February 7, 2023

Nick Nicholson
Stoll Keenon Ogden PLLC, Attorney Services
300 West Vine Street
Suite 2100
Lexington, KY 40507-1801

Vibra-Tech
9117 Leesgate Rd
Suite 100
Louisville, KY 40222
Phone 502.326.4144
Fax 502.326.4155

Ref: River Metals Recycling, Louisville, Kentucky Ground Vibration Analysis (6/4/22 – 1/6/23)

Dear Mr. Nicholson:

This letter reports the results of ground vibration monitoring conducted at River Metals Recycling (RMR) at 2045 River Rd, Louisville Kentucky from June 4, 2022, to January 6, 2023.

Summary

- Vibra-Tech Engineers installed five (5) seismic monitoring stations near the RMR property boundary on June 2nd, 2022. Each seismic monitoring station consists of a 4-channel digital seismograph calibrated to ensure compliance with the International Society of Explosive Engineers' recommended performance specifications for seismographs (2011).

- The seismic monitoring stations were programmed to continuously monitor ground vibration for seven months. Upon the occurrence of a seismic event, a high-resolution vibration time history recording is stored in the instrument's memory and then uploaded to Vibra-Tech computer servers for further analysis.

- Thirty-three (33) seismic events originating at the RMR shredder occurred over the seven-month (216 days) monitoring period from June 4, 2022 – January 6, 2023. Each event had a maximum duration of approximately one second.

- Comparison of the measured ground vibration amplitudes near the RMR property boundary with ground vibration guidelines from State of Kentucky Administrative Regulations “805 KAR 4:155” and The United States Bureau of Mines RI-8507 shows that vibration levels from the thirty-three seismic events are approximately 20 times below what is necessary to cause cosmetic cracking and damage to residential structures. This includes fatigue damage resulting from repeated vibrations.

- Ground vibrations at the neighborhoods and structures surrounding the RMR property will be less than what was measured at the property boundary, this follows the law of ground vibration attenuation with distance.

Introduction

River Metals Recycling (RMR) located at 2045 River Rd, in Louisville Kentucky is an industrial metal processing and recycling facility. Part of the RMR process includes the crushing and shredding of large metal products such as cars and trucks into smaller metal pieces. The mechanical device used for this process is known as a "shredder". Crushing and shredding scrap metal increases the remelting efficiency making it easier to reuse in future products. Sometimes, an event occurs that causes seismic waves "vibration", originating at the shredder traveling outward.

To address concerns of the community surrounding the RMR facility regarding vibrations at their structures originating from the "shredder", Vibra-Tech Engineers, Inc. was hired to measure ground vibration levels at the RMR property boundary and to compare these levels with government guidelines for vibration levels necessary to cause cosmetic damage to the surrounding structures.

This document reports the measurement of ground vibration from five remote seismic stations installed around the RMR facility near the property boundary for the period of June 4, 2022 – January 6, 2023, and a comparison of the measured vibration amplitudes from seismic events originating at the shredder with government guidelines regarding vibration levels necessary to cause cosmetic damage to the surrounding structures.

Equipment

Vibra-Tech Engineers completed the installation of five (5) seismic monitoring stations on the RMR property on June 2nd, 2022. Figure 1 illustrates the seismic station installation locations. The stations are installed around the facility near the RMR property boundary.

Each seismic monitoring station consists of a 4-channel digital seismograph calibrated to ensure compliance with the International Society of Explosive Engineers ISEE (2011) recommended performance specifications for seismographs, a solar panel for power, and a cellular modem for remote communications to Vibra-Tech Engineers' computer servers.

The seismic monitoring stations continuously monitor ground vibration, upon the occurrence of a seismic event, a high-resolution vibration time history recording is stored in the instrument's memory and then uploaded to Vibra-Tech computer servers for further analysis.

Complete seismic station performance specifications and example photographs of some of the installation locations are included below.

Table 1 Seismic Monitoring Station Locations

Station Name	Distance from Shredder (feet)	GPS Coordinates	
		North	West
Station #1	1145	38 16’ 17.06”	85 42’ 47.29”
Station #2	873	38 16’ 20.13”	85 42’ 40.49”
Station #3	813	38 16’ 27.90”	85 42’ 33.15”
Station #4	628	38 16’ 33.98”	85 42’ 40.74”
Station #5	1380	38 16’ 20.25”	85 42’ 57.71”

Figure 1 Seismic Monitoring Station Locations River Metals Recycling 2045 River Rd Louisville, Kentucky (6-2-2022)

Data Analysis and Results

Thirty-three (33) seismic events originating at the RMR shredder occurred over the seven-month monitoring period of June 4, 2022 – January 6, 2023. Each event had a maximum duration of less than one second. **Table 2** shows the time and date of the seismic events.

