UNDERSTANDING THE VIBRATION MEASUREMENT

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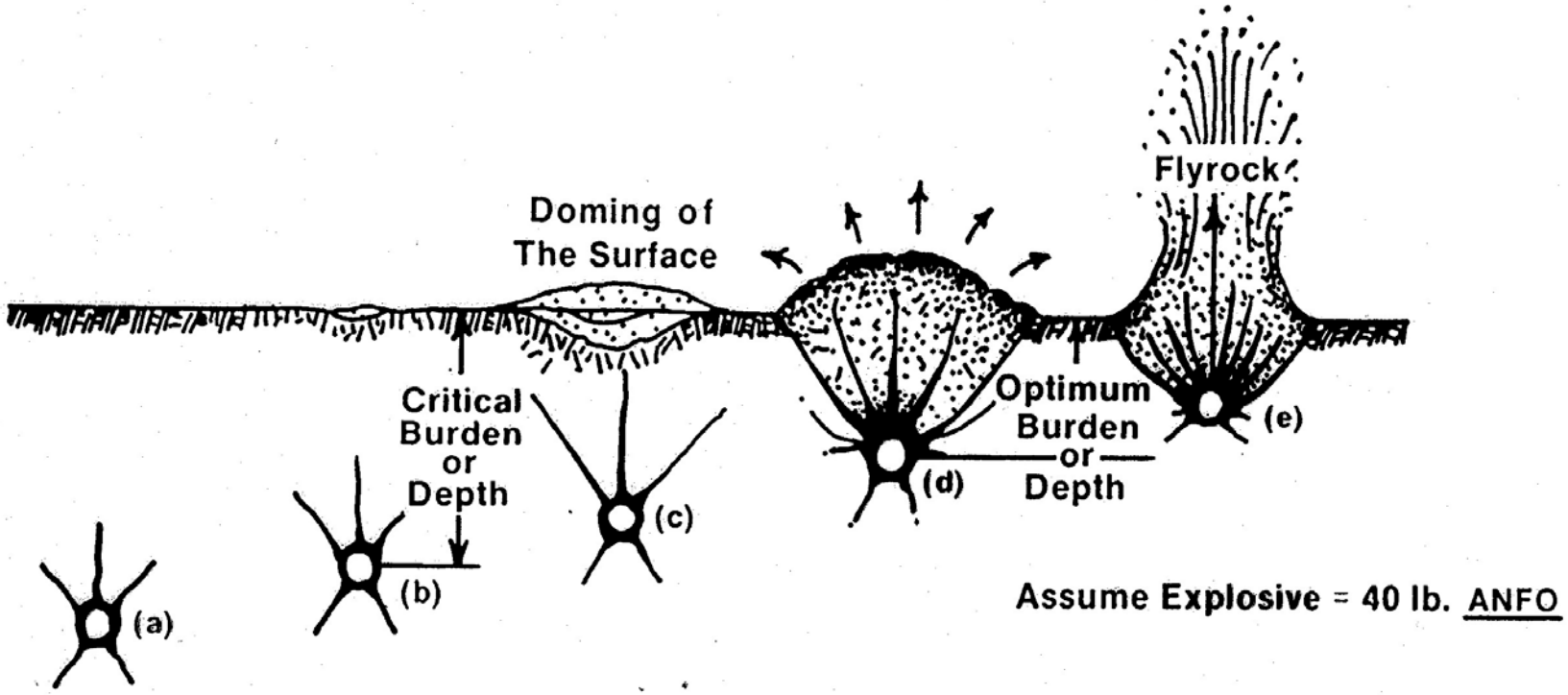
Confinement



(a) B = 15′

Completely contained, only failure is pulverisation near the charge and radial tensile failure running out from it.

(b) B = 12′

Start of surface failure. Burden not broken. Some doming of the surface.

(c) B = 9′

Surface and subsurface failure almost meet. There will be a shelf of unbroken rock between the two. Doming or surface bulging.

