This is to certify that the

thesis entitled

EXAMINATION OF INSTRUMENTED SHIPPING BOX
TO EVALUATE DYNAMIC COMPRESSION FORCE
DURING TRANSPORTATION VIBRATION

presented by

David Alan Leinberger

has been accepted towards fulfillment
of the requirements for

M.S. degree in School of Packaging

Major professor

Date 11/11/93

EXAMINATION OF INSTRUMENTED SHIPPING BOX TO EVALUATE DYNAMIC COMPRESSION FORCE DURING TRANSPORTATION VIBRATION

By

David Alan Leinberger

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

School of Packaging

1993

Paul Singh, Ph.D.

ABSTRACT

EXAMINATION OF INSTRUMENTED SHIPPING BOX TO EVALUATE DYNAMIC COMPRESSION FORCE DURING TRANSPORTATION VIBRATION

By

David Alan Leinberger

For years, packaging engineers have designed corrugated fiberboard containers to provide stacking strength to support the static load of the boxes stacked on top. Even with safety factors used to account for loss in strength due to humidity, temperature, creep, stacking pattern variations, etc., corrugated boxes still fail. One unknown variable has been the variation in compression force experienced by boxes when they are vibrated during transportation.

A self-contained compression recorder was built, and proven to accurately measure dynamic force during vibration. This system was used in simulated transportation environments with varying loads using five different random vibration spectra.

The maximum compression occurs to the bottom box in a stack. In simulated vibration tests, 99.5% of the force readings were below 1.2 to 5.2 times the weight of the static load. The maximum measured force was about 9.5 times the weight of the static load.

In memory of my late mother, Joan Leinberger, whose love and support continue to inspire me beyond words.

ACKNOWLEDGMENTS

I would like express my sincere thanks to the members of my graduate committee, Dr. S. Paul Singh, Dr. Gary Burgess, and Dr. Galen Brown. Thanks to Dennis Young, Dale Root and especially Chuck Pierce at Lansmont as well as Mike Bogar and Bill Vertner at Tektronix for the use of their testing equipment. Thanks to Bernard Fehr for his assistance with electronics and software. Thanks to Al Voss and Mark Kerr at IBM for sharing their knowledge and advice.

I would also like to thank the Consortium of Distribution Packaging for the funding which made this research possible.

Finally, I am especially thankful to my father, Ken Leinberger, and my sister and brother-in-law, Kelly and Mark Allison for their guidance and support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF ABBREVIATIONS

A = Peak Acceleration

Ca = Actual Peak Compression Force

Cm = Measured Peak Compression Force

%E = Percent Error

F = Force

Fs = Sampling Frequency

Fv = Vibration Frequency

g = Acceleration Due to Gravity = 386.4 in/sec^2

K = Spring Constant

K_{eq} = Equivalent Spring Constant

m = Mass

|M| = Absolute Magnification Factor

t = Time

Δt = Time Increment Between Samples = 1/Fs

T = Period of Vibration = 1/Fv

W = Weight

Y = Amplitude at Any Instant of Time

1.0 INTRODUCTION

The purpose of this study was to develop the methodology, equipment, and hardware necessary to measure dynamic compression forces experienced by packages during transportation. Various studies have examined the effect of static compression on packages during warehouse storage conditions. For example, the stacking pattern has a great effect on compression strength. Misalignment of boxes can reduce stacking strength by 50%. Even perfectly aligned, 3-box high column stacks show a 23% reduction in compression strength (Kellicutt, 1963).

The effect of creep during long term storage has been shown to reduce compression strength. In a study by Moody and Skidmore (1966), containers were found to retain only 55% of their original yield force after three months of storage.

Temperature and humidity affect the final box compression strength. As the cellulose in the corrugated fiberboard absorbs moisture, the compression strength decreases. The moisture content of the board is in turn affected by the temperature (Laufenberg, 1992).

Recycled fiber content has also been shown to reduce compression strength to corrugated boxes. In a study using 100% recycled fibers, repeated recycling caused a 25% decline in top-to-bottom compression strength of containers (Koning and Godshall, 1975).

A recent trend toward high-performance corrugated has added yet another variable in compression strength. Cyclic conditions of temperature and humidity have been shown to have a greater negative effect on fiberboard made from fiber-efficient liner board than standard fiberboard. However, both fiberboards performed similarly under non-cyclic environments (Boonyasarn, 1990).

On the basis of these factors, packages are designed to withstand a maximum compression load produced by the static load on top. However, this approach does not consider the dynamic compression forces experienced during transportation.

This study aimed at developing a instrumented shipping box (ISB) capable of measuring the compressive force experienced by the bottom package during transportation. This system was then used in a lab along with an electrohydraulic vibration table to simulate different transportation environments. The dynamic compressive forces were measured and analyzed for four different stacked package column weights. Five different transit vibration levels were investigated simulating truck, rail, and inter-modal shipments using random vibration power density spectrums.

With increasing public pressure to reduce the amount of packaging, it is essential to know what role each of these factors plays in the overall strength of a corrugated container.

The objectives of this study were:

1. To develop a data acquisition system to measure dynamic compression forces of stacked corrugated boxes.
2. To measure dynamic compression forces on boxes during random vibration in laboratory simulated transportation tests.

2.0 THE DATA ACQUISITION SYSTEM

The ISB consisted of a rigid outer casing constructed of reinforced plywood capable of withstanding 5000 pound compression load. The instrument measured 16 in (length) x 13 in (width) x 10 in (height) and was designed to fit one ninth of a standard GMA pallet. The instrument weighed 45 lb. The major components of the instrument include:

A) One, 8-bit controller style microprocessor containing 64K of non-volatile static RAM, a real-time clock/calendar, both a synchronous and asynchronous serial port, and a lithium backup battery.

B) Four, 8-Megabit dynamic RAM storage (mass storage) memory banks. These memory devices used synchronous serial to communicate with the microprocessor.

C) Two, 8-channel multiplexed 12-bit analog to digital converters (A/D). The A/D used synchronous serial to communicate with the microprocessor.

D) Four, 0 to 5000 lb shear beam style load cells. These load cells were temperature compensated from 0° to 150° F providing 3 mV/V signal at full output and used 350 Ω bridge resistance.

E) Four, instrumentation amplifiers to process the signal from the shear beams.

F) One, 0 to ± 50 g monolithic capacitive accelerometer. The sensitivity was approximately 20 mV/g with a frequency response from 0 Hz to 500 Hz (3 dB down). The range of the accelerometer was limited to ±20 g's.

G) Two, 4 amp/hour 6 V lead acid, gel type batteries.

H) A hexadecimal rotary input switch to control the mode of operation. Two push button switches to increment, decrement or start the functions of a given mode.

I) An RS232 serial port (9600 baud) to send or receive information from a personal computer.

J) Three power supplies, one 5 V power supply for the digital circuitry, one 8 V power supply for the analog circuitry, and one precision 5 V power supply for the A/D. A crowbar is used to protect the circuitry against over voltage.

K) A built in battery charger for the gel batteries. The batteries could be recharged in approximately 5 hours. A two color LED indicated the unit was charging. The instrument could run for about 20 hours on a full charge.

L) A 16x2 full alpha-numeric liquid crystal display (LCD) was included to provide information to the user.

The four load cells were placed at each corner of the box's lid. The lid was undercut so that it could float free of the box sides and was supported by the load cells (Figure 1). With this configuration, the forces acting on individual corners could be measured (0 to 5000 lb) as well as the sum of the forces on the entire lid (0 to 20,000 lb). The box was constructed of 5/8 in. plywood with a 3/4 in. plywood lid. The load cells were supported on an internal steel box-type

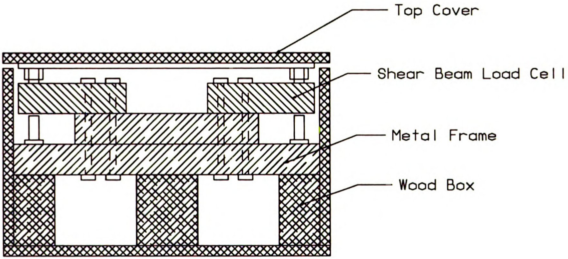

Figure 1. Drawing of Instrumented Shipping Box (ISB)

frame that provided rigid support and overload protection. The lid could be removed and replaced by a smaller platform to test the accuracy of a given load cell.

The microprocessor used an 11.0592 MHz crystal resulting in a machine cycle time of 1.1 μs. This crystal frequency provided the highest processor speed and allowed the development of special timing for the asynchronous serial port. The real-time clock calendar provided a means of time and date stamping test data. The lithium backup battery provided for the retention of microprocessor programs and data without the need for EPROM or EEPROM type memory. The bulk of the test data was stored in the mass storage devices. A means of testing the mass storage for stuck bits was included. The LCD provided an independent means of viewing the load cell weights, box temperature, battery charge, and the amount of filled memory.

The two A/Ds provided a total of sixteen channels of 12-bit data acquisition. One A/D provided information from the four shear beams, monitored the analog voltage supply, 12 V battery pack, and two thermometers (shear beam and ambient temperatures). The second A/D provided information from the single-axis accelerometer and allowed for further expansion. Due to the amount of time required to access the A/Ds and save the data into mass storage, the maximum sampling rate was 200 Hz. For convenience and due to differing testing criteria, the sampling rate could be set from 0.1 Hz to 200 Hz. Reading and saving data from one channel of A/D required approximately 0.275 ms. To achieve the most "instantaneous" reading of the A/D channels, they were read in bursts at the beginning of a sampling cycle and saved to the microprocessor. After reading all channels, the data was sent from the microprocessor to mass storage. Using a 200 Hz sampling rate, the mass storage was filled in approximately 21 minutes.

To calibrate the ISB, each load cell was calibrated from 0 to 330 lb. Weight was added tc one load cell at a time in increments of approximately 55 lb. The voltage output versus load was plotted for the load cell. All of the load cells produced a linear calibration graph. The slope of the line was used as a conversion from voltage output to weight. The cover was then placed on the ISB and all four cells were tested together from 0 to 825 lb to verify these conversions for the entire ISB. The ISB consistently read the known weight. The ISB was periodically tested against these known weights to verify its accuracy. However no significant deviation was observed.

2.1 ACCURACY OF ISB

Due to limitations of the load cells and the A/D conversion, the smallest discernible increment for any load cell was approximately 1.2 lb For this reason, the entire ISB was limited to an accuracy of ±4.8 (or 5) lb. To verify the ISB's accuracy, it was allowed to record continuously for 5 minutes. First it was tested with no weight. The sampling rate was set at 200 Hz, producing 60,000 readings. The results are listed in Figure 2. The mean weight was 0 lb with a standard deviation 1.6 lb All but four readings fell within the expected ± 5 lb accuracy, or 99.993%.

This test was then repeated with a 327 lb static load. The results are given in Figure 3. The mean weight was 327 lb with a standard deviation of 2.1 lb. All but 556 readings fell within the ± 5 lb accuracy, or 99.073%.

Since the ISB was limited to a maximum sampling rate of 200 Hz, it would not necessarily capture the peak compression force for every wave. The maximum possible error occurs when two readings are evenly distributed on

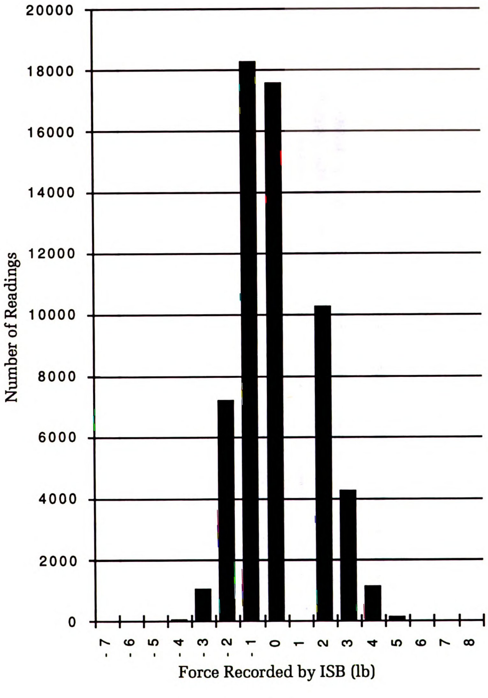

Figure 2. Accuracy: Static load = 0 lb

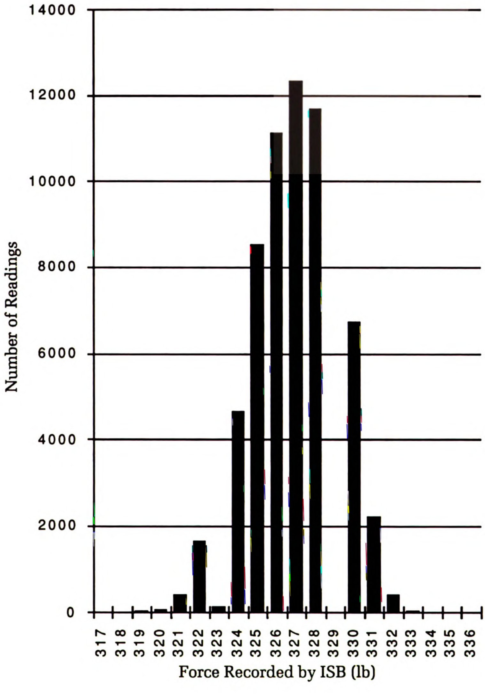

Figure 3. Accuracy: Static Load = 325 lb

either side of the peak compression (Figure 4). Sinusoidal motion is represented mathematically by the equation:

$$Y = A \cdot \sin\left(\frac{2\pi \cdot \Delta t}{T}\right) \qquad [2\text{-}1]$$

Where:

Y = amplitude at any instant of time

A = peak acceleration

Δt = time increment

T = time period of oscillation

t = time

The peak amplitude occurs when t = T/4 and the maximum peak measurement error occurs when t = T/4 ± Δt /2. At this time, the measured compression load, Cm, will be:

$$Cm = A \cdot \sin\left[\frac{2\pi}{T}\left(\frac{T}{4} - \frac{\Delta t}{2}\right)\right] \qquad [2\text{-}2]$$

or

$$Cm = A \cdot \cos\left(\frac{\pi \Delta t}{T}\right) \qquad [2\text{-}3]$$

Therefore, the maximum percentage error, %E, for any measured value of compression is:

$$\%E = 100\left(\frac{A - Cm}{A}\right) \qquad [2\text{-}4]$$

or

$$\%E = 100\left[1 - \cos\left(\frac{\pi Fv}{Fs}\right)\right] \qquad [2\text{-}5]$$

Where:

Fs = sampling frequency

Fv = vibration frequency

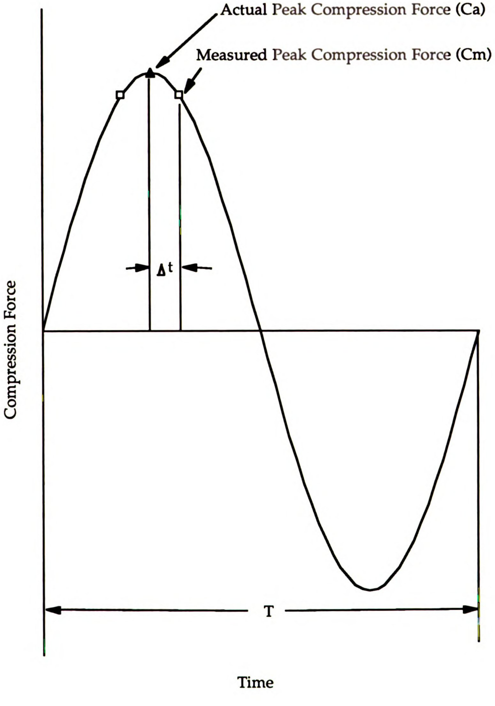

Figure 4. Example of Maximum Sampling Error

The vibration frequency for which the maximum error for any sample exceeds 5% when using a sampling rate of 200 Hz:

$$Fv = \frac{200 \cdot \arccos\left(1 - \frac{5}{100}\right)}{\pi} = 20.2\text{Hz} \qquad [2\text{-}6]$$

Therefore, for any individual reading, the maximum possible error in the measured compression force exceeds 5% for vibrations above 20.2 Hz.

