PENNSYLVANIA BLASTER'S LICENSE TRAINING MANUAL

COMMONWEALTH OF PENNSYLVANIA

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF MINING PROGRAMS

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For more information, visit DEP's website at www.dep.pa.gov, Search term: Blasting Training.

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APPRENTICESHIP / KNOWLEDGE

Expectations of Blaster Knowledge Obtained During 1 Year of Experience as a Blaster Learner:

- To be eligible for a blaster's license, a person shall be 21 years of age or older, have at least 1 year of experience as a blaster learner in preparing blasts in the classification for which a license is being sought, have taken the Pennsylvania Department of Environmental Protection's (DEP) class on explosives and passed the Department's examination for a blaster's license.
- It is not necessary, but is highly recommended for a blaster to retake the class when adding an additional classification to a license.

Every applicant for a Pennsylvania Blaster's License should have:

- An understanding of Pennsylvania's regulations regarding explosives storage and use.
- Knowledge of explosives products including best available technologies.
- Knowledge of widely used calculations to predict blasting outcomes.
- An understanding of blast record keeping. This may include, but is not limited to, properly locating the nearest structures and providing the information required by regulations including detailed information relating to how each hole was loaded, how the blast was timed, the explosives products used and the amounts used, the condition of the area immediately surrounding the blast and directional seismograph monitoring.

Pennsylvania Blaster's license applicants seeking General, Trenching or Surface Mining Licenses should have the following:

- An understanding of how to safely use explosives in construction and mining applications.
- An understanding of commonly used blast design terms such as burden, spacing, stemming, and powder factor.
- An understanding of methods of achieving regulatory compliance such as flyrock prevention, designing blasts which comply with regulatory ground vibration and airblast limits and how to protect workers and the public for gasses generated by blasting.
- An understanding of how to load blast holes, including knowledge of how to load holes in blasts in inconsistent rock, how to determine the extent of the rock, and that stemming unloaded holes which are near loaded holes is necessary.
- Knowledge of the characteristics of blasting generated ground vibration and airblast, including travel path, atmospheric influence on airblast, the importance of ground vibration frequency and how to evaluate blast performance based on ground vibration or airblast levels.

- Knowledge of different types of blasts such as lift blasts or sinking cut blasts, trench blasting, blasts with open faces and the hazards associated with the different types of blasts.
- Knowledge of widely accepted rules-of-thumb for effective and safe blast design.

Pennsylvania Blaster's license applicants seeking Demolition Licenses should have the following:

- An understanding of how to safely use explosives in demolition operations.
- An understanding of commonly used blast design terms such as burden, spacing, stemming, and powder factor.
- An understanding of methods of achieving regulatory compliance such as flyrock prevention and designing blasts which comply with regulatory airblast limits.
- Knowledge of the characteristics of airblast generated for explosives detonation, including travel path and atmospheric influence on airblast.

Pennsylvania Blaster's license applicants seeking Limited Licenses should have the following:

- An understanding of Pennsylvania's regulations regarding explosives storage and use.
- An understanding of how to safely use explosives in operations where explosives use is not related to excavation or demolition.
- Knowledge of the characteristics of airblast generated by explosives detonation, including travel path and atmospheric influence on airblast.

REFERENCE MATERIALS

The following links are to regulations applicable to explosives use in Pennsylvania.

PA Blasting Regulations (25 Pa. Code Chapters 210 and 211) apply to licensing of blasters and all blasting in Pennsylvania:

http://www.pacode.com/secure/data/025/chapter210/chap210toc.html

http://www.pacode.com/secure/data/025/chapter211/chap211toc.html

25 PA Code Chapter 77 covers non-coal surface mine blasting. Blasting covered by §§ 77.453, 77.561-77.565:

http://www.pacode.com/secure/data/025/chapter77/chap77toc.html

25 PA Code Chapter 87 covers bituminous coal mine blasting. Blasting covered by §§ 87.64, 87.124-87.129:

http://www.pacode.com/secure/data/025/chapter87/chap87toc.html

25 PA Code Chapter 88 covers anthracite coal mine blasting. Blasting covered by §§ 88.45, 88.134-88.137:

http://www.pacode.com/secure/data/025/chapter88/chap88toc.html

25 PA code Chapter 211 adopts federal ATF Regulations by reference. Subpart K specifically:

https://www.ecfr.gov/cgi-bin/text-idx?SID=70394195a3edf623eba7ce77a1bddff1&node=27:3.0.1.3.5&rgn=div5

25 PA Code Chapter 207 covers underground industrial minerals regulation and adopts MSHA regulation by reference:

http://www.pacode.com/secure/data/025/chapter207/chap207toc.html

For Underground Industrial Mineral Blaster's Licenses the explosives section of 30 CFR 57 MSHA Safety Standards Underground Metal Non-metal applies. The explosives regulations found in Subpart E, Explosives:

https://www.ecfr.gov/cgi-bin/text-idx?SID=f5ff1fce9f05571ffe09da566623376b&mc=true&tpl=/ecfrbrowse/Title30/30cfr57_main_02.tpl

For Mine Opening Blaster's Licenses the explosives section of both 30 CFR 57 and 30 CFR 75 Mandatory Safety Standards-Underground Coal Mines apply. The explosives regulations found in Subpart N, Explosives and Blasting:

https://www.ecfr.gov/cgi-bin/text-idx?SID=e3ebb5eb1ad2ef73dfe1e749e35f50c2&mc=true&tpl=/ecfrbrowse/Title30/30cfr75_main_02.tpl

The following is a source of blasting investigation reports and blasting related information including all the U.S. Bureau of Mines investigation reports:

https://www.osmre.gov/resources/blasting/ARblast.shtm

BLAST DESIGN CALCULATIONS

Blasters-in-charge need to employ efficient blast designs. Efficient blast designs result in better rock breakage and minimize the risk of having regulatory issues such as flyrock, high ground vibration or high airblast. Scale blasts in consideration of the condition of the rock being blasted as well as the proximity to nearby structures. Blasters-in-charge should design blasts so that the energy from the detonation of the explosives is sufficiently contained in the rock to be utilized in breaking rock, not vented to the atmosphere.