(d) B = 6′

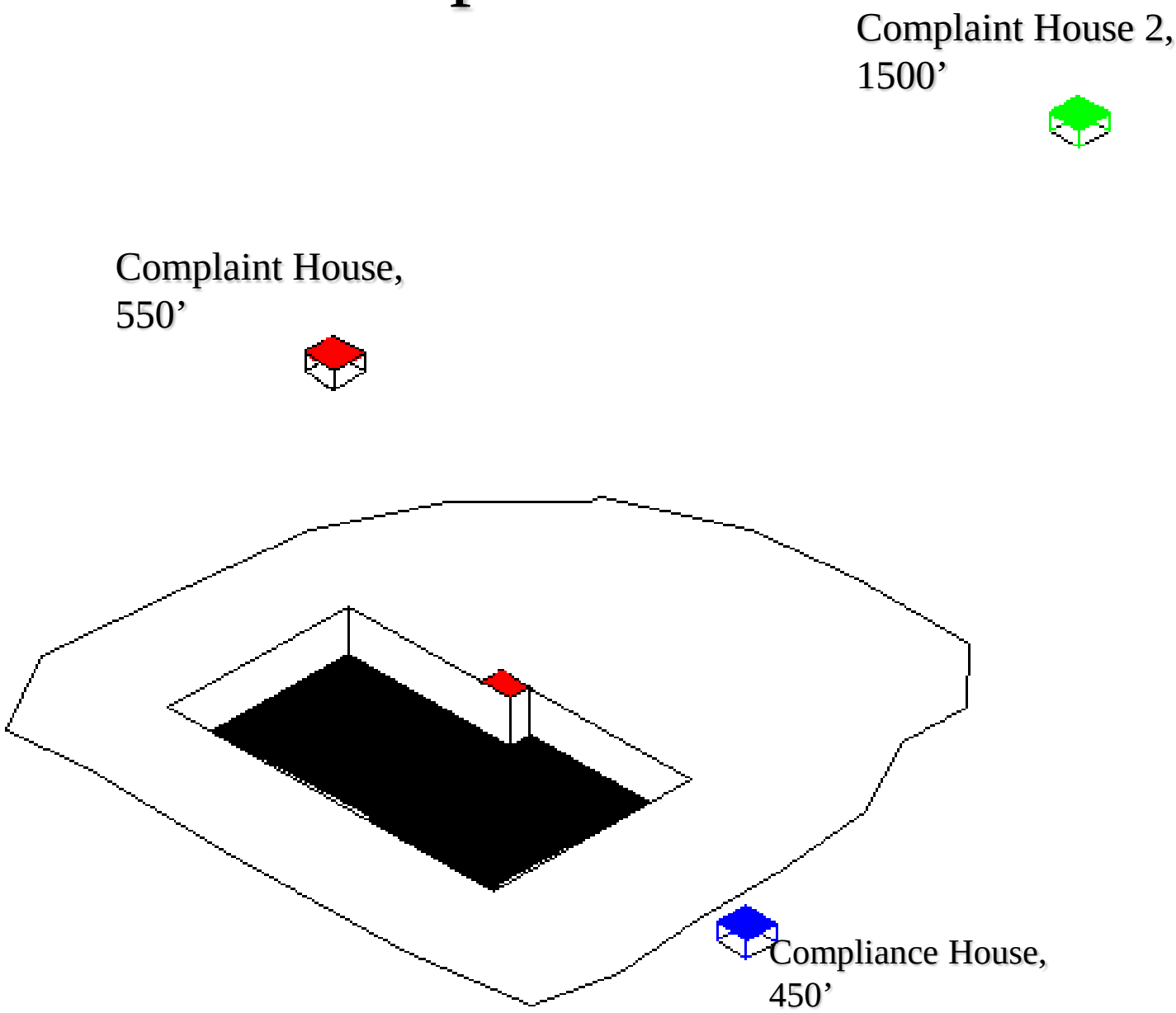
Full crater, burden completely broken out. Surface and subsurface failures run through to the surface.

(e) B = 3′

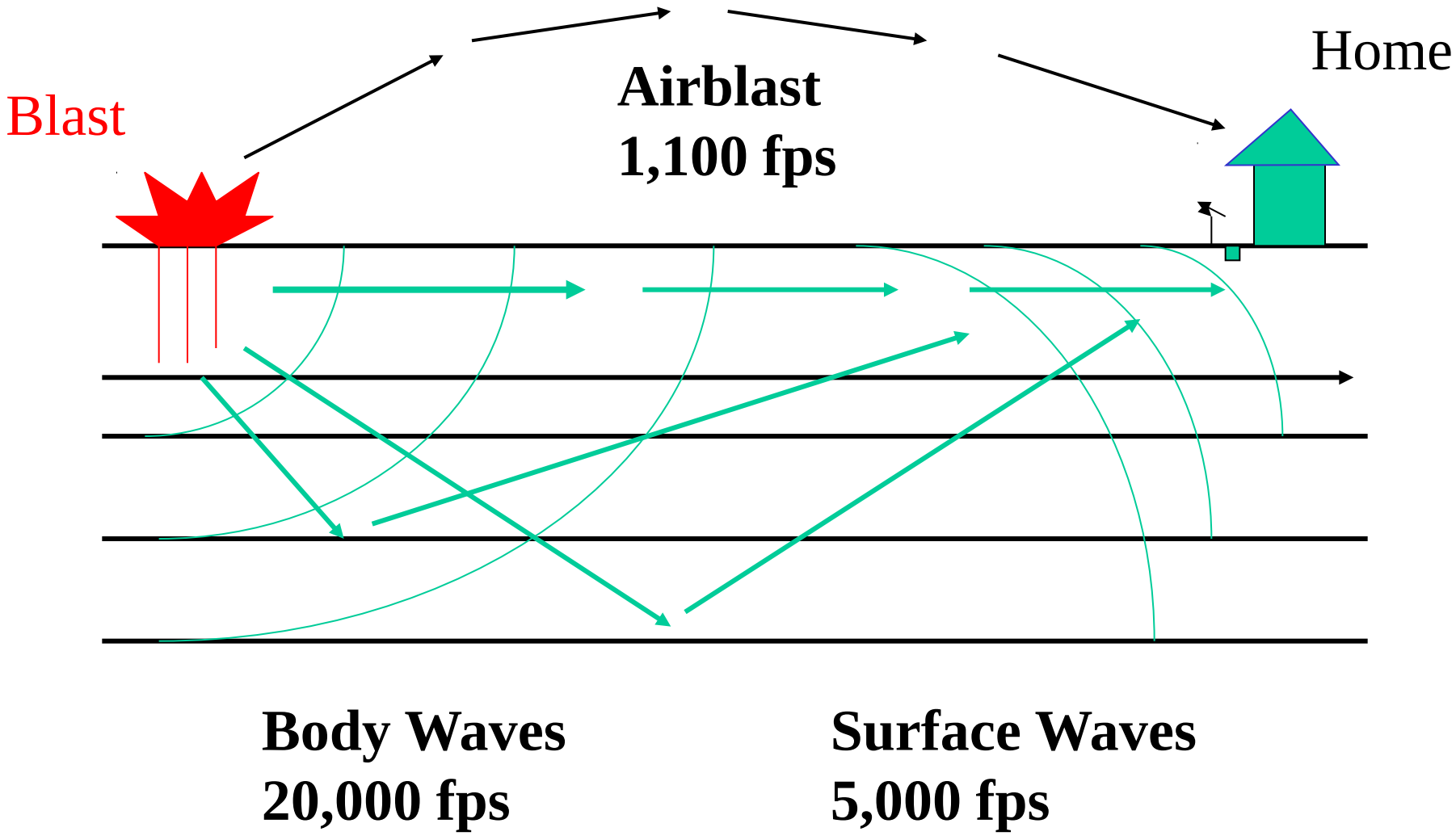
Full crater, lower volume than optimum fine fragmentation. Noise, flyrock, bowl shaped crater.

