DETONATION SAFETY ENGINEERING
P.O. BOX 173
KEENE, KY 40339
PHONE (859) 312-0625
FAX (859) 223-1762

Review of
Blasting Attenuation Study,
Structure Response Study,
Proposed Blasting Ordinance and
Current Blasting Ordinance,

August 12, 2005

Prepared for the
City of Henderson, NV

Prepared by:
Larry Schneider P.E.

Detonation Safety Engineering

INTRODUCTION

Pursuant to an agreement with the City of Henderson, Nevada, a examination of four documents was undertaken in order to evaluate the technical studies completed by Aimone-Martin Associates LLC and to review the current and proposed blasting ordinances. The documents were provided by Assistant City Attorney Mark Zalaoras and included the following:

1. Blasting Attenuation Study
   Crystal Ridge, MacDonald Ranch, and McDonald Highlands
   Prepared by Catherine T. Aimone-Martin, May 27, 2005
2. Stucture Response Study
   Crystal Ridge, MacDonald Ranch, and McDonald Highlands
   Prepared by Catherine T. Aimone-Martin, May 27, 2005
3. Draft Ordinance of Blasting Regulations to the Henderson Municipal Code
4. Section 7705 Development-Related Blasting Activities

The Aimone-Martin studies were evaluated on their technical validity and relevance of their conclusions as related to the data obtained. The proposed ordinance was assessed based upon its effectiveness in achieving the goals expressed in its preamble, as well as its potential impact upon the safety of blasting for development within the City of Henderson. The current regulation was assessed based upon the same criteria.

BLASTING ATTENTUATION STUDY

This study of the seismic and airblast energy from blasting operations in the Henderson area was done by Aimone-Martin Associates in order to evaluate the blasting being conducted, verify the seismograph measurements being taken, and to determine if any geological influence or blasting methodology existed that could produce unusual or unpredictable results.

The first section of this study is a description of the blasting operations conducted in the Henderson area, the seismograph monitoring procedures, and the site where the study took place. The drilling and blasting methodology and explosives used are typical of construction practices in use throughout the country. Likewise if the use of seismographs to monitor off-site vibration and air blast is done in accordance with the International Society of Explosives Engineers Standards for Field Practice as cited by the Aimone report, there should be no concern over the methods of use or the accuracy of the results.

The Aimone-Martin's evaluation of the site geology including the soil analysis is very thorough, and indicates nothing of concern as far as blasting related problems. In fact, as described, the soil stability and lack of clays and moisture represent an area less prone to blast damage than most other areas.

In the subsequent pages of the report, the necessity of statistical regression analysis is explained and the methodology used in this study is detailed. The quality and validity of any regression study depends upon having sufficient data covering a wide enough range to represent all charge weights and distances that could be of concern. It is commonly accepted that for blast vibrations or air blast regression analysis, at least 30 data points are needed for a statistically significant results. The Aimone-Martin study has a minimum of 81 data points listed in the Appendix, though not all of those points were used in the regression development.

Furthermore, this data covered both close-in and far distances with a wide variety of charge weights. Blasts were monitored at a minimum distance of 40 feet to a maximum of over 6700 feet to a blast. The charge weights monitored ranged from a low of 9 lb/delay to a high of 1040 lb/delay. This is an impressive range of both distances and charge weights and allows the creation of a regression analysis that is more universally applicable than is often the case.

The purpose of a regression analysis is to find the relationship (an equation) relating the intensity of the ground vibrations (or air blast) to an independent variable called "scaled distance." Due to the wide range of data available in the Aimone-Martin study, it was possible to plot scaled distances from 4.1 $ft/lb^{1/2}$ to over 800 $ft/lb^{1/2}$) . I would emphasize that this is an excellent collection of data, allowing predictions over a correspondingly large range of scaled distances.

To confirm the results of the attenuation study, I used the data points listed in the Appendix of the Aimone-Marin report to plot several regression models, which are included as attachments to this report. Dr. Aimone-Martin found best fit equations for a number of different data sets, which she describes in detail, and from which she draws conclusions. My regression plots produced different equations and correlation coefficients, but these differences in these values are due to the fact that I plotted all the raw data contained in the appendix, whereas the Aimone-Martin report drew the regression line through only data points for which they had verifiable charge weight and distance values and discarded questionable seismic data.

Without access to the actual seismic waveforms, I could not make such distinctions and there are some obviously problematic data points contained in the appendix. For example, a recording on 4/12/2005 showing a PPV of 0.25 in/sec at a scaled distance of 648.4 $ft/lb^{1/2}$ is highly improbable.

However, even a casual comparison of the regression plots in this report to the ones in the Aimone-Martin study should make it clear that the relationship between peak particle velocity and scaled distance is sufficiently well documented to support the conclusions made in the study. This is particularly obvious in the assessment that the fit of the data closely correlates the peak particle velocity to scaled distance in a manner comparable to that found in the Bureau of Mines research. This research is generally accepted to be the standard in this country.

Dr. Aimone-Martin's conclusion that there are "measureable" but "minor" influences of geology and terrain on the ground vibrations is supported by the data from the seismic arrays positioned in varying geographic directions. This data as presented in Figure 8 of the report may be limited in significance due to the limited number of data points presented on the graph; (6 to 10 points in each direction). While more data may be needed to verify this within an adequate degree of certainty, the analysis of the data presented is accurate and would likely be confirmed with either further monitoring or with additional analysis of the geographic relationship of the seismograph to blast for the data already taken.

The assertion in the report that there is only a slight variation in the ground transmission characteristics along the three predominant ridgeline orientations would be the expected result in an area such as this with relatively uniform soil and rock geology, and free of faults or other structural anomalies.

