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NONEX® ATTENUATION STUDY

Prepared for

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July 26, 2007

ABSTRACT

Vibration monitoring was performed on a two test shots using Nonex®[1].

Analysis of the vibration readings from these shots indicate that Nonex® produces lower vibration levels than standard explosives and Nonex® may be an effective method for close in rock removal.

INTRODUCTION

There is a growing need for safe and economical methods to remove rock close to existing structures. Nonex® is a non-explosive rapid expanding gas agent that can be used to fracture rock in a method similar to blasting. Vibration monitoring was performed on two test shots to assess the potential for reduced vibration levels during close in rock removal activities.

METHODS

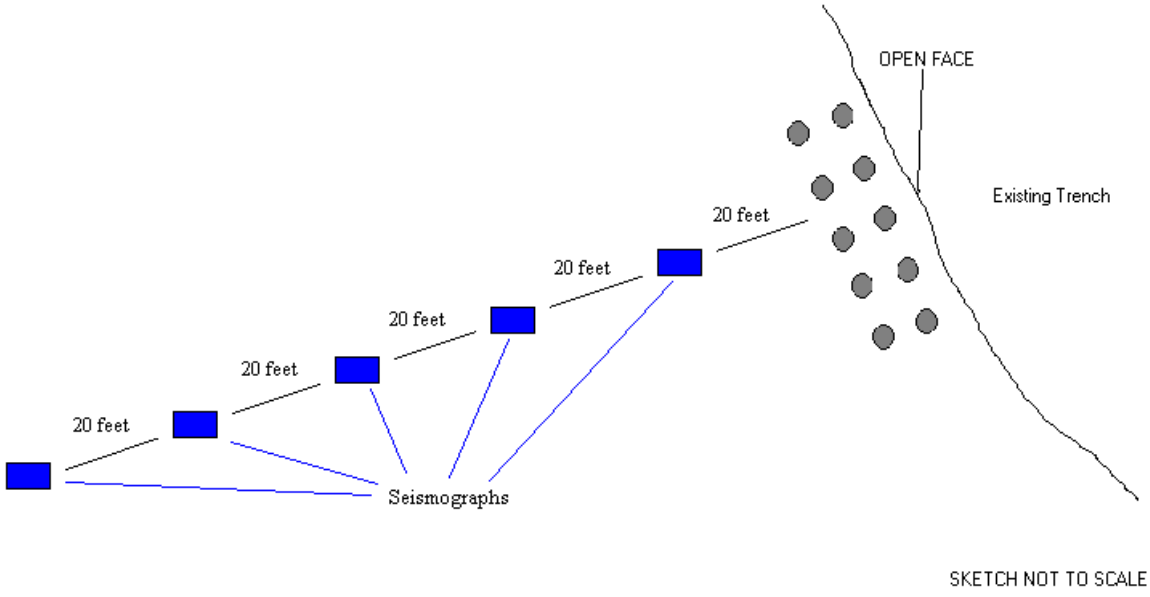
Vibration data was collected from two Nonex® test shots and the data was analyzed to create vibration prediction formulas for the product.

Monitoring Setup

Five seismographs were placed at 20-foot intervals in a straight line from each shot. The sensors were buried 4-6 inches deep for the test shots. On the site there was a shallow layer of dirt (2-4 inches) on top of the underlying rock.

The sketch below shows the basic layout for the first test shot. Seismographs were placed in a similar fashion for the second shots.

[1] Nonex is a registered trademark of Nonex, LLC.



Seismographs are typically used to monitor and record ground vibrations from blasting activities. Seismographs measure the ground motion using a transducer (sometimes called a geophone). The transducer monitors ground motion in three perpendicular directions. These directions are front to back, side to side, and up and down. These directions are typically referred to as ***L***ongitudinal, ***T***ransverse and ***V***ertical. In addition, most seismographs also record the sound pressure level in the air during the vibration event.

Particle Velocity

The ground motion is usually recorded as a Particle Velocity (PV). The PV is the speed that the particles in the ground are moving. This information is typically reported in inches/second (ips or in/sec) and it is recorded in all three directions of motion of the transducer.

Peak Particle Velocity

The most common measurement used for damage criteria during blasting is the Peak Particle Velocity (PPV). The PPV is simply the highest particle velocity recorded during the entire vibration event on any of the three directions monitored by the seismograph. The PPV will also include a corresponding frequency for the ground vibration, which is essential for calculating the actual displacements and strains. The PPV and frequency are commonly used for specifying vibration limits because cracking does not occur until the strain exceeds the failure limit of the material.

RESULTS

Information on each of the test shots and the vibration data collected is presented below.

Test Shot 1

On June 25, 2007, the first test shot was performed at a site in Lawrenceville, Georgia.

BEFORE

Basic Shot Characteristics

Number of Holes: 10
Hole Diameter: 2 inches
Drill Pattern: 3 X 3 feet
Drill Depth: 7 feet
Rock Volume: 23.33 cubic yards
Total Charge: 48.8 pounds (no delays)
Powder Factor: 2.09 pounds/cubic yard

This was an active construction site where earthwork and conventional blasting were taking place. This shot was at a location on the site where a trench area had previously been shot. The test shot was laid out on the side of the trench wall. The test shot was 5 holes long and 2 holes deep, providing an open face along the long side of the shot.

When initiated, this shot fractured the rock and the material fell into the preexisting trench.

The vibration data collected is summarized below.

AFTER

VIBRATION DATA

				Velocity			Frequency			Airblast	
Date	Time	Distance	Max/Delay	L	T	V	L	T	V	dBf	hz
6/25/2007	14:27	100	48.8	0.180	0.160	0.160	44.2	74.6	51.5	120	22.5
6/25/2007	14:27	80	48.8	0.180	0.160	0.220	37.2	67.7	38.6	123	12.5
6/25/2007	14:27	60	48.8	0.300	0.180	0.230	27.1	28.3	32.0	126	13.7
6/25/2007	14:27	40	48.8	0.420	0.200	0.310	37.0	54.1	87.1	129	12.7
6/25/2007	14:27	20	48.8	1.100	0.660	2.300	41.3	83.4	39.4	136	12.9

Test Shot 2

On June 25, 2007, a second test shot was also performed at the site in Lawrenceville, Georgia.

BEFORE

Basic Shot Characteristics

Number of Holes: 16
Hole Diameter: 2 inches
Drill Pattern: 2.5 X 2.5 feet
Drill Depth: 6 feet
Rock Volume: 32 cubic yards
Total Charge: 87 pounds (no delays)
Powder Factor: 2.72 pounds/cubic yard

This was an active construction site where earthwork and conventional blasting were taking place. This was a sinking shot with four holes in the center and twelve holes on the perimeter.

When this shot was initiated, the material heaved up and appeared to have broken into small pieces that could be easily dug.

The vibration data collected is summarized below.

AFTER

VIBRATION DATA

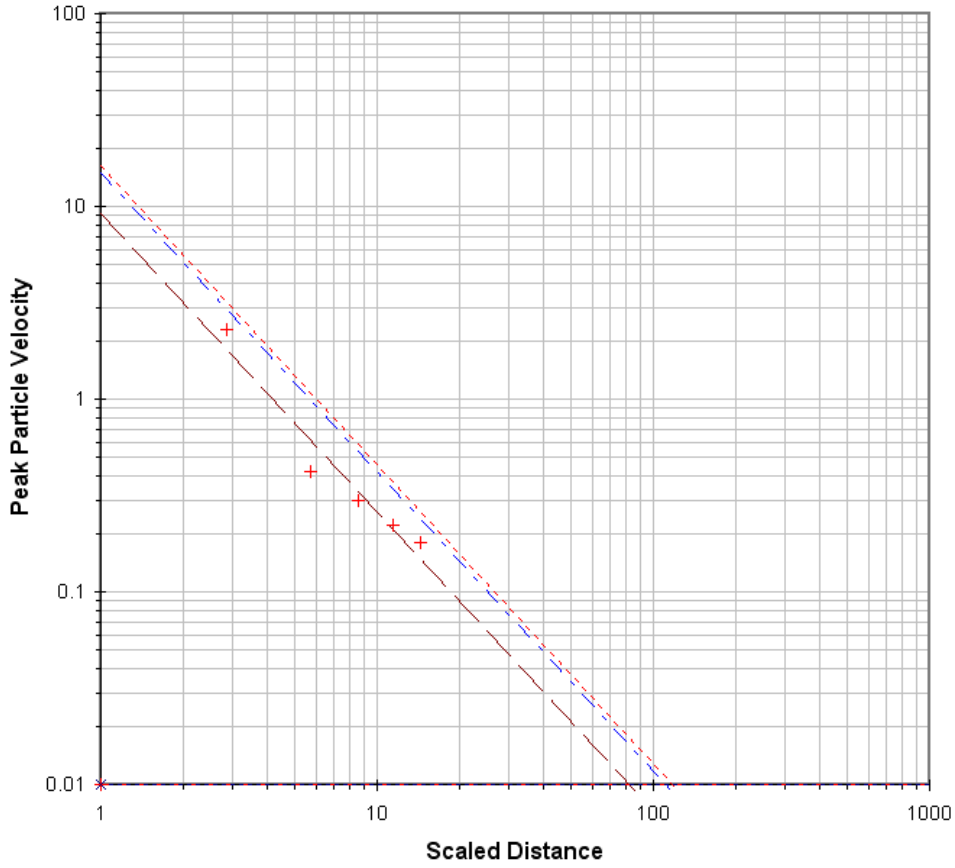
				Velocity			Frequency			Airblast	
Date	Time	Distance	Max/Delay	L	T	V	L	T	V	dBf	hz
6/25/2007	14:27	100	87	0.100	0.060	0.130	57.0	68.3	28.0	129	9.2
6/25/2007	14:27	80	87	0.100	0.060	0.130	25.6	39.4	27.5	130	8.5
6/25/2007	14:27	60	87	0.180	0.160	0.250	36.6	34.1	30.5	132	18.2
6/25/2007	14:27	40	87	0.500	0.450	0.570	85.0	147.6	52.8	136	11.2
6/25/2007	14:27	20	87	2.130	1.950	0.700	30.2	39.2	26.1	140	15.8

ANALYSIS

A regression analysis for predicting vibration uses the blasting and seismograph information collected at the site. Using this information, a formula is created which predicts the vibration level at any distance from a shot based on the maximum pounds per delay in the shot. This type of analysis is used to provide predicted values that are calculated to be higher than actual readings 95% of the time.

The data collected on each shot was analyzed independently and then combined. The results of the individual regression analyses are shown below.

REGRESSION FOR TEST SHOT 1



The 95% confidence prediction formula created from the data collected is;

$$V = 14.9\left(R/\sqrt{W}\right)^{-1.551}$$

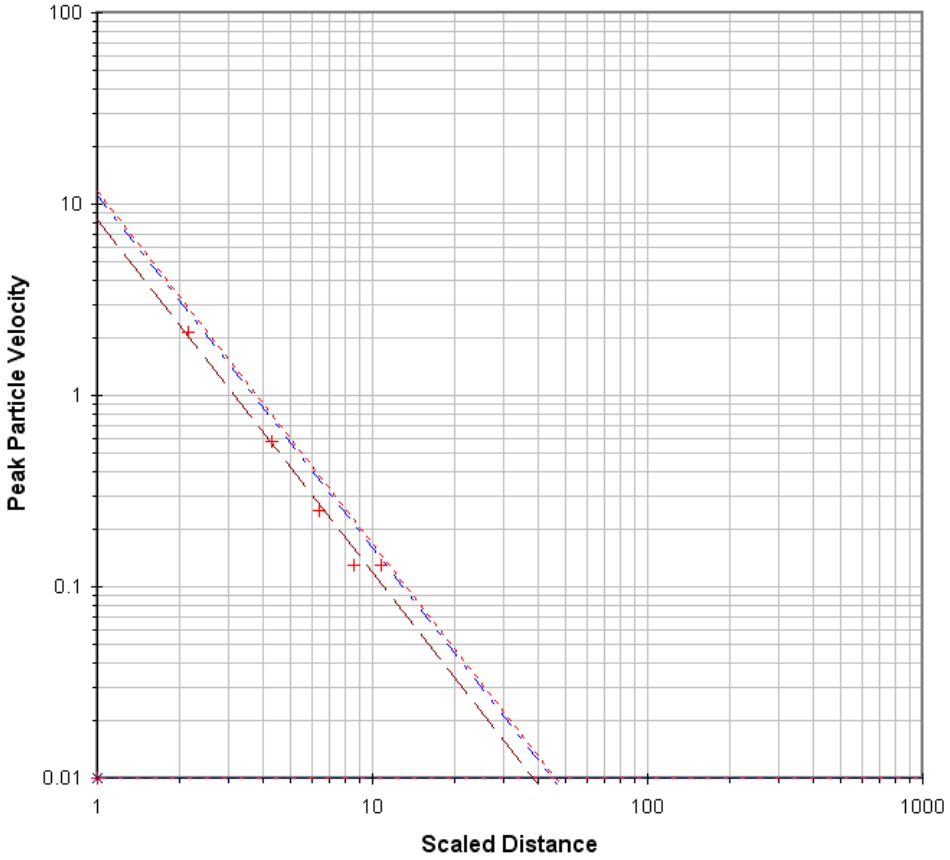
Where

V = Peak particle velocity (in/sec)
R = Distance from blasting (ft)
W = Max. Weight of explosives per delay (lbs.)