Figure 7.17. Schematic of the Effect of Decreasing the Burden on Charges Fired in Rock.

Spatial Relationships



Vibration Energy



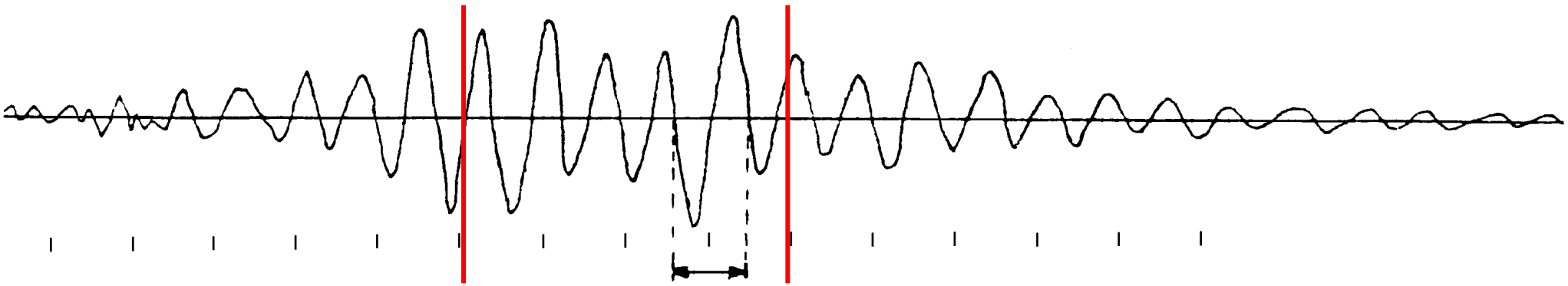
GV-BLAST TIME HISTORY RECORD EXAMPLE

BLASTING TIME HISTORY

Amplitude versus time.
For this record, it is particle velocity amplitude. Vibration records could also be acceleration or displacement time histories depending on the devices used to measure the motion.

Period (T) is the time in seconds for one complete vibration cycle or "seconds per cycle."

Frequency (f) is 1/T or "cycles per second" also "Hz"



Period (T)

Period (and frequency) can usually be estimated by measuring the time between zero crossings, particularly for a record which has a uniform or one dominant frequency.

In this example, the timing marks represent 0.1 sec (100 ms) and the measured period is about 88 percent of the time between marks

Period (T): 0.88 x 0.1 sec = .088 sec
Frequency (f): 1/.088 = 11.4 Hz

Frequency

- Number of cycles per second
- Measured in Hertz (Hz)

$$\mathbf{f = 1/T}$$

T is the time of one cycle

- Zero-crossing used by seismographs

$$f = 1 / (2t)$$

t is the time of ½ a cycle or where the wave crosses zero

Displacement or Amplitude

- The distance a particle moves (D)
- D measured in inches (in)
- Important for damage assessment

Velocity

- The rate or speed at which a particle moves
- V is in inches per second (in/s)
- For sine waves: **$V = 2 \Pi f D$**
  - f is frequency, Hz
  - Π is 3.14
- Important for compliance

Acceleration

- The rate at which a particle changes speed
- A is in inches per second squared (in/s^2) or gravities (g)
- For sine waves, $\mathbf{A = 2 \Pi f V}$
- Important for coupling

Acceleration

- Acceleration in “g’s” **$A = 2 \Pi f \ V/386$**

Where A = Acceleration

f = frequency

V = velocity

(To express acceleration in “g’s” divide by 386)

Why Use Seismographs?

- *Establish Compliance with Rules*
- *Evaluate Blast Performance*
- *Provide Liability Protection*

** SAFEGUARD SEISMIC UNIT 2000DK **
SN: 2243

DATE: 09/12/95 TIME: 15:18:06
Event: 009 Recording Time: 10
Client: ROBERTSON
Operation: BUCKEYE IND. MINING CO.
SSU Location: ROBERTSON YARD
Distance to blast: 1385
Operator: M.MANN/ODNR
Comments:
Trigger Level: .05 IN/SEC

