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Low Frequency Vibration Characteristics of the Space Acceleration Measurement System II Tape Drive Assembly

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LOW FREQUENCY VIBRATION CHARACTERISTICS OF THE SPACE ACCELERATION MEASUREMENT SYSTEM II TAPE DRIVE ASSEMBLY

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ABSTRACT

This report summarizes the results of force and moment measurements of the Space Acceleration Measurement System II (SAMS II) Tape Drive Assembly (TDA) over the frequency range from 0.35 Hz to 256 Hz for steady state operations including write, read, rewind, and fast forward. Time domain force results are presented for transient TDA operations that include software eject, manual eject, and manual load. Three different mounting configurations were employed for attaching the inner box with the tape drive unit to the outer box. Two configurations employed grommets with spring rates of 42 and 62 pounds per inch respectively. The third configuration employed a set of metallic washers. For all four steady state operations the largest average forces were on the Y axis with the metallic washers and were less than 0.005 pounds. The largest average moments were about the X axis with the washers and were less than 0.030 pound inches. At the one third octave centerband frequency of 31.5 Hz, the 42 pound per inch grommets showed the greatest forces and moments for read and write operations. At the one third octave centerband frequency of 49.6 Hz, the 62 pound per inch grommets showed the greatest forces and moments for rewind operation. Transient operation forces ranged from 0.75 pounds for the software eject to greater than 1 pound for manual load and eject.

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INTRODUCTION

The test results presented, document the low frequency vibration characteristics of the Space Acceleration Measurement System II (SAMS II) Tape Drive Assembly (TDA). SAMS II will monitor the microgravity environment onboard the Space Station. It will be mounted at various locations in the U.S. Lab possibly including an International Standard Payload Rack (ISPR) containing microgravity science experiments. The SAMS II contains a TDA to record the measured acceleration values. The TDA is designed to contain two tape drive units. However, the TDA provided for this test contained only one tape drive unit. This reduced the mass of the TDA, but also reduced the disturbance levels, since only one tape drive was operating during the test.

The TDA was tested, because it is one of the primary disturbance sources of the SAMS II. The test results will provide insight into the ability of the NASA Langley low frequency vibration test apparatus to measure vibration characteristics of devices used in microgravity science facilities.

EQUIPMENT DESCRIPTION

The equipment description includes the test apparatus, the data acquisition system and the SAMS II Tape Drive Assembly.

Test Apparatus

The test apparatus consists of a 21 inch diameter solid aluminum plate with a thickness of 1.94 inches that is suspended from a Zero Spring Rate Mechanism (ZSRM). Under the circular plate is a 1 inch thick solid aluminum trapezoidal keel that is 8 inches high, 10 inches long at the where it attaches to the plate and 1.375 inches long at the bottom. The keel is mounted such that its centroid in the XY plane aligns with the centroid of the XY plane of the circular plate, and the keel length is parallel to the X axis. The circular plate is supported by three eyebolts that are located 120 degrees apart at a radius of 10 inches from the plate center. One of the eyebolts is aligned with the X axis. Three 0.25 inch diameter threaded zinc rods about 14 inches long with turnbuckles were connected to the eyebolts. The ends of the zinc rods hook into a 1 inch diameter cylinder that has three clearance holes on the bottom. The 0.19 inch walled cylinder is 1 inch high and is suspended with a ball joint connection to the Kevlar suspension system. The suspension system consists of a 0.25 inch diameter, 32.75 feet long Kevlar cable that is in turn connected to a 7.33 foot long, 3/32 inch diameter twisted steel cable. The steel cable is suspended from the ZSRM. Figure 1 shows a schematic of the test apparatus with the suspension system.

The test apparatus has three pairs of Sundstrand QA-700 micro-g accelerometers that are matched with respect to amplitude and phase angle. Each accelerometer pair is aligned along one of the orthogonal axis and thus are in the plane of the center of gravity

(CG). The X and Z axes accelerometers are attached to 1.5 inch cubic blocks that are mounted on each side of the top of the circular plate at a radius of 8 inches. Both Y axis accelerometers are mounted below the plate on 1.5 inch cubic blocks. The top Y axis accelerometer block is bolted to the bottom center of the circular plate. The keel has a center cutout for this accelerometer. The bottom Y axis accelerometer was mounted to the bottom of the keel and is separated from the top accelerometer by a distance of 8 inches. The sensitivity of the accelerometers allows measurements down to 1 micro-g. The frequency spectra of the six (6) acceleration measurements were used to compute the three translational and three rotational acceleration measurements at the center of gravity of the TDA. Figures 2a, 2b, and 2c show the dimensions and details of the test apparatus and the locations of the accelerometers.

Data Acquisition System

The signal processing equipment includes a Servo Accel 85 Signal Conditioner, a Precision Filters Model 416 Filter/Amplifier, and a GenRad GR2515 Test System computer. The accelerometers are powered by a +15 volt and - 15 volt dc power supply that is provided in the Servo Accel 85. The Servo Accel Conditioners were fabricated by the Instrument Research Division of NASA Langley Research Center. Currently the accelerometer external resistance loads are set up to provide output acceleration signal levels of 5.4 to 6 volts per g depending on the particular accelerometer and the frequency. Furthermore the Servo Accel provides a reference voltage level for each accelerometer to eliminate any DC acceleration signal. The nominal accelerometer output signal for 1 micro-g with no amplification is 5.5 microvolts. The Servo Accel 85 amplifies the signal of each accelerometer by a factor of 10.

The output signal from the Servo Accel 85 is fed into the Precision Filters Model 416. The Model 416 consists of a prefilter amplifier, a low pass filter, and a post filter amplifier. Two sets of data are acquired for each operating condition. The high frequency data set ranges from 0 to 256 Hz and the low frequency data set ranges from 0 to 32 Hz. The low pass filter cutoff frequency is set at 50 Hz for the low frequency measurements and 350 Hz for the high frequency measurements. For both the high and low frequency data the prefilter amplifiers are set to 1 and the post filter amplifiers are set to 10 resulting in a system gain of 100 and an output signal of 0.5 millivolts per micro-g.

The output signals from the Precision Filters Model 416 Filter/Amplifier are fed into the GenRad GR2515 Test System that employs a 12 bit analog to digital converter. Thus for a full scale value of 1 volt on the GenRad computer, the minimum voltage that can be observed is 0.25 millivolts. However for 12 bit analog to digital converters, the last bit generally is not consistent, so that the minimum voltage that can be obtained for a full scale value of 1 volt is 0.5 millivolts. For this system the 0.5 millivolts corresponds to 1 micro-g which is acceptable. The GenRad system allows the six accelerometer data channels to be recorded simultaneously. It also allows continuous acquisition of the real time data, that can later be averaged over a number of runs to obtain steady state vibration spectra. Figure 3 shows a schematic of the data processing and acquisition system.

SAMS II Tape Drive Assembly

The SAMS II Tape Drive Assembly (SAMS II TDA) consists of an EXABYTE Corporation EXB-8505 8mm Cartridge Tape Subsystem that is hard mounted to an aluminum frame. The aluminum frame is mounted to an external box frame using eight (8) silicon rubber isolator mounts. Four (4) of the mounts are located on the bottom and two (2) mounts are located on each side. The external box frame has a base length of 8.19 inches, a base width of 7.75 inches and a height of 5.50 inches. The aluminum frame has room for two tape drives, however, the unit tested employed only one tape drive mounted in the top slot. The mass of the SAMS II TDA complete with tape was 5.95 pounds. Figure 4 shows a drawing of the SAMS II TDA with the tape drive units installed.

The SAMS II TDA is mounted to the test apparatus using an interface plate that was drilled to match both the hole locations of the test apparatus and the SAMS II TDA attachment bolts. The holes in the interface plate for the attachment bolts are located such that the SAMS II TDA is aligned with the X axis of the test apparatus. In addition, the center-of-gravity (CG) in the XY plane of both the SAMS II TDA and the interface plate are very close to the CG of the XY plane for the test apparatus. The interface plate is a 0.5 inch thick aluminum plate that is 6 inches long and 9 inches wide. It has four lightening holes that are 2.00 inches wide by 2.614 inches long and have a 0.50 inch radius at each corner. The lightening holes are located symmetrically about the plate and are 0.50 inches from both axes of symmetry. The mass of the interface plate alone is 1.62 pounds and the attachment weight was 0.11 pounds. Figure 5 shows a drawing of the interface plate. Figure 6 shows the installation of the SAMS II TDA on the test apparatus.

CENTER OF GRAVITY AND MOMENTS OF INERTIA

Moment of inertia and center of gravity measurements were made on all three axes of the test apparatus using the Space Electronics Mass Properties Instrument Model KSR1320-1500. Moment of inertia and center of gravity measurements were also made on the test apparatus with the SAMS II TDA and the interface plate attached. In addition, the Z axis moment of inertia and the X and Y center of gravity measurements were performed on the SAMS II TDA with only the interface plate attached. The results of the moments of inertia and CG measurements are summarized in Table I. Table I shows that for the test apparatus, the X axis and Y axis CG locations are within 0.02 inches of the center of the plate. With the SAMS II TDA and interface plate mounted on the test apparatus, the X axis and Y axis CG locations are within 0.01 inches of the center of the plate. The CG location for the Z axis is 1.11 inches below the top surface of the plate for the test apparatus alone. With the SAMS II TDA and interface plate installed, the Z axis CG location is 0.73 inches below the top surface of the circular plate.

For the test apparatus alone, the moment of inertia about the X axis is 23 lb-in^2 greater than the moment of inertia about the Y axis. This is because of the orientation of the keel plate. The moment of inertia of the Z axis is almost 75 percent higher than either the X or Y moment of inertia for the test apparatus. With the SAMS II TDA and the interface plate installed the moments of inertia of the system increase approximately 173 lb-in^2 for the X axis and 155 lb-in^2 for the Y axis and only increase 79 lb-in^2 for the Z axis. The effect of the SAMS II TDA on the location of the Z axis CG significantly increases the moments of inertia about the X and Y axes.

Table II shows the moments of inertia of the system about the CG of the SAMS II TDA. The masses, CG locations, and moments of inertia presented in Table II were used to compute the disturbance forces and moments associated with the operation of the SAMS II TDA about the CG of SAMS II TDA.

OPERATION OF SAMS II TAPE DRIVE ASSEMBLY

A 13 volt power supply and a SUN Sparcstation were used to operate the EXABYTE EXB 8 mm tape drive. The SUN Sparcstation allowed the tape drive unit to be operated with UNIX commands. There were no cables provided with the SAMS II TDA and therefore cables were fabricated. The power cable consists of four(4) 18 gauge insulated wires with a 4 pin connector on each end. The power cable was fabricated using separate wires to obtain a flexible connection.

The data cable is a standard 50 pin SCSI ribbon cable that is only flexible in one direction and does not allow the SAMS II TDA and test platform to move freely in space. Therefore a special data cable consisting of twenty-six 30 gauge individually shielded wires was fabricated to connect the TDA to the SUN Sparcstation. The 25 shields were connected with jumpers. This cable is much more flexible than the ribbon cable and allowed the test platform and test article to float freely in space for short distances. One of the main concerns in establishing a microgravity environment is the effect of umbilicals. To reduce the mass and stiffness effects, both the power cable and computer interface cable were suspended from above. The cable connectors that were mounted to the SAMS II TDA made a slight increase to the mass.

Initially background vibration measurements were taken with all systems off. Then background measurements were made with power off and the computer on. Lastly, background measurements were made with power on and the computer on. The results of these tests, which are presented in the results section on page 7, show that the TDA power and computer do not affect the background vibration levels. Before each test series, background vibration levels were measured.

The SAMS II TDA computer operations included writing to the tape, reading from the tape, rewinding tape, fast forward of the tape, and unloading the tape. In addition two hands on operations were performed. These were manually loading and manually unloading the tape.

Each of these tape operations were performed for three different SAMS II TDA mounting configurations. The mounting configurations include two sets of vibration isolation grommets that are used to mount the aluminum inner box containing the tape drive to the outer box. The grommets with a stiffness of 42 pounds per inch were designed for a 1 pound load and the grommets with a stiffness of 62 pounds per inch were designed for a 2 pound load. The other configuration involved replacing the grommets with metal washers to hard mount the inner box to the outer box. Comparisons of these configurations will provide data on the effectiveness of the grommet isolation mounts. Table III presents a summary of the SAMS II TDA test conditions.

TEST PROCEDURE AND DATA PROCESSING

For steady state tape operations of write, read, rewind, and fast forward, the operations were initiated prior to the time that data were recorded. For the transient operations of software eject, manual load, and manual unload, the data recording was initiated prior to the operation of the TDA.

Figure 7 shows the steps used in processing the data. To obtain narrow band frequency data at the low frequencies, two separate tests were performed for each test condition listed in Table III. The high frequency test covered the range from 0 to 256 Hz and the low frequency test covered the range from 0 to 32 Hz. The high frequency test involved recording operational data at a rate of 1024 points per second for 100 seconds. The 100 seconds of data was divided into 50 intervals of 2 seconds each. The data for each 2 second interval for each accelerometer was operated on separately and converted to the frequency domain giving frequency bandwidths of 0.5 Hz over the range from 0 to 256 Hz. The FFT algorithm used employed the 4 sample Kaiser Bessel window [ref 2]. This was repeated 50 times. The 50 sets of frequency data for each accelerometer were then averaged to obtain one set of frequency domain data for each accelerometer over the range from 0 to 256 Hz.

The low frequency test consisted of recording data at a rate of 128 points per second for 160 seconds. The data for each 16 second interval for each accelerometer was converted to the frequency domain as a separate entity, resulting in a bandwidth of 0.0625 Hz. Again the FFT algorithm with the 4 sample Kaiser Bessel window was employed. The 10 sets of frequency domain data were then averaged to obtain one set of frequency data for each accelerometer.

Accelerometer calibration corrections were then applied to the frequency domain data of both the high and low frequency tests. The magnitudes of these corrections varied from

0 to 5 percent and are a function of frequency. The corrections for each accelerometer are presented in the test apparatus calibration report [ref 1].

In the calibration report [ref 1], there is a discussion about the effect of the keel plate on the X axis moment of inertia. The Y axis accelerometer at the bottom of the keel plate is significantly affected by the natural frequency of the keel plate and therefore needs to be corrected to remove this effect. All other accelerometers are attached to the large circular plate and are not significantly affected by the keel plate natural frequency. Figure 8 shows how the keel plate natural frequency of 400 Hz affects responses at frequencies below 256 Hz. The response of the Y accelerometer at the bottom of the keel is corrected for this effect. This correction was only applied to the high frequency data set.

At each frequency the data from each of the six accelerometers was then converted to forces and moments about the CG of the SAMS II TDA using 6 degree-of-freedom rigid body equations. The total response included the low frequency data set for the 0 to 30 Hz range and the high frequency data set for the 30 to 256 Hz range.

These procedures were applied to both the background measurements and the TDA operation measurements.

The TDA operation measurements were corrected for background effects by subtracting the background forces and moments from the forces and moments of the TDA operation.

In addition to correcting keel effects and background noise, there were also low frequency inputs from the suspension system that are described in detail in the calibration report [ref 1]. The setup of the double pendulum results in a natural frequency of 2.4 Hz on the X and Y axes. Thus at frequencies between 2.2 and 2.9 Hz, the test data were corrected to remove this effect. Also the suspension cord has an associated natural frequency in the transverse direction of approximately 5 Hz. The data between 4.7 and 6.1 Hz were corrected to remove this effect. The suspension cord also had a natural frequency in the longitudinal direction of 9.6 Hz. This effect was accounted for by correcting the data between 9.3 and 10 Hz. Another effect on the test data were the 60 Hz signal and its associated harmonics including 120, 180, and 240 Hz. These signals had a very narrow frequency band. The corrections involved data within a 1 Hz range of these specified values. All the above corrections involved removing both moment and force data in each of the specified frequency bands on all three axes. The data on each side of the frequency band of interest were then interpolated across the frequency band to represent the behavior of the device in the specified frequency bands. The last consideration was the effect of the ZSRM. The ZSRM has a natural frequency of 0.3 Hz. Therefore all data below 0.35 Hz were excluded.

The forces and moments on the X, Y, and Z axes were converted to Power Spectral Densities (PSD) that were then converted to one third octave band spectra.

For the transient operations of software eject, manual load, and manual unload, the force and moment computations were performed in the time domain. Thus there were no corrections applied for keel plate effects. Also the data were not corrected for background noise effects. The background noise effects are considerably less than the magnitudes of the transient operations.

RESULTS

The data analysis results consist of summarizing the one third octave band data for the background and for each of the steady state operations on each of the three axes for both forces and moments for each of the three mounting systems. Thus for the background and for each steady state condition there were 18 sets of one third octave band data covering the frequency range from 0.35 to 256 Hz. Data analysis results for each transient operation consist of time plots of the forces and moments on each axis for each of the three mounting configurations.

Steady State Operations

From the one third octave band data, the average forces and moments and the peak values of the forces and moments with the associated peak frequencies were defined for the four steady state operations. The peak force values are presented in Table IV and the peak moment values are presented in Table V . Table IV shows that for the write, read, and fast forward operations, the dominant forces with the grommets occurred at the one third octave center band (OTOCB) frequency of 31.25 Hz, and with the hard mount at the OTOCB frequency of 157.5 Hz. For the rewind operation, Table IV shows that the peak forces occurred at the OTOCB frequency of 49.6 Hz. However, for the hard mount the peak OTOCB frequency was 157.5 Hz in the Y and Z directions. Table V shows that the peak moments for the write and fast forward operations occurred at OTOCB frequencies of 31.25 Hz with the grommets and 157.5 Hz with the hard mount system. For the rewind case, the peak moment occurred at OTOCB frequency of 49.6 Hz. However, for the X axis with the hard mount system the peak moment occurred at a OTOCB frequency of 157.5 Hz. Throughout Tables IV and V there were several peak forces and moments that occurred at OTOCB frequency of 62.5 Hz. However these occurred generally on the Z axis and the magnitudes were generally less than at the other peak OTOCB frequencies on the X and Y axes.

For all four steady state operations both the forces and the moments, the average forces and moments over the range from 0.35 Hz to 256 Hz were tabulated as well as the forces and moments associated with the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz for the three mounting configurations on the X, Y, and Z axes. The force data are presented in Table VI and the moment data are presented in Table VII. The disturbances associated with the four steady state operations have been corrected by subtracting out the background forces and moments at each one-third octave frequency band.

Background Measurements. - As previously stated, background force and moment measurements were made for three cases with each of the three tape drive mounting configurations. The three cases were: (1) computer off and the tape drive off, (2) computer on and the tape drive off, and (3) computer on and the tape drive on. Figures 9a, 9b, and 9c show the average forces and the forces at OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz for the X, Y, and Z axes respectively. Figure 9 shows that the background forces were reduced when both the computer and tape drive unit were turned on (case 3). This occurred on all three axes for all three mounting configurations. The reason for this phenomenon was not researched. Figure 9 shows that the mounting configuration had very little effect on the background vibration forces. A comparison of Figure 9a with Figures 9b and 9c shows that the background forces on the X axis were less than the background forces on the Y and Z axes. It should be noted that the scale for the background forces at OTOCB frequencies of 49.6 Hz and 157.5 Hz is different from the scale used for the operation force data at these two OTOCB frequencies.

Figures 10a, 10b, and 10c show the average moments and the moments associated with OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz for the X, Y, and Z axes respectively. The scales used for the background moments are not the same as the scales used for operation moment data. Figure 10 shows that the background moments associated with the computer on and the tape drive on (case 3) was less than the background moments with all systems off or with just the computer on. A comparison of Figure 10 a with Figures 10b and 10c, shows that the background moments on the X axis were greater than the background moments on either the Y or Z axis.

The forces and moments presented with the steady state operation data have been corrected by subtracting the background data of case 2 (computer on and the tape drive off) from the measured values.

Write Operation. - Figure 11 shows the average forces and the forces at OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz. Figure 11 shows that the highest average force occurred on the Y axes with the hard mount system. For the OTOCB frequency of 31.25 Hz, the forces in the X and Y axes were considerably greater than the Z axis forces. At the OTOCB frequency of 31.25 Hz the highest forces occurred on all three axes with grommet #1. Also the forces associated with grommet #2 mounting system were greater than the forces associated with the hard mount system. From discussions with SAMS II development personnel, it was found that the natural frequency of the TDA with grommet #1 mounting system was near 30 Hz and that the natural frequency of the TDA with grommet #2 was near 50 Hz. It is known that the natural frequency of the TDA with the hard mount system is considerably higher than with either of the grommet mounting systems. At tape drive speeds that are near the natural frequency the amplitude of the disturbance was magnified as shown on Figure 12. Figure 11 shows that at OTOCB frequencies of 49.6 Hz and at 157.5 Hz the forces were very low except for the hard mount system on the Y axis at the high frequency. This large force is the reason that the average force of the hard mount system on the Y axes was significantly greater than all other forces associated with the other axes and other mounting systems. Thus for the write operation the maximum forces were in the Y direction.