Using the airblast data contained in the appendix, I similarly plotted all data points on a graph attached to this report. The intensity of the air blast as measured in decibels was plotted against a cubed root scaled distance. As before there are differences in the equation's intercepts and slopes in my analysis and the Aimone-Martin plots. However, these differences are again due to the fact that Dr. Aimone-Martin was able to eliminate the questionable data points and use only verifiable readings. Both airblast regression plots show the clear trend of airblast intensity as a function of cube root scaled distance. The plots also plainly show that air blast data is subject to a great deal more scatter than ground vibration data due to atmospheric variables. This is very normal as all plots of airblast data will show significant scatter due to these effects.

An airblast data set presented in graphical form in Figure 12 of the Aimone-Martin report is interpreted to show that air blast levels are somewhat influenced by the elevation of the blast site. The data used to draw this conclusion is limited to approximately 10 readings above 2580 feet and approximately 7 readings below 2418 feet from six blasts. While this sample is too small to draw any statistically significant conclusion, it does point to a well accepted fact that topography affects airblast.

Overall, this study is a thorough description of the seismic characteristics of this area and can be used to provide accurate predictions of the seismograph and airblast results from blasts being conducted. The conclusions drawn from the data and its analysis are technically valid, though additional monitoring data would make them statistically more certain.

STRUCTURE RESPONSE STUDY

This purpose of this study was to measure the response of two residential structures to blasting vibrations by comparing the differential motion within the structure to the motion of the ground as the blast vibration passed. It also intended to determine the effect of frequencies of the blast vibration on the residence, measure any amplification of the ground motion in the residences, and to calculate both the tension and bending strains in the walls. In order to accomplish this, the opening and closing of existing cracks in the structures were measured during the duration of blasting vibrations. This methodology also produces a measurement of the changes in crack width during environmental fluctuations and due to adjacent construction activities .

The first few pages of the Structure Response Study are devoted to a description of the devices used to measure the data. The equipment used on this project is state of the art and the configuration of it is well designed to provide the information desired. This equipment set up was used to monitor the following data:

- Vibrations in the ground, and air over-pressures adjacent to the residence due to near-by blasting,
- Motion of the whole structure and bending of a wall due to blasting,
- The changing width of existing crack openings as they respond to a blast and as they change throughout the day or night in response to environmental effects.
- Temperature and relative humidity.

The text points out that structural damage in a residence does not result from high structural particle velocities. Rather, it is the differential movement in walls that can generate sufficient strains in the material to cause it to fail. This differential movement can be due to many causes, one of which is blasting vibrations. This is an accurate description of how blast damage occurs.

According to the data in the appendix of the study report, ground vibrations from six blasts at the BigHorn residence and five blasts at the High Mesa residence were above the trigger level of the exterior seismograph. All but one of these blast vibrations were very small (range of 0.025 to 0.075 in/sec) at the location of the two residences being monitored. The one exception was the blast on

March 23, 2005 which recorded a ground vibration of 0.45 in/sec and predominant frequency of 21 Hz at the location of the BigHorn residence. The data from this one blast was used to calculate the natural frequency of this residence, a damping factor, and the amplification factor as well. All of these parameters were found to be within the normal range of values for typical residential values.

The opening and closing of an existing crack in exterior stucco was measured in each of the structures during a blast vibration event. At High Mesa, the maximum crack displacement of 113 micro-inches (1 micro-inch= one millionth of an inch) occurred on 3/16/2005 during a blast which recorded 0.05 in/sec in the ground adjacent to this residence. At Bighorn, the maximum crack displacement was 243 micro-inches during the blast which occurred on 3/23/2005 which was recorded as 0.45 in/sec at the BigHorn residence.

For comparison, the Aimone-Martin report shows that a variation in crack opening during a 12 hour period at BigHorn was 4583 micro-inches and 6844 micro-inches at High Mesa. This displacement is due to the daily cycle of temperature and relative humidity and is clearly seen in the graphs in Figure 11 tracking temperature, humidity, and crack displacement. Likewise, a correlation between small crack displacement and wind velocity is also apparent from the data.

The conclusion that Dr. Aimone-Martin draws from this data is obvious and correct. That is, at these levels of ground vibration, the actual differential displacement that these residences experience from a blast vibration is much smaller than the displacements due to weather variation. And since the strain that produces either cosmetic or threshold damage is due to differential displacements, the variation of environmental conditions are much more likely to cause damage than the blast vibrations *at these levels.*

The intensity of the airblast monitored at both of these two sites was too low to have an appreciable effect on the structures.

The only deficiency of this study that I could cite is its limited amount of data from blasts of a larger magnitude. While a number of blasts transmitted sufficient energy to be recorded by seismographs placed outside these residences, only one blast (3/23/2005) was significant enough in intensity to actually compute the parameters of damping, amplification, etc. A large amount of information is inferred from this one blast. More data at comparable ground velocities would allow more certainty in these calculations.

Likewise, the lack of high airblast levels provides no information about the structural response to airblast.

But, even with the deficiency noted above, the data taken and its analysis support the conclusions Dr. Aimone-Martin expresses on page 25 of the study report. While more data would

verify these conclusions, there is nothing in the current data that would contradict these findings or put them in doubt. This method of measuring the change in crack width is the most objective and direct way of measuring the actual impact of blasting on a residence. As shown in the Aimone-Martin report, blasts of this magnitude have less impact on a structure than environmental changes.

DRAFT OF ORDINANCE FOR REGULATING BLASTING

This document consists of twenty-two pages with the first page containing a pre-amble detailing the purpose of this ordinance and the intentions of the city council in adopting it. I will comment on these sections and offer my opinions based upon my thirty years of experience as an explosives regulator for the Commonwealth of Kentucky. My overall impression of this ordinance is that it is a very extensive set of rules primarily designed to protect the neighboring structures from damage and the neighboring people from any disturbance. However, it trys to accomplish this by regulating all blasting operations with too much specificity. By that I mean, the "Performance Standards" contained in the ordinance are specified for all blasting operations regardless of their size or their location relative to the neighboring structures.

