ANIMATICS

Environmental Testing: Mechanical Vibration Testing

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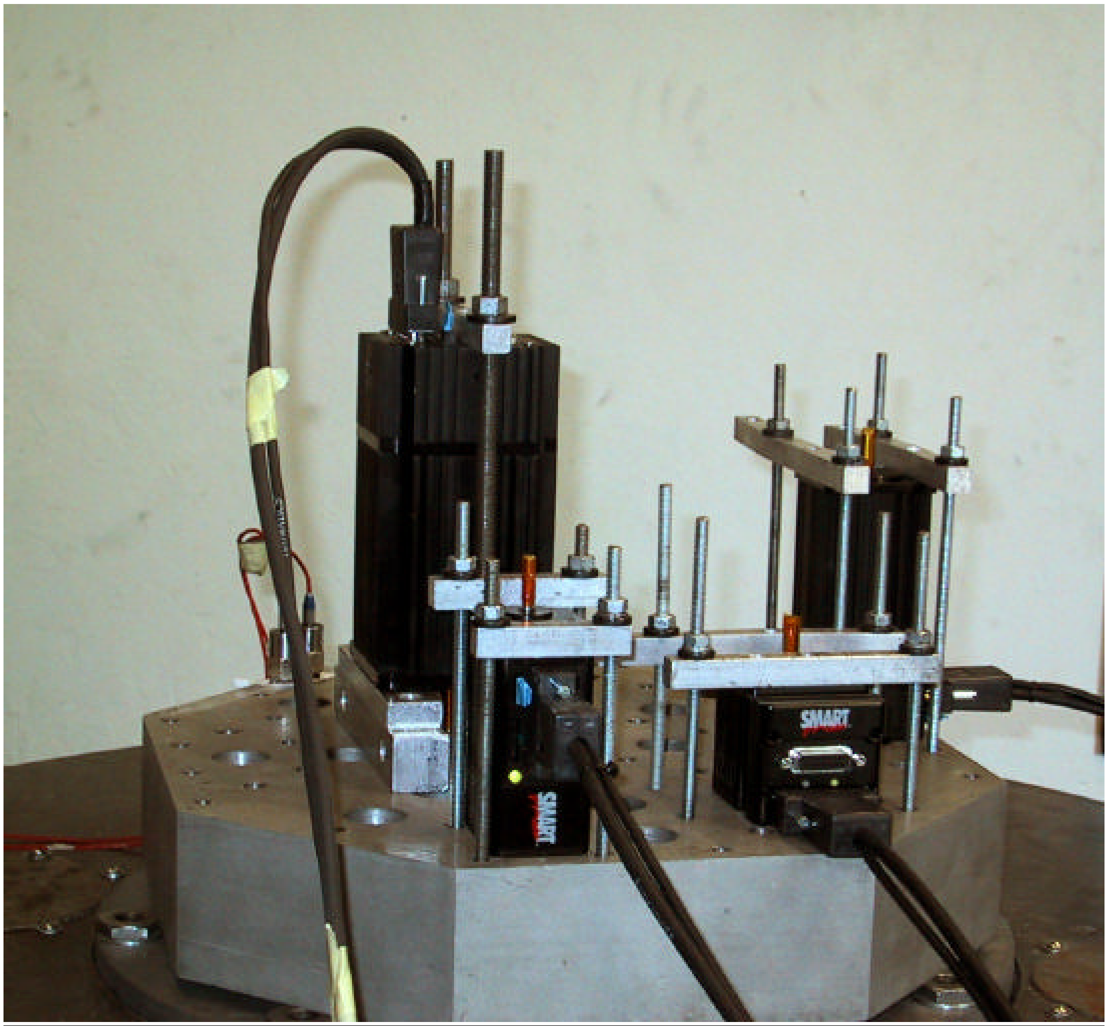

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ABSTRACT

To understand the vibration effects on the SmartMotor, vibration test was performed at Bell Technologies Laboratory, Mountain View CA on October 24,2000. The objective of the test was to determine the vibration effects and at what acceleration level would cause the SmartMotor to not execute a program from its external/internal memory.

We tested the heaviest motor per model line (17xx, 23xx and 2315) would display the highest vibration effects. The shorter models will display equal or less severe vibration effects. The units under test (UUT) were the 1720, 2315 and 2340.

The motors were tested on a shake table with motion in the direction of the shaft (vertical orientation test) and with motion perpendicular to the shaft at accelerations (horizontal orientation test). The acceleration of the shake table was recorded with accelerometers.
The motors were vibrated at random frequency (2-2000Hz) at acceleration levels of 3,5,7 and 9 g rms (20 minute duration of at each acceleration level) in the vertical direction. Then they were tested in the horizontal orientation at 5,7 and 9 g rms.

We found from the vibration test that:

SM1720:
The SM1720 was able to continuously run the program from memory module for duration of 20 minutes at acceleration levels of 3, 5, 7& 9 g rms (motion in the direction of the shaft) and 5, 7 and 9 g rms (motion perpendicular to shaft). The motor was fully functional at the completion of the vibration test. The SM1720 was inspected after the test and was found to be fully functional and passed Animatics production tests.

SM2315:
The SM2315 was able to continuously run the program from internal memory for duration of 20 minutes at acceleration levels of 3, 5, 7& 9 g rms (motion in the direction of the shaft) and 5, 7 and 9 g rms (motion perpendicular to shaft). The motor was fully functional at the completion of the vibration test. The SM2315 was inspected after the test and was found to be fully functional and passed Animatics production tests.