Associated with the forces are the moments. Figure 13 shows the average moments over the frequency range from 0.35 to 256 Hz and the moments at OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz. Figure 13 shows that the maximum average force occurred with the hard mount system about the X axes. This is associated with the maximum force that occurred in the Y direction. The Y axis accelerometers are used to determine moments about the X axes. Figure 13 also shows that for the write operation at the OTOCB frequency of 31.25 Hz, the maximum moments occurred on the X and Y axes and not the Z axes. This is because the rotation of the TDA was parallel to the XY plane. Again, because of the natural frequency effects of the mounting system, grommet #1 had the highest moments and the hard mount system had the lowest moments at the OTOCB frequency of 31.25 Hz. Figure 13 shows that the moments associated with the write operation were very low at OTOCB frequencies of 49.6 Hz and 157.5 Hz on all three axes, except for the hard mount system on the X axis at the OTOCB frequency of 157.5 Hz. Again this high moment contributed significantly to producing the highest average moment on the X axis with the hard mount system.

Read Operation. - Like the write operation, the values for the forces associated with the read operation are tabulated in Table VI and presented in Figure 14. Figure 14 shows that the highest average force occurred with the hard mount system on the Y axes. As with the write operation, at the OTOCB frequency of 31.25 Hz, the highest forces were in the X and Y direction. A comparison of the write operation forces and the read operation forces at the OTOCB frequency of 31.25 Hz presented in Table VI and Figures 11 and 14 show that there is virtually no difference. Because of the natural frequencies of the mounting systems and the 31 Hz drive speed of the TDA, the highest average forces on all three axes occurred with grommet #1 mounting system, and the lowest forces occurred with the hard mount system. Figure 14 shows that at the OTOCB frequencies of 49.6 Hz and 157.5 Hz, the read forces were low. However, at 157.5 Hz, the Y axis force with the hard mount system was considerably greater than the other forces. However this did not seem to contribute significantly to the average.

Table VII and Figure 15 show the values of the average moments for the read operation and the moment values at the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz. A comparison of the read operation moments and the write operation moments at the OTOCB frequency of 31.25 Hz, as presented in Table VII and Figures 13 and 15, shows that the differences were negligible except on the Z axis, where the moments are considerably less than the moments of the X and Y axes. Figure 15 shows that at the OTOCB frequencies of 49.6 Hz and 157.5 Hz, the read operation moments were low except for the hard mount system on the X axis at the OTOCB frequency of 157.5 Hz. This high moment value did have a significant effect on the average moment associated with the hard mount on the X axis.

Rewind Operation. - Table VI and Figure 16 present the average forces and the forces associated with the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz for the three mounting systems on the X, Y, and Z axes. Figure 16 shows that the highest average force occurred on the Y axis with the hard mount system. It also shows that on the X and Y axes, the forces obtained with grommet #2 are greater than the forces obtained with grommet #1. This is attributed to the fact that the natural frequency of the TDA with grommet #2 is approximately 50 Hz, which is the same as the rewind operating speed. The figure shows that at the OTOCB frequency of 31.25 Hz, the maximum forces on the X and Y axes were obtained with grommet #1 mounting system, and that the minimum force was obtained with the hard mount system. Figure 16 also shows that at the OTOCB frequency of 157.5 Hz, the forces on all three axes for each mounting system were very low, except for the Y axes force with the hard mount system.

The average moments and the moments associated with the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz are presented in Table VII and Figure 17. The highest average moment occurs on the X axis with the hard mount system. Figure 17 shows that for the Y axes the average moment was not significantly affected by the type of mounting system. Again the Z axis average moments were less than the average moments on the X or Y axes for all three mounting systems. At the TOBC frequency of 31.25 Hz, the largest moments occurred on the X and Y axes with the grommet #1 mounting system. The grommet #2 mounting system experienced higher moments than the hard mount system. The natural frequencies of the various mounting configurations result in the relative magnitudes of the forces and moments at the OTOCB frequency of 31.25 Hz. Again the Z axis moments were less than the moments on the X and Y axes. At the OTOCB frequency of 49.6 Hz, which is very near the rewind operating frequency of 50 Hz, the moments associated with grommet #2 were highest. This is because of the 50 Hz natural frequency associated with grommet #2 mounting system. Figure 17 shows that the highest moment occurred on the X axes and that at the OTOCB frequency of 49.6 Hz, the Z axes moments were considerably less than the X or Y axes moments. At the OTOCB frequency of 157.5 Hz, the moments on the X, Y, and Z axes for all three mounting configurations were very low except for the X axis hard mount system.

Figures 16 and 17 show that the peak forces were associated with the Y axis, and the peak moments were associated with the X axis.

Fast Forward Operation. - Table VI and Figure 18 present the average forces and the forces associated with the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz for the three mounting systems on the X, Y, and Z axes. The average forces were less than 0.001 pounds for all mounting systems on all three axes, except for the hard mount system on the Y axis. As in the other steady state operations, at the OTOCB frequency of 31.25 Hz, the highest forces on the X and Y axes were obtained with grommet #1 mounting system. Also the lowest forces were obtained with the hard mount system on the X and Y axes. The Z axes forces are less than 0.0006 pounds for each mounting system. At the OTOCB frequency of 49.6 Hz, the forces for each mounting system on each axis was less than 0.001 pounds. At the OTOCB frequency of 157.5 Hz, the highest force was obtained with the hard mount system on the Y axis. The forces with grommet #1 and grommet #2 mounting systems were less than 0.001 pounds. The peak force with the hard mount system on the Y axis contributed significantly to the highest average force.

The average moments and the moments at the OTOCB frequencies of 31.25 Hz, 49.6 Hz, and 157.5 Hz are presented in Table VII and Figure 19. Figure 19 shows that the highest average moment was obtained on the X axis with the hard mount system. Again at the OTOCB frequency of 31.25 Hz, the highest moments were obtained on the X and Y axes with grommet #1 mounting system. The hard mount system yielded the lowest forces. At the OTOCB frequency of 49.6 Hz, the moments like the forces were minimal. Similarly, at the OTOCB of 157.5 Hz the peak moment was obtained on the X axis with the hard mount system. This contributed to the highest average moment. The moments obtained on the other axes with the hard mount system and the moments obtained with the grommet #1 and grommet #2 mounting systems were very small.

Steady State Operation Summary. - The magnitude of the peak forces and moments at the OTOCB frequencies of 49.6 Hz and 157.5 Hz were considerably greater than the peak average forces and moments and the peak forces and moments at the OTOCB frequency of 31.25 Hz. The highest average forces and highest average moments for all four steady state operations were obtained with the hard mount system. The highest average forces occurred on the Y axis, and the highest average moments occurred on the X axis. For all four operations, the highest forces and moments occurred at the OTOCB frequency of 31.25 Hz on the X and Y axes with grommet #1 mounting system. At the OTOCB frequency of 49.6 Hz, the forces and moments were relatively low except for the rewind operation. The peak forces and moments for the rewind operation occurred with grommet #2 mounting system. At the OTOCB frequency of 157.5 Hz, the highest forces and highest moments were obtained with the hard mount system. The forces and moments for all cases were very low except for the Y axis force and the X axes moment. The average values appeared to be significantly affected by the values in the OTOCB frequency of 157.5 Hz. At frequencies at or below the OTOCB frequency of 31.25 Hz, the force and moment values were less than 0.005 pounds and 0.030 pound inches respectively.

Transient Operations

The three transient operations include software eject, manual eject and manual load. For the transient operations, the forces were primarily in the X direction with corresponding moments about the Y and Z axes. The large magnitude of the forces resulted in significant displacements of the test apparatus that affected the measurement of the moments. Therefore, only the time histories of the X axis forces are presented.

Software Eject. - Figures 20 and 21 show the X axis transient forces of the software eject operation for the three mounting systems. Figure 20 shows that the disturbance occurred after 25 seconds from the start of the software eject operation. The primary force was the ejection of the tape from the tape drive and it occurred about 25 seconds after the software command was input. Figure 20 shows that the software eject operation was less than 0.5 pounds for all three mounting systems. Figure 21 shows the expanded view of the software eject disturbance. Figure 21 shows that the maximum forces ranged from 0.35 to 0.4 pounds and that the hard mount had the lowest force and grommet #1 mounting system had the greatest force.

Manual Eject. - Figures 22 and 23 show the X axis transient forces associated with the manual eject operation for all three mounting systems. Figure 22 shows that the initial force applied to the eject button ranges from 0.75 to 1.25 pounds and then some 25 seconds later the tape was ejected from the tape drive. To perform this manual eject some training was required so as to not jerk the apparatus. However, the large forces did move the test apparatus and there was a ringing effect for about 5 seconds as the apparatus returned to the neutral position. Figure 23 shows the manual push and the ejection of the tape on expanded scales. Figure 23 shows that the maximum eject push button force with the hard mount was 1.25 pounds. The maximum push button force with grommet #1 or grommet #2 mounting system was less than 1 pound. Figure 23 shows that for the manual push the ringing effect was approximately 3 Hz. This frequency is considerably greater than the measured pendulum frequency of the test apparatus of 0.15 Hz [ref 1].

Figure 23 also shows that there is very little force difference between the ejection of the tape using the manual eject and the software tape eject presented in Figure 21. Figure 23 shows that the hard mount system had the least force and that grommet #1 mounting system had the greatest force.

Manual Load. - Figures 24 and 25 show the X axis transient forces for the manual load operation. Figure 24 shows that the primary force occurred at the beginning when the tape was inserted into the tape drive. This operation also required practice, so that the insertion of the tape did not jerk the apparatus. Figure 24 shows that after 5 seconds there was no ringing effect due to the insertion of the tape into the tape drive. Figure 25 shows the forces on an expanded time scale. From Figure 25 it can be seen that the maximum forces of 1 pound were independent of the type of mounting system. A comparison of Figures 23 and 25 show that the forces associated with the manual eject were greater than the manual load forces for the hard mount configuration. For the two grommet mounting systems, the manual load force was slightly greater than the manual unload force.

CONCLUSIONS AND RECOMMENDATIONS

The highest average forces and highest average moments for the four steady state operations were obtained with the hard mount system. The highest average forces occur on the Y axis, and the peak average moments occur on the X axis. For all four operations, the highest forces and moments occur at the OTOCB frequency of 31.25 Hz on the X and Y axes with grommet #1 mounting system. It is recommended that grommet #1 not be used for the TDA because the natural frequency of the TDA with grommet #1 is almost the same frequency as the operating speed of the TDA during write and read operations. The associated forces were magnified.

The peak forces and moments for the rewind operation occur with grommet #2 mounting system at the OTOCB frequency of 49.7 Hz. It is also recommended that grommet #2 not be used for the TDA because the natural frequency of the TDA with grommet #2 is very close to the operating speed of the TDA during the rewind operation. Thus the rewind forces and moments were magnified.

At the OTOCB frequency of 157.5 Hz, the highest forces and highest moments were obtained with the hard mount system. The average force and moment values appeared to be significantly affected by the values in the OTOCB frequency of 157.5 Hz. The natural frequency of the hard mount system is probably in the one-third octave band that has the center band frequency of 157.5 Hz. Therefore the vibrations in this frequency band were magnified with the hard mount configuration.

The X axis forces associated with the transient operations range from 0.35 pounds for the software ejection to 1 pound for the manual load. The manual ejection force with the hard mount system is 1.25 pounds. These transient forces are considerably greater than the steady state forces and probably should be avoided during times of microgravity science quiescent periods.

The TDA tested here employed only one tape drive unit. The SAMS II TDA is designed to have two tape drives. The disturbance characteristics associated with both tape drives operating simultaneously could be significantly different than the results presented here. Therefore it is recommended that a follow up test be performed to evaluate the disturbance characteristics with two tape drives installed and operating simultaneously.

REFERENCES

1. Javeed, M. and Russell, J.W.; "Mass Properties Calibration of the NASA Langley Low Frequency Vibration Test Apparatus," NASA CR 198208, Lockheed Engineering & Sciences Company,Langley Program Office, Hampton, VA, September 1995.

2. Harris, F.J.;"On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform," Proceedings of the Institute of Electrical and Electronic Engineers, Vol 66, No. 1, pp 51-83, January 1978.

TABLE I - CENTER OF GRAVITY AND MOMENTS OF INERTIA ABOUT SYSTEM CENTER OF GRAVITY

SPACE ACCELERATION MEASUREMENT SYSTEM II- TAPE DRIVE ASSEMBLY

Component	Weight lb.	Center of Gravity in.	MOI about CG of part lb-in sq.	CG offset from total in.	MOI offset correction lb-in sq.	MOI about CG of total lb-in sq.
X axis						
apparatus	74.4	-0.0166	2,203.88	0.012	11.049	2,214.93
interface plate	1.73	0	14.718	0.0046	1.6559	16.37
SAMS II TDU	5.95	0.01613	34.128	0.02073	122.2351	156.36
TOTAL	82.08	-0.0046	2,387.66	0	0	2,387.66
Y axis						
apparatus	74.4	-0.0024	2,226.33	0.0116	11.050	2,237.38
interface plate	1.73	0	5.762	0.0092	1.6558	7.42
SAMS II TDU	5.95	0.06764	25.28	0.05844	122.2173	147.50
TOTAL	82.08	0.0092	2,392.30	0	0	2,392.30
Z axis						
apparatus	74.4	-1.1145	3,867.02	0.3852	0.0207	3,867.04
interface plate	1.73	0.249	20.408	0.9783	0.0002	20.41
SAMS II TDU	5.95	3.80284	58.745	4.53214	0.0229	58.77
TOTAL	82.08	-0.7293	3946.18	0	0	3,946.18

CG position is referenced to top center of 21 inch diameter test apparatus plate
Interface plate values are calculated using massprop program. SAMS II TDU values are derived.

TABLE II - CENTER OF GRAVITY AND MOMENTS OF INERTIA ABOUT SAMS II TDA CENTER OF GRAVITY

SPACE ACCELERATION MEASUREMENT SYSTEM II - TAPE DRIVE ASSEMBLY

Component	Weight lb	Center of in.	MOI about lb-in sq.	CG offset from TDA in.	MOI offset lb-in sq.	MOI about CG of TDA lb-in sq.
X axis						
apparatus	74.4	-0.0166	2,203.88	0.03273	1799.374	4,003.25
interface plate	1.73	0	14.718	0.01613	21.8574	36.58
SAMS II TDU	5.95	0.01613	34.13	0	0.0000	34.13
TOTAL	82.08	-0.0046				4,073.96
Y axis						
apparatus	74.4	-0.0024	2,226.33	0.0700	1799.089	4,025.42
interface plate	1.73	0	5.762	0.06764	21.8500	27.61
SAMS II TDU	5.95	0.06764	25.28	0	0.0000	25.28
TOTAL	82.08	0.0092				4,078.31
Z axis						
apparatus	74.4	-1.1145	3,867.02	4.91734	0.4447	3,867.46
interface plate	1.73	0.249	20.408	3.55384	0.0084	20.42
SAMS II TDU	5.95	3.80284	58.745	0	0.0000	58.75
TOTAL	82.08	-0.7293				3,946.63

CG position is referenced to top center of 21 inch diameter test apparatus plate
Interface plate values are calculated using massprop program.

TABLE III - SUMMARY OF TEST RUNS FOR SAMS II TDA

TEST CONDITION	MOUNTING SYSTEM		
	HARD MOUNT	GROMMET #1	GROMMET#2
BACKGROUND		TEST RUN NUMBER	
Computer off, TDA off	101	301	201
Computer on, TDA off	103	303	203
Computer on, TDA on	105	305	205
TAPE OPERATIONS			
Steady State			
Write	107	307	207
Read	109	309	209
Rewind	111	311	211
Fast Forward	113	313	213
Transient			
Software Eject	116	316	216
Manual Load	121	321	221
Manual Eject	122	322	222

TABLE III - SUMMARY OF TEST RUNS FOR SAMS II TDA

TEST CONDITION	MOUNTING SYSTEM		
	HARD MOUNT	GROMMET #1	GROMMET#2
BACKGROUND			
Computer off, TDA off	101	301	201
Computer on, TDA off	103	303	203
Computer on, TDA on	105	305	205
TAPE OPERATIONS			
Steady State			
Write	107	307	207
Read	109	309	209
Rewind	111	311	211
Fast Forward	113	313	213
Transient			
Software Eject	116	316	216
Manual Load	121	321	221
Manual Eject	122	322	222

TABLE IV - PEAK AND AVERAGE FORCES FOR STEADY STATE OPERATION

SPACE ACCELERATION MEASUREMENT SYSTEM II TAPE DRIVE ASSEMBLY

Operation and Type of Mounting	X axis			Y axis			Z axis		
	Peak Force lb	Peak Freq Hz	Average Force lb	Peak Force lb	Peak Freq Hz	Average Force lb	Peak Force lb	Peak Freq Hz	Average Force lb
WRITE									
Hard mount	0.00188	31.25	0.000494	0.0077	157.5	0.002250	0.0011	157.5	0.000571
Grommet #1	0.00358	31.25	0.000370	0.0039	31.25	0.000761	0.0007	24.80	0.000379
Grommet #2	0.00228	31.25	0.000444	0.0026	31.25	0.000719	0.0013	62.50	0.000383
READ									
Hard mount	0.00195	31.25	0.000686	0.0132	157.5	0.003407	0.0014	157.5	0.000595
Grommet #1	0.00378	31.25	0.000746	0.0039	31.25	0.001481	0.0006	62.50	0.000402
Grommet #2	0.00254	31.25	0.000786	0.0031	62.50	0.001383	0.0013	62.50	0.000453
REWIND									
Hard mount	0.00600	49.61	0.000977	0.0218	157.5	0.004824	0.0024	157.5	0.000965
Grommet #1	0.00865	49.61	0.000930	0.0121	49.61	0.141900	0.0024	49.61	0.000536
Grommet #2	0.01250	49.61	0.001179	0.029	49.61	0.002088	0.0013	62.50	0.000498
FAST FORWARD									
Hard mount	0.00187	31.25	0.000710	0.0243	157.5	0.004742	0.0026	157.5	0.000807
Grommet #1	0.00357	31.25	0.000363	0.0039	31.25	0.000715	0.001	62.50	0.000395
Grommet #2	0.00225	31.25	0.000464	0.0026	31.25	0.000755	0.0014	62.50	0.000412

TABLE V - PEAK AND AVERAGE MOMENTS FOR STEADY STATE OPERATION

SPACE ACCELERATION MEASUREMENT SYSTEM II TAPE DRIVE ASSEMBLY

Operation and Type of Mounting	X axis Peak Moment lb in	X axis Peak Freq Hz	X axis Average Moment lb in	Y axis Peak Moment lb in	Y axis Peak Freq Hz	Y axis Average Moment lb in	Z axis Peak Moment lb in	Z axis Peak Freq Hz	Z axis Average Moment lb in
WRITE									
Hard mount	0.03908	157.5	0.011640	0.00899	31.25	0.002987	0.00393	62.50	0.002123
Grommet #1	0.01907	31.25	0.003917	0.01826	31.25	0.002058	0.00544	62.50	0.002359
Grommet #2	0.01226	31.25	0.003747	0.01127	31.25	0.002578	0.00529	125.0	0.002679
READ									
Hard mount	0.06635	157.5	0.017334	0.00912	31.25	0.003703	0.00763	62.50	0.004145
Grommet #1	0.01905	31.25	0.007642	0.01849	31.25	0.002429	0.01747	62.50	0.008738
Grommet #2	0.01595	62.50	0.007169	0.01136	31.25	0.002453	0.01826	62.50	0.009532
REWIND									
Hard mount	0.10996	157.5	0.025128	0.02821	49.61	0.005963	0.00424	49.61	0.002089
Grommet #1	0.06506	49.61	0.007349	0.05223	49.61	0.00556	0.00766	49.61	0.002313
Grommet #2	0.14413	49.61	0.010552	0.06401	49.61	0.006035	0.00628	99.21	0.002876
FAST FORWARD									
Hard mount	0.12252	157.5	0.024050	0.00906	157.5	0.004244	0.003683	157.5	0.002045
Grommet #1	0.01882	31.25	0.003617	0.01832	31.25	0.002318	0.003966	62.5	0.001832
Grommet #2	0.01252	31.25	0.00392	0.01102	31.25	0.002444	0.00570	99.21	0.002346