There also was some degree of error caused by the shear beam's natural frequency. To determine the shear beam's natural frequency, a force versus deflection curve was established. Weight was added in increments while measuring the deflection using feeler gauges. The slope of the line produced the spring constant for one load cell: K=768 lb/.011 in = 69818 lb/in (Figure 5). Since there are four load cells, the spring constant for the entire box was: Keq = 4 x 69818 = 279,272 lb/in. The cover weighed 5.7 lb and each shear beam weighed 2.5 lb. From this, the ISB's natural frequency was calculated:

$$Fn = \frac{1}{2\Pi}\sqrt{\frac{K_{eq}\, g}{W}} = 417\,\text{Hz} \qquad [2\text{-}7]$$

Where:

W = 5.7 + 4(2.5) = 15.7 lb

g= 386.4 in /sec^2

The ISB's natural frequency was used to determine the frequency of vibration which exceeds the maximum error of 5% or |M| › 1.05:

$$|M| = \frac{1}{1 - \left(\frac{Fv}{Fn}\right)^2} \qquad [2\text{-}8]$$

$$1.05 = \frac{1}{1 - \left(\frac{Fv}{417}\right)^2} \qquad [2\text{-}9]$$

$$Fv = 91\,\text{Hz}$$

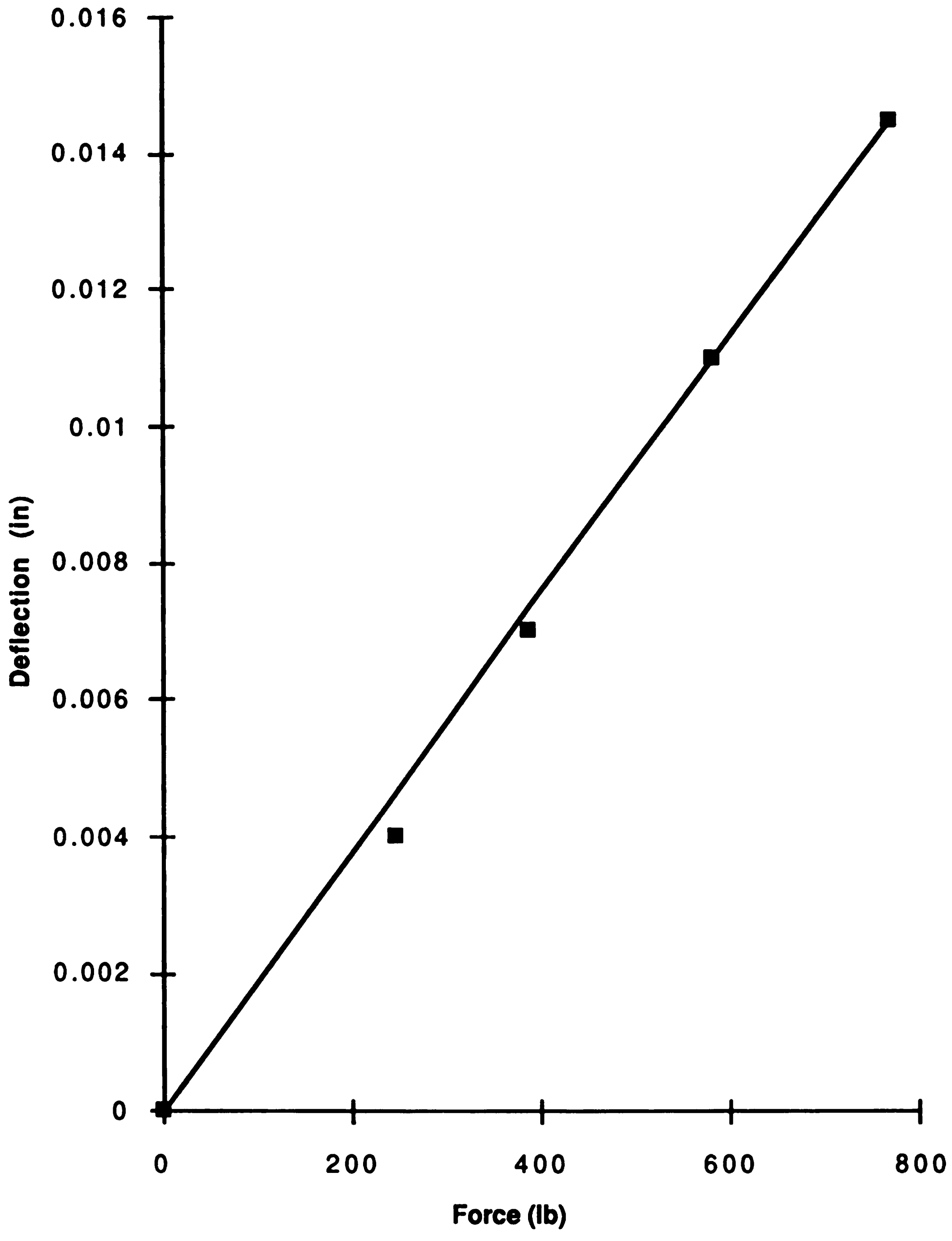

Figure 5. Force vs. Deflection Curve for One Shear Beam

The error exceeds 5% for vibrations above 91 Hz. Since the natural frequencies of the loads used in this study were below 15 Hz, the error induced by the ISB's natural frequency was negligible.

The ISB was also tested to verify its ability to record accurately before and after a 5 minute period of random vibration. To do this, the ISB was placed on the vibration table and loaded with 438 lb. This load exceeded the highest load used during this study. The sampling rate was set at 200 Hz. The ISB was allowed to record for 30 seconds to develop a baseline for comparison. Then random vibration was performed for 5 minutes using Truck Composite Spectrum, assurance level 1 (ASTM). This represented the most severe random vibration spectrum used in this study. The ISB was allowed to continue recording for another 30 seconds after random vibration was stopped. A comparison of the recordings before and after vibration is given in Figure 6. The mean before vibration was 438 lb with a standard deviation 1.6 lb. After vibration, the mean was 440 lb with a standard deviation 1.8 lb. Both readings fell within the expected accuracy of ±5%. Therefore, the ISB accuracy was not significantly affected by the bouncing experienced during random vibration.

All of the experiments up to this point tested the ISB's ability to measure static forces. The next experiment focused on the ISB's ability to accurately measure dynamic forces experienced during vibration. Force can be measured directly using transducers or load cells, like the ISB, or can be calculated from a known mass and a measured acceleration using Newton's second law applied to the load on top of the ISB:

Force = Mass x (1 + Acceleration at the Center of the Mass) [2-10]

See Appendix A for more information. Two different tests were performed using different loads and accelerations: lead weights strapped together weighing 226 lb using an acceleration of 0.25 g. The second test incorporated a stack of four

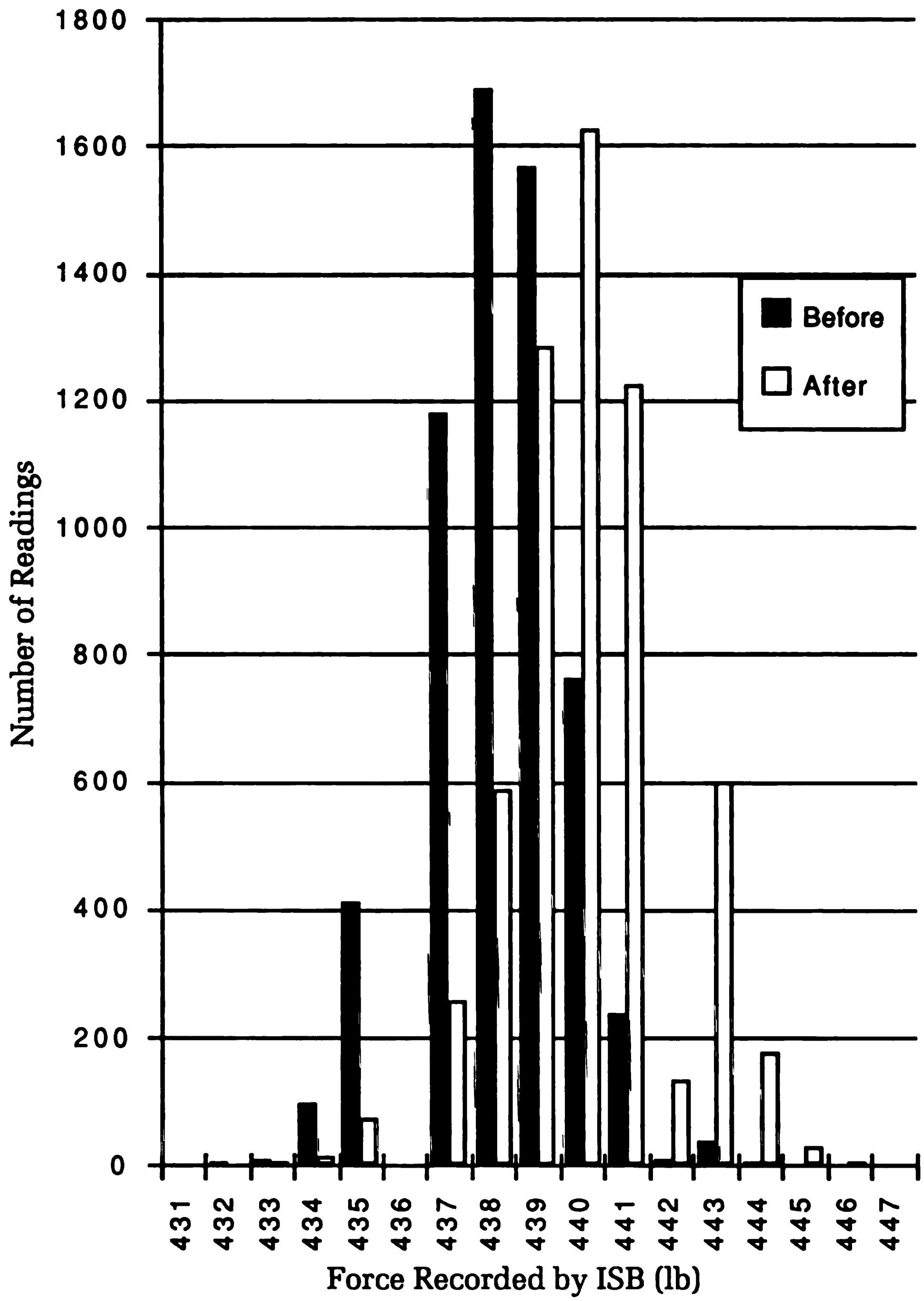

Figure 6. Comparison of Accuracy Before and After Random Vibration

concrete filled boxes weighing 217 lb using 0.5 g acceleration. The 0.5 g acceleration caused the boxes to separate and "bounce" during the test. The loads were stacked on top of the ISB and vibrated using sinusoidal vibration. An accelerometer was placed in the center of the load to monitor acceleration. One minute samples were taken at a sampling rate of 200 Hz. Measurements were taken for frequencies below, near, and above the load natural frequencies.

The results using the lead weights verify the ISB measured dynamic compression within the expected range of accuracy, ± 5% (Table 1). Either direct measurement of force or calculation of force using Newton's second law could be used to quantify dynamic compression force in this example. However in the second experiment, Newton's second law no longer applied since the boxes separated during vibration (Table 2). Separation or "bouncing" changed the center of mass in this experiment and precluded the use of Newton's second law. To use Newton's law, an accelerometer must be placed at the center of each box, since each box moves independently. Most of the random spectra used in this study caused the boxes to "bounce". Therefore, the dynamic compression forces exerted by a column of boxes were measured directly using the ISB for the rest of this study.

In summary, the compression ISB's accuracy was determined by the smallest increment of measurement, the sampling rate, the ISB's natural frequency, and the frequency of the vibration. Since a sampling rate of 200 Hz was used throughout this study, the maximum error was 5% of the top load ±5 lb, for vibration frequencies under 20 Hz.

Table 1. Calculated vs. Measured Peak Force Using Lead Weights

Table Acceleration (g's)	0.25
Load Natural Frequency (Hz)	32.4
Load Weight (lb)	226

Vibration Frequency (Hz)	Measured Peak Acceleration at Load Center (g's)	Calculated Peak Force (lb) F=m(1+A)	Measured Peak Force From ISB (lb)	Difference Between Calculated and Measured Peak
5.6	0.25	283	269	-4.78%
12.5	0.3	294	308	4.83%
53.4	0.3	294	307	4.36%
90.6	0.125	254	244	-4.11%

Table 2. Calculated vs. Measured Peak Force Using Boxes

Table Acceleration (g's)	0.5 **(Boxes were bouncing)**
Load Natural Frequency (Hz)	11
Load Weight (lb)	217

Vibration Frequency (Hz)	Measured Peak Acceleration at Load Center (g's)	Calculated Peak Force (lb) F=m(1+A)	Measured Peak Force From ISB (lb)	Difference Between Calculated and Measured Peak
7.5	0.85	401.45	521.00	29.78%
10.6	1.3	499.10	514.00	2.99%
17	0.5	325.50	286.00	-12.14%
23	0.175	254.98	246.00	-3.52%

c

c

b

p

v

-

-

-

-

-

Th

spe

3.0 EXPERIMENTAL DESIGN

The first step was to determine where the maximum dynamic compression force occurs in a stack of boxes. To accomplish this, the ISB was placed on the bottom, middle and top of a stack of four boxes during five minute tests using random vibration. Truck Composite Spectrum, Assurance Level 1 (ASTM), was used as the random vibration spectrum. The results are summarized in Figure 7. The test showed that the maximum compression force occurred to the bottom box during transportation. For the rest of this study, dynamic compression force was measured at the bottom of the stack, since the bottom represents the worst case during shipment.

The next step was to measure dynamic compression forces exerted on packages during simulated shipping environments. Five different random vibration spectrums were used in this study. They include:

- Truck Composite Spectrum, Assurance Level 1 (ASTM, 1992) (Figure 8)
- Truck Composite Spectrum, Assurance Level 2 (ASTM, 1992) (Figure 9)
- Rail Composite Spectrum, Assurance Level 1 (ASTM, 1992) (Figure 10)
- Inter-modal spectrum, (Association of American Railroads, 1992) (Figure 11)
- Truck Composite Spectrum, (Singh and Marcondes, 1992) (Figure 12)

The PSD's show the vibration level along a spectrum of frequencies. These spectra define the random vibration tests.

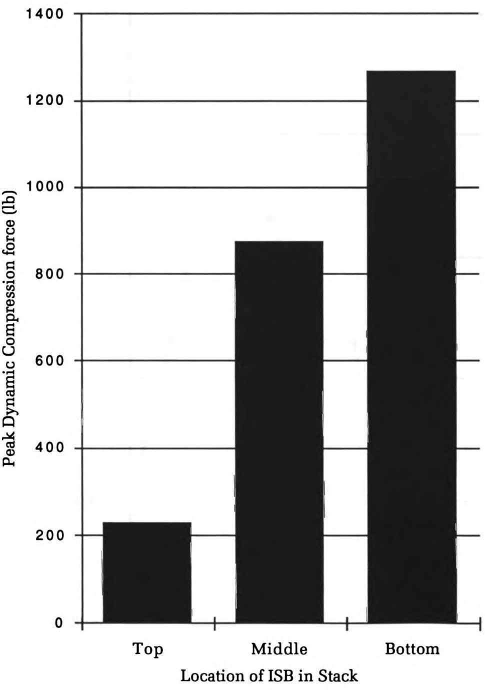

Figure 7 ISB Location Test

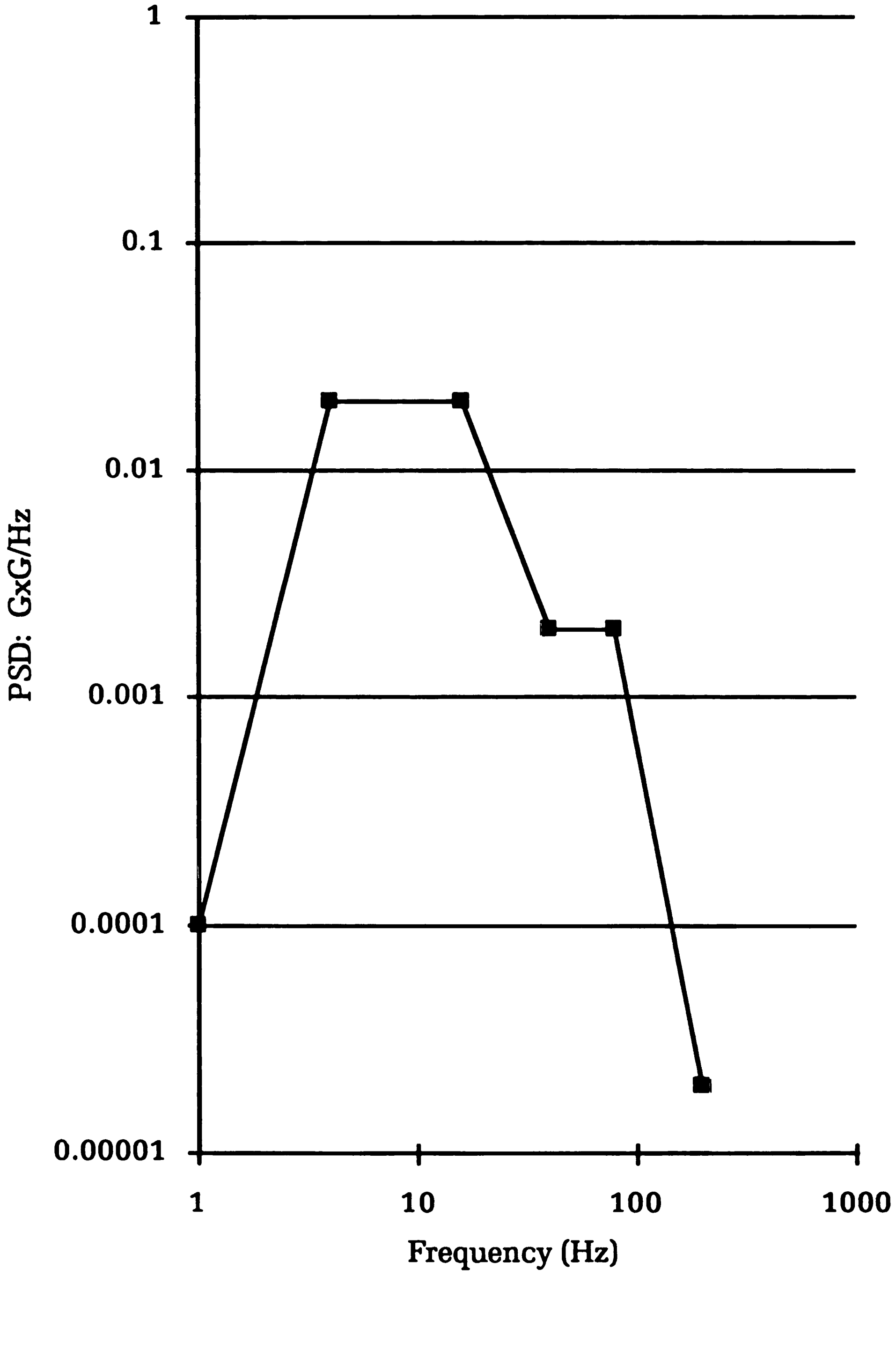

Figure 8. PSD: Truck Composite Spectrum, Assurance Level 1 (ASTM)

