BLASTING AWARENESS PROGRAM FOR UNDERGROUND INDUSTRIAL MINERALS MINES

PRESENTED BY PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION BUREAU OF MINE SAFETY

Preface

This program is for instructional purposes only and does not constitute an endorsement by Pennsylvania Department of Environmental Protection, Bureau of Mine Safety, of any specific product. Attendance of this program *does not* constitute certification under state or federal laws or regulations.

Disclaimer

The information and recommendations contained in this program have been compiled from sources believed to be reliable and to represent the best current opinion on the subject. No warranty, guarantee, or representation is made by the Pennsylvania Department of Environmental Protection, Bureau of Mine Safety, as to the absolute correctness or sufficiency of any representation contained in this course and publication, and assumes no responsibility in connection therewith; nor can it be assumed that all acceptable safety measures are contained in this, or that other or additional measures not be observed under particular or exceptional conditions or circumstances.

COURSE OBJECTIVES

Upon completion of instructions, applicants should be knowledgeable in the following:

1. Title 25: Chapters 210
   Chapter 211

   ATF: Safe Explosive Act - Background Checks
   Subpart K - Storage

   Title 30 CFR 57.6000 – Explosives

2. Definitions
3. Calculations
4. Planning the firing circuit
5. Series / Parallel / Series-Parallel Circuits
6. Electric Firing Techniques
7. Extraneous Electricity
8. Testing Blasting Circuits
9. Date / Plant / Shift Code
10. Ammonium Nitrate
11. Emulsions
12. Dynamites
13. Electric Detonators
14. Primers
15. Detonating Cord
16. Blasting Fumes / Gasses

Section I

CHAPTER 210

BLASTERS' LICENSES
GENERAL PROVISIONS

Annex A
TITLE 25. ENVIRONMENTAL PROTECTION
PART I. DEPARTMENT OF ENVIRONMENTAL PROTECTION
Subpart D. ENVIRONMENTAL HEALTH AND SAFETY
ARTICLE IV. OCCUPATIONAL HEALTH AND SAFETY

CHAPTER 210. BLASTERS' LICENSES

GENERAL PROVISIONS

§ 210.1--210.6. (Reserved).

§ 210.11. Definitions.

The following words and terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise:

Blaster--A person who is licensed by the Department under this chapter to detonate explosives and supervise blasting activities.

Blaster learner--An individual who is learning to be a blaster and who participates in blasting activities under the direct supervision of a blaster.

Blaster's license--A license to detonate explosives and supervise blasting activities issued by the Department under this chapter.

Demolition and demolition blasting--The act of wrecking or demolishing a structure with explosives.

Person--A natural person.

§ 210.12. Scope.

This chapter applies to persons engaging in the detonation of explosives within this Commonwealth. This chapter does not apply to persons authorized to detonate explosives or to supervise blasting activities under:

(1) The Pennsylvania Anthracite Coal Mine Act (52 P. S. §§ 70.101--70.1405).

(2) The Pennsylvania Bituminous Coal Mine Act (52 P. S. §§ 701-101--701-706).

§ 210.13. General.

(a) A person may not detonate explosives or supervise blasting activities unless the person has obtained a blaster's license.

(b) The Department may exempt certain individuals from needing a blaster's license if the person is detonating extremely small amounts of explosives for industrial or research purposes. The Department will consider a written request for an exemption from the person seeking the exemption.

(c) Upon request, a blaster shall exhibit a blaster's license to the following:

(1) An authorized representative of the Department.

(2) The blaster's employer or an authorized representative of the employer.

(3) A police officer acting in the line of duty.

(d) A blaster's license is not transferable.

§ 210.14. Eligibility requirements.

(a) To be eligible for a blaster's license, a person shall:

(1) Be 21 years of age or older.

(2) Have at least 1 year of experience as a blaster learner in preparing blasts in the classification for which a license is being sought.

(3) Have taken the Department's class on explosives. It is not necessary for a blaster to retake the class when adding an additional classification to a license.

(4) Have successfully passed the Department's examination for a blaster's license.

(b) The Department will not issue or renew a license if the applicant, as indicated by past or continuing violations, has demonstrated a lack of ability or intention to comply with the Department's regulations concerning blasting activities.

§ 210.15. License application.

(a) The license application shall be on forms provided by the Department and be accompanied by a check for $50 payable to the Commonwealth of Pennsylvania. The complete application shall be submitted to the Department at least 2 weeks prior to the examination.

(b) The license application shall include a signed notarized statement from a person who has direct knowledge of the applicant's expertise, such as the blaster who supervised the applicant, or the applicant's employer. The statement shall:

(1) Describe the applicant's experience in blasting. In particular, the statement shall describe in detail how the applicant assisted in the preparation of the blasts and for how long.

(2) State whether the applicant is competent to prepare and detonate blasts in the classification for which the license is being sought.

§ 210.16. Examinations.

(a) The Department will conduct examinations for specific types of blasting, as specified in § 210.17(a) (relating to issuance and renewal of licenses).

(b) The Department will schedule and conduct examinations as needed.

(c) An applicant failing to appear for a scheduled examination forfeits the application fee unless the applicant provides written notice to the Department prior to the examination date or submits a valid medical excuse in writing.

(d) Refund of the fee or admittance to a subsequent examination without a reapplication fee will be at the discretion of the Department.

§ 210.17. Issuance and renewal of licenses.

(a) A blaster's license is issued for a specific classification of blasting activities. The classifications will be determined by the Department and may include general blasting (which includes all classifications except demolition and underground noncoal mining), trenching and construction, seismic and pole line work, well perforation, surface mining, underground noncoal mining, industrial, limited and demolition.

(b) A person may apply to amend the blaster's license for other classifications by meeting the requirements of § 210.14 (relating to eligibility requirements) and by submitting a complete application.

(c) A blaster's license will be issued for 3 years.

(d) A blaster's license is renewable if the blaster can demonstrate that he has had 8 hours of continuing education in Department-approved courses related to blasting and safety within the 3-year period.

(e) The blaster's license may be renewed for a 3-year term by submitting a renewal application to the Department and a check for $30, payable to the Commonwealth of Pennsylvania.

(f) A person who intends to be a blaster and whose blaster's license was not renewed within 1 year of its expiration date shall apply for a new license under §§ 210.14--210.16 (relating to eligibility requirements; license application; and examinations).

(g) A person who conducted demolition blasting under a general blaster's license may conduct demolition blasting after July 14, 2001, by applying for and receiving a demolition blaster's license. The Department may waive the examination required by § 210.14 (relating to eligibility requirements) and the application fee if the blaster demonstrates at least 3 years of experience in demolition blasting. The demonstration shall be in the form of a notarized statement from the blaster's employer that describes the blaster's experience.

§ 210.18. Recognition of out-of-State blaster's license.

(a) The Department may license a person who holds a blaster's license or its equivalent in another state. The Department may issue the license if, in the opinion of the Department, that state's licensing program provides training on the storage, handling and use of explosives and an examination that is equivalent to the requirements of this chapter.

(b) A request for a license under this section shall be made in writing. Copies of the other state's explosives training and examination material and proof that the applicant holds a license in the other state shall be provided to the Department in order to make a proper evaluation.

§ 210.19. Suspension, modification and revocation.

The Department may issue orders suspending, modifying or revoking a blaster's license. Before an order is issued, the Department will give the blaster an opportunity for an informal meeting to discuss the facts and issues that form the basis of the Department's determination to suspend, modify or revoke the license. The Department may suspend, modify or revoke a blaster's license for violations of this chapter and Chapter 211 (relating to storage, handling and use of explosives in surface applications).

Section II

CHAPTER 211

STORAGE, HANDLING AND USE OF EXPLOSIVES

CHAPTER 211. STORAGE, HANDLING AND USE OF EXPLOSIVES

§ 211.101. Definitions.

The following words and terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise:

Airblast--An airborne shock wave resulting from an explosion, also known as air overpressure, which may or may not be audible.

Blast area--The area around the blast site that should be cleared to prevent injury to persons and damage to property.

Blast site--The specific location where the explosives charges are loaded into the blast holes.

Blaster--An individual who is licensed by the Department under Chapter 210 (relating to blasters' licenses) to detonate explosives and supervise blasting activities.

Blaster-in-charge--The blaster designated to have supervision and control over all blasting activities related to a blast.

Blasting activity--The actions associated with the use of explosives from the time of delivery of explosives to a worksite until all post blast measures are taken, including priming, loading, stemming, wiring or connecting, detonating, and all necessary safety, notification and monitoring measures.

Building--A structure that is designed for human habitation, employment or assembly.

Charge weight--The weight in pounds of an explosive charge.

Delay interval--The designed time interval, usually in milliseconds, between successive detonations.

Detonator--A device containing an initiating or primary explosive that is used for initiating detonation of explosives. The term includes electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses, detonating cord, delay connectors and non-electric instantaneous and delay blasting caps.

Explosive--A chemical compound, mixture or device that contains oxidizing and combustible materials or other ingredients in such proportions or quantities that an ignition by fire, friction, concussion, percussion or detonation may result in an explosion.

(i) The term includes safety fuse, squibs, detonating cord and igniters.

(ii) The term does not include the following:

(A) Commercially manufactured black powder, percussion caps, safety and pyrotechnic fuses, matches and friction primers, intended to be used solely for sporting, recreational or cultural purposes in antique firearms or antique devices, as defined in 18 U.S.C.A. § 921 (relating to definitions).

(B) Smokeless powder, primers used for reloading rifle or pistol cartridges, shot shells, percussion caps and smokeless propellants intended for personal use.

Flyrock--Overburden, stone, clay or other material ejected from the blast area by the force of a blast.

Magazine--A structure used for the storage of explosives.

Misfire--Incomplete detonation of explosives.

Particle velocity--A measure of the intensity of ground vibration, specifically the time rate of change of the amplitude of ground vibration.

Peak particle velocity--The maximum intensity of particle velocity.

Person--A natural person, partnership, association, or corporation or an agency, instrumentality or entity of state government.

Primer--A cartridge or package of high explosives into which a detonator has been inserted or attached.

Purchase--To obtain ownership of explosives from another person.

Sale or *sell*--To transfer ownership of explosives to another person.

Scaled distance (Ds)--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 of the maximum weight of explosives (W) in pounds, that is detonated per delay period of less than 8 milliseconds.

$$Ds = D \div \sqrt{W}$$

Stemming--Inert material placed in a blast hole after an explosive charge for the purpose of confining the explosion gases to the blast hole, and inert material used to separate explosive charges in decked holes.

Structure--A combination of materials or piece of work built or composed of parts joined together in some definite manner for occupancy, use or ornamentation. The term includes everything that is built or constructed, including bridges, offices, water towers, silos and dwellings.

Utility lines--An electric cable, fiber optic line, pipeline or other type of conduit used to transport or transmit electricity, gases, liquids and other media including information.

§ 211.102. Scope.

(a) This chapter applies to persons using, storing, purchasing and selling explosives and engaging in blasting activities within this Commonwealth. Persons using and storing explosives at underground mines are exempt from this chapter. The storage of explosives in magazines on the surface at an underground noncoal mine is subject to the applicable requirements of this chapter. The provisions of this chapter that are more stringent than the blasting provisions in Chapters 77, 87 and 88 (relating to noncoal mining; surface mining of coal; and anthracite coal) apply to blasting activities at coal or noncoal surface mines.

(b) Compliance with this chapter does not relieve a person who is engaged in the purchase or sale of explosives, or blasting activities, from compliance with other applicable laws or regulations of the Commonwealth.

§ 211.103. Enforcement.

(a) The Department may issue orders necessary to implement this chapter including an order to suspend, modify or revoke a license or permit authorized by this chapter.

(b) Before issuing an order modifying peak particle velocity or airblast limits in a blasting activity permit, the Department will first provide the permittee with an opportunity to meet and discuss modifications.

Subchapter B. STORAGE AND CLASSIFICATION OF EXPLOSIVES

§ 211.111. Scope.

This subchapter applies to the classification and storage of explosives. It establishes the requirements, procedures and standards for licensing, constructing, site and maintaining magazines.

§ 211.112. Magazine license and fees.

(a) A person storing explosives shall do so in a magazine licensed by the Department. A person may not construct, install or modify a magazine until the Department has issued or amended the license in writing. The licensee shall store explosives in accordance with the approved application, the license and this chapter.

(b) The license specifies the types and quantities of explosives to be stored in the magazine and any other condition necessary to ensure that the proposed activity complies with applicable statutes and this chapter.

(c) Licenses expire annually on December 31 of each year. If the Department receives a complete renewal application by December 31, the licensee may continue to operate under the current license until the Department acts on the renewal application.

(d) License fees are as follows:

(1) License:

(i) Application--$50

(ii) Site inspection--$50

(2) License modifications--$50

(3) License renewals--$50

(4) License transfers--no fee

§ 211.113. Application contents.

(a) An application to obtain, renew, modify or transfer a magazine license shall be on forms approved by the Department. Before the Department issues, renews, transfers or modifies a license, the application must demonstrate that the applicant has complied with the applicable requirements of this chapter.

(b) A completed license application shall include:

(1) The applicant's name, address and telephone number.

(2) A contact person, including name, title and telephone number.

(3) The types and quantities of explosives to be stored within the magazine.

(4) A map, plan or a sketch of the site location showing the nearest buildings, nearest railways, nearest highways, and existing barricades, if any, and proposed barricades.

(5) A plan showing the design and specifications of the magazine to be licensed.

(c) A license renewal application shall include:

(1) The applicant's name, address and telephone number.

(2) A contact person, including name, title and telephone number.

(3) The maximum amount and type of explosives for which the magazine is currently licensed.

§ 211.114. Displaying the license.

The magazine license, or a legible copy of the license, shall be conspicuously displayed. If possible, the license shall be displayed inside the magazine. In all other cases, the license shall be displayed at the site and adjacent to the magazine to which it applies.

§ 211.115. Standards for classifying and storing explosives and constructing, maintaining and site magazines.

(a) The provisions of 27 CFR Part 55, Subpart K (relating to storage), are incorporated herein by reference. These provisions shall be used to:

(1) Classify explosives.

(2) Determine which class of explosives may be stored in each type of magazine.

(3) Determine the quantity of explosives that may be stored.

(4) Determine the applicable construction standards for each type of magazine.

(5) Site the magazine.

(6) Specify maintenance and housekeeping standards for a magazine.

(7) Grant variances.

(b) For purposes of incorporation by reference of 27 CFR Part 55 Subpart K, the term "Department" is substituted for the term "director," and the term "representatives of the Department" is substituted for the term "ATF Official."

Subchapter C. PERMITS

§ 211.121. General requirements.

(a) Except as otherwise provided in this subchapter, a person may not engage in blasting activities, or sell or purchase explosives in this Commonwealth without first obtaining the appropriate permit from the Department issued under this chapter.

(b) Permits under this chapter are not required for the sale, purchase or use of fireworks governed by the act of May 15, 1939 (35 P. S. §§ 1271--1277).

(c) A permit issued under the Surface Mining Conservation and Reclamation Act (52 P. S. §§ 1396.1--1396.19a), or the Noncoal Surface Mining and Conservation and Reclamation Act (52 P. S. §§ 3301--3326), and the regulations promulgated there under, authorizing blasting activity shall act as a blasting activity permit issued under this chapter.

(d) An application for a permit for the sale or purchase of explosives or to conduct blasting activities shall be on a form provided by the Department. A permit will not be issued unless the application is complete and demonstrates that the proposed activities comply with the applicable requirements of this chapter. The Department will notify applicants of an incomplete application and identify the items necessary to complete the application. The permittee shall comply with the approved application, the permit and this chapter.

(e) The Department will not issue a permit to any person who has either:

(1) Failed and continues to fail to comply with this chapter or a condition of a permit issued under this chapter or an order issued to enforce this chapter.

(2) Demonstrated an inability or lack of intention to comply with this chapter as indicated by past or continuing violations.

§ 211.122. Permits to sell explosives.

(a) An application for a permit to sell explosives shall:

(1) Identify the applicant's name, address, telephone number and type of business.

(2) Identify a contact person, including name, title and telephone number.

(3) Specify the type of explosives to be sold.

(4) State whether the applicant will purchase or manufacture the explosives to be sold.

(5) For in-State sellers, include the applicant's magazine license number, if applicable.

(b) Permits to sell explosives are not transferable.

(c) Permits to sell explosives expire on April 30 of each year. If the Department receives a complete renewal application by April 30, the permittee may continue to operate under the current permit until the Department acts on the renewal application.

(d) A permit to sell explosives shall:

(1) Identify the permittee.

(2) Specify the type of explosives that the permittee may sell.

(3) Contain conditions, as necessary, to ensure that the proposed activity complies with applicable statutes and this chapter.

§ 211.123. Permits to purchase explosives.

(a) An application for a permit to purchase explosives shall:

(1) Identify the applicant's name, address, telephone number and type of business.

(2) Identify a contact person, including name, title and telephone number.

(3) Identify the location and license number of the magazine to be used for storing the explosives, if applicable.

(4) Specify the type of explosives that will be purchased.

(5) Specify whether the explosives are being purchased for sale or use by the permittee.

(b) Permits to purchase explosives are not transferable.

(c) Permits to purchase explosives expire on April 30 of each year. If the Department receives a complete renewal application by April 30, the permittee may continue to operate under the current permit until the Department acts on the renewal.

§ 211.124. Blasting activity permits.

(a) An application for a blasting activity permit shall be prepared by a blaster and shall include:

(1) The applicant's name, address, telephone number and type of business.

(2) A contact person's name, title and telephone number.

(3) The identity of independent subcontractors who will be performing the blasting activities.

(4) The type of explosives to be used.

(5) The maximum amount of explosives that will be detonated per delay interval of less than 8 milliseconds.

(6) The maximum amount of explosives that will be detonated in any one blast.

(7) A map indicating the location where the explosives will be used.

(8) The purpose for which the explosives will be used.

(9) The location and license number of the magazine that will be used to store the explosives, if applicable.

(10) A description of how the monitoring requirements of Subchapter G (relating to requirements for monitoring) will be satisfied.

(11) Proof of third party general liability insurance in the amount of $300,000 or greater per occurrence. This requirement is not applicable if the permittee is a noncoal surface mine operator who produces no more than 2,000 tons (1,814 metric tons) of marketable minerals per year from all its noncoal surface mining operations.

(12) The anticipated duration of the blasting activity for which the permit is needed.

(13) The anticipated days of the week and times when blasting may occur.

(14) The distance and direction to the closest building not owned by the permittee or its customer.

(15) Other information needed by the Department to determine compliance with applicable laws and regulations.

(16) The printed name, signature and license number of the blaster who prepared the application.

(17) Proof that residents within 200 feet (65.61 meters) of the blast site were informed of the proposed blasting operation. This notification could be a personal notification, written material left at each residence, or first class mail. The notification will provide general information about the blasting operation including the duration of the operation.

(b) Blasting activity permits are not transferable.

(c) The blasting activity permit shall specify:

(1) The blasting activity permittee.

(2) Any independent subcontractors performing work under this permit.

(3) Limits on particle velocity and airblast.

(4) The types of explosives that may be used.

(5) The duration of the permit.

(6) Other conditions necessary to ensure that the proposed blasting activity complies with the applicable statutes and this chapter.

(d) The permittee may request extensions and modifications by submitting an amended application.

§ 211.125. Blasting activity permit-by-rule.

(a) A person shall be deemed to have a permit for a blasting activity if:

(1) The blasts are designed and performed for a scaled distance of 90 or greater.

(2) No more than 15 pounds (6.81 kilograms) of explosives are detonated per delay interval of less than 8 milliseconds.

(3) The total charge weight per blast does not exceed 150 pounds (68.18 kilograms).

(4) The person notifies the Department either verbally, in writing, or by other means approved by the Department prior to the initial blast. If the person gives verbal notification, a written notice shall be received by the Department within 5 working days. The notification shall indicate the following information for all blasts that will occur under this permit:

(i) The identity of the person.

(ii) The location where the blasting will occur.

(iii) The purpose of the blasting.

(iv) The distance to the nearest building not owned or leased by the person or its customer.

(v) The days of the week and times when blasting may occur.

(vi) The duration of blasting activities under this permit by rule.

(vii) The minimum scaled distance.

(viii) The maximum weight of explosives detonated per delay period of less than 8 milliseconds.

(ix) The maximum total weight of explosives per blast.

(x) A contact person and telephone number.

(5) Blast reports are completed in accordance with § 211.133 (relating to blast report).

(6) The other monitoring and performance standards of this chapter are met.

(b) The Department may revoke a blasting activity permit by rule under one of the following:

(1) The permittee has demonstrated an unwillingness or inability to comply with the applicable regulations.

(2) The blasting activity possesses a sufficient risk of harm to the public or the environment to warrant an individual blasting activity permit.

Subchapter D. RECORDS OF DISPOSITION OF EXPLOSIVES

§ 211.131. Sales records.

The seller shall keep an accurate record of every sale of explosives for 3 years. The record shall identify the purchaser's name and address, the Department purchase permit number, the date of the sale and the amount and types of explosives.

§ 211.132. Purchase records.

The purchaser shall keep a record of all purchases of explosives for 3 years. The record shall identify the date, types and amounts of explosives purchased and the name and address of the seller.

§ 211.133. Blast reports.

(a) The blaster-in-charge shall prepare a report of each blast to provide the Department with sufficient information to reconstruct the conditions and events surrounding a blast. The Department may develop and require a blast report form to be used. The blasting activity permittee shall retain the blast report for at least 3 years and shall make the blast report available to the Department upon request. Blast reports shall contain, at a minimum, the following:

(1) The locations of the blast and monitoring readings.

(2) The name of the blasting activity permittee.

(3) The blasting activity permit or appropriate mining permit number.

(4) The date and time of the blast.

(5) The printed name, signature and license number of the blaster-in-charge.

(6) The type of material blasted.

(7) A sketch showing the number of blast holes, burden, spacing, pattern dimensions and point of initiation.

(8) The diameter and depth of blast holes.

(9) The height or length of stemming and deck separation for each hole.

(10) The types of explosives used and arrangement in blast holes.

(11) The total weight in pounds of explosives and primer cartridges used.

(12) The maximum weight in pounds of explosives detonated per delay period of less than 8 milliseconds.

(13) The type of circuit, if electric detonation was used.

(14) The direction and distance in feet from the blast site to the nearest building not owned by the blasting activity permittee or its customer.

(15) A description of the nearest building location not owned or leased by the blasting activity permittee or its customer based upon local landmarks.

(16) The scaled distance.

(17) The weather conditions.

(18) The direction from which the wind was coming.

(19) The measures taken to control flyrock, including whether or not mats were used.

(20) The total quantity and type of detonators used and delays used.

(21) The number of individuals in the blasting crew.

(22) The maximum number of blast holes or portions of blast holes detonated per delay period less than 8 milliseconds.

(23) The monitoring records required by § 211.173 (relating to monitoring records). Monitoring records shall be made part of the blast report within 30 days of the blast. Beginning July 14, 2004, monitoring records shall be made part of the blast report within 14 days of the blast. The Department may grant a waiver to allow monitoring records to be made part of the blasting record within 30 days of the blast if all blasts, regardless of scaled distance, are monitored and monthly summaries of these reports, including the information required in subsection (b), are provided. Monitoring records shall be made part of the blast report within 7 days, if requested by the Department.

(24) If a misfire occurred, the actions taken to make the site safe as specified in § 211.157 (relating to post blast measures).

(b) The Department may require monthly summaries of these reports. The summaries shall include the date and time of the blasts, scaled distance, peak particle velocity, airblast, monitoring location, amount and types of explosives used and other information the Department deems necessary to ensure compliance with this chapter.

Subchapter E. TRANSPORTATION OF EXPLOSIVES

§ 211.141. General requirements.

The blasting activity, purchase or sale permittee shall:

(1) Immediately unload a vehicle carrying explosives upon reaching a magazine location. The unloaded vehicle shall be removed from the site. The only exception to this requirement is if the vehicle is a licensed magazine under Subchapter B (relating to the storage and classification of explosives).

(2) Load or unload explosives from a vehicle only after the engine is turned off, unless power is needed for the loading or unloading operation. The permittee shall take all precautions necessary, such as blocking the wheels, to prevent the movement of the vehicle while it is being loaded or unloaded.

(3) Load explosives only into a vehicle that is marked in accordance with the Department of Transportation standards for placarding vehicles transporting explosives.

(4) Prohibit smoking within 100 feet of a vehicle used for transporting explosives. "NO SMOKING" signs shall be posted when a vehicle containing explosives is parked at a blast site or magazine.

(5) Load no more than 2,000 pounds (908 kilograms) of explosives into an open body vehicle for transporting. The ends and sides shall be high enough to prevent explosives from falling off, and the load shall be covered with a fire-resistant tarpaulin, unless the explosives are transported in a magazine securely attached to the vehicle.

(6) Load explosives into a closed body vehicle if the load is more than 2,000 pounds (908 kilograms) of explosives.

(7) Only load explosives into a vehicle with a bed made of wood or other non-sparking material.

(8) Load explosives into a vehicle which is also transporting metal, metal tools, blasting machines or other articles or materials likely to damage the explosives, only if these items are separated from the explosives by substantial non-sparking bulkheads constructed to prevent damage to the explosives.

(9) Load detonators and other explosives into the same vehicle only if the detonators are in containers that conform to the current version of the *Institute of Makers of Explosives Safety Library Publication # 22* available from the Institute of Makers of Explosives, 1120 Nineteenth Street, N. W., Suite 310, Washington, DC 20036-3605.

(10) Not load explosives into the same vehicle with materials such as matches, firearms, electric storage batteries, corrosive compounds, flammable substances, acids, oxidizing agents and ammonium nitrate not in the original containers.

(11) Only load explosives into vehicles equipped with a fire extinguisher having a National Board of Underwriters Laboratories rating of 10 B:C or more. The fire extinguisher shall be easily accessible and ready for immediate use.

(12) Load explosives into a vehicle so that explosives containers are not exposed to sparks or hot gases from the exhaust tailpipe. Exhaust

systems that discharge upwards are recommended to avoid possible exposure of sparks or hot gases to explosives.

(13) Only load explosives into vehicles that have passed the State safety inspection or certification.

Subchapter F. BLASTING ACTIVITIES

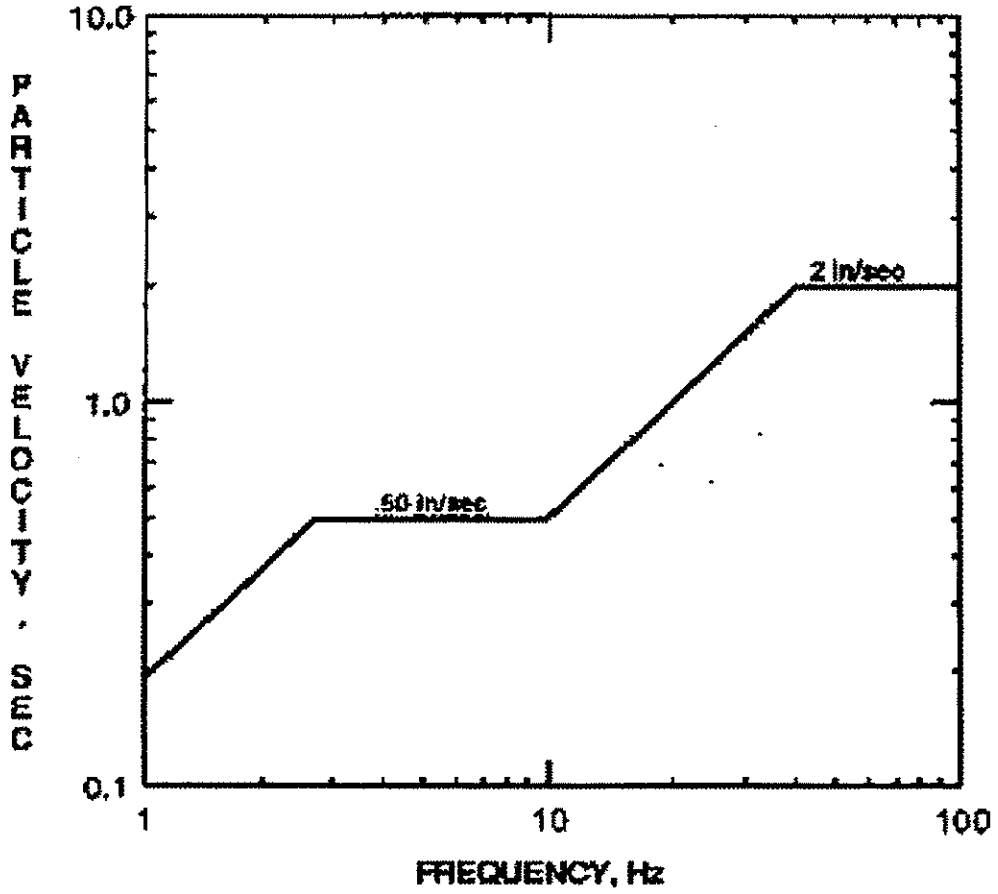
§ 211.151. Prevention of damage.

(a) Blasting may not damage real property except for real property under the control of the permittee. If damage occurs, the blaster-in-charge shall notify the Department within 4 hours of learning of the damage.

(b) Blasting may not cause flyrock. If flyrock occurs, the blaster-in-charge shall notify the Department within 4 hours of learning of the flyrock.

(c) Blasts shall be designed and conducted in a manner that achieves either a scaled distance of 90 or meets the maximum allowable peak particle velocity as indicated by Figure 1 at the closest building or other structure designated by the Department. However, blasting activities authorized prior to July 14, 2001, may continue as authorized unless the authorization is modified, suspended or revoked by the Department. The scaled distance and maximum allowable peak particle velocity does not apply at a building or other structure owned or leased by the permittee or its customer.

Figure 1.



(d) Blasts shall be designed and conducted to control airblast so that it does not exceed the noise levels specified in Table 1 at a building or other structure designated by the Department unless the building is owned or leased by the permittee or its customer.

Table 1	
Lower frequency limits of measuring System in Hz(+3dB)	Maximum allowable levels in dBL
0.1 Hz or lower -- flat response*	134 peak
2.0 Hz or lower -- flat response	133 peak
6.0 Hz or lower -- flat response	129 peak
C - weighted -- slow response*	105 peak
*only when approved by the Department	

(e) The Department may establish an alternative peak particle velocity or airblast level if it determines that an alternative standard is appropriate because of density of population, land use, age or type of structure, geology or hydrology of the area, frequency of blasts or other factors.

§ 211.152. Control of noxious gases.

A blast shall be conducted so that the gases generated by the blast do not affect the health and safety of individuals. Effects from gases may be prevented by taking measures such as venting the gases to the atmosphere, interrupting the path along which gases may flow, and evacuating people from areas that may contain gases.

§ 211.153. General requirements for handling explosives.

(a) Only a nonferrous, non-sparking tool shall be used to open containers of explosives.

(b) Matches, lighters and smoking are prohibited within 100 feet (30.48 meters) of the blast site and areas where explosives are used or stored.

(c) If it becomes necessary to destroy damaged or deteriorated explosives, the permittee shall immediately contact the manufacturer for technical advice and assistance.

(d) Detonators may not be forced into cartridges of explosive or cast boosters. Detonators shall be completely inserted into a hole in an explosive cartridge made with an approved powder punch or into the detonator well of a cast booster.

(e) Explosives may not be left unattended. They are to be stored in a licensed magazine or kept under the permittee's supervision and control.

(f) A loaded blast shall always be under the continuous observation of the blaster-in-charge or a designee.

(g) Shooting or carrying ammunition or firearms on a blast site and in areas where explosives are used or stored is prohibited, except for material needed to initiate the blast.

(h) If blasting activities are conducted in the vicinity of electric lines such as transmission lines or electrified railways, a test shall be made for presence of stray electric currents. Electric blasting caps may not be used if stray electric currents in excess of 50 milliamperes are present.

(i) A package of explosives may not be thrown, slid along floors or over other packages of explosives, or handled roughly.

(j) If an electrical storm approaches an area where there is an activity involving explosives, the area shall be cleared by the permittee or licensee, who shall post guards at all approaches to prevent trespass of unauthorized persons.

(k) Explosives and equipment that are obviously damaged or deteriorated may not be used.

(l) Explosives may not be abandoned.

§ 211.154. Preparing the blast.

(a) The blasting activity permittee shall designate a blaster-in-charge for each blast. The blaster-in-charge shall control and supervise the blasting activity. The blaster-in-charge is responsible for all effects of the blast.

(b) Only equipment necessary for loading blast holes may be allowed to operate within 50 feet (15.24 meters) of the blast site. The Department may establish, in writing, a different distance limitation.

(c) A blaster-in-charge may not prepare or detonate a blast unless another person is present, able and ready to render assistance in the event of accident or injury.

(d) The blaster-in-charge shall make every effort to determine the condition of the material to be blasted from the individual who drilled the blast holes or from the drill log.

(e) Only the blaster-in-charge, other blasters, and up to six assistants per blaster may be at a blast site once loading of blast holes begins.

(f) While loading a blast hole, the following measures shall be followed:

(1) Ferrous material may not be used in the blast hole unless the use is approved by the Department in writing. This includes the use of steel casings, ferrous tools and retrieving equipment.

(2) Only nonferrous, non-sparking tamping sticks may be used in loading a blast hole. Sectional poles connected by brass fittings are permitted, if only the nonferrous, non-sparking end of the pole is used for tamping. Retrieving hooks shall be made from non-sparking metal such as brass or bronze.

(3) When using a pneumatic loading device, every precaution shall be taken to prevent an accumulation of static electricity. A loading operation shall be stopped immediately if static electricity or stray electrical currents are detected. The condition shall be remedied before loading may be resumed.

(4) The blast hole shall be carefully checked for obstructions with a nonferrous, non-sparking tamping pole, a tape, a light or a mirror before it is loaded. The use of magnifying mirrors is prohibited. Explosives may not be forced past an obstruction in a blast hole.

(5) Each blast hole shall be logged throughout the leading process to measure the amount and location of explosives placed in the blast hole. The information is to be recorded on the blast report required by § 211.133 (relating to blast report).

(6) A blast hole containing loose dynamite shall be stemmed but not tamped.

(7) The Department may specify the type and amount of stemming.

(g) Before connecting one loaded blast hole to another, all activity within the blast area shall cease, and all nonessential persons shall retreat to a safe place. The blaster-in-charge shall determine the blast area.

(h) Primers shall be prepared only at the hole to be loaded, immediately prior to loading. The components of the primer are to be kept separated at the collar of the blast hole. The primer may not be slit, dropped, deformed or carelessly handled and may not be tamped or forced into the blast hole.

(i) Immediately upon completing the loading of a blast hole, any wood, paper or other materials used to pack explosives shall be inspected for the presence of explosives and removed to an isolated area. These materials may be burned after the blast has been fired. Persons may not be within 100 feet (30.48 meters) of these burning materials.

(j) Measures shall be taken to reduce the chance of flyrock including:

(1) The use of blasting mats or other protective devices, if, in the opinion of the blaster-in-charge, the measures are necessary to prevent injuries to persons or damage to property.

(2) When blasting to an open, vertical face, checking the face for loose, hanging material or other faults prior to loading the blast holes.

(k) Explosives may not be brought to a blast site in greater quantities than are expected to be needed for that blast. Surplus explosives may not be stored in the blast area.

