A SAFE PRACTICES MANUAL FOR THE MANUFACTURING, TRANSPORTATION, STORAGE AND USE OF EXPLOSIVES

James B. Willis
Patricia D. Taylor
Sally W. Snyder
Rafael V. Lopez
Pamela H. Errico

Tracor Jitco, Inc.
1776 E. Jefferson St.
Rockville, Maryland 20852

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U.S. Department of Health, Education, and Welfare
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Safety Research
Morgantown, West Virginia 26505

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Federal regulatory authority for control of non-military explosives is fragmented. This has led to confusion in the control of the use of such explosives.

This manual describes the existing regulations, consensus standards and professional recommendations used to provide guidance in safe practices for supervisors and employees. The hazards are stated and work practices described to protect workers in manufacturing, mixing, transporting, storing, and using explosives.

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NIOSH Project Officer: John A. Gerard

Tracor Jitco Project Manager: Pamela H. Errico

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ABSTRACT

Federal regulatory authority for control of non-military explosives is fragmented. This has led to confusion in the control of the use of such explosives.

Reported in this manual are the existing promulgated regulations, consensus standards and professional recommendations to provide guidance in safe practices for supervisors and employees. The hazards are stated and work practices described to protect workers in manufacturing, mixing, transporting, storing, and using explosives.

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INTRODUCTION

According to du Pont, 7 million pounds of explosives are used everyday.* They are used in tunneling, construction, road-building, agriculture, mining, forestry, firefighting, well-drilling, pipeline construction, harbor clearing, foundation excavating, and building demolition; these are only a few of the uses. The accident record has been relatively good (in 1974 there were 24 blasting materials associated deaths; in 1975, there were 17), but explosives are often handled, moved and set by inexperienced persons.

Since federal regulatory authority is fragmented, we have gathered existing promulgated regulations, consensus standards and professional recommendations and combined them to provide guidance in safe practices for supervisors and employees. We have stated the hazards and provided for the protection of workers in manufacturing, mixing, storing, transporting, and using of explosives.

*E. I. du Pont de Nemours & Company, Inc. 1977. Blaster's Handbook. Explosives Products Division, Wilmington, Delware 19898.

HANDLING RAW MATERIALS

A significant hazard in the explosives industry is presented by raw materials. Because these chemicals are not explosives per se, there is often a tendency to regard them as nonhazardous materials. Many of these chemicals are highly flammable and will, in fact, explode under certain conditions. In addition, since these chemicals are often used in bulk operations there is a significant potential for toxic hazards. Appendix A is a compilation of chemicals frequently used by the explosives industry. Short discussions of the combustion hazards (i. e., flammability, explosibility), toxic hazards (especially symptoms of poisoning), precautions to be taken in the handling and storage of the material, hygienic precautions to be taken when handling the material, (including immediate first aid procedures in case of contact), fire precautions (fire prevention and firefighting techniques), and proper procedures for cleaning up spills or leaks are included under the specific raw material.

While the best safety procedure is accident prevention, it is imperative to have well designed first aid and firefighting programs. The first few minutes after an accident occurs are the most important in terms of lives saved and reduced material loss.

MANUFACTURE

The manufacture of explosives and blasting agents presents many potentially hazardous situations. The dangerous materials are not only mixed, but are also packaged, transported and stored within the manufacturing plant. The materials come into contact not only with moving equipment but with the workers. This contact provides many opportunities for accidental explosions. The handling of explosive materials necessitates that special precautions be taken to ensure safe operations. These precautions include careful site selection, proper construction of plant buildings, installation and maintenance of applicable equipment, and instruction of the workers in the safe handling of materials.

SAFETY OFFICE

The most important step toward insuring safe practices within a plant is the creation of a Safety Office. It is the responsibility of the Safety Office to assure that every facet of operations is run as safely as possible. The Safety Office not only develops company safety policy, but also sees that it is followed. This effort begins with the instruction of every employee about the dangers inherent on the job. All employees, including maintenance and clerical workers, should be given this instruction, since all employees may encounter hazardous situations. These classes should be repeated at regular intervals to assure continued compliance with safe practices. Enforcement of this safety policy does not come directly from the Safety Office. Rather, the Safety Office coordinates the efforts through supervisors. In this way, the working habits of each employee can be closely monitored and unsafe practices can be corrected. Although accidents cannot be prevented every time, it is the responsibility of the Safety Office to see that they are minimized.

SITE SELECTION

Buildings in which explosives are manufactured should be separated from each other, and from other inhabited buildings, highways, railways, and magazines. This separation must be great enough to protect against loss of life or injury, major structural damage to buildings, and propagation of detonation to nearby explosive materials. Within the explosives manufacturing plant, all buildings in an operating line, including storage magazines, should be separated by the "intraline distance." This distance will protect against propagation of explosion due to blast effects, though not against propagation due to fragments, but offers little protection against structural damage to surrounding buildings. Therefore, buildings should be even further separated, if possible. The minimum allowable distance is computed according to the amount of explosives contained in each building, as shown in Appendix B, Table B-1.

These operating buildings should also be separated from public highways, railways and buildings. The separation from inhabited buildings should be great enough to offer a high degree of protection to frame and masonry buildings from structural damage. At these distances, building inhabitants will be greatly protected against death or serious injury. These separations do not protect against damage to glass or injury from broken glass, so, as reommended for intraline distances, larger separations than those listed in Appendix B, Table B-2, will provide more protection. Separation from highays and railways should be 60 percent of the inhabited building distance for the amount of explosives present.

BARRICADES

Proper barricades, in addition to the required separation distances, will decrease the likelihood of structural damage and personal injury due to accidental detonation. Their main function, however, is to prevent propagation of an explosion to nearby buildings. In many cases, restrictions on quantity and distance can be lessened by the use of barricades.

Whenever possible, natural barricades such as hills and valleys can be advantageously used. When these are not available, artificial barricades should be constructed. Artificial barricades are made of earth with little or no organic matter that may break down with time and no large rocks that may become dangerous missiles due to the force of an explosion. These barricades may be unsupported earth mounds with natural slopes or may be revetted (supported by wood or concrete walls) on one or both sides. If a barricade is double revetted, it should be anchored properly so that the force of an explosion will not merely push it over. Barricades should be:

- At least 3 feet wide at the top,
- Tall enough so that imaginary lines drawn from the eaves of the buildings they screen to the eaves of nearby buildings or to a point 12 feet above roads or railways will pass through the barricade,
- As close as possible to the buildings they screen, but not less than 4 feet away,
- Inspected at frequent intervals to ensure that they remain in good condition.

ROADWAYS

Good all weather roads should be provided among the buildings. If a road is to be used for access to a group of production buildings or magazines, it should be constructed without dead ends. The interconnecting roads to prevent dead ends need not be hard surfaced, but should be passable by the types of vehicles expected to use the roads. Roads leading to only one production building or magazine may dead end at that building. The road system should be designed so that one may proceed directly to the intended destination without passing through another explosives area. All roads and walkways should be kept as free as possible of foreign matter and debris.

Roads and walkways leading to building entrances should be hard-surfaced or boardwalks. This, along with door mats and foot scrapers installed at each entrance, will help prevent rocks and mud from being tracked into the buildings.

All walkways between buildings which are to be used for transportation of explosive materials should have steeply sloping roofs that hang over the walkway edge enough to afford protection from the weather. It is inadvisable to construct these walkways with side walls. Covered passageways should have walls with abrupt changes in direction, sections built of weak materials, or open areas to vent an explosion and prevent propagation. Fire stops, of course, should be included in all passageways to prevent the possible spread of fire from one building to the other.

Tunnels between buildings should also be designed to avoid propagation of any explosion. They should:

- o Be well ventilated,
- o Be well lit, and
- o Have at least two exits.

Only personnel required to enter the tunnels should be allowed to do so.

BUILDING DESIGN AND CONSTRUCTION

Exterior

The construction of buildings containing explosives is very important to worker safety. The buildings should have no basements and should be one story tall unless the equipment to be installed necessitates constructing a taller building. Exterior wall and roof surfaces should be noncombustible, however avoid using bricks, cinder block or corrugated metal as they can produce extremely dangerous missiles.

Any room or building in which more than 50 pounds of explosives will be present at any time should have at least one explosion-relief wall. This wall should be constructed so that it will pose the least hazard to nearby buildings.

If explosive venting is necessary, one square foot of venting should be provided for each 35 cubic feet of room or building space. The roof and all walls that are not specifically designed for the purpose of worker protection should be constructed of materials as light in weight as is feasible so they will vent an explosion inside the building and form as few large missiles as possible. The safest construction plan and the one generally used is 3 strong walls, 1 weak wall and a weak roof. In a building having several rooms, this is accomplished by the use of internal substantial dividing walls. These internal strong walls consist of one central wall running the length of the building having walls to separate the individual rooms branching off of this central wall. There are absolutely no openings

of any kind in these walls. Entrance to each room is from the outside of the building only. Since these walls, by their nature and depending on their strength, prevent or delay propagation of an explosion, the amount of explosive materials within a building can be split to comply with the appropriate quantity-distance table.

Interior

All interior surfaces should be smooth with no cracks or crevices in which explosive materials may accumulate. The use of porous material for surfaces is not recommended and, if necessary, a coating or sealing should be applied to prevent absorption of the explosives and to ensure thorough cleaning. This coating or sealing should not react with any of the materials used in the explosives manufacturing process. All surfaces including floors, walls and work surfaces should be painted a color on which spills and dust can be easily seen. The paint, also, should be compatible with the materials that will be present in the area, and should be easy to clean and able to withstand repeated washings. To avoid accumulation of dust all ledges should be beveled and all pipes should be sealed at their joints and where they enter and exit machinery, rooms or buildings.

All fasteners, such as nuts and bolts, should be non-sparking. Metallic fasteners should not be used. All fasteners must be mechanically bonded so that they will not be loosened by vibration and become a hazard, possibly falling into the explosive materials being processed. An example of mechanical bonding is a leather thong threaded through a hole drilled through the center of a bolt and tied to hold the bolt in place. Nails, bolts, or screws exposed on a work surface should be countersunk.

Non-sparking floors and work surfaces should be installed. In areas where static-sensitive explosives or volatile solvents will be present, conductive or semiconductive floors and work benches should be installed. The floors should be made of lead, conductive rubber or some other conductive flooring material that, when grounded, would dissipate static electricity as it is generated. In areas where the hazard is localized, conductive runners or mats may be used in place of an entire flooring. However, the greatest amount of protection from static sparking is provided when all flooring in a building has the same resistance.

Exits

The floor plans should leave plenty of room for adequate aisle space and include enough exits. All areas should be designed with at least 2 exits separated by at least one fifth the perimeter of the room or building. If the area is 100 square feet or less and 2 or fewer workers are present and working less than 12 feet from an exit, then only one exit will be sufficient. As many as eight persons may work in a room or building having two exits; an additional exit should be provided for each five additional workers or portion of five. Exits should be at least 78 inches high and 30 inches wide; each additional 30 inches of width is considered as another exit. The exits should open to the outside of the building rather than into another room or hallway. All exits in fire walls should be equipped with

self-closing fire doors which open outward. Panic hardware should be used on the doors which will open with the use of less than 15 pounds of force.

If an exit door is more than four feet from the ground, it should open onto a platform. Descent from the platform may be by way of stairway, ramp, or safety chute. Safety chutes are to be used wherever rapid departure from a building may be vital and other methods of descent are not fast enough. The chutes are used properly by running, not sliding, down the length of the chute. These chutes should begin at the outside edge of a three feet square platform having guardrails. If needed, a horizontal length of chute can be provided at the bottom to prevent worker injury. Escape routes from the chutes should be free of obstructions that may hamper or prevent rapid departure. For recommended safety chute specifications see the Army Materiel Command Safety Manual, AMCR 385-100.

If conventional exterior fire escapes are provided, they should be constructed of non-combustible materials and they should not extend across any windows or doorways where a vented explosion could injure an escaping worker.

Whether inside or outside a building, stairways more than 3 risers tall should have handrails. Landings should be provided not less than 12 feet apart within particularly long stairways. Spiral staircases should not be used. Stairs should be used for any rise between 20° and 50°. For a rise of less than 20°, a ramp can be used.

Fixed ladders are adequate for a rise between 50° and 90°. These ladders should be constructed of steel, although wood may be used where there is no danger of absorption of explosive materials into the wood. If the ladder is more than 20 feet high, a cage or basket guard should be provided to prevent falling. Handrails should be provided for ladders as well as stairways and, if needed, landings must be not more than 16 feet apart.

Windows

The number of windows in buildings facing possible explosion sites should be kept to a minimum, as should their size. Shatter-resistant plastic glazing and wire mesh screening should be used to reduce the hazard due to broken glass from these windows. Buildings in which the explosion hazard is mild should be equipped with large windows to vent any possible explosion. Skylights should never be installed in any building in an explosives plant.

