Ohio Dept. of Natural Resources

Division of Mineral Resources Management

Applying Science to the Human Perception Problem

Presented by

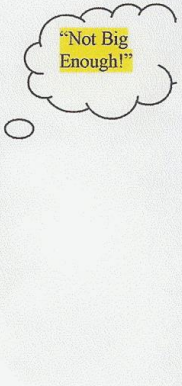
Mike Mann, Blasting Specialist

ODNR Div. of Mineral Resources Mgt.

THE HOLOBLAST

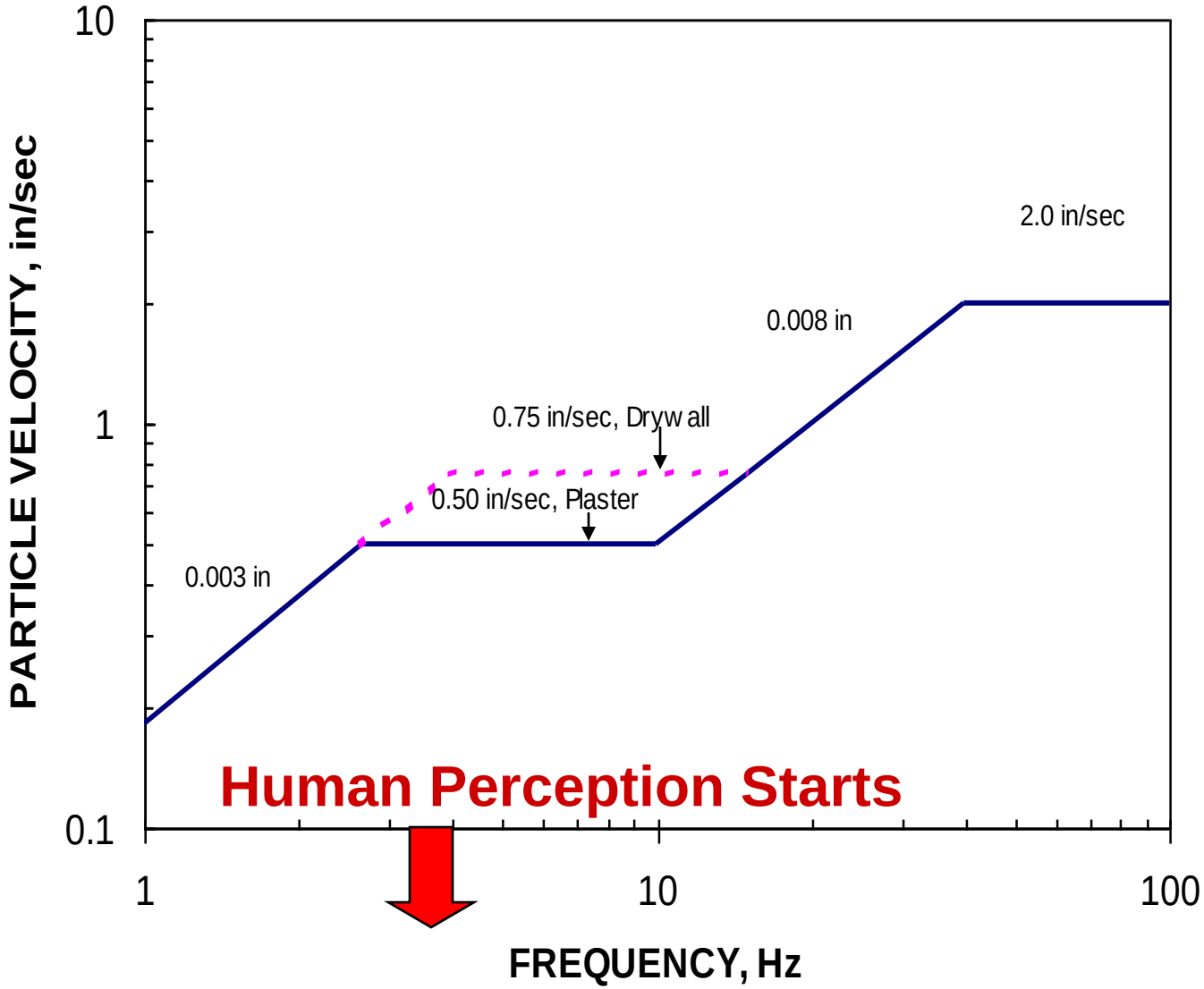
NEVER AGAIN

Thursday December 16, 2004 @ 3:30pm
Compliments of

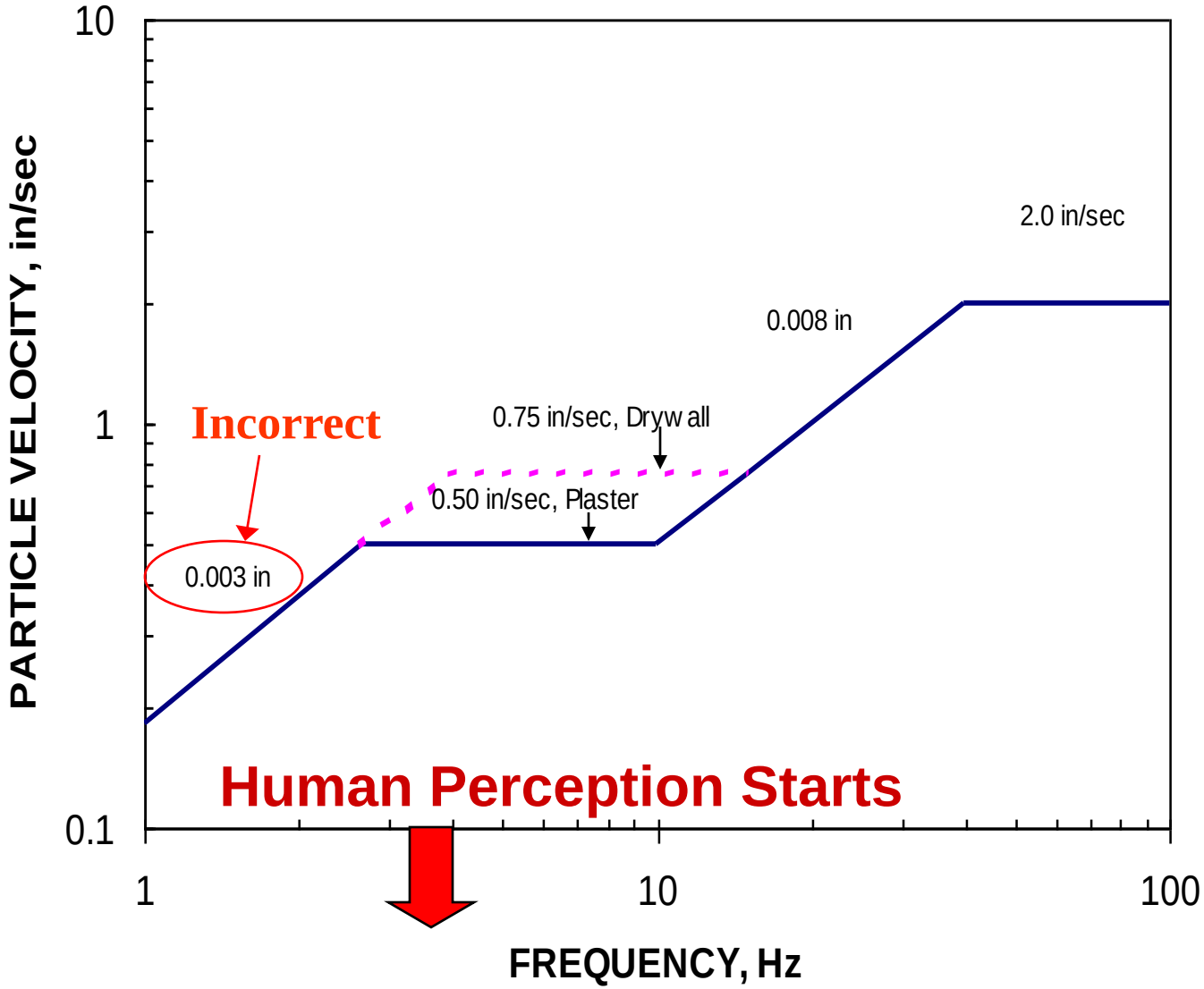


A Real TSUNAMI

FROM USBM RI 8507, APPENDIX B
ALTERNATIVE BLASTING LEVEL CRITERIA



FROM USBM RI 8507, APPENDIX B
ALTERNATIVE BLASTING LEVEL CRITERIA



BLASTING IN OHIO'S QUARRIES AND SURFACE COAL MINES

Revised June 2004

Ohio Department of Natural Resources
Division of Mineral Resources Management
ohiodnr.com

Columbus 614.265.6633
New Philadelphia 330.339.2207

Each day in Ohio, nearly half a million pounds of explosives are safely detonated in quarries and surface coal mines.

The word "blasting" often conjures up visions of destruction - mushroom clouds, gigantic craters, high-rise buildings collapsing, bridges falling and cars exploding. However, each day in Ohio, nearly half a million pounds of explosives are safely detonated in quarries and surface coal mines. The Ohio Department of Natural Resources, Division of Mineral Resources Management is the agency responsible for regulating the environmental effects of mining and blasting. This article will address some of the commonly asked questions and misconceptions regarding blasting.

Why is blasting necessary?

Blasting is the most cost effective way to fracture rock so that it can be excavated by earth-moving equipment. This, in turn, reduces the costs of building materials, such as gravel and concrete, energy produced from coal, and many other products derived from limestone, coal and other minerals.

Is dynamite still used?

People living near quarries and coal mines often express concern about "the dynamiting going on over there." In fact, dynamite, a nitroglycerin-based explosive, is rarely used today in Ohio's quarries and surface coal mines. The most widely used explosive is a mixture of ammonium nitrate (AN) and fuel oil (FO) called ANFO. The ammonium nitrate is in the form of a prill (small, bead-like pellet), which absorbs the fuel oil. ANFO is far less hazardous than dynamite and breaks more rock per unit of cost.

How far do fractures extend from a blasthole?

Blastholes are normally drilled vertically and arranged in a grid pattern. Typical blasthole diameters range from two to seven inches in quarries and five to nine inches in surface coal mines, with typical depths from 10 to 70 feet. Upon detonation, fracturing of rock generally occurs no greater than 20 to 30 feet from any blasthole, depending largely upon hole diameter and the densities of the rock and explosive. A common misconception is that fracturing extends far beyond the mine property - even miles from the blast site. If this were true, the blastholes could be placed much farther apart than the commonly used spacing of six to 18 feet in quarries and 12 to 25 feet in surface coal mines, and blasting would be much more economical since less drilling and explosives would be necessary.

Another common misconception associated with blasting is that significant fracturing occurs far below the bottom of a blasthole. In fact, most of the gas pressure forces created by the detonation of the explosive radiate outward along the length of the cylindrical blasthole. Depending upon the hole diameter, type of explosive and nature of the rock, gas-pressure forces below the bottom of the blasthole are comparatively minimal and fracturing of rock is generally limited to several feet. In most surface coal mines, a buffer of only three to five feet between the bottom of the blastholes and the top of the coal seam adequately protects the coal (which is brittle to begin with) from being fractured and contaminated by the rock material immediately above it. Failure to protect the coal from fracturing can increase the cost of cleaning the coal and significantly reduce the mine operator's profits.

What causes ground vibration and how is it measured?

When a blast detonates, some of the explosive energy not utilized in breaking rock travels through the ground in all directions as wave motion, similar to the ripple created in a pond when a stone hits the water. This wave motion, or ground vibration, travels mainly along the surface at speeds of 5,000 to 20,000 feet per second, depending upon the density and thickness of the rock and soil. Its energy level decreases rapidly with distance from the blast and normally decays to levels undetectable by humans beyond several thousand feet. Because explosives are expensive and vibration represents wasted energy, it is to the blaster's advantage to utilize as much of the energy as possible in fragmentation, thereby minimizing vibration.

Blasting seismographs are used to measure ground vibration in terms of particle velocity, which is the speed at which each particle in the ground oscillates as the wave motion passes. This would be similar to measuring the speed of a fishing bobber in a pond as it moves up and down when a ripple passes under it. Particle velocity is measured in inches per second, but beyond several hundred feet from a blast the actual movement of the ground, or displacement, is generally only a tiny fraction of an inch, about the thickness of a piece of paper, or less. So it is important to understand that a particle velocity reading expressed in inches per second refers to the speed at which the ground moved, and not the amount of movement.

How is ground vibration controlled?

Blasters control ground vibration mainly by limiting the weight of explosives detonated within any 8-millisecond period of time. They do this by using millisecond delay detonators (blasting caps) to separate the firing time of each hole from adjacent holes. In a typical 50-hole blast, the result would be 50 smaller and separate explosions instead of one large blast. A common misconception is that the number of blastholes determines the resulting intensity

of vibration. However, given the same charge-weight per delay (pounds of explosive detonated within any 8-ms period) and the same distance, a 100-hole blast can be designed to produce no more vibration than a 10-hole blast.

What is airblast and how is it measured?

When a blast detonates, some energy is lost to the atmosphere in the form of noise and/or concussion. This phenomenon is caused by the venting of gases through cracks and fissures and the upward and outward movement of the rock on top and in front of the blastholes. The resulting increase in the air pressure is commonly called airblast. Like ground vibration, airblast levels decrease rapidly with distance from the blast. However, airblast travels only at the speed of sound, around 1,100 feet per second, depending upon air temperature, and can be greatly influenced by wind direction and speed, and by atmospheric temperature inversions which can bend it back toward the earth and focus its energy several miles away.

Airblast is usually measured with a special microphone connected to the same type of seismograph that measures ground vibration. The most common units of airblast measurement are pounds per square inch (psi) and the decibel (dB), which is based on a logarithmic sound-pressure scale related to human hearing. The threshold of hearing begins at zero decibels (see Figure 1). An increase of six decibels represents a doubling of air pressure. As an example, an airblast measured at 126 dB would have twice the air pressure of an airblast at 120 dB.

How is airblast controlled?

Airblast is controlled mainly by the proper use of stemming material (the drill cuttings or crushed stones that are shoveled back into the blasthole after the explosive material has been loaded to a predetermined depth from the surface), and by not loading explosives into portions of holes with cracks, voids or mud seams. These techniques minimize the escape of gases and confine the explosive energy where it is needed to efficiently break rock.

What are the ground vibration and airblast limits?

The United States Bureau of Mines (USBM) conducted extensive research over a 35-year period on the effects of blast-induced ground vibration and airblast on residential structures. This research produced recommended limits that, if adhered to, will effectively protect residential structures from damage, even if the blasting is repeated on a daily basis over a period of many years.

Around 1983, the State of Ohio adopted a modified version of the USBM ground vibration and airblast limits for surface blasting in Ohio coal mines, as required by the federal Office of Surface Mining. In their simplest form, ground vibration must not exceed 1.0 inch per second and airblast must not exceed 133 decibels at any dwelling. And in 2002, the USBM limits were adopted for Ohio quarries. In quarries and coal mine blasting, seismographic monitoring is required if the explosive charge-weight per delay will exceed the maximum allowed by specific formulas, based on the distance to the nearest dwelling.

Who may conduct blasting?

Only a certified blaster may conduct blasting in Ohio's quarries and surface coal mines. To become certified, a blaster must obtain 2 years of blasting crew experience including on-the-job training, attend 30 hours of classroom training, and pass an exam covering blast design, safety, vibration control and monitoring, and state and federal blasting regulations. Once certified, a blaster must attend 24 hours of continuing education during every 3-year renewal period.

If the dishes rattle, is my home being damaged?

It is helpful for homeowners to know that even when blast vibrations are far below the legal limit, highly perceptible vibration can be experienced inside the home; windows and dishes might rattle, knickknacks and pictures might move or fall if not securely fastened, and hanging lamps might sway. These effects can be generated by ground vibration or airblast acting separately or together, and can last from one to three seconds or more, depending upon the distance from the blast, geologic influences and other factors. Despite these sometimes startling effects, there is no direct correlation between how a blast "feels" or sounds and its potential for causing structural damage to a home. In fact, cultural stresses (e.g., doors slamming, kids jumping, people pounding nails) and natural stresses (e.g., sunlight, wind, rain, temperature and humidity fluctuations and changes in soil moisture) can place greater stresses on a home than legal blast vibrations.

