

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: M8-1MR-0M004-X**

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 01/95

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: DOCKING MECHANISM ASSEMBLY NPO-ENERGIA	33U.5316.003-05 33U.5316.003-05
SRU	: ASSY, ELECTRO-MAGNETIC DAMPER NPO-ENERGIA	33U.6661.006 33U.6661.006
SRU	: ASSY, ELECTRO-MAGNETIC DAMPER NPO-ENERGIA	33U.6661.007 33U.6661.007

PART DATA

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
HIGH ENERGY ELECTRO-MAGNETIC DAMPER ASSEMBLY**

REFERENCE DESIGNATORS:

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

FUNCTION:

A HIGH ENERGY ELECTRO-MAGNETIC DAMPER IS LOCATED BETWEEN EACH ROD OF THE BALLSCREW PAIRS AND IS ENGAGED BY A SOLENOID DRIVEN MECHANICAL LOCK (CLUTCH) DEVICE. ALL THREE DAMPER ASSEMBLIES ARE INTERCONNECTED THROUGH THE KINEMATIC CHAIN TO DAMP OUT RELATIVE PITCH AND YAW ROTATIONAL VELOCITIES OF THE RING FOLLOWING CAPTURE.

SERVICE IN BETWEEN FLIGHT AND MAINTENANCE CONTROL:

VISUAL INSPECTION, SERVICEABILITY CONTROL, DOCKING WITH CALIBRATING DOCKING MECHANISM.

MAINTAINABILITY

REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.6661.006
33U.6661.007
33U.6316.003-05
33U.6321.004



Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: MB-1MR-BM004-01

REVISION# 1 9/1/96

SUBSYSTEM NAME: MECHANICAL - EDS
 LRU: DOCKING MECHANISM ASSEMBLY
 ITEM NAME: ASSEMBLY, HIGH ENERGY DAMPER

CRITICALITY OF THIS
 FAILURE MODE: 2/2

FAILURE MODE:
 JAMMING, INCREASED RESISTANCE

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:

VISUAL OBSERVATION - NO CAPTURE INDICATION DURING DOCKING. 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 PREVENT/RESTRICT PITCH AND YAW MOVEMENT OF
 ITS ASSOCIATED BALLNUT PAIR AND SUBSEQUENTLY, RESTRICT PITCH/YAW
 MOVEMENT OF THE DOCKING RING. AN INCREASED RESISTANCE COULD BE
 OVERCOME BY THE POWER OF THE DOCKING MECHANISM ASSEMBLY ALLOWING
 CAPTURE TO OCCUR. HOWEVER, TOTAL JAMMING OF A HIGH ENERGY DAMPER
 ASSEMBLY WOULD PRECLUDE CAPTURE. DAMAGE SUSTAINED BY THE MECHANISM,

**Proprietary Data**

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE
NUMBER: M8-1MR-BM004-01**

DUE TO EXCESSIVE CAPTURE LOADS, COULD PREVENT EXTENSION OR RETRACTION OF THE DOCKING RING.

(B) INTERFACING SUBSYSTEM(S):

EXCESSIVE LOADS INCURRED DURING DOCKING AS THE RESULT OF A JAMMED HIGH ENERGY DAMPER COULD PROPAGATE TO EXTERNAL AIRLOCK AND ORBITER STRUCTURE.

(C) MISSION:

WORST CASE, HIGH LOADS AND MISALIGNMENT WILL MAKE CAPTURE IMPOSSIBLE. EXCESSIVE LOADS INCURRED DURING CONTACT COULD CAUSE DAMAGE TO ORBITER AND MIR DOCKING MECHANISMS RESULTING IN THE LOSS OF CAPABILITY TO EXTEND OR RETRACT DOCKING RING. INABILITY TO PERFORM CAPTURE OR MOVE RING TO MATE BOTH MECHANISMS WILL PRECLUDE DOCKING CAPABILITIES RESULTING IN LOSS OF ORBITER/MIR MISSION CAPABILITIES.

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

EXCESSIVE LOADS EXPERIENCED DURING CAPTURE AS THE RESULT OF A JAMMED DAMPER COULD CAUSE EXTENSIVE DAMAGE TO BOTH ORBITER AND MIR DOCKING MECHANISMS. CREW AND ORBITER STRUCTURE ARE UNAFFECTED BY THESE LOADS.