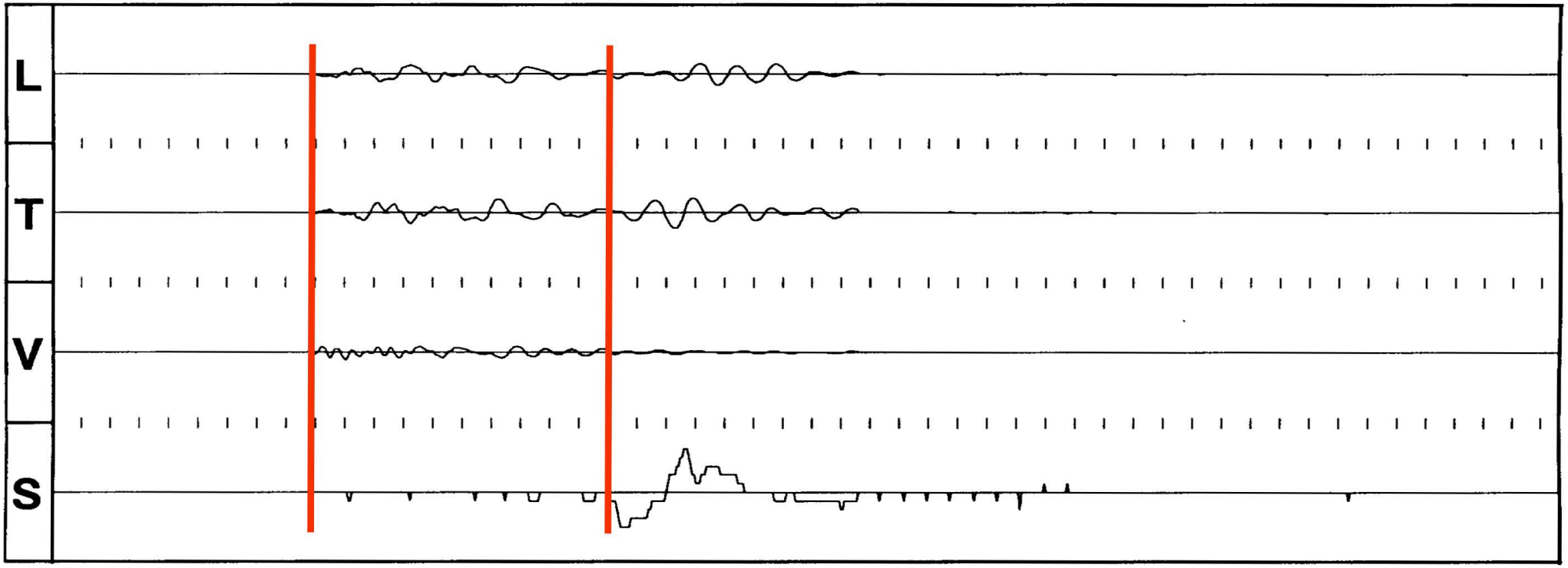
Summary

	L	T	V
PPV (in/sec)	0.10	0.14	0.07
PD (in x.001)	2.39	2.97	1.38
PPA (g)	.02	.02	.02
FREQ (Hz)	8.0	7.6	16.6

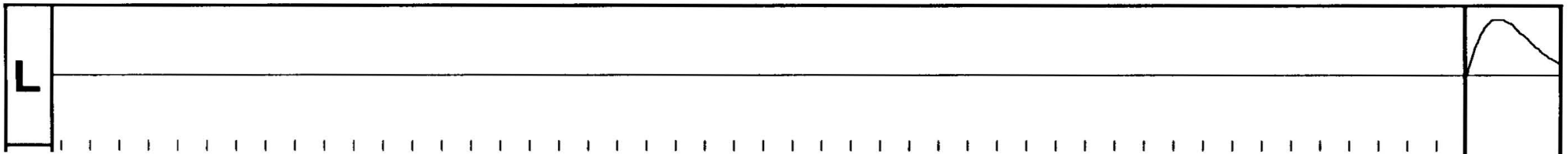
RESULTANT PPV (in/sec): 0.15
PEAK AIR PRESSURE: (dB) 114
(psi) 0.00145

VELOCITY WAVEFORM GRAPH SCALE
TIME = 100 MSEC PER MARK
SEISMIC = +/- .64 IN/SEC
SOUND = +/- 0.00232 PSI

SHAKETABLE CALIBRATED: 06/20/95
By GeoSonics, Inc.
Box 779, Warrendale, PA 15095 U.S.A.
TEL: 412.934.2900 FAX: 412.934.2999



CAL



Blasting Seismographs

- Measure ground velocity time histories
  - Component directions
- Measure airblast time history
  - Measured in pressure (psi)
  - Converted to Decibles (dB)
- Provide Summary information
- Conduct internal operations check

SN: 3210 v2.69

Date:	10/30/2003	Time: 17:11:40	
Event:	9	Record Time: 5.0 s	
Client:	Jimmy Clem		
Operation:	Harrod UG		
Location:			
Distance:	0.		
Operator:	Ralph King DSMRE		
Comment:	distance variable		
Trigger Level:	0.020 in/s		
	133 db		

