Vibration

68-105-104. Blasting standards. – [Amended effective January 1, 2008. See the Compiler's Notes.]

(a) In all blasting operations, except as otherwise provided in this chapter, the maximum ground vibration at any dwelling, public building, school, church, or commercial or institutional building normally occupied adjacent to the blasting site shall not exceed the limitations specified in the following table:

TABLE 1

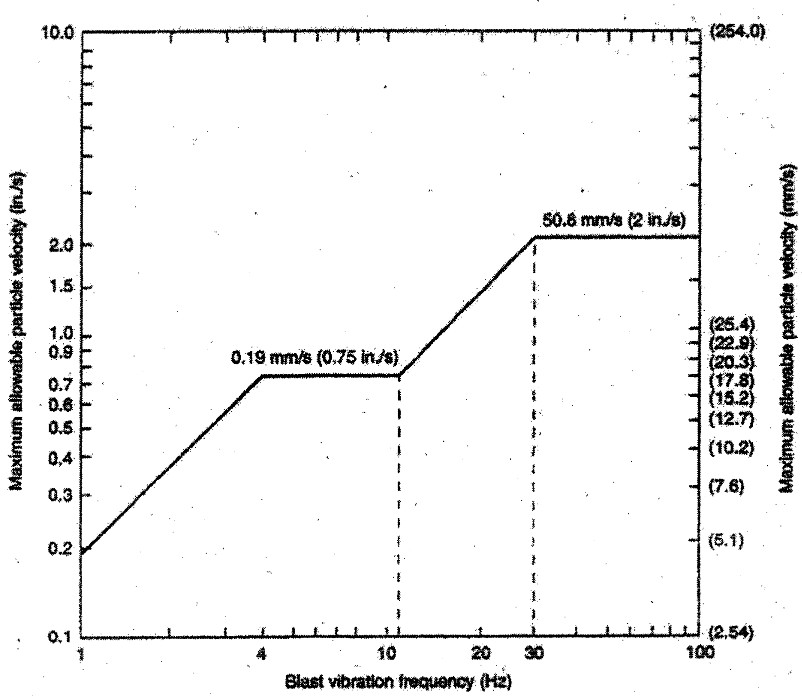
PEAK PARTICLE VELOCITY LIMITS

Distance from blasting site	Maximum allowable peak particle velocity[1]
0 to 300 ft (91.4 m)	1.25 in/sec (31.75 mm/sec)
301 to 5000 ft (91.5 m to 1524 m)	1.00 in/sec (25.4 mm/sec)
5001 ft (1525 m) and beyond	0.75 in/sec (19 mm/sec)

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

(b) In lieu of Table 1, a blaster has the option to use the graph shown in Figure A to limit peak particle velocity based upon the frequency of the blast vibration.

Figure A



Maximum allowable particle velocity vs. blast vibration frequency graph.

(c) Unless a blaster uses a seismograph to monitor a blast to ensure compliance with Table 1 or Figure A, the operation shall comply with the scaled distance equations shown in Table 2.

TABLE 2

SCALED DISTANCE EQUATIONS

Distance from Blasting Site	**Scaled Distance Equation**
0 to 300 ft (91.4 m)	Standard Table of Distance (see below)
301 to 5000 ft (92 m to 1524 m)	$W (lbs) = (d (ft)/55)^2$ or $W (kg) = (d (m)/24.9)^2$
5001 ft (1524 m) and beyond	$W (lbs) = (d (ft)/65)^2$ or $W (kg) = (d (m)/29.4)^2$

Key:

W = *The maximum weight of explosives in pounds (or kilograms) that can be detonated per delay interval of 8 milliseconds or greater.*

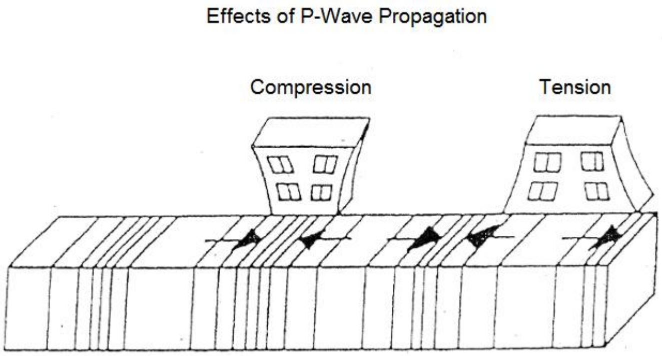
d = *The distance in feet (or meters) from the blast site to the nearest dwelling, public building, school, church, commercial, or institutional building normally occupied not owned, leased, or contracted by the blasting operation, or on property where the owner has not given a written waiver to the blasting operation.*