Figure 1

Airblast Effects

dB	psi	
180	3.0	Conventional structures severely damaged
		Plaster cracks at 176 dB
170	1.0	Most windows break at 171 dB
160	0.3	
150	0.1	Some windows may break at 151 dB
140	0.03	Exceeded by strong wind gusts in Ohio
130	0.009	DMRM limit is 133 dB
120	0.003	
100	$3x10^{-4}$	Pneumatic hammer
80	$3x10^{-5}$	
60	$3x10^{-6}$	Conversational speech
40	$3x10^{-7}$	
20	$3x10^{-8}$	
0	$3x10^{-9}$	Threshold of hearing

Modified from DuPont (1977) and Konya (1990).

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150	0.1	Some windows may break at 151 dB
140	0.03	Exceeded by strong wind gusts in Ohio
130	0.009	DMRM limit is 133 dB
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100	$3x10^{-4}$	Pneumatic hammer
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0	$3x10^{-9}$	Threshold of hearing

Modified from DuPont (1977) and Konya (1990).

Human Annoyance Threshold (+/-)

How do we deal with the human perception problem?

By Applying Science With:

- Seismographs
- Structural response studies
- Crack gauge studies
- Video cameras

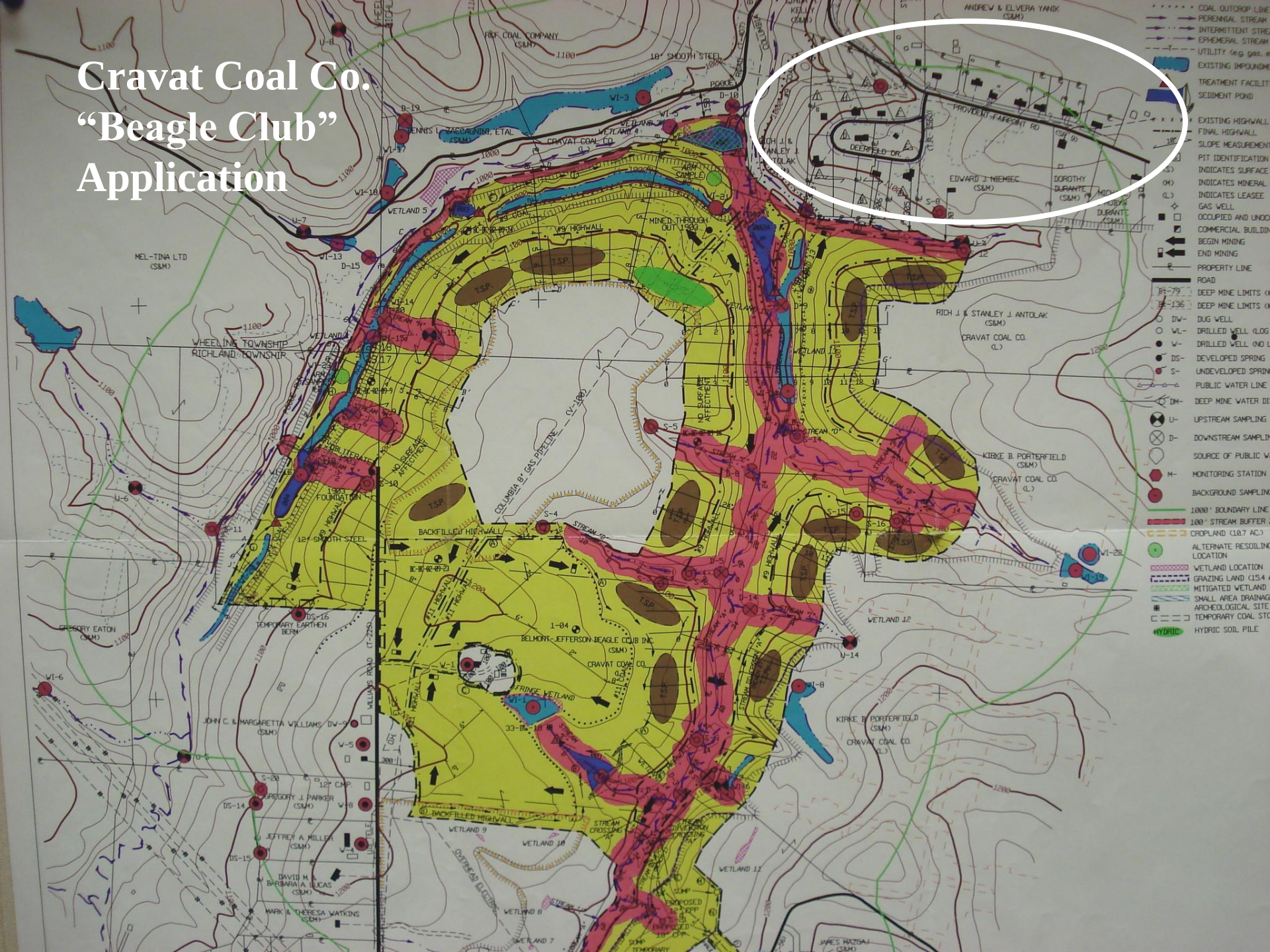
And By Communicating With the Complainant/Homeowner

- One-on-one
- A report with a few seismograms and charts
- Information sheet or pamphlet

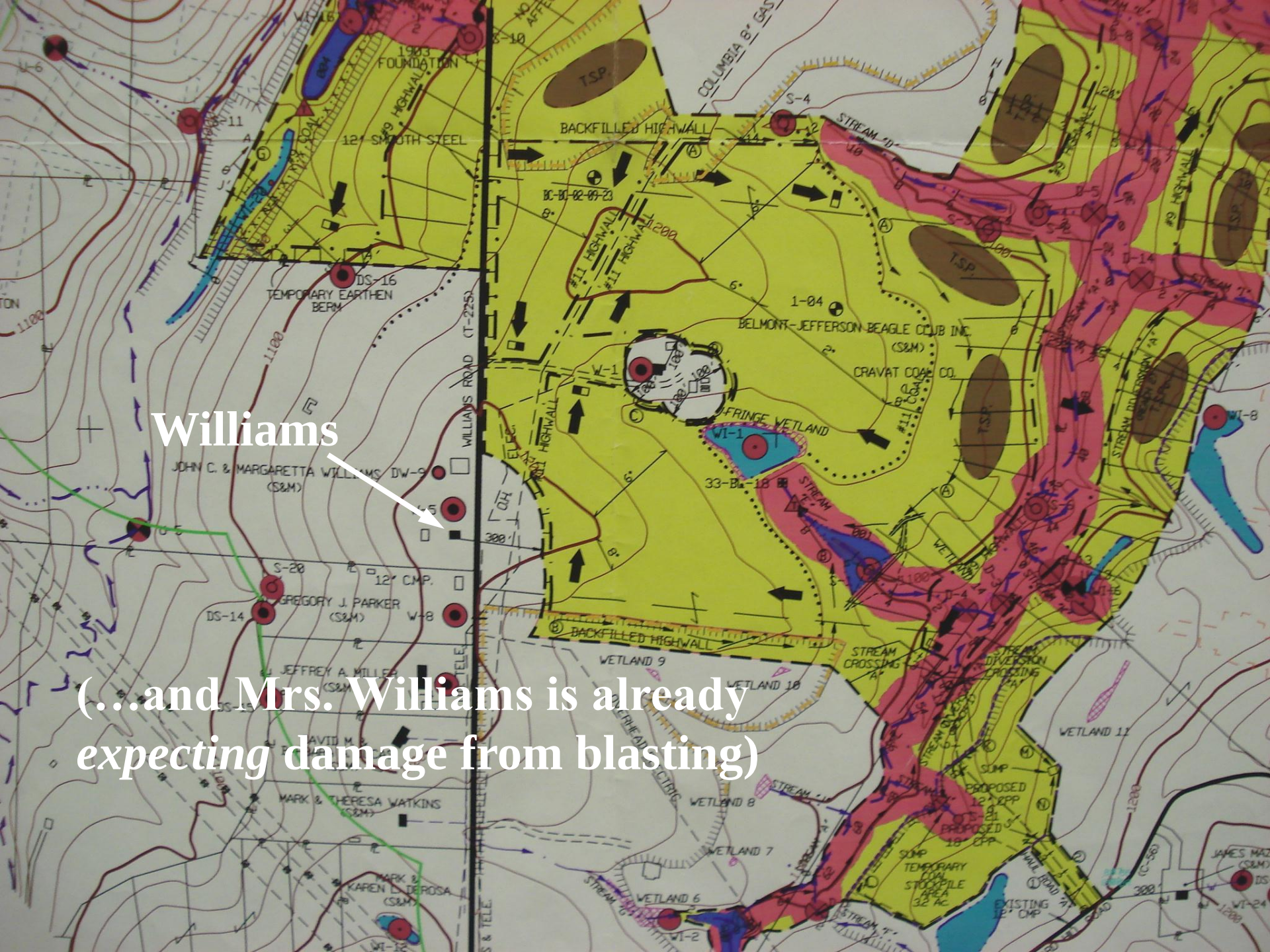
Case 1 - Williams

- Seismographic monitoring
- Digital crack gauge monitoring

Cravat Coal Co. "Beagle Club" Application



The Permit is issued…


Williams
(…and Mrs. Williams is already *expecting* damage from blasting)
1903 FOUNDATION
12" SMOOTH STEEL
BACKFILLED HIGHWALL
COLUMBIA 8" GAS
T.S.P.
TEMPORARY EARTHEN BERM
WILLIAMS ROAD (T-225)
JOHN C. & MARGARETTA WILLIAMS
BELMONT-JEFFERSON BEAGLE CLUB INC.
CRAVAT COAL CO.
FRINGE WETLAND
33-BM-18
12" CMP.
GREGORY J. PARKER
JEFFREY A. MILLER
MARK & THERESA WATKINS
MARK & KAREN DEROSA
WETLAND 9
WETLAND 10
WETLAND 8
WETLAND 7
WETLAND 6
WETLAND 11
STREAM CROSSING
STREAM DIVERSION CROSSING
PROPOSED 12" CPP
TEMPORARY COAL STOCKPILE AREA 32 AC.
EXISTING 18" CMP

ODNR/DMRM Seismograph
Installed July 26, 2006

Initial Blast Detonated Aug. 4, 2006
(About 1,025’ East of Williams House)

PERCEPTION:

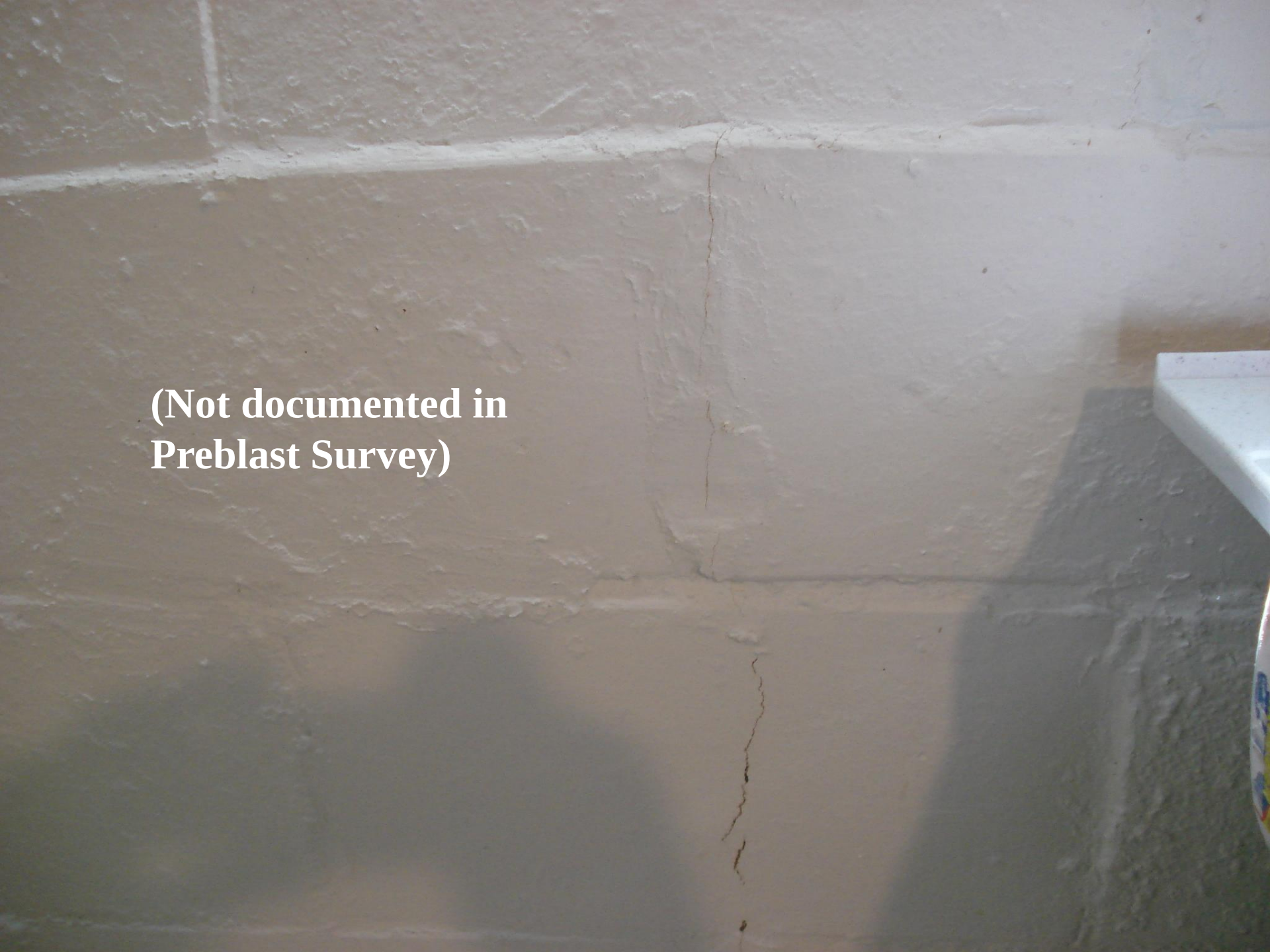
“We were out by the barn and the blast was pretty loud; we found new cracks in the basement walls.”

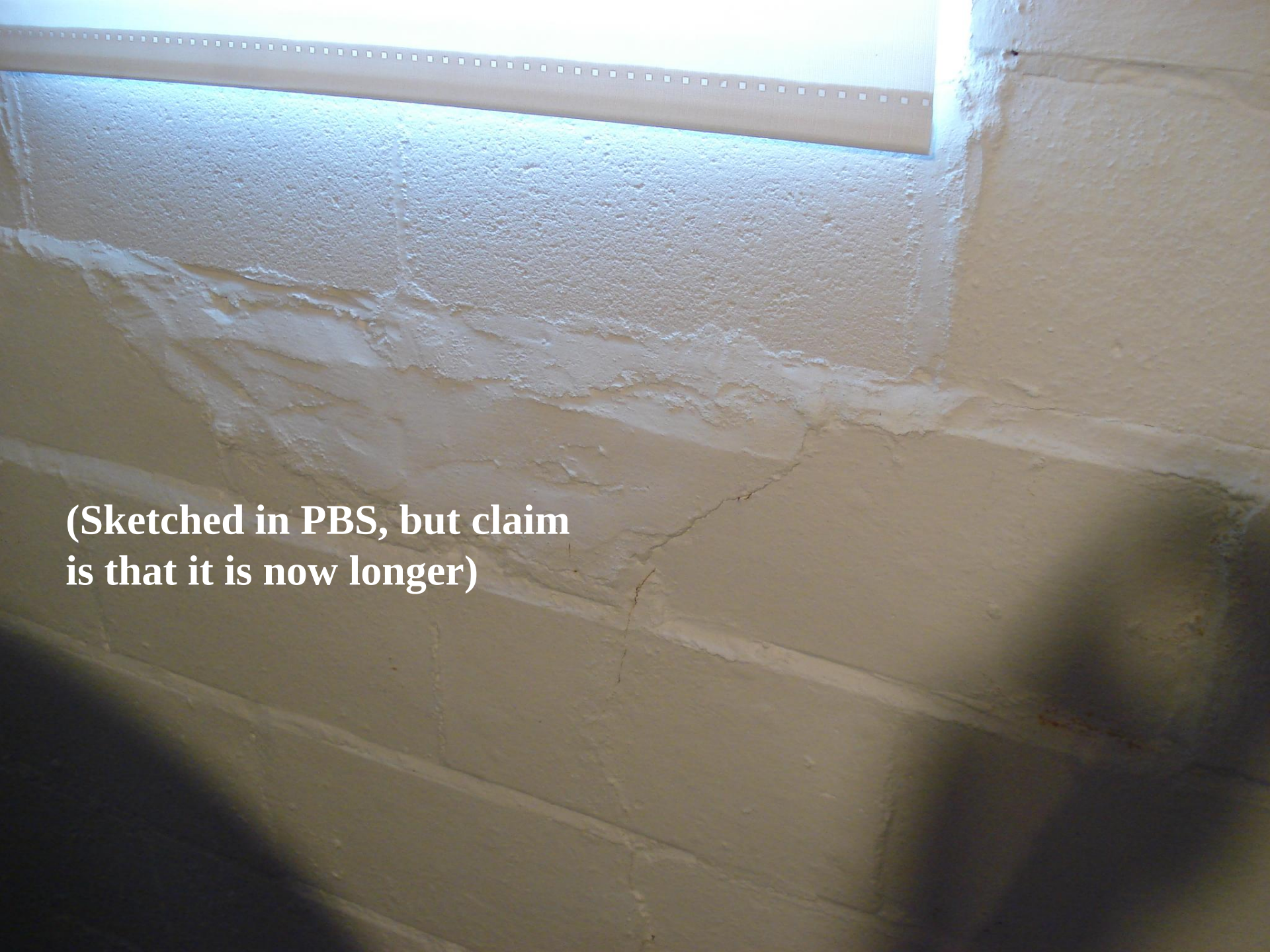
Major Dilemma!

