

PAGE: 147

PRINT DATE: 08/25/95

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: M8-1MR-8M009-X**

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 9/1/95

| | PART NAME VENDOR NAME | PART NUMBER VENDOR NUMBER |
|-----|--|------------------------------------|
| LRU | : ASSY, DISPLACEMENT SENS/LOCKING NPO-ENERGIA | 33U.5325.005 33U.5325.005 |
| LRU | : ASSY, DISPLACEMENT SENS/LOCKING NPO-ENERGIA | 33U.5325.005-01 33U.5325.005-01 |
| SRU | : FIXER NPO-ENERGIA | 33Y.6662.002 33Y.6662.002 |

PART DATA

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
DISPLACEMENT SENSOR/LOCKING (DIFFERENTIAL) ASSEMBLY FIXER**

REFERENCE DESIGNATORS:

**QUANTITY OF LIKE ITEMS: 2
TWO**

FUNCTION:

CONTAINED WITHIN THE EACH DISPLACEMENT SENSOR/LOCKING ASSEMBLY OF THE DIFFERENTIAL, THE FIXER BYPASSES THE SPRING MECHANISM TO ALLOW DIRECT COUPLING OF THE DIFFERENTIAL ASSEMBLY TO LOCK THE DOCKING RING IN ITS ALIGNED POSITION. WHEN POWER IS APPLIED TO THE FIXER WINDINGS A MAGNETIC FIELD IS CREATED WHICH EXTENDS A ROD TO MECHANICALLY COUPLE THE TWO INDIVIDUAL DIFFERENTIAL SEGMENTS TO PROVIDE SYNCHRONIZED ROTATION, (LIMITING RING MOVEMENT IN THE PITCH AND YAW DIRECTIONS), THUS MAINTAINING THE RING IN ITS ALIGNED POSITION (ALIGNMENT IN RESPECT TO ITS OWN MECHANISM). WHEN POWER IS REMOVED, A SPRING RETRACTS THE ROD WHICH UNCOUPLES BOTH DIFFERENTIAL SEGMENTS, ALLOWING THE DIFFERENTIAL TO MOVE NORMALLY.

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

MAINTAINABILITY

REPAIR METHOD - NONE (REPAIRING IN MANUFACTURING CONDITIONS ONLY).

REFERENCE DOCUMENTS: 33U.5325.005
33U.5325.005-01
33U.6662.002



Proprietary Data

PAGE: 156

PRINT DATE: 08/25/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM009-02

(B) INTERFACING SUBSYSTEM(S):

EXCESSIVE LOADS INCURRED DURING DOCKING, AS THE RESULT OF A SINGLE DIFFERENTIAL FIXER BEING LOCKED PRIOR CAPTURE, COULD PROPAGATE TO EXTERNAL AIRLOCK AND ORBITER STRUCTURE.

(C) MISSION:

A SINGLE LOCKED FIXER ADDS STIFFNESS TO THE RING WHICH AFFECTS DYNAMICS OF CAPTURE. WORST CASE IS THE INABILITY TO PERFORM CAPTURE GIVEN A FAILURE TO UNLOCK A SINGLE FIXER, RESULTING IN THE LOSS OF DOCKING CAPABILITIES. LOSS OF ORBITER/MIR MISSION OBJECTIVES WITH FAILURE TO PERFORM DOCKING.

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

NO EFFECT ON CREW AND ORBITER STRUCTURE. HOWEVER, EXCESSIVE LOADS COULD CAUSE DAMAGE TO BOTH ORBITER AND MIR DOCKING MECHANISMS.

(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:**

DIFFERENTIAL FIXERS ARE NORMALLY UNLOCKED WHEN POWER IS REMOVED BY A SPRING THAT RETRACTS THE ROD. DESIGN OF THE SPRING IS SUCH THAT MULTIPLE BREAKS ARE REQUIRED TO LOSE ITS CAPABILITY. THE PRELOAD ON THE SPRING ALLOWS FOR TWO BREAKS TO OCCUR AND STILL PERMITS THE FIXER TO FUNCTION PROPERLY. FIXERS ARE NORMALLY IN THE UNLOCKED POSITION. A FAILURE TO UNLOCK A FIXER CAN OCCUR MECHANICALLY DURING RING MOVEMENT TO ITS INITIAL POSITION PRIOR TO CAPTURE. FIXERS ARE LOCKED WHENEVER THE RING IS MOVED.

LOAD ANALYSIS HAS SHOWN THAT IN THREE OF THE SIX DOCKING CASES MODELED, THE DOCKING RING DID NOT CAPTURE AS THE RESULT OF A SINGLE DIFFERENTIAL FIXER BEING ENGAGED PRIOR TO CAPTURE.