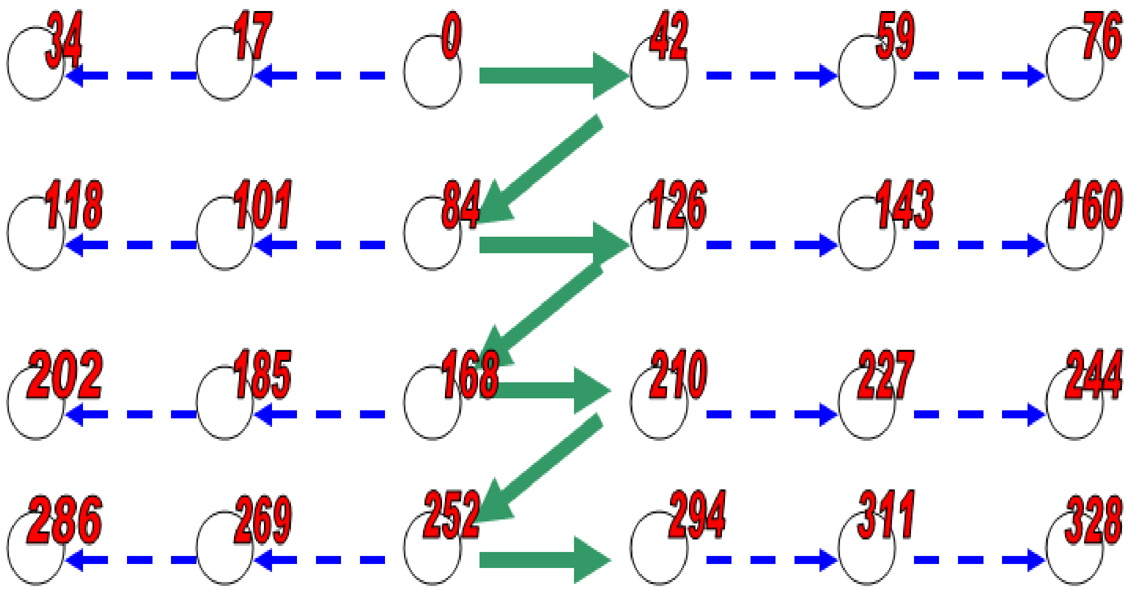
When designing blasts, blasters-in-charge need to first consider the proximity of nearby structures. Scaled distance, used to predict ground vibration and airblast levels, should be the first consideration given to blast design.

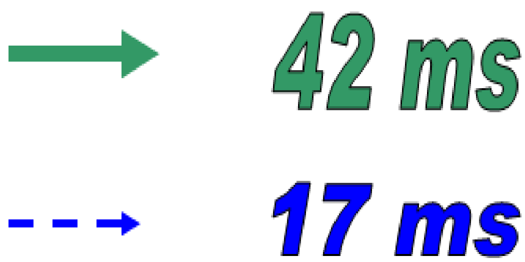
Scaled distance is defined in 25 Pa. Code Chapter 211. Scaled distance is a value calculated by using the actual distance (D) in feet, measured in a horizontal line from the blast site to the nearest building or structure, neither owned nor leased by the blasting activity permittee or its customer, divided by the square root (for ground vibration) or the cube root (for airblast) of the maximum weight of explosives (W) in pounds, that is detonated per delay period of less than 8 milliseconds (ms).

On blast plans for mining permits or typical Blasting Activity Permits (BAPs), the minimum square root scaled distance that will be used on the permit must be provided. On demolition BAPs, the cube root scaled distance must be provided.

The three values related to scaled distance are scaled distance, the maximum charge weight per delay, and the distance to a point of concern. To calculate scaled distance, maximum pounds per delay for a scaled distance or the distance to which a scaled distance applies, you need to know two of the three values. Determine distance using the best technology available. GPS technology is widely available and at a reasonable price. Since the transmission of ground vibration and airblast from blasting results in levels varying significantly due to the direction the measurement is taken from the blasting, determining direction, is important as well.

The pounds per delay is determined by the amount of explosives detonated in any period of less than 8 ms during the blast. That can be determined by the delay timing sequence of the blast and determining the charge weight in each hole, portion of each hole or holes which are detonated within 8 ms. The delay sequence optimizes the horizontal movement of material for the entire blast. Below is an example of a non-electric shock tube detonator timing pattern in which the blast is center-initiated and one hole is designed to detonate per any 8 ms time period. If more than one charge detonates at less than 8 ms. those charge weights must be added together to determine the maximum pounds of explosives per delay period.



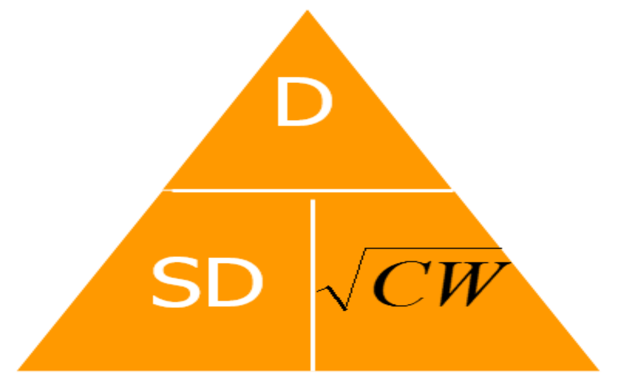


Generally, ground vibration and airblast levels from blasting attenuate rapidly over distance. Ground vibration levels at a given distance typically drop to 1/3 the level at double that distance. Airblast levels, expressed in pounds per square inch (psi), typically attenuate at about the same rate, but when expressed in decibels (dBL), the drop-off rate over distance is considerably less. Using widely accepted prediction equations from U. S. Bureau of Mines research, airblast from a 500 lb./delay mining blast measured at 1,000 feet would be expected to be 122 dBL and at 2,000 feet 117 dBL. Conversely, ground vibration from the same blast would be expected not to exceed .37 in/sec at 1,000 feet and .13 at 2,000 feet. That’s a nominal reduction of 4% for airblast using the dBL scale versus 65% for ground vibration.