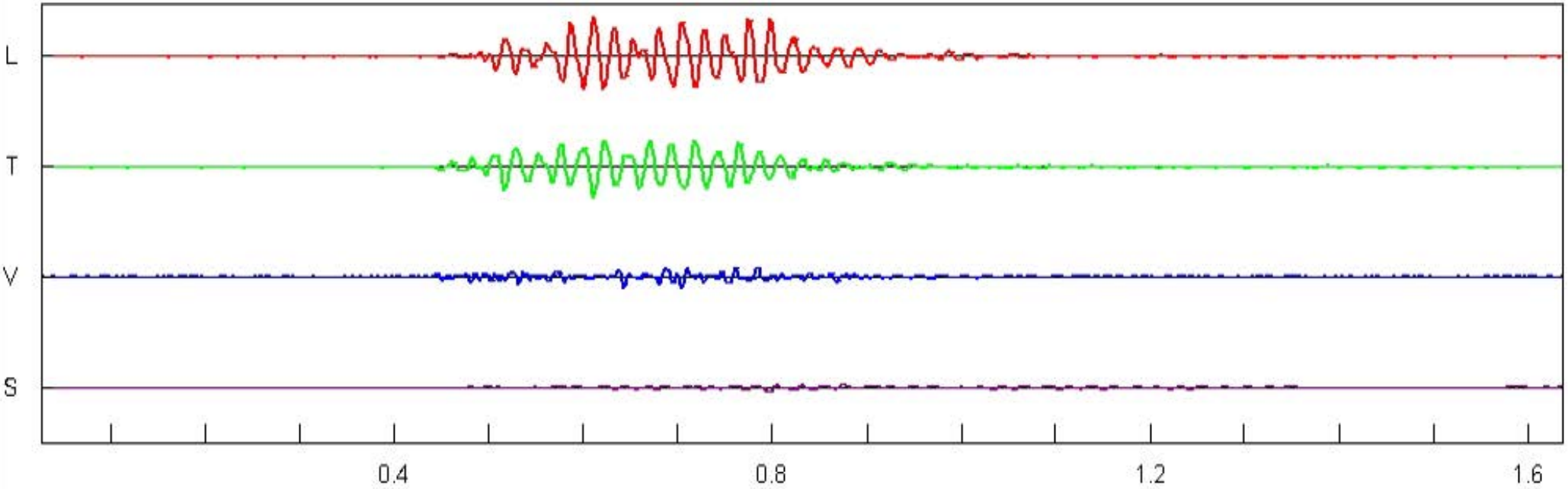
Summary Data

	L	T	V
PPV (in/s)	0.115	0.090	0.030
PD (.001")	0.42	0.32	0.09
PPA (g)	0.098	0.072	0.039
FREQ (Hz)	41.7	45.5	83.3

Resultant PPV: 0.145 in/s

Peak Air Pressure: 89 db

0.0002 psi



Velocity Waveform

Velocity Waveform Graph Scale:

Time = 0.100 s

Seismic = +/- 0.160 in/s

Sound = +/- 0.0023 psi

Recordings are controlled by:

- How the seismograph is made
  - **ISEE Performance Specifications for Blasting Seismographs (2000)**

- How the seismograph is placed in the field
  - **ISEE Field Practice Guidelines for Blasting Seismographs (1999**)

- For specifications on each, go to: **http://www.isee.org/sections/blast.htm**

INDIANA DEPARTMENT OF NATURAL RESOURCES
SOLAR SOURCES INC PRIDES CREEK WEST
BURKHART RESIDENCE

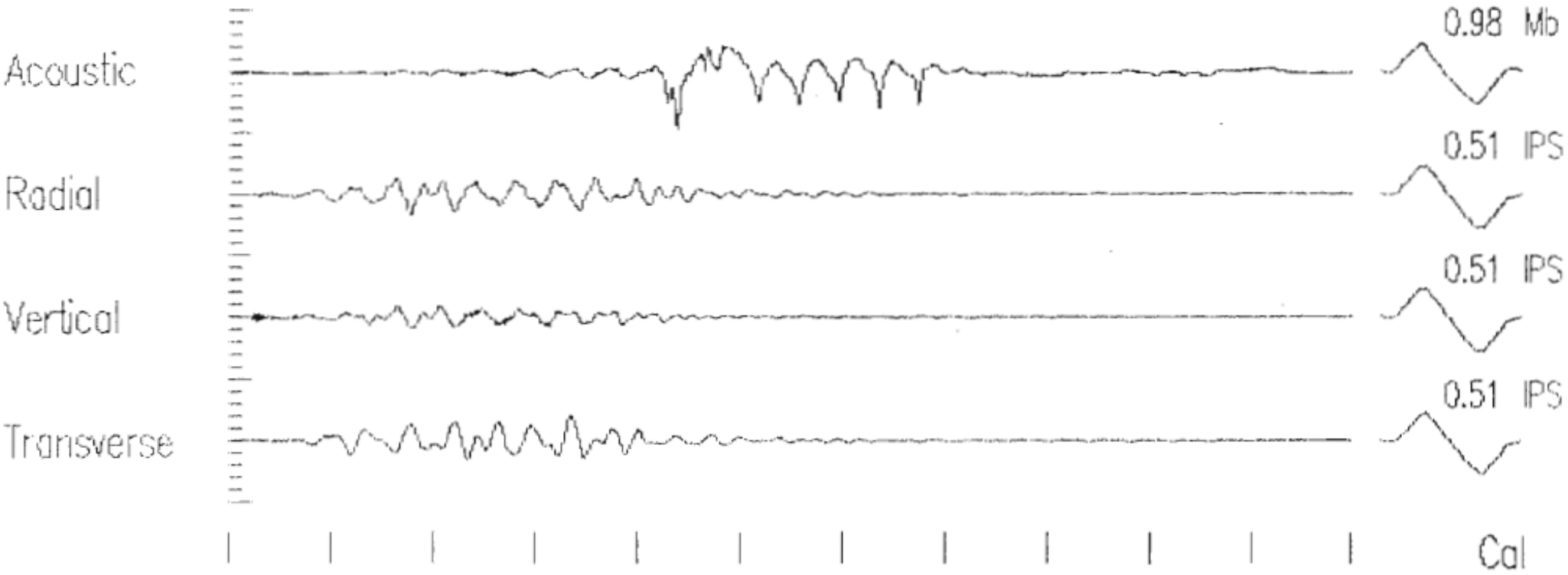
Date: 8/29/91 Time: 16:39 Triggers: 125 dB .1 in/Sec Serial No: 71