Sanitary Facilities

If workers must change from street clothes to uniforms, change rooms with showers, wash basins, toilets and lockers large enough to hold street clothes and personal effects should be provided. Additional sanitary facilities may be necessary depending on local requirements.

Laundries may also be required for cleaning the uniforms. Prior to washing, safe storage should be provided for uniforms and rags contaminated with explosive materials. The compatibility of the contaminating explosives should

be known before mixing the uniforms in the washing machines. Sumps should be installed to trap the explosives in the wash. If a commercial laundry is employed to wash uniforms, they should be informed of the hazard.

Work Stations

Individual work stations for less than one pound of explosives should be separated by distance and/or barrier so that a fire or explosion at one station will not propagate to material at adjacent stations. If one or more pounds of explosive materials are being processed and the type of material and processing warrants, there should be shield walls built between the workers and the explosive materials or devices at the work stations. These shields should be constructed as follows:

- If 1 to 15 pounds of explosives are to be used, build the shield wall of concrete at least one foot thick. Reinforce the wall with rods, at least 1/2 inch in diameter, placed not more than 12 inches apart both horizontally and vertically. Stagger these rods on opposite faces of the wall. Mild steel may be substituted for the reinforced concrete; one inch of steel is equivalent to one foot of the concrete.

- If more than 15 pounds of explosives are to be processed, design the shield wall to protect against the force of at least a 25 percent overload above the maximum expected charge. If this wall becomes so large as to be impractical because a large amount of explosives are present, the operation should be performed by remote control or from behind a shelter built to withstand the blast from 4 times the maximum amount of explosives expected to be present at any time.

If necessary, the processing equipment should be separated by the distances shown in the table of intraline separations, Appendix B, Table B-1. The operations should be performed by remote control or from behind adequate barricades.

Electrical

The electrical equipment and wiring used should fulfill the minimum requirements of the National Electrical Code. Only equipment approved by the Underwriters' Laboratories or other recognized testing agencies should be used.

Whenever possible, electrical equipment should be located in areas which are less hazardous or nonhazardous. Electric motors should be installed outside of the hazardous room or building with no interconnection except through mechanical glands or other apertures properly sealed to prevent the entry of hazardous materials into the motor or the surrounding area. Those electrical motors which must be installed in hazardous areas should be designed so as to be explosion proof: completely surrounded by shielding which can withstand an explosion inside the shielding and prevent propagation of that explosion to the vapors or particles in the outside atmosphere. When operating, this equipment should not reach an external temperature high

enough to ignite the surrounding atmosphere. In addition, the hazardous atmospheres themselves can be made less hazardous by adequate ventilation from a source of uncontaminated air. Controls for the electrical motors, safety switches and circuit breakers should be installed either on the outside walls of buildings containing hazardous areas or in separate buildings connected only by properly sealed electrical conduits.

In no case should overhead power transmission lines be run closer to a hazardous building than a distance of 50 feet. Overhead lines to buildings containing explosives should be run underground for at least the last 50 feet, although this is not necessary for inert buildings. Lightning arrestors should be installed to protect electrical services entering the buildings. The wiring for the entire explosives area should be designed so that the primary electrical supply can be cut off by one or more switches located away from the hazardous area. If the lack of power supply to certain operations could cause fire or explosion, alternate sources of power to these operations should be provided.

Installation of lighting fixtures, wiring or panel boards in areas where explosive dusts or flammable vapors are present should be avoided. To light the interior of a building or room from the outside, the fixtures should be positioned so that the light will shine through approved transparent panels set in the walls of the hazardous area. When this is highly impractical, only that lighting equipment approved for use in the appropriate class of hazardous location should be installed. These fixtures should not have an external temperature higher than 228°F (109°C) when operating at a room temperature of 80.6°F (27°C). Fixtures with no horizontal flat surfaces which could collect explosive dust should be installed. The lens should be clamped to the fixture body by means of a ring having no external bolts.

Lightning Protection

Lightning protection should be installed on all permanent buildings and structures containing explosive materials. All lightning protection equipment should be approved by the Underwriters' Laboratories (UL) or another recognized testing agency. The basic equipment consists of air terminals, ridge cables, down conductors, ground connections, and grounds. These should be connected electrically along the shortest path practicable to ground while avoiding contact with any nonconducting parts of the building or structure. The purpose of the air terminals is to intercept lightning a safe distance above flammable and vulnerable parts of buildings. Therefore the greater the likelihood of fire or explosion, the higher the top of the air terminals should be. Braces should be provided to secure every air terminal and each air terminal should be provided with more than one path to ground when possible. Every air terminal should be electrically connected to the ridge cable or roof conductor. Metal structures on the roof (ventilators, smoke stacks, etc.) should be made electrically continuous with the lightning protection system. If practicable, individual air terminals should be mounted on these metal projections. All metal doors, gutters, windows, etc. should also be electrically continuous with the system. If the roof and walls of a building are metal and electrically continuous, no ridge cables or down conductors are necessary. But down conductors should be installed at the

corners of buildings and wherever else necessary to avoid "dead ends" in the ridge cables, especially on T-, L-, or H-shaped buildings. If the possibility of mechanical damage is present, the down conductors should be protected and they should be connected to ground making certain that these connections, also, are electrically continuous. Large underground metallic objects and metal water pipes are the best ground connections. Consistently damp areas are also preferable, except those that are wet because of waste water containing chemicals, especially chemicals which may corrode metal. Grounds connections should, in turn, be electrically continuous with the grounding electrodes. The grounds should be positioned uniformly around each building or structure. The type and size of the grounds will depend on the local soil condition. Underground water pipes, ground plates, wells, etc., may be used in addition to the grounding electrodes.

Lightning protection may also be provided by a grounded mast which is not connected to any building or structure. If the mast is not constructed of a conductive material, an air terminal and down conductor should be used. The mast type of protection establishes a "cone of protection." The height of this cone is the height of the mast; the radius of the base is equal to twice the height of the mast. The mast should be positioned so that all parts of the structure(s) to be protected are within the "cone." However, the mast should not be closer to the structure(s) than one third the height of the structure(s), the smallest distance being six feet. If desired, two or more poles connected by overhead conductors can be used to form a zone of protection in the shape of a triangular prism with a rectangular base 4 times as wide as the height of the poles. Each pole should be located six feet from structures or the distance of one third the height of the structures, whichever is greater.

In addition to buildings, lightning protection may also be necessary for fences, tanks, and stacks. The same basic principles described above apply here also. For further details, see the Army Materiel Command Safety Manual.

Heating and Steam

Buildings should be heated or cooled by use of steam, water, other indirect means or electrical units. Heating or cooling units powered by combustion should never be used as incandescent particles from the fires may ignite explosives materials. Floor registers should never be installed as explosives may accumulate there and pose a hazard. The registers themselves may also be dangerous and cause employees to trip or fall. Steam used for heating may have a maximum pressure of 5 psi and temperature of 228°F. Steam used for processing explosives may have a maximum pressure of 15 psi. The exterior of pipes carrying the steam or hot water must be no hotter than 160°F. If the temperature of the steam must exceed 228°F, the pipes should be further protected against contact with explosives. If necessary, the steam pipes should be grounded where they enter the buildings.

Ventilation

If dust collection systems are used, they should be electrically powered and grounded to a maximum resistance of 5 ohms. Adequate filters to protect the

equipment should be assured so that no explosive dust enters the vacuum pump or exhauster. The collection system should be planned with no sharp turns, pockets or dead ends where dust could accumulate and pose a hazard. Exhausting this explosive dust into the atmosphere should not be allowed; collection chambers should be used instead. These chambers should be located away from working areas unless adequate barriers are provided to protect workers if an explosion in the dust collector should occur. When sensitive explosive dusts are being collected, they should be moistened with a compatible wetting agent immediately upon entry into the system and should remain wet until they are removed from the collector.

No more than 2 rooms may share a common connection to a vacuum collection chamber. If 2 rooms do share a connection, some way should be devised to prevent carrying fire or an explosion from one room to the other via the shared connection. The collection chambers should be emptied whenever they are nearly full, and the whole system cleaned frequently to avoid hazardous accumulation of dust in the pipes, tubing and ducts.

Hazardous fumes, vapors and gases should also be exhausted from working areas using only non-ferrous blades for fans that will come into contact with the hazardous materials. Motors to power these fans should be located outside the ducts carrying the hazardous materials.

Liquid Waste Disposal System

All drain lines intended for explosive wastes should be provided with basins or sumps for settling of the explosive materials. These drain lines are to be separate from the normal sewage systems for inert wastes and they should be installed so that the explosives will not settle until they reach the sump. The sump should be designed so that neither the explosive materials that settle nor those that float will be carried beyond the sump in the wash waters. Collection trays for the explosive materials in the sump should be non-ferrous and should be easy to remove. Waste water exiting the sump may have to be chemically treated to degrade partly soluble explosives. Explosives which are fully soluble in water should not be allowed to enter this drainage system, they should be swept or collected by other dry collection methods.

EQUIPMENT

Tools

Single-phase electric hand tools and portable equipment should be approved by the Underwriter's Laboratories (UL) or another recognized testing agency. None of these single-phase appliances or tools may have a rating of more than 230 volts. All metallic noncurrent carrying parts should be grounded. To supply power to the equipment, hard electrical cords which are approved for extra hard usage in damp locations should be used. For the equipment that must be grounded, three-wire cord should be used, the third wire acting as a ground. Plugs for these cords should be three-pronged, the third prong carrying the ground. Under no circumstances should these cords be spliced. The cords should be long enough so that there is no tension in them when

they are connected to the equipment and to the power source. When these cords are to be used in hazardous atmospheres, the appropriate seals should be provided at points of connection with machinery or other cords. All cords, plugs, and electrical equipment should be examined for signs of wear and tested for defects at regular intervals. No appliance or equipment which seems to have a defect should be used; the equipment should be reported as defective and repaired if possible.

All of the above also applies to three-phase portable equipment. However, the voltage may exceed 230 volts and the flexible cords should have 4 wires, one of which will serve as the ground, instead of the three wires required for single-phase portable equipment.

Generators

Portable engine-driven generators are considered safe if the following precautions are taken. All non-current carrying metal parts should be grounded and the generator positioned at least 50 feet from any building containing explosives. The area between the generator and building(s) should be kept free of all debris and combustible materials. The power transmission cord should be supported and protected to prevent accidental damage to the cord and the generator and gasoline supply containers should be positioned so that spilled gasoline will flow away from buildings containing explosives. If this is impossible, a trench should be dug between the generator and the building to halt the flow of any spilled gasoline. Fire extinguishers should be readily available at all times. When it is necessary to replenish the gasoline supply, only an approved gasoline safety can equipped with a pour spout should be used; both the engine supply gas tank and the safety can should be grounded while transferring the fuel. The gasoline should be poured slowly and continuously to avoid spilling. The supply tank should not be filled to the top; at least 1/2 inch clearance should be provided. The cap on the supply tank should be securely tightened and the vapor vent on the cap opened.

Static Protection

In any area where the processing of static-sensitive explosives takes place, the relative humidity should be kept above 20 to 30 percent. Protection against the accumulation of static electricity is especially effective if the relative humidity is over 60 percent. If the relative humidity falls below 20 percent, all processing should be ceased until the relative humidity is again raised above 20 percent. If metal powders are being processed, the relative humidity should be kept between 50 and 60 percent. However, there is the hazard of spontaneous ignition of metallic powders at levels over 60 percent, so great care should be taken to keep the relative humidity under that level.

The appropriate non-sparking tools and equipment should be used near explosives. All machinery and tools should be properly grounded to prevent accumulation of static charges in buildings containing static-sensitive explosives. Grounding only the exterior parts of machinery is not enough,

however. Even if all parts of the equipment are conductive, electrical continuity can be broken by rust, paint, or lubricating oil. If needed, bonding straps should be used to make a continuous circuit past oiled joints and other non-conductive parts of equipment. Contact with conductive floors or table tops is also not enough. Each piece of equipment should be grounded. Pipes for gas, steam, air, or dry pipe sprinkler systems may not be used as grounds; neither may air terminals of lightning protection systems. However, down conductors or grounds for lightning protection may be used, as well as water pipes, ground cones, or buried copper plates.

A means should be devised to discharge the static electricity from hand trucks, buggies, and other movable equipment before entry into buildings containing static-sensitive explosives. An alternative to this is the use of conductive wheels, including metal wheels that do not spark. Only non-sparking stainless steel, wood, or beryllium tools should be used. Hydraulic or air presses and hand jacks should be equipped with pressure relief valves to avoid a build-up of pressure sufficient to detonate the material being processed. Jammed or plugged equipment should not be hit as this may also cause detonation.

