Appendix 3

C 100.106.P

To: Cripple Creek & Victor Gold Mining Company
P. O. Box 191
100 North Third Street
Victor, Colorado 80860

Date: November 26, 1997

Subject: **GROUND MOTION ATTENUATION STUDY**
CONSTRUCTION TEST SITE
October 16, 1997

Matheson Mining Consultants

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Wheat Ridge, Co 8003
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CRIPPLE CREEK AND VICTOR GOLD MINING COMPANY
GROUND VIBRATION ATTENUATION STUDY
CONSTRUCTION BLAST TESTING - COUNTY ROAD 14

October 16, 1997

Executive Summary

Matheson Mining Consultants (MMC) monitored seven test blasts at the construction blast test site located on Cripple Creek and Victor Gold Mining Company property west of the town of Victor, CO with five seismographs. All data and analyses are attached to this report.

The recommended scaled distance to not exceed the regulatory limit of 0.50 inches per second peak particle velocity for the construction site is 13.43. The analysis is comprised of thirty-one data points and has a correlation coefficient of 0.704.

Scaled distance is a relationship used in explosives engineering to interrelate blasts with different maximum charge weights per delay.

$$SD = \frac{D}{\sqrt{W}}$$

Where: SD is Scaled Distance
D is distance in feet
W is maximum charge weight per 8 millisecond delay period.

Below is a table of distance and charge weight based on the regulatory limit of 0.50 inches per second and the site specific scaled distance determination of 13.43. The charge weight per delay is the maximum explosive that may be fired at the given distance to not exceed the 0.50 inch per second regulatory limit.

Table 1: Distance versus charge weight for SD=13.43

Distance (FT)	Charge Weight/Delay (Lbs/Delay)
100	55
200	222
300	499
400	887

Introduction

Matheson Mining Consultants (MMC) was retained by Cripple Creek and Victor Gold Mining Company to perform a ground motion attenuation study of ground vibrations created by blasting at the construction blasting test site located west of the town of Victor, Colorado. Appendix I contains a map showing the test blast and instrument locations. Five blasting seismographs were used to monitor each blast. Seismographs were positioned at varying distances from each test blast. The resulting data set were analyzed and used to determine distance and charge weight relationships required for ground vibration regulatory compliance. The distance study predict statistically safe distances for any given charge weight per delay period and peak particle velocity.

The procedure for the analyses performed on the test blasts is outlined in "Blasting Guidance Manual", March 1987, published by United States Department of the Interior Office of Surface Mining Reclamation and Enforcement.

The tests performed at the two sites were designed to be conservative in nature. The intent of these studies was to maximize ground motion. Typically in mine production blasting, explosive energy is consumed by fragmentation and displacement of the rock mass. The confined test blasts minimized fragmentation and displacement while maximizing ground motion.

Instrumentation

Vibration records were collected with two Blastmate III and three MiniMate Plus digital blasting seismographs. These seismographs measure three orthogonal planes of ground motion, transverse, longitudinal and vertical, and one channel of air overpressure. The frequency response is 1.5 to 250 Hertz. All instruments have a valid annual calibration. Copies of the calibration certificates are attached as Appendix II. Each vibration recording is printed on a single sheet of paper with: Date/Time, Trigger Source, Range, Record Time, instrument Serial Number, Battery Level, Calibration date and File Name in the title block. The instruments are seismically triggered and record each channel digitally at 1024 samples per second.

Fourier transforms of each of the three waveform components are calculated to determine frequency response. Frequency versus particle velocity plots of each wave trace are plotted on each record. The United States Bureau of Mines (USBM) and the Office of Surface Mining, Reclamation and Enforcement (OSMRE) regulatory criteria are plotted on each vibration record.

Attached as Appendix III is an excerpt from the Blastmate III User's Manual describing the specifications and function of the instrumentation and record processing.

Procedure

Seven 2-1/2 inch diameter drill holes were drilled to a depth of 20 feet on 10 foot centers at the test site. Attached as Appendix I is a map of the test areas. Each drill hole was loaded with 20 pounds of ANFO, primed with one cast booster, and detonated individually. The charge weight was selected to maximize the ground motion created by the explosive detonation while eliminating flyrock and permanent ground displacement. Seismographs were placed at varying distances between the blast site and the closest non-mine owned residence. Distances, ground motion amplitudes, statistical analysis, particle velocity versus distance tables, charge weight versus distance tables and the complete set of vibration records for the Ajax test site are attached as Appendix IV.

Ground vibrations were measured at distances varying from 50 to 260 feet from the test blasts. Scaled distances varied from 11 to 58. Least squares regression analysis was performed on each data set to determine the +95% confidence intervals as recommended by OSM and USBM regulatory guidelines. The statistical validity of the data is evaluated using the correlation coefficients calculated in the analyses. The equations for the +95% confidence interval are then used to calculate maximum charge weight per delay interval for any given particle velocity and distance. Recommendations are made based on regulatory criteria, accepted citizen tolerance levels and historic vibration monitoring from the existing mine production.

Results

The least squares regression analysis performed is in Appendix IV and contains the tables and seismograph recordings for the test site.

The +95% confidence equation and correlation coefficient calculated with the collected data is:

$$\text{PPV} = 11.0 * (SD)^{-1.19} \qquad r^2 = 0.704$$

Given a not to exceed peak particle velocity and a known distance a maximum charge weight per delay may be calculated using the above equations. Tables are attached to the regression analyses in Appendices IV using the above equations to calculate maximum allowable charge weight per delay at given distances given a not to exceed peak particle velocity. Additional tables show peak particle velocities at given distances given a charge weight.

The equation is in the expected range for this site. The data set has a good correlation coefficient. A high degree of reliability may be placed on these results.

Conclusions

Colorado Mined Land Reclamation imposes a 0.50 inches per second peak particle velocity limit on ground motion created by Cripple Creek and Victor Gold Mining Company blasting operations. The Construction analysis recommends a scaled distance of 13.43 in order to not exceed 0.50 inches per second. Below is a table listing scaled distances for other not to exceed peak particle velocities.

Table 2: Peak Particle Velocity versus Scaled Distance for Construction site.

Peak Particle Velocity (inches per second)	Construction Scaled Distance
0.10	51.9
0.20	29.0
0.30	20.6
0.40	16.2
0.50	13.4

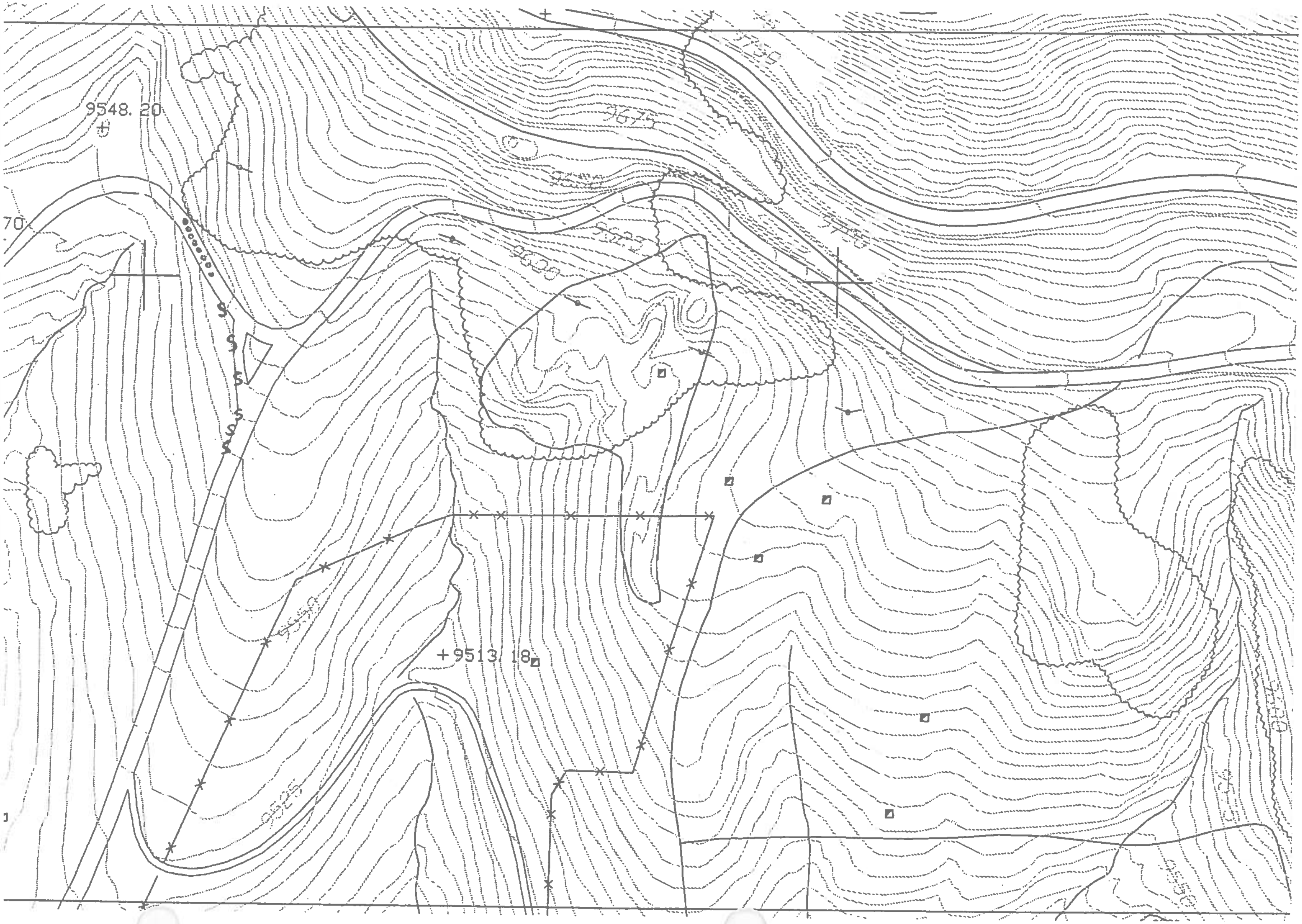
Attached in Appendices IV are tables listing maximum particle velocities at varying distances for given charge weights. Corresponding tables list maximum allowable charge weights per delay at varying distances given a peak particle velocity. Appendix V contains a summary sheet and the individual seismograph records measured and used in this study.

Sincerely,

Colin Matheson
Mining Engineer

Appendix I

Map



9548. 20
+9513.18

Appendix II

Calibration Certificates

Calibration Certificate

Model: BlastMate III

Date: September 19, 1997

Unit S/N: BA5738

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Signal Analyzer	3562A	2847A03947
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: W.B. Shaver

*References are traceable to NRC, NIST or equivalent

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Calibration Certificate

Model: Geophone

Date: September 19, 1997

Unit S/N: BG5586

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Signal Analyzer	3582A	1809A03540
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: W.B. Shaver

*References are traceable to NRC, NIST or equivalent

Calibration Certificate

Model: BlastMate III

Date: January 10, 1997

Unit S/N: BA5552

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Spectrum Analyzer	3582A	1809A03540
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: B TRAN

*References are traceable to NRC, NIST or equivalent

Calibration Certificate

Model: Geophone

Date: January 10, 1997

Unit S/N: BG5412

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Spectrum Analyzer	3582A	1809A03540
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: W B Shaver

*References are traceable to NRC, NIST or equivalent

Calibration Certificate

Model: MiniMate Plus

Date: January 10, 1997

Unit S/N: BC5534

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Spectrum Analyzer	3582A	1809A03540
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: aBShaver

*References are traceable to NRC, NIST or equivalent

Calibration Certificate

Model: MiniMate Plus

Date: January 10, 1997

Unit S/N: BC5536

TEST REFERENCES*	Model	Serial No.
Bruel & Kjaer Accelerometer	4381	1160721
Bruel & Kjaer Charge Amplifier	2635	1423229
Hewlett Packard Spectrum Analyzer	3582A	1809A03540
Good Will Inst. Frequency Counter	GUC-2010G	5110825
Bruel & Kjaer HPMC	4221	745522
Bruel & Kjaer Mic Carrier System	2804	1904864
Bruel & Kjaer Microphone	4193	1863904

INSTANTEL INC. hereby certifies that this unit has been calibrated and that the results are consistent with the specifications published regarding this instrument. The SENSORCHECK™ feature of the unit is sufficiently reliable to indicate proper operation, although it is recommended that this unit be sent to INSTANTEL or an authorized service centre for regular calibration.

AUTHORIZED BY: *(signature)*

*References are traceable to NRC, NIST or equivalent

Appendix III

Instrument Specifications

3. Compliance Module

This chapter provides instructions to install and setup the BlastMate III.

3.1 What is Event Monitoring?

Event monitoring measures both ground vibrations and air pressure. The monitor measures transverse, vertical, and longitudinal ground vibrations. Transverse ground vibrations agitate particles in a side to side motion. Vertical ground vibrations agitate particles in an up and down motion. Longitudinal ground vibrations agitate particles in a forward and back motion progressing outward from the event site. Events also affect air pressure by creating what is commonly referred to as "air blast". By measuring air pressures, we can determine the effect of air blast energy on structures, measured on the Linear "L" scale, or as perceived by the human ear, measured on the "A" Weight scale.

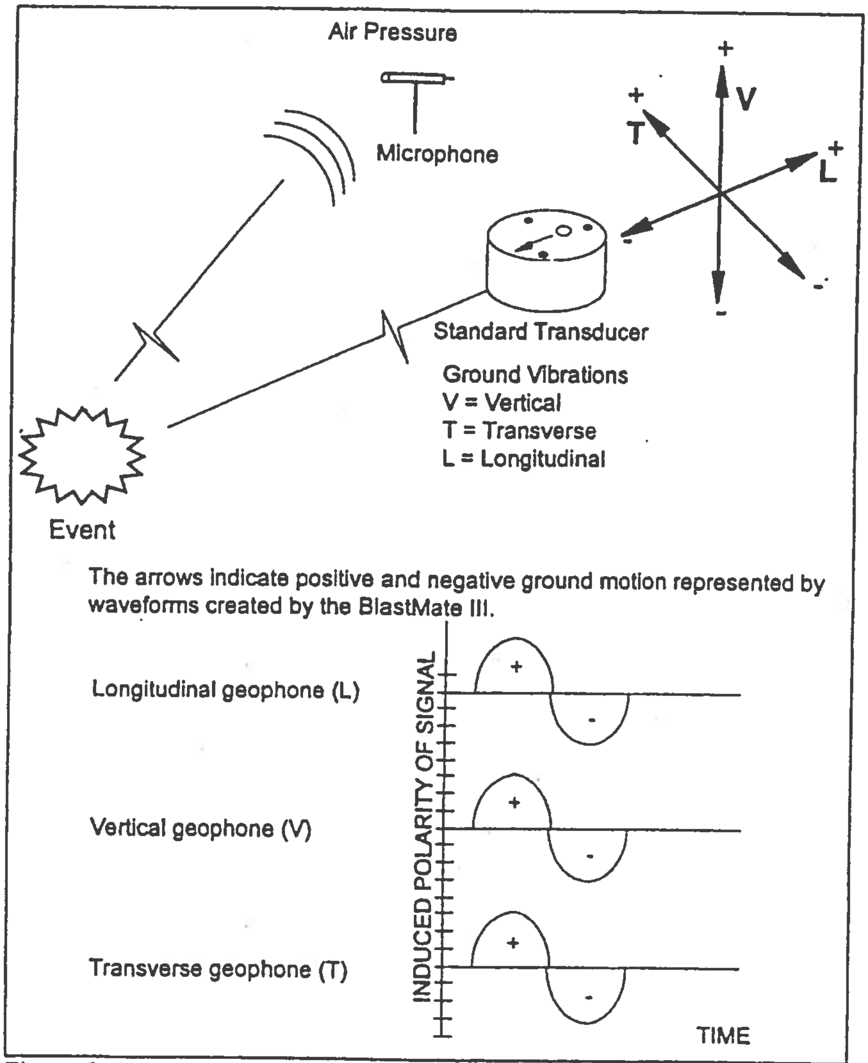


Figure 3.1 How the BlastMate III Monitors Events.

a. Geophone Operation

Functionally a geophone sensor is a coil of wire suspended around a magnet. The magnet is free to move in a field of magnetic flux lines. By Lenzs' Law, induced voltage is proportional to the speed at which flux lines are traversed. Induced coil voltage is therefore proportional to the relative velocity of the coil to the magnet. In practice, it does not matter whether the coil or the magnet moves. Only the motion and speed relative to each other are important.

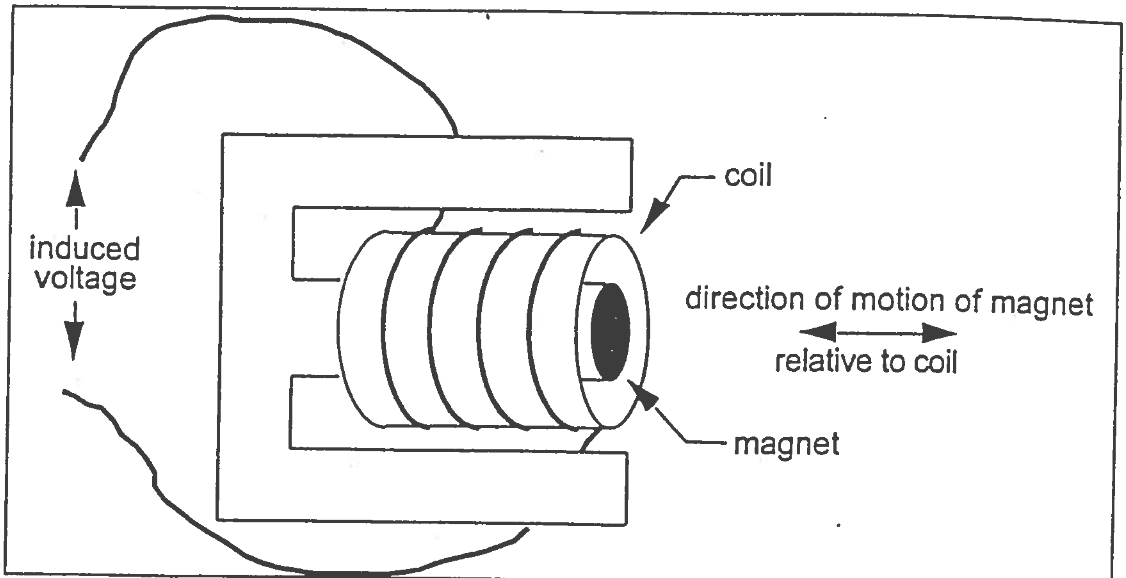


Figure 5.5 Geophone Sensor Operation.

Geophone sensor specifications give a number known as the Intrinsic Voltage Sensitivity. It is the coil voltage induced for a given coil versus magnet speed with units of V/in/s. In seismic applications, the magnet is moved by the blast energy because it is coupled to the particles of the surrounding terrain. The coil, because of its inertia, does not move and the resulting magnet versus coil motion induces a voltage which is proportional to particle velocity.

b. Instantel Standard Transducer

Instantel offers a 2 to 300 Hz standard transducer in a round package. The transducer may be installed on a floor, wall, or ceiling using a variety of installation procedures including ground spikes, burying, mounting rod, or optional levelling plate with levelling feet and integrated bubble level. The figure below includes an Instantel Standard Transducer (a) and a Standard Transducer with levelling plate (b).

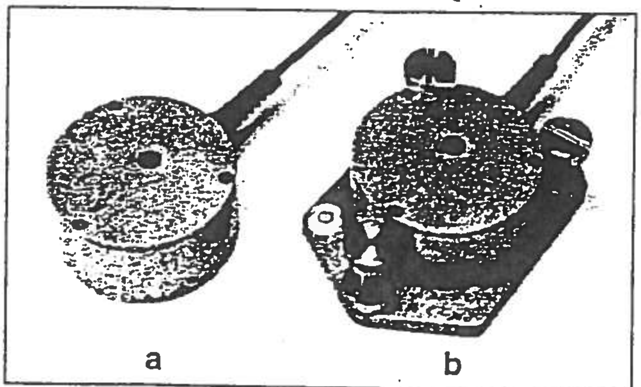


Figure 5.6 Instantel Standard Transducer (a) and Standard Transducer with Optional Levelling Plate (b).

c. Transducer Calibration Requirements

The geophone sensors inside Instantel's transducers must be calibrated annually by Instantel or an authorized Instantel service facility. Contact your dealer for further information.

5.2.2 Microphone

The microphone measures air pressure. Instantel offers two types, Linear "L" (standard) and "A" Weight (optional). Both come with a three foot (one meter) microphone mounting stand.

a. Measurement Scales

The BlastMate III supports two sound pressure measurement scales: Linear "L" and "A" Weight.

(1) Linear "L"

Linear measurement is generally used to measure the effect of low frequency air pressure on buildings. The linear scale records sound pressure without modification in the 2 to 300 Hz range. Measurement units may be in absolute, Pascal, or relative dB scales.

(2) "A" Weight

"A" Weight measures noise levels people may consider an annoyance. The incoming signal is filtered over a 20 Hz to 20,000 Hz range reflecting the hearing range of the human ear. The signal is then converted to root mean square (RMS). Units are measured using the decibel scale, dB(A).

b. Microphone Calibration Requirements

Instantel's microphone must be calibrated annually by Instantel or an authorized Instantel service facility. Contact your dealer for further information.

5.3 Sensorcheck®

Sensorcheck performs a two stage test on the BlastMate III and its sensors. In the first stage, the program displays the BlastMate III serial number, software version, the total amount of memory installed in the BlastMate III, the total amount of memory available to store events, and the number of events presently stored in memory. The second stage tests each geophone within Instantel's transducer and the microphone operation. The program also tests the operation of the BlastMate III itself and the sensor connecting cables. Pass or fail results appear on the display. See the Basic Reference chapter of this manual to choose when Sensorcheck operates automatically.

5.3.1 Checking the Transducer's Geophones

Sensorcheck measures a geophone's natural frequency and damping indicated by an Overswing Ratio (OR). Sensorcheck sends an electric pulse to the geophones and measures the response. If the geophone's response falls within a specified calibration range, the geophone is in calibration and monitoring operations can continue. If the geophone's response does not fall within a specified calibration range, the geophone is not calibrated. You cannot record events until you fix or replace the geophones. See the troubleshooting section of this manual for the appropriate procedures to follow.

a. Natural Frequency

Waveform measurements check the natural period (t) of a geophone's sensor coil assembly. Referring to the figure below, the distance from P_1 to P_2 represents 0.125 seconds. Since Frequency is the reciprocal of the period, $F=1/t$, the frequency is approximately 8 Hz. A calibrated sensor has a natural frequency between 6.5 and 9.5 Hertz. Calculations for all geophones appears with each recorded event.

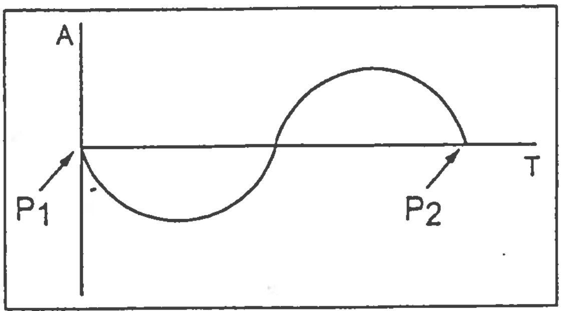


Figure 5.7 Calculating a Geophone's Natural Frequency.

b. Damping – Overswing Ratio (OR)

The overswing ratio (OR) measures damping and is calculated by computing the ratio of the magnitude of adjacent waveform peaks according to the following formula:

$$OR=\frac{A_1}{A_2}$$

Acceptable overswing ratios range from 2.8 to 4.8. The figure below displays a graph of a geophone coil's "free fall" response. A_1 and A_2 are used for overswing calculations.

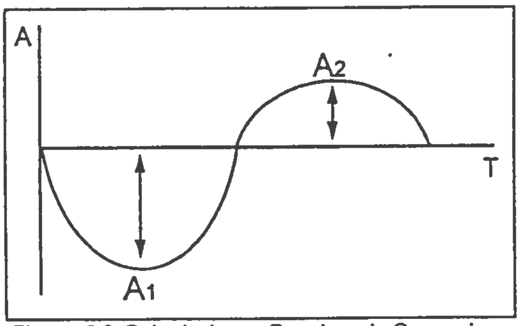


Figure 5.8 Calculating a Geophone's Overswing Ratio.

5.3.2 Checking the Microphone

Sensorcheck tests the microphone's operation by sending a signal to the microphone and measuring its frequency and amplitude response. If the results of the test fall within specified ranges, the microphone is within calibration.

5.3.3 Sensorcheck Report

The Sensorcheck report appears on the BlastMate III display. The message "All Channels Working, Press Print to Print" indicates the BlastMate III sensors have passed the Sensorcheck.

5.4 Antialias Filters

Aliasing occurs when a high–frequency signal appears as an erroneous low frequency because the waveform was sampled at too low a sampling rate. An antialiasing filter solves this problem by removing the high–frequencies.

5.5 Data Analysis Techniques

The following sections define the BlastMate III data analysis techniques. The first section, ground vibrations, discusses calculations applied to event data recorded by a transducer. The second section, sound pressure, describes the microphone event data calculations.

5.5.1 Ground Vibrations

The BlastMate III calculates the Peak Particle Velocity, Zero Crossing Frequency, Peak Acceleration, and Peak Displacement for each of the transverse, vertical, and longitudinal axes. The BlastMate III calculates Peak Vector Sum using data from all three axes.

a. Peak Particle Velocity (PPV)

Peak Particle Velocity indicates the maximum speed particles travel resulting from an event's ground vibrations. The BlastMate III calculates the PPV for each geophone.

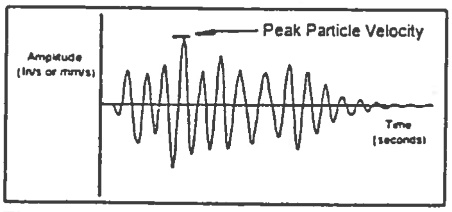


Figure 5.9 Calculating Peak Particle Velocity.

b. Zero Crossing Frequency (ZC Freq)

The Zero Crossing Frequency calculates the event waveform's frequency at the largest peak.

(1) Calculating Zero Crossing Frequency

To calculate the Zero Crossing Frequency, we need to determine the period of oscillation of the waveform. Convenient waveform positions for measuring period, the time for one complete cycle, occur between two successive peaks, troughs, or zero crossings. The BlastMate III measures between zero crossings. Frequency is the number of periods that occur in one second calculated by the formula: Frequency = 1/period.

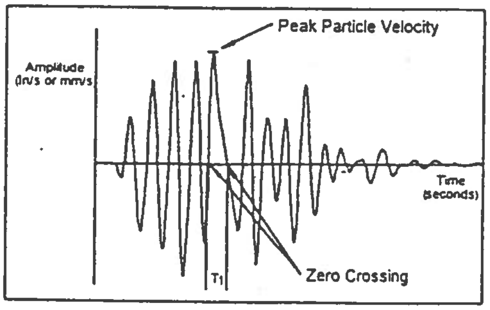


Figure 5.10 Calculating the Zero Crossing Frequency.

(2) Zero Crossing Frequency Limitation

The Zero Crossing Frequency calculation is limited because it assumes a single predominant frequency at the peak, typically represented by sinusoidal waveforms. In practice, the peak may be the result of two or more major frequency components representing compound waveforms as illustrated in the figure below. It is therefore only an approximation of the frequency of the Peak Particle Velocity.

Waveforms may have the same Peak Particle Velocities but different Zero Crossing Frequencies depending on the shape of the waveforms involved. With reference to the figures above and below; both waveforms have the same Peak Particle Velocities however their Zero Crossing Frequencies differ. In the figure above, the zero crossing frequency uses the 1/2 period indicated by T_1. In the figure below, the zero crossing frequency uses the 1/2 period indicated by T_2. Notice that T_1 is less than T_2 because of the different waveform shapes, therefore the Zero Crossing Frequency in figure above is greater than the Zero Crossing Frequency in the figure below. It is for this reason, the Zero Crossing Frequency may differ for peaks having the same Peak Particle Velocity.

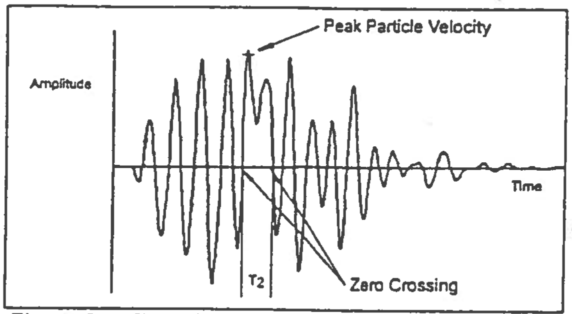


Figure 5.11 Zero Crossing Frequency Calculation Limitation.

(3) Sample Rate Error

The Zero Crossing Frequency requires the period of a wavelength before it can calculate the wavelength's frequency using the formula 1/period. A sampling error occurs for higher frequencies when wavelength periods become relatively small and the sampling rate begins to miss zero crossing points. In other words, the wavelength periods occur much faster than a BlastMate III can sample and use in the calculation.

At higher frequencies there are fewer sample points per cycle and therefore greater error. The following table illustrates how error increases with frequency.