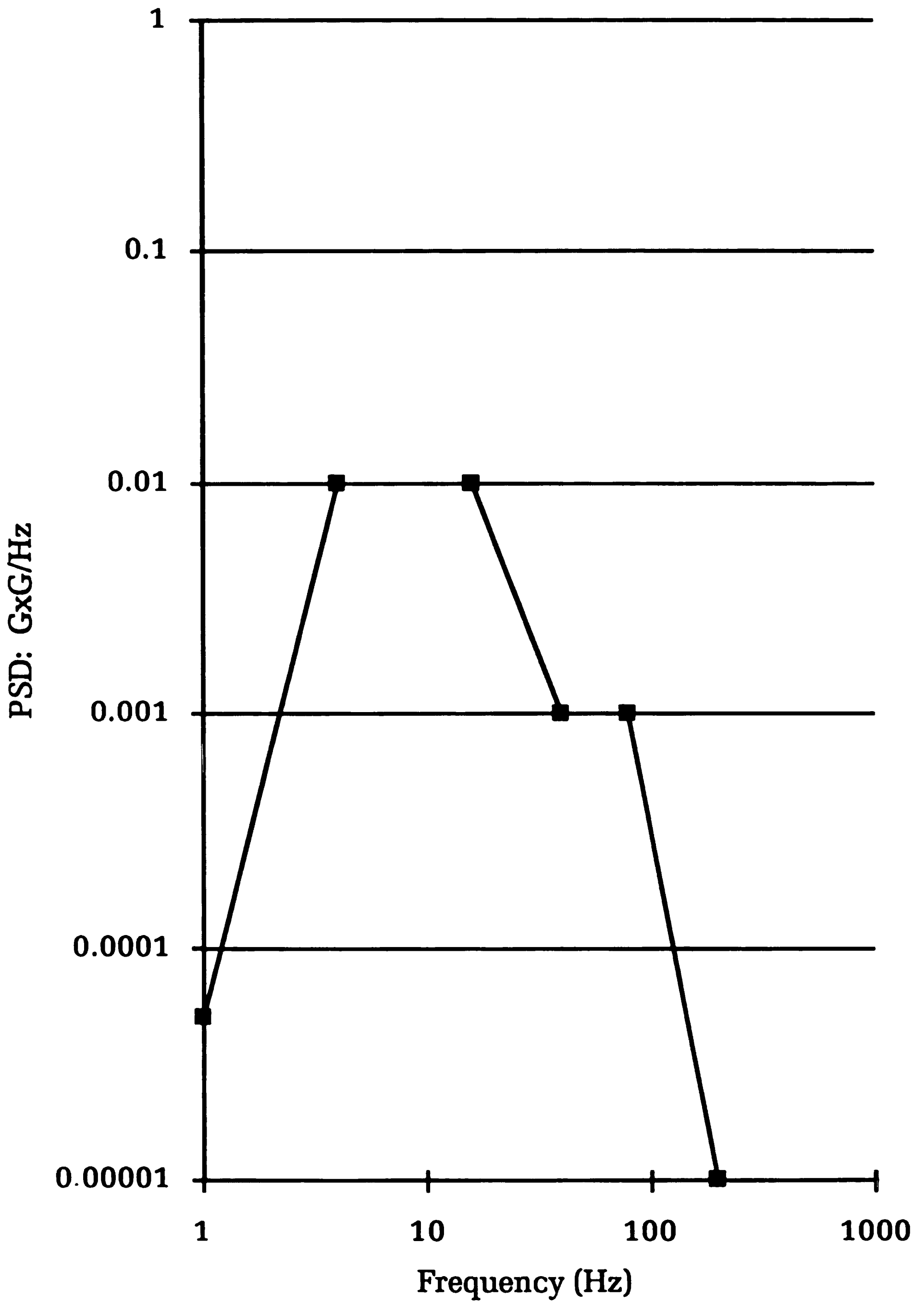

Figure 9. PSD: Truck Composite Spectrum, Assurance Level 2 (ASTM)

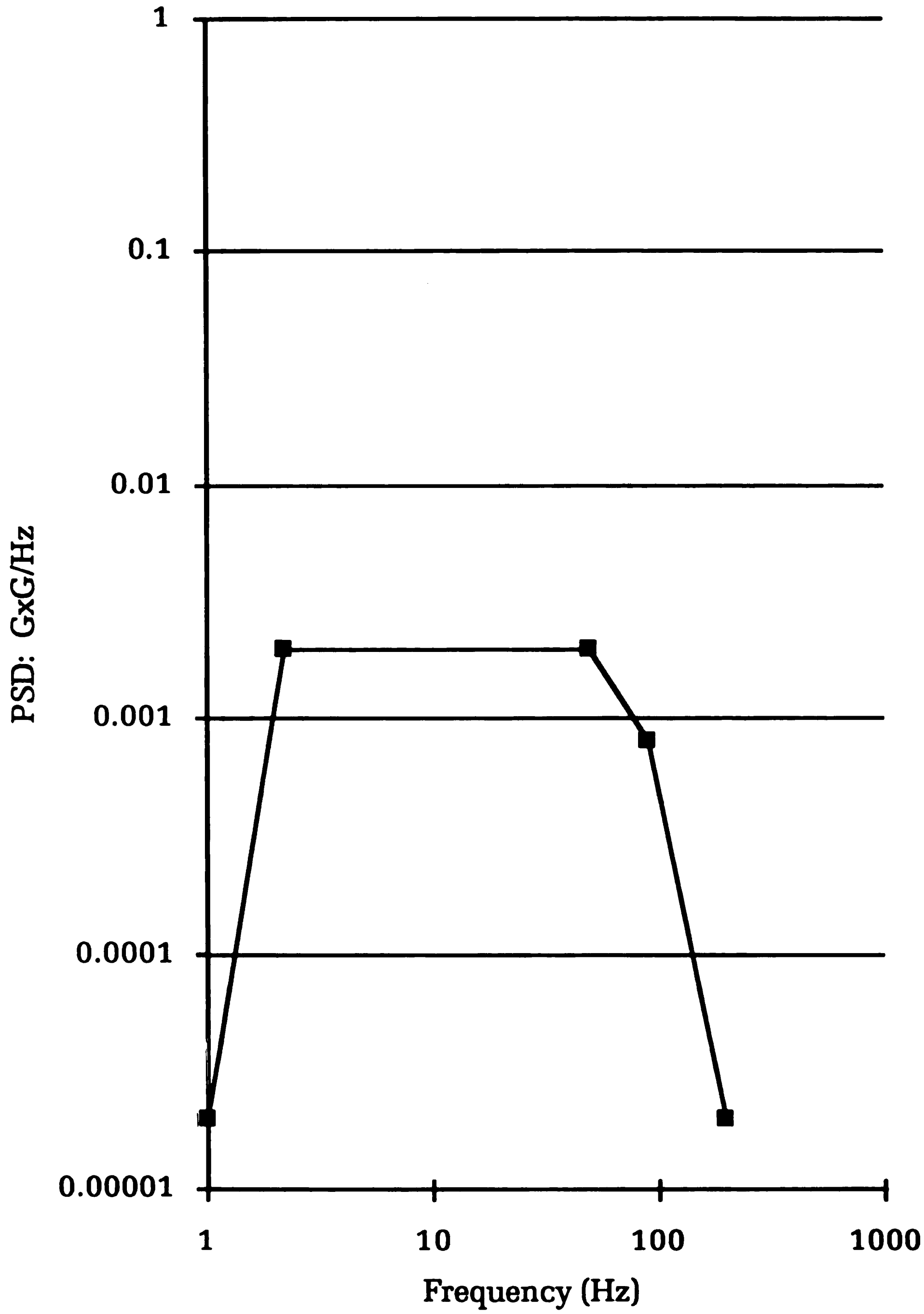

Figure 10. PSD: Rail Composite Spectrum, Assurance Level 1 (ASTM)

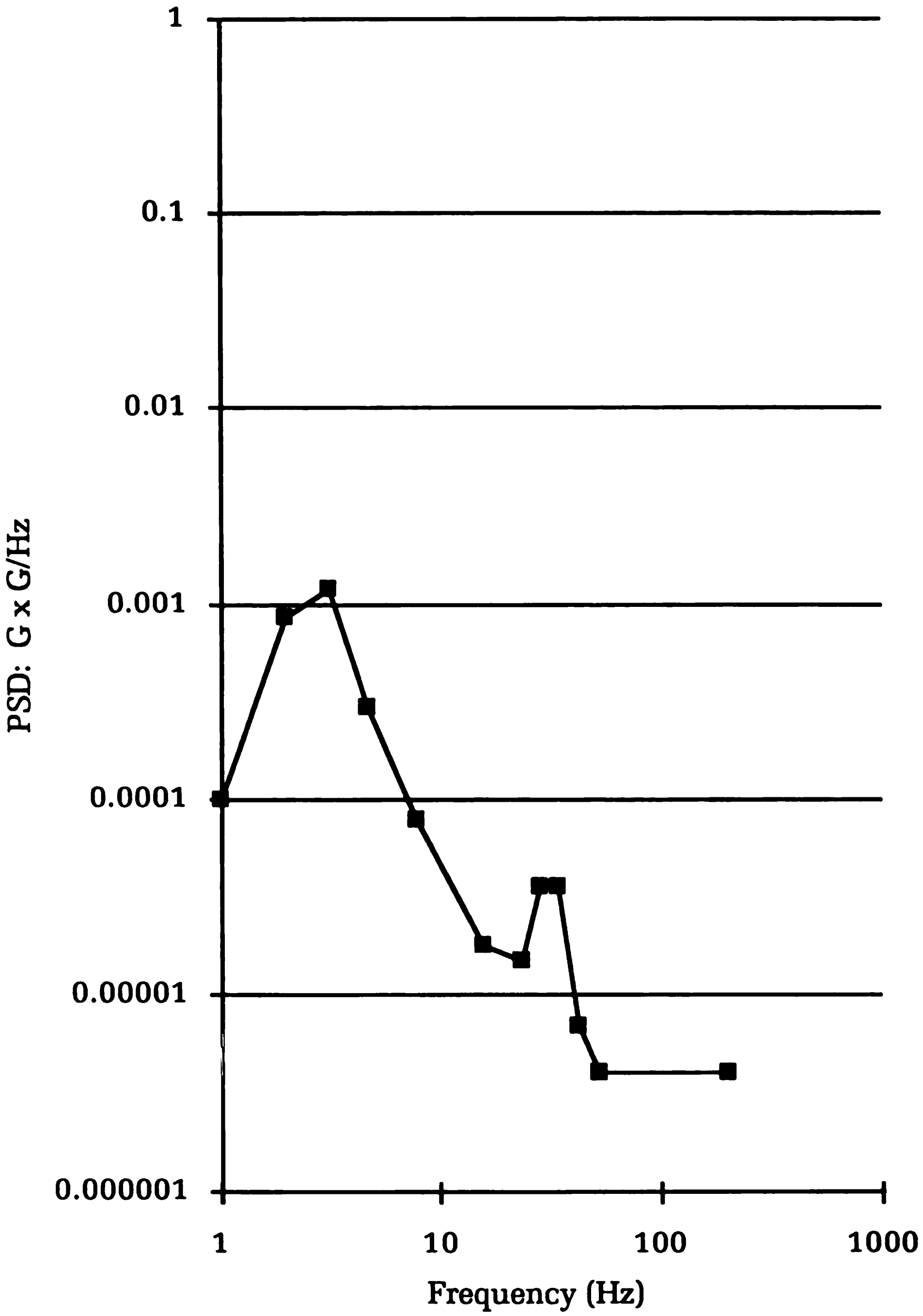

Figure 11. PSD: Inter-modal Spectrum, (Assoc. of American Railroads)

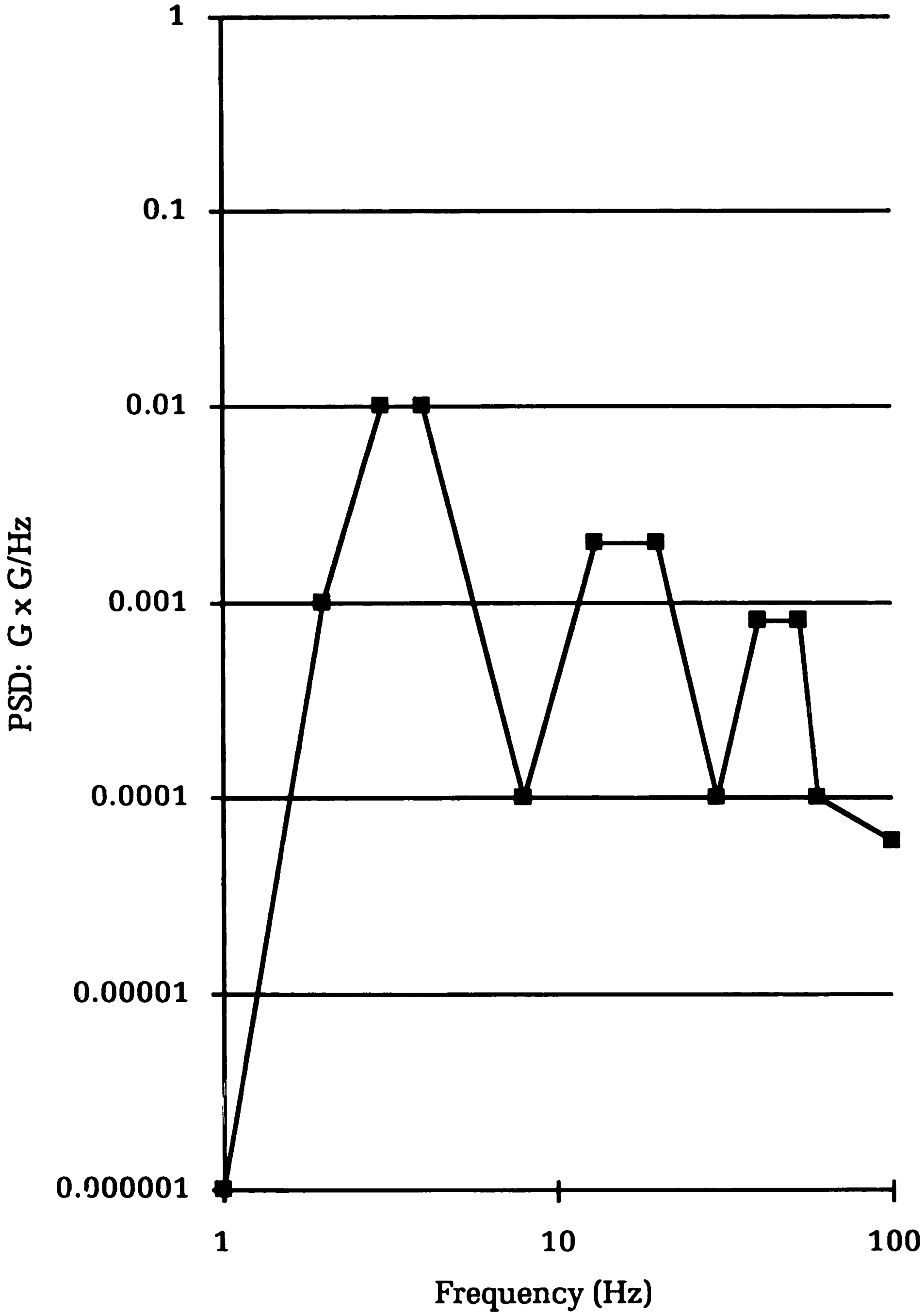

Figure 12. PSD: Truck Composite Spectrum, (Singh and Marcondes)

Corrugated boxes containing concrete blocks cushioned with polyethylene foam, were used to simulate a packaged product. Four different loads were used in this study. A rigid wood interface was constructed so that an accelerometer could be located at the stack's mass center (Figure 13). Resonance searches were performed on all four loads using sinusoidal vibration at 0.5 g's constant acceleration and are included in Figure 14 to 17 as graphs of transmissibility versus vibration frequency. These graphs define the natural frequency of the four different stacks of boxes. The loads used include:

1) 109 lb, 2 boxes, natural frequency ~ 12 Hz
2) 217 lb, 4 boxes, natural frequency ~ 10 Hz
3) 325 lb, 6 boxes, natural frequency ~ 8 Hz
4) 426 lb, 8 boxes, natural frequency ~ 6 Hz

Dynamic Compression forces were measured for the four loads using all five random spectra according to the following procedure:

1. Zero the ISB with no weight on it.
2. Stack the appropriate load on top.
3. Install a retaining fence around the stack (Figure 18).
4. Start vibration table.
5. Wait for vibration table to ramp up to full power.
6. Start recording with ISB.
7. Record for 5 minutes.
8. Stop recording with ISB.
9. Stop vibration table.
10. Download data to personal computer.

This procedure provided a uniform means to collect the data from the five simulated shipping tests being evaluated.