SM2340:
The SM2340 was able to continuously run the program from memory module for duration of 20 minutes at acceleration levels of 3, 5, 7& 9 g rms (motion in the direction of the shaft) and 5, 7 and 9 g rms (motion perpendicular to shaft). The motor was fully functional at the completion of the vibration test. The SM2340 was inspected after the test and was found to be fully functional and passed Animatics production tests.

OBJECTIVE

1) Determine the vibration level that makes the SmartMotor models 17xx, 2315, 23xx stop functioning. Test at various acceleration levels from 3g rms to 9g rms with direction of motion in the direction of motor shaft and perpendicular to the shaft. The worst case scenario is the heaviest size for each model line will produce the largest forces due to the mass being accelerated rapidly. The smaller size per model will show equal or may even exhibit reduced effects due to vibration. The Units Under Test (UUT) are: SM1720, SM2315 and SM2340.

EQUIPMENT

AnimaticsCorporation supplied:

UUT

1x-SM1720
1x-SM2315D
1x-SM2340

2x EEPROM programmed with file vibetest.sms see Appendix B.1 for program listing.
3xcblsm1-10
3xpowersupplies
Laptop computer

Bell Technologies Laboratory supplied:

Bell Technologies supplied the following equipment and was operated by D. Wiltshire (Bell Technology Laboratory technician #21). Bell Technology supplied equipment specification data (Bell Tech Laboratory job#149340) which is presented in Table1.

Table 1: Vibration System Equipment Specifications

Description	*Manufacturer*	*Model*	*Range*	*Accuracy*	*Calibration Date*	*Calibration Period*
Vibration System	Unholtz-Dickie	T1000	17500 LB Force: 2Hz –3kHz	±10%	10/24/00	Time of Test
Accelerometer 1	Endevco corp.	2271A	1000g's Max: 2Hz-5.5kHz	±5%	6/28/00	6 month
Accelerometer 2	Endevco corp.	2271A	1000g's Max: 2Hz-5.5kHz	±5%	8/16/00	6 month
Charge Amp.	Unholtz-Dickie	D22-8	Freq. Response: 5Hz-5kHz		6/29/00	6 month
Digital Vibration	Data Physics	Dp550	Frequency Range: 31.25,62.15,125,250, 500,1000,4000, 8000 Hz	±1dB	5/15/00	6 month
Vibration Monitor- Limiter	Unholtz-Dickie	AM12 3	Accel Range:10-100g Disp.Range .1"or 1."DA Limits:1-199% of Full Scale	±1% ±2% ±1%	6/27/00	6 month

PROCEDURE

1) Mount the SmartMotors, with motor shaft oriented in direction of motion to mounting fixture plate of vibration system. This orientation is refereed to as “vertical” orientation in data sheets. Make sure aluminum bars and bolts are properly tightened to the mounting plate. Verify the two accelerometers are secured to shake table.

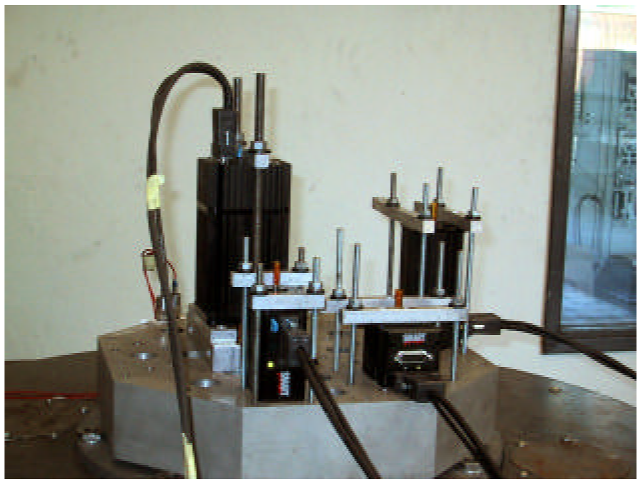

Figure 1: Vertical Vibration Test Set Up

2) Connect one cable to each motor and tighten connector screws. Connect other end to power supply. Install program “vibetest.sms” on memory module of SmartMotors (SM2315 was downloaded to it’s internal memory) and verify they snap into memory module socket.
3) While vibration system is off, power on all motors to verify they are running the program from memory module. Then, connect to laptop computer and verify all motors are fully functional and communicate via theRS232 communication cable using SmartMotor Interface Software. Refer to Figure 2.

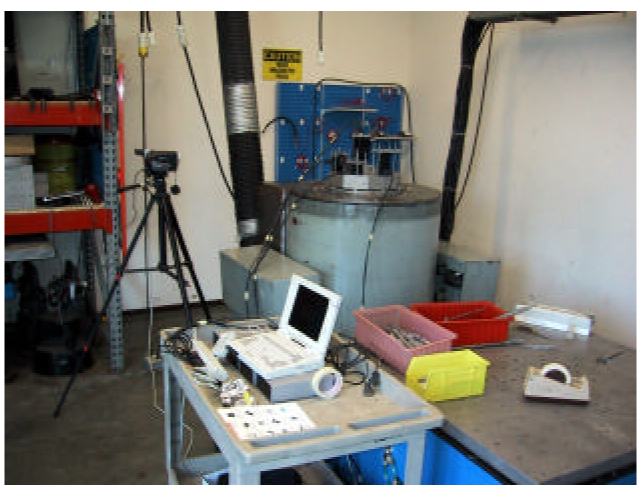

Figure 2: Mounting Motors to Shake Table System

4) Warm-up and calibrate the vibration system.
5) Perform a random frequency (20-2000Hz) at acceleration level 3 g rms for 20 minutes. Observe and record if motor is running program sequence “vibetest.sms” at 1-minute intervals.
6) After 20 minutes testing period is completed, verify each motor is functional by checking if it can receive and communicate using SmartMotor Interface Software.
7) Repeat step 5 & 6 for acceleration levels of 5, 7 and 9 g rms.
8) Remount the motors so they are positioned horizontally with the motion perpendicular to the motor shaft. Refer to Figure 3: Horizontal Vibration Test Setup