- Basement walls painted November 2005
- Preblast survey conducted May 5, 2006
- Initial blast August 4, 2006 (1,025’ from Williams)
- Seismograph: **0.09 ips**/124 dB
- They are already claiming damage
- Future blasts to be 300’ from Williams!

The Damage Claim…

ENERGYGUIDE


(Not documented in
Preblast Survey)


(Sketched in PBS, but claim
is that it is now longer)

Initial Blast

ODNR SEISMO. DATA/S. KULLMAN/RECORDED AT:
Peggy Williams, 69544 Williams Rd.
St. Clairsville, OH 43950
Approx. 1,025' W of Blast Site At:
Cravat Coal Co., Permit D-2266

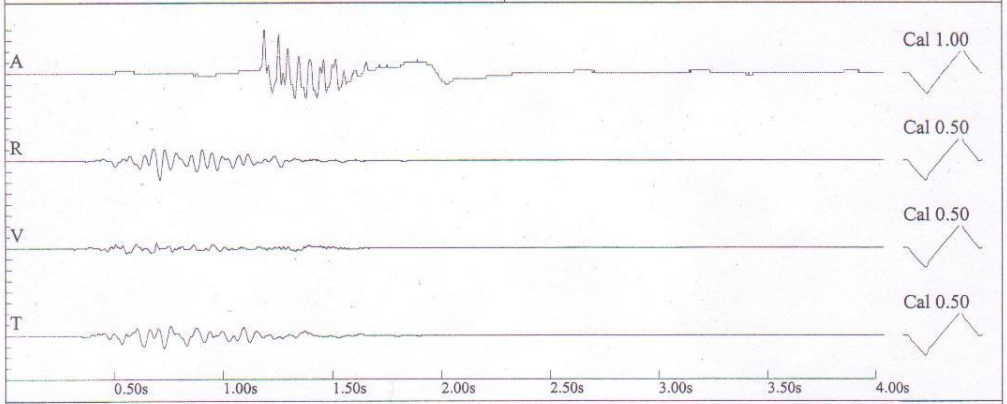
File Name: PWILA005.DTB
Number: 005
Date: 8/4/2006
Time: 13:46
Serial Number: 1837
Seismic Trigger: 0.0300 in/sec
Acoustic Trigger: 129 dB
Sample Rate: 1024
Record Duration: 7.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 7.0

Amplitudes and Frequencies

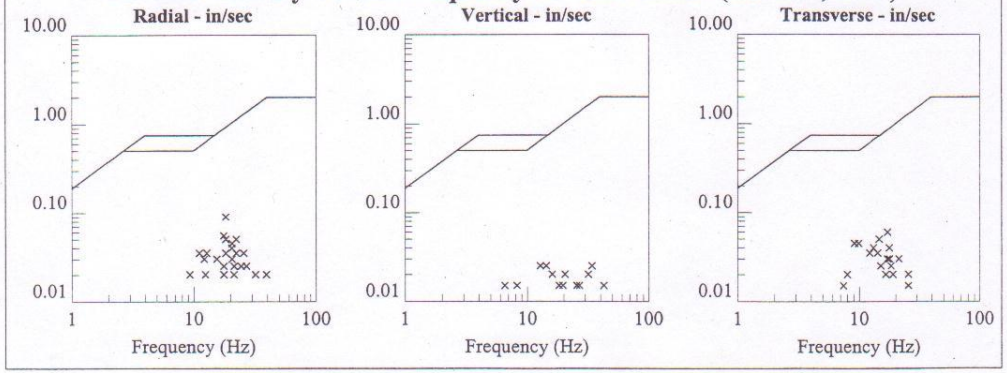
Acoustic: 124 dB, 0.32 Mb @ 16.0 Hz
***Radial:* 0.0900 in/sec @ 18.9Hz**
Vertical: 0.0250 in/sec @ 36.5Hz
Transverse: 0.0600 in/sec @ 17.6Hz
Displacement: 0.00084 in
Acceleration: 0.02650 g's

Graph Information

Duration: 0.000 s To: 4.000 s
Acoustic Scale: 124 dB
Seismic Scale: 0.20 in/sec (0.050 in/sec/div)
Time Line Intervals at: 0.50 s

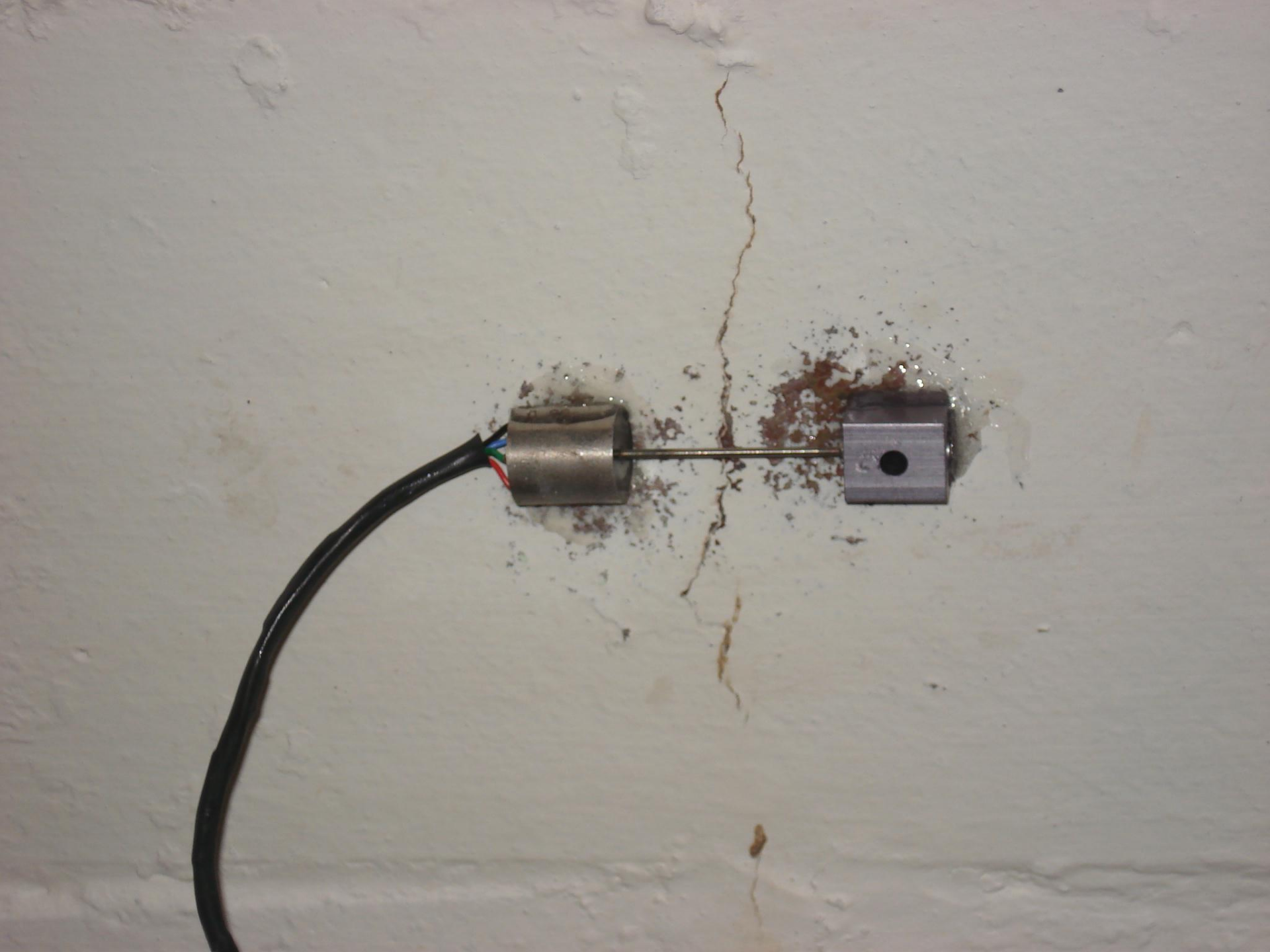


Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)

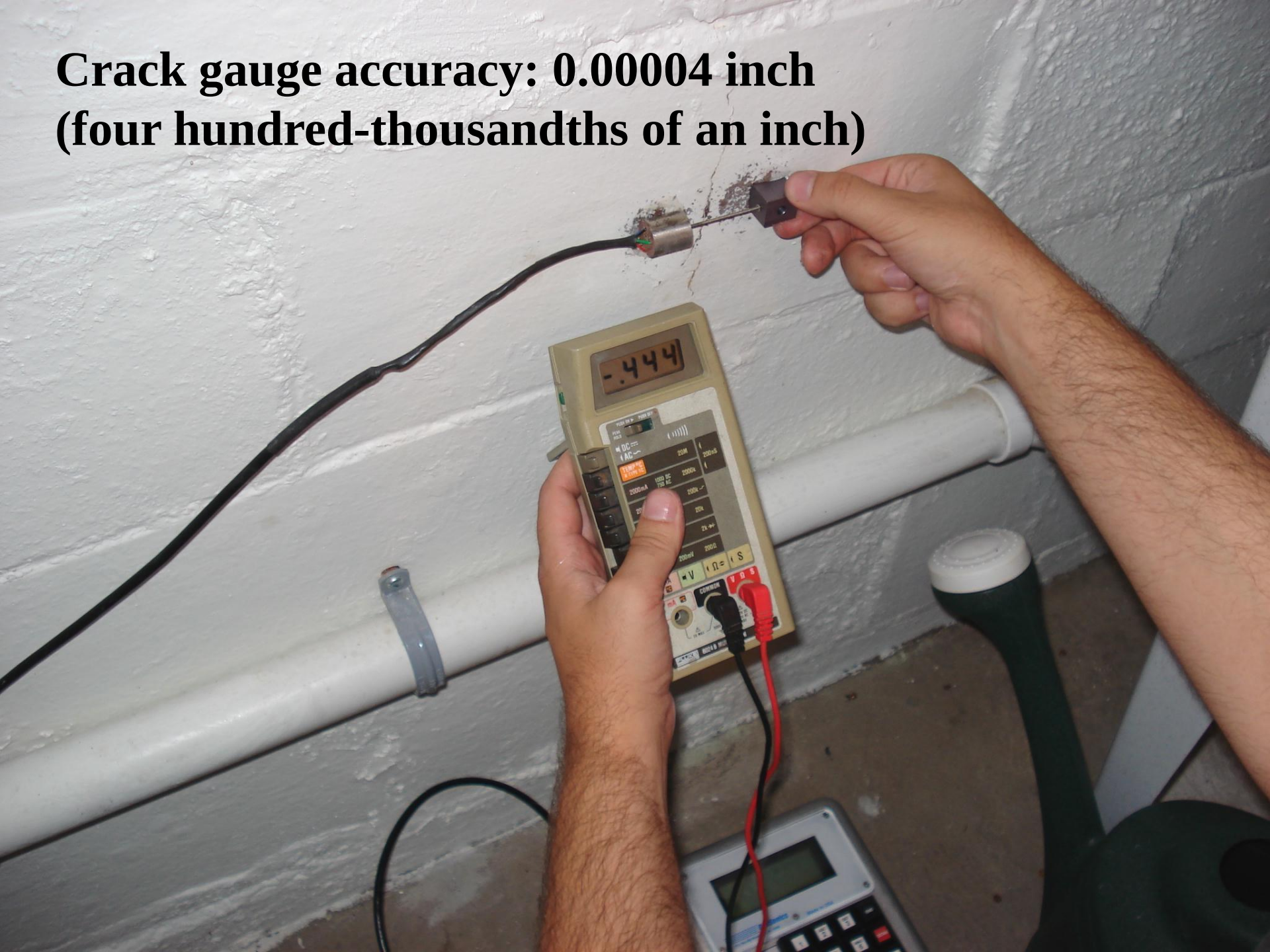


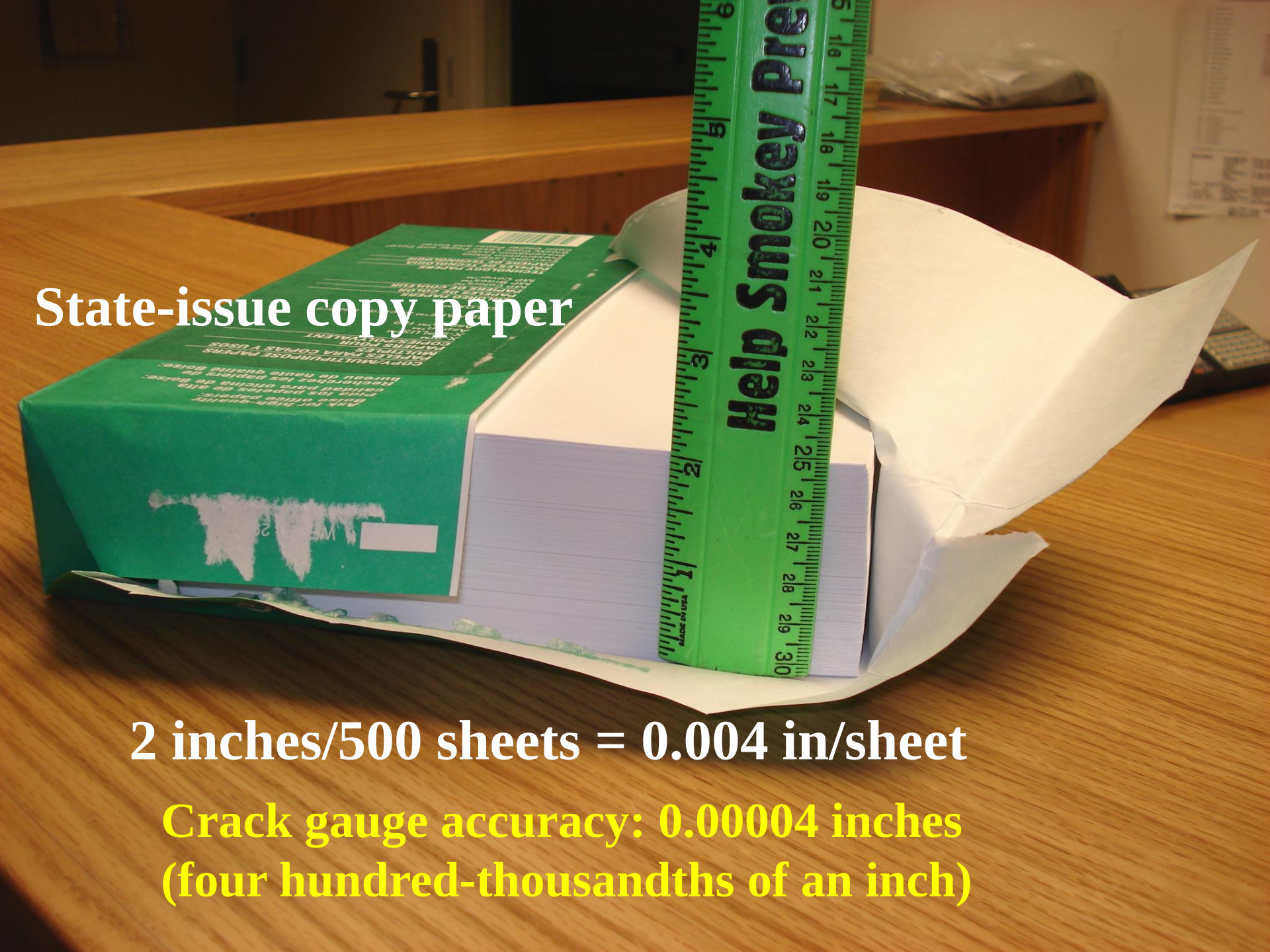
Vibra-Tech crack gauge study

JOHN
St. C
Schools



Crack gauge accuracy: 0.00004 inch (four hundred-thousandths of an inch)