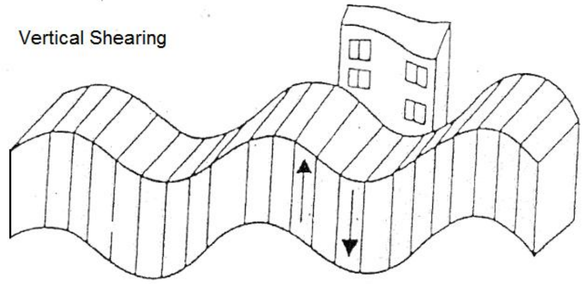
Note*: To convert English Units of scaled distances (ft/lb^2) to metric units (m/kg^2) divide by a factor of 2.21.*

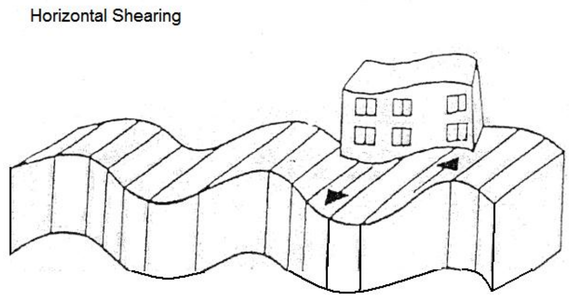
STANDARD TABLE OF DISTANCE (0 to 300 feet (91.4 m))

Distance in Feet	Weight in Pounds
0-10	1/8
11-15	1/4
16-20	1/2
21-25	3/4
26-30	1.00
40	2.25
50	3.50
60	4.75
70	6.00
80	7.25
90	8.50
100	9.75
110	11.00
130	13.50
150	16.00
170	18.50
190	21.00
210	23.50
230	26.00
250	28.50
270	31.00
290	33.50
300	34.75

(d) Airblast resulting from blasting activities shall not exceed one hundred forty decibels (140dB) at the location of any dwelling, public building, school, church, or commercial or institutional building that is not owned or leased by the person engaged in the blasting operation, or on property for which the owner has not provided a written waiver to the person engaged in the blasting operation.







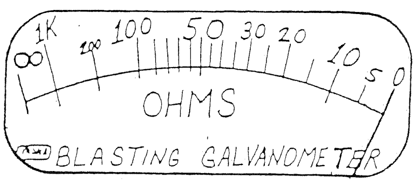
ELECTRIC INITIATION SYSTEMS

A galvanometer measures resistance in Ohms. Mats, water, skinned cap wires, and nicked wires contribute to increased resistance and current loss.

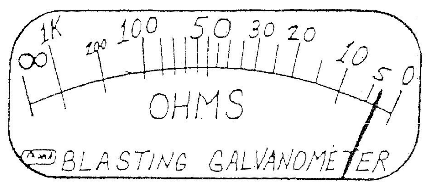
<u>CAUTION:</u> Use only electrical test equipment marked "BLASTER'S" or "BLASTING" when testing caps.

Sample galvanometer displays:

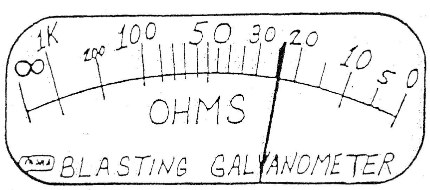
Zero Resistance, a short:



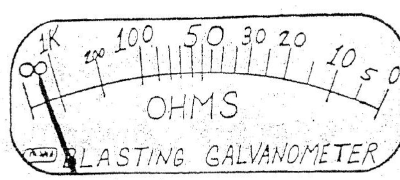
Low Resistance, few caps:



Resistance in a typical series:



High Resistance pinched or nicked wire, a fired cap, shot hole or weak cell (battery):



∞ is the symbol for infinity (cannot be measured), an open circuit, broken connection.
0 is zero resistance, a reading at or near zero may be a short.