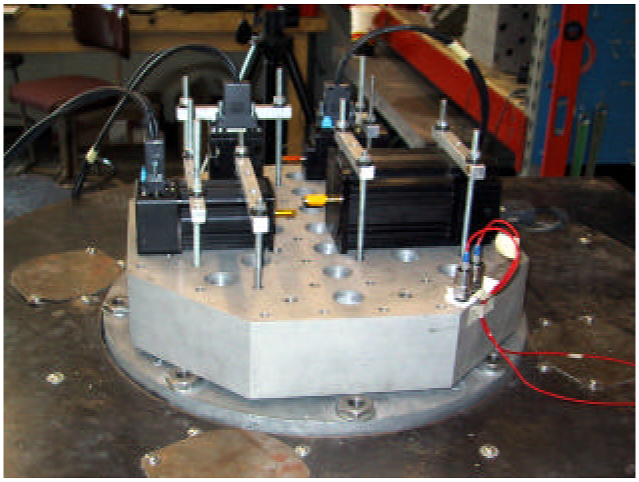

Figure 3: Horizontal Vibration Test Set Up

9) Warm up and calibrate system.
10) Perform a random frequency (20-2000Hz) at acceleration level 5 g rms for 20 minutes. Observe and record if motor is running program sequence “vibetest.sms” at 1-minute intervals.
11) After 20 minutes testing period is completed, verify each motor is functional by checking if it can receive and communicate using SmartMotor Interface Software.
12) Repeat step 10 & 11 for acceleration level of 7 and 9 g rms for 20-minute duration.
13) After all testing is completed, run tests used to verify motors from production line to check if the processor module is functional.
14) Inspect motor section for mechanical effects.
15) Disassembly processor module and look for inspect for signs of physical damage to processor boards and components. Pay attention if there is dust in processor module, which may indicate circuit board damage.

DATA

The Smart Motor 1720, 2315 and 2340 were tested at varying acceleration levels from 3 g rms (root mean square) to 9 g rms in orientation with motion in direction of shaft ("vertical" orientation). Two accelerometers were attached to the shake table mounting plate of the accelerometer to record the actual acceleration of the shake table.

Refer to Figures 4,5, 6 and 7 for plot of accelerometer readings for the vertical vibration test.

The motors then were tested in the horizontal direction at 5,7 & 9 g rms. Refer to Figures 8,9 and 10 for plot of accelerometer for the horizontal test.

A summary of test parameters is presented in Table 2.

Table 2: Vibration Parameters for Vertical and Horizontal Tests

ORIENTATION	ACELLERATION [g rms]	MEASURED ACCELERATION [g rms]	MOTOR TESTED	DURATION [minutes: sec]
Vertical	3	2.99	1720, 2315 2340	20:01
Vertical	5	5.002	1720, 2315 2340	20:01
Vertical	7	6.94	1720, 2315 2340	20:01
Vertical	9	8.93	1720, 2315 2340	20:01
Horizontal	5	4.96	1720, 2315 2340	20:01
Horizontal	7	6.96	1720, 2315 2340	20:01
Horizontal	9	8.94	1720, 2315 2340	20:01