Zero Crossing Frequency Sample Rate Error		
Frequency Range	Recording Rate	
	Standard (1024 Hz)	Fast (2048 Hz)
0 – 30 Hz	negligible error	negligible error
31 – 50 Hz	up to 5 Hz error	up to 2.5 Hz error
51 – 70 Hz	up to 8 Hz error	up to 4 Hz error
71 – 90 Hz	up to 18 Hz error	up to 9 Hz error
91 – 150 Hz	up to 50 Hz error	up to 25 Hz error

The BlastMate III does not calculate frequencies above 100 Hz because of the high error level at 1024 samples per second. The message ">100 Hz" displays. Furthermore if a waveform is very complex, or if it contains a large offset value, the zero crossings may lie outside an acceptable window. Whenever a frequency cannot be calculated the message "<1 Hz" displays. The message

N/A indicates an entire waveform was not captured and therefore no frequency could be calculated. More accurate analysis is available using the BlastWare III software.

c. Peak Acceleration

The BlastMate III calculates peak acceleration, the rate of change of velocity, by dividing the difference in velocity by the difference in time. To obtain the peak acceleration, the BlastMate III subtracts two velocity readings and divides the result by the elapsed time between them.

$$a = \frac{dV}{dT} \approx \frac{\Delta V}{\Delta T}$$

where:

Δt = a small interval

The BlastMate III calculates the peak acceleration at each point along the entire waveform and reports the peak value. Note that this is not necessarily at the peak velocity for an individual waveform.

d. Peak Displacement

The BlastMate III calculates peak displacement, or particle distance travelled, by multiplying speed by time. In the BlastMate III the interval velocity is multiplied by the time interval and the resulting displacement segments are summed.

$$s = \int V dt \approx \sum (V \Delta t)$$

where:

V = the velocity in each interval

To obtain the peak displacement, the BlastMate III integrates each wave segment of the entire waveform between zero crossings, selects the largest, then divides the value by half. Note that this is not necessarily at the peak velocity of the waveform.

e. Peak Vector Sum (PVS)

The figure below displays three event waveforms. The figure illustrates the procedure of graphically calculating peak vector sums. Measured magnitudes are tabulated for six different times and represent velocities in each of the three axes. The vector sum represents the resultant particle velocity magnitude and is calculated by squaring and adding the magnitudes and taking the square root.

$$PVS = \sqrt{T^2 + V^2 + L^2}$$

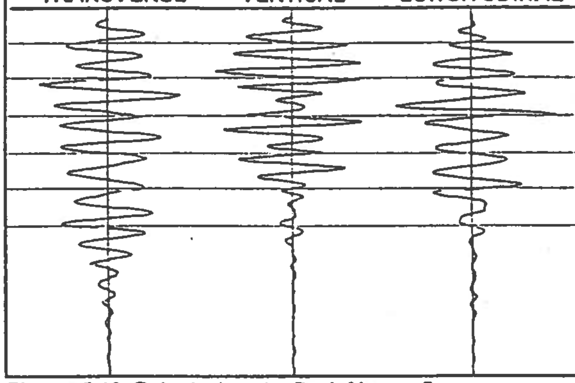
where:

T = particle velocity along the transverse plane

V = particle velocity along the vertical plane

L = particle velocity along the longitudinal plane

The BlastMate III calculates the peak vector sum for each point of the sampled waveforms and displays the largest value. Note that this is not necessarily at the peak velocity for an individual waveform.



MAGNITUDE T	MAGNITUDE V	MAGNITUDE L	PEAK VECTOR
-0.34	-0.33	0.14	0.494
0.38	-0.47	0.38	0.714
0.29	-0.31	0.51	0.663
-0.53	0.23	-0.31	0.655
0.24	0.07	0.36	0.44
-0.23	-0.16	-0.15	0.318

Figure 5.12 Calculating the Peak Vector Sum.

5.5.2 Sound Pressure

The BlastMate III calculates two sound pressure indicators, peak sound pressure and zero crossing frequency.

a. Peak Sound Pressure (PSP)

The BlastMate III checks the entire event waveform and displays the largest sound pressure called the Peak Sound Pressure (PSP), also referred to as the Peak Air Over–Pressure. Results appear on the BlastMate III display and in the Event Summary Report.

b. Zero Crossing Frequency (ZC Freq)

The Zero Crossing Frequency calculation for sound pressure is the same calculation used for ground vibrations. Please see above for a complete discussion.

Note: The Zero Crossing Frequency calculation is performed for Linear microphones only. This calculation does not appear on the BlastMate III display or on Event Summary Reports when using an "A" Weight microphone.

5.6 Alternate Manual Waveform Calculations

The following sections discuss manual waveform analysis techniques. These have been included for reference purposes only. They do not represent the calculation techniques employed by the BlastMate III.

Graphical methods for calculating area and slope depend on the shape of the waveform being analyzed. A complete discussion of the procedures is beyond the scope of this manual. Two useful reference texts are G. A. BOLLIGER, *BLAST VIBRATION ANALYSIS*, Southern Illinois University Press and CHARLES H. DOWDING, *BLAST VIBRATION MONITORING AND CONTROL*, Prentice-Hall Inc.

In each of the subsequent examples some formulae appear with no attempt at derivation. The following definitions apply:

A = amplitude in inches/second measured from the zero line

A_m = amplitude measured in millimetres/second

T = period in seconds

Y = absolute change in amplitude over time measured in inches/second

Y_m = absolute change in amplitude over time measured in millimetres/second

5.6.1 Sinusoidal Waveforms

The motion is essentially sinusoidal with gradual amplitude and frequency changes.

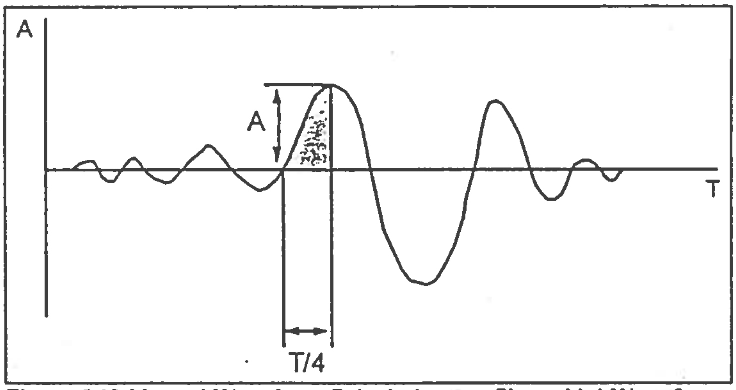


Figure 5.13 Manual Waveform Calculations on Sinusoidal Waveforms.

a. Calculating Displacement:

Maximum Displacement (in.) $= \frac{T}{2\pi} \times A$

Maximum Displacement (mm) $= \frac{T}{2\pi} \times A_m$

b. Calculating Acceleration:

Maximum Acceleration (in./s²) $= \frac{2\pi}{T} \times A$

Maximum Acceleration (mm/s²) $= \frac{2\pi}{T} \times A_m$.

5.6.2 Nearly Triangular Waveforms

Motion is irregular and has large amplitude.

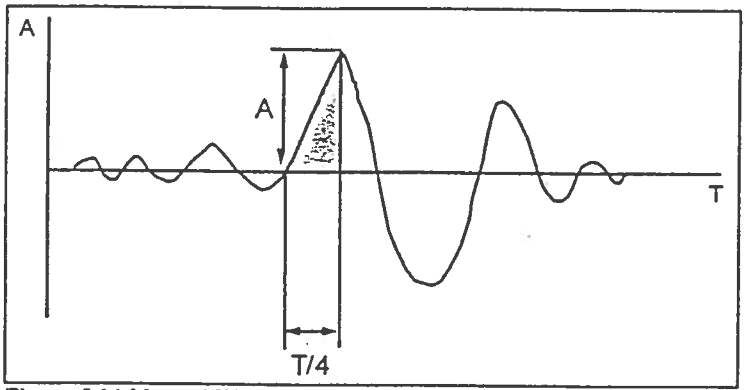


Figure 5.14 Manual Waveform Calculations on Nearly Triangular Waveforms.

a. Calculating Displacement:

Maximum Displacement (in.) $= \frac{T}{8} \times A$

Maximum Displacement (mm) $= \frac{T}{8} \times A_m$

b. Calculating Acceleration:

Maximum Acceleration (in./s^2) $= \frac{1}{T} \times Y$

Maximum Acceleration (mm/s^2) $= \frac{1}{T} \times Y_m$

5.6.3 Compound Waveforms

If the record exhibits interference by two or more predominant frequencies then the maximum displacement will be the sum of the maximum of each individual frequency component.

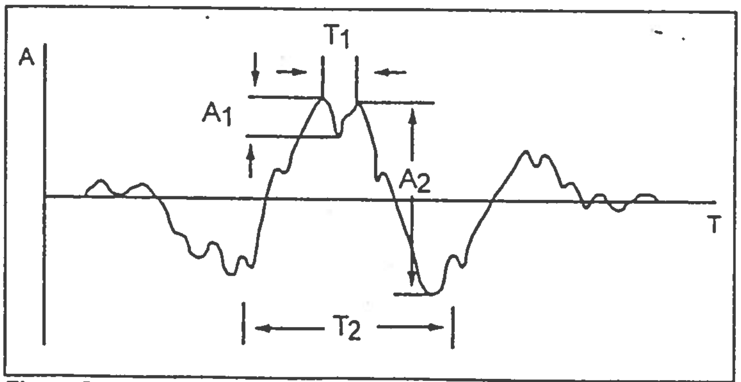


Figure 5.15 Manual Waveform Calculations on Compound Waveforms.

a. Calculating Displacement:

Maximum Displacement (in.) $= \frac{T_1}{2\pi} \times A_1 + \frac{T_2}{2\pi} \times A_2$

Maximum Displacement (mm) $= \frac{T_1}{2\pi} \times A_{1m} + \frac{T_2}{2\pi} \times A_{2m}$

b. Calculating Acceleration:

Maximum Acceleration (in./s²) $= \frac{2\pi}{T_1} \times A_1 + \frac{2\pi}{T_2} \times A_2$

Maximum Acceleration (mm/s²) $= \frac{2\pi}{T_1} \times A_{1m} + \frac{2\pi}{T_2} \times A_{2m}$

5.6.4 Irregular Waveforms

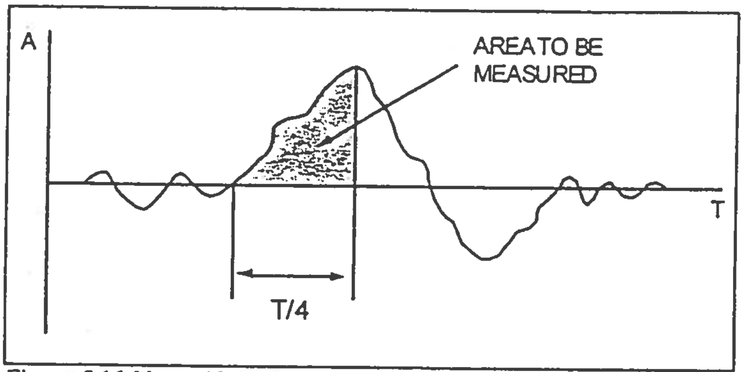


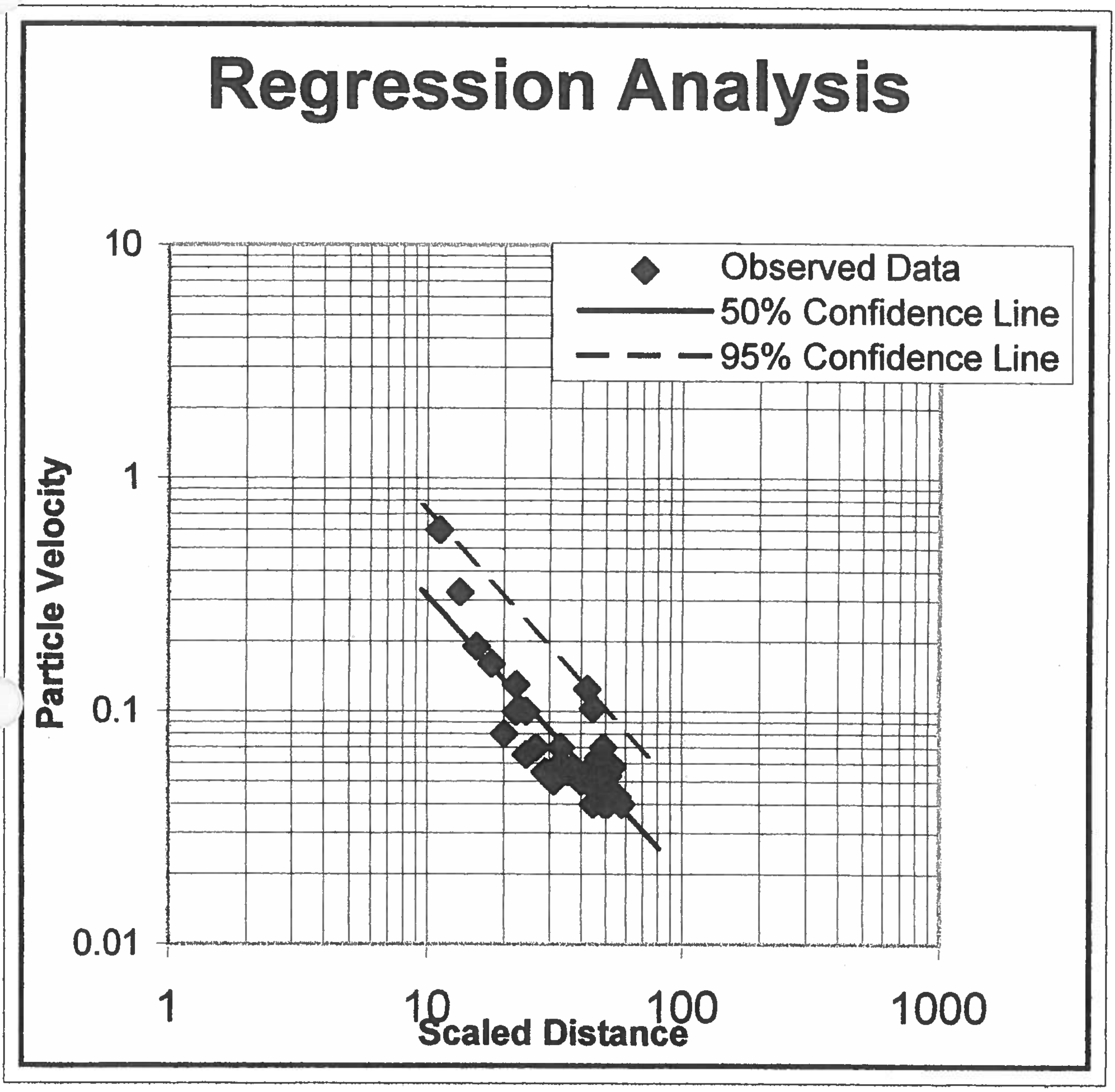
Figure 5.16 Manual Waveform Calculations on Irregular Waveforms.

a. Calculating Displacement:

Maximum Displacement = area under curve measured by a planimeter.

Appendix IV

Regression Analysis and Tables



The 95% Confidence Equation

PPV= 11.0 X (SD)^ $^{-1.19}$

The Correlation Coeficient r^2 is: 0.704

Matheson Mining Consultants 10/21/97

REGRESSION ANALYSIS

Data Statisics							
N	Max_PPV		Min_PPV			Max_SD	Min_SD
32.0	0.6		0.04			58	11
Calculated Sums							
Sum_X	Sum_Y		Sum_X2			Sum_Y2	Sum_XY
112.5	-83.433		401.545			229.767	-300.5
Sums Of Squares							
SS_X	SS_Y		SS_XY			SumXSumY	$(SumX)^2$
6.08	12.23		-7.23			-9385.800	12655.022
Calculated Means & Calulated Coefficients							
X_Bar	Y_Bar	a	K_{50}	K_{95}	K_{99}	K_{99}	B_{50}
3.515	-2.607	1.58	4.8	11.0	15.5	1.5	-1.19
Sample Standard Deviation & Coefficient of Correlation							
S	S_{e2}				r	r^2	
0.347	3.617				-0.839	0.704	
The 95% Confidence Level Equation							
PPV=	11.0	X (SD)^ $^{-1.19}$					

Prepared by Matheson Mining Consultants 10/21/97

Charge Weight per Delay
calculated from given distance and particle velocity
PV=11.0*(SD)^-1.19
PV=0.1 ips

Distance (feet)	Charge Weight (pounds)	Distance (feet)	Charge Weight (pounds)
100	3.7	4,000	5,932.1
200	14.8	4,100	6,232.4
300	33.4	4,200	6,540.1
400	59.3	4,300	6,855.3
500	92.7	4,400	7,177.8
600	133.5	4,500	7,507.8
700	181.7	4,600	7,845.2
800	237.3	4,700	8,190.0
900	300.3	4,800	8,542.2
1,000	370.8	4,900	8,901.8
1,100	448.6	5,000	9,268.9
1,200	533.9	5,100	9,643.4
1,300	626.6	5,200	10,025.2
1,400	726.7	5,300	10,414.5
1,500	834.2	5,400	10,811.2
1,600	949.1	5,500	11,215.4
1,700	1,071.5	5,600	11,626.9
1,800	1,201.2	5,700	12,045.9
1,900	1,338.4	5,800	12,472.2
2,000	1,483.0	5,900	12,906.0
2,100	1,635.0	6,000	13,347.2
2,200	1,794.5	6,100	13,795.8
2,300	1,961.3	6,200	14,251.9
2,400	2,135.6	6,300	14,715.3
2,500	2,317.2	6,400	15,186.2
2,600	2,506.3	6,500	15,664.4
2,700	2,702.8	6,600	16,150.1
2,800	2,906.7	6,700	16,643.2
2,900	3,118.1	6,800	17,143.7
3,000	3,336.8	6,900	17,651.7
3,100	3,563.0	7,000	18,167.0
3,200	3,796.5	7,100	18,689.8
3,300	4,037.5	7,200	19,220.0
3,400	4,285.9	7,300	19,757.6
3,500	4,541.8	7,400	20,302.6
3,600	4,805.0	7,500	20,855.0
3,700	5,075.6	7,600	21,414.9
3,800	5,353.7	7,700	21,982.1
3,900	5,639.2	7,800	22,556.8

Charge Weight per Delay
calculated from given distance and particle velocity
PV=11.0*(SD)^-1.19
PV=0.2 ips

Distance (feet)	Charge Weight (pounds)	Distance (feet)	Charge Weight (pounds)
100	11.9	4,000	19,016.9
200	47.5	4,100	19,979.7
300	107.0	4,200	20,966.2
400	190.2	4,300	21,976.5
500	297.1	4,400	23,010.5
600	427.9	4,500	24,068.3
700	582.4	4,600	25,149.9
800	760.7	4,700	26,255.3
900	962.7	4,800	27,384.4
1,000	1,188.6	4,900	28,537.3
1,100	1,438.2	5,000	29,714.0
1,200	1,711.5	5,100	30,914.4
1,300	2,008.7	5,200	32,138.6
1,400	2,329.6	5,300	33,386.6
1,500	2,674.3	5,400	34,658.4
1,600	3,042.7	5,500	35,953.9
1,700	3,434.9	5,600	37,273.2
1,800	3,850.9	5,700	38,616.3
1,900	4,290.7	5,800	39,983.1
2,000	4,754.2	5,900	41,373.7
2,100	5,241.5	6,000	42,788.1
2,200	5,752.6	6,100	44,226.3
2,300	6,287.5	6,200	45,688.2
2,400	6,846.1	6,300	47,173.9
2,500	7,428.5	6,400	48,683.4
2,600	8,034.7	6,500	50,216.6
2,700	8,664.6	6,600	51,773.6
2,800	9,318.3	6,700	53,354.4
2,900	9,995.8	6,800	54,959.0
3,000	10,697.0	6,900	56,587.3
3,100	11,422.1	7,000	58,239.4
3,200	12,170.8	7,100	59,915.3
3,300	12,943.4	7,200	61,614.9
3,400	13,739.7	7,300	63,338.3
3,500	14,559.8	7,400	65,085.5
3,600	15,403.7	7,500	66,856.4
3,700	16,271.4	7,600	68,651.2
3,800	17,162.8	7,700	70,469.7
3,900	18,078.0	7,800	72,311.9

Charge Weight per Delay
calculated from given distance and particle velocity
PV=11.0*(SD)^-1.19
PV=0.3 ips

Distance (feet)	Charge Weight (pounds)	Distance (feet)	Charge Weight (pounds)
100	23.5	4,000	37,591.7
200	94.0	4,100	39,494.8
300	211.5	4,200	41,444.9
400	375.9	4,300	43,441.9
500	587.4	4,400	45,486.0
600	845.8	4,500	47,577.0
700	1,151.2	4,600	49,715.1
800	1,503.7	4,700	51,900.1
900	1,903.1	4,800	54,132.1
1,000	2,349.5	4,900	56,411.1
1,100	2,842.9	5,000	58,737.1
1,200	3,383.3	5,100	61,110.1
1,300	3,970.6	5,200	63,530.0
1,400	4,605.0	5,300	65,997.0
1,500	5,286.3	5,400	68,510.9
1,600	6,014.7	5,500	71,071.9
1,700	6,790.0	5,600	73,679.8
1,800	7,612.3	5,700	76,334.7
1,900	8,481.6	5,800	79,036.6
2,000	9,397.9	5,900	81,785.5
2,100	10,361.2	6,000	84,581.4
2,200	11,371.5	6,100	87,424.3
2,300	12,428.8	6,200	90,314.1
2,400	13,533.0	6,300	93,251.0
2,500	14,684.3	6,400	96,234.8
2,600	15,882.5	6,500	99,265.7
2,700	17,127.7	6,600	102,343.5
2,800	18,420.0	6,700	105,468.3
2,900	19,759.2	6,800	108,640.1
3,000	21,145.4	6,900	111,858.9
3,100	22,578.5	7,000	115,124.7
3,200	24,058.7	7,100	118,437.5
3,300	25,585.9	7,200	121,797.2
3,400	27,160.0	7,300	125,204.0
3,500	28,781.2	7,400	128,657.7
3,600	30,449.3	7,500	132,158.4
3,700	32,164.4	7,600	135,706.2
3,800	33,926.5	7,700	139,300.9
3,900	35,735.6	7,800	142,942.6

Charge Weight per Delay
calculated from given distance and particle velocity
PV=11.0*(SD)^-1.19
PV=0.4 ips

Distance (feet)	Charge Weight (pounds)	Distance (feet)	Charge Weight (pounds)
100	38.1	4,000	60,964.0
200	152.4	4,100	64,050.3
300	342.9	4,200	67,212.8
400	609.6	4,300	70,451.5
500	952.6	4,400	73,766.4
600	1,371.7	4,500	77,157.6
700	1,867.0	4,600	80,624.9
800	2,438.6	4,700	84,168.4
900	3,086.3	4,800	87,788.2
1,000	3,810.2	4,900	91,484.1
1,100	4,610.4	5,000	95,256.2
1,200	5,486.8	5,100	99,104.6
1,300	6,439.3	5,200	103,029.2
1,400	7,468.1	5,300	107,029.9
1,500	8,573.1	5,400	111,106.9
1,600	9,754.2	5,500	115,260.1
1,700	11,011.6	5,600	119,489.4
1,800	12,345.2	5,700	123,795.0
1,900	13,755.0	5,800	128,176.8
2,000	15,241.0	5,900	132,634.8
2,100	16,803.2	6,000	137,169.0
2,200	18,441.6	6,100	141,779.4
2,300	20,156.2	6,200	146,466.0
2,400	21,947.0	6,300	151,228.8
2,500	23,814.1	6,400	156,067.8
2,600	25,757.3	6,500	160,983.1
2,700	27,776.7	6,600	165,974.5
2,800	29,872.4	6,700	171,042.1
2,900	32,044.2	6,800	176,186.0
3,000	34,292.2	6,900	181,406.0
3,100	36,616.5	7,000	186,702.2
3,200	39,017.0	7,100	192,074.7
3,300	41,493.6	7,200	197,523.4
3,400	44,046.5	7,300	203,048.2
3,500	46,675.6	7,400	208,649.3
3,600	49,380.8	7,500	214,326.6
3,700	52,162.3	7,600	220,080.0
3,800	55,020.0	7,700	225,909.7
3,900	57,953.9	7,800	231,815.6

Charge Weight per Delay
calculated from given distance and particle velocity
PV=11.0*(SD)^-1.19
PV=0.5 ips

Distance (feet)	Charge Weight (pounds)	Distance (feet)	Charge Weight (pounds)
100	55.4	4,000	88,704.9
200	221.8	4,100	93,195.5
300	499.0	4,200	97,797.1
400	887.0	4,300	102,509.6
500	1,386.0	4,400	107,332.9
600	1,995.9	4,500	112,267.1
700	2,716.6	4,600	117,312.2
800	3,548.2	4,700	122,468.1
900	4,490.7	4,800	127,735.0
1,000	5,544.1	4,900	133,112.7
1,100	6,708.3	5,000	138,601.3
1,200	7,983.4	5,100	144,200.8
1,300	9,369.5	5,200	149,911.2
1,400	10,866.3	5,300	155,732.5
1,500	12,474.1	5,400	161,664.6
1,600	14,192.8	5,500	167,707.6
1,700	16,022.3	5,600	173,861.5
1,800	17,962.7	5,700	180,126.3
1,900	20,014.0	5,800	186,502.0
2,000	22,176.2	5,900	192,988.5
2,100	24,449.3	6,000	199,585.9
2,200	26,833.2	6,100	206,294.2
2,300	29,328.0	6,200	213,113.4
2,400	31,933.7	6,300	220,043.5
2,500	34,650.3	6,400	227,084.4
2,600	37,477.8	6,500	234,236.3
2,700	40,416.2	6,600	241,499.0
2,800	43,465.4	6,700	248,872.6
2,900	46,625.5	6,800	256,357.0
3,000	49,896.5	6,900	263,952.4
3,100	53,278.4	7,000	271,658.6
3,200	56,771.1	7,100	279,475.7
3,300	60,374.7	7,200	287,403.7
3,400	64,089.3	7,300	295,442.6
3,500	67,914.7	7,400	303,592.4
3,600	71,850.9	7,500	311,853.0
3,700	75,898.1	7,600	320,224.5
3,800	80,056.1	7,700	328,706.9
3,900	84,325.1	7,800	337,300.2

Particle Velocity (+95%)
calculated from given distance and charge weight
PV =11.0*(SD)^-1.19
Charge Weight = 50 pounds

Distance (feet)	PV (inches/second)	Distance (feet)	PV (inches/second)
100	0.470	4000	0.006
200	0.206	4100	0.006
300	0.127	4200	0.006
400	0.090	4300	0.005
500	0.069	4400	0.005
600	0.056	4500	0.005
700	0.046	4600	0.005
800	0.040	4700	0.005
900	0.034	4800	0.005
1000	0.030	4900	0.005
1100	0.027	5000	0.004
1200	0.024	5100	0.004
1300	0.022	5200	0.004
1400	0.020	5300	0.004
1500	0.019	5400	0.004
1600	0.017	5500	0.004
1700	0.016	5600	0.004
1800	0.015	5700	0.004
1900	0.014	5800	0.004
2000	0.013	5900	0.004
2100	0.013	6000	0.004
2200	0.012	6100	0.004
2300	0.011	6200	0.003
2400	0.011	6300	0.003
2500	0.010	6400	0.003
2600	0.010	6500	0.003
2700	0.009	6600	0.003
2800	0.009	6700	0.003
2900	0.009	6800	0.003
3000	0.008	6900	0.003
3100	0.008	7000	0.003
3200	0.008	7100	0.003
3300	0.007	7200	0.003
3400	0.007	7300	0.003
3500	0.007	7400	0.003
3600	0.007	7500	0.003
3700	0.006	7600	0.003
3800	0.006	7700	0.003
3900	0.006	7800	0.003

Particle Velocity (+95%)
calculated from given distance and charge weight
PV =11.0*(SD)^-1.19
Charge Weight = 100 pounds

Distance (feet)	PV (inches/second)	Distance (feet)	PV (inches/second)
100	0.710	4000	0.009
200	0.311	4100	0.009
300	0.192	4200	0.008
400	0.136	4300	0.008
500	0.105	4400	0.008
600	0.084	4500	0.008
700	0.070	4600	0.007
800	0.060	4700	0.007
900	0.052	4800	0.007
1000	0.046	4900	0.007
1100	0.041	5000	0.007
1200	0.037	5100	0.007
1300	0.034	5200	0.006
1400	0.031	5300	0.006
1500	0.028	5400	0.006
1600	0.026	5500	0.006
1700	0.024	5600	0.006
1800	0.023	5700	0.006
1900	0.021	5800	0.006
2000	0.020	5900	0.006
2100	0.019	6000	0.005
2200	0.018	6100	0.005
2300	0.017	6200	0.005
2400	0.016	6300	0.005
2500	0.015	6400	0.005
2600	0.015	6500	0.005
2700	0.014	6600	0.005
2800	0.013	6700	0.005
2900	0.013	6800	0.005
3000	0.012	6900	0.005
3100	0.012	7000	0.005
3200	0.011	7100	0.004
3300	0.011	7200	0.004
3400	0.011	7300	0.004
3500	0.010	7400	0.004
3600	0.010	7500	0.004
3700	0.010	7600	0.004
3800	0.009	7700	0.004
3900	0.009	7800	0.004

Particle Velocity (+95%)
calculated from given distance and charge weight
PV =11.0*(SD)^-1.19
Charge Weight = 200 pounds

Distance (feet)	PV (inches/second)	Distance (feet)	PV (inches/second)
100	1.073	4000	0.013
200	0.470	4100	0.013
300	0.290	4200	0.013
400	0.206	4300	0.012
500	0.158	4400	0.012
600	0.127	4500	0.012
700	0.106	4600	0.011
800	0.090	4700	0.011
900	0.079	4800	0.011
1000	0.069	4900	0.010
1100	0.062	5000	0.010
1200	0.056	5100	0.010
1300	0.051	5200	0.010
1400	0.046	5300	0.010
1500	0.043	5400	0.009
1600	0.040	5500	0.009
1700	0.037	5600	0.009
1800	0.034	5700	0.009
1900	0.032	5800	0.009
2000	0.030	5900	0.008
2100	0.029	6000	0.008
2200	0.027	6100	0.008
2300	0.026	6200	0.008
2400	0.024	6300	0.008
2500	0.023	6400	0.008
2600	0.022	6500	0.007
2700	0.021	6600	0.007
2800	0.020	6700	0.007
2900	0.020	6800	0.007
3000	0.019	6900	0.007
3100	0.018	7000	0.007
3200	0.017	7100	0.007
3300	0.017	7200	0.007
3400	0.016	7300	0.007
3500	0.016	7400	0.006
3600	0.015	7500	0.006
3700	0.015	7600	0.006
3800	0.014	7700	0.006
3900	0.014	7800	0.006

Particle Velocity (+95%)
calculated from given distance and charge weight
PV =11.0*(SD)^-1.19
Charge Weight = 500 pounds

Distance (feet)	PV (inches/second)	Distance (feet)	PV (inches/second)
100	1.850	4000	0.023
200	0.811	4100	0.022
300	0.501	4200	0.022
400	0.355	4300	0.021
500	0.273	4400	0.020
600	0.219	4500	0.020
700	0.183	4600	0.019
800	0.156	4700	0.019
900	0.135	4800	0.018
1000	0.119	4900	0.018
1100	0.107	5000	0.018
1200	0.096	5100	0.017
1300	0.087	5200	0.017
1400	0.080	5300	0.016
1500	0.074	5400	0.016
1600	0.068	5500	0.016
1700	0.064	5600	0.015
1800	0.059	5700	0.015
1900	0.056	5800	0.015
2000	0.052	5900	0.014
2100	0.049	6000	0.014
2200	0.047	6100	0.014
2300	0.044	6200	0.014
2400	0.042	6300	0.013
2500	0.040	6400	0.013
2600	0.038	6500	0.013
2700	0.037	6600	0.013
2800	0.035	6700	0.012
2900	0.034	6800	0.012
3000	0.032	6900	0.012
3100	0.031	7000	0.012
3200	0.030	7100	0.012
3300	0.029	7200	0.011
3400	0.028	7300	0.011
3500	0.027	7400	0.011
3600	0.026	7500	0.011
3700	0.025	7600	0.011
3800	0.024	7700	0.011
3900	0.024	7800	0.010