Analysis Results

Channel:	Acoustic	Radial	Vertical	Transverse	Vector Sum
Peak Amplitude:	0.48 Mb 128 dB	0.35 In/Sec	0.20 In/Sec	0.41 In/Sec	0.46 In/Sec
Frequency:	3.3 Hz	6.0 Hz	6.5 Hz	7.3 Hz	N/A

Seismogram

Data Scale: Acoustic = 0.10 Mb/Div Seismic =0.20 IPS/Div Time Scale = 0.50 Sec/Div



DATE: 11/09/95 TIME: 05:58:21
Event: 003 Recording Time: 10
Client: ODNR, ROBERTSON
Operation: BUCKEYE IND.
SSU Location: ROBEORTSON SILO TOP
Distance to blast: NA
Operator: KELTSCHLAGER/MMANN
Comments:
Trigger Level: 1.2 IN/SEC 112 (db)

Summary

	L	T	V
PPV (in/sec)	0.43	0.24	0.46
PD (in x.001)	14.42	1.59	4.21
PPA (g)	.2	.42	.45
FREQ (Hz)	4.8	2.3	9.6

RESULTANT PPV (in/sec): 0.48
PEAK AIR PRESSURE: (dB) 124
(psi) 0.00464

VELOCITY WAVEFORM GRAPH SCALE
TIME = 100 MSEC PER MARK
SEISMIC = +/- .64 IN/SEC
SOUND = +/- 0.00928 PSI

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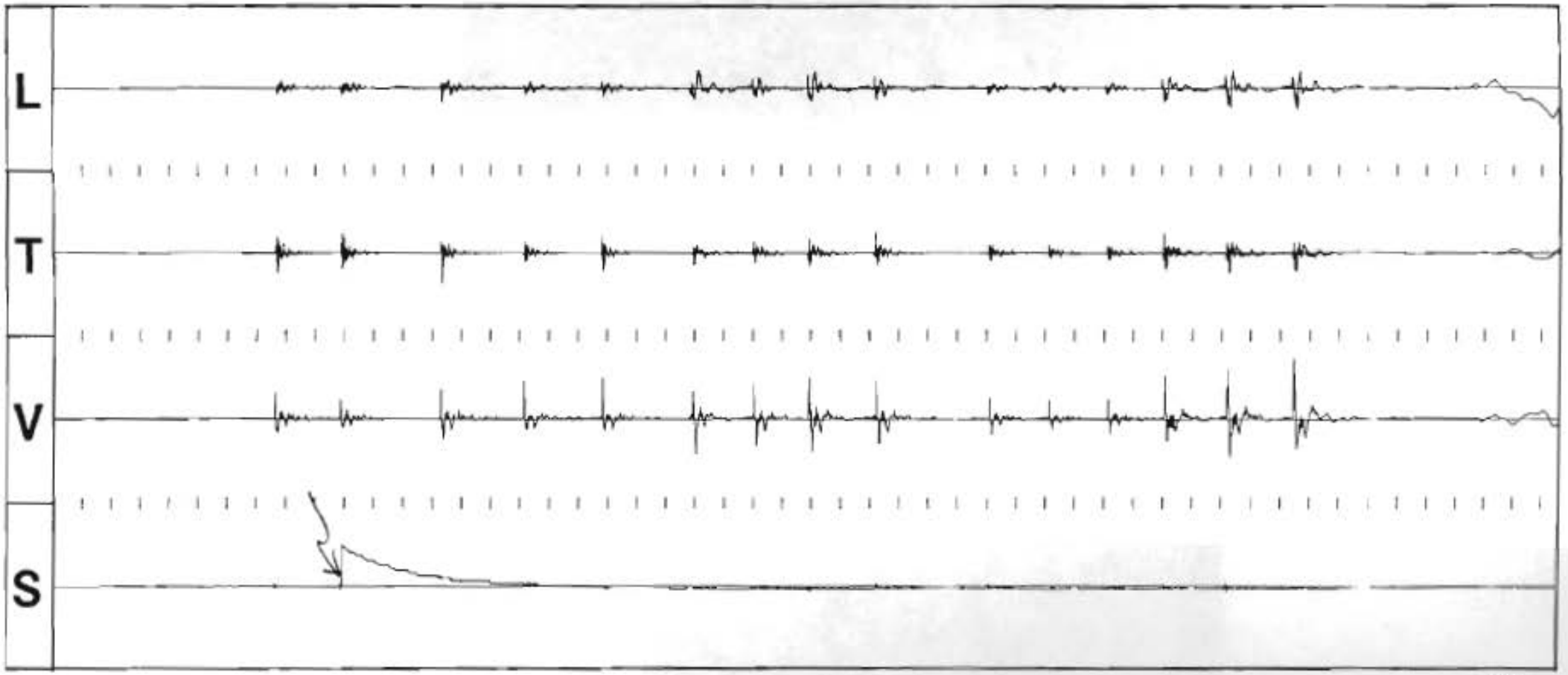
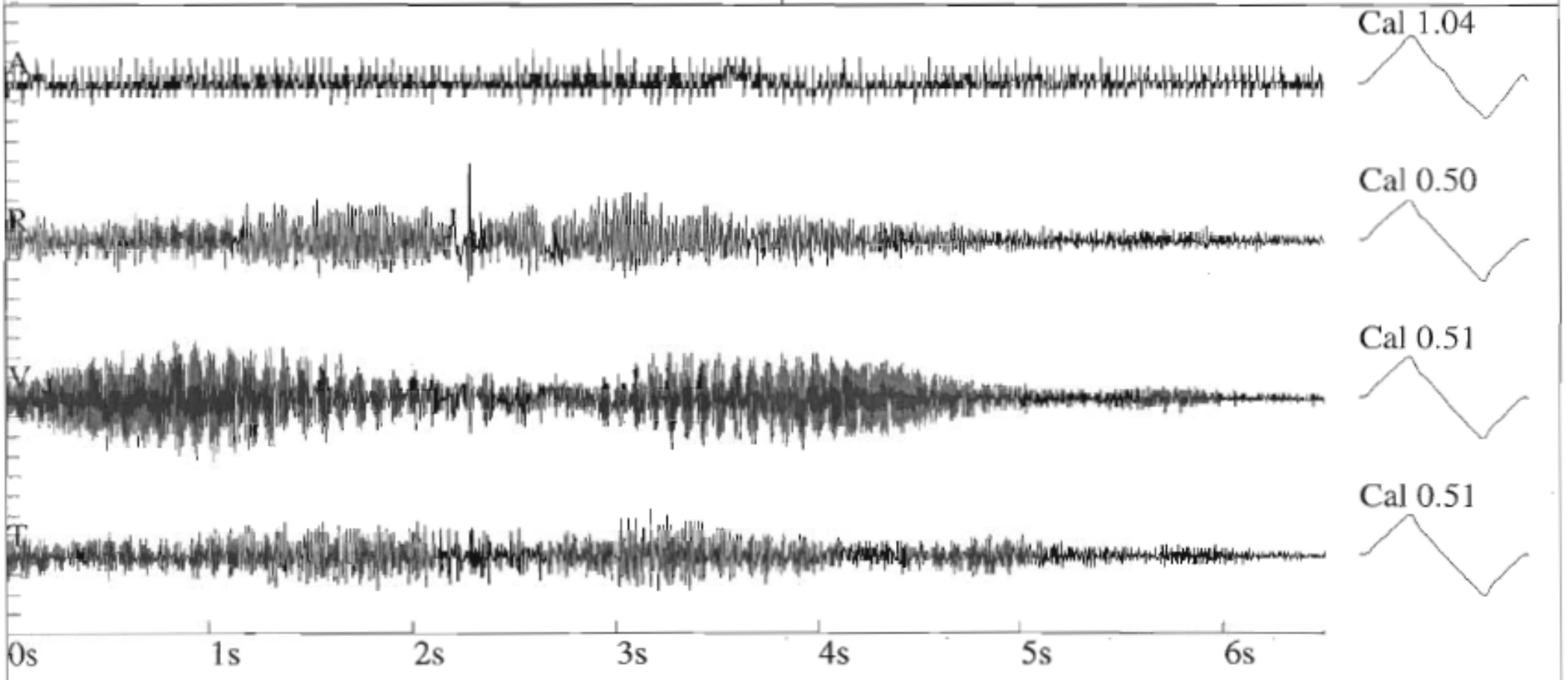