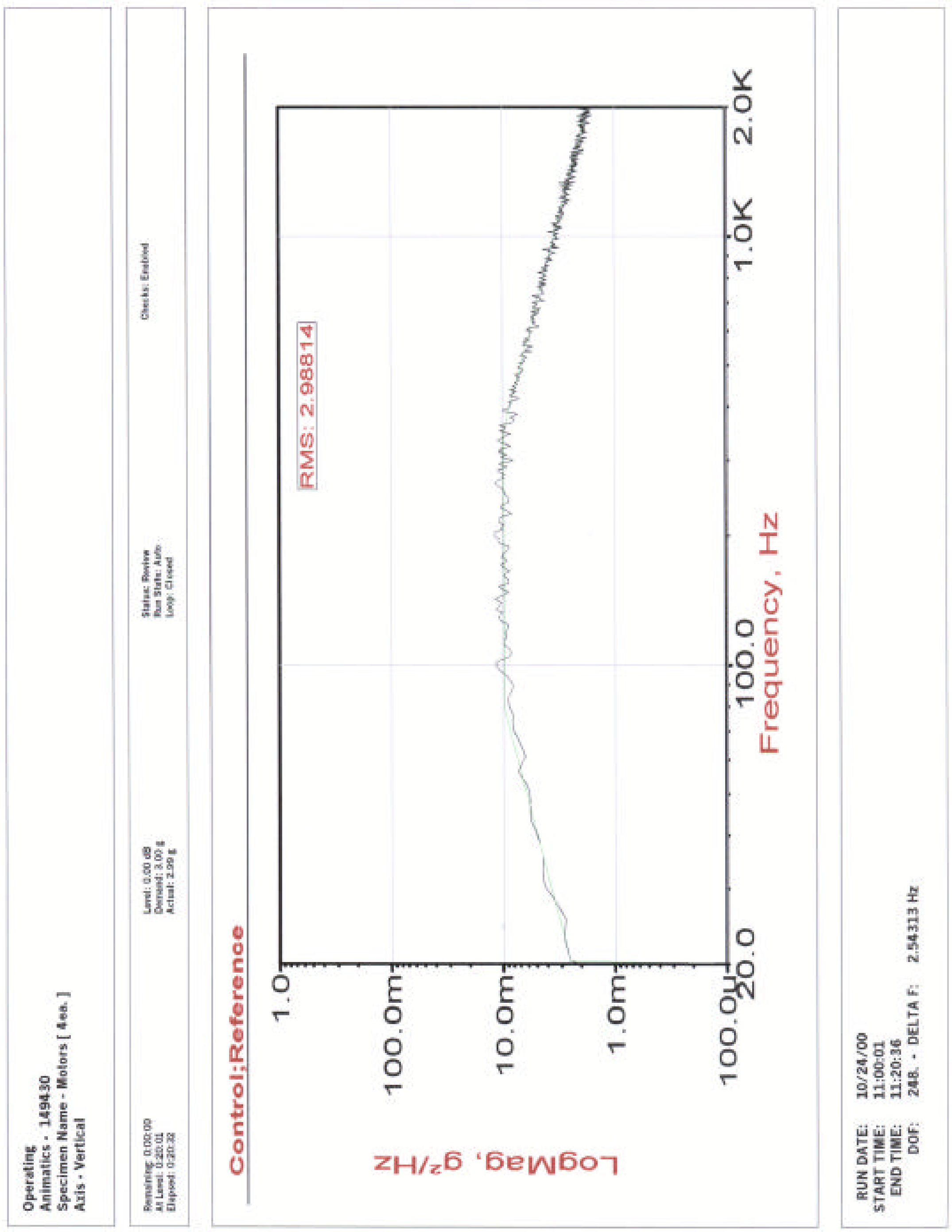

Figure 4: Acceleration Profile (Vertical Test 3 g rms)

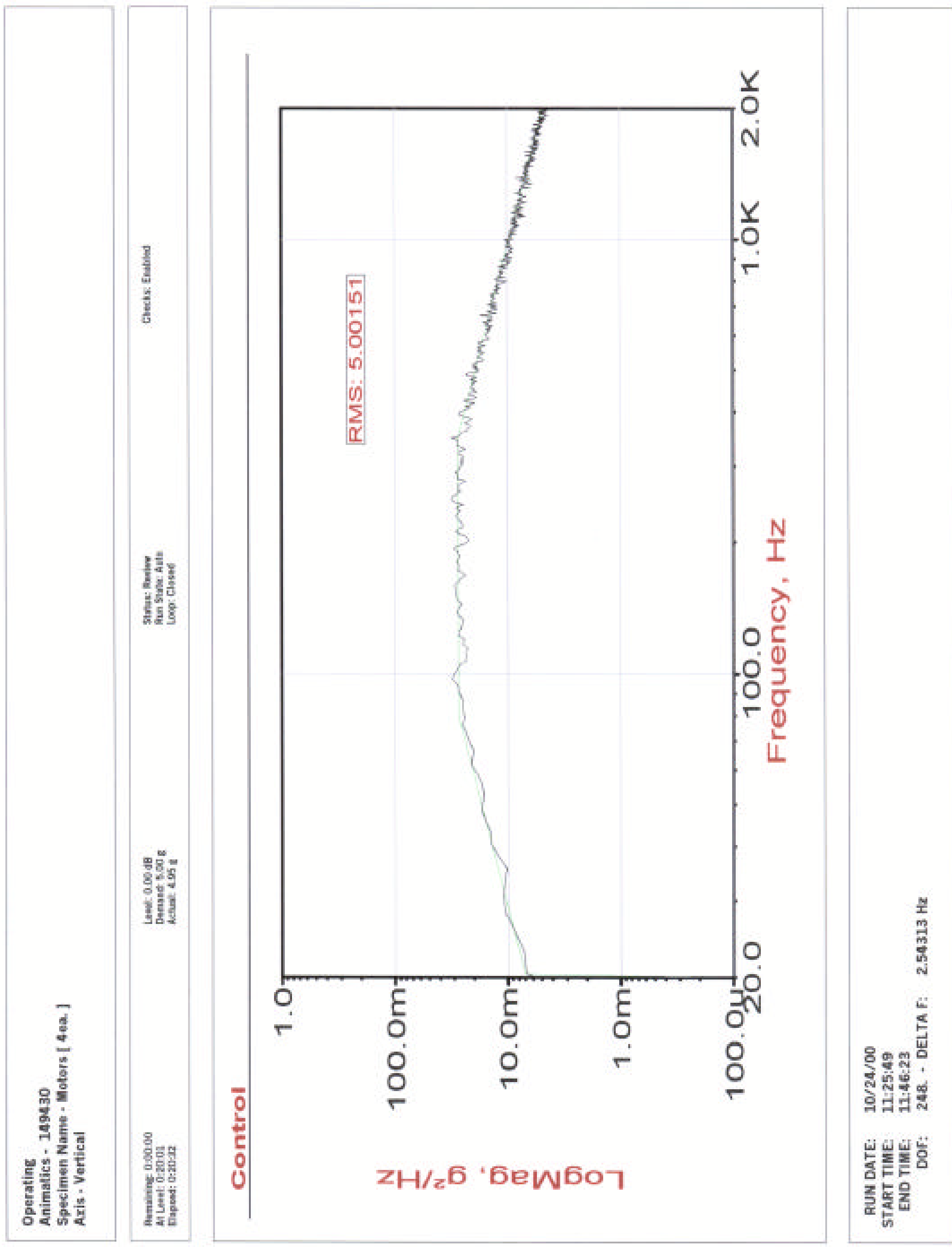

Figure 5 Acceleration Profile (Vertical Test 5 g rms)