Appendix V

Seismograph Records

Construction Test Site

#	Distance (feet)	Charge Weight (pounds)	Particle Velocity (inches/second)	Hole #	Instrument #	Time
1	50	20	0.600	1	BC5536	9:16:22
2	100	20	0.130	1	BA5738	9:13:11
3	150	20	0.070	1	BA5552	9:17:28
4	200	20	0.103	1	3184	9:15:50
5	60	20	0.325	2	BC5536	9:36:28
6	110	20	0.065	2	BA5738	9:33:17
7	160	20	0.055	2	BA5552	9:37:34
8	210	20	0.063	2	3184	9:35:56
9	70	20	0.190	3	BC5536	9:46:51
10	120	20	0.070	3	BA5738	9:43:40
11	170	20	0.055	3	BA5552	9:47:57
12	220	20	0.070	3	3184	9:46:19
13	190	20	0.125	3	BC5534	9:43:02
14	80	20	0.160	4	BC5536	9:54:51
15	130	20	0.055	4	BA5738	9:51:40
16	180	20	0.050	4	BA5552	9:55:57
17	200	20	0.040	4	BC5534	9:55:24
18	230	20	0.053	4	3184	9:54:19
19	90	20	0.080	5	BC5536	10:01:04
20	140	20	0.500	5	BA5738	9:57
21	190	20	0.055	5	BA5552	10:02:10
22	210	20	0.045	5	BC5534	10:01:37
23	240	20	0.058	5	3184	10:00:32
24	100	20	0.100	6	BC5536	10:07:54
25	150	20	0.060	6	BA5738	10:04:44
26	200	20	0.050	6	BA5552	10:09:00
27	220	20	0.040	6	BC5534	10:08:28
28	250	20	0.043	6	3184	10:07:22
29	110	20	0.100	7	BC5536	10:19:37
	160	20	No Trigger<0.05	7	BA5738	
30	210	20	0.050	7	BA5552	10:12:57
31	230	20	0.040	7	BC5534	10:12:24
32	260	20	0.040	7	3184	10:11:19

Event Report

Date/Time	Long at 09:16:22 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAP.RA0

Notes

Location: Victor, CO
Client: CC & V
User Name: M.M.C. Colin Matheson
General: Attenuation Study

Post Event Notes

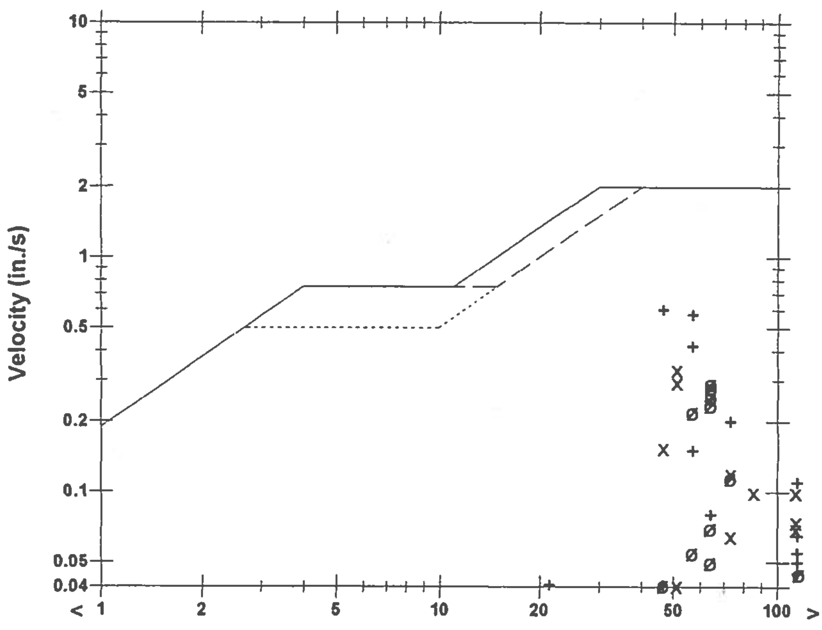
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

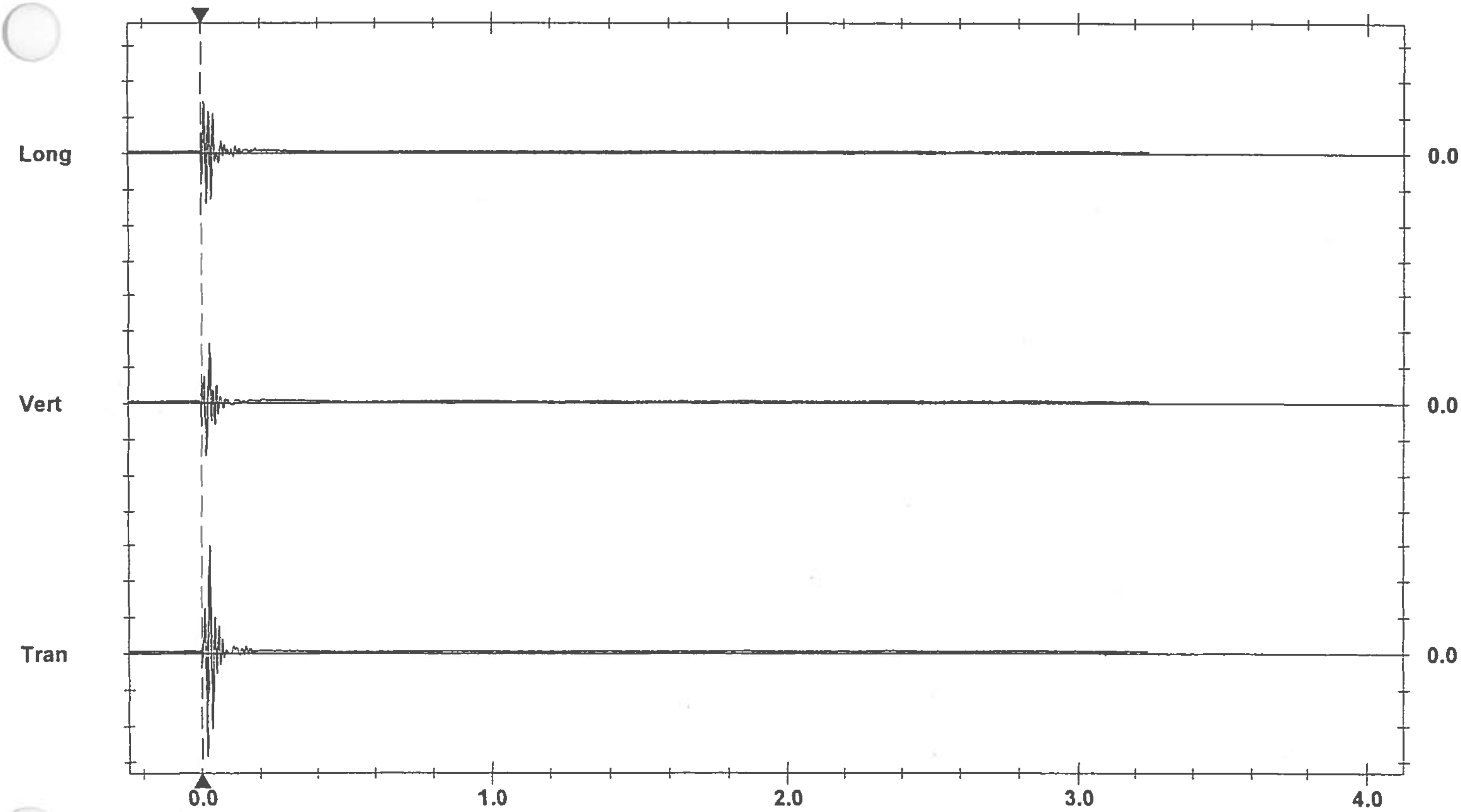
	Tran	Vert	Long	
PPV	0.600	0.335	0.290	in./s
ZC Freq	47	51	64	Hz
Time (Rel. to Trig)	0.026	0.028	0.010	sec
Peak Acceleration	0.530	0.292	0.305	g
Peak Displacement	0.00191	0.00813	0.00126	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.701 in./s at 0.027 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.200 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Vert at 09:13:11 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAP.LZ0

Notes
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

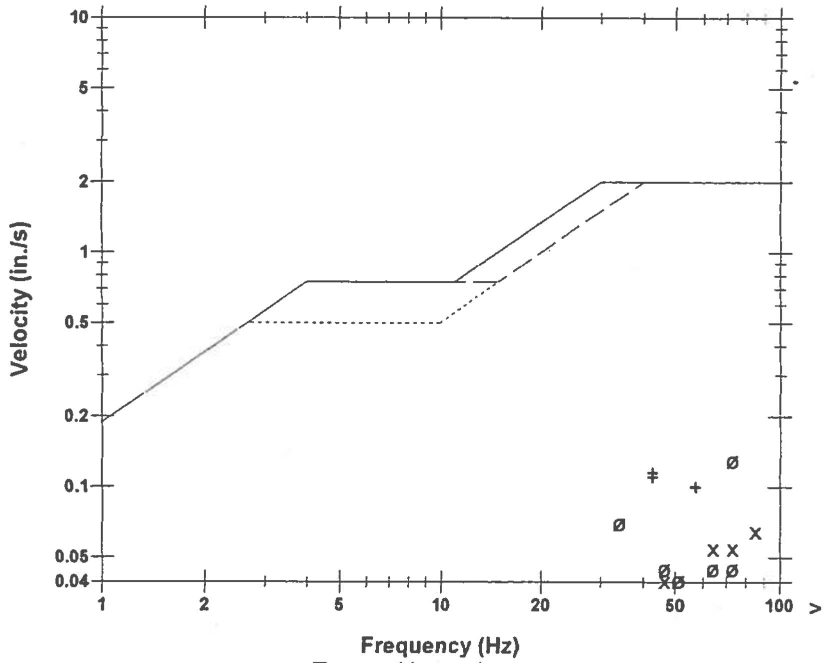
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

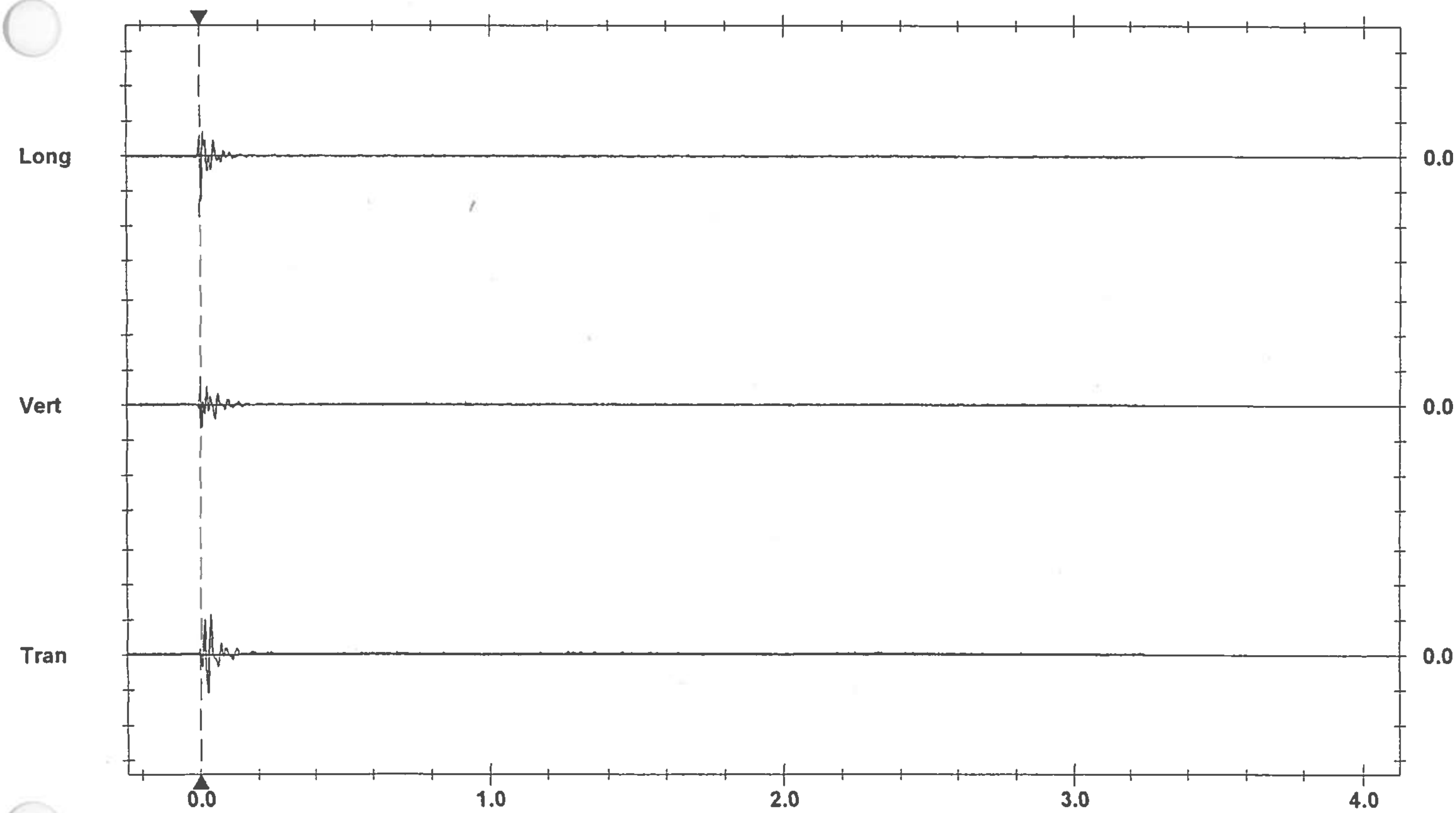
	Tran	Vert	Long	
PPV	0.115	0.0650	0.130	in./s
ZC Freq	43	85	73	Hz
Time (Rel. to Trig)	0.036	0.006	0.004	sec
Peak Acceleration	0.106	0.0928	0.119	g
Peak Displacement	0.00044	0.00014	0.00029	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.137 in./s at 0.005 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 09:17:28 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP0.H40

Notes
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction Test Blast

Other:

Post Event Notes
Test shot #1 - 20 lbs ANFO per delay
Distance 150 feet

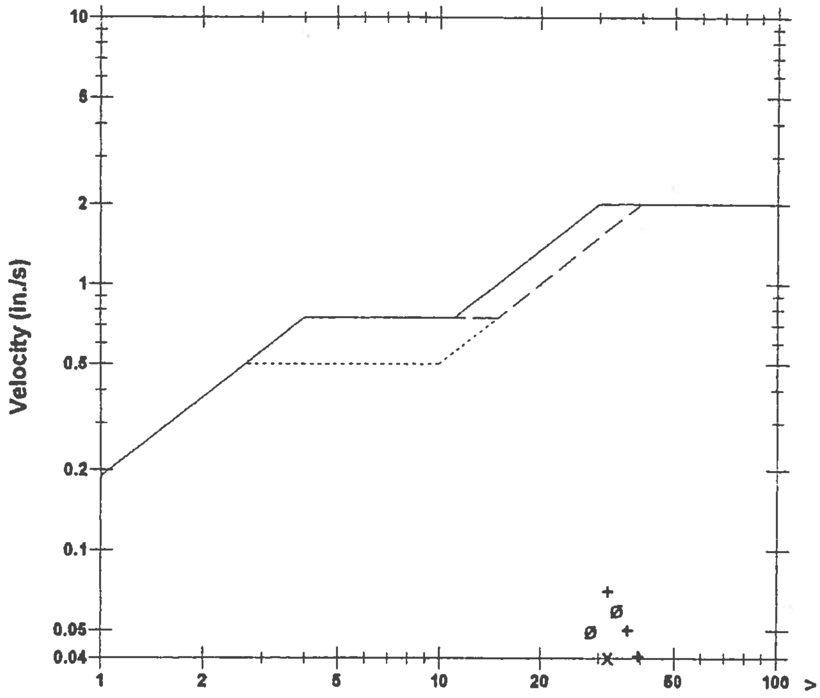
Microphone	Linear Weighting
PSPL	0.00018 psi(L) at -0.006 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

	Tran	Vert	Long	
PPV	0.0700	0.0400	0.0600	in./s
ZC Freq	32	32	34	Hz
Time (Rel. to Trig)	0.036	0.021	0.005	sec
Peak Acceleration	0.0530	0.0398	0.0530	g
Peak Displacement	0.00035	0.00019	0.00152	in.
Sensorcheck ™	Passed	Passed	Passed	

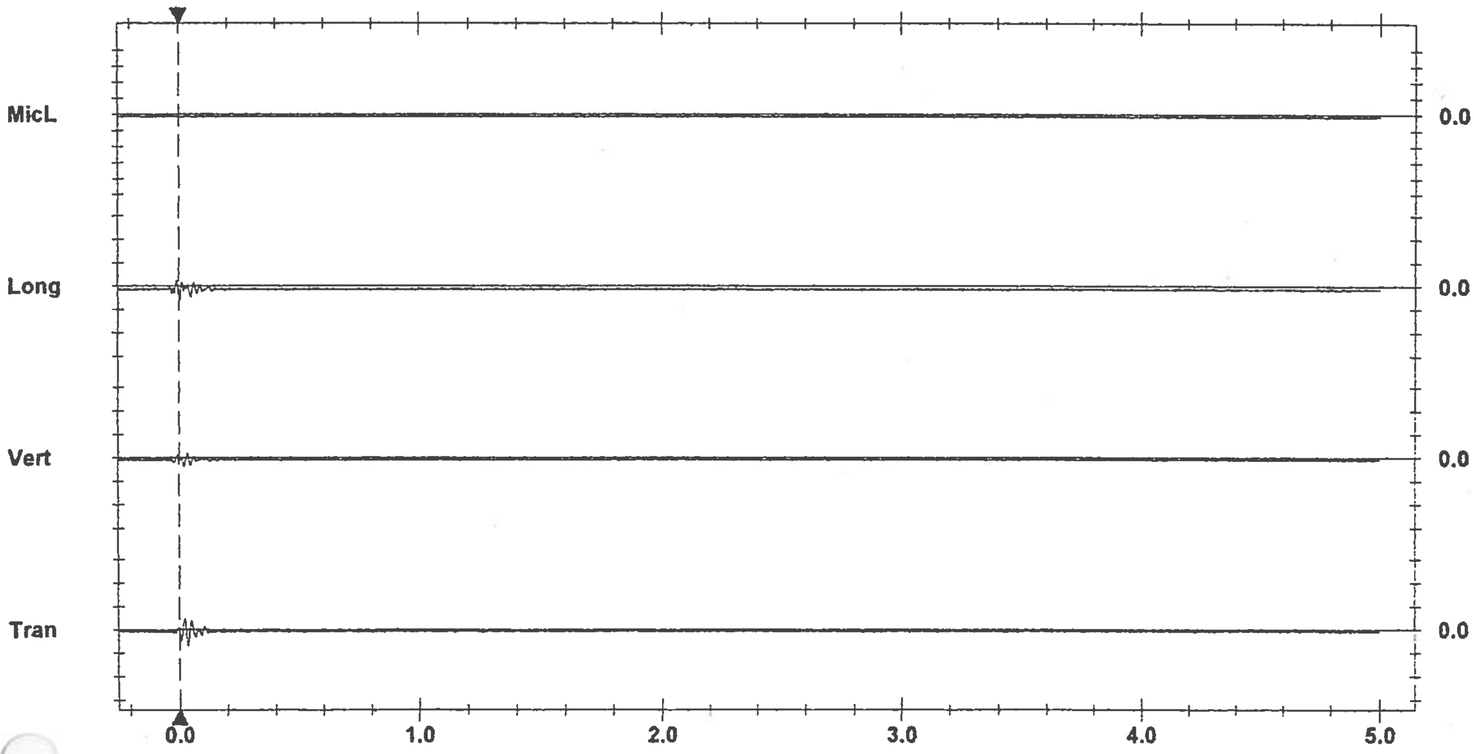
Peak Vector Sum 0.0730 in./s at 0.036 sec

N/A: Not Applicable
Out of Range

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø

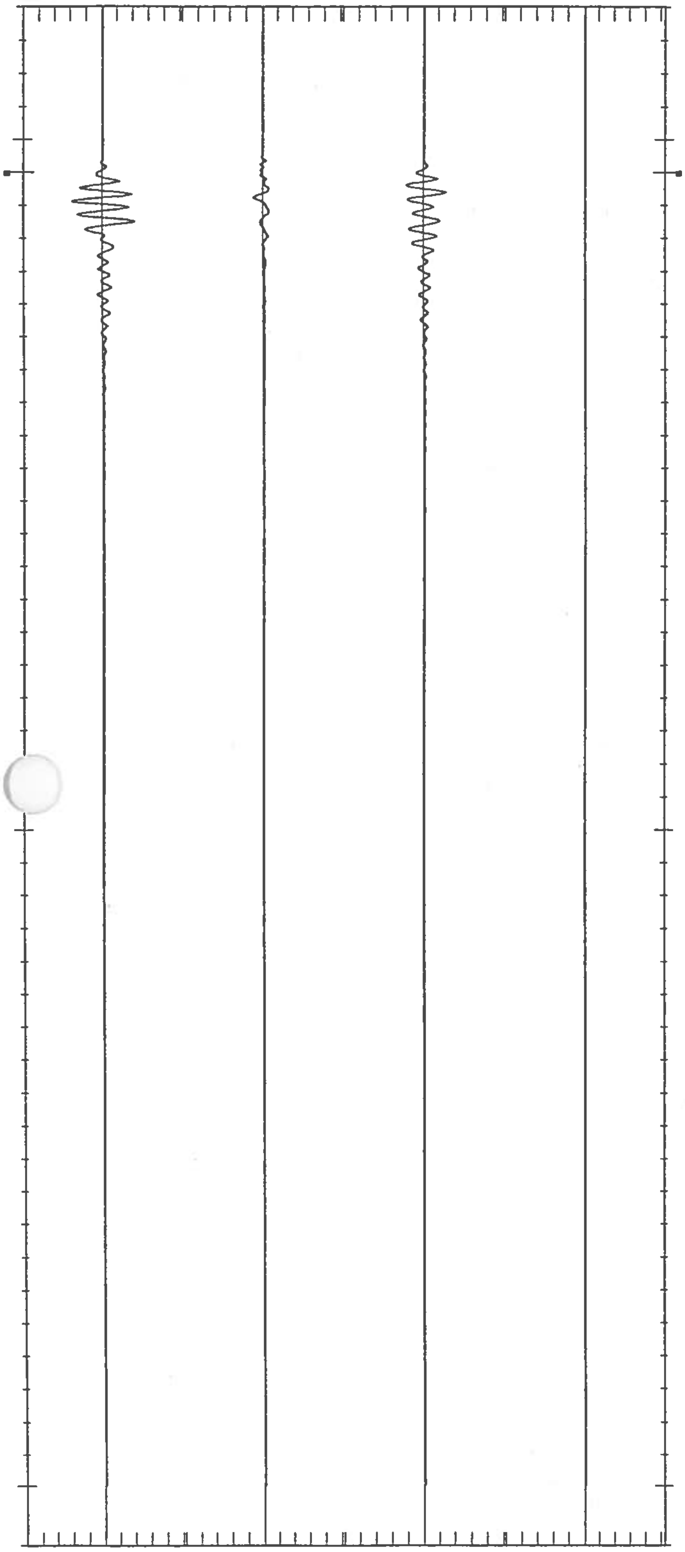


Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶— — — —◀

Printed: October 21, 1997 (V 3.42 - 3.41)

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.050 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER =

SERIAL NO.	3184 V2.4-MSV			
CODE	E1846OEF.2EV			
TIME & DATE	Long. at 09:15:50 Oct 17, 1997			
TRIGGER SOURCE	Geo 0.020 in/sec			
RECORD TIME	2 sec			
LOCATION				
CLIENT				
USER				
NOTES				
SCALED DISTANCE	N/A			
PEAK VECTOR SUM	0.114 in/sec at 75 ms			
MICROPHONE	LINEAR WEIGHTING			
PK AIR	<100 dB(L) at -249 ms			
ZC FREQ	N/A			
	TRAN	**VERT**	**LONG**	
PPV	0.103	0.030	0.070	in/sec
ZC FREQ	39	39	47	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	75	39	31	ms
ACCEL	0.08	0.02	0.05	g
1/4 WAVE DISP	0.0004	0.0001	0.0003	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

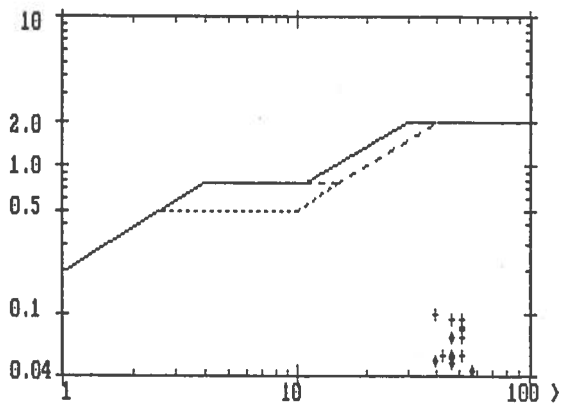
INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
(in/sec)



FREQUENCY (Hz)
+ TRAN X VERT LONG

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Long at 09:36:28 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAQ.OS0

es

Location:	Victor, CO
Client:	CC & V
User Name: M.M.C.	Colin Matheson
General:	Attenuation Study

Post Event Notes

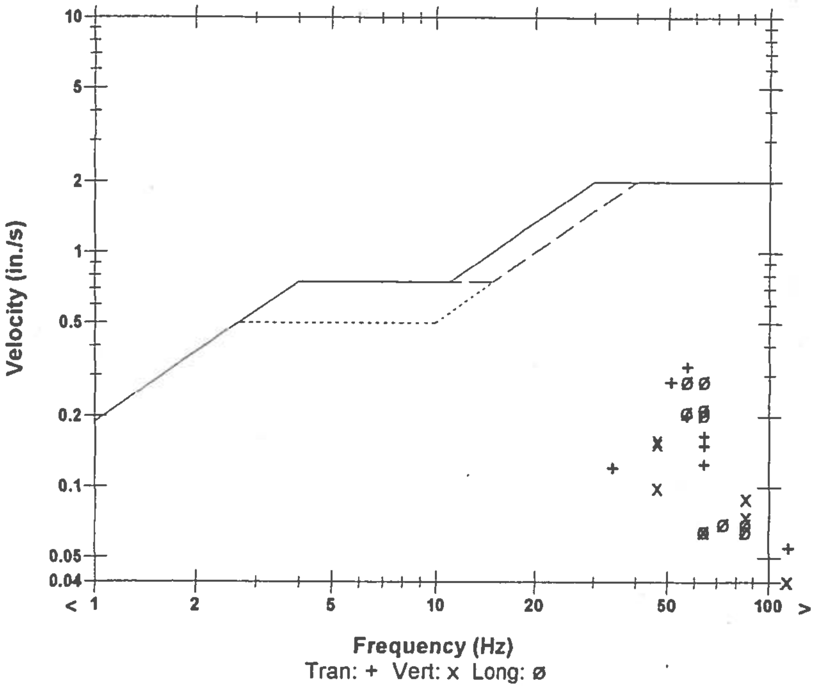
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

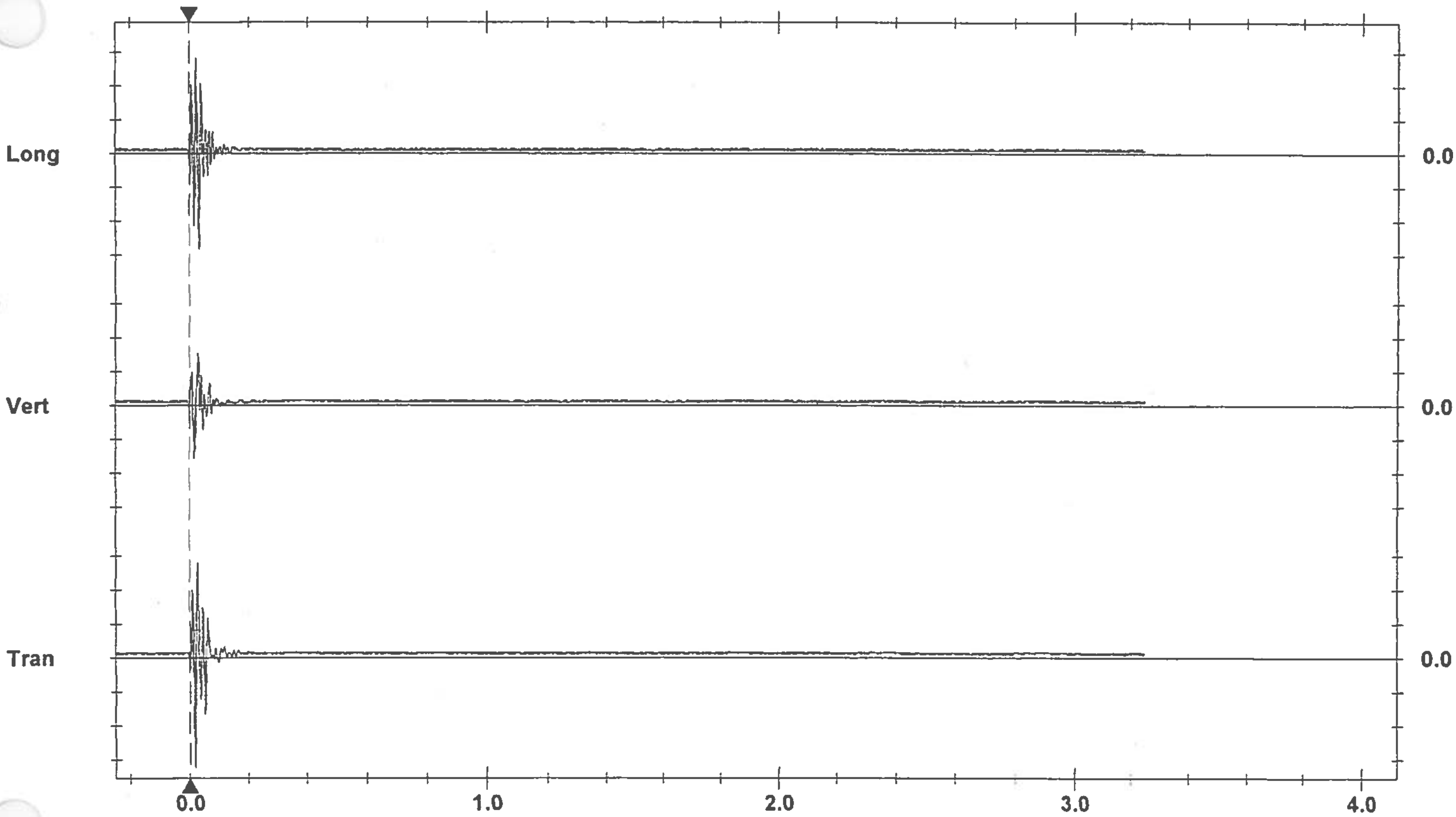
	Tran	Vert	Long	
PPV	0.325	0.160	0.285	in./s
ZC Freq	57	47	64	Hz
Time (Rel. to Trig)	0.018	0.016	0.022	sec
Peak Acceleration	0.305	0.159	0.278	g
Peak Displacement	0.00168	0.00566	0.00201	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.397 in./s at 0.017 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 09:33:17 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAQ.JH0