Confidence Level[2] = 77.3%

[2] Confidence Level is the likelihood - expressed as a percentage - that the results of a test are real and repeatable, and not just random. (http://www.malwarwick.com/learning-resources/confidence-level-calculator.html)

REGRESSION FOR TEST SHOT 2



The 95% confidence prediction formula created from the data collected is;

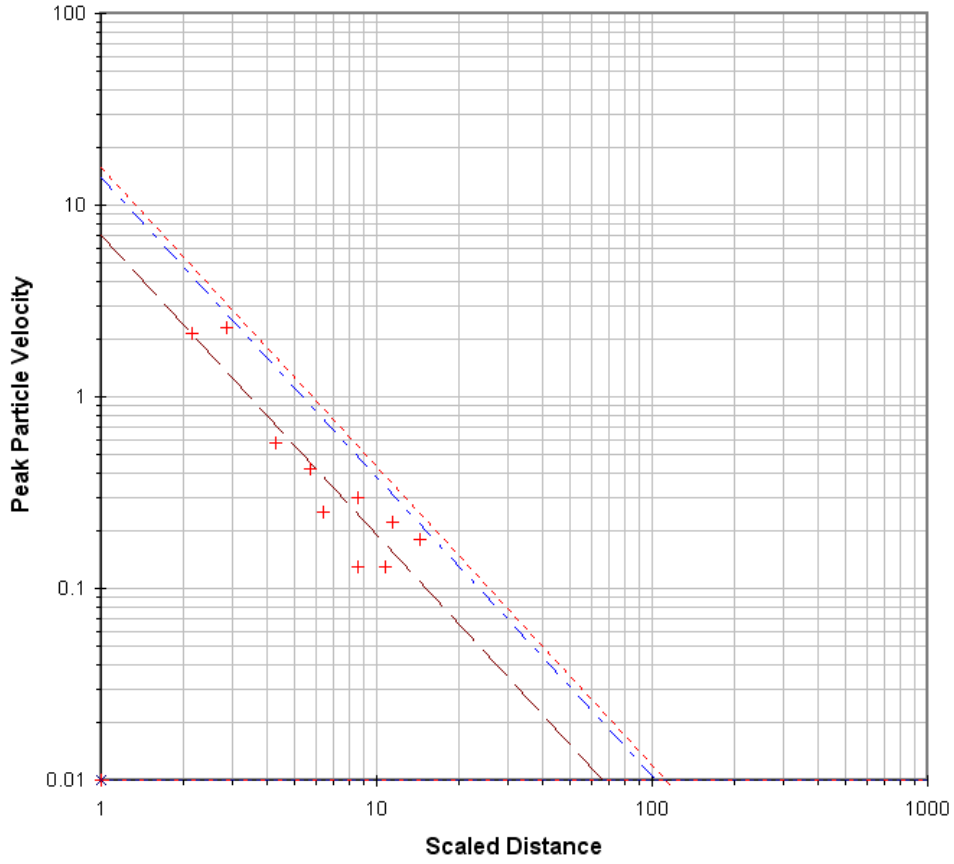
$$V = 11.1\left(R/\sqrt{W}\right)^{-1.842}$$

Where

V = Peak particle velocity (in/sec)
R = Distance from blasting (ft)
W = Max. Weight of explosives per delay (lbs.)

Confidence Level = 82.5%

COMBINED REGRESSION FOR TEST SHOTS



The 95% confidence prediction formula created from the data collected is;

$$V = 13.8\left(R/\sqrt{W}\right)^{-1.56}$$

Where

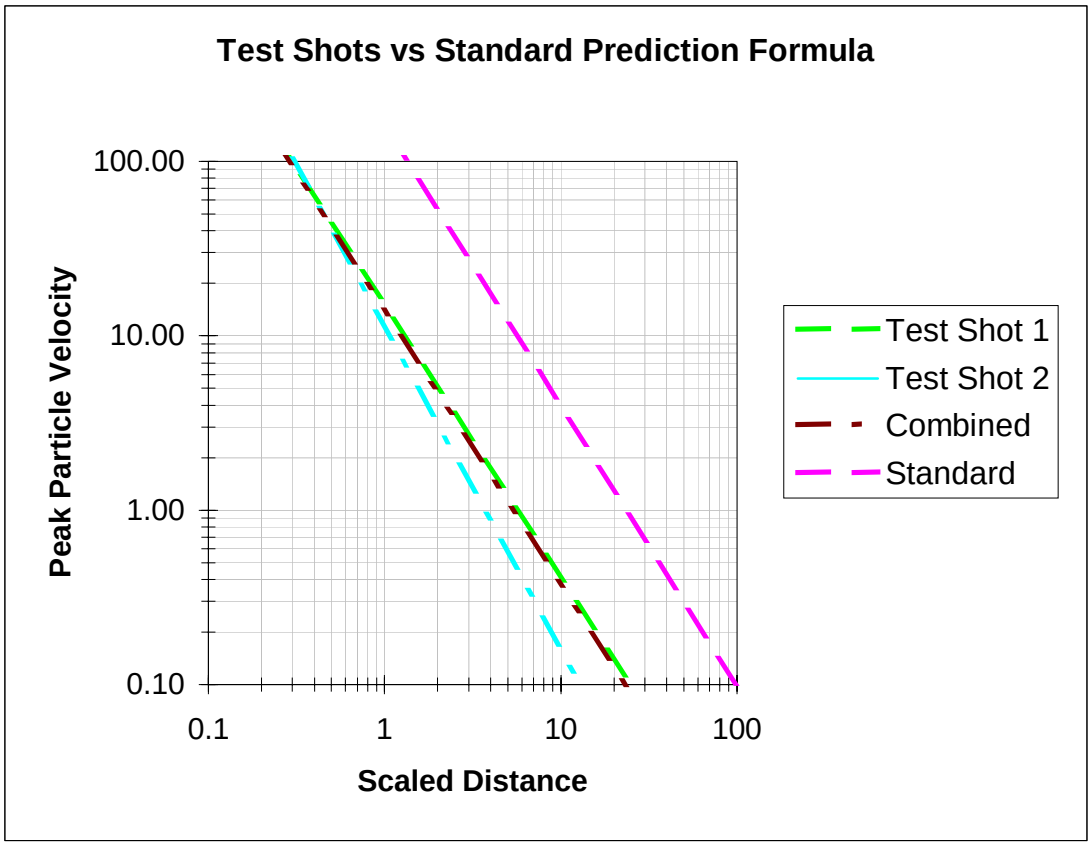
V = Peak particle velocity (in/sec)
R = Distance from blasting (ft)
W = Max. Weight of explosives per delay (lbs.)

Confidence Level = 74.8%

For reference, the prediction formulas created from this data were compared to the standard vibration prediction formula from the "Blasters Handbook" by E.I. Dupont de Nemours & Co, which is;

$$V = 160\left(R/\sqrt{W}\right)^{-1.6}$$

The graph below plots the prediction lines for the Nonex® prediction formulas and the Standard prediction formula.



When using the prediction formulas created, the graph indicates that show that a Scaled Distance below 3 could produce vibration levels below 2.0 in/sec. The Scaled Distance is a method of correlating the amount of explosives used in a shot with a given distance to determine if there is a safe level of vibration at the given distance. The scaled distance is calculated by dividing the distance from the shot by the square root of the maximum pounds per delay. This formula is;

$$SD = R/\sqrt{W}$$

Where

SD = Scaled Distance
R = Distance from blasting (ft)
W = Max. Weight of explosives per delay (lbs.)

The general rule is that a scaled distance that is greater than 50 indicates that the vibration levels at the given distance are well below damage causing levels.

> The U.S. Bureau of Mines conducted a program establishing that a Scaled Distance of 50 assures that the particle velocity damage criterion will not be exceeded under a wide variety of ground conditions. In fact, the Bureau's data indicate that a 2-inch-per-second particle velocity corresponds to a Scaled Distance of 5 to 17, depending on ground conditions.[3]

Blasters often use the Scaled Distance to aid in the design of their shots. When this method is utilized, the blaster can be confident that the blasting activities will not damage nearby structures. The table below shows the predicted velocities for each of the formulas created for low Scaled Distance values[4].

Scaled Distance (R/√W)	Test Shot 1 (in/sec)	Test Shot 2 (in/sec)	Combined (in/sec)	Standard (in/sec)
30	0.08	0.02	0.07	0.69
29	0.08	0.02	0.07	0.73
28	0.08	0.02	0.08	0.77
27	0.09	0.03	0.08	0.82
26	0.10	0.03	0.09	0.87
25	0.10	0.03	0.09	0.93
24	0.11	0.03	0.10	0.99
23	0.12	0.03	0.10	1.06
22	0.12	0.04	0.11	1.14
21	0.13	0.04	0.12	1.23
20	0.14	0.04	0.13	1.33
19	0.15	0.05	0.14	1.44
18	0.17	0.05	0.15	1.57
17	0.18	0.06	0.17	1.72
16	0.20	0.07	0.18	1.89
15	0.22	0.08	0.20	2.10
14	0.25	0.09	0.22	2.35
13	0.28	0.10	0.25	2.64
12	0.32	0.11	0.29	3.00
11	0.36	0.13	0.33	3.45
10	0.42	0.16	0.38	4.02
9	0.49	0.19	0.45	4.76
8	0.59	0.24	0.54	5.74
7	0.73	0.31	0.66	7.11
6	0.93	0.41	0.84	9.10
5	1.23	0.57	1.12	12.18
4	1.74	0.86	1.59	17.41
3	2.71	1.47	2.49	27.59
2	5.08	3.10	4.68	52.78
1	14.90	11.10	13.80	160.00

[3] Electric Blasting In A Vibration-Conscious World - Copyright© 1997 International Society of Explosives Engineers - Fred C. Drury - Hercules, Inc. - Wilmington, DE

[4] Caution should be used when utilizing vibration predictions for low Scaled Distances due to the exponential nature of the prediction formulas.

These calculations indicate that the Nonex® product will produce significantly lower particle velocities than the standard prediction formula for close in rock removal. The current data shows predicted particle velocities from the Nonex® product are 10 times less than the predicted velocities using the standard prediction formula with the same scaled distance. If the predicted particle velocities can be reproduced consistently in the field, this would be very effective for close in rock removal.

DISCUSSION

When the regression data from each of the individual shots is analyzed independently, they provide very good confidence levels. Combining all of the data from the two shots also produces a prediction formula with a good confidence level.