CAL

Event Number: 023 Date: 6/26/1999 Time: 15:11
Acoustic Trigger: 127 dB Seismic Trigger: 0.03 in/s Serial Number: 914

Amplitudes and Frequencies	Graph Information
Acoustic: 112 dB @ 170.6 Hz.	*Duration:* 0.000 sec To: 6.500 sec
Radial: 0.0575 in/s @ 56.8 Hz.	*Acoustic:* 0.20 Mb (0.05 Mb/div)
Vertical: 0.05 in/s @ 128.0 Hz.	*Seismic:* 0.06 in/s (0.015 in/s/div)
Transverse: 0.035 in/s @ 85.3 Hz.	*Time Lines at:* 1.00 sec intervals



Ground Vibrations

Distance	**SD**	**PPV**
< 301	50	1.25
301 – 5000	55	1.00
>5001	65	0.75

-

Blasting Equations

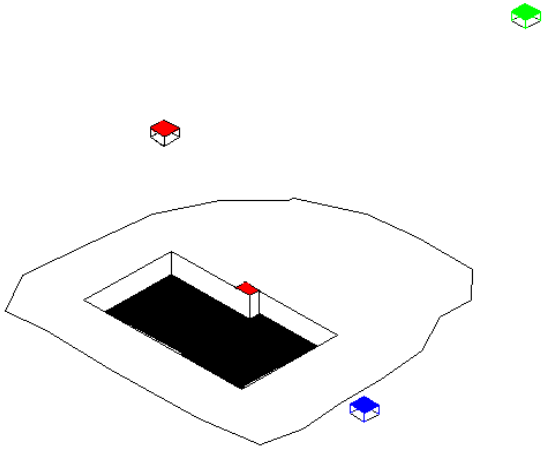
Airblast

2 Hz microphone **133 dB**

All seismographs manufactured today have 2 Hz lower frequency response range.

What are the Most Important Parameters in Evaluating the Adverse Effects?