Notes
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

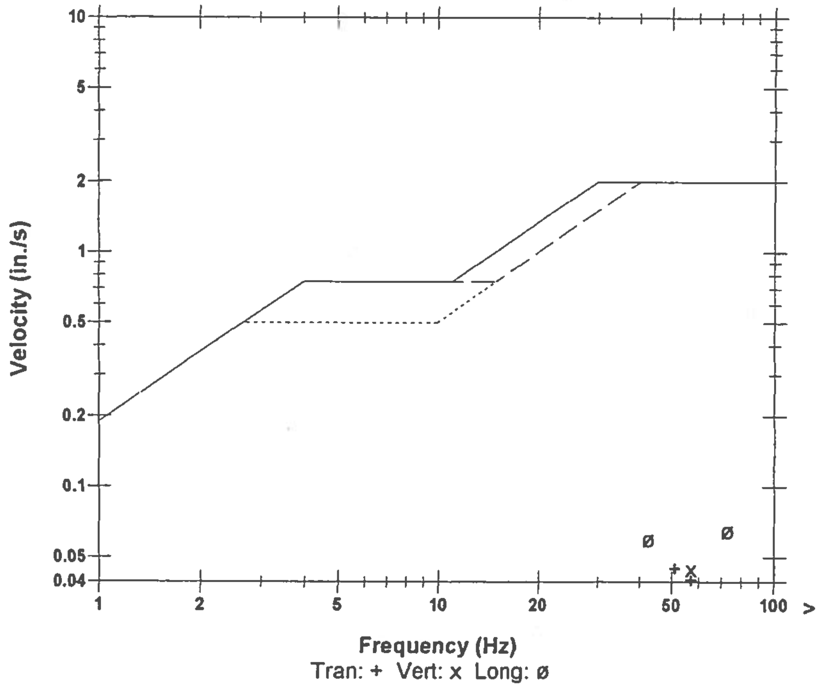
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

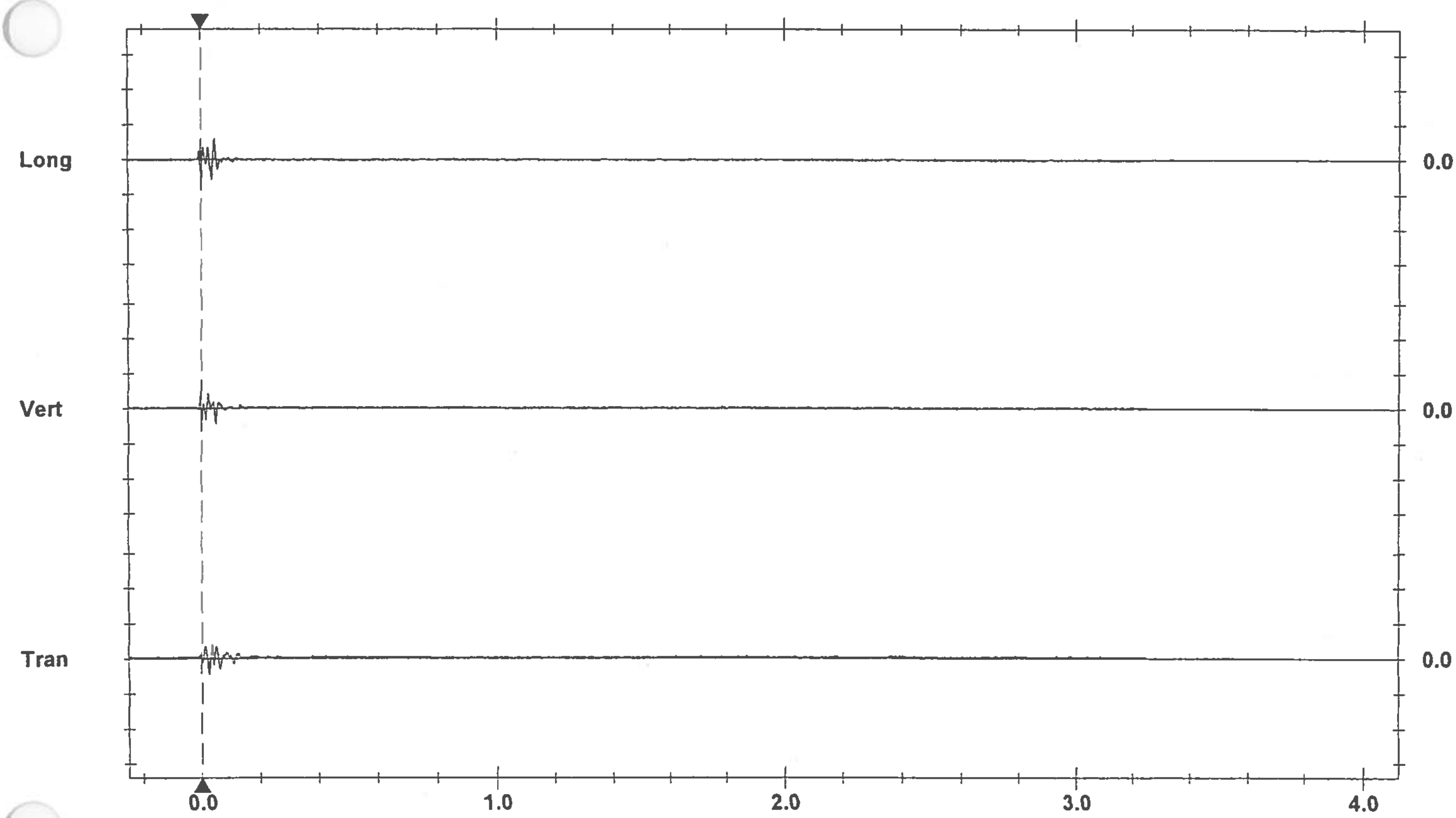
	Tran	Vert	Long	
PPV	0.0450	0.0450	0.0650	in./s
ZC Freq	51	57	73	Hz
Time (Rel. to Trig)	0.025	0.024	0.001	sec
Peak Acceleration	0.0530	0.0530	0.0663	g
Peak Displacement	0.00014	0.00013	0.00021	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0723 in./s at 0.035 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

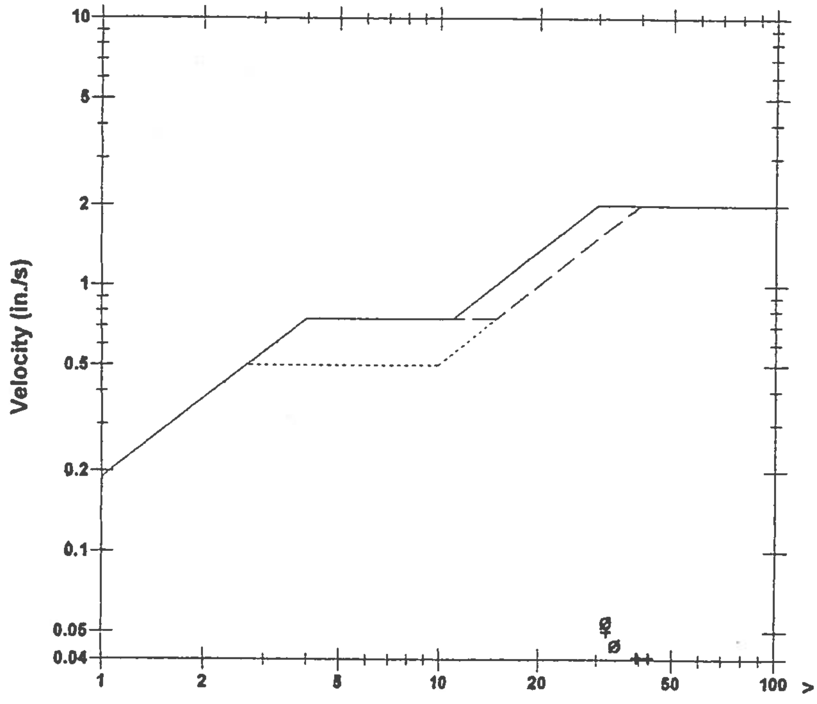
Date/Time	Long at 09:37:34 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP1.EM0

s
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction   Test Blast

Other:

Post Event Notes
Test Shot #2 - 20 Lbs ANFO per delay
Distance - 160 feet

USBM RI8507 And OSMRE

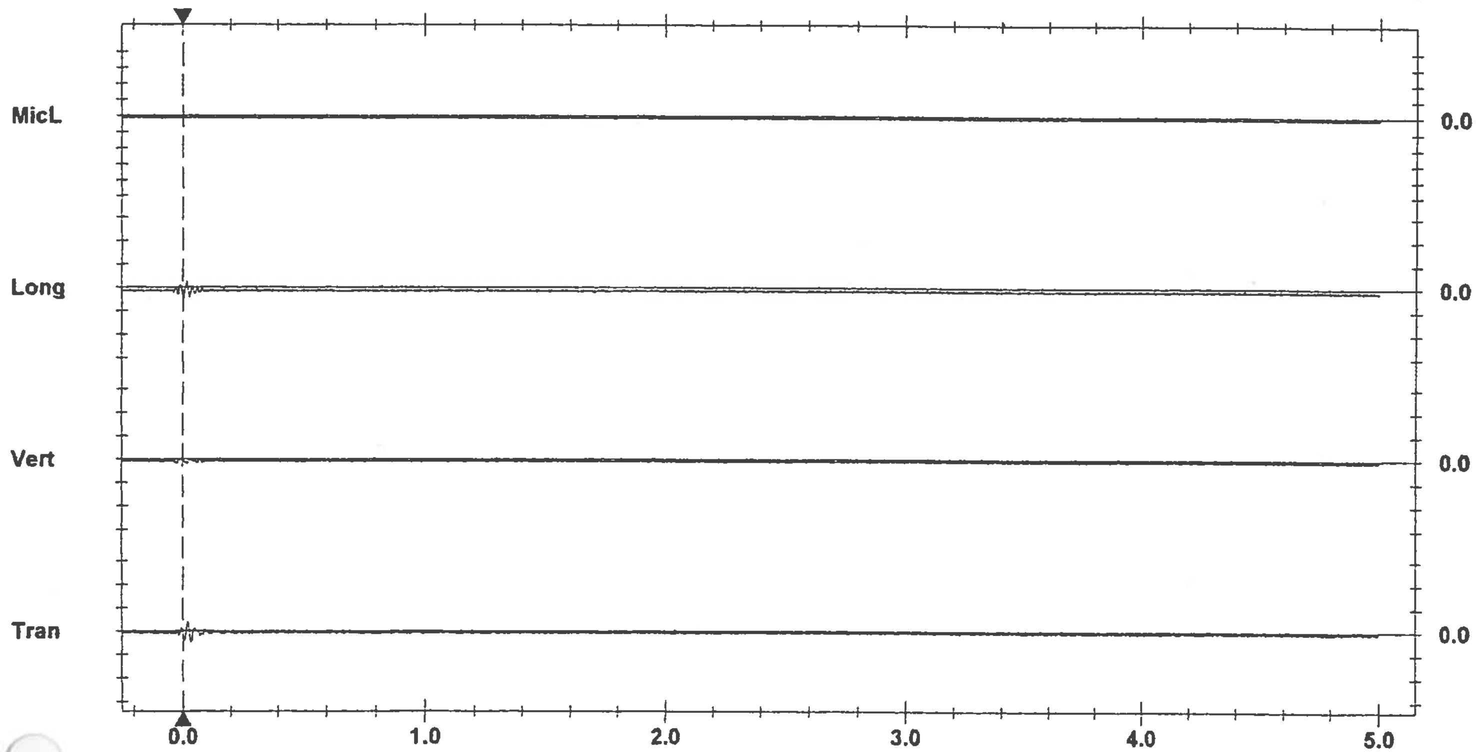


Microphone	Linear Weighting	
PSPL	0.00015 psi(L) at -0.249 sec	
ZC Freq	N/A	
Channel Test	Passed (Freq = *** Amp = ***)	

	Tran	Vert	Long	
PPV	0.0500	0.0200	0.0550	in./s
ZC Freq	32	37	32	Hz
Time (Rel. to Trig)	0.034	-0.026	0.002	sec
Peak Acceleration	0.0265	0.0265	0.0398	g
Peak Displacement	0.00025	0.00016	0.00161	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0610 in./s at 0.005 sec

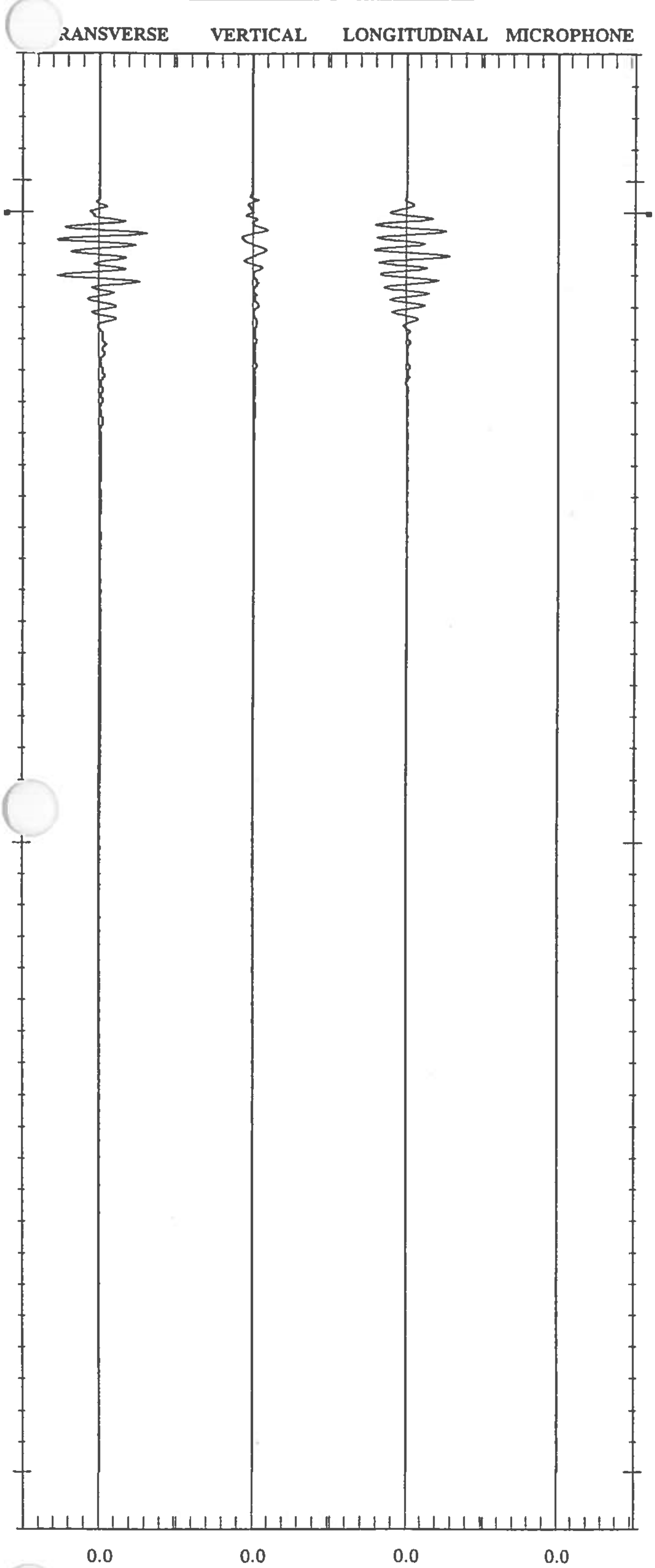
N/A: Not Applicable
Out of Range



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶— — — —◀

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.020 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER = •——•

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEF.ZWV
TIME & DATE	Long. at 09:35:56 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	
SCALED DISTANCE	N/A
PEAK VECTOR SUM	0.073 in/sec at 33 ms
MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.063	0.020	0.058	in/sec
ZC FREQ	47	39	43	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	34	29	70	ms
ACCEL	0.05	0.02	0.04	g
1/4 WAVE DISP	0.0002	0.0001	0.0002	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEF.ZWV
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Vert at 09:46:51 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAR.630

...es
Location: Victor, CO
Client: CC & V
User Name: M.M.C. Colin Matheson
General: Attenuation Study

Post Event Notes

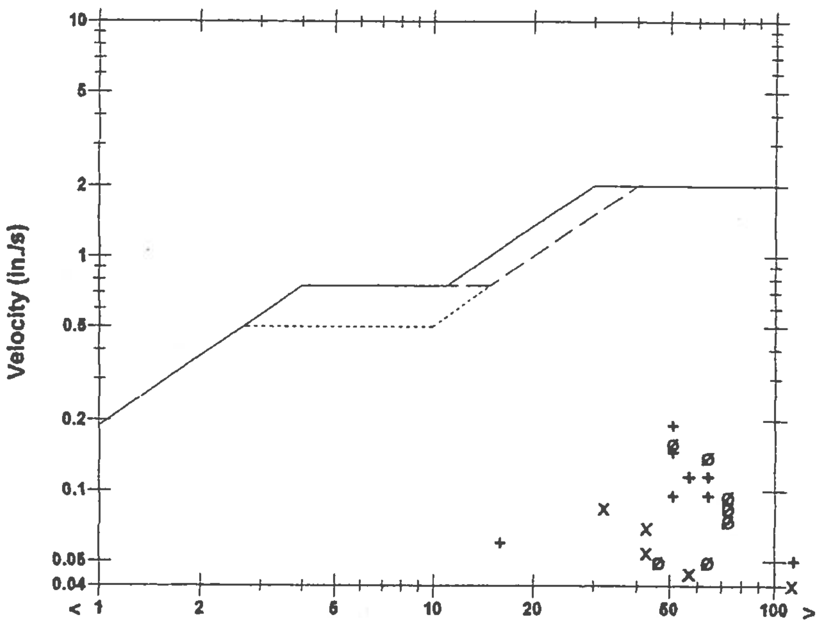
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

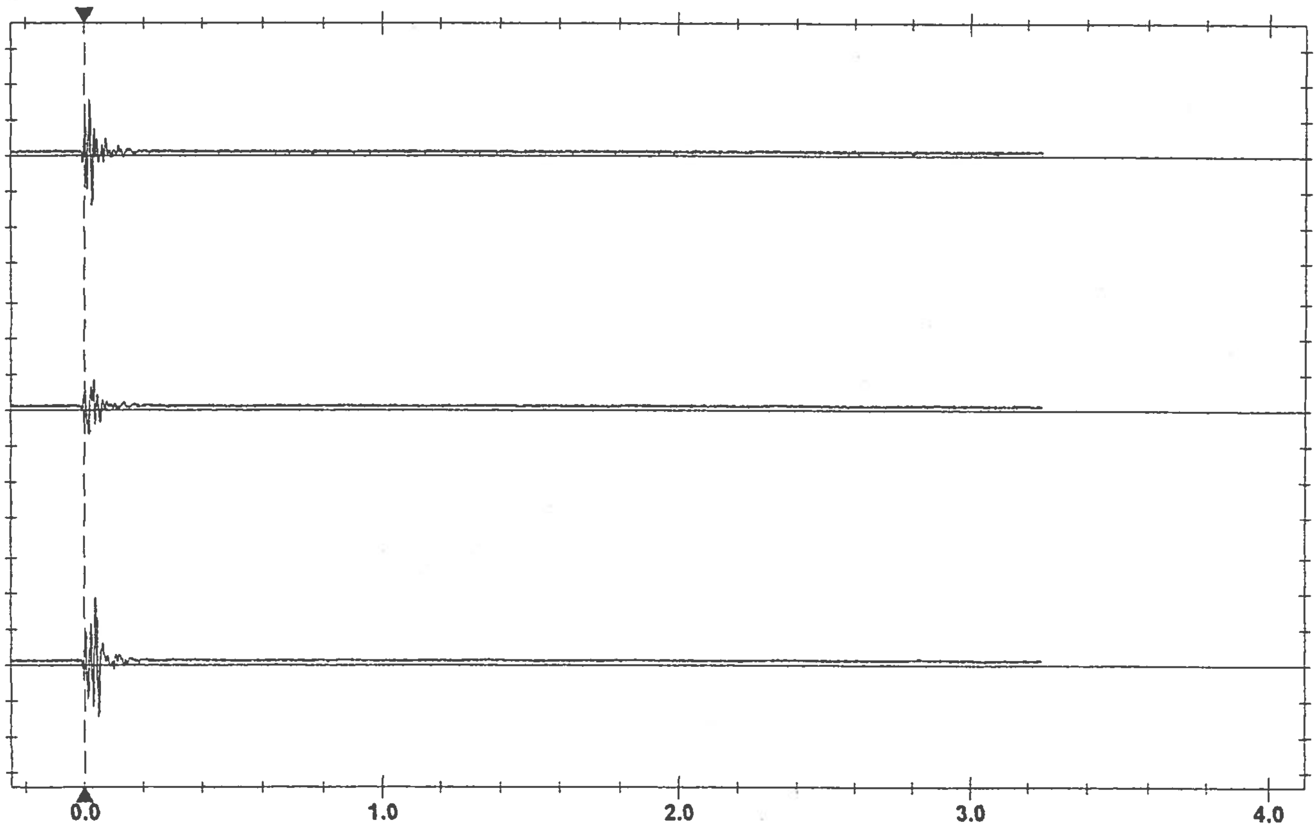
	Tran	Vert	Long	
PPV	0.190	0.0850	0.160	in./s
ZC Freq	51	32	51	Hz
Time (Rel. to Trig)	0.038	0.030	0.016	sec
Peak Acceleration	0.159	0.0928	0.159	g
Peak Displacement	0.00164	0.00854	0.00112	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.192 in./s at 0.038 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 09:43:40 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAR.0S0

Notes
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

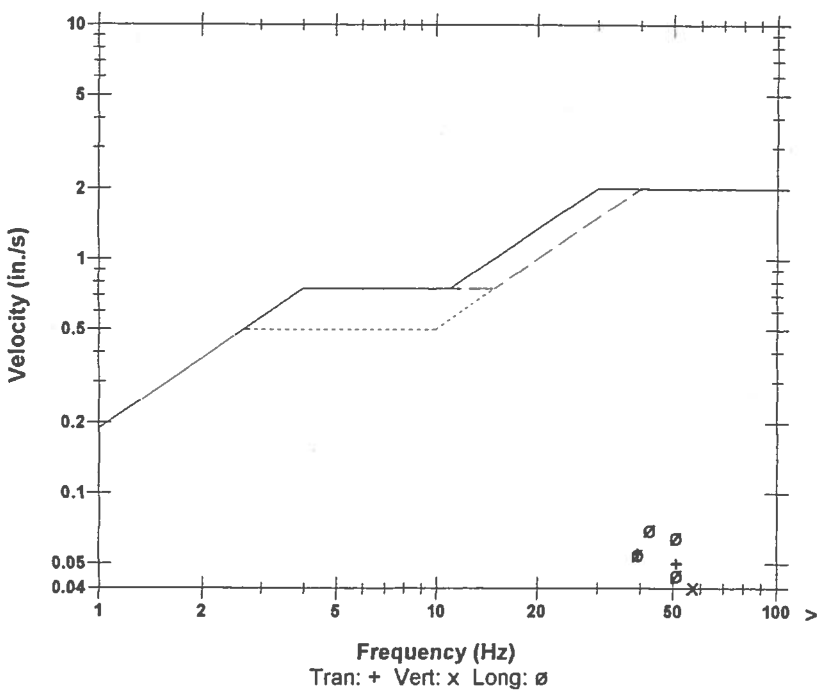
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

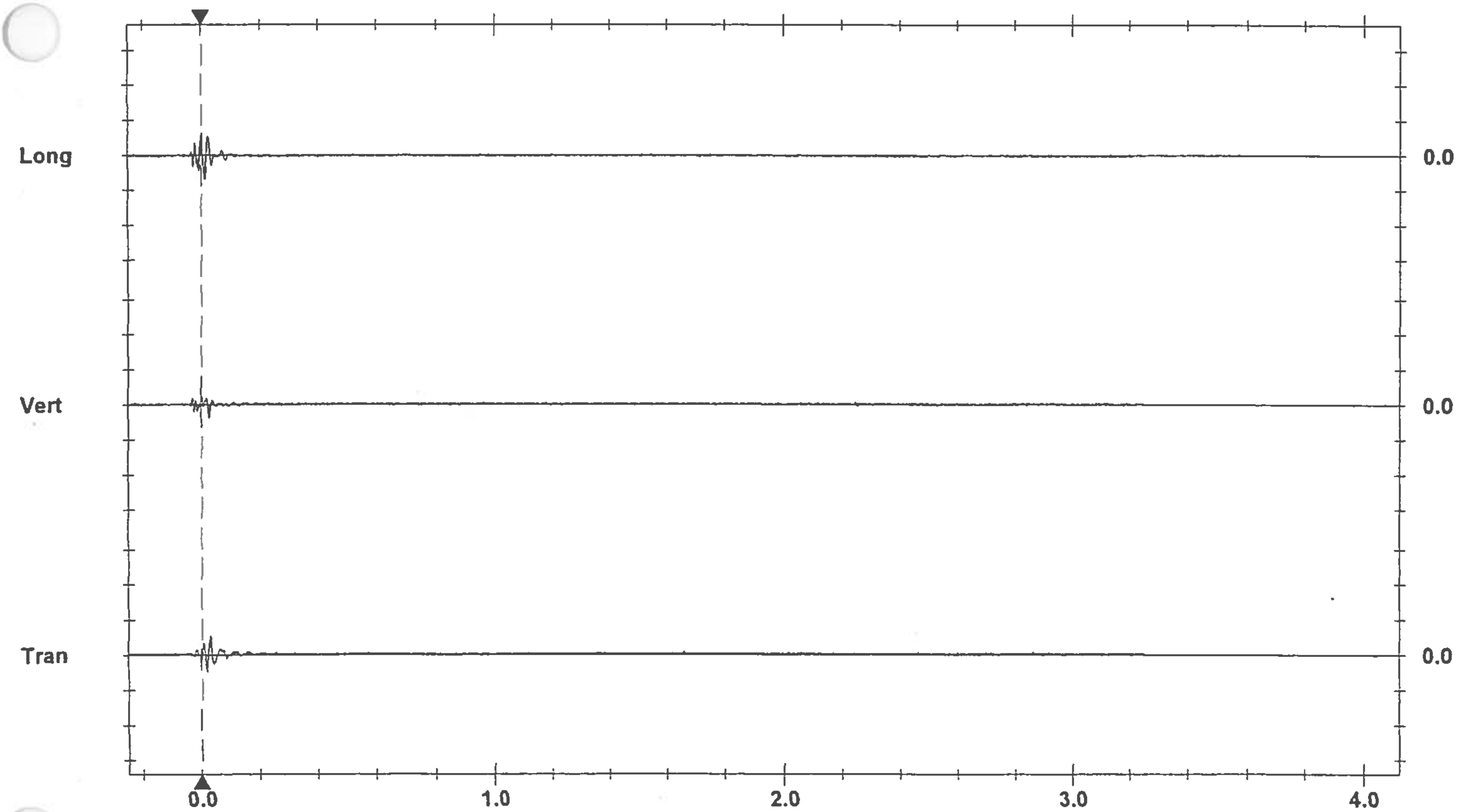
	Tran	Vert	Long	
PPV	0.0550	0.0400	0.0700	in./s
ZC Freq	39	57	43	Hz
Time (Rel. to Trig)	0.030	0.027	0.012	sec
Peak Acceleration	0.0398	0.0398	0.0663	g
Peak Displacement	0.00022	0.00011	0.00026	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0718 in./s at 0.012 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 09:47:57 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP1.VX0

Notes
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction   Test Blast

Other:

Post Event Notes

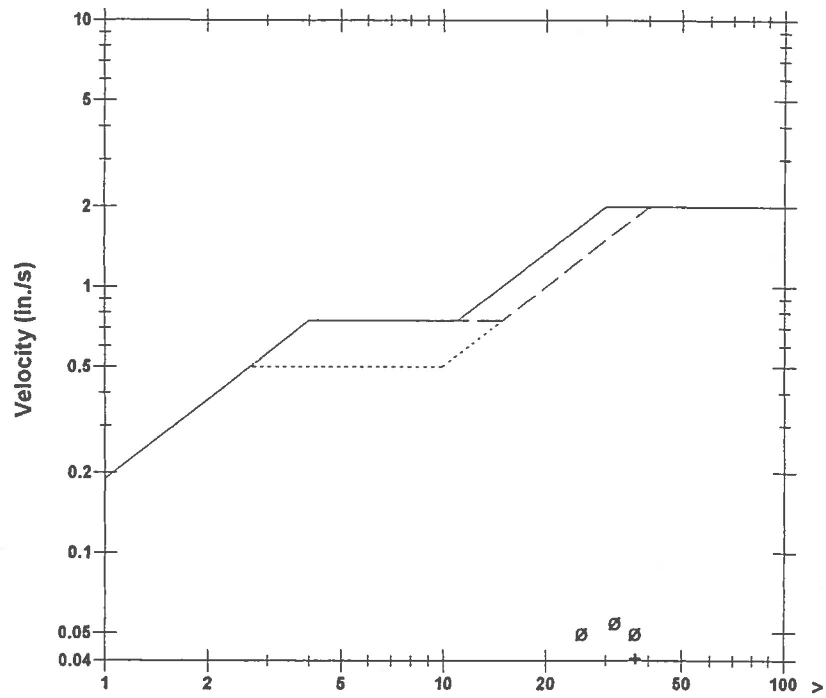
Microphone	Linear Weighting
PSPL	0.00015 psi(L) at -0.249 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