(l) Before a blast hole is loaded, it shall be checked to ensure that it is cool and does not contain any hot metal or smoldering material remaining from drilling the hole.

(m) The use of abrasive or sharp-edged constituents in stemming material shall be avoided if tamping is necessary and the tamping may sever blasting cap leg wires, shock tubes or detonating cords.

(n) Blasting activities may not be conducted within 800 feet (243.84 meters) of a public roadway unless precautionary measures are taken to safeguard the public. Precautionary measures include stopping or slowing of traffic and posting signs.

§ 211.155. Pre-blast measures.

Prior to detonating a blast, the blaster-in-charge shall:

(1) Ensure that all excess explosives have been removed from the blast area and are located in a safe area.

(2) Inspect the blast site to ensure that connections are proper and adequate.

(3) Ensure that the blast area is cleared and safeguarded.

(4) In addition to the warning signal, notify all persons who may be in danger.

(5) Ensure that the necessary precautions are in place to protect the public on public roads.

(6) At least 1 minute but no more than 2 minutes prior to detonation, sound a warning signal of three blasts, each lasting approximately 5 seconds. The warning signal shall be of sufficient power to be heard 1,000 feet (304.80 meters) from the blast site.

§ 211.156. Detonating the blast.

(a) A blast may be detonated only between sunrise and sunset unless the Department authorizes a blast at another time of day.

(b) Only the blaster-in-charge may detonate a blast.

§ 211.157. Post blast measures.

(a) After a blast has been detonated, no one may return to the blast area until all smoke and fumes have dissipated.

(b) After the smoke and fumes have cleared, the blaster-in-charge shall return to the blast site and closely inspect the blast site to ensure that it is safe with respect to the blasting activity.

(c) After the blaster-in-charge has determined the blast area is safe, the blaster-in-charge shall sound an all-clear signal, consisting of one long blast, lasting approximately 10 seconds. This all-clear signal shall be of sufficient power to be heard 1,000 feet (304.80 meters) from the blast site.

(d) The blaster-in-charge shall determine if a misfire occurred and shall take all actions necessary to render the blast site safe. The blast site shall be made safe before drilling or muck removal begins.

(e) If the blaster-in-charge suspects that undetonated ammonium nitrate/fuel mixture remains in the muck pile, the muck pile shall be thoroughly wetted down with water before any digging is attempted. Special attention shall be given to determine if primers, other explosives or detonators are present in the muck pile.

(f) The blaster-in-charge shall immediately complete the blast report as required by § 211.133 (relating to blast report).

(g) The blaster-in-charge shall notify the Department within 24 hours of the occurrence of a misfire. A copy of the blast report shall be forwarded to the Department.

§ 211.158. Mudcapping.

Mudcapping in blasting activities is allowed only if the blaster-in-charge determines that drilling the material to be blasted would endanger the safety of the workers. If mudcapping is necessary, no more than 10 pounds (4.53 kilograms) of explosives shall be used for a blast.

§ 211.159. Electric detonation.

(a) Electric blasting caps shall be tested for continuity with a blaster's galvanometer or blaster's multimeter specifically designed for testing blasting circuits. Testing shall be done:

(1) Before the primers are made up.

(2) After the blast hole has been loaded but prior to stemming.

(3) As the final connecting of the circuit progresses.

(b) When a shunt is removed from electric blasting cap leg wires, the exposed wires shall be reshunted.

(c) Electric blasting caps may not be employed in a blast if there is any possibility of wires from the circuit being thrown against overhead or nearby electric lines.

(d) An effort may not be made to reclaim or reuse electric blasting caps if the leg wires have been broken off near the top of the cap.

(e) Leg wires on electric blasting caps shall extend above the top of the blast hole. Wire connections and splices are not allowed in the blast hole.

(f) Only solid wire shall be used in a blasting circuit. The use of stranded wire is prohibited.

(g) When electric detonation is used near public roads, signs shall be erected at least 500 feet (152.40 meters) from the blast areas reading: "BLAST AREA - SHUT OFF ALL TWO-WAY RADIOS."

(h) A blasting machine is the only permissible source of electrical power for a detonation.

(i) The blasting circuit shall remain shunted until the time for detonation unless the circuit is being tested or connections are being made.

(j) A sticker shall be displayed on blasting machines that shows they have been tested within the last 30 days by procedures recommended by the manufacturer or supplier to ensure performance at rated capacity. If blasting caps are used in the test, they shall be covered with earth or sand.

(k) When electronic detonation is used, the blaster-in-charge shall determine that adequate current, as specified by the manufacturer of the detonators, is available to properly energize the detonators in the circuit.

§ 211.160. Non-electric detonation.

Non-electric initiation systems shall be checked and tested for secure connections in accordance with recommendations of the manufacturer of the system in use.

§ 211.161. Detonating cords.

(a) Detonating cord shall be cut from the supply roll immediately after placement in the blast hole. A sufficient length of down lines shall be left at the top of the blast hole for connections to trunk lines. The supply roll shall be immediately removed from the site. Scrap pieces of detonating cord shall be destroyed after connections are made.

(b) A trunk line shall be covered with at least 12 inches (0.30 meter) of earth or sand, unless otherwise authorized by the Department.

(c) Detonating cord may not be spliced if the resulting splice will fall within a blast hole.

§ 211.162. Safety fuse.

(a) When safety fuse is used in blasting, it shall be long enough to provide a burn time of 120 seconds or longer.

(b) Prior to using safety fuse, the blaster-in-charge shall conduct a test burn. The test burn will utilize at least a 12-inch (0.30-meter) section of fuse which is lit, then timed to determine actual burn time.

(c) A blasting cap shall only be crimped to a safety fuse with a proper crimping tool. A blasting cap may not be attached to a safety fuse in or within 10 feet (3.05 meters) of a magazine.

Subchapter G. REQUIREMENTS FOR MONITORING

§ 211.171. General provisions for monitoring.

(a) If the scaled distance of a blast is 90 or numerically less at the closest building not owned or leased by the blasting activity permittee or its customer, ground vibration and airblast monitoring shall be conducted. The Department may require the permittee to conduct ground vibration and airblast monitoring at other buildings or structures even if the scaled distance is greater than 90.

(b) Blasting activities without monitoring may be considered in compliance with this chapter if at a specified location, on at least five blasts, monitoring has demonstrated that the maximum peak particle velocity at the specified location represents more than a 50% reduction from the limit in the permit and this chapter. Future blasts shall maintain a scaled distance equal to or greater than the scaled distance for the monitored blasts.

(c) If monitoring is required, a ground vibration and airblast record of each blast shall be made part of the blast report.

(d) If monitoring is performed with instruments that have variable "trigger levels," the trigger for ground vibration shall be set at a particle velocity of no more than .25 inches per second unless otherwise directed by the Department.

(e) If the peak particle velocity and airblast from a blast are below the set trigger level of the instrument, a printout from the instrument shall be attached to the blast report. This printout shall provide the date and time

when the instrument was turned on and off, the set trigger levels and information concerning the status of the instrument during the activation period. When an instrument is used that does not provide this information, the Department will allow the permittee to supply on/off times on a signed statement.

§ 211.172. Monitoring instruments.

If monitoring is required, the monitoring instrument shall provide a permanent record of each blast.

(1) A monitoring instrument for recording ground vibration, at a minimum, shall have:

(i) A frequency range of 2 Hz to 100 Hz.

(ii) Particle velocity range of .02 to 4.0 inches (5.08×10^{-4} to 0.10 meters) per second or greater.

(iii) An internal dynamic calibration system.

(2) A monitoring instrument used to record airblast shall have:

(i) A lower frequency limit of 0.1, 2.0 or 6.0 Hz.

(ii) An upper end flat-frequency response of at least 200 Hz.

(iii) A dynamic range that, at a minimum, extends from 106 to 142 dBL.

(3) A monitoring instrument shall be calibrated annually and when an instrument is repaired and the repair may effect the response of the instrument. Calibration shall be done by the manufacturer of the equipment, or by an organization approved by the manufacturer, or by an organization having verifiable knowledge of the calibration procedures developed by the manufacturer. The calibration procedure shall include testing the response of the entire system to externally-generated dynamic inputs. These inputs shall test the entire monitoring system at a sufficient number of discrete frequency intervals to assure flat response throughout the frequency ranges specified by this chapter. Dynamic reference standards used for calibration shall be traceable to the National Institute of Standards and Technology (NIST). Calibration procedures and documentation of calibration shall be made available for review by the Department.

(4) A non-alterable sticker that is clearly visible shall be firmly affixed to the instrument. The sticker shall indicate the name of the calibration facility, the calibration technician, the date of calibration and frequency range of the airblast monitor.

§ 211.173. Monitoring records.

(a) Anyone using a monitoring instrument shall be trained on the proper use of that instrument by a representative of the manufacturer or distributor, or other competent individual. A record of that training is to be maintained and available for review by the Department.

(b) Monitoring records, at a minimum, shall contain:

(1) A calibration pulse on each of the mutually-perpendicular ground vibration traces. These pulses shall represent the dynamic response of the entire recording system to an internally-generated calibration signal, and shall allow the Department to verify that the seismograph is recording ground vibration to its specific accuracy.

(2) The time history of particle velocities for three mutually perpendicular ground vibration traces and one air-overpressure trace, including time base, amplitude scales and peak values for all traces.

(3) The results of a field calibration test for each channel.

(4) The frequency content of all vibration signals using either single degree of freedom (SDF) response spectrum or half-cycle zero-crossing analysis methods.

(5) Frequency versus particle velocity plots as indicated in § 211.151(c), Figure 1 (relating to prevention of damage).

(6) The name and signature of the individual taking the recording.

(7) The location of the monitoring instrument, date and time of the recording.

(8) The last calibration date of the monitoring instrument.

(c) If the Department questions the validity of a ground vibration or airblast record, or the interpretation of the record, the Department may require a ground vibration or airblast recording to be analyzed or certified by an independent, qualified consultant who is not related to the blasting activity permittee or its customer. When the Department requires that a recording be analyzed or certified, it shall be performed and included with the blast report within 30 days.

Subchapter H. BLASTING ACTIVITIES NEAR UTILITY LINES

§ 211.181. Scope.

This subchapter applies to buried or underground utility lines and utility lines making contact with the surface of the ground.

§ 211.182. General provisions.

(a) Blasts shall be designed and conducted so that they provide the greatest relief possible in a direction away from the utility line and to keep the resulting vibration and actual ground movement to the lowest possible level.

(b) Blasting shall use a type of explosive specifically designed to minimize the likelihood of propagation between explosive charges.

(c) When blasting within 200 feet (60.96 meters) of a utility line, blast holes may not exceed 3 inches (7.62×10^{-2} meters) in diameter.

(d) Blasting in the vicinity of a utility line shall be conducted as follows:

(1) Excavation from the ground surface to a depth corresponding to the elevation of the top of the buried utility line may proceed at the discretion of the blaster-in-charge, using safe, accepted techniques.

(2) Once the excavation has attained a depth equal to the elevation of the top of the buried utility line or if the line is exposed, or makes solid contact with the surface, the vertical depth of subsequent blast holes shall be restricted to one half the horizontal distance from the closest portion of the utility line.

(e) If one or more of the requirements listed in this section are not feasible or creates a potential safety problem, the permittee may apply to the Department for a waiver of the provision or provisions in question. This waiver will be granted if, in the judgment of the Department and the utility owning the lines, the alternate procedure does not endanger the utility line.

Section III

ATF Background Checks
Safe Explosives Act Fact Sheet

ATF Background Checks

Department of the Treasury
Bureau of Alcohol, Tobacco and Firearms
Washington, DC 20226

SAFE EXPLOSIVES ACT FACT SHEET
12/12/02

The Safe Explosives Act (the Act) was signed into law by the President on November 25, 2002. The legislation takes effect in two parts. The first two provisions outlined below are effective 60 days after enactment. The last three provisions outlined below are effective 180 days after enactment.

Effective January 24, 2003:

1. New Prohibited Persons Categories: The Act adds three new categories of persons prohibited from receiving or possessing explosives: (1) aliens (with limited exceptions); (2) persons who have been dishonorably discharged from the military; and (3) citizens of the United States who have renounced their citizenship. These categories have been added to the pre-existing list of prohibited persons, which includes felons; fugitives; users of, and persons addicted to, controlled substances; and persons who have been adjudicated mental defectives or committed to mental institutions. All prohibited persons are permitted to apply to the Bureau of Alcohol, Tobacco and Firearms (ATF) for relief from Federal explosives disabilities.

2. Samples: When requested by ATF, manufacturers and importers of explosive materials, including Ammonium Nitrate, must submit samples of these materials to ATF, as well as information on their chemical composition or other information. This will assist ATF in the identification of explosives found at crime scenes.

Effective May 24, 2003:

1. Intrastate Permit: Intrastate users of explosives must first obtain an ATF "limited permit" prior to receiving explosive materials. Intrastate users may include, for example, farmers or construction companies that acquire and use explosives infrequently and within their own State of residence. The limited permit will allow the purchaser to receive explosive materials from an in-State

explosives licensee or permittee on no more than six (6) occasions during the period of the permit. The limited permit will be valid for one year. Currently, intrastate users are exempt from most provisions of Federal explosives law. By contrast, *interstate* users of explosives must obtain ATF user permits; importers, manufacturers, and dealers in explosive materials must obtain ATF licenses. The limited permit will not authorize the permittee to transport or use explosives interstate. This provision is significant, as ultimately all persons possessing explosive materials in either interstate or intrastate commerce must first obtain a Federal license or permit issued by ATF.

2. New Required Industry Information for More Thorough ATF Background Checks: ATF must approve an explosives license or permit application if, among other things, the applicant is not prohibited from possessing explosives. Responsible persons (e.g., facility site managers, corporate officers) will now be required to submit to ATF identifying information, fingerprints, and photographs. Employees of licensees and permittees who will be possessing explosive materials must submit only identifying information. ATF must issue "letters of clearance" for those responsible persons and possessor employees who are not prohibited from possessing explosives. If ATF determines that a responsible person or employee is subject to an explosives prohibition, ATF must provide specific information to the employer and to the prohibited person (e.g., advise of appeal procedures). This new provision is significant, as all persons possessing explosive materials in either interstate or intrastate commerce will have to undergo a background check conducted by ATF.

3. Inspections: Generally, ATF will have to physically inspect all ATF licensees and permittees at least once every three calendar years for compliance with Federal explosives storage regulations.

In the case of user permits and licenses, ATF must verify by visual inspection that new applicants and renewal applicants have places of storage for explosive materials that meet the standards of safety and security set forth in the regulations.

In the case of new applicants for limited permits, ATF is not required to conduct a visual inspection of places of storage. Instead, ATF may verify by inspection or by "such other means as the Secretary determines appropriate" that there is acceptable storage. For the first and second renewal of limited permits, ATF may continue to verify storage by "such other means. "However, if a field inspection has not been conducted during the previous three years, ATF must, for the third renewal and at least once every three years after that renewal, verify by a field inspection that the limited permittee has acceptable places of storage.

Section IV

ATF—Subpart K—Storage

Subpart K--Storage

§ 55.201 General

(a) Section 842(j) of the Act and § 55.29 of this part require that the storage of explosive materials by any person must be in accordance with the regulations in this part. Further, section 846 of this Act authorizes regulations to prevent the recurrence of accidental explosions in which explosive materials were involved. The storage standards prescribed by this subpart confer no right or privileges to store explosive materials in a manner contrary to State or local law.

(b) The Director may authorize alternate construction for explosives storage magazines when it is shown that the alternate magazine construction is substantially equivalent to the standards of safety and security contained in this subpart. Any alternate explosive magazine construction approved by the Director prior to August 9, 1982, will continue as approved unless notified in writing by the Director. Any person intending to use alternate magazine construction shall submit a letter application to the regional director (compliance) for transmittal to the Director, specifically describing the proposed magazine. Explosive materials may not be stored in alternate magazines before the applicant has been notified that the application has been approved.

(c) A licensee or permittee who intends to make changes in his magazines, or who intends to construct or acquire additional magazines, shall comply with § 55.63.

(d) The regulations set forth in §§ 55.221 through 55.224 pertain to the storage of display fireworks, pyrotechnic compositions, and explosive materials used in assembling fireworks and articles pyrotechnic.

(e) The provisions of § 55.202(a) classifying flash powder and bulk salutes as high explosives are mandatory after March 7, 1990: **Provided**, that those persons who hold licenses or permits under this part on that date

shall, with respect to the premises covered by such licenses or permits, comply with the high explosives storage requirements for flash powder and bulk salutes by March 7, 1991.

(f) Any person who stores explosive materials shall notify the authority having jurisdiction for fire safety in the locality in which the explosive materials are being stored of the type, magazine capacity, and location of each site where such explosive materials are stored. Such notification shall be made orally before the end of the day on which storage of the explosive materials commenced and in writing within 48 hours from the time such storage commenced.

[T.D. ATF-87, 46 FR 40384, Aug. 7, 1981, as amended by T.D. ATF-293, 55 FR 3722, Feb. 5, 990; T.D. ATF-400, 63 FR 44999, 45003, Aug. 24, 1998]

§ 55.202 Classes of explosive materials.

For purposes of this part, there are three classes of explosive materials. These classes, together with the description of explosive materials comprising each class, are as follows:

(a) High explosives. Explosive materials which can be caused to detonate by means of a blasting cap when unconfined, (for example, dynamite, flash powders, and bulk salutes). See also § 55.201(e).

(b) Low explosives. Explosive materials which can be caused to deflagrate when confined (for example, black powder, safety fuses, igniters, igniter cords, fuse lighters, and "display fireworks" classified as UN0333, UN0334, or UN0335 by the U.S. Department of Transportation regulations at 49 CFR 172.101, except for bulk salutes).

(c) Blasting agents. (For example, ammonium nitrate-fuel oil and certain water-gels (see also § 55.11). [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981, as amended by T.D. ATF-293, 55 FR 3722, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45003, Aug. 24, 1998]

§ 55.203 Types of magazines.

For purposes of this part, there are five types of magazines. These types, together with the classes of explosive materials, as defined in § 55.202, which will be stored in them, are as follows:

(a) Type 1 magazines. Permanent magazines for the storage of high explosives, subject to the limitations prescribed by §§ 55.206 and 55.213. Other classes of explosive materials may also be stored in type 1 magazines.

(b) Type 2 magazines. Mobile and portable indoor and outdoor magazines for the storage of high explosives, subject to the limitations prescribed by §§ 55.206, 55.208(b), and 55.213. Other classes of explosive materials may also be stored in type 2 magazines.

(c) Type 3 magazines. Portable outdoor magazines for the temporary storage of high explosives while attended (for example, a "daybox"), subject to the limitations prescribed by §§ 45 55.206 and 55.213. Other classes of explosives materials may also be stored in type 3 magazines.

(d) Type 4 magazines. Magazines for the storage of low explosives, subject to the limitations prescribed by §§ 55.206(b), 55.210(b), and 55.213. Blasting agents may be stored in type 4 magazines, subject to the limitations prescribed by §§ 55.206(c), 55.211(b), and 55.213. Detonators that will not mass detonate may also be stored in type 4 magazines, subject to the limitations prescribed by §§ 55.206(a), 55.210(b), and 55.213.

(e) Type 5 magazines. Magazines for the storage of blasting agents, subject to the limitations prescribed by §§ 55.206(c), 55.211(b), and 55.213. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.204 Inspection of magazines.

Any person storing explosive materials shall inspect his magazines at least every seven days. This inspection need not be an inventory, but must be sufficient to determine whether there has been unauthorized entry or attempted entry into the magazines, or unauthorized removal of the contents of the magazines. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.205 Movement of explosive materials.

All explosive materials must be kept in locked magazines meeting the standards in this subpart unless they are:

(a) In the process of manufacture;

(b) Being physically handled in the operating process of a licensee or user;

(c) Being used; or

(d) Being transported to a place of storage or use by a licensee or permittee or by a person who has lawfully acquired explosive materials under § 55.106. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.206 Location of magazines.

(a) Outdoor magazines in which high explosives are stored must be located no closer to inhabited buildings, passenger railways, public highways, or other magazines in which high explosives are stored, than the minimum distances specified in the table of distances for storage of explosive materials in § 55.218.

(b) Outdoor magazines in which low explosives are stored must be located no closer to inhibited buildings, passenger railways, public highways, or other magazines in which explosive materials are stored, than the minimum distances specified in the table of distances for storage of low explosives in § 55.219, except that the table of distances in §55.224 shall apply to the storage of display fireworks. The distances shown in § 55.219 may not be reduced by the presence of barricades.

(c)(1) Outdoor magazines in which blasting agents in quantities of more than 50 pounds are stored must be located no closer to inhabited buildings, passenger railways, or public highways than the minimum distances specified in the table of distances for storage of explosive materials in § 55.218.

(2) Ammonium nitrate and magazines in which blasting agents are stored must be located no closer to magazines in which high explosives or other blasting agents are stored than the minimum distances specified in the table of distances for the separation of ammonium nitrate and blasting agents in § 55.220. However, the minimum distances for magazines in which explosives and blasting agents are stored from inhabited buildings, etc., may not be less than the distances specified in the table of distances for storage of explosives materials in § 55.218. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981, as amended by T.D. ATF-293, 55 FR 3722, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45003, Aug. 24, 1998]

§ 55.207 Construction of type 1 magazines.

A type 1 magazine is a permanent structure: a building, an igloo or "Army-type structure", a tunnel, or a dugout. It is to be bullet-resistant, fire-resistant, weather-resistant, theft-resistant, and ventilated.

(a) Buildings. All building type magazines are to be constructed of masonry, wood, metal, or a combination of these materials, and have no openings except for entrances and ventilation. The ground around building magazines must slope away for drainage or other adequate drainage provided.

(1) Masonry wall construction. Masonry wall construction is to consist of brick, concrete, tile, cement block, or cinder block and be not less than 6 inches in thickness. Hollow masonry units used in construction must have all hollow spaces filled with well-tamped, coarse, dry sand or weak concrete (at least a mixture of one part cement and eight parts of sand with enough water to dampen the mixture while tamping in place). Interior walls are to be constructed of, or covered with, a non-sparking material.

(2) Fabricated metal wall construction. Metal wall construction is to consist of sectional sheets of steel or aluminum not less than number 14-gauge, securely fastened to a metal framework. Metal wall construction is either lined inside with brick, solid cement blocks, hardwood not less than four inches thick, or will have at least a six inch sand fill between interior and exterior walls. Interior walls are to be constructed of, or covered with, a non-sparking material.

(3) Wood frame wall construction. The exterior of outer wood walls is to be covered with iron or aluminum not less than number 26-gauge. An inner wall of, or covered with non-sparking material will be constructed so as to provide a space of not less than six inches between the outer and inner walls. The space is to be filled with coarse, dry sand or weak concrete.

(4) Floors. Floors are to be constructed of, or covered with, a non-sparking material and shall be strong enough to bear the weight of the maximum quantity to be stored. Use of pallets covered with a non-sparking material is considered equivalent to a floor constructed of or covered with a non-sparking material.

(5) Foundations. Foundations are to be constructed of brick, concrete, cement block, stone, or wood posts. If piers or posts are used, in lieu of a continuous foundation, the space under the buildings is to be enclosed with metal.

(6) Roof. Except for buildings with fabricated metal roofs, the outer roof is to be covered with no less than number 26-guage iron or aluminum, fastened to at least 7/8 inch sheathing.

(7) Bullet-resistant ceilings or roofs. Where it is possible for a bullet to be fired directly through the roof and into the magazine at such an angle that the bullet would strike the explosives within, the magazine is to be protected by one of the following methods:
(i) A sand tray lined with a layer of building paper, plastic, or other nonporous material, and filled with not less than four inches of coarse, dry sand, and located at the tops of inner walls covering the entire ceiling area, except that portion necessary for ventilation.

(ii) A fabricated metal roof constructed of 3/16-inch plate steel lined with four inches of hardwood. (For each additional 1/16 inch of plate steel, the hardwood lining may be decreased one inch.)

(8) Doors. All doors are to be constructed of not less than 1/4 inch plate steel and lined with at least two inches of hardwood. Hinges and hasps are to be attached to the doors by welding, riveting or bolting (nuts on inside of door). They are to be installed in such a manner that the hinges and hasps cannot be removed when the doors are closed and locked.

(9) Locks. Each door is to be equipped with (i) two mortise locks; (ii) two padlock fastened in separate hasps and staples; (iii) a combination of a mortise lock and a padlock; (iv) a mortise lock that requires two keys to open; or (v) a three-point lock. Padlocks must have at least five tumblers and a casehardened shackle of at least 3/8 inch diameter. Padlocks must be protected with not less than ¼ inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples. These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be
actuated from the outside.

(10) Ventilation. Ventilation is to be provided to prevent dampness and heating of stored explosive materials. Ventilation openings must be screened to prevent the entrance of sparks. Ventilation openings in side walls and foundations must be offset or shielded for bullet-resistant purposes. Magazines having foundation and roof ventilators with the air circulating between the side walls and the floors and between the side walls and the ceiling must have a wooden lattice lining or equivalent to prevent the packages of explosive materials from being stacked
against the side walls and blocking the air circulation.

(11) Exposed metal. No sparking material is to be exposed to contact with the stored explosive materials. All ferrous metal nails in the floor and side walls, which might be exposed to contact with explosive materials, must be blind nailed, countersunk, or covered with a non-sparking lattice work or other non-sparking material.

(b) Igloos, "Army-type structures", tunnels, and dugouts. Igloo, "Army-type structure", tunnel, and dugout magazines are to be constructed of reinforced concrete, masonry, metal, or a combination of these materials. They must have an earth mound covering of not less than 24 inches on the top, sides and rear unless the magazine meets the requirements of paragraph (a)(7) of this section. Interior walls and floors must be constructed of, or covered with, a non-sparking material. Magazines of this type are also to be constructed in conformity with the requirements of paragraph (a)(4) and paragraphs (a)(8) through (11) of this section. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.208 Construction of type 2 magazines.

A type 2 magazine is a box, trailer, semi trailer, or other mobile facility. .

(a) Outdoor magazines.

(1) General. Outdoor magazines are to be bullet-resistant, fire-resistant, weather-resistant, theft-resistant, and ventilated. They are to be supported to prevent direct contact with the ground and, if less than one cubic yard in size, must be securely fastened to a fixed object. The ground around outdoor magazines must slope away for drainage or other adequate drainage provided.

When unattended, vehicular magazines must have wheels removed or otherwise effectively immobilized by kingpin locking devices or other methods approved by the Director.

(2) Exterior construction. The exterior and doors are to be constructed of not less than 1/4-inch steel and lined with at least two inches of hardwood. Magazines with top openings will have lids with water-resistant seals or which overlap the sides by at least one inch when in a closed position.

(3) Hinges and hasps. Hinges and hasps are to be attached to doors by welding, riveting, or bolting (nuts on inside of door). Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) Locks. Each door is to be equipped with

(i) two mortise locks;
(ii) two padlocks fastened in separate hasps and staples;
(iii) a combination of a mortise lock and a padlock;
(iv) a mortise lock that requires two keys to open; or
(v) a three-point lock.

Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter. Padlocks must be protected with not less than 1/4-inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples. These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be actuated from the outside.

(b) Indoor magazines

(1) General. Indoor magazines are to be fire-resistant and theft-resistant. They need not be bullet-resistant and weather-resistant if the buildings in which they are stored provide protection from the weather and from bullet penetration.

No indoor magazine is to be located in a residence or dwelling. The indoor storage of high explosives must not exceed a quantity of 50 pounds. More than one indoor magazine may be located in the same building if the total quantity of explosive materials stored does not exceed 50 pounds. Detonators must be stored in a separate magazine (except as provided in § 55.213) and the total quantity of detonators must not exceed 5,000.

(2) Exterior construction. Indoor magazines are to be constructed of wood or metal according to one of the following specifications:

(i) Wood indoor magazines are to have sides, bottoms and doors constructed of at least two inches of hardwood and are to be well braced at the corners. They are to be covered with sheet metal of not less than number 26-gauge (.0179 inches). Nails exposed to the interior of magazines must be countersunk. **(ii)** Metal indoor magazines are to have sides, bottoms and doors constructed of not less than number 12-gauge (.1046 inches) metal and be lined inside with a non-sparking material. Edges of metal covers must overlap sides at least one inch.

(3) Hinges and hasps. Hinges and hasps are to be attached to doors by welding, riveting, or bolting (nuts on inside of door).

Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) Locks. Each door is to be equipped with
(i) two mortise locks;
(ii) two padlocks fastened in separate hasps and staples;
(iii) a combination of a mortise lock and a padlock;
(iv) a mortise lock that requires two keys to open; or
(v) a three-point lock.

Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter. Padlocks must be protected with not less than 1/4-inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples. Indoor magazines located in secure rooms that are locked as provided in this subparagraph may have each door locked with one steel padlock (which need not be protected by a steel hood) having at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter, if the door hinges and lock hasp are securely fastened to the magazine.

These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be actuated from the outside.

(c) Detonator boxes. Magazines for detonators in quantities of 100 or less are to have sides, bottoms and doors constructed of not less than number 12-gauge (.1046 inches) metal and lined with a non-sparking material. Hinges and hasps must be attached so they cannot be removed from the outside. One steel padlock (which need not be protected by a steel hood) having at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter is sufficient for locking purposes. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.209 Construction of type 3 magazines.

A type 3 magazine is a "day-box" or other portable magazine. It must be fire-resistant, weather-resistant, and theft-resistant. A type 3 magazine is to be constructed of not less than number 12-gauge (.1046 inches) steel, lined with at least either 1/2-inch plywood or 1/2-inch Masonite type hardboard. Doors must overlap sides by at least one inch. Hinges and hasps are to be attached by welding, riveting or bolting (nuts on inside). One steel padlock (which need not be protected by a steel hood) having at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter is sufficient for locking purposes. Explosive materials are not to be left unattended in type 3 magazines and must be removed

to type 1 or 2 magazines for unattended storage. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981

§ 55.210 Construction of type 4 magazines.

A type 4 magazine is a building, igloo or "Army type structure", tunnel, dugout, box, trailer, or a semi trailer or other mobile magazine.

(a) Outdoor magazines

(1) General. Outdoor magazines are to be fire-resistant, weather-resistant, and theft-resistant. The ground around outdoor magazines must slope away for drainage or other adequate drainage be provided. When unattended, vehicular magazines must have wheels removed or otherwise be effectively immobilized by kingpin locking devices or other methods approved by the Director.

(2) Construction. Outdoor magazines are to be constructed of masonry, metal- covered wood, fabricated metal, or a combination of these materials. Foundations are to be constructed of brick, concrete, cement block, stone, or metal or wood posts. If piers or posts are used, in lieu of a continuous foundation, the space under the building is to be enclosed with fire-resistant material. The walls and floors are to be constructed of, or covered with, a non-sparking material or lattice work. The doors must be metal or solid wood covered with metal.

(3) Hinges and hasps. Hinges and hasps are to be attached to doors by welding, riveting, or bolting (nuts on inside of door). Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) Locks. Each door is to be equipped with

(i) two mortise locks;
(ii) two padlocks fastened in separate hasps and staples;
(iii) a combination of a mortise lock and a padlock;
(iv) a mortise lock that requires two keys to open; or
(v) a three-point lock.

Padlocks must have at least five tumblers and case-hardened shackle of at least 3/8 inch diameter. Padlocks must be protected with not less than 1/4 inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples.

These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be actuated from the outside.

(b) Indoor magazine

(1) **General.** Indoor magazines are to be fire-resistant and theft-resistant. They need not be weather-resistant if the buildings in which they are stored provide protection from the weather. No indoor magazine is to be located in a residence or dwelling. The indoor storage of low explosives must not exceed a quantity of 50 pounds. More than one indoor magazine may be located in the same building if the total quantity of explosive materials stored does not exceed 50 pounds. Detonators that will not mass detonate must be stored in a separate magazine and the total number of electric detonators must not exceed 5,000.

(2) **Construction.** Indoor magazines are to be constructed of masonry, metal-covered wood, fabricated metal, or a combination of these materials. The walls and floors are to be constructed of, or covered with, a non-sparking material. The doors must be metal or solid wood covered with metal.

(3) **Hinges and hasps.** Hinges and hasps are to be attached to doors by welding, riveting, or bolting (nuts on inside of door). Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) **Locks.** Each door is to be equipped with
- **(i)** two mortise locks;
- **(ii)** two padlocks fastened in separate hasps and staples;
- **(iii)** a combination of a mortise lock and padlock;
- **(iv)** a mortise lock that requires two keys to open; or
- **(v)** a three-point lock.

Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8 inch diameter. Padlocks must be protected with not less than 1/4 inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples. Indoor magazines located in secure rooms that are locked as provided in this subparagraph may have each door locked with one steel padlock (which need not be protected by a steel hood) having at least five tumblers and a case-hardened shackle of at least 3/8 inch diameter, if the door hinges and lock hasp are securely fastened to the magazine. These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or

bar that cannot be actuated from the outside. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.211 Construction of type 5 magazines.

A type 5 magazine is a building, igloo or "Army type structure", tunnel, dugout, bin, box, trailer, or a semi-trailer or other mobile facility.

(a) Outdoor magazines

(1) General. Outdoor magazines are to be weather-resistant and theft-resistant. The ground around magazines must slope away for drainage or other adequate drainage be provided. When unattended, vehicular magazines must have wheels removed or otherwise be effectively immobilized by kingpin locking devices or other methods approved by the Director.

(2) Construction. The doors are to be constructed of solid wood or metal.

(3) Hinges and hasps. Hinges and hasps are to be attached to doors by Welding, riveting, or bolting (nuts on inside of door). Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) Locks. Each door is to be equipped with
(i) two mortise locks;
(ii) two padlocks fastened in separate hasps and staples;
(iii) a combination of a mortise lock and a padlock;
(iv) a mortise lock that requires two keys to open; or
(v) a three-point lock.

Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8 inch diameter. Padlocks must be protected with not less than 1/4 inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples.

Trailers, semi-trailers, and similar vehicular magazines may, for each door, be locked with one steel padlock (which need not be protected by a steel hood) having at least five tumblers and a casehardened shackle of at least 3/8 inch diameter, if the door hinges and lock hasp are securely fastened to the magazine and to the door frame.

These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be actuated from the outside.

(4) Placards. The placards required by Department of Transportation regulations at 49 CFR part 172, subpart F, for the transportation of blasting agents shall be displayed on all magazines.

(b) Indoor magazines

(1) General. Indoor magazines are to be theft resistant. They need not be weather-resistant if the buildings in which they are stored provide protection from the weather. No indoor magazine is to be located in a residence or dwelling. Indoor magazines containing quantities of blasting agents in excess of 50 pounds are subject to the requirements of § 55.206 of this subpart.

(2) Construction. The doors are to be constructed of wood or metal.

(3) Hinges and hasps. Hinges and hasps are to be attached to doors by welding, riveting, or bolting (nuts on inside). Hinges and hasps must be installed so that they cannot be removed when the doors are closed and locked.

(4) Locks. Each door is to be equipped with
(i) two mortise locks;
(ii) two padlocks fastened in separate hasps and staples;
(iii) a combination of a mortise lock and a padlock;
(iv) a mortise lock that requires two keys to open; or
(v) a three-point lock.

Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8 inch diameter. Padlocks must be protected with not less than 1/4 inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples. Indoor magazines located in secure rooms that are locked as provided in this subparagraph may have each door locked with one steel padlock (which need not be protected by a steel hood) having at least five tumblers and a case-hardened shackle of at least 3/8 inch diameter, if the door hinges and lock hasps are securely fastened to the magazine and to the door frame.

These requirements do not apply to magazine doors that are adequately secured on the inside by means of a bolt, lock, or bar that cannot be actuated from the outside. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981, as amended by T.D. ATF-298, 55 FR 21863, May 30, 1990]

§ 55.212 Smoking and open flames.

Smoking, matches, open flames, and spark producing devices are not permitted:

(a) In any magazine;

(b) Within 50 feet of any outdoor magazine; or 50

(c) Within any room containing an indoor magazine.

[T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.213 Quantity and storage restrictions.

(a) Explosive materials in excess of 300,000 pounds or detonators in excess of 20 million are not to be stored in one magazine unless approved by the Director.

(b) Detonators are not to be stored in the same magazine with other explosive materials, except under the following circumstances:

(1) In a type 4 magazine, detonators that will not mass detonate may be stored with electric squibs, safety fuse, igniters, and igniter cord.

(2) In a type 1 or type 2 magazine, detonators may be stored with delay devices and any of the items listed in paragraph (b)(1) of this section. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.214 Storage within types 1, 2, 3, and 4 magazines.

(a) Explosive materials within a magazine are not to be placed directly against interior walls and must be stored so as not to interfere with ventilation. To prevent contact of stored explosive materials with walls, a non-sparking lattice work or other non-sparking material may be used.

(b) Containers of explosive materials are to be stored so that marks are visible. Stocks of explosive materials are to be stored so they can be easily counted and checked upon inspection.

(c) Except with respect to fiberboard or other nonmetal containers, containers of explosive materials are not to be unpacked or repacked inside a magazine or within 50 feet of a magazine, and must not be unpacked or repacked close to other explosive materials. Containers of explosive materials must be closed while being stored.

(d) Tools used for opening or closing containers of explosive materials are to be of non-sparking materials, except that metal slitters may be used for opening fiberboard containers. A wood wedge and a fiber, rubber, or wooden mallet are to be used for opening or closing wood containers of explosive materials. Metal tools other than non-sparking transfer conveyors are not to be stored in any magazine containing high explosives.
[T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.215 Housekeeping.

Magazines are to be kept clean, dry, and free of grit, paper, empty packages and containers, and rubbish. Floors are to be regularly swept. Brooms and other utensils used in the cleaning and maintenance of magazines must have no spark producing metal parts, and may be kept in magazines. Floors stained by leakage from explosive materials are to be cleaned according to instructions of the explosives manufacturer. When any explosive material has deteriorated it is to be destroyed in accordance with the advice or instructions of the manufacturer. The area surrounding magazines is to be kept clear of rubbish, brush, dry grass, or trees (except live trees more than 10 feet tall), for not less than 25 feet in all directions. Volatile materials are to be kept a distance of not less than 50 feet from outdoor magazines. Living foliage which is used to stabilize the earthen covering of a magazine need not be removed.
[T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.216 Repair of magazines.

Before repairing the interior of magazines, all explosive materials are to be removed and the interior cleaned. Before repairing the exterior of magazines, all explosive materials must be removed if there exists any possibility that repairs may produce sparks or flame. Explosive materials removed from magazines under repair must be

(a) placed in other magazines appropriate for the storage of those explosive materials under this subpart, or

(b) placed a safe distance from the magazines under repair where they are to be properly guarded and protected until the repairs have been completed. T.D. ATF-87, 46 FR 40384, Aug. 7, 1981.

§ 55.217 Lighting.

(a) Battery-activated safety lights or battery activated safety lanterns may be used in explosives storage magazines.

(b) Electric lighting used in any explosives storage magazine must meet the standards prescribed by the "National Electrical Code," (National Fire Protection Association, NFPA 70-81), for the conditions present in the magazine at any time. All electrical switches are to be located outside of the magazine and also meet the standards prescribed by the National Electrical Code.

(c) Copies of invoices, work orders or similar documents which indicate the lighting complies with the National Electrical Code must be available for inspection by ATF officers. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.218 Table of distances for storage of explosive materials.

QUANTITY OF EXPLOSIVES (IN POUNDS)		DISTANCES (IN FEET)							
		INHABITED BUILDINGS		PUBLIC HIGHWAYS, CLASS A to D**		PASSENGER RAILWAYS & PUBLIC HIGHWAYS: With traffic volume of more than 3,000 vehicles per day		SEPARATION OF MAGAZINES	
OVER	NOT OVER	BARRICADED	UNBARRICADED	BARRICADED	UNBARRICADED	BARRICADED	UNBARRICADED	BARRICADED	UNBARRICADED
2	5	70	140	30	60	51	102	6	12
5	10	90	180	35	70	64	128	8	16
10	20	110	220	45	90	81	162	10	20
20	30	125	250	50	100	93	186	11	22
30	40	140	280	55	110	103	206	12	24
40	50	150	300	60	120	110	220	14	28
50	75	170	340	70	140	127	254	15	30
75	100	190	380	75	150	139	278	16	32
100	125	200	400	80	160	150	300	18	36
125	150	215	430	85	170	159	318	19	38
150	200	235	470	95	190	175	350	21	42
200	250	255	510	105	210	189	378	23	46
250	300	270	540	110	220	201	402	24	48
300	400	295	590	120	240	221	442	27	54
400	500	320	640	130	260	238	476	29	58
500	600	340	680	135	270	253	506	31	62
600	700	355	710	145	290	266	532	32	64
700	800	375	750	150	300	278	556	33	66
800	900	390	780	155	310	289	578	35	70
900	1,000	400	800	160	320	300	600	36	72
1,000	1,200	425	850	165	330	318	636	38	76
1,200	1,400	450	900	170	340	336	672	41	82
1,400	1,600	470	940	175	350	351	702	43	86
1,600	1,800	490	980	180	360	366	732	44	88
1,800	2,000	505	1,010	185	370	378	756	45	90
2,000	2,500	545	1,090	190	380	408	816	49	98
2,500	3,000	580	1,160	195	390	432	864	52	104
3,000	4,000	635	1,270	210	420	474	948	56	116
4,000	5,000	685	1,370	225	450	513	1,026	61	122
5,000	6,000	730	1,460	235	470	546	1,092	65	130
6,000	7,000	770	1,540	245	490	573	1,146	69	138
7,000	8,000	800	1,600	250	500	600	1,200	72	144
8,000	9,000	835	1,670	255	510	624	1,248	75	150
9,000	10,000	865	1,730	260	520	645	1,290	78	156
10,000	12,000	875	1,750	270	540	687	1,374	82	164
12,000	14,000	885	1,770	275	550	723	1,446	87	174
14,000	16,000	900	1,800	280	560	756	1,512	90	180
16,000	18,000	940	1,880	285	570	786	1,572	94	188
18,000	20,000	975	1,950	290	580	813	1,626	98	196
20,000	25,000	1,055	2,000	315	630	876	1,752	105	210
25,000	30,000	1,130	2,000	340	680	933	1,866	112	224
30,000	35,000	1,205	2,000	360	720	981	1,962	119	238
35,000	40,000	1,275	2,000	380	760	1,026	2,000	124	248
40,000	45,000	1,340	2,000	400	800	1,068	2,000	129	258
45,000	50,000	1,400	2,000	420	840	1,104	2,000	135	270
50,000	55,000	1,460	2,000	440	880	1,140	2,000	140	280
55,000	60,000	1,515	2,000	455	910	1,173	2,000	145	290
60,000	65,000	1,565	2,000	470	940	1,206	2,000	150	300
65,000	70,000	1,610	2,000	485	970	1,236	2,000	155	310
70,000	75,000	1,655	2,000	500	1,000	1,263	2,000	160	320
75,000	80,000	1,695	2,000	510	1,020	1,293	2,000	165	330
80,000	85,000	1,730	2,000	520	1,040	1,317	2,000	170	340
85,000	90,000	1,760	2,000	530	1,060	1,344	2,000	175	350
90,000	95,000	1,790	2,000	540	1,080	1,368	2,000	180	360
95,000	100,000	1,815	2,000	545	1,090	1,392	2,000	185	370
100,000	110,000	1,855	2,000	550	1,100	1,437	2,000	195	390
110,000	120,000	1,855	2,000	555	1,110	1,479	2,000	205	410
120,000	130,000	1,875	2,000	560	1,120	1,521	2,000	215	430
130,000	140,000	1,890	2,000	565	1,130	1,557	2,000	225	450
140,000	150,000	1,900	2,000	570	1,140	1,593	2,000	235	470
150,000	160,000	1,935	2,000	580	1,160	1,629	2,000	245	490
160,000	170,000	1,955	2,000	590	1,180	1,662	2,000	255	510
170,000	180,000	1,980	2,000	600	1,200	1,695	2,000	265	530
180,000	190,000	2,010	2,010	605	1,210	1,726	2,000	275	550
190,000	200,000	2,030	2,030	610	1,220	1,755	2,000	285	570
200,000	210,000	2,055	2,055	620	1,240	1,782	2,000	295	590
210,000	230,000	2,100	2,100	635	1,270	1,836	2,000	315	630
230,000	250,000	2,155	2,155	650	1,300	1,890	2,000	335	670
250,000	275,000	2,215	2,215	670	1,340	1,950	2,000	360	720
275,000	300,000	2,275	2,275	690	1,380	2,000	2,000	385	770

** = See § 55.11, "Highway."

Table: American Table of Distances for Storage of Explosives

(December 1910), as
Revised and Approved by the Institute of Makers of Explosives-July, 1991.

Notes to the Table of Distances for Storage of Explosives

(1) Terms found in the table of distances for storage of explosive materials are defined in § 55.11.

(2) When two or more storage magazines are located on the same property, each magazine must comply with the minimum distances specified from inhabited buildings, railways, and highways, and, in addition, they should be separated from each other
by not less than the distances shown for "Separation of Magazines," except that the quantity of explosives contained in cap magazines shall govern in regard to the spacing of said cap magazines from magazines containing other explosives. If any two or more magazines are separated from each other by less than the specified "Separation of Magazines" distances, then such two or more magazines, as a group, must be considered as one magazine, and the total quantity of explosives stored in such group must be treated as if stored in a single magazine located on the site of any magazine of the group, and must comply with the minimum of distances specified from other magazines, inhabited buildings, railways, and highways.

(3) All types of blasting caps in strengths through No. 8 cap should be rated at 11/2 lbs. of explosives per 1,000 caps. For strengths higher than No. 8 cap, consult the manufacturer.

(4) For quantity and distance purposes, detonating cord of 50 or 60 grains per foot should be calculated as equivalent to 9 lbs. of high explosives per 1,000 feet. Heavier or lighter core loads should be rated proportionately. [T.D. ATF-87, 46 FR 40384, Aug. 7, 1981; T.D. ATF-400, 63 FR 44999, 45003, Aug. 24, 1998]

§ 55.219 Table of Distance for Storage of Low Explosives.

§ 55.219 Table of distances for storage of low explosives.

POUNDS		DISTANCES IN FEET		
OVER	NOT OVER	FROM INHABITED BUILDING	FROM PUBLIC RAILROAD AND HIGHWAY	FROM ABOVE-GROUND MAGAZINE
0	1,000	75	75	50
1,000	5,000	115	115	75
5,000	10,000	150	150	100
10,000	20,000	190	190	125
20,000	30,000	215	215	145
30,000	40,000	235	235	155
40,000	50,000	250	250	165
50,000	60,000	260	260	175
60,000	70,000	270	270	185
70,000	80,000	280	280	190
80,000	90,000	285	285	195
90,000	100,000	300	300	200
100,000	200,000	375	375	250
200,000	300,000	450	450	300

TABLE: DEPARTMENT OF DEFENSE AMMUNITION AND EXPLOSIVES STANDARDS, TABLE 5-4.1 EXTRACT; 4145.27 M, MARCH 1969.

§ 55.220 Table of Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents.

§ 55.220 Table of separation distances of ammonium nitrate and blasting agents from explosives or blasting agents.

DONOR WEIGHT (POUNDS)		MINIMUM SEPARATION DISTANCE OF ACCEPTOR FROM DONOR WHEN BARRICADED (FEET)		MINIMUM THICKNESS OF ARTIFICIAL BARRICADES (INCHES)
OVER	NOT OVER	AMMONIUM NITRATE	BLASTING AGENT	
0	100	3	11	12
100	300	4	14	12
300	600	5	18	12
600	1,000	6	22	12
1,000	1,600	7	25	12
1,600	2,000	8	29	12
2,000	3,000	9	32	15
3,000	4,000	10	36	15
4,000	6,000	11	40	15
6,000	8,000	12	43	20
8,000	10,000	13	47	20
10,000	12,000	14	50	20
12,000	16,000	15	54	25
16,000	20,000	16	58	25
20,000	25,000	18	65	25
25,000	30,000	19	68	30
30,000	35,000	20	72	30
35,000	40,000	21	76	30
40,000	45,000	22	79	35
45,000	50,000	23	83	35
50,000	55,000	24	86	35
55,000	60,000	25	90	35
60,000	70,000	26	94	40
70,000	80,000	28	101	40
80,000	90,000	30	108	40
90,000	100,000	32	115	40
100,000	120,000	34	122	50
120,000	140,000	37	133	50
140,000	160,000	40	144	50
160,000	180,000	44	158	50
180,000	200,000	46	172	50
200,000	220,000	52	187	60
220,000	250,000	55	202	60
250,000	275,000	60	216	60
275,000	300,000	64	230	60

TABLE: NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) OFFICIAL STANDARD NO. 492, 1968.

Notes of Table of Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives or Blasting Agents

(1) This table specifies separation distances to prevent explosion of ammonium nitrate and ammonium nitrate-based blasting agents by propagation from nearby stores of high explosives or blasting agents referred to in the table as the "donor." Ammonium nitrate, by itself, is not considered to be a donor when applying this table. Ammonium nitrate, ammonium nitrate-fuel oil or combinations thereof are acceptors. If stores of ammonium nitrate are located within the sympathetic detonation

distance of explosives or blasting agents, one-half the mass of the ammonium nitrate is to be included in the mass of the donor.
(2) When the ammonium nitrate and/or blasting agent is not barricaded, the distances shown in the table must be multiplied by six. These distances allow for the possibility of high velocity metal fragments from mixers, hoppers, truck bodies, sheet metal structures, metal containers, and the like which may enclose the "donor." Where explosives storage is in bullet-resistant magazines or where the storage is protected by a bullet-resistant wall, distances and barricade thickness in excess of those prescribed in the table in § 55.218 are not required.
(3) These distances apply to ammonium nitrate that passes the insensitivity test prescribed in the definition of ammonium nitrate fertilizer issued by the Fertilizer Institute.[1] Ammonium nitrate failing to pass the test must be stored at separation distances
in accordance with the table in § 55.218.

[1] Definition and Test Procedures for Ammonium Nitrate Fertilizer, Fertilizer Institute
1015-18th St. N.W. Washington, D.C. 20036.

(4) These distances apply to blasting agents which pass the insensitivity test prescribed in regulations of the U.S. Department of Transportation (49 CFR part 173).
(5) Earth or sand dikes, or enclosures filled with the prescribed minimum thickness of earth or sand are acceptable artificial barricades. Natural barricades, such as hills or timber of sufficient density that the surrounding exposures which require protection cannot be seen from the "donor" when the trees are bare of leaves, are also acceptable.
(6) For determining the distances to be maintained from inhabited buildings, passenger railways, and public highways, use the table in § 55.218.
[T.D. ATF-87, 46 FR 40384, Aug. 7, 1981]

§ 55.221 Requirements for display fireworks, pyrotechnic compositions, and explosive materials used in assembling fireworks or articles pyrotechnic.

(a) Display fireworks, pyrotechnic compositions, and explosive materials used to assemble fireworks and articles pyrotechnic shall be stored at all times as required by this Subpart unless they are in the process of manufacture, assembly, packaging, or are being transported.
(b) No more than 500 pounds (227 kg) of pyrotechnic compositions or explosive materials are permitted at one time in any fireworks mixing building, any building or area in which the pyrotechnic compositions or explosive materials are pressed or otherwise prepared for finishing or assembly, or any finishing or assembly building. All pyrotechnic

compositions or explosive materials not in immediate use will be stored in covered, nonferrous containers.
(c) The maximum quantity of flash powder permitted in any fireworks process building is 10 pounds (4.5 kg).

(d) All dry explosive powders and mixtures, partially assembled display fireworks, and finished display fireworks shall be removed from fireworks process buildings at the conclusion of a day's operations and placed in approved magazines.
[T.D. ATF-293, 55 FR 3722, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45004, Aug. 24, 1998]

---

§ 55.222 Table of distances between fireworks process buildings and between fireworks process and fireworks nonprocess buildings.

Net Weight of Fireworks (1)	Special Fireworks (4)	Common Fireworks (3)
Pounds	Feet	Feet
0—100	57	37
101—200	69	37
201—300	77	37
301—400	85	37
401—500	91	37
Above 500	Not Permitted (4) & (5)	Not Permitted (4) & (5)

[1] Net weight is the weight of all pyrotechnic compositions, and explosive materials and fuse only.
[2] The distances in this column apply only with natural or artificial barricades. If such barricades are not used, the distances must be doubled.
[3] While consumer fireworks or articles pyrotechnic in a finished state are not subject to
regulation, explosive materials used to manufacture or assemble such fireworks or articles are subject to regulation. Thus, fireworks process buildings where consumer fireworks or articles pyrotechnic are being processed shall meet these requirements.
[4] A maximum of 500 pounds of in-process pyrotechnic compositions, either loose or in partially assembled fireworks, is permitted in any fireworks process building. Finished display fireworks may not be stored in a fireworks process building.

[5] A maximum of 10 pounds of flash powder, either in loose form or in assembled units, is permitted in any fireworks process building. Quantities in excess of 10 pounds must be kept in an approved magazine.
[T.D. ATF-293, 55 FR 3723, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45004, Aug. 24, 1998]

§ 55.223 Table of distances between fireworks process buildings and other specified areas.

Distance from Passenger Railways, Public Highways, Fireworks Plant Buildings Used to Store Common Fireworks, Magazines and Fireworks Shipping Buildings, and Inhabited Buildings (3) & (4).

Net Weight of Fireworks (1)	Special Fireworks (2)	Common Fireworks (3)
Pounds	Feet	Feet
0—100	300	25
101—200	200	50
201—300	200	50
301—400	200	50
401—500	200	50
Above 500	Not Permitted	Not Permitted

[1] Net weight is the weight of all pyrotechnic compositions, and explosive materials and fuse only.
[2] While consumer fireworks or articles pyrotechnic in a finished state are not subject to regulation, explosive materials used to manufacture or assemble such fireworks or articles are subject to regulation. Thus, fireworks process buildings where consumer fireworks or articles pyrotechnic are being processed shall meet these requirements.
[3] This table does not apply to the separation distances between fireworks process buildings (see § 55.222) and between magazines (see §§ 55.218 and 55.224).
[4] The distances in this table apply with or without artificial or natural barricades or screen barricades. However, the use of barricades is highly recommended.
[5] No work of any kind, except to place or move items other than explosive materials from storage, shall be conducted in any building designated as a warehouse. A fireworks plant warehouse is not subject to § 55.222 or this section, tables of distances.
[T.D. ATF-293, 55 FR 3723, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45004, Aug. 24, 1998]

§ 55.224 Table of distances for the storage of special fireworks (except bulk salutes).

Net Weight of Fireworks (1)	Distance Between Magazine and Inhabited Building, Passenger Railway or Public Highway (2) & (4)	DISTANCE BETWEEN MAGAZINES (2)
Pounds	Feet	Feet
0— 1000	150	100
1001— 5000	230	150
5001—10000	300	200
Above 10000	Use table in § 55.218	

[1] Net weight is the weight of all pyrotechnic compositions, and explosive materials and fuse only.

[2] For the purposes of applying this table, the term magazine" also includes fireworks shipping buildings for display fireworks.

[3] For fireworks storage magazines in use prior to (30 days from the date of publication of the final rule in the Federal Register), the distances in this table may be halved if properly barricaded between the magazine and potential receptor sites.

[4] This table does not apply to the storage of bulk salutes. Use table at § 55.218.

[T.D. ATF-293, 55 FR 3723, Feb. 5, 1990; T.D. ATF-400, 63 FR 44999, 45004, Aug. 24, 1998]

Section V

Title 30

Code of Federal Regulations
30 CFR § 57.6000

Title 30 Code of Federal Regulations
30 CFR § 57.6000

Definitions.

The following definitions apply in this subpart.

Attended. Presence of an individual or continuous monitoring to prevent unauthorized entry or access.

Barrier. A material object, or objects that separates, keeps apart, or demarcates in a conspicuous manner such as cones, a warning sign, or tape.

Blast area. The area in which concussion (shock wave), flying material, or gases from an explosion may cause injury to persons. In determining the blast area, the following factors shall be considered:

(1) Geology or material to be blasted.

(2) Blast pattern.

(3) Burden, depth, diameter, and angle of the holes.

(4) Blasting experience of the mine.

(5) Delay system, powder factor, and pounds per delay.

(6) Type and amount of explosive material.

(7) Type and amount of stemming.

Blast site. The area where explosive material is handled during loading, including the perimeter formed by the loaded blast holes and 50 feet (15.2 meters) in all directions from loaded holes. A minimum distance of 30 feet (9.1 meters) may replace the 50-foot (15.2-meter) requirement if the perimeter of loaded holes is demarcated with a barrier. The 50-foot (15.2-meter) and alternative 30-foot (9.1-meter) requirements also apply in all directions along the full depth of the hole.

Blasting agent. Any substance classified as a blasting agent by the Department of Transportation in 49 CFR 173.114a(a). This document is available at any MSHA Metal and Nonmetal Safety and Health district office.

Detonating cord. A flexible cord containing a center core of high explosives which may be used to initiate other explosives.

Detonator. Any device containing a detonating charge used to initiate an explosive. These devices include electric or non-electric instantaneous or delay blasting caps and delay connectors. The term ``detonator" does not include detonating cord. Detonators may be either ``Class A" detonators or ``Class C" detonators, as classified by the Department of Transportation in 49 CFR 173.53, and 173.100. This document is available at any MSHA Metal and Nonmetal Safety and Health district office.

Emulsion. An explosive material containing substantial amounts of oxidizers dissolved in water droplets, surrounded by an immiscible fuel.

Explosive. Any substance classified as an explosive by the Department of Transportation in 49 CFR 173.53, 173.88, and 173.100. This document is available at any MSHA Metal and Nonmetal Safety and Health district office.

Explosive material. Explosives, blasting agents, and detonators.

Flash point. The minimum temperature at which sufficient vapor is released by a liquid to form a flammable vapor-air mixture near the surface of the liquid.

Igniter cord. A fuse that burns progressively along its length with an external flame at the zone of burning, used for lighting a series of safety fuses in a desired sequence.

Laminated partition. A partition composed of the following material and minimum nominal dimensions: \1/2\-inch-thick plywood, \1/2\-inch- thick gypsum wallboard, \1/8\-inch-thick low carbon steel, and \1/4\- inch-thick plywood, bonded together in that order (IME-22 Box). A laminated partition also includes alternative construction materials described in the Institute of Makers of Explosives (IME) Safety Library Publication No. 22, ``Recommendations for the Safe Transportation of Detonators in a Vehicle with other Explosive Materials," (May 1993), and the ``Generic Loading Guide for the IME-22 Container," (October 1993). This incorporation by reference has been approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies are available at MSHA, 4015 Wilson Boulevard, Room 728, Arlington, VA 22203, and at all Metal and Nonmetal Mine Safety and Health district offices, or available for inspection at the Office of the Federal Register, 800 North Capitol Street, NW., 7th Floor, suite 700, Washington, DC.

Loading. Placing explosive material either in a blast hole or against the material to be blasted.

Magazine. A bullet-resistant, theft-resistant, fire-resistant, weather-resistant, ventilated facility for the storage of explosives and detonators (BATF Type 1 or Type 2 facility).

Misfire. The complete or partial failure of explosive material to detonate as planned. The term also is used to describe the explosive material itself that has failed to detonate.

Multipurpose dry-chemical fire extinguisher. An extinguisher having a rating of at least 2-A:10-B:C and containing a nominal 4.5 pounds or more of dry-chemical agent.

Primer. A unit, package, or cartridge of explosives which contains a detonator and is used to initiate other explosives or blasting agents.

Safety switch. A switch that provides shunt protection in blasting circuits between the blast site and the switch used to connect a power source to the blasting circuit.

Slurry. An explosive material containing substantial portions of a liquid, oxidizers, and fuel, plus a thickener.

Storage facility. The entire class of structures used to store explosive materials. A ``storage facility" used to store blasting agents corresponds to a BATF Type 4 or 5 storage facility.

Water gel. An explosive material containing substantial portions of water, oxidizers, and fuel, plus a cross-linking agent.

30 CFR § 57.6100 Separation of stored explosive material.

STORAGE--SURFACE AND UNDERGROUND

(a) Detonators shall not be stored in the same magazine with other explosive material.

(b) When stored in the same magazine, blasting agents shall be separated from explosives, safety fuse, and detonating cord to prevent contamination.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6101 Areas around explosive material storage facilities.

(a) Areas surrounding storage facilities for explosive material shall be clear of rubbish, brush, dry grass, and trees for 25 feet in all directions, except that live trees 10 feet or taller need not be removed.

(b) Other combustibles shall not be stored or allowed to accumulate within 50 feet of explosive material. Combustible liquids shall be stored in a manner that ensures drainage will occur away from the explosive material storage facility in case of tank rupture.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6102 Explosive material storage practices.

(a) Explosive material shall be--

(1) Stored in a manner to facilitate use of oldest stocks first;

(2) Stored according to brand and grade in such a manner as to facilitate identification; and

(3) Stacked in a stable manner but not more than 8 feet high.

(b) Explosives and detonators shall be stored in closed nonconductive containers except that non-electric detonating devices may be stored on nonconductive racks provided the case-insert instructions and the date-plant-shift code are maintained with the product.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6130 Explosive material storage facilities.

STORAGE--SURFACE ONLY

(a) Detonators and explosives shall be stored in magazines.

(b) Packaged blasting agents shall be stored in a magazine or other facility which is ventilated to prevent dampness and excessive heating, weather-resistant, and locked or attended. Drop trailers that are currently licensed by the Federal, State, or local authorities for over-the-road use do not have to be ventilated. Facilities other than magazines used to store blasting agents shall contain only blasting agents.

(c) Bulk blasting agents shall be stored in weather-resistant bins or tanks which are locked, attended, or otherwise inaccessible to unauthorized entry.

(d) Facilities, bins or tanks shall be posted with the appropriate United States Department of Transportation placards or other appropriate warning signs that indicate the contents and are visible from each approach.

[58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of the first sentence in §57.6130(b) is stayed until January 31, 1994.

30 CFR § 57.6131 Location of explosive material storage facilities.

(a) Storage facilities for any explosive material shall be--

(1) Located so that the forces generated by a storage facility explosion will not create a hazard to occupants in mine buildings and will not damage dams or electric substations; and

(2) Detached structures located outside the blast area and a sufficient distance from power lines so that the power lines, if damaged, would not contact the magazines.

(b) Operators should also be aware of regulations affecting storage facilities in 27 CFR part 55, in particular, §§ 55.218 and 55.220. This document is available at any MSHA Metal and Nonmetal Safety and Health district office.

[56 FR 46508, Sept. 12, 1991; 56 FR 52193, Oct. 18, 1991; 58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of §57.6131(a)(1) is stayed until January 31, 1994.

30 CFR § 57.6132 Magazine requirements.

(a) Magazines shall be--

(1) Structurally sound;

(2) Noncombustible or the exterior covered with fire-resistant material;

(3) Bullet resistant;

(4) Made of non-sparking material on the inside;

(5) Ventilated to control dampness and excessive heating within the magazine;

(6) Posted with the appropriate United States Department of Transportation placards or other appropriate warning signs that indicate the contents and are visible from each approach, so located that a bullet passing through any of the signs will not strike the magazine;

(7) Kept clean and dry inside;

(8) Unlighted or lighted by devices that are specifically designed for use in magazines and which do not create a fire or explosion hazard;

(9) Unheated or heated only with devices that do not create a fire or explosion hazard;

(10) Locked when unattended; and

(11) Used exclusively for the storage of explosive material except for essential non-sparking equipment used for the operation of the magazine.

(b) Metal magazines shall be equipped with electrical bonding connections between all conductive portions so the entire structure is at the same electrical potential. Suitable electrical bonding methods include welding, riveting, or the use of securely tightened bolts where individual metal portions are joined. Conductive portions of nonmetal magazines shall be grounded.

(c) Electrical switches and outlets shall be located on the outside of the magazine.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6133 Powder chests.

(a) Powder chests (day boxes) shall be--

(1) Structurally sound, weather-resistant, equipped with a lid or cover, and with only non-sparking material on the inside;

(2) Posted with the appropriate United States Department of Transportation placards or other appropriate warning signs that indicate the contents and are visible from each approach;

(3) Located out of the blast area once loading has been completed;

(4) Locked or attended when containing explosive material; and

(5) Emptied at the end of each shift with the contents returned to a magazine or other storage facility, or attended.

(b) Detonators shall be kept in chests separate from explosives or blasting agents, unless separated by 4-inches of hardwood or equivalent, or a laminated partition. When a laminated partition is used, operators must follow the provisions of the Institute of Makers of Explosives (IME) Safety Library Publication No. 22, ``Recommendations for the Safe Transportation of Detonators in a Vehicle with other Explosive Materials," (May 1993), and the ``Generic Loading Guide for the IME-22 Container," (October 1993). This incorporation by reference has been approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies are available at MSHA, 4015 Wilson Boulevard, Room 728, Arlington, VA 22203, and at all Metal and Nonmetal Mine Safety and Health district offices, or available for inspection at the Office of the Federal Register, 800 North Capitol Street, NW., 7th Floor, suite 700, Washington, DC.

30 CFR § 57.6140 Magazine location.

Magazines shall be located in accordance with the current American Table of Distances for storage of explosives.

[58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, §57.6140 is effective until January 31, 1994, unless terminated earlier by FEDERAL REGISTER notice.

For more information: See MSHA'S Program Policy Manual

30 CFR § 57.6160 Main facilities.

STORAGE--UNDERGROUND ONLY

(a) Main facilities used to store explosive material underground shall be located--

(1) In stable or supported ground;

(2) So that a fire or explosion in the storage facilities will not prevent escape from the mine, or cause detonation of the contents of another storage facility;

(3) Out of the line of blasts, and protected from vehicular traffic, except that accessing the facility;

(4) At least 200 feet from work places or shafts;

(5) At least 50 feet from electric substations;

(6) A safe distance from trolley wires; and

(7) At least 25 feet from detonator storage facilities.

(b) Main facilities used to store explosive material underground shall be--

(1) Posted with warning signs that indicate the contents and are visible from any approach;

(2) Used exclusively for the storage of explosive material and necessary equipment associated with explosive material storage and delivery;

(b)(2)(i) Portions of the facility used for the storage of explosives shall only contain non-sparking material or equipment.

(b)(2)(ii) The blasting agent portion of the facility may be used for the storage of other necessary equipment.

(3) Kept clean, suitably dry, and orderly;

(4) Provided with unobstructed ventilation openings;

(5) Kept securely locked unless all access to the mine is either locked or attended; and

(6) Unlighted or lighted only with devices that do not create a fire or explosion hazard and which are specifically designed for use in magazines.

(c) Electrical switches and outlets shall be located outside the facility.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6161 Auxiliary facilities.

(a) Auxiliary facilities used to store explosive material near work places shall be wooden, box-type containers equipped with covers or doors, or facilities constructed or mined-out to provide equivalent impact resistance and confinement.

(b) The auxiliary facilities shall be--

(1) Constructed of non-sparking material on the inside when used for the storage of explosives;

(2) Kept clean, suitably dry, and orderly;

(3) Kept in repair;

(4) Located out of the line of blasts so they will not be subjected to damaging shock or fly rock;

(5) Identified with warning signs or coded to indicate the contents with markings visible from any approach;

(6) Located at least 15 feet from all haulage ways and electrical equipment, or placed entirely within a mined-out recess in the rib used exclusively for explosive material;

(7) Filled with no more than a one-week supply of explosive material;

(8) Separated by at least 25 feet from other facilities used to store detonators; and

(9) Kept securely locked unless all access to the mine is either locked or attended.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6200 Delivery to storage or blast site areas.

TRANSPORTATION--SURFACE AND UNDERGROUND

Explosive material shall be transported without undue delay to the storage area or blast site.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6201 Separation of transported explosive material.

Detonators shall not be transported on the same vehicle or conveyance with other explosives except as follows:

(a) Detonators in quantities of more than 1000 may be transported in a vehicle or conveyance with explosives or blasting agents provided the detonators are--

(1) Maintained in the original packaging as shipped from the manufacturer; and

(2) Separated from explosives or blasting agents by 4-inches of hardwood or equivalent, or a laminated partition. The hardwood or equivalent shall be fastened to the vehicle or conveyance. When a laminated partition is used, operators must follow the provisions of the Institute of Makers of Explosives (IME) Safety Library Publication No.22, ``Recommendations for the Safe Transportation of Detonators in a Vehicle with other Explosive Materials," (May 1993), and the ``Generic Loading Guide for the IME-22 Container," (October 1993). This incorporation by reference has been approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies are available at MSHA, 4015 Wilson Boulevard, Room 728, Arlington, VA 22203, and at all Metal and Nonmetal Mine Safety and Health district offices, or available for inspection at the Office of the Federal Register, 800 North Capitol Street, NW., 7th Floor, suite 700, Washington, DC.

(b) Detonators in quantities of 1000 or fewer may be transported with explosives or blasting agents provided the detonators are--

(1) Kept in closed containers; and

(2) Separated from explosives or blasting agents by 4-inches of hardwood or equivalent, or a laminated partition. The hardwood or equivalent shall be fastened to the vehicle or conveyance. When a laminated partition is used, operators must follow the provisions of IME Safety Library Publication No. 22, ``Recommendations for the Safe Transportation of Detonators in a Vehicle with other Explosive Materials," (May 1993), and the ``Generic Loading Guide for the IME-22 Container," (October 1993). This incorporation by reference has been approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies are available at MSHA, 4015 Wilson Boulevard, Room 728, Arlington, VA 22203, and at all Metal and Nonmetal Mine Safety and Health district offices, or available for inspection at the Office of the Federal Register, 800 North Capitol Street, NW., 7th Floor, suite 700, Washington, DC.

30 CFR § 57.6202 Vehicles.

(a) Vehicles containing explosive material shall be--

(1) Maintained in good condition and shall comply with the requirements of subpart M of this part;

(2) Equipped with sides and enclosures higher than the explosive material being transported or have the explosive material secured to a nonconductive pallet;

(3) Equipped with a cargo space that shall contain the explosive material (passenger areas shall not be considered cargo space);

(4) Equipped with at least two multipurpose dry-chemical fire extinguishers or one such extinguisher and an automatic fire suppression system;

(5) Posted with warning signs that indicate the contents and are visible from each approach;

(6) Occupied only by persons necessary for handling the explosive material; (7) Attended or the cargo compartment locked, except when parked at the blast site and loading is in progress; and

(8) Secured while parked by having--

(i) The brakes set;

(ii) The wheels chocked if movement could occur; and

(iii) The engine shut off unless powering a device being used in the loading operation.