The regression from the combination of the two shots produces a prediction formula that should be applicable. The graph of this prediction formula has a slope that is almost identical to the standard vibration prediction formula, which helps support the confidence of the combined prediction formula.

$$V = 13.8\left(R/\sqrt{W}\right)^{-1.56}$$

It should also be noted that both of these shots were wired together and fired simultaneously due to an approaching electrical storm. Because of the large trench between the two shots and their separation, it is believed that the energy released from each individual shot had minimal impact on the vibration data collected for the other shot.

CONCLUSIONS

Based on the data collected, it appears that the Nonex® product can produce significantly lower ground vibrations than comparable blasting activities.

RECOMMENDATIONS

Until more data is collected, it is suggested that the regression formula from the combination of both shots be utilized for vibration predictions. In order to produce a more comprehensive regression analysis it is recommended that additional data be collected from a variety of situations. The accuracy of this prediction formula is dependent on the amount of data collected. In this case, there were two shots analyzed with five seismograph readings taken on each. This number of data points is generally considered too low to provide a good overall prediction formula.

REFERENCES

Nonex® Literature is available at www.advnrg.com

APPENDIX

Seismograph printouts are attached to this report.

NOMIS Seismographs - Report

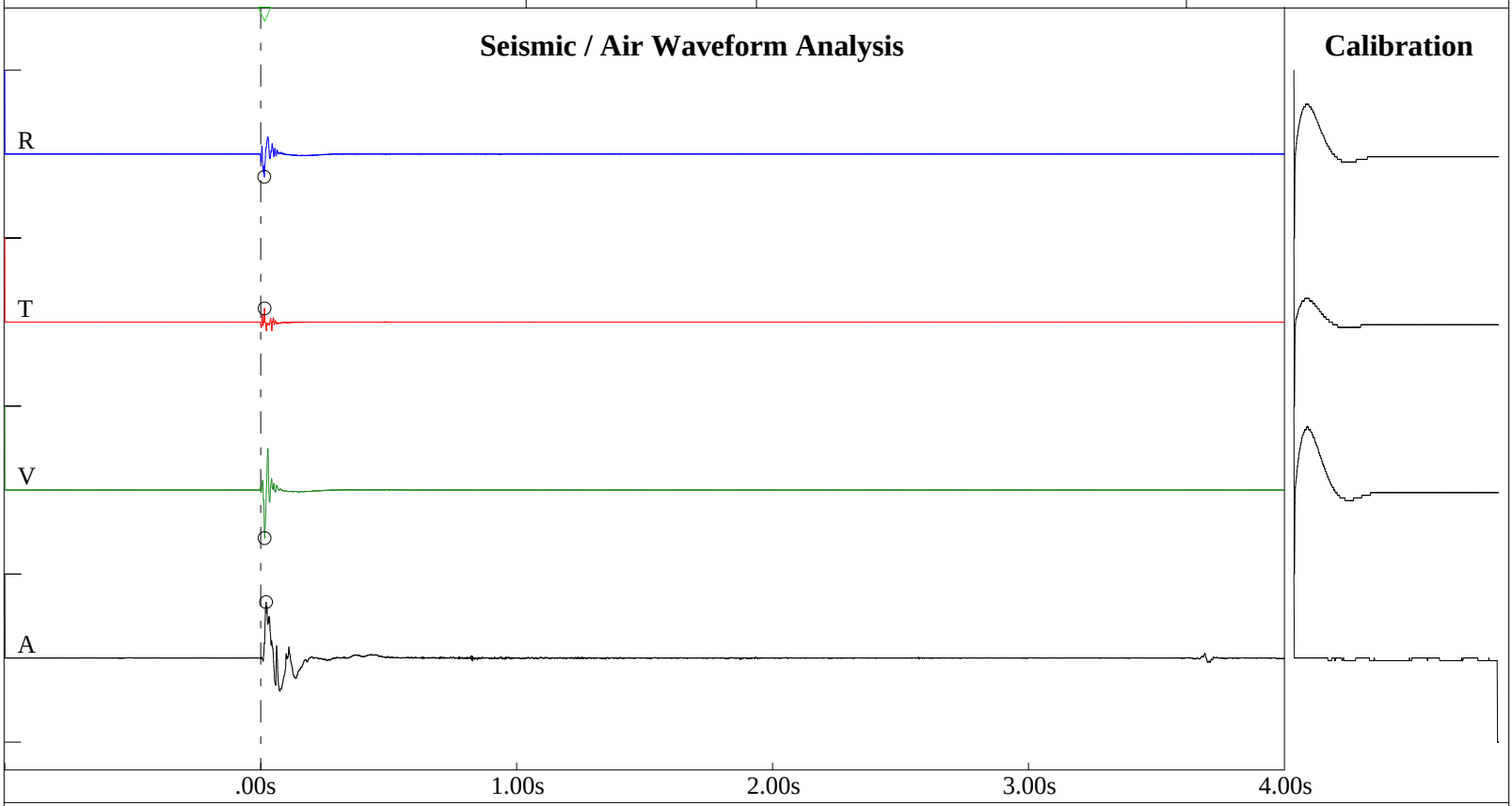
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 1
Location: Lawrenceville, GA
Distance: 20 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:27:03 Event # 14
Graph: NS5400I-2886
Last Calibration: 11OCT06
Sample Rate:1024/sec
Record Duration: 5 sec

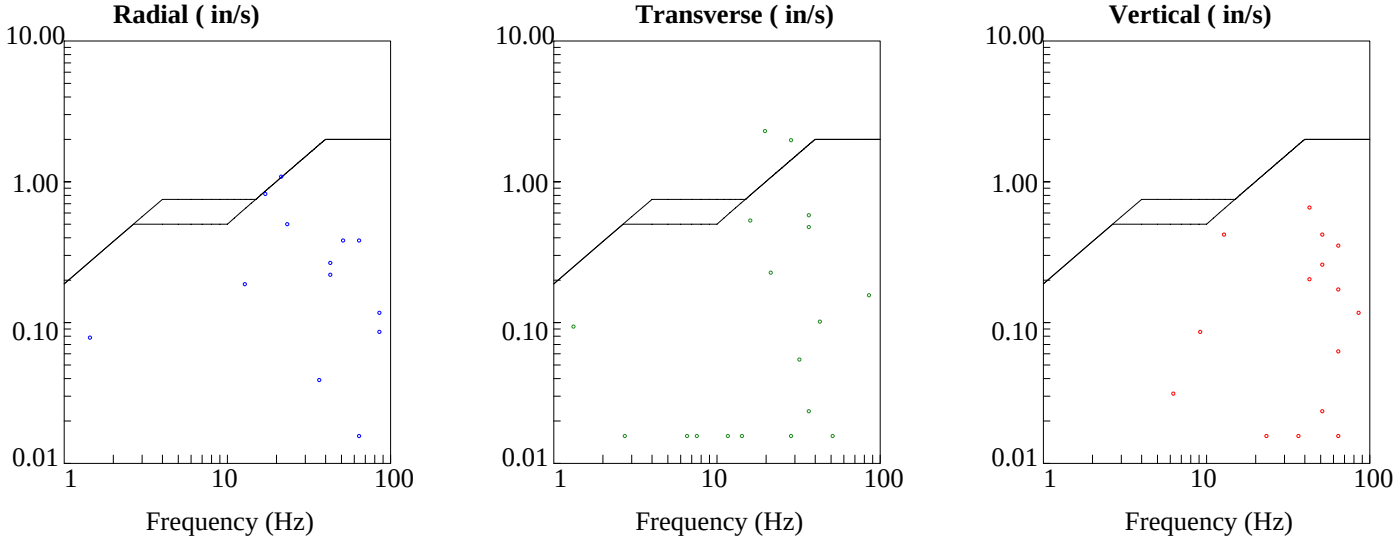
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 1.10 in/s @ 41.3 Hz	14.6 ms	Air Scale: .03686 psi/div.	Wgt. Per Delay: 48.8 lb
○ Transverse: 0.66 in/s @ 83.4 Hz	15.6 ms	Seismic Scale: 4.0 in/s/div.	Distance: 20.00 ft
○ Vertical: 2.30 in/s @ 39.4 Hz	15.6 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 2.9
○ Air: 136 dB / .01876 psi @ 12.9 Hz	21.5 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 2.49 in/s	15.6 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

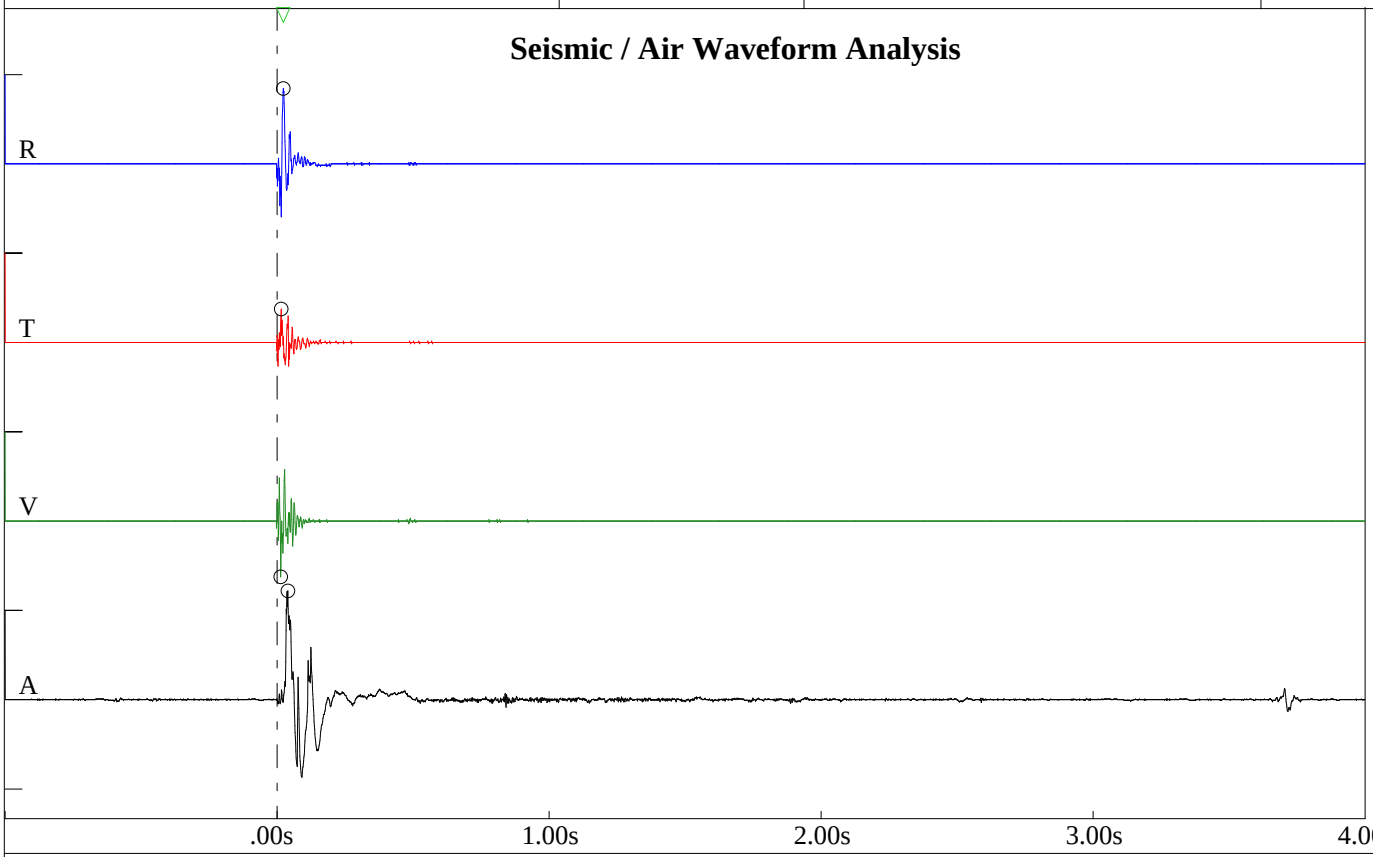
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 1
Location: Lawrenceville, GA
Distance: 40 feet
Monitored By: Sauls Technical Services, Inc.