	Tran	Vert	Long	
PPV	0.0400	0.0250	0.0550	in./s
ZC Freq	37	34	32	Hz
Time (Rel. to Trig)	0.030	0.082	0.026	sec
Peak Acceleration	0.0398	0.0265	0.0398	g
Peak Displacement	0.00021	0.00022	0.00180	in.
Sensorcheck ™	Passed	Passed	Passed	

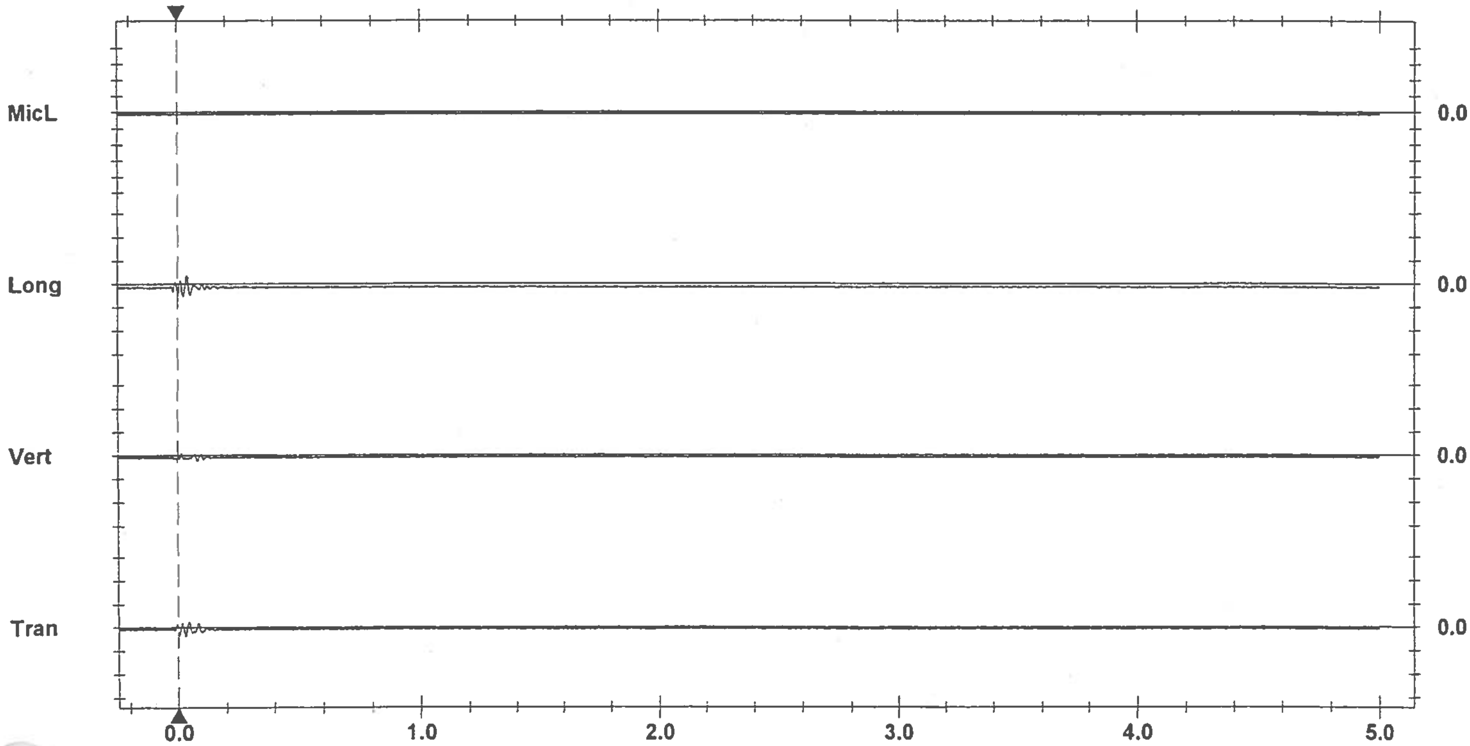
Peak Vector Sum 0.0612 in./s at 0.026 sec

N/A: Not Applicable
*****:** Out of Range

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø

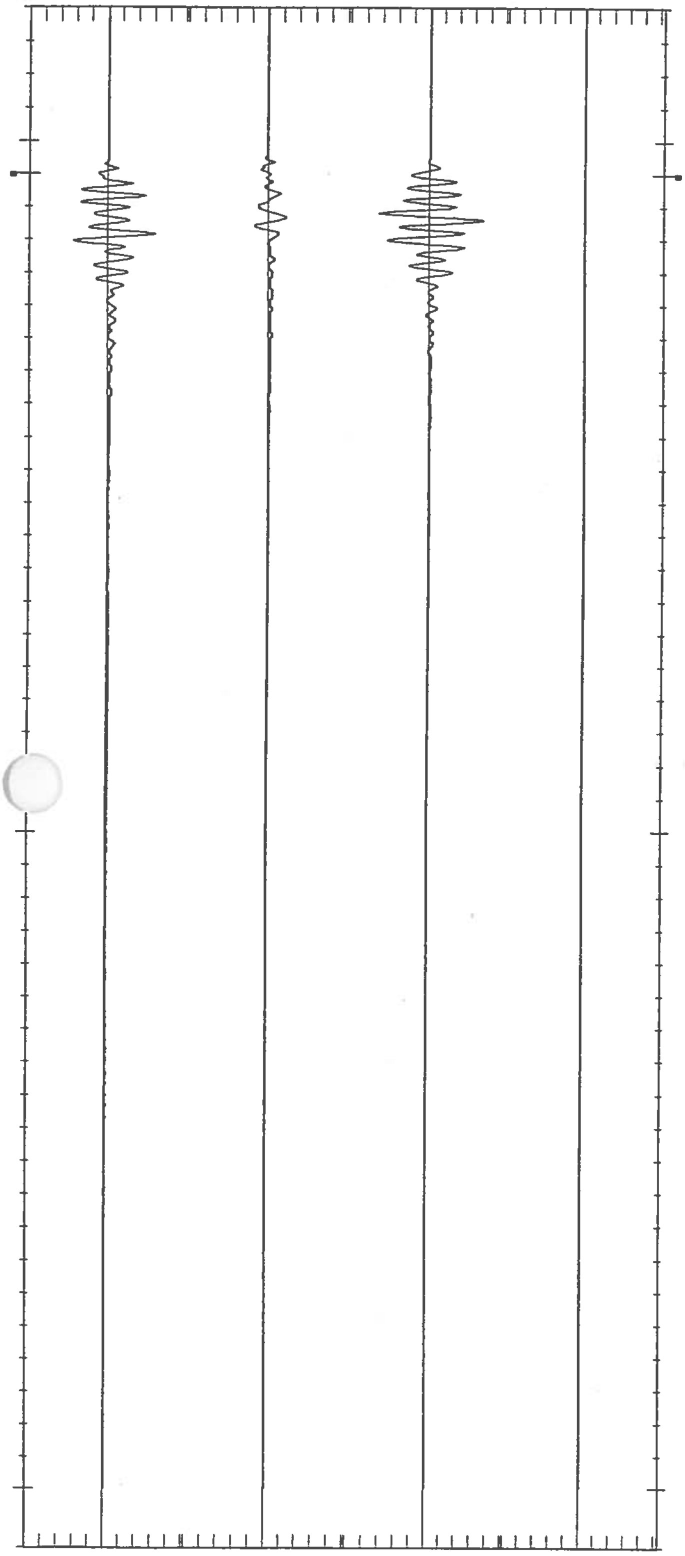


Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶— — — —◀

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS

TRANSVERSE VERTICAL LONGITUDINAL MICROPHONE



0.0 0.0 0.0 0.0

AMPLITUDE SCALE:GEO: 0.020 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER = •——•

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEG.H7V
TIME & DATE	Long. at 09:46:19 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	
SCALED DISTANCE	N/A
PEAK VECTOR SUM	0.076 in/sec at 72 ms
MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.060	0.023	0.070	in/sec
ZC FREQ	43	32	43	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	93	66	71	ms
ACCEL	0.05	0.01	0.05	g
1/4 WAVE DISP	0.0002	0.0001	0.0003	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEG.H7V
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Long at 09:43:02 October 16, 1997
Trigger Source	Geo: 0.508 mm/s
Range	Geo: 254 mm/s
Record Time	11.75 sec (Auto=3 sec) at 1024 sps
Serial Number	BC5534 V 3.41-3.41 MiniMate Plus
Battery Level	5.9 Volts
Calibration	January 10, 1997 by Instantel Inc.
File Name	G5346OAQ.ZQ0

Notes

Post Event Notes

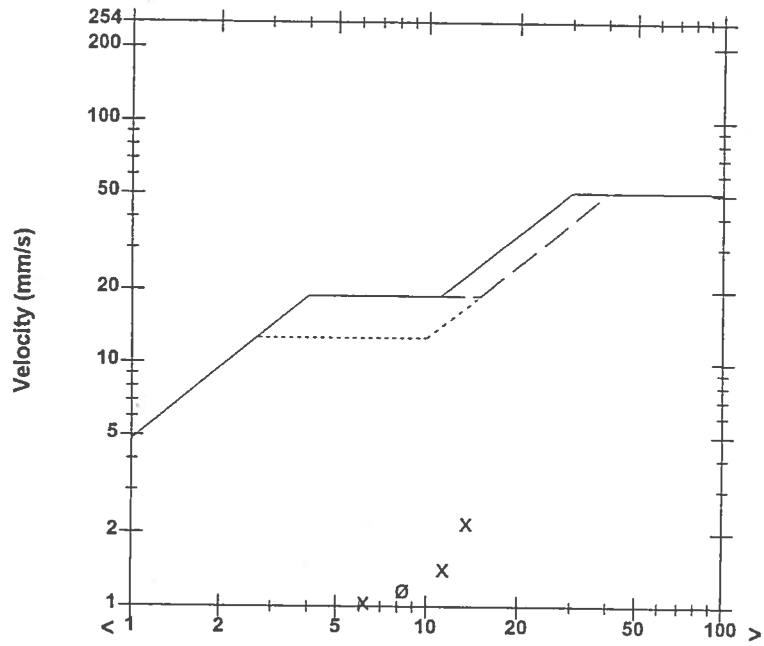
Microphone	Linear Weighting
PSPL	1.25 pa.(L) at 3.086 sec
ZC Freq	1.2 Hz
Channel Test	Check (Freq = 0.0 Hz Amp = 0 mv)

	Tran	Vert	Long	
PPV	0.889	3.17	1.14	mm/s
ZC Freq	11	N/A	8.4	Hz
Time (Rel. to Trig)	11.865	11.974	11.931	sec
Peak Acceleration	0.0265	0.0398	0.0265	g
Peak Displacement	1.33	0.135	2.20	mm
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 3.30 mm/s at 11.974 sec

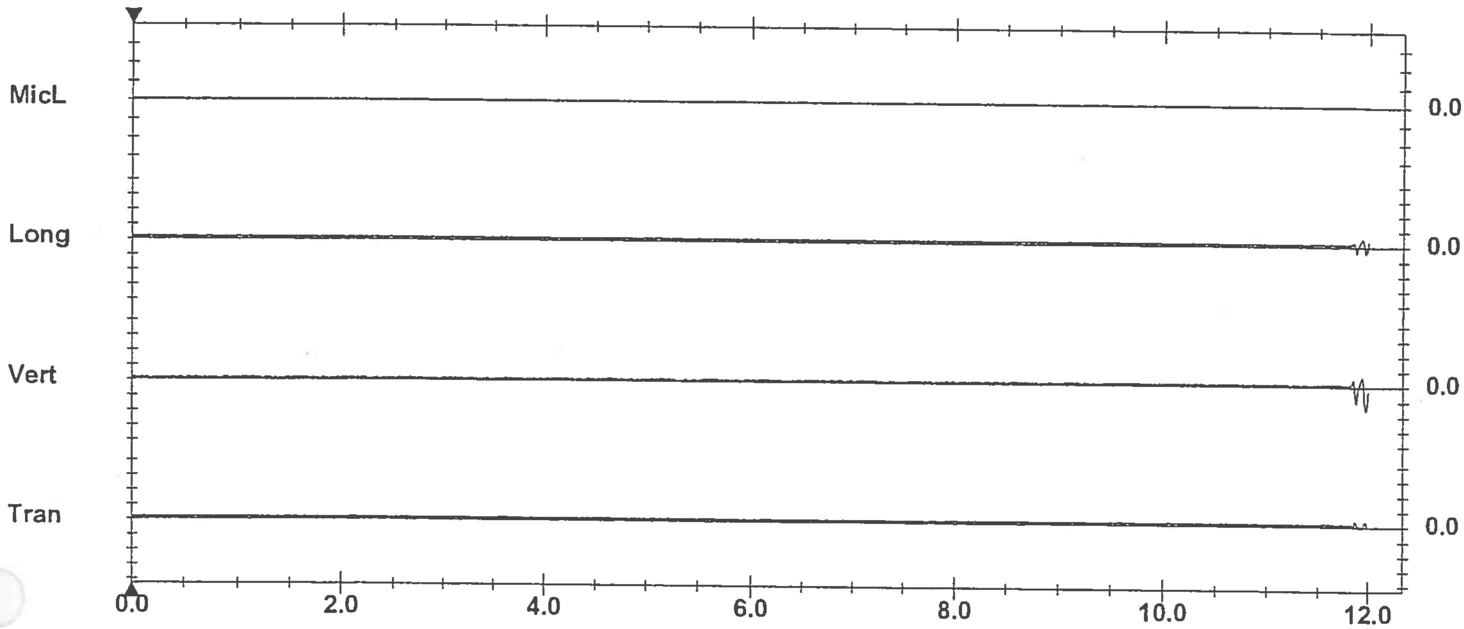
N/A: Not Applicable

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø

Monitor Log
Oct 16 /97 09:43:02 Oct 16 /97 09:43:14 Event recorded. (Keyboard Exit)



Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger = ▶— — — —◀

Event Report

Date/Time	Long at 09:54:51 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAR.JF0

...s
Location: Victor, CO
Client: CC & V
User Name: M.M.C. Colin Matheson
General: Attenuation Study

Post Event Notes

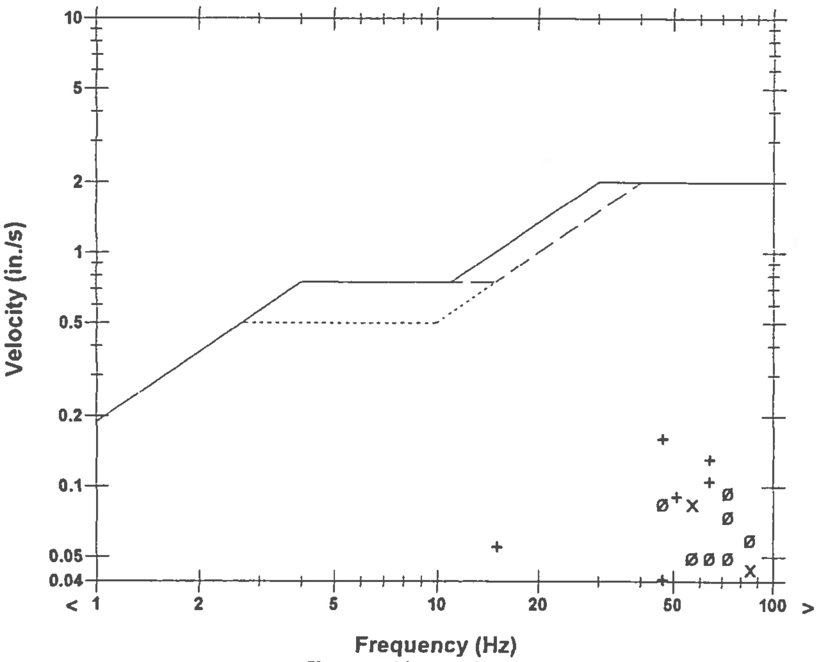
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

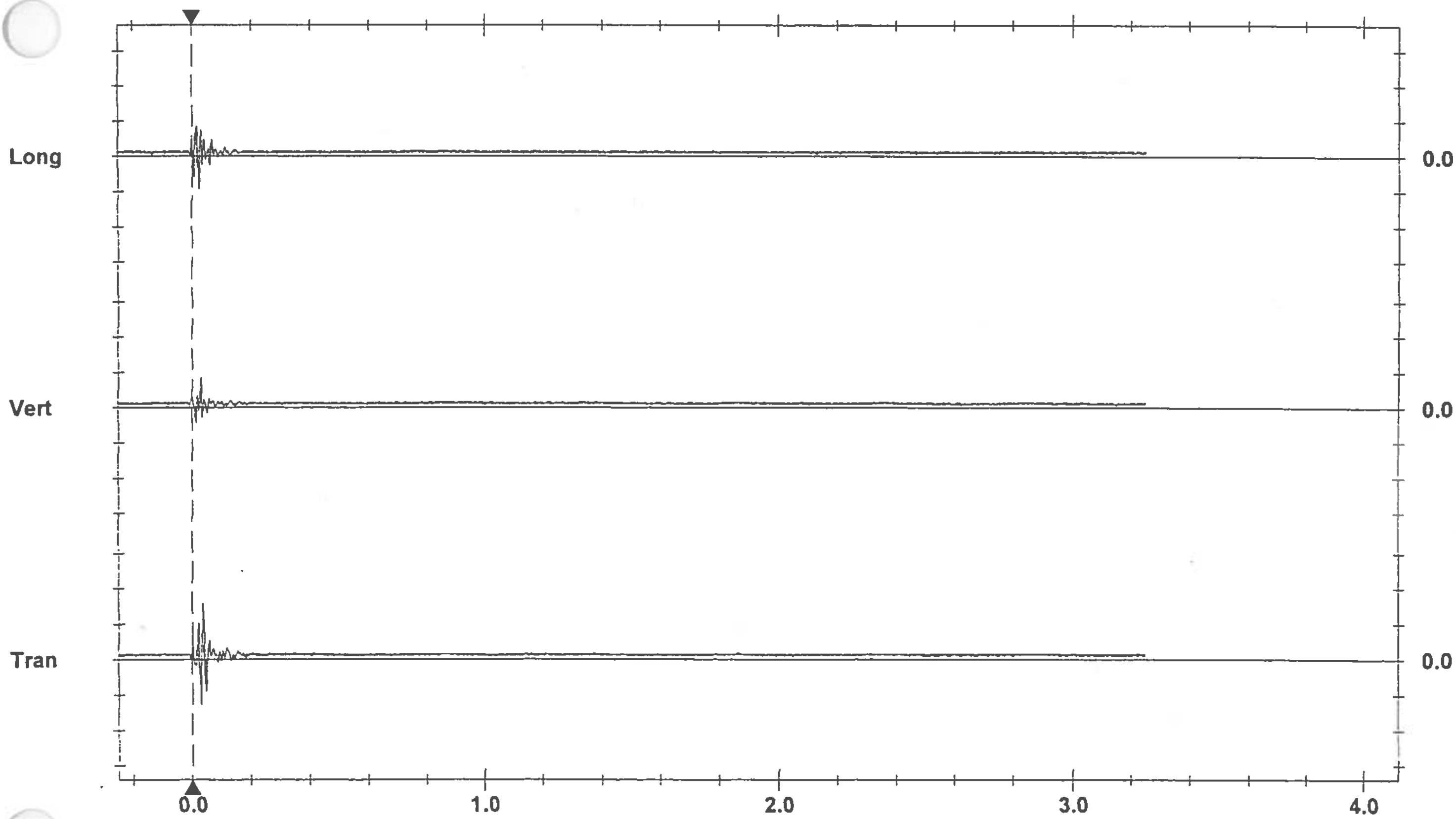
	Tran	Vert	Long	
PPV	0.160	0.0850	0.0950	in./s
ZC Freq	47	57	73	Hz
Time (Rel. to Trig)	0.036	0.030	0.023	sec
Peak Acceleration	0.146	0.0795	0.106	g
Peak Displacement	0.00338	0.00599	0.00216	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.165 in./s at 0.036 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Event Report

Date/Time	Long at 09:51:40 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAR.E40

s
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

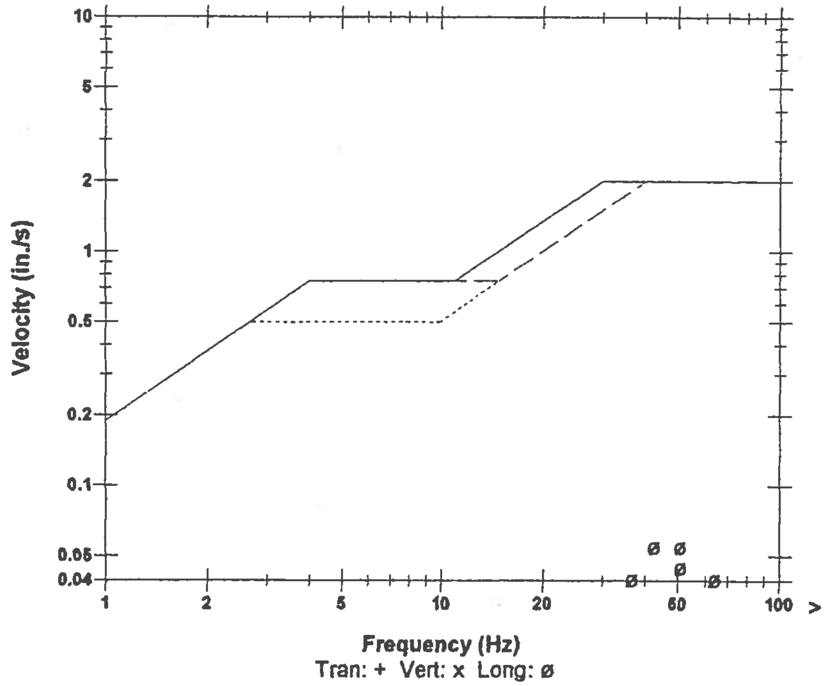
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

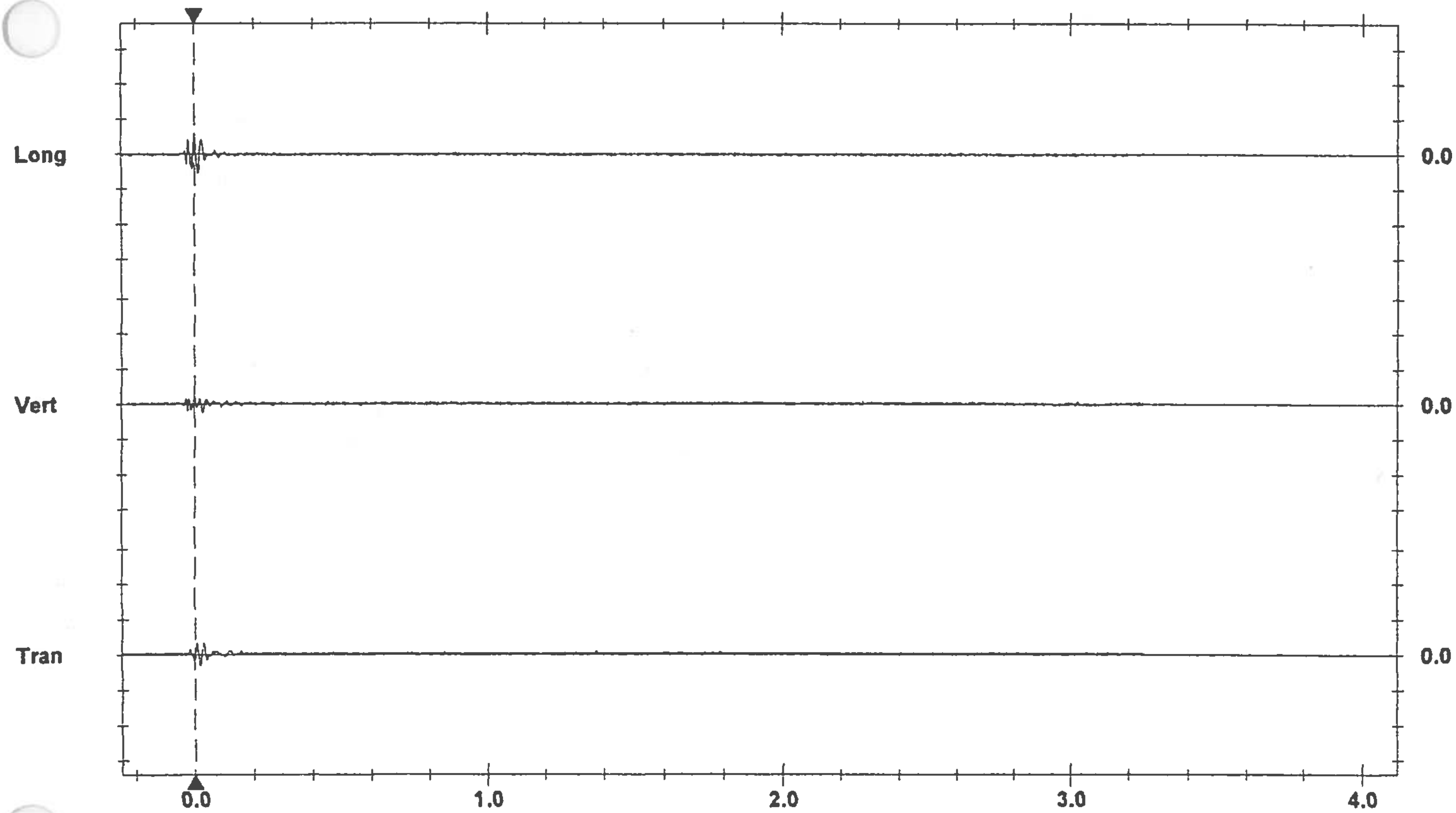
	Tran	Vert	Long	
PPV	0.0350	0.0250	0.0550	in./s
ZC Freq	47	57	51	Hz
Time (Rel. to Trig)	0.007	0.027	0.001	sec
Peak Acceleration	0.0265	0.0398	0.0663	g
Peak Displacement	0.00014	0.00008	0.00021	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0594 in./s at 0.001 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Event Report

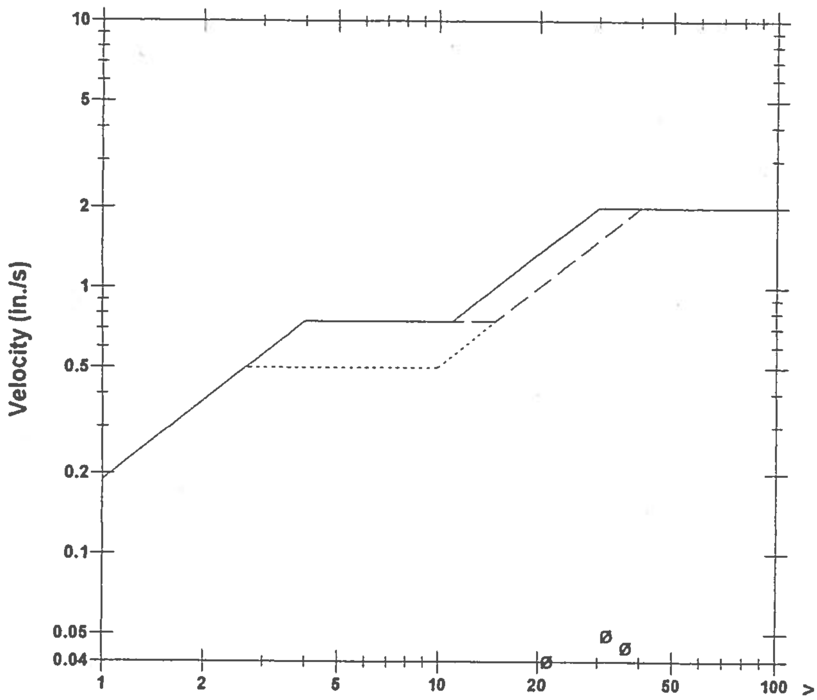
Date/Time	Long at 09:55:57 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP2.990

..es
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction Test Blast

Other:

Post Event Notes

USBM RI8507 And OSMRE

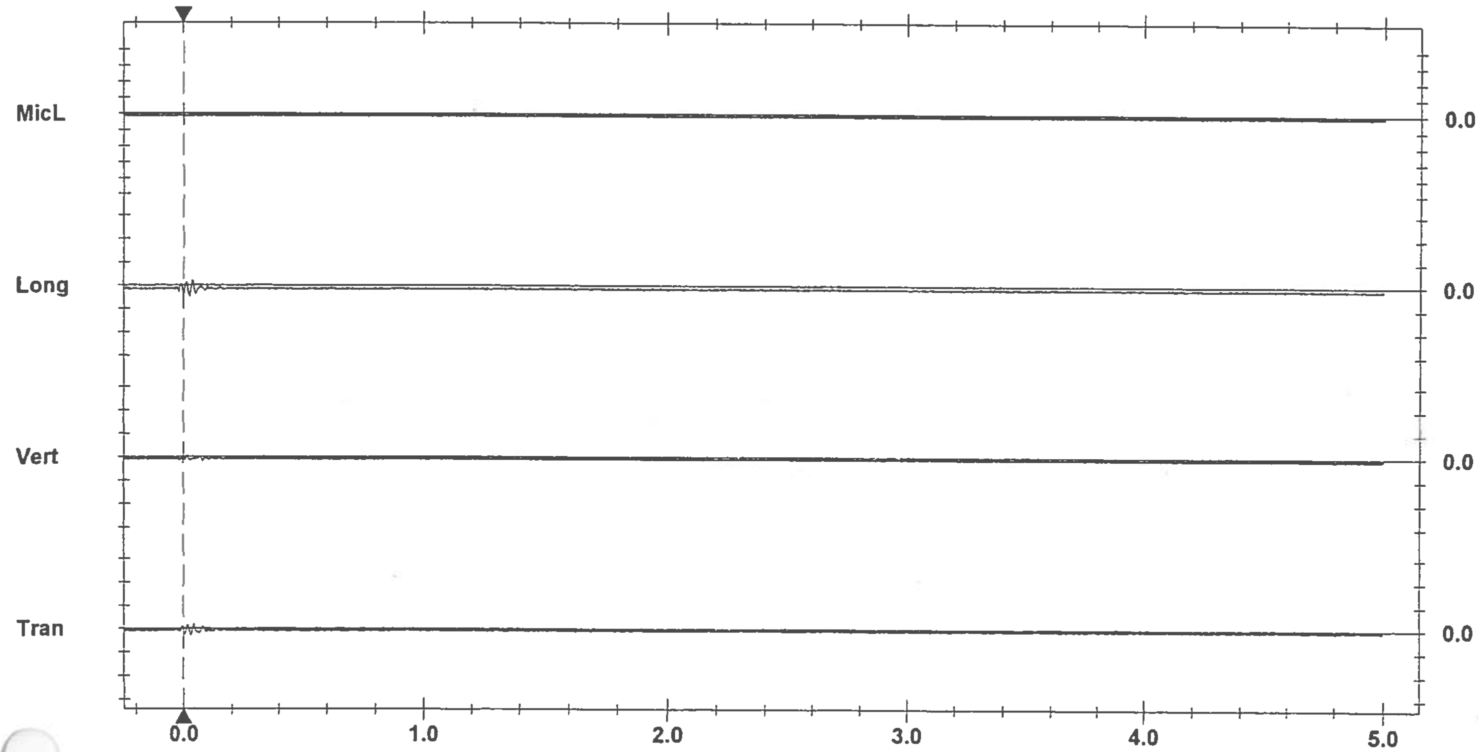


Microphone	Linear Weighting
PSPL	0.00015 psi(L) at -0.248 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