(b) Vehicles containing explosives shall have--

(1) No sparking material exposed in the cargo space; and

(2) Only properly secured non-sparking equipment in the cargo space with the explosives.

(c) Vehicles used for dispensing bulk explosive material shall--

(1) Have no zinc or copper exposed in the cargo space; and

(2) Provide any enclosed screw-type conveyors with protection against internal pressure and frictional heat.

30 CFR § 57.6203 Locomotives.

Explosive material shall not be transported on a locomotive. When explosive material is hauled by trolley locomotive, covered, electrically insulated cars shall be used.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6204 Hoists.

(a) Before explosive material is transported in hoist conveyances--

(1) The hoist operator shall be notified; and

(2) Hoisting in adjacent shaft compartments, except for empty conveyances or counterweights, shall be stopped until transportation of the explosive material is completed.

(b) Explosive material transported in hoist conveyances shall be placed within a container which prevents shifting of the cargo that could cause detonation of the container by impact or by sparks. The manufacturer's container may be used if secured to a nonconductive pallet. When explosives are transported, they shall be secured so as not to contact any sparking material.

(c) No explosive material shall be transported during a mantrip.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6205 Conveying explosives by hand.

Closed, nonconductive containers shall be used to carry explosives and detonators to and from blast sites. Separate containers shall be used for explosives and detonators.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6220 Maintenance and operation of transport vehicles.

Vehicles containing explosives or detonators shall be maintained in good condition and shall be operated at a safe speed and in accordance with all safe operating practices.

[58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, §57.6220 is effective until January 31, 1994, unless terminated earlier by FEDERAL REGISTER notice.

30 CFR § 57.6300 Control of blasting operations.

USE--SURFACE AND UNDERGROUND

(a) Only persons trained and experienced in the handling and use of explosive material shall direct blasting operations and related activities.

(b) Trainees and inexperienced persons shall work only in the immediate presence of persons trained and experienced in the handling and use of explosive material.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6301 Blast hole obstruction check.

Before loading, blast holes shall be checked and, wherever possible, cleared of obstructions.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6302 Separation of explosive material.

Explosives and blasting agents shall be kept separated from detonators until loading begins.

30 CFR § 57.6303 Initiation preparation.

(a) Primers shall be made up only at the time of use and as close to the blast site as conditions allow.

(b) Primers shall be prepared with the detonator contained securely and completely within the explosive or contained securely and appropriately for its design in the tunnel or cap well.

(c) When using detonating cord to initiate another explosive, a connection shall be prepared with the detonating cord threaded through, attached securely to, or otherwise in contact with the explosive.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6304 Primer protection.

(a) Tamping shall not be done directly on a primer.

(b) Rigid cartridges of explosives or blasting agents that are 4 inches (100 millimeters) in diameter or larger shall not be dropped on the primer except where the blast hole contains sufficient depth of water to protect the primer from impact. Slit packages of prill, water gel, or emulsions are not considered rigid cartridges and may be drop loaded.

[56 FR 46508, Sept. 12, 1991; 56 FR 52193, Oct. 18, 1991; 58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of §57.6304(b) is stayed until January 31, 1994.

30 CFR § 57.6305 Unused explosive material.

Unused explosive material shall be moved to a protected location as soon as practical after loading operations are completed.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6306 Loading, blasting, and security.

(a) When explosive materials or initiating systems are brought to the blast site, the blast site shall be attended; barricaded and posted with warning signs, such as ``Danger,'' ``Explosives,'' or ``Keep Out;'' or flagged against unauthorized entry.

(b) Vehicles and equipment shall not be driven over explosive material or initiating systems in a manner which could contact the material or systems, or create other hazards.

(c) Once loading begins, the only activities permitted within the blast site shall be those activities directly related to the blasting operation and the activities of surveying, stemming, sampling of geology, and reopening of holes, provided that reasonable care is exercised. Haulage activity is permitted near the base of a highwall being loaded or awaiting firing, provided no other haulage access exists.

(d) Loading and blasting shall be conducted in a manner designed to facilitate a continuous process, with the blast fired as soon as possible following the completion of loading. If blasting a loaded round may be delayed for more than 72 hours, the operator shall notify the appropriate MSHA district office.

(e) In electric blasting prior to connecting to the power source, and in non-electric blasting prior to attaching an initiating device, all persons shall leave the blast area except persons in a blasting shelter or other location that protects them from concussion (shock wave), flying material, and gases.

(f) Before firing a blast--

(1) Ample warning shall be given to allow all persons to be evacuated;

(2) Clear exit routes shall be provided for persons firing the round; and

(3) All access routes to the blast area shall be guarded or barricaded to prevent the passage of persons or vehicles.

(g) Work shall not resume in the blast area until a post-blast examination addressing potential blast-related hazards has been conducted by a person with the ability and experience to perform the examination.

30 CFR § 57.6307 Drill stem loading.

Explosive material shall not be loaded into blast holes with drill stem equipment or other devices that could be extracted while containing explosive material. The use of loading hose, collar sleeves, or collar pipes is permitted.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6308 Initiation systems.

Initiation systems shall be used in accordance with the manufacturer's instructions.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6309 Fuel oil requirement for ANFO.

(a) Liquid hydrocarbon fuels with flash points lower than that of No. 2 diesel oil (125 °F) shall not be used to prepare ammonium nitrate-fuel oil, except that diesel fuels with flash points no lower than 100 °F may be used at ambient air temperatures below 45 °F.

(b) Waste oil, including crankcase oil, shall not be used to prepare ammonium nitrate-fuel oil.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6310 Misfire waiting period.

When a misfire is suspected, persons shall not enter the blast area--

(a) For 30 minutes if safety fuse and blasting caps are used; or

(b) For 15 minutes if any other type detonators are used.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6311 Handling of misfires.

(a) Faces and muck piles shall be examined for misfires after each blasting operation.

(b) Only work necessary to remove a misfire and protect the safety of miners engaged in the removal shall be permitted in the affected area until the misfire is disposed of in a safe manner.

(c) When a misfire cannot be disposed of safely, each approach to the area affected by the misfire shall be posted with a warning sign at a conspicuous location to prohibit entry, and the condition shall be reported immediately to mine management.

(d) Misfires occurring during the shift shall be reported to mine management not later than the end of the shift.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6312 Secondary blasting.

Secondary blasts fired at the same time in the same work area shall be initiated from one source.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6400 Compatibility of electric detonators.

ELECTRIC BLASTING--SURFACE AND UNDERGROUND

All electric detonators to be fired in a round shall be from the same manufacturer and shall have similar electrical firing characteristics.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6401 Shunting.

Except during testing--

(a) Electric detonators shall be kept shunted until connected to the blasting line or wired into a blasting round;

(b) Wired rounds shall be kept shunted until connected to the blasting line; and

(c) Blasting lines shall be kept shunted until immediately before blasting.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6402 Deenergized circuits near detonators.

Electrical distribution circuits within 50 feet of electric detonators at the blast site shall be deenergized. Such circuits need not be deenergized between 25 to 50 feet of the electric detonators if stray current tests, conducted as frequently as necessary, indicate a maximum stray current of less than 0.05 amperes through a 1-ohm resistor as measured at the blast site.

58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6403 Branch circuits.

(a) If electric blasting includes the use of branch circuits, each branch shall be equipped with a safety switch or equivalent method to isolate the circuits to be used.

(b) At least one safety switch or equivalent method of protection shall be located outside the blast area and shall be in the open position until persons are withdrawn.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6404 Separation of blasting circuits from power source.

(a) Switches used to connect the power source to a blasting circuit shall be locked in the open position except when closed to fire the blast.

(b) Lead wires shall not be connected to the blasting switch until the shot is ready to be fired.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6405 Firing devices.

(a) Power sources shall be capable of delivering sufficient current to energize all electric detonators to be fired with the type of circuits used. Storage or dry cell batteries are not permitted as power sources.

(b) Blasting machines shall be tested, repaired, and maintained in accordance with manufacturer's instructions.

(c) Only the blaster shall have the key or other control to an electrical firing device.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6406 Duration of current flow.

If any part of a blast is connected in parallel and is to be initiated from power lines or lighting circuits, the time of current flow shall be limited to a maximum of 25 milliseconds. This can be accomplished by incorporating an arcing control device in the blasting circuit or by interrupting the circuit with an explosive device attached to one or both lead lines and initiated by a 25-millisecond delay electric detonator.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6407 Circuit testing.

A blasting galvanometer or other instrument designed for testing blasting circuits shall be used to test the following:

(a) In surface operations--

(1) Continuity of each electric detonator in the blast hole prior to stemming and connection to the blasting line;

(2) Resistance of individual series or the resistance of multiple balanced series to be connected in parallel prior to their connection to the blasting line;

(3) Continuity of blasting lines prior to the connection of electric detonator series; and

(4) Total blasting circuit resistance prior to connection to the power source.

(b) In underground operations--

(1) Continuity of each electric detonator series; and

(2) Continuity of blasting lines prior to the connection of electric detonators.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6500 Damaged initiating material.

NON-ELECTRIC BLASTING--SURFACE AND UNDERGROUND

A visual check of the completed circuit shall be made to ensure that the components are properly aligned and connected. Safety fuse, igniter cord, detonating cord, shock or gas tubing, and similar material which is kinked, bent sharply, or damaged shall not be used.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6501 Non-electric initiation systems.

(a) When the non-electric initiation system uses shock tube--

(1) Connections with other initiation devices shall be secured in a manner which provides for uninterrupted propagation;

(2) Factory-made units shall be used as assembled and shall not be cut except that a single splice is permitted on the lead-in trunkline during dry conditions; and

(3) Connections between blast holes shall not be made until immediately prior to clearing the blast site when surface delay detonators are used.

(b) When the non-electric initiation system uses detonating cord--

(1) The line of detonating cord extending out of a blast hole shall be cut from the supply spool immediately after the attached explosive is correctly positioned in the hole;

(2) In multiple row blasts, the trunkline layout shall be designed so that the detonation can reach each blast hole from at least two directions;

(3) Connections shall be tight and kept at right angles to the trunkline;

(4) Detonators shall be attached securely to the side of the detonating cord and pointed in the direction in which detonation is to proceed;

(5) Connections between blast holes shall not be made until immediately prior to clearing the blast site when surface delay detonators are used; and

(6) Lead-in lines shall be manually unreeled if connected to the trunklines at the blast site.

(c) When non-electric initiation systems use gas tube, continuity of the circuit shall be tested prior to blasting.

[56 FR 46509, Sept. 12, 1991; 56 FR 52193, Oct. 18, 1991; 58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of §57.6501(a) is stayed until January 31, 1994.

30 CFR § 57.6502 Safety fuse.

(a) The burning rate of each spool of safety fuse to be used shall be measured, posted in locations which will be conspicuous to safety fuse users, and brought to the attention of all persons involved with the blasting operation.

(b) When firing with safety fuse ignited individually using handheld lighters, the safety fuse shall be of lengths which provide at least the minimum burning time for a particular size round, as specified in the following table.

TABLE E-1--SAFETY FUSE--MINIMUM BURNING TIME

Number of holes in a round	Minimum burning time
1	1 2 minutes.
2-5	2 minutes 40 seconds.
6-10	3 minutes 20 seconds.
11-15	5 minutes.

1 For example, at least a 36-inch length of 40-second-per-foot safety fuse

or at least a 48-inch length of 30-second-per-foot safety fuse would have to be used to allow sufficient time to evacuate the area.

(c) Where flyrock might damage exposed safety fuse, the blast shall be timed so that all safety fuses are burning within the blast holes before any blast hole detonates.

(d) Fuse shall be cut and capped in dry locations.

(e) Blasting caps shall be crimped to fuse only with implements designed for that purpose.

(f) Safety fuse shall be ignited only after the primer and the explosive material are securely in place.

(g) Safety fuse shall be ignited only with devices designed for that purpose. Carbide lights, liquefied petroleum gas torches, and cigarette lighters shall not be used to light safety fuse.

(h) At least two persons shall be present when lighting safety fuse, and no one shall light more than 15 individual fuses. If more than 15 holes per person are to be fired, electric initiation systems, igniter cord and connectors, or other non-electric initiation systems shall be used. [58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6600 Loading practices.

EXTRANEOUS ELECTRICITY--SURFACE AND UNDERGROUND

If extraneous electricity is suspected in an area where electric detonators are used, loading shall be suspended until tests determine that stray current does not exceed 0.05 amperes through a 1-ohm resister when measured at the location of the electric detonators. If greater levels of extraneous electricity are found, the source shall be determined and no loading shall take place until the condition is corrected.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6601 Grounding.

Electric blasting circuits, including power line sources when used, shall not be grounded.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6602 Static electricity dissipation during loading.

When explosive material is loaded pneumatically into a blast hole in a manner that generates a static electricity hazard--

(a) An evaluation of the potential static electricity hazard shall be made and any hazard shall be eliminated before loading begins;

(b) The loading hose shall be of a semi conductive type, have a total of not more than 2 megohms of resistance over its entire length and not less than 1000 ohms of resistance per foot;

(c) Wire-countered hoses shall not be used;

(d) Conductive parts of the loading equipment shall be bonded and grounded and grounds shall not be made to other potential sources of extraneous electricity; and

(e) Plastic tubes shall not be used as hole liners if the hole contains an electric detonator.

30 CFR § 57.6603 Air gap.

At least a 15-foot air gap shall be provided between the blasting circuit and the electric power source.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6604 Precautions during storms.

During the approach and progress of an electrical storm--

(a) Surface blasting operations shall be suspended and persons withdrawn from the blast area or to a safe location.

(b) Underground electrical blasting operations that are capable of being initiated by lightning shall be suspended and all persons withdrawn from the blast area or to a safe location.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6605 Isolation of blasting circuits.

Lead wires and blasting lines shall be isolated and insulated from power conductors, pipelines, and railroad tracks, and shall be protected from sources of stray or static electricity. Blasting circuits shall be protected from any contact between firing lines and overhead power lines which could result from the force of a blast.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6700 Non-sparking tools.

EQUIPMENT/TOOLS--SURFACE AND UNDERGROUND

Only non-sparking tools shall be used to open containers of explosive material or to punch holes in explosive cartridges.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6701 Tamping and loading pole requirements.

Tamping and loading poles shall be of wood or other nonconductive, non-sparking material. Couplings for poles shall be non-sparking.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6800 Storage facilities.

MAINTENANCE--SURFACE AND UNDERGROUND

When repair work which could produce a spark or flame is to be performed on a storage facility--

(a) The explosive material shall be moved to another facility, or moved at least 50 feet from the repair activity and monitored; and

(b) The facility shall be cleaned to prevent accidental detonation.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6801 Vehicle repair.

Vehicles containing explosive material and oxidizers shall not be taken into a repair garage or shop.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6802 Bulk delivery vehicles.

No welding or cutting shall be performed on a bulk delivery vehicle until the vehicle has been washed down and all explosive material has been removed. Before welding or cutting on a hollow shaft, the shaft shall be thoroughly cleaned

inside and out and vented with a minimum 1/2-inch diameter opening to allow for sufficient ventilation.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6803 Blasting lines.

Permanent blasting lines shall be properly supported. All blasting lines shall be insulated and kept in good repair.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6900 Damaged or deteriorated explosive material.

GENERAL REQUIREMENTS--SURFACE AND UNDERGROUND

Damaged or deteriorated explosive material shall be disposed of in a safe manner in accordance with the instructions of the manufacturer.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6901 Black powder.

(a) Black powder shall be used for blasting only when a desired result cannot be obtained with another type of explosive, such as in quarrying certain types of dimension stone.

(b) Containers of black powder shall be--

(1) Non-sparking;

(2) Kept in a totally enclosed cargo space while being transported by a vehicle;

(3) Securely closed at all times when--

(b)(3)(i) Within 50 feet of any magazine or open flame,

(b)(3)(ii) Within any building in which a fuel-fired or exposed-element electric heater is operating, or

(b)(3)(iii) In an area where electrical or incandescent-particle sparks could result in powder ignition; and

(4) Open only when the powder is being transferred to a blast hole or another container and only in locations not listed in paragraph (b)(3) of this section.

(c) Black powder shall be transferred from containers only by pouring.

(d) Spills shall be cleaned up promptly with non-sparking equipment. Contaminated powder shall be put into a container of water and shall be disposed of promptly after the granules have disintegrated, or the spill area shall be flushed promptly with water until the granules have disintegrated completely.

(e) Misfires shall be disposed of by washing the stemming and powder charge from the blast hole, and removing and disposing of the initiator in accordance with the requirement for damaged explosives.

(f) Holes shall not be reloaded for at least 12 hours when the blast holes have failed to break as planned.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6902 Excessive temperatures.

(a) Where heat could cause premature detonation, explosive material shall not be loaded into hot areas, such as kilns or sprung holes.

(b) When blasting sulfide ores where hot holes occur that may react with explosive material in blast holes, operators shall--

(1) Measure an appropriate number of blast hole temperatures in order to assess the specific mine conditions prior to the introduction of explosive material;

(2) Limit the time between the completion of loading and the initiation of the blast to no more than 12 hours; and

(3) Take other special precautions to address the specific conditions at the mine to prevent premature detonation.

[58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of §57.6902(b) is stayed until January 31, 1994.

30 CFR § 57.6903 Burning explosive material.

If explosive material is suspected of burning at the blast site, persons shall be evacuated from the endangered area and shall not return for at least one hour after the burning or suspected burning has stopped.

[58 FR 31908, June 7, 1993; 58 FR 69596, Dec. 30, 1993]

NOTE: At 58 FR 69596, December 30, 1993, the effective date of §57.6903 is stayed until January 31, 1994.

30 CFR § 57.6904 Smoking and open flames.

Smoking and use of open flames shall not be permitted within 50 feet of explosive material except when separated by permanent noncombustible barriers. This standard does not apply to devices designed to ignite safety fuse or to heating devices which do not create a fire or explosion hazard.

[58 FR 69596, Dec. 30, 1993]

30 CFR § 57.6905 Protection of explosive material.

(a) Explosive material shall be protected from temperatures in excess of 150 degrees Fahrenheit.

(b) Explosive material shall be protected from impact, except for tamping and dropping during loading.

30 CFR § 57.6960 Mixing of explosive material.

GENERAL REQUIREMENTS--UNDERGROUND ONLY

(a) The mixing of ingredients to produce explosive material shall not be conducted underground unless prior approval of the MSHA district manager is obtained. In granting or withholding approval, the district manager shall consider the potential hazards created by--

(1) The location of the stored material and the storage practices used;

(2) The transportation and use of the explosive material;

(3) The nature of the explosive material, including its sensitivity;

(4) Any other factor deemed relevant to the safety of miners potentially exposed to the hazards associated with the mixing of the bulk explosive material underground.

(b) Storage facilities for the ingredients to be mixed shall provide drainage away from the facilities for leaks and spills.

[58 FR 69596, Dec. 30, 1993]

Appendix I to Subpart E--MSHA Tables of Distances

TABLE 1--SURFACE STORAGE OF EXPLOSIVE MATERIAL

Quantity of explosive material (pounds) Not over	Minimum separation distances (feet) From mine buildings, dams and electric substations		Between magazines	
	Barricaded	Unbarricaded	Barricaded	Unbarricaded
5	70	140	6	12
10	90	180	8	16
20	110	220	10	20
30	125	250	11	22
40	140	280	12	24
50	150	300	14	28
75	170	340	15	30
100	190	380	16	32
125	200	400	18	36
150	215	430	19	38
200	235	470	21	42
250	255	510	23	46
300	270	540	24	48
400	295	590	27	54
500	320	640	29	58
600	340	680	31	62
700	355	710	32	64
800	375	750	33	66
900	390	780	35	70
1,000	400	800	36	72
1,200	425	850	39	78
1,400	450	900	41	82
1,600	470	940	43	86
1,800	490	980	44	88
2,000	505	1,010	45	90
2,500	545	1,090	49	98
3,000	580	1,160	52	104
4,000	635	1,270	58	116
5,000	685	1,370	61	122
6,000	730	1,460	65	130
7,000	770	1,540	68	136
8,000	800	1,600	72	144
9,000	835	1,670	75	150
10,000	865	1,730	78	156
12,000	875	1,750	82	164
14,000	885	1,770	87	174
16,000	900	1,800	90	180
18,000	940	1,880	94	188
20,000	975	1,950	98	196
25,000	1,055	2,000	105	210
30,000	1,130	2,000	112	224
35,000	1,205	2,000	119	238
40,000	1,275	2,000	124	248
45,000	1,340	2,000	129	258
50,000	1,400	2,000	135	270
55,000	1,460	2,000	140	280
60,000	1,515	2,000	145	290
65,000	1,565	2,000	150	300

70,000	1,610	2,000	155	310
75,000	1,655	2,000	160	320
80,000	1,695	2,000	165	330
85,000	1,730	2,000	170	340
90,000	1,760	2,000	175	350
95,000	1,790	2,000	180	360
100,000	1,815	2,000	185	370
110,000	1,835	2,000	195	390
120,000	1,855	2,000	205	410
130,000	1,875	2,000	215	430
140,000	1,890	2,000	225	450
150,000	1,900	2,000	235	470
160,000	1,935	2,000	245	490
170,000	1,965	2,000	255	510
180,000	1,990	2,000	265	530
190,000	2,010	2,010	275	550
200,000	2,030	2,030	285	570
210,000	2,055	2,055	295	590
230,000	2,100	2,100	315	630
250,000	2,155	2,155	335	670
275,000	2,215	2,215	360	720
300,000	2,275	2,275	385	770

For purposes of this table, "barricaded" means that the storage facility containing explosive material is screened effectively by a natural barricade or an artificial barricade consisting of a mound or riveted wall of earth with a minimum thickness of three feet.

TABLE 2--MSHA TABLE OF SEPARATION DISTANCES

Quantity of ammonium nitrate of blasting agents (pounds) Not over	Storage facilities--minimum separation distances when barricaded * (feet)		Minimum thickness of artificial barricades** (inches)
	Ammonium nitrate	Blasting agents	
100	3	11	12
300	4	14	12
600	5	18	12
1,000	6	22	12
1,600	7	25	12
2,000	8	29	12
3,000	9	32	15
4,000	10	36	15
6,000	11	40	15
8,000	12	43	20
10,000	13	47	20
12,000	14	50	20
16,000	15	54	25
20,000	16	58	25
25,000	18	65	25
30,000	19	68	30
35,000	20	72	30
40,000	21	76	30
45,000	22	79	35
50,000	23	83	35
55,000	24	86	35
60,000	25	90	35
70,000	26	94	40
80,000	28	101	40
90,000	30	108	40
100,000	32	115	40
120,000	34	122	50
140,000	37	133	50
160,000	40	144	50
180,000	44	158	50
200,000	48	173	50
220,000	52	187	60
250,000	56	202	60
275,000	60	216	60
300,000	64	230	60

* When the ammonium nitrate or blasting agents are not barricaded, the distances shown in the table must be multiplied by six.

** For purposes of this table, "barricaded" means that the storage facility is screened effectually by a natural barricade or an artificial barricade consisting of amount of riveted wall or earth with the prescribed minimum thickness. Note: At 56 FR 69596, December 30, 1993, appendix I to subpart E of part 57 is stayed until January 31, 1994.

Section VI

General Definitions

General Definitions

Disclaimer

The definitions provided herein are solely for the purpose of general information. They should not be substituted for technical a questions. These definitions are not necessarily intended to conform to those set forth in any governmental regulations or guidelines, nor are they intended to describe any manufacturer's particular product configuration.

AC Alternating current.

Acceptor A charge of explosives or blasting agent receiving an impulse from an exploding donor charge.

Adobe Charge A mud-covered or unconfined explosive charge fired in contact with a rock surface without the use of a borehole-, Synonymous with Bulldoze and Mudcapping.

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

American Table of Distances The quantity-distance table, prepared and approved by IME, for storage of explosive materials to determine safe distances from inhabited buildings, public highways, passenger railways, and other stored explosive materials.

Ammonium Nitrate The ammonium salt of nitric acid represented by the NH_4NO_3

Ampere A unit of electrical current produced by 1 volt acting through a resistance of I ohm.

ANFO An explosive material consisting of ammonium nitrate and fuel oil.

ANSI American National Standards Institute, a nongovernmental organization concerned with developing safety and health standards for industry.

Approved, Approval, or Authorized Terms that mean Approved, Approval, or Authorized by the authority having jurisdiction.

Artificial Barricade An artificial mound or revetted wall of earth of a minimum thickness of 3 ft.

Authorized Person An individual approved or assigned by management to perform a specific duty or duties or to be at a specific location or locations.
Authority Having Jurisdiction The governmental agency, office, or individual responsible for approving equipment, an installation, or a procedure.

Available Energy The energy from an explosive material that is capable of performing useful work.

Back Break Rock broken beyond the limits of the last row of holes in a blast.

Ballistic Mortar A laboratory instrument used for measuring the relative power or strength of an explosive material.

Barricaded The effective screening of a building containing explosives from a magazine or other building, railway, or highway by a natural or an artificial barrier. A straight line from the top of any sidewall of the building containing explosives to the eave line of any magazine or other building or to a point 12 ft above the center of a railway or highway shall pass through such barrier.

Base Charge The main explosive charge in the base of a detonator.

Bench A horizontal ledge in or at the top of a highwall from which holes are drilled vertically down into the material to be blasted; benching is a process of excavating where a highwall is worked in steps or lifts.

Bench Height The vertical distance from the top of a bench to the floor or to the top of the next lower bench.

Black Powder A deflagrating or low-explosive compound of an intimate mixture of sulfur, charcoal, and an alkali nitrate, usually potassium or sodium nitrate.

Blast, Blasting The firing of explosive materials for such purposes as breaking rock or other material, moving material, or generating seismic waves; the assembly of explosive materials for such purpose.

Blast Area The area of a blast within the influence of flying rock missiles, gases, and concussion.

Blast Pattern The plan of the drill holes laid out on a bench; an expression of the burden distance and the spacing distance and their relationship to each other.

Blast Site The area where explosive material is handled during loading, including the perimeter of blast holes and 50 ft in all directions from loaded holes or holes to be loaded. In underground mines, 15 ft of solid rib or pillar can be substituted for the 50-ft distance.

Blaster That qualified person in charge of, and responsible for the loading and firing of a blast (same as *Shot Firer).*
Blasting Accessories Nonexplosive devices and materials used in blasting, such as, but not limited to, cap crimpers, tamping bags, blasting machines, blasting galvanometers, and cartridge punches.

Blasting Agent An explosive material that meets prescribed criteria for insensitivity to initiation. For storage, Title 27, Code of Federal Regulations, Section 55.11 defines a blasting agent as any material or mixture, consisting of fuel and oxidizer intended for blasting, not otherwise defined as an explosive, provided that the finished product, as mixed for use or shipment, cannot be detonated by means of a No. 8 test blasting cap when unconfined (Bureau of Alcohol. Tobacco and Firearms Regulation). For transportation, Title 49, Code of Federal Regulations defines a blasting agent as a material designed for blasting that has been tested in accordance with Section 173.114a and found to be so insensitive that there is very little probability of accidental initiation to explosion or transition from deflagration to detonation (U.S. Department of Transportation Regulation).

Blasting Cap A detonator that is initiated by a safety fuse (see Fuse Cap)

Blasting Crew A group of persons who assist the blaster in loading, tying in, and firing a blast.

Blasting Galvanometer An electrical resistance instrument designed specifically for testing electric detonators and circuits containing them. Along with blasting ohmmeters and blaster's multimeters, it is used to measure resistance or to check electrical continuity.

Blasting Log A written record of information about a specific blast as may be required by law or regulation.

Blasting Machine An electrical or electromechanical device that provides electrical energy for the purpose of energizing detonators in an electric blasting circuit.

Blasting Machine-CD Type See *Capacitor-Discharge Blasting Machine.*

Blasting Machine-Generator Type A hand-operated electromechanical device that provides an output current to energize electric detonators.

Blasting Machine Rheostat A graduated electrical resistance device used to simulate electric detonator resistances in the testing of blasting machines.

Blasting Mat A mat of woven steel wire, rope, scrap tires, or other suitable material or construction to cover blast holes for the purpose of preventing flying rock missiles.

Blasting Vibrations The energy from a blast that manifests itself in earthborne vibrations that are transmitted through the earth away from the immediate blast area.

Block-Holing The breaking of boulders by loading and firing small explosive charges in small-diameter drilled holes.

Booster An explosive charge, usually of high strength and high detonation velocity, used to improve the initiation of less sensitive explosive materials.

Bootleg The part of a drilled blast hole that remains when the force of the explosion does not break the rock completely to the bottom of the hole.

Borehole (Blast hole) A hole drilled in the material to be blasted, for the purpose of containing an explosive charge.

Breakage A term used to describe the size distribution of the rock fragments created by a blast.

Bridgewire A resistance wire connecting the ends of the legwires inside an electric detonator and which is imbedded in the ignition charge of the detonator.

Brisance The shattering power of an explosive material as distinguished from its total work capacity.

Bulk Mix A mass of explosive material prepared for use in bulk form without packaging.

Bulk Mix Delivery Equipment Equipment (usually a motor vehicle with or without a mechanical delivery device) that transports explosive materials in bulk form for mixing and/or loading directly into blast holes.

Bulk Strength The strength per unit volume of an explosive calculated from its weight strength and density.

Bulldoze A mud-covered or unconfined explosive charge fired in contact with a rock surface without the use of a borehole; Synonymous with Adobe Charge and Mudcapping.

Bullet-Resistant Magazine walls or doors of construction resistant to penetration of a bullet of 150-grain M2 ball ammunition having a nominal muzzle velocity of 2,700 ft/sec fired from a .30-caliber rifle from a distance of 100 ft perpendicular to

the wall or door. When a magazine ceiling or roof is required to be bullet-resistant, the ceiling or roof shall be constructed of materials comparable to the sidewalls or of other materials that will withstand penetration of the bullet described above when fired at an angle of 45 degrees from the perpendicular. Tests to determine bullet resistance should be conducted on test panels or empty magazines that will resist penetration of 5 out of 5 shots placed independently of each other in an area at least 3 ft. x 3 ft.

Bullet-Sensitive Explosive Material Explosive material that can be detonated by 150-grain M2 ball ammunition having a nominal muzzle velocity of 2,700 ft/sec when the bullet is fired from a .30-caliber rifle at a distance of not more than 100 ft and the test material, at a temperature of 70 - 75°F, is placed against a backing material of $^1/_2$-in. steel plate.

Bureau of Explosives A bureau of the Association of American Railroads that the U.S. Department of Transportation may consult for recommendations on classification of explosive materials for the purpose of interstate transportation

Burden The distance from the borehole and the nearest free face or the distance between boreholes measured perpendicular to the spacing. Also the total amount of material to be blasted by a given hole, usually measured in cubic yards or tons.

Bureau of Alcohol, Tobacco, and Firearms (BAFT) A bureau of the Department of Treasury having responsibility for the promulgation and enforcement of regulations related to the unlawful use of explosive materials under 18 U.S.C. Chapter 40, Section 847.

Bureau of Mines See U.S. Bureau of Mines.

Bus Wire Expendable heavy-gauge bare copper wire used to connect detonators or series of detonators in parallel

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.

Cap Sensitivity The sensitivity of an explosive to initiation by a detonator. An explosive material is considered to be cap sensitive if it detonates with an IME No. 8 Test Detonator.

Capacitor-Discharge Blasting Machine A blasting machine in which electrical energy, stored on a capacitor, is discharged into a blasting circuit containing electric detonators..

Carton A lightweight inner container for explosive materials, usually encased in a substantial shipping container called a case.

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

Cartridge Count (Stick Count) The number of cartridges in a standard case. A standard case typically contains about 50 LB of 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.

Cartridge Strength Same as *Bulk Strength.*

Case An outer substantial shipping container meeting DOT specifications for explosive materials.

Case Liner A plastic or paper barrier used to prevent the escape of explosive materials from a case.

Cast, Extrude, or Pressed Booster A cast, extruded, or pressed solid high explosive used to detonate less sensitive explosive materials.

Certified Blaster A blaster certified by a governmental agency to prepare, execute, and supervise blasting.

Chemical Manufacturers Association (CMA) A nonprofit chemical trade organization of companies in the United States and Canada who manufacture chemicals for sale.

Circuit A completed path for conveying electrical current.

Class A Explosives Explosives, as defined by the U.S. Department of Transportation, that possess detonating or otherwise maximum hazard, such as, but not limited to, dynamite, nitroglycerin, lead azide, blasting caps, and detonating primers

Class B Explosives Explosives, as defined by the U.S. Department of Transportation, that possess flammable hazard, such as, but not limited to, propellant explosives. photographic flash powders, and some special fireworks.

Class C Explosives Explosives, as defined by the U.S. Department of Transportation, that contain Class A or Class B explosives, or both, as components but in restricted quantities.

Collar The term applied to the timbering or concrete around the mouth or top of a shaft. It also refers to the mouth or top of a drill hole in blasting.

Column Charge A charge of explosives in a blast hole in the form of a long, continuous unbroken column.

Column Depth/Column Height The length of each portion of a blast hole filled with explosive materials.

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

Confined Detonation Velocity The detonation velocity of an explosive material in a substantial container or a borehole.

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

Core Load The explosive core of detonating cord, expressed as the number of grains of explosive per foot.

Coupling The degree to which an explosive fills the cross section of a borehole; bulk-loaded explosives are completely coupled; untamped cartridges are decoupled.

Coyote Shooting A method of blasting using a number of relatively large concentrated charges of explosives placed in one or more small tunnels driven in a rock formation.

Crimp The folded ends of paper explosive cartridges, the circumferential depression at the open end of a fuse cap or igniter cord connector that serves to secure the fuse; or the circumferential depression in the blasting cap shell that secures a sealing plug or sleeve into electric or non-electric detonators.

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.

Critical Diameter The minimum diameter for propagation of a detonation wave at a stable velocity. Critical diameter is affected by conditions of confinement, temperature, and pressure on the explosive.

Crosscut A horizontal opening driven across the course of a vein or in general across the direction of the main workings. a connection from a shaft to a vein.

Current Leakage Portion of the firing current bypassing part of the blasting circuit through unintended paths.

Current-Limiting Device An electric or electromechanical device that limits:
1) current amplitude,
2) duration of current flow. or
3) total energy of the current delivered to an electric blasting circuit
Cushion Blasting A blasting technique used to produce competent slopes. The cushion holes, fired after the main charge, have a reduced spacing and employ decoupled charges.

Cutoff A break in a path of detonation or initiation caused by extraneous interference, such as flyrock or shifting ground.

Date-Shift Code A code applied by manufacturers to the outside shipping containers, and, in many instances, to the immediate containers of explosive materials to aid in their identification and tracing.

D'Autriche Method-Detonation Velocity A method of determining the detonation velocity of an explosive material by employing detonating cord and a witness plate.

DC Direct current.

Decibel A unit of air overpressure commonly used to measure air blast.