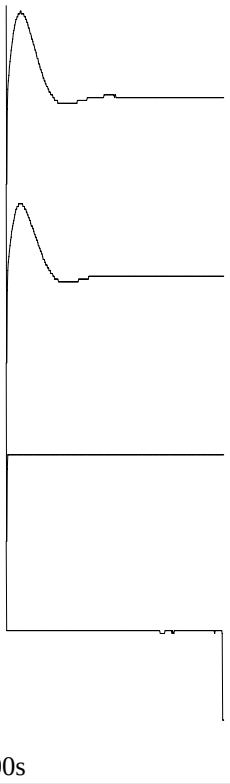
25JUN07 at 14:27:42 Event # 7
Graph: NS5400I-2843
Last Calibration: 14MAY07
Sample Rate:1024/sec
Record Duration: 5 sec

Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.42 in/s @ 37.0 Hz	23.4 ms	Air Scale: .00922 psi/div.	Wgt. Per Delay: 48.8 lb
○ Transverse: 0.20 in/s @ 54.1 Hz	15.6 ms	Seismic Scale: 0.5 in/s/div.	Distance: 40.00 ft
○ Vertical: 0.31 in/s @ 87.1 Hz	13.7 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 5.7
○ Air: 129 dB / .00858 psi @ 12.7 Hz	40.0 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.43 in/s	23.4 ms		

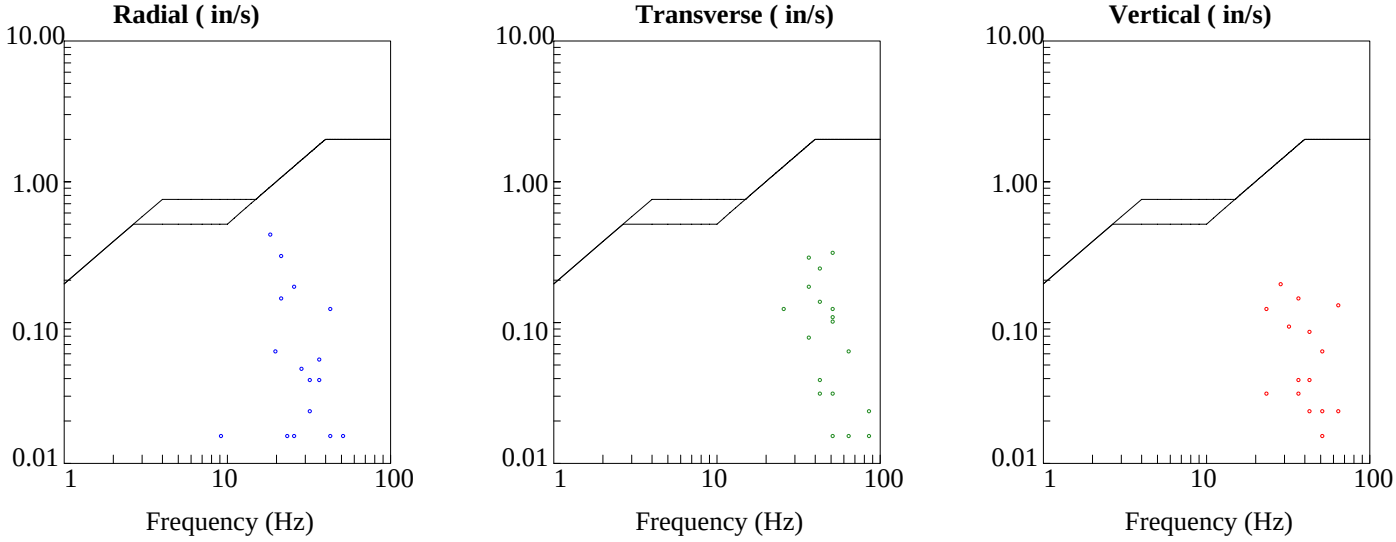
Seismic / Air Waveform Analysis



Calibration



Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

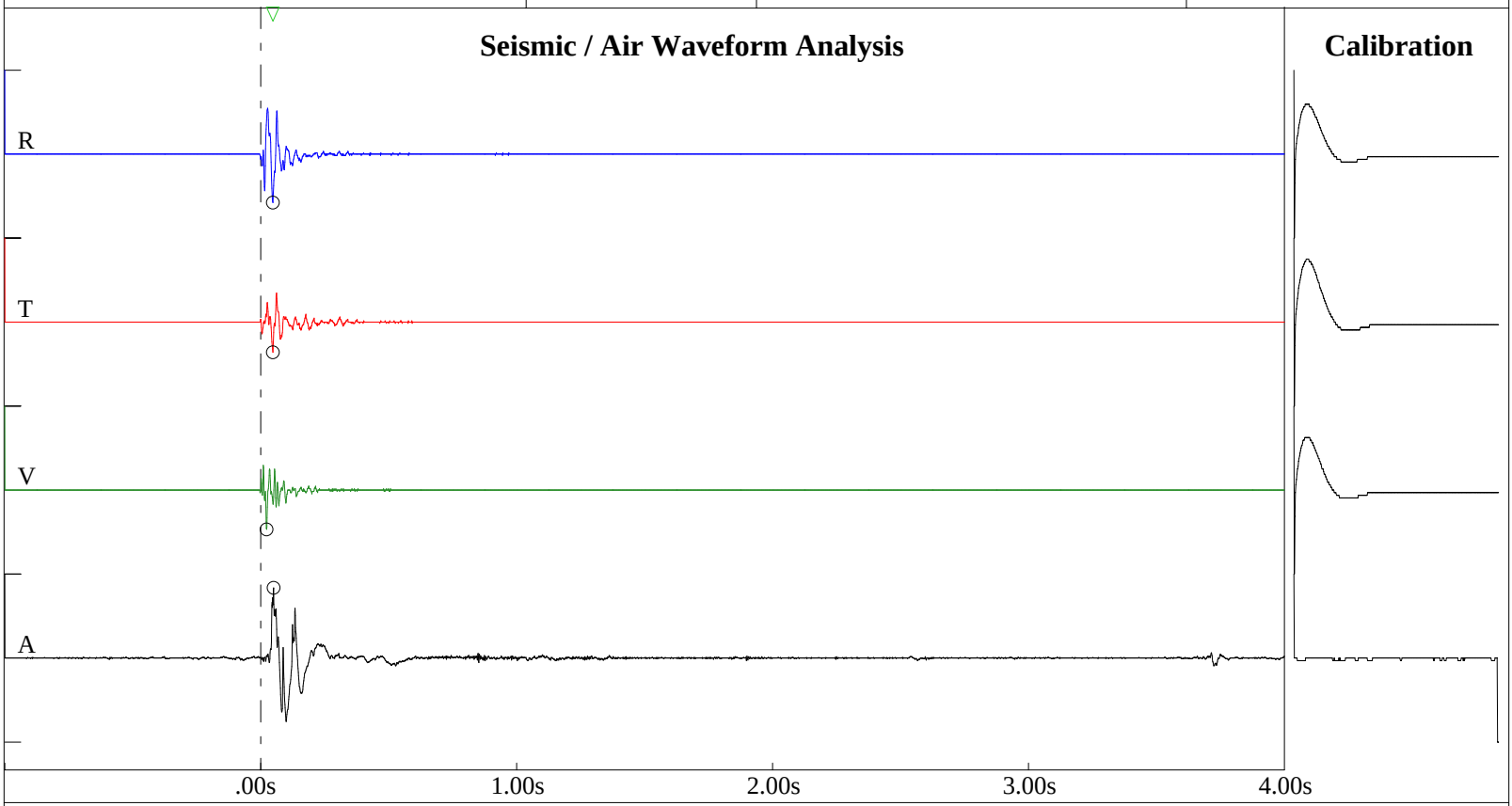
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 1
Location: Lawrenceville, GA
Distance: 60 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:28:37 Event # 81
Graph: NS5400I-2581
Last Calibration: 18OCT06
Sample Rate:1024/sec
Record Duration: 5 sec

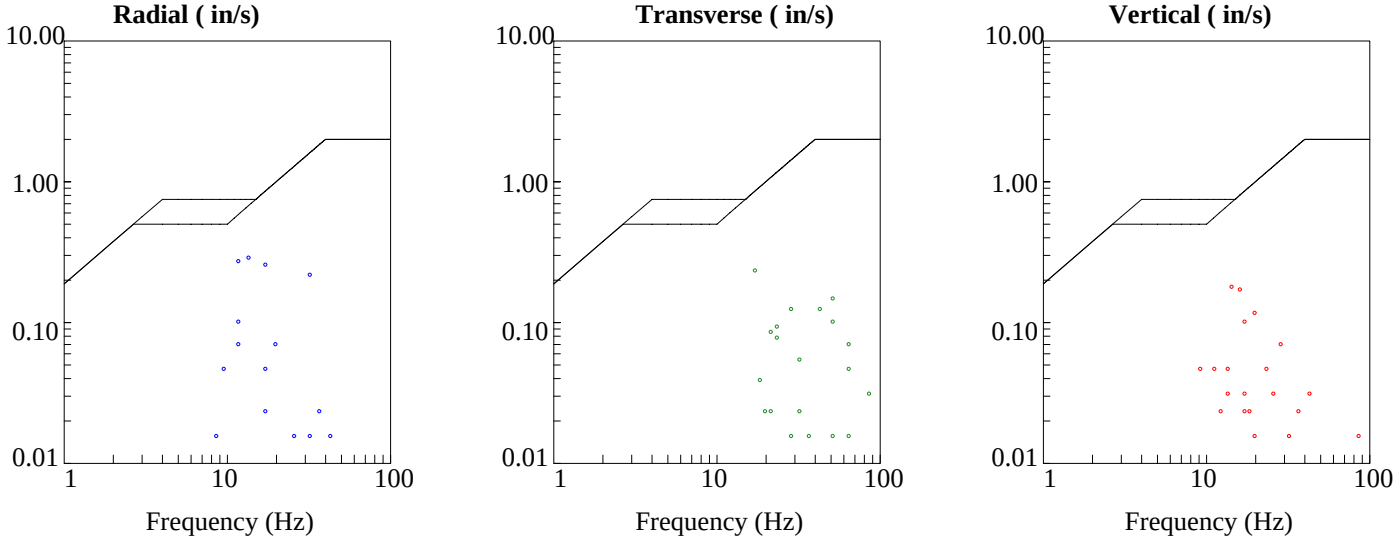
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.30 in/s @ 27.1 Hz	47.9 ms	Air Scale: .00922 psi/div.	Wgt. Per Delay: 48.8 lb
○ Transverse: 0.18 in/s @ 28.3 Hz	47.9 ms	Seismic Scale: 0.5 in/s/div.	Distance: 60.00 ft
○ Vertical: 0.23 in/s @ 32.0 Hz	23.4 ms	Air Trigger (dBL): 120 dBL	Scaled Distance 8.6
○ Air: 126 dB / .006 psi @ 13.7 Hz	50.8 ms	Seismic Trigger: 0.03 in/s	
▽ Vector Sum: 0.35 in/s	47.9 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