	Tran	Vert	Long	
PPV	0.0300	0.0200	0.0500	in./s
ZC Freq	39	37	32	Hz
Time (Rel. to Trig)	0.028	0.081	0.025	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00018	0.00012	0.00177	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0579 in./s at 0.026 sec

N/A: Not Applicable
Out of Range



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Tran at 09:55:24 October 16, 1997
Trigger Source	Geo: 1.02 mm/s
Range	Geo: 254 mm/s
Record Time	5.0 sec at 1024 sps

Serial Number	BC5534 V 3.41-3.41 MiniMate Plus
Battery Level	5.8 Volts (Battery Low)
Calibration	January 10, 1997 by Instantel Inc.
File Name	G5346OAR.KC0

Notes

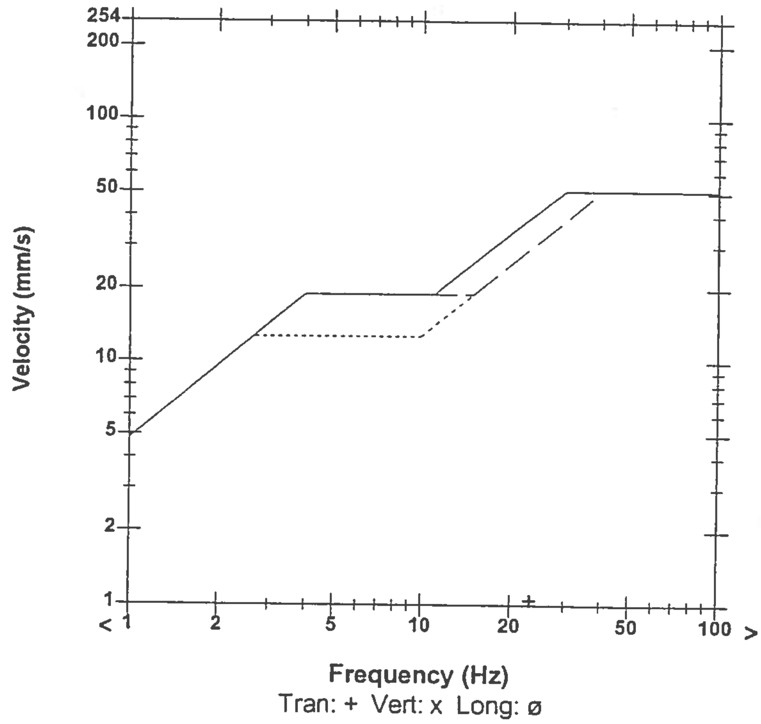
Post Event Notes

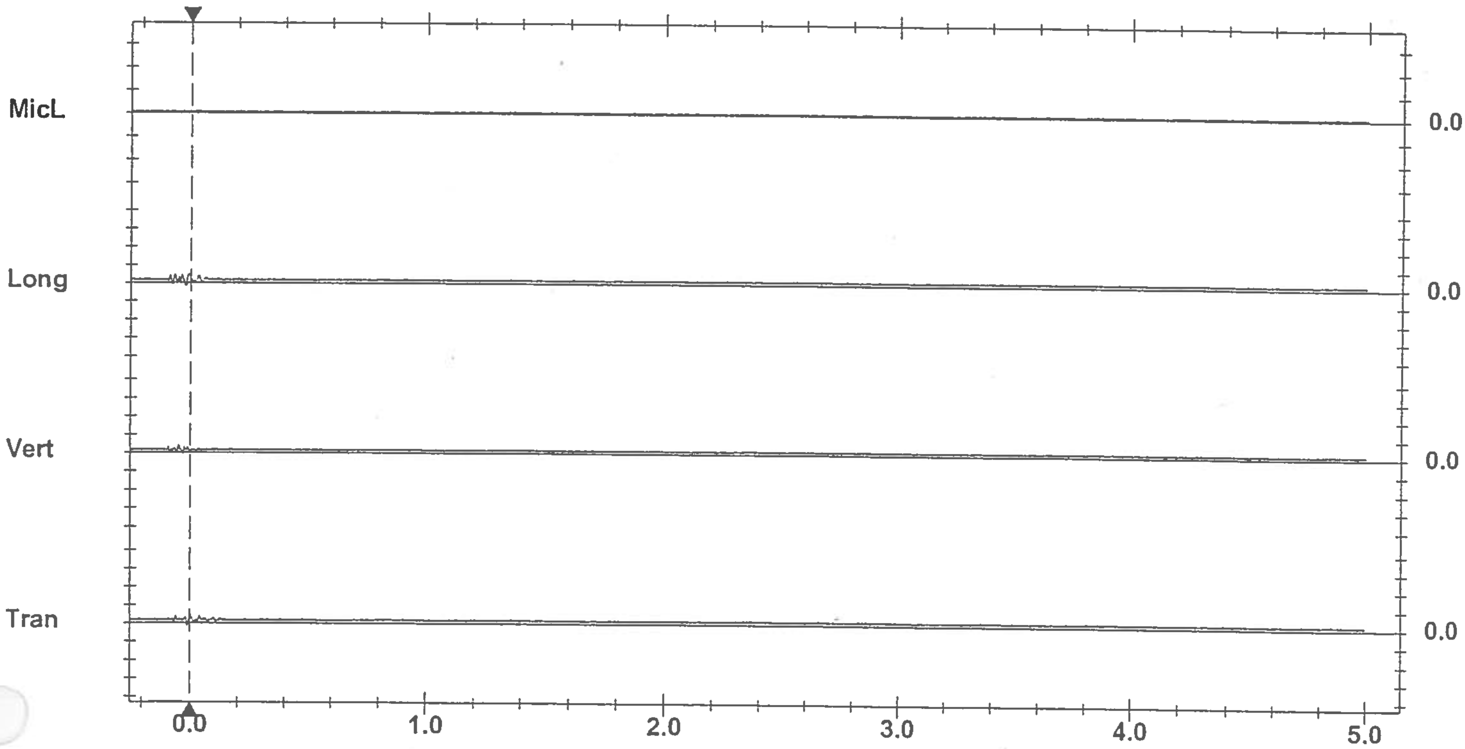
Microphone	Linear Weighting
PSPL	1.25 pa.(L) at 0.843 sec
ZC Freq	64 Hz
Channel Test	Check (Freq = 0.0 Hz Amp = 0 mv)

	Tran	Vert	Long	
PPV	1.02	0.762	0.889	mm/s
ZC Freq	23	24	37	Hz
Time (Rel. to Trig)	0.000	-0.048	-0.066	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.191	0.571	0.0296	mm
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 1.20 mm/s at 0.000 sec

USBM RI8507 And OSMRE

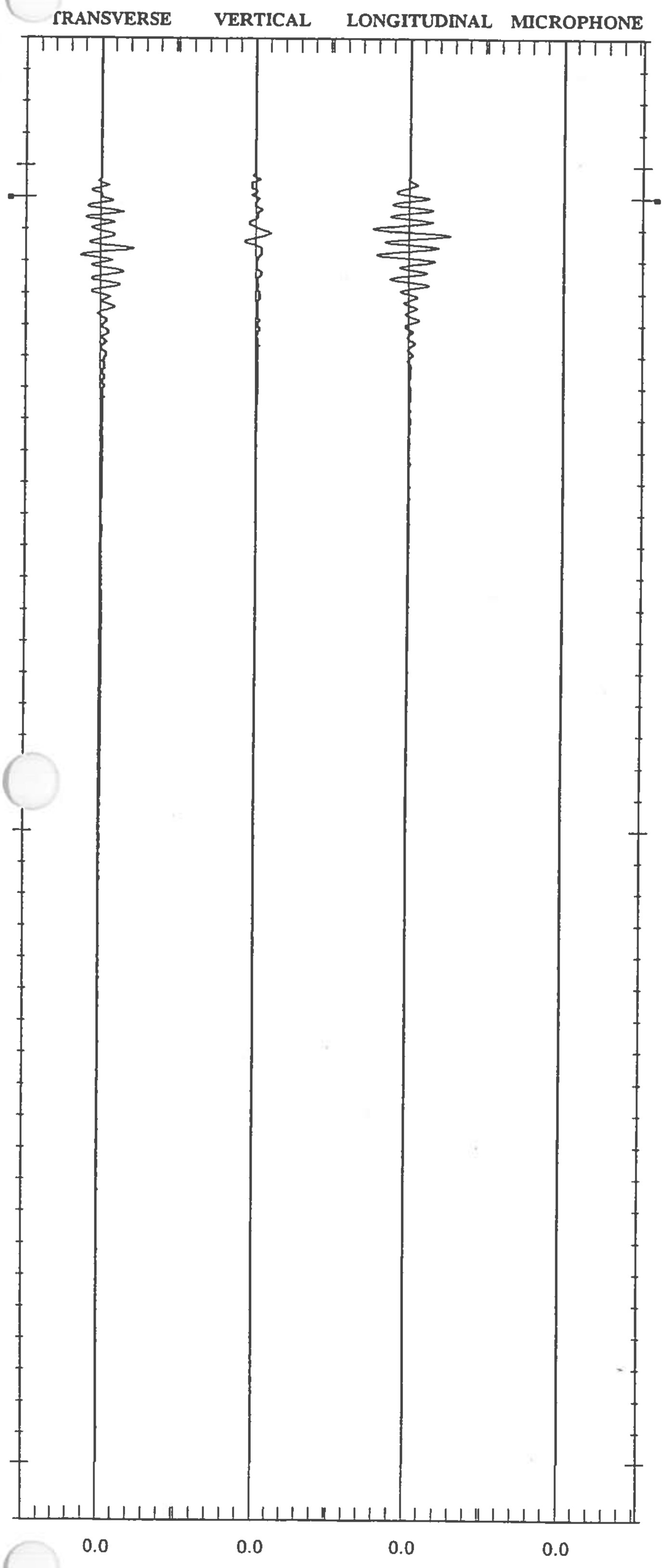




Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger = ▶— — — —◀

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.020 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER = •———•

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEG.UJV
TIME & DATE	Long. at 09:54:19 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	

SCALED DISTANCE N/A

PEAK VECTOR SUM 0.058 in/sec at 60 ms

MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.043	0.020	0.053	in/sec
ZC FREQ	43	34	43	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	81	57	60	ms
ACCEL	0.03	0.01	0.04	g
1/4 WAVE DISP	0.0002	0.0001	0.0002	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEG.UJV
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Long at 10:01:04 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAR.TS0

...s

Location: Victor, CO
Client: CC & V
User Name: M.M.C. Colin Matheson
General: Attenuation Study

Post Event Notes

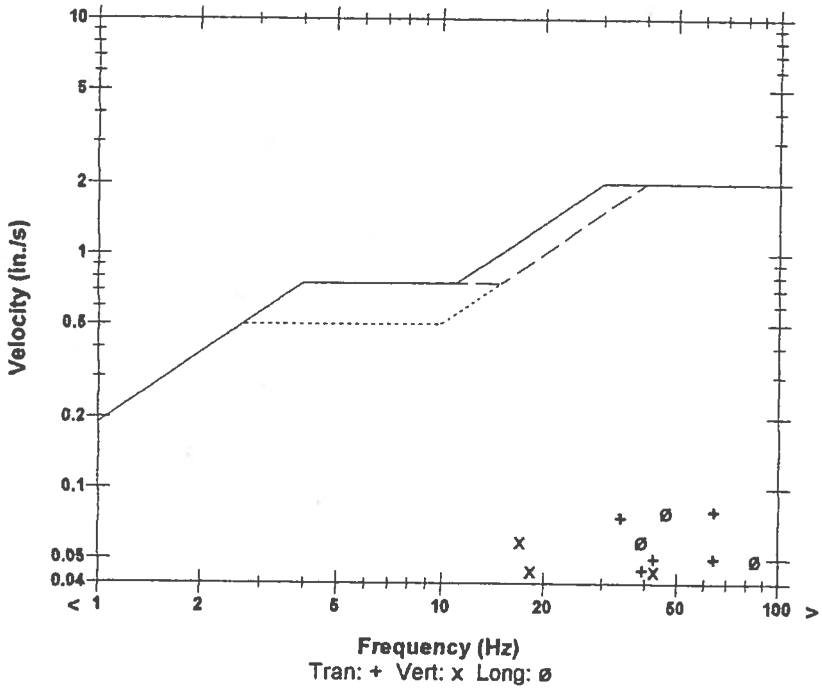
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

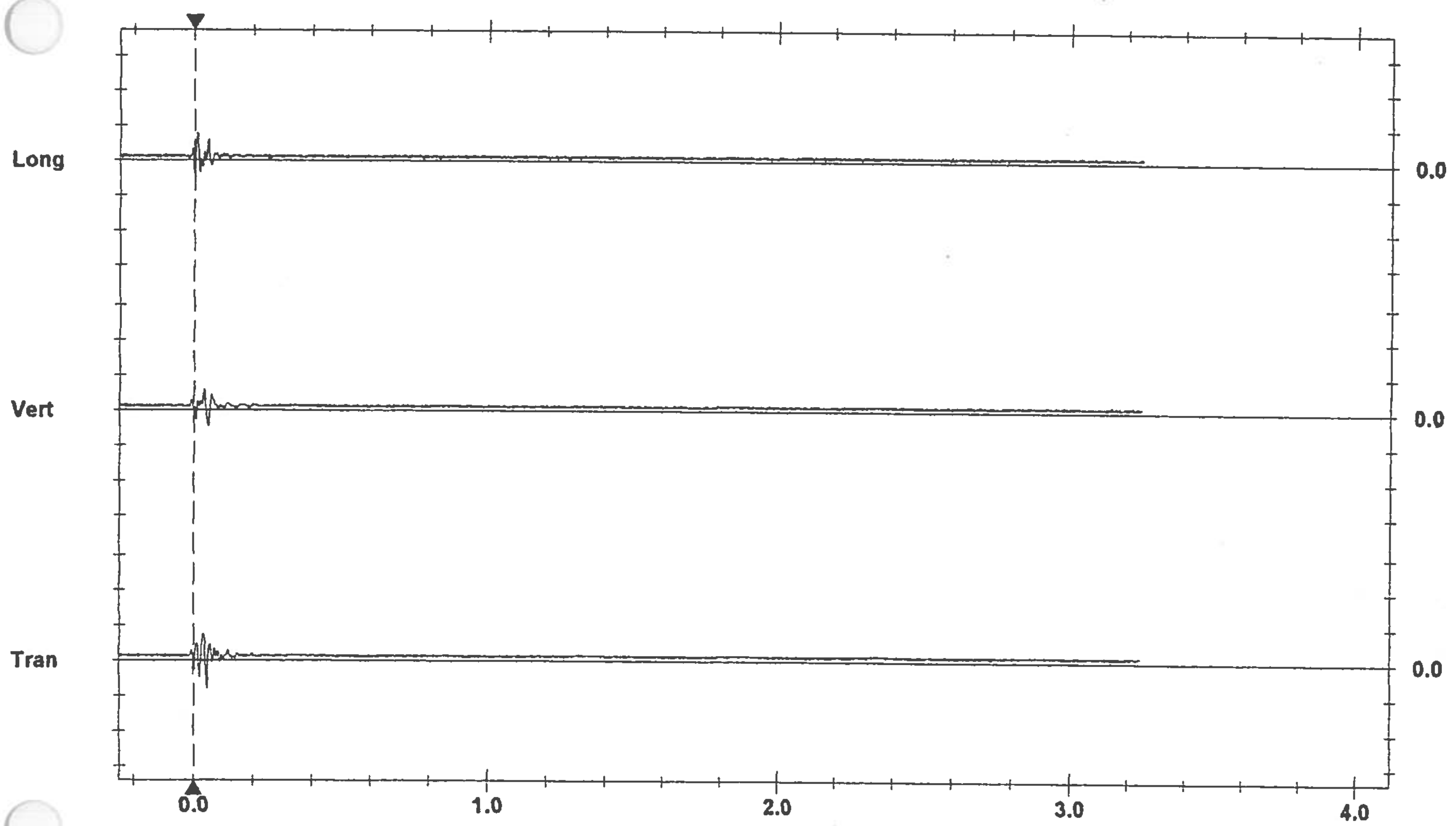
	Tran	Vert	Long	
PPV	0.0800	0.0600	0.0800	in./s
ZC Freq	64	17	47	Hz
Time (Rel. to Trig)	0.044	0.033	0.008	sec
Peak Acceleration	0.0795	0.0530	0.0663	g
Peak Displacement	0.00180	0.0121	0.00100	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.103 in./s at 0.045 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Tran at 09:57:53 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAR.OH0

[illegible]s
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

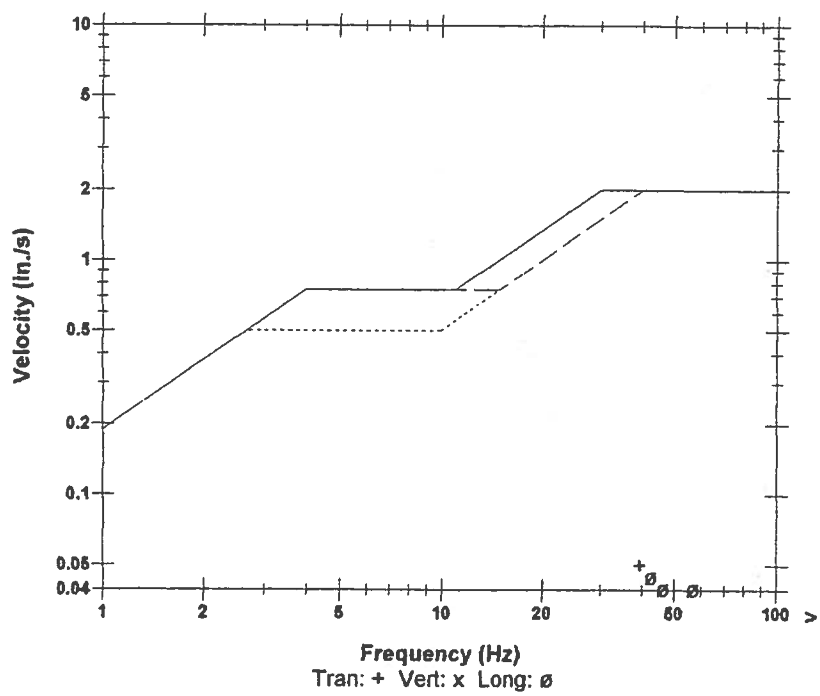
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

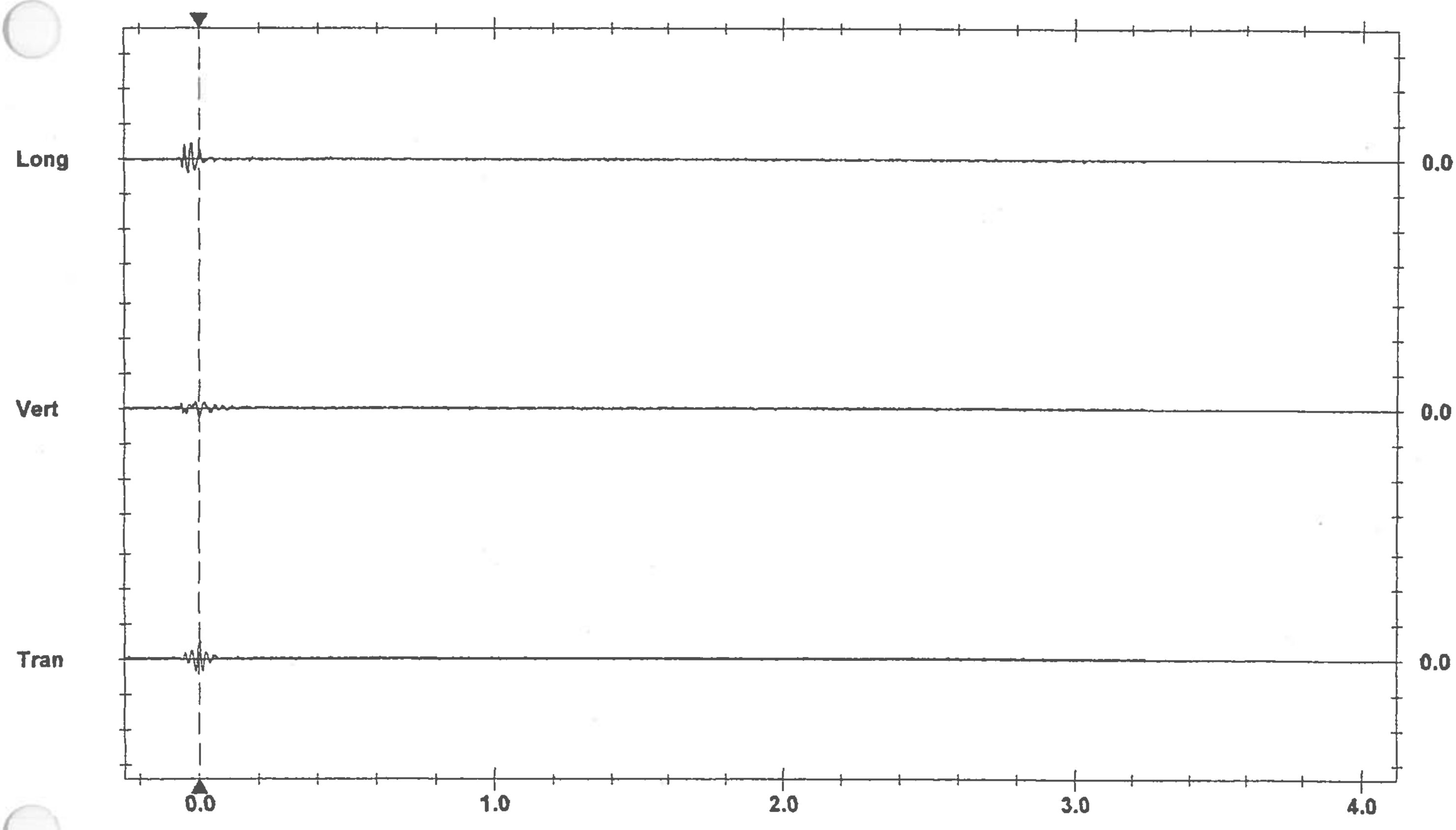
	Tran	Vert	Long	
PPV	0.0500	0.0250	0.0450	in./s
ZC Freq	39	34	43	Hz
Time (Rel. to Trig)	0.000	-0.001	-0.028	sec
Peak Acceleration	0.0398	0.0265	0.0398	g
Peak Displacement	0.00021	0.00013	0.00017	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0612 in./s at 0.001 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Event Report

Date/Time	Long at 10:02:10 October 16, 1995
Trigger Source	Geo: 0.0400 in./s
Range	Geo :10.00 in./s
Record Time	5.0 sec at 1024 sps

Serial Number	BA5552 V 3.11-3.11 BlastMate III
Battery Level	6.4 Volts
Calibration	January 10, 1997 by Instantel Inc.
File Name	G5525MP2.JM0

Notes
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction Test Blast

Other:

Post Event Notes

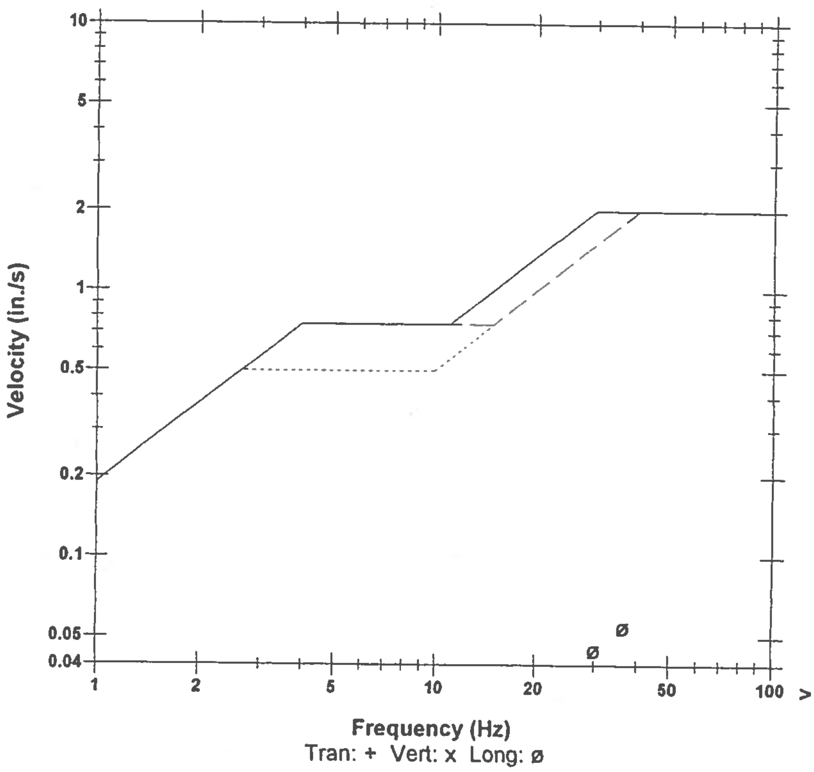
Microphone	Linear Weighting
PSPL	0.00018 psi(L) at 0.019 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

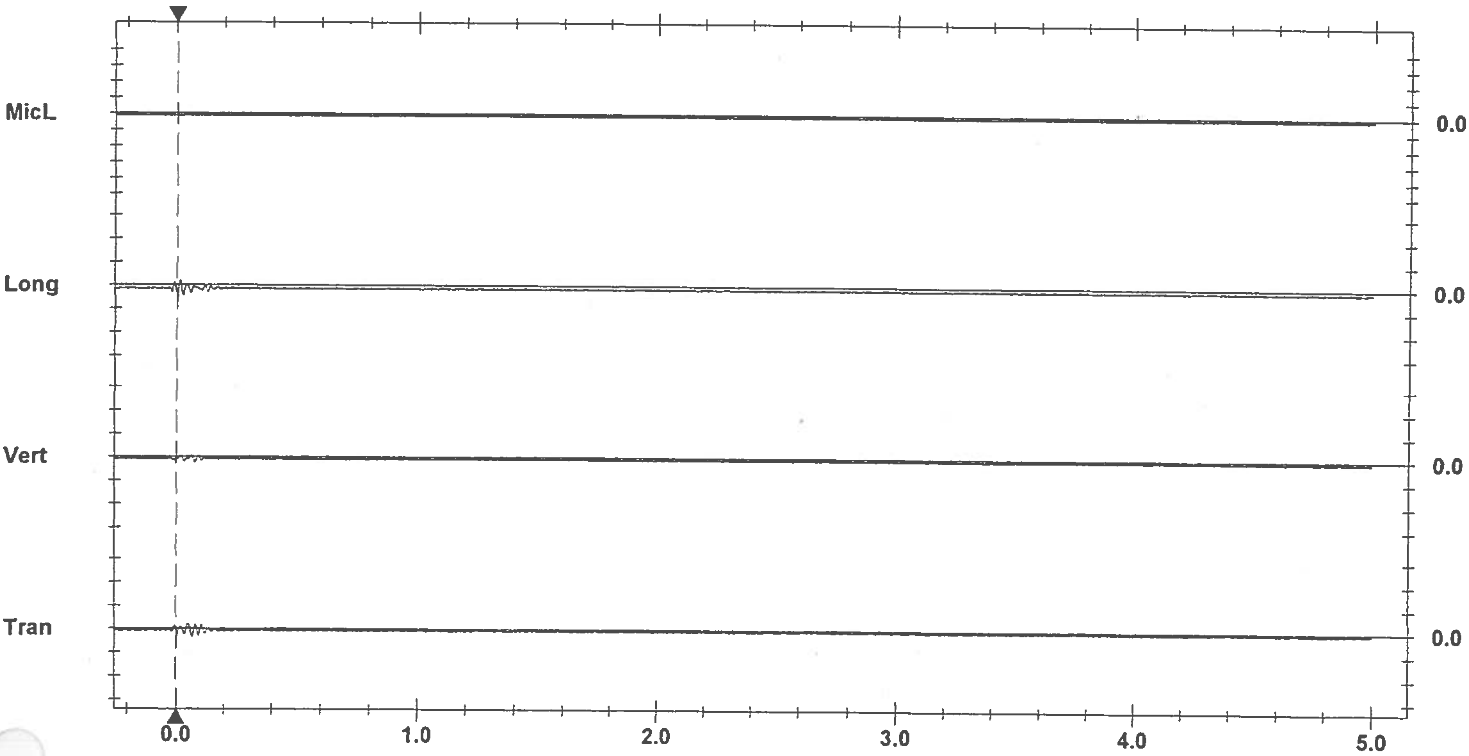
	Tran	Vert	Long	
PPV	0.0350	0.0250	0.0550	in./s
ZC Freq	30	30	37	Hz
Time (Rel. to Trig)	0.065	0.034	0.003	sec
Peak Acceleration	0.0265	0.0265	0.0398	g
Peak Displacement	0.00019	0.00013	0.00180	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.0626 in./s at 0.003 sec

N/A: Not Applicable
: Out of Range

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶— — — —◀

Event Report

Date/Time	Long at 10:01:37 October 16, 1997
Trigger Source	Geo: 1.02 mm/s
Range	Geo: 254 mm/s
Record Time	5.0 sec at 1024 sps

Serial Number	BC5534 V 3.41-3.41 MiniMate Plus
Battery Level	5.8 Volts (Battery Low)
Calibration	January 10, 1997 by Instantel Inc.
File Name	G5346OAR.UP0