Table 2 Seismic Events Originating at RMR Facility (June 4, 2022 – January 6, 2023)

Event Number	Date and Time	Duration (Seconds)
1	6/27/2022 2:00	<1
2	7/27/2022 9:15	<1
3	8/10/2022 12:34	<1
4	8/15/2022 13:05	<1
5	8/23/2022 14:59	<1
6	9/2/2022 7:26	<1
7	9/22/2022 10:11	<1
8	10/4/2022 8:10	<1
9	10/10/2022 8:02	<1
10	10/12/2022 14:34	<1
11	10/17/2022 9:45	<1
12	10/17/2022 14:36	<1
13	10/24/2022 8:15	<1
14	10/25/2022 12:16	<1
15	11/10/2022 12:51	<1
16	11/14/2022 12:54	<1
17	11/17/2022 9:46	<1
18	11/22/2022 9:42	<1
19	11/23/2022 13:12	<1
20	11/29/2022 12:11	<1
21	11/30/2022 10:17	<1
22	12/8/2022 13:06	<1
23	12/8/2022 14:44	<1
24	12/9/2022 15:37	<1
25	12/13/2022 14:22	<1
26	12/14/2022 13:38	<1
27	12/15/2022 14:46	<1
28	12/19/2022 13:03	<1
29	12/19/2022 14:55	<1
30	12/20/2022 8:16	<1
31	12/20/2022 8:23	<1
32	12/27/2022 12:16	<1
33	1/6/2023 10:11	<1

All measured ground vibration events are compared with the State of Kentucky Administrative Regulations "805 KAR 4:155 Ground vibration standards for surface coal mines" for the protection of structures from blasting-induced ground vibration. This Kentucky vibration standard follows recommendations from the U.S. Bureau of Mines (USBM) RI-8507 guidelines discussed later in this report.

The next three pages contains the following figure and tables analyzing the data from the ground vibration events and compliance with the above standards:

Table *3* summarizes the ground vibration level measurements for all seismic events.

Table *4* shows the summary statistics for each monitoring location.

Figure 2 shows the seismic events (green dots) are approximately 20 times below what is necessary to cause cosmetic cracking and damage to residential structures (orange line). This includes fatigue damage resulting from repeated vibrations.

Based on a statistical analysis of the measured ground vibration, over 99% of all future ground vibrations from the shredder are expected to be 0.027 in/sec or lower at the closest property boundary. This amplitude is 19 times below what is necessary to cause cosmetic cracking and damage to residential structures. Ground vibrations at the neighborhoods and structures surrounding the RMR property will be less than what was measured at the property boundary; this follows the law of ground vibration attenuation with distance.

Table 3 Summary of Seismic Events Originating at RMR Facility (June 4, 2022 - January 6, 2023)

