/-5	23	YES
7*	---	---	---	-(60+/-5)	---	YES
7	0.10	0°	4°	-(30 +/-5)	23	YES
8*	---	---	---	+60+/-5	---	YES
8	0.12	4°	4°	50 +/-5	34	YES
9*	---	---	---	-(60+/-5)	---	YES
9	0.12	4°	4°	-(30 +/-5)	34	YES
10*	---	---	---	+60+/-5	---	YES
10	0.10	4°	0°	+50+/-5	27	YES
11*	---	---	---	-(60+/-5)	---	YES
11	0.10	0°	4°	-(30 +/-5)	27	YES
12*	---	---	---	+60+/-5	---	YES
12*	0.10	0°	4°	+50+/-5	27	YES
13*	---	---	---	-(60+/-5)	---	YES
13*	0.12	4°	4°	-(30 +/-5)	27	YES
14*	---	---	---	+60+/-5	---	YES
14*	0.12	4°	4°	+50+/-5	27	YES
15*	0.12	4°	4°	+25+/-10	23	YES

\*MC621-0087-2001, -4001, &amp; -5001 ONLY

AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

6. TARGET SERVICE LIFE TEST - TESTS ARE PERFORMED TO VERIFY PROPER DOCKING OPERATIONS OVER ITS LIFE OF 100 DOCKINGS. PROPER OPERATION OF THE DAMPERS VERIFIED DURING 100 DOCKING CYCLES (FOR MC621-0087-

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**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE**  
**NUMBER: M8-1MR-BM005-01**

1001/-3001 UNITS ONLY). FOR MC521-0087-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED DURING 388 CYCLES (44 VACUUM/LOAD CYCLES, 16 LOAD CYCLES, & 324 NO-LOAD CYCLES). SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

7. CONTROL DISASSEMBLY - UPON COMPLETION OF ALL QUAL TESTING THE DOCKING MECHANISM IS DISMANTLED AND ELECTRO-MAGNETIC DAMPER ASSEMBLIES ARE CHECKED FOR EVIDENCE OF WEAR OR FAILURE.

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**

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:**

THERE IS NO WORKAROUND TO JAMMING OF A RING DAMPER.

**- APPROVALS -**

DESIGN ENGINEER  
 DESIGN MANAGER  
 NASA SS/MA  
 NASA SUBSYSTEM MANAGER

M. NIKOLAYEVA  
 A. SOUBCHEV

*[Handwritten signatures and initials over approval lines]*



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