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HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: RTS Coupe

Date: 6 February, 2000

Subject/Title: **SVA FM Thermal Vacuum and Functional Test Report**

Description/Summary/Contents:

The Flight Model (FM) Space View Aperture (SVA) Assembly, Serial No. FM001, was subjected to acceptance level thermal vacuum testing and functional checks. All testing was carried out at MMS, Portsmouth.

The objective of the test programme was to demonstrate compliance to the performance requirements in the SVA Subsystem Specification SP-HIR-050D. All testing was carried out in accordance with the Test Procedure TP-MMS-451.

The test results confirm that the SVA has successfully completed the Test Programme without any significant change in operating performance.

Keywords: SVA, FM, Test

Purpose of this Document: SVA FM Assembly T-V and Functional Test Report

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SVA FM THERMAL VACUUM AND FUNCTIONAL TEST REPORT

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1. INTRODUCTION

The Flight Model (FM) Space View Aperture (SVA) Assembly, Serial No. FM001, has been subjected to workmanship testing. Both vibration and thermal vacuum testing were carried out at MMS, Portsmouth.

The objective of the testing was to subject the SVA to the workmanship test programme defined in the SVA Subsystem Specification (AD1) and the Test Procedure (AD3), correlate the results with the EM test performance, and verify that the operation was within specification.

This report summarises the thermal vacuum and functional test results, and where applicable, deviations from the procedure. For details of vibration testing refer to AD 5.

1.1 Executive summary

The test results confirm that the SVA has successfully survived the Workmanship test programme without any signifcant change in operating performance.

The major performance parameters are summarised below.

1.1.1 SVA Cover Operation Results Summary

Table 1.1.1-1 summarises the minimum voltage required to drive the motor measured at various stages throughout the test programme. This was determined by gradually increasing motor voltage until the mechanism operates.

Note : The results provided herein summarise SVA operating performance for the zero g configuration which is most representative of in-orbit conditions, i.e. with the cover hinge axis vertical.

Test Operation	Drive Motor	Baseline Test	Post-vibe test	Vacuum @ -25°C	Vacuum @ +25°C	Vacuum @ Ambient
Open cover (from locked position)	Prime	9.3V	9.5V	12V	11.5V	9.8V
	Redundant	10.5V	9.5V	11.8V	11.5V	10V
Start to close cover	Prime	2.4V	2.4V	3.5V	3.5V	3V
	Redundant	2.4V	2.4V	3.5V	3.5V	3V
Fully close cover	Prime	6V	4.5V	8V	8V	6.4V
	Redundant	5.8V	5.3V	10V	7.8V	6.8V

Table 1.1.1-1 SVA Cover Operation Results Summary

The above Table demonstrates consistent performance of the SVA mechanism throughout the test programme and that its' operating characteristics are similar to the EM unit.

Test Operation	Drive Motor	Baseline Test	Post-vibe test	Vacuum @ -25°C	Vacuum @ +25°C	Vacuum @ Ambient
Open cover (from locked position)	Prime	3	2.95	2.33	2.43	2.86
	Redundant	2.66	2.95	2.37	2.43	2.8
Start to close cover	Prime	11	11	8	8	9
	Redundant	11	11	8	8	9
Fully close cover	Prime	4.6	6.2	4.6	3.5	4.4
	Redundant	4.8	5.3	2.8	3.6	4.1

Table 1.1.1-2 SVA Cover Operation Torque Margin Results Summary

Note: Torque Margin for each test is calculated by :- Nominal 28V / operating voltage

"Torque Margin" can also be termed "Torque Ratio".

2. APPLICABLE DOCUMENTS

AD1	SP-HIR-050 Issue D	SVA Subsystem Specification
AD2	HR2L040 Issue 5	SVA Assembly Bill of Materials
AD3	TP-MMS-451 Issue 3	Space View Aperture FM Test Procedure
AD4	TC-MMS-400 Issue 1	Manual for SSH and SVA Test Equipment
AD5	TR-MMS-485 Issue 1	FM SVA Vibration Test Report
AD6	HR.NCR00002.MMS	Occurrence Report for Motor Anomaly
AD7	HR.NCR00003.MMS	Occurrence Report for TV Test Anomaly
AD8	PO-DIS-MMB-GM-0030	Motor Assembly Burn-in Test Procedure
AD9	TC-MMS-465	SVA End Item Data Package

3. TEST SPECIMEN

The unit tested was the SVA FM Serial No FM001 as defined in Bill of Materials AD 2.

4. TEST SEQUENCE

4.1 Preliminary Tests

The torque required to manually operate the mechanism was measured as **1 Nm**.