Event Number	Date and Time	Seismic Station #1 Ground Vibration PPV (in/sec)	Seismic Station #2 Ground Vibration PPV (in/sec)	Seismic Station #3 Ground Vibration PPV (in/sec)	Seismic Station #4 Ground Vibration PPV (in/sec)	Seismic Station #5 Ground Vibration PPV (in/sec)
1	6/27/2022 2:00	0.01	0.01	0.013	0.023	0.01
2	7/27/2022 9:15	0.01	0.01	0.013	0.02	*
3	8/10/2022 12:34	0.013	0.013	0.018	0.02	< 0.05
4	8/15/2022 13:05	0.01	0.008	0.008	0.01	< 0.05
5	8/23/2022 14:59	0.01	0.008	0.01	0.015	< 0.05
6	9/2/2022 7:26	0.013	0.015	0.018	0.02	0.013
7	9/22/2022 10:11	0.01	0.008	0.01	0.015	0.013
8	10/4/2022 8:10	0.01	0.01	0.013	0.018	0.01
9	10/10/2022 8:02	0.01	0.008	0.008	0.013	0.013
10	10/12/2022 14:34	0.008	0.01	0.013	*	0.008
11	10/17/2022 9:45	0.008	0.008	0.008	0.013	0.008
12	10/17/2022 14:36	0.01	0.013	0.015	0.018	0.01
13	10/24/2022 8:15	0.015	0.01	0.01	0.015	0.015
14	10/25/2022 12:16	0.008	0.008	0.008	0.015	*
15	11/10/2022 12:51	0.01	0.01	0.018	0.02	0.01
16	11/14/2022 12:54	0.01	0.013	0.015	0.018	0.01
17	11/17/2022 9:46	0.013	0.008	0.01	0.013	0.01
18	11/22/2022 9:42	0.013	0.008	0.01	0.018	0.01
19	11/23/2022 13:12	0.01	0.008	0.008	0.01	0.008
20	11/29/2022 12:11	0.008	0.01	0.0125	0.015	0.008
21	11/30/2022 10:17	0.01	0.008	0.01	0.015	0.01
22	12/8/2022 13:06	0.013	0.01	0.0125	0.0175	0.01
23	12/8/2022 14:44	0.01	0.008	0.008	0.013	0.01
24	12/9/2022 15:37	0.008	0.008	0.01	0.015	0.008
25	12/13/2022 14:22	0.01	0.01	0.01	0.0175	0.01
26	12/14/2022 13:38	0.01	0.01	0.01	0.015	0.013

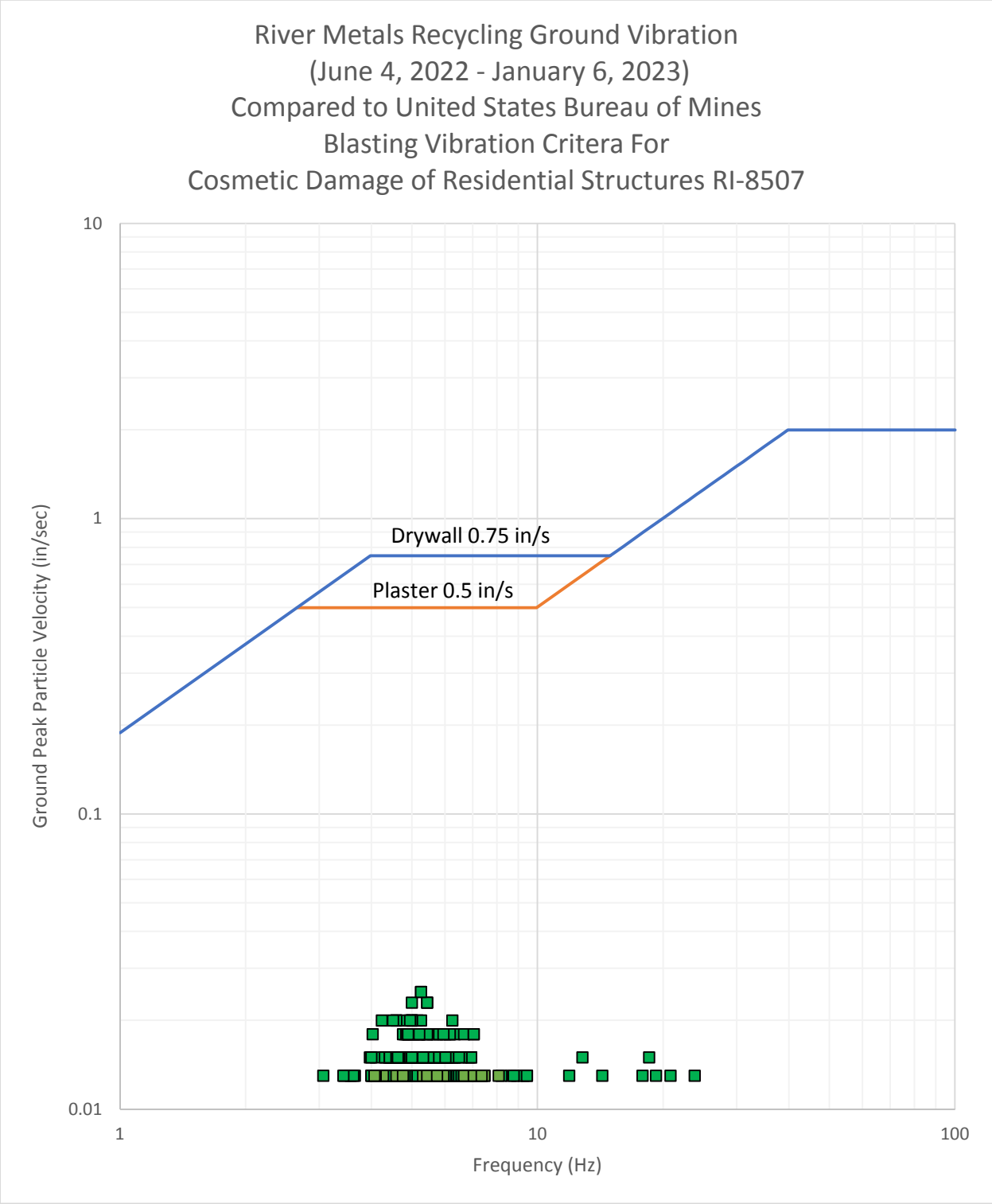
Event Number	Date and Time	Seismic Station #1 Ground Vibration PPV (in/sec)	Seismic Station #2 Ground Vibration PPV (in/sec)	Seismic Station #3 Ground Vibration PPV (in/sec)	Seismic Station #4 Ground Vibration PPV (in/sec)	Seismic Station #5 Ground Vibration PPV (in/sec)
27	12/15/2022 14:46	0.008	0.008	0.01	0.013	0.005
28	12/19/2022 13:03	0.0125	0.0125	0.015	0.02	0.01
29	12/19/2022 14:55	0.01	0.0125	0.015	0.0175	0.01
30	12/20/2022 8:16	0.01	0.01	0.0075	0.01	0.01
31	12/20/2022 8:23	0.0125	0.0125	0.015	*	0.01
32	12/27/2022 12:16	0.013	0.013	0.013	0.025	0.01
33	1/6/2023 10:11	0.01	0.008	0.008	0.01	0.008