TABLE VI - STEADY STATE OPERATING FORCES
SPACE ACCELERATION MEASUREMENT SYSTEM II TAPE DRIVE ASSEMBLY

OPERATION	X axis	Y axis	Z axis	X axis	Y Axis	Z axis
WRITE	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.000494	0.002252	0.000571	0.001883	0.001850	0.000311
Grommet #1	0.000370	0.000761	0.000379	0.003584	0.003917	0.000678
Grommet #2	0.000444	0.000719	0.000383	0.002283	0.002556	0.000379
	49.61 Hz	49.61 Hz	49.61 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.000093	0.000233	0.000154	0.000509	0.007733	0.001115
Grommet #1	0.000225	0.000874	0.000278	0.000295	0.000573	0.000318
Grommet #2	0.000179	0.000627	0.000073	0.000458	0.000550	0.000360
READ	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.000686	0.003407	0.000595	0.001955	0.001834	0.000382
Grommet #1	0.000746	0.001481	0.000402	0.003775	0.003926	0.000444
Grommet #2	0.000786	0.001383	0.000453	0.002542	0.002568	0.000364
	49.61 Hz	49.61 Hz	49.61 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.000290	0.000834	0.000266	0.000979	0.013149	0.001360
Grommet #1	0.000795	0.002210	0.000400	0.000763	0.001552	0.000422
Grommet #2	0.000798	0.001862	0.000266	0.000914	0.001622	0.000442
REWIND	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.000977	0.004824	0.000965	0.001996	0.001922	0.000494
Grommet #1	0.000930	0.001419	0.000536	0.004011	0.003883	0.000417
Grommet #2	0.001179	0.002088	0.000498	0.002421	0.002727	0.000798
	49.61 Hz	49.61 Hz	49.61 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.006002	0.006488	0.001014	0.001124	0.021813	0.002364
Grommet #1	0.008646	0.012132	0.002384	0.000290	0.000546	0.000424
Grommet #2	0.012498	0.029044	0.000581	0.000671	0.000639	0.000474
FAST FRWRD	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.000710	0.004742	0.000807	0.001868	0.001866	0.000536
Grommet #1	0.000363	0.000715	0.000395	0.003566	0.003861	0.000399
Grommet #2	0.000464	0.000755	0.000412	0.002254	0.002591	0.000557
	49.61 Hz	49.61 Hz	49.61 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.000122	0.000351	0.000231	0.001521	0.024280	0.002644
Grommet #1	0.000274	0.000104	0.000334	0.000280	0.000523	0.000409
Grommet #2	0.000216	0.000979	0.000067	0.000485	0.000615	0.000436

TABLE VII - STEADY STATE OPERATING MOMENTS
SPACE ACCELERATION MEASUREMENT SYSTEM II TAPE DRIVE ASSEMBLY

OPERATION	X axis	Y axis	Z axis	X axis	Y Axis	Z axis
WRITE	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.011640	0.002987	0.002123	0.008870	0.008994	0.001156
Grommet #1	0.003917	0.002059	0.002359	0.019073	0.018258	0.001685
Grommet #2	0.003747	0.002578	0.002678	0.012263	0.011274	0.001058
	49.6 Hz	49.6 Hz	49.6 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.001171	0.000779	0.001296	0.039077	0.003892	0.002204
Grommet #1	0.004590	0.001319	0.002157	0.002916	0.002159	0.001602
Grommet #2	0.003138	0.000966	0.001270	0.002910	0.002738	0.001924
READ	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.017334	0.003703	0.004145	0.008727	0.009123	0.001976
Grommet #1	0.007642	0.002429	0.008738	0.019049	0.018486	0.004645
Grommet #2	0.007169	0.002454	0.009532	0.012241	0.011358	0.004487
	49.6 Hz	49.6 Hz	49.6 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.004368	0.000637	0.005426	0.066355	0.006137	0.004910
Grommet #1	0.011493	0.001704	0.011980	0.007937	0.002234	0.010554
Grommet #2	0.009584	0.001217	0.012814	0.008473	0.002914	0.012110
REWIND	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.025128	0.005963	0.002089	0.009236	0.009699	0.000740
Grommet #1	0.007349	0.005557	0.002313	0.018835	0.020753	0.001817
Grommet #2	0.010552	0.006035	0.002876	0.013156	0.011727	0.002543
	49.6 Hz	49.6 Hz	49.6 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.030712	0.028211	0.004245	0.109964	0.007366	0.002677
Grommet #1	0.065058	0.052235	0.007655	0.002733	0.002069	0.001576
Grommet #2	0.144127	0.064009	0.005333	0.003534	0.002489	0.001962
FAST FRWRD	AVG	AVG	AVG	31.25 Hz	31.25 Hz	31.25 Hz
Hard Mount	0.024050	0.004244	0.002045	0.008993	0.008894	0.001135
Grommet #1	0.003617	0.002318	0.001832	0.018818	0.018329	0.001862
Grommet #2	0.003920	0.002445	0.002346	0.012525	0.011021	0.001134
	49.6 Hz	49.6 Hz	49.6 Hz	157.49 Hz	157.49 Hz	157.49 Hz
Hard Mount	0.001701	0.001078	0.001353	0.122523	0.009056	0.003683
Grommet #1	0.005386	0.002105	0.002511	0.002610	0.001999	0.001347
Grommet #2	0.004863	0.001332	0.001402	0.003366	0.002506	0.001819

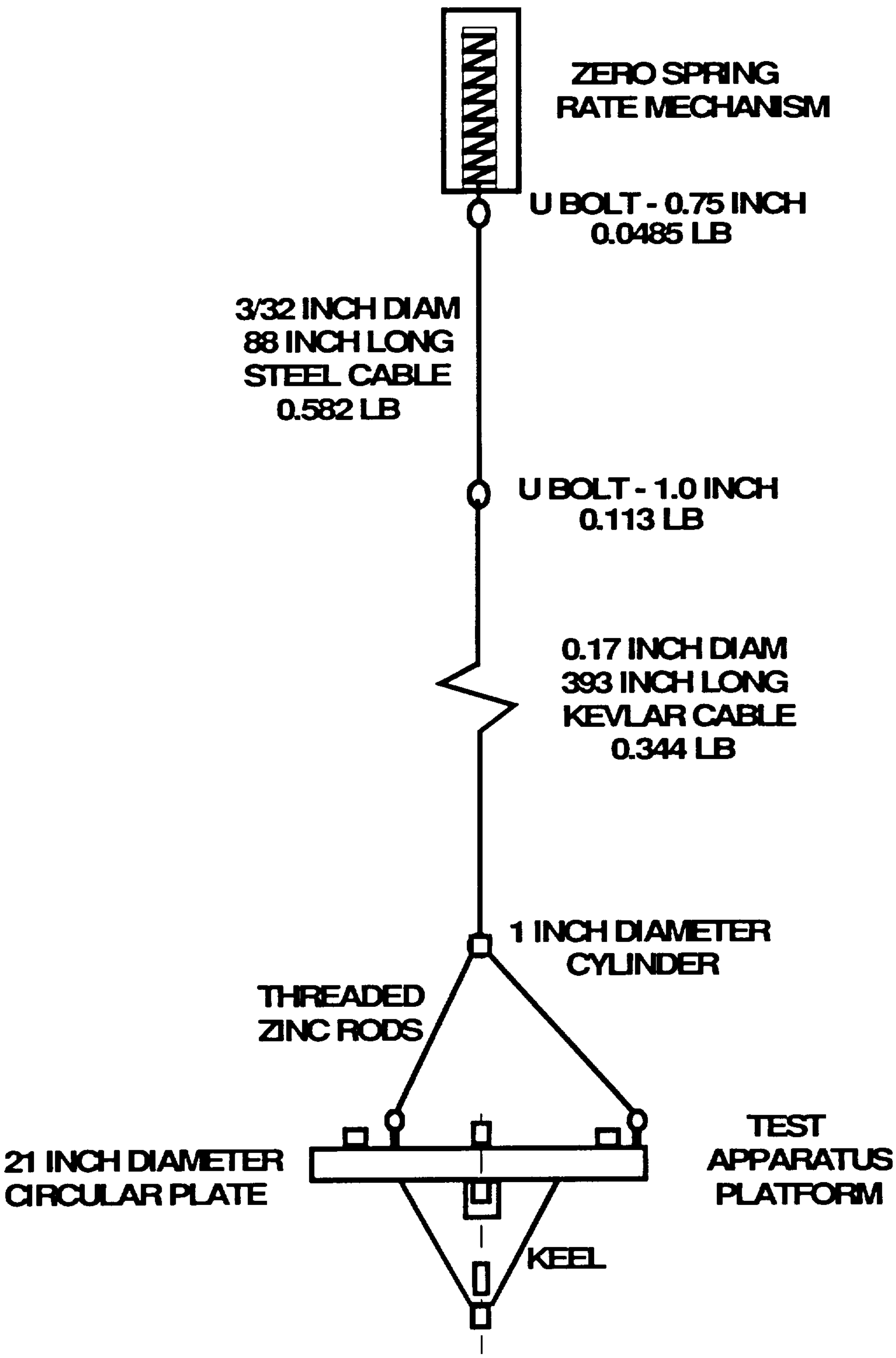

Figure 1. - Test Apparatus Suspension System Schematic.

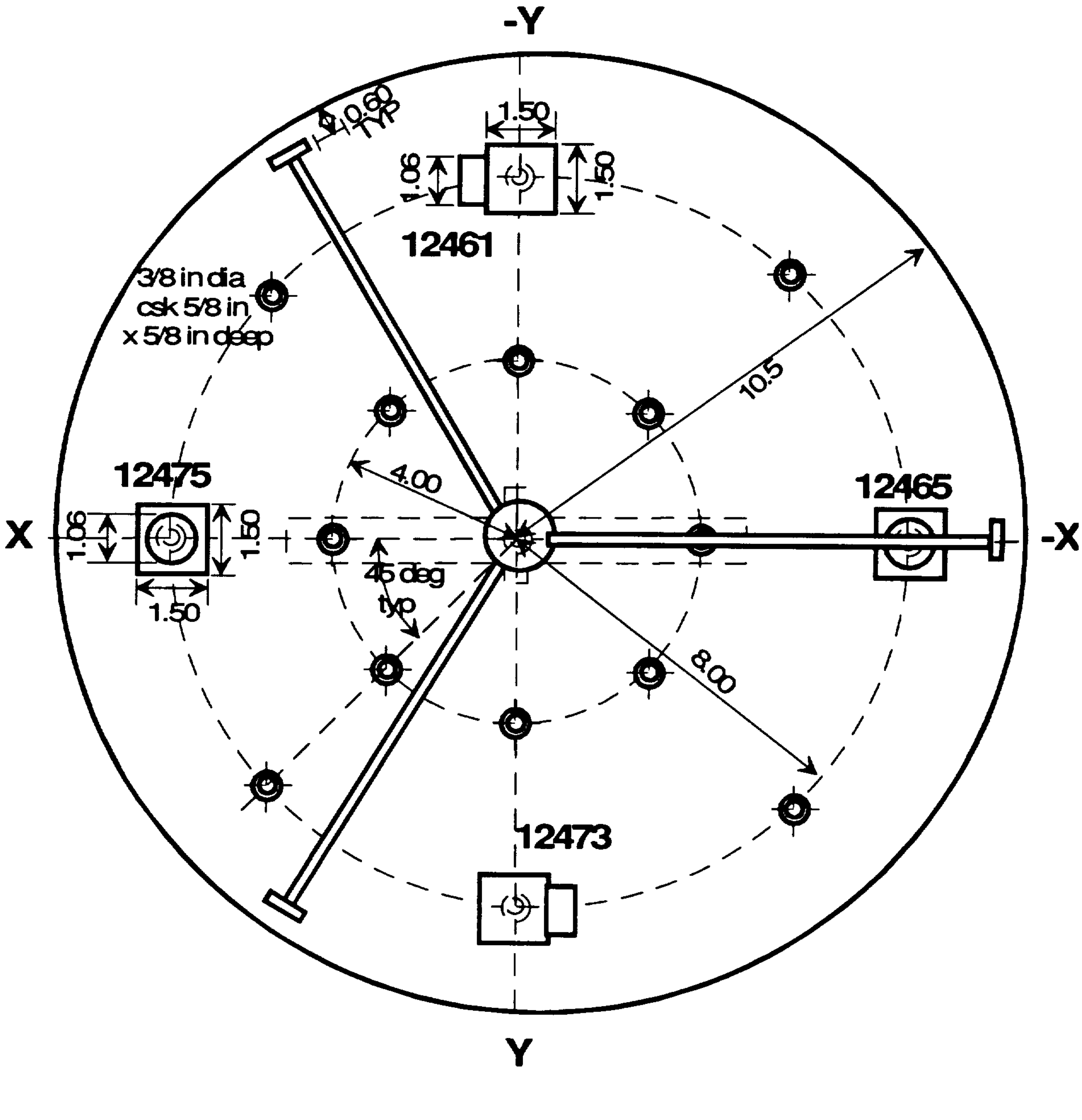

Figure 2. - Detailed Drawing of Test Apparatus Platform with Accelerometers
a. Top View - XY plane

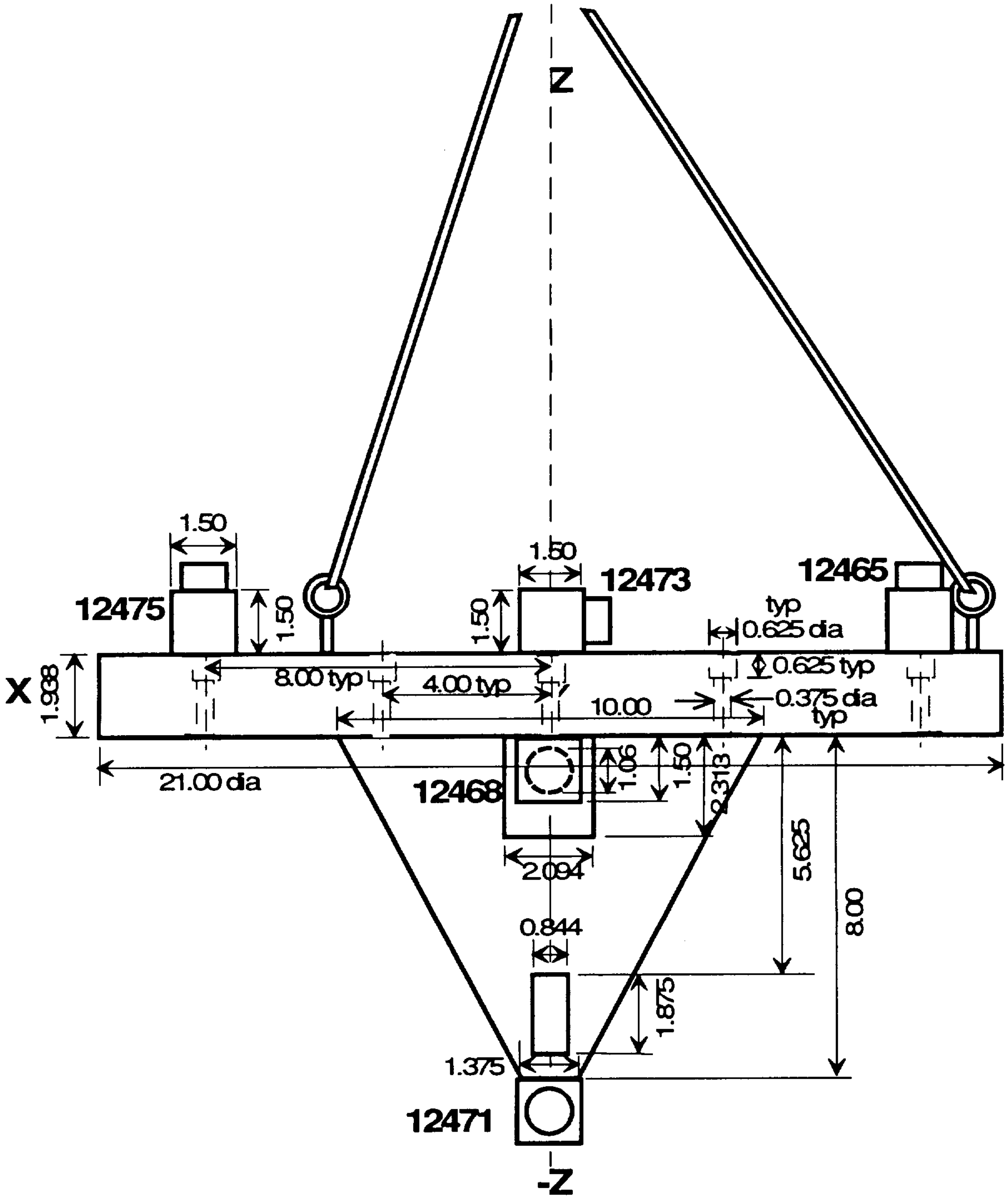

Figure 2. - Detailed Drawing of Test Apparatus with Accelerometers
b. Side View - XZ Plane

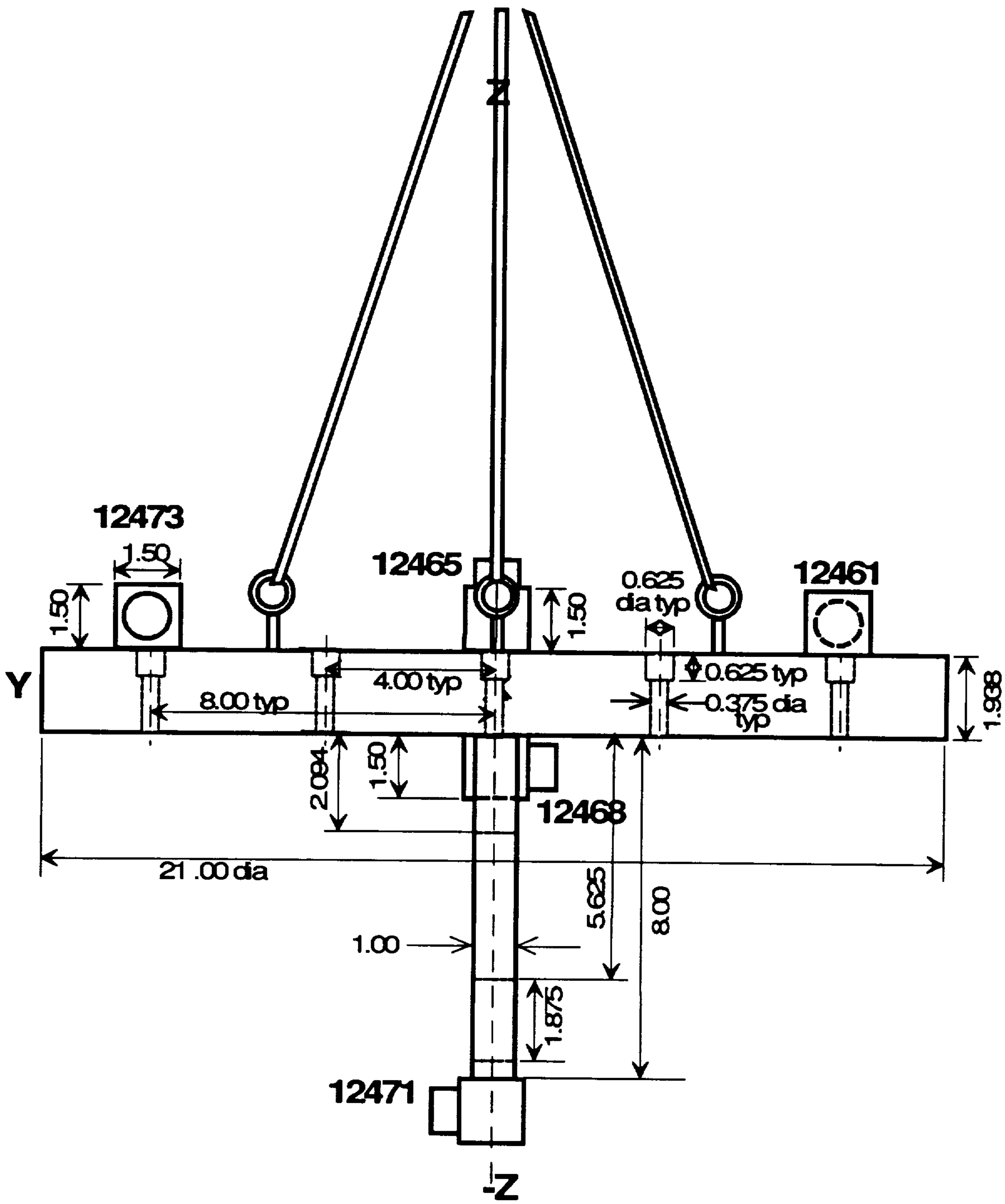

Figure 2. - Detailed Drawing of Test Apparatus Platform with Accelerometers
c. Side View - YZ Plane

