FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: M8-1MR-SM017-X

SUBSYSTEM NAME: MECHANICAL - EDS

REVISION: 1 9/1/95

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:	STRUCTURAL LATCH MECHANISM	33U.6365.010-05
		NPO-ENERGIA	33U.6365.010-05
SRU	:	PUSHER, SPRING	33U.6411.004
		NPO-ENERGIA	33U.6411.004

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
SPRING PUSHER

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 2
TWO

FUNCTION:
TWO SPRING PUSHERS ARE LOCATED ON OPPOSITE SIDES OF EACH DOCKING FRAME (MIR AND ORBITER). WHEN MATED FOUR SPRING PUSHERS ARE LOCATED EQUALLY AROUND THE MATED SURFACE. TOGETHER THEY PROVIDE THE FORCE NECESSARY TO OVERCOME THE CONNECTION BETWEEN THE ORBITER AND MIR DOCKING MECHANISMS RESULTING FROM THE MECHANICAL INTERFACE CONNECTORS AND SEAL ADHESION. (ELECTRICAL INTERFACE CONNECTORS WILL NOT BE INSTALLED ON THE ORBITER DOCKING MECHANISM UNTIL NEXT FLIGHT.) ALL SPRING PUSHERS TOGETHER PROVIDE ABOUT 4 KG-M OF INITIAL SEPARATION ENERGY. THE VELOCITY CREATED BY THIS SEPARATION IS ABOUT 14 MM/SEC.

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

MAINTAINABILITY
REPAIR METHOD - REPLACEMENT.

REFERENCE DOCUMENTS: 33U.6411.004
33U.6365.010-05

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE
NUMBER: M8-1MR-BM017-02

REVISION# 1 9/1/95

SUBSYSTEM NAME: MECHANICAL - EDS
LRU: STRUCTURAL LATCH MECHANISM
ITEM NAME: PUSHER, SPRING

CRITICALITY OF THIS FAILURE MODE: 2R3

FAILURE MODE:
FAILS TO COMPRESS

MISSION PHASE:
OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 104 ATLANTIS

CAUSE:
STUCK IN EXTENDED POSITION DUE TO: A COCKED PLUNGER; CONTAMINATION BETWEEN PLUNGER AND RETAINER WALL OR BETWEEN SPRING COILS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

REDUNDANCY SCREEN
A) FAIL
B) FAIL
C) PASS

PASS/FAIL RATIONALE:
A)
FAILS SCREEN A SINCE FIRST SURFACE FAILURE IS NOT DETECTABLE ON GROUND.

B)
FAILS SCREEN B SINCE FIRST SURFACE FAILURE IS NOT DETECTABLE IN FLIGHT.

C)

METHOD OF FAULT DETECTION:
VISUAL OBSERVATION - LITTLE OR NO SEPARATION BETWEEN BOTH VEHICLES.

- FAILURE EFFECTS -

(A) SUBSYSTEM:
AFFECTED SPRING PUSHER FAILS TO COMPRESS. POSSIBLE LOSS OF CAPABILITY TO MATE ORBITER DOCKING MECHANISM WITH MIR DOCKING MECHANISM FOR STRUCTURAL LATCHING.

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

(C) MISSION:
NO EFFECT FIRST FAILURE. POTENTIAL LOSS OF DOCKING FOLLOWING SECOND FAILURE RESULTING IN LOSS OF ORBITER/MIR MISSION OBJECTIVES.

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(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT ON CREW OR VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST FAILURE (FAILURE OF FIRST SLIDING SURFACE) - NO EFFECT
SECOND FAILURE (FAILURE OF REDUNDANT SLIDING SURFACE - WORST CASE, INABILITY TO MATE AND STRUCTURALLY LATCH THE INTERFACE RESULTING IN LOSS OF DOCKING CAPABILITIES. LOSS OF DOCKING WILL RESULT IN LOSS OF MISSION OBJECTIVES.