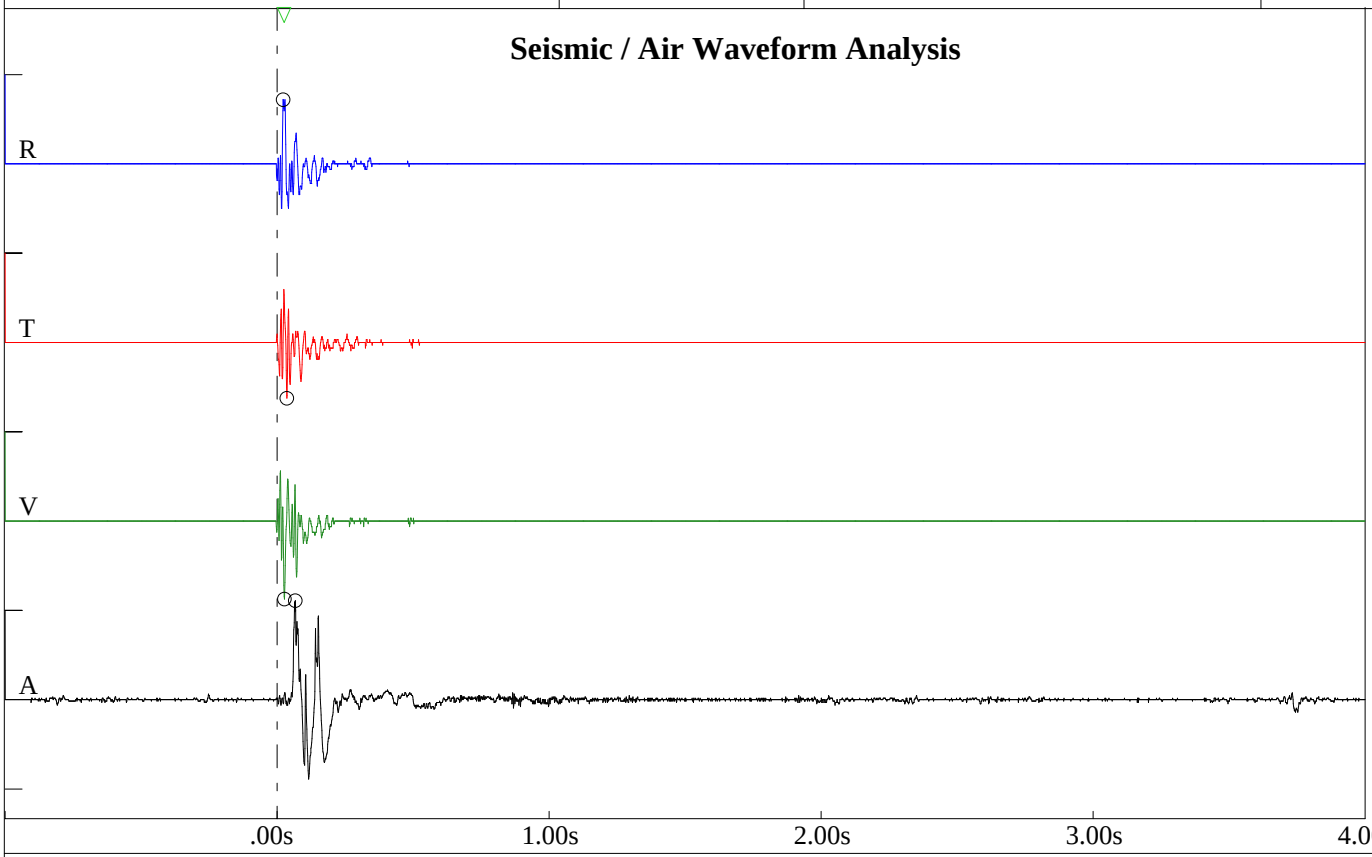
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 1
Location: Lawrenceville, GA
Distance: 80 feet
Monitored By: Sauls Technical Services, Inc.

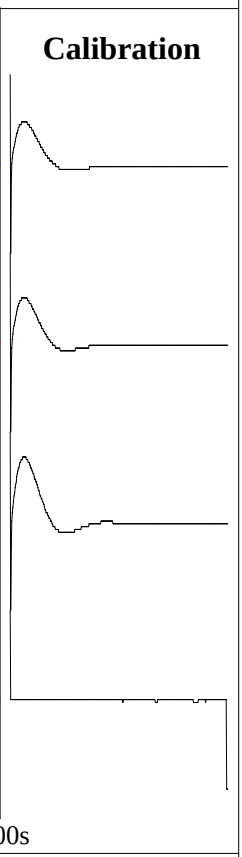
25JUN07 at 14:29:12 Event # 44
Graph: NS5400I-3031
Last Calibration: 16FEB07
Sample Rate:1024/sec
Record Duration: 5 sec

Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.18 in/s @ 37.2 Hz	22.5 ms	Air Scale: .00461 psi/div.	Wgt. Per Delay: 48.8 lb
○ Transverse: 0.16 in/s @ 67.7 Hz	36.1 ms	Seismic Scale: 0.25 in/s/div.	Distance: 80.00 ft
○ Vertical: 0.22 in/s @ 38.6 Hz	27.3 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 11.5
○ Air: 123 dB / .00391 psi @ 12.5 Hz	67.4 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.29 in/s	26.4 ms		

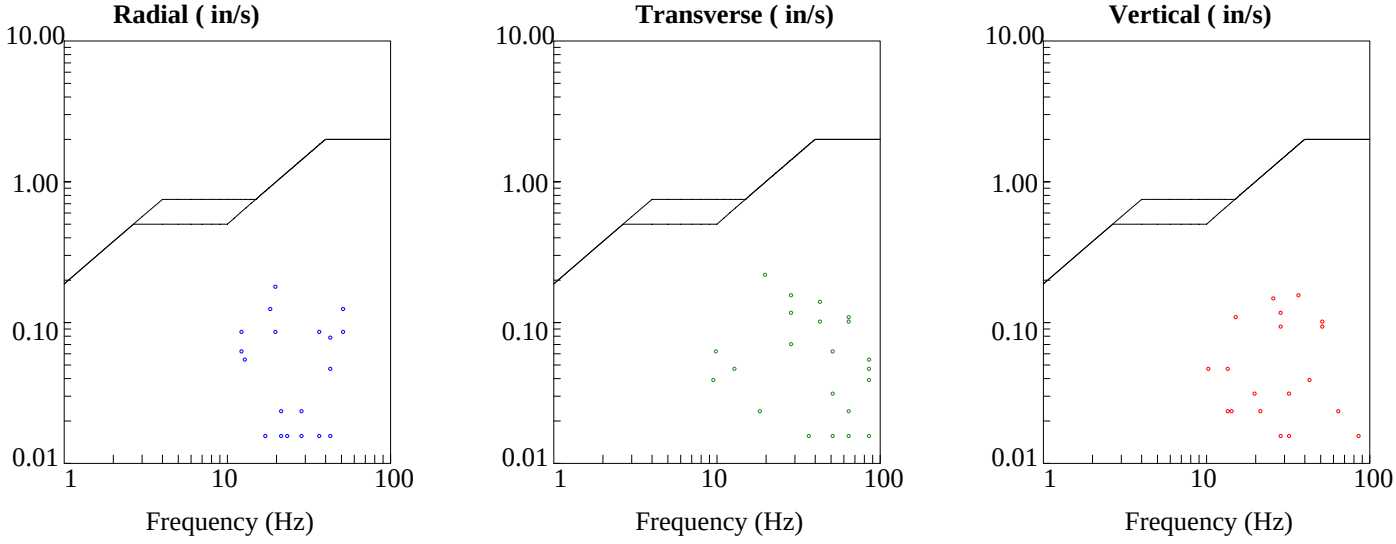
Seismic / Air Waveform Analysis



Calibration



Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

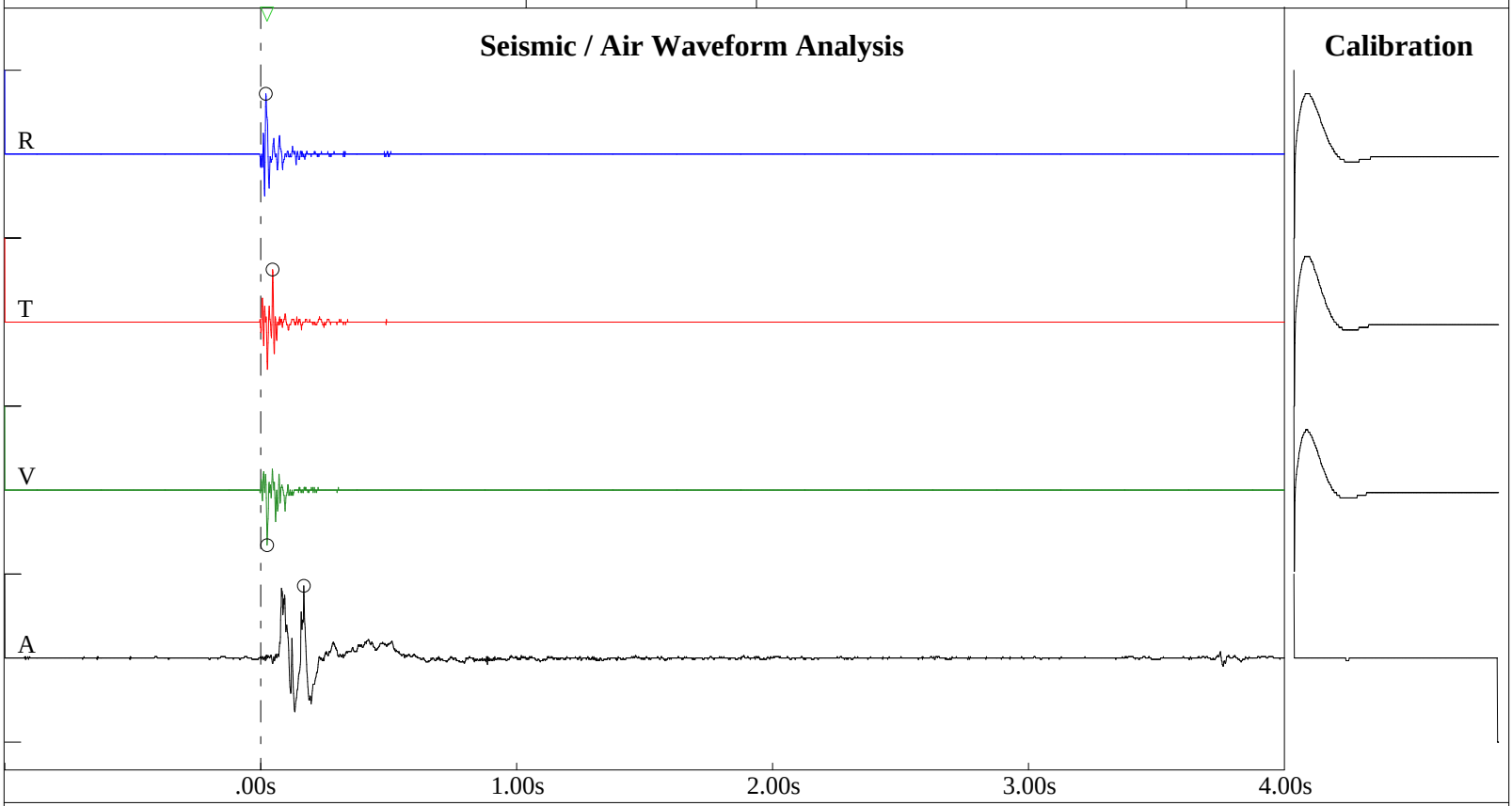
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 1
Location: Lawrenceville, GA
Distance: 100 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:29:15 Event # 16
Graph: NS5400I-2533
Last Calibration: 23APR07
Sample Rate:1024/sec
Record Duration: 5 sec