NONELECTRIC SHOCKTUBE INITIATION

This method of initiation utilizes hollow flexible tubing which confines a small mount of explosive with other volatile materials, commonly aluminum dust. This material, when subjected to moderately intense shock and heat, reacts in a manner resembling a gas explosion in an underground mine. The fire moves through the shocktube at a rate of 6500 feet per second. The fire energizes the blasting cap.

In addition to the transfer of energy, the blasting caps are also used to achieve timing between adjacent holes and rows of holes. In discussing pattern design we must differentiate between the "in-hole caps" which are a component of the primers and the "surface delays" which relay the energy to the in-hole caps and determine the firing sequence (for the most part). While there may be a 1 to 1 ratio of surface delays to in-holes, often this is not the case. It is important to remember that every in-hole cap receives its energy from a source on the surface.

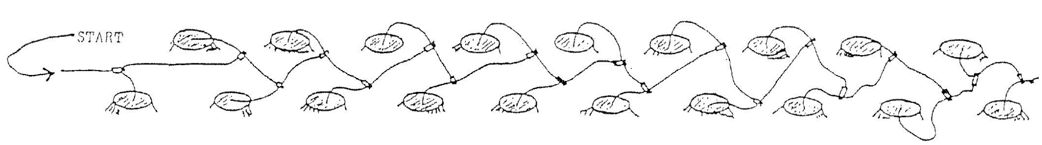
For the most part, anything you can accomplish with a sequential electric blasting machine and a full selection of delay caps, you can duplicate with nonelectric caps and fewer delays. This includes: multiple delays per hole, complex non-duplicating patterns and other demanding applications. Another advantage is the independence from a power source like a blasting machine; each surface delay delivers its full force to its "in-holes" and connected surface delays then the process repeats itself. Because of this trait, the system has far more potential in terms of pure numbers of delays.

Another advantage to this system is its near total insensitivity to electrical currents and radio wave energy. Over 100,000 volts have been applied in tests with no accidental detonation. All lightning safety precautions still apply however. Along with these advantages there are some disadvantages. There is no test device available for this system. A thorough, detailed inspection of all hook-ups is a must. Due to the inherent scatter in pyrotechnic delay material, remembering each delay is dependent on two of these caps for its firing time, this system cannot quite duplicate the accuracy of a sequential electrical application.

A key concern in sequential applications, electric or nonelectric, is the activation of the in-hole caps. In a fully activated pattern, all caps have received energy before the first one (in-hole) fires. In a partially activated pattern some of the surface system either electrical wiring, surface delays, detonating cord, etc., is exposed to flyrock and shifting material as the shot evolves. While fully activated patterns are preferable, they are not always achievable. Partially activated patterns occur more often in nonelectric applications. By energizing the shot along its axis of movement, this exposure is somewhat lessened.

Simplified, hole-to-hole, shocktube system

It consists of standard surface and in-hole delays fixed to each end of a length of shocktube. Typically the same surface and in-hole delay are used throughout the shot, hooked up hole to hole.

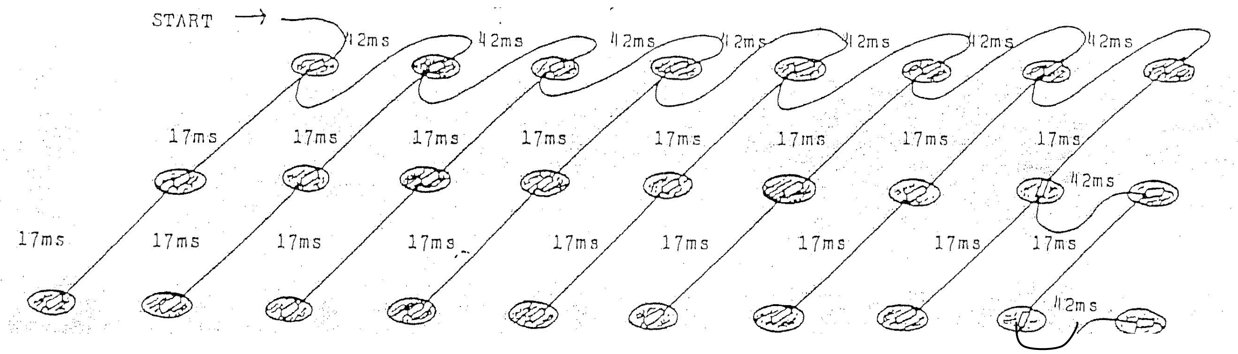


Common trade names for these type caps are: E-Z Det, Snapdet, Handi-Det and TwinStar, In the example above if the surface delays are 25ms and the in-hole delays are 350ms then the surface caps are activating 14 holes ahead of the progress of detonation. Provided the throw is minimal, this system experiences little exposure to a shutdown. This example is of a one-hole-per-delay shot.