- Location of the blast
- Location of the compliance house
- Distance between the two
- Charge weight per delay
- Confinement
- Type of blast



Flyrock

- Beyond the permit area
- Beyond the blast area
- > ½ the distance to a house

115' behind Corner 5 @
59 degree bearing

Flyrock landing exactly on top of buried geophone.

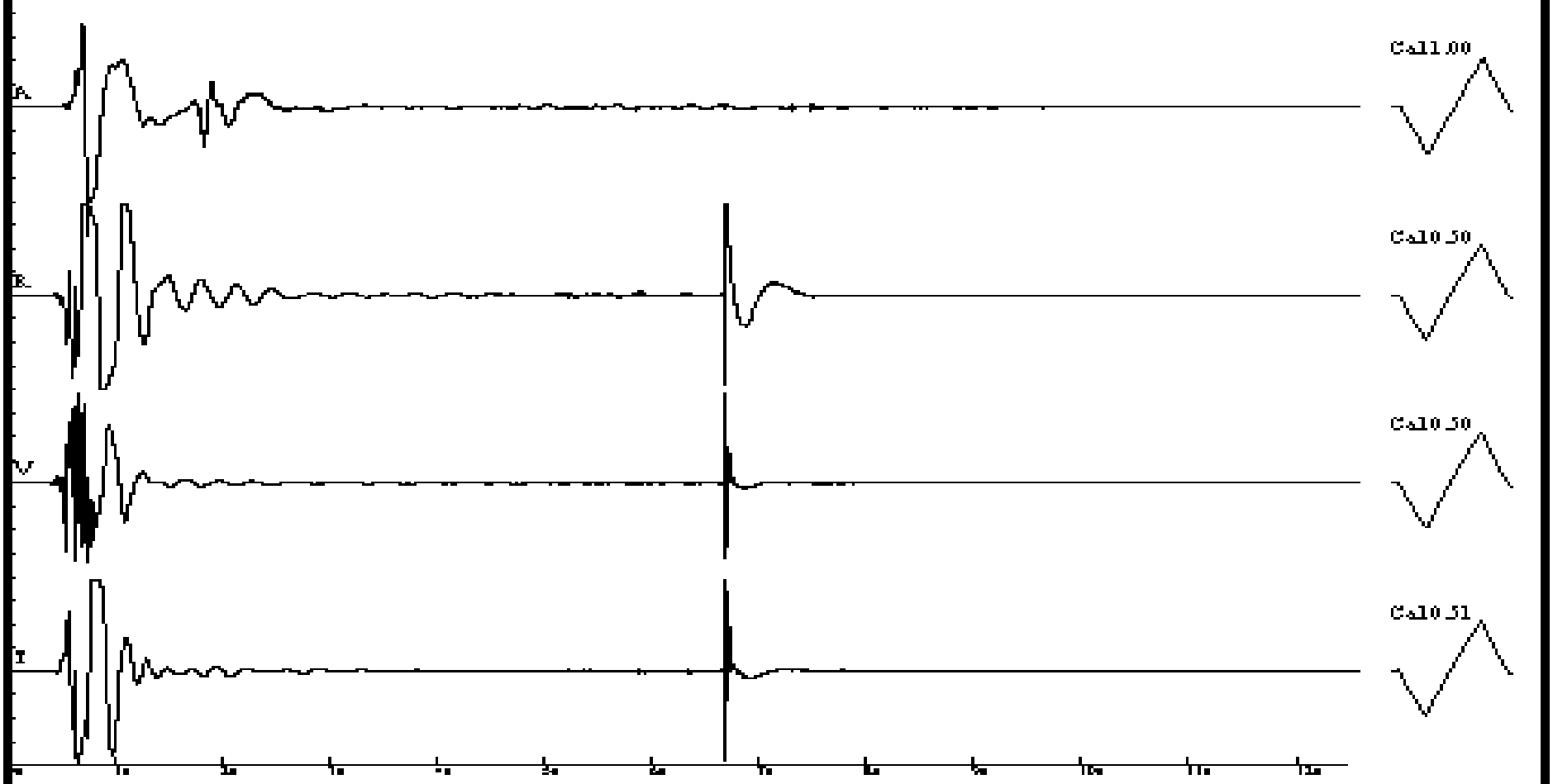
File Name: 8N2832200403230001.DTB
Number: 001
Date: 3/23/2006
Time: 16:42
Serial Number: 2832
Seismic Trigger: 0.2000 in/s 5.0800 mm/s
Acoustic Trigger: 148 dB
Sample Rate: 1024
Record Duration: 12.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 8x
Battery: 6.5

Amplitudes and Frequencies

Acoustic: 148 dB @ 3.2 Hz
(5.08Mb 0.0737psi 0.5079kPa)
Radial: **2.56in/s 65.024mm/s @ 2.6Hz**
Vertical: 2.44in/s 61.976mm/s @ 22.2Hz
Transverse: 2.48in/s 62.992mm/s @ 3.8Hz

Graph Information

Duration: 0.000s To: 12.500s
Acoustic Scale:
148dB 5.02Mb (1.256Mb/div)
Seismic Scale:
2.56in/s (0.640in/s/div) 65.02mm/s (16.256mm/s/div)
Time Line Intervals at: 1.00 s



OSM Resources

- Appalachian Region Blasting Web Page
  - **www.ARblast.osmre.gov**
  - Reports and Publications

- Technical Innovation and Professional Services (TIPS)
  - **www.tips.osmre.gov**
  - Blast Log Evaluation Program (BLEP)

- keltschlager@osmre.gov or (412) 937-2169