4.1.1 Preliminary Electrical Tests

The preliminary motor checks were carried out in July 1999 and it was found that the prime motor resistance had increased from 23Ω approx. to 43Ω approx. The investigation is detailed in Occurrence Report HR.NCR00002.MMS (AD 6). A section of the rotor winding was found to be faulty, the motor was replaced and the assembly rebuilt to HR2L004 and tested in accordance with Motor Assembly Burn-in test PO-DIS-MMB-GM-0030 (AD 8). Refer to Appendix 1 for details.
The test procedure was modified to reduce the power supply current limit from 0.5 to 0.4A as a prudent measure to protect the motor windings.

Motor terminal resistance	Prime	**20.9 Ω**
	Redundant	**21.2 Ω**

Microswitches open and close status confirmed.
Resistance of thermistors at 20°C ≅ 1.9MΩ confirmed.
Grounding resistance between cover and baseplate 20 mΩ.

4.2 Determine Torque Limiting Resistor Value

Minimum voltage to fully operate cover	Prime	**5.8 V**
	Redundant	**5.2 V**

Using the following parameters from above, calculate the torque limiting resistor value required to provide a torque margin of x3 when operated at 28V.

- Terminal resistance $R1$ = 21.2 Ω
- Minimum operating voltage $V1$ = 5.8 V

$$\text{Resistor Value} = \left\{\frac{R1 \times 28}{V1 \times 3}\right\} - R1 = \mathbf{12.9\ \Omega}$$

∴ 12 Ω resistor selected for both motor windings

4.3 Baseline Functional Test

This test was carried out to demonstrate the operation of SVA in different configurations and to determine the torque margins for the drive motors prior to environmental testing.

4.3.1 Hinge Drive Axis Vertical

SVA was set up in assembly fixture TAA2127, with cover hinge axis vertical.

4.3.1.1 Prime Motor

Unit was connected by a short cable harness to a break-out box. The power supply was connected, the +ve lead connected to pin 3 and -ve lead to pin 14. (This configuration opened cover using the prime motor).

- Power supply switched on
- Fully open microswitch indicates correct status of cover
- +ve and -ve power supply leads reversed, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- Power supply set to 28 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **9.3V**
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully opened and power supply switched off
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on.
- Power supply voltage gradually increased until drive starts to rotate at **2.4V, and 6V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover

4.3.1.2 Redundant Motor

Power supply was then connected, the +ve lead was connected to pin 4 and the -ve lead to pin 9. (This configuration opened cover using the redundant motor).

- Power supply set to 28 Volts and 0.4 Amps
- Power supply switched on
- Fully open microswitch indicates correct status of cover.
- +ve and -ve power supply leads reversed, power supply switched on.
- Mechanism cover fully closed and power supply switched off.
- Fully closed microswitch indicates correct status of cover.
- Power supply set to 0 Volts and 0.4 Amps.
- +ve and -ve power supply leads reversed, power supply switched on.
- Power supply voltage gradually increased until drive starts to rotate at **10.5V**

- Power supply voltage increased to 28V, power supply switched on.
- Mechanism cover fully opened and power supply switched off.
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **2.4V, and 5.8V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover

4.3.2 Hinge Drive Axis Horizontal

SVA was set up in assembly fixture TAA2127, with cover hinge axis horizontal and the operations detailed in Section 4.3.1 were repeated.

4.3.2.1 Prime Motor

- Power supply set to 28 Volts and 0.4 Amps
- Power supply switched on
- Fully open microswitch indicates correct status of cover
- +ve and -ve power supply leads reversed, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- Power supply set to 28 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **10.1V**
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully opened and power supply switched off
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.5 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **2.3V,** and **9.1V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover

4.3.2.2 Redundant Motor

- Power supply set to 28 Volts and 0.4 Amps
- Power supply switched on
- Fully open microswitch indicates correct status of cover.
- +ve and -ve power supply leads reversed, power supply switched on.
- Mechanism cover fully closed and power supply switched off.
- Fully closed microswitch indicates correct status of cover.

- Power supply set to 0 Volts and 0.4 Amps.
- +ve and -ve power supply leads reversed, power supply switched on.
- Power supply voltage gradually increased until drive starts to rotate at **9.2V**
- Power supply voltage increased to 28V, power supply switched on.
- Mechanism cover fully opened and power supply switched off.
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **3.0V, and 9.1V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover

4.4 Vibration Test

Refer to FM SVA Vibration Test Report TR-MMS-485 (AD 5) for full details of vibration testing.

4.5 Post Vibration Function Test

4.5.1 Prime Motor

SVA was set up in assembly fixture TAA2127, with cover hinge axis vertical. Unit was then connected by a short cable harness to a break-out box. The power supply was connected, the +ve lead connected to pin 3 and -ve lead to pin 14. (This configuration opened cover using the prime motor).

- Power supply set to 28 Volts and 0.4 Amps
- Power supply switched on
- Fully open microswitch indicates correct status of cover
- +ve and -ve power supply leads reversed, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- Power supply set to 28 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **9.5V**
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully opened and power supply switched off
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage increased to 28V, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **2.4V, and 4.5V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off

- Fully closed microswitch indicates correct status of cover

4.5.2 Redundant Motor

Power supply was then connected, the +ve lead was connected to pin 4 and the -ve lead to pin 9. (This configuration opened cover using the redundant motor).

- Power supply set to 28 Volts and 0.4 Amps
- Power supply switched on
- Fully open microswitch indicates correct status of cover
- +ve and -ve power supply leads reversed, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **9.5V**
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully opened and power supply switched off
- Fully opened microswitch indicates correct status of cover
- Power supply set to 0 Volts and 0.4 Amps
- +ve and -ve power supply leads reversed, power supply switched on
- Power supply voltage gradually increased until drive starts to rotate at **2.4V, and 5.3V** to overcome axial friction lock
- Power supply voltage increased to 28V, power supply switched on
- Mechanism cover fully closed and power supply switched off
- Fully closed microswitch indicates correct status of cover

4.5.3 Results Summary

The drive test results compare favourably with the baseline test. They show no significant change in operating characteristics and demonstrate repeatability of all functions for both motors.

4.6 Thermal Vacuum Testing (19-31 January 2000)

The FM unit has been tested in vacuum ($<1*10^{-5}$ mBar) at its upper and lower Acceptance temperature limits and operated by test bench electronics (EGSE Ref. AD4).

The SVA was mounted in the test chamber with the motor axis vertical and functional tests were performed at the following stages :

- prior to closing chamber (to verify harness)
- at -25°C
- at +25°C
- at ambient temperature (after 4 thermal cycles)

For the final test, the unit was still under vacuum at ambient temperature. On the second operation to open the cover at 28V, the power supply tripped at the current limit of 0.4A. The investigation is detailed in Occurrence Report HR.NCR00003.MMS (AD 7).

The chamber was opened and diagnostic checks revealed that the mechanism could have locked axially due to a small operating clearance found in the lost motion drive. This clearance was adjusted and noted in the Occurrence Report. However, tests and checks revealed this locking was very unlikely to occur.

The current limit was reset to the procedure value of 0.5 A. (The current limit was set purely for in-house protection of the motors during their assembly and integration sequence).

Following adjustment of this clearance, the Thermal Vacuum test was repeated.

Refer to Appendix 2 for thermal vacuum temperature cycling details.

4.6.1 Thermal Vacuum test results

Test Operation	Drive Motor	Baseline Test	Post-vibe test	Vacuum @ -25°C	Vacuum @ +25°C	Vacuum @ Ambient
Open cover (from locked position)	Prime	9.3V	9.5V	12V	11.5V	9.8V
	Redundant	10.5V	9.5V	11.8V	11.5V	10V
Start to close cover	Prime	2.4V	2.4V	3.5V	3.5V	3V
	Redundant	2.4V	2.4V	3.5V	3.5V	3V
Fully close cover	Prime	6V	4.5V	8V	8V	6.4V
	Redundant	5.8V	5.3V	10V	7.8V	6.8V

All AD590 thermistors operated satisfactorily.
SVA was inspected and no obvious degradation or damage was noted. All operations were nominal at temperature extremes.
The above table demonstrates the SVA mechanism performance has not changed during the test programme and its operating characteristics are similar to the EM unit.

DISTRIBUTION LIST

INTERNAL	EXTERNAL
I Stewart	N Morris (RAL)
RTS Coupe	
N Crossland	

CHANGE RECORD

CHANGE NUMBER	CLASS	CHANGE DETAILS	ISSUE
3164- 00361	-	First Issue	1

APPENDICES

APPENDIX 1 - Motor Assembly Burn-in test (PO-DIS-MMB-GM-0030)

APPENDIX 2 - SVA Thermal Vacuum Test operations log

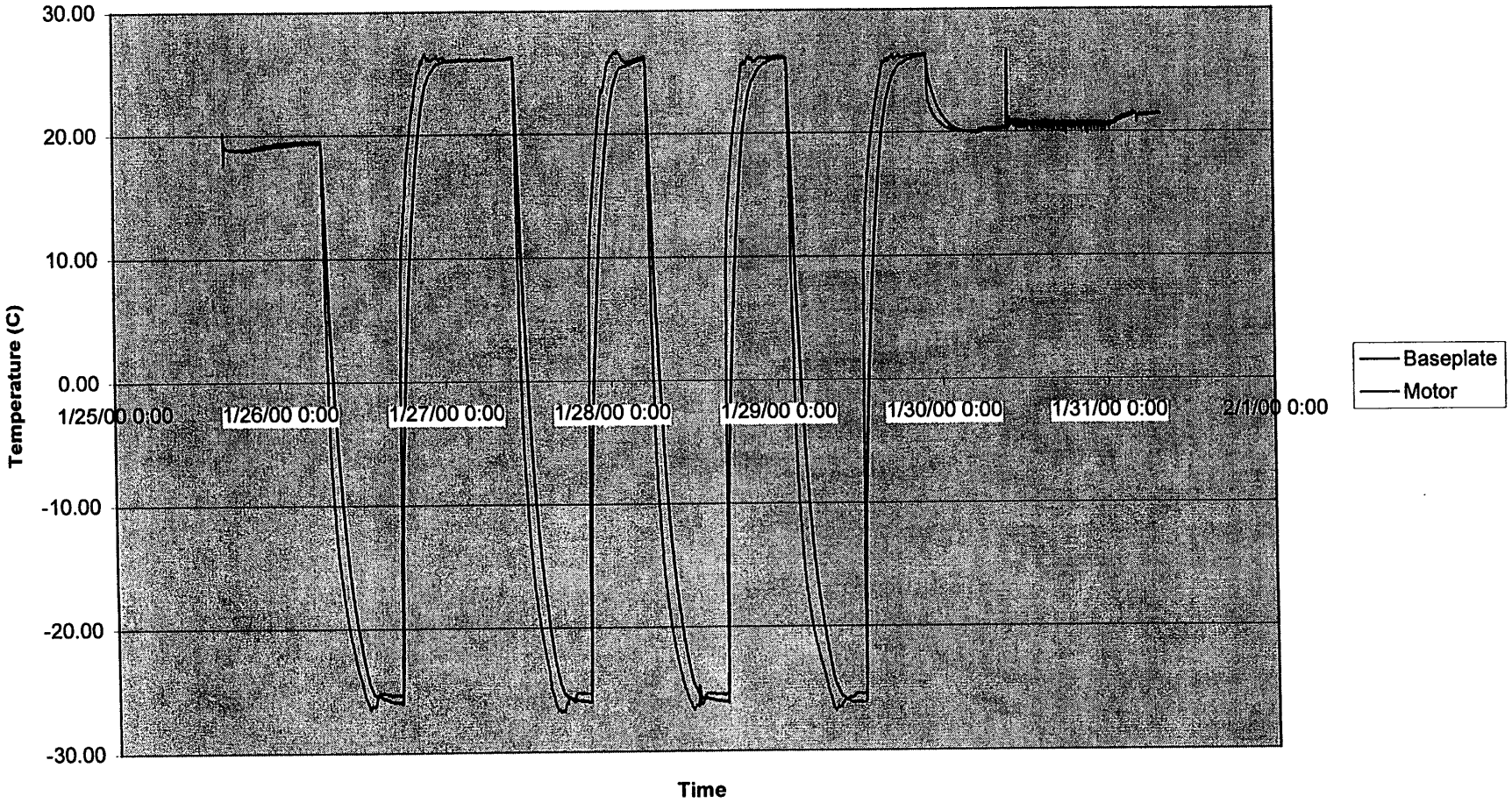
APPENDIX 3 - SVA Accumulative Operations Log sheet

APPENDIX 1 MOTOR ASSEMBLY BURN-IN TEST (PO-DIS-MMB-GM-0030)

Refer to End Item Data Pack TC-MMS-465, Section 4 for details

APPENDIX 2 SVA THERMAL VACUUM TEST TEMPERATURE PROFILE

FM SVA Thermal Vacuum Re-test Temperature Profile



APPENDIX 3 SVA ACCUMULATIVE OPERATIONS LOG SHEET

SVA Operations Log Serial No. FM 001

	No. Operations	Activity	Engineer	Date
	8	MANUAL OPERATIONS	KTSC	20-7-99
	6	Preliminary Electrical Tests	KTSC	5-1-00
	8	Baseline Functional Test	KTSC	5-1-00
	4	Post Vibration Funct. Test	KTSC	19-1-00
	4	Thermal-Vacuum @ -25°C	KTSC	20-1-00
	4	" " " +25°C	KTSC	20-1-00
	4	" " " AMBIENT	KTSC	24-1-00
REPEAT TV TEST	4	Thermal-Vacuum @ AMBIENT	KTSC	25-1-00
	4	" " @ -25°C	KTSC	26-1-00
	4	" " @ +25°C	KTSC	27-1-00
	4	" " @ AMBIENT.	KTSC	30-1-00

Note 1 Operation = Open and Close