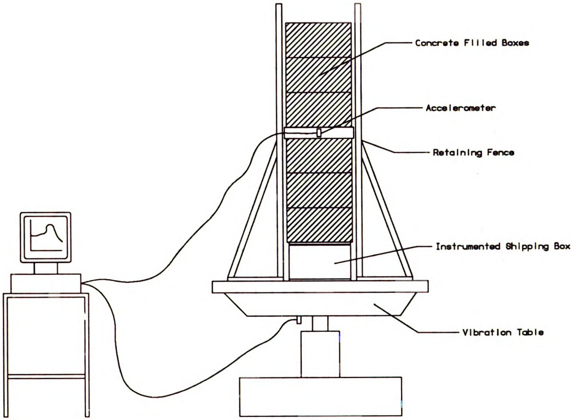

Figure 13. Drawing of Test Setup for Resonance Searches

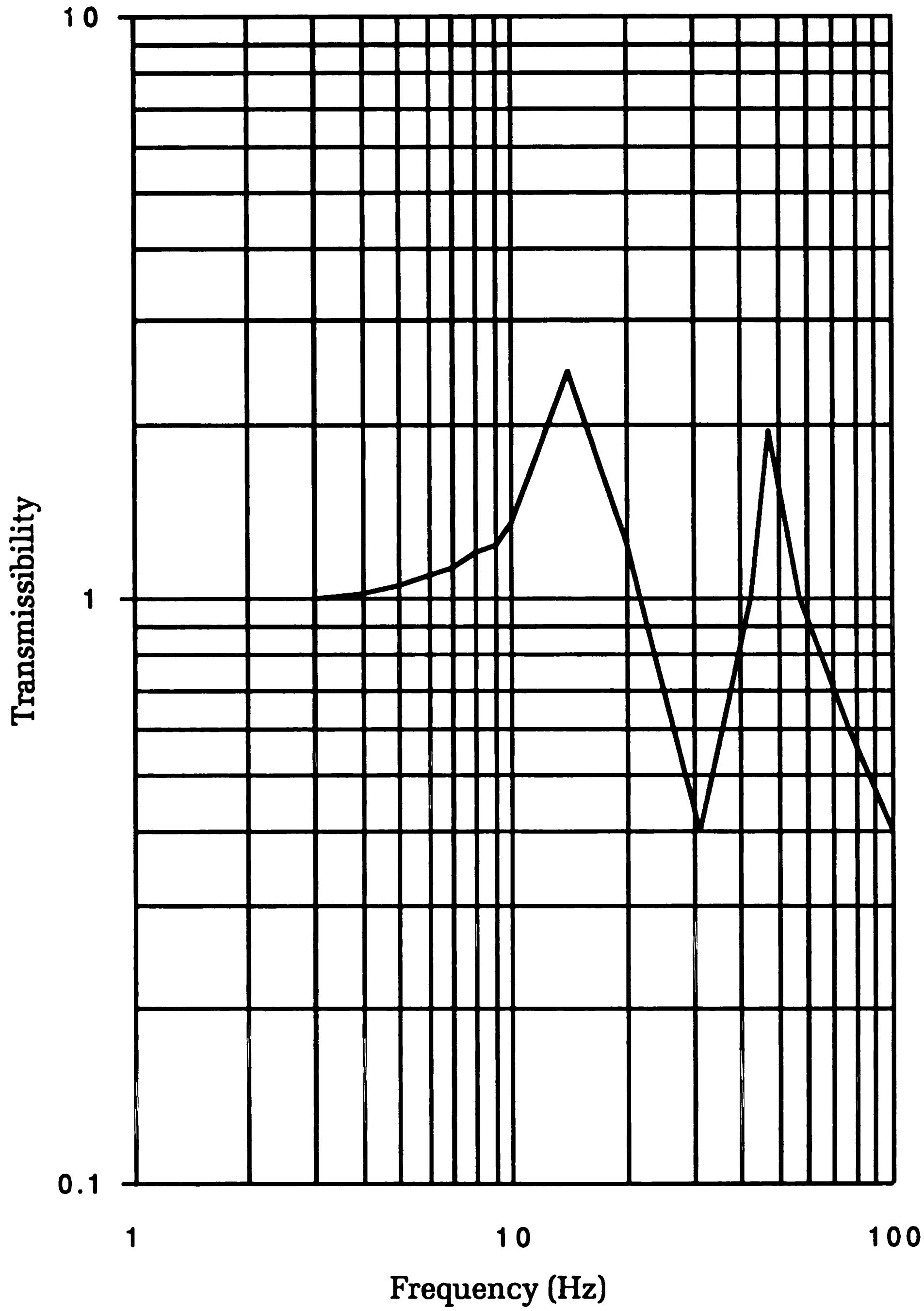

Figure 14. Resonance Search for 109 lb Load

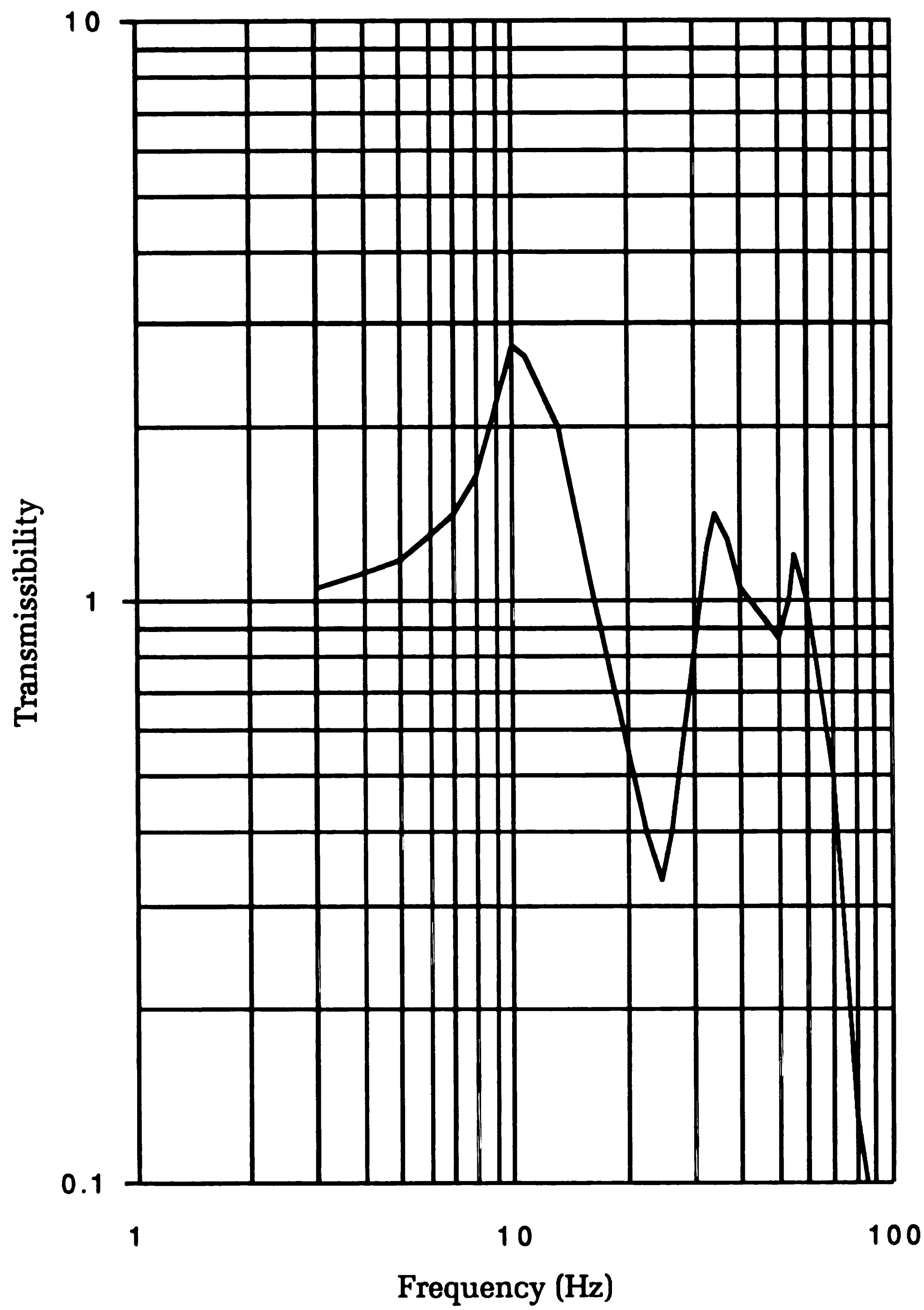

Figure 15. Resonance Search for 217 lb Load

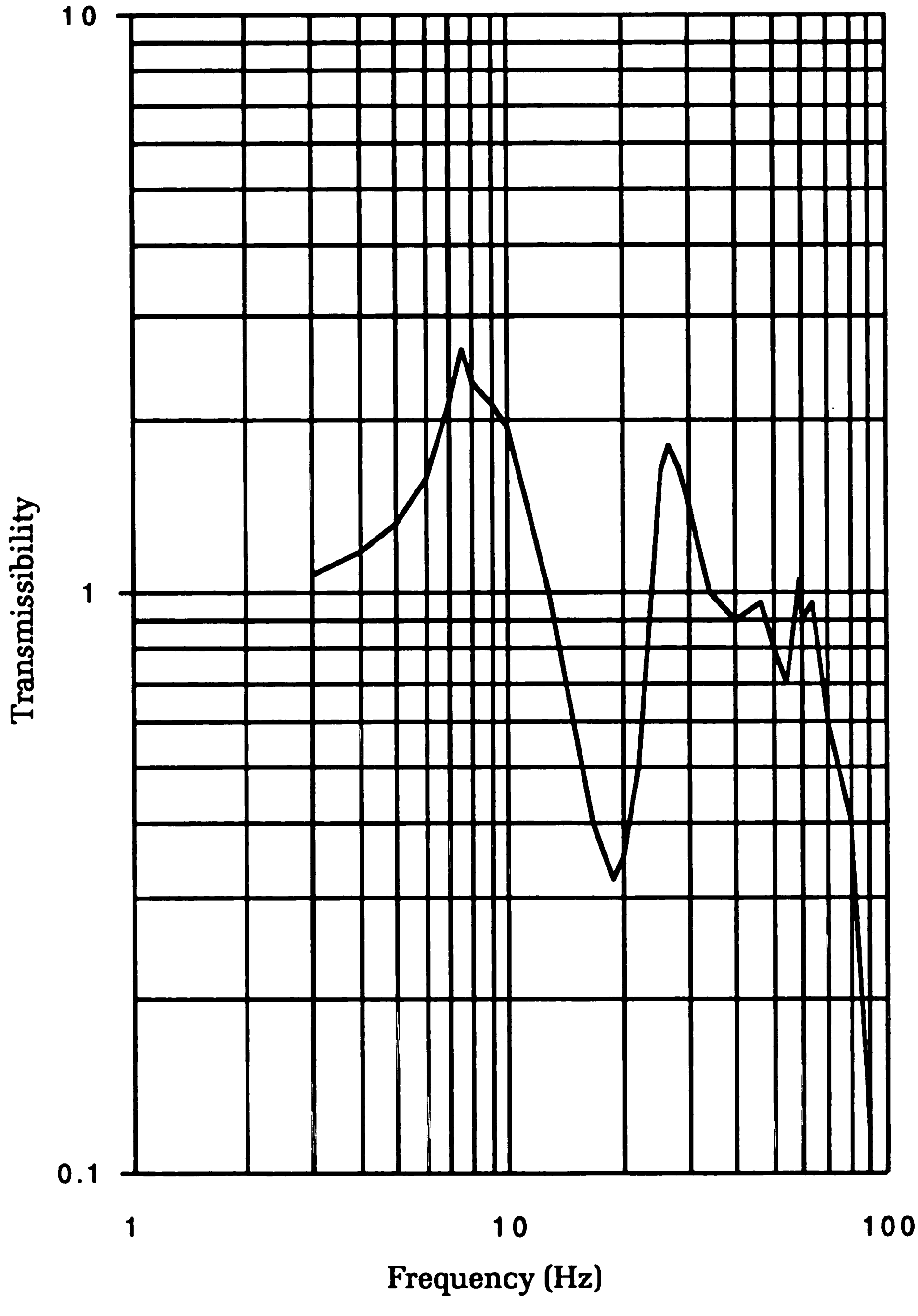

Figure 16. Resonance Search for 325 lb Load

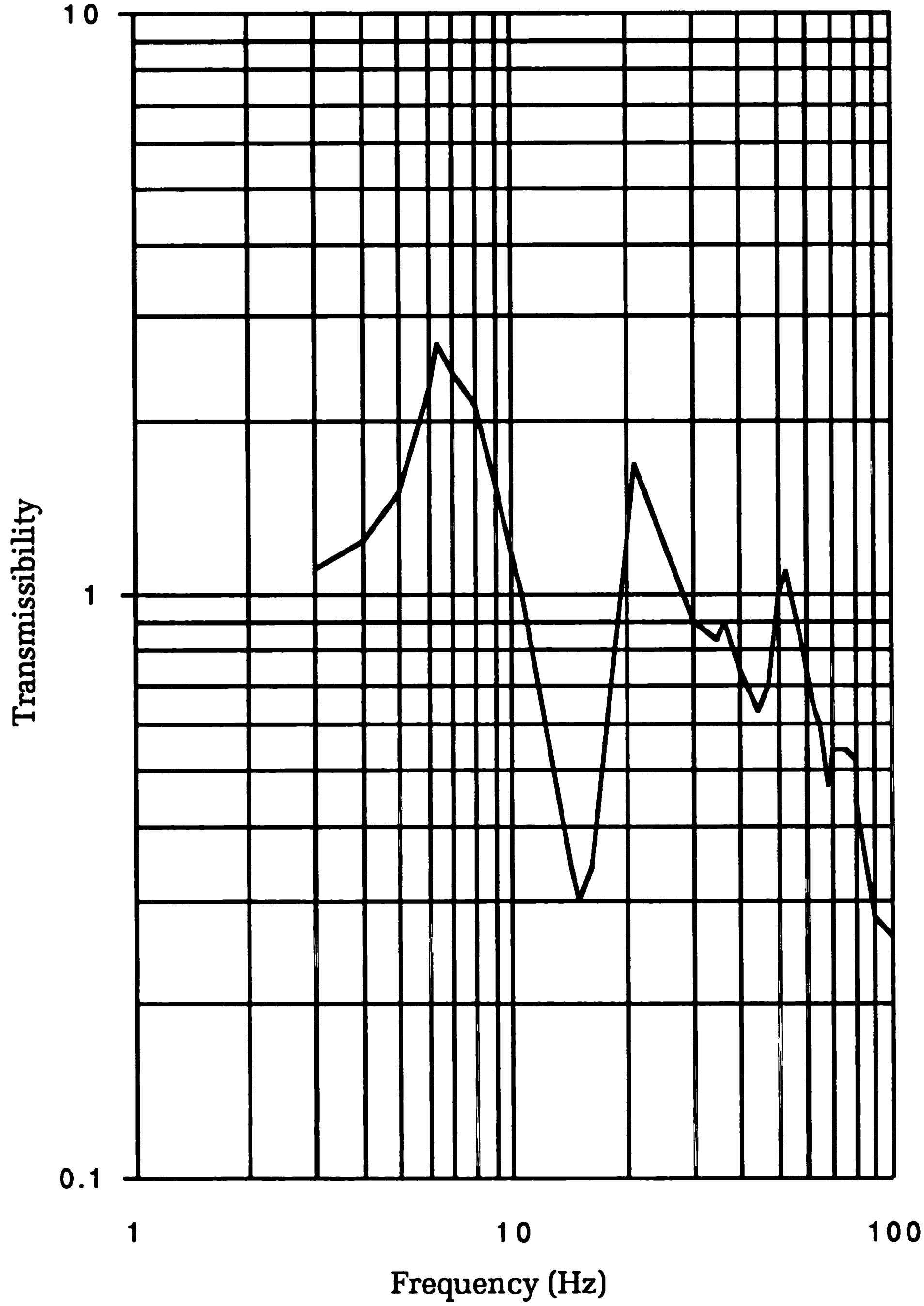

Figure 17. Resonance Search for 426 lb Load

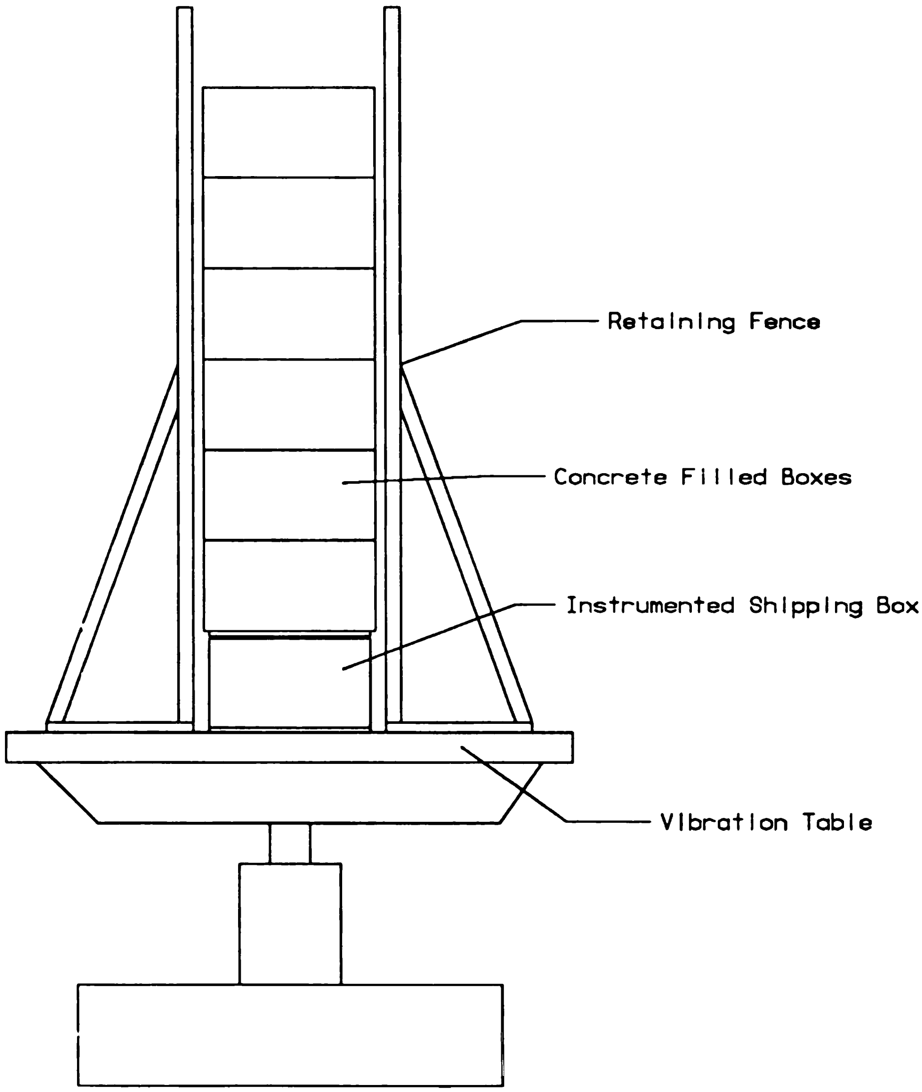

Figure 18. Simulated Shipping Test Setup

4.0 DATA AND RESULTS

The data was analyzed and the dynamic compression force values were established as a percentage of the static load. These were then plotted as a cumulative percentage of occurrence. The results of these tests were summarized in Figures 19 to 23. A complete distribution of the dynamic force readings was included as an example for the 109 lb load, vibrated using Truck Composite Spectrum, Assurance Level 1 (ASTM) (Table B-1). Since a complete distribution contained 60,000 measurements for each of the 20 tests, the data was condensed into a table format showing the dynamic force/static load versus cumulative occurrence. The lowest and highest readings for each test were also included in these tables (Table 3 to Table 7).