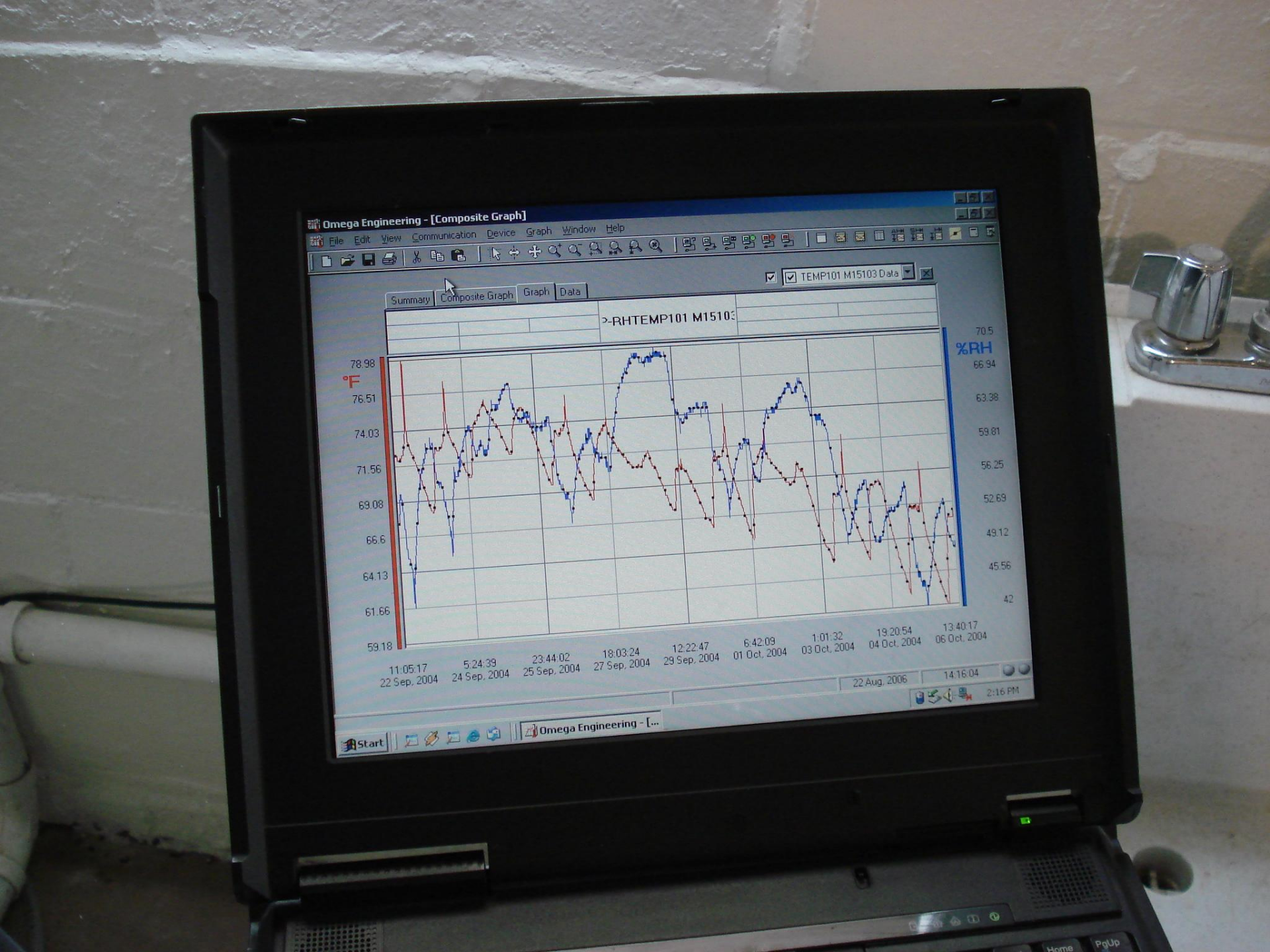

State-issue copy paper
2 inches/500 sheets = 0.004 in/sheet
Crack gauge accuracy: 0.00004 inches
(four hundred-thousandths of an inch)

Null
gauge
Crack
gauge

Humidity and Temperature Recorder

The blasts progressed much closer to Williams, to as close as 325’ on February 6, 2007.

GOJO
Comet
COTTONS
EASY CARE
DELICATES
START
STOP/PAUSE


Omega Engineering - [Composite Graph]
File Edit View Communication Device Graph Window Help
TEMP101 M15103 Data
Summary
Composite Graph
Graph
Data
°F
%RH
78.98
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71.56
69.08
66.6
64.13
61.66
59.18
70.5
66.94
63.38
59.81
56.25
52.69
49.12
45.56
42
11:05:17 22 Sep, 2004
5:24:39 24 Sep, 2004
23:44:02 25 Sep, 2004
18:03:24 27 Sep, 2004
12:22:47 29 Sep, 2004
6:42:09 01 Oct, 2004
1:01:32 03 Oct, 2004
19:20:54 04 Oct, 2004
13:40:17 06 Oct, 2004
22 Aug, 2006
14:16:04
2:16 PM
Start
Omega Engineering - [...

Communication!

Summary of DMRM Seismographic Data Recorded at Williams

- 144 blasts recorded from 7-26-06 to 7-3-07
- Highest PPV: 0.45 ips
- Highest airblast: 126 dB
- Most critical period: 1-9-07 to 2-15-07, when 17 blasts were 324’ to 500’ from Williams, and the PPV’s ranged from 0.16 to 0.45 ips
- (Crack gauge study terminated on March 1, 2007)

Max. PPV recorded near SE corner of Williams house.

ODNR SEISMO. DATA/S. KULLMAN/RECORDED AT:
Peggy Williams, 69544 Williams Rd.
St. Clairsville, OH 43950
Approx. 366' WSW of Blast Site At
Cravat Coal Co., Permit D-2266

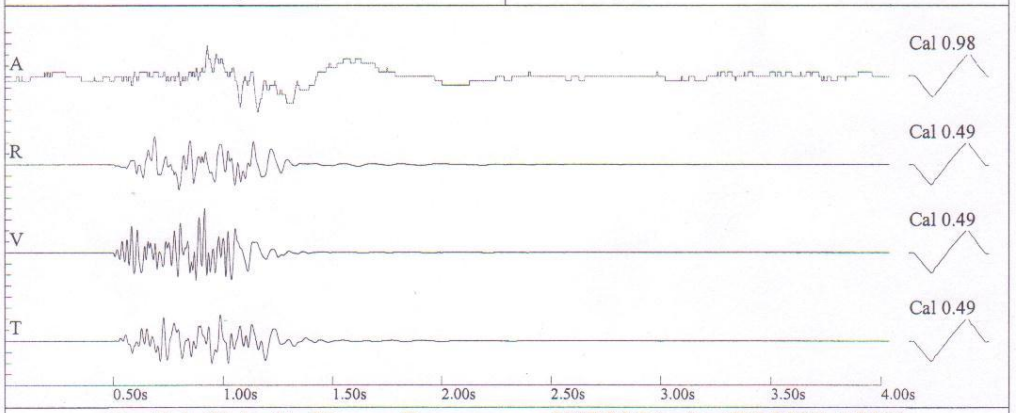
File Name: WILLJ006.DTB
Number: 006
Date: 1/25/2007
Time: 14:54
Serial Number: 1837
Seismic Trigger: 0.0200 in/sec
Acoustic Trigger: 129 dB
Sample Rate: 1024
Record Duration: 7.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 7.3

Amplitudes and Frequencies

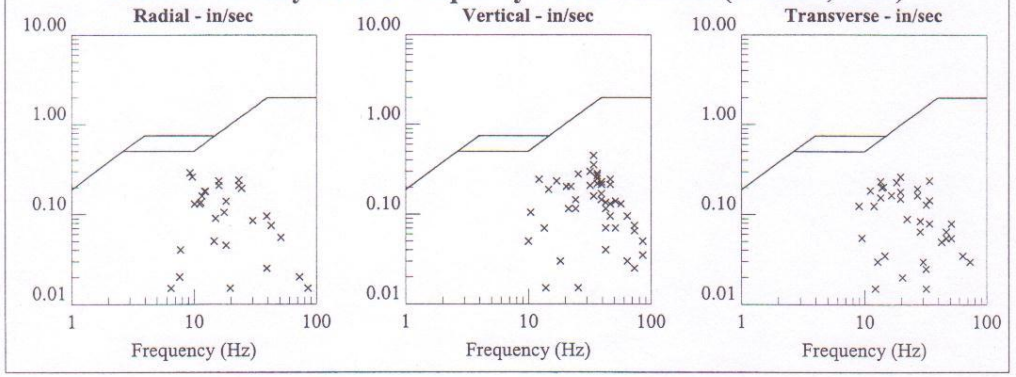
Acoustic: 118 dB, 0.16 Mb @ 1.8 Hz
Radial: 0.2900 in/sec @ 9.3Hz
***Vertical:* 0.4500 in/sec @ 34.1Hz**
Transverse: 0.2650 in/sec @ 19.6Hz
Displacement: 0.00403 in
Acceleration: 0.26501 g's

Graph Information

Duration: 0.000 s To: 4.000 s
Acoustic Scale: 120 dB
Seismic Scale: 0.45 in/sec (0.113 in/sec/div)
Time Line Intervals at: 0.50 s



Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)



VIBRA-TECH®

REPORT

TO CRAVAT COAL COMPANY
40580 Cadiz-Piedmont Road
Cadiz, OH 43907

RECEIVED
MAY - 7 2007
By

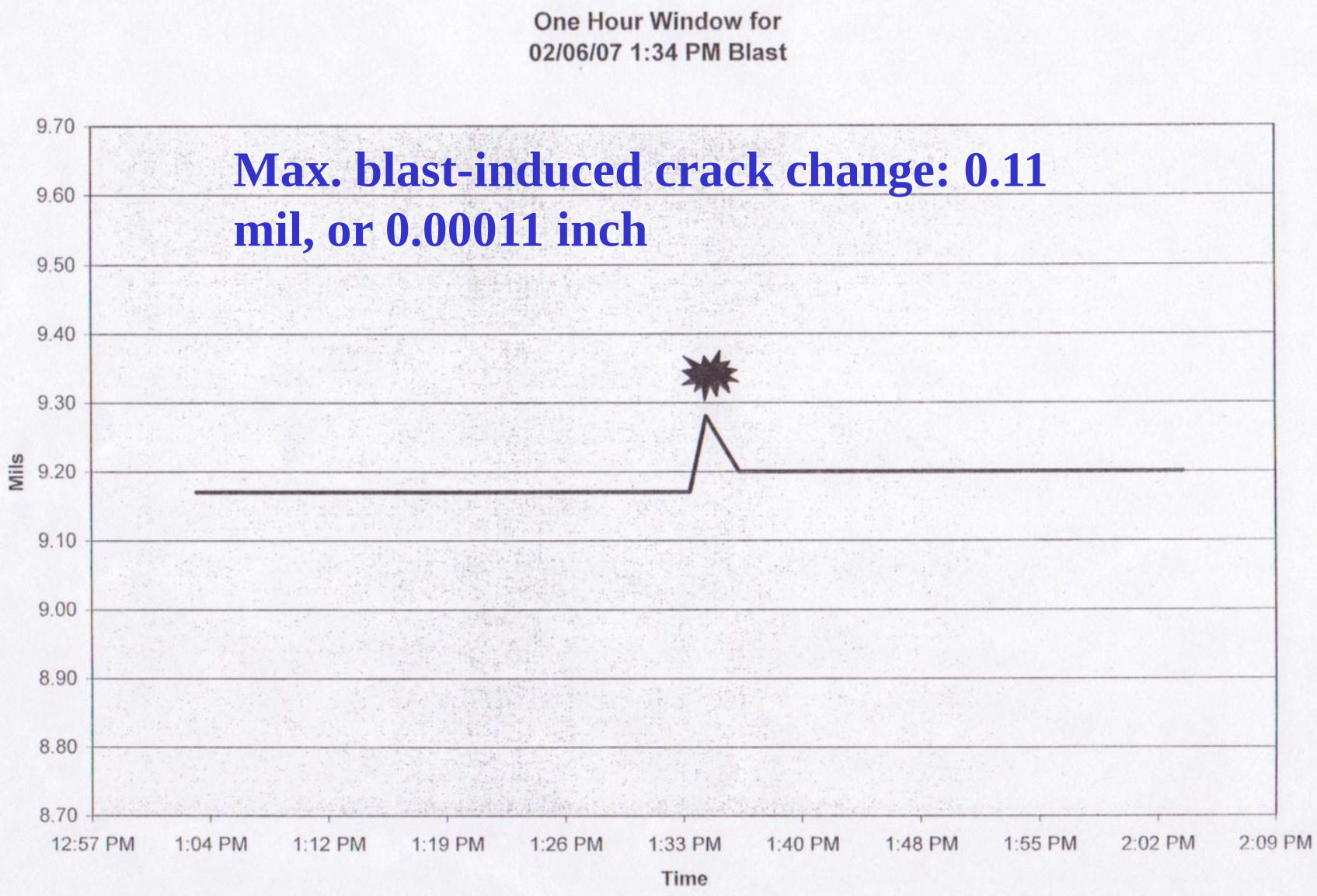
DATE April 26, 2007

SUBJECT **DIGITAL CRACK GAUGE REPORT**

Cravat Coal Company
Beagle Club Permit
St. Clairsville, Ohio

August 22, 2006 - March 1, 2007

COPY NUMBER 2 **OF** 3


One Hour Window for
02/06/07 1:34 PM Blast
Max. blast-induced crack change: 0.11 mil, or 0.00011 inch
9.70
9.60
9.50
9.40
9.30
9.20
9.10
9.00
8.90
8.80
8.70
Mils
12:57 PM
1:04 PM
1:12 PM
1:19 PM
1:26 PM
1:33 PM
1:40 PM
1:48 PM
1:55 PM
2:02 PM
2:09 PM
Time

Blast that induced the maximum crack change (0.00011 inch) from any blast

ODNR SEISMO. DATA/S. KULLMAN/RECORDED AT:
Peggy Williams, 69544 Williams Rd.
St. Clairsville, OH 43950
Approx. 325' W of Blast Site At
Cravat Coal Co., Permit D-2266

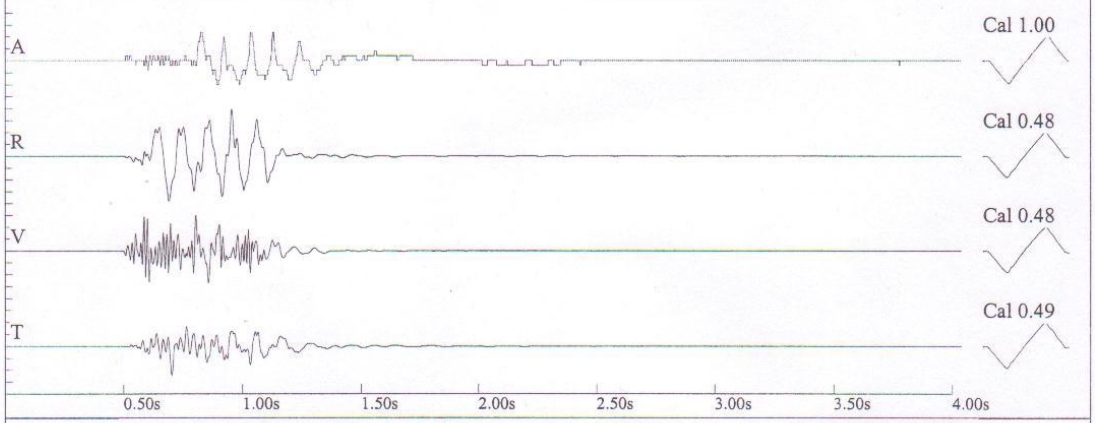
File Name: WILLK015.DTB
Number: 015
Date: 2/6/2007
Time: 13:34
Serial Number: 1837
Seismic Trigger: 0.0200 in/sec
Acoustic Trigger: 129 dB
Sample Rate: 1024
Record Duration: 7.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 7.4