It seems apparent that most if not all of these performance standards were written to address a specific problem which has occurred, or is expected to occur during some blasting operation in the City of Henderson. However, numerous difficulties arise when you try to correct a particular problem by requiring all operations to comply with a particular solution. For example, a requirement, such as using a minimum of three seismographs placed in two different directions and at least one in a line to measure attenuation, may be eminently reasonable for someone blasting with charges on the order of hundreds of pounds per delay. But for a small contractor, shooting 5 to 10 pounds per delay, this is well beyond what is necessary.

The ordinance has very strong permitting provisions, which is a beneficial precaution in populated areas, and which serves two purposes. First, it informs and notifies the public safety agencies of where, when, and how blasting operations are being conducted within their jurisdiction. Secondly, it requires the blasting contractor to make adequate plans to control any possible adverse effects of the blasting. It is my opinion that specific performance standards should be set within the confines of the permitting process.

I concur with most of the principles and goals expressed in the pre-amble to this ordinance with one exception. The finding that construction blasting within 100 feet of a structure is inherently unsafe and has an unacceptable the risk to life and property is a subjective determination. Blasting is

done safely and efficiently within 100 feet of structures in many places of this country every day. Many in-fill projects or renovations of infrastructure demand blasting within this limit.

Based upon my experience investigating explosive accidents and claims of property damage, the number of accidents or property damage claims is no more common when the blasting operation is located 75 feet from a structure than it is when the blasting is done 175 feet or 375 feet from a structure. In fact, often the necessity to limit explosive charges and take added precautions when in close proximity to structures ensures a more careful operation and improved safety to persons and property. As for preserving the quality of life, if blasting is completely prohibited within 100 feet of any residence, any rock excavation within that distance will need to be done by rock hammer or other heavy equipment. This entails a time consuming and noisy process, which will cause as much if not more vibrations and nuisance than a controlled blasting project.

Another consideration is that applying the 100 foot prohibition to utilities will mean that blasting cannot be done within areas 200 feet wide centered on a water, sewer, or gas line. This will preclude blasting in the vicinity of any existing utility lines and make the cost of rock excavation for future development prohibitively expensive. This is certainly an unnecessary restriction since nearly every experienced blasting contractor has at one time or another successfully blasted rock much closer than 100 feet to a utility. It is not unusual to find projects where blasting has safely been done within less than four or five feet from water lines or even gas lines.

Furthermore, there has been substantial research done to document that buried pipelines can withstand levels of vibration well above the limits for protection of residential structures. I would strongly recommend that the prohibition around utilities be removed and replaced with a requirement that the contractor take adequate precautions to protect utilities anytime he is in the vicinity of a utility line. The requirement contained elsewhere in this ordinance that the utility owners/operators be notified could be expanded to require consultation with the utility representatives to determine what constitutes safe precautions.

Section 15.33.050 gives authorization for the city officials to require a technical opinion and report for projects where they deem it necessary. Such a provision can be valuable in enabling government representatives to make informed decisions on matters in which they may have little expertise. My one concern in this section is the last sentence specifying that a "registered design professional or engineer" be the person submitting the technical opinion. While I am a registered professional engineer and personally appreciate the confidence that people place on that credential, when it comes to the effects of blasting operations, a registered engineer may not always be the best technical advisor. There are many technically competent blasting specialists who are seismologists,

geologists, physicists and are not registered engineers, but are exceedingly qualified to prepare such a report as specified in this section. I would suggest eliminating that last sentence and retain the description of the person in line 5 of this paragraph; ie. a "qualified engineer" or "specialist" as determined by his or her experience in matters pertaining to blasting and explosives.

The sections in the proposed draft dealing with variance when in substantial compliance, inspection and enforcement authority, penalties, and due process for assessing penalties permits seem to be thorough and fair. The definitions used in this ordinance are standard in usage and meaning as commonly understood in the explosive industry. The administrative procedures as described in this ordinance to obtain such a permit, and the right of a contractor for written explanation if a permit is refused are suitable. Likewise, the causes for revocation and suspension are appropriate and the right to a timely hearing upon such action is fair.

I have serious reservations about section 15.33.130.01 which requires a blaster to request an approved time to detonate each blast and to have the blasts scheduled by the Building and Fire Safety Department. Restrictively scheduling the times when a blast can be detonated has the potential to create situations where the blaster is forced to work in haste to meet a deadline. Haste is a leading cause of accidents in any occupation and can be especially detrimental in the preparation of a blast. I have investigated too many blasting accidents where haste was a major contributory cause. In addition, there are too many variables in the field when drilling and loading a blast to conform to a rigid schedule, even one that is self imposed. For example, in the event of an equipment breakdown after a portion of the blast has been loaded, it may be impossible to complete the blast in the allotted time frame. Even when things work well, forcing the blaster to conform to an arbitrary schedule dictated from outside will result in the blasting crew working under additional pressure. A blaster handling explosives does not need any unnecessary demands on his concentration. There may be provisions to modify such a time schedule, but the process would be seen as burdensome by some blasters who would be reluctant to go through the bureaucratic process to effect a change. I strongly recommend that this provision be deleted.

The provision in section 15.33.130.02 requiring a minimum of three seismographs for all blasting operations was mentioned previously as an example of a regulatory scheme that may be appropriate for some but not all operations. Placing seismographs at the two closest buildings in two different directions could be justifiable for large blasting operations, but to specify such monitoring for all operations is excessive. This is the type of requirement that should be imposed as part of the permitting process a contractor goes through prior to blasting. For those blasting operations where it would serve a useful purpose, it should be required. Likewise, the requirement to place an additional

seismograph on the same bearing and 500 to 1000 ft from the first should be something determined on a case by case basis, not be compulsory for all blasting operations.