The shape of the graphs indicated a normal distribution of the force measurements. Approximately 50% of the measurements fell above the static load and 50% below. The normal distribution of the force measurements was consistent with the normal distribution of acceleration produced by random vibration.

The ISB reported some negative force values in most of the tests. This was true for all the spectra except inter-modal. One possible explanation is that when the vibration table produced enough acceleration to cause the entire load to lift off the ISB, the lid on the ISB also lifted. When this occurred, the measured force dropped below the level previously set as 0 lb. Also when this happened, the

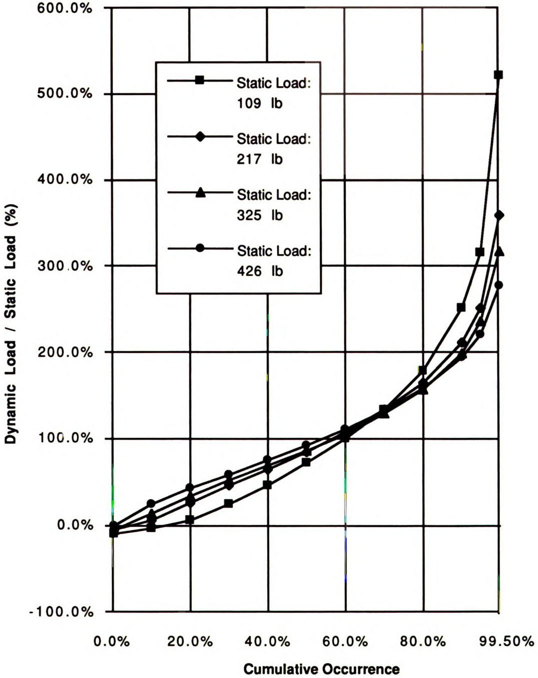

Figure 19. Dynamic Force: Truck Composite Spectra, Level 1 (ASTM)

Table 3. Data: Truck Composite Spectrum, Assurance Level 1 (ASTM)

	Dynamic Load/Static Load (%)			
Cumulative Occurrence	Static Load: 109 lb	Static Load: 217 lb	Static Load: 325 lb	Static Load: 426 lb
0.5%	-9.2%	-4.6%	-4.6%	-0.2%
10.0%	-2.8%	5.1%	13.5%	23.7%
20.0%	6.4%	25.8%	34.1%	42.3%
30.0%	24.0%	46.1%	51.6%	58.5%
40.0%	46.2%	65.0%	68.6%	75.1%
50.0%	72.0%	85.0%	86.1%	92.3%
60.0%	100.6%	107.8%	105.1%	111.0%
70.0%	134.0%	133.2%	128.5%	132.2%
80.0%	178.2%	165.0%	157.4%	158.0%
90.0%	251.2%	211.5%	198.9%	193.4%
95.0%	316.8%	251.2%	235.8%	220.2%
99.5%	520.8%	359.5%	317.3%	277.0%
Lowest reading:	-36.1%	-11.1%	-15.4%	-6.3%
Highest reading:	957.5%	583.0%	407.6%	336.2%

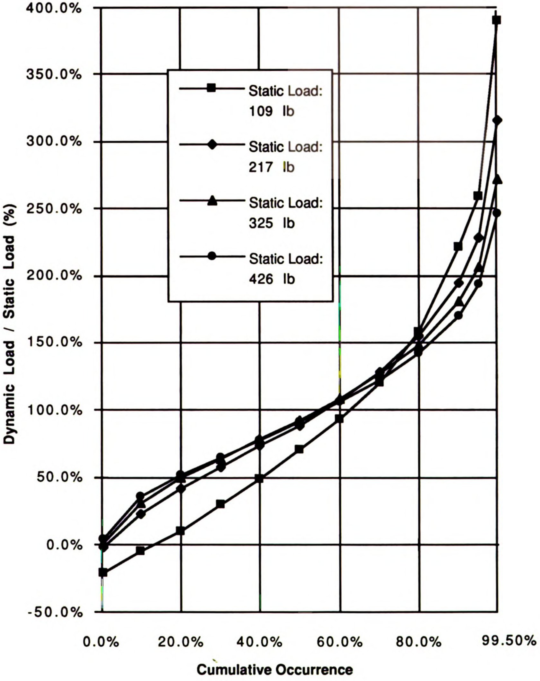

Figure 20. Dynamic Force: Truck Composite Spectra, Level 2 (ASTM)

Table 4. Data: Truck Composite Spectrum, Assurance Level 2 (ASTM)

	Dynamic Load/Static Load (%)			
Cumulative Occurrence	Static Load: 109 lb	Static Load: 217 lb	Static Load: 325 lb	Static Load: 426 lb
0.5%	-21.2%	-2.3%	1.2%	3.8%
10.0%	-4.6%	23.0%	31.1%	35.7%
20.0%	10.1%	41.9%	49.4%	51.6%
30.0%	30.3%	58.0%	63.9%	65.0%
40.0%	48.8%	73.3%	78.1%	77.9%
50.0%	70.9%	88.9%	92.8%	91.5%
60.0%	93.9%	106.9%	108.5%	106.1%
70.0%	120.6%	128.6%	127.0%	122.5%
80.0%	158.3%	155.3%	148.5%	142.0%
90.0%	221.7%	194.5%	180.4%	170.0%
95.0%	259.6%	228.1%	206.6%	193.4%
99.5%	390.4%	316.1%	272.1%	246.2%
Lowest reading:	-30.4%	-5.5%	-2.2%	-4.9%
Highest reading:	593.0%	488.9%	355.4%	297.9%

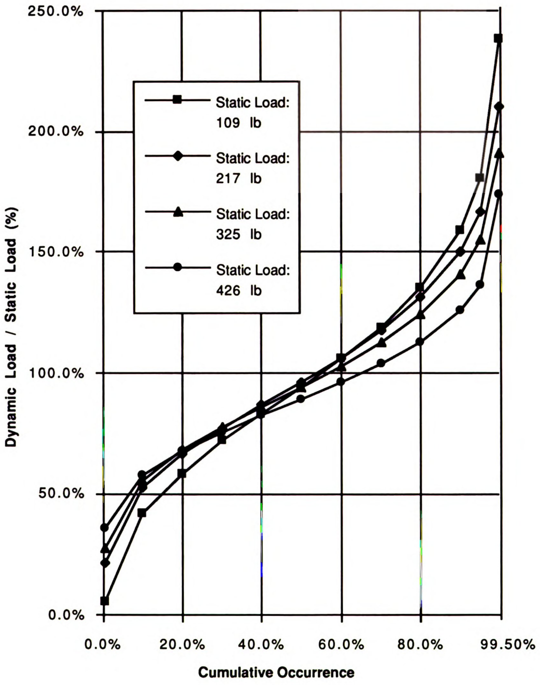

Figure 21. Dynamic Force: Rail Composite Spectra, Level 1 (ASTM)

Table 5. Data: Rail Composite Spectrum, Assurance Level 1 (ASTM)

	Dynamic Load/Static Load (%)			
Cumulative Occurrence	Static Load: 109 lb	Static Load: 217 lb	Static Load: 325 lb	Static Load: 426 lb
0.5%	6.0%	21.6%	27.7%	35.9%
10.0%	42.4%	52.5%	55.6%	57.9%
20.0%	58.0%	66.4%	67.9%	67.8%
30.0%	71.8%	77.0%	77.5%	75.0%
40.0%	82.8%	87.0%	85.8%	82.3%
50.0%	93.9%	96.0%	94.1%	88.8%
60.0%	105.9%	106.3%	103.0%	96.0%
70.0%	118.8%	117.7%	112.5%	103.7%
80.0%	135.6%	131.5%	124.5%	112.7%
90.0%	159.3%	150.2%	141.1%	125.9%
95.0%	180.5%	167.0%	155.0%	136.6%
99.5%	238.5%	210.6%	191.2%	173.9%
Lowest reading	-11.1%	-0.9%	7.1%	13.2%
Highest reading	320.4%	270.5%	254.8%	211.3%

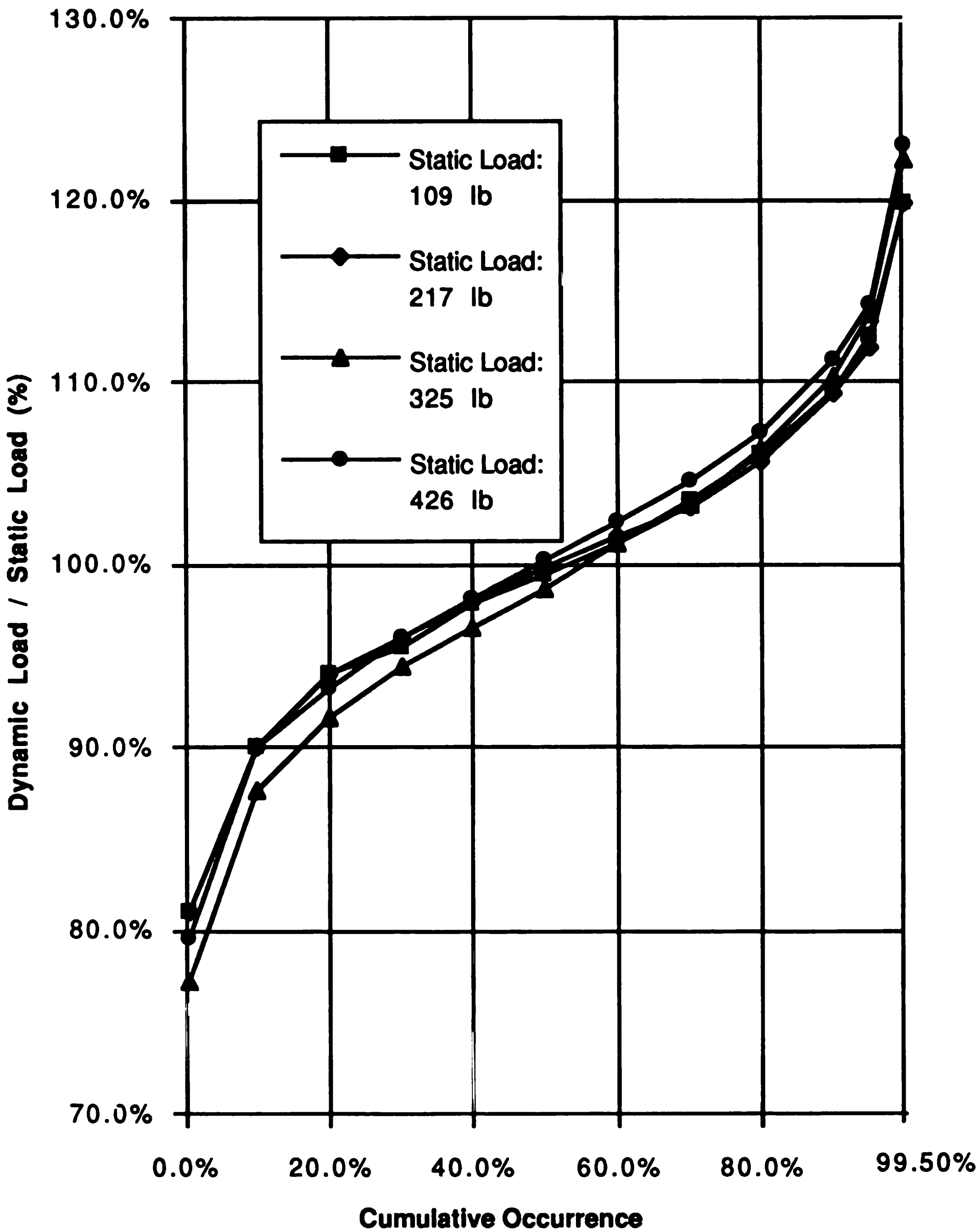

Figure 22. Dynamic Force: Inter-modal Spectrum (AAR)

Table 6. Data: Inter-modal Spectrum (AAR)

Cumulative Occurrence	Dynamic Load/Static Load (%) Static Load: 109 lb	Static Load: 217 lb	Static Load: 325 lb	Static Load: 426 lb
0.5%	81.0%	81.0%	77.2%	79.6%
10.0%	90.0%	90.0%	87.6%	90.1%
20.0%	94.0%	94.0%	91.6%	93.2%
30.0%	95.5%	96.0%	94.4%	96.0%
40.0%	97.9%	98.0%	96.5%	98.1%
50.0%	99.5%	99.9%	98.7%	100.2%
60.0%	101.2%	101.6%	101.1%	102.3%
70.0%	103.6%	103.2%	103.3%	104.6%
80.0%	106.0%	105.7%	106.4%	107.2%
90.0%	109.5%	109.4%	110.4%	111.2%
95.0%	112.5%	111.9%	113.7%	114.2%
99.5%	119.8%	119.8%	122.2%	123.0%
Lowest reading	71.20%	70.70%	69.50%	71.80%
Highest Reading	148.30%	132.30%	131.60%	135.50%

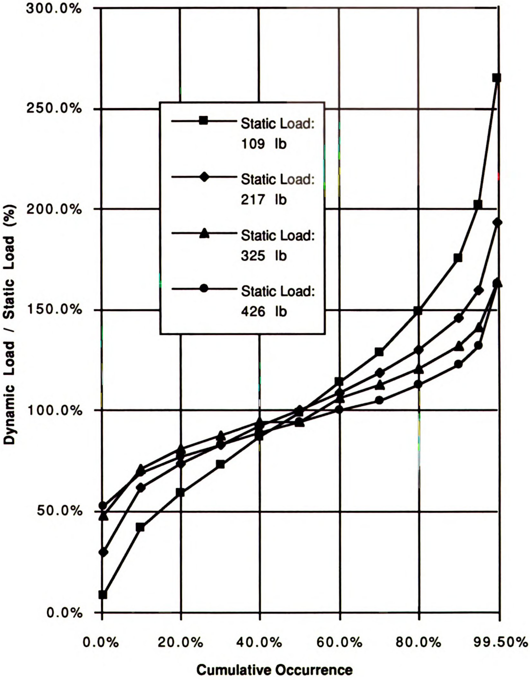

Figure 23. Dynamic Force: Truck Spectrum (Singh and Marcondes)

Table 7. Data: Truck Composite Spectrum, (Singh and Marcondes)

	Dynamic Load/Static Load (%)			
Cumulative Occurrence	Static Load: 109 lb	Static Load: 217 lb	Static Load: 325 lb	Static Load: 426 lb
0.5%	9.2%	30.4%	47.7%	52.3%
10.0%	42.0%	62.0%	71.0%	69.0%
20.0%	59.0%	74.0%	81.0%	77.0%
30.0%	73.0%	83.0%	88.0%	83.0%
40.0%	87.0%	92.0%	94.0%	89.0%
50.0%	99.0%	100.0%	94.0%	94.0%
60.0%	114.0%	109.0%	106.0%	100.0%
70.0%	129.0%	119.0%	113.0%	105.0%
80.0%	149.0%	130.0%	121.0%	113.0%
90.0%	176.0%	146.0%	132.0%	123.0%
95.0%	202.0%	160.0%	141.0%	132.0%
99.5%	265.2%	193.6%	163.9%	163.4%
Lowest reading	-10.1%	10.1%	28.9%	34.7%
Highest reading	365.6%	245.2%	189.7%	190.8%

momentum of the shear beams may have caused them to flex upward further exaggerating these negative measurements.

In tests where the acceleration level was equal at the load natural frequencies, the dynamic load/static load ratio was consistently greatest for the 109 lb, 2 box load and smallest for the 426 lb, 8 box load. This trend was seen in tests using both Truck Composite Spectra (ASTM), (Figures 19 and 20), as well as using Rail Composite Spectrum (ASTM), (Figure 21). This trend suggests that as the number of boxes increased, more energy was absorbed by the stack, lowering the dynamic load/static load ratio.

In the inter-modal test, the random vibration level was not evenly distributed across the natural frequencies of the test loads. In this test, the 426 lb, load with a natural frequency = 6 Hz, experienced the highest vibration level, while the 109 lb load, natural frequency = 12 Hz, experienced the lowest. The graph (Figure 22) shows that the heavier, lower natural frequency loads produced a higher dynamic force/static force ratio than the lighter, higher natural frequency loads. Clearly, the frequency content of the random vibration affected the dynamic compression force measured by the ISB under different loads.

5.0 CONCLUSIONS

On the basis of this study, the following conclusions were made:

1. The instrumented shipping box is capable of measuring dynamic compression forces exerted on packages during simulated shipping tests in stacked configurations.

2. Dynamic compression force can be calculated from a known mass and a measured acceleration using the equation:
   Dynamic Compression Force = Mass x (1 + Acceleration at mass center) only for loads that remain in contact during vibration.