Amplitudes and Frequencies

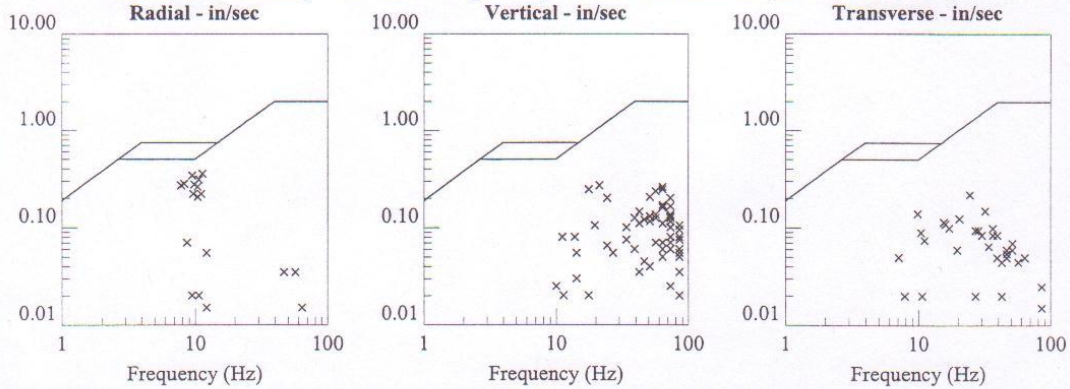
Acoustic: 116 dB, 0.12 Mb @ 14.2 Hz
***Radial:* 0.3550 in/sec @ 11.6Hz**
Vertical: 0.2700 in/sec @ 21.3Hz
Transverse: 0.2200 in/sec @ 24.3Hz
Displacement: 0.00580 in
Acceleration: 0.26501 g's

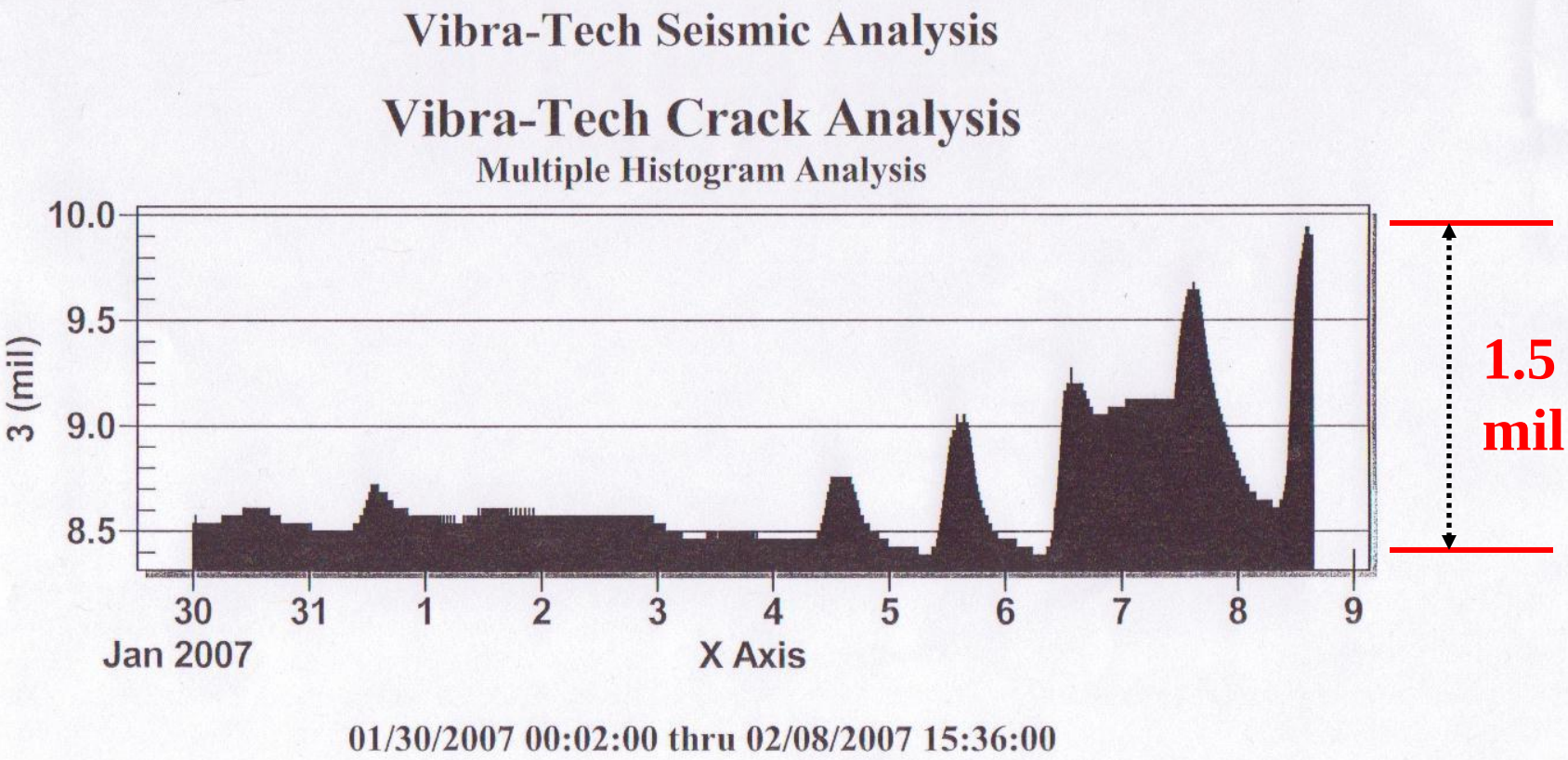
Graph Information

Duration: 0.000 s To: 4.000 s
Acoustic Scale: 120 dB
Seismic Scale: 0.36 in/sec (0.090 in/sec/div)
Time Line Intervals at: 0.50 s

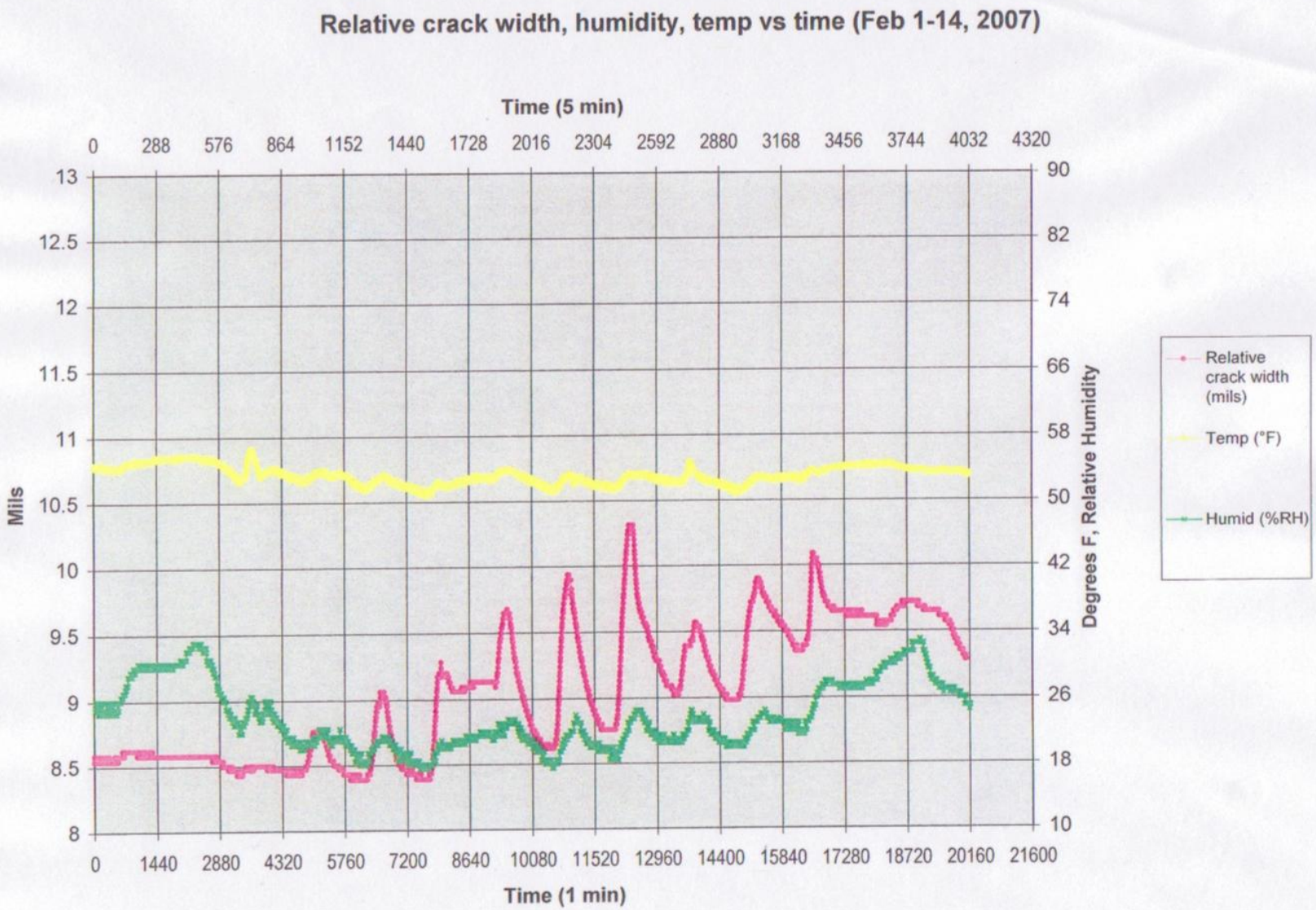


Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)





Max. crack change over this 9½-day period was 1.5 mils (0.0015 inch), which was 13 times greater than the max. blast-induced crack change (0.00011 inch) during this same period.



Crack changes correlated with humidity changes.

Summary of Findings

- Max. PPV at Williams: 0.45 ips
- Max. crack change *from a blast*: 0.00011 inch
- Max. crack change over study: 0.006 inch, which was 54 times greater than the max. blast-induced change
- Crack opened when humidity increased
- **PPV at Williams from initial blast: 0.09 ips**

CONCLUSION: Cracks in clay-tile block walls cannot be linked to the blast vibrations.

Likely Contributing Factors

- Chemical and physical aging of the clay-tile blocks and mortar
- Daily cycling of humidity and temperature
- Increased soil pressure after heavy rains
- Changes in surface and subsurface drainage patterns
- Cyclic shrinking/swelling of clay soils
- Freeze-thaw cycles
- Past stress points gradually expressing themselves through November 2005 paint job

Case 2 - Finsley

- Seismographic monitoring
- Structural response monitoring
- Appliance/cabinet response monitoring

Finsley

W-1
CR. 41
WI-10
WI-7
JEFFERY & GRETCHEN RHODES
(S&M)
WI-15
BESSIE M.
HARTLEY
(S)
ROBERT E. &
NICOLE L. FINSLEY
(S&M)
HAROLD
JOHNSON
(S&M)
DAVID & ANDREA SWANN
(S&M)
W-2
WI-9A
EXISTING
18" CMP
REPLACE w/
12" CPP
STATE ROUTE 5
AMERITECH FIBER OPTIC
T.S.P.
T.H. 1-03
9 HIGHWAY
TRANS.
SOIL SAMPLE #3
T.H. 2
POND 002
HAUL RD.
COLUMBIA GAS
AMERITECH FIBER OPTIC
BEAL HAUL ROAD
OVERHEAD ELEC.
DAVID BEAL JR.
(S & M)

"WARNING"
EXPLOSIVES
IN USE
SIGNS POSTED WITHIN PERMIT
AREA DESIGNATING BLASTING
AREA OR CHARGED HOLES
AT LEAST 1 MINUTE BUT NOT MORE THAN
2 MINUTES BEFORE BLAST: 3 LONG SIGNALS
ALL CLEAR : 1 LONG SIGNAL
NO UNAUTHORIZED ENTRY
COAL MINING PERMIT: D-2286
PICKENS MINE
OPERATED BY:
VALLEY MINING, INC.
4412 PLEASANT VALLEY ROAD S.E.
DENNISON, OHIO 44621
"ONE OF THE BEST COAL COMPANIES
IN THE UNITED STATES"
740-922-3942
DANGER
BLASTING
AREA
STAY AWAY

2nd Blast Detonated March 14, 2007 (about 1,700' SE of Finsley House; SD = 111)

PPV at nearest dwelling (Swann): 0.06 ips

Perception/Claim:

- Shook house back-and-forth three times
- Several items fell from shelves
- Noticed “lip” under carpeting between an interior doorway
- Laundry room door now drifts shut on its own
- Can hear water dripping under floor, long after shutting off sink faucet in master bath

- 28’ x 70’ modular sited May 2002 on reclaimed spoil
- Supported by stacked concrete blocks on isolated pads
- Preblast survey conducted February 13, 2007
- First blasts on March 5 and 14, 2007

8 days after March 14 blast, lip is "not as noticeable."

Listening for prolonged dripping sound
SCOPE

Crawling under master bathroom

Is it water or insulation?

Lag Screw

Supports on west end

Anchor straps at SE corner

Underside Findings

- No evidence of leaky plumbing
- Center joint appeared to be well bolted and tight
- Concrete-block piers appeared to be in good condition and shims were tight
- Low ground under south-central portion was still wet from rain and/or snow melt
- Per Mr. Finsley: lip in carpet is no longer as noticeable, and laundry room door no longer drifts shut on its own

RI 8507

Bureau of Mines Report of Investigations/1980

Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting

By D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding

UNITED STATES DEPARTMENT OF THE INTERIOR

(From RI 8507)

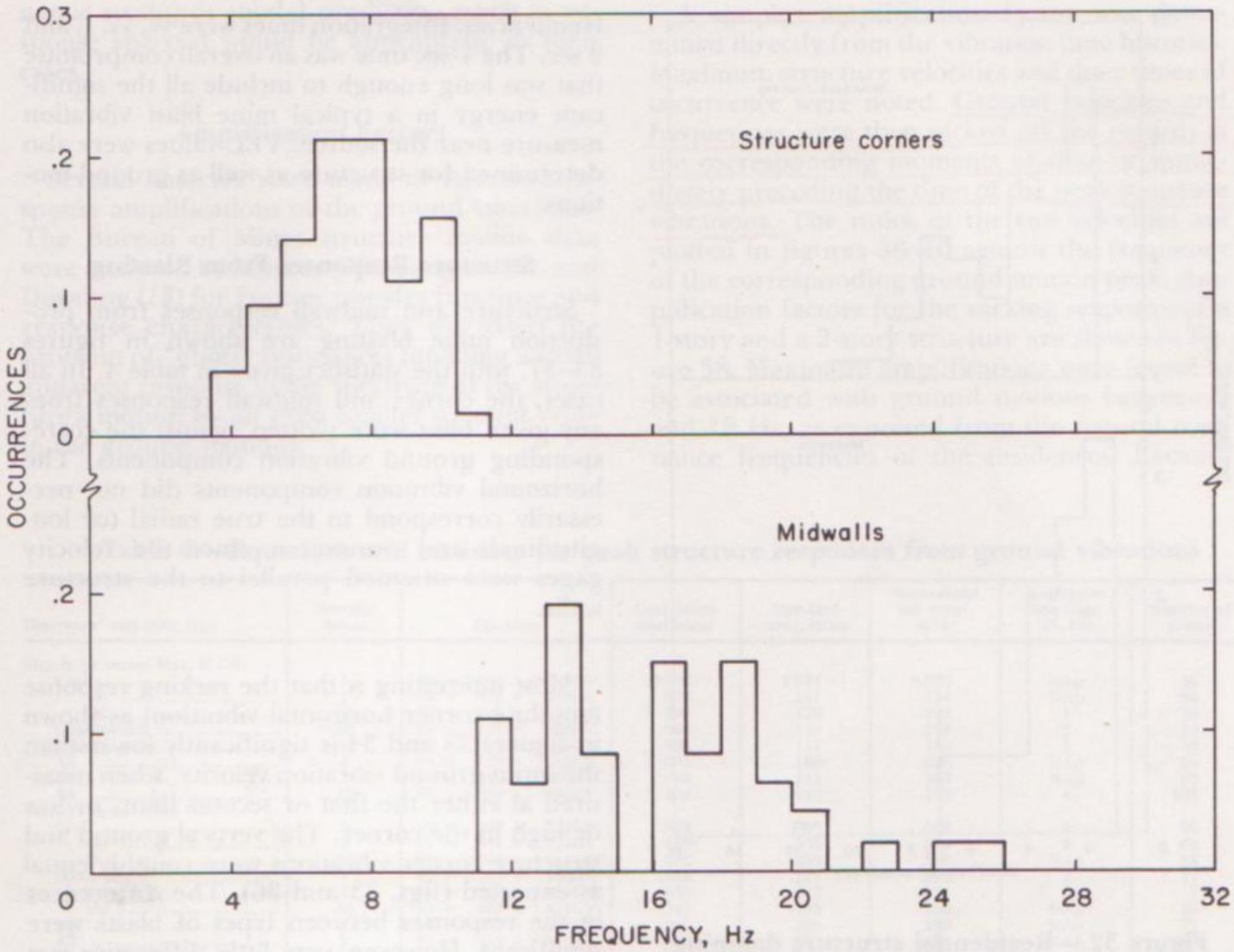


Figure 31.—Residential structure natural frequencies.