WASTE DISPOSAL

The amount of explosives at each work station should be limited in accordance with the table of intraline separations, Appendix B, Table B-1. Only 4-hour supply of material or finished product should be kept at an individual work station at any time. If this proves to be a hazardous amount of explosives, the maximum allowable amount should be limited still further.

Bulk explosives should be kept in closed containers when they are not being processed and should never be stored or moved in open containers.

There should be appropriate receptacles with covers for waste materials at each work station. These receptacles should be emptied once a day or once each shift, more often if necessary. Any waste materials contaminated with explosives, including cleaning rags and empty shipping containers, should be removed daily and disposed of in the same manner as deteriorated explosives burning them in a secluded area under the direction of a competent person.

The burn site should be as far as possible from other plant buildings, public highways and inhabited buildings. This distance should be at least that shown in The American Table of Distances for Storage of Explosives, Appendix B, Table B-2. Whenever possible, the burn location should be selected so that there are barricades between the site and buildings or highways. A blasting shelter should be constructed near the burn site for emergency use and a spot for the burning pit selected, making sure that there are no cracks, crevices or large rocks in the pit area. All combustible material should be removed within a 700-foot radius from the pit and the pit located so that prevailing winds will not blow sparks toward nearby buildings. The bottom of the pit should be covered with combustible material such as excelsior or wood shavings soaked with No. 2 fuel oil. On top of this, a thin layer of the explosives to be burned should be spread.

Only one type of explosive should be burned at a time; mixing explosives increases the possibility of accidental detonation. A fuse should be used to ignite the material to be burned. All burning explosives have the potential for accidental detonation so suitable shelter should be found before lighting the fuse. A warning should be sounded before igniting the waste materials or deteriorated explosives, and unauthorized persons should be cleared from the area. Fire fighting equipment should be readily available to extinguish any brush fires and to wet down the area thoroughly 1 hour after the fire seems to have gone out. The pit should not be approached before this hour has passed and at least 48 hours should pass after the fire goes out before that particular burn site is reused. Therefore, several burn locations may be necessary.

MAINTENANCE AND REPAIRS

Before regular maintenance, construction, or alterations are performed, or in the event that repairs to the building or machinery become necessary, the explosive materials should first be removed from the building. This will be done only after first obtaining written permission from the proper supervisor and the plant's safety office. This written permission should be in the form of a standard release document on which the exact repairs to be made and any special precautions to be taken should be stated. There should be complete cooperation and communication between the explosives workers and the maintenance workers. The maintenance crew must be made aware of all hazards present in the particular area and the operating crew should be informed of the condition in which the equipment is left after the repairs are made.

It is the responsibility of the operating crew to make certain that the building is totally free of explosives. To be safe, they should wash down the building and flash the empty machinery to burn off any possible hazardous accumulations of explosive materials. The area may then be turned over to the maintenance crew.

After maintenance and repairs have been completed, the maintenance crew should make a dry run of the equipment, i.e., a run with no material in the machinery. If no more maintenance or repairs are necessary, the area may be returned to the operating crew. They should then make a dummy run, i.e. a run with non-hazardous material in the machinery. If everything seems to be in order, the equipment may be returned to normal operations. Minor adjustments may be made without taking these precautions and, of course, emergency repairs needed to ensure immediate safety should be made without delay.

PERSONNEL PRACTICES

A warning system should be installed to alert people that they are approaching or entering a hazardous area. This system must be activated at any time that processing of dangerous materials is taking place. Within the buildings, personnel and explosive limits should be posted and enforced. Operating instructions for the processing machinery should be posted at each work station. Although personnel must be completely familiar with all

safety rules concerning general operation and particular processes, these rules should still be posted at each work station, also. These rules should include some or all of the following:

Eye Protection

Eye or face protection should be worn in any area where chemical, mechanical or manual work is occurring and signs should be posted in these areas warning of the dangers and stating that protection must be worn. Accidents which would cause only minor burns, cuts or irritations on other parts of the body could permanently damage exposed eyes. This is especially true for explosives handling because most explosions, no matter how small, produce some type of shrapnel. Eye or face protection must be worn by everyone entering an area where explosives or chemical splashes are a hazard. This includes supervisors, maintenance workers, clerical workers and visitors. It does not matter how briefly any of these people will be present in the hazardous area; they must wear eye or face protection. If desks are in or near hazardous areas, anyone sitting at those desks must wear eye protection unless the desk area is protected by a partition at least seven feet high.

At times, safety glasses alone will not provide enough protection. Goggles and/or face shields in addition to safety glasses will help prevent eye damage caused by fumes, splashing liquids or flying particles.

In addition, contact lenses should not be worn when working with explosives or chemicals; corrosive chemicals or small particles could become trapped between the lenses and eyes, increasing damage to the eyes .

Smoking

Smoking, open flame, or heating elements of any type should be prohibited in an area containing explosive materials. The reason for this rule is obvious: all explosives are, to some degree, sensitive to detonation by heat or flame. No matches, lighters or other spark or flame producing devices should be allowed beyond the plant entrance gates. At each gate, a special depository should be established for these devices. Special areas such as employee lounges or administration areas should be set aside within the plant boundaries where smoking is allowed. Electric lighters should be provided at these locations. No lighted smoking matter must be allowed to leave these areas.

Spills

Explosives are also sensitive to detonation by physical disturbances such as impact or friction, though different explosives vary in their sensitivity. Sufficient physical disturbance to cause detonation could be provided by accidentally grinding a small amount of explosive material between a tool and the work bench, or some other seemingly innocent act. In addition, explosives become more sensitive to detonation by shock or friction when they are contaminated with grit or glass. For this reason among others, spilled or dropped explosives should be cleaned up immediately. The spilled explosive, when contaminated, is extremely hazardous. The area should be

sealed off and the supervisor notified. The plant should have a written spill procedure. Based on this procedure, the employee and the supervisor should decide the best way to clean up the spill. Only the two of them may be present at the spill. Each step should be carefully thought out before beginning.

In general, the first step is to make a dam around the spilled explosives to hold a desensitizing agent. The proper desensitizing agent will, of course, depend upon the type of explosive spilled, but engine oil will desensitize many types. The desensitizing agent should be allowed to thoroughly soak the hazardous material. If the explosives are tightly packed, for example, in blasting caps, it may take days for the agent to completely desensitize the explosives. Tests should be run before any spills occur to determine the necessary length of time for total desensitization. When this time span has passed, the explosives should be cleaned up slowly, beginning at the top of the spill. Vaccum, if possible, or use a wet sponge. Even though the explosive has supposedly been desensitized, caution is still recommended. When the spill has been cleaned up, the entire area should be washed down with water.

Static Protection

Static electricity is a special danger because many explosives are static-sensitive and because static electricity can be generated in so many ways. When the relative humidity is less than 50%, a person can store about 25,000 volts if he is well insulated from the floor by rubber soled shoes. This is more than enough to detonate some types of explosives.

To prevent accidental explosions, certain precautions should be taken. Clothing made of silk, wool, nylon, dacron, or other synthetic fabrics should not be worn as they will accumulate static electricity. Denim, linen, or hard cotton should be worn instead; this includes undergarments. All jewelry should be removed while in the presence of explosives. Rings, bracelets and other jewelry can act as electrodes for the discharge of static electricity.

Static electricity can also be generated by certain packaging materials, such as paper and polyethylene, or by plastic safety shields. Explosive materials should not be poured from paper or plastic sheets. Whenever possible, pouring granular explosives from one container or surface through the air to another container or surface should be avoided.

Any static electricity which might be accumulated by workers can be dissipated in several ways. Conductive shoes, especially when in contact with properly grounded floors, will prevent the build up of static charges. These shoes are recommended for all employees including maintenance workers but not electricians who should be well insulated from the floor. When wearing conductive shoes, silk, woolen or synthetic socks or foot powder should not be used. The shoe soles should be kept clean and free from oils and grease which might interfere with electrical continuity with the floor. Legstats may be used as a temporary substitute for conductive shoes for visitors or new employees; they may also be worn with conductive shoes to

provide additional contact with the conductive flooring. If the plant is equipped with conductive work benches, body contact with them will serve to dissipate static charges, as will the use of grounding bracelets.

Clothing

Other personal safety equipment should be supplied depending on the particular hazards involved in each employee's job. In addition to the safety glasses and conductive shoes mentioned above, flameproof shop coats and head covers should be assigned to and worn by all employees working in hazardous areas. The head covers should be large enough to completely cover the hair. Long hair which might fall forward while the employee is working should be tied back or held in place by some other means. If applicable, beard covers should also be worn.

Explosives plant clothing, also called powder uniforms, may be needed. They should be made of tightly woven, smooth, flame-retardant fabric. If the fabric is not naturally flame-retardant, it should be chemically treated after each washing to make it so. Pant legs and sleeves should be tapered and should have no cuffs. The uniforms should fit the neck and wrists snugly but not too tightly and should be easy to put on and take off. The powder uniforms should never be taken out of the plant, especially if they are contaminated. It should be the responsibility of the management to see that the uniforms are properly laundered.

Available and applicable safety equipment should always be used. This includes not only the personal protective clothing but also any safety shields or devices on machinery. Safety equipment should never be bypassed simply for the sake of convenience.

Explosives Handling

Working alone or without someone within hearing and/or seeing distance is forbidden. This is for individual safety. In the event of an accident, the presence of a second person may mean the difference between life and death.

There should be absolutely no food or drink in explosives processing areas. The reason for this is obvious: many highly toxic chemicals are used in the preparation of explosives. Similarly, hands should always be washed before eating, drinking, or smoking. Explosives should not be handled needlessly. There are two important reasons for this: the explosives may deteriorate as a result of too much handling and, more importantly, any handling of explosives poses a certain degree of hazard. Unnecessary handling simply increases this hazard, especially if the particular explosive is experimental.

Explosives materials should never be taken home. The potential display may be fun and interesting, but the potential consequences are disastrous. Rough housing or joking around should never be engaged in while working with explosives. At the least, this will distract other workers who may be performing hazardous tasks. At the worst, dropped or spilled explosives may detonate upon hitting the floor.

First Aid

First aid kits, fire extinguishers and fire blankets are very important pieces of safety equipment. Every employee should know their location and their proper use. Every employee should be encouraged to take a first aid course if instruction is available. Lists of emergency phone numbers and emergency procedures should be posted in all parts of the plant.

If a fire is spotted in an area containing explosives, that area must be immediately evacuated and the appropriate supervisor notified. If a fire is spotted in an area known to be completely free of explosive material, attempts may be made to extinguish the fire. If, however, the total absence of explosives is in doubt, the area must be evacuated and the supervisor notified. To facilitate evacuation, employees should be aware of the nearest exits at all times. A diagram should be posted in each plant building showing the nearest exit from each room and each building. The evacuation should be orderly, putting a safe distance between personnel and the fire. Personnel should remain outside of the hazardous area until instructed by the supervisor to return to the area.

Electrical Storm Procedure

Evacuation is also necessary whenever there is an electrical storm in the vicinity. A system should be devised to track the progress of these storms when they are still more than 10 miles distant. If it is determined that the storm is approaching, the area should be evacuated and sealed off, allowing no one to reenter the buildings for any reason. Certain operations (e.g., nitrations) are extremely dangerous to halt once they have begun and should be watched throughout the reaction. A minimum number of workers should be left to watch these operations until they can be safely completed. Obviously, if a storm is approaching, it is not wise to start one of these procedures. When supervision has decided that the storm has passed without damage to the plant, workers may then return to work.

Explosives Testing

The testing of explosives poses particular hazards because explosives are constantly being detonated. Although these detonations are planned and prepared for in advance, there is still some uncertainty inherent in the detonation of explosive material. This is particularly true if the material being tested is a new, experimental mixture. Therefore, extra precautions should be taken in addition to general safety practices. The testing should be performed in isolated areas at distances from other structures at least those shown in The American Table of Distances for Storage of Explosives, Appendix B, Table B-2. Employees performing the tests should be protected from injury by barricades and suitable separation from the explosion. Only authorized personnel may be in the area when testing is taking place. All other people should be alerted by fences, warning signs, and loud warning devices that they are entering a hazardous area.

In the event of a misfire, no one may approach the area for 1 hour. After that time, only one person may approach the misfired item to either retrieve

the item or repeat the attempt to detonate it. After any detonation, the area must be cleaned of any debris and all test equipment returned to the proper place.

No testing may be performed without notifying the proper supervisor, especially if unusual testing is to occur. If the explosion is to be especially noisy or will produce an unusual amount of smoke or fragmented debris, all plant personnel must be notified of the time and conditions of the test.

Above all, if there are any questions about the safety of a particular operation or explosive material, the supervisor should be asked. Lives might be saved by calling attention to unusual occurences.

BLASTING AGENTS

Many of the safety precautions which apply to explosives also apply to blasting agents. There are some differences, however, which are discussed below.