3. The maximum compression force in a stack of boxes occurs to the bottom box.

4. Using simulated shipping environments, 99.5% of the measured forces were below a range of 1.2 to 5.2 times the static load. The maximum dynamic compression force measured was about 9.5 times the static load when using the Truck Composite Spectrum, assurance level 1 (ASTM).

5. Lighter loads containing fewer boxes produced higher dynamic load/static load ratios than heavier loads made up of more boxes.

6.0 RECOMMENDATIONS

The major limitation to the ISB's accuracy was determined by its sampling rate. Therefore, an increase in the sampling rate would decrease the maximum error threshold, below 5% and allow for more accurate measurements above the present 20 Hz vibration limit.

This study used random vibration to represent the shipping environment. For this reason, the actual amplitude and frequency of vibration was unknown at any instant of time. Similar tests could incorporate a real time vibration controller reproducing previously recorded shipments. Alternatively, the ISB could be placed in a truck during shipments. However, the reproducibility of these shipments would be limited.

Lastly, the movement of boxes on top of the ISB during vibration needs further study. This study indicates that the boxes in a stack may not be accurately described as a single mass. A time history of dynamic compression along with the acceleration at the center of mass of each box may provide a better understanding. A high speed camera may also provide insight.

LIST OF REFERENCES

LIST OF REFERENCES

ASTM. 1992a. "Standard Practice for Performance Testing of Shipping Containers and Systems." ASTM Standard D 4169 - 92a.

"Study of the Shock and Vibration Environment in Boxcars." Association of American Railroads. Report #DP7-92, Washington, DC, November, 1992

Brandenburg, R.K. and Lee, J.J. "Fundamentals of Packaging Dynamics." MTS Systems Corporation. Minneapolis, Minnesota, 1990.

Boonyasarn, A. "The Effect of Cyclic Environments on the Compression Strength of Boxes Made from High-Performance (Fiber-Efficient) Corrugated Fiberboards." 1990.

Kellicutt, K.Q. "Effect of Contents and Load Bearing Surface on Compressive Strength and Stacking Life on Corrugated Containers." 1963.

Koning, J.W. and Godshall, W.D. "Effect of Repeated Recycling of Fiber on Corrugated Container Strength.", Paperboard Packaging, December 1975, pp. 37-40.

Laufenberg, T.L. "Cyclic Humidity Effect on Paperboard Packaging." Forest Products Lab, Madison, Wisconsin, September 1992

Moody, R.C., and Skidmore, K.E., 1966. " How Dead Load Downward Creep Influences Corrugated Box Design."

Singh, S.P. and Marcondes, J. "Vibration Levels in Commercial Truck Shipments as a Function of Suspension and Payload," Journal of Testing And Evaluation, Vol. 20, No. 6, November 1992.

APPENDICES

APPENDIX A

Calculating Force Using F = m(1+A)

To verify that Newton's law was being applied correctly, a force transducer was securely fastened to a small vibration table. On top of the transducer was a mass, glued to a 2 in. thick piece of polyurethane foam (Figure A-1). This created a spring mass system with a natural frequency of 21 Hz. Since the mass and foam were glued together, there was no separation or "bouncing" even when the acceleration exceeded 1 g. An accelerometer was mounted close to the mass center and fed to an oscilloscope. The transducer was also connected to the oscilloscope. The acceleration and compression force were recorded at various frequencies with the vibration table running at a constant acceleration of 0.5 g's. The results are shown in Figure A-2. This graph clearly shows that Newton's law was being applied correctly and dynamic force could be calculated from a measured acceleration.

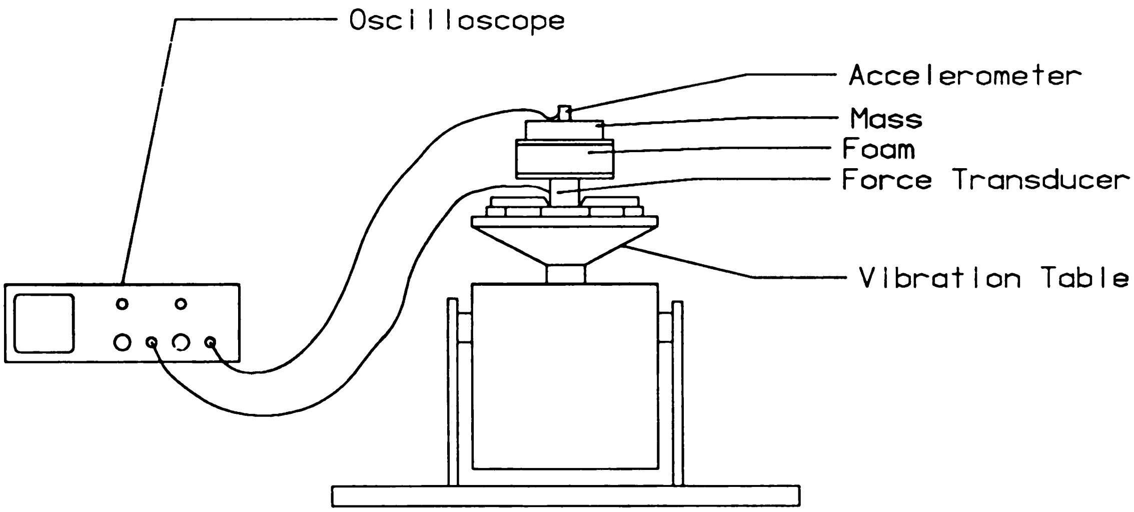

Figure A-1. Force Transducer Test Setup

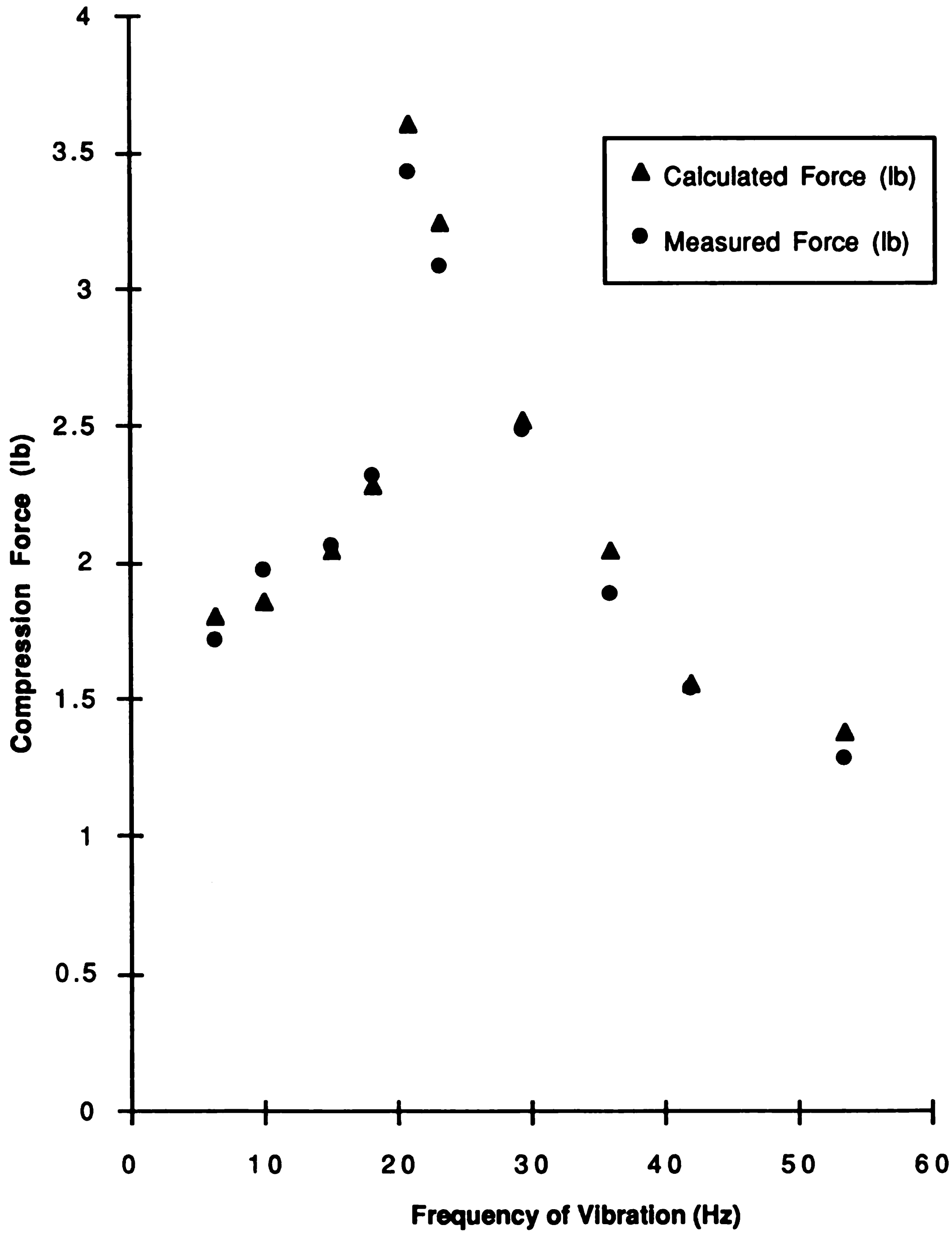

Figure A-2. Calculated vs. Measured Force Transducer

APPENDIX B

Table B-1 Complete Data for Composite Truck Spectrum, Level 1

Load: 109 lb		Load: 217 lb		Load: 325 lb		Load: 426 lb	
Dynamic Force (lb)	Number of Readings	Dynamic Force (lb)	Number of Readings	Dynamic Force (lb)	Number of Readings	Dynamic Force (lb)	Number of Readings
-39	1	-24	1	-50	1	-27	1
-29	2	-22	4	-29	1	-18	1
-23	2	-21	3	-28	2	-13	1
-22	2	-19	1	-27	2	-12	1
-21	2	-18	3	-26	1	-11	1
-20	1	-17	6	-24	1	-10	1
-19	1	-16	5	-23	5	-9	1
-18	3	-15	16	-22	5	-7	14
-17	6	-13	34	-21	7	-6	16
-16	14	-12	58	-20	16	-5	29
-15	15	-11	89	-18	21	-4	50
-14	1	-10	131	-17	30	-3	11
-13	27	-9	207	-16	74	-2	62
-12	39	-8	1	-15	185	-1	133
-11	60	-7	347	-13	269	0	194
-10	89	-6	682	-12	295	1	157
-9	171	-5	814	-11	277	2	134
-8	6	-4	672	-10	272	4	104
-7	331	-3	1	-9	265	5	90
-6	890	-2	518	-7	210	6	58
-5	1806	-1	368	-6	145	7	69
-4	2383	0	243	-5	126	8	60
-3	4	1	248	-4	135	9	4

Table B-1 (cont.)

-2	1371	2	236	-3	68	10	52
-1	1112	3	4	-2	52	11	59
0	836	4	222	-1	118	12	48
1	628	5	212	0	102	13	61
2	613	6	198	1	118	15	52
3	2	7	166	2	97	16	62
4	511	8	63	3	3	17	60
5	480	9	126	4	90	18	49
6	487	10	184	5	90	19	60
7	445	11	196	6	80	20	1
8	108	12	182	7	77	21	72
9	362	13	201	8	74	22	52
10	408	14	7	9	7	23	56
11	397	15	157	10	72	24	55
12	429	16	149	11	87	25	34
13	400	17	177	12	81	26	16
14	24	18	170	13	107	27	65
15	401	19	145	14	15	28	61
16	431	20	20	15	80	29	50
17	386	21	183	16	71	30	56
18	336	22	152	17	83	31	1
19	318	23	167	18	97	32	59
20	55	24	137	19	88	33	46
21	364	25	44	20	3	34	59
22	359	26	107	21	95	35	42
23	378	27	162	22	91	36	49
24	313	28	159	23	97	37	3
25	82	29	182	24	89	38	61
26	244	30	140	25	61	39	59
27	303	31	6	26	21	40	66
28	301	32	182	27	97	41	60
29	310	33	151	28	90	42	13
30	301	34	135	29	94	43	40
31	17	35	173	30	96	44	55
32	303	36	114	31	5	45	55
33	344	37	49	32	71	46	68
34	298	38	156	33	85	47	62

Table B-1 (cont.)

35	296	39	148	34	81	48	1
36	192	40	144	35	93	49	66
37	93	41	143	36	93	50	49
38	288	42	19	37	1	51	52
39	310	43	140	38	87	52	54
40	319	44	142	39	92	53	38
41	316	45	152	40	109	54	8
42	50	46	142	41	83	55	82
43	252	47	155	42	54	56	55
44	309	48	10	43	58	57	75
45	253	49	157	44	110	58	70
46	246	50	160	45	79	59	3
47	280	51	160	46	101	60	58
48	36	52	176	47	98	61	60
49	275	53	87	48	7	62	74
50	298	54	79	49	101	63	71
51	305	55	170	50	100	64	62
52	256	56	153	51	94	65	6
53	139	57	167	52	110	66	49
54	156	58	160	53	74	67	63
55	266	59	13	54	9	68	58
56	270	60	156	55	97	69	67
57	288	61	168	56	103	70	20
58	250	62	146	57	92	71	31
59	47	63	154	58	93	72	65
60	211	64	135	59	8	73	72
61	254	65	43	60	81	74	74
62	242	66	189	61	96	75	68
63	254	67	179	62	113	76	2
64	178	68	161	63	102	77	83
65	73	69	148	64	110	78	58
66	273	70	42	65	5	79	55
67	274	71	109	66	89	80	81
68	247	72	169	67	98	81	53
69	232	73	180	68	98	82	14
70	109	74	151	69	127	83	78
71	156	75	177	70	64	84	59

Table B-1 (cont.)

72	229	76	15	71	32	85	92
73	229	77	169	72	103	86	76
74	252	78	168	73	115	87	12
75	247	79	159	74	112	88	61
76	51	80	162	75	106	89	71
77	210	81	104	76	17	90	78
78	203	82	58	77	74	91	67
79	279	83	184	78	110	92	76
80	248	84	184	79	104	93	3
81	154	85	186	80	103	94	69
82	103	86	175	81	124	95	74
83	217	87	32	82	7	96	83
84	267	88	136	83	115	97	70
85	212	89	175	84	103	98	43
86	236	90	142	85	114	99	35
87	90	91	192	86	111	100	71
88	162	92	157	87	61	101	83
89	210	93	23	88	66	102	75
90	243	94	161	89	109	103	76
91	240	95	147	90	124	104	3
92	201	96	159	91	116	105	73
93	66	97	167	92	112	106	93
94	216	98	97	93	4	107	70
95	283	99	95	94	115	108	88
96	211	100	193	95	114	109	76
97	235	101	167	96	120	110	17
98	131	102	162	97	123	111	88
99	125	103	171	98	96	112	87
100	233	104	22	99	16	113	84
101	231	105	160	100	126	114	66
102	191	106	172	101	132	115	18
103	233	107	161	102	117	116	63
104	66	108	180	103	121	117	85
105	196	109	124	104	21	118	95
106	203	110	45	105	95	119	101
107	212	111	149	106	119	120	90
108	221	112	154	107	131	121	4

Table B-1 (cont.)

109	145	113	182	108	125	122	81
110	74	114	187	109	109	123	91
111	197	115	65	110	9	124	86
112	213	116	118	111	131	125	80
113	208	117	172	112	116	126	63
114	208	118	177	113	129	127	28
115	94	119	158	114	130	128	95
116	138	120	178	115	70	129	78
117	206	121	35	116	60	130	95
118	226	122	174	117	137	131	81
119	199	123	197	118	112	132	12
120	166	124	169	119	121	133	64
121	58	125	183	120	116	134	108
122	190	126	95	121	5	135	89
123	222	127	65	122	95	136	105
124	214	128	173	123	120	137	90
125	212	129	177	124	108	138	6
126	131	130	180	125	119	139	95
127	101	131	160	126	111	140	83
128	175	132	53	127	17	141	109
129	185	133	109	128	116	142	85
130	213	134	188	129	123	143	35
131	182	135	166	130	132	144	58
132	80	136	164	131	133	145	92
133	133	137	136	132	54	146	92
134	197	138	41	133	78	147	100
135	196	139	170	134	130	148	94
136	169	140	194	135	118	149	16
137	152	141	171	136	134	150	69
138	71	142	161	137	127	151	100
139	153	143	89	138	10	152	91
140	185	144	87	139	139	153	100
141	174	145	143	140	118	154	68
142	173	146	163	141	157	155	19
143	96	147	175	142	114	156	98
144	106	148	147	143	104	157	84
145	180	149	35	144	33	158	104

Table B-1 (cont.)

146	190	150	151	145	137	159	96
147	194	151	151	146	120	160	14
148	143	152	155	147	116	161	68
149	68	153	163	148	145	162	110
150	123	154	124	149	33	163	111
151	163	155	50	150	121	164	104
152	191	156	178	151	131	165	88
153	191	157	157	152	146	166	15
154	108	158	177	153	143	167	113
155	69	159	166	154	122	168	79
156	158	160	63	155	5	169	107
157	146	161	117	156	115	170	112
158	155	162	152	157	139	171	46
159	132	163	174	158	144	172	51
160	77	164	179	159	99	173	105
161	93	165	121	160	61	174	97
162	180	166	41	161	63	175	96
163	173	167	144	162	148	176	109
164	161	168	167	163	112	177	18
165	136	169	166	164	133	178	81
166	67	170	135	165	139	179	114
167	119	171	91	166	14	180	108
168	154	172	72	167	147	181	103
169	161	173	189	168	130	182	74
170	147	174	151	169	134	183	22
171	80	175	175	170	128	184	93
172	75	176	154	171	97	185	97
173	136	177	67	172	23	186	94
174	151	178	107	173	131	187	105
175	141	179	168	174	136	188	32
176	127	180	153	175	127	189	53
177	65	181	146	176	139	190	114
178	118	182	122	177	46	191	99
179	133	183	48	178	87	192	108
180	142	184	133	179	144	193	100
181	148	185	154	180	131	194	11
182	102	186	168	181	151	195	99

Table B-1 (cont.)