Square root may be expressed by any one of the following:

- $\sqrt{CW},$ CW ^ 1/2, or CW ^ .5

Below is the square root scaled distance triangle. SD = scaled distance, D = distance and CW = charge weight. To solve for SD, CW, or D you need to know the two other values. Cover up the one you don't know and you have the equation to solve for that value.



Below are the three arrangements of the square root scaled distance equation.

- SD = D/$\sqrt{CW}$ (Used to solve for scaled distance)
- D = SD X $\sqrt{CW}$ (Used when you know the scaled distance and charge weight you wish to use and want to know the minimum distance from the blast that scaled distance applies to)
- $\sqrt{CW}$ = (D/SD) then CW = $(D/ SD)^2$ (Used when you know the scaled distance you want to use and the distance to the closest point of concern and want to know the appropriate maximum charge weight)

Scaled Distance Example Problems:

CW = 125 663/125^.5 = 59.3	D = 663 SD = 59.3
SD = 59.3 663/59.3 = 11.18	D = 663 SD = 11.18^2 = 125
SD = 59.3 125 ^ .5 * 59.3 = 663	CW = 125 D = 663

Prediction Equations:

The following prediction equations represent worst case ground vibration levels for scaled distances:

- PPV (in/s) = SD $^{-1.52}$ X 438 (Worst case surface coal) (Upper Bounds Siskind, et.al. USBM 8507) (General Test)
- PPV (in/s) = SD $^{-1.38}$ X 138 (Worst case quarry) (Upper Bounds USBM Crum et.al. 1995b-Original vibration data from USBM Bulletin, 656 Nichols et.al.) (Surface Mining Test)
- PPV (in/s) = SD $^{-1.60}$ X 242 (Worst Case construction, normal confinement) (Oriard) (Trenching and Construction Test, General Test)
- PPV (in/s) = 605 X (SD) $^{-1.60}$ (Worst Case-unusually high confinement construction) (Oriard)

Using worst case prediction equations to estimate peak particle velocities is a prudent way to ensure that ground vibration levels will be below the regulatory limit.

Average prediction equations can be used only for comparison or to ballpark ppv's. Average should only be used with existing site data.

Average should never be used for first time assumptions, i.e. new operations or changes in design. In these situations, use worst case predictions.

Using Prediction Equations:

Enter scaled distance.

Enter exponent (generally y^x, x^y or ^ on the calculator.)

Make exponent negative (generally +/- or (-)). How you enter a negative exponent varies with different calculators. Generally, with calculators that have y^x or x^y you enter the exponent number then press the +/- or (-) key. With calculators that have the ^ key you press the +/- or (-) key then the exponent number.

Example Problems:

If a blast is designed for a scaled distance of 30 on a bituminous coal mine:

- Using Worst Case: PPV = SD$^{-1.52}$ X 438 PPV = 2.5 in./sec.
- Using Average: PPV = SD$^{-1.52}$ X 119 PPV = 0.68 in./sec.

If a blast is designed at a scaled distance of 90 on a bituminous coal mine:

- Using Worst Case: PPV = SD$^{-1.52}$ X 438 PPV = 0.47 in./sec.
- Using Average: PPV = SD$^{-1.52}$ X 119 PPV = 0.13 in./sec.

If a blast is designed for a scaled distance of 50 on a quarry:

- Using Worst Case: PPV = $SD^{-1.38}$ X 138 PPV = .62 in./sec.
- Using Average: PPV = $SD^{-1.38}$ X 53 PPV = 0.22 in./sec.

If a blast is designed at a scaled distance of 50 on a construction site:

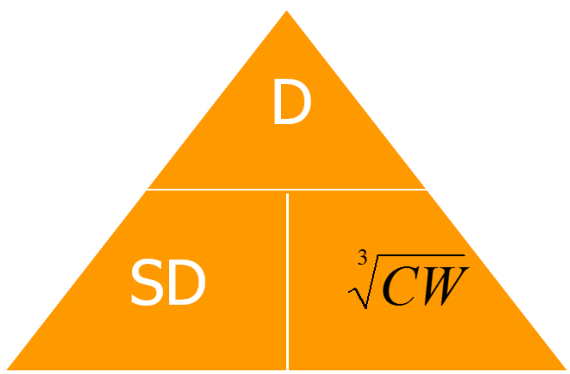
- Using Worst Case: PPV = $SD^{-1.60}$ X 242 PPV = 0.46 in./sec.
- Using Average: PPV = $SD^{-1.60}$ X 160 PPV = 0.30 in./sec.

Cube Root Scaled Distance:

Cube root may be expressed by any of the following:

- $\sqrt[3]{CW}$, CW ^ 1/3, CW ^ .3333

Below is the cube root scaled distance triangle. SD = scaled distance, D = distance and CW = charge weight. To solve for SD, CW, or D you need to know the two other values. Cover up the one you don't know and you have the equation to solve for that value.



SD = Distance / $\sqrt[3]{CW}$ (Used to solve for scaled distance.)

Distance = SD X $\sqrt[3]{CW}$ (Used when you know the scaled distance and charge weight you wish to use and want to know the minimum distance from the blast that scaled distance applies to.)

- $\sqrt[3]{CW}$ = (Distance/SD), then CW = (Distance / SD)^3

(Used when you know the scaled distance you want to use and the distance to the closest point of concern and want to know the appropriate maximum charge weight.)

Example problems:

CW = 10	D = 512
512/10^.3333 = 237.6	SD = 237.6
SD = 410	D = 751
751/410 = 1.83	SD = 1.83^3 = 6.15
SD = 510	CW = 12.5
12.5 ^ .3333 * 510 =	D = 1183

When estimating airblast levels using scaled distance you can apply the scaled distance to the appropriate line on the chart below (from USBM RI 8485, Siskind etal.) Note that the chart is a log-log chart.