The recommended separation of ammonium nitrate and blasting agents from explosives or blasting agents is shown in Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives or Blasting Agents, Appendix B, Table B-3. The distances listed apply to both mixing buildings and structures for temporary storage. Ammonium nitrate alone is not considered to be a donor. However, if ammonium nitrate is close enough to a donor that any explosion of the donor will propagate to the ammonium nitrate, one half the weight of the ammonium nitrate must be added to the donor weight when computing distances using the table. If any buildings containing blasting agents or ammonium nitrate are not separated by at least the recommended distance they will be considered as one donor. If there are no barricades between the buildings, multiply the recommended distance by six.

The buildings containing ammonium nitrate and blasting agents should also be separated from inhabited buildings, public highways and public railroads. The minimum distances are shown in American Table of Distances for Storage of Explosives, Appendix B, Table B-2.

The mixing buildings themselves should be built of sheet metal on wood studs or other noncombustible construction. The floors should be made of concrete or other non-absorbant materials and should be built with no drains or pipes in which flammable materials could be trapped in case of fire. The electrical equipment and wiring in the mixing room should be approved for hazardous locations; any equipment which is not approved for these locations should be installed outside the mixing room. Internal combustion generators may be used to produce electrical power, but they should be located outside the building or isolated by a firewall and well ventilated. Exhaust systems for the generators should be designed to eliminate the possibility of sparks reaching the hazardous materials. All electric generators and motors must

be equipped with overload protection devices and the generators, motors and any other equipment including the mixer and its frame should be electrically bonded together and connected to ground.

The restrictions on combustion-powered heating units in explosives buildings also pertain to blasting agent mixing and storage areas. Those heating units which are permissible in the mixing room should be kept at least 30 inches from the hazardous materials. If desired, an automatic water-deluge system can be installed where raw materials and the finished product are present to reduce the possibility of detonation due to fire. Although the water deluge will probably not extinguish a well-established fire, it may keep the temperature of the hazardous materials below the point at which they will detonate. In addition, the land around each mixing building should be kept free of debris and dry vegetation for a distance of 50 feet.

The mixing plant should be designed with physical separation of the stocks of ammonium nitrate and blasting agent from the mixing buildings or packaging areas. No more than one day's production of blasting agent should be kept in the plant. Fuel oil should not be stored within the mixing building but separate storage structures should be built and located so that an oil leak will drain away from the mixing building. A means should be devised to stop the flow of fuel oil to the mixing building in the event of fire.

All equipment, especially the mixer, should be built of materials that are compatible with the raw materials and finished product. Zinc or chromium should not be used because they tend to promote decomposition of ammonium nitrate and copper should not be used because it will corrode. The mixer should be designed so that frictional heating, compaction and confinement of the hazardous materials is kept to a minimum. The bearings and drive assemblies should be mounted on the outside of the mixer, and protected against accumulation of dust. All precautions necessary should be taken to prevent contamination of the blasting agents with foreign objects or materials and the equipment designed with this in mind. All equipment and all surfaces in mixing and packaging areas should be cleaned frequently and thoroughly to prevent accumulation of hazardous materials. All surfaces should, therefore, be easily accessible for cleaning. Waste materials including empty ammonium nitrate bags should be safely disposed of as often as necessary, but at least daily. No repairs, especially welding, may take place until all hazardous materials are removed and the equipment and internal surfaces of the building washed down. A daily visual inspection is necessary to ensure that all equipment is in good working condition; a system of regular maintenance is essential.

Water Gels (Slurries)

Water gels are classified as either explosives or blasting agents depending on their composition. Any water gel containing a material classified as an explosive is itself classified as an explosive. Any water gel not containing an explosive but which can be detonated by a No. 8 blasting cap is also

classified as an explosive. Those water gels not containing explosive materials and not sensitive to detonation by a No. 8 blasting cap are classified as blasting agents.

The minimum separation of plant buildings from other plant buildings or public buildings, roads, or railways are shown in Appendix B. The requirements of blasting agent mixing buildings and mixers also apply to those used to produce water gels. However, the ammonium nitrate solutions used to produce water gels can be stored in tank trucks or fixed tanks without distance or quantity limits. If explosives are to be used as ingredients, necessary special precautions should be taken.

TRANSPORTATION

The movement of explosives involves the use of all modes of transportation. The translocation of these hazardous materials along public thoroughfares could cause dangerous mishaps if precautions were not taken to prevent accidents. It is the obligation of management to insure the public welfare by familiarizing themselves and their employees with procedures for safely transporting explosives.

This chapter is divided into six parts. The first part details general information applicable to all methods of explosive carriage. The remaining parts describe safety practices for each of the five major means of transport: public highway, rail, vessel, air and underground. 49 CFR contains the Department of Transportation's (DOT) regulations governing the safe transportion of all classes of hazardous materials and should be consulted as needed for more detailed information, such as exceptions to rules, specifications for labels, placards and packagings, and safety recommendations of a general nature.

GENERAL

The transportation of the following explosives is forbidden:

- explosive compositions that ignite spontaneously or undergo marked decomposition when subjected for 48 consecutive hours to a temperature of 75°C (167°F)
- explosives containing an ammonium salt and a chlorate
- liquid nitroglycerin, diethylene glycol dinitrate or other liquid explosives that have not been authorized
- explosives condemned by the Bureau of Explosives (except properly packed samples for laboratory examinations)
- leaking or damaged packages of explosives*
- new explosives and explosive devices, unless approved.

Condemned or leaking dynamite must not be repacked and offered for shipment unless the repacking is done by a competent person in the presence of, or with the written consent of, an inspector, or with the written authority of the chief inspector of the Bureau of Explosives.

*Leaking packages can be repacked in large enough boxes to allow absorbant material such as sawdust to be packed around them. Under supervision they can then be removed for destroying.

Prior to delivery of explosive materials at the distributor's premises to an employee of a Federal licensee or permittee, or to an employee of a carrier transporting explosive materials to a licensee or permittee, the delivering distributor shall obtain an executed ATF Form 4721, Explosives Delivery Record, from such an employee before releasing the explosive materials (27 CFR 181.109).

Shipping Papers

A shipping paper is required for transfer of explosives over public transport routes. It contains valuable information to identify the shipment. This information is vital in case of spills or other accidents that pose a hazard to public health and safety. The shipping paper should contain the following information:

- the proper shipping name as prescribed by the Hazardous Materials Table (49 CFR 172.101)
- the class of the explosive as prescribed by the Hazardous Materials Table
- the total quantity of the material by weight, volume or as otherwise appropriate
- the type of packaging such as barrels, drums, cylinders and boxes
- the number of each type of package including those in a freight container or a pallet
- the gross weight of each type of package or the individual gross weight of each package
- a statement certifiying that the material is offered for tansportation in accordance with DOT regulations.

In addition to the shipping papers, a vessel carrying explosives must have a storage plan giving the location of the explosives on board the vessel. In the case of a flatcar carrying containers, an indication of which trailers or containers contain explosives must be marked on each waybill. Complete requirements for the completion of shipping papers can be found in 49 CFR, Part 172, subpart C.

Package Marking and Labelling

Each package containing explosives must be marked with the proper shipping name of the material in a clearly visible and easily read manner. Each package must also have a label as specified for the material in the Hazardous Materials Table printed on or affixed to the surface of the package near the proper shipping name. A label must not be obscured by markings or attachments. The labels should be displayed on at least two sides or two ends. Color, size and printing specifications for package labels are given in more detail in 49 CFR, 172.411.

In addition to Department of Transportation marking requirements, all manufacturers must place marks of identification on the outside of packages as required by 27CFR 181.109.

Placarding

Each rail car and freight container containing any quantity of explosives must be placarded on each end and each side. Each motor vehicle containing 1000 pounds or more of packages bearing the Explosive C label must be placarded, and vehicles containing packages of Class C Explosives which require no labelling, e.g., small arms ammunition, are not required to be labelled. Any sign or other device that by its color, design, shape, or content could be confused with any placard may not be affixed or displayed on a motor vehicle, rail car, or freight container. Each placard on a motor vehicle and each placard on a rail car must be readily visible from the direction it faces except from the direction of another motor vehicle or rail car to which it is coupled. A motor vehicle may be placarded on the front of a truck tractor instead of or in addition to the placarding on the front of the cargo body to which a truck tractor is attached. Each placard must also be:

- o securely attached or affixed
- o located clear of appurtenances and devices such as ladders, pipes, doors, and tarpaulins
- o located so that dirt or water is not directed to it from the wheels of the transport vehicle
- o located away from any marking (such as advertising) that could substantially reduce its effectiveness (in any case at least 3 inches away from such markings)
- o maintained by the carrier in a condition so that the format, legibility, color, and visibility of the placard will not be substantially reduced due to damage, deterioration, or obscurement by dirt or other matter.

The packaging of explosives for transportation by air, highway, rail, or water must be as specified in DOT regulations. Boxes previously used for high explosives containing a liquid explosive ingredient not contained in an inside metal container must not be used again for shipments of any character. Boxes that have been contaminated by a liquid explosive composition must not be used again. Each package which last contained explosives and on which the word "EXPLOSIVES" or the shipping name is printed, stenciled, or otherwise marked or applied, when shipped as empty, must have this marking completely covered or obliterated if shipped in less-than-carload or less-than-truckload lots, or on open-top or flat railcars, or on open-top or flat bed motor vehicles or trailers. Complete packaging specifications including type of packaging to be used for various

kinds and quantities of explosives, construction materials and techniques, and marking requirements are found in 49 CFR, Part 173, Subpart C and Part 178.

Safety Recommendations

There are several safety recommendations that apply to the transport of explosives regardless of the mode of transit. Smoking cannot be permitted near explosives nor should any person in the vicinity of explosives carry matches, lighters, or other flame-producing devices. Open fires or flame should not be allowed within 100 feet of areas where explosives are being handled. Firearms should not be permitted in the vicinity of explosives. Where portable lights are needed around explosives, only electric flashlights or electric lanterns should be permitted.

Exposure to weather damages most kinds of explosives, especially dynamite and caps. Every precaution should be taken to keep them dry and relatively cool.

Packages of explosives should not be handled roughly. Sparking metal tools should not be used to open wooden cases. Metallic slitters may be used for opening fiberboard cases, provided the slitter does not come in contact with the metallic fasteners of the case.

Explosives shall not be carried or transported in or upon a public conveyance or vehicle carrying passengers for hire except under the provisions of 49CFR 177.870.

Explosives shall not be delivered to or received from any railway station, truck terminal, pier, wharf, harbor facility, or airport terminal between the hours of sunset and sunrise. Delivery shall only be made to authorized persons and into authorized magazines or authorized temporary storage handling areas.

PUBLIC HIGHWAY TRANSPORTATION

Specific DOT regulations will be followed in the transport of explosives by private, common and contract carriers and by motor vehicles engaged in interstate or foreign commerce.

Each motor vehicle shall be inspected daily to see that the fire extinguishers are in good condition, that the chassis, motor and pan are free from grease and oil, and that all of the mechanical parts are in good working order. Daily inspection shall also determine that:

- electrical wiring is effectively insulated and firmly secured
- fuel tank and feed line are securely fastened and have no leaks
- brakes, lights, horn, windshield wipers and steering apparatus are in good condition

- o tires are properly inflated and free of defects
- o the vehicle is in proper condition for transporting explosives.

Vehicles should carry fire extinguishers, maintained according to manufacturer's recommended recharging schedules, as follows:

- o trucks of 14,000 or less pounds (GVW rating); minimum of two extinguishers with total fire-extinguishing rating of at least 20 B:C
- o trucks over 14,000 pounds (GVW rating); two or more extinguishers with total fire-extinguishing rating of at least 70 B:C
- o tractor semi-trailer unit; two or more extinguishers with total fire-extinguisher rating of at least 70 B:C.

Fire extinguishers should be securely mounted on the vehicle and should be designed, constructed and maintained to permit visual determination of whether they are fully charged. Extinguishers shall be located where they will be convenient and ready for immediate use. Where trucks are operated in sub-zero temperatures, dry powder extinguishers should be pressurized with nitrogen gas in lieu of carbon dioxide.

Explosive materials shall not be carried or transported in or upon a public conveyance or vehicle carrying passengers for hire except under the provisions of 49CFR 177.870. Nor shall explosive materials be transported through any prohibited vehicular tunnel, or subway, or over any prohibited bridge, roadway, or elevated highway.

No explosives shall be loaded into or on, or be unloaded from, any motor vehicle with the engine running. No bale hooks or other metal tools shall be used for the loading, unloading, or other handling of explosives, nor shall any package or other container of explosives, except barrels or kegs, be rolled. No packages of explosives shall be thrown or dropped during the process of loading or unloading and special care shall be exercised so that packages or containers of explosives shall not catch fire from sparks or hot gases from the exhaust tailpipe.