183	64	187	158	182	126	196	109
184	119	188	82	183	12	197	114
185	123	189	73	184	125	198	96
186	124	190	160	185	149	199	71
187	138	191	154	186	130	200	42
188	70	192	172	187	120	201	114
189	59	193	136	188	88	202	110
190	127	194	52	189	33	203	101
191	120	195	123	190	124	204	93
192	129	196	161	191	123	205	32
193	113	197	158	192	144	206	84
194	65	198	170	193	137	207	101
195	98	199	113	194	22	208	117
196	118	200	51	195	122	209	126
197	127	201	148	196	147	210	103
198	122	202	156	197	131	211	22
199	100	203	145	198	126	212	102
200	58	204	138	199	127	213	81
201	113	205	70	200	30	214	99
202	110	206	100	201	133	215	107
203	103	207	123	202	141	216	37
204	103	208	172	203	131	217	62
205	58	209	168	204	113	218	95
206	78	210	120	205	62	219	122
207	105	211	33	206	66	220	104
208	109	212	148	207	138	221	116
209	116	213	149	208	136	222	26
210	82	214	148	209	120	223	86
211	47	215	147	210	135	224	86
212	82	216	87	211	14	225	91
213	131	217	62	212	124	226	109
214	86	218	148	213	141	227	58
215	96	219	154	214	144	228	40
216	55	220	161	215	103	229	116
217	62	221	149	216	100	230	92
218	77	222	61	217	36	231	83
219	89	223	86	218	134	232	92

Table B-1 (cont.)

220	103	224	121	219	123	233	23
221	82	225	149	220	109	234	71
222	58	226	138	221	129	235	122
223	74	227	116	222	38	236	110
224	74	228	59	223	105	237	100
225	85	229	130	224	144	238	96
226	107	230	132	225	124	239	30
227	72	231	147	226	137	240	113
228	53	232	128	227	121	241	111
229	79	233	91	228	30	242	110
230	80	234	89	229	107	243	116
231	83	235	137	230	123	244	62
232	79	236	168	231	135	245	51
233	55	237	153	232	143	246	104
234	57	238	107	233	66	247	101
235	87	239	53	234	69	248	107
236	79	240	137	235	119	249	93
237	88	241	140	236	151	250	35
238	76	242	147	237	141	251	81
239	41	243	142	238	140	252	111
240	65	244	92	239	22	253	104
241	83	245	53	240	111	254	82
242	83	246	129	241	155	255	111
243	60	247	127	242	147	256	33
244	55	248	152	243	115	257	95
245	42	249	116	244	105	258	110
246	63	250	64	245	27	259	102
247	76	251	71	246	119	260	121
248	78	252	136	247	115	261	35
249	72	253	142	248	135	262	74
250	47	254	122	249	132	263	112
251	52	255	116	250	49	264	101
252	73	256	55	251	76	265	90
253	73	257	141	252	148	266	114
254	83	258	157	253	128	267	32
255	51	259	118	254	112	268	80
256	43	260	113	255	107	269	96

Table B-1 (cont.)

257	66	261	75	256	27	270	110
258	67	262	44	257	127	271	91
259	71	263	126	258	118	272	66
260	64	264	129	259	133	273	54
261	49	265	125	260	122	274	94
262	48	266	107	261	73	275	117
263	68	267	46	262	48	276	101
264	89	268	93	263	112	277	96
265	94	269	136	264	128	278	23
266	52	270	146	265	131	279	82
267	26	271	129	266	109	280	99
268	47	272	103	267	35	281	102
269	52	273	44	268	100	282	113
270	67	274	115	269	99	283	80
271	63	275	111	270	144	284	34
272	54	276	121	271	132	285	100
273	39	277	135	272	101	286	91
274	63	278	48	273	27	287	102
275	79	279	59	274	112	288	103
276	42	280	113	275	110	289	45
277	41	281	123	276	123	290	48
278	42	282	143	277	121	291	105
279	39	283	91	278	53	292	112
280	47	284	48	279	65	293	105
281	73	285	88	280	116	294	78
282	61	286	120	281	131	295	21
283	46	287	118	282	117	296	67
284	35	288	113	283	128	297	98
285	46	289	93	284	31	298	97
286	47	290	44	285	130	299	82
287	60	291	107	286	123	300	77
288	55	292	112	287	117	301	38
289	38	293	122	288	105	302	80
290	34	294	97	289	84	303	101
291	57	295	55	290	39	304	107
292	61	296	63	291	121	305	98
293	64	297	106	292	127	306	20

Table B-1 (cont.)

294	42	298	141	293	122	307	90
295	44	299	116	294	122	308	99
296	46	300	87	295	33	309	132
297	35	301	42	296	84	310	104
298	59	302	80	297	120	311	94
299	46	303	128	298	112	312	30
300	33	304	107	299	101	313	87
301	29	305	108	300	103	314	103
302	26	306	81	301	27	315	105
303	54	307	52	302	113	316	108
304	54	308	96	303	110	317	53
305	39	309	108	304	118	318	51
306	42	310	119	305	103	319	86
307	31	311	102	306	71	320	118
308	50	312	60	307	63	321	113
309	61	313	73	308	88	322	112
310	43	314	110	309	105	323	30
311	42	315	96	310	135	324	71
312	39	316	85	311	98	325	92
313	29	317	88	312	29	326	89
314	45	318	42	313	101	327	106
315	44	319	109	314	102	328	94
316	38	320	129	315	103	329	30
317	37	321	100	316	116	330	88
318	22	322	102	317	75	331	127
319	32	323	58	318	34	332	98
320	42	324	38	319	116	333	92
321	41	325	94	320	107	334	30
322	40	326	105	321	107	335	73
323	25	327	90	322	107	336	102
324	31	328	88	323	39	337	99
325	36	329	38	324	84	338	109
326	36	330	85	325	115	339	102
327	31	331	103	326	100	340	33
328	37	332	101	327	105	341	76
329	30	333	73	328	90	342	85
330	29	334	88	329	18	343	98

Table B-1 (cont.)

331	42	335	58	330	116	344	93
332	36	336	90	331	133	345	58
333	31	337	97	332	111	346	44
334	31	338	93	333	100	347	96
335	27	339	104	334	75	348	114
336	29	340	58	335	50	349	105
337	33	341	54	336	134	350	108
338	33	342	100	337	105	351	37
339	31	343	105	338	111	352	57
340	23	344	101	339	105	353	106
341	21	345	82	340	33	354	114
342	36	346	48	341	72	355	115
343	39	347	67	342	127	356	82
344	39	348	95	343	96	357	30
345	24	349	110	344	105	358	77
346	20	350	90	345	80	359	102
347	20	351	66	346	38	360	91
348	30	352	48	347	96	361	79
349	28	353	88	348	117	362	37
350	31	354	127	349	107	363	55
351	15	355	87	350	128	364	87
352	26	356	70	351	46	365	90
353	23	357	59	352	53	366	89
354	27	358	64	353	106	367	104
355	25	359	97	354	101	368	30
356	20	360	88	355	108	369	66
357	27	361	89	356	85	370	100
358	26	362	65	357	26	371	108
359	30	363	47	358	60	372	106
360	33	364	62	359	105	373	51
361	18	365	93	360	98	374	47
362	16	366	81	361	86	375	81
363	27	367	68	362	75	376	102
364	24	368	68	363	31	377	102
365	34	369	46	364	110	378	108
366	34	370	88	365	100	379	37
367	39	371	68	366	92	380	83

Table B-1 (cont.)

368	24	372	92	367	90	381	81
369	26	373	62	368	44	382	112
370	22	374	44	369	73	383	99
371	18	375	59	370	96	384	97
372	22	376	84	371	94	385	41
373	17	377	86	372	99	386	70
374	19	378	82	373	76	387	93
375	18	379	60	374	34	388	107
376	17	380	45	375	74	389	81
377	23	381	63	376	101	390	51
378	29	382	79	377	84	391	63
379	24	383	72	378	82	392	91
380	19	384	75	379	66	393	88
381	20	385	61	380	49	394	90
382	28	386	33	381	82	395	93
383	24	387	80	382	100	396	31
384	27	388	77	383	111	397	78
385	21	389	89	384	81	398	98
386	18	390	66	385	26	399	100
387	20	391	41	386	89	400	106
388	24	392	52	387	94	401	78
389	18	393	80	388	93	402	43
390	24	394	77	389	95	403	70
391	14	395	76	390	67	404	77
392	14	396	49	391	28	405	100
393	19	397	41	392	86	406	95
394	16	398	75	393	98	407	37
395	18	399	89	394	100	408	68
396	17	400	64	395	106	409	81
397	18	401	69	396	41	410	103
398	21	402	42	397	63	411	87
399	20	403	51	398	86	412	80
400	11	404	81	399	88	413	36
401	9	405	71	400	95	414	83
402	18	406	84	401	77	415	92
403	11	407	51	402	33	416	89
404	9	408	53	403	93	417	101

Table B-1 (cont.)

405	12	409	56	404	99	418	65
406	19	410	70	405	83	419	50
407	17	411	61	406	76	420	73
408	11	412	67	407	64	421	79
409	13	413	56	408	47	422	77
410	28	414	37	409	83	423	104
411	16	415	66	410	103	424	34
412	19	416	61	411	91	425	76
413	12	417	64	412	85	426	86
414	14	418	50	413	36	427	88
415	19	419	33	414	62	428	100
416	23	420	53	415	82	429	96
417	12	421	72	416	96	430	43
418	15	422	63	417	101	431	73
419	16	423	62	418	86	432	84
420	13	424	68	419	29	433	76
421	17	425	37	420	83	434	95
422	16	426	45	421	98	435	52
423	22	427	60	422	87	436	55
424	15	428	59	423	81	437	72
425	12	429	51	424	43	438	77
426	10	430	51	425	43	439	80
427	18	431	30	426	101	440	67
428	19	432	68	427	77	441	36
429	15	433	62	428	71	442	78
430	13	434	73	429	75	443	81
431	15	435	46	430	30	444	92
432	18	436	32	431	68	445	87
433	14	437	48	432	92	446	80
434	16	438	49	433	75	447	39
435	7	439	46	434	84	448	87
436	9	440	60	435	64	449	78
437	13	441	41	436	45	450	90
438	13	442	30	437	78	451	77
439	18	443	40	438	94	452	39
440	15	444	56	439	85	453	67
441	10	445	68	440	79	454	78

Table B-1 (cont.)

442	12	446	36	441	45	455	85
443	5	447	31	442	57	456	82
444	11	448	30	443	99	457	74
445	11	449	61	444	88	458	32
446	10	450	40	445	70	459	71
447	11	451	69	446	73	460	77
448	10	452	49	447	28	461	92
449	10	453	20	448	79	462	76
450	15	454	49	449	73	463	59
451	8	455	51	450	69	464	56
452	10	456	46	451	66	465	60
453	15	457	54	452	54	466	77
454	11	458	43	453	31	467	79
455	13	459	38	454	67	468	77
456	2	460	47	455	74	469	40
457	12	461	58	456	74	470	70
458	9	462	52	457	66	471	61
459	7	463	45	458	26	472	90
460	10	464	34	459	50	473	91
461	17	465	33	460	65	474	70
462	13	466	59	461	66	475	39
463	8	467	48	462	81	476	80
464	9	468	61	463	70	477	80
465	10	469	29	464	34	478	90
466	13	470	28	465	67	479	90
467	13	471	43	466	84	480	41
468	12	472	45	467	73	481	61
469	4	473	40	468	66	482	76
470	10	474	53	469	44	483	75
471	9	475	28	470	47	484	100
472	15	476	23	471	79	485	77
473	5	477	35	472	63	486	34
474	6	478	46	473	83	487	58
475	5	479	35	474	68	488	78
476	3	480	44	475	27	489	76
477	6	481	36	476	55	490	82
478	6	482	29	477	75	491	53

Table B-1 (cont.)

479	7	483	47	478	76	492	54
480	7	484	41	479	76	493	61
481	5	485	39	480	59	494	82
482	9	486	37	481	36	495	91
483	11	487	22	482	76	496	87
484	8	488	38	483	60	497	26
485	7	489	39	484	64	498	67
486	11	490	36	485	61	499	64
487	10	491	34	486	34	500	88
488	7	492	22	487	45	501	85
489	11	493	30	488	62	502	65
490	7	494	53	489	72	503	30
491	6	495	35	490	77	504	70
492	5	496	34	491	54	505	65
493	4	497	40	492	27	506	85
494	7	498	23	493	59	507	89
495	12	499	37	494	66	508	39
496	5	500	40	495	84	509	62
497	7	501	43	496	56	510	62
498	6	502	45	497	40	511	78
499	5	503	35	498	35	512	78
500	7	504	19	499	71	513	92
501	6	505	27	500	86	514	29
502	9	506	45	501	65	515	78
503	6	507	43	502	70	516	67
504	10	508	30	503	33	517	70
505	8	509	24	504	46	518	68
506	11	510	25	505	66	519	64
507	1	511	44	506	60	520	48
508	6	512	45	507	72	521	58
509	3	513	40	508	46	522	81
510	6	514	29	509	27	523	80
511	6	515	18	510	57	524	87
512	6	516	35	511	65	525	36
513	7	517	39	512	64	526	64
514	5	518	43	513	61	527	61
515	2	519	28	514	46	528	74

Table B-1 (cont.)

516	8	520	30	515	49	529	74
517	3	521	13	516	60	530	69
518	7	522	27	517	51	531	39
519	7	523	40	518	80	532	76
520	6	524	28	519	32	533	54
521	6	525	34	520	22	534	78
522	7	526	36	521	57	535	82
523	6	527	30	522	56	536	54
524	5	528	35	523	68	537	34
525	4	529	28	524	62	538	58
526	3	530	36	525	39	539	68
527	6	531	32	526	35	540	90
528	7	532	23	527	58	541	81
529	9	533	28	528	57	542	31
530	5	534	24	529	57	543	66
531	1	535	36	530	45	544	67
532	4	536	24	531	24	545	74
533	4	537	16	532	48	546	77
534	3	538	22	533	64	547	52
535	6	539	34	534	65	548	39
536	3	540	35	535	73	549	57
537	4	541	37	536	38	550	61
538	1	542	16	537	27	551	82
539	3	543	16	538	53	552	90
540	4	544	30	539	66	553	50
541	5	545	24	540	62	554	50
542	2	546	29	541	55	555	67
543	3	547	20	542	35	556	74
544	3	548	24	543	50	557	77
545	4	549	10	544	62	558	73
546	6	550	18	545	50	559	36
547	3	551	32	546	53	560	56
548	2	552	34	547	45	561	59
549	5	553	24	548	27	562	75
550	3	554	22	549	50	563	84
551	8	555	20	550	56	564	57
552	4	556	18	551	74	565	32

Table B-1 (cont.)

553	2	557	26	552	61	566	80
554	3	558	29	553	35	567	72
555	3	559	28	554	30	568	88
556	3	560	19	555	61	569	73
557	5	561	20	556	54	570	25
558	3	562	24	557	59	571	48
559	2	563	23	558	57	572	59
560	1	564	30	559	28	573	66
561	7	565	24	560	36	574	86
562	1	566	21	561	52	575	61
563	1	567	23	562	62	576	31
564	3	568	21	563	48	577	75
565	5	569	25	564	41	578	58
566	4	570	23	565	21	579	71
567	1	571	11	566	53	580	73
568	5	572	16	567	60	581	44
569	3	573	24	568	59	582	42
570	2	574	15	569	48	583	55
571	5	575	19	570	35	584	68
572	6	576	21	571	24	585	66
573	2	577	4	572	52	586	58
574	2	578	21	573	61	587	25
575	1	579	18	574	60	588	64
576	3	580	29	575	59	589	51
577	4	581	22	576	29	590	64
578	4	582	18	577	34	591	64
580	2	583	13	578	57	592	67
581	2	584	10	579	55	593	36
582	1	585	22	580	58	594	55
583	2	586	16	581	37	595	63
584	5	587	25	582	28	596	62
585	1	588	15	583	41	597	61
586	4	589	17	584	56	598	49
588	3	590	23	585	46	599	43
589	2	591	20	586	53	600	66
590	3	592	24	587	30	601	60
591	4	593	12	588	27	602	70

Table B-1 (cont.)

592	2	594	12	589	39	603	72
593	7	595	17	590	54	604	32
594	2	596	25	591	59	605	67
595	2	597	18	592	39	606	48
596	3	598	23	593	27	607	70
597	4	599	11	594	47	608	61
600	2	600	12	595	44	609	48
601	1	601	18	596	43	610	21
602	3	602	21	597	50	611	73
603	1	603	15	598	28	612	63
604	4	604	18	599	38	613	59
605	2	605	12	600	42	614	60
606	2	606	12	601	36	615	31
607	3	607	21	602	49	616	58
608	4	608	34	603	33	617	62
610	3	609	22	604	25	618	61
611	5	610	13	605	38	619	61
612	3	611	15	606	45	620	55
614	2	612	16	607	49	621	31
615	4	613	20	608	46	622	67
616	6	614	13	609	27	623	63
617	2	615	14	610	24	624	57
618	4	616	16	611	46	625	58
619	6	617	11	612	41	626	41
620	4	618	16	613	48	627	33
621	1	619	19	614	43	628	69
622	1	620	18	615	29	629	64
623	1	621	17	616	33	630	42
624	2	622	3	617	48	631	70
626	2	623	13	618	48	632	31
627	2	624	19	619	46	633	49
628	1	625	12	620	41	634	41
630	1	626	9	621	12	635	73
631	1	627	11	622	36	636	64
632	1	628	7	623	39	637	42
633	1	629	17	624	44	638	25
635	1	630	20	625	40	639	68

Table B-1 (cont.)