DESIGN CRITICALITY (PRIOR TO OPERATIONAL DOWNGRADE, DESCRIBED IN F): 2R3

(F) RATIONALE FOR CRITICALITY CATEGORY DOWNGRADE:
N/A (THERE ARE NO WORKAROUNDS TO CIRCUMVENT THIS FAILURE.)

-DISPOSITION RATIONALE-

(A) DESIGN:
A SPRING PUSHER FAILING TO COMPRESS IS CONSIDERED TO BE VERY REMOTE. THE CLEARANCE BETWEEN THE PLUNGER AND RETAINER IS VERY MINIMAL. THE POSSIBILITY THAT CONTAMINATION CAN PENETRATE INTO THIS AREA OR MIGRATE BETWEEN THE SPRING COILS (OF SUFFICENT SIZE TO CAUSE IT TO JAM) IS CONSIDERED VERY REMOTE. BECAUSE OF THIS MINIMAL CLEARANCE THE POSSIBILITY THAT THE PLUNGER CAN COCK AND JAM IS ALSO CONSIDERED TO BE VERY REMOTE. SINCE THERE IS VERY LITTLE CLEARANCE BETWEEN THE SPRING AND RETAINER WALL, FRACTURED SPRING COILS WOULD REMAIN IN PLACE. SLIGHT FRICTION BUILT UP BETWEEN THE PLUNGER AND RETAINER WALL WOULD PROBABLY BE OVERCOME BY THE MATING FORCE OF THE TWO MECHANISMS.

(B) TEST:
DOCKING MECHANISM ACCEPTANCE TESTS:

1. 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. ONCE THE DOCKING MECHANISM IS LATCHED TO THE SIMULATOR SEALING OF THE INTERFACE IS VERIFIED. A FAILURE OF A SPRING PUSHER TO DEPRESS WOULD PREVENT MATING OF THIS INTERFACE. PROPER MATING IS VERIFIED FOR A TEMPERATURE RANGE OF -55°C TO +55°C.

2. CONTROLLED DOCKING TEST - DURING CONTROLLED DOCKING, UNDER LOAD CONDITIONS, PROPER PRESSURIZATION OF THE DOCKING MECHANISM WITH THE D/M MASTER TOOL IS VERIFIED. SINCE SPRING PUSHERS MUST BE DEPRESSED TO SEAL THE INTERFACE FOR PRESSURIZATION, PROPER OPERATION OF THE SPRING PUSHERS IS VERIFIED.

3. SEPARATION FORCE TEST - AT COMPONENT LEVEL: INITIAL FORCE OF SPRING PUSHER IS VERIFIED TO BE 30 +/- 1KGF AND 30 +/- 2 MM FORCE IS VERIFIED TO BE 78 +/- 1KGF. FINAL FORCE FOR TWO PUSHERS IN A SINGLE ASSEMBLY IS VERIFIED TO BE WITHIN 1 KGF OF EACH OTHER.

DOCKING MECHANISM QUALIFICATION TESTS:

1. OPERATIONAL CAPABILITY TEST - DURING THE STRUCTURAL LATCH SYSTEM LOAD TEST THE DOCKING MECHANISM IS MATED AND THE STRUCTURAL HOOKS CLOSED. SINCE THE SPRING PUSHERS MUST BE CLOSED TO MATE THE INTERFACE, PROPER OPERATION OF THE SPRING PUSHERS IS VERIFIED.

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

FOLLOWING THIS TEST AN OPERATIONAL CAPABILITY TEST IS CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TEST #1, TO VERIFY PROPER MATING AND SPRING PUSHER OPERATIONS.

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	7-15	15-30	30-40	40-60		
		TEST DURATION, MIN					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	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 #1 ABOVE, IS PERFORMED TO VERIFY PROPER MATING AND SPRING PUSHER OPERATIONS.