*Instrument did not record the event.

Table 4 Summary Statistics of Seismic Events Originating at RMR Facility (June 4, 2022 - January 6, 2023)

Seismic Station	Distance (ft)	Maximum Ground Vibration PPV (in/sec)	Average Ground Vibration PPV (in/sec)	Standard Deviation Ground Vibration PPV (in/sec)	Predicted Future Ground Vibration 99% Confidence PPV (in/sec)
1	1145	0.015	0.0105	0.00183	0.016
2	873	0.015	0.0099	0.00206	0.016
3	813	0.018	0.0116	0.00319	0.021
4	628	0.025	0.016	0.00378	0.027
5	1380	0.015	0.010	0.00202	0.016

Figure 2 Comparison of Measured Ground Vibration at RMR Property Boundary with 805 KAR 4:155 and USBM RI-8507 Safe Vibration Limits to Prevent Damage to Residential Structures



Ground Vibration Criteria from USBM RI-8507

The U.S. Bureau of Mines has studied various aspects of ground vibration. The culmination of over 50 years of research was compiled into RI-8507[1], entitled "Structure Response and Damage Produced by Ground Vibrations from Surface Mine Blasting". In this study, direct measurements of structural response and damage from actual surface-mine production blasting were observed in 76 residences for 219 production blasts. This data along with damage data from six additional studies were combined with the historical data from an earlier report entitled Bulletin 656. Emphasis was placed on the frequency dependence of structure response and its relationship to damage.

The culmination of this study was the Appendix B curve which was entitled "Alternative Blasting Level Criteria". The Appendix B curve used both measured structure amplification and damage evaluations to develop criteria that involved both displacement and velocity. This curve (Figure 3) shows that above 40 Hz, a constant peak particle velocity of 2.0 in/sec is the maximum safe value. This level was established to protect the interior walls and ceilings of structures, regardless of construction material.

Below 40 Hz, however, the maximum velocity decreases at a rate equivalent to a constant peak displacement of 0.008 inches. For intermediate frequencies (4 to 12 Hz), a 0.5 inch per second maximum particle velocity is the accepted level to preclude 'threshold' damage to the plaster-on-wood-lath interior portions of older structures. **Threshold damage is defined by the USBM as the loosening of paint, small plaster cracks at joints between construction elements, or the lengthening of old plaster cracks.**

A maximum of 0.75 inches per second is the accepted level for the protection of modern drywall interior construction. The damage threshold is normally considerably higher for load-bearing or other structural portions of a house. An ultimate maximum displacement of 0.03 inches is recommended when frequencies below 4 Hz are encountered.