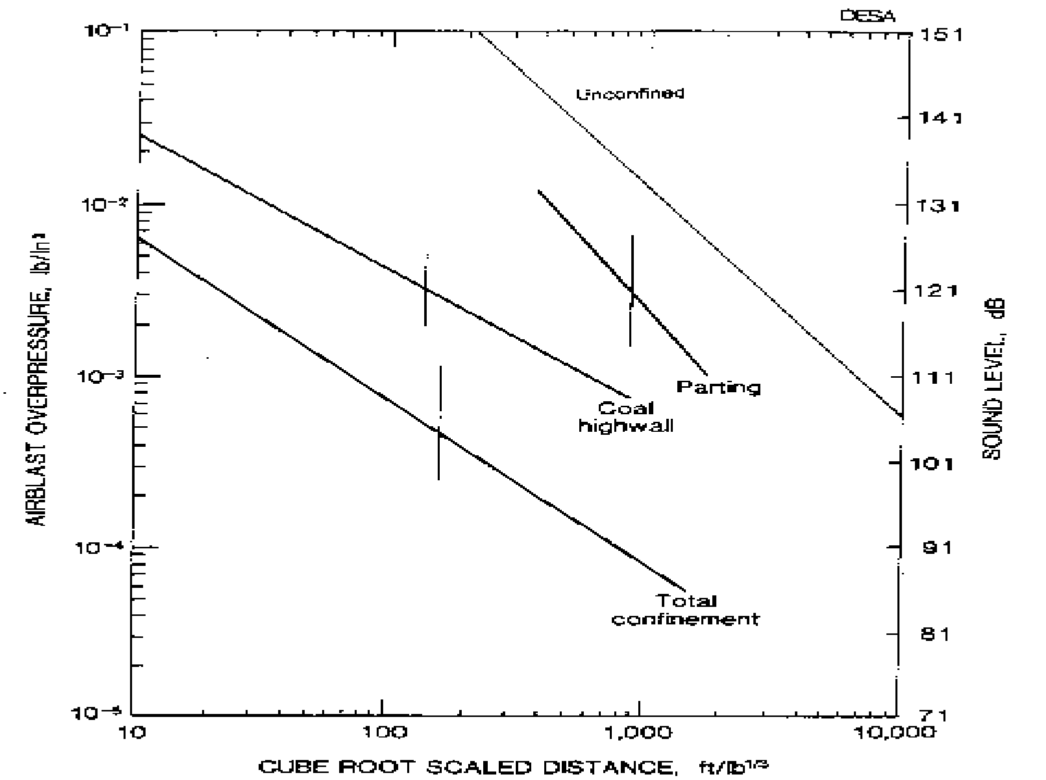


Figure 25. Propagation plot regressions of airblast from surface mining, adapted from USBM RI 8485, 1980.

If you wish to make more accurate predictions, you can use the following prediction equations which represent the lines from the chart above (from Vibrations From Blasting, Siskind ISEE, 2000):

- Open Air dBL = $SD^{-1.38}$ X 187
  - Example: $237.6^{-1.38}$ X 187 = .098 psi
- Parting dBL = $SD^{-1.623}$ X 169
  - Example: $237.6^{-1.623}$ X 169 = .024 psi
- Highwall dBL = $SD^{-0.794}$ X .162
  - Example: $237.6^{-0.794}$ X .162 = .0021 psi

The following equation converts psi to decibels (dBL):

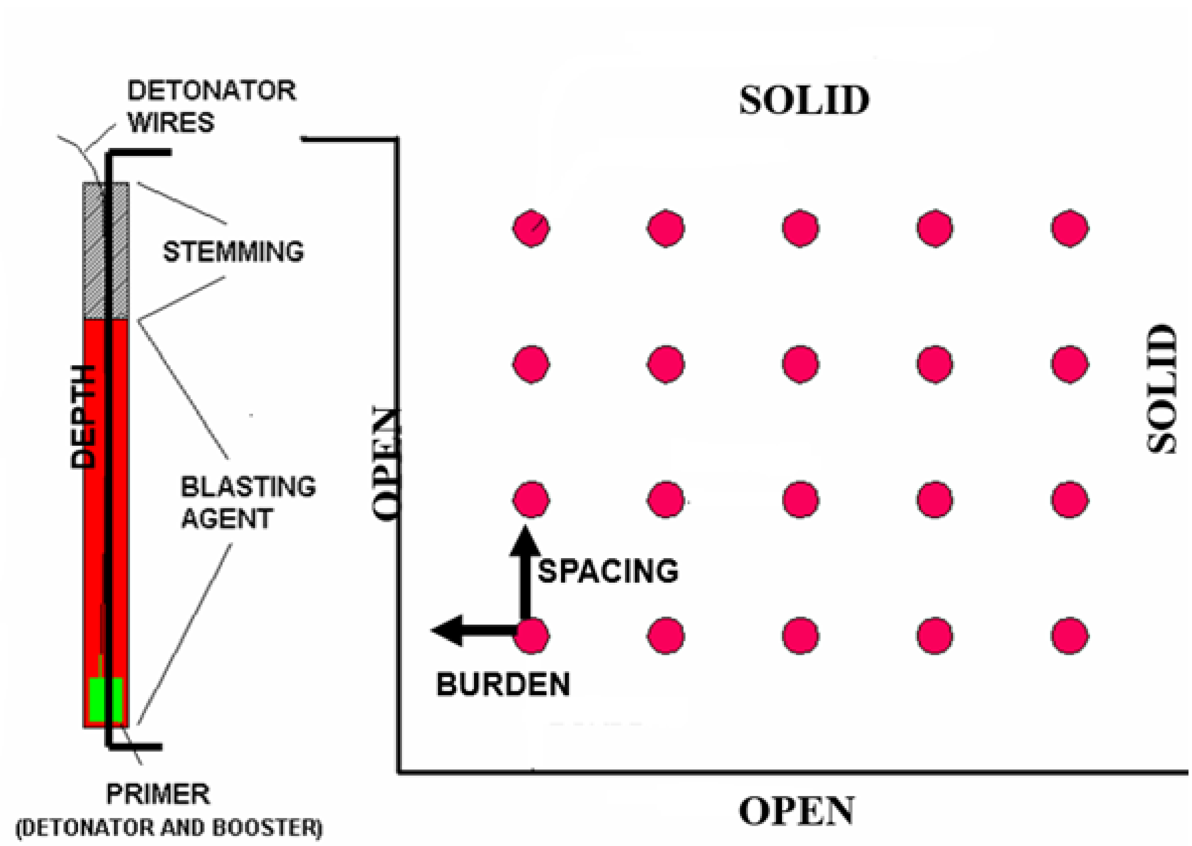
- dBL = 20 X $\log_{10}$[psi/ (2.9 X 10^{-9})]
  - Example: 20 X $\log_{10}$[.098/ (2.9 X 10^{-9})] = 150.6 dBL