Finally, the requirement to use one seismograph if there is no structure within 2640 feet (one half mile) is unnecessary except for blasting operations detonating very large charges and is absurd for small blasting operations detonating only a few pounds of explosives. One obvious question would be: "If there is no structure within 2640 feet, where is the appropriate place to set the seismograph?" Paragraph C in this section which allows the city officials to require additional seismographs when deemed necessary is more than adequate to replace the mandatory specifications in paragraph (a) and (b).

Paragraph (a) in section 15.33.130.03 on Seismograph Monitoring Equipment is redundant since in paragraph (b) the ordinance states that all seismographs meet the ISEE Performance Specifications. These Performance Specifications outline a wider frequency range (2 -250 Hz) and include the criteria that can be used to judge whether the response is sufficiently flat.

The graph referred to as Figure 1 in Section 15.33.130.03 effectively restricts all vibrations to 0.5 in/sec. The sloped portion of the line representing frequencies below 2.5 Hz is meaningless since typical blast seismographs do not record energy below 2 Hz and it is unlikely that any is amount of measurable seismic energy will be found between 2.0 to 2.5 Hz. If the intention is to restrict ground vibration to a level of 0.5 inch/second, it is simpler to use the language contained in the current blasting regulations (paragraph 5 of 7705.3) omitting the reference to vector sum contained in that paragraph.

However, in my opinion, a flat limit on ground vibration at 0.5 inches per second regardless of frequency is not technically justifiable if the purpose is to protect property from damage. While scientific research has shown that some threshold damage may occur to plaster walls at 0.50 in/sec, that research also shows that this is only possible when the frequency of the vibrations are 12 Hz or less. To restrict PPV to 0.5 in/sec across all frequencies exceeds the finding of the research and recommendations.

If, on the other hand, the purpose of the 0.5 in/sec limit is to eliminate the adverse human response to these vibrations, such a limit will be ineffective. Due to their sensitivity to ground vibrations at the frequencies generated, most people can detect PPV at levels of 0.03 inches/second and many consider vibrations intensity on the order of 0.2 inches/second as intolerable. These are purely subjective responses and completely unrelated to damage potential. Furthermore this human response to vibration is so far below the 0.5 inch/second, that having it as the limit will preclude no one from complaining about how the vibrations "feel".

My recommendation for any government entity considering regulations limiting ground vibration levels is to use the complete graph from Bureau of Mines RI 8507, as referenced in the National Fire Protection Association Code (NFPA 495) Explosive Materials Code. The section from the 1996 edition is attached as Attachment B to this report, and I believe it is essentially unchanged in the later editions of NFPA Codes. This standard has been based upon the most widely accepted research on blasting vibrations and their damage potential. It is used in numerous cities and states throughout this country as well as in many other countries. It serves its purpose well by providing adequate protection for residences while still allowing efficient blasting operations.

In section 15.33.120.06, the restrictions on flyrock to less than one half the distance to the nearest building or not beyond the permit area are similar to limitations imposed on blasting projects on which I have worked on for many years. They have been proven as useful and workable methods of setting safe limits on flyrock.

The information mandated in section 15.33.130.07 for both the blasting reports and seismograph reports seems to be standard and comparable to what is required in other jurisdictions and will provide the necessary information to evaluate a previous blast.

Section 15.33.140.04 which details the information required to be submitted in the blast plan is appropriate, though some items in it may be too specific for the blaster to precisely address prior to starting the project. Some information must be given in general terms because it can vary from shot to shot, or from hole to hole within a shot. Things such as subdrilling depths, location of the primers, length of stemming, etc. should be determined by the blaster on site using his experience and knowledge. These factors need to be determined in response to the type and amount of rock the driller encounters in each borehole.

In the section15.33.140.05, the information for the Seismograph Monitoring plan should be the appropriate place for the contractor and the person or company who will be analyzing the seismograph records to specify how many seismographs will be used and where they will be located. This information should be justified in the plan based upon the size of the explosive charges and the potential for affecting nearby structures. The ordinance clearly states that there will be a sufficient number to measure the influence of distance and direction on vibrations, and the seismograph monitoring plan submitted should demonstrate that it will.

Section 15.33.140.07 which deals with the notification plan appear to me to be very cumbersome and makes little distinction between large scale blasting projects which could last for months or years and smaller construction projects with limited scale or short duration of operation. The chart in Figure 2 of this section is an attempt to link the size of the blast with the distance that

people must be notified. However, consider that a contractor intending to set off a single charge of only 100 pounds per delay would have to notify all households within $210*(100)^{1/2}$ or 2100 feet from his project. A circle of radius 2100 feet from a single point encompasses an area of about 318 acres. If a circle of this radius is drawn around the boundary of the blast operation, the area would be correspondingly larger.

According to census statistics, the City of Henderson has an population density of 892 households per square mile, or about 1.4 households per acre. So our hypothetical blaster above would have to notify approximately 318 * 1.4 = 445 households of his intention to blast and invite them for a neighborhood meeting. A blasting operation using 500 pounds of explosives would be required to notify everyone within a distance of 4695 feet which encompasses an area of nearly 2.5 square miles and potentially 2200 households. In addition, 7 to 14 days before blasting begins, households within half that distance would need to be mailed a copy of the blasting schedule, and then every two weeks thereafter, a recurring notice for the duration of the blast. This is a huge mailing burden for any business.

Understandably, not every project would face this magnitude of a mailing list, since many would be in less developed areas of the city. But the calculations give a example of what is possible with such a standard. As an alternative, I would suggest keeping some sort of tiering of this requirement based upon planned maximum charge size and duration of the project, with an exemption for small blasting operations that will last for brief periods of time. For example, a contractor detonating small scale shots, such as for a swimming pool or the foundation for a house, should not be required to notify more than the adjoining property owners, which could be done personally. Possibly blasting operations using less than 100 pounds of explosives should notify everyone within 300 feet of the operation or another appropriate distance; operations using more than 100 pounds of explosives per charge should notify everyone within 500 feet or 1000 feet.