Explosives placards or markings shall be secured, in the appropriate locations, directly to the equipment transporting the explosives. If the vehicle is provided with placard boards the placards must be applied to these boards.

Motor vehicles transporting Class A or Class B explosives shall have tight floors and shall have the interior lined with either non-metallic material or non-ferrous metals. The interior of the cargo space must be in good condition so that there will not be any likelihood of containers being damaged by exposed bolts, nuts, broken side panels or floor boards.

No motor vehicle transporting any explosive may transport as a part of its load any metal or other articles or materials likely to damage explosives or

any packages in which they are contained, unless the different parts of such a load are segregated or secured in place and separated by bulkheads or other suitable means to prevent damage.

Spark-producing metal including metal tools, oils, matches, firearms, electric storage batteries, flammable substances, acids, oxidizing materials, or corrosive compounds should not be carried in the body of the truck with the explosives. It may be necessary, therefore, to make a separate trip or use a separate vehicle to transport the tools to the blasting site.

The portion of the loading of any motor vehicle which consists of explosives shall be contained entirely within the body of the vehicle or within its horizontal outline without overhang or projection of any part of the load. If the motor vehicle has a tailboard or tailgate, it shall be closed and secured in place during transportation. Every motor vehicle transporting explosives must have either a closed body or have the body covered with a tarpaulin, and in either event care must be taken to protect the load from moisture and sparks. Explosives other than black powder may be transported on flat-bed vehicles if the explosive portion of the load on each vehicle is packed in fire and water resistant containers or covered with a fire and water resistant tarpaulin. Whenever tarpaulins are used for covering explosives, they shall be secured by rope or wire tie-downs. No hazardous materials may be loaded into, or on, or transported in or on any pole trailer.

Smoking on or about any motor vehicle while loading or unloading any explosive is forbidden. Extreme care shall be taken in the loading or unloading of any explosive into or from any motor vehicle to keep fire away and to prevent persons in the vicinity (within 25 feet of the motor vehicle) from smoking, lighting matches, or carrying any flame or lighted cigar, pipe, or cigarette. Nor shall firearms or loaded cartridges be carried.

No hazardous material shall be loaded into, or on, or unloaded from, any motor vehicle unless the handbrake is securely set and all other reasonable precautions be taken to prevent motion of the motor vehicle during the loading or unloading process.

Containers of explosives must be braced to prevent shifting while in transit. Containers having valves or other fittings must be loaded so that there will be no likelihood of damage to them during transportation. Reasonable care should be taken to prevent undue rise in temperature of containers and their contents during transit. A motor vehicle equipped with a cargo heater of any type may transport explosives only if the cargo heater is rendered inoperable by draining or removing the cargo heater fuel tank and disconnecting the heater's power source. There must be no tampering with containers or their contents or discharge of the contents of any container between the point of origin and the point of billed destination. The discharge of contents of any container must not be made prior to removal from the motor vehicle.

Any package of high explosive showing excessive dampness, mold or showing outward signs of any oily stain or other indication that absorption of the liquid part of the explosive is not perfect, or that the amount of the liquid part is greater than the absorbent can carry must be refused when offered for shipment.

Explosives, whenever possible, shall be transported in daylight.

The driver of a motor vehicle carrying any type of explosives shall not cross a railroad track or tracks at grade unless he first:

- o stops the vehicle within 50 feet of, and not closer than 15 feet to, the tracks

- o listens and looks in each direction along the tracks for an approaching train and ascertains that no train is approaching.

The driver must not shift gears while crossing the tracks. Exceptions to this rule are listed in 49 CFR 390.10.

Unless there is no practicable alternative (operating convenience is not a factor in this determination), a motor vehicle which contains hazardous materials must be operated over routes which do not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys. Before a motor carrier allows a motor vehicle containing Class A or Class B explosives to be operated, he must prepare a written plan of a route that complies and must furnish a copy to the driver.

A motor vehicle containing hazardous materials must not be operated near an open fire unless its driver has first taken precautions to ascertain that the vehicle can safely pass the fire without stopping. A motor vehicle containing explosives materials must not be parked within 300 feet of an open fire.

When a motor vehicle which contains hazardous materials is being fueled its engine must not be operating and a person must be in control of the fueling process at the point where the fuel tank is filled.

A motor vehicle which contains Class A or Class B explosives must not be parked:

- o on or within 5 feet of the traveled portion of a public street or highway

- o on private property (including the premises of a fueling or eating facility) without the knowledge and consent of the person who is in charge of the property and who is aware of the nature of the hazardous materials the vehicle contains

- o within 300 feet of a bridge, tunnel, dwelling, building, or place where people work, congregate, or assemble, except for brief

periods when the necessities of operation require the vehicle to be parked and make it impracticable to park the vehicle in any other place.

A motor vehicle which contains Class C explosives must not be parked on or within five feet of the traveled portion of a public street or highway except for brief periods when the necessities of operation require the vehicle to be parked and make it impracticable to park the vehicle in any other place.

A motor vehicle which contains Class A or Class B explosives must be attended at all times by its driver or a qualified representative of the motor carrier that operates it. A motor vehicle which contains Class C explosives and which is located on a public street or highway or the shoulder of a public highway must be attended by its driver. However, the vehicle carrying Class C explosives, need not be attended while its driver is performing duties which are incident and necessary to his duties as the operator of the vehicle. These rules do not relieve a driver from any obligation relating to the placing of warning devices when a motor vehicle is stopped on a public street or highway.

If a motor vehicle which contains hazardous materials is equipped with dual tires on any axle, its driver must stop the vehicle in a safe location at least once during each 2 hours or 100 miles of travel, whichever is less, and must examine its tires. The driver must also examine the vehicle's tires at the beginning of each trip and each time the vehicle is parked. If a tire is found to be flat, leaking, or improperly inflated the driver must have it repaired, replaced, or properly inflated before the vehicle is driven. However, the vehicle may be driven to the nearest safe place to perform the required repair, replacement, or inflation. If a tire is found to be overheated, the driver shall immediately have the overheated tire removed and placed at a safe distance from the vehicle. The driver shall not operate the vehicle until the cause of the overheating is corrected.

No Class A or Class B explosive shall be transferred from one container to another, or from one motor vehicle to another vehicle, or from another vehicle to a motor vehicle, on any public highway, street, or road, except in case of emergency. In such cases red electric lanterns, red emergency reflectors or red flags shall be set out in the manner prescribed in 49 CFR 392 for disabled or stopped motor vehicles. All practicable means shall be taken to protect and warn other users of the highway against the hazard involved in any such transfer or against the hazard occasioned by the emergency making such transfer necessary.

No person except the vehicle operator, helpers, and powder man shall ride on vehicles transporting explosives. The transfer of explosives from storage places shall be so arranged that no undue delay will occur between the time the explosives leave the storage place and the time they are used.

Parking of unattended vehicles within 100 feet of explosives magazines is prohibited. Motor vehicles carrying explosives, blasting agents, or blasting supplies shall not be taken inside a garage or shop for repairs or

servicing. No service or repairs involving the use of flame-producing devices shall be performed on explosives-carrying vehicles.

No driver of a vehicle containing explosives shall leave the cab without first stopping the motor and setting the parking brake. All reasonable precautions shall be taken to prevent the movement of the vehicle. In the case of horse drawn vehicles, the team shall be securely tied and the brakes set.

Motor trucks or vehicles loaded with explosives shall keep at least one thousand feet apart, except when necessary to pass.

Each operator of a vehicle carrying explosives must be familiar with the state laws and regulations and with the local ordinances relating to the transportation of explosives. Additional regulations can be found in 49 CFR 390-397 and IME Publication No. 6 Recommended Industry Safety Standards. These regulations concern all factors of motor vehicle operation including mechanical condition of and necessary equipment for the vehicle, requirements for drivers, including hours of service and qualifications, and procedures for the reporting and recording of accidents.

RAIL

Specific DOT regulations will be followed in the transport of all classes of explosives by rail car. Class A or Class B explosives may be loaded and transported in a truck body or trailer on a flatcar in which case each truck body or trailer must meet the requirements applicable to shipments of explosives by motor vehicle.

Each package of explosives being transported by rail car must be loaded, blocked and braced to prevent the packages from changing position, falling to the floor, or sliding into each other during transportation. Recommended methods of blocking and bracing in cars, truck bodies, or trailers are given in Bureau of Explosives (Association of American Railroads) Pamphlet Nos. 6 and 6C. A truck body, trailer or freight container containing explosives must be designed and loaded so that it will not rupture or become seriously damaged under normal transport conditions. Packages of explosives must be blocked and braced within the truck body, trailer or container to prevent their movement. Ends, sidewalls, or doors of the truck body, trailer, or container may not be relied on to prevent the shifting of heavy loads. Each unit must be secured on a flatcar so that it cannot permanently change position during transit.

Section 174.81 of 49 CFR provides information on the segregation and separation requirements for hazardous materials in rail cars. Under no circumstances will Class A explosives and initiating or priming explosives be transported together in the same rail car or stored on carrier property with charged electric storage batteries or with any hazardous material for which a NONFLAMMABLE GAS, FLAMMABLE GAS, FLAMMABLE LIQUID, FLAMMABLE SOLID, OXIDIZER, ORGANIC PEROXIDE, RADIOACTIVE or CORROSIVE label is required. Forbidden explosives already noted and dry initiating explosives may not be transported by rail. Leaking or damaged packages of explosives also may not be transported by rail.

A car placarded "EXPLOSIVES A" may not be cut off while in motion or coupled into with more force than is necessary to complete the coupling. No car moving under its own momentum shall be allowed to strike any car placarded "EXPLOSIVES A". It must also be separated from the engine by at least one non-placarded car when it is being transported in a terminal yard, or on a side track, or siding. It must be placed so that it will be safe from all probable danger of fire and it may not be placed under a bridge or overhead highway crossing, not in or alongside a passenger shed or station except for loading or unloading purposes.

A placarded rail car may not be transported in a passenger train. Additional regulations pertaining to the position of rail cars in a train and their separation from other cars is found in Subpart D of Section 174 of 49 CFR.

Before Class A explosives may be loaded into a rail car, the car must have been inspected and certified by a qualified person to be in compliance with the requirements of 49 CFR 174.104. These requirements cover the condition of the brakes, roller bearings, trucks, roof, sides, ends, floor and doors of the rail car. Each rail car used for transporting Class A explosives must meet the applicable requirements. The certification shall be made in Car Certificate No. 1 (Figure 1).

The interior of a rail car, furnished by a carrier to a shipper for transporting Class A explosives, must be inspected by the shipper prior to loading. After loading the shipper will certify to the proper condition of the car and the loading in Car Certificate No. 2 (Figure 1). In addition, the finished load must also be inspected and certified, by a qualified person as to its compliance with DOT requirements before the car goes forward. If the car is loaded by the carrier then only the qualified person need sign Car Certificate No. 2.

If a trailer or container containing Class A explosives is loaded on a flatcar, the loading and securing of the load on the car must be supervised by the shipper or carrier. The certification shall be made in Car Certificate No. 3 (Figure 1).

Each car certificate, used in connection with the inspection of rail cars for the carriage of Class A explosives, must be filled out in triplicate by the carrier, and by the shipper if he loads the shipments. The original is filed by the carrier at the forwarding station and the other two must be attached to the car, one to each outer side. All certificates, where applicable, must be signed.

When a car seal is changed on a car requiring "EXPLOSIVES A" placards while enroute or before delivery to a consignee, a record of the change must be made. The required information is shown in Figure 2. The change record must be made on or attached to the waybill or other form which must accompany the car to its destination.

_____ Railroad

CAR CERTIFICATE

No. 1_____ Station_____
19__

I hereby certify that I have this day personally examined Car Number ___ and that the car is in condition for service and complies with FRA Freight Car Safety Standards (49 CFR Part 215) and with the requirements for foreign cars used to transport explosives prescribed by the DOT Hazardous Materials Regulation (49 CFR 174).

_____
Qualified Person Designated Under 49 CFR 215.15

No. 2_____ Station_____
19__

I have this day personally examined the above car and hereby certify that the explosives in or on this car, or in or on vehicles or in containers have been loaded and braced; that placards have been applied, according to the regulations prescribed by the Department of Transportation; and that the doors of cars so equipped fit or have been stripped so that sparks cannot enter.

_____
Shipper or his authorized agent

No. 3_____ Station _____
19__

I herby certify that I have this day personally supervised the loading of the vehicles or containers on and their securement to the above car.

_____
Shipper or railway employee inspecting loading and securement

Figure 1.

Railroad _____ Place _____ Date _____

Car Initials _____ Car Number _____

Number or description of seal broken _____

Number or description of seal used to reseal car _____

Reason for opening car _____

Condition of load _____

Name and occupation of person opening car _____

Figure 2.