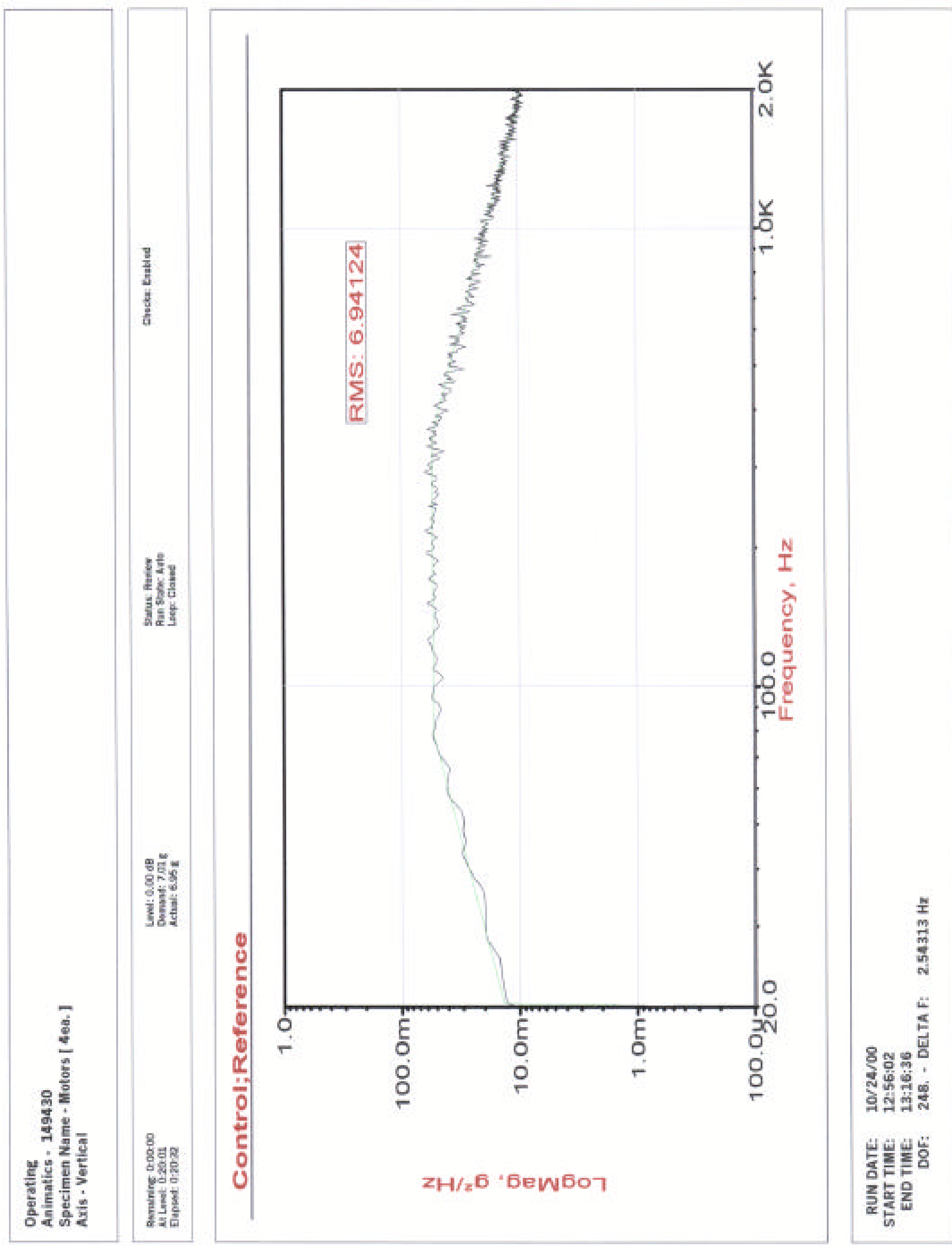

Figure 6: Acceleration Profile (Vertical Test 7 g rms)