4. 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 IS CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TEST #1, TO VERIFY PROPER MATING AND SPRING PUSHER OPERATIONS.

5. PRESSURE INTEGRITY TEST - PROPER SPRING PUSHER OPERATIONS IS VERIFIED DURING MATING OF THE DOCKING MECHANISM TO THE SIMULATOR FOR PRESSURE TESTING THE INTERFACE.

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. EACH DOCKING THE INTERFACE BETWEEN THE DOCKING MECHANISM AND SIMULATOR IS MATED AND PRESSURIZED. PROPER SPRING PUSHER OPERATIONS ARE VERIFIED DURING MATING OF THIS INTERFACE. SUBSEQUENT TO THIS TEST AN ENGINEERING INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE AND AN OPERATIONAL CAPABILITY TEST IS CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TEST #1, TO VERIFY PROPER MATING AND SPRING PUSHER OPERATIONS.

7. 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. FOLLOWING EACH DOCKING, AS SHOWN IN THE FOLLOWING TABLE, THE INTERFACE IS SEALED AND PRESSURIZED. PROPER SPRING PUSHER OPERATIONS ARE VERIFIED DURING MATING OF THE DOCKING MECHANISM TO THE SIMULATOR.

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*	—	—	—	+50+/-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

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*MC621-0087-2001, -4001, & -5001 ONLY

AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE; AND AN OPERATIONAL CAPABILITY TEST IS CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TEST #1 TO VERIFY PROPER MATING AND SPRING PUSHER OPERATIONS.

8. TARGET SERVICE LIFE TEST - TESTS ARE PERFORMED TO VERIFY PROPER DOCKING AND UNDOCKING OPERATIONS OVER ITS LIFE OF 100 DOCKINGS. PROPER MATING/CLOSING OF THE STRUCTURAL HOOKS IS VERIFIED DURING 100 DOCKINGS (FOR MC621-0087-1001/-3001 UNITS ONLY). FOR MC621-0087-2001, -4001, & -5001 UNITS PROPER OPERATION VERIFIED DURING 368 CYCLES (44 VACUUM/LOAD CYCLES, 16 LOAD CYCLES, & 324 NO-LOAD CYCLES). SPRING PUSHERS MUST BE DEPRESSED TO MATE THE INTERFACE. AFTER COMPLETION AN INSPECTION IS PERFORMED TO IDENTIFY BROKEN OR LOOSE HARDWARE AND AN OPERATIONAL CAPABILITY TEST IS CONDUCTED, AS DEFINED PREVIOUSLY IN QTP TEST #1, TO VERIFY PROPER PERFORMANCE OF THE SPRING PUSHERS.

9. BACKUP UNDOCKING MEANS CHECK - LATCHING OF STRUCTURAL LATCHES IS VERIFIED DURING COUPLING OF THE APDA ASSEMBLY WITH THE SIMULATOR BY THE LOCKING AND PRESSURIZING OF THE INTERFACE. SINCE SPRING PUSHERS MUST BE DEPRESSED TO SEAL THE INTERFACE, PROPER SPRING PUSHER OPERATION IS VERIFIED.

10. CONTROL DISASSEMBLY - UPON COMPLETION OF ALL QUAL TESTING THE DOCKING MECHANISM IS DISMANTLED AND SPRING PUSHER OPERATING SURFACES ARE CHECKED FOR EVIDENCE OF WEAR OR FAILURE.

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

(C) INSPECTION:
RECEIVING INSPECTION
SPRING PUSHERS 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
ANODIZING AND HEAT TREATING 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.

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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 IF SPRING PUSHER CANNOT BE COMPRESSED. HOWEVER, SLIGHT FRICTION BUILT UP BETWEEN THE PLUNGER AND RETAINER WALL WOULD MOST LIKELY BE OVERCOME BY THE MATING FORCE OF THE TWO DOCKING MECHANISMS.

- APPROVALS -

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