RESPONSE OF MANUFACTURED HOUSES TO BLAST VIBRATIONS

by

Michael J. Mann
OHIO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES & RECLAMATION
New Philadelphia, Ohio, USA

2000 HIGH-TECH SEMINAR
Blasting Technology, Instrumentation and Explosives Applications

Orlando, Florida, USA
July 24 – 27, 2000

Previous study of 3 pillar-supported manufactured houses

Canter trailer response

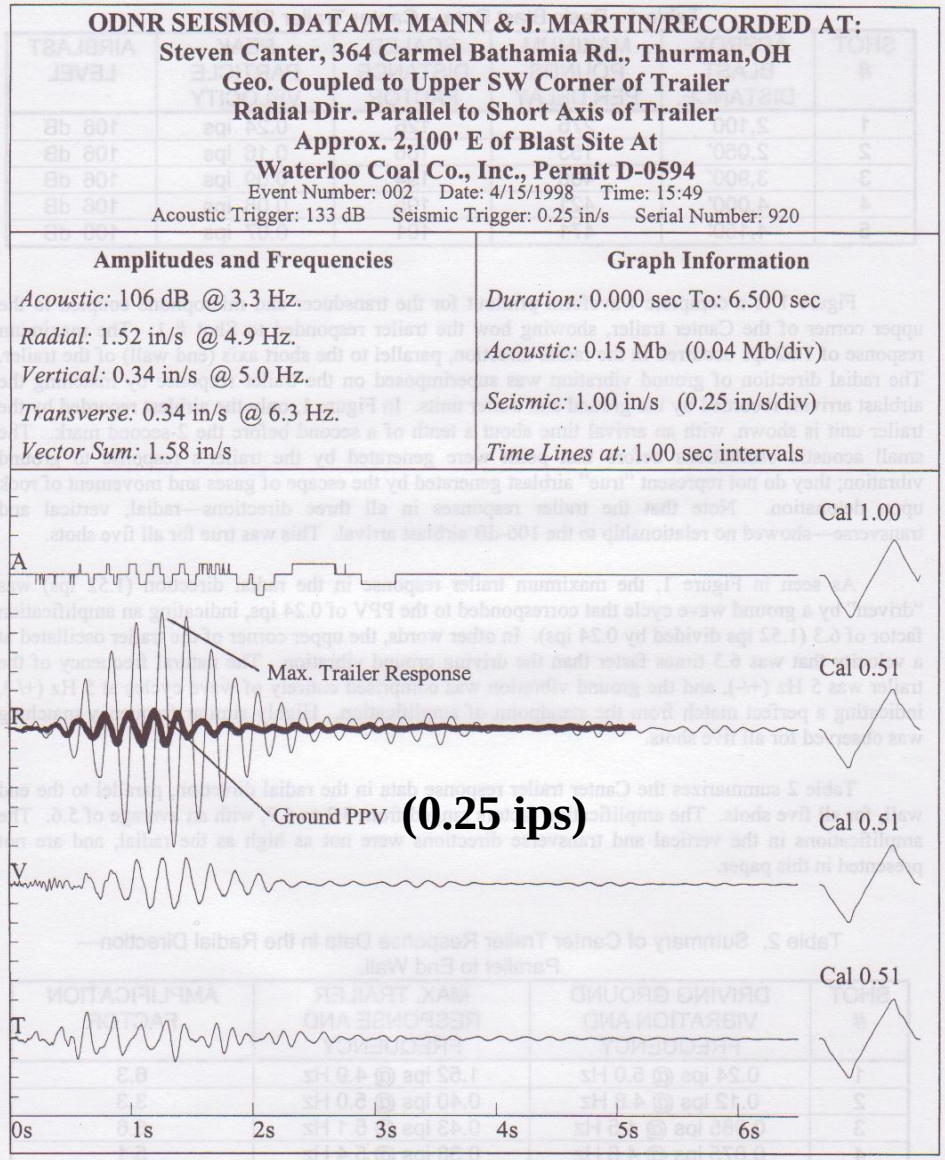


Figure 1.

Ground vibration at May trailer

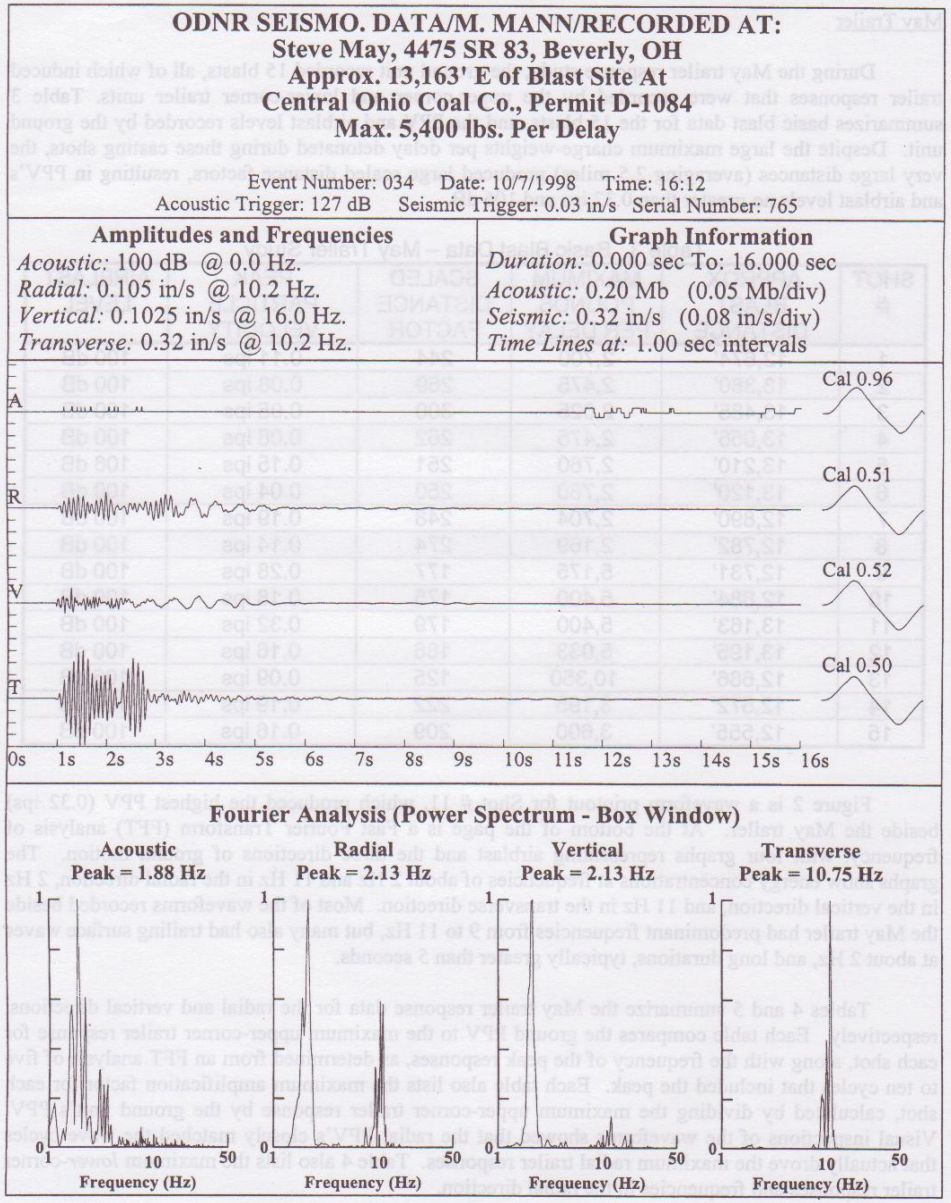


Figure 2.

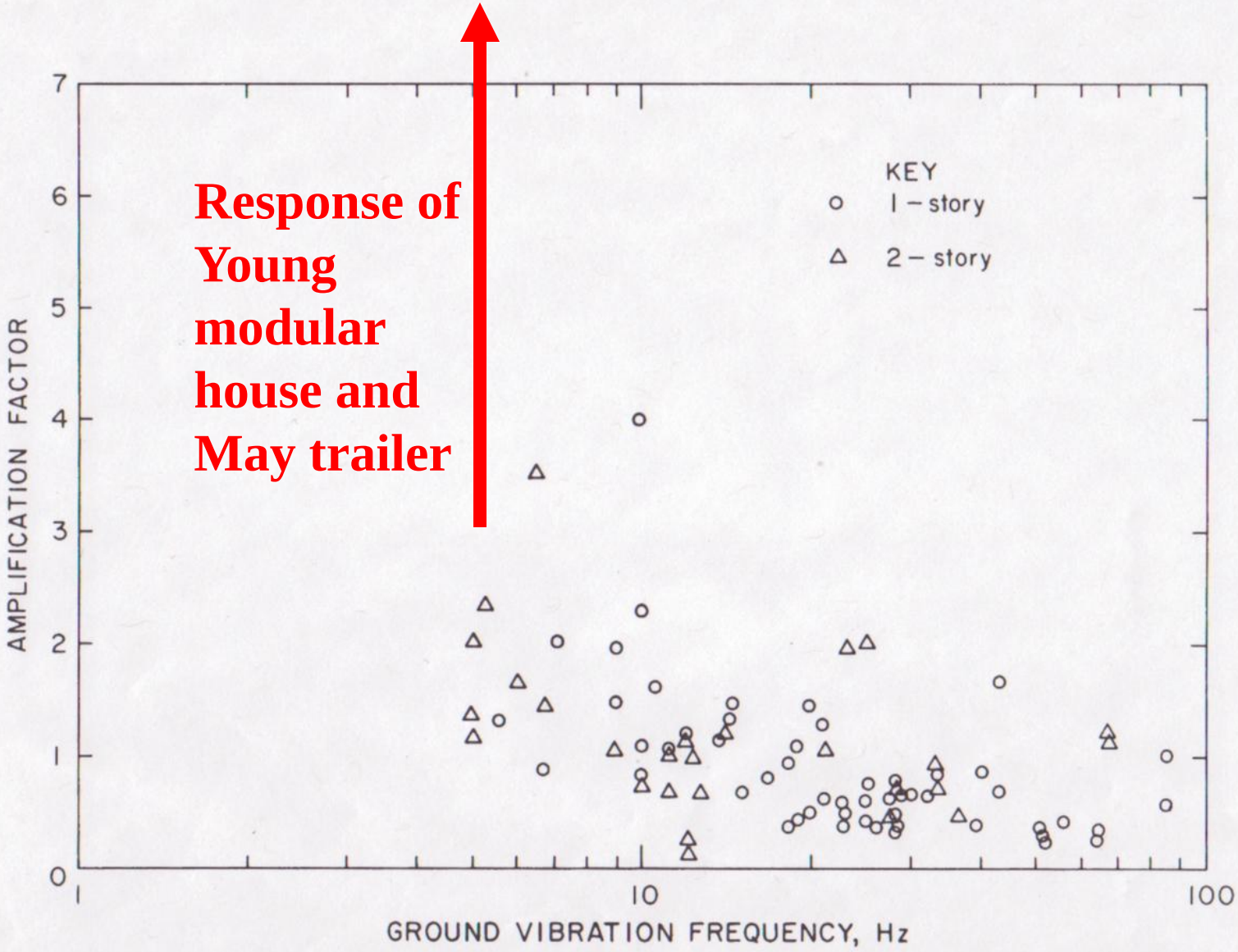
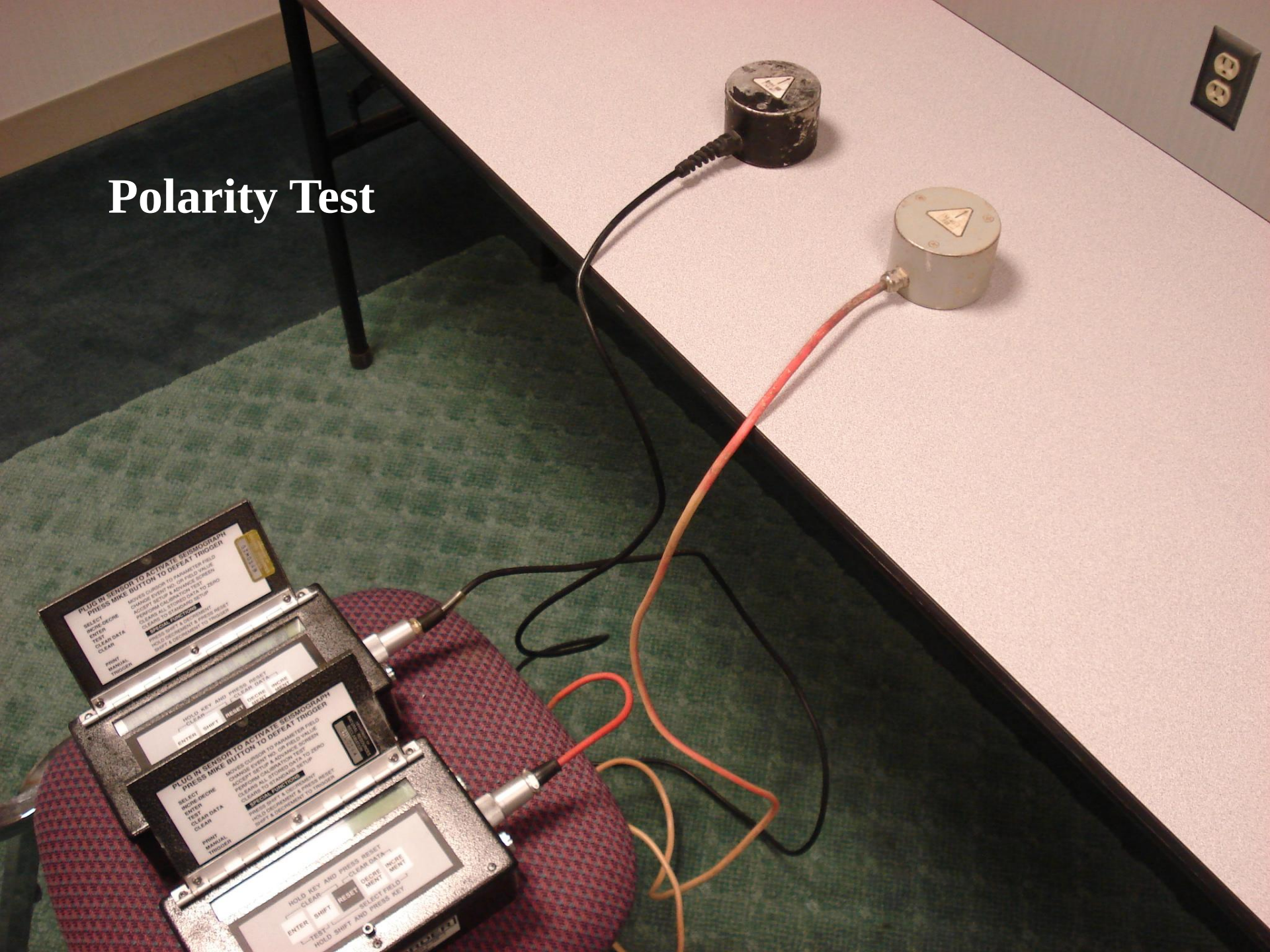


Figure 39.—Amplification factors for blast-produced structure vibration (corners), all homes.