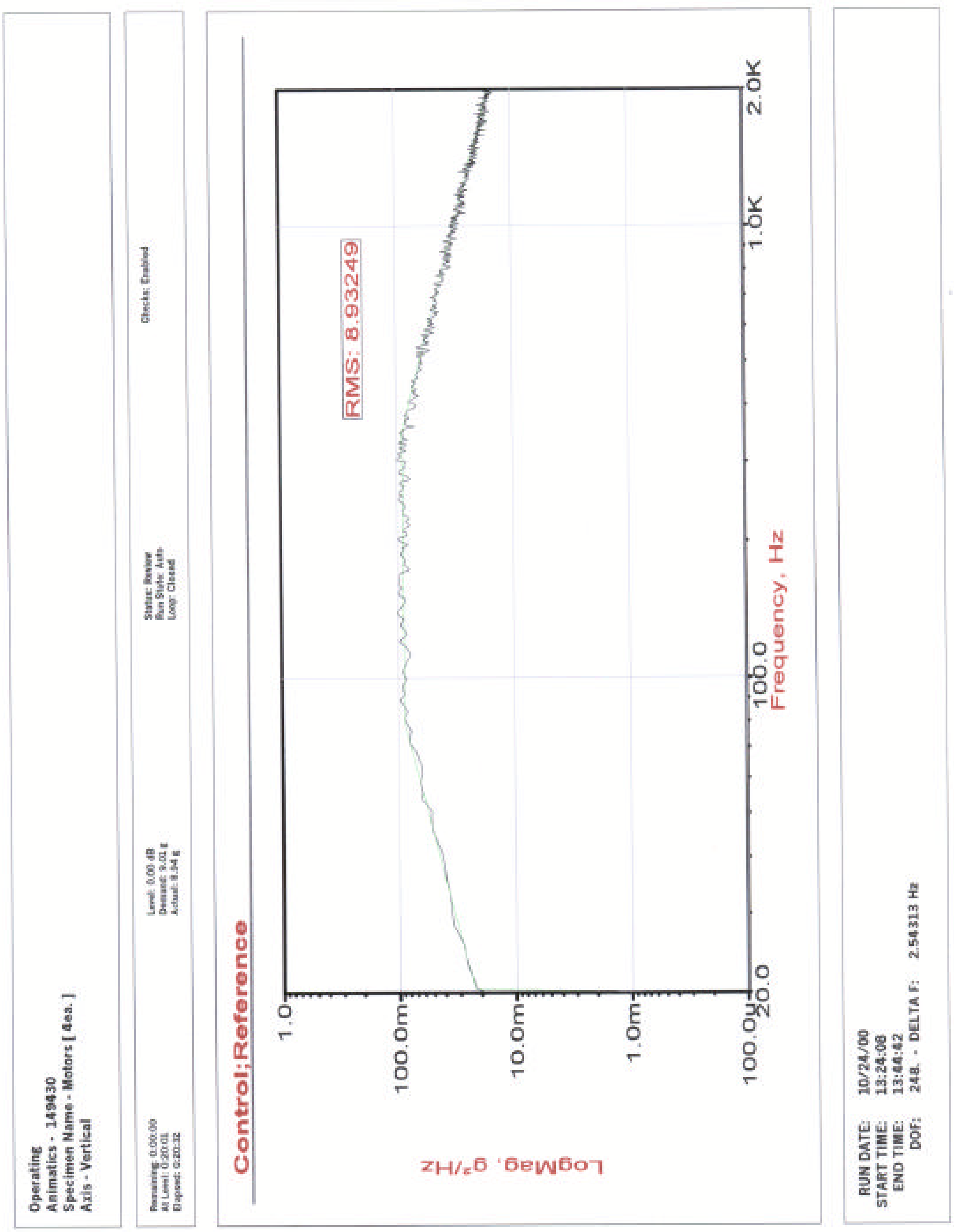

Figure 7: Acceleration Profile (Vertical Test 9 g rms)