636	2	631	11	626	32	640	59
637	1	632	11	627	17	641	70
638	3	633	11	628	31	642	71
639	1	634	12	629	41	643	37
640	1	635	16	630	61	644	46
641	1	636	11	631	29	645	46
642	3	637	15	632	22	646	60
643	2	638	11	633	30	647	65
644	1	639	7	634	47	648	69
646	2	640	8	635	47	649	31
647	3	641	11	636	30	650	44
648	2	642	14	637	32	651	42
649	3	643	10	638	22	652	49
650	1	644	16	639	34	653	60
652	3	645	12	640	41	654	42
654	1	646	10	641	46	655	39
655	1	647	12	642	31	656	60
657	3	648	10	643	40	657	52
658	1	649	8	644	25	658	71
659	1	650	8	645	43	659	45
661	1	651	7	646	50	660	29
662	3	652	16	647	46	661	49
663	1	653	10	648	34	662	53
665	1	654	17	649	19	663	41
667	2	655	13	650	24	664	57
668	2	656	8	651	39	665	55
670	2	657	18	652	47	666	34
672	1	658	12	653	42	667	60
674	2	659	13	654	19	668	48
675	1	660	9	655	21	669	74
676	3	661	5	656	27	670	51
679	2	662	10	657	32	671	39
681	1	663	21	658	30	672	31
683	1	664	12	659	28	673	53
685	1	665	13	660	27	674	54
688	1	666	13	661	19	675	62
691	1	667	5	662	48	676	46

Table B-1 (cont.)

692	1	668	9	663	40	677	20
693	1	669	11	664	40	678	46
696	2	670	10	665	28	679	64
697	1	671	12	666	16	680	45
700	2	672	15	667	29	681	57
701	1	673	6	668	30	682	54
702	1	674	7	669	41	683	27
703	1	675	8	670	44	684	58
705	2	676	10	671	23	685	45
708	1	677	10	672	19	686	56
709	1	678	9	673	37	687	58
711	1	679	8	674	37	688	26
712	1	680	8	675	47	689	39
713	1	681	8	676	27	690	33
714	1	682	10	677	16	691	42
715	1	683	7	678	24	692	51
717	1	684	7	679	33	693	52
718	1	685	14	680	41	694	34
723	1	686	7	681	34	695	50
726	3	687	8	682	17	696	49
735	1	688	5	683	32	697	52
737	1	689	8	684	23	698	54
738	2	690	6	685	40	699	27
741	1	691	6	686	33	700	42
742	1	692	7	687	31	701	54
744	1	693	9	688	20	702	32
747	1	694	17	689	22	703	68
748	1	695	2	690	34	704	50
754	1	696	3	691	30	705	32
755	1	697	9	692	28	706	43
757	1	698	6	693	29	707	35
764	1	699	6	694	18	708	44
765	1	700	7	695	31	709	49
766	2	701	4	696	26	710	47
773	1	702	5	697	24	711	38
774	1	703	8	698	32	712	53
775	1	704	6	699	24	713	33

Table B-1 (cont.)

778	2	705	5	700	18	714	52
782	1	706	4	701	40	715	50
783	1	707	5	702	29	716	30
784	1	708	6	703	25	717	37
786	1	709	5	704	31	718	50
790	1	710	13	705	7	719	43
792	1	711	9	706	23	720	58
797	1	712	6	707	28	721	39
798	1	713	5	708	37	722	21
800	1	714	7	709	28	723	57
802	1	715	6	710	25	724	37
803	1	716	9	711	18	725	54
809	1	717	6	712	34	726	56
827	2	718	6	713	34	727	47
846	2	719	8	714	24	728	21
848	1	720	9	715	21	729	59
860	1	721	8	716	16	730	48
865	1	722	3	717	19	731	48
915	1	723	5	718	23	732	50
1037	1	724	8	719	35	733	27
		725	6	720	18	734	54
		726	9	721	20	735	47
		727	4	722	13	736	50
		728	4	723	16	737	46
		729	4	724	25	738	38
		730	9	725	28	739	18
		731	8	726	28	740	42
		732	5	727	17	741	51
		733	13	728	7	742	43
		734	3	729	14	743	50
		735	7	730	29	744	36
		736	1	731	22	745	23
		737	5	732	25	746	43
		738	7	733	19	747	39
		739	3	734	16	748	45
		740	3	735	21	749	43
		741	5	736	35	750	20

Table B-1 (cont.)

742	2	737	23	751	26
743	9	738	15	752	50
744	1	739	16	753	29
745	2	740	22	754	61
746	3	741	25	755	39
747	2	742	25	756	24
748	9	743	21	757	53
749	6	744	11	758	41
750	5	745	15	759	42
751	7	746	19	760	52
752	6	747	21	761	19
753	5	748	30	762	29
754	3	749	16	763	34
755	3	750	11	764	38
756	2	751	15	765	47
757	4	752	28	766	37
758	6	753	15	767	19
759	3	754	21	768	40
760	4	755	15	769	47
761	7	756	10	770	30
762	2	757	12	771	35
763	3	758	26	772	32
764	2	759	20	773	25
765	4	760	18	774	53
766	4	761	16	775	41
767	5	762	12	776	47
768	1	763	24	777	33
769	3	764	14	778	36
770	2	765	26	779	23
771	8	766	19	780	40
772	8	767	19	781	40
773	3	768	16	782	37
774	6	769	22	783	31
775	6	770	20	784	17
776	5	771	22	785	45
777	2	772	16	786	38
778	4	773	18	787	37

Table B-1 (cont.)

779	4	774	10	788	45
780	4	775	18	789	25
781	5	776	22	790	27
782	3	777	20	791	39
783	7	778	18	792	24
784	5	779	16	793	34
785	3	780	11	794	47
786	3	781	22	795	32
787	3	782	18	796	24
788	3	783	12	797	28
789	1	784	14	798	41
790	2	785	14	799	33
791	1	786	20	800	25
794	3	787	20	801	23
795	2	788	18	802	41
796	2	789	14	803	30
797	2	790	14	804	37
798	10	791	19	805	42
799	5	792	21	806	23
800	4	793	20	807	27
801	2	794	27	808	42
802	1	795	15	809	28
803	5	796	13	810	41
804	1	797	17	811	32
805	7	798	19	812	23
806	3	799	16	813	38
807	1	800	14	814	37
808	2	801	17	815	33
809	2	802	19	816	40
810	3	803	12	817	32
811	2	804	15	818	18
812	3	805	18	819	41
813	2	806	10	820	42
814	1	807	10	821	38
816	2	808	12	822	33
817	1	809	19	823	24
818	2	810	18	824	35

Table B-1 (cont.)

819	2	811	13	825	31
820	1	812	17	826	34
821	1	813	15	827	38
822	3	814	18	828	28
823	2	815	18	829	15
824	2	816	8	830	27
825	7	817	11	831	36
826	3	818	8	832	31
827	2	819	15	833	35
828	1	820	26	834	29
829	7	821	25	835	34
830	4	822	19	836	37
831	3	823	12	837	27
832	1	824	12	838	39
833	1	825	16	839	47
834	2	826	14	840	19
835	5	827	24	841	33
836	2	828	8	842	34
837	4	829	22	843	32
838	3	830	10	844	43
840	1	831	27	845	21
841	4	832	16	846	21
842	1	833	15	847	43
843	2	834	11	848	39
844	1	835	14	849	25
845	2	836	23	850	39
847	1	837	14	851	23
848	3	838	17	852	31
849	3	839	11	853	43
850	1	840	15	854	20
851	1	841	15	855	25
852	3	842	14	856	31
853	1	843	16	857	15
854	1	844	13	858	32
855	1	845	13	859	20
856	3	846	7	860	28
857	3	847	12	861	29

Table B-1 (cont.)

858	3	848	19	862	26
859	1	849	18	863	23
861	2	850	11	864	26
862	1	851	9	865	44
863	3	852	8	866	26
864	2	853	13	867	35
865	2	854	11	868	16
866	2	855	14	869	25
867	2	856	12	870	29
868	1	857	6	871	28
870	3	858	14	872	41
871	2	859	16	873	28
873	2	860	12	874	21
876	1	861	19	875	25
877	3	862	22	876	26
879	1	863	7	877	31
880	1	864	10	878	28
883	2	865	11	879	22
885	1	866	12	880	23
891	1	867	9	881	23
892	1	868	7	882	18
893	2	869	11	883	28
894	1	870	10	884	23
895	1	871	17	885	17
900	4	872	15	886	28
910	1	873	7	887	28
911	1	874	8	888	23
912	1	875	14	889	30
913	1	876	18	890	22
914	1	877	16	891	18
915	2	878	13	892	28
916	2	879	5	893	33
918	1	880	11	894	22
920	1	881	9	895	25
921	1	882	10	896	23
922	1	883	15	897	23
923	2	884	10	898	27

Table B-1 (cont.)

925	1	885	6	899	18
928	2	886	11	900	25
936	1	887	9	901	21
939	1	888	11	902	14
941	1	889	9	903	34
943	1	890	6	904	28
944	1	891	7	905	34
949	2	892	8	906	28
952	3	893	17	907	23
953	1	894	23	908	14
956	1	895	7	909	28
957	1	896	6	910	25
958	1	897	4	911	30
960	1	898	9	912	25
961	1	899	10	913	10
962	1	900	13	914	27
965	1	901	4	915	25
970	1	902	7	916	20
974	1	903	8	917	36
978	1	904	10	918	14
979	2	905	11	919	9
982	1	906	11	920	26
983	1	907	1	921	28
985	1	908	7	922	26
990	1	909	8	923	22
999	1	910	13	924	19
1001	1	911	12	925	20
1012	1	912	10	926	25
1019	1	913	3	927	26
1022	1	914	12	928	25
1032	2	915	9	929	23
1034	1	916	8	930	9
1049	1	917	11	931	22
1051	1	918	8	932	22
1057	1	919	4	933	23
1069	1	920	11	934	24
1079	1	921	13	935	23

Table B-1 (cont.)

1093	1	922	9	936	13
1109	1	923	11	937	25
1111	1	924	10	938	14
1139	1	925	7	939	26
1265	1	926	10	940	21
		927	9	941	19
		928	14	942	18
		929	8	943	14
		930	5	944	22
		931	4	945	18
		932	12	946	15
		933	7	947	21
		934	4	948	23
		935	2	949	23
		936	5	950	29
		937	9	951	23
		938	13	952	20
		939	5	953	19
		940	11	954	24
		941	6	955	24
		942	9	956	22
		943	3	957	22
		944	8	958	13
		945	5	959	21
		946	7	960	19
		947	13	961	25
		948	8	962	23
		949	4	963	18
		950	7	964	10
		951	8	965	15
		952	4	966	24
		953	5	967	14
		954	7	968	23
		955	9	969	8
		956	6	970	17
		957	5	971	20
		958	8	972	21

Table B-1 (cont.)

959	4	973	14
960	9	974	14
961	4	975	12
962	4	976	17
963	4	977	19
964	9	978	21
965	7	979	18
966	7	980	14
967	6	981	8
968	5	982	17
969	3	983	21
970	1	984	10
971	3	985	17
972	6	986	7
973	15	987	12
974	2	988	17
975	6	989	12
976	9	990	16
977	6	991	19
978	5	992	11
979	7	993	14
980	5	994	8
981	9	995	16
982	6	996	26
983	8	997	10
984	6	998	16
985	6	999	22
986	5	1000	15
987	5	1001	12
988	7	1002	7
989	4	1003	6
990	4	1004	17
991	7	1005	17
992	1	1006	12
993	3	1007	10
994	8	1008	9
995	7	1009	15

Table B-1 (cont.)

996	5	1010	22
997	4	1011	28
998	4	1012	14
999	5	1013	21
1000	7	1014	6
1001	5	1015	15
1002	3	1016	25
1003	4	1017	20
1004	2	1018	11
1005	5	1019	12
1006	2	1020	9
1008	1	1021	18
1009	2	1022	12
1010	1	1023	15
1011	7	1024	8
1012	3	1025	9
1013	4	1026	13
1014	2	1027	14
1015	5	1028	16
1016	9	1029	12
1017	2	1030	10
1018	3	1031	7
1019	1	1032	13
1020	2	1033	22
1021	2	1034	16
1022	5	1035	8
1023	5	1036	6
1024	3	1037	7
1025	1	1038	19
1026	2	1039	16
1027	2	1040	14
1028	4	1041	13
1029	6	1042	17
1030	6	1043	7
1031	4	1044	8
1032	3	1045	13
1033	3	1046	10

Table B-1 (cont.)

1034	2	1047	4
1035	7	1048	4
1036	2	1049	16
1037	5	1050	20
1038	3	1051	5
1039	4	1052	13
1040	3	1053	9
1041	2	1054	10
1042	2	1055	6
1044	3	1056	10
1045	1	1057	10
1046	5	1058	12
1047	3	1059	6
1048	5	1060	12
1049	4	1061	9
1050	4	1062	12
1051	1	1063	8
1053	7	1064	10
1054	2	1065	9
1056	1	1066	7
1057	3	1067	8
1058	3	1068	10
1059	2	1069	16
1061	3	1070	12
1062	1	1071	11
1063	2	1072	15
1064	1	1073	5
1065	1	1074	8
1067	4	1075	12
1068	1	1076	10
1069	2	1077	11
1070	4	1078	11
1071	5	1079	14
1072	1	1080	7
1073	3	1081	5
1074	2	1082	4
1075	4	1083	10

Table B-1 (cont.)

	1076	3	1084	5
	1077	2	1085	10
	1078	2	1086	2
	1079	6	1087	8
	1080	2	1088	7
	1081	3	1089	9
	1082	3	1090	8
	1083	6	1091	15
	1084	1	1092	7
	1085	2	1093	6
	1086	1	1094	9
	1087	1	1095	12
	1088	1	1096	7
	1089	1	1097	10
	1090	2	1098	4
	1091	4	1099	3
	1092	2	1100	11
	1094	1	1101	10
	1095	1	1102	8
	1096	2	1103	6
	1097	3	1104	5
	1098	2	1105	6
	1099	3	1106	11
	1100	3	1107	4
	1101	4	1108	10
	1102	2	1109	9
	1103	2	1110	6
	1104	2	1111	7
	1105	3	1112	1
	1106	2	1113	9
	1107	3	1114	7
	1109	5	1115	6
	1110	2	1116	6
	1112	3	1117	11
	1113	2	1118	5
	1115	1	1119	10
	1116	1	1120	5

Table B-1 (cont.)

1117	3	1121	5
1119	1	1122	3
1120	2	1123	6
1121	3	1124	10
1123	1	1125	4
1124	2	1126	3
1125	2	1127	4
1128	1	1128	6
1131	1	1129	3
1133	1	1130	6
1134	1	1131	5
1135	3	1132	5
1136	2	1133	5
1137	2	1134	7
1140	4	1135	16
1141	1	1136	6
1143	1	1137	7
1145	2	1138	5
1146	1	1139	7
1148	1	1140	5
1149	2	1141	14
1151	3	1142	4
1152	1	1143	3
1153	1	1144	2
1155	1	1145	11
1158	2	1146	13
1160	1	1147	8
1161	2	1148	8
1163	2	1149	5
1167	1	1150	4
1174	3	1151	4
1175	2	1152	5
1176	2	1153	2
1179	1	1154	5
1180	2	1155	3
1181	1	1156	10
1185	1	1157	9

Table B-1 (cont.)

1186	1	1158	2
1187	1	1159	6
1188	2	1160	3
1189	2	1161	2
1192	2	1162	5
1193	1	1163	10
1196	1	1164	6
1203	1	1165	5
1205	1	1166	9
1206	1	1167	6
1210	1	1168	5
1212	1	1169	9
1213	1	1170	5
1215	1	1171	6
1224	1	1172	4
1229	2	1173	7
1237	3	1174	8
1240	1	1175	4
1241	1	1176	2
1242	1	1177	2
1246	1	1178	5
1254	1	1179	5
1256	2	1180	2
1258	1	1181	7
1264	1	1182	6
1268	1	1183	8
1270	1	1184	2
1274	1	1185	3
1286	1	1186	5
1313	2	1187	2
1326	1	1188	2
		1189	2
		1190	6
		1191	5
		1192	5
		1193	5
		1194	3

Table B-1 (cont.)

1196	4
1197	8
1198	1
1199	3
1200	1
1201	1
1202	3
1203	6
1204	2
1205	6
1207	2
1208	3
1209	2
1210	2
1211	5
1212	1
1213	2
1214	1
1215	1
1216	5
1218	3
1219	2
1220	3
1221	3
1222	4
1223	1
1224	5
1225	2
1226	2
1227	1
1228	3
1229	2
1230	4
1231	5
1232	4
1234	3
1235	4

Table B-1 (cont.)

1236	2
1237	3
1240	2
1241	1
1242	2
1243	2
1244	3
1245	2
1247	1
1248	4
1249	1
1250	2
1251	1
1252	2
1253	2
1254	1
1256	1
1257	2
1258	3
1259	3
1260	2
1262	1
1263	2
1266	2
1267	1
1268	1
1269	4
1270	5
1271	1
1272	1
1273	1
1274	2
1275	4
1277	1
1278	1
1279	1
1283	2

Table B-1 (cont.)

1284	1
1286	1
1287	3
1291	2
1298	4
1303	1
1304	6
1305	2
1307	1
1313	3
1314	4
1318	2
1319	1
1320	1
1321	2
1322	1
1327	1
1328	1
1331	1
1332	1
1333	2
1337	1
1342	1
1346	1
1347	1
1356	2
1358	2
1360	1
1362	1
1363	1
1370	1
1371	1
1378	1
1379	1
1387	1
1389	1
1432	1