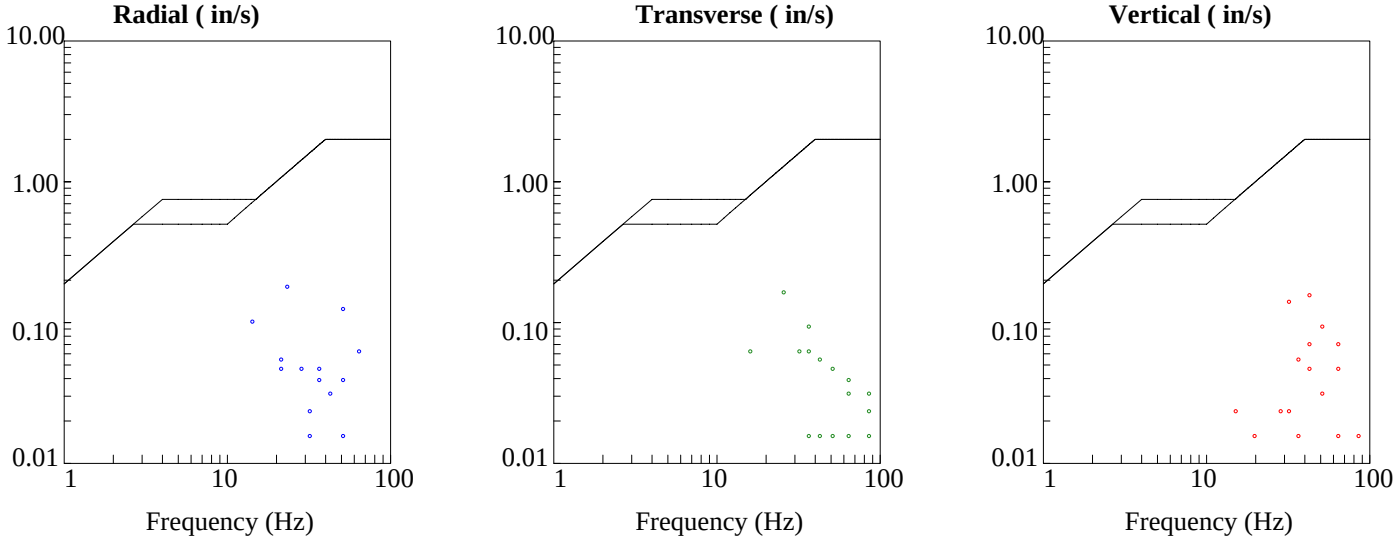
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.18 in/s @ 44.2 Hz	20.5 ms	Air Scale: .00461 psi/div.	Wgt. Per Delay: 48.8 lb
○ Transverse: 0.16 in/s @ 74.6 Hz	46.9 ms	Seismic Scale: 0.25 in/s/div.	Distance: 100.00 ft
○ Vertical: 0.16 in/s @ 51.5 Hz	25.4 ms	Air Trigger (dBL): 120 dBL	Scaled Distance 14.3
○ Air: 120 dB / .00303 psi @ 22.5 Hz	168.9 ms	Seismic Trigger: 0.03 in/s	
▽ Vector Sum: 0.23 in/s	25.4 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

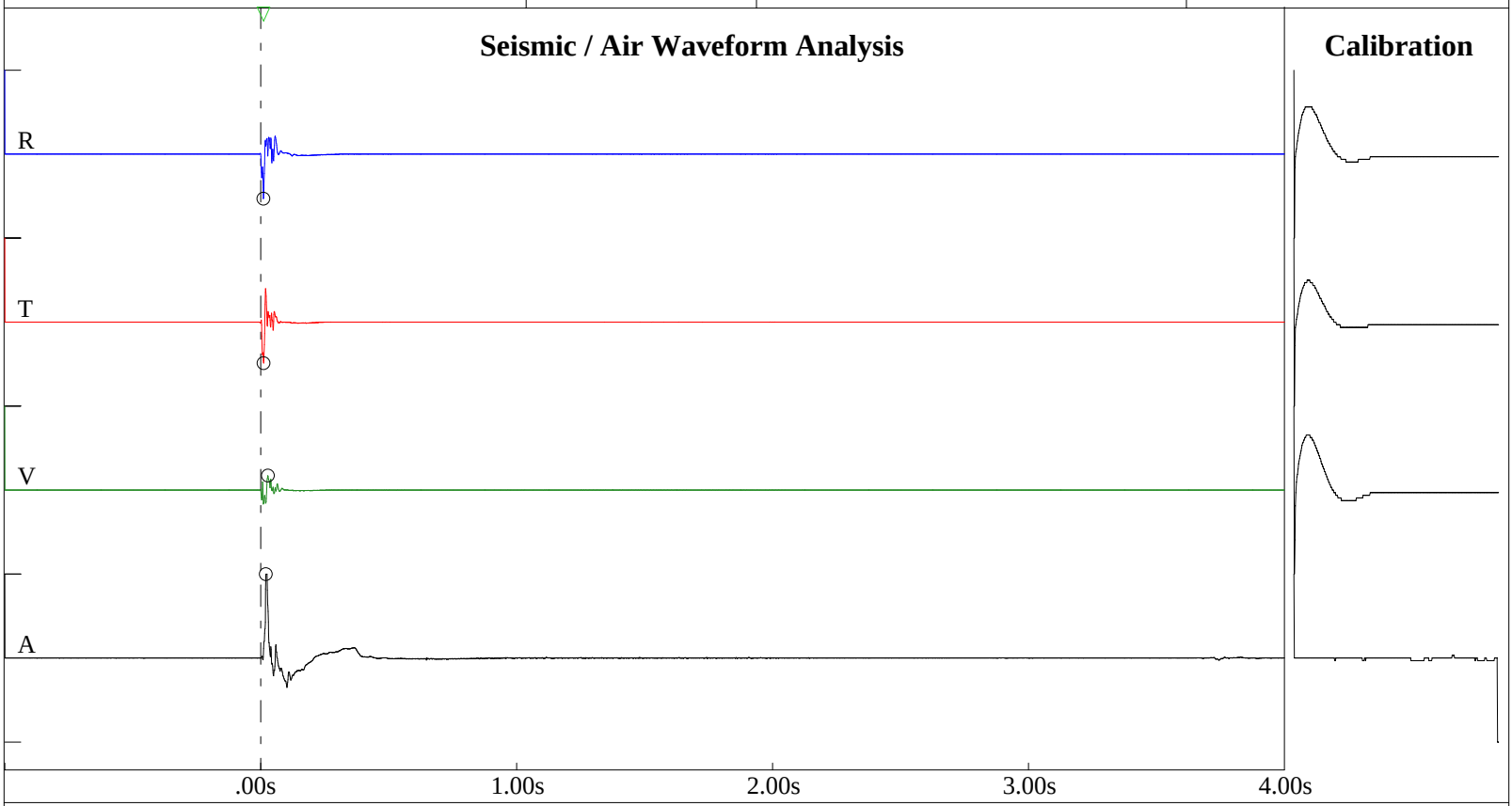
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 2
Location: Lawrenceville, GA
Distance: 20 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:28:39 Event # 17
Graph: NS5400I-2426
Last Calibration: 10NOV06
Sample Rate:1024/sec
Record Duration: 5 sec

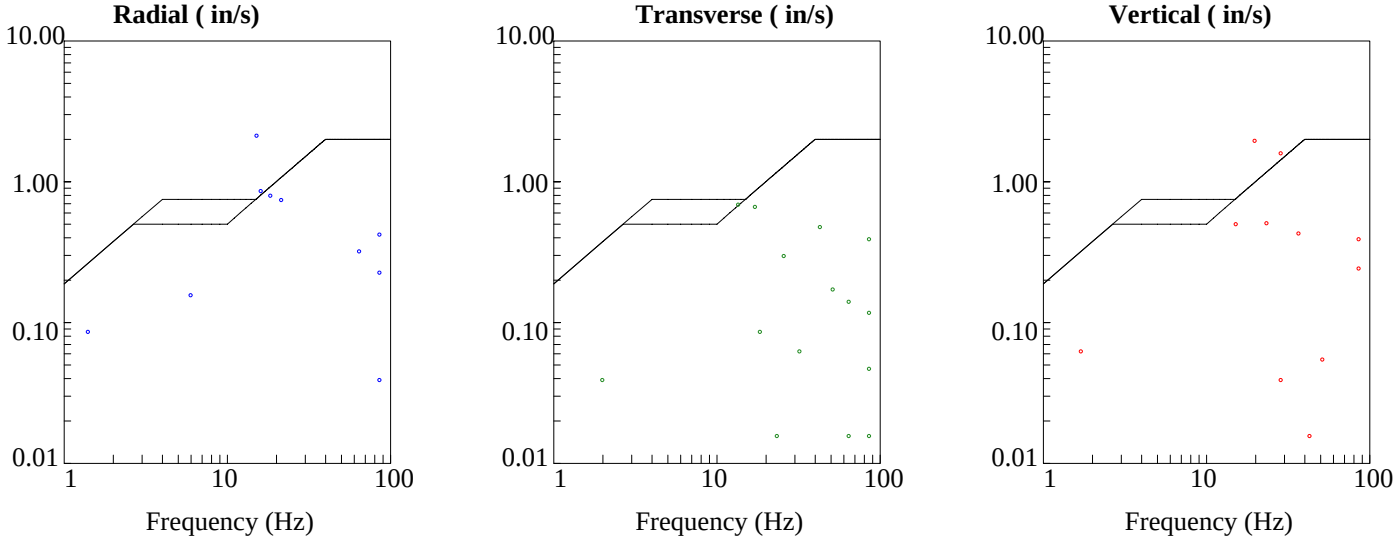
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 2.13 in/s @ 30.2 Hz	10.7 ms	Air Scale: .03686 psi/div.	Wgt. Per Delay: 87 lb
○ Transverse: 1.95 in/s @ 38.2 Hz	11.7 ms	Seismic Scale: 4.0 in/s/div.	Distance: 20.00 ft
○ Vertical: 0.70 in/s @ 26.1 Hz	28.3 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 2.1
○ Air: 140 dB / .02811 psi @ 15.8 Hz	20.5 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 2.92 in/s	11.7 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

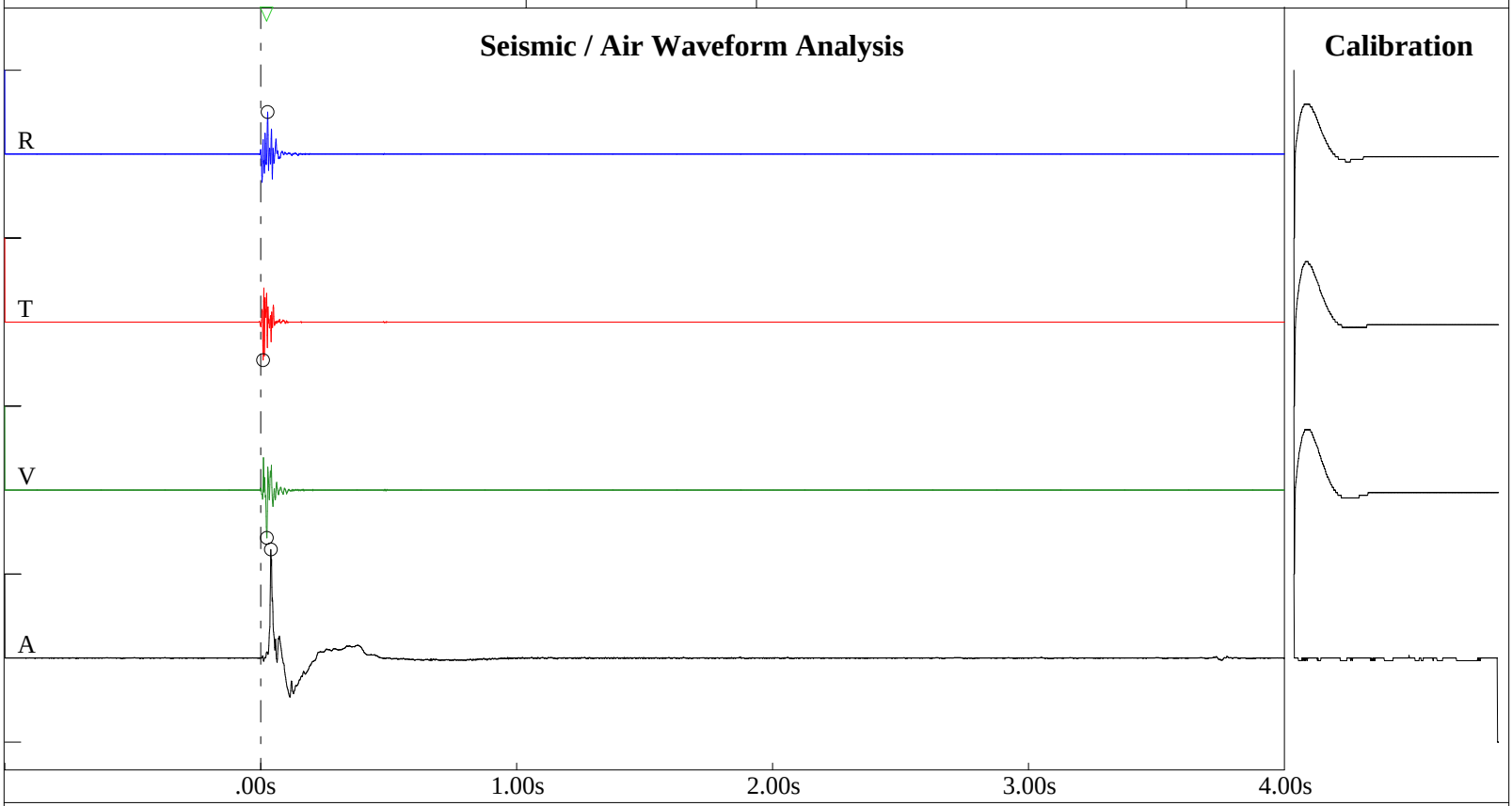
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 2
Location: Lawrenceville, GA
Distance: 40 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:30:34 Event # 17
Graph: NS5400I-2017
Last Calibration: 23APR07
Sample Rate:1024/sec
Record Duration: 5 sec