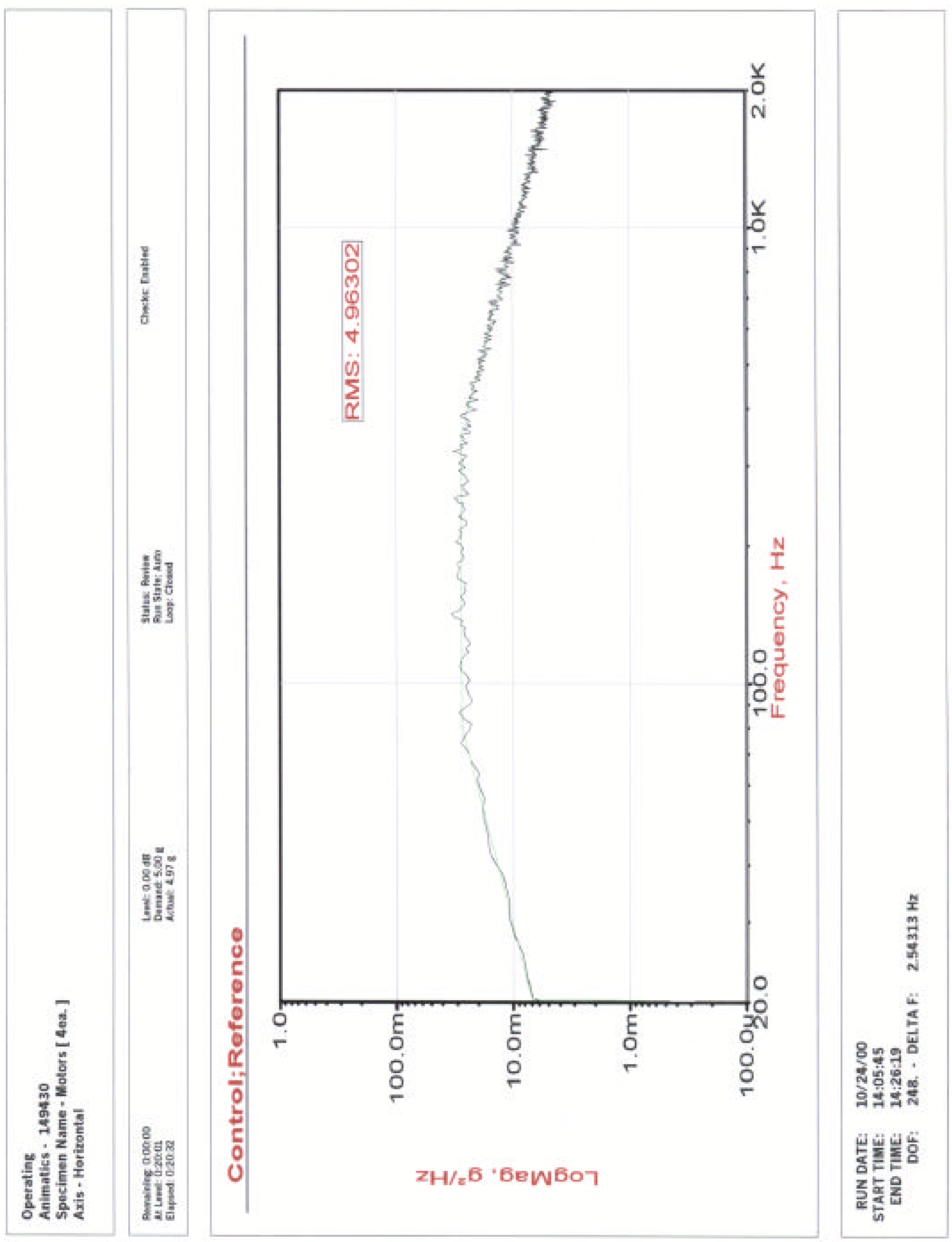

Figure 8: Acceleration Profile (Horizontal Test 5 g rms)

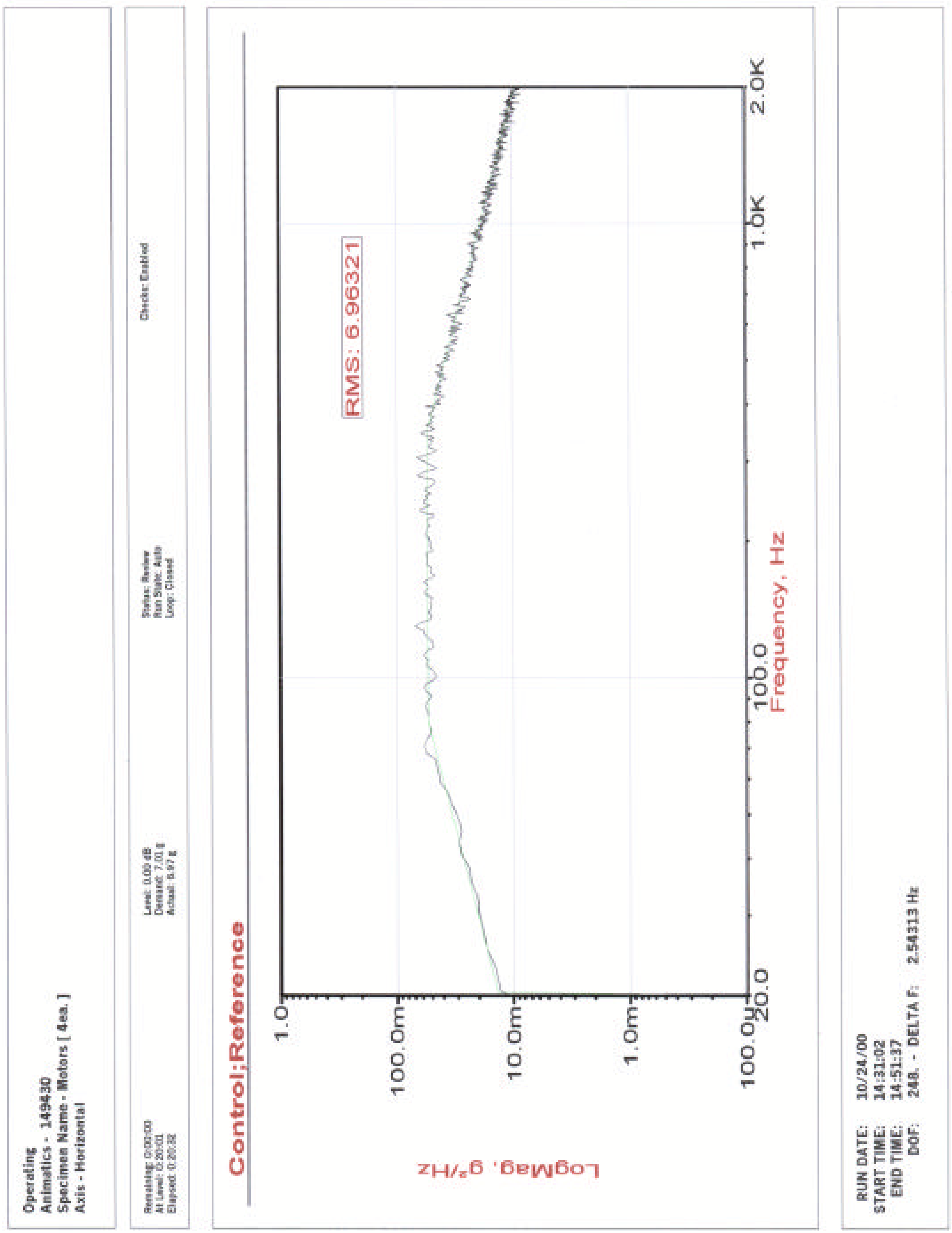

Figure 9: Acceleration Profile (Horizontal Test 7 g rms)