The following equation converts decibels (dBL) to psi:

- psi = $10^{[(dBL/20)-8.537]}$
  - Example: $10^{[(130.6/20)-8.537)}$ = 0.098 psi

Other Blast Design Considerations:

The next considerations should to be given to the adequate confinement of the explosives within the rock being blasted and promoting the horizontal movement of the burden. In its simplest form, blast design parameters such as hole diameter, burden, spacing and stemming amounts are calculated from the depth of the borehole. Widely held rules-of-thumb can be applied that provide ranges of values. Specific values can be determined based on the type of rock and the condition of the rock. The illustration below shows an example of a loaded borehole with stemming and illustrates a blast pattern and burden and spacing.



Widely held rules-of-thumb below, provided by the U. S. Department of Interior, Office of Surface Mining, Reclamation and Enforcement (OSM) are what DEP considers when reviewing permit applications or assessing blast designs on blast records for normalcy.

Blast Design Rules of Thumb (OSM):

Borehole Diameter (d) = hole depth/5 to 10
d(in.) = depth(ft.)/5 to 10
Example: 50 ft. deep borehole – 5 in. to 10 in. borehole diameter

Burden (B) = 2 to 3 X hole diameter (d)	
B (ft.) = 2(d) in. to 3(d) in.	Typically 2.5(d)
Example: 6 in. diameter borehole – 12 ft. to 18 ft. burden	Typical-15 ft.
Spacing(S) = 1 to 2 X Burden(B)	
S = 1(b) to 2 (B)	Typically 1.5 (B)
Example: 15 ft. burden – 15 ft. to 30 ft. spacing	Typical 22.5 ft.
Stemming (T) = 0.5 to 1 X Burden (B)	
T = 0.5(b) to 1.0 (b)	Typically 0.7(b)
Example: 15 ft. burden – 7.5 ft. to 15 of stemming	Typical 10.5 ft.

The blast design equations below allow calculation of the amount of explosives in a bore hole.

The powder column is the portion of the borehole which is filled with explosives. Powder column (PC) = hole depth (H) minus stemming (T).

PC(ft.) = H (ft.) – T (ft.)
Example using a 17 ft. bore hole in which 7 ft. of stemming will be used: 17 ft. – 7 ft. = 10 ft.
Example using a 40 ft. bore hole in which 10 ft. of stemming will be used: 40 ft. – 10 ft. = 30 ft.

Calculating the Explosives Amount in A Borehole:

Loading density is the pounds of explosives product per foot of a borehole. Loading density (LD) = 0.3405 times the explosive density, in g/cc, times the hole diameter (d) (in inches) squared.

LD (lb./ft.) = 0.3405 X density (g/cc) X d^2 (in) (or Mfg. design guide)

Charge weight (CW) = powder column times the loading density.

CW (lb.) = PC (ft.) X LD (lb./ft.)

The amount of explosives in the bore hole is determined first by calculating the loading density (LD) which provides the pounds per foot of bore hole.

Loading Density (LD):

Explosives Density X $(d)^2$ X .3405

Example using an explosives product with a density of 1.15 g/cc and a borehole diameter of 3 inches:

1.15 X 3^2 X .3405 = 3.5 lb./ft.

Example using an explosives product with a density of .85 g/cc and a borehole diameter of 6 inches:

.85 X 6^2 X .3405 = 10.42 lb./ft.

Then the amount of explosives in the bore hole (charge weight) can be calculated by multiplying the loading density by the powder column.

Charge weight (CW) = powder column (PC) x loading density (LD.)

Example using a loading density of 3.5 lb./ft. and a powder column of 10 ft.:
3.5 X 10 = 35 lb.

Example using a loading density of 10.14 lb./ft. and a powder column of 30 ft.:
10.14 X 30 = 304.2 lb.

Powder Factor:

Powder factor is a determination of the amount of explosives used to break a cubic yard of rock and varies due to the hardness, or difficulty to break different types of rock. Powder factor is the pounds of explosive used to break a cubic yard of rock, expressed as lb./cu.yd.

The first step is to determine the cubic yards of rock surrounding the borehole, the borehole volume.

Cubic yards(yd^3) = (burden X spacing X hole depth) /27

Example using a burden of 6, a spacing of 6 and a bore hole depth of 17:

(6 X 6 X 17)/27 = 22.7 cu/yd.

Example using a burden of 14, a spacing of 15 and a bore hole depth of 40:

(14 X 15 X 40)/27 = 311 cu/yd.

To determine powder factor (PF) the total amount of explosives loaded into a borehole the charge weight (CW) is divided by the cubic yards of rock surrounding the borehole, the borehole volume (yd^3.)