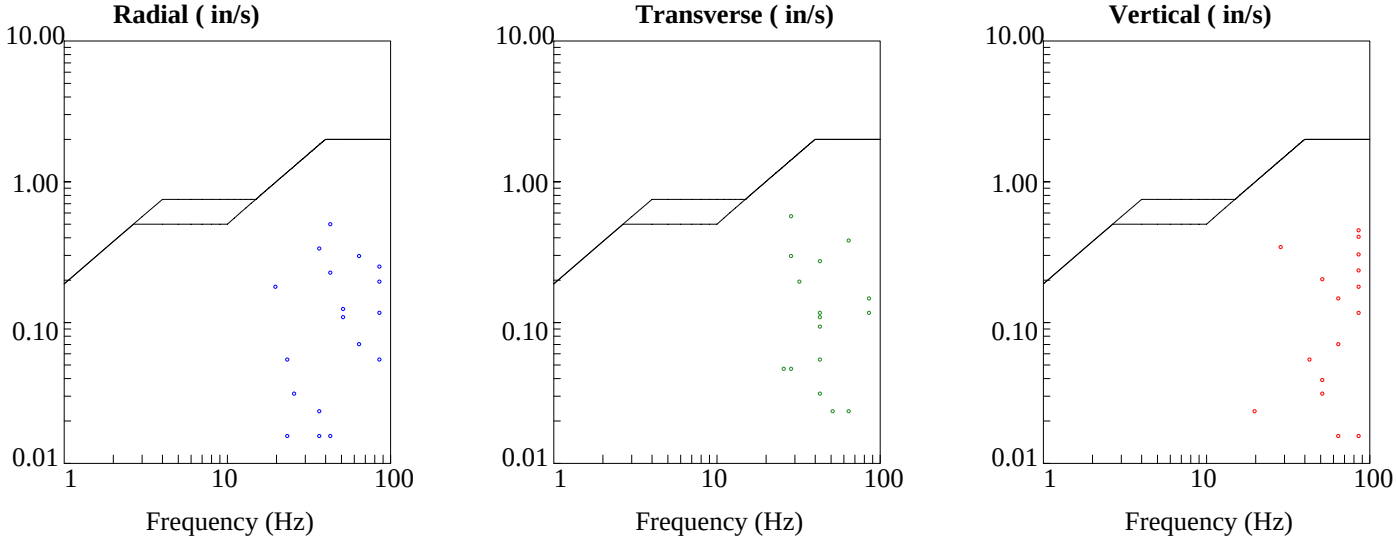
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.50 in/s @ 85.0 Hz	27.3 ms	Air Scale: .01843 psi/div.	Wgt. Per Delay: 87 lb
○ Transverse: 0.45 in/s @ 147.6 Hz	9.8 ms	Seismic Scale: 1.0 in/s/div.	Distance: 40.00 ft
○ Vertical: 0.57 in/s @ 52.8 Hz	24.4 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 4.3
○ Air: 136 dB / .01821 psi @ 11.2 Hz	40.0 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.63 in/s	23.4 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

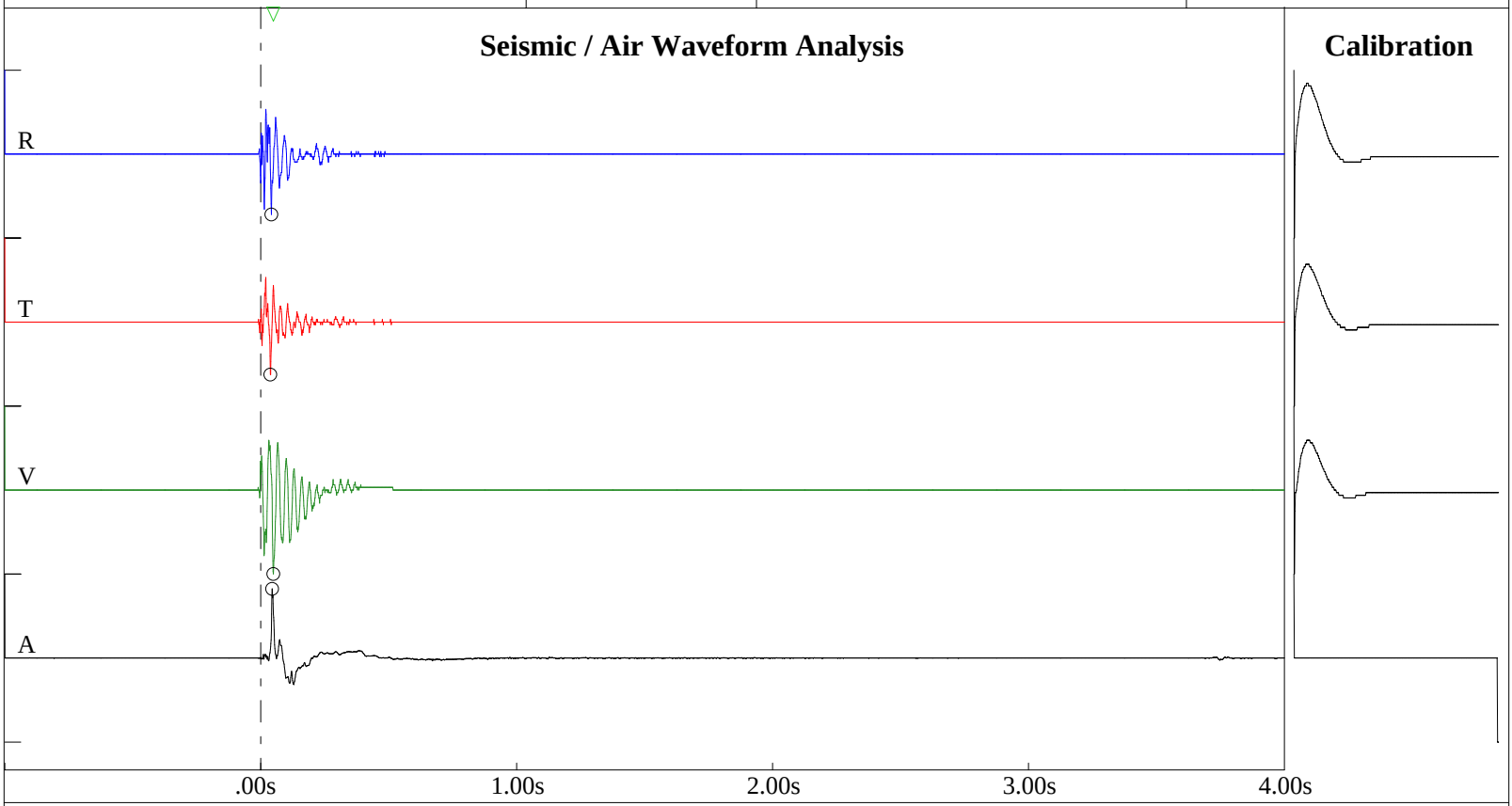
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 2
Location: Lawrenceville, GA
Distance: 60 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:29:46 Event # 22
Graph: NS5400I-2416
Last Calibration: 12APR07
Sample Rate:1024/sec
Record Duration: 5 sec

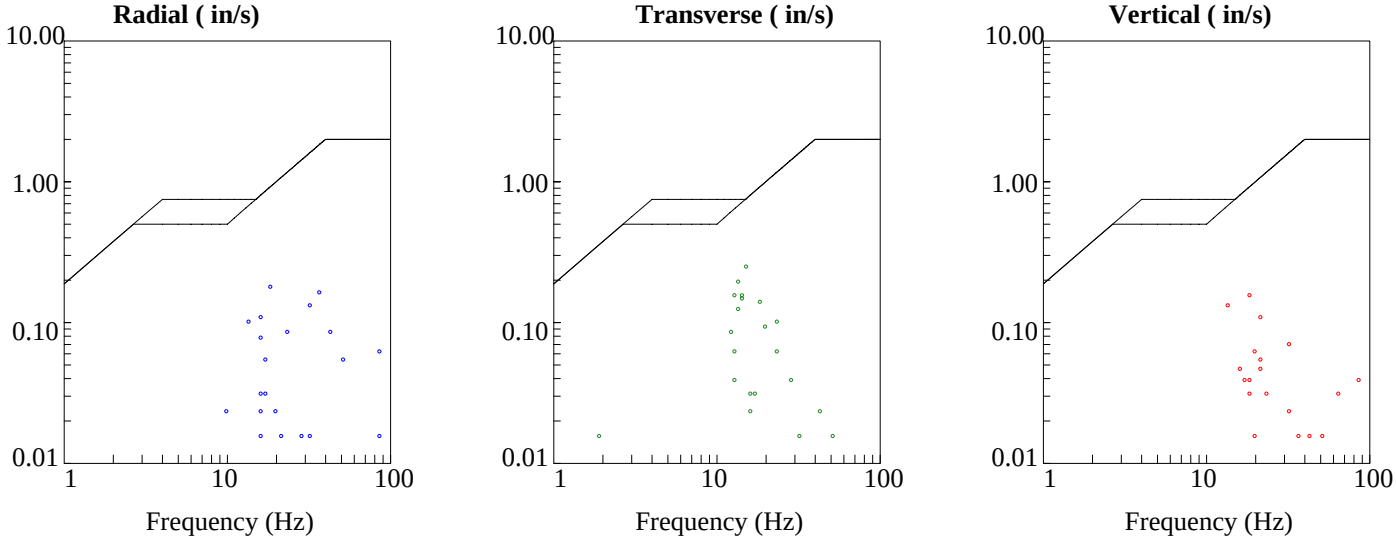
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.18 in/s @ 36.6 Hz	42.0 ms	Air Scale: .01843 psi/div.	Wgt. Per Delay: 87 lb
○ Transverse: 0.16 in/s @ 34.1 Hz	38.1 ms	Seismic Scale: 0.25 in/s/div.	Distance: 60.00 ft
○ Vertical: 0.25 in/s @ 30.5 Hz	49.8 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 6.4
○ Air: 132 dB / .01161 psi @ 18.2 Hz	44.9 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.28 in/s	49.8 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