(From RI 8507)

Structural Response Monitoring

Polarity Test

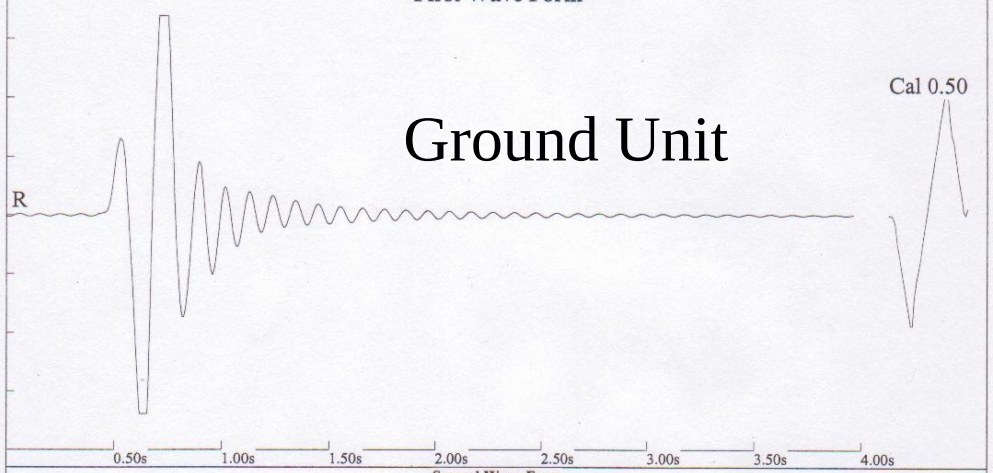


POLARITY TEST - RADIAL
Units 918 and 984

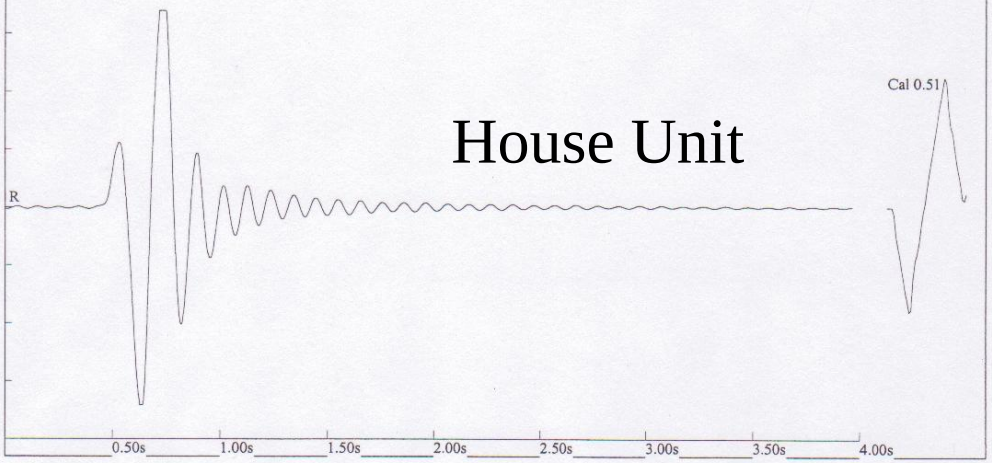
File Name: 918POLARITY001.DTB / 984POLARITY001.DTB
Number: 001 / 001
Date: 12/27/2007 / 12/27/2007
Time: 18:01 / 18:01
Serial Number: 918 / 984
Seismic Trigger: 0.4000 in/sec / 0.4000 in/sec
Acoustic Trigger: 130 dB / 130 dB
Sample Rate: 1024 / 1024
Record Duration: 5.0 Seconds / 5.0 Seconds
Pre-Trigger: 0.50 Seconds / 0.50 Seconds
Sensor Gain: 4x / 4x

First Wave Form	Second Wave Form
Radial: **2.5400 in/sec @ 4.6Hz**	***Radial:*** **2.5600in/sec @ 4.4Hz**

First Wave Form



Second Wave Form

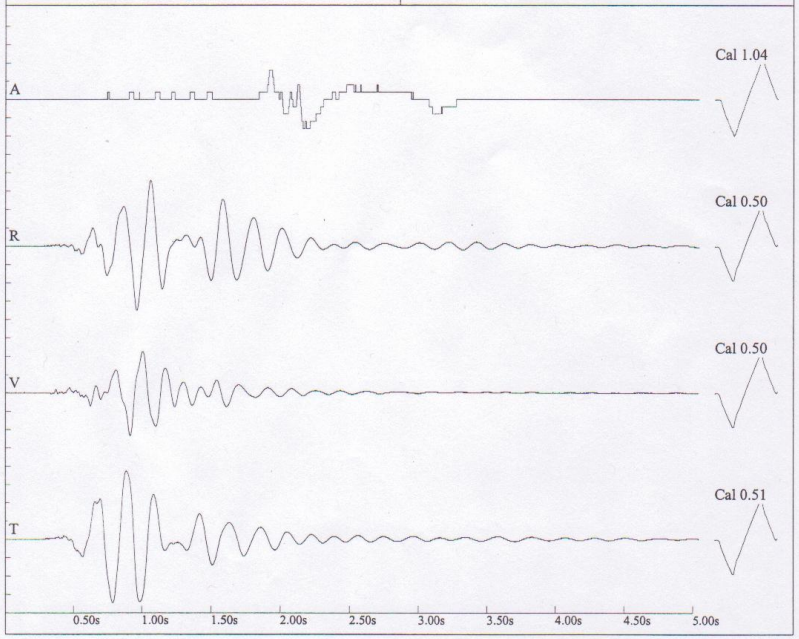


Ground Unit

ODNR SEISMO. DATA/MANN & KULLMAN/RECORDED AT:
Robert Finsley, 44910 Georgetown Rd., Cadiz, OH
GROUND Unit at SE Corner of Modular House
Radial Pointed W Along Rear of House
Nearest Blast Sites At:
Valley Mining, Inc., Permit D-2286

File Name: FINGC019.DTB
Number: 019
Date: 5/11/2007
Time: 15:46
Serial Number: 918
Seismic Trigger: 0.0200 in/sec
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 8.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 4x
Battery: 6.1

Amplitudes and Frequencies	Graph Information
Acoustic: 112 dB, 0.08 Mb @ 6.0 Hz	*Duration:* 0.000 s To: 5.000 s
Radial: 0.1800 in/sec @ 5.3Hz	*Acoustic Scale:* 120 dB
Vertical: 0.1175 in/sec @ 5.1Hz	*Seismic Scale:* 0.20 in/sec (0.050 in/sec/div)
***Transverse:* 0.1875 in/sec @ 4.9Hz**	*Time Line Intervals at:* 0.50 s
Displacement: 0.00595 in	
Acceleration: 0.01988 g's	

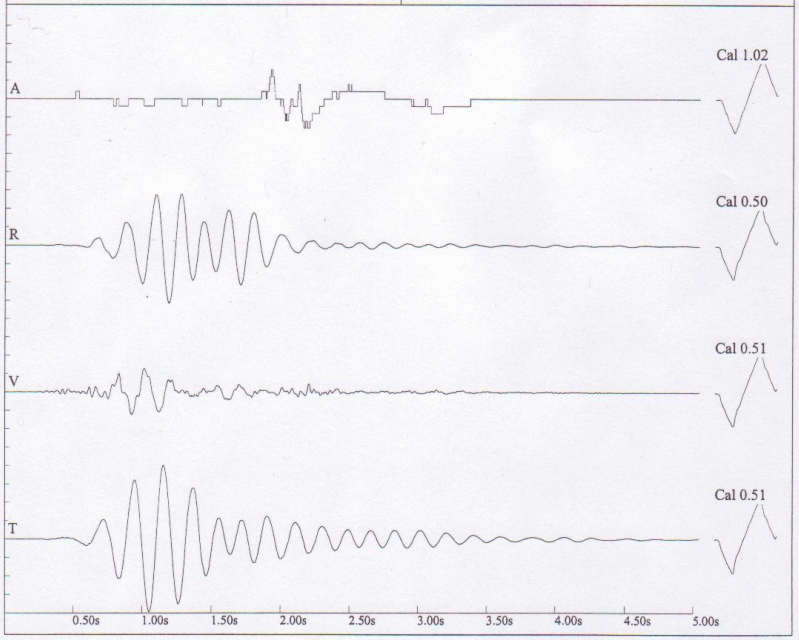


House Unit

ODNR SEISMO. DATA/MANN & KULLMAN/RECORDED AT:
Robert Finsley, 44910 Georgetown Rd., Cadiz, OH
HOUSE Unit at SE Corner, Fastened to Fascia Board
Radial Pointed W Along Rear of House
Nearest Blast Sites At:
Valley Mining, Inc., Permit D-2286

File Name: FINHC019.DTB
Number: 019
Date: 5/11/2007
Time: 15:46
Serial Number: 984
Seismic Trigger: 0.0200 in/sec
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 8.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 4x
Battery: 6.1

Amplitudes and Frequencies	Graph Information
Acoustic: 112 dB, 0.08 Mb @ 10.8 Hz	*Duration:* 0.000 s To: 5.000 s
Radial: 0.6500 in/sec @ 5.4Hz	*Acoustic Scale:* 120 dB
Vertical: 0.2600 in/sec @ 5.9Hz	*Seismic Scale:* 0.82 in/sec (0.205 in/sec/div)
***Transverse:* 0.8200 in/sec @ 4.6Hz**	*Time Line Intervals at:* 0.50 s
Displacement: 0.02290 in	
Acceleration: 0.09275 g's	



ODNR SEISMO. DATA/MANN & KULLMAN/RECORDED AT:
Robert Finsley, 44910 Georgetown Rd., Cadiz, OH
HOUSE Unit at SE Corner, Fastened to Fascia Board
Radial Pointed W Along Rear of House
Nearest Blast Sites At:
Valley Mining, Inc., Permit D-2286

File Name: FINHC019.DTB
Number: 019
Date: 5/11/2007
Time: 15:46
Serial Number: 984
Seismic Trigger: 0.0200 in/sec
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 8.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 4x
Battery: 6.1

Amplitudes and Frequencies	Graph Information
***Transverse:* 0.8200 in/sec @ 4.6Hz**	*Duration:* 0.000 s To: 5.000 s
Displacement: 0.02290 in	*Seismic Scale:* 0.85 in/sec (0.213 in/sec/div)
Acceleration: 0.09275 g's	*Time Line Intervals at:* 0.50 s

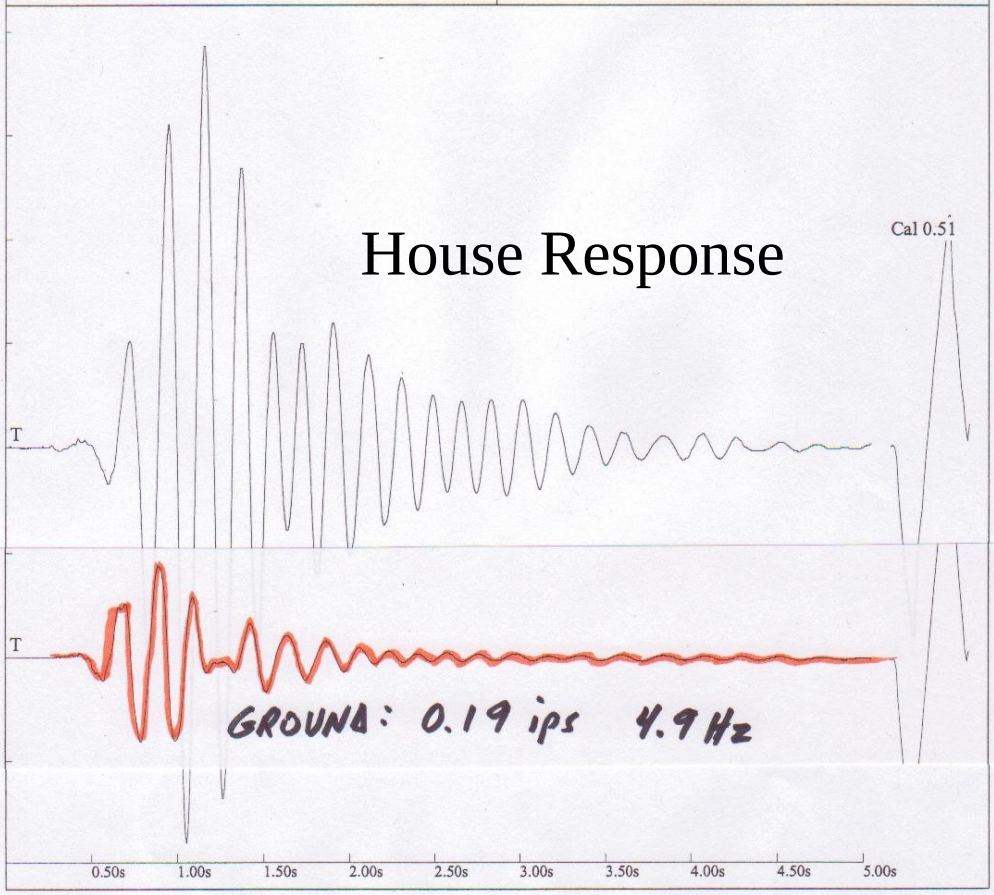


Table 1. Summary of FFT frequency data for the ground vibrations and house responses recorded at the Finsley modular house, in the Radial, Vertical and Transverse directions.

Blast Date	Record Time	Ground FFT (Hz)			House FFT (Hz)		
		R	V	T	R	V	T
4-14-07	11:17a	4.4	5.6	5.2	5.9	5.3	5.3
4-16-07	1:08 p	4.4	7.1	4.3	5.8	6.0	5.5
4-19-07	3:24 p	4.1	4.3	4.2	4.3	4.3	4.5
4-20-07	1:43 p	4.1	5.6	4.2	4.2	4.9	4.8
4-21-07	3:12 p	3.8	7.4	3.8	5.8	24.3	4.6
5-11-07	3:46 p	4.3	5.6	4.2	5.5	5.8	5.3
5-12-07	11:47a	4.2	5.8	4.1	4.3	5.8	5.4
5-14-07	9:25 a	4.2	5.6	5.6	5.6	5.6	5.4
5-14-07	3:34 p	4.1	8.3	5.5	4.3	5.3	5.2
5-16-07	3:52 p	4.3	7.4	4.3	6.5	4.9	4.9
5-17-07	3:17 p	3.8	5.6	3.4	3.8	5.3	4.8
5-18-07	12:11p	3.8	5.7	5.8	5.9	5.7	5.6
5-18-07	3:43 p	3.7	5.6	5.2	5.6	5.3	5.3
5-19-07	11:06a	3.9	7.3	3.4	3.9	24.3	5.3
6-9-07	12:14p	5.3	7.0	3.9	5.4	5.3	5.4
7-6-07	12:12p	3.5	7.0	5.5	5.5	5.8	5.5
7-16-07	1:24 p	4.3	4.3	4.3	4.3	4.5	4.8
7-17-07	1:23 p	7.0	7.5	4.3	7.0	4.5	4.3

Note: Based on FFT analysis, the typical frequency ranges were **4 to 7 Hz for the ground** vibrations, and **4 to 6 Hz for the whole-house motions**, with simple, sinusoidal-type wave cycles predominating most wave trains (ground and house).

Table 2. Summary of ground PPV's, house response velocities, and amplification factors at Finsley modular house, in the Radial, Vertical and Transverse directions.