Deck Loading(Decking) A method of loading blast holes in which the explosive charges, called decks or deck charges, in the same hole are separated by stemming or an air cushion.

Decks An explosive charge that is separated from other charges in the blast hole by stemming or an air cushion.

Deflagration An explosive reaction such as a rapid combustion that moves through an explosive material at a velocity less than the speed of sound in the material.

Delay A distinct pause of predetermined time between detonation or initiation impulses, to permit the firing of explosive charges separately.

Delay Blasting The practice of initiating individual explosive decks, boreholes, or rows of boreholes at predetermined time intervals using delay detonators, as compared to instantaneous blasting where all holes are fired essentially simultaneously.

Delay Detonator An electric or non-electric detonator used to introduce a predetermined lapse of time between the application of a firing signal and the detonation of the base charge.

Delay Element The device in a delay detonator that produces the predetermined time lapse between the application of a firing signal and detonation.

Delay Interval The nominal time between the detonations of delay detonators of adjacent periods in a delay series; the nominal time between successive detonations in a blast.

Delay Period A designation given to a delay detonator to show its relative or absolute delay time in a given series.

Delay Series A series of delay detonators designed to satisfy specific blasting requirements. There are basically two types of delay series: millisecond (MS) with delay intervals on the order of milliseconds, and long period (LP) with delay times on the order of seconds.

Delay Tag A tag, band, or marker on a delay detonator that denotes the delay series, delay period, and/or delay time of the detonator.

Delay Time The lapse of time between the application of a firing signal and the detonation of the base charge of a delay detonator.

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

Department of Transportation (DOT) A cabinet-level agency of the 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.

Detonating Cord A flexible cord containing a center core of high explosive and used to initiate other explosives.

Detonating Cord Downline The section of detonating cord that extends within the blast hole from the ground surface down to the explosive charge.

Detonating Cord MS Connectors Non-electric, short-interval (millisecond) delay devices for use in delaying blasts that are initiated by detonating cord.

Detonating Cord Trunkline The line of detonating cord that is used to connect and initiate other lines of detonating cord.

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

Detonation An explosive reaction that moves through an explosive material at a velocity greater than the speed of sound in the material.

Detonation Pressure The pressure produced in the reaction/zone of a detonating explosive.

Detonation Velocity The velocity at which a detonation progresses through an explosive.

Detonator Any device containing any initiating or primary explosive that is used for initiating detonation. A detonator may not contain more than 10 g of total explosives by weight, excluding ignition or delay charges. The term includes, but Is not limited to, electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses, detonating cord delay connectors, and non-electric instantaneous and delay blasting caps that use detonating cord, shock tube, or any other replacement for electric legwires.

Development The work of driving openings to and in a proved ore body, to prepare it for mining and transporting the ore.

Diameter The cross-sectional width of a borehole or an explosive cartridge.

Ditch Blasting The formation of a ditch by the detonation of a series of explosive charges.

Ditching Dynamite A nitroglycerin-type explosive especially designed to propagate sympathetically from hole to hole in ditch blasting.

Donor An exploding charge producing an impulse that impinges upon an explosive "acceptor" charge.

Dope Individual, dry, nonexplosive ingredients that comprise a portion of an explosive formulation.

Do's and Don'ts A list of precautions *(IME Safety Library Publication No. 4)* printed by the Institute of Makers of Explosives pertaining to the transportation, storage, handling, and use of explosive materials and inserted in cases of explosive materials and cartons of detonators.

Downline A line of detonating cord or plastic tubing in blast hole that transmits the detonation from the trunkline or surface delay system down the hole to the primer.

Drift A horizontal opening in or near an ore body and parallel to the course of the vein or long dimension of the ore body.

Drill Hole A hole drilled in the material to be blasted for the purpose of containing an explosive charge, also called *Blast hole or Borehole.*

Drilling Pattern The location of blast holes in relationship to each other and the free face, if any.

Dynamite A high explosive used for blasting, consisting essentially of a mixture of, but not limited to, nitroglycerin, nitrocellulose, ammonium nitrate, sodium nitrate, and carbonaceous materials.

Electric Blasting Circuit An electric circuit containing electric detonators and associated wiring.

Electric Detonator A detonator designed for, and capable of, initiation by means of an electric current.

Electrical Storm An atmospheric disturbance characterized by intense electrical activity, producing lightning strokes and strong electric and magnetic fields.

Emergency Procedure Card Instructions carried on a truck transporting explosive materials and giving specific procedures in case of emergency.

Emulsion An explosive material containing substantial amounts of oxidizers dissolved in water droplets, surrounded by an immiscible fuel.

Energy A measure of the potential for the explosive to do work.

Exploration The work involved in gaining a knowledge of the size, shape, position, and value of an ore body.

Explosion A chemical reaction involving an extremely rapid expansion of gases, usually associated with the liberation of heat

Explosive Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion.

Explosive-Actuated Device Any tool or special mechanized device that is actuated by explosives. The term does not include propellant-actuated devices.

Explosive Charge The quantity of explosive material used in a blast hole, coyote tunnel, or explosive device.

Explosive Loading Factor The amount of explosive used per unit of rock; also called *Powder Factor*

Explosive Materials These include explosives, blasting agents, and detonators. The term includes, but is not limited to, dynamite and other high explosives; slurries, emulsions, and water gels; black powder and pellet powder; initiating explosives; detonators (blasting caps); safety fuse; squibs; detonating cord; igniter cord; and igniters. A list of explosive materials determined to be within the coverage of 18 USC Chapter 40, "Importation, Manufacture, Distribution, and Storage of Explosive Materials" is issued at least annually by the Director of the Bureau of Alcohol, Tobacco, and Firearms of the Department of the Treasury. The U.S. Department of Transportation classifications of explosive materials used in commercial blasting operations are not identical with the statutory definitions of the Organized Crime Control Act of 1970, Title 18 USC, Section 84 1. To achieve uniformity in transportation, the U.S. Department of Transportation in Title 49, *Code of Federal Regulation.* Parts 1-999 subdivides these materials into:

Class A Explosives-detonating or otherwise maximum hazard
Class B Explosives-flammable hazard
Class C Explosives-minimum hazard
Blasting Agents-see definition of *Blasting Agent*

Explosive Oils Liquid sensitizers for explosives such as nitroglycerin, ethylene glycol dinitrate, and metriol trinitrate.

Explosive Strength The amount of energy released by an explosive upon detonation that is an indication of the capacity of the explosive to do work.

Extra (Ammonia) Dynamite A dynamite that derives a major portion of its energy from reaction of ammonium nitrate.

Extraneous Electricity Electrical energy, other than actual firing current or the test current from a blasting galvanometer, that is present at a blast site and that could enter an electric blasting circuit. It includes stray current, static electricity, RF (electromagnetic) waves, and time-varying electric and magnetic fields.

Fertilizer-Grade Ammonium Nitrate A grade of ammonium nitrate as defined by The Fertilizer Institute.

Fire Extinguisher Rating A rating set forth in the National Fire Code that may be 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.

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

Fireworks Combustible or explosive compositions or manufactured articles designed and prepared for the purpose of producing audible or visible effects.

Firing Current An electric current of recommended magnitude and duration to sufficiently energize an electric detonator or a circuit of electric detonators.
Firing Line The wire(s) connecting the electrical power source with the electric blasting circuit.

Flags-Danger Flags, usually red, that may or may not be Imprinted with a warning and used to caution personnel around explosives operations, or displayed on trucks transporting explosives.

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

Flare A pyrotechnic device designed to produce a single source of intense light.

Flashover The sympathetic detonation between explosive charges or between charged blast holes.

Flash Point The lowest temperature at which vapors from a volatile combustible substance ignite in air when exposed to flame, as determined in an apparatus specifically designed for such testing.

Flyrock Rocks propelled from the blast area by the force of an explosion.

Foot Wall The wall or rock under a vein. It's called the floor in bedded deposits.

Forbidden or Not Acceptable Explosives Explosives that are forbidden or not acceptable for transportation by common, contract, or private carriers, by rail freight, rail express, highway, air, or water in accordance with the regulations of the U.S. Department of Transportation.

Fragmentation The breaking of a solid mass into pieces by blasting.

Free Face A rock surface exposed to air or water that provides room for expansion upon fragmentation; sometimes called open face.

Freezing The semifusing and nonejection of the pulverized rock or ore in the cut portion of a blasting round; generally caused by providing insufficient void space for the initial holes blasted in the cut, little or no delay between charges, and/or excessive charge weights.

Fuel A substance that may react with oxygen to produce combustion

Fume Classification See *IME Fume Classification*

Fumes The gaseous products of an explosion. For the purpose of fume classification, only poisonous or toxic gases, such as carbon monoxide, hydrogen sulfide, and nitrogen oxides are considered.

Fuse See *Safety Fuse.*
Fuse Cap (Fuse Detonator) A detonator that is initiated by a safety fuse; also referred to as an ordinary blasting cap.

Fuse Cutter A mechanical device for cutting safety fuse clean and at right angles to its long axis.

Fuse Lighters Pyrotechnic devices for the rapid and certain lighting of safety fuse.

Gauge (Wire) A series of standard sizes such as the American Wire Gauge (AWG), used to specify the diameter of wire

Galvanometer See *Blasting Galvanometer.*

Gap Sensitivity The maximum distance for propagation between standard charge sizes of explosive donor and acceptor. It is used for measuring the likelihood of sympathetic propagation.

Gelatin Dynamite A type of highly water-resistant dynamite characterized by its gelatinous consistency.

Geology A description of the types and arrangement of rock in an area; the description usually includes the dip and strike, the type and extent of preexisting breaks in the rock, and the hardness and massiveness of the rock as these affect blast design.

Grains A system of weight measurement where 7,000 grains are equivalent to one standard 16-ounce pound (0.45 kg).

Ground Fault An electrical contact between part of the blasting circuit and earth.

Ground Vibration Shaking of the ground, by elastic waves emanating from a blast, usually measured in inches per second of particle velocity.

GVW-Gross vehicle weight.

Hangfire The detonation of an explosive charge at some nondetermined time after its normally designed firing time.

Hanging Wall The wall or rock on the upperside of an inclined vein. It is called the roof in bedded deposits.

Hardwood Red oak, white oak, hard maple, ash, or hickory, free from loose knots, wind shakes, or similar defects.

Heading Refers to the driving of openings of the various exploration and development passageways.

Hertz (Hz) A synonym for "cycles per second".

High Explosives Explosives that are characterized by a very high rate of reaction, high pressure development, and the presence of a detonation wave in the explosive.

Highwall A nearly vertical face at the edge of a bench, bluff or ledge on a surface excavation.

Highway Any public street, public alley, or public road.

Hole Diameter The cross-sectional width of the borehole.

Igniter Cord A small-diameter pyrotechnic cord that burns at a uniform rate with an external flame and used to ignite a series of safety fuses.

IME Fume Classification A classification indicating the amount of poisonous or toxic gases produced by an explosive or blasting agent. The IME Fume Classification is expressed as follows:

	Cubic Feet of Poisonous Gases
Fume Class	Per (1 $^{1}/_{4}$' x 8") Cartridge of Explosive Material
1	Less than 0.16
2	0.16 - 0.33
3	0.33 - 0.67

Incendivity The property of an igniting agent (e.g., spark, flame, or hot solid) whereby the agent can cause ignition.

Inhabited Building A building regularly occupied in whole or part as a habitation for human beings, 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.

Instantaneous Detonator A detonator that has a firing time of essentially 0 sec as compared to delay detonators with firing times of from several milliseconds to several seconds.

Institute of Makers of Explosives (IME) A nonprofit safety-oriented trade association representing leading producers of commercial explosive materials in the United States and Canada and dedicated to safety in the manufacture, transportation, storage, handling, and use of explosive materials.

Institute of Makers of Explosives No. 8 Test Detonator IME No. 8 test detonator has 0.40 - 0.45 g of PETN base charge pressed to a specific gravity of 1.4 g/cc and primed with standard weights of primer, depending on manufacturer.

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

Issuing Authority The governmental agency, office, or official vested with the authority to issue permits or licenses.

Jackleg A single rotary-percussion pneumatically actuated machine with a hinged air-assisted feedleg; primarily used in small development headings and production stopes for drilling holes up to $1^{3}/_{4}$ in. in diameter.

Jumbo Vehicle mounted, boom-fed rotary-percussion drills, actuated by either compressed air or hydraulics, primarily used in large tunnels and room-and-pillar mining applications; generally capable of drilling holes $1^{3}/_{4}$ - $3^{1}/_{2}$ in. in diameters.

Kelly Bar A hollow bar attached to the top of the drill column in rotary drilling; also called grief joint, kelly joint, kelly stem.

Leading(Lead) Lines or 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 or one duplex wire extending out from an electric detonator.

Level Mines are customarily worked from shafts through horizontal passages or drifts called levels. These are commonly spaced at regular intervals in depth and

are either numbered from the surface in regular order or designated by their actual elevation below the top of a shaft..

Liquid Fuels Fuels in a liquid state. They may be used with oxidizers to form explosive materials.

Loading Placing explosive material in a blast hole or against the material to be blasted.

Loading Density The weight of explosive loaded per unit length of borehole occupied by the explosive, expressed as pounds per foot or kilograms per meter of borehole.

Loading Pole A nonmetallic pole used to assist the placing and compacting of explosive charges in boreholes.

Low Explosives Explosives 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.

Magazine Keeper A person responsible for the inventory and safe storage of explosive materials, including the proper maintenance of explosive materials, storage magazines, and areas.

Magazine, Surface A specially designed and constructed structure for the storage of explosive materials on the surface of the ground.

Magazine, Underground A specially designed and constructed structure for the storage of explosive materials underground.

Main Explosive Charge The explosive material that performs the major work of blasting.

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

Mass Detonate (Mass Explode) Explosive materials mass detonate (mass explode) when a unit or any part of a larger quantity of explosive material explodes and causes all or a substantial part of the remaining material to detonate or explode simultaneously. With respect to detonators, "a substantial part" means 90% or more.

Maximum Recommended Firing Current The highest recommended electric current to ensure safe and effective performance of an electric detonator.

Millisecond One thousandth of a second.

Mine Safety and Health Administration (MSHA) An agency of the Department of Labor concerned with promulgation and enforcement of health and safety regulations in the mining field.

Miniaturized Detonating Cord Detonating cord with a core load of 5 or less grains of explosive per foot.

Minimum Recommended Firing Current The lowest recommended electric current to ensure reliable performance of an electric detonator.

Minimum Gap Sensitivity An air gap, measured in inches, that determines whether the explosive material is within specific tolerances for gap sensitivity.

Misfire A blast that fails to detonate completely after an attempt at initiation; also the explosive material itself that failed to detonate as planned.

Motor Vehicle Any self-propelled vehicle, truck, tractor, semitrailer, or full trailer used for the transportation of freight over public highways.

MS Connectors Non-electric, short-interval (millisecond) delay devices for use in delaying blasts that are initiated by detonating cord.

Muck The broken rock or ore displaced from its position in the earth by blasting or caving.

Muckpile The pile of broken material resulting from a blast.

Mudcapping A mud-covered or unconfined explosive charge fired in contact with a rock surface without the use of a borehole.

Munroe Effect The concentration of explosive action through the use of a shaped charge.

National Fire Protection Association (NFPA) Standards Standards for explosive materials and ammonium nitrate issued by the National Fire Protection Association.

National Safety Council (NSC) A non profit organization chartered by Congress to provide a regular information service on the causes of accidents and ways to prevent them.

Natural Barricade Natural features of the ground, such as hills, or timber of sufficient density that the surrounding exposures that require protection cannot be seen from the magazine when the tress are bare of leaves.

Nitroglycerin An explosive chemical compound used as a sensitizer in dynamite and represented by the formula $C_3H_5(ONO_2)_3$.

No. 8 Test Cap See *Institute of Makers of Explosives No. 8 Test Detonator.*

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

Non-sparking 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 Department of Labor active in eliminating occupational hazards and promoting employee health and safety.

Office of Surface Mining (OSM) An agency of the U.S. Department of the Interior regulating surface coal mining and the surface effects of underground coal mining.

Overburden Worthless material lying on top of a deposit of useful material

Oxidizer or Oxidizing Material A substance, such as a nitrate, that readily yields oxygen or other oxidizing substances to stimulate the combustion of organic matter or other fuel.

Oxygen Balance The theoretical percentage of oxygen in an explosive material or ingredient that exceeds (+) or is less than (-) what is needed to produce ideal reaction products.

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

Parallel-Series Circuit See *Series in Parallel Blasting Circuit.*

Particle Board A composition board made of small pieces of wood bonded together.

Particle Velocity A measure of the intensity of ground vibration, specifically the time rate of change of the amplitude of ground vibration.

Parting A rock mass located between two seams of coal; a joint or crack in rock.

Passenger Railway Any steam, electric, or other railroad or railway that carries passengers for hire.

Pellet Powder Blackpowder pressed into cylindrical pellets 2 in. in length and $1^1/_4$ in. in diameter.

Permissible Diameter (Smallest) The smallest diameter of a permissible explosive, as approved by the Mine Safety and Health Administration (MSHA)

Permissible Explosives Explosives that are permitted for use in gassy and dusty atmospheres and that must be approved by the Mine Safety and Health Administration. Permissible explosives must be used and stored in accordance with certain conditions specified by the Mine Safety and Health Administration (MSHA).

Person Any individual, corporation, company, association, firm, partnership, society, or joint stock company.

PETN An abbreviation for the name of the explosive, pentaerythritoltetranitrate.

Placards Signs placed on vehicles transporting hazardous materials (including explosive materials) indicating the nature of the cargo.

Plywood Exterior construction-grade plywood.

Pneumatic Loading The loading of explosive materials into a borehole using compressed air as the loading or conveying force.

Powder A common synonym for explosive materials.

Powder Factor The amount of explosive used per unit of rock.

Power Source The source of power for energizing electric blasting circuits, e.g., a blasting machine or power line.

Pre-blast Survey A documentation of the existing condition of structures near an area where blasting is to be conducted.

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

Presplitting (Preshearing) A smooth blasting method in which cracks for the final contour are created by firing a single row of holes prior to the initiation of the rest of the holes in the blast pattern.

Prilled Ammonium Nitrate Ammonium nitrate in a pelleted or prilled form.

Primary Blast A blast used to fragment and displace material from its original position to facilitate subsequent handling and crushing.
Primary Explosive A sensitive explosive that nearly always detonates by simple ignition from such means as spark, flame, impact, friction, or other primary heat sources of appropriate magnitude.

Primer A unit. package, or cartridge of explosives used to initiate other explosives or blasting agents, and which contains;
1) a detonator, or
2) detonating cord to which is attached a detonator designed to initiate the detonating cord.

Propagation The detonation of explosive charges by an impulse received from adjacent or nearby explosive charges.

Propellant Explosive An explosive material that normally functions by deflagration and is used for propulsion purposes. It may be a Class A or Class B explosive, depending upon its susceptibility to detonation.

Propellant-Actuated Power Device Any tool or special mechanized device or gas generator system that is actuated by a propellant or that releases and directs work through a propellant charge.

Public Conveyance Any railroad car, streetcar, ferry, cab, bus, aircraft, or other vehicle that carries passengers for hire.

Pyrotechnics Any combustible or explosive compositions or manufactured articles designed and prepared for the purpose of producing audible or visible effects. Pyrotechnics are commonly referred to as fireworks.

Quantity-Distance Table A table listing minimum recommended distances from explosive materials stores of various weights to a specific location.

Radio Frequency Energy (RF) The energy transferred by electromagnetic wave in the radio frequency spectrum.

Radio Frequency Transmitter An electronic device that radiates radio frequency waves; the device may be fixed (stationary) or mobile.

Railway Any steam, electric, or other railroad or railway that carries passengers for hire.

Raise A vertical or incline opening driven upward from a level to connect with the level above, or to explore the ground for a limited distance above one level. After

two levels are connected, the connection may be a winze or a raise, depending upon which level is taken as the point of reference.

Receptor (Acceptor) A charge of explosive materials receiving an impulse from an exploding donor charge.

Regulations-Federal, State, Local Regulations promulgated by federal, state, or local regulatory agencies governing the manufacture, transportation. storage, sale, possession, handling, and use of explosive materials.

Relief The effective distance from a blast hole to the nearest free face.

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

Rotational Firing Delay blasting system used so that the detonating explosives will successively displace the burden into the void created by previously detonated explosives in holes that fired at an earlier delay period.

Round A set of holes drilled and charged with explosives in any phase of underground work, which are fired instantaneously or with delay detonators.

Safety Fuse A flexible cord containing an internal burning medium by which fire or flame is conveyed at a continuous and uniform rate from the point of ignition to the point of use, usually a fuse detonator.

Safety Standard Suggested precautions relative to the safety practices to be employed in the manufacture, transportation, storage, handling, and use of explosive materials.

Scaled Distance A factor relating similar blast effects from various size charges of the same explosive at various distances. Scaled distance referring to blasting effects is obtained by dividing the distance of concern by a fractional power of the weight of the explosive materials.

Seam A stratum or bed of coal or other mineral.

Secondary Blasting Blasting to reduce the size of boulders resulting from a primary blast.

Seismograph An instrument, useful in monitoring blasting operations, that records ground vibration. Particle velocity, displacement, or acceleration is generally measured and recorded in three mutually perpendicular directions.

Semi conductive Hose A hose used for pneumatic conveying of explosive materials having an electrical resistance high enough to limit flow of stray electric

currents to safe levels, yet not so high as to prevent drainage of static electric charges to ground. Hose of not more than 2 megohms resistance over its entire length and of not less than 5,000 ohms per foot meets the requirements.
Sensitiveness A measure of an explosive's cartridge-to-cartridge propagating ability under certain test conditions. It is expressed as the distance through air at which a primed half-cartridge (donor) will detonate an unprimed half-cartridge (receptor).

Sensitivity A physical characteristic of an explosive material classifying its ability to be initiated upon receiving an external impulse such as impact, shock, flame, friction, or other influences that can cause explosive decomposition.

Separation Distances Minimum recommended distances from explosive materials accumulations to certain specific locations.

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 in which the ends of two or more series of electric detonators are connected across the firing line directly or through buswire.

Shaft A vertical or inclined excavation in a mine extending downward from the surface or from some interior point as a principal opening through which the mine is exploited. A shaft is provided with a hoisting engine at the top for handling men, rock, and supplies, or it may be used only in connection with pumping or ventilating operations.

Shaped Charge An explosive with a shaped cavity, specifically designed to produce a high-velocity cutting or piercing jet of product reaction; usually lined with metal to create a jet of molten liner material.

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.

Short-Delay Blasting The practice of detonating blast holes in successive intervals where the time difference between any two successive detonations is measured in milliseconds.

Shot Anchor A device that anchors explosive material charges in the borehole so that the charges will not be blown out by the detonation of other charges.

Shot Firer That qualified person in charge of and responsible for the loading and firing of a blast (same as a *Blaster).*

Shunt The shorting together of the free ends of :
1) electric detonator legwires, or
2) the wire ends of an electric blasting circuit or part thereof-, the name of an electrical shorting device applied to the free ends of electric detonators by the manufacturer.

Signs-Explosive (Placards) Signs, called placards, placed on vehicles transporting explosives denoting the character of the cargo, or signs placed near storage areas as a warning to unauthorized personnel.

Silver Chloride Cell A special battery of relatively low current output used in a blasting galvanometer.

Slurry An explosive material containing substantial portions of a liquid, oxidizers, and fuel, plus a thickener.

Small-Arms Ammunition Any cartridge for shotgun, rifle, pistol, revolver. and cartridges for propellant-actuated power devices and industrial guns. Military-type ammunition containing explosive bursting charges or any incendiary, tracer, spotting, or pyrotechnic projectile is excluded from this definition.

Small-Arms Ammunition Primers Small percussion-sensitive explosive charges encased in a cap or capsule and used to ignite propellant powder.

Smoke The airborne suspension of solid particles from the products of detonation or deflagration.

Smokeless Propellant (Smokeless Powder) Solid propellant, commonly called smokeless powder in the trade, used in small-arms ammunition, cannon, rockets, propellant-actuated power devices, etc.

Snakehole A borehole drilled in a slightly downward direction from the horizontal into the floor elevation of a quarry face: also, a hole driven under a boulder.

Softwood Douglas fir or other wood of equal bullet resistance and free from loose knots, wind shakes, or similar defects.

Spacing The distance between boreholes. In bench blasting, the distance is measured parallel to the free face and perpendicular to the burden.

Specific Gravity The ratio of the weight of any volume of substance to the weight of an equal volume of pure water.

Springing The practice of enlarging the bottom of a blast hole by the use of a relatively small charge of explosive material; typically used in order that a larger

charge of explosive material can be loaded in a subsequent blast in the same borehole.

Squib A firing device that burns with a flash and used for igniting black powder or pellet powder.

Stability The ability of an explosive material to retain chemical and physical properties specified by the manufacturer when exposed to specific environmental conditions over a particular period of time.

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.

Steady State Velocity The characteristic velocity at which a specific explosive at a given charge diameter will detonate.

Steel General purpose (hot or cold rolled) low-carbon steel, such as specification ASTM A366 or equivalent.

Stemming Inert material placed in a borehole after the explosive; used for the purpose of containing explosive materials or to separate charges of explosive material in the same borehole.

Stope An excavation from which ore has been extracted. The term stoping is commonly applied to the extraction of ore, but does not include the ore removed in sinking shafts and in driving levels, drifts. and other development openings.

Storage The safekeeping of explosive materials, usually in specially designed structures called magazines.

Stray Current A flow of electricity outside an insulated conductor system

Subdrilling The practice of drilling boreholes below floor level or working elevation to ensure breakage of rock to working elevation.

Subsonic Less than the speed of sound.

Supersonic Greater than the speed of sound.

Sympathetic Propagation The detonation of an explosive material as the result of receiving an impulse from another detonation through air, earth, or water.

Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents A quantity-distance table from National Fire Protection Association Standard No. 495.

Tachograph A recording device in a truck that indicates on a time basis the running and stopping times of a vehicle.

Tamping The action of compacting the explosive charge or the stemming in a blast hole.

Tamping Bags Cylindrical bags containing stemming material and used in boreholes to confine the explosive material charge.

Tamping Pole A wooden or plastic pole used to compact explosive charges or stemming.

Test Blasting Cap No. 8 *See Institute of Makers o Explosive No. 8 Test Detonator.*

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

Toe In bench blasting, the distance from the free face to the blast hole, measured at the floor level of the bench.

Trunkline The line of detonating cord on the ground surface that connects detonating cord down lines.

Tunnel A horizontal or nearly horizontal underground passage that is open to the atmosphere at both ends. The term is loosely applied in many cases to an adit.

Unbarricaded The absence of a natural or artificial barricade around explosive storage areas of facilities.

Unconfined Detonation Velocity The detonation velocity of an explosive material without confinement, for example, a charge fired in the open.

Underwriters Laboratory, Inc. (UL) A nationally recognized incorporated testing laboratory qualified and equipped to conduct the necessary tests to determine compliance with appropriate standards and the satisfactory performance of materials or equipment in actual usage.

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

Volume Strength Same as *Cartridge Strength or Bulk Strength.*

Warning Signal A visual or audible signal that is used for warning personnel in the vicinity of the blast area of the impending explosion.

Waste Acid Residual or spent acid from a nitration process.

Water Gel An explosive material containing substantial portions of water, oxidizers, and fuel, plus a cross-linking agent

Water Stemming Bags Water-filled plastic bags with a self-sealing valve classified as a permissible stemming device by the Mine Safety and Health Administration (MSHA)

Watt A unit of electrical power equal to 1 joule/sec

Weather-Resistant Construction designed to offer reasonable protection against weather.

Weight Strength The energy of an explosive material per unit of weight expressed as a percentage of the energy per unit of weight of a specified explosive standard.

Winze A vertical or inclined opening sunk from a point inside a mine for the purpose of connecting with a lower level and exploring the ground for a limited depth below a level.

Section VII

Calculations

Borehole Diameter

Selection of the proper hole diameter is important to obtain maximum fragmentation at minimum cost. For best fragmentation and design control, the rule of thumb is that the borehole diameter in inches should be approximately one tenth of the face height in feet.

$$D = \frac{H}{10}$$

Where

D = borehole diameter (inches)
H = bench height (feet)

Burden

Burden is defined as the distance from a borehole to the nearest free face at the time of detonation.
Burden is a function of charge diameter. The rule of thumb for burden calculation is dependent on the borehole diameter.

Burden Calculation:

$$B = \frac{25\text{-}35 \times D_e}{12}$$

Where

B = burden (feet)
D_e = explosive column diameter (inches)

For a given rock type, explosive, and blast hole spacing, there is an optimum burden dimension. The optimum burden dimension depends upon a combination of variables, which include the borehole diameter, the borehole depth, spacing between boreholes, the millisecond delay pattern, the explosive used, the rock mass characteristics, and degree of fragmentation and muck pile shape sought.

Spacing

The distance between adjacent blast holes, measured perpendicular to the burden, is defined as the spacing. Spacing calculations are a function of the burden.

S = 1.8 x B

Where
S = spacing (feet)
B = burden (feet)

Spacings that are significantly less than the burden tend to cause early stemming ejection and premature splitting between blast holes. These effects encourage rapid release of gases to the atmosphere, and result in noise and air blast. Conversely, when the spacing is too large, the rock may be inadequately fragmented between holes, leaving an uneven floor. Consequently, burden and spacing decisions are made by careful analysis of geology, explosives, conditions at the site, and experience.

Bench Height

To maintain a successful blast design, it is important that the burden and bench height are reasonably compatible. However, the face height is often determined by other factors; the rule of thumb covers only the recommended minimum.

H = 2 x B

Where
H = bench height (feet)
B = burden (feet)

Stemming

Stemming is an inert substance, loaded on top of the explosive charge to give confinement of the explosion gases. The amount of stemming required may be calculated from the burden dimension using the following formula:

T = 0.7 – 1.3 x B

Where
T = stemming (feet)
B = burden (feet)

Explosive Column Weight

The explosive column weight per borehole is a function of the density of the explosive, its diameter, and the explosive column length. The explosive column weight can be calculated by using the following formula:

$E_w = 0.34 \times D_e^2 \times \rho \times E_{cl}$

Where

E_w = explosives column weight (pounds)
D_e = diameter of explosive column (inches)
ρ = density of explosives (grams per cubic centimeter)
0.34 = coefficient of determination
E_{cl} = explosives column length (feet)

For example, given an explosive column diameter of 6.25 in. and 50 ft. in length and ANFO at a density of 0.81 g/cc, the charge weight is calculated by:

$E_w = 0.34 \times D_e^2 \times \rho \times E_{cl}$
$E_w = (0.34)(6.25)^2 (0.81)(50)$
$E_w = (0.34)(39.06)(0.81)(50)$
$E_w = 537.9$ lb.

Powder Factor

Powder factor is the mathematical relationship between the weight of explosives and a given quantity of rock. The explosive weight is normally expressed in pounds and the rock quantity is normally expressed in cubic yards or tons. There are four methods of expressing powder factor.

1. Pounds of explosive per cubic yard of rock.
2. Pounds of explosive per ton of rock.
3. Cubic yards of rock per pound of explosive.
4. Tons of rock per pound of explosive.

- ***Cubic Yards*** To calculate cubic yards per borehole, the following formula is used:

$$V = \frac{B \times S \times H}{27}$$

Where

B = burden dimension (feet)

S = spacing dimension (feet)
H = Bench height (feet)
V = rock volume (cubic yards)

For example, given a burden of 10 ft., a spacing of 15 ft., a bench height of 50 ft., the calculated rock volume is as follows:

$$V = \frac{B \times S \times H}{27}$$

$$V = \frac{10 \times 15 \times 50}{27}$$

$$V = \frac{7{,}500}{27}$$

V = 277.77 cu yd per borehole

- ***Tons*** To calculate the tons of rock per borehole, the following formula is used:

$$\mathbf{W = \frac{B \times S \times H}{27} \times \frac{27\rho}{2{,}000}}$$

Where
B = burden dimension (feet)
S = spacing dimension (feet)
H = bench height (feet)
ρ = rock density (pounds per cubic foot)
W = rock tonnage

For example, given a burden of 10 ft., a spacing of 15 ft., a bench height of 50 ft., and a rock density of 168 lb/cu ft, the calculation for the total rock weight per borehole is as follows:

$$W = \frac{B \times S \times H}{27} \times \frac{27\rho}{2{,}000}$$

$$W = \frac{B \times S \times L}{27} \times \frac{(27)(168)}{2{,}000}$$

$$W = \frac{277.77}{} \times \frac{4{,}536}{2{,}000}$$

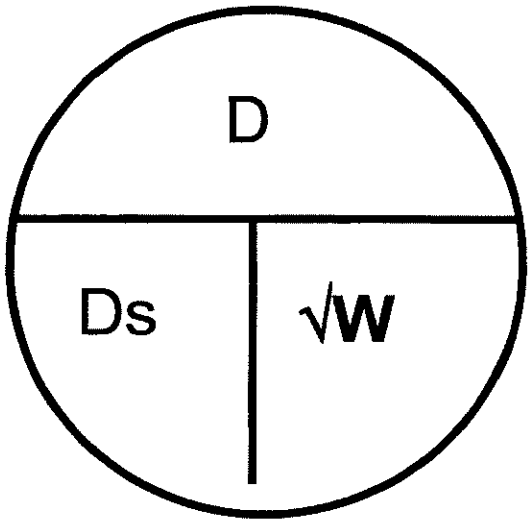
W = 277.77 cu yd x 2.268 tons per cubic yards

W = 629.98 tons per hole

Powder factor has generally been equated with the amount of explosive energy required to fragment and displace rock. A powder factor of 0.75-lb/cu yd would be expected to exhibit relatively less fragmentation and displacement than a powder factor of 1.0 lb/cu yd.

Scaled Distance

$$Ds = \frac{D}{\sqrt{W}}$$



W = Explosives Weight Per Delay Period
D = Actual Distance
Ds = Scaled Distance

We shall designate the W, D, and Ds relationships shown in the above chart as follows:

Equation #1:

$$W = \left(\frac{D}{Ds}\right)^2$$

Equation #2:

$$\sqrt{W} = \frac{D}{Ds}$$

Equation #3:

$$Ds = \frac{D}{\sqrt{W}}$$

Equation #4:

$$D = Ds\ \sqrt{W}$$

Scaled Distance

The four equations cited above are very useful, in fact necessary, tools for the licensed blaster. Here are a few examples of how they work.

1. A blast is to be fired at a distance (D) of 1,000 feet from a residence, and it is desired that the Scaled Distance, (Ds) value be not less than 50. To find the weight (W) of explosive per delay period, which will give a Ds value of 50, substitute the values for D and Ds in Equation 1 or Equation 2. It will be found that 400 pounds of explosives may be used per delay period.

2. Given a blast involving 400 pounds (W) of explosives per delay period to be fired at a distance (D) of 1,000 feet from an office building. Commonwealth of PA regulations require seismograph readings on any blast having a Scaled Distance value below 50. Will the Ds value be 50 or greater and so make seismograph readings unnecessary. To arrive at the answer to this question, substitute the eight and distance values in Equation 3. A Scaled Distance of 50 will be found. Thus, seismograph readings will not be required by Regulations for this blast. Had the distance (D) been 800 feet the Ds value would have been 40 and seismograph recordings would have been required.