$PF = CW/ yd^3$

Example using a charge weight of 35 lbs. and a borehole volume of 22.7 yd^3:
$35/22.7 = 1.54$ lbs./ yd^3

Example using a charge weight of 304.2 lbs. and a borehole volume of 311 yd^3:

$304.2/311 = .98$ lbs./ yd^3

Designing A Blast Using Scaled Distance:

Knowing These Parameters:

Scaled distance, borehole depth (ft.), distance to closest building, explosives loading factor, hole diameter target powder factor and priming.

Solve for these parameters:

Stemming, burden (ft.), spacing (ft.), actual powder factor, pounds per delay/hole using the example below:

Hole depth.. 40 ft.
Scaled distance..................................... 90 ft./lb.$^{1/2}$
Distance to closest building.................... 1300 ft.
Explosives loading factor........................ 1.15 g/cc
Hole Diameter .... 4 in
Target powder factor .... 1.5 lb./yd.
Priming.. 2 X 1 lb. (cast)

The distance to the nearest building is 1300 feet and we are designing to a scaled distance of 90.

Using the triangle, the amount of explosives that can be used is $1300/90 = CW^{1/2}$

$14.44 = CW^{1/2}$ $14.44^2 = CW$

CW = 208.6 lb.

With a 4 inch bore hole 40 feet deep, up to 208.6 lb. of explosives can be used. You are using 2 X 1 lb. boosters. The explosives density is 1.15 g/cc. You know that:

Explosives density X (bore hole dia.)^2 X .34 = lb./ft. borehole.

$1.15 \text{ X } 4^2 \text{ X } .34 = 6.26$ lb./ft.

208.6 lb./6.26 lb./ft. = 33.3 ft. Use 33 ft. that allows for 7 ft. of stemming (40 ft. – 33 ft. = 7 ft.)

33 ft. X 6.26 lb./ft. = 206.6 lb. add the boosters at 2 X 1 lb. = 208.6 lb.

Divide the pounds (208.6 lb.) by the borehole depth (40) and then divide the result by the target powder factor (1.5 lb./cu.yd.). Remember that when starting a new project, it is generally a good idea to keep burdens and spacings close to even. Round to the nearest practical measurement. Burden and Spacings will be referred to as dimensions (D) in the equations below:

208.6 lb./40 ft. = 5.2 lb./ft.

5.2 lb./ft./1.5 lb./cu.yd. = 3.47 cu.yd./ft.

$D^2 / 27 = 3.47$ $\quad$ $D^2 = 27 \text{ X } 3.47$

$D^2 = 93.7$ $\quad$ $D = \sqrt{93}.7$ $\quad$ $D = 9.67$

Burden = 10 Spacing = 10

Remember we had a target powder factor. Because of limitations on measurements in the field the actual powder factor may vary somewhat from the target powder factor.

Powder Factor = Pounds per Bore Hole / Borehole volume

Bore Hole Volume = 148.1 cu.yd.

Actual Powder Factor = 1.41 lb./cu.yd.

$$\frac{10 X 10 X 40}{27}$$

$$\frac{208.6}{148.1}$$

How does our design fit within the rules of thumb?

Burden 2 to 3 times hole diameter-usually 2.5

10 / 4 = 2.5

Spacing 1 to 2 times Burden-usually 1.5 times

10 / 10 = 1

Stemming .5 to 1.0 times the Burden

10 / 7 = .7

Powder Factor 1.41 lb./cu.yd. L.S. & HARD S.S. –

Our design, typical of a limestone quarry has a high powder factor > 1.25.

Once you determine burdens and spacings which are the same you can easily adjust.

For example:

Burden = 10 Spacing = 10

nets the same powder factor as

Burden = 8 Spacing = 12.5

Simply square your initial burden and spacing (10) then divide that number by your new burden (8) to determine the spacing (12.5).

10 X 10 = 100 100/8=12.5

When you adjust, make sure that the design continues to conform to the rules of thumb.

DEFINITIONS

Air Blast – The airborne shock wave or acoustic transient generated by an explosion.

ANFO – An explosive material ideally consisting of 94% ammonium nitrate and 6% fuel oil by weight. ANFO is used as a blasting agent.

Back Break – Rock broken beyond the limits of the rear row of holes in a blast pattern.

Bench – The horizontal ledge in an excavation or mining operation along which holes are drilled vertically.

Binary Explosive – An explosive prepared by mixing 2 non-explosive materials which when combined form a cap-sensitive explosive.

Blast – The action of breaking and displacing rock by means of explosives. Shot also means blast.

Blast Area – A sufficient area surrounding a blast site that must be cleared and secured to ensure that no person is exposed to hazards resulting from the blast.

Blasting Agent – An ammonium nitrate based explosives compound that is not cap sensitive. (ANFO, emulsions, etc.)

Blasting Cap – (see detonator) – A metallic tube closed at one end, containing a charge of one or more detonating compounds, and designed to initiate detonation.

Blasting Galvanometer – An electrical resistance instrument designed to test electric detonators and circuits for resistance and continuity.

Blast Hole – A hole drilled in rock or other material for the placement of explosive.

Blast Site – The location of the loaded explosives.

Blast Record – A required, detailed written record that contains sufficient information to reconstruct the conditions and events surrounding a specific blast.

Blasting Machine – An electrical or electromechanical device that provides electrical energy to energizing detonators in an electric blasting circuit. You must only use a blasting machine to fire an electric detonator blast.

Blasting Vibration – The energy from a blast that manifests itself in airborne and earth borne vibrations (airblast, ground vibration) that are transmitted through the earth and atmosphere away from the blast site.

Blockhole – A method of secondary blasting utilizing a hole drilled into a boulder to allow the placement of an explosive charge.

Bureau of Alcohol, Tobacco, and Firearms (ATF) – A bureau of the United States Department of Treasury having responsibility for the promulgation and enforcement of regulations related to the use of explosive materials.

Burden – The distance in feet from an explosive charge, in the direction of relief.

Cap Crimper – A mechanical device for crimping the metallic shell of a fuse detonator or igniter cord connector securely to a section of inserted safety fuse. A mechanical device for crimping the metallic shell of detonator.