Notes

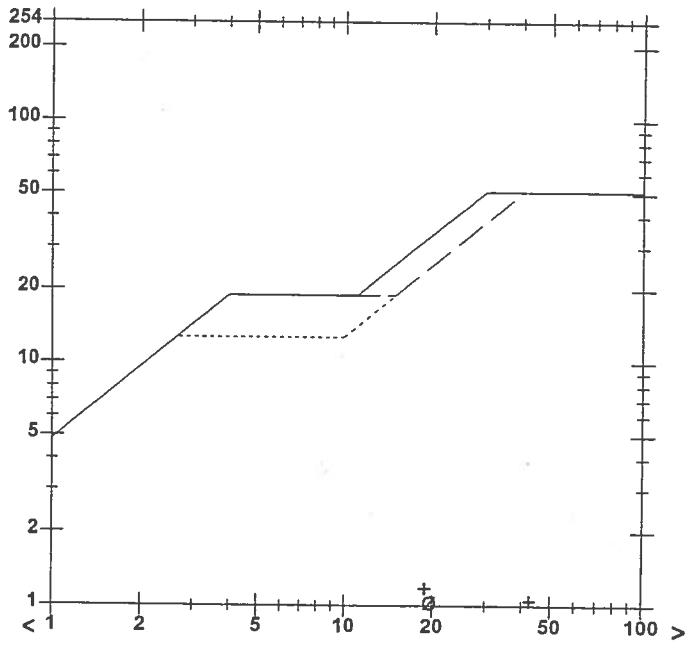
Post Event Notes

Microphone	Linear Weighting
PSPL	1.25 pa.(L) at 0.343 sec
ZC Freq	43 Hz
Channel Test	Check (Freq = 0.0 Hz Amp = 0 mv)

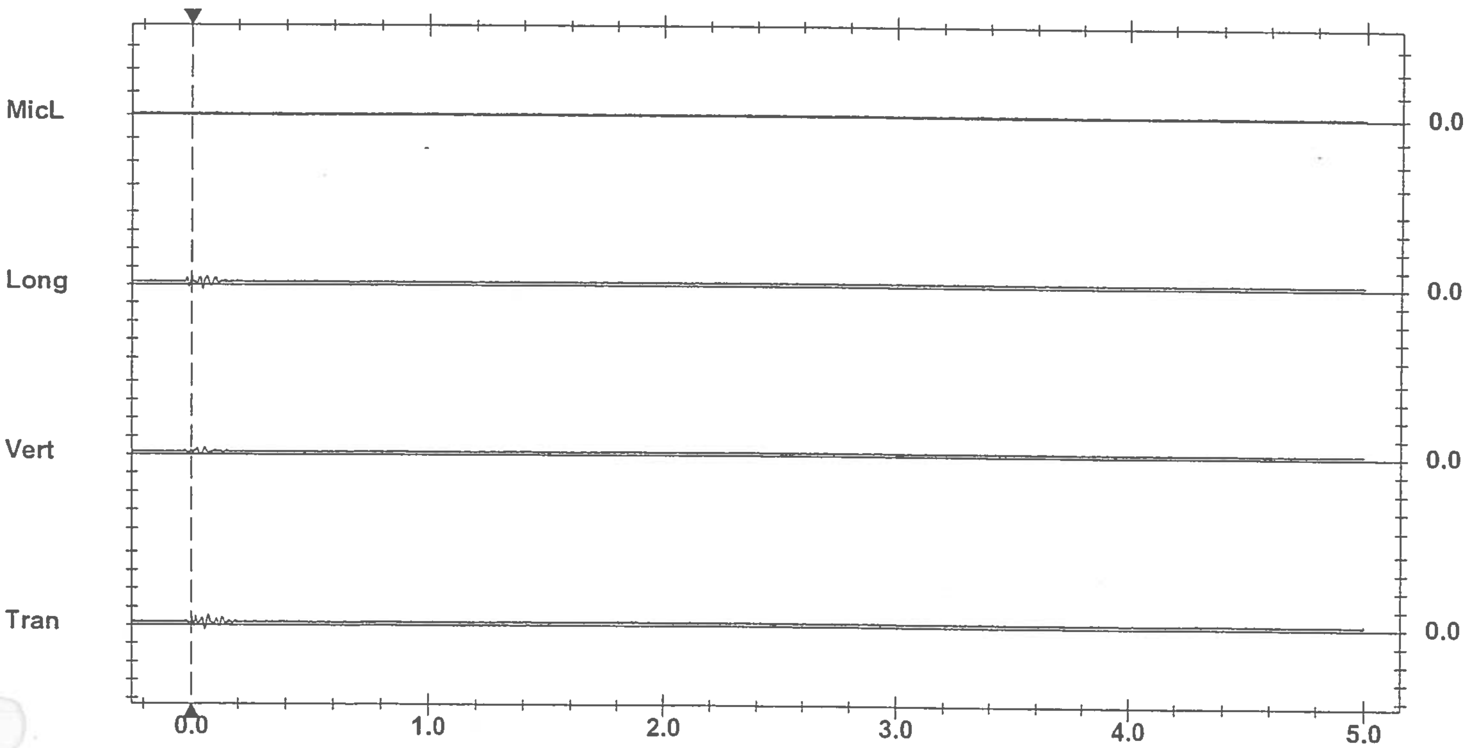
	Tran	Vert	Long	
PPV	1.14	0.762	1.02	mm/s
ZC Freq	19	21	20	Hz
Time (Rel. to Trig)	0.074	0.057	0.000	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.337	0.317	0.0451	mm
Sensorcheck ™	Passed	Passed	Passed	

eak Vector Sum 1.30 mm/s at 0.070 sec

USBM RI8507 And OSMRE



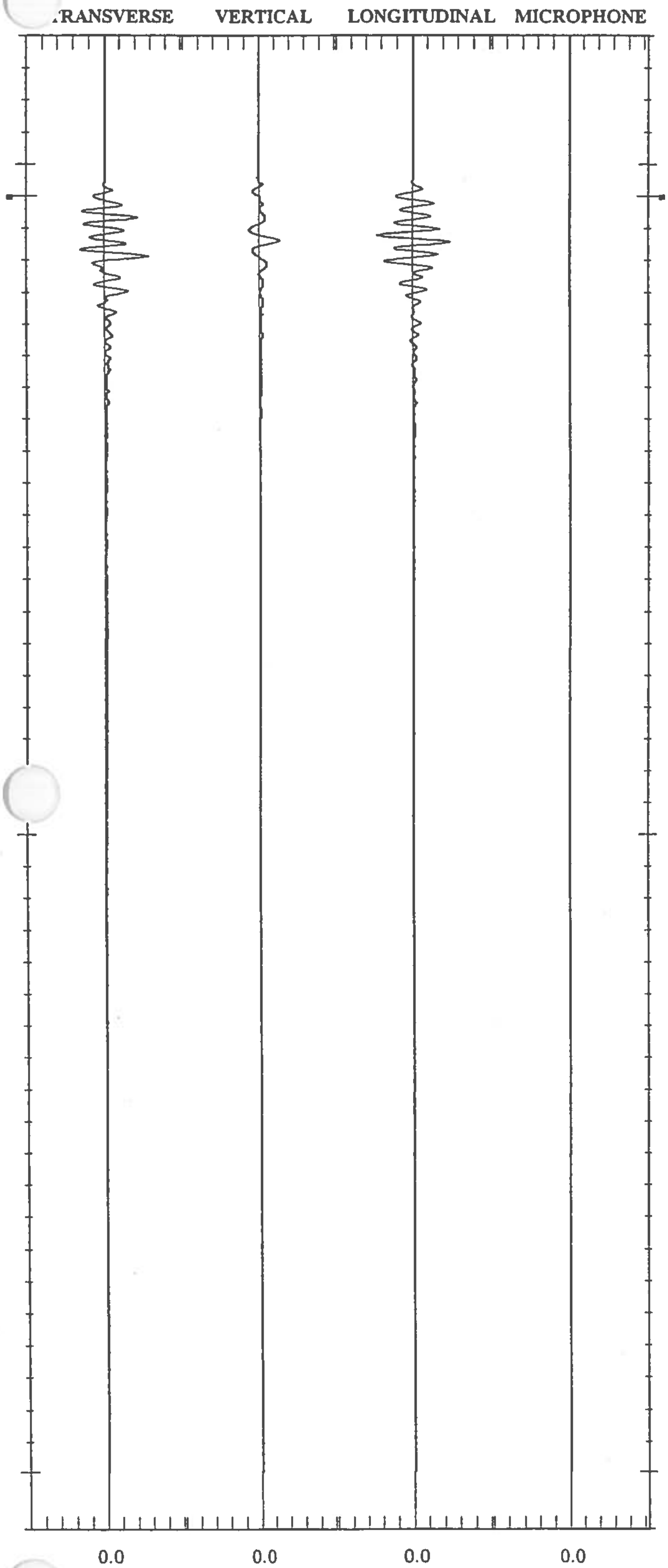
Frequency (Hz)
Tran: + Vert: x Long: ø



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger = ▶— — — —◀

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.020 in/sec/div MIC: 1.0000 psi(L)/div

TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER = •——•

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEH.4WV
TIME & DATE	Long. at 10:00:32 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	
SCALED DISTANCE	N/A
PEAK VECTOR SUM	0.062 in/sec at 94 ms
MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.058	0.028	0.048	in/sec
ZC FREQ	39	32	51	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	95	69	62	ms
ACCEL	0.04	0.01	0.04	g
1/4 WAVE DISP	0.0002	0.0001	0.0002	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEH.4WV
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Long at 10:07:54 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAS.560

s

Location:	Victor, CO
Client:	CC & V
User Name: M.M.C.	Colin Matheson
General:	Attenuation Study

Post Event Notes

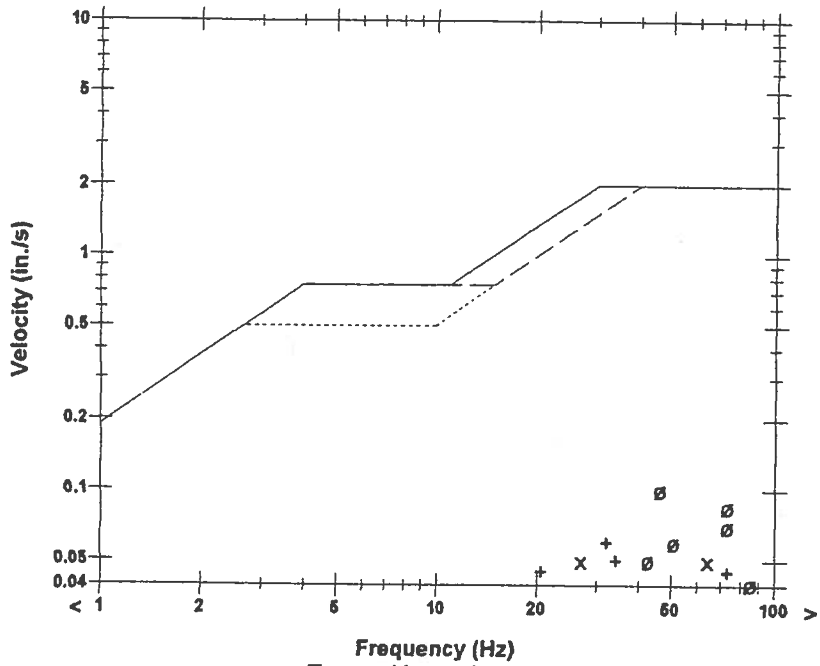
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

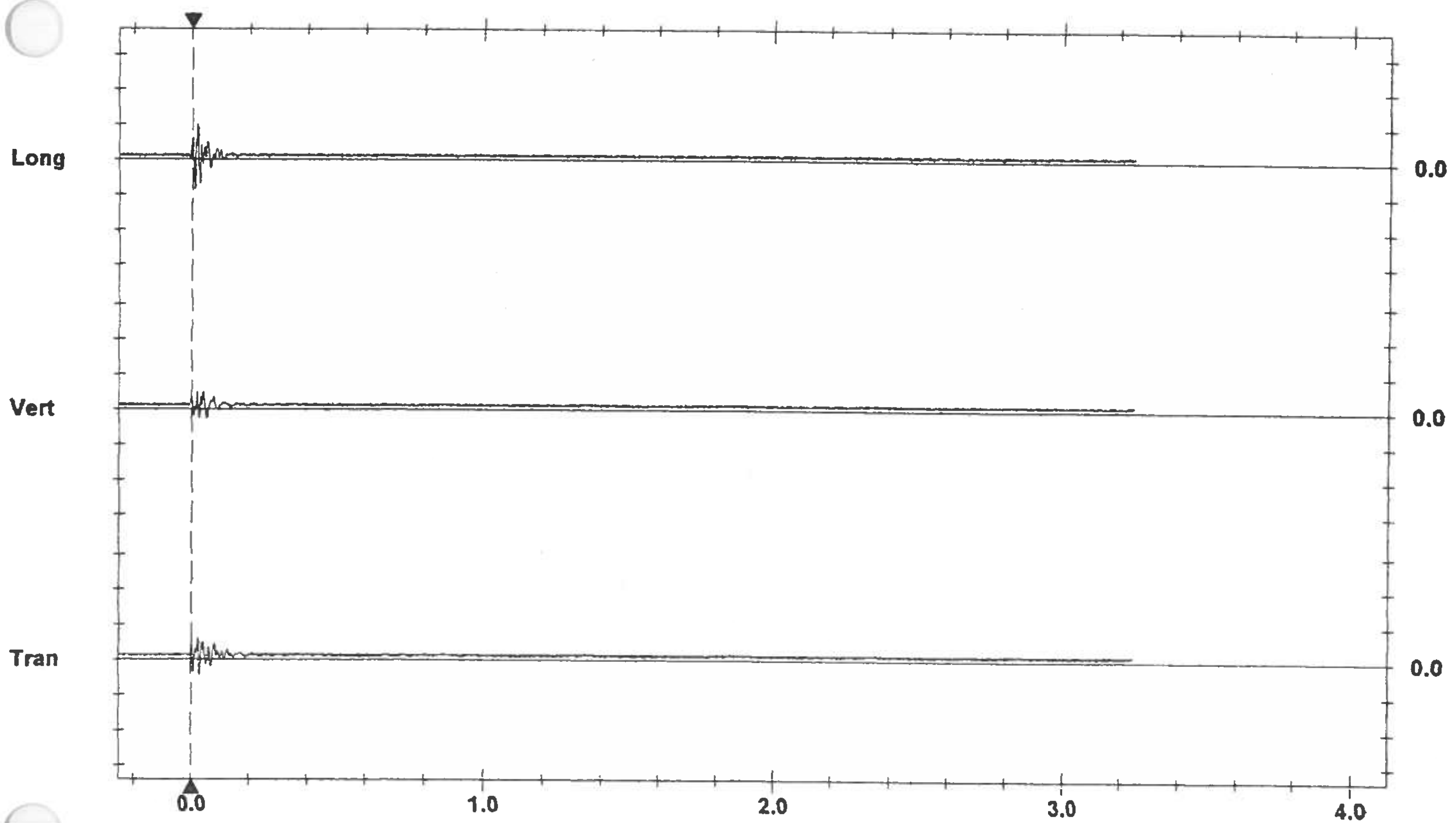
	Tran	Vert	Long	
PPV	0.0600	0.0500	0.1000	in./s
ZC Freq	32	64	47	Hz
Time (Rel. to Trig)	0.022	0.021	0.017	sec
Peak Acceleration	0.0530	0.0530	0.0928	g
Peak Displacement	0.00183	0.00802	0.00124	in.
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 0.106 in./s at 0.019 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 10:04:44 October 16, 1997	**Serial Number**	BA5738 V 3.42-3.42 BlastMate III
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	September 19, 1997 by Instantel Inc.
Record Time	3.25 sec (Auto=3Sec) at 1024 sps	**File Name**	G7386OAR.ZW0

s
Location:Victor, CO
Client:CC & V
User Name:Colin Matheson
General:Attenuation Study

Post Event Notes

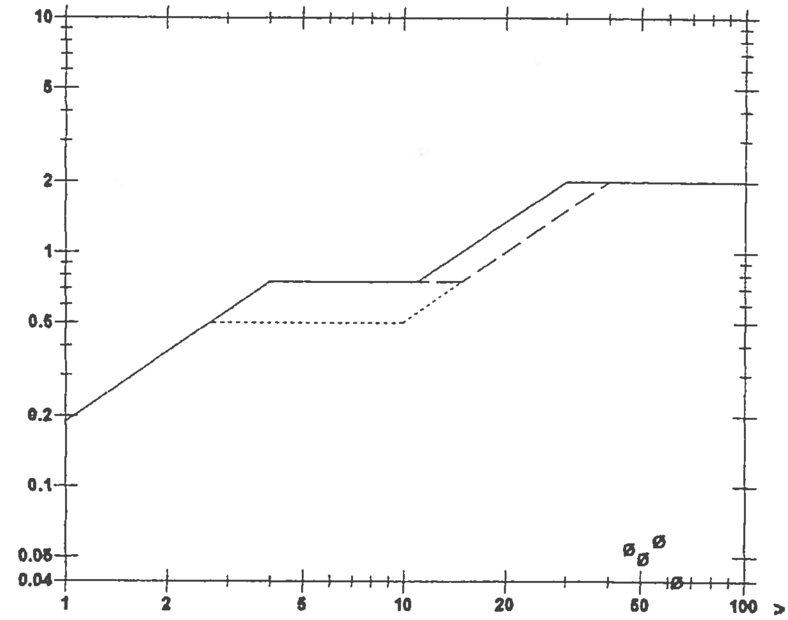
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.0200	0.0250	0.0600	in./s
ZC Freq	47	85	57	Hz
Time (Rel. to Trig)	0.050	-0.003	0.000	sec
Peak Acceleration	0.0265	0.0398	0.0530	g
Peak Displacement	0.00008	0.00005	0.00020	in.
Sensorcheck ™	Passed	Passed	Passed	

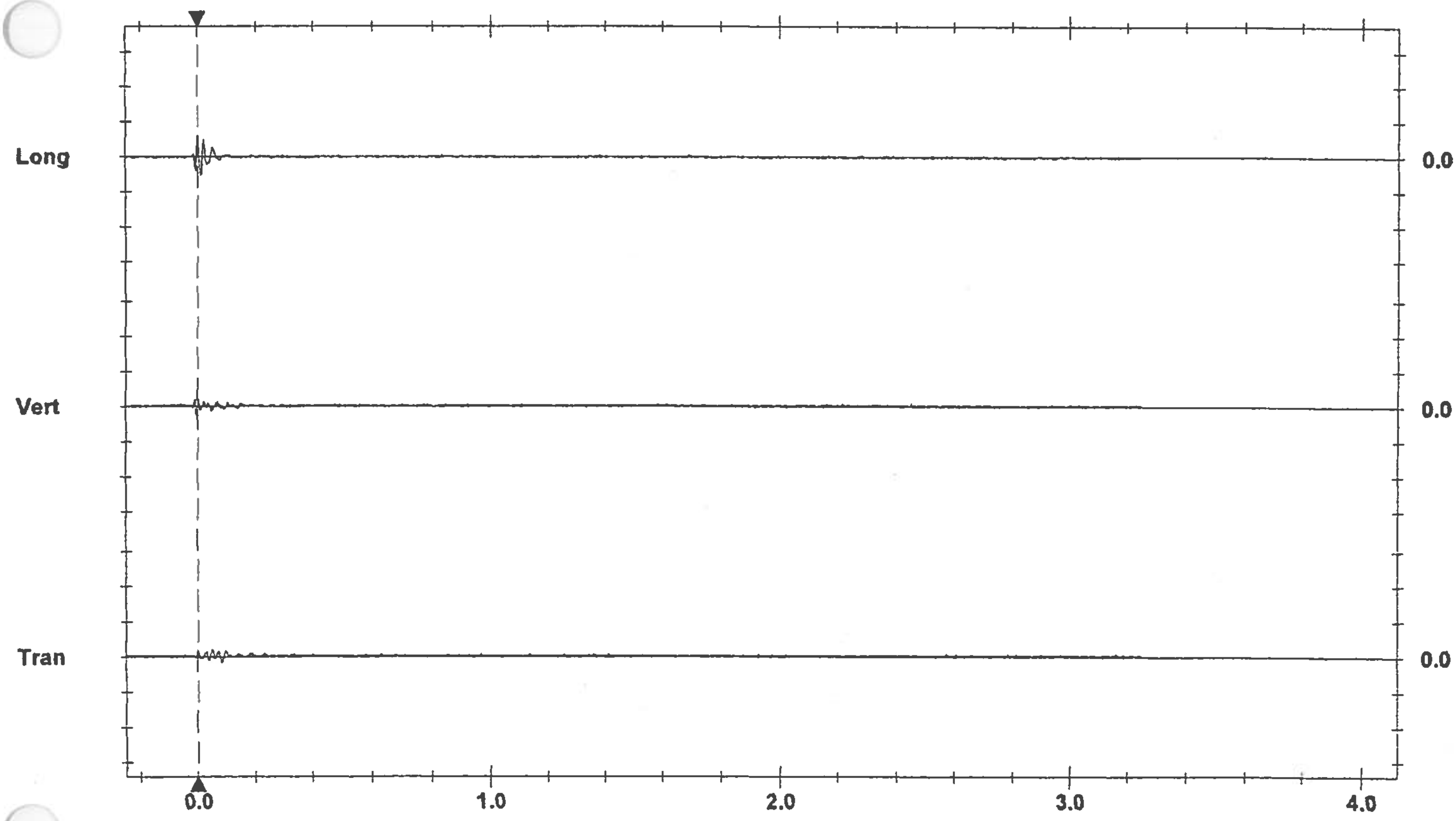
Peak Vector Sum 0.0636 in./s at 0.002 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Tran: + Vert: x Long: ø



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Event Report

Date/Time	Long at 10:09:00 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP2.V00

...es
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction Test Blast

Other:

Post Event Notes

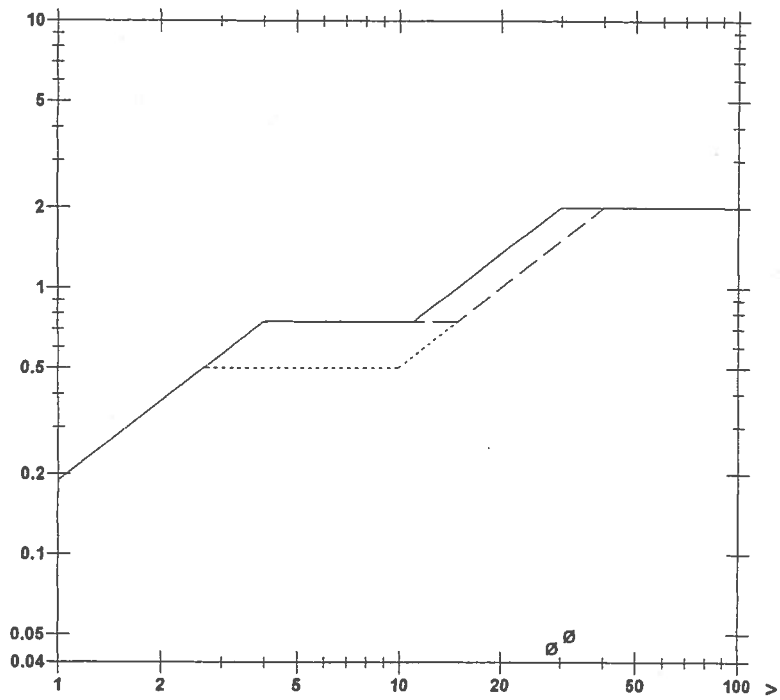
Microphone	Linear Weighting
PSPL	0.00018 psi(L) at -0.008 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

	Tran	Vert	Long	
PPV	0.0300	0.0200	0.0500	in./s
ZC Freq	39	43	32	Hz
Time (Rel. to Trig)	0.033	-0.020	0.002	sec
Peak Acceleration	0.0265	0.0265	0.0398	g
Peak Displacement	0.00017	0.00013	0.00178	in.
Sensorcheck ™	Passed	Passed	Passed	

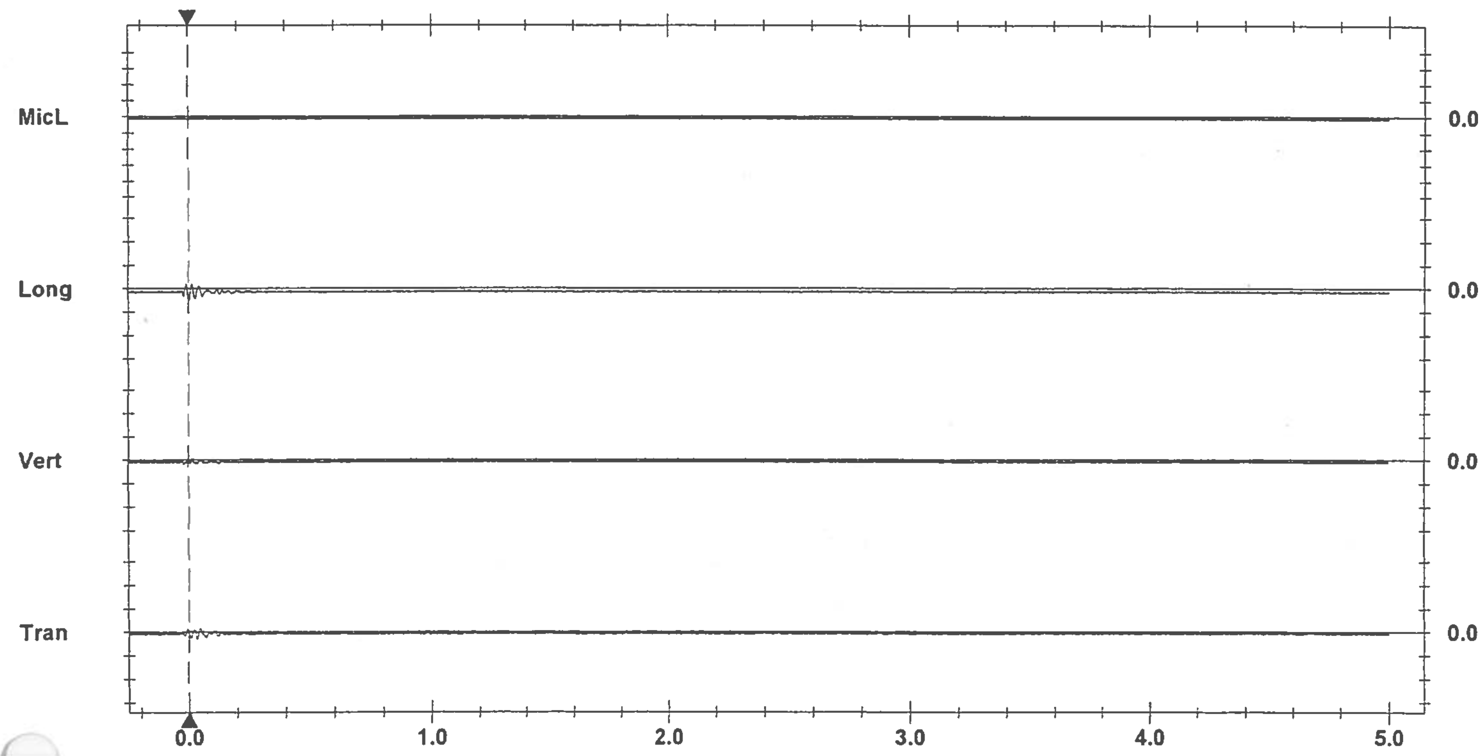
Peak Vector Sum 0.0541 in./s at 0.002 sec

N/A: Not Applicable
...: Out of Range

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ▶– — — —◀

Event Report

Date/Time	Long at 10:08:28 October 16, 1997
Trigger Source	Geo: 1.02 mm/s
Range	Geo: 254 mm/s
Record Time	5.0 sec at 1024 sps

Serial Number	BC5534 V 3.41-3.41 MiniMate Plus
Battery Level	5.8 Volts (Battery Low)
Calibration	January 10, 1997 by Instantel Inc.
File Name	G5346OAS.640

Notes

Post Event Notes

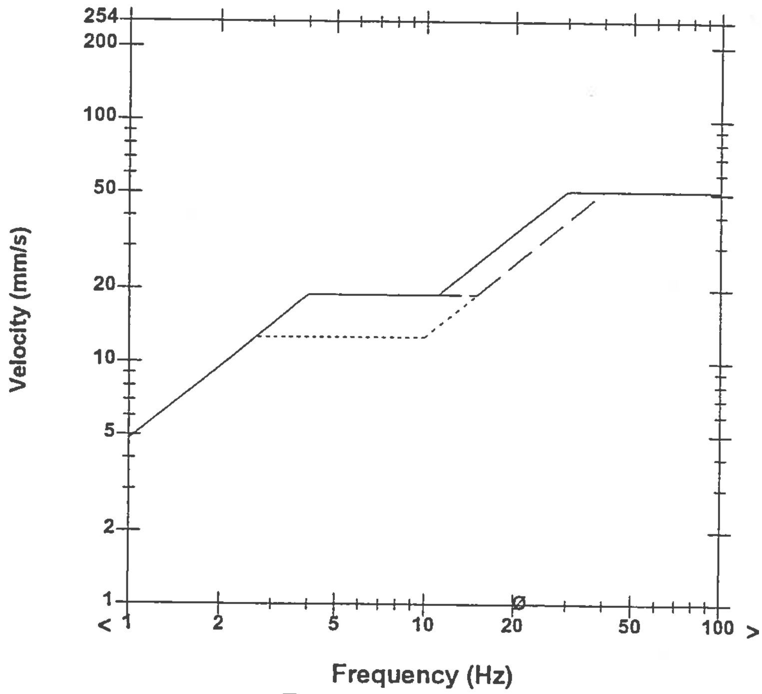
Microphone	Linear Weighting
PSPL	1.25 pa.(L) at 0.030 sec
ZC Freq	21 Hz
Channel Test	Check (Freq = 0.0 Hz Amp = 0 mv)