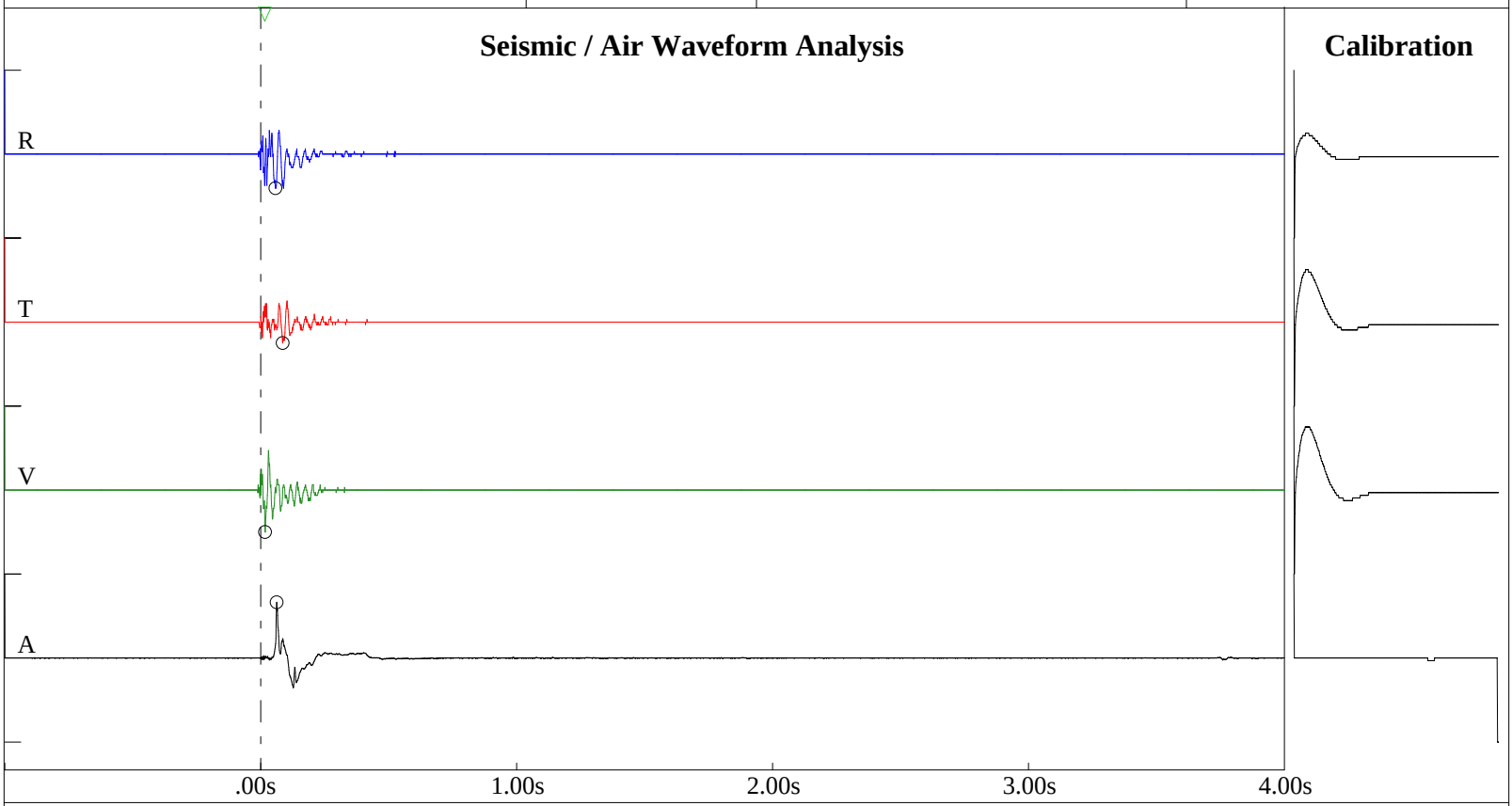
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 2
Location: Lawrenceville, GA
Distance: 80 feet
Monitored By: Sauls Technical Services, Inc.

25JUN07 at 14:30:23 Event # 88
Graph: NS5400I-2115
Last Calibration: 22AUG06
Sample Rate:1024/sec
Record Duration: 5 sec

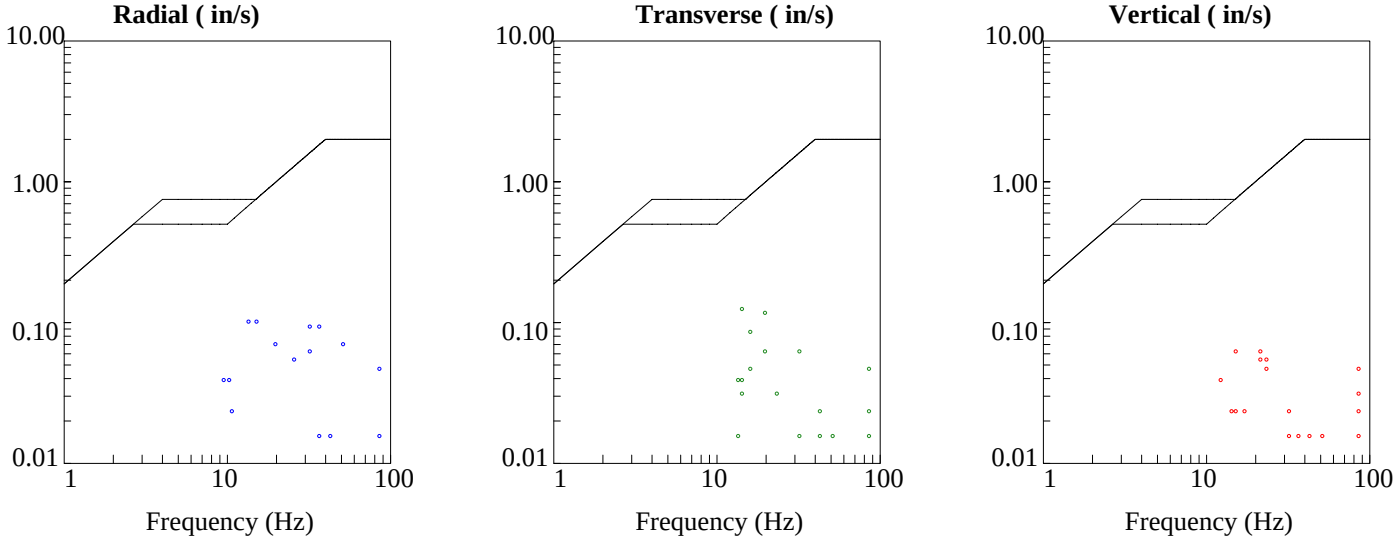
Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.10 in/s @ 25.6 Hz	57.6 ms	Air Scale: .01843 psi/div.	Wgt. Per Delay: 87 lb
○ Transverse: 0.06 in/s @ 39.4 Hz	85.9 ms	Seismic Scale: 0.25 in/s/div.	Distance: 80.00 ft
○ Vertical: 0.13 in/s @ 27.5 Hz	17.6 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 8.6
○ Air: 130 dB / .00935 psi @ 8.5 Hz	62.5 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.14 in/s	16.6 ms		

Seismic / Air Waveform Analysis



Calibration

Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)



NOMIS Seismographs - Report

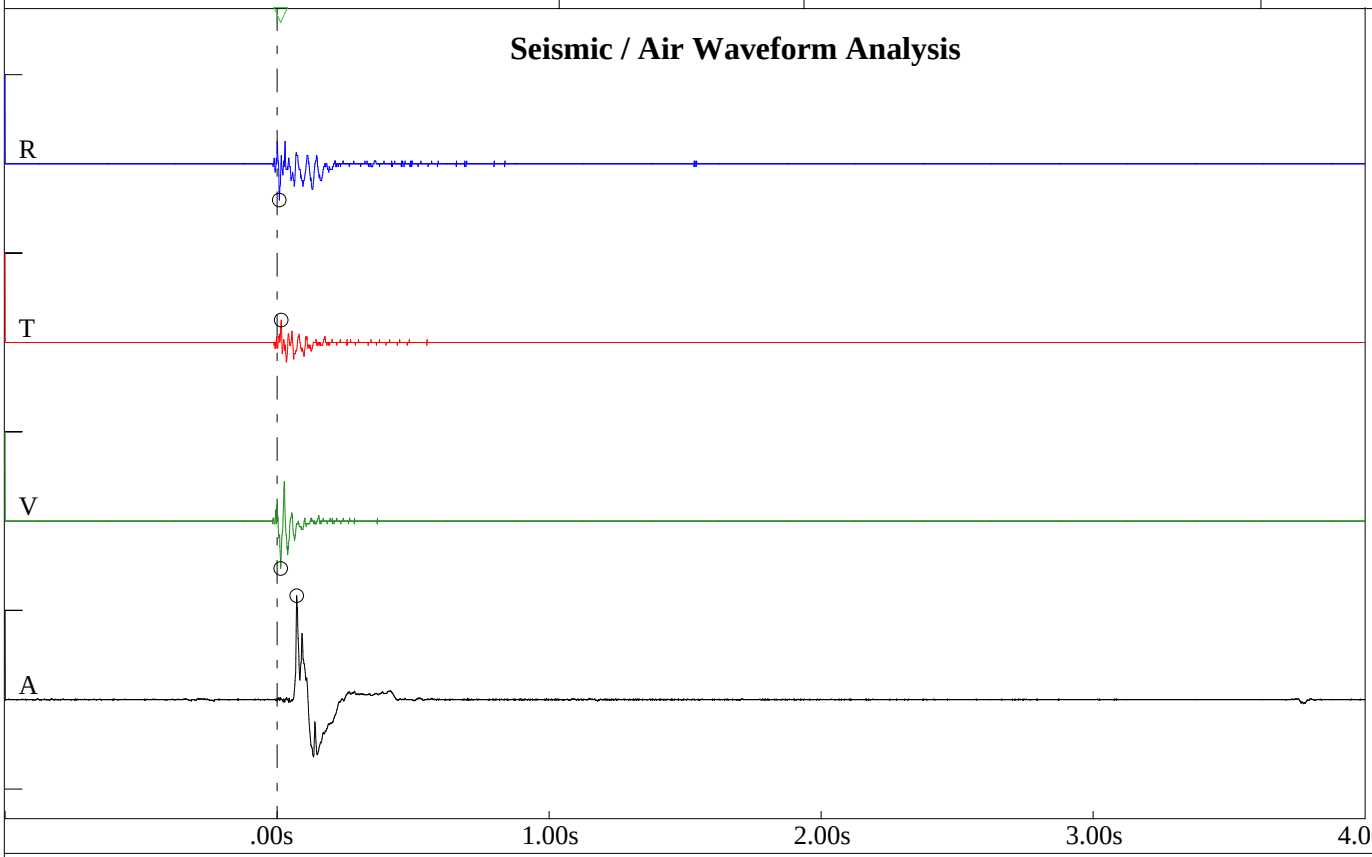
Telephone: (205)592-2488 x 22

Project: NONEX TEST SHOT 2
Location: Lawrenceville, GA
Distance: 100 feet
Monitored By: Sauls Technical Services, Inc.

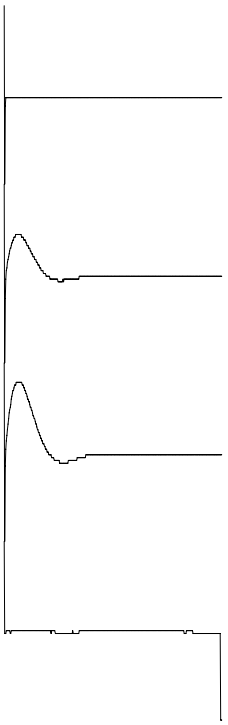
25JUN07 at 14:28:00 Event # 6
Graph: NS5400I-2651
Last Calibration: 17MAY07
Sample Rate:1024/sec
Record Duration: 5 sec

Amplitudes / Frequencies	Trigger >>> Peak	Scales / Triggers	Charge / Distance
○ Radial: 0.10 in/s @ 57.0 Hz	8.8 ms	Air Scale: .00922 psi/div.	Wgt. Per Delay: 87 lb
○ Transverse: 0.06 in/s @ 68.3 Hz	15.6 ms	Seismic Scale: 0.25 in/s/div.	Distance: 100.00 ft
○ Vertical: 0.13 in/s @ 28.0 Hz	13.7 ms	Air Trigger (dBL): 125 dBL	Scaled Distance 10.7
○ Air: 129 dB / .0082 psi @ 9.2 Hz	72.3 ms	Seismic Trigger: 0.05 in/s	
▽ Vector Sum: 0.14 in/s	13.7 ms		

Seismic / Air Waveform Analysis



Calibration



Frequency vs. Amplitude Plot - USBM Limits (RI 8507, 1980)