Sequential nonelectric shocktube initiation systems

These often use combinations of different surface and in-hole delays. The example below is a fairly simple straightforward application. In this pattern, a standard in-hole delay is used throughout the shot.

Surface delays of 17ms and 42ms have been selected to set the timing. The shot is oriented to cast toward the start point (two open faces):



While the timing between holes along the front row is 42ms, the echelons require 34ms (17+17). This leaves 8ms remaining between detonations, satisfying the requirement for a separate delay period. The additional 42ms delays at he end of the second and third rows maintain the uniformity of the firing times

NONELECTRIC INITIATION WITH DETONATING CORD

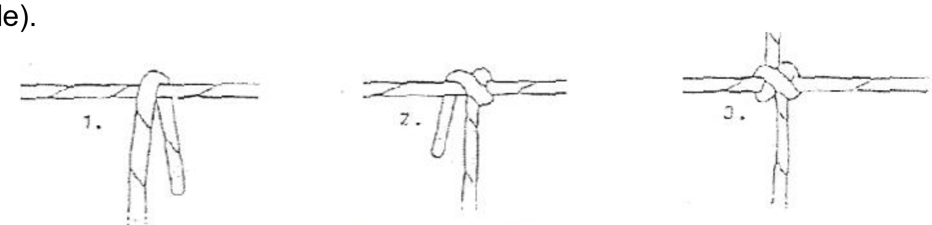
Detonating cord is commonly used in pre-splitting, cross-country pipeline construction, marine blasting and in conjunction with shocktube systems.

Detonating cord is sold in multiple sizes and loads. It is typically rated by the number of grains of explosive per linear foot (there are 7000 grains in a pound). Velocity of detonation is generally given as 21,000 feet per second.

It is important to remember that all standard precautions apply when blasting with detonating cord; this includes both lightning and the handling of misfires.

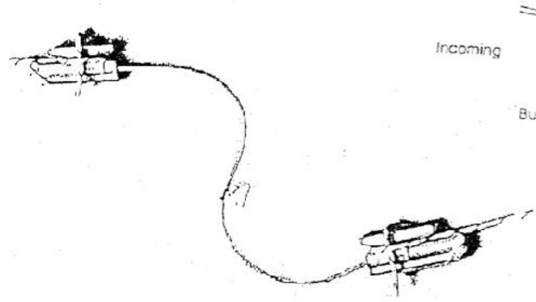
Joining detonating cords and combining cord with shocktube call for special knots and techniques. The two general rules are: straight lines for joining and 90 degree angles for intersecting. When connecting cord to cord, the square knot and clove hitch are usually recommended. In attaching shocktube to detonating cord, the 90 degree angle becomes critical due to the tremendous differences in detonating velocity (if joining at the end of the cord, 180 degrees is acceptable).

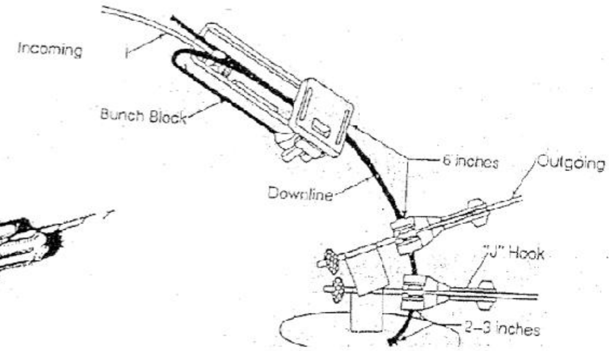
Clove Hitch



Recommended for cords of 25 gr. or more

Square Knot





Malfunctions and Misfires

Most of these instances are more properly classified in the-category of “failure to initiate”. These failures are directly attributable to causes such as:

- Inadequate training
- Ignoring the manufacturer’s recommendations
- Insufficient current
- Improper hook-ups, splices or knots
- Failure to perform tests and inspections

The point is that human failure far exceeds product failure in these incidents. It is, however, important to recognize product problems when they arise. Many of these product problems are in fact application problems, another human failing:

- Dead Press: Desensitization of a charge caused by shock from an adjacent borehole. Product application and timing of delays.
- Deflagration: A rapid burning down short of true detonation.
- Propagation: Sympathetic detonation of a charge caused by shock from an adjacent borehole. Usually more than a few holes are involved, and the display is dramatic. Products with greater sensitivity, close hole spacing, the presence of seams and water figure into this occurrence.
- Shutdown/Cutoffs etc.: In shocktube and detonating cord shots, may be due to many causes: hookup, timing, and shift in over-burden or flyrock. Nonelectric blast design, where possible, should favor a simple shutdown so that re-initiation can be attempted.

When misfires occur and the borehole and charge are intact, the preferred remedy is to reinitiate. This may require removing stemming through the use of compressed air and water to expose explosives. It may require replacing burden lost to back-break and using materials or mats to compensate for top priming. Contact your supplier if you have any questions.

If the decision is made unload the hole or reduce the charge, use non-sparking tools, and exercise extreme caution, especially with the primer.

When explosives are encountered in the muckpile, cease work until the problem is evaluated. Ensure there is someone familiar with the materials used in the shot, and their handling and disposal there. Brief the equipment operator in what to look for and what the recovery procedures will be. Have a spotter looking where the operator cannot.

GENERAL SAFETY NOTES

- In the event of lightning, evacuate the blast site and guard the blast area—regardless of the initiation system.
- Burning explosives may detonate; confinement increases the risk of detonation.
- Never fight explosives fires; evacuate the area around burning explosives.
- Before explosives catch fire: fight the fire, evacuate the explosives; take any reasonable step to prevent burning explosives.
- Radio wave energy is a potential threat where electric detonators are in use. Consult Institute of Makers of Explosives; *Safety Library Publication Number 20* to evaluate a given exposure.
- Use only galvanometers and multimeters marked "Blaster's" or "Blasting" to check electric cap circuits.
- Read the "Always and Nevers" included in each container of explosive materials.
- Contact your supplier regarding any distressed explosive material which may need to be destroyed.
- Except by special permit, all blasting is done during daylight hours only.

68-105-109. Notification of accidents — Cessation of blaster operations — Preservation of evidence — Penalties — Hearings and judicial review — Variations from requirements. —

(a) Notification of Accident. In the event of a blasting accident, the blaster in charge of the site shall notify the department where death, personal injury requiring hospital admission, or property damage of at least five thousand dollars ($5,000) due to flying debris occurs as a result of a blasting operation. If the blaster in charge is incapacitated, the blasting firm shall be responsible for notifying the department immediately in the event of an accident described in this subsection (a).

(b) Cessation of Blaster Operations. When a reportable accident occurs, the blaster in charge shall cease blasting operations immediately and shall be prohibited from conducting further blasting operations until such time as the department's investigation is completed. In no event, however, shall this cessation last longer than five (5) working days, unless the commissioner determines that a longer period of time is necessary based upon the commissioner's finding of just cause.

(c) Preservation of Evidence. When a reportable accident occurs, blasting operations at the site shall cease and a reasonable effort shall be made to ensure that the immediate blasting area remains undisturbed sufficient to preserve evidence of the accident until the department completes its initial investigation. In no event, however, shall this cessation last longer than three (3) working days, unless the commissioner determines that a longer period is necessary based upon the commissioner's finding of just cause. The requirements of this section do not apply to measures taken at the site to resume traffic flow, to facilitate emergency operations, or for the mitigation of damage.

State laws may be found at: http://www.michie.com and navigating to Tennessee Code, Safety, Title 68, Chapter 105.

Rules may be found at: http://www.state.tn.us/sos/rules/0780/0780-02/0780-02-15.pdf.

Cross Section illustrations of blasting caps and blast site appear courtesy of Dyno Nobel, Inc.
Illustrations of detonating cord knots and connections appear courtesy of Ensign-Bickford Company.
Other illustrations and text are the work of Hermitage Explosives Corporation.