As for the recurring notice of the blasting schedule every two weeks, it seems that a more reasonable requirement would be to send another notice of the blasting schedule only when it changes. A person living in close enough proximity to be aware of blasting going on in his neighborhood should not need a reminder in the mail every two weeks that the blasting is going according to the same schedule.

Finally in Section 15.33.150.03, the concept of an independent "Special Inspector" hired by the contractor to provide inspections of all proximate blasting operations seems extraordinary. This section implies that these proximate blast sites are so hazardous that they require a full time inspector who has constant control over what is being done. And essentially this requires the contractor to hire

another "independent person in charge" who would have authority over the company's superintendent and blaster in matters relating to blasting.

The responsibility for safe and legal conduct of the blasting operations should be the responsibility of the blaster in charge. Nearly all agencies that have comprehensive blasting rules, place the burden of conducting a safe and legal blasting operation squarely on the blaster in charge. Failure on his part results in suspension or revocation of his certification. In fact, some jurisdictions have provisions that forbid a blaster from taking orders from anyone who is not also certified as a blaster. According to the definitions in this proposed ordinance, a blaster in the City of Henderson must hold a valid Certificate of Registration and be qualified for the job. Therefore the blaster should be expected to assume his responsibilities, and not turn those duties are turned over to a "special inspector." Doing so implies that the inspector is more competent in blasting matters than the blaster himself.

Also I cannot help but to note that one of the grounds for suspending or revoking the approval of a "special inspector" is conflict of interest. But to expect someone who is hired and paid by the contractor to report that contractor's violations, to require corrective action, and to issue cease orders seems to be the very definition of "conflict of interest." Furthermore, the level of trust in this "company paid inspector" will be practically non-existent.

My recommendation would be to do away with this section completely ; require the blaster to fulfill his duties, and impose disciplinary actions if he doesn't. I also think that it is equally important is to have city officials perform the inspections as needed. Code enforcement is truly a government responsibility, and one that should not be "out-sourced." In that way, the integrity and the authority of the inspector is not in question.

CURRENT ORDINANCE Section 7705 Development Related Blasting Activities

This ordinance as provided to me consists of only three sections licensing the limitations and responsibilities of a contractor using explosives for excavation or development. At first glance, this regulation seems rather incomplete, and I assume it is a part of a municipal law that addresses other aspects of safety and security around explosives. A number of my comments above on the proposed ordinance could be applied to some of the requirements in this current ordinance.

As touched on above, Section 7705.2 that mandates a contractor to obtain a permit prior to any drilling or blasting activity within the City of Henderson is an eminently reasonable requirement. For safety to people and property, blasting in populated areas requires more attention to detail and correspondingly more preparation and planning than blasting done in an isolated region. Therefore the

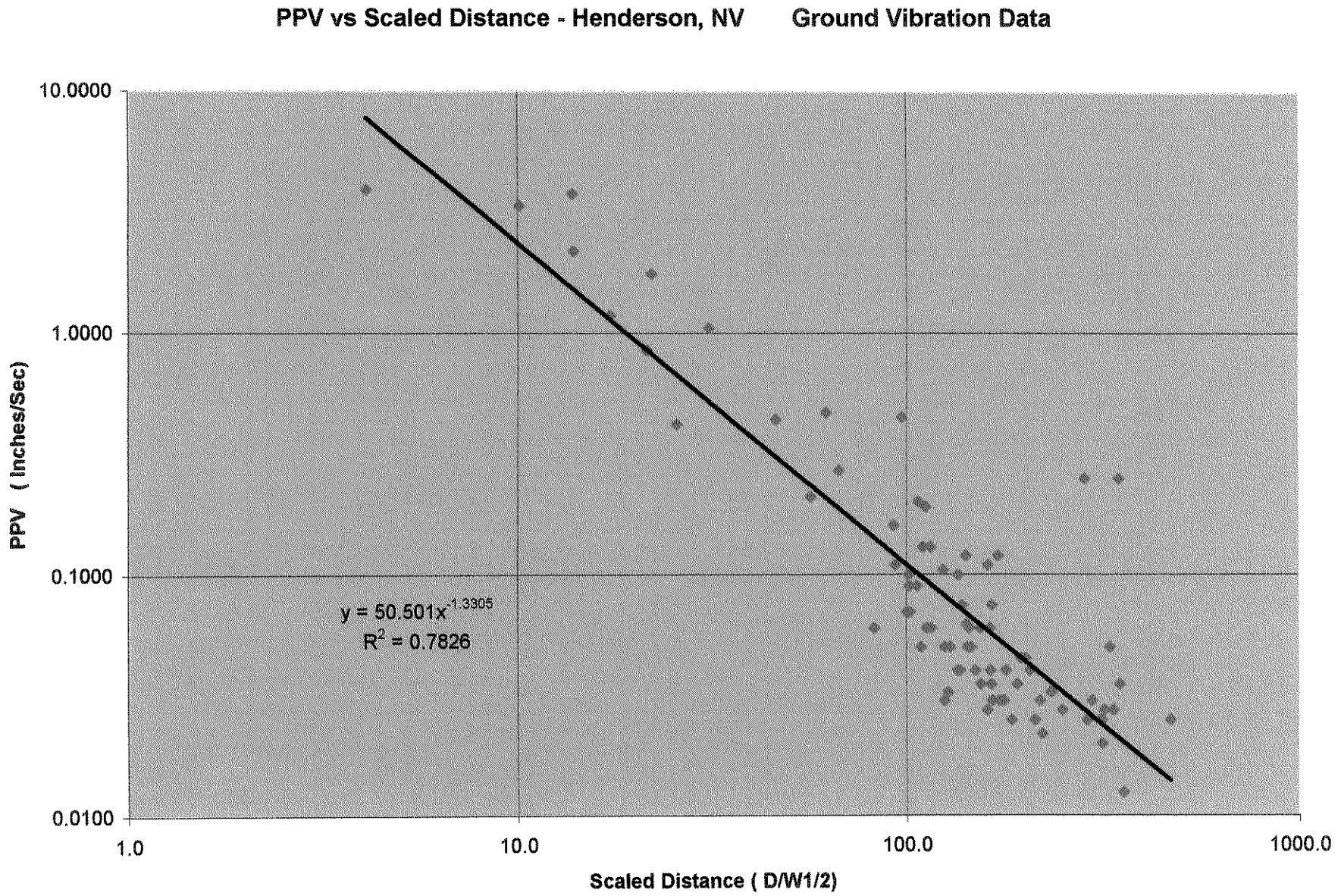
requirement that a contractor submit sufficient information to a government entity to prove that he can safely accomplish the project is beneficial to the public good. The amount of information that must be provided, and any other conditions attached to obtaining this permit , should be reasonable and done to provide a margin of safety in the blasting operation.