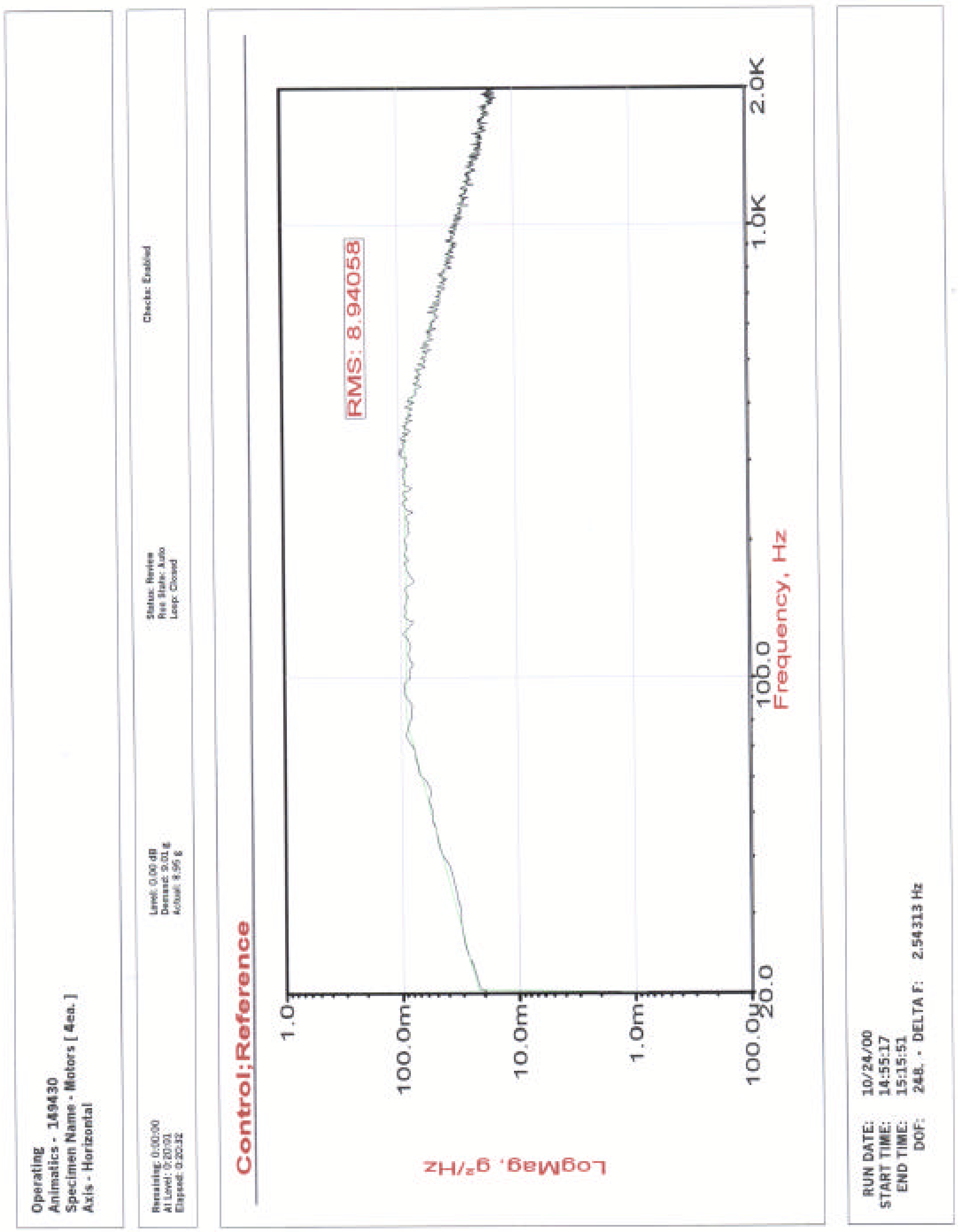

Figure 10 Acceleration Profile (Horizontal Test 9 g rms)

RESULTS

We observed the following:

SM1720:
DURING VIBRATION TEST:
-Successfully withstood 20minute duration of vibration test at:
-3,5,7 & 9 g rms : Motion in direction of shaft (Vertical Orientation).
-5,7,9 g rms : Motion perpendicular to shaft (Horizontal Orientation).
-Passed communication test at each acceleration level 3,5,7 & 9 g rms.
-Continuously ran program from memory module EEPROM (3,5,7 & 9rms) .

POST VIBRATION TEST EXAMINATION
-Passed Animatics production processor function test using production line testpod.
-No physical damage to processor module
-No physical damage to motor section

SM2315:
DURING VIBRATION TEST:
Successfully withstood:
-3,5,7 & 9 g rms : Motion in direction of shaft (Vertical Orientation).
-5,7,9 g rms : Motion perpendicular to shaft (Horizontal Orientation).
-Passed communication test at each acceleration level 3,5,7 & 9 g rms.
-Continuously ran program from internal memory.

POST VIBRATION TEST EXAMINATION
-Passed Animatics production processor function test using production line testpod.
-No physical damage to processor module
-No physical damage to motor section

SM2340:
DURING VIBRATION TEST:
Successfully withstood:
-3,5,7 & 9 g rms : Motion in direction of shaft (Vertical Orientation).
-5,7,9 g rms : Motion perpendicular to shaft (Horizontal Orientation).
-Passed communication test at each acceleration level 3,5,7 & 9 g rms.
-Continuously ran program from memory module EEPROM.

POST VIBRATION TEST EXAMINATION
-Passed Animatics production processor function test using production line testpod.
-No physical damage to processor module
-No physical damage to motor section