DATA ACQUISITION PROCESS

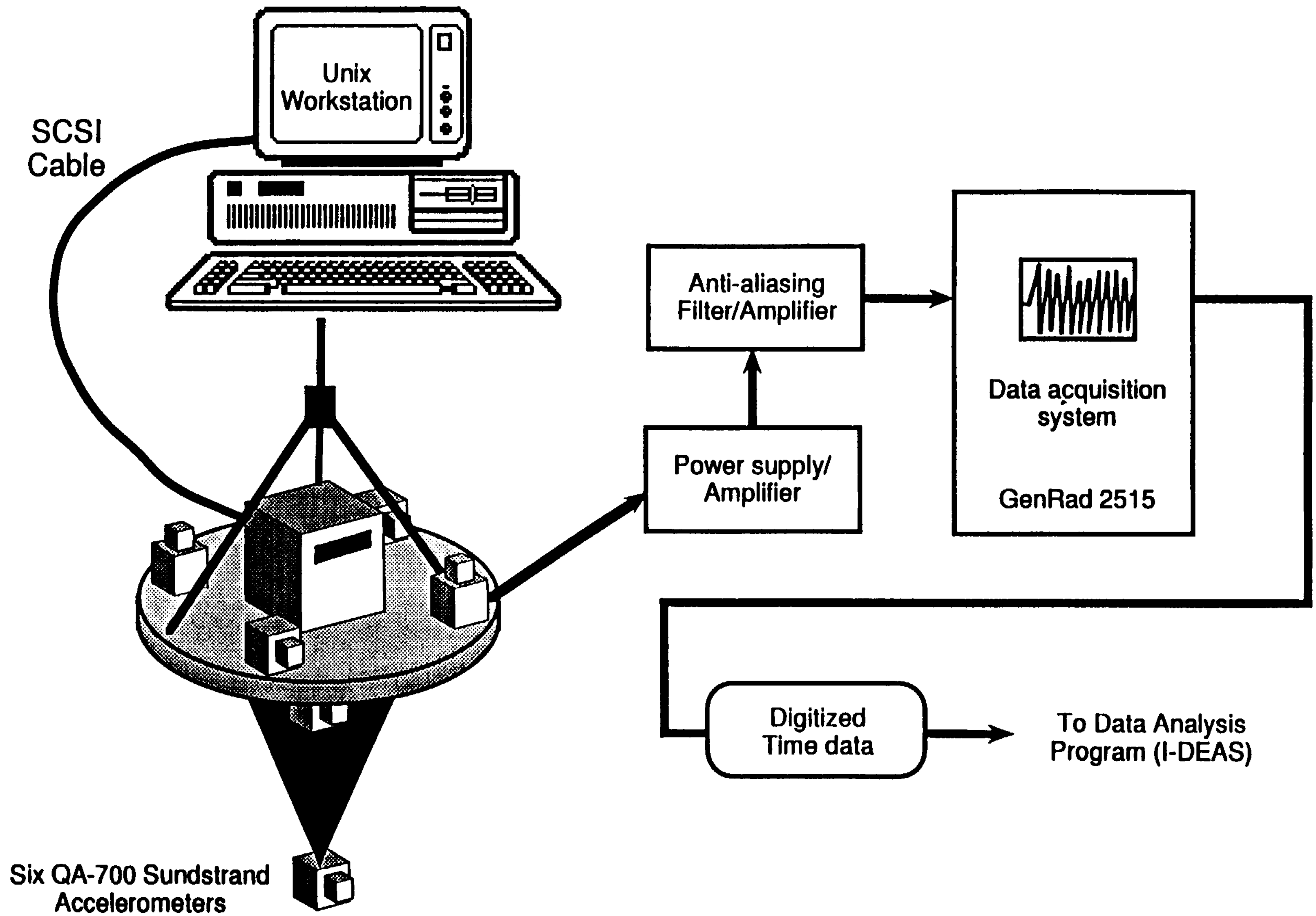

Figure 3. - Schematic of Accelerometer Data Acquisition Process

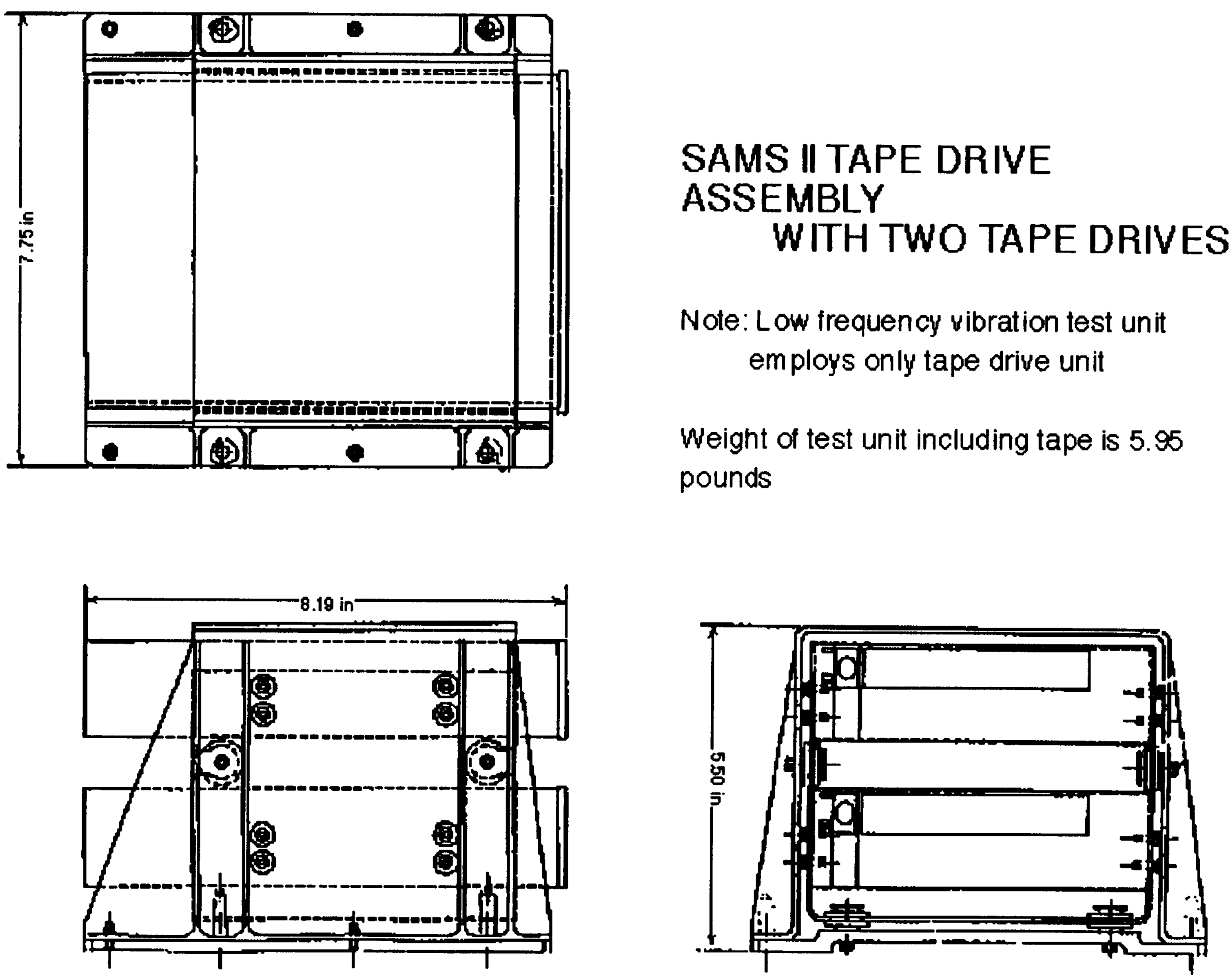

Figure 4. - Space Acceleration Measurement System II Tape Drive Assembly Drawing

NOTE: USE 1/2 INCH ALUMINUM PLATE

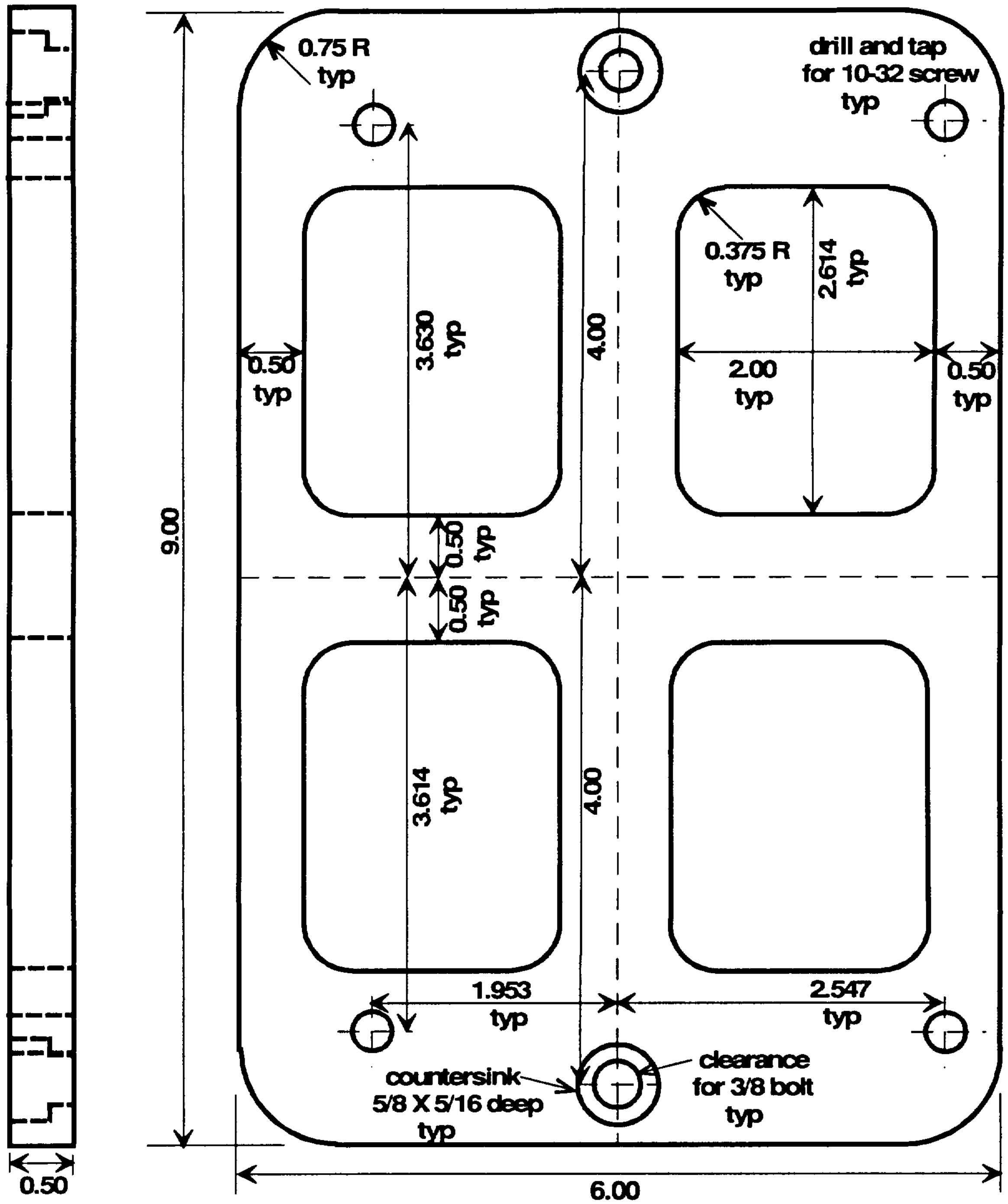

Figure 5. - Interface Plate for SAMS II Tape Drive Assembly

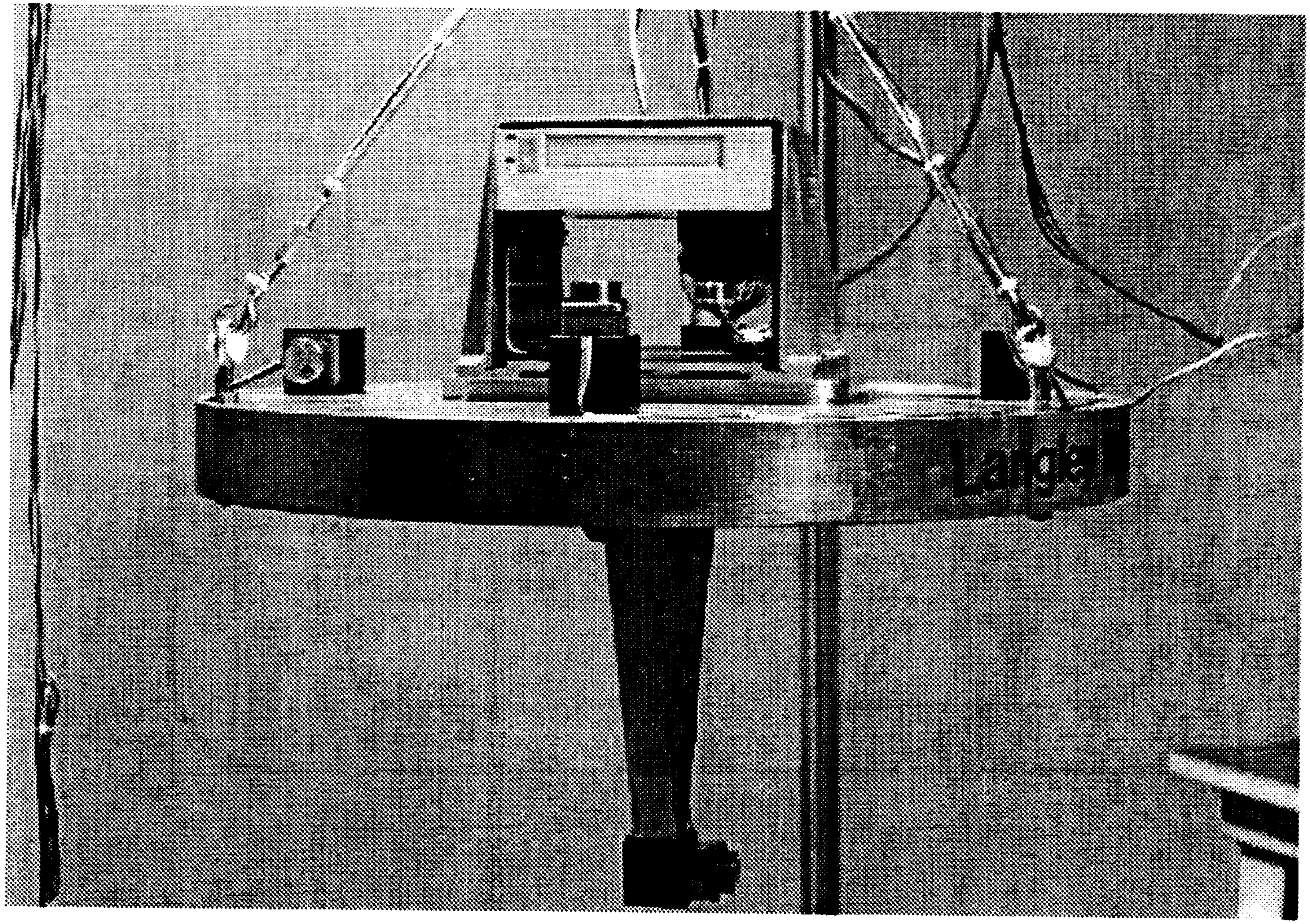

Figure 6. - Installation of SAMS II Tape Drive Unit on Test Apparatus

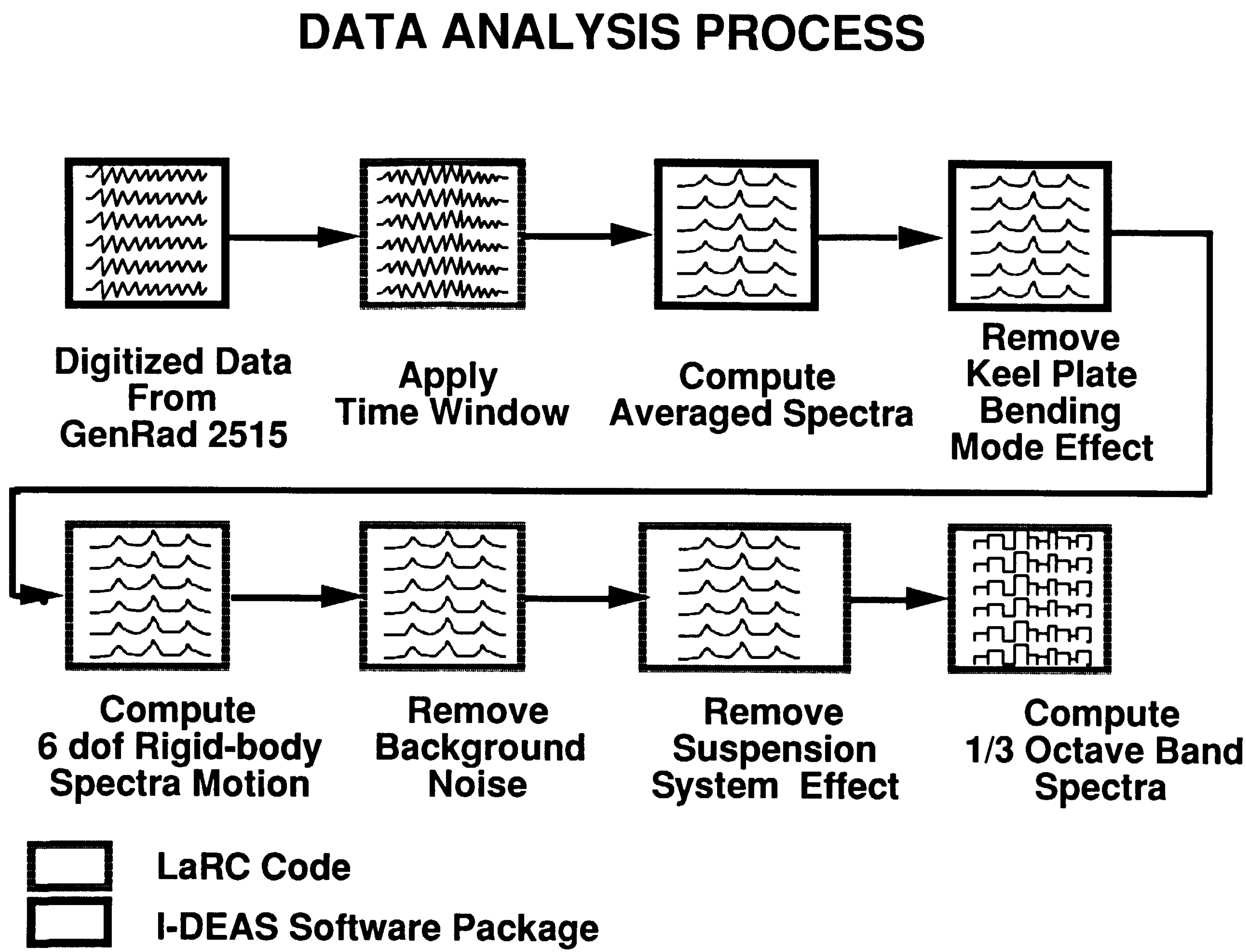

Figure 7.- SAMS II Tape Drive Assembly - Data Analysis Process

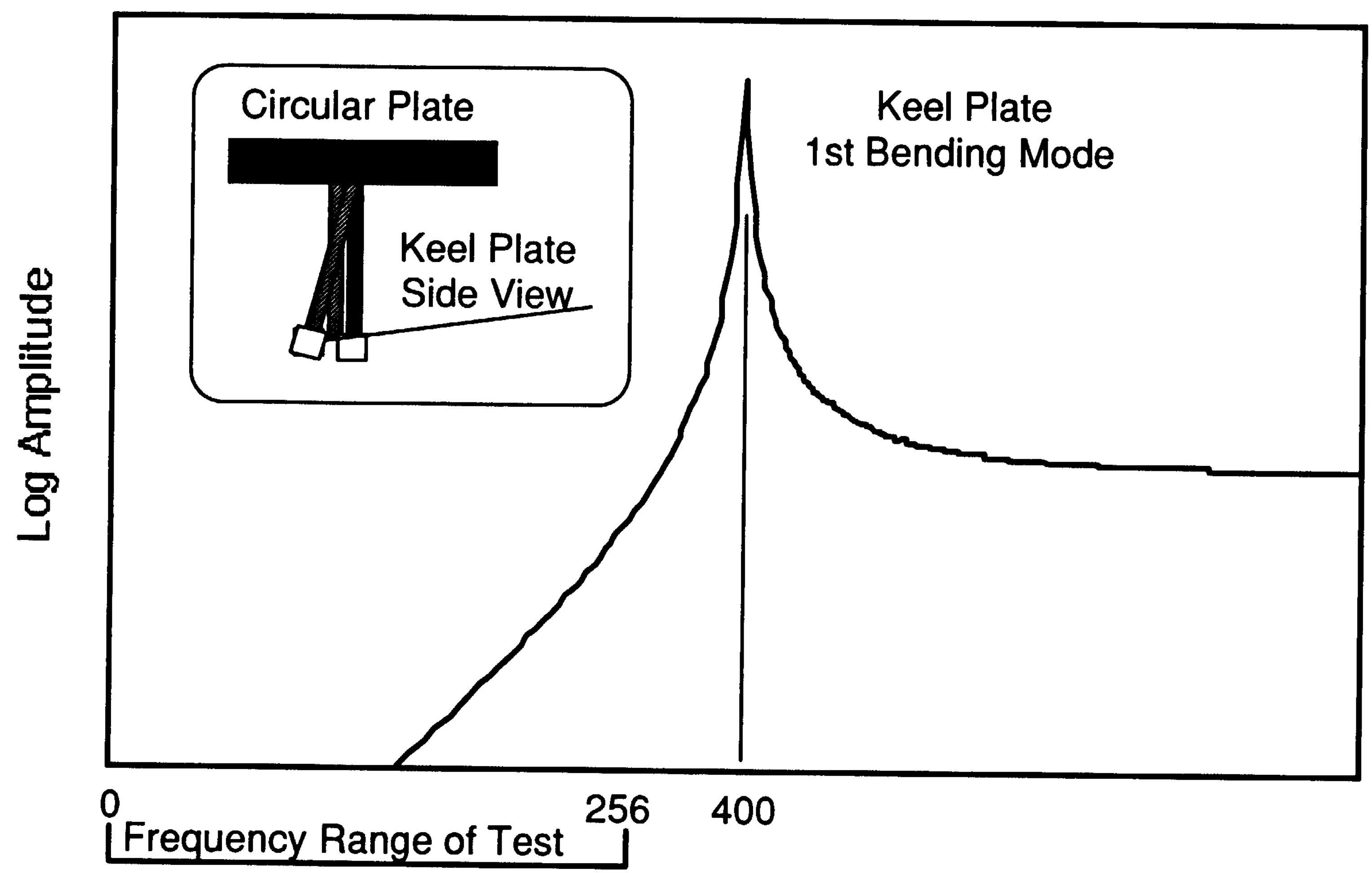