3. A 52 – hole blast is planned in which each hole will contain 181 pounds of explosives, and it is to be wired four holes (724 lbs. Of explosives) per delay period. This will require 13 delay periods: 0, 2-13. There is a residence 1,000 feet distant. It is desired to hold the Scaled Distance value above 50. To verify the accuracy of planning, substitute the above W and D values in Equation 3. Calculation shows a Ds value of 37, far below the desired value of 50.

   Wiring the blast at two holes per delay period, that is, 362 pounds for explosives per period, should resolve the problem, although twice as many delay periods will be required. When the W value is used in Equation 3, one finds an acceptable Ds value of 53. Seismograph readings will not be required.

4. **A certain blasting operation, located 1263 feet from a residence, consists of 60 holes, each containing 242 pounds of explosives. The blast is wired two holes (484 lbs.) per delay period. Using Equation 3, it will be found that the Ds value is 58.**

   Desiring to maintain a Ds value of 58 in another blast only 900 feet from the same residence, what will be the maximum quantity of explosives permitted per delay period? Substituting the D and Ds values in Equation 1 or Equation 2 on finds a maxim weight of 240 pounds per delay period.

   Since the Ds value above is greater than 50, what would be the closest distance to the house that blasting could be done and yet maintain a Ds value of 50, using 240 pounds (W) of explosive per delay period? To find

the answer to this problem, substitute a Ds value of 50 and the W value in Equation 4. By this procedure, one finds the closest distance (D) to be 775 feet.

1. **A home is 900' away from a Blast; you have 120 lbs. per delay. What is the Scaled Distance?**

$$Ds = \frac{D}{\sqrt{W}}$$

$$Ds = \frac{900'}{\sqrt{120 \text{ lbs.}}} \qquad \sqrt{120} = 10.95$$

$$Ds = \frac{900'}{10.95}$$

Ds = 82.19

2. You have 400 lbs. per delay and you want to have a Scaled Distance of 90. How do you do this? What is the distance to the home?

$$D = Ds\sqrt{W}$$

$$D = 90(\sqrt{400}) \qquad \sqrt{400} = 20$$

$$D = 90(20)$$

D = 1800 ft.

3. You have a home 1500 ft. away. You want a Scaled Distance of 90. What are the pounds per delay to keep a Scaled distance of 90?

$$W = \left(\frac{D}{Ds}\right)^2$$

$$W = \left(\frac{1500'}{90}\right)^2$$

$$W = (16.66)^2$$

W = 277.56 Maximum Pounds per Delay

4. A home is 1100 ft. away from a Blast; you have 140 lbs. per delay. What is the Scaled Distance?

$$Ds = \frac{D}{\sqrt{W}}$$

$$Ds = \frac{1100'}{\sqrt{140 \text{ lbs.}}} \qquad \sqrt{140} = 11.83$$

$$Ds = \frac{1100'}{11.83}$$

Ds = 92.98

5. You have a 500-pound per delay. You want a Scaled distance of 90. What can be the closest dwelling to the Blast

$D = Ds \sqrt{W}$
$D = 90 (\sqrt{500})$ $\sqrt{500} = 222.36$
$D = 90 (22.36)$
D = 2012 ft.

6. You have a home 1300 ft. away. You want a scaled distance of 95. What are the pounds per delay?

$$W = \left(\frac{D}{Ds} \right)^2$$
$$W = \left(\frac{1300'}{95} \right)^2$$
$W = (13.68)^2$
W = 187.25 Maximum Pounds per Delay

Planning the Firing Circuit

Ohms Law:

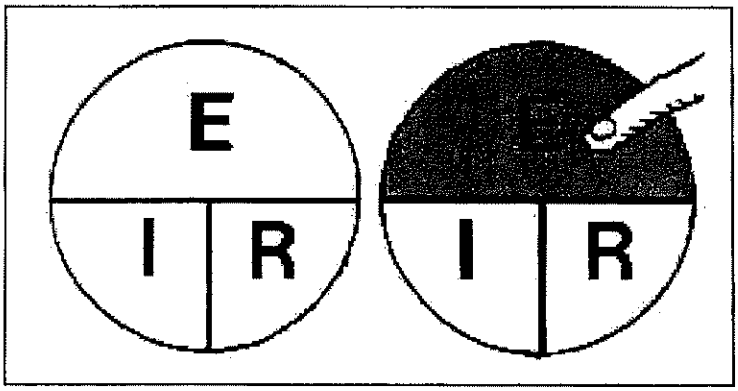
Electric current initiates electric blasting caps. Too little current will not provide enough energy to initiate a cap, while too much current can cause arcing. The blaster can calculate the amount of current using OHMS LAW. OHMS LAW states: VOLTAGE (in volts) is equal to the current (in amperes) MULTIPLIED BY THE RESISTANCE (in ohms), or;

E = I X R

Where: E is the voltage (in volts) of the power source,
I is the current (in amperes) flowing in the circuit, and
R is the resistance (in ohms) of the circuit.

Using basic algebra, OHMS LAW can be rearranged as:

$$I = \frac{E}{R} \quad \text{or} \quad R = \frac{E}{I}$$



NOTE: Put your finger over the unknown that you want to find. For example, cover E (voltage), and I (current) times R (resistance) remains. Similarly, cover R (resistance), and E divided by I (current) remains.

Blasting Circuitry Design and Analysis

Capacitor discharge blasting machines, when used properly, are the most dependable means of firing electric detonators. Power lines can also be used to fire electric detonators. With any power source it is essential that sufficient energy be provided to initiate all detonators in a few milliseconds.

When firing from power lines, the calculations required to provide sufficient current to every detonator in the circuit are straight forward by applying the basic principles of Ohm's and Kirchhoff's Laws.

The problem is more complex with capacitor discharge machines. The discharge current from a capacity-type machine decays exponentially from a high initial value to near zero within a short period of time. The concept of steady minimum firing currents, as demanded for AC and DC power-line firing, cannot be used. Ohm's and Kirchhoff's Laws must be supplemented by transient circuit calculations to determine the effective firing current required from a capacitor discharge blasting machine must be considerably in excess of the minimum DC firing current required for a circuit because of the rapid current decay.

To have a thorough understanding of blasting circuit design, it is necessary to apply the basic principles of Ohm's and Kirchhoff's Laws.

- **Ohm's Law** – The current flowing in an electrical circuit is equal to the applied voltage divided by the resistance.

$$I = \frac{E}{R}$$

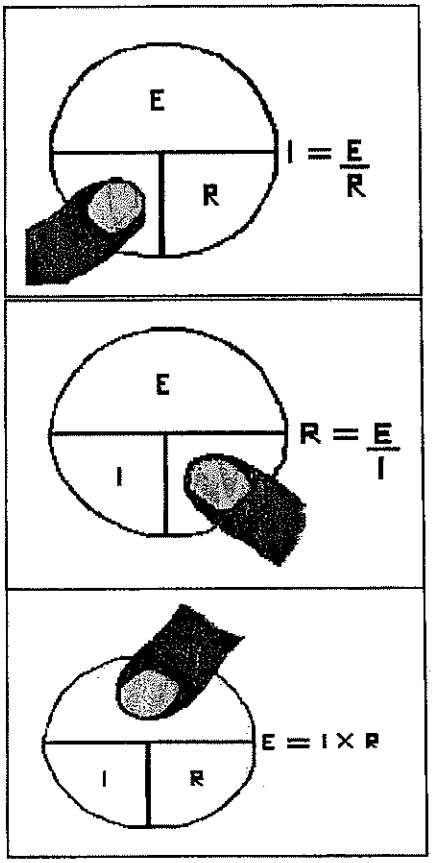
Where:
I = Current in amperes
V = Applied voltage in volts
R = Resistance in Ohms.

This may also be expressed as:

$$R = \frac{E}{I}$$

or:

$$E = I \times R$$



Kirchhoff's Law

1. The algebraic sum of all applied voltages and potential differences in any closed circuit is equal to zero.

$$V_0 = I.\ R. - I_2R_2 - I_3R_3 - \ldots I_MR_M - 0$$

2. The algebraic sum of all currents flowing to any point in a circuit is equal to zero.

$$I_0 - I_1 - I_3 - \ldots I_M - 0$$

- Resistance of a Series Circuit (ohms)

$$R = R_1 + R_2 + R_3 + 0$$

- Resistance of a Parallel Circuit (ohms)

$$\frac{1}{R} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1V}{R_3} \ldots \frac{1}{R_M}$$

Planning The Series Firing Circuit

Before loading a blast you must determine how much explosive will be needed. You should also determine what type of wiring circuit will be used, and then make the calculations that show you the basting machine will supply adequate current to fire the blast. Of the three wiring circuits used in electrical blasting, the series circuit is the simplest and most commonly used. In planning the series circuit, follow these steps:

1. Determine the *TOTAL RESISTANCE* (ohms) of the circuit.
2. Calculate the *CURRENT* (amperes) that the power source will deliver the total resistance.
3. Compare the calculated current with the recommended minimum firing current requirements for a series circuit.

FINDING TOTAL RESISTANCE (R_1)

For a series circuit, the total resistance (R_1) is simply the sum of all the individual resistances in the circuit. This will include the detonators (R_1), connecting wire (R_2), and firing line (R_3).

The formula is:

$$R_T = R_1 + R_2 + R_3$$

EXAMPLE:

Consider a series circuit with 20 Millidet delay electric blasting detonators having 40 ft. long copper leg wires, 200 lineal ft. of #20 B&S copper connecting wire and a 1,200 ft. long #14 B&S copper firing line. For the resistance values, ***see Table I and II.***

Resistance of one Millidet detonator with 40 ft. copper leg wire = *2.72 ohms.*
Resistance of 20 Millidet detonators = 20 x 2.272 ohms = ***54 ohms***

Resistance of #20 B&S connecting wire = *10.15 ohms per 1,000 ft.*

Resistance of 200 lineal ft. - $\frac{200 \times 10.15 \text{ ohms}}{1{,}000} \times 2^* =$ ***4 ohms***

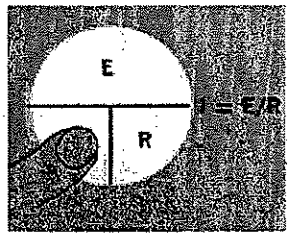
Resistance of #14 B&S firing line = *2.52 ohms per 1,000 ft.*
Resistance of 1,200 lineal ft. – $\frac{1{,}200 \times 2.52}{1{,}000} \times 2^* =$ ***6 ohms***

Total resistance $R_t = R_1 + R_2 + R_3$
$R_t = 54$ *ohms* + 4 *ohms* + 6 *ohms*
$R_t = 64$ *ohms*

*Multiply by 2 because the firing cable and connecting wire have 2 wires.

Calculating Current (I)

Use Ohms Law to calculate the current for the circuit described under total resistance.



Example:

Consider a condenser-discharge blasting machine with a 225-volt output. Now, applying Ohms Law:

Current (I) = $\frac{225 \text{ volts (E)}}{64 \text{ ohms (R)}}$

I = 35 amperes

Compare:

The minimum recommended firing current (***Table III***) required for a series circuit is 1.5 amps DC or 3 amps AC. In the examples given, the answer for the calculated current is 3.5 amps DC. This is greater than 1.5, the minimum, so the amperage in this case is adequate. If the current is not adequate, here are some alternatives:

1. Use a blasting machine that will deliver the needed current, or

2. Use a different wiring circuit. A series-in-parallel circuit can reduce the total resistance without the need for reducing the number of holes (detonators).

Leg Wire Length	Instadet*	Millidet* and Superdet*	Instadet*	Millidet, Superdet, and Coaldet*
4	1.41	1.86	2.25	2.7
6	1.49	1.94	2.75	3.2
8	1.58	2.03	3.25	3.7
10	1.66	2.11	3.75	4.2
12	1.74	2.19	4.25	4.7
14	1.82	2.27	4.75	5.2
16	1.9	2.35	5.25	5.7
20	2.06	2.51	6.25	6.7
24	2.22	2.68	7.25	7
No 12 Copper Wire				
30	2.02	2.47		
40	2.27	2.72		
50	2.53	2.98		
60	2.79	3.21		
70	3.04	3.49		
80	3.3	3.75		
100	3.81	4.26		
120	4.33	4.77		

B&S Gauge	Ohms per 1,000 ft.
No. 8	0.628
No. 10	0.999
No. 12	1.59
No. 14	2.52
No. 16	4.02
No. 18	6.38
No. 20	10.15
No. 22	16.14

CAP FACTS

HERCULES

150	5.09	5.54		
200	6.37	6.82		
250	7.65	8.1		
300	8.93	9.38		
350	10.16	10.66		
400	11.49	11.94		

* **CAUTION:** These resistance values apply only to detonators manufactured by Hercules Incorporated. Do not use these values with detonators made by other manufacturers.

Table III: RECOMMENDED MINIMUM FIRING CURRENT

Series Wiring	1.5 amps DC or 3 amps AC
Parallel Wiring	1 amp AC or DC per Detonator
Series-In-Parallel Wiring	2 amps AC or DC per Series

Maximum recommended firing current is not to exceed 10 amperes continuous current through any detonator.

Series Circuit

The total resistance of a series circuit is equal to the resistance of each detonator multiplied by the number of detonators plus the resistance of the lead line and connecting wire.

Example 1
Assume a series circuit of 25 40-foot copper wire delay detonators with a 600-foot 14-gauge copper lead line:

Step 1 – Determine the resistance of the detonator circuit.
Consult ***Table 16.1*** for the resistance of a 40 foot copper wire Delay. This is 2.06 ohms/detonator.

Resistance of Detonator Circuit = No. of Detonators x Resistance/detonator

$$R = 25x\ 2.06$$
$$R = 51.5\ ohms$$

Step 2 – Determine resistance of the lead line:
Consult ***Table 16.2*** for the resistance of 14-gauge copper wire.
This is 2.525 ohms/1000 feet. A lead line that is 600 feet long has 1200 feet of wire.

(600 feet x 2 conductors = 12000 feet)

$$\underline{Resistance\ of\ Lead\ Line = Length\ of\ Wire\ x\ Resistance\ /\ 1000\ ft.}$$
$$1000$$

$$R = \frac{1200\ x\ 2.525}{1000}$$
$$R = 3.03\ ohm$$

Step 3 – Determine total resistance of the blasting circuit.

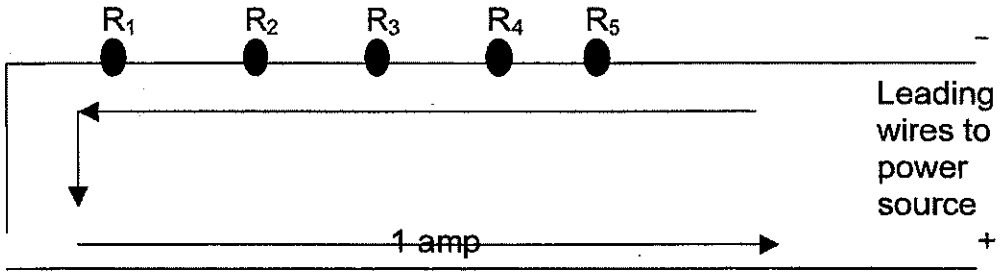
Total Resistance = Detonator Circuit Resistance + Lead Line Resistance

$$R = 51.5 + 3.03$$
$$R = 54.53\ ohms$$

On a "swing needle" type tester the needle on the instrument must be adjusted to "zero" when it is shorted between terminals. Digital instruments should show "zero" on the readout. The terminals are then connected to the lead line. The instrument should then read approximately 54 to 55 ohms. Too low a reading indicates some detonators are not connected into the circuit. Too high a reading indicates too many detonators in the series or loose or dirty connections.

Series Circuit

1. A series circuit provides a single path for the current through all detonators.
2. The same current flows through each part of a series circuit.
3. The total resistance of a series circuit is equal to the sum of individual resistances.
4. Voltage applied to a series circuit is equal to the sum of the individual voltage drops.
5. The voltage drop across a resistor in a series circuit is directly proportional to the size of the resistor.
6. If the circuit is broken at any point, no current will flow.



- In a series circuit, the amperage at any point in the circuit is the same. This will help in calculating circuit values using Ohm's Law.
- In a series circuit you will need to calculate the total resistance of the circuit in order to figure out the amperage. This is done by adding up the individual values of each component in series.
- In this example we have three resistors. To calculate the total resistance we use the formula:

$$R_T = R_1 + R_2 + R_3 + R_4 + R_5$$

Parallel Circuit

A parallel circuit cannot be tested with the instruments usually available in field operation as the total resistance of the circuit is so small it will read close to zero resistance on the instrument and will not indicate a meaningful reading. This is true whether using a "swing needle" or digital meter.

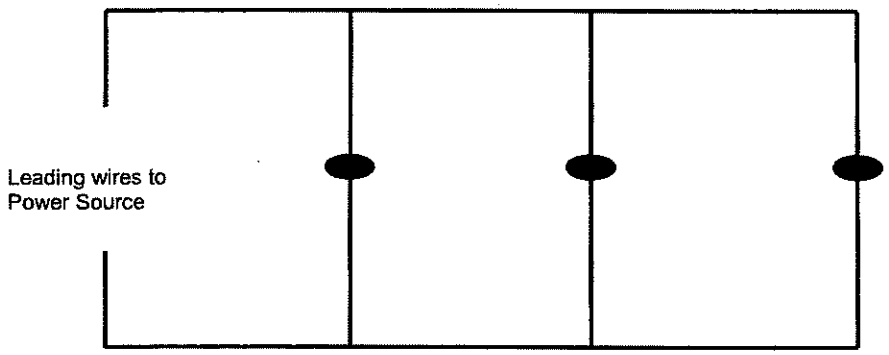
A Parallel circuit has certain characteristics and basic rules surmised here:

1. A parallel circuit has two or more paths for current to flow through.
2. Voltage is the same across each component of the parallel circuit.
3. The sum of the currents through each path is equal to the total current that flows from the source.

You can find total resistance in a Parallel circuit with the following formula:

1/Rt = 1/R1 + 1/R2 + 1/R3 + Rt = R (t)otal

If one of the parallel paths is broken, current will continue to flow in all the other paths.



Series-In-Parallel

In a series-in-parallel circuit each series should be electrically balanced with each series reading the same number of ohms. Usually, an equal number of detonators in each series will produce a balanced series.

In a balanced series-in- parallel circuit, the resistance of one series divided by number of series will equal the total resistance of the circuit.

Example 2

Assume a blast of 300 50-foot copper wire MS delays connected in six series with 50 detonators-per-series and a 700-foot 14-gauge copper wire lead line.

Step 1 – Determine the resistance of a single series. Resistance of one series = No. of Detonators x Resistance of each. Consult **Table 16.1** for detonator and wire resistance.

$$R = 50 \times 2.32$$

$$\mathbf{R = 116 \text{ ohms}}$$

Step 2 – Determine the resistance as each series is connected to the lead line or bus wire:

$$\textit{Resistance} = \frac{\textit{Resistance / Series}}{\textit{No of Series}}$$

$$\textit{One Series Resistance} = \frac{116.0}{1}$$

$$\textit{Two Series Resistance} = \frac{116.0}{2}$$

$$\textit{Three Series Resistance} = \frac{116.0}{3}$$

Series-in-Parallel

The series-in-parallel circuit is the most common type of circuit used in blasting. The simplest series-in-parallel circuit is made by dividing a single series into two series as shown in ***Figure 16.6***. As shown, each of the two rows of electric detonators is connected in a straight series. The two free ends from each series are connected together and these are connected to the lead line.

The main advantage of the series-in-parallel circuit is the large number of detonators, which can be fired from a blasting machine without a large input voltage requirement. A series-in-parallel hookup with five balanced series is shown in
Figure 16.7.

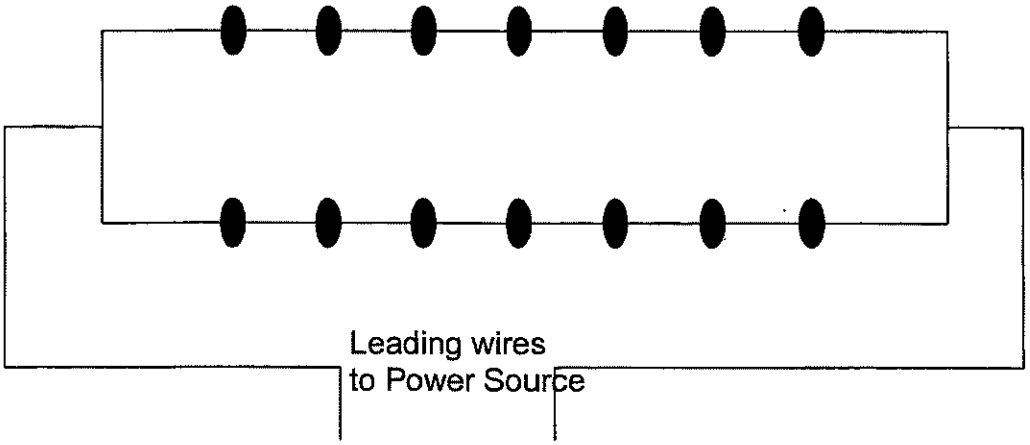


Figure 16.6 – Simplest series-in-parallel circuit is made by dividing a single series into two series. The two free ends from each series are then connected to the lead line.

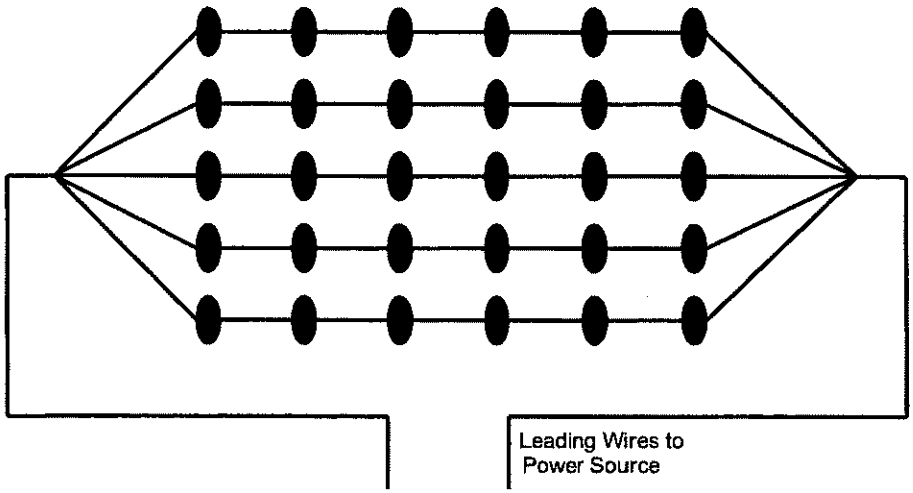
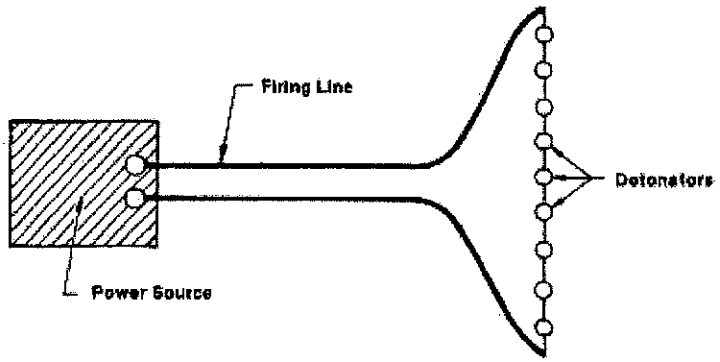
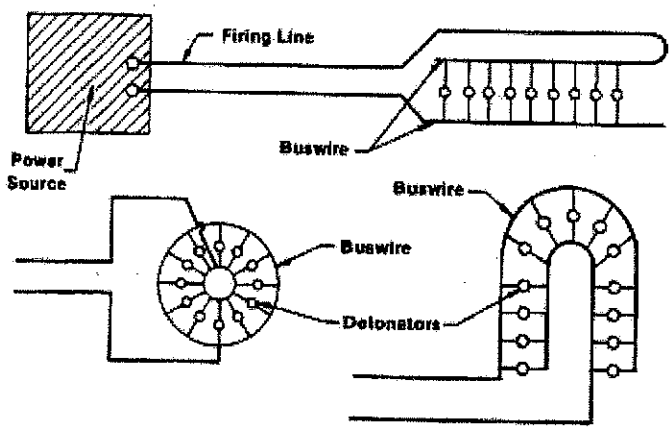


Figure 16.7 – Main advantage of the series-in-parallel is large number of detonators that can be fired from the blasting machine without large input voltage requirement.

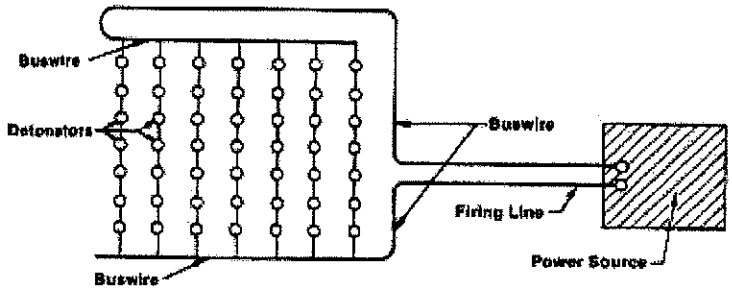
Single-Series Electric Blasting Circuit



Parallel Electric Blasting Circuit



Parallel Series Electric Circuit



Electric Firing Techniques

Electric blasting, with such refinements as delay detonators and electronic timers, has made possible the safe firing of a large number of charges in a predesigned sequence from a remote, safe location with precise control over the time of firing. The remarkable safety record compiled by explosives consumers is the result of knowledge applied with care.

Successful electrical blasting depends on four general principles: (1) proper selection and layout of the blasting circuit; (2) an adequate energy source compatible with the type of blasting circuit selected; (3) recognition and elimination of all electrical hazards; and (4) circuit balancing, good electrical connections, and careful circuit testing.

The selection of the circuit will depend on the number of detonators to be fired and type of operation. In general, a simple series circuit is used on small blasts consisting of less than 50 electric detonators. A series-in-parallel circuit is used where a large number of detonators are involved.

In almost every application capacitor discharge blasting machines offer the safest, cost dependable, and economical source of electrical energy for blasting.

Elimination of electrical hazards must be the first consideration before starting to load any blast.

Lack of attention to details is the most frequent cause of electrical misfires resulting in fatal or serious injury and costly property damage. The electrical connections must be tight, clean, and insulated from the ground. Care must be taken to avoid abrading or stripping the leg wires either in the hole or on the surface. Lead lines should be inspected and tested prior to every blast.

The resistance of all circuits should be calculated, and a Blaster's Multimeter or Blasting Ohmmeter should be used to verify the calculations. No attempt should be make to fire the blast until the theoretical calculations and test readings are the same.
In brief, extreme care in wiring and testing the circuit is absolutely necessary to avoid misfires.

Current Requirements

Successful simultaneous initiation of a large number of electric detonators requires delivery of sufficient current to all devices with a few milliseconds. The time required to heat the bridgewire in an electric detonator or to a temperature that will cause burning of the ignition charge is a function of the current intensity.

Although manufacturer's specifications may vary, the bridgewire in domestic commercial detonators is approximately 0.5 millimeters in diameter and requires 1 to 1.5 amperes for reliable initiation. The bridgewire heats up very quickly, but it rapidly transfers heat to the bridge posts and ignition mix. As a result, energy delivered over a time interval of more than 10 milliseconds is not as efficient in heating the bridge wire as the same amount of energy delivered in a few milliseconds.

The importance of delivering sufficient current to all detonators in the circuit within a few milliseconds cannot be overemphasized. At marginal low current levels, slight differences from one device to another can result in large variations in initiation times. In series circuits this can result in one detonator functioning prior to initiation of others in the circuit. This fast firing of one detonator cuts off the flow of current before all others have been initiated and results in failure of one or more detonators.

The internal construction of electric detonators manufactured by different companies varies considerably. As a result, they are not compatible in the same blasting circuit. Therefore, electric detonators of different manufacturers must never be used in the same blast. Such a practice is almost certain to result in dangerous misfires. Further, in the U.S., it is in direct violation of MSHA regulation 30 CFR 56/57.6400.

Basic Safety Requirements

In any blasting operation the blasting machine, or blasting switch, should be directly under the control of the blaster in charge. It should be kept locked while not in use with the key in blaster's possession.

The lead wires should never be laid out until the blast circuit is completely wired and all unnecessary personnel have been removed to a safe location. After the lead line is laid out, it should be checked electrically with a Blaster's Multimeter for continuity of circuit. It should also be visually inspected for cuts and serious abrasions in the insulation. The end of the lead line must be shunted before the other end of the line is connected to the blasting circuit. After the final connections are completed, the resistance of the entire circuit should be tested with a Blaster's Multimeter or a Blasting Ohmmeter (Blasting Galvanometer). The calculated resistance of the entire circuit must always agree with the readings on the instrument or no attempt should be made to fire the blast. If proper readings are not obtained, reshunt the lead line before returning to the blast area to locate and correct the source of trouble. Do not allow the bare ends of the circuit or the lead line to come in contact with the ground or with any metallic object.

When the instrument readings confirm the calculated resistance, the blasting machine, or blasting switch, can be unlocked and the lead lines can be connected for firing.

After the blast, the blasting machine, or blasting switch, should be locked before returning to the blast area. Never leave a blasting machine or blasting switch unguarded.

Lead Lines

Lead lines or firing lines are an essential part of the blasting circuit and must be inspected, tested, and kept in good repair to insure a successful blast.

Well-insulated, solid-core copper wire or 10-gauge to 14-gauge is recommended for series and series-in-parallel circuits of normal size. Where the basting line is soled on a reel after every blast, stranded wire should never be used because individual strands may break due to flexing. This results in a reduced load-carrying capacity that is not readily detectable with the instruments normally available in the field.

The lead line should be tested with a Blaster's Multimeter for continuity of circuit before every blast. It should be replaced when there is any evidence of physical damage to the insulation.

Where lead lines are permanently installed, the lines should be tested under load by an electrician. This test should be carried out on a regular schedule.

Connecting Wires

Connecting wire is usually 16-gauge to 20 gauge, plastic-insulated copper wire used to connect between holes or to connect individual series to the lead line. They are always subject to damage by the blast and should be considered expendable. Never reuse connecting wire.

Bus Wire

Bus wire is usually 10, 12, or 14-gauge, solid-core uninsulated copper wire used in connecting parallel circuits in tunnel and shaft rounds. Aluminum bus wire is not recommended because oxidation of the aluminum can result in high resistance connections.

Misfires

Incomplete detonation of explosives.

CHAPTER 211. STORAGE, HANDLING AND USE OF EXPLOSIVES

§ 211.133. Blast reports.

(24) If a misfire occurred, the actions taken to make the site safe as specified in § 211.157 (relating to post blast measures).

§ 211.157. Post blast measures.

(d) The blaster-in-charge shall determine if a misfire occurred and shall take all actions necessary to render the blast site safe. The blast site shall be made safe before drilling or muck removal begins.

(e) If the blaster-in-charge suspects that undetonated ammonium nitrate/fuel mixture remains in the muck pile, the muck pile shall be thoroughly wetted down with water before any digging is attempted. Special attention shall be given to determine if primers, other explosives or detonators are present in the muck pile.

(f) The blaster-in-charge shall immediately complete the blast report as required by § 211.133 (relating to blast report).

(g) The blaster-in-charge shall notify the Department within 24 hours of the occurrence of a misfire. A copy of the blast report shall be forwarded to the Department.

30 CFR (Code of Federal Regulations), Part 57.6000, defines a misfire as:

The complete or partial failure of explosive material to detonate as planned. The term also is used to describe the explosive material itself that has failed to detonate.
A misfire is described as the failure of an explosive charge to detonate. The best advice that can be given regarding the handling of misfires is to take every precaution to prevent their occurrence.
Anytime misfired holes, portions of a misfired hole, or unexploded explosive material remains after a blast is fired, a hazardous situation is created that will

exist until the proper handling of unfired explosive material. A misfire requires sound judgment and a comprehensive understanding of explosives. Most misfires occur because of improper techniques or short cuts, and sometimes because of the geological formation.
It is important that any investigation into a misfire be conducted with a fair and open mind. Any preconceived idea of the cause may mask the true cause, and prevent a future occurrence.

MSHA - 30 CFR. PART 57.6311 ADDRESSES THE HANDLING OF MISFIRES AS:

(a) Faces and muck piles shall be examined for misfires after each blasting operation.

(b) Only work necessary to remove a misfire and protect the safety of miners engaged in the removal shall be permitted in the affected area until the misfire is disposed of in a safe manner.

(c) When a misfire cannot be disposed of safely, each approach to the area affected by the misfire shall be posted with a warning sign at a conspicuous location to prohibit entry, and the condition shall be reported immediately to mine management.

(d) Misfires occurring during the shift shall be reported to mine management not later than the end of the shift.

MSHA - 30 CFR. PART 57.6310 DEFINES THE MISFIRE WAITING PERIOD AS:

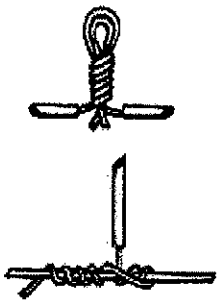
When a misfire is suspected, persons shall not enter the blast area until:

(a) For 30 minutes if safety fuse and blasting caps are used: or

(b) For 15 minutes if any other type detonators are used.

Splices

The reliability of every circuit is dependent on the number and quality of the wire splices in that circuit. Their importance is as significant as any other factor in good blasting practice.



The twisted loop shown is recommended for joining light gauge wires of similar size (legwire to legwire or connecting wire). It is easy and quick to make, yet strong and reliable. It is also a highly visible splice that is easy to disassemble if a circuit has to be taken apart for any reason

When joining lighter gauge legwires or connecting wire to heavier gauge firing line or buswire, the lighter gauge wire is wrapped around the heavier gauge wire as shown. These splices are easy to make and provide a strong and

To prevent current leakage or the shorting out of two wires, the bare wire at the splices should be insulated with electrical tape. If insulating tape is not available, support the splices in the air by propping up the wire on boxes or dry cardboard and staggering their locations so that they cannot accidentally short out. The need to make a splice stronger and keep the bare wire connections from pulling apart can be accomplished by various means. One method is to join the insulated portion of the wires about 4 in. back from the splice by tying or twisting the together. This secondary connection will then absorb strain induced into the wire and prevent separation of the splices. It is now easier to position the bare wire splice so that it is off the ground, hence reducing the chance of current leakage.

Extraneous Electricity

Sources of hazardous extraneous electricity include: (1) Lightning discharges to ground from electrical storms; (2) Stray ground currents from poorly insulated and improperly grounded electrical equipment; (3) Radio Frequency (RF) energy from transmitters; (4) Induced currents, present in alternating electromagnetic fields, such as those commonly found near high-voltage transmission lines; (5) Static electricity generated by wind-driven dust and snow storms, by moving conveyor belts, and by the pneumatic conveying of ANFO; (6) Galvanic currents generated by dissimilar metals touching or separated by a conductive material.