(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. CLUTCH SURFACES ARE MADE OF STEEL ALLOYS AND ARE AN INTER-MESHING TOOTH DESIGN. THE DAMPING PORTION IS A MAGNETIC FIELD DEVICE. GRAPHITE LUBRICATION IS PROVIDED TO PREVENT MOVING SURFACES FROM STICKING. ALL DAMPER PARTS HAVE A SAFETY FACTOR NO LESS THAN 1.4.

LOAD ANALYSIS HAS SHOWN THAT THE MAXIMUM DOCKING LOADS INCURRED AS THE RESULT OF THIS FAILURE WILL NOT EXCEED EXTERNAL AIRLOCK/ORBITER STRUCTURAL LIMITS.

(B) TEST:

DOCKING MECHANISM ACCEPTANCE TESTS:

1. INSPECTION SERVICEABILITY TEST (SENSOR FUNCTIONAL TEST) - OPERATIONAL CHECKOUT OF THE ELECTROMAGNETIC DAMPERS IS PERFORMED THROUGH CAPTURE SENSOR PER STEP 13 OF INSTRUCTION 33U.6201.008-05 PM-3.

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



RSC
Energia

Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM004-01

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

SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE AND A FUNCTIONAL CHECK IS PERFORMED, PER ATP #1 ABOVE, TO VERIFY PROPER OPERATION OF THE ELECTROMAGNETIC DAMPERS.

3. DOCKING MECHANISM CHECKOUT (STATIC) TEST - A HIGH ENERGY DAMPER FUNCTIONAL PERFORMANCE TEST IS PERFORMED AS PART OF THE CHECKOUT OF THE DOCKING MECHANISM. WITH THE GUIDE RING IN ITS INITIAL POSITION IT IS ROTATED ABOUT THE Y AND Z AXES AND THE MOMENT WAS MEASURED WITH AND WITHOUT HIGH ENERGY DAMPERS ENGAGED. THIS TEST VERIFIES THAT THE DOCKING RING RETURNS TO INITIAL POSITION WITH DAMPERS OFF AND DOES NOT RETURN TO INITIAL POSITION WITH DAMPERS ON. A JAMMED DAMPER WOULD BE DETECTED AT THIS TIME.

4. 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 10⁻⁴ TO 10⁻⁵ 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). AT EACH TEMPERATURE ELECTRO-MAGNETIC DAMPERS ARE TURNED ON FOLLOWING RING EXTENSION AND CURRENT TO EACH IS MEASURED. PROPER OPERATION OF THESE DAMPERS IS VERIFIED FOR A TEMPERATURE RANGE OF -50°C/-55°C TO 50°C/55°C.

5. CONTROLLED DOCKING TEST - CONTROLLED DOCKING IS PERFORMED UNDER LOAD CONDITIONS. PROPER RING PERFORMANCE WILL VERIFY HIGH ENERGY 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
		TEST DURATION, 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	13	16	7	10	7	--	53
ALONG Z-AXIS	1.1	--	4	--	--	--	--	4
	1.0	32	40	16	26	16	2	10

RSC
Energy

Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM004-01

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

2. 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.

3. 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 ² /HZ
FROM 80 TO 350	CONSTANT 0.067G ² /HZ
FROM 350 TO 2000	DECREASING 3DB OCTAVE WITH 0.067G ² /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.

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 ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

5. 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 M0821-0087-1001/-3001 UNITS ONLY). FOR M0821-0087-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED DURING 398 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.

6. 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.

RSC
Energia

Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: MB-1MR-5M004-01

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, & -5001 ONLY

AFTER COMPLETION AN 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

RSC
Energy

Proprietary Data

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: M8-1MR-BM004-01**

OPERATIONS OF THE TECHNOLOGICAL PROCESS WHICH PROVIDES CLEANLINESS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
ANODIZING, HEAT TREATING, CHEMICAL PLATING, SOLDERING, AND CURING 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:
NONE FOR A COMPLETE JAMMING OF THE DAMPER. HOWEVER AN INCREASE IN RESISTANCE CAN BE OVERCOME BY THE EXTERNAL FORCES OF DOCKING.

- APPROVALS -

DESIGN ENGINEER
DESIGN MANAGER
NASA SS/MA
NASA SUBSYSTEM MANAGER

M. NIKOLAYEVA
A. SOUBCHEV

[Handwritten signatures and initials over approval lines]



RSC
Energie

Proprietary Data