Figure 8. - Effect of Keel Plate Natural Frequency

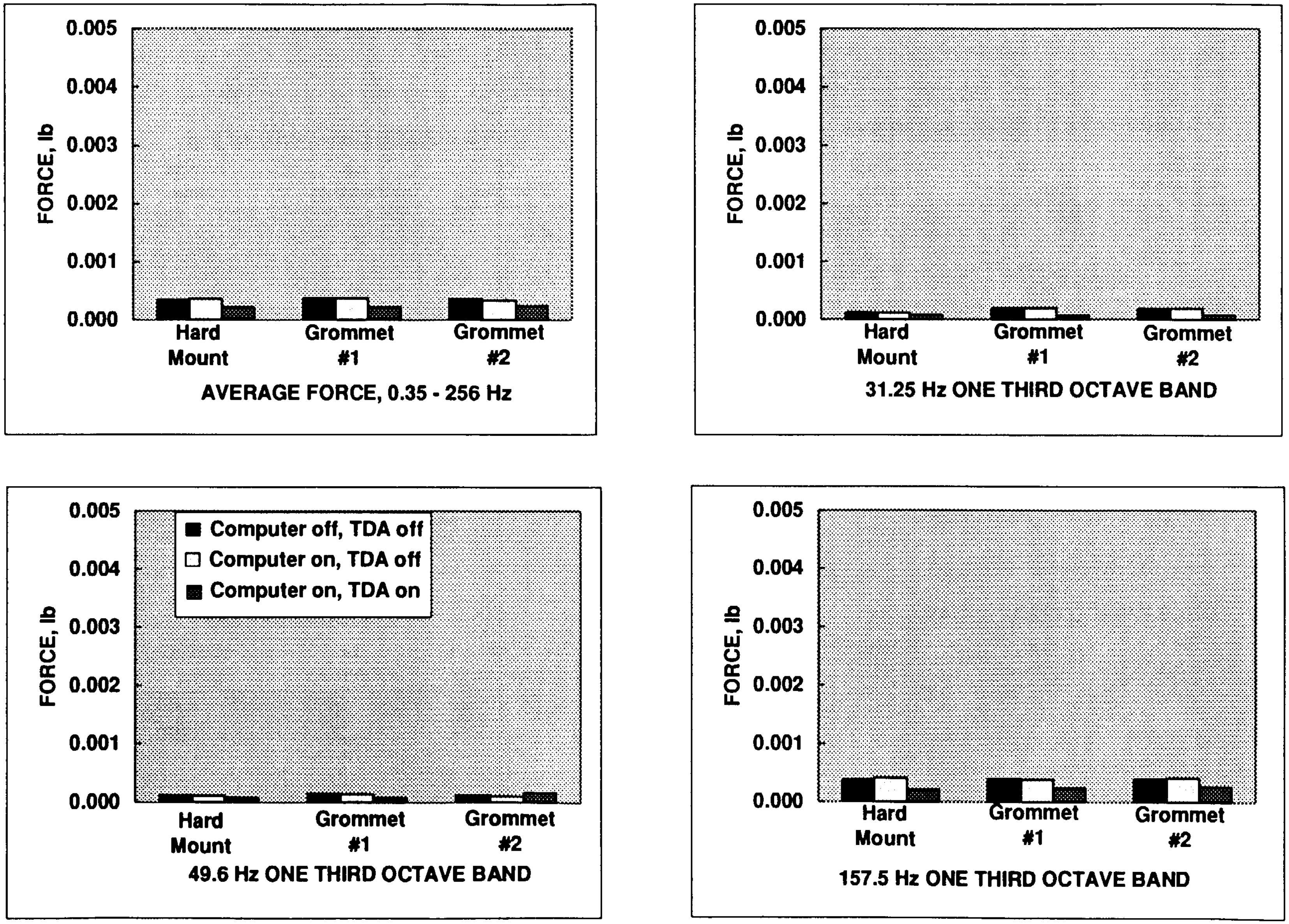

Figure 9. - SAMS II Tape Drive Assembly - Background Force Measurements
a. X axis

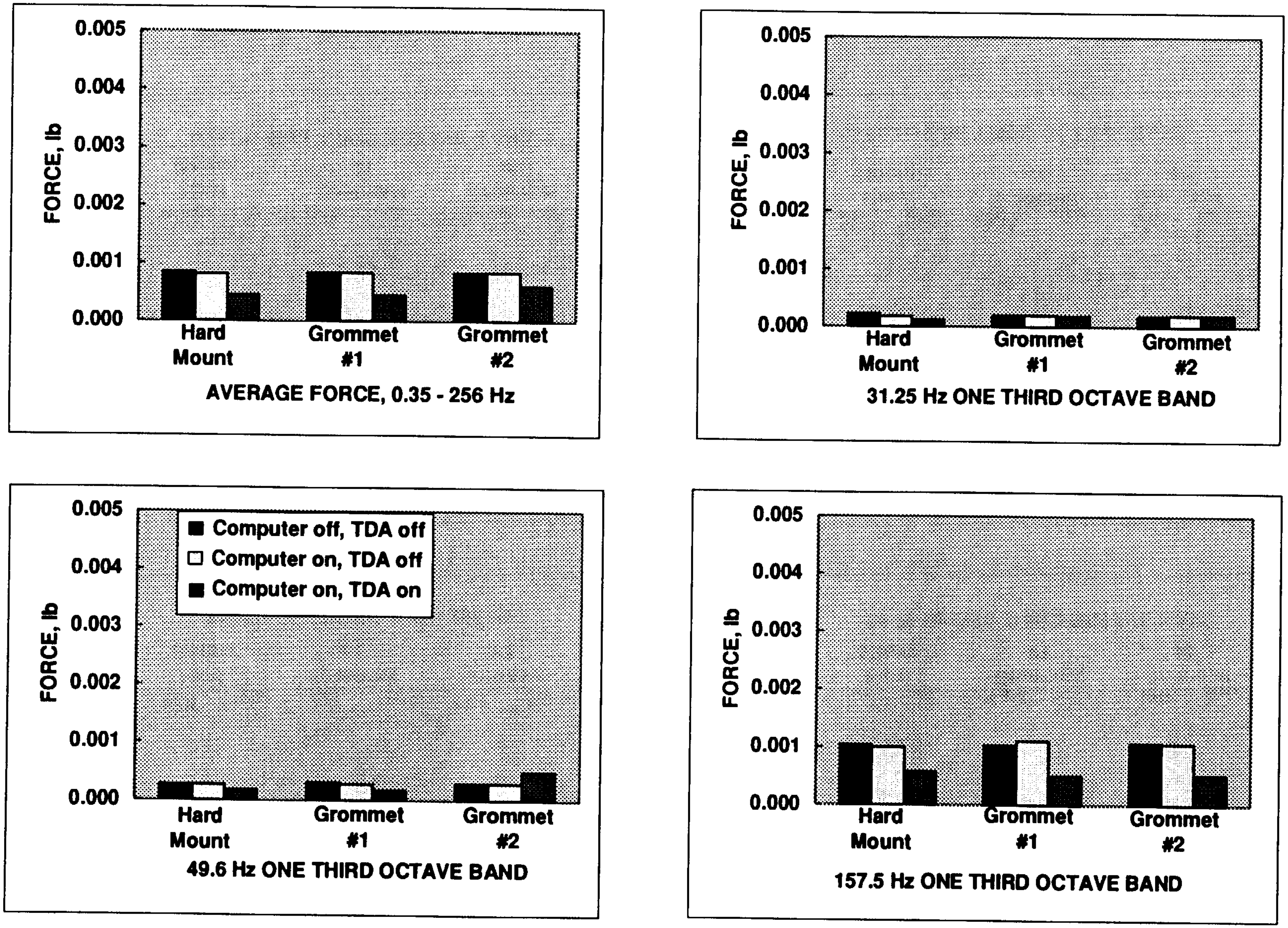

Figure 9. - SAMS II Tape Drive Assembly - Background Force Measurements
b. Y axis

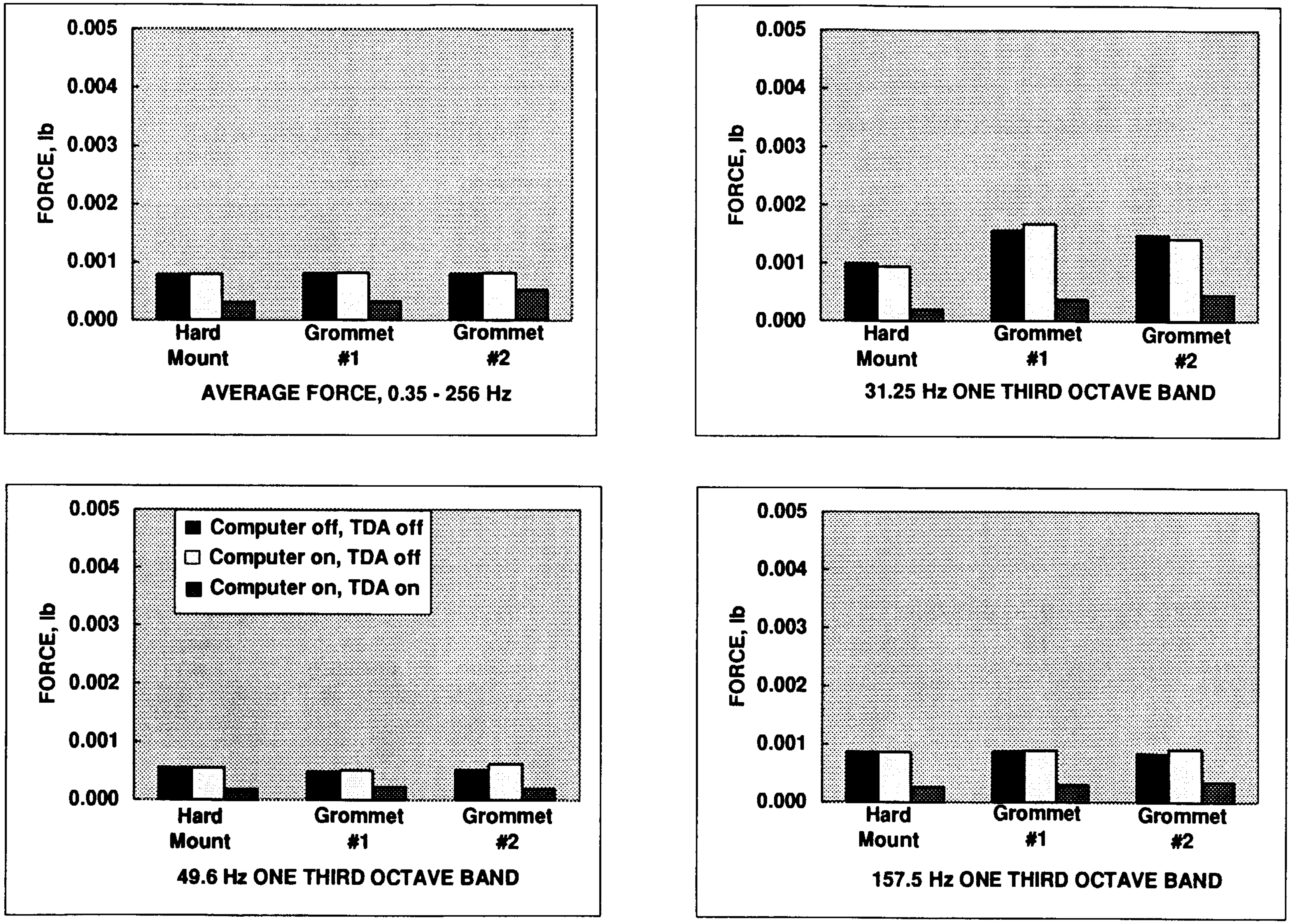

Figure 9. - SAMS II Tape Drive Assembly - Background Force Measurements
c. Z axis

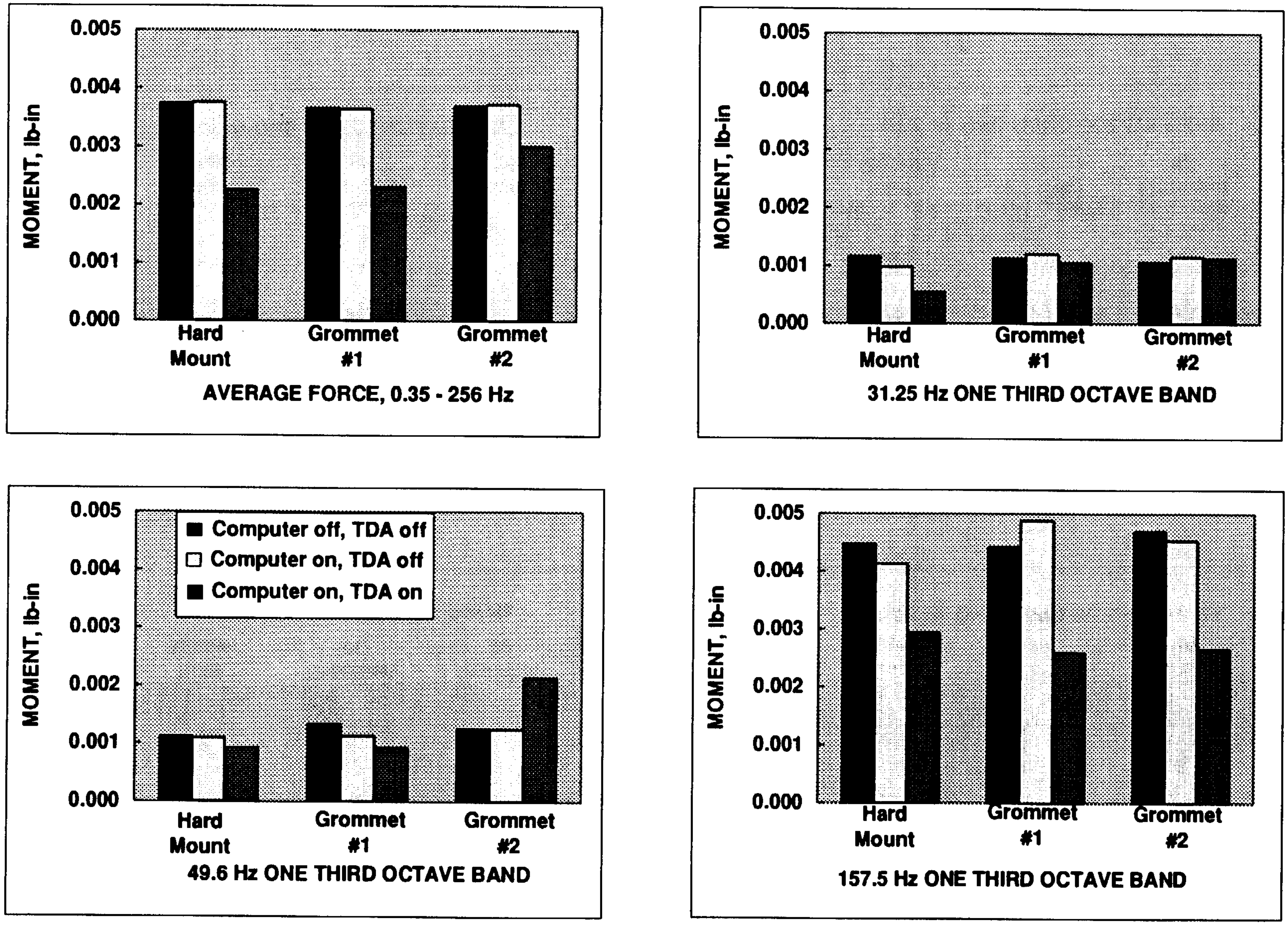

Figure 10. - SAMS II Tape Drive Assembly - Background Moment Measurements
a. X axis

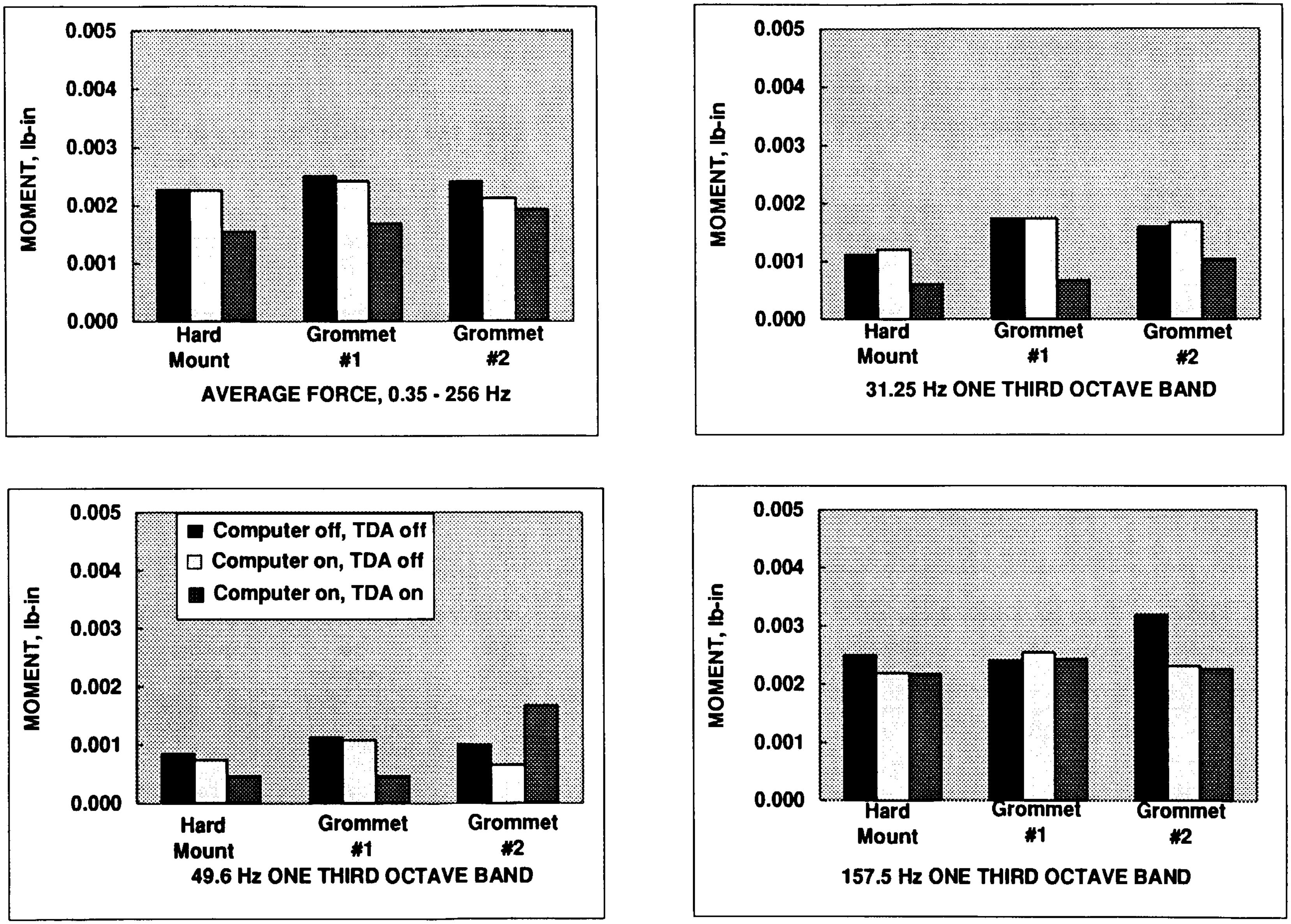

Figure 10. - SAMS II Tape Drive Assembly - Background Moment Measurements
b. Y axis