Class A and Class B explosives may not be loaded, transported or stored in a rail car equipped with any type of lighted heater or open-flame device, or electric devices having exposed heating coils, or in a rail car equipped with any apparatus or mechanism utilizing an internal combustion engine in its operation. All possible precautions must be taken against fire.

Class B explosives must be transported in a closed car or container car which is in good condition and into which sparks cannot enter. Class C explosives may be loaded into any closed car in good condition. With the exception of blasting caps and electric blasting caps, Class C explosives may be loaded into any container car in good condition. These cars carrying Class B and Class C explosives do not require car certificates.

Care must be exercised in repacking damaged containers so that no spark is produced by contact with metal or other hard surfaces which could ignite loose particles of explosive compositions that may be strewn on car floors or freight. In addition, the car floors must be thoroughly swept, and washed with a plentiful supply of water. Iron-wheel trucks, metal hammers, or other metal tools that may produce sparks may not be used. Metal tools must be limited to those made of brass, bronze, or copper.

Each package of explosives showing evidence of leakage of liquid ingredients must:

- be refused if leakage is discovered before acceptance,
- be disposed of to a person able to safely remove them from the carrier's property, if the leakage is discovered while the shipment is in transit, or
- be removed immediately by consignee, if the leakage is discovered at the shipment's destination.

When a leaking package cannot be disposed of as noted above, it must be packed in other boxes large enough to permit enclosure and the leaking boxes must be surrounded by at least 2 inches of dry, fine sawdust or dry and clean cotton waste. It must be stored in a station magazine or other safe place until the arrival of an inspector of the Bureau of Explosives, or other authorized person, to superintend the destruction or disposition of the condemned material.

Railroad cars should be unloaded promptly and in accordance with instructions on cards tacked on the inside of the cars. When cars are opened, the seals should be retained and a record taken of seal numbers. Railroad cars should not be left unattended between trips unless the car is locked.

Every precaution should be taken to prevent fire from reaching explosives while they are being unloaded. There should be no dry grass or debris within 25 feet of the car and there should be no smoking or carrying of matches by personnel. Any runways, chutes or conveyors used for unloading should have no exposed sparking metal parts.

Any damaged or leaking explosives packages should be segregated, placed in supplementary tight containers, if necessary, and set aside in a magazine after which a full report should be made to the manufacturer. All loose explosives and debris should be swept up and burned in the recommended manner.

SHIP

Specific DOT regulations will be followed in the transport of all classes of explosives by vessel. Before a shipment of Class A explosives may be discharged from, loaded on, handled, or restored on board a vessel the carrier must obtain a permit from the nearest Coast Guard District Commander.

In any particular port, Class A or Class B explosives may not be loaded on a vessel until all other cargo has been loaded on board the vessel. No explosives may be loaded or unloaded at the time that other cargo is being handled. All explosives must be handled carefully. Packages of explosives may not be thrown, dropped, rolled, dragged, or slid over each other or over a deck.

Packaged Class A explosives must be loaded and discharged from a vessel by using a chute (described in 49 CFR 176.163) or by a mechanical pallet, skipboard, tray or pie plate, fitted with a cargo net or sideboards. The maximum load handled in a pallet, skidboard, pie plate or similar base must be loaded so that a minimum displacement of items occurs when it is lifted; the cargo net must completely encompass the cotton and sides of the load. Not more than one-third of the vertical dimension of any package may extend above the sideboard of a tray. A cargo net is not needed for palletized Class A explosives. A chute may not be used when loading or discharging blasting caps, detonating fuses, fulminate of mercury, and other initiating or priming explosives. They must be handled with extreme care.

A "can" hook may not be used for raising or lowering a barrel, drum, or other container of explosives. A fire hose of sufficient length to cover the area of the loading operation and connected with an adequate water supply must be laid out and ready for use when explosives are being loaded or unloaded.

Explosives stowed on deck may not be stored on or under a bridge deck and may not be stowed nearer than 25 feet in a horizontal plane to the crew's quarters. Explosives being transported on deck on a vessel between receiving points and delivery points within the same harbor, bay, sound, lake, or river including explosive anchorages must be covered with a fire resistant or flameproof tarpaulin securely lashed in place.

Packages containing hazardous materials stowed on deck must be secured by enclosing in boxes, cribs or cradles and proper lashing by use of wire rope, strapping or other means, including shoring and bracing, or both. Lashing of deck cargo is permitted if eye pads are used to attach the lashings. Lashings may not be secured to guard rails. Bulky articles must be shored. A packaging susceptible to weather or water damage must be protected so that it will not be exposed to the weather or to sea water. Not more than fifty

percent of the total open deck area should be used for stowage of hazardous materials. Fireplugs, hoses, standing pipes, and access to these must be free and clear of all cargo. Crew and passenger spaces and areas set aside for the crew's use may not be used to stow any hazardous material. A hazardous material may not be stowed within a horizontal distance of 25 feet of an operating or embarkation point of a lifeboat. Hazardous materials must be stowed to permit safe access to the crew's quarters and to all parts of the deck required in navigation and necessary working of the vessel.

All decks, gangways, and hatches over or through which explosives must be passed or handled in loading or unloading must be freed of all loose material and must be swept broom clean before loading and unloading. All hatches and cargo ports opening into a compartment in which any explosives are stowed must be kept closed, except during loading or unloading of the compartment. After loading, hatches must be securely closed against the weather. If tarpaulins are used, they must be securely battened. A deck load over which explosives must be passed may not exceed the height of the hatch coaming, bulwark, or three feet, whichever is greater.

Each package of explosives must be secured and dunnaged to prevent movements in any direction. Vertical restraints are not required if the shape of the package and the stuffing pattern precludes shifting of the load. Each keg of black powder must be stowed in an upright position with the bungs up and each tier must be completely dunnaged. Each package of explosives must be braced and dunnaged so that it is not likely to be pierced by the dunnaging or crushed by any superimposed weight.

Class A or B explosives may not be stowed in the same hold or compartment with combustible liquids. An explosive may not be stowed in a hold containing coal or in a hold above or adjacent to a hold containing coal. Each magazine in which explosives are stowed must be protected from damage which may be caused by any heavy cargo stowed in the same hold. When any shafting, steel bar, pipe, heavy machinery, or similar type of cargo is stowed in the same hold with explosives, it must be isolated, dunnaged, or secured to prevent damage to the magazine under any conditions likely to be encountered during the voyage.

No artificial light except electric lights or electric lamps or floodlights may be used on board a vessel during the loading or unloading of explosives. The carrier shall provide flashlights of a non-sparking type for persons required to enter holds in which explosives are stowed.

No person on board a vessel loading, unloading or transporting explosives may carry firearms, matches, bale hooks, or metallic tools of other than the non-sparking type on board. No person engaged in loading or unloading Class A or B explosives may wear boots or shoes shod or strengthened with iron nails or other metal, unless the boots or shoes are covered with rubber, leather, felt or other non-sparking material.

No fire is permitted on any dock or vessel involved in the loading or unloading of explosives during the loading or unloading unless the fire is necessary. If a fire is necessary it must be properly safeguarded and under

the direct observation of a competent person assigned for that purpose by the master of the vessel for the entire period of cargo transfer.

Smoking is prohibited on and near any vessel loading or unloading explosives at a waterfront facility or at an explosives anchorage. At least one "NO SMOKING" sign must be conspicuously posted on the pier at a reasonable distance from the vessel during the handling, loading or unloading of explosives. "NO SMOKING" signs must be posted conspicuously throughout the vessel during the loading or unloading operations.

A person who the master of a vessel finds, in his judgement, to be under the influence of liquor or drugs, may not be permitted on board during the loading, unloading, or transporting of explosives.

Location, construction and ventilation requirements of magazines used for the stowage of explosives aboard vessels are discussed under STORAGE and in 49 CFR 176.135-155.

Each magazine must be located in a hold that is dry and well ventilated. It may not be located in horizontal proximity to crew or passenger accommodations or below their living spaces. A magazine may not be built on or under the principal bridge structure or any navigation spaces.

All magazine construction and other conditioning of holds, deck, or hatches on a vessel, must be completed before the actual loading of explosives is begun. Each magazine must be constructed of steel or wood. Steel magazines must have the interior completely protected by wood sheathing to form a smooth surface free of projections. Upright framing on wood magazines must be secured so that nails do not penetrate the interior of the magazine. The construction must separate all containers of explosives from contact with metal surfaces of the structures of the vessel. All screws or nails used in the interior of the magazine for fastening must be countersunk below the surface of the wood.

When a complete hold or compartment is used for the stowage of explosives requiring magazine stowage, the entire hold or compartment may be considered a magazine. Any frames or bulkhead stiffeners protruding into the hold or compartment must be effectively sheathed to provide a smooth surface. Overhead beams need not be sheathed when the explosives are stowed more than 12 inches from these beams.

49 CFR 176.95-99 gives specific restrictions for the transport of explosives on barges. Explosives required to be stowed in a magazine must, when on board a barge as cargo, be stowed either in a house or under deck when permitted for the particular type of barge.

Repairs or work involving welding or burning, or the use of power-actuated tools or appliances which may produce intense heat may not be undertaken on any vessel having explosives on board as cargo. This does not apply if the repairs or work are approved by the local Coast Guard Captain of the port or his authorized representative or if emergency repairs to the vessel's main propelling or boiler plant or auxiliaries are necessary.

Each hold or compartment in which hazardous materials are to be transported must be swept clean of all debris before the hazardous materials are stowed therein. Bilges must be examined and all residue of previous cargo removed.

49 CFR 176.83 sets segregation requirements for hazardous materials being transported by vessel. Certain materials may not be stowed in the same hold or compartment with explosives. Minimum separation requirements that apply when transporting different classes of hazardous materials on board a vessel are also given. In addition to 49 CFR, the International Maritime Dangerous Goods Code published by the Inter-Governmental Maritime Consultative Organization (IMCO) makes the following additional recommendations:

Explosives should be stored in a cool part of the ship and kept as cool as possible during transit. Explosives should be stowed away from all sources of heat including sparks, flame, steam-pipes, heating coils and the like. Fiberboard boxes should be stowed under the deck. If they are stowed on deck, they should be protected so that at no time are they exposed to seawater or the weather. Explosives stowed on deck should not be stowed within 20 feet of any fire, ash hoist or locker used for combustible ship stores.

Mail, baggage and personal effects should not be stowed in the same compartment as, or in compartments immediately above or below, explosives. Explosives which may give rise to toxic fumes or dust should be stowed away from foodstuffs.

Ships carrying explosives must have efficient lightning conductors.

Before the storage of explosives is begun, all electrical cables passing through a compartment that will contain explosives should be inspected and tested to ensure that they are safe and to determine satisfactory grounding, insulation resistance and continuity of the cable cores and metal sheathing or armoring. Any electrical circuits terminating in holds in which explosives are to be stowed should be electrically disconnected from the power source at a point external to the stowage space and at the main panel (by the removal of fuses and opening of switches or circuit breakers). The main panel should be tagged to warn against re-energizing these circuits.

No artificial light except electric lights, electric lamps or floodlights should be used while loading or unloading explosives. Arc lights should not be used. Glass covers on lights should be protected by wire mesh.

Explosives containing electrically sensitive initation devices should be effectively secured from external sources of energy such as radio and radar transmitters. During loading and unloading, all equipment such as radio transmitters and radar devices should be de-energized. Explosives should be stowed at a safe distance from the vessel's radio cabin, receiving or transmitting apparatus, radio antenna or lead-in. This precaution should be applied also to the vessel's radar installation.

Explosives should not be on loaded or unloaded when bunkering is in progress.

The smoke stack or exhaust of vessels conveying explosives should be equipped with adequate means of preventing the emission of sparks.

To ensure prompt and effective firefighting, during loading and unloading of explosives, hoses should be kept rigged and connected on deck and kept ready for immediate use with pressure on the main. The hose lines should be of sufficient length to cover all areas of the weather deck, and to reach all parts of the hold or compartment being worked on.

AIRPLANE

Specific DOT regulations will be followed in the transport of explosives aboard, attached to and suspended from civil aircraft.

Prior to placing hazardous material aboard an aircraft, an inspection must be made of the package or the outside container which contains the material to determine that it has no holes, leakage, or other indication that its integrity has been compromised. The pilot-in-command must be advised in writing before take-off of the contents of the package, its location in the aircraft and the results of the required inspection.

Hazardous materials carried aboard cargo-only aircraft must be stowed in a location accessible to a crewmember during flight unless the materials are being carried aboard a small, single pilot, cargo-only aircraft. In this latter case no person other than the pilot, an FAA inspector, the shipper or consignee of the material or a representative of the shipper or consignee so designated in writing, or a person necessary for handling the material may be carried on the aircraft. Class C explosives being transported aboard passenger-carrying aircraft must be located in a place in the aircraft that is inaccessible to persons other than crewmembers.

