

PAGE: 202

PRINT DATE: 08/25/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: M8-1MR-BM022-X

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 9/1/95

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: GUIDE RING ASSEMBLY NPO-ENERGIA	33U.6271.011-05 33U.6271.011-05
SRU	: SENSOR NPO-ENERGIA	33U.5319.027 33U.5319.027

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CAPTURE SENSOR

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
THREE

FUNCTION:

THREE SENSORS, LOCATED ON THE GUIDE RING ASSEMBLY, ARE USED TO MONITOR THE RING MATCHING OF BOTH THE ORBITER AND MIR DOCKING RING ASSEMBLIES. EACH SENSOR CONTAINS TWO REDUNDANT SHORT CONTACTS AND TWO REDUNDANT LONG CONTACTS. THE SHORT CONTACTS OF THE THREE SENSORS ARE CONNECTED IN SERIES AND THE LONG CONTACTS OF THE THREE SENSORS ARE CONNECTED IN PARALLEL. TOGETHER THEY SENSE THE MATING OF THE TWO DOCKING RINGS AND SEND A SIGNAL TO THE DSCU TO ACTIVATE THE HIGH ENERGY DAMPERS AND TO ILLUMINATE THE 'CAPTURE' INDICATOR LIGHT ON THE DOCKING CONTROL PANEL WHEN ALL THREE SENSORS ACTUATE SIMULTANEOUSLY. THE LONG CAPTURE SIGNAL IS DOWNLINKED TO GROUND PERSONNEL. THESE SENSORS SENSE THE SECOND POINT IN THE AUTOMATIC DOCKING SEQUENCE - MATING OF THE TWO DOCKING RINGS.

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

MAINTAINABILITY
REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.5319.027
33U.6271.011-05



Proprietary Data

M8-1MR - 247

PAGE: 217

PRINT DATE: 06/25/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM022-03

REVISION# 1 9/1/95

SUBSYSTEM NAME: MECHANICAL - EDS

LRI: GUIDE RING ASSEMBLY

ITEM NAME: SENSOR, CAPTURE

CRITICALITY OF THIS

FAILURE MODE: 2/2

FAILURE MODE:

PLUNGER JAMS IN EXTENDED POSITION

MISSION PHASE:

OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 104 ATLANTIS

CAUSE:

CONTAMINATION, PIECE PART STRUCTURAL FAILURE DUE TO MECHANICAL/THERMAL SHOCK, VIBRATION, OR MANUFACTURER/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/AB)
N/AC)
N/A**METHOD OF FAULT DETECTION:**

PHYSICAL OBSERVATION - ORBITER DOCKING RING CANNOT CAPTURE TO MIR MECHANISM BODY MOUNTED LATCH.

- FAILURE EFFECTS -**(A) SUBSYSTEM:**

INABILITY OF SENSOR TO DEPRESS WHEN IN CONTACT WITH MIR DOCKING MECHANISM WILL PREVENT AFFECTED CAPTURE LATCH FROM ENGAGING OPPOSING MIR MECHANISM BODY MOUNTED LATCH. ALTHOUGH IT MAY BE POSSIBLE TO CAPTURE AND RETRACT THE DOCKING RING WITH ONLY TWO CAPTURE LATCHES ENGAGED, MATING OF THE TWO DOCKING MECHANISMS FOR CLOSING STRUCTURAL HOOKS WOULD BE IMPAIRED.

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Energia

Proprietary Data

PAGE: 218

PRINT DATE: 08/25/96

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE
NUMBER: M8-1MR-BM022-03**

(B) INTERFACING SUBSYSTEM(S):
NO EFFECT ON INTERFACING ORBITER SUBSYSTEMS.

(C) MISSION:
WORST CASE, LOSS OF DOCKING CAPABILITIES RESULTING IN LOSS MISSION OBJECTIVES FOLLOWING A FAILURE TO ENGAGE A SINGLE CAPTURE LATCH.

(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 SENSOR, SELECTION OF MATERIALS, AND SMALL ELECTRICAL LOADS REDUCE THE FAILURE PROBABILITY OF BOTH CONTACTS. DESIGN OF THE CONTACT PAIR (DUAL CHANNEL) HAS PASSED MAGNITUDES OF GROUND FUNCTIONAL TESTING AND MULTIPLE USES DURING PILOTED VEHICLE OPERATIONS IN SPACE. SPRING WHICH RETURNS THE INTERNAL ROD TO THE INITIAL POSITION IS DESIGNED TO OPERATE BEYOND LIMITS OF FATIGUE AND THUS, POSSIBILITY OF SPRING FAILURE IS VERY LOW. MISALIGNMENT OF THE ROD IS NOT POSSIBLE BY DESIGN. SENSOR IS COMPLETELY ENCASED TO PREVENT THE SIZE OF CONTAMINATION NECESSARY TO CAUSE THE PLUNGER TO JAM IN THE EXTENDED POSITION.

(B) TEST:
DOCKING MECHANISM ACCEPTANCE TESTS:

1. INSPECTION SERVICEABILITY TEST - DURING SENSOR FUNCTIONAL PERFORMANCE TEST, CAPTURE SENSOR CHECKOUT IS PERFORMED WITH DOCKING RING AT ITS INITIAL POSITION. THE PLUNGER OF EACH CAPTURE SENSOR IS MANUALLY DEPRESSED AND APPROPRIATE LIGHTS ON THE TEST PANEL ARE VERIFIED TO ILLUMINATE.
2. 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 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 INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND A SENSOR FUNCTIONAL TEST IS PERFORMED AS DEFINED IN ATP TEST #1 ABOVE TO VERIFY PROPER CAPTURE SENSOR OPERATION.



Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - GIL FAILURE MODE

NUMBER: M8-1MR-BM022-03

3. DOCKING MECHANISM CHECKOUT (STATIC) TEST - THE DM SIMULATOR ON THE STAND IS LOWERED UNTIL IT MAKES CONTACT WITH THE RING ASSEMBLY. PROPER ENGAGEMENT OF THE RING CAPTURE LATCHES WITH THE BODY MOUNTED LATCHES ON THE SM SIMULATOR IS VERIFIED. A JAMMED PLUNGER ON A CAPTURE SENSOR 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/CAPTURE. DOCKING IS ACCOMPLISHED AT A SPEED OF 0.15M/SEC BETWEEN THE SIMULATOR AND MOVEABLE PLATFORM (CONTAINING THE DOCKING MECHANISM) AND CAPTURE INDICATION IS VERIFIED DURING CAPTURE. PROPER OPERATION OF CAPTURE SENSORS 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. VISUAL OBSERVATION OF CAPTURE INDICATION DURING CAPTURE WILL VERIFY PROPER SENSOR OPERATION.

DOCKING MECHANISM QUALIFICATION TESTS

1. OPERATIONAL CAPABILITY TESTS - DURING EXTEND/RETRACT MECHANISM LIMIT/ULTIMATE LOAD TESTS AND CAPTURE AND BODY LATCH LOAD TESTS THE CAPTURE LATCHES ARE ENGAGED TO THE DOCKING SIMULATOR. A JAMMED PLUNGER ON A CAPTURE SENSOR WOULD BE DETECTED AT THIS TIME.

2. 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	40-50	HR	MIN
		TEST DURATION, MIN						
ALONG X-AXIS	1.4	-	4	-	-	-	-	4
	1.2	76	83	32	81	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

SUBSEQUENT TO THIS TEST AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

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; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS

RSC
Energia

Proprietary Data

PAGE: 220

PRINT DATE: 08/25/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM022-03

DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

4. 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. AFTER EACH DOCKING/CAPTURE, AS SHOWN IN THE FOLLOWING TABLE, CAPTURE INDICATIONS ARE VERIFIED.

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°	+60 +/-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°	60 +/-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°	+60 +/-5	27	YES
15*	0.12	4°	4°	+25 +/-10	23	YES

*MC621-0067-2001, -4001, & -5001 ONLY

AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

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



Proprietary Data

M8-1MR - 268

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-8M022-03

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 INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

6. 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, WHICH INCLUDES CAPTURE. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

7. TARGET SERVICE LIFE TEST - TESTS ARE PERFORMED TO VERIFY PROPER DOCKING AND UNDOCKING OPERATIONS OVER ITS LIFE OF 100 DOCKINGS. PROPER CAPTURE INDICATION (CAPTURE SENSOR OPERATION) IS VERIFIED DURING 100 DOCKING AND UNMATING CYCLES (FOR MC621-0087-1001/3001 UNITS ONLY). FOR MC621-0087-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED DURING 388 CYCLES (44 VACUUM/LOAD CYCLES, 18 LOAD CYCLES, & 324 NO-LOAD CYCLES). AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND OPERATIONAL CAPABILITY TESTS ARE PERFORMED, AS DEFINED IN QTP TEST #1 ABOVE, TO VERIFY PROPER FUNCTIONING OF THE CAPTURE SENSORS.

8. CONTROL DISASSEMBLY - UPON COMPLETION OF ALL QUAL TESTING THE DOCKING MECHANISM IS DISMANTLED AND CAPTURE SENSORS ARE CHECKED FOR EVIDENCE OF WEAR OR FAILURE.

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

(C) INSPECTION:**RECEIVING INSPECTION**

ALL INCOMING PARTS ARE SUBJECTED TO EXTERIOR INSPECTION.

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, SOLDERING, CHEMICAL PLATING, AND CURING VERIFIED BY INSPECTION.

RSC
Energia

Proprietary Data

PAGE: 222

PRINT DATE: 29.08.95

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: M8-1MR-BM022-03

ASSEMBLY/INSTALLATION
ASSEMBLY/INSTALLATION VERIFIED BY INSPECTION.

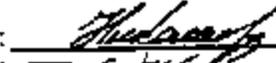
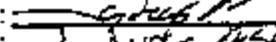
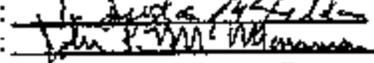
TESTING
ATP/QTP/OMRSD TESTING VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PROPER PACKAGING, STORAGE, AND TRANSPORTATION VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
ONE FAILURE OCCURRED RELATING TO A STUCK ROD RESULTING FROM MOISTURE INGRESS BETWEEN THE ROD AND THE GUIDE AT -50 DEGREES C. TO PREVENT FAILURES OF THIS NATURE, A LUBRICANT WAS INTRODUCED INTO THE GAP AND THE QUALITY OF THE ROD SURFACE WAS IMPROVED. 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

- APPROVALS -

DESIGN ENGINEER	:	M. NIKOLAYEVA	:	
DESIGN MANAGER	:	A. SOUBCHEV	:	
NASA SS/MA	:		:	
NASA SUBSYSTEM MANAGER	:		:	



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