Connecting Wire – Wire used to extend the firing line or legwires in an electric blasting circuit.

Circuit – A completed path for conveying electrical current.

Crimping – The act of securing a fuse cap or igniter cord connector to a section of a safety fuse by compressing the metal shell of the cap against the fuse by means of a cap crimper.

Cap Sensitivity – An explosive material is considered to be cap sensitive if it detonates with an IME No. 8 Test Detonator.

Cartridge – An individual closed shell, bag, or tube of circular cross section containing explosive material.

Cartridge Punch – A wooden, plastic, or non-sparking metallic device used to punch an opening in an explosive cartridge to accept a detonator or a section of detonating cord.

Commercial Explosives – Explosives designed, produced, and used for commercial or industrial applications rather than for military purposes.

Continuity Check (Circuit Continuity Check) – A determination made by instrumentation where possible, and visually in all cases, showing that an initiation system is continuous and contains no breaks or improper connections that could cause stoppage or failure of the initiation process.

Cushion Blasting – The technique of firing a single row of holes along a neat excavation line to shear the web between the closely drilled holes.

Cutoff – A break in a path of detonation or initiation usually caused by hook-up errors, ejected debris, shifting ground, insufficient down hole delay time or product malfunction.

Date-Shift-Code – A code applied by manufacturers to the outside of explosives cartridges to aid in their identification and tracing.

Decibel – A unit of measurement used to measure air blast. In blasting applications, the linear decibel scale is commonly used.

Density – The mass of an explosive per unit of volume, usually expressed in grams per cubic centimeter or pounds per cubic foot.

Department of Environmental Protection (DEP) – Commonwealth of Pennsylvania, Department of Environmental Protection. DEP regulates the storage, handling, use and off-road transportation of explosives in Pennsylvania.

Delay Series – A series of detonators designed to detonate at specific times upon initiation to provide the timing at which charges will detonate during a blast. There are basically two types of delay series: millisecond (MS) and long period (LP) with delay times of seconds. For the purpose of scaled distance all charges detonated less than 8 MS from one another are considered within the same delay period.

<u>Detonating Cord</u> – A flexible cord containing a center core of high explosive and used to initiate other explosives.

<u>Detonating Cord Trunkline</u> – The line of detonating cord that is used to connect and initiate other lines of detonating cord. Detonating cord trunk line must be buried under 1 foot of sand or the equivalent.

<u>Detonating Primer</u> – A name applied for transportation purposes to a device consisting of a detonator and an additional charge of explosives, assembled as a unit.

<u>Detonation</u> – The explosive reaction that moves through an explosive material at a velocity greater than the speed of sound.

<u>Detonation Velocity</u> – The velocity at which a detonation progresses through an explosive.

<u>Detonator (blasting cap)</u> – A device containing no more than 10 grams of total explosives by weight, used to initiate detonation of explosives charges. The term includes, electric blasting caps, electronic blasting caps, fuse caps, detonating cord delay connectors, and nonelectric blasting caps.

<u>Department of Transportation (PENNDOT)</u> – A cabinet-level agency of the state or federal government. It has the responsibility for the comprehensive regulation of transportation safety and issues regulations governing interstate shipments of explosives and other hazardous materials on public highways.

<u>Electric Blasting Circuit</u> – An electric circuit containing electric detonators and associated wiring.

<u>Electric Detonator</u> – A detonator that initiates by means of an electric current.

<u>Electronic Programmable Detonators</u> – Blasting caps that initiate by means of an electric current and are variably and individually programmable.

<u>Emulsion</u> – An oxidizer dissolved in water and an emulsifier to maintain its consistency. Emulsions which are sensitized may be either blasting agents or high explosives. Emulsions that are not sensitized are oxidizers.

<u>Energy</u> – A measure of the potential for the explosive to do work.

<u>Explosive Materials</u> – Explosives regulated and listed by ATF. Includes high explosives, low explosives, blasting agents and detonators.

<u>Explosive Strength</u> – The amount of energy released by the detonation of an explosive indicating a capacity of the explosive to do work.

<u>Extraneous Electricity</u> – Electrical energy, other than actual firing current, that is present at a blast site and that could enter an electric blasting circuit. It includes stray current, static electricity, RF (electro-magnetic) waves, and time-varying electric and magnetic fields. *<u>Electric detonators must not be used if extraneous electric charges exceed 50 milliamps.</u>*

Fire Extinguisher Rating – The National Fire Code rating that is identified on an extinguisher by a number (5,20,30, etc.) indicating the extinguisher's relative effectiveness followed by a letter (A, B, C, etc.) indicating the class or classes of fires for which the extinguisher has been found to be effective.

Firing Line (lead line) – The duplex wire connecting the electrical power source with the electric blasting circuit. Reused, it must be checked for nicks, cuts, and continuity prior to each use.

Fire-Resistant – Construction designed to offer reasonable protection against fire.

Flammability – The ease with which an explosive material may be ignited by flame and heat.

Flyrock – Rocks or any other debris propelled from the blast area by the force of the detonation.

Frequency – The number of vibration waves that pass through a given point during one second, measured in Hertz (Hz) (cycles per second).

Fuel – A substance that is combined with an oxidizer to make up an explosive.

Fumes – Gases released during a detonation of explosives. These include toxic gases such as carbon monoxide, and oxides of nitrogen.

Hertz (Hz) – Cycles per second.

High Explosives – Explosives that are characterized by a very high detonation velocity, develop high pressure, and generate a shock wave (dynamite, cast boosters, detonating cord, etc.)

IME-22 Container (Compartment) – A container affixed to a vehicle, constructed in accordance with IME SLP-22 specifications, that contains separate compartments for the transportation of detonators and other explosives on the same vehicle.

Gap Sensitivity – The maximum distance for propagation between standard charge sizes of explosive donor and acceptor.

Ground Vibration – Elastic waves emanating from a blast, usually measured as particle velocity (PPV) expressed in inches per second (in/sec).