Any package that appears to be damaged or leaking shall be removed from the aircraft.

All Class A and some Class B explosives that are the subject of this report are forbidden from transport aboard both passenger-carrying and cargo-only aircraft; 49 CFR 175.320 details the only exceptions. This section includes high explosives to be used for blasting and electric blasting caps. The aircraft operator must have advance permission from each manned airport where the material is to be loaded or unloaded or where the aircraft is to land while the material is on board. When the destination is changed after departure because of weather or other unforeseen circumstances, permission from the alternate airport should be obtained as soon as practicable before landing. The loading and unloading of the aircraft and its operation in takeoff, en route, and in landing must be conducted at a safe distance from heavily populated areas and from any place of human abode or assembly. When Class A explosives are carried route approval from the FAA inspector in the operator's FAA District Office must be obtained. During loading and unloading, no person may smoke, carry a lighted cigarette, cigar, or pipe, or operate any device capable of causing an open flame or spark within 50 feet of the aircraft.

UNDERGROUND TRANSPORTATION OF EXPLOSIVES

Specific DOT and Bureau of Mines regulations will be followed in the underground transportation of explosives.

The quantity of explosives or blasting agents taken to an underground area shall not exceed the amount estimated to be necessary for the blast. All explosives or blasting agents in transit underground shall be taken to the place of use or storage without delay. During operating shifts, explosives shall be transported at times and over routes that expose a minimum number of persons to danger. Explosives shall not be left on the station level near the shaft collar or tunnel entrance.

Explosives in transit shall not be left unattended. When vehicles containing explosives or detonators are parked, the brakes shall be set, the motive power shut off, and the vehicles shall be blocked securely against rolling.

Explosives and blasting agents shall be hoisted, lowered, or conveyed in a powder car. No other materials, supplies, or equipment shall be transported in the same conveyance at the same time. The powder car or conveyance especially built for the purpose of transporting explosives or blasting agents shall bear a reflectorized sign on each side with the word "EXPLOSIVES" in letters, not less than four inches in height, upon a background of sharply contrasting color.

No explosives or blasting agents shall be transported on any locomotive. At least two car lengths shall separate the locomotive from the powder car. (California limits the powder train to the powder car and locomotive). No one, except the operator, his helper, and the powder man, shall be permitted to ride on a conveyance transporting explosives and blasting agents. No explosives or blasting agents shall be transported on a man haul trip.

Cars containing explosives or detonators shall be pulled, not pushed, except when hand-trammed or when switching or traveling at the dead end of a line. When explosives and detonators are hauled by trolley locomotive, covered electrically insulated cars shall be used.

When explosives or detonators are transported underground by locomotive, rope or shuttle car, they shall be in covered cars or in special containers. The bodies and covers of special cars and the containers shall be constructed of non-conductive material. If explosives and detonators are hauled in the same explosive car or in the same special containers, they shall be separated by at least a distance of 24 inches or by at least a 4-inch substantially fastened solid hardwood partition or the equivalent. Some states require a solid partition at least 6 inches thick. Where quantities of explosives and detonators are transported in special cars or in special containers in cars, they shall be hauled on a special trip, not connected to any other trip, and shall not be hauled into or out of a mine within 5 minutes preceding or following a man-trip or any other trip.

Trucks used for the transportation of explosives underground shall have the electrical system checked weekly to detect any failures which may constitute

an electrical hazard. A written record of such inspections shall be kept on file. The installation of auxiliary lights on truck beds, which are powered by the truck's electrical system, shall be prohibited.

The hoist operator shall be notified before explosives or blasting agents are transported in a shaft conveyance. No person shall ride in any shaft conveyance transporting explosives and blasting agents. Detonators and other explosives shall not be transported at the same time in any shaft conveyance.

Hoisting in adjacent shaft compartments shall be stopped while explosives are being handled. Explosives shall not be lowered or hoisted in the same cage, skip, or bucket with other materials, supplies, or equipment. Explosives must be promptly transferred from cage, skip or bucket to the powder car. They shall not be temporarily stored or stacked around the shaft collar or station.

Explosives and detonators can be transported by belt underground only under certain conditions. They must be in the original and unopened case, in special closed cases constructed of non-conductive material, or in suitable individual containers. A minumum clearance of 18 inches must be maintained between the belt and the roof or cross bars, projecting equipment, cap pieces, overhead cables, wiring, and other objects. Suitable loading and unloading stations shall be provided. These stations must be illuminated properly. There shall be an attendant at loading and unloading points and stop controls at these points. Belt conveyors shall be stopped while loading or unloading.

Explosives or detonators shall not be transported on flight or shaker conveyors, or by scraper or mechanical loading machines.

Explosives or blasting agents, not in original containers shall be placed in suitable containers when transported manually. Detonators, primers, and other explosives shall be carried in separate containers when transported manually.

Self-propelled vehicles used to transport explosives or detonators shall be equipped with suitable fire extinguishers.

Vehicles containing explosives or detonators shall not be taken to a repair garage or shop for any purpose. They shall be maintained in good condition and shall be operated at a safe speed and in accordance with all safe operating practices.

STORAGE

All explosive materials must be stored in magazines unless the explosives are in the process of manufacture, use, or transport. The federal government and most states have detailed regulations pertaining to the storage of explosive materials, and these regulations must be consulted and followed at all times. All rules and recommendations for storage are intended to keep the explosives from fire, theft, and deterioration, and to minimize the hazards to life and property these could cause.

PERMITS AND RECORDS

Many states require a permit to store explosive materials. This permit can be issued only to persons 21 years of age or older, and it must be available for inspection at all storage facilities. The permit is non-transferrable and must be renewed yearly. The permit may be revoked or denied for a number of reasons, including noncompliance with regulations. A permit holder intending to change the location of a permanent magazine, add onto or change existing facilities, or upgrade the class of explosives stored in a magazine must apply for an amended permit. The Bureau of Alcohol, Tobacco, and Firearms requires that all explosive materials be stored in conformity with 27 CFR Part 181.

Any loss or theft of explosive materials may be reported to the Bureau of Alcohol, Tobacco, and Firearms by calling toll free 800-424-9555.

A daily record of transactions at each magazine must be kept. It should include the total quantity of explosives received, the total quantity removed, and the total remaining on hand at the close of business for each class of explosives. If loss or theft of any explosives is determined, it must be reported to the Bureau of Alcohol, Tobacco, and Firearms and local regulatory authorities within 24 hours. Failure to do so could result in a maximum fine of $1,000 and/or 1 year imprisonment.

MAGAZINES

There are five types of magazines designed for the storage of various types and amounts of explosive materials. The federal requirements for these are described in 27 CFR 181.183. A Type 1 magazine is a permanent structure that is bullet resistant, fire resistant, theft resistant, weather resistant, and ventilated. A Type 2 magazine is a portable or mobile structure (such as a box, skid-magazine, trailer, or semitrailer) that is fire resistant, theft resistant, weather resistant, and ventilated; Type 2 magazines used outdoors are also bullet resistant. A Type 3 magazine is a portable "day box" type of magazine intended for the temporary attended storage of explosive materials. When unattended it is stored in another appropriate magazine. A Type 3 magazine is bullet resistant, fire resistant, theft resistant, and weather resistant. A Type 4 magazine is a

permanent, portable, or mobile structure (e.g., building, igloo, box, semitrailer) that is fire resistant, theft resistant, and weather resistant. A Type 5 magazine is a permanent, portable, or mobile structure that is theft resistant, and if kept outdoors, it is also weather resistant. Examples are buildings, igloos, boxes, tanks, semitrailers, bulk trailers, bulk trucks, etc. The following table indicates the kinds of explosive materials stored in the five kinds of magazines:

TABLE 1. CLASSES OF MAGAZINES FOR EXPLOSIVE MATERIALS STORAGE

EXPLOSIVE MATERIAL	MAGAZINE TYPE				
	1	2	3	4	5
High Explosives (bullet sensitive)	x	x	x		
Low Explosives (not bullet sensitive)	x	x	x	x	
Blasting Agents	x	x	x	x	x
Detonators	x	x	x		
Detonating Cord	x	x	x		
Electric Blasting Caps with at least 4' leg wires	x	x	x	x	

SEPARATION OF MAGAZINES AND EXPLOSIVE MATERIALS

All outdoor magazines must be located in accordance with the American Table of Distances, Appendix B, Table B-2. Additionally, magazines should be located at least 25 feet from low voltage lines and at least 50 feet from high voltage lines. When ammonium nitrate is stored with other explosive materials, one half the mass of the ammonium nitrate should be added to the mass of the explosives to arrive at the total mass stored in the magazine. Ammonium nitrate-fuel oil (ANFO) mixtures, however, are considered to have the same blast effect as explosives. In unbarricaded, nonbullet-resistant magazines ammonium nitrate and ANFO should have 6 times the separation distances in the American Table of Distances as barricaded stores. This is to protect the stores from high velocity metal fragments. In barricaded magazines the separation distance for ammonium nitrate may be 1/6 the separation distance for explosives, and ANFO may be 6/10 the separation for explosives. These changes are for separation of magazines only and do not effect the separation distances from inhabited buildings, public highways, and railroads given in the American Table of Distances.

Ammonium nitrate can be stored with blasting agents in a magazine suitable for blasting agents, and both may be stored with explosives in a magazine

suitable for explosives. Detonators such as blasting caps, electric blasting caps, and detonating primers must be stored in separate magazines from those for explosive materials. Detonating cord may be stored with explosives in Types 1, 2, or 3 magazines.

The Tables to be applied when determining separation distances of specific materials are indicated in Table 2.

TABLE 2. TABLES FOR SEPARATION OF EXPLOSIVE MATERIALS

Explosive Materials to be Separated	Appendix B Tables
Explosives - Explosives	B2
Ammonium Nitrate - Explosives	B2, B3
Ammonium Nitrate - Blasting Agents	B3
Blasting Agents - Explosives	B2, B3
Ammonium Nitrate - Blasting Agents - Explosives	B2, B3

MAGAZINE CONSTRUCTION

There are many sources of information on the construction of storage magazines. Any construction must comply with federal (See Appendix C) and state requirements, and the site of the magazine inspected and approved by an authorized state or Federal agent before construction begins. Persons who purchase explosives intrastate and may store the explosives so purchased must store then in magazines meeting the requirements of 27 CFR Part 181; however, their storage magazines would not normally be inspected or approved prior to construction because they would not be subject to federal license or permit requirements.

The following specifications for the five types of storage magazines follow the regulations of the Bureau of Alcohol, Tobacco and Firearms (27CRF 181.187 - 181.191) and the recommendations of the National Fire Protection Association (NFPA). Even more detailed information can be found in the Institute of Makers of Explosives, Safety Library Publication Nos. 1, 6, and 17.

General

The following general construction information applies to all types of magazines unless noted otherwise in the discussion of specific magazine types that follows.

Grading -- The ground must always be graded so that water will drain away from the magazine.

Heat -- Heating systems should not be installed unless necessary and must be approved first. Heating can be by either hot water radiant heating inside or forced hot air warmed when blown over hot water, or low pressure (not more than 15 psig) steam coils or electrically heated coils, located outside the magazine. There must be controls to keep the ambient temperature below 54.4°C (130°F).

When using radiant heat the air must be free to circulate between explosives and coils. Explosives containers must not come into contact with heating coils. Storage of the explosives should be in a manner to allow uniform air circulation to maintain uniform temperatures. Ducts for forced air heat should not be allowed to blow hot air directly on the explosives.

Electric fans or pumps must be mounted outside, separate from the wall of the magazine, and they must be grounded. The electric fan motor and controls for electric heat must have overload protection and disconnects as specified in NFPA 70-1975, National Electrical Code. All electrical switching gear and an electrical heating source for water or steam must be at least 25 feet from the magazine, and a fuel fired heating source must be at least 50 feet away. No portable magazine should be allowed within 20 feet of a heat source. The area between the heating source and the magazine must be kept clear of combustible materials.

Lights -- The only recommended lights are electric safety flashlights or electric safety lanterns. However, if other kinds of electric lights are authorized, the following safety precautions prevail:

- The junction box must be 25 feet from the magazine.
- Switches, fuses, or breakers must be protected by an arrester up to 2,500 amps for 0.1 seconds.
- All wiring must be contained in rigid conduit, and outside wiring must be underground. (The depth depends on the geographical area. Check the National Electrical Code.)
- Conduit and fixtures must be protected from physical damage by either placement or guards.
- The light fixture must be suitably enclosed to prevent a spark from reaching the floor or stored materials, e.g. explosion proof fixtures.
- Interior junction boxes should have no openings and be fitted with a tight cover.
- Magazines that contain flammable vapors must conform to the National Electrical Code Class 1, Division 1 recommendations.

- Interior lights must always be left off when the magazine is unattended.