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

1. DOCKING MECHANISM CHECKOUT (STATIC) TEST - RING IS EXTENDED AND RETRACTED AS NECESSARY TO FULLY TEST ITS OPERATION DURING A SINGLE DOCKING. FIXERS ARE TURNED OFF WHEN THE RING REACHES ITS INITIAL POSITION AND A FORCE IS APPLIED TO THE RING TO SIMULATE LOADS THAT CAN OCCUR DURING RING CAPTURE AND MATING OF THE TWO MECHANISMS. THIS TEST WILL VERIFY THAT THE FIXERS ARE NOT LOCKED UNDER LOAD CONDITIONS.

2. THERMO VACUUM TEST - DOCKING OF THE MECHANISM IS THERMALLY CYCLED, UNDER LOAD CONDITIONS, FROM +20°C TO -50/-55°C TO +60/+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

RSC
Energia

Proprietary Data

M8-1MR - 192

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-BM009-02

IS ACCOMPLISHED AT A SPEED OF 0.15M/SEC BETWEEN THE SIMULATOR AND MOVEABLE PLATFORM (CONTAINING THE DOCKING MECHANISM). A LOCKED FIXER WOULD BE DETECTED AT TIME OF CAPTURE.

3. 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 ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE.

4. CONTROLLED DOCKING TEST - CONTROLLED DOCKING IS PERFORMED UNDER LOAD CONDITIONS. THIS TESTS WILL DETECT A LOCKED FIXER DURING THE CAPTURE PROCESS.

DOCKING MECHANISM QUALIFICATION TESTS:

1. OPERATIONAL CAPABILITY TEST - FIXER OPERATION VERIFIED BY THE ULTIMATE TRANSLATIONAL LOAD TEST. WITH RING IN ITS INITIAL POSITION FIXERS ARE TURNED OFF AND A 700 KGF LOAD IS APPLIED PARALLEL TO THE SEAL INTERFACE. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME. THE SYSTEM IS THEN INSPECTED FOR EVIDENCE OF DAMAGE OR DEGRADATION.

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; AND AN OPERATIONAL CAPABILITY TEST, AS DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

3. 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 | 7-16 | 15-30 | 30-40 | 40-60 | 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 AN OPERATIONAL CAPABILITY TEST, AS DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

RSC
Energia

Proprietary Data

PAGE: 158

PRINT DATE: 08/25/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-8M009-02

4. COLD AND HEAT RESISTANCE 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. FIVE CYCLES WERE PERFORMED AGAINST THE GUIDE RING EXTEND AND FINAL POSITION MECHANICAL STOPS FOR 10 SECONDS EACH. DOCKING PARAMETERS ARE SHOWN IN THE FOLLOWING TABLE.

| 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 | 29 | 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 | 29 | YES |

*MC821-0087-2001, -4001, & -5001 ONLY

AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN OPERATIONAL CAPABILITY TEST, AS DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

5. VIBRATION STRENGTH TEST - APDS SUBJECTED TO THE FOLLOWING VIBRATION LEVELS IN EACH AXIS FOR A 400 SECOND DURATION. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN OPERATIONAL CAPABILITY TEST, AS



Proprietary Data

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE

NUMBER: M8-1MR-8M008-02

DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

| 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 |

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. A LOCKED FIXER WOULD BE DETECTED DURING ABSORPTION OF ENERGY OF RELATIVE MOVEMENT ASSOCIATED WITH EACH DOCKING. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN OPERATIONAL CAPABILITY TEST, AS DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

7. TARGET SERVICE LIFE TEST - TESTS ARE PERFORMED TO VERIFY PROPER DOCKING AND UNDOCKING OPERATIONS OVER ITS LIFE OF 100 DOCKINGS. PROPER OPERATION OF THE FIXERS VERIFIED DURING 100 DOCKING AND UNMATING CYCLES (FOR M0621-0067-1001/-3001 UNITS ONLY). FOR M0621-0067-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED DURING 388 CYCLES (44 VACUUM/LOAD CYCLES, 16 LOAD CYCLES, & 324 NO-LOAD CYCLES). A LOCKED FIXER WOULD BE DETECTED DURING CAPTURE. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN OPERATIONAL CAPABILITY TEST, AS DEFINED IN QTP TEST #1 ABOVE, IS PERFORMED. A LOCKED FIXER WOULD BE DETECTED AT THIS TIME.

8. CONTROL DISASSEMBLY - UPON COMPLETION OF ALL QUAL TESTING THE DOCKING MECHANISM IS DISMANTLED AND ALL FIXER OPERATING SURFACES 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.

RSC
Energia

Proprietary Data

PAGE: 160

PRINT DATE: 08/31/95

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CIL FAILURE MODE
NUMBER: M8-1MR-BM009-02**

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/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

- APPROVALS -

DESIGN ENGINEER :
DESIGN MANAGER :
NASA SS/MA :
NASA SUBSYSTEM MANAGER :

M. NIKOLAYEVA
A. SOUBCHEV

[Handwritten signatures and initials over approval lines]



Proprietary Data