Hangfire – A burning explosives charge that failed to detonate during a blast. In the event that a hangfire is present, extreme caution must be exercised as detonation could occur at any moment.

Heading – Refers to mine openings used for various exploration and development passageways.

Inhabited Building – For the purpose of explosives storage, a building regularly occupied or any church, schoolhouse, railroad station, store, or other structure where people are accustomed to assemble, except any building or structure occupied in connection with the manufacture, transportation, storage, or use of explosive materials.

Initiation – The act of causing an explosive material to detonate or deflagrate.

Initiator – A detonator or detonating cord used to start detonation in an explosive material.

Inner Perimeter Security – Measures taken to increase the intrusion resistance and theft resistance of a magazine that encircles an individual or a group of magazines. These measures lie within the outer perimeter security measures.

Inventory – A listing of all explosive materials stored in a magazine.

Lead Line or Leading Wires – The wire(s) connecting the electrical power source with the circuit containing electric detonators.

Leakage Resistance – The resistance between the blasting circuit (including lead wires) and the ground.

Legwires – The two single wires of differing color extending out from an electric detonator.

Lift Shot – A blast that is confined on all sides and has no free face to provide relief. This type of blast has a high risk of flyrock, excessive ground vibration levels, or excessive airblast levels.

Loading – Placing explosive material in a blasthole or against the material to be blasted.

Loading Factor – For bulk loading of explosives in a borehole. It calculates lbs./ft. in a borehole. (Can be determined by .34 x Borehole diameter squared X density of explosives product).

Low Explosive – Explosives (e.g. black powder) that are characterized by deflagration or a low rate of reaction and the development of low pressure.

Magazine – Any building, structure, or container, other than an explosives manufacturing building, approved for the storage of explosive material.

Main Explosive Charge – The explosive material, usually a blasting agent, that performs the major work of blasting.

Manufacturing Codes – Code markings stamped on explosive materials packages, indicating, among other information, the date of manufacture.

Mat – Used to cover a blast to hold down ejected debris, usually made of woven wire cable, rope, or reinforced rubber.

Millisecond – One thousandth of a second.

Misfire – A blast that fails to detonate completely after an attempt at initiation.

Nonelectric Detonator – A detonator that does not require the use of electric energy or safety fuse to function.

Nonsparking Metal – A metal that will not produce a spark when struck with other tools, rock, or hard surfaces.

Occupational Safety and Health Administration (OSHA) – An agency of the United States Department of Labor who regulates safety on construction (non-mining) sites.

Outer Perimeter Security – Security surrounding explosives storage magazines that deters access by wheeled vehicles.

Oxidizer – A substance, usually ammonium nitrate, that readily yields oxygen to stimulate the combustion of organic matter or fuel.

Parallel Blasting Circuit – An electric blasting circuit in which the legwires of each detonator are connected across the firing line directly or through buswire.

Peak Particle Velocity – A measurement of ground vibration amplitude which represents the highest amplitude of any half-cycle in a vibration wave time history.

Post plot – A map indicating the actual locations of bore holes to be loaded. The actual locations are based on the proposed locations indicated on the pre plot but subjected to environmental limitations on the locations (i.e. too close to homes, streams, wells, springs).

Powder – A generic term describing any explosive.

Powder Column – A continuous length of explosives loaded into a borehole.

Powder Factor – The ratio of weight of explosive (in pounds) to cubic yards of material blasted.

Premature Firing – The detonation of an explosive charge before the intended time.

Pre-Blast Survey – An inspection and documentation of the condition of a structure prior to blasting; they are required on most mining permits, recommended for all blasting operations.

Pre-plot – A map indicating the proposed location of boreholes to be loaded.

Pre-Splitting – A single row of holes drilled along an excavation line, where detonation of explosives in the holes causes shearing of the web or rock between the holes. Pre-split holes are usually fired in advance of production holes.

Prilled Ammonium Nitrate – Ammonium nitrate in a pelleted or prilled form used in ANFO.

Primer – A detonator or detonating cord inserted into, or attached to, high explosives cartridges used to initiate other explosives or blasting agents.

Resistance – The measure of opposition to the flow of electrical current, expressed in ohms.

Scaled Distance – Used to predict ground vibration and airblast from blasting operations. The charge weight is scaled (square root for ground vibration, cube root for airblast) to the distance to a point of concern.

Seismograph (Blasting Seismograph) – An instrument used to measure and record ground vibration and airblast from blasting operations.

Sensitivity – An explosive material's ability to be initiated upon receiving impact, shock, flame, friction, or pressure.

Series Blasting Circuit – An electric blasting circuit that provides one continuous path for the current through all caps in the circuit.

Series in Parallel Blasting Circuit – An electric blasting circuit containing two or more separate series of electric detonators.

Shelf Life – The length of time of storage during which an explosive material retains adequate performance characteristics.

Shock Wave – A transient pressure pulse that propagates at supersonic velocity.

Shunt – The shorting together of the free ends of electric detonator legwires or the wire ends of an electric blasting circuit. Also, an electrical shorting device applied to the free ends of electric detonators by the manufacturer.

Sleep Time – The length of time that a loaded charge remains in the ground from loading to detonation.

Specific Gravity – The ratio of the weight of any volume of substance (solid or liquid) to the weight of an equal volume of pure water. Gas volumes are compared to an equal volume of air.

Sympathetic Propagation – The detonation of an explosive charge as a direct result of the detonation of another explosives charge.

Static Electricity – Electric charge at rest on a person or object. It is most often produced by the contact and separation of dissimilar insulating materials.

Storage – The safekeeping of explosive materials in specially designed and secured structures called magazines.

Stray Current – A flow of electricity outside an insulated conductor system.

Theft-Resistant – Construction designed to deter illegal entry into facilities used for the storage of explosive materials.

Volt – The unit of electromotive force. It is the difference in potential required to make a current of 1-ampere flow through a resistance of 1 ohm.

Warning Signal – An audible signal that is used for warning personnel in the vicinity of the blast area of the impending detonation.