Paragraph 1 of Section 7705.3 that requires an "inspection" of neighboring properties in close proximity to the blasting. I would assume this means a written "pre-blast survey" complete with photos that document the condition of the structure prior to blasting. This is good for both the protection of the contractor as well as the security of the property owner provided that the "close proximity" is defined as the vicinity where blasting could reasonably be of concern to property owners. Extending the zone of pre-blast survey beyond such an area can become extremely expensive to the contractor and serves no purpose where there is no potential for ground vibrations affecting the structure.

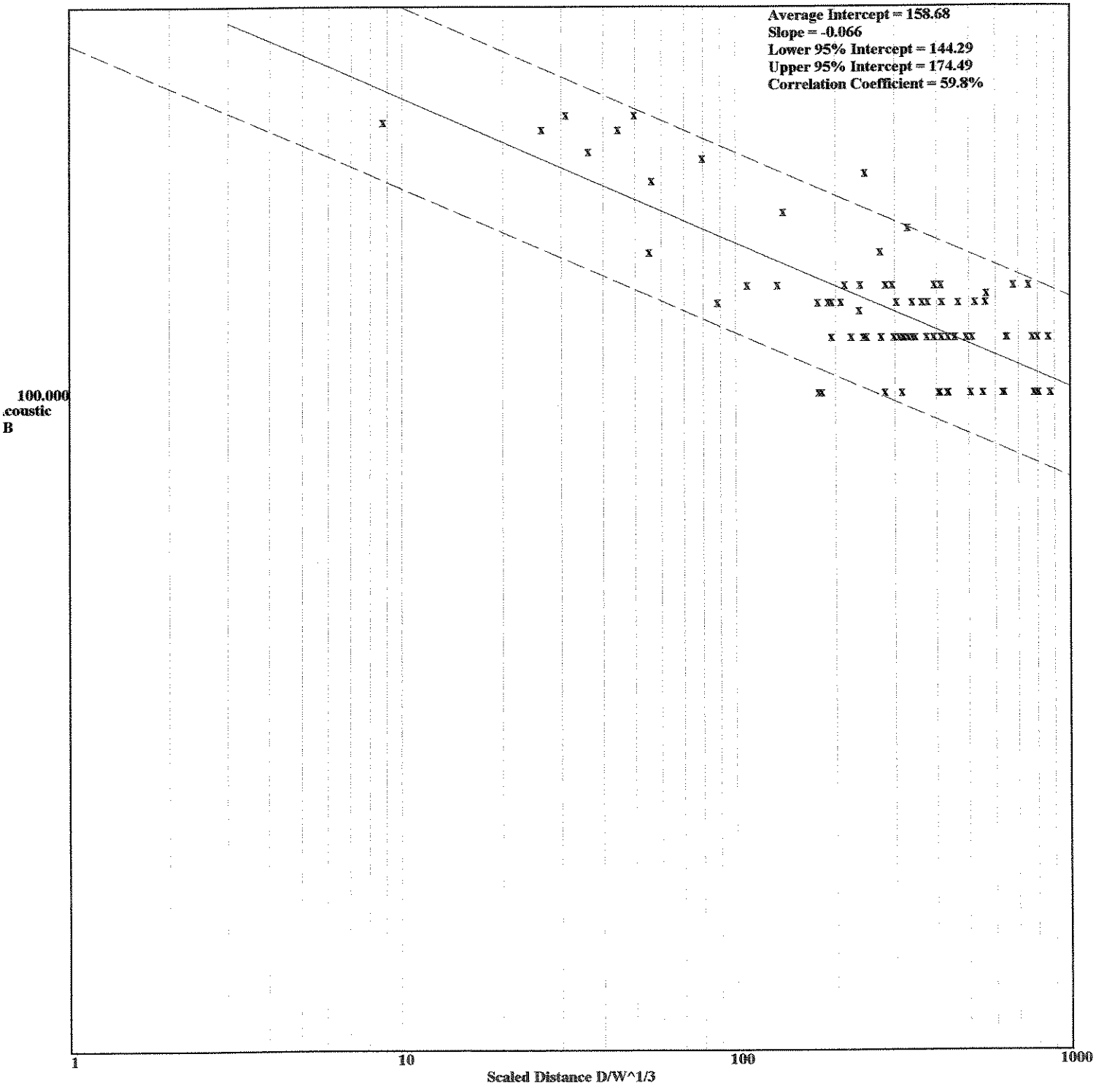
Paragraph 2 of Section 7705.2 mandating 24 hours written notice to all residences within 1000 feet of the blasting area seems extremely burdensome to me. This is especially true for contractors using relatively small quantities of explosives such as those in utility line construction, or basement excavation. The effects of such small blasting operations rarely extend more than several hundred feet. Also this regulation should be clarified to mean notification should be given 24 hours prior to the commencement of blasting operations. As written, it is not clear if that is the case or if notification is required 24 hours before every blast which would be an extraordinary burden on the contractor and nuisance to the homeowner.