Type 1 Magazine

A Type 1 magazine is the largest and most secure of the magazines. A single magazine is designed to contain any kind of permissible explosive material up to 300,000 pounds of explosives, or 20 million blasting caps.

Foundation -- The foundation must be of masonry, wood, or metal. The only permissible openings are those for cross-ventilation.

Walls -- The walls must be bullet resistant as well as fire and weather resistant. There are several types of construction that will fill this requirement.

- The walls can be of 8 inch hollow masonry block filled with tamped dry sand or tamped cement and sand mixture.

- They can be 8 inches of brick or solid cement.

- They can be wood covered with 26 gauge metal and with a three-quarter inch sheathing of wood or plywood. There must be at least 6 inches between interior and exterior sheathings, filled with tamped sand or tamped cement and sand mixture of at least 1:8 ratio, respectively.

- They can be 14 gauge metal lined with 4 inches of brick, solid cement block, or hardwood; or filled with 6 inches of sand.

There must be no ferrous metal exposed on the interior because of the danger of sparks.

Roof -- The construction of the roof can be of 14 gauge metal, or three-quarter inch wood sheathed with 26 gauge metal, or some other non-combustible material. Any wood exposed to the exterior must be covered with 26 gauge metal.

Floors -- Hardwood or other suitable flooring is recommended. Any material that could cause sparks must be covered with non-sparking material. Alternatively, wooden pallets can be built over unsuitable flooring and the explosives stacked on these. Two inches of air space must be left between the edge of the floor and the walls for air circulation.

Ceiling -- If it is possible to shoot a bullet through the roof at such an angle that it could hit the explosive stores, then the roof or ceiling has to be made bullet resistant. For example, a sand tray 4 inches deep or 4 inches of hardwood should cover the whole ceiling, except for ventilation spaces.

Ventilation -- To prevent dampness and overheating, adequate ventilation should be built into the magazine. To prevent sparks entering the magazine

all vents should be screened with one-quarter inch or smaller wire mesh. Vents in the ceiling should be of water proof sheet metal. Vents in the walls should be offset or shielded. Magazines with vents that are designed to allow air circulation between floors and walls or ceilings and walls should have a wooden lattice "lining" installed to prevent explosive materials from being stacked against the wall where they would restrict air flow.

Doors -- Two examples of bullet resistant doors are:

- three-eighths inch steel plate lined with 4 layers of three-quarter inch, tongue-and-groove hardwood, and
- 14 gauge (or thicker) metal plate lined with 4 inches of hardwood.

Locks -- It is important to protect explosive materials from theft by having adequate locks. The NFPA recommends the following locking systems for each door of a Type 1 magazine:

- 2 mortise locks, or
- 2 padlocks fastened in separate hasps and staples, or
- a mortise lock with 2 keys, or
- a 3-point, or equivalent lock.

Doors locked by internal bolts do not need the additional locks above. The locks should secure the door to the frame at more than one place. The steel padlocks, with a minimum of 5 tumblers and at least 7/16 inch diameter case-hardened shackle, must have steel hoods over them to prevent the shackle being cut with bolt cutters. Hinges and hasps must be fastened to the magazine itself, and all locking hardware must be secured directly to the door frame.

The Bureau of Alcohol, Tobacco, and Firearms requires that all padlocks be protected with 1/4-inch steel caps constructed to prevent sawing or lever action on the locks or hasps. There is no Bureau requirement for specific shackle diameter (27 CFR 181.187(a)(9)).

Finally, when testing a Type 1 or any other magazine for bullet resistance, use test panels or be sure the magazine itself is empty.

Type 2 Magazine

A Type 2 magazine is designed to store a maximum of 50 pounds of explosive materials in warehouses and wholesale or retail establishments.

Indoor -- The floor on which a Type 2 magazine is located must have an entrance at outside grade level, and the magazine must be kept within 10 feet of this entrance. The magazine must have wheels or castors so that it can be quickly removed in emergencies. A second magazine can be in the same building if one of the two magazines has no more than 5,000 blasting caps and the two magazines are separated by at least 10 feet. The local fire department must be notified of the location of a Type 2 magazine within a building and advised of any changes in location.

The sides, bottom and cover can be made of 2 inches of hardwood braced at the corners and covered with 20 gauge or thicker sheet metal. Interior nails must be countersunk. Alternatively, the magazine can be made of 12 gauge metal lined with non-sparking material. The edges of metal covers must overlap the sides by at least 1 inch. The cover must be attached with substantial strap hinges and be locked with a 5 tumbler steel padlock or the equivalent. The box must be painted red and say "EXPLOSIVES - KEEP FIRE AWAY" on the top in 3 inch high, white letters.

Outdoor -- A Type 2 magazine to be used outdoors must be bullet resistant and at least 1 cubic yard in size. It can be constructed of metal lined with at least 4 inches of hardwood or equivalent bullet resistant material. The floor must be of wood or other non-sparking material. Therefore, ferrous metal floors must be covered with other material. As in indoor boxes, the lid must overlap the sides by at least 1 inch when closed. The floor cannot be in direct contact with the ground. Small magazines will be securely fastened to a fixed object to prevent theft. Hinges, hasps, and locks must conform to Type 1 magazine specifications.

Cap Magazine -- A Type 2 cap magazine is designed to hold not more than 100 blasting caps. The sides, bottom and cover can be of 12 gauge metal lined with a non-sparking material. Hinges and hasps are welded, and a single 5 tumbler padlock is the only necessary lock. If the magazine is to be used outdoors to store other kinds of explosive materials, it must be bullet resistant.

Vehicular -- The sides and roof of a mobile Type 2 magazine must be of at least 20 gauge metal. The walls must be lined with:

- 4 inches of brick, solid cement block, or hardwood, or
- 6 inches of sand or other bullet resistant material.

The roof or ceiling must also be bullet resistant as in a Type 1 magazine. Exposed interior walls may be lined with wood. The floors are to conform to Type 1 construction. The doors can be either:

- metal lined with 4 inches of hardwood, or
- a metal exterior door and a 4 inch hardwood interior door.

There must be 2 paddlocks on each entrance to the magazine:

- 2 padlocks on the exterior, on separate hasps and staples, or
- 1 padlock each on an exterior and an interior door.

The padlocks must be steel, with 5 tumblers, and at least a 7/16 inch diameter case-hardened shackle. They need not be protected by a steel hood. As in a Type 1 magazine, hinges and hasps are attached directly to the magazine, and all locks are mounted directly to the door frame. When unattended, the wheels must be removed or locked with a kingpin, or the trailer must be otherwise immobilized.

As for Type 1 magazines, the Bureau of Alcohol, Tobacco, and Firearms requires that all padlocks be protected with 1/4-inch steel caps constructed to prevent sawing or lever action on the locks or hasps. The Bureau presently has no requirements for specific shackle diameter.

Type 3 Magazine

A Type 3 magazine is designed to hold explosive materials at a job site and must remain attended. It must be situated away from neighboring inhabited buildings, railroads, highways, and other magazines. If the contents of the day box are greater than 25 pounds of explosives, 150 feet or more must be maintained between it and any other magazine; if the contents are less than 25 pounds, 50 feet distance shall be observed. Two Type 3 magazines may be at a blasting site when one is used exclusively for blasting caps or electric blasting caps.

A Type 3 magazine shall be made of:

- 4 inches of hardwood braced at the corners and covered with at least 20 gauge metal, or
- 12 gauge metal lined with a nonsparking material; cover edges must overlap sides by at least 1 inch.

Nails exposed to the interior of wooden magazines must be countersunk. Type 3 magazines must have a 5 tumbler padlock.

Type 4 Magazine

The Type 4 magazine is made for 50 pounds or less of explosive materials stored in warehouses and retail establishments.

Indoor -- An indoor Type 4 magazine shall be on a floor with an entrance at outside grade level. It must be kept within 10 feet of this entrance. A second magazine may be kept in the same building if one contains not more than 5,000 blasting caps, and the magazines are kept at least 10 feet apart. The local fire department must be notified of the location of the magazine within a building and advised of any changes in location. Construction of an indoor Type 4 magazine shall conform to Type 2 construction.

Oudoor -- An outdoor Type 4 magazine will have the same foundations as a Type 1 magazine. The walls and roof must be constructed of:

- masonry, or
- wood covered with metal, or
- fabricated metal, or
- any combination of above.

The doors should be metal or wood covered with metal. The floors, ventilation, locks, hinges and hasps shall also conform to Type 1 specifications.

Vehicular -- Type 4 magazines should meet Type 2 specifications for locks,

hinges, hasps, and locking hardware. The vehicle must be immobilized when unattended as described for Type 2.

Type 5 Magazine

A Type 5 magazine is designed to store not more than 50 pounds of explosives materials in a warehouse, wholesale, or retail establishment. Neither an outdoor nor an indoor Type 5 magazine has to have ventilation, and ferrous metal on the interior need not be covered. An indoor magazine does not have to be weather-resistant but is otherwise the same as an outdoor Type 5 magazine. A Type 5 magazine must not be located in a residence or dwelling.

Outdoor -- An outdoor Type 5 magazine must be weather resistant. It must be locked with at least 1 steel case, 5 tumbler padlock with a 7/16 inch diameter, case-hardened shackle. A protective hood is not required. Hinges and hasps must be secured to the magazine, and locking hardware must be secured directly to the door frame.

Vehicles -- Vehicles must be immoblized as specified for Type 2 magazines.

UNDERGROUND STORAGE

Most places prohibit underground storage; therefore, check the local regulations before building an undergound facility. Wyoming, however, requires powder magazines to be built substantially underground. Because of humidity problems, explosive materials must not be stored underground for long periods of time. It is recommended that only a few days supply be brought in at a time. It may be necessary to have warm air flow through the magazine to reduce moisture. The magazine must be well drained and the crates of explosives stacked on flats up off the floor.

If feasible, underground storage should be limited to a daily supply or distributing magazine supplemented with box type magazines. Separate boxes must be available for dynamite and detonators. Surplus or loose explosives should be kept in boxes.

The magazine should be located so as not to close off the exit if there is an explosion. Alabama requires the storage to be at least 200 feet from the opening of a mine, unless the magazine is effectively barricaded. Alabama also requires that magazines and section boxes be kept in a crosscut or idle room 25 feet from roadways, trolley wires or power lines and 75 feet from the working face. Furthermore, a day box must be kept at least 15 feet from roadways, trolley wires, and power lines. The distance for day boxes may be reduced to 5 feet if they are in a niche in the rib, 75 feet from the working face, and out of line of the blasting, thus not subject to shock.

Ventilation should be provided to the magazine to carry fumes out of the mine in case of an explosion. There should be no electric wiring and no open lights inside the magazine. Lighting may be provided through a window or an open door. Some states allow vapor-proof lights in accessible, outside walls.

As in above ground magazines, explosives and detonators must be stored separately, and Alabama requires that they be kept at least 5 feet apart at all times. Empty cases and debris must be removed daily to the surface for disposal.

At surface mines, the main magazine should be located outside of the pit.

STORAGE ON WATER

The safety recommendations for storing explosive materials on water are taken from the Massachusetts Fire Prevention Regulations. Any boat or vessel used exclusively for the purpose of storing explosive materials must be securely moored according to the directions of the Harbor Master. The mooring will be subject to the requirements of the American Table of Distances, Appendix B, Table B-2. (Distances can be halved if the cargo is Class B explosives only.) No detonators may be stored with explosives. No Class A explosives may be delivered for storage during foggy weather.

Boats or vessels being used to store explosives must display the International Code Flag B on a suitable staff, visible from 1000 feet at day and illuminated at night. Each side of the boat or vessel will have the words "EXPLOSIVES - DANGEROUS" painted on it.

MOTOR VEHICLE TERMINALS

The following recommendations for storing explosive materials at motor vehicle lots are taken from NFPA 498-1976, Explosives Motor Vehicle Terminals. The NFPA strongly urges the terminal operator to provide and maintain an active safety program for employees. Furthermore, written emergency instructions should be posted and readily accessible to all employees. Portable fire extinguishers with a minimum rating of 4-A:30-B:C shall be kept within easy reach at each interchange lot and storage facility. Water lines with hoses may also be installed, as well as fire hydrants in accordance with NFPA 14-1974, Standard for the Installation of Standpipe and Hose Systems. Smoking, matches, open flames, spark producing devices, and firearms are not allowed within 50 feet of an interchange lot or a storage facility.

Interchange Lots

All explosives interchange lots must be located in remote areas. They should be separated by at least 100 feet from buildings and structures, parking lots, fuel and power facilities, and other facilities. Combustible materials, including weeds and underbrush must be cleared for a distance of 25 feet from the lot. When flood lights are provided, overhead power lines should not be erected within the perimeter of the lot. The lot should be protected from unauthorized personnel by warning signs, fences, gates, and intermittant patrols. Patrolling is not required if the lot is enclosed by security fence, