SMEI Flight Model Cameras

Vibration Test Plan

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1. Introduction

This document describes the requirements and specification for vibration testing of the SMEI Flight Model (and Flight Spare) Cameras.

In these tests the Cameras are to be vibrated to *acceptance* levels. The Flight Spare Camera, fitted with an engineering grade CCD, has previously been vibrated to *protoqual* levels. An Engineering Model Camera, which had slightly different designs of Baffle Door and Radiator, was previously vibrated to substantially higher *qualification* levels.

It is expected that the testing will be performed in the Vibration Test Facility at Rutherford Appleton Laboratory using the LDS 954 vibrator.

2. Test Item

The test item for each set of tests is a SMEI Flight Model (or Flight Spare) Camera, whose approximate size and mass are given in Table 2.1.

	Dimensions (mm)	Mass (Kg)
Cameras (each)	500 x 460 x 410	7.6

Table 2.1 - Approximate Dimensions and Mass of SMEI Cameras

Each Camera shall be attached to the vibrator interface plate (supplied by Birmingham University), using four M5 fasteners (tightening torque = 4.7 Nm) fitted to the spacecraft interface attachment holes in the Camera Strong-Box

An aluminium spacer plate of thickness 10mm fitted between the Strong-box and the vibrator interface plate will ensure that loads are only transferred via the Strong-Box, and in particular that the Camera E-Box is not in contact with the interface plate.

3. Test Specification

3.1 Introduction

Vibration in all three Camera axes is required. The directions of the axes are defined as follows:

- Z-axis is in the direction of the optical axis of the Camera, with +Z outwards from the Baffle aperture.
- Y-axis is perpendicular to the spacecraft interface plate, with +Y towards the spacecraft.
- X-axis forms a right-handed orthogonal set (and is in the wide direction of the Baffle aperture).

The order of the axes for the testing is not important. The order of vibration may be chosen to minimise the amount of handling required, and the total test time.

For each axis the following set of tests shall be performed (to identical specifications in all cases):

1. Preliminary low-level sine survey.
2. Quasi-static load test.
3. Random vibration.
4. Final low-level sine survey.

3.2 Preliminary Low-Level Sine Survey

One sweep shall be performed at 0.5g from 5 Hz to 2000 Hz at 2 octaves per minute.

3.3 Quasi-Static Load Test

A minimum of 5 cycles shall be performed at 22.5g and at a frequency of 35 Hz (this frequency is chosen to lie significantly below the lowest natural frequencies seen during previous testing of the Cameras).

It is recommended that 10 cycles are performed to guarantee that more than 5 cycles are at the full specified level, taking into account the response time of the vibrator and controller.

3.4 Random Vibration

The random vibration levels shall be as specified in Table 3.1 and Figure 3.1 (acceptance levels). The overall test level is 7.24 g rms.

The duration shall be 1 minute.

Frequency (Hz)	Test Level (g^2/Hz)
20	0.0330
40	0.0650
470	0.0650
2000	0.0036

Table 3.1 - Acceptance Vibration Test Levels for SMEI Flight Model Cameras

3.5 Final Low-Level Sine Survey

One sweep shall be performed at 0.5g from 5 Hz to 2000 Hz at 2 octaves per minute.

Accelerometer traces shall be examined to confirm that there are no substantial deviations from the characteristic ‘signature’ recorded in the preliminary low-level sine survey.

4. Accelerometer Locations

The control accelerometer shall be mounted on the interface plate.

One tri-axis and four single axis monitoring accelerometers shall be mounted at the approximate locations specified in Table 4.1. The single axis accelerometers shall be removed and re-installed for each test axis in order that they respond in the direction of the excitation.

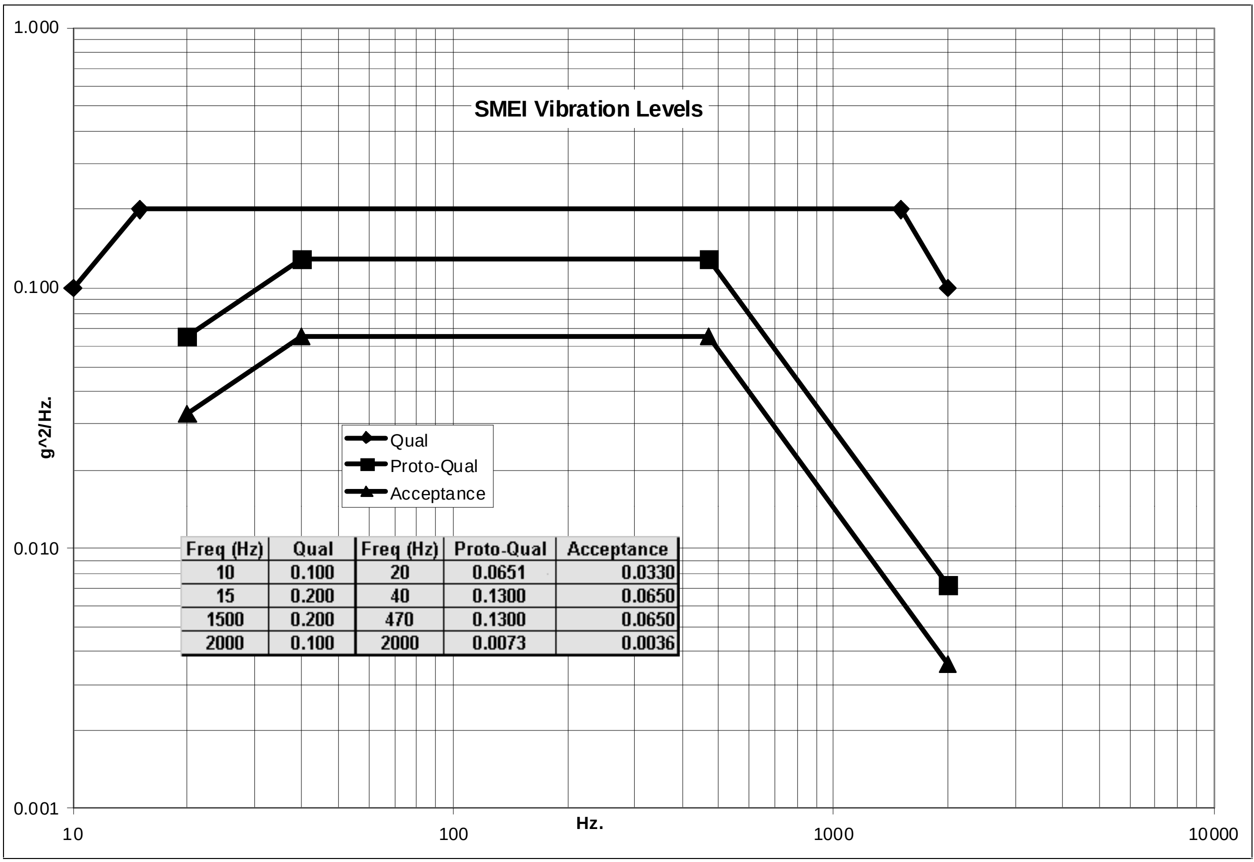

Figure 3.1 - Vibration Test Levels for SMEI (Acceptance Levels to be used for Flight Cameras)

Channel No	Accelerometer Type	Response Axis	Mounting Location
2	Tri-axis	X	Top corner (-Y, -Z) of Radiator
3	Tri-axis	Y	Top corner (-Y, -Z) of Radiator
4	Tri-axis	Z	Top corner (-Y, -Z) of Radiator
5	Single axis	Test axis	Top end (-Y) of Cold Finger
6	Single axis	Test axis	Top corner (+X, -Y, +Z) of Baffle
7	Single axis	Test axis	Front top corner (+X, -Y, +Z) of S-Box
8	Single axis	Test axis	Rear top corner (+X, -Y, -Z) of E-Box

Table 4.1 - Locations for Monitoring Accelerometers

5. Test Item Verification

5.1 Pre-Vibration

After the Camera has been installed on the vibrator table but before any vibration has commenced the following tests will be performed (using SMEI EGSE) to verify correct operation and integrity of the unit:

- Check operation of Shutter Motor and Monitors.
- Record typical Camera images with 4s exposure with internal and external flat-field LEDs operating.
- Record strain gauge readings for Baffle tie-rods.

5.2 Between Vibration Axes

After each of the first and second axes of vibration are completed the following tests will be performed to verify correct operation and integrity of the Camera:

- Check operation of Shutter Motor and Monitors.
- Record typical Camera images with 4s exposure with internal and external flat-field LEDs operating.

5.3 Post-Vibration

After completion of the final axis of vibration the following tests will be performed to verify correct operation and integrity of the Camera:

- Check operation of Shutter Motor and Monitors.
- Record typical Camera images with 4s exposure with internal and external flat-field LEDs operating.
- Perform a Baffle Door unlatching test (with Teflon restraints fitted to limit the Door opening to the minimum required to demonstrate unlatching).
- Record strain gauge readings for Baffle tie-rods.

(In accordance with normal good practice during vibration testing, visual inspections, *etc* will be carried out to establish that there is no visible damage, unusual noises, significant changes to characteristic ‘signatures’, *etc* at any stage during the testing).

5.4 Subsequent Verification

Following return of the Camera to Birmingham University the following additional verifications will be performed to verify correct operation and integrity of the unit:

- A full deployment test of the Baffle Door (with the Camera X-axis vertical) in the Class 1000 cleanroom.
- Inspection of the interior of the Baffle under UV light for particulate debris. Any such debris will be blown out using a jet of dry N_2 in accordance with the normal cleaning procedures for the SMEI Cameras.
- Separation of the Baffle from the Strong-Box and inspection of the interior of the Strong-Box under UV light for particulate debris. Any such debris will be blown out using a jet of dry N_2 in accordance with the normal cleaning procedures for the SMEI Cameras.

Note: Separation of the Baffle from the Strong-Box involves removing external fasteners only. These fasteners can readily be locked again afterwards and this operation will in no way compromise the validity of the qualification test. It is considered that the risks involved in this operation are much lower than the potential risks associated with a piece of debris, dislodged during vibration, subsequently landing on the optics or the unprotected CCD chip.

6. Handling Requirements

The test items are **flight units** and appropriate precautions shall be taken during handling at the vibration test facility. In particular the following shall be rigorously adhered to:

- The Cameras shall be handled with approved cleanroom gloves at all times.
- Appropriate ESD precautions (grounded wrist straps) shall be used during the testing when connecting the Cameras to the EGSE.
- Teflon restraints shall be fitted to the Baffle to limit the Door opening to the minimum required to demonstrate operation of the latch mechanism during the door unlatching test.