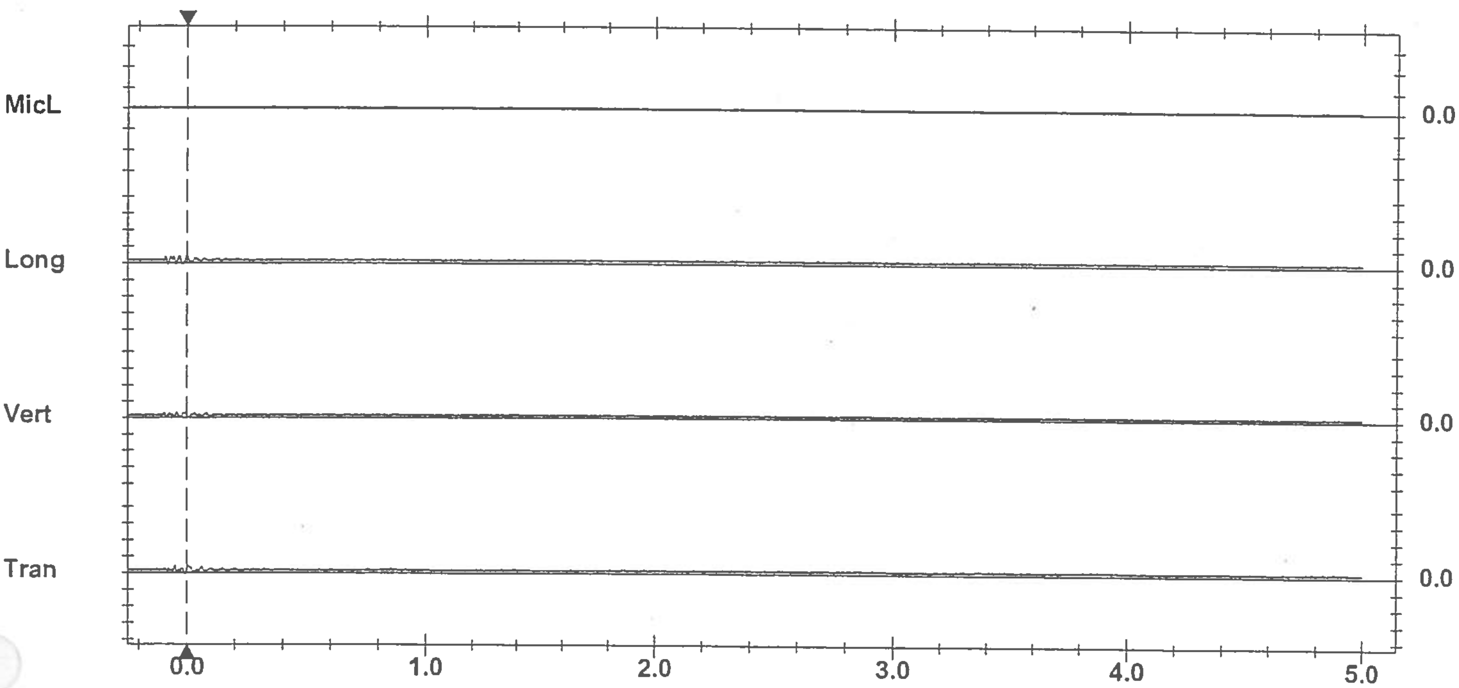
	Tran	Vert	Long	
PPV	0.889	0.635	1.02	mm/s
ZC Freq	37	N/A	21	Hz
Time (Rel. to Trig)	-0.050	-0.094	0.000	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.558	0.419	0.0322	mm
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 1.11 mm/s at 0.000 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



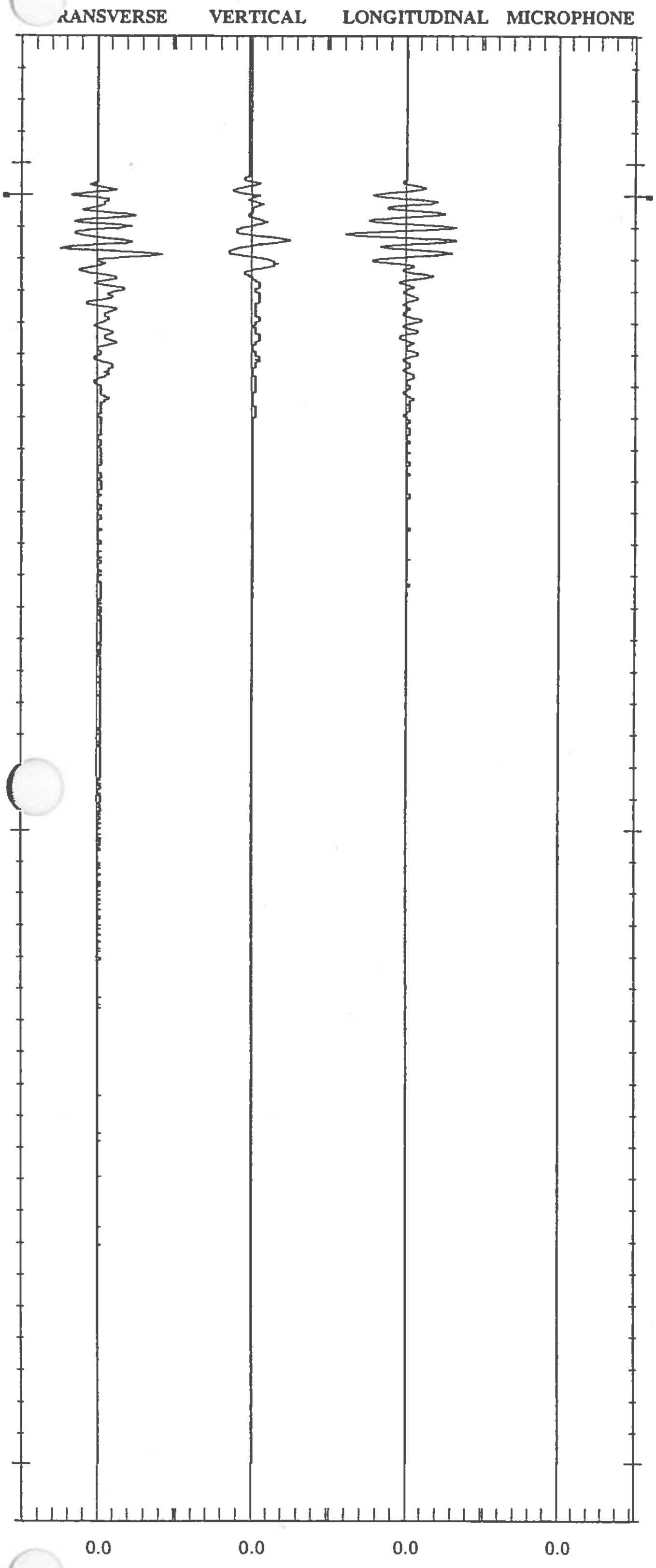


Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger = ▶— — — —◀

Printed: October 16, 1997 (V 3.11 - 3.11) **Format Copyrighted 1996**

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.010 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER = •——•

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEH.GAV
TIME & DATE	Long. at 10:07:22 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	
SCALED DISTANCE	N/A
PEAK VECTOR SUM	0.051 in/sec at 94 ms
MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.043	0.025	0.040	in/sec
ZC FREQ	37	32	47	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	94	70	62	ms
ACCEL	0.03	0.01	0.03	g
1/4 WAVE DISP	0.0002	0.0001	0.0001	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEH.GAV
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS

Event Report

Date/Time	Tran at 10:19:37 October 16, 1997	**Serial Number**	BC5536 V 3.11-3.11 MiniMate Plus
Trigger Source	Geo: 0.0500 in./s	**Battery Level**	6.5 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	2.75 sec (Auto=3Sec) at 1024 sps	**File Name**	G5366OAS.OP0

.s

Location: Victor, CO
Client: CC & V
User Name: M.M.C. Colin Matheson
General: Attenuation Study

Post Event Notes

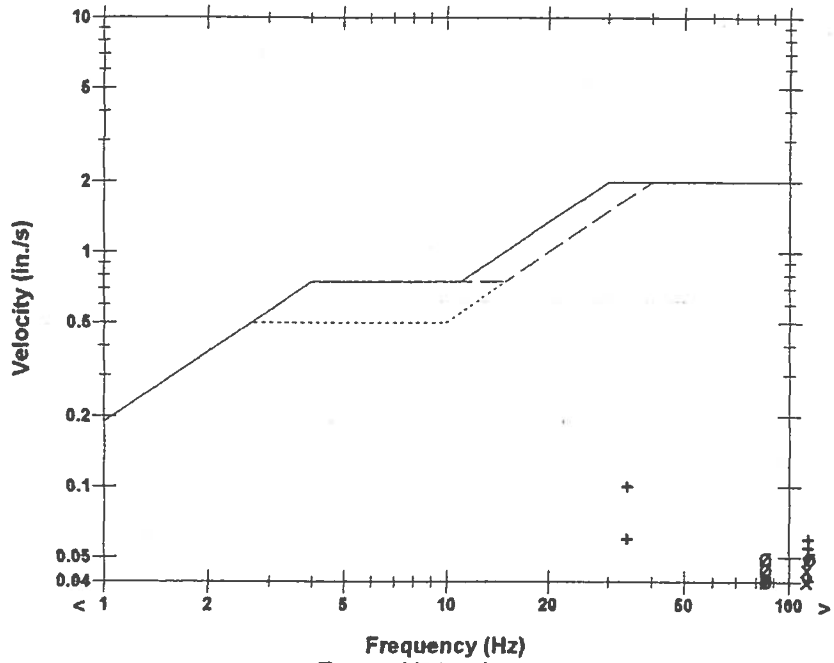
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	0.1000	0.0450	0.0500	in./s
ZC Freq	34	>100	>100	Hz
Time (Rel. to Trig)	0.572	0.590	0.000	sec
Peak Acceleration	0.106	0.106	0.0928	g
Peak Displacement	0.0120	0.00504	0.00087	in.
Sensorcheck ™	Passed	Passed	Passed	

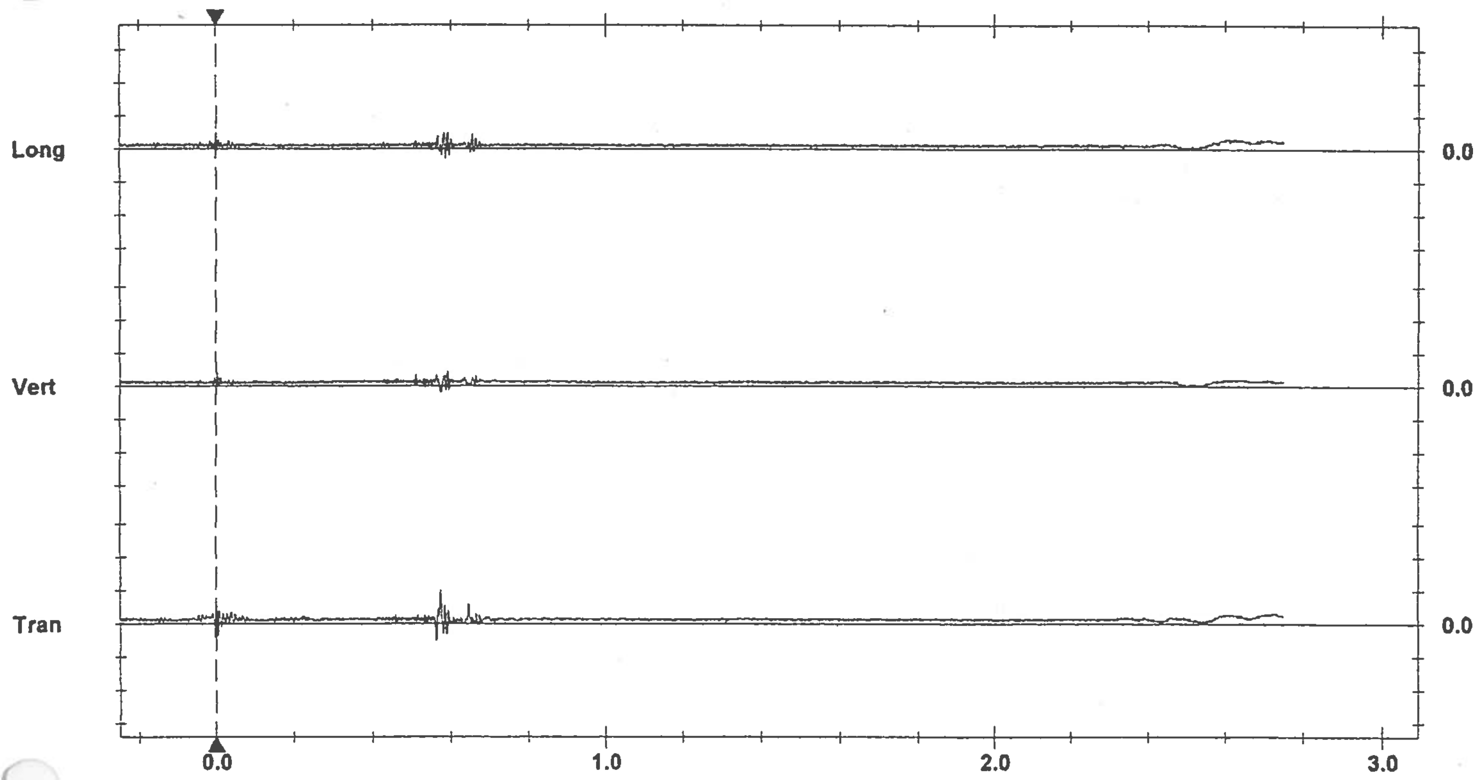
Peak Vector Sum 0.103 in./s at 0.572 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Monitor Log
16 /97 10:11:55 Oct 16 /97 10:19:40 Event recorded. (Keyboard Exit)



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div
Trigger = ▶— — — —◀

Printed: October 30, 1997 (V 3.42 - 3.41)

Event Report

Date/Time	Long at 10:12:57 October 16, 1995	**Serial Number**	BA5552 V 3.11-3.11 BlastMate III
Trigger Source	Geo: 0.0400 in./s	**Battery Level**	6.4 Volts
Range	Geo :10.00 in./s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5525MP3.1L0

es
Location: CC&V
Client: CC & V
User Name: CMM
General:Construction Test Blast

Other:

Post Event Notes

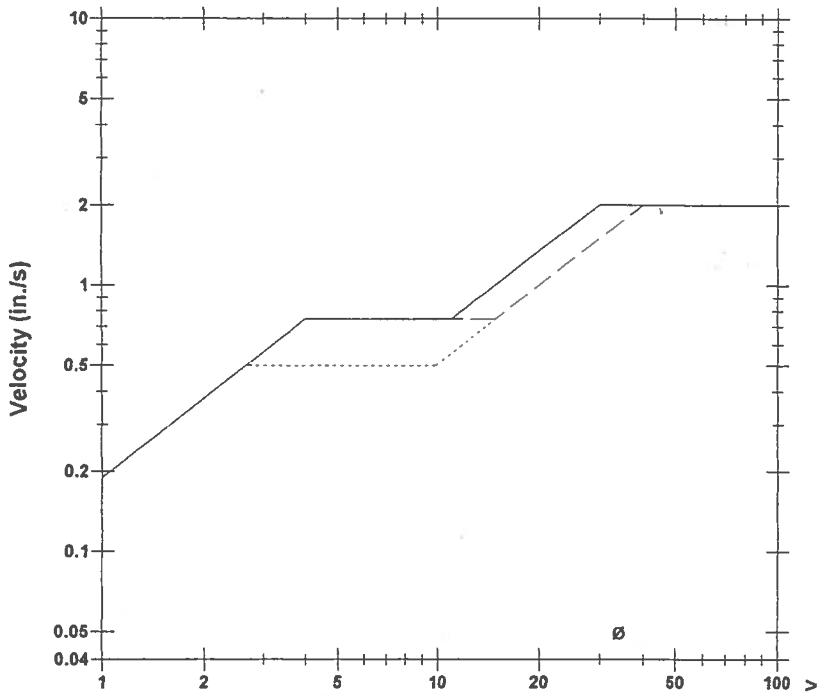
Microphone	Linear Weighting
PSPL	0.00015 psi(L) at -0.250 sec
ZC Freq	N/A
Channel Test	Passed (Freq = *** Amp = ***)

	Tran	Vert	Long	
PPV	0.0300	0.0150	0.0500	in./s
ZC Freq	37	37	34	Hz
Time (Rel. to Trig)	0.009	-0.022	0.001	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00015	0.00013	0.00177	in.
Sensorcheck ™	Passed	Passed	Passed	

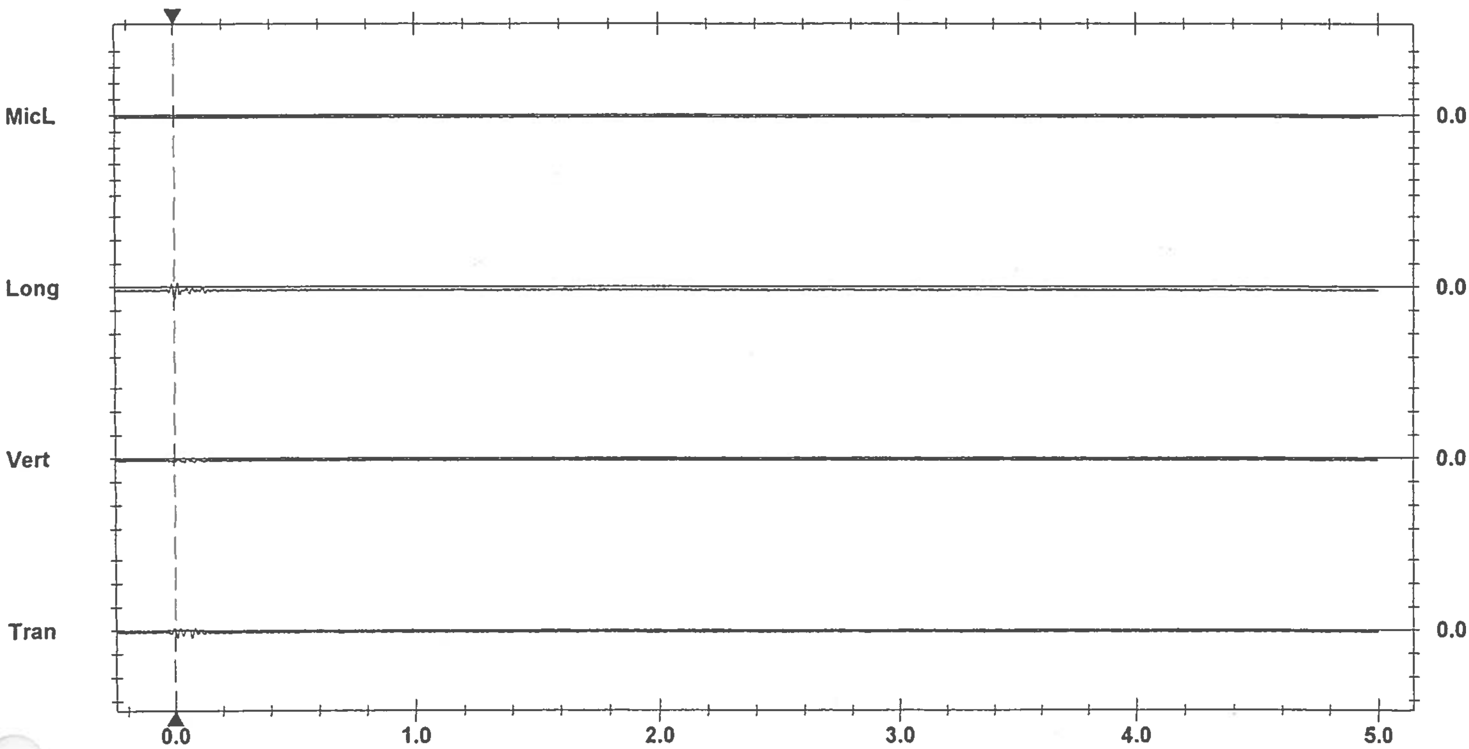
Peak Vector Sum 0.0520 in./s at 0.005 sec

N/A: Not Applicable
: Out of Range

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø



Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 0.100 in./s/div Mic: 0.00100 psi(L)/div
Trigger = ►— — — —◄

Event Report

Date/Time	Long at 10:12:24 October 16, 1997	**Serial Number**	BC5534 V 3.41-3.41 MiniMate Plus
Trigger Source	Geo: 1.02 mm/s	**Battery Level**	5.8 Volts (Battery Low)
Range	Geo: 254 mm/s	**Calibration**	January 10, 1997 by Instantel Inc.
Record Time	5.0 sec at 1024 sps	**File Name**	G5346OAS.CO0

Notes

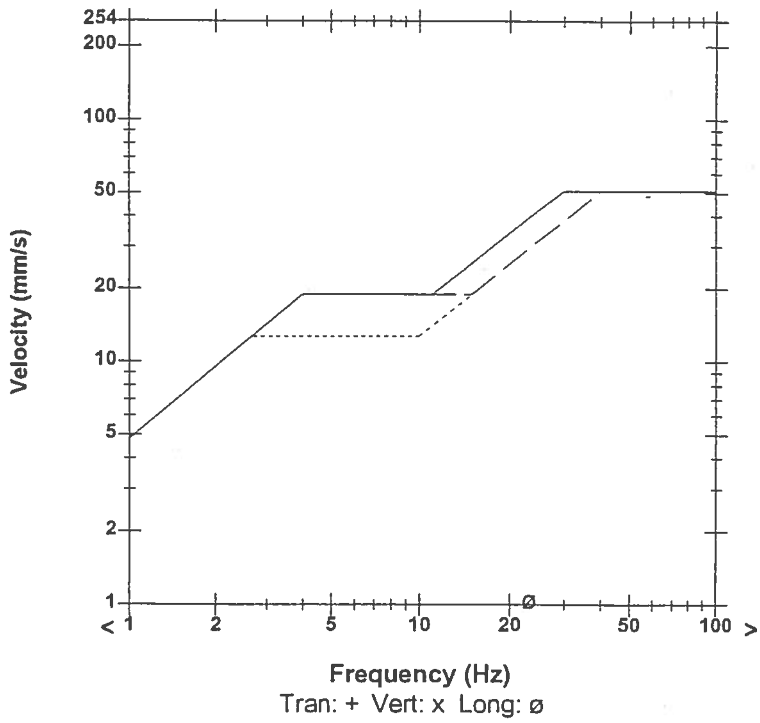
Post Event Notes

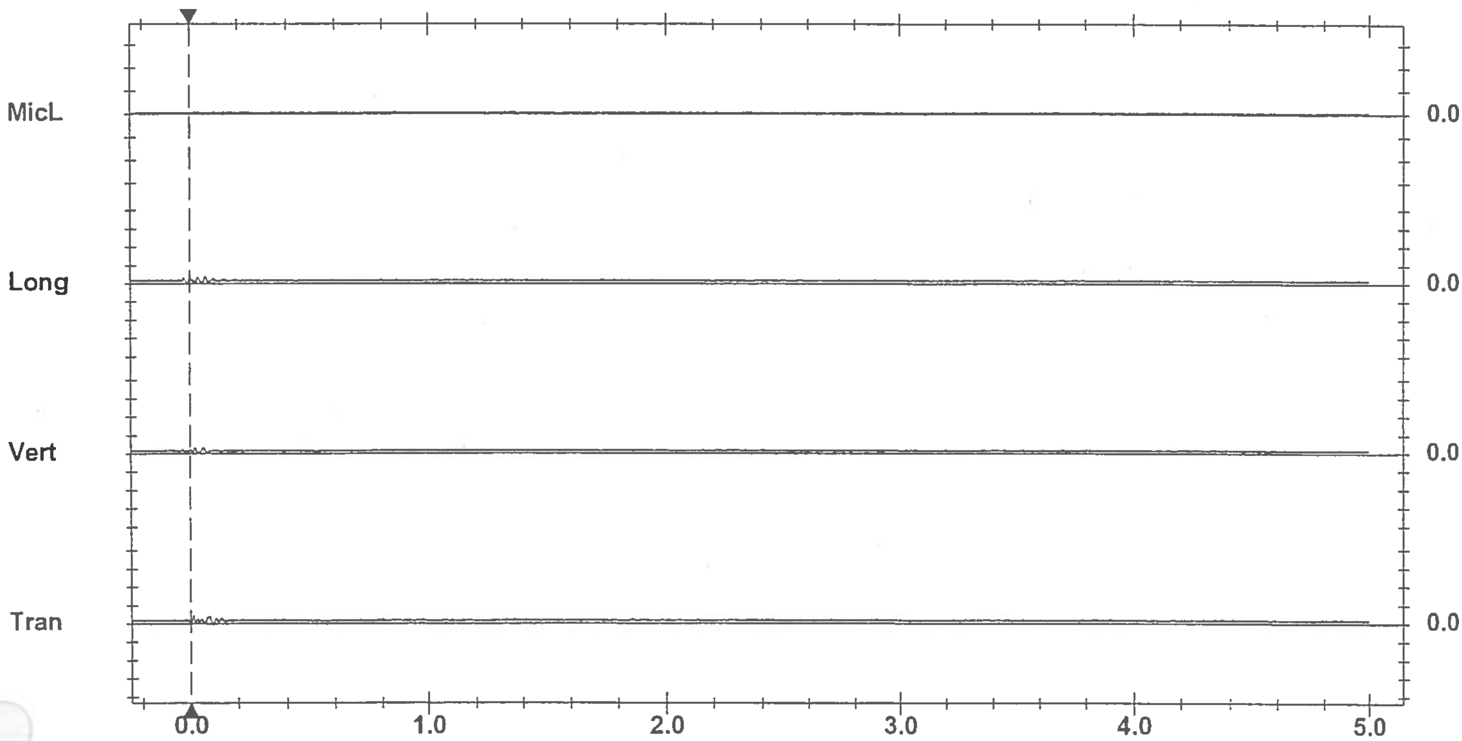
Microphone	Linear Weighting
PSPL	1.25 pa.(L) at 1.861 sec
ZC Freq	1.3 Hz
Channel Test	Check (Freq = 0.0 Hz Amp = 0 mv)

	Tran	Vert	Long	
PPV	0.889	0.635	1.02	mm/s
ZC Freq	30	30	23	Hz
Time (Rel. to Trig)	0.014	0.021	0.000	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.0450	0.505	0.0450	mm
Sensorcheck ™	Passed	Passed	Passed	

Peak Vector Sum 1.16 mm/s at 0.000 sec

USBM RI8507 And OSMRE

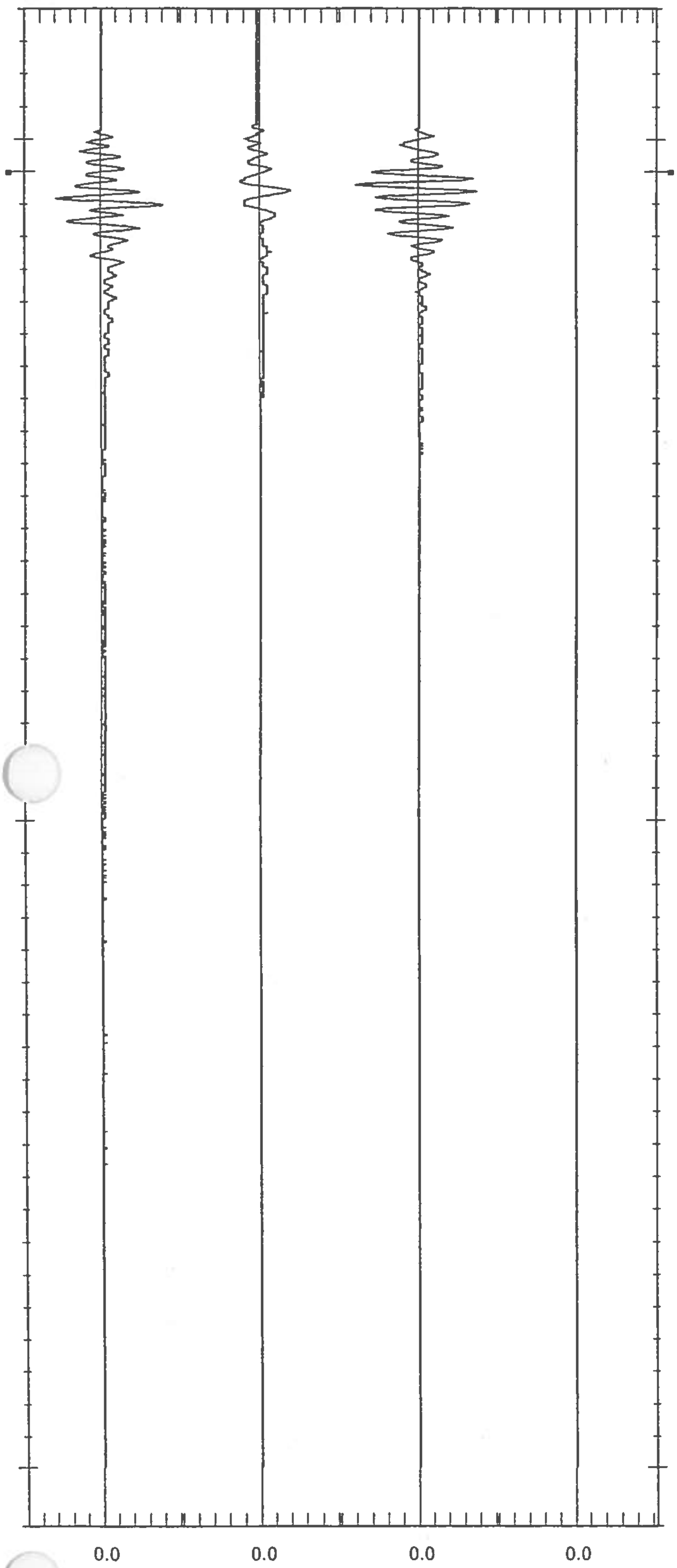




Time Scale: 0.20 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger = ▶— — — —◀

SEISMOGRAPH ANALYSIS REPORT

EVENT WAVEFORMS



AMPLITUDE SCALE:GEO: 0.010 in/sec/div MIC: 1.0000 psi(L)/div
TIME SCALE: 50 msec/div 2.344 sec/page TRIGGER =

SERIAL NO.	3184 V2.4-MSV
CODE	E1846OEH.MVV
TIME & DATE	Long. at 10:11:19 Oct 17, 1997
TRIGGER SOURCE	Geo 0.020 in/sec
RECORD TIME	2 sec
LOCATION	
CLIENT	
USER	
NOTES	
SCALED DISTANCE	N/A
PEAK VECTOR SUM	0.051 in/sec at 52 ms
MICROPHONE	LINEAR WEIGHTING
PK AIR	<100 dB(L) at -249 ms
ZC FREQ	N/A

	TRAN	VERT	LONG	
PPV	0.040	0.020	0.040	in/sec
ZC FREQ	43	32	57	Hz
FFT FREQ	N/A	N/A	N/A	Hz
TIME(REL.TO TRIG)	52	29	21	ms
ACCEL	0.03	0.01	0.03	g
1/4 WAVE DISP	0.0001	0.0001	0.0001	in
DYNAMIC GEO CAL	Passed	Passed	Passed	

INTERNAL MIC CHANNEL TEST: Failed Freq = 0 Amp = 0

BATTERY LEVEL 6.3 volts

CALIBRATED ON Jun 23, 1997 by VIBRA-TECH

(N/A) - not applicable

USBM RI8507 AND OSMRE ANALYSIS
ERROR INFORMATION
OPERATION = OPENING S:\APPS\MULTV\WAVE\TEMP\E1846OEH.MVV
ERROR = FILE ACCESS DENIED

Vibra-Tech
THE VIBRATION MONITORING EXPERTS