Using this method, the Bureau was able to recognize the displacement-bound requirement for house responses to blast vibrations and provide a smooth transition for intermediate frequency cases.

[1] Siskind, David et al, Structural Response and Damage Produced by Ground Vibration from Blasting, U.S. Bureau of Mines, RI 8507, 1980.

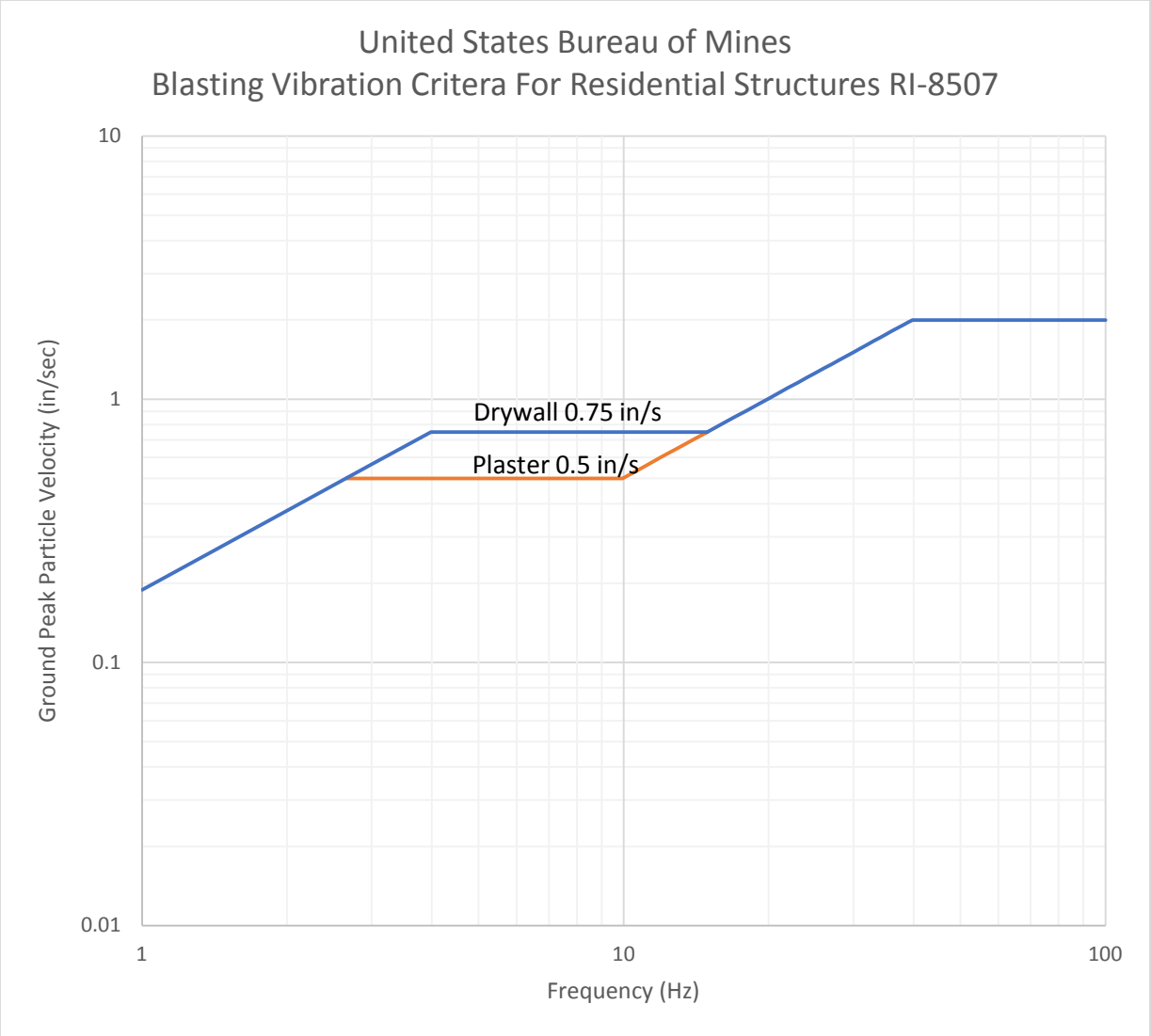


Figure 3 USBM Blasting Vibration Criteria for Residential Structures

Research on Repeated Vibrations from RI-8896

Homeowner reaction to the research used to develop the Appendix B curve in RI-8507 is typically met with skepticism. Residents often counter the fact that their homes are repeatedly being subjected to vibration loads and that there must be a cumulative effect on the structure. In 1984, the USBM published RI-8896 entitled, "Effects of Repeated Blasting on a Wood Frame House". This study was the first to document the long-term strain response of a house. Strain is an engineering measure of deformation used to predict failure. A strain of 1 mil/in. indicates that on average, every inch of material was stretched or compressed one-thousandth of an inch. For example, the length of an eight-foot-long section of wallboard would change by approximately ± 0.1 in. Long-term strain measurements allowed blast-induced strains to be compared with those produced by changes in environmental factors such as temperature, humidity, and human activity.

During this study, the Bureau arranged to have a wood-frame test house built in the path of an advancing surface coal mine so that the effects of repeated blasting on a residential house could be studied. In a two-year test period, 587 production blasts were fired with peak particle velocities ranging from 0.10 in/sec to 6.94 in/sec. The blasting studies brought the mine's high wall within 200 feet of the test house. The USBM then supplemented the blasting results with mechanical shaking tests to accelerate fatigue. The worst-case scenario was tested by shaking the structure at its natural frequency. The first crack appeared in a drywall tape joint after the equivalent of 56,000 cycles of motion.

Conclusions in RI-8896 indicate that threshold-type cracks appeared in the test house with and without blasting. Because of this, the researchers felt that observations of individual cracks were not the best indicator of the effects of blasting. The better indicator would be observations of the rate of threshold crack occurrences. In this study, the rate of threshold cracking when ground motions were less than 0.50 in/sec was not significantly different than when motions were between 0.50 and 1.0 in/sec. However, when ground motions exceeded 1.0 in/sec within the frequency range of residential structures, the rate of crack formation was more than three times the rate observed when vibrations were less than 1.0 in/sec.

Construction materials can fail by fatigue. However, for most materials, the stresses must be a significant fraction of the ultimate strength of the material for this to occur. Siskind states that in general, it must be at least 50%. He further states that load levels well below failure strength will not produce failure no matter how long they are applied**. In terms of the ground vibration criteria developed in RI-8507, if ground vibrations are kept below the safe level no fatigue for repeated vibrations could be expected for construction materials.**

Research on Block/Concrete Construction

The U.S. Bureau of Mines and various other investigators have studied the dynamic effects of blast-induced ground vibrations on both concrete and block walls. A study by the USBM entitled, "Effects of Repeated Blasting on a Wood-Frame House" observed localized cracks at interfaces of mortar joints of brick or concrete blocks at peak ground vibrations of 3.4 in/sec. Similar studies by the Canadian Building Research Council also found that block walls always failed along mortar joints, due to the failure of the bond between the mortar and the blocks. The particle velocity at which this failure took place was around 3.0 in/sec.

In these studies, poured concrete walls were found to be much stronger than concrete block walls. Poured concrete walls showed no visible signs of damage until the particle velocity approached 10.0 in/sec. The failure of the poured concrete walls was sudden and consisted of large cracks originating at the junction of two walls.

Finally, none of the United States Bureau of Mines, Swedish, Canadian, or UK blasting studies, including those achieving 5 to 10 in/sec vibration, found a case of horizontal masonry slab cracking8507[2].

[2] David E. Siskind, Ph.D. "Vibrations from Blasting" ISEE publication, 2000, page 64

Conclusion

- Vibra-Tech Engineers installed five (5) seismic monitoring stations near the RMR property boundary on June 2nd, 2022. Each seismic monitoring station consists of a 4-channel digital seismograph calibrated to ensure compliance with the International Society of Explosive Engineers' recommended performance specifications for seismographs (2011).

- The seismic monitoring stations were programmed to continuously monitor ground vibration for seven months. Upon the occurrence of a seismic event, a high-resolution vibration time history recording is stored in the instrument's memory and then uploaded to Vibra-Tech computer servers for further analysis.