The requirement that all blasting within 1000 feet of a residence or 300 feet of a utility be monitored again seems excessive for the blasting contractor using very small quantities of explosives. For example a contractor blasting a trench for utility line may detonate a maximum of 5 pounds per delay. The vibrations from such a shot will not travel much beyond several hundred feet. If there is no structure closer than that, it is wasted effort to put a seismograph 800 or 900 feet from the site. The number and location of seismographs to be used should be an item specified in the application for a permit. The permit reviewer could judge better whether the proposed monitoring plan is satisfactory.

The limits of 0.5 inch/sec and 120 dB are much more restrictive than limits used in nearly all other jurisdictions and much lower than any criteria determined to prevent property damage. I have addressed this in the discussion above. Furthermore, sounds exceeding 120 dB can be experienced every day from many sources other than blasting. To permit aircraft, fireworks, mechanical tools, and some music to exceed this limit, but impose it selectively on air blast from explosives makes little technical sense.


PPV vs Scaled Distance - Henderson, NV Ground Vibration Data
10.0000
1.0000
0.1000
0.0100
PPV (Inches/Sec)
y = 50.501x-1.3305
R2 = 0.7826
1.0
10.0
100.0
1000.0
Scaled Distance (D/W1/2)

Henderson Nevada Data
Air Blast
Cube Root Scaling



and shall not be connected to the blasting machine or other source of current until the blast is to be fired.

7-3.8 No blast shall be fired until the blaster in charge has made certain that all surplus explosive materials are in a safe place, all persons and equipment are at a safe distance or under sufficient cover, and an adequate warning signal has been given.

7-4 Procedures after Blasting.

7-4.1 No person shall return to the blast area until permitted to do so by the blaster.

7-4.2 The blaster shall allow sufficient time for smoke and fumes to dissipate and for dust to settle before returning to the blast site.

7-4.3 The blaster shall inspect the entire blast site for misfires before allowing other personnel to return to the blast area.

7-5 Misfires.

7-5.1 Where a misfire is found, the blaster shall provide the proper safeguards for excluding all personnel from the blast area. Misfires shall be reported to the supervisor immediately.

7-5.2 No additional work, other than that necessary to remove the hazard, shall be performed. Only those persons needed to do such work shall remain at the blast site.

7-5.3 No attempt shall be made to extract explosive materials from a misfired hole. A new primer shall be inserted, and the hole shall be reblasted.

Exception: Where reblasting presents a hazard, the explosive materials shall be permitted to be washed out with water, or, where the misfire is under water, blown out with air.

7-5.4 Where there are misfires using cap and fuse, all personnel shall stay clear of the blast site for at least 1 hour.

7-5.5 Where there are misfires using other nonelectric detonators (i.e., other than cap and fuse) or using electric detonators, all personnel shall stay clear of the blast site for at least 30 minutes.

7-5.6 Misfires shall be the responsibility of the person in charge of the blasting operation.

7-5.7 Where a misfire is suspected, all initiating circuits (electric or nonelectric) shall be traced carefully and a search made for unexploded charges.

7-5.8 No drilling, digging, or picking shall be permitted until all misfires have been detonated or until the authority having jurisdiction approves the resumption of work.

7-6 Disposal of Explosive Materials.

7-6.1 Empty containers and paper and fiber packing materials that previously contained explosive materials shall be disposed of or reused in an approved manner.

7-6.2 All personnel shall remain at a safe distance from the disposal area.

7-6.3 All explosive materials that are obviously deteriorated or damaged shall not be used and shall be destroyed in accordance with the requirements of 6-7.13.

7-6.4* In the event that it becomes necessary to destroy any explosives, either because of damage to containers, deterioration, or any other reason, all handling of explosives shall cease and the manufacturer shall be contacted for assistance immediately. The manufacturer's advice shall be followed without deviation.

Chapter 8 Ground Vibration, Airblast, Flyrock

8-1 Ground Vibration.

8-1.1 At all blasting operations, the maximum ground vibration at any dwelling, public building, school, church, or commercial or institutional building adjacent to the blasting site shall not exceed the limitations specified in Table 8-1.1.

Exception: As otherwise authorized or restricted by the authority having jurisdiction.

Table 8-1.1 Peak Particle Velocity Limits

Distance from Blasting Site	Maximum Allowable Peak Particle Velocity[1]
0 ft to 300 ft (0 m to 91.4 m)	1.25 in./sec (31.75 mm/s)
301 ft to 5000 ft (91.5 m to 1524 m)	1.00 in./sec (25.4 mm/s)
5001 ft (1525 m) and over	0.75 in./sec (19 mm/s)

[1]Peak particle velocity shall be measured in three (3) mutually perpendicular directions, and the maximum allowable limits shall apply to each of these measurements.

8-1.2 Frequency Versus Particle Velocity Graphs. In lieu of Table 8-1.1, a blasting operation shall have the option to use the graphs shown in either Figure 8-1.2(a) or (b) to limit peak particle velocity based upon the frequency of the blast vibration. If either graph in Figure 8-1.2(a) or (b) is used to limit vibration levels, the methods for monitoring vibration and calculating frequency shall be approved by the authority having jurisdiction.

8-1.3 Scaled Distance Equations. Unless a blasting operation uses a seismograph to monitor a blast to ensure compliance with Table 8-1.1 or Figure 8-1.2(a) or (b), or has been granted special permission by the authority having jurisdiction to utilize a modified scaled distance factor, the operation shall comply with the scaled distance equations shown in Table 8-1.3.