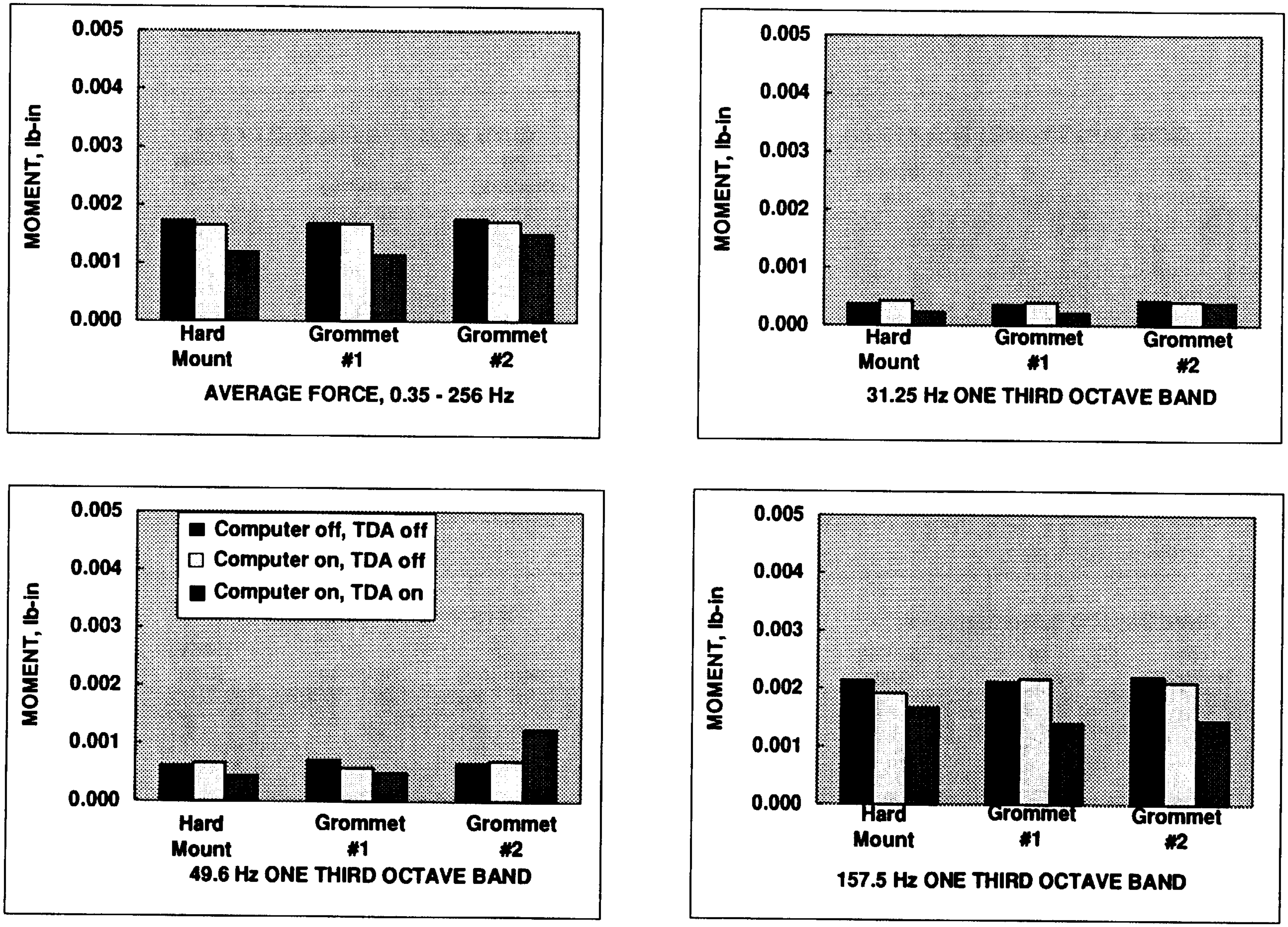

Figure 10. - SAMS II Tape Drive Assembly - Background Moment Measurements
c. Z axis

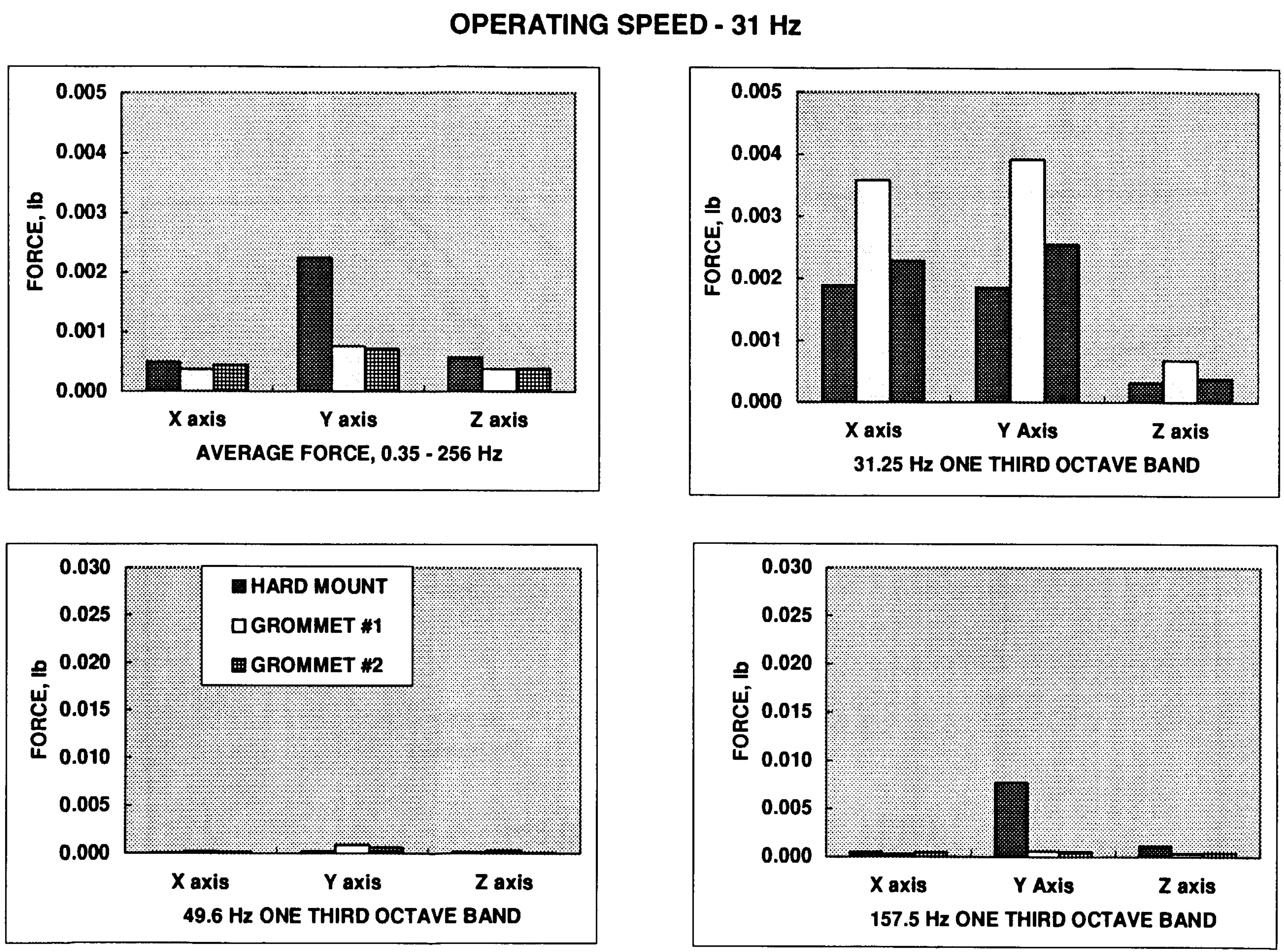

Figure 11. - SAMS II Tape Drive Assembly - Write Operation Forces

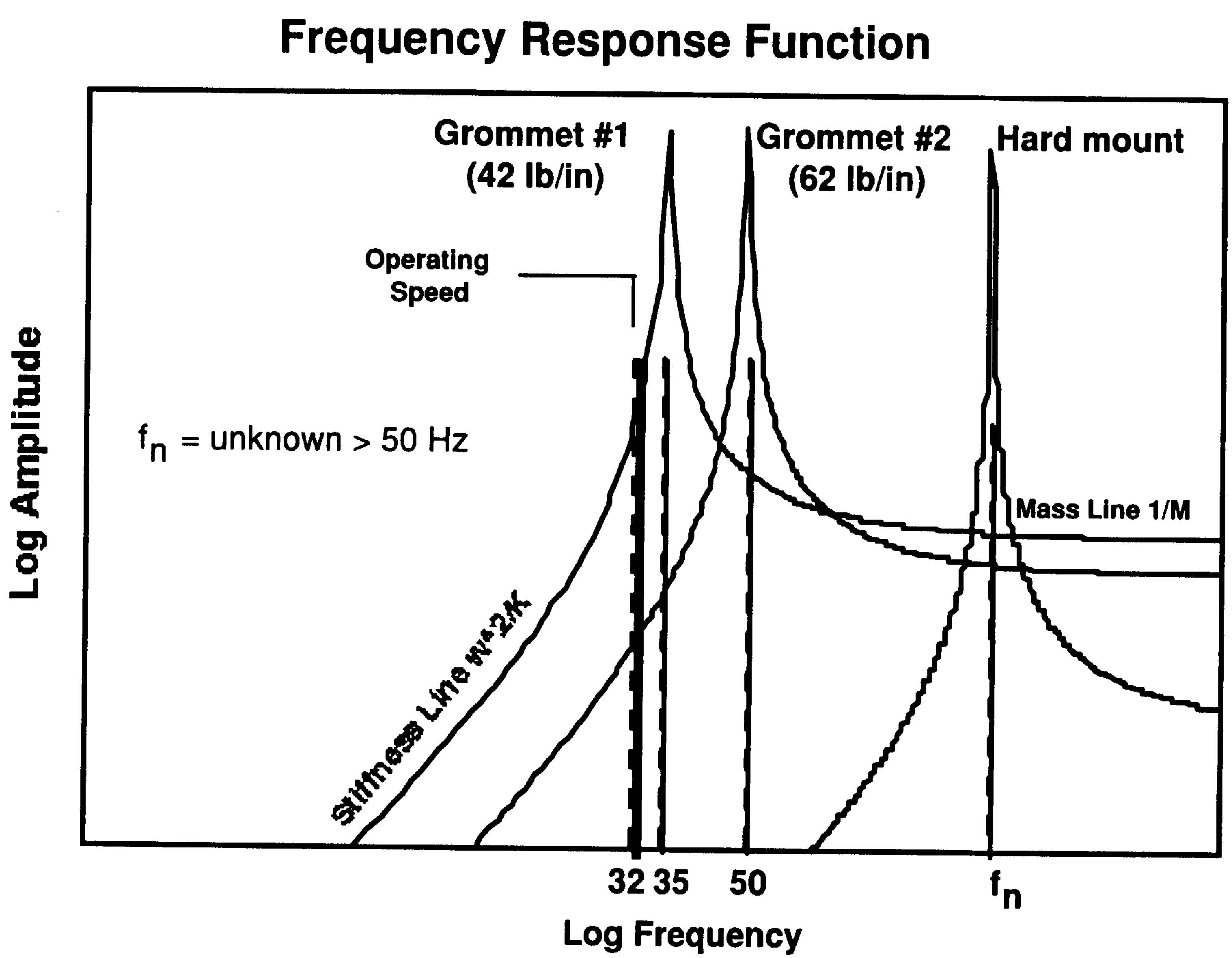

Figure 12. - Natural Frequency Effects of SAMS II Tape Drive Assembly Mounting Systems

OPERATING SPEED - 31 Hz

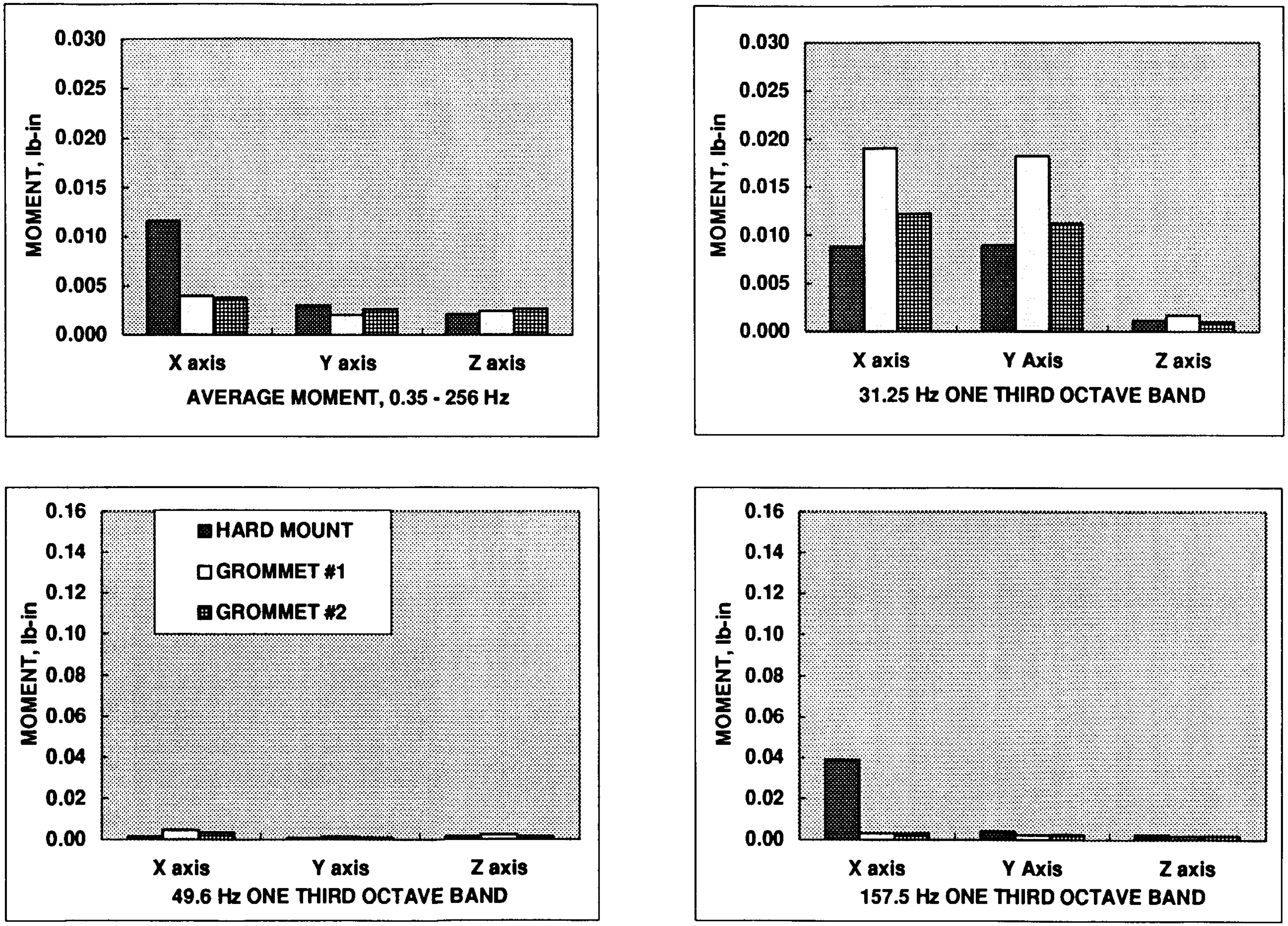

Figure 13. - SAMS II Tape Drive Assembly - Write Operation Moments

OPERATING SPEED - 31 Hz

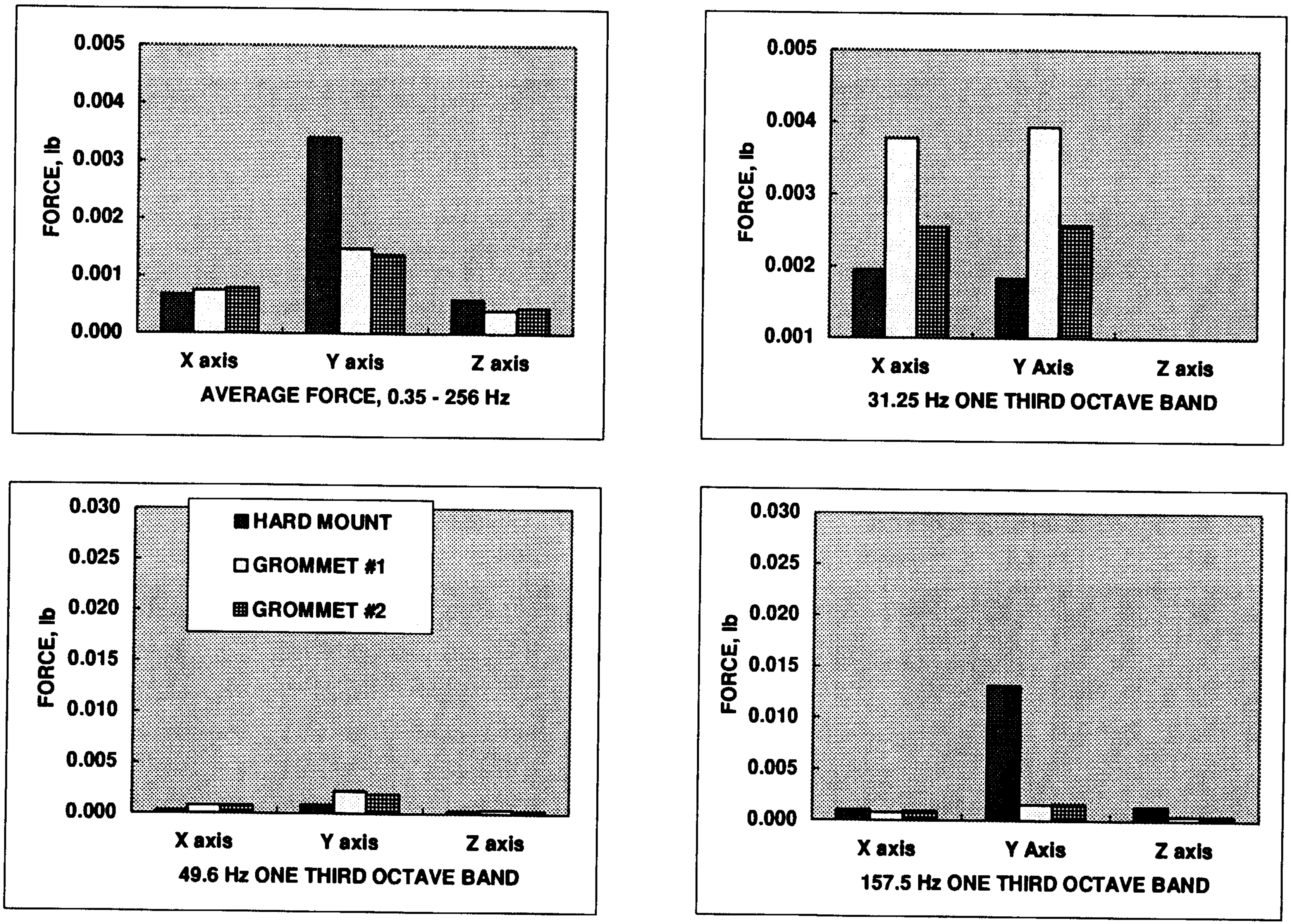

Figure 14. - SAMS II Tape Drive Assembly - Read Operation Forces

OPERATING SPEED - 31 Hz

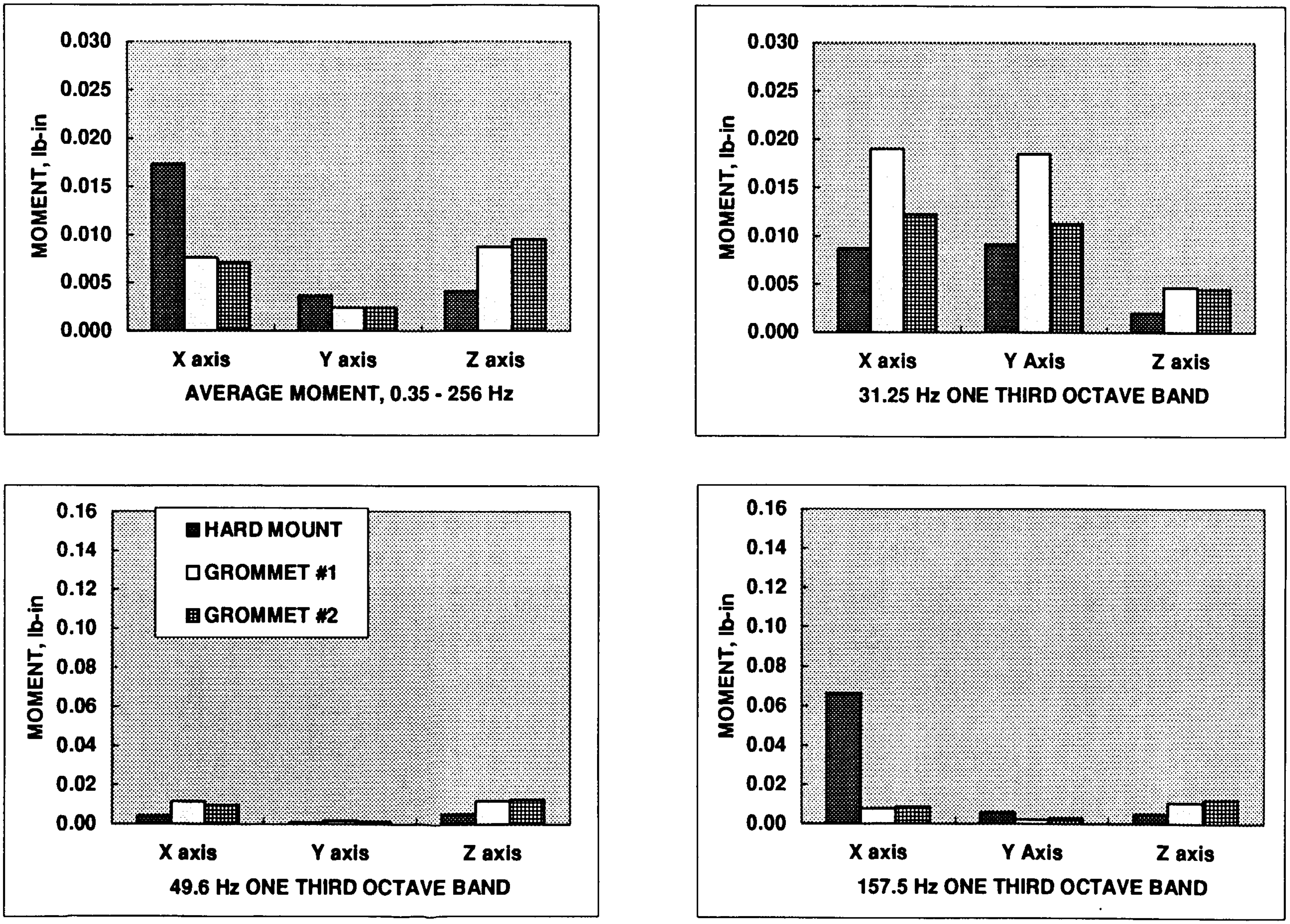

Figure 15. - SAMS II Tape Drive Assembly - Read Operation Moments

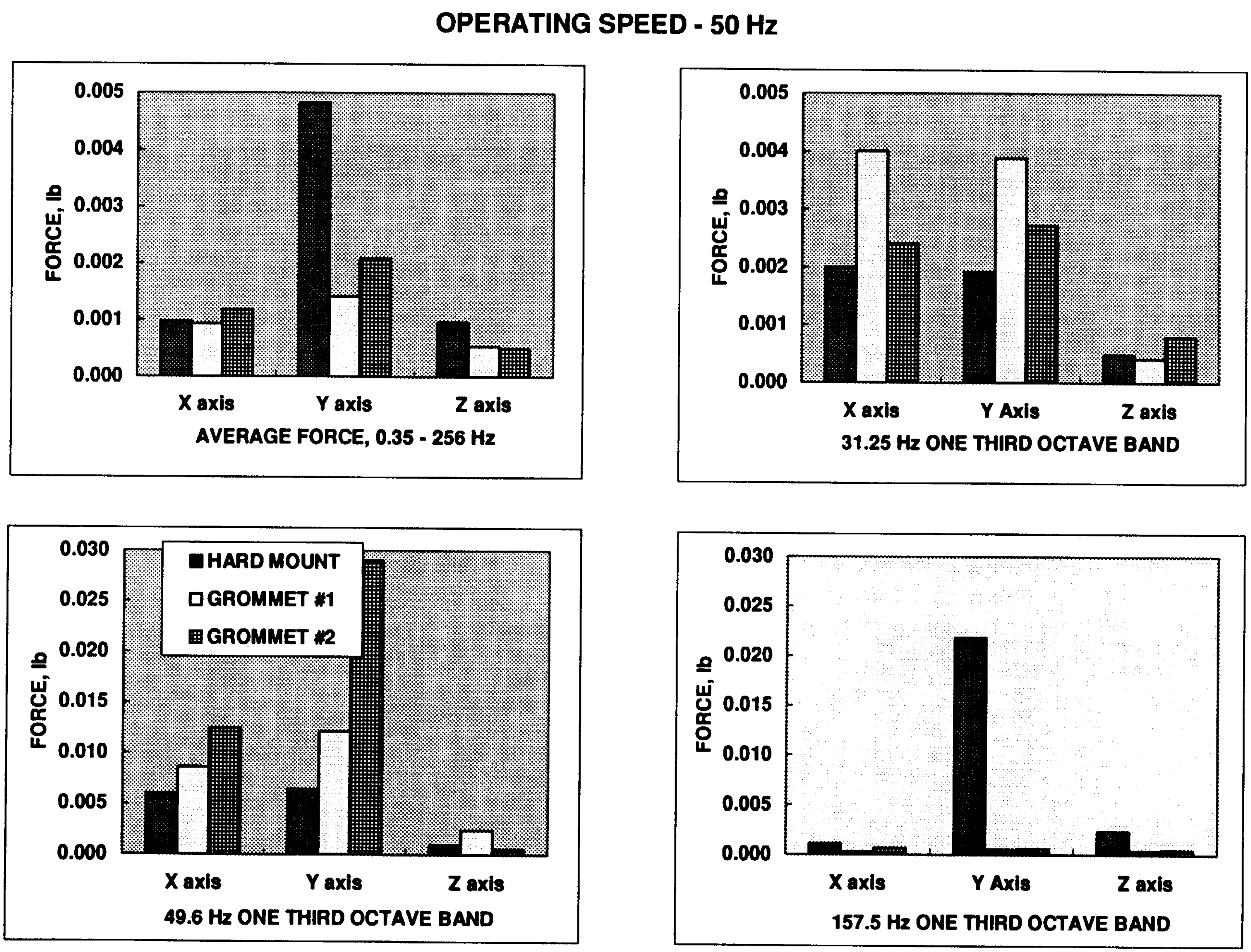

Figure 16. - SAMS II Tape Drive Assembly - Rewind Operation Forces

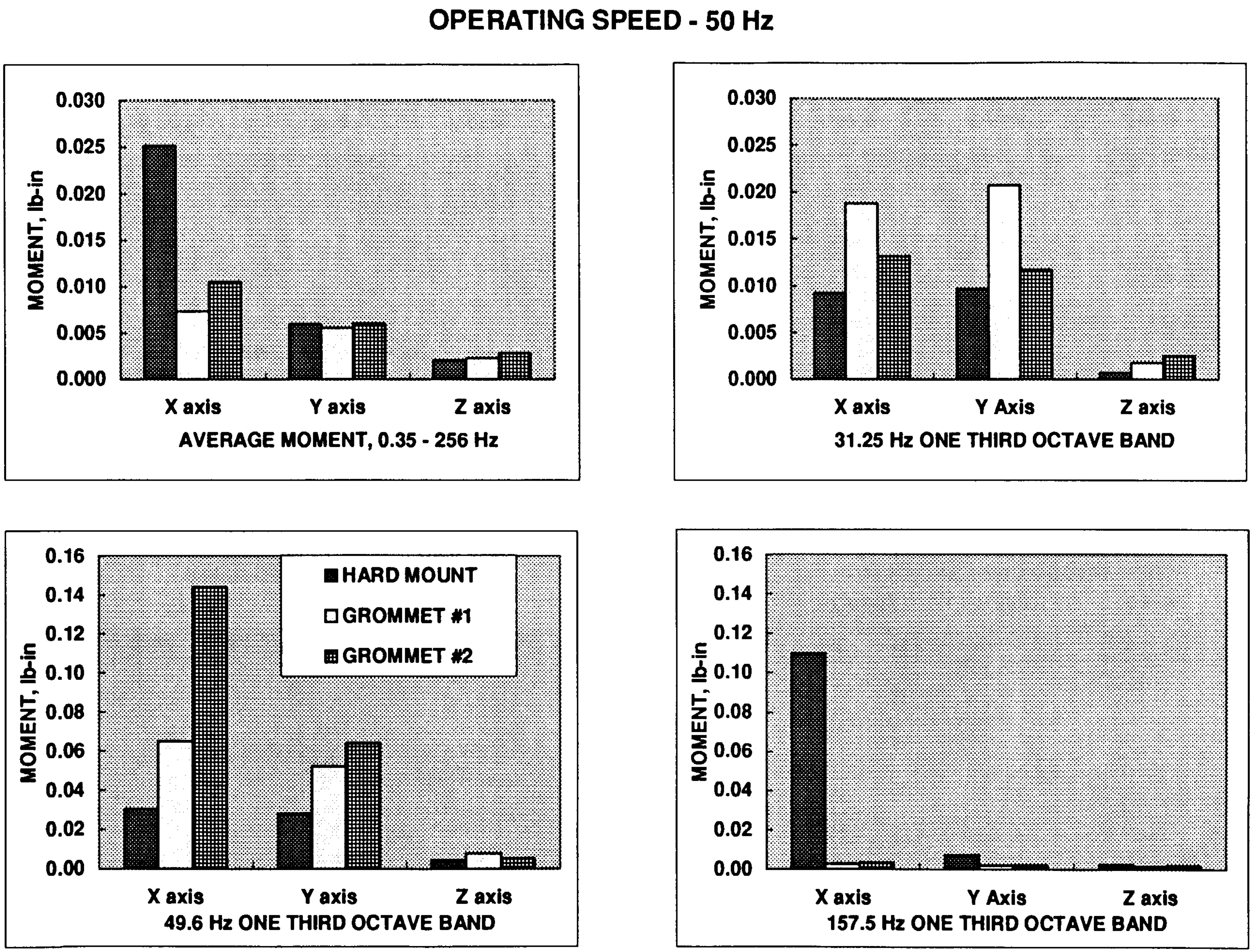

Figure 17. - SAMS II Tape Drive Operation - Rewind Operation Moments

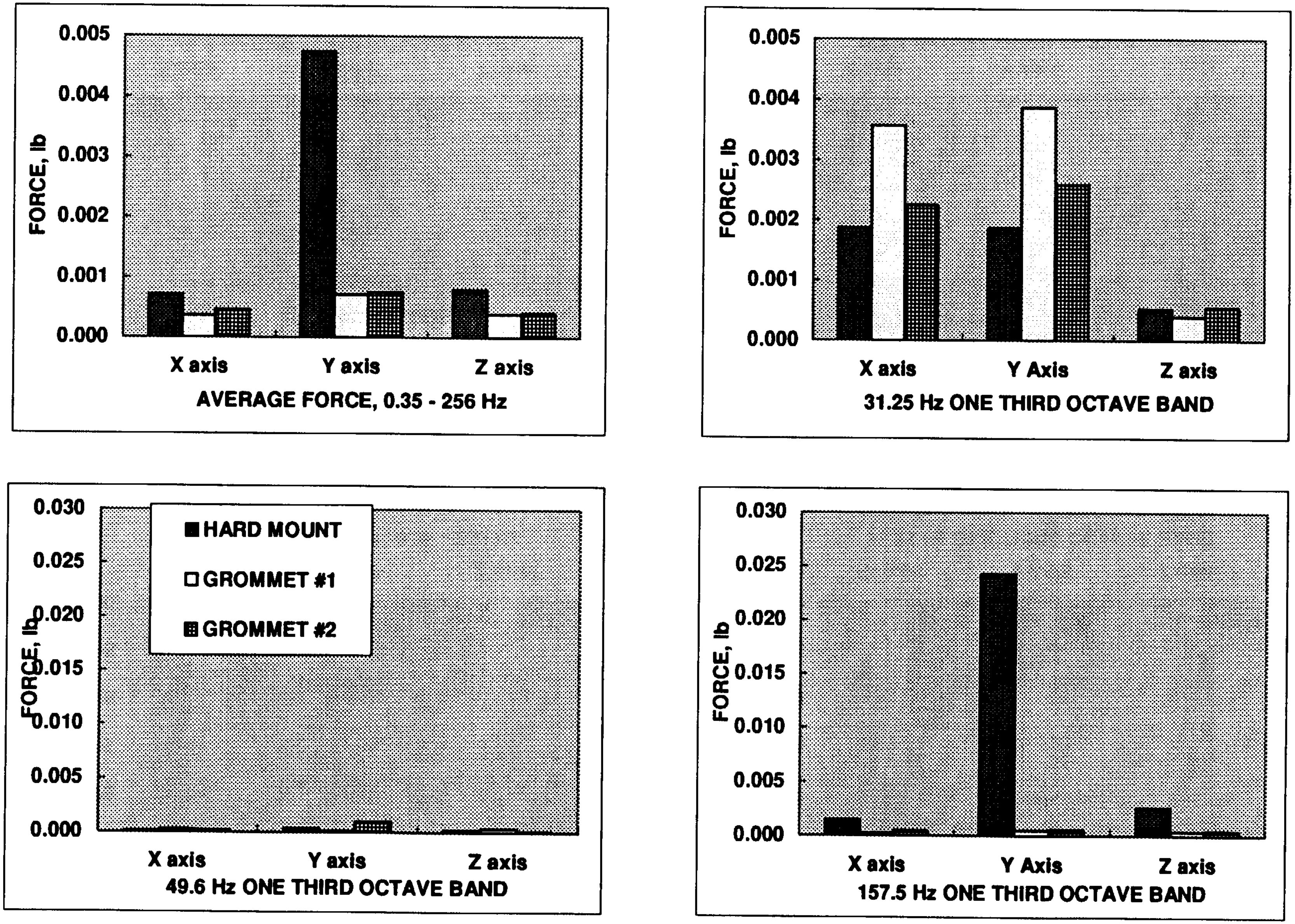

Figure 18. - SAMS II Tape Drive Assembly - Fast Forward Operation Forces

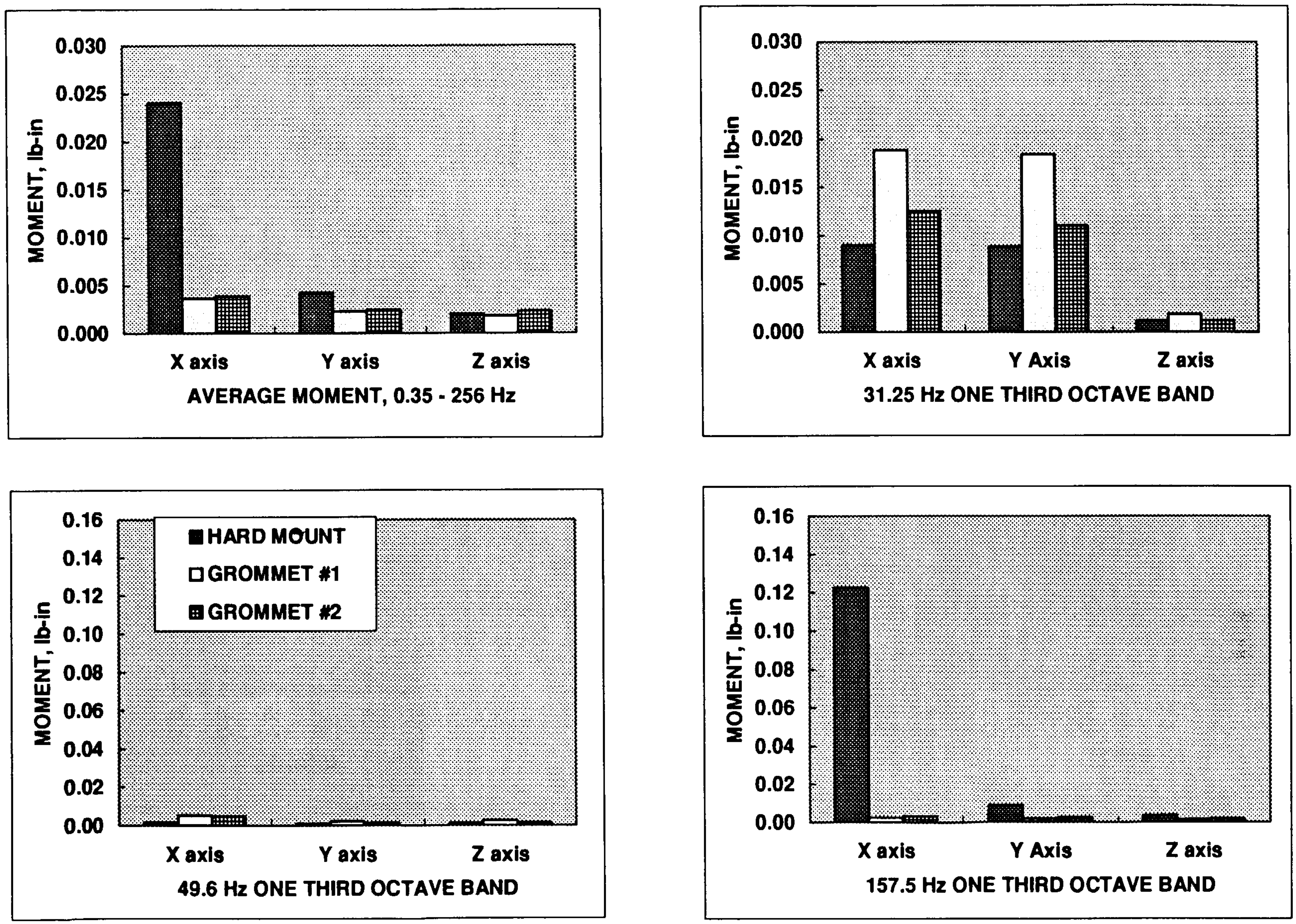

Figure 19. - SAMS II Tape Drive Assembly - Fast Forward Operation Moments

X AXIS FORCES

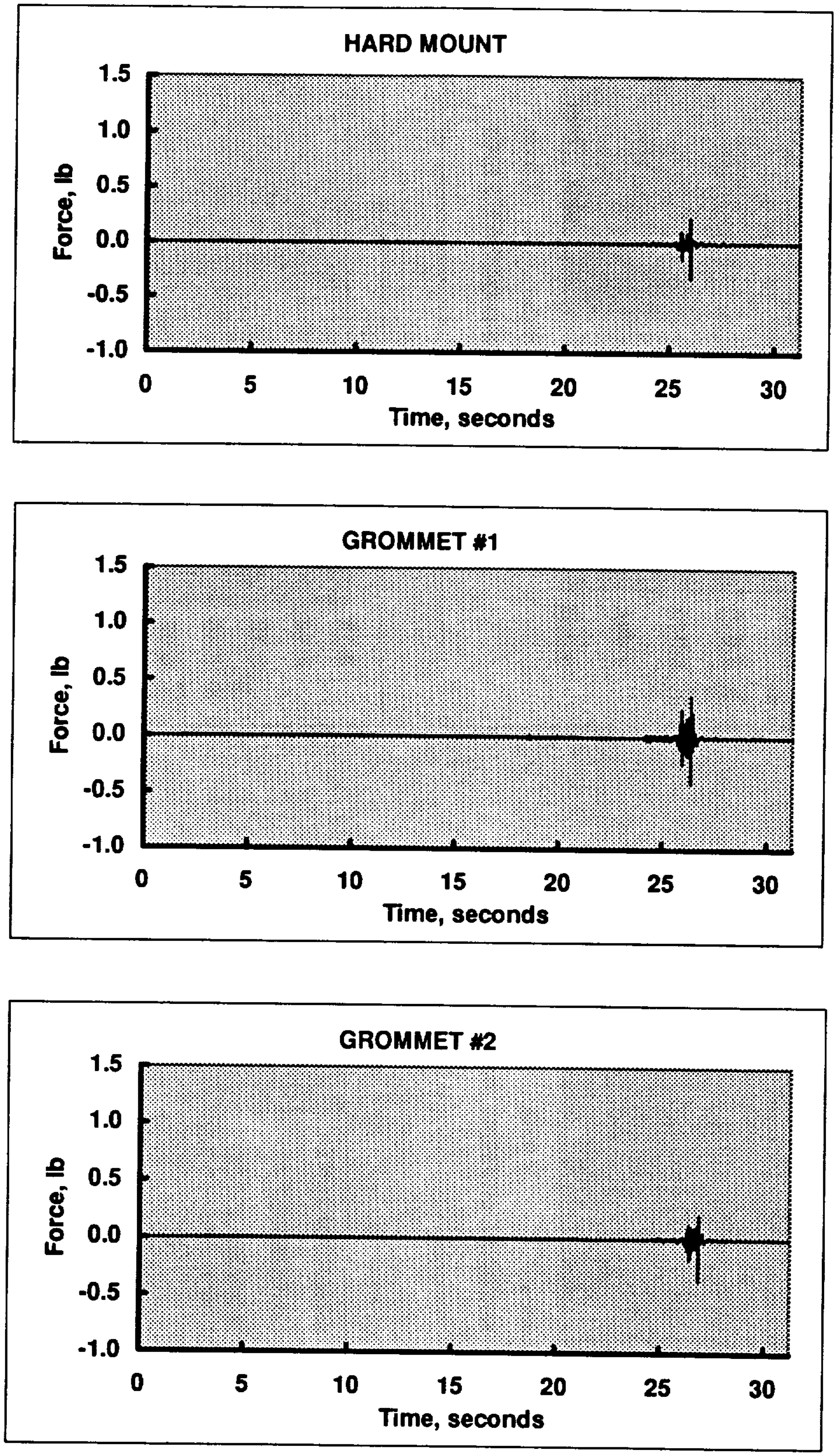

Figure 20. - SAMS II Tape Drive Assembly - Software Eject

X AXIS FORCES

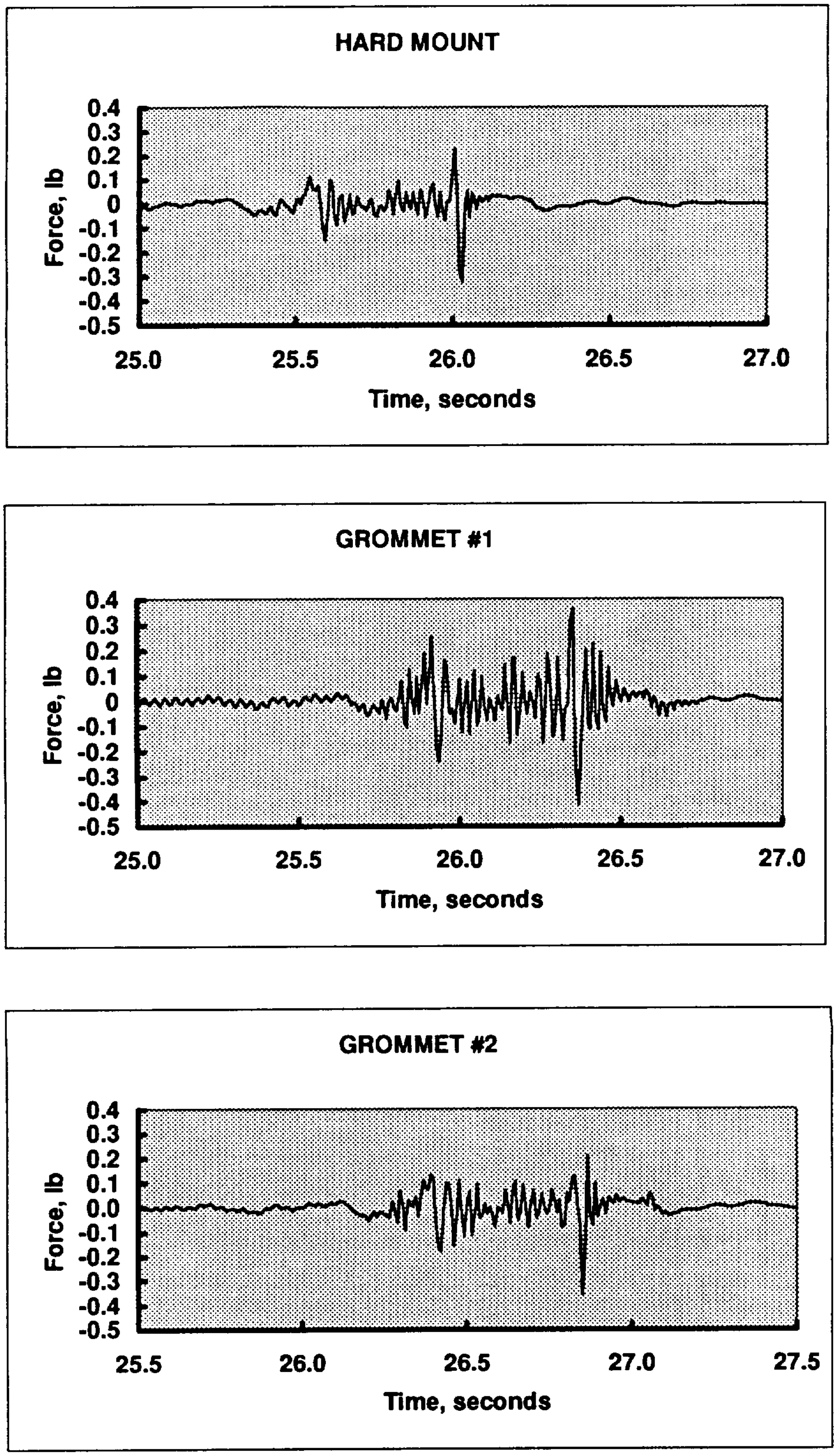

Figure 21. - SAMS II Tape Drive Assembly - Amplified Software Eject

X AXIS FORCES

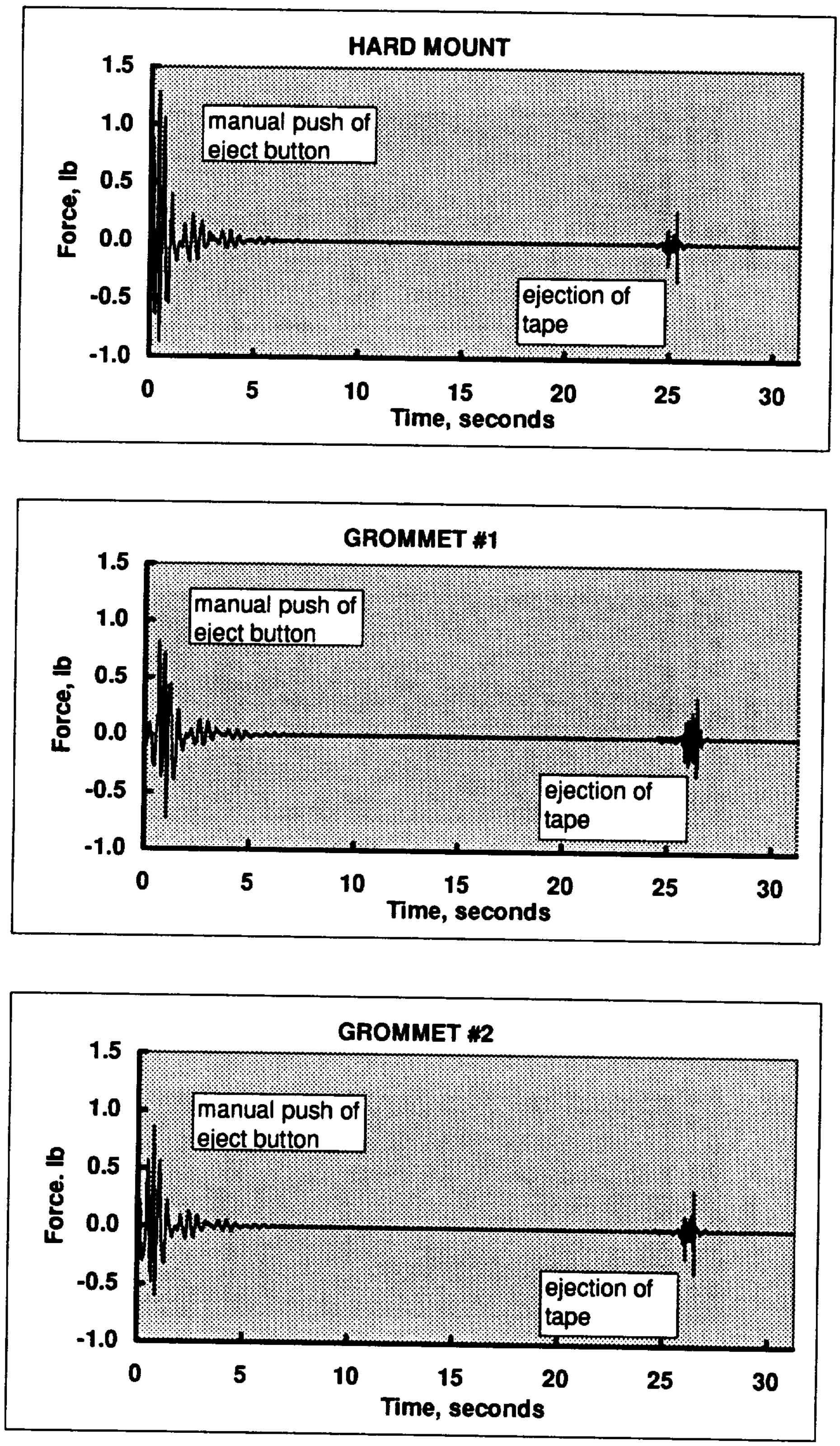

Figure 22. - SAMS II Tape Drive Assembly - Manual Eject

X AXIS FORCES

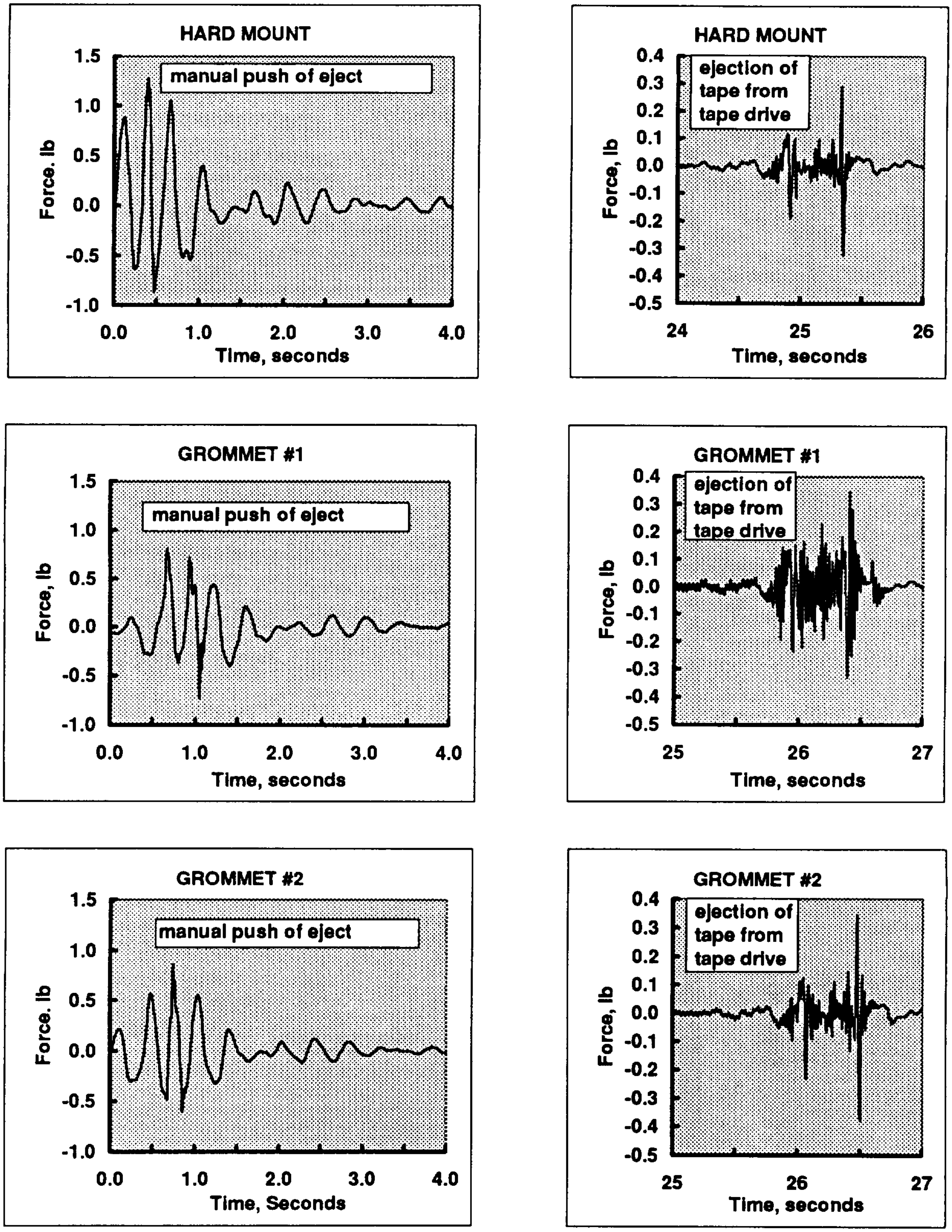

Figure 23. - SAMS II Test Drive Assembly - Amplified Manual Eject

X AXIS FORCES

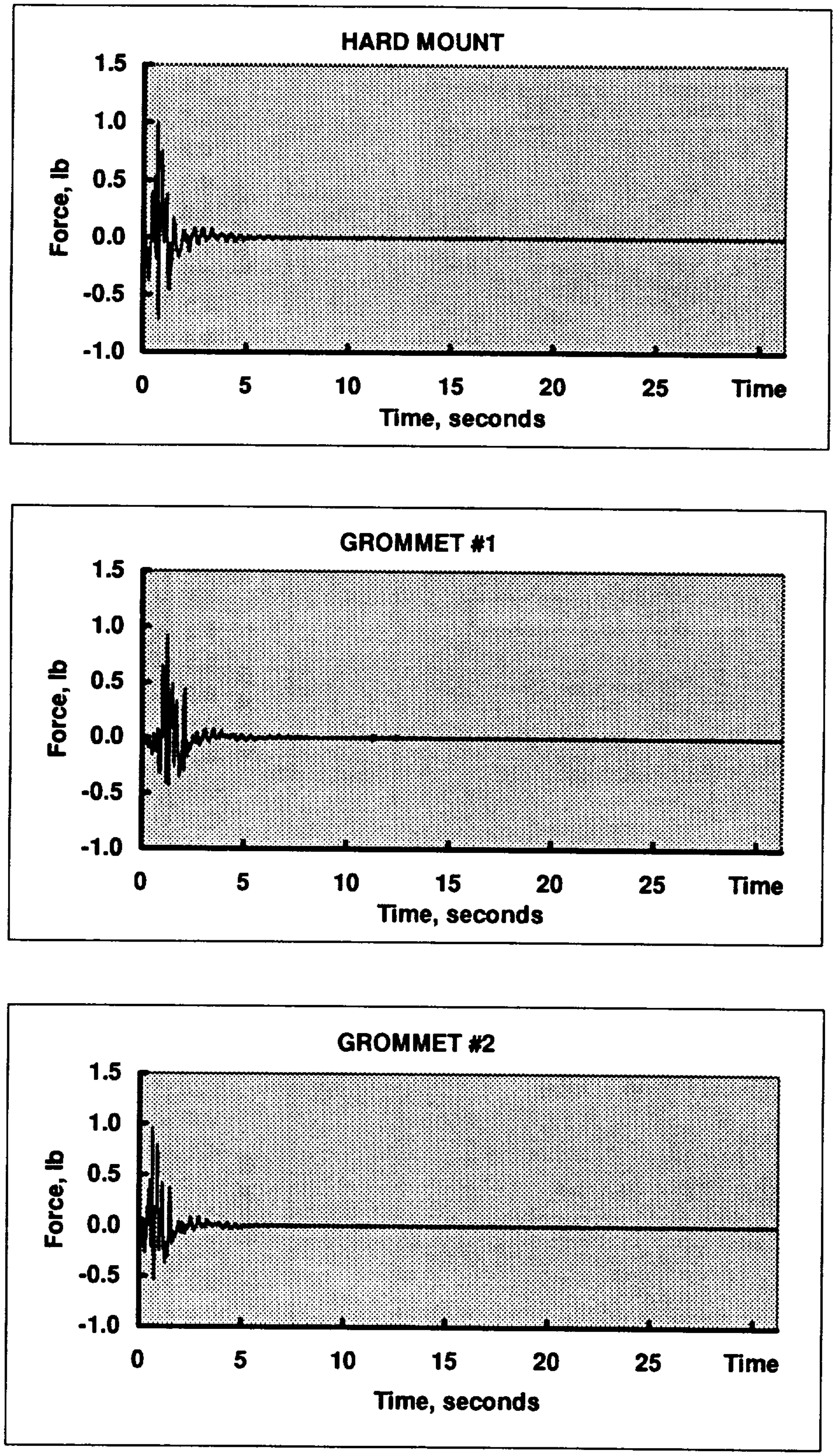

Figure 24. - SAMS II Tape Drive Assembly - Manual Load

X AXIS FORCES

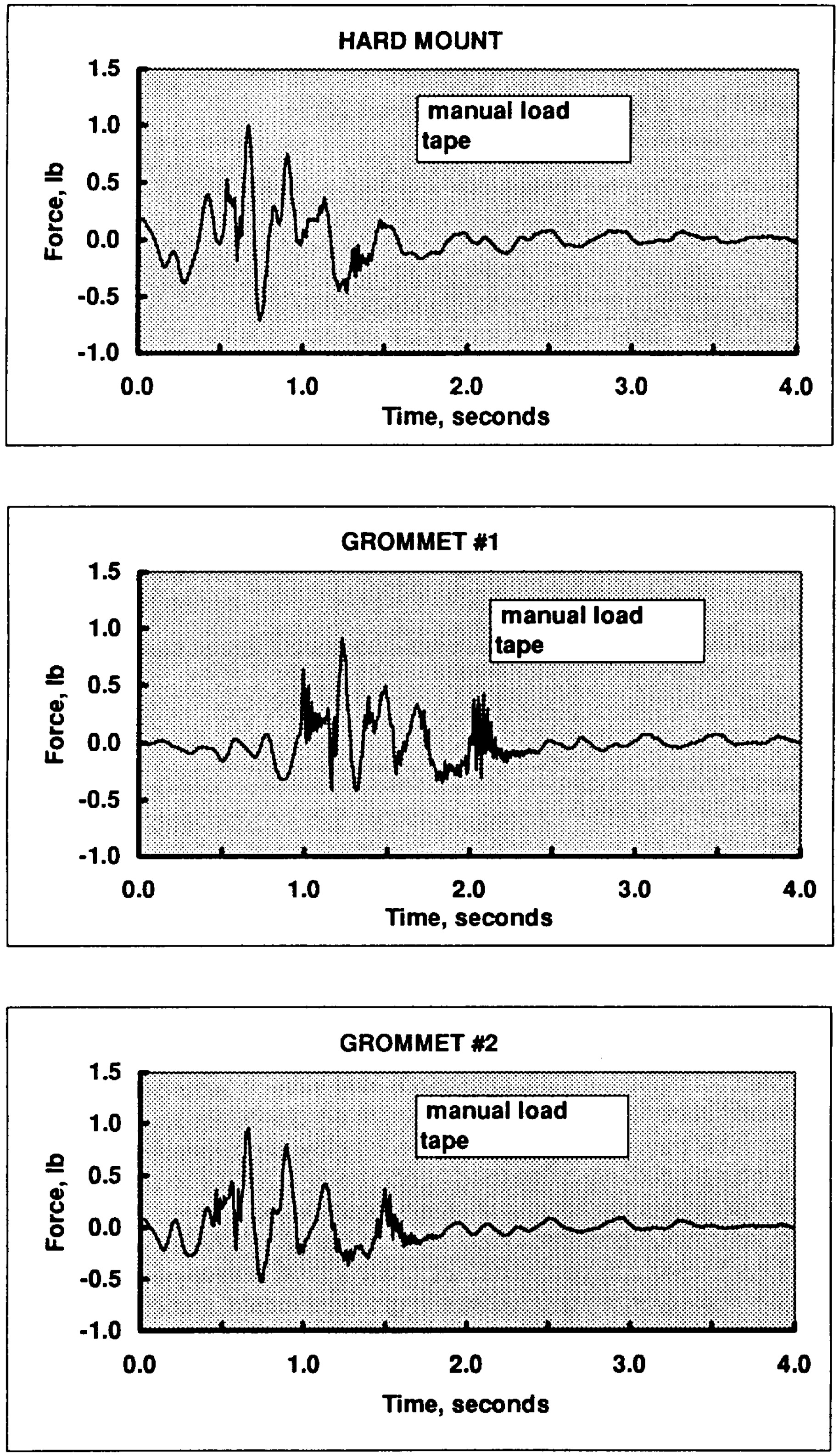

Figure 25, - SAMS II Tape Drive Assembly - Amplified Manual Load

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13. ABSTRACT (Maximum 200 words)

This report summarizes results of force and moment measurements of the Space Acceleration Measurement System II (SAMS II) Tape Drive Assembly (TDA) over the frequency range from 0.35 Hz to 256 Hz for steady state operations including write, read, rewind, and fast forward. Time domain force results are presented for transient TDA operations that include software eject, manual eject, and manual load. Three different mounting configurations were employed for attaching the inner box with the tape drive unit to the outer box. Two configurations employed grommet sets with spring rates of 42 and 62 pounds per inch respectively. The third configuration employed a set of metallic washers. For all four steady state operations the largest average forces were on the Y axis with the metallic washers and were less than 0.005 pounds. The largest average moments were on the X axes with the washers and were less than 0.030 pound inches. At the third octave centerband frequency of 31.5 Hz, the 42 pound per inch grommets showed the greatest forces and moments for read and write operations. At the third octave centerband frequency of 49.6 Hz, the 62 pound per inch grommets showed the greatest forces and moments for rewind operation. Transient operation forces ranged from 0.75 pounds for the software eject to greater than 1 pound for manual load and eject.

14. SUBJECT TERMS
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