Blast Date	Record Time	Ground PPV (ips)			House Velocity (ips)			Amplification Factor		
		R	V	T	R	V	T	R	V	T
4-14-07	11:17a	0.09	0.05	0.08	0.16	0.14	0.38	1.8	2.8	4.8
4-16-07	1:08 p	0.07	0.05	0.09	0.22	0.15	0.47	3.1	3.0	5.2
4-19-07	3:24 p	0.19	0.05	0.15	0.40	0.12	0.57	2.1	2.4	3.8
4-20-07	1:43 p	0.11	0.04	0.08	0.29	0.16	0.39	2.6	4.0	4.9
4-21-07	3:12 p	0.12	0.07	0.13	0.39	0.20	0.56	3.3	2.9	4.3
5-11-07	3:46 p	0.18	0.12	**0.19**	0.65	0.26	**0.82**	3.6	2.2	**4.3**
5-12-07	11:47a	0.16	0.07	0.13	0.42	0.20	0.33	2.6	2.9	2.5
5-14-07	9:25 a	0.15	0.13	0.13	0.56	0.30	0.54	3.7	2.3	4.2
5-14-07	3:34 p	0.16	0.08	0.18	0.50	0.20	0.67	3.1	2.5	3.7
5-16-07	3:52 p	0.09	0.10	0.17	0.27	0.23	0.52	3.0	2.3	3.1
5-17-07	3:17 p	0.13	0.08	0.21	0.23	0.18	0.63	1.8	2.3	3.0
5-18-07	12:11p	0.18	0.12	0.15	0.46	0.31	0.61	2.6	2.6	4.1
5-18-07	3:43 p	0.15	0.14	0.13	0.35	0.32	0.67	2.3	2.3	5.2
5-19-07	11:06a	0.14	0.07	0.13	0.45	0.37	0.42	3.2	5.3	3.2
							AVG:	**2.8**	**2.8**	**4.0**

REV 8/00

ODNR/Division of Mineral Resources Management

BLAST OBSERVATION SHEET

Seismograph Location: FINSLEY

DATE	TIME	*PERCEPTION	OBSERVER	LOCATION	OBSERVATIONS
EXAMPLE: 11-1-97	*1:53 PM*	*3*	*MJM*	*KITCHEN*	*RATTLED DISHES HARD, PICTURE FELL OFF WALL*
4-14-07	11:18AM	2	R.E.F.	KITCHEN	rattled windows Bookshelf curio & dishes in sink
4-16-07	1:09 PM	3	R.E.F.	LIVING ROOM	RATTLED WINDOWS, SHOOK WHOLE HOUSE, RATTLED CURIOS, BOOKSHELF
4-19-07	3:25PM	3	R.E.F.	KITCHEN	SHOOK FRIG. + STOVE SHOOK HOUSE RATTLED WINDOWS. RATTLED CABINETS RATTLED CURIO
4-20-07	1:45PM	1	R.E.F.	KITCHEN	SHOOK HOUSE + FRIG
4-21-07	3:13 PM	3	R.E.F.	COMPUTER ROOM	SHOOK FREEZER, DESK + SHOOK WHOLE HOUSE
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5-12-07	11:49AM	3	N.L.F. R.E.F.	FAMILY ROOM	shook whole house pulled nails holding pictures out of wall TV Entertainment center rocked
5-14-07	9:27AM	3	R.E.F.	LIVING ROOM	SHOOK WHOLE HOUSE BADLY, SHOOK + RATTLED CURIOS, SHOOK CELING FAN, RATTLED WINDOWS
5-14-07	3:37PM	3	R.E.F.	KITCHEN	SHOOK WHOLE HOUSE, ALSO SHOOK FRIG. + DISHES.
5-16-07	4:55PM	2	R.E.F.	KITCHEN	SHOOK WHOLE HOUSE. SHOOK FRIG + DISHES.

* Please rate the vibration as a 1, 2, or 3.
(1 = barely perceptible; 2 = unpleasant; and 3 = intolerable.)

GOD
BLESS OUR
HOME
HAVE A
GOOD
DAY
Wavy
Original

Hamilton Beach
OUR LOVE SHOULD NOT BE JUST WORDS & TALK IT MUST BE TRUE LOVE WHICH SHOWS ITSELF IN ACTION.
I will make Thy name

Cable from upper-corner seismograph

GOD
BLESS OUR
HOME
HAVE
A
GOOD
DAY

Refrigerator Response

ODNR SEISMO. DATA/M. MANN/RECORDED AT:
Robert Finsley, 44910 Georgetown Rd., Cadiz, OH
REFRIGERATOR Unit
Nearest Blast Sites At:
Valley Mining, Inc., Permit D-2286

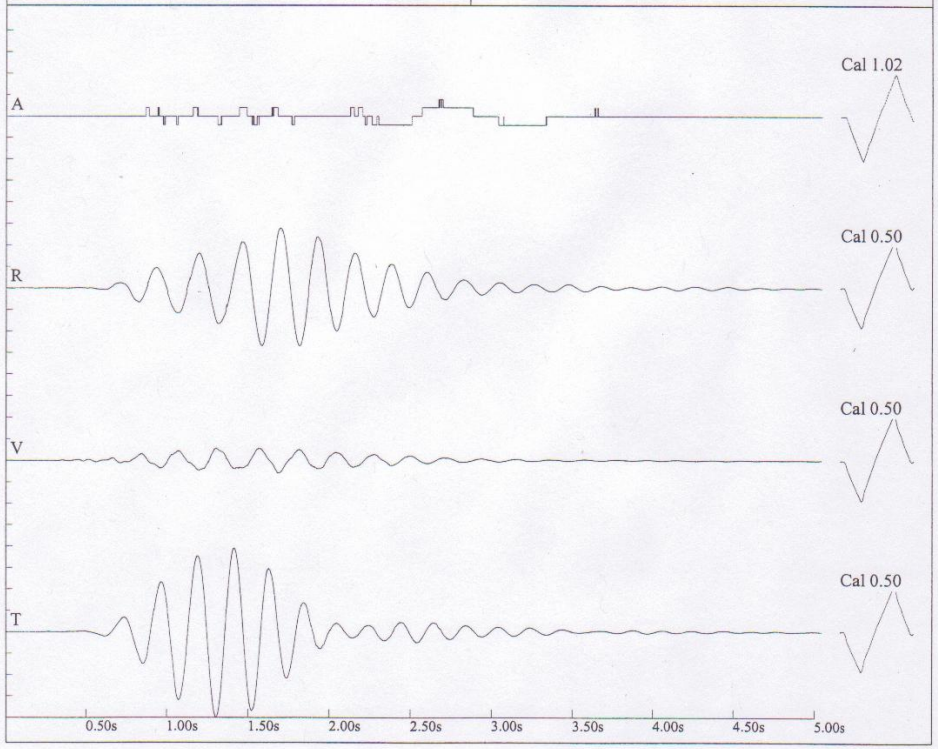
File Name: FRIDGA003.DTB
Number: 003
Date: 7/16/2007
Time: 13:24
Serial Number: 3599
Seismic Trigger: 0.0300 in/sec
Acoustic Trigger: 129 dB
Sample Rate: 1024
Record Duration: 8.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.8

Amplitudes and Frequencies

Acoustic: 106 dB, 0.04 Mb @ 0.0 Hz
Radial: 1.6200 in/sec @ 4.3Hz
Vertical: 0.3400 in/sec @ 4.5Hz
***Transverse:* 2.3200 in/sec @ 4.5Hz**
Displacement: 0.07413 in
Acceleration: 0.28489 g's

Graph Information

Duration: 0.000 s To: 5.000 s
Acoustic Scale: 120 dB
Seismic Scale: 2.32 in/sec (0.580 in/sec/div)
Time Line Intervals at: 0.50 s



ODNR SEISMO. DATA/M. MANN/RECORDED AT:
Robert Finsley, 44910 Georgetown Rd., Cadiz, OH
REFRIGERATOR BUMP TEST
Nearest Blast Sites At:
Valley Mining, Inc., Permit D-2286

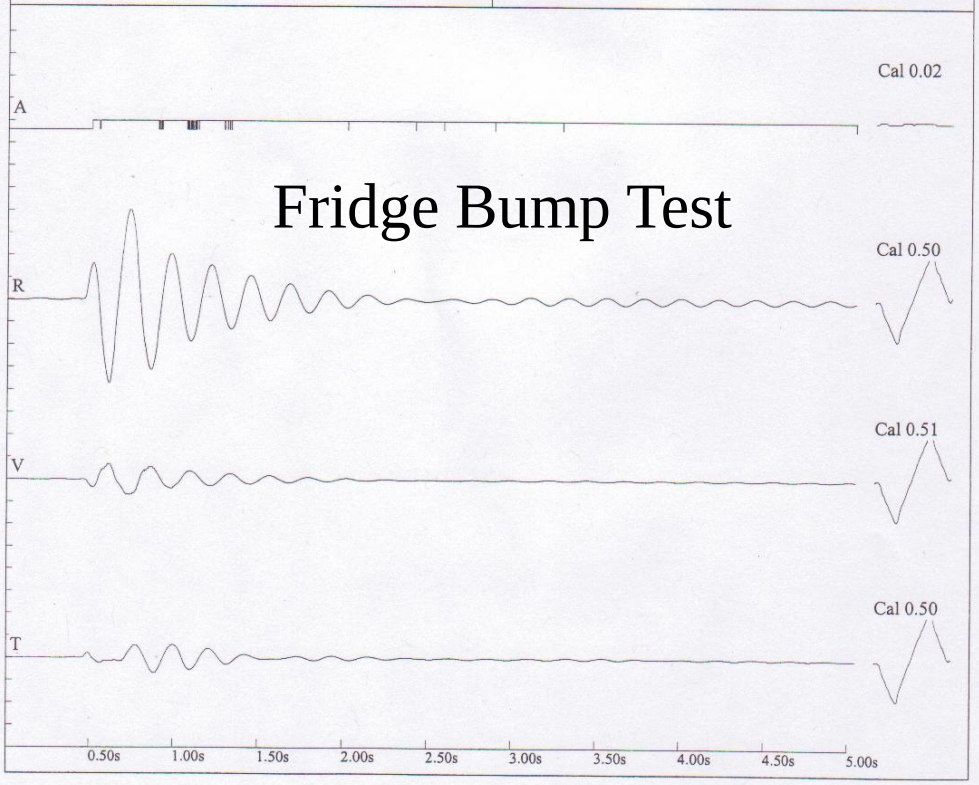
File Name: FRIDGEBUMP004.DTB
Number: 004
Date: 12/21/2007
Time: 16:14
Serial Number: 984
Seismic Trigger: 0.6375 in/sec
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 8.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 4x
Battery: 6.5

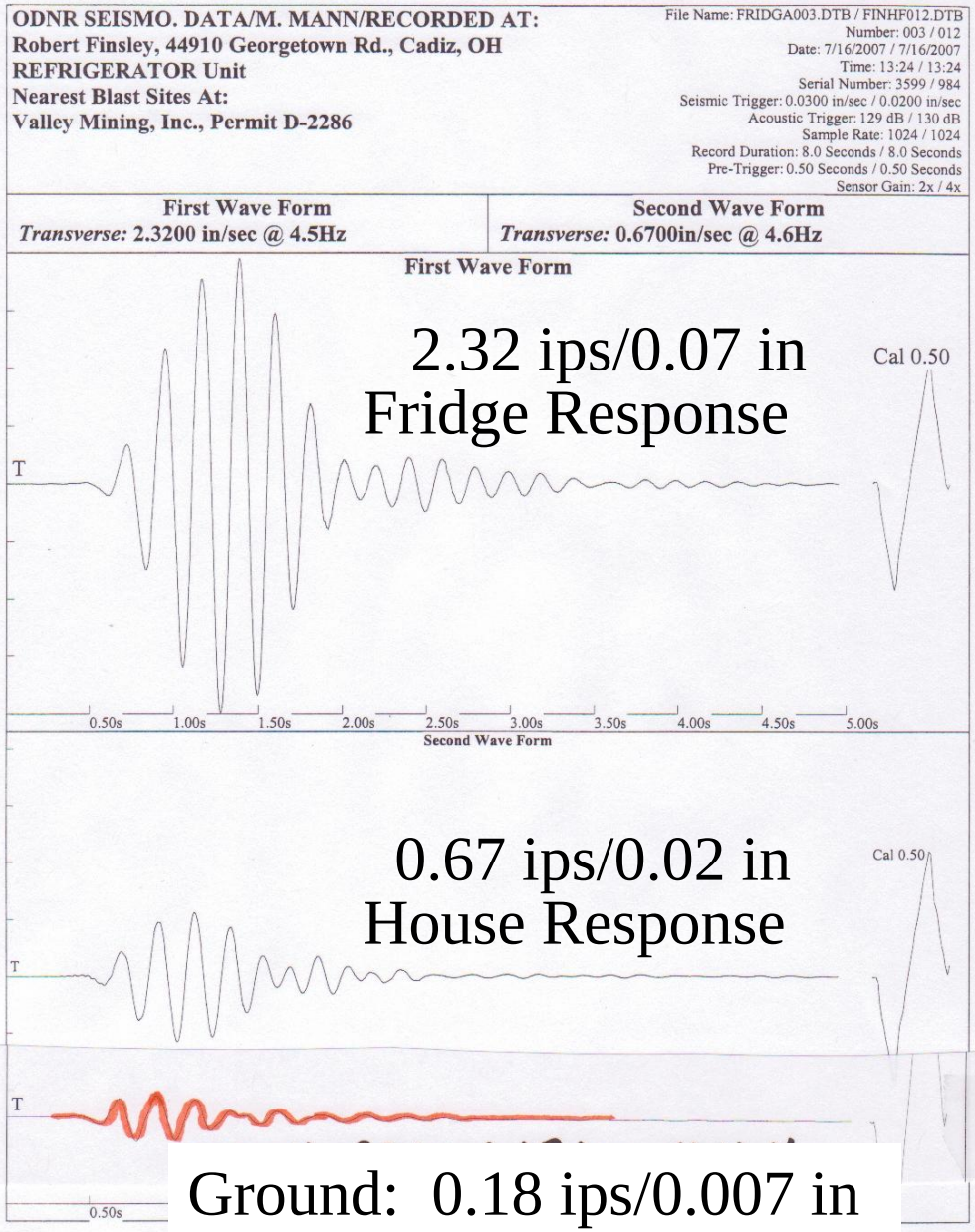
Amplitudes and Frequencies

Acoustic: 100 dB, 0.02 Mb @ 0.0 Hz
***Radial:* 2.3600 in/sec @ 3.8Hz**
Vertical: 0.4000 in/sec @ 4.7Hz
Transverse: 0.4000 in/sec @ 4.7Hz
Displacement: 0.09457 in
Acceleration: 0.33126 g's

Graph Information

Duration: 0.000 s To: 5.000 s
Acoustic Scale: 120 dB
Seismic Scale: 2.36 in/sec (0.590 in/sec/div)
Time Line Intervals at: 0.50 s





Ground: 0.18 ips/0.007 in (4.4 Hz)

Amplification Factors:

2.32/0.67 = 3.5x

0.67/0.18 = 3.7x

PLUG IN SENSOR TO ACTIVATE SEISMOGRAPH
PRESS DISARM SWITCH TO DISARM TRIGGER
SELECT MOVES CURSOR TO PARAMETER FIELD
- + CHANGE EVENT NO. OR FIELD VALUE
ENTER ACCEPT SETUP & ADVANCE SCREEN
TEST PERFORM CALIBRATION TEST
CLEAR DATA CLEARS ALL STORED DATA TO ZERO
CLEAR CLEARS TO STANDARD SETUP
SPECIAL FUNCTIONS
PRINT PRESS SHIFT & DECREMENT
MANUAL HOLD DECREMENT & PRESS RESET
TRIGGER SHIFT & DECREMENT TO TRIGGER
CLEAR
CLEAR DATA
MANUAL
ENTER
SHIFT
RESET
TRIGGER DISARM
TEST
TRIGGER
SELECT
ENTER TO WAKE
NEMIS
NCSG 2000
MINI-GRAPH
Petmate

Panasonic

Applying Science to the Human Perception Problem Can Help Us:

- Resolve damage claims
- Understand what actually happens that annoys homeowners and leads to fear of damage
- Be more sympathetic to complaints about loose objects moving and falling

Thank you for listening!

Mike Mann

330-339-2207

mike.mann@dnr.state.oh.us