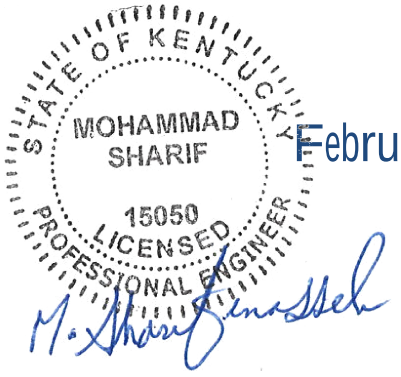
- Thirty-three (33) seismic events originating at the RMR shredder occurred over the seven-month (216 days) monitoring period from June 4, 2022 – January 6, 2023. Each event had a maximum duration of approximately one second.

- Comparison of the measured ground vibration amplitudes near the RMR property boundary with ground vibration guidelines from State of Kentucky Administrative Regulations “805 KAR 4:155” and The United States Bureau of Mines RI-8507 shows that vibration levels from the thirty-three seismic events are approximately 20 times below what is necessary to cause cosmetic cracking and damage to residential structures. This includes fatigue damage resulting from repeated vibrations.

- Ground vibrations at the neighborhoods and structures surrounding the RMR property will be less than what was measured at the property boundary, this follows the law of ground vibration attenuation with distance.

Sincerely,

Vibra-Tech Engineers, Inc.



February 10, 2023

Brian Warner

Senior Engineer, Structural Dynamic Analyst

Acoustic & Vibration Specialist

Appendix A
Monitoring Equipment Specifications

GeoSonics

Ip2 and IpWR Re:mote Blasting Monitoring Seismographs

GeoSonics Internet Protocol Seismic Remote Specifications

Ip2 and IpWR Remote Blast Monitoring Seismographs

Velocity measurements-

Resolution:	0.0025 in/sec. (0.06 mm/sec.).
Range:	0.003 to 5.120 in/sec. (130 mm/sec.), (other ranges available)
Frequency Response:	2 to 250 Hz (3 dB) / 2 to 1,000 Hz (Nyquist).
Sampling Rate:	1, 2 or 3 milliseconds.

Accuracy: 5% within one year (multi-frequency calibrated).*
Calibration: Internal dynamic.

Air over-pressure measurements-

Resolution:	0.0000178 psi
Range:	78dB – 142dB, (other ranges available)

Frequency Range (3 dB): 2 to 250 Hz (3 dB) / 2 to 1,000 Hz (Nyquist).

Accuracy: 10% (1dB) within one year (multi-frequency calibrated).*
Calibration: Internal electronic.

Sound Trigger: Range (Linear): 81 to 142 dB. / Off

Vibration Trigger: Selectable- 0.005 to 5.120 Ips / Off

System Time: System time is GMT (UTC) with provisions for storing preferred time zone, (typically, local recording time) for report generation.

Operational Modes: Continuous Monitor (Histogram), Triggered mode (waveform recording) and Dual Mode

Continuous (Histogram):

- Vibration Data: Peak particle velocity and frequency for L, T & V
- Sound Data (Linear): 78 to 142 dB.
- Recording Intervals: Selectable: 1 to 60 seconds

Time History Recordings- (Triggered mode operation): When data is collected as time history recordings, the unit continually scans at the appropriate sampling rate (0.5,1,2 or 3 milliseconds) and holds the most current 500 samples for pre-trigger data. On trigger exeedance, pre-trigger data is written to the record and data collection continues until selected record time has elapsed (including pre-trigger).

- 1 to 2.5 sec. - 500 microsecond sampling (2000sps)
- 2.6 to 5 sec. - 1 millisecond sampling (1000sps)
- 6 to 10 sec. - 2 millisecond sampling (500sps)
- 11 to 15 sec. - 3 millisecond sampling (333sps)

Multiple part time history records: Consecutive waveform recordings up to 2-1/2 minutes.

Dual Mode:

- When initiated in Dual-mode - unit begins to record an interval peak histogram (without freq.) according to instrument setup
- On trigger exceedance, unit closes histogram, records a time-history, according to setup, on completion, unit initiates a new histogram.
- Pre-trigger data of waveform contains last 500 samples of preceding histogram.

Data Storage Capacity: Ip Interface Controller archives all recordings for up to 2 years or until remotely managed or manually cleared.

* GeoSonics Blast Monitoring Seismographs are manufactured, tested and calibrated to insure compliance with the ISEE recommended Performance Specifications for Blasting Seismographs, 2011 Edition.

GeoSonics, Inc.
359 Northgate Drive, Warrendale, PA 15086
800-992-9395 www.geosonics.com

Vibration Monitoring Equipment Example Photographs