The accepted "safe" level of extraneous electricity for electrical blasting is derived from the current required to detonate the most sensitive commercial electric detonators plus a safety factor. The minimum firing current for commercial electric detonators presently manufactured in the United States is approximately 0.25 amperes (250 milliamperes). The Institute of Makers of Explosives (IME) has established the maximum "safe" current permitted to flow through an electric detonator without hazard of initiation as one-fifth of the minimum firing current, or 0.05 amperes (50 milliamperes). Operators using electric detonators must be alerted to the measure of extraneous current and if a source is suspected, should measure for extraneous currents in the area of the blast site at frequent intervals to insure that all extraneous currents are at a safe level.

When extraneous currents exceed 0.05 amperes (50 milliamperes), the source of the current must be traced and eliminated before electric detonators can be safely used. If the source of the current cannot be traced and eliminated, a Non-electric initiating system must be utilized. It must be remembered however that high voltages such as lightning can potentially initiate even Non-electric initiating devices. Extremely high static levels also can be reached by the pneumatic loading of ANFO.

ELECTRICAL HAZARDS TO BLASTING

Electrical Energy	Source	Products Affected	Safety Measures	Shunt Protection
Lightning (DC)	Atmosphere	Direct hit, all Products, Nearby, Electric Detonators	Detect potential Lightning, Clear & guard	No help, keep shunted but don't assume protected
Stray Current (AS and DC)	Leaking power Source, utilities & Machinery	Electric Detonators	Stray Current Test, Place wires safely	Yes, Keep detonators & circuits shunted
Radio Frequency (AC)	RF Transmitters	Electric Detonators in use, & in original package.	Follow IME Safety Library Publication No.20	No Help
Induced Current (AC)	AC Power Lines	Electric Detonators	Keep shunted & avoid high voltage transmission lines	Some protection, Keep shunted until blast
Static (DC)	Pneumatic loading of ANFO, dust & snow storms, belts	Electric and Non-electric detonators, cap and fuse	Do not use in dust or snowstorms. Use grounded semi-conductive hose	Some protection. Keep shunted until blast
Galvanic Current (DC)	Dissimilar metals in ionic solutions	Electric Detonators	Keep shunted until blast	Yes

Mechanical Static

The following recommended precautions should be taken for cases in which static electricity is generated mechanically.

1) All parts of moving equipment in the vicinity of blasting operations should be electrically connected at a common point and this common point should be connected to a good earth ground rod.
2) All conductors and metal parts of the system should be kept away from electric detonators and blasting circuit wires.
3) The ground wires and earth ground rod for the system should be kept away from rails, wiring, and piping that might conduct stray currents from these sources to the blasting site.
4) All moving equipment in the immediate area that might be capable of generating static electricity should be shut down while the blasting circuits are being connected and until the blast has been fired.

Electrostatic Discharges
Lightning

Lightning undoubtedly represents the greatest single hazard to blasting because of its erratic nature and high energy. A lightning strike can have over a million volt potential and discharge currents of over 100,000 ampere. If lightning strikes a blast area, all or part of the blast probably will be detonated. Because of the extremely high currents involved, even distant lightning strikes can be hazardous to electric initiating systems in both underground and surface operations.

Therefore, in the interest of safety, blasting on land, on water, and in some underground operations should be suspended, and all personnel should be evacuated to a safe distance from the blast area whenever lightning storms are in the vicinity.

The danger from lightning is considerably increased if there is a transmission line, water line, compressed air line, fence, stream, or other conductor available to carry the current between the storm and the shot location.

Where permanent firing lines and electric blasting caps are used, typically in underground operations, a 15-foot (4.6m) air gap should be provided to act as a "lightning break" between the blasting system and the supply power circuit. This air gap should be bridged by a flexible jumper cable just prior to firing the bla

Blasting operations must constantly be alert to atmospheric conditions that indicate the possibility of lightning and be prepared to temporally abandon all explosive loading activities until the threat passes. Lightning storms tend to be somewhat seasonal and often occur during the late afternoon and early evening hours. Scheduling blasting to avoid these hours is a common sense option.

A common sense rule is to evacuate the shot area when thunderstorm activity comes within 5 miles of the shot site. Regulations require that electric blasting circuits be shunted at all times unless being tested or tied in. In wiring situations where some series are complete and shunted and some are incomplete and in the process of being wired and the approach of thunderstorm activity is noted, common sense dictates that the shot wiring activity be abandoned and the area cleared and guarded.

Radio Frequency (RF)

All radio transmitters send out energy in the form of electromagnetic waves; leg wires and lead lines can act as antennae, converting energy from these waves into electrical energy in the wire.

The amount of electric produced in the wires depends upon: the output power of wattage of the transmitter; the frequency of the radio waves; he distance from the source of the RF energy to the blast site; the configuration of the wires which act as the antenna

The hazard exists regardless of whether the wires are shunted (short circuited) or left unshunted (open circuit).

Recommended Distances for Blasting

50,000 watt AM radio (540 – 16500 KHz).....2900 ft (880 m)
100,000 watt FM radio (88 – 108 MHz).....2600 ft (790 m)
300,000 watt VHFTV (Channels 7-13).....2500 ft (760 m)
1,000,000 watt UHFTV (Channels 14-83).....2000 ft (610 m)
100 watt mobile police radio (35-44 MHz).....260 ft (80 m)
5 watt Citizen's Band radio (26.96 – 27.41 MHz).....5 ft (1.5 m)

Precaution

Keep mobile transmitters away from the area.
Posting adequate signs to remind operators to turn off radio transmitters.

Testing Blasting Circuits

A Blaster's Multimeter, Blasting Ohmmeter or Blasting Galvanometer can be used to test blasting circuits for continuity and resistance.

Never use any test instruments not specifically designed for blasting circuits.

Before using an instrument, make certain the needle can be adjusted to "zero" when the terminals are shunted. Digital meters should read, "zero" in the display. If not replace the batteries and make the necessary adjustments as recommended in the meter instructions.

Replace the battery with the same type of battery specified by the manufacturer for use in the blasting instrument. If in doubt, contact your supplier's technical representative. Do not change batteries in the presence of electric detonators.

To properly test the circuit, the theoretical resistance of the circuit must be calculated. ***Table 16.1*** gives the resistance of a typical series of electric detonators with copper and iron leg wire of various lengths. This table is presented only for purposes of illustrating how to make circuit calculations. The actual resistances of the electrical detonators available to the blaster from the various manufacturers may vary widely from those shown in the table. Be sure to use your manufacturer's data when actually making circuit calculations in the field. ***Table 16.2*** gives the resistance per 1,000 feet for the various types of wire.

NOMINAL RESISTANCE* OF ELECTRIC BLASTING DETONATORS IN OHMS PER DETONATOR

(This is for example calculation only: refer to your supplier for actual resistances of your products)

COPPER WIRE			***IRON WIRE***		
Length of Wire in Feet	Instantaneous Delay Detonators	Delay Detonators	Instantaneous Detonator	Delay Detonators	Length of Wire in Feet
4	1.26	1.16	2.10	2.00	4
6	1.34	1.24	2.59	2.49	6
7	-	-	2.84	-	7
8	1.42	1.32	3.09	2.99	8
9	-	-	3.34	-	9
10	1.50	1.40	3.59	3.49	10
12	1.58	1.48	4.09	3.99	12
14	1.67	1.57	4.58	4.48	14
16	1.75	1.65	5.08	4.98	16
20	1.91	1.81	6.06	5.98	20
24	2.07	1.97			24
30	2.31	2.21			30
40	2.15	2.06			40
50	2.42	2.32			50
60	2.69	2.59			60
80	2.71	2.61			80
100	3.11	3.01			100
120	3.51	3.41			120
150	4.11	4.01			150
200	5.12	5.02			200
250	6.12	6.02			250
300	7.13	7.03			300
400	9.13	9.03			400

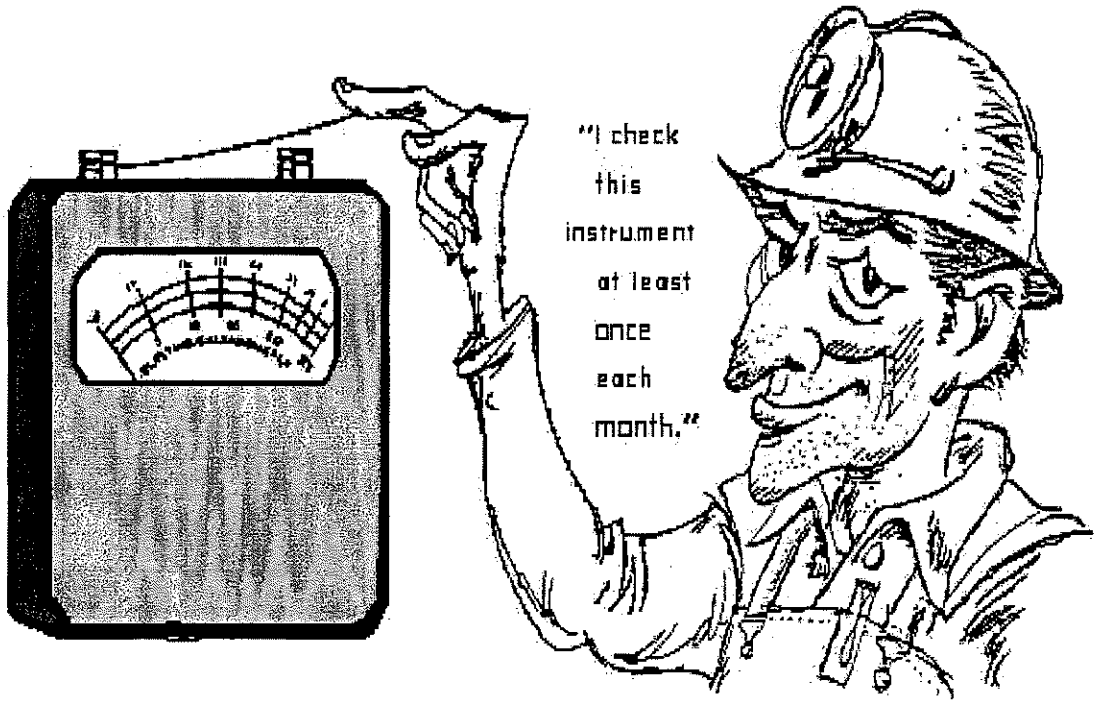
Table 16.1

*At 68^0 Fahrenheit

Resistance* of Copper Wire	
AWG Gauge No.	**Ohms per 1,000 Feet**
6	0.395
8	0.628
10	0.999
12	1.588
14	2.525
16	4.02
18	6.39
20	10.15
22	16.14

*At 68^0 Fahrenheit

***Table 16.2* – Resistance* of Copper Wire**



USING A BLASTING GALVANOMETER

Proper use of the blasting galvanometer helps assure safe blasting practice. You should consider using this test instrument in some, or all, of the following cases:

1. Check electric blasting caps for circuit continuity prior to stemming the hole. If this is done, be sure to twist the cap leg wires together after the test, so that they are short-circuited.
2. When wiring a blasting circuit series-in-parallel, check each series after wiring is completed and also when hooking up to the bus line or firing cable. Note the galvanometer reading. Readings should be approximately the same for every series. This assures an equal current distribution to each series.
3. Check firing cables in both the open are shunted positions. This will verify that there are no shorts or breaks in the cable.
4. When placing protective mats over a shot, lead wires on the terminals of the blasting galvanometer and make sure there is no change in instrument reading. If mats are of wire cable good practice to tape each leg wire connection.
5. Upon completion of all wiring, check circuit continuity at the firing end of the firing cable. Read the continuity check immediately prior to hooking up to the blasting machine.
6. Inspect the shot after blasting for possible missed holes. Use the galvanometer to check suspected misfired caps.

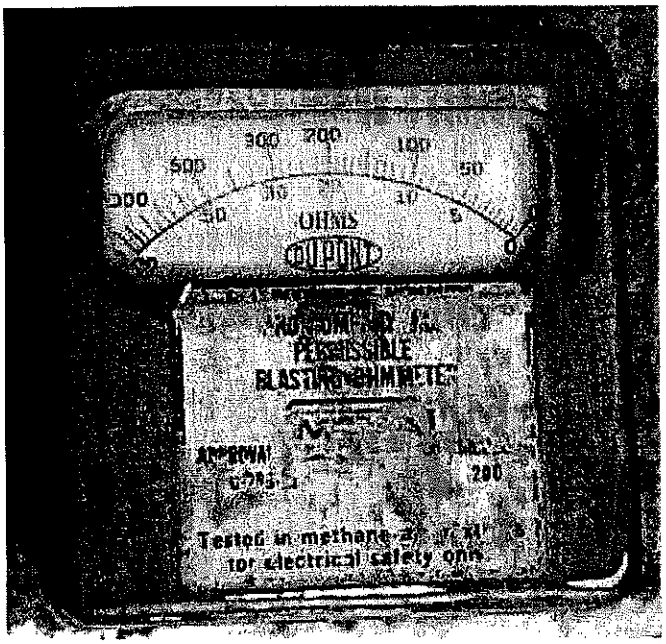
Blaster Multimeter

The Blaster's Multimeter is a compact volt-ohm-milli-volt meter specifically designed to measure resistance, voltage, and current in electric blasting operations. As with all blasting test devices, be certain the name includes the work ***Blaster's***. **A standard multimeter should never be used to test a blasting circuit.**

This versatile meter can be used to:

- Measure the resistance of a single blasting circuit for continuity, and the total resistance in a series-in-parallel circuit, with a high degree of precision and accuracy.
- Survey blast sites in order to determine if extraneous current hazards exist. For operating instructions, refer to stray current measurement methods recommended by the manufacturer.
- Measure a wide range of resistances necessary to investigate static electricity hazards, such as those possible in a pneumatic loading operation.
- Measure power line voltages up to 1500 volts AC and DC.

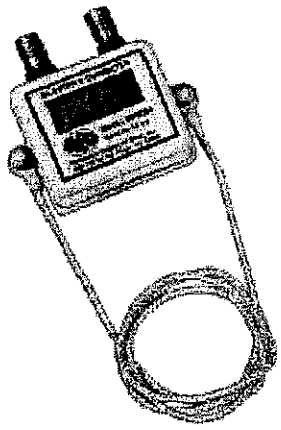
Blasting Ohmmeter



The Blasting Ohmmeter (sometimes called "Blaster's Ohmmeter") is an analog ("swing needle") device utilized to measure the resistance in ohms of the blasting circuit: (1) in order to determine if the bridgewire of an individual electric detonator is intact; (2) to determine the continuity of an electric detonator series circuit, (3) to locate broken wires and connections in a series or series-in-parallel circuit. To measure resistance with this compact instrument, place each of the two lead-in wires from the open end of the circuit on the two contact posts that extend out of the top of the Blasting Ohmmeter. The meter reading will approximate the circuit's resistance (number of ohms). To determine if the meter is functioning properly, short circuit the contact posts and determine if the meter is reading zero. If not, turn the adjustment screw on the instrument until the needle indicates zero ohms on the scale that will be used to test the circuit. If the needle cannot be adjusted to zero, or the needle is drifting when the instrument is shorted, the battery may be weak or other circuitry must be repaired prior to use. Never use an instrument that cannot be adjusted to zero.

Some Blasting Ohmmeters use special silver chloride batteries. When the battery is exhausted, it must be replaced with the same type of cell. Never attempt to replace it with a standard battery. Never change batteries near electric detonators. Never allow the silver chloride cell, or any battery, to come in direct contact with electric detonators.

Blasting Digital Ohmmeter



The Blasting digital ohmmeter is used to measure the resistance of blasting circuits and individual detonators in the same manner as the Blasting Ohmmeter, but with greater accuracy and range. Blasting Digital Ohmmeters are available in both permissible and non-permissible versions. Never use a non-permissible instrument underground in a gassy environment. The Blasting Digital Ohmmeter will give a direct reading of the resistance (ohms) of the blasting circuit when the two wires from the circuit are placed against the posts of the ohmmeter. A test of the ohmmeter can be made by shorting across the posts. The reading should be zero.

Blasters must use only the recommended batteries in these machines. Other batteries will produce a hazardous current level. Never test an electric detonator or blasting circuit directly with a battery, recommended or otherwise, and never allow any battery to come in direct contact with electric detonators.

Date / Plant / Shift Code

In 1971 IME member companies implemented a product identification system for packaged explosive products manufactured in the United States.

The code for the date, work shift and plant of manufacture is plainly marked on each unit to be identified. Marked units include all cartridges of dynamite, blasting agent, water gel, slurry, cast boosters, primers, cartons of detonating cord, containers of blasting caps and similar accessories. The shipping case bears the same number as the units.

The following is the format for the Date / Plant / Shift code used for product tracing:

Day	Month	Year	Location	Shift or Machine
2 digits	2 digits	2 digits	1 digit	1 digit
Numeric	**Alpha**	**Numeric**	**Alpha**	**Numeric**

When writing months, a two letter abbreviation is used:

January	**JA**	**July**	**JY**
February	**FE**	**August**	**AU**
March	**MA**	**September**	**SE**
April	**AP**	**October**	**OC**
May	**MY**	**November**	**NO**
June	**JU**	**December**	**DE**

As an example, a product manufactured on September 30, 1997 during the first shift at a plant which the manufacturer has assigned the letter "A" would be **30SE97A1**.

Manufacturers advise the Bureau of Alcohol, Tobacco and Firearms (BATF) when codes are changed.

Approved by the IME Board of Governors December 8-9, 1987

Ammonium Nitrate Oil (ANFO)

Ammonium nitrate is an essential ingredient in nearly all-commercial explosives including dynamite, emulsions, and water gels. Its predominant use, however, is in the form of a small porous pellet, called a prill, mixed with fuel oil. Nearly four billion pounds of these mixtures, commonly referred to as ANFO, are consumed each year in the U.S. They account for approximately 80 percent of the domestic commercial explosive market.

Since their introduction in the 1950's, ANFO products have found extensive use in a wide variety of blasting applications such as surface mining of coal, metal mining, quarrying, and construction. Their dominant use is attributed to economy and convenience.

Their limitations—no water resistance and low-product density—should be recognized as product deficiencies prior to introducing ANFO into a blasting system.

The most widely used ANFO product is an oxygen-balanced, free flowing mixture of about 94 percent ammonium nitrate prills and 6 percent No. 2 diesel fuel oil. Other ANFO products are modifications of this basic ANFO formula in which:

1) Substances such as finely-sized aluminum or carbon aceous materials are used in conjunction with No. 2 diesel fuel, or,
2) The AN prill is crushed, mixed with No. 2 diesel fuel (and possibly other substances), and packaged in water resistant package for use in damp to slightly wet boreholes.

The AN Blasting prill

This material is also frequently referred to by the terminology *porous, explosive-grade, industrial,* or *low-density* prilled ammonium nitrate.

Production of ammonium nitrate (AN) prills is a multi-step process that begins with natural gas and air.

The end point in this process involves spraying a concentrated (94% to 96%) AN solution through perforated plates or shower heads at the top of a prill tower. Liquid AN droplets are formed as the solution exits the shower heads.

During a free fall of 100 to 200 feet (30.5 – 61m), the droplets crystallize into spherical AN prills. These prills are dried, cooled, and may be coated with anti-setting agents prior to shipment.

A major domestic use of AN prills is for agricultural fertilizers. However, the agricultural AN prill differs from the AN prills most suitable for explosive use. Blasting prills are usually less dense and, consequently, more porous.

Density

Prills best suited for blasting products have a particle density in the range of 1.3 to 1.5 g/cc. AN prills with particle densities approaching the density of solid ammonium nitrate (slightly over 1.7 g/cc) are less sensitive to detonation. The voids in the porous, less dense blasting prill serve two functions:

1) They enable the prill to absorb and retain fuel oil in a uniform and intimate manner; and
2) They improve sensitivity by acting as sites for high-temperature "hot spots" or ignition points.

Anti-setting Coating

Liquid surface-active agents (surfactants) and finely ground (minus 325 mesh) kaolin or talc coat prill to disperse ambient humidity. This retards the prill's affinity for moisture on its surface, thereby minimizing caking. In some cases, the use of the surfactant alone has proven to be an effective anti-setting coating. Excessive amounts of talc or kaolin will, 1) decrease ANFO sensitivity because of the inert nature of those minerals and 2) interfere with the oil distribution, which will affect ANFO performance. Excessive quantities of certain surfactants may affect the stability of the emulsifier in blasting emulsions. This could in turn affect the performance of ANFO/emulsion blends. A good blasting rill has typically less than 1.0 percent anti-setting coating.

Loading of Holes

ANFO is extensively used because of the low cost advantages. When property stored, handled, and used, ANFO will give good performance. ANFO mixed to the proper proportion (94.3% ammonium nitrate and 5.7% fuel oil or Corvus oil for less oil fumes) has a Fume Class 1 rating. However, improper storage or usage can result in the generation of toxic fumes. Prolonged storage can also result in evaporation of the fuel oil. Ammonium nitrate is highly hydroscopic and will absorb moisture from the humid mine air if left stored in an open container. The loading of wet holes must also be avoided. Excessive moisture and/or unbalanced fuel ratios will result in poor sensitivity reduced explosive efficiency, and the generation of toxic fumes.

ANFO is normally packaged in 50-lb pillow - type or poly-burlap bags for easy handling by the mine personnel. However, recently some mine operators have adopted a bulk handling system to reduce handling cost. Since mine layout and systems vary greatly, any bulk handling system must be evaluated and designed for each situation.

Pneumatic Loading

The degree of sensitivity of ANFO mixes allows for the use of pneumatic loaders. Pneumatic loaders can be classified into three categories: pressure pots, Venturi loaders, or a combination of both systems.

A pressure pot consists of a pressure vessel with a conical base and a loading hose of proper diameter and length, the pot is sealed and a pressure of 25 - 40 psi is applied. The flow of ANFO is controlled by a ball valve at the base. Pressure pots can load at a rate of 25-50 lb per minute through a 100 ft 1in. ID hose. A disadvantage of a pressure pot is that it will not crush or compact the ANFO in the blast hole because of its lower air stream velocity in the loading hole as efficiently as the Venturi loader. This will result in lower velocity of detonation, density, and energy. Boreholes that are inclined upward cannot readily be loaded with the pressure pot system.

A Venturi loader consists of a hopper with suction at its base supplied by a Venturi. Venturi loaders are simple, portable, and inexpensive. This is offset by slow loading rates of 8-15 lb per minute. They are also restricted to short boreholes, but provide very good compaction of the ANFO prill in the blast hole.

The pressure pot/Venturi loader combines the advantages of both loaders. It has a high loading rate (50 - 75 lb per minute) with good crushing and compaction of the ANFO in the blast hole.

Static Electricity

Static electricity is a form of potential energy in which electric charges are stored on some person or object. When the static electricity is converted to kinetic energy by means of a static discharge, it represents a possible hazard to the use of flammable or explosive materials. When considering commercial blasting, the primary concern is that static electricity may cause a premature detonation when blasting electrically. Experience has shown, however, that static electricity, under some conditions, may also represent a hazard to non-electric blasting.

The safety procedures that eliminate the accumulation of a static charge are listed below. They should be made an integral part of the pneumatic loading Operation, since they are the principal mechanism for minimizing the static electricity hazard.

1. *Ground the Pneumatic Loader* The pneumatic loader (includes both pressure pot and Venturi types) should be constructed of a conductive material and should be grounded to earth. The resistance between the loader and earth should be a maximum of 1,000,000 ohms. This can usually be accomplished by physical contact between the loader and earth. If the loader is mounted on a vehicle of some type, a positive grounding means should be used. One grounding method

that has proved satisfactory is to bolt or weld one end of a heavy, flexible wire to the loader. The opposite end should be connected to a metal rod imbedded in the earth. If the loader is moved often, the opposite end of the wire should be bolted or welded to a metal plate (about 8" x 8" x 1/2" thick with a handle for easy handling) that is rested on wetted earth during loading. Never ground the loader to metal air or water lines, metal support frames, or to any fixture that is also used to ground electrical equipment, as these may be sources of stray currents.

2. *Use a Semi conductive Loading Hose* when loading ANFO pneumatically, use a semi conductive hose that is electrically connected to the pneumatic loader. In most cases, this can be accomplished by clamping the hose to the outlet from the loader. The semi conductive hose should have a minimum resistance of 5,000 ohms per foot and a maximum total resistance of 2,000,000 ohms. There are a number of companies that manufacture acceptable semi conductive hoses.

3. *The Operator Handling the Loading Hose Should Not Wear Gloves* unless some other positive means is utilized to ground the operator, he or she should be in direct physical contact with the semi conductive loading hose. This is necessary to prevent the accumulation of a static charge on his or her person. If he or she wears gloves, the direct physical contact between the two cannot be achieved.

4. *The Resistance of the Earth between the Ground from the Pneumatic Loader and the Boreholes Should Be a Maximum of 1,000,000 0hms* The resistance of the ore body and/ or rock between the ground from the pneumatic loader and the location of the boreholes being pneumatically loaded must be less than 1,000,000 ohms, so that the charge on the ANFO particles can neutralize the opposite charge that is left on the loading hose. Experience has shown that this requirement is easily satisfied in most mines.

5. *The Ambient Relative Humidity Should Be a Minimum of 5O%* Humidity serves two functions in minimizing the accumulation of static electricity, Under conditions of high humidity, a thin film of moisture condenses onto the surfaces of objects on which static accumulates. The moisture film is usually sufficiently conductive that it backs up the grounding procedures by permitting electrostatic charges to drain to earth as they are being generated. The humidity in the compressed air that conveys the ANFO to the boreholes provides moisture that is absorbed by the ANFO particles. This provides a conductive film on the surfaces of the particles that drains any electrostatic charges to earth that may be on the ANFO as it is packed in the borehole.

6. *Avoid the Use of Nonconductive Borehole Liners* A plastic liner is sometimes used to keep the water in the borehole away from the ANFO or to prevent the ANFO from escaping from the borehole into cavities, cracks, or vugs. The nonconductive nature of these liners prevents the grounding of the static charge on the ANFO particles. Hence, they should not be used in boreholes that are

pneumatically loaded unless some positive means is provided to drain electrostatic charges to earth from inside the liner. There are semi conductive ground straps available to accomplish this grounding.

7. *Make Periodic Tests to Check the Effectiveness of the Recommended Safety Procedures* There are three types of tests that should be made prior to the introduction of pneumatic loading and periodically thereafter. These are:
1) Grounding resistance measurements,
2) Static voltage measurements, and
3) Relative humidity measurements.
The purpose of the grounding resistance measurements is to ensure that static charges will be dissipated to earth and neutralized instead of accumulating on some person or object. They entail checking the resistance of the loading hose, the pneumatic loader grounding, and the surrounding ore body to ascertain that they do not exceed the maximum values previously recommended. The purpose of the static voltage measurements is also to ensure that static electricity is not being accumulated. These measurements entail using an electrostatic voltmeter to monitor the pneumatic loader, the loading hose, the operator, and the ANFO particles as they are packed into the borehole for the presence of excessive electrostatic' voltages. Although condensation on the surfaces of objects is not depended only to drain off static charges, experience has shown that static is more likely to be a problem when the relative humidity is low less than 50%. Therefore, measurements of the relative humidity of the ambient air and the compressed air that services the pneumatic loader will help to further define the overall background conditions. The test instruments and procedures that are used in making the grounding resistance, static voltage, and relative humidity measurements are discussed in the next section.

When blasting non-electrical, the safety procedures listed above should be followed to eliminate the accumulation of static electricity generated by pneumatic loading.

Emulsion Explosives

Explosive Properties--Physical Form

An emulsion is an intimate mixture of two immiscible liquids with one liquid phase dispersed uniformly throughout the second phase. Emulsion explosives are dispersions of water solutions of oxidizers in oil medium or "water-in-oil" emulsions. It is this unique structure and high ratio of oxidizer to fuel that give emulsion explosives their special characteristics.

The oil or fuel phase is known as the continuous or external phase because it surrounds and coats all of the oxidizer droplets. The fuel phase is generally oil or

wax or a combination of the two. No. 2 diesel fuel oil (FO) is common to emulsion explosives.

The water or oxidizer solution phase is called the discontinuous or internal phase because the microscopically fine droplets are kept apart and surrounded by the continuous fuel phase. The oxidizer phase always contains ammonium nitrate. Other salts such as sodium nitrate, calcium nitrate and ammonium or sodium perchlorate may also be included.

The oxidizer remains dispersed in the fuel to form a stable emulsion through the action of a surfactant (emulsifier). For example, oil and vinegar are held together by egg yolks to form the emulsion known as mayonnaise. There are many different emulsifiers, and choosing which one to use depends on the particular requirements for the product. The emulsion formed from the fuel phase, oxidizer phase and emulsifier, before any addition of bulking agent, aluminum, or solid ammonium nitrate, is called the matrix and is the foundation of subsequent products.

Structure

Because of the necessity to have close to zero oxygen balance, emulsion explosives need the volume of oxidizer to be much greater than the volume of fuel: the ratio is approximately 9 to 1. Because the relative volume of fuel is so much less than tat of the oxidizer, it must be spread in a very thin layer in order to cover all of the oxidizer droplets. The size of the droplets is very small: and, due to the oxidizer/fuel ratio, the droplets are in the shape of many-sided polyhedrons. Droplets are usually in the range of 0.2-10 microns in diameter, or about $1/4^{th}$ to $1/2000^{th}$ the size of a grain of table salt.

The rheology or viscosity of the emulsion is controlled by the nature of the fuel phase and the droplet size. The composition (wax, oil, emulsifier) of the full fuel phase has the greatest influence on the final viscosity of the product. Low viscosity oils, such as No. 2 diesel fuel, can be used to make pumpable emulsions. Waxes and high viscosity oils are used to make thick, putty-like packaged products. The droplet size is controlled by the amount of work pt into the emulsion. The faster and longer it is stirred, the greater the work input and the smaller the droplet size and size distribution. The smaller the droplet size, the thicker the emulsion.

Thermochemical Energy

The addition of aluminum or ANFO to an emulsion explosive can be used to increase its energy (cal/g). Aluminum does not significantly increase the sensitivity of emulsions, so a much coarser and less costly aluminum can be used rather than the high cost paint-grade aluminum used to attain sensitivity in some water gels. Theoretically, an addition of 5% aluminum will increase the

energy of the emulsion by about 25-35%. Ten percent aluminum increases the energy by about 40-60%. Above 10% the addition of aluminum may not be cost effective.

ANFO added to emulsions can increase the energy by about 5% for every 10% increment added. ANFO also has the added advantage of producing only gaseous detonation products, and therefore, an increase in gas volume is also realized. An increase in gas volume usually leads to better heave and throw of rock being blasted.

The ratio of the amount of energy released to the calculated thermochemical energy is the measure of the efficiency of an explosive. Water gels generally have a liquid and a solid phase. They are generally made at elevated temperatures; as the product cools, oxidizer salt crystals begin to form. The colder the product becomes, the greater the tendency for crystals to form. The more crystals present and the larger they are, the more insensitive and less efficient the product becomes. The components are not intimately associated with one another because a relatively large amount of oxidizer surrounds a relatively small amount of fuel. In contrast, the increased intimacy between fuel and oxidizer in emulsions, and the very small particle size of the droplets, is believed to be responsible for the greater efficiency and enhanced detonation properties of these products.

The emulsions are two phase systems. In order to have a suitable oxygen balance, only a very small amount of fuel is available to spread over each individual oxidizer droplet. This results in a very intimate mixture. Because there are so many oxidizer droplets and because they are so small, the oxidizer salts, regardless of temperature, will not easily crystallize and grow. Since the oxidizer salts remain in solution, the detonation properties of emulsion explosives remain unchanged for long periods of time and over wide temperature ranges.

Detonation, Physical and Safety Properties

Safety

Emulsions fail to detonate in impact and friction tests, which have been standard to the explosive industry for years. When placed against a metal plate, the emulsions fail to detonate under the impact of a 30-06 projectile. Other high velocity impact tests with larger caliber projectiles show emulsions to have a greater resistance to initiation by impact than either water gels or dynamites. Normally, emulsion explosives will not detonate during burning, but there is no guarantee of this, particularly if the material is contaminated with foreign materials such as rust, detonators, dynamites or aluminum powders. When pumping emulsions, care must be taken so that the pump does not run dry or against a closed system ("deadhead"). In either case, friction can raise the temperature of the emulsion in the pump beyond the decomposition point of

ammonium nitrate or other ingredients. If this happens a detonation can occur. Remember—it can be just as hazardous to pump unsensitized emulsion oxidizers, as it is to pump sensitized ones. Although tests have demonstrated that emulsions offer a great degree of safety, they will detonate if subjected to severe conditions. They are explosives, and regardless of their degree of safety should never be abused.

Velocity

It is an established fact that the smaller the particle size of the ingredients of an explosive, the higher the velocity of detonation (VOD). Since the droplet size of emulsions is so fine, the VOD of explosive emulsions is very high – close too theoretical. The VOD does decrease somewhat as the charge diameter decreases or as solids such as aluminum or AN prills are added, but the VOD generally remains relatively high when compared to most water gels.

Detonation Pressure

Since emulsions have a high velocity of detonation and a reasonable density, they also have a relatively high detonation pressure. Emulsion detonation pressures measured by the "aquarium" technique are found to be between 100 and 120 Kbar/(1.45-1.74 x 10^6 psi). As a result, emulsions are particularly well-suited for improving fragmentation in hard massive rock, for breaking hard bottom rock, and for use as a booster for ANFO mixtures and other blasting agents.

Sensitivity

Because emulsions have a very fine particle size and are an extremely intimate mixture of fuel and oxidizer, only a density reducing agent needs to be added to make them detonate. It is not necessary to use high explosives or chemical sensitizers for sensitivity. The density can be reduced by occluded air, chemically generated gas, perlite, expanded plastic, hollow glass or phenolic microspheres, or even AN prills. The sensitivity of the emulsions can be made to vary from that of a No. 8 strength detonator (or less) for a high explosive classification at 68°F (-20°C) to booster sensitivity for blasting agent 1.5D products. The emulsions are sensitive over a wide temperature range, and they also maintain their sensitivity over a wide range of diameters (7/8 inch [22mm] and up for "Explosive, Blasting, type E 1.5D" [blasting agent]). Different density reducing agents are used for different reasons, but the glass microspheees are the most common, although chemical gassing is becoming popular. Because certain glass microspheres will withstand high pressures, they are especially useful in sensitizing emulsion products for use in deep bore holes or close borehole spacing where high hydrostatic or shock pressures are likely to be encountered.

Generally, the lower the density of an emulsion explosive, the more sensitive it becomes. Also, the lower the water content of the emulsion explosive, the more sensitive it becomes. The water content of blasting agents is usually higher than that of 1.1D emulsions, but so is the density. This keeps the overall bulk strength energy level of blasting agents close to that of the high explosive emulsions.

Water Resistance

Water-in-oil emulsions have a continuous, water-immiscible oil phase and are extremely water resistant. They do not depend upon the integrity of the package for water resistance. Emulsions are a good choice when wet holes are encountered, because they will perform successfully after sleeping underwater for weeks or even months.

DYNAMITES

Straight Dynamite

Guhr dynamite, originally formulated by Nobel in 1864, was the forerunner of today's straight dynamites. Nobel's guhr dynamite contained kieselguhr totally saturated with liquid NG. The kieselguhr absorbes three times its weight in NG; as such, guhr dynamite contained about 75% NG. Kieselguhr, being inert, detracted from the explosive strength. In time, this problem was solved by using sawdust to absorb the NG, which added to the energy.