Table 8-1.3 Scaled Distance Equations

Distance from Blasting Site	Scaled Distance[1] Equation
0 ft to 300 ft (0 m to 91.4 m)	$W\ (lb) = (D\ (ft)/50)^2$ [$W\ (kg) = (D\ (m)/22.6)^2$]
301 ft to 5000 ft (92 m to 1524 m)	$W\ (lb) = (D\ (ft)/55)^2$ [$W\ (kg) = (D\ (m)/24.9)^2$]
5001 ft (1525 m) and over	$W\ (lb) = (D\ (ft)/65)^2$ [$W\ (kg) = (D\ (m)/29.4)^2$]

W = The maximum weight of explosives in pounds (or kilograms) that can be detonated per delay interval of 8 milliseconds or longer.
D = The distance in feet (or meters) from the blast to the nearest dwelling, public building, school, church, or commercial or institutional building not owned, leased, or contracted by the blasting operation, or on property for which the owner has not provided a written waiver to the blasting operation.

[1]To convert English units of scaled distances (ft/lb^2) to metric units (m/kg^2), divide by a factor of 2.21.

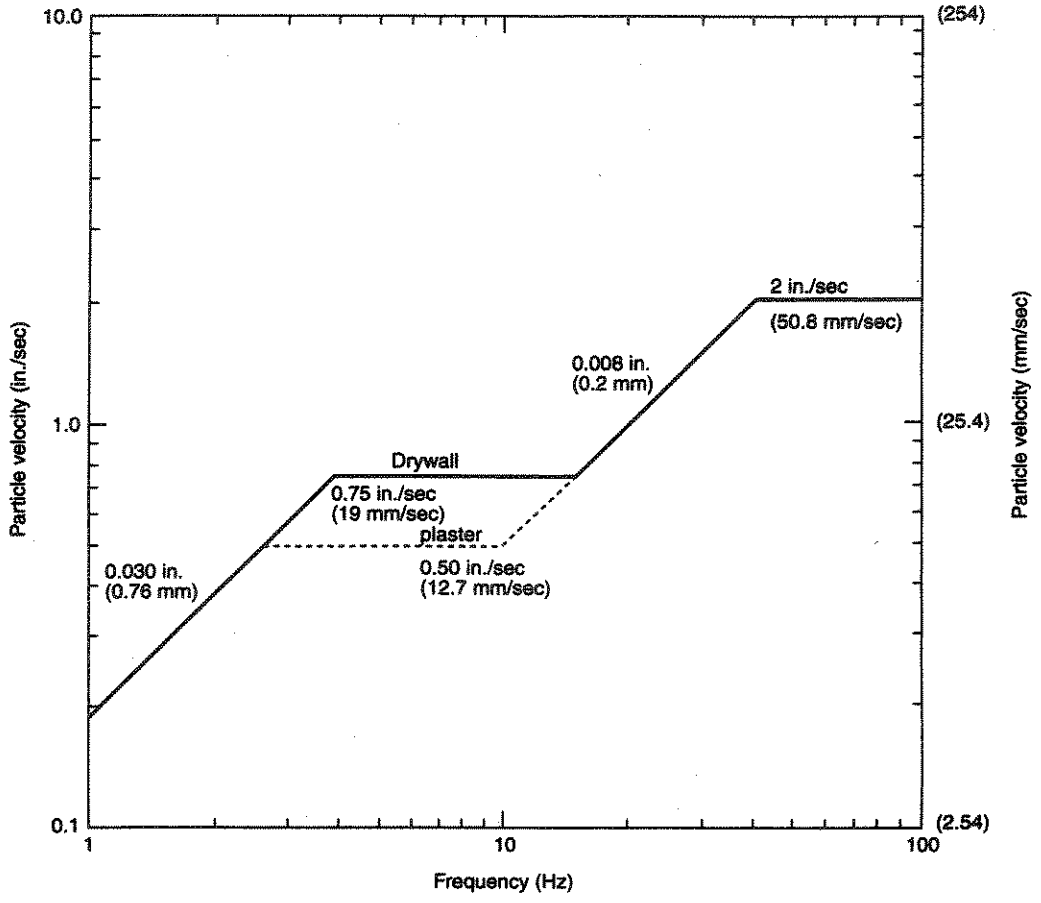


Figure 8-1.2(a) Frequency vs. particle velocity graph.

8-1.4 Where the blasting operation considers the scaled distance equations of Table 8-1.3 as being too restrictive, the operation shall have the right to petition the authority having jurisdiction to use a modified scaled distance equation. Such a petition shall demonstrate that the use of the modified scaled distance equation would not cause predicted ground vibration that exceeds the peak particle velocity limits specified in Table 8-1.1. Any petition for modification of the scaled distance equations of Table 8-1.3 shall be substantiated thoroughly by seismograph recordings to show that the limitations of Table 8-1.1 cannot be exceeded.

8-2 Airblast.

8-2.1 Airblast at the location of any dwelling, public building, school, church, or commercial or institutional building that is not owned, leased, or contracted by the blasting operation, or on property for which the owner has not provided a written waiver to the blasting operation, shall not exceed the maximum limits specified in Table 8-2.1.

Table 8-2.1 Airblast Limits

Lower Frequency of Measuring System [Hz (± 3 dcb)]	Measurement Level (dcb)
0.1 Hz or lower ..... flat response[1]	134 peak
2 Hz or lower..... flat response	133 peak
6 Hz or lower..... flat response	129 peak
C-Weighted ..... slow response[1]	105 peak

[1]Only where approved by the authority having jurisdiction.

8-3 Flyrock.

8-3.1 Flyrock traveling in the air or along the ground shall not be cast from the blast site in an uncontrolled manner that could result in personal injury or property damage.

8-3.2 Flyrock shall not be propelled from the blast site onto property not contracted by the blasting operation or onto property for which the owner has not provided a written waiver to the blasting operation.

8-3.3 Where blasting operations do not conform to 8-3.1 and 8-3.2, the authority having jurisdiction shall require that special precautions be employed to reduce or control flyrock.