Present-day straight dynamites are no longer straight because they contain various proportions of active ingredients substituted for much of the kieselguhr, with resulting higher performance. Among the ingredients added to increase the performance was sodium nitrate, which created higher energy and a more favorable oxygen balance.
High density and high velocity result in good *brisance*, the shattering effect. They generally have fair water resistance, but poor fume characteristics, which disqualifies them for underground applications. Because of their high cost, industrial use and importance are declining, with ammonia dynamites being used as a substitute. Today straight dynamite is used in ditch blasting in wet soil by the sympathetic propagation technique.

Ammonia Dynamite

The first use of ammonium nitrate in explosives was patented by Nobel in 1867. In the first ammonia dynamite, ammonium nitrate was mixed with charcoal and nitroglycerin. This was an advancement, as the ammonium nitrate decomposes completely, adding to the energy. It also supplies oxygen to the reaction for better fume characteristics.

Since a portion of the NG is replaced by ammonium nitrate, ammonia dynamite generally has a lower density and higher shock and friction tolerance. Ammonia dynamites have low to medium VODs and exhibit good heaving action due to increased gas production. Ammonia dynamites are suited for use in relatively soft ground. The strength and density of ammonia dynamite can be varied greatly by changing the ingredient ratios. Most ammonia dynamites, however, have poor to fair water resistance and are thus limited in their use.

Gelatin Dynamite

In 1862, Alfred Nobel first prepared nitrocotton (nitrocellulose), searching for a substance that would retain NG in the presence of water. Guncotton (i.e., nitrocotton or nitrocellulose), listed as an absorbent in a dynamite patent by Nobel in 1863, did not perform as desired. In 1873, Maynard, an American medical student, found that a nitrocellulose with a lower nitrogen content than that used earlier by Nobel would produce a solution called collodion. Initially, it was used as a protective film over a cut as it dried into a thin tough coating. In 1875, Nobel cut his finger and applied the collodion. He then decided to try its effects on NG, which resulted in a very plastic and cohesive gelatin.

Straight Gelatin Dynamite

Straight gelatin contains a high ratio of nitrocellulose to nitroglycerin. Because of its highly gelatinous "rubber like" consistency, it has excellent water resistance. Nobel's straight gelatin composition contained 91% NG, 8% nitro cotton, and 1% chalk, and produced a plastic substance resembling crepe rubber in appearance and texture. This was called 100% blasting gelatin. Similar to the development of the straight dynamites, sodium nitrate and other carbonaceous ingredients were added to obtain a closer oxygen balance and higher energy characteristics.

Ammonia Gelatin Dynamite

This type of gelatin dynamite has ammonium nitrate substituted for some of the nitroglycerin to form a plastic cohesive product with good water resistance. Ammonia gelatins have high densities and high velocities, giving them high detonation pressure, which make them excellent boosters. Because of high-energy output, they are particularly suited for shooting tough rock.

Semi-gelatin Dynamite

A semi-gelatin is a cross between the high-density ammonia dynamites and the ammonia gelatins. The semi-gelatin dynamites exhibit moderately high detonation pressure and an adequate amount of water resistance for all but the most severe conditions. The rationale of the semi-gelatin dynamite is based upon economics. They have a higher cartridge count per case and cost less per cartridge than gelatins of equivalent strength, but exhibit less water resistance.

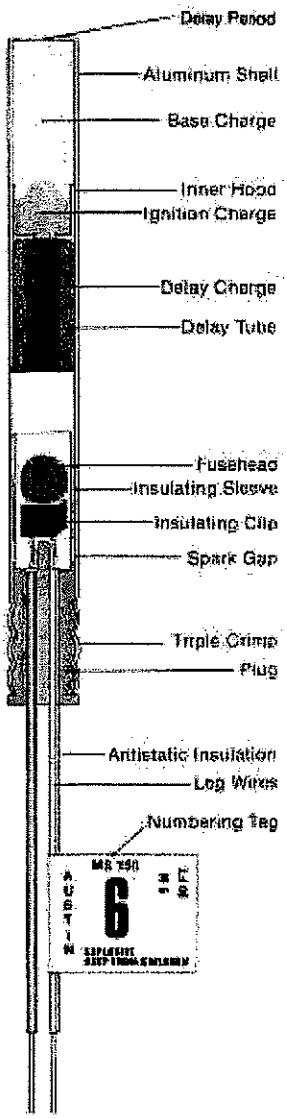
Permissible Dynamite

Permissible dynamites are specifically formulated and developed for underground coal mining. Each formula must pass many tests conducted by the U.S. Bureau of Mines and has been assigned an individual permissible certificate by MSHA. They are also subject to periodic testing to ensure permissibility for use in underground coal and gaseous metal and nonmetal mines.

Electric Detonators

This classification includes high, medium, and low firing-current electric detonators, semiconductor bridge detonators, toroid induction/electric blasting detonator. Exploding bridgewire (EBW) detonators and the electronic detonator.

Over the years, in the North American market the most widely used electric detonator has been of the low firing-current variety. With the proper electrical energy source and blast circuitry, large numbers of electric detonators can be initiated on command from a location that is safely removed from the immediate blast area.



The electric detonator consists of a metal shell containing a high explosive base charge designed to initiate other explosives. Above the base charge is a small charge of primary explosive (primer charge) that converts a burning reaction transmitted from the ignition or pyrotechnic fuse into a detonating reaction. Above the primer charge, in delay detonators, is a pyrotechnic delay element that burns at a known rate and whose length and composition control the transit time of the burning front. Detonators classified as instantaneous or zero delay does not contain a delay feature. The topmost reactive element in the electric detonator is the ignition area where a bridge wire is attached between the leg wire pins and is embedded in an ignition mixture. The ignition mixture may be in the form of loose powder, a primer spot, or match head, depending on the manufacturer's design. When sufficient electrical current passes through the system, a bridge becomes hot enough to ignite the ignition mixture. The majority of electric detonators surround the ignition area with a plastic ferrule that insulates and protects the ignition mixture from the shell. The leg wire pins are embedded in a thermosetting resin plug, and are connected to the detonator's leg wires within an electrometric material above the resin plug. The electrometric material top seal is securely crimped near the open end of the initiator shell, forming a water-resistant closure that firmly positions and secures the leg wires inside the shell.

All modern commercial electric detonators include an internal feature to prevent electrostatic energy from accidentally initiating the detonator. There are several designs, some of which provide a bypass path around the bridgewire using a semi conductive material and others, which utilize a printed circuit, which provides a controlled path to ground.

Detonator leg wires are made of solid copper, iron, or copper-clad iron wire in a variety of gauges and lengths. Iron or copper-clad iron leg wires are designed for use in operations where it is desirable or necessary to remove the leg wire remnants from the blasted rock by magnetic means. Plastic insulation provides insulation, abrasion resistance, and flexibility. The wire insulations typically color-coded to provide product identification with maximum visibility and to assist in wiring hookups. Most short-length electric detonator leg wires are coiled in a figure eight fold that is secured with a paper band. Longer length detonator wires are usually supplied as either duplex wire with a single color and wound on spools or single individually colored wires that are coiled in a figure eight fold. Longer length leg wires are typically heavier gauge wire in order to provide improved tensile strength and lower resistance per unit of length.

All electric detonators produced in North America have shuts on the free ends of the leg wires to provide a low resistance path to prevent current from flowing through the bridgewire. In addition, some designs completely enclose the ends of the wires in order to prevent corrosion and to keep bare wires from contacting extraneous electrical current sources. In one design the shunt consists of aluminum foil with an insulation layer on the outside.

Electric detonators are supplied with a distinctive, numbered tag to facilitate easy identification of the delay period.

Instantaneous Electric Detonators generally contain the same charges as fuse caps and function in a similar manner with the exception that the activating energy is applied electrically.

Two electrical wires, commonly called leg wires, enter the shell through a non-conductive plug of rubber or plastic around which the shell is crimped during manufacture. These are connected to each other within the shell at a point within or close to the ignition charge by a high resistance bridge wire or match head. The plug through which the leg wires enter prevents moisture or other contaminants from reaching the ignition charge. Electric detonators are not as subject to mass detonation as are fuse caps provided that the leg wires are kept folded until the cap is to be used. They are, however more subject to accidental initiation by extraneous electricity.

When the proper amount of current is passed through the leg wires, the high resistance of the bridge wire or match head causes it to heat very quickly. This

heat ignites the ignition charge and from that point functioning is essentially the same as in a fuse cap.

Leg wires may be made of copper or iron. Iron wires are normally used only in coal and salt mines where the iron can later be magnetically separated from the coal or salt. Where iron wires are used, they are available in standard lengths from 4 to 20 ft.

Electric detonators with copper legwires are most commonly used because of their lower electrical resistance. Generally, they are available in standard lengths from 4 ft. to 400 ft. Other lengths are available on special order.

Because of differences in resistance, timing characteristics and designation of delay periods, brands of different manufacture should never be mixed in the same round, as risk of misfire is likely.

For all practical purposes, instantaneous electric detonators detonate when sufficient current is applied, although there actually is a measurable interval between the application of the current and the development of sufficient heat in the bridge wire or matchhead to activate the cap. This interval varies so slightly within **caps of the same manufacturer** that it can normally be ignored so long as sufficient current is applied. Thus, instantaneous electric detonators, unlike fuse caps, can be used for reliable simultaneous detonation of a large number of separate charges.

Long period electric detonators contain a delay train as an additional component. The delay train is interposed between the ignition and primer charges and delays detonation of the cap by the amount of time required to burn through it. This may depend on either the composition or the length or diameter of the delay train or both. Because the time interval between successive delay periods approximates one-half second, this type is sometimes referred to as slow or long delay electric detonators. It should be clearly understood, however, that each manufacturer establishes his own delay interval and numbers his delays in accordance with his own system. These facts provide an additional reason why caps of different manufacture must not be used in the same round.

Long period detonators are numbered to indicate progression and can normally also be identified by the manufacturers color code system. The lowest number, normally "0", indicates the shortest delay while the highest, presently 14 or 15, indicates the highest. It is emphasized that a "0" delay is not an instantaneous cap and that it will delay from 8 to 25 thousandths of a second, depending on the brand.

Primer:

A unit, package, or cartridge of explosives used to initiate other explosives or blasting agents, and which contains:

1) A detonator, or
2) Detonating cord to which is attached a detonator designed to initiate the detonating cord.

MAKING PRIMERS WITH ELECTRIC / ELECTRONIC DETONATORS

SMALL DIAMETER CARTRIDGES

(Less than four inches in diameter) –

Step 1: Punch a hole straight into one end of cartridge,
Step 2: Insert the detonator into the hole.
Step 3: Tie leg wires around the cartridge using a half hitch.
NEVER pull the wires too **tightly.** This may break them or damage the insulation

Figure 1: Recommended method of making primer with small diameter cartridge and electric detonator.

LARGE DIAMETER CARTRIDGE

(Four inches and larger in diameter) –

Step 1: Punch a slanting hole from the center of one end of the cartridge coming out through the side two or more inches from the end.
Step 2: Fold over the leg wires about 12 inches from the detonator to form a sharp bend.
Step 3: Push the folded wires through the hole starting at the end of the cartridge and coming out through the side.
Step 4: Open the folded wires and pass the loop over the other end of the cartridge
Step 5: Punch another hole straight into the end of the cartridge beside the first, insert the detonator in this hole, and take up all the slack in the wires.

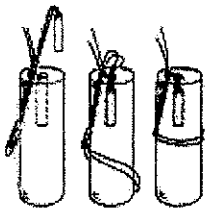


Figure 2: Recommended method of making primer with large diameter cartridge and electric / electronic detonator.

CAST BOOSTERS –

ALWAYS **follow the manufacturer's recommendations for the attachment and use of detonators with cast or manufactured boosters.**

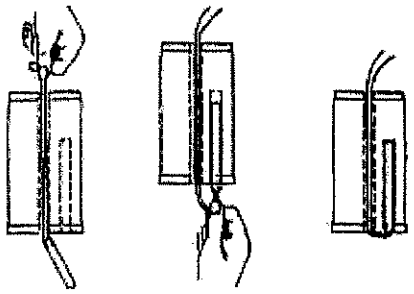


Figure 3: Recommended method of making primer with cast booster and electric detonator.

PLASTIC FILM CARTRIDGES –

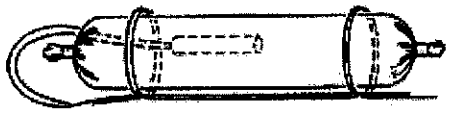


Figure 4: Recommended method of making primer with plastic film cartridge and electric / electronic detonator.

MAKING PRIMERS WITH FUSE OR NON-ELECTRIC DETONATORS

SIDE PRIMING METHOD –

Step 1: **Punch a hole in the side of the cartridge. Make the hole deeper than length of detonator and pointed downward rather than across the cartridge.**
Step 2: **Insert the detonator.**
Step 3: **Fold back the fuse, shock tube or plastic tubing over the end so that it lies along the length of the cartridge.**
Step 4: **Tape the fuse, shock tube or plastic tubing over the end so that it lies along the length of the cartridge.**

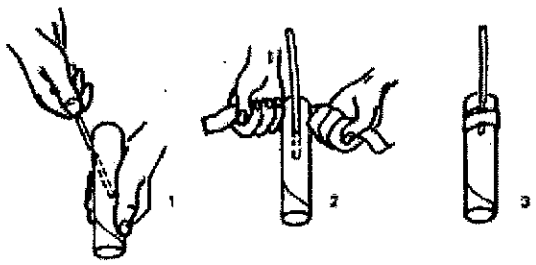


Figure 5: *Recommended method of making primer using the side priming method.*

REVERSE PRIMING METHOD

***Step 1*: Punch a hole in the side of the cartridge. Make the hole deeper than length of detonator.**
***Step 2*: Insert the detonator.**
***Step 3*: Fold back the fuse, shock tube or plastic tubing over the end so that it lies along the length of the cartridge.**
***Step 4*: Tape the fuse, shock tube to the cartridge.**

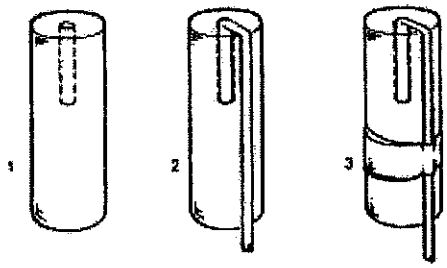


***Figure 6**: Recommended method for making primer by reverse priming method.*

- ***CAUTION:* If miniaturized detonating cord is used, the explosives must be insensitive to initiation by the detonating cord for this method to work.**

PLASTIC FILM CARTRIDGE PRIMER –

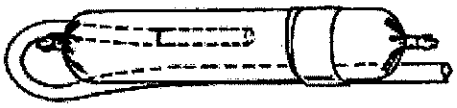


***Figure 7**: Recommended method of making primer with plastic film cartridge and fuse or non-electric detonator.*

MAKING PRIMERS WITH DETONATING CORD

DETONATING CORD WITH CAST BOOSTERS –

ALWAYS **follow manufacturer's recommendations for using detonating cord with cast or manufactured boosters.**

***Figure 8**: Recommended method for making primer with cast booster and detonating cord.*

MISCELLANEOUS TYPES OF PRIMERS

ALWAYS **follow manufacturer's recommendations for preparation of primers not covered elsewhere in these recommendations.**

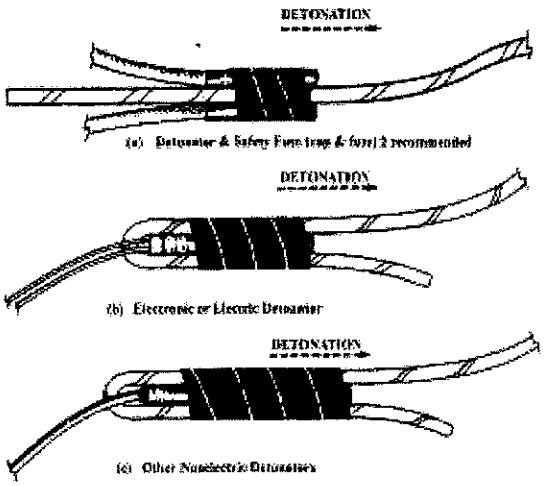


Figure 9: *Methods for attaching detonators to detonating cord.*

ALWAYS **use a detonating cord matched to the blasting methods and type of explosive materials being used.**
ALWAYS **Handle detonating cord as carefully as other explosive materials.**
ALWAYS **Cut the detonating cord from the spool before loading the rest of the explosive material.**
ALWAYS **Use a sharp knife, razor blade, or instrument designed for cutting detonating cord.**
ALWAYS **Make tight connections, following manufacture's directions.**
ALWAYS **Attach detonators to detonating cord with tape or methods recommended by the manufacturer.**
ALWAYS **Point the detonators toward the direction of detonation.**

ALWAYS **Attach the cord initiating detonator at least six inches from the cut end of the detonating cord.**
ALWAYS **Use a suitable booster to initiate wet detonating cord.**
ALWAYS **Use surface delay connectors designed for use with detonating cord.**
NEVER Make loops, kinks, sharp angles in the cord, which might direct the cord back toward the oncoming line of detonation.
NEVER Damage detonating cord prior to firing.
NEVER Attach detonators for initiating the blast to detonating cord until the blast area has been cleared and secured for the blast.
NEVER use damaged detonating cord.
NEVER cut detonating cord with devices such as scissors, pliers type cutters, cap crimpers, or similar instruments.

Detonating Cord

Standard detonating cords commonly consist of a core of PETN (Pentaerythritoltetranitrate) encased in various textile wrappings and waterproofing compounds for the purpose of either:

1) Direct initiation of high explosives at any one point along its length and;

2) Propagation of the detonation wave from one detonating cord to another or;

3) Propagation of the detonation wave of the detonating cord to a non-electric delay detonator, by transmission of the detonation wave in the core.

The various textile wrappings and waterproofing compounds that encase the core are intended to:

1) Provide protection of the core from abrasion.

2) Provide a reasonable working tensile strength.

3) Resist side penetration of contaminating fluids.

4) Enhance knot-tying characteristics while maintaining flexibility.

Therefore, any procedure that may damage the protective encasement of the core, or permitting contaminating fluid to reach the core, will result in erratic performances.

DESCRIPTION AND APPLICATION OF DETONATING CORD

Type of Cord

1. Fineline, 10 grain, 100 lb. tensile strength, magenta in color.

General Applications: Recommended for use as a downline when used with a specially designed Austin Powder cast booster.

2. Lite Line, 15 grain, 230 lb. tensile strength, pink in color.

General Applications: Downline or upline under all but the most severe conditions.

3. Scotch Cord, 18 grain, 230 lb. tensile strength, orange in color.

General Applications: Surface trunklines, secondary blasting and down lines in shallow small diameter holes.

4. "A" Cord, 25 grain, 230 lb. tensile strength, green in color.

General Applications: Small, medium and large hole down lines and trunklines, secondary blasting and one hole blasting underground.

5. 50 Reinforced, 50 grain, 250 lb. tensile strength, yellow in color.

General Applications: Excellent general purpose cord for reliable blasting initiation under virtually all conditions.

6. Heavy Duty, 100, 150, and 200 grain. 100 grain has 200 lb. tensile strength and is orange in color, 150 grain has 275 lb. tensile strength and is purple in color, and 200 grain has 275 lb. tensile strength and is red in color.

General Applications: Constructed for severe service to meet a wide range of specialized applications such as presplit or dimensional stone.

7. Slide Line, different core loads available, 15 grain through 50 grain General Applications: For use with bulk loaded blends and emulsions.

Selection of Detonating Cord

1. Type of explosives being used (example, whether using ANFO, Emulsions or High Explosives)

2. Hole Diameter (example, if using detonating cord in small diameter holes in the lowest core load is preferred.

3. Using cord as trunkline, things to consider:

   A. Locations (example, if you are close to a dwelling or other structures where airblast or noise is a problem, you should use a lower core load detonating cord and cover it with at least 6" of dirt or sand.

   B. Avoid using sharp angles such as 10^0.

   C. Avoid kinks in the trunkline or downlink.

4. Using detonating cord with NDS (Non-Electric Delay Slider).

A low core load of 15 gr/ft to 25 gr/ft is a must when using NDS, because if you use a 50 grain cord, you will destroy the delay element attached to the booster.

5. Slide Line - Slide Line is detonating cord without the woven outer layer. It is used when using bulk emulsions or blends, because of the build-up of product along the cord length prohibiting the NDS booster from easily sliding down the cord.

6. When tying detonating cord to down lines or trunklines, make sure the knots are snug to the cord for detonation. A square knot will do fine in splicing.

7. When hooking a detonator to detonating cord, a few things must be considered:

1. The detonator must be attached pointing in the direction of detonation.

2. The detonator should be attached several inches from the end of the cord because of PETN leakage from the core. If the cord is wet at the end, the PETN will not perfor

Firing with Detonating Cord

Detonating cord is a flexible cord containing a center core of a high velocity, detonator-sensitive explosive, usually PETN, which is used to:

- Detonate other high explosives with which it comes in contact.
- Transmit a detonation wave from one detonating cord to another or to a non-electric delay detonator.

Other core loadings, such as RDX and HMX are used in cords designed for specialized uses, such as in oil wells or other hot environments. If such applications arise, contact the cord manufacturer for recommendations.

The number of grains of explosive per linear foot and the type and thickness of countering (coverings or wrappings) determine the cord's priming ability. With this product, the term "50 grain" used in relation to cord means "50 grains per linear foot of cord." The various combinations of textile and plastic wrappings provide the cord's tensile strength, tie-in characteristics, and abrasion and water resistance.

Although PETN detonating cords are sensitive enough to be initiated by all strengths of commercial detonators, they are relatively resistant to accidental detonation from impact, shock, friction, or extraneous electricity.

The most widely used detonating cords have 15 to 50 grains of PETN per foot (3.2 – 10.6 g/m) of cord. All cords detonate at approximately 23,000 fps (7,000

m/s). Their explosives initiating energy varies with the core load. In all cases, they will initiate nitroglycerin-based explosives and many other detonator-sensitive products. Some products may not be initiated, but might be dead pressed or otherwise damaged by the energy output of cord. Consult with the explosive manufacturer as to which products can safely be used with detonating cord. Detonating cord initiation is particularly well suited for:

- Operators who prefer a non-electric blasting system because potentially hazardous stray currents may be present.
- Firing multiple charges of explosives without significant delay between charges (e.g., as done in preshear blasting).
- Multiple priming or decking in deep, large-diameter boreholes.
- Coyote blasting or for large blasts to fracture low-grade ore bodies for in situ leaching.
- Initiating chute-blasting charges in underground mines.
- Submarine blasting where it is difficult to insulate electrical connections.
- Firing a single down line to initiate multiple non-electric delay detonators for each explosive deck.

Fumes

The reaction product gases resulting from the detonation of commercial explosives and blasting agents consist principally of carbon dioxide, nitrogen, and water vapor (steam). Admixed with air these are, in the ordinary sense nontoxic. However, poisonous gases, including carbon monoxide and nitrogen oxides, are also present in some small concentration in the detonation reaction products from all real explosives. In the explosives industry these toxic gases are called fumes. The toxic gas components, carbon monoxide and nitrogen oxides are sometimes referred to jointly as noxious gas. Fumes should not be confused with smoke, which is composed mainly of steam and the solid products of combustion or detonation. Although smoke is nontoxic, excessive exposure to smoke, especially that produced by dynamite, can cause severe headaches and should be avoided. The headache may be the result of small particles of unreacted or partially reacted nitroglycerin/nitro glycol in the smoke. Both the nature and the total quantity of poisonous gases and smoke vary between types of explosives. For example, the detonation of emulsion explosives or water gels may produce significantly less smoke than dynamite. Fumes may also vary according to conditions of use. Anything that tends to cool the gases quickly increases the formation of oxides of nitrogen.

In open blasting, fumes cause little concern if they can be quickly dispersed by air movement, but in underground work the type and amount of explosive, the conditions, ventilation, and other factors should be considered.

Where fumes can be a problem, properly formulated and manufactured explosives and basting agents will give minimum quantities of toxic gases.

However, it must be recognized that some carbon monoxide and some oxides of nitrogen will result from every detonation of an explosive or blasting agent and that conditions of use can drastically shift the types of gases produced.

Some factors that increase fumes are poor product formulation, inadequate priming, insufficient water resistance, lack of confinement, reactivity of the product with the rock or other material being blasted, and incomplete product reaction. Adequate waiting periods before returning to the blast area are mandatory. This is important because some toxic gases are odorless and colorless. Absence of post blast smoke is no guarantee that hazardous levels of toxic gases are not still present. Never return to an area before ventilation has cleared the fumes from the area.

IME Fume Classification

A classification indicating the amount of poisonous or toxic gases produced by an explosive or blasting agent. The IME Fume Classification is expressed as follows:

Fume Class	Cubic Feet of Poisonous Gases Per (1 ¼" x 8") Cartridge of Explosive Material
1	Less than 0.16
2	0.16 – 0.33
3	0.33 – 0.67

Note: The U.S. Bureau of Mines limits poisonous or toxic gases to 2.5 cu ft per pound of permissible explosive

For the purpose of fume classification, only poisonous or toxic gases, such as carbon monoxide, hydrogen sulfide, and nitrogen oxides are considered.

Category of gases

Noxious: Asphyxiant due to lack of oxygen

Toxic: Poisonous - short term exposure

Physics of gases

Specific Gravity / Vapor Density: The weight of a ratio of a specific gas compared to the same ratio of air. (Air = 1.000)

Temperature: Cold gases will diffuse slowly - hot gases will diffuse quickly

Barometric Pressure: The lower the pressure, the faster a gas will diffuse.

Solubility: The ability to dissolve in water (taste and / or smell)

Exposure Limits

Threshold Limit Value (TLV): The amount of a gas exposure for an 8-hour day for 5 days a week without any harmful effects.

Ceiling Limits: The amount of gas at no time a person can be exposed to..

Immediately dangerous to life or health (IDLH): The maximum concentration of a gas, incase of SCBA failure, one could escape without any irreversible health effects.

Measurement of Gases

Parts Per Million (PPM): The most accurate measurement of a contaminant in the atmosphere.

PERCENT	PPM
1.0	10,000
.1	1,000
.01	100
.001	10
.0001	1

MINE GASES & THEIR COMPONENTS

Air:

Chemical Formula: None
Specific Gravity: 1.00
Source: Atmosphere
Characteristics: No color, odor, or taste

Pure dry air at sea level contains the following:

Oxygen	20.94 %
Nitrogen	78.09 %
Argon	0.94 %
Carbon Dioxide	0.03 %

Oxygen:

Chemical Formula: O_2
Specific Gravity: 1.105
Source: Atmosphere
Characteristics: No color, odor, or taste, Oxygen will not burn or explode.

Note: When another gas is introduced into the atmosphere of artificial environment, such as a mine, tunnel or manholes, oxygen is usually displaced causing asphyxiation.
Health Effects:

CONCENTRATION (%)	PHYSIOLOGICAL EFFECT
21 %	Breathing easiest
19.5 %	Minimum required by law
17 %	Breathing faster and deeper, possible impaired judgment
16.25 %	First signs of anoxia or hypoxia occur
15 %	Dizziness, buzzing in ears, headache, blurred vision, rapid breathing
12 % to 16 %	Rapid breathing and pulse, impaired muscular coordination
10 % to 12 %	Emotional upset and abnormal fatigue on exertion
6 % to 10 %	Nausea and vomiting, inability to move, unconsciousness
< 6 %	Convulsive movements, gasping respiration, breathing ceases, cardiac arrest occurs

CARBON MONOXIDE

Chemical Formula: (CO)
Specific Gravity: 0.967
Source: Carbon monoxide results from incomplete combustion of organic carbon-based materials. It is also an after-product of detonated explosives and diesel engines. Carbon monoxide is highly toxic to the body. When inhaled, CO quickly bonds with the body's hemoglobin, thus reducing the blood's ability to carry oxygen throughout the body.

Characteristics: Flammable, Colorless, Tasteless, Odorless, Lighter than air.
Ignition Temperature: 1100°
Explosive Range: 12.5 % to 74 %
Limits: TLV – 50 PPM
Ceiling – 200 PPM
IDLH – 1500 PPM

Health Effects:

CONCENTRATION (PPM)	PHYSIOLOGICAL EFFECT
200	Slight headache, tiredness, dizziness, and nausea after 2 to 3 hrs.
400	Frontal headache within 1 to 2 hrs, life threatening after 3 hrs.
800	Dizziness, nausea and convulsions within 45 minutes. Unconsciousness within 2 hours. Death in 2 to 3 hours.
1,600	Headache, dizziness, nausea within 20 minutes. Death within 1 hour.
3,200	Headache, dizziness, and nausea within 5 to 10 minutes. Death within 30 minutes.
6,400	Headache, dizziness, and nausea within 1 to 2 minutes. Death within 10 to 15 minutes.

NITROGEN

Chemical Formula: (N_2)
Specific Gravity: 0.967
Source: Nitrogen composes 78.09 % of the atmosphere. It is a non-flammable gas.
Characteristics: Colorless, Odorless, Tasteless, Non-flammable, Lighter than air.
Limits: Ceiling – 810,000 PPM

NITROGEN DIOXIDE

Chemical Formula: (NO_2)
Specific Gravity: 1.44
Source: Nitrogen dioxide is an extremely toxic gas to the human body. It is produced from the detonation of explosives and it is found in diesel exhaust. It is a non-flammable gas that is heavier than air. In high concentrations, nitrogen dioxide forms nitric acid in the lungs causing pulmonary edema.

Characteristics: Reddish-brown color in high concentrations, Acrid or "bleach" odor, Non-flammable, Heavier than air.

Limits: TLV – 1 PPM
Ceiling – 3 PPM
IDLH – 50 PPM

Health Effects:

CONCENTRATION (PPM)	PHYSIOLOGICAL EFFECT
1 to 13	Irritation of nose and throat
10 to 20	Mild irritation of eyes, nose and upper respiratory tract
80	Tightness in chest after 3 to 5 minutes
90	Pulmonary edema after 30 minutes

HYDROGEN SULFIDE

Chemical Formula: (H_2S)
Specific Gravity: 1.191
Source: Hydrogen sulfide is an extremely toxic gas. It blocks the use of oxygen by the body's cells. It is produced when sulfur compounds decompose. It is commonly associated with acid mine water. This gas is released whenever a mine pool is agitated. Can be produced in mine fires should sulfide ores be present.

Characteristics: Colorless, Sweet taste, Odor similar to rotten eggs at very low concentrations (0.003 PPM), Extremely flammable, heavier than air, highly soluble.
Ignition Temperature: 700°
Explosive Range: 4.3 % to 46 %
Limits: TLV – 10 PPM
Ceiling 15 PPM
IDLH 300 PPM

Health Effects:

CONCENTRATION (PPM)	PHYSIOLOGICAL EFFECT
10	Obvious and unpleasant odor (rotten eggs)
50	Mild conjunctivitis, respiratory tract irritation in 30 to 60 minutes
100	Kills sense of smell in 3 to 5 minutes, may sting eyes and throat
200	Stings eyes and throat
250	Exposure for 1 hour is the Hazardous Limit concentration which may cause death
300	Immediately dangerous to life
500	Dizziness, coughing, breathing ceases within minutes, artificial respiration required
600	May cause death within 2 minutes
700	Unconscious quickly, death if not rescued immediately
1000	Unconscious instantly, breathing ceased, death within a few breaths. Death may occur even if rescued immediately.

SULFUR DIOXIDE

Chemical Formula: (SO_2)
Specific Gravity: 2.264
Source: Sulfur dioxide is produced when iron pyrite burns in gob fires or by blasting sulfide ores. It is also found in diesel exhaust. Sulfur dioxide has the same effect on the body as nitrogen dioxide, except that sulfuric acid is created in the lungs. It is a non-flammable gas.

Characteristics: Colorless, Heavy sulfur odor, Acidic taste, Heavier than air, Non-flammable.
Limits: TLV – 5 PPM
Ceiling – 10 PPM
IDLH – 100 PPM

Health Effects:

CONCENTRATION (PPM)	PHYSIOLOGICAL EFFECT
0.3 to 1	Detectable by taste rather than odor
3 to 5	Detectable odor
10	Maximum concentration allowable for prolonged exposure
20	Least amount causing coughing and irritation of eyes
50	Irritation to eyes, lungs, throat
50 to 100	Maximum concentration for short exposure (30 to 60 minutes)
150	May be endured for several minutes. Extremely disagreeable
400 to 500	Life threatening

CARBON DIOXIDE

Chemical Formula: (CO_2)
Specific Gravity: 1.529
Source: Carbon Dioxide is a natural component of air at approximately 0.03 %. It is also a key component of Black Damp, caused by biological oxidation such as rotting mine timbers. Increased concentrations of carbon dioxide replace the oxygen content of the mine air thus producing a toxic atmosphere.

Characteristics: Colorless, Odorless, Heavier than air, Acidic taste at high concentrations.
Health Effects: At 5 %, stimulated respiration
At 7 % to 10 %, unconsciousness after few minutes of exposure.

Limits: Ceiling – 1.5 %
IDLH – 50,000 PPM

METHANE

Chemical Formula: CH_4
Specific Gravity: 0.555
Source: Carbon products decaying in anoxic environment.
Characteristics: No color, odor or taste. Needs 12.5 % O_2 to ignite.
Ignition Temperature: 1100° -1300° F
Explosive Range: 5 – 15 %

HYDROGEN

Chemical Formula: (H_2)
Specific Gravity: 0.0695
Source: Hydrogen is an extremely explosive gas that is commonly found in battery charging stations. It can also be created when water is applied to super hot mine fires or from the incomplete combustion in explosions. Adding strong acids to iron or steel can also release hydrogen into the atmosphere.

Characteristics: Colorless, Odorless, Tasteless, Flammable, Lighter than air, Explosive when exposed to heat or flame, Needs 5 % oxygen to ignite.
Ignition Temperature: 1030° - 1130° F
Explosive Range: 4.1 % - 74 %
Health Effects: Asphyxiant at high concentrations

Reference

Hopler, Robert A. *Blasters' Handbood,* 17th Edition, published 1998 Second Printing 2000.

Safety Library Publications, Institute of Makers of Explosives, Vols. 1-22, (August 1993).

Morhard, Robert C., 1954, Explosives and Rock Blasting (copyright 1987 by Atlas Powder Company).

Code of Federal Regulations, Parts 1- 199, (July 1, 2001)

Internet Citations

U.S. Department of Labor, Mine Safety and Health Administration: http://www.msha.gov/regdata/CFRINTRO.HTM

Pennsylvania Department of Environmental Protection, Bureau of Mine Safety: http://www.dep.state.pa.us/dep/deputate/minres/dms/website/laws/mininglaw.htm

U.S. Department of Justice, Bureau of Alcohol, Tobacco, Firearms, and Explosives: http://www.atf.gov

United States Mine Rescue Association: http://usmra.com/popquiz.htm

Pennsylvania Department of Environmental Protection, Bureau of Mining and Reclamation: http://www.dep.state.pa.us/dep/deputate/minres/districts/Blasting/training.htm

NIOSH National Institute of Occupational Health and Safety: http://www.cdc.gov/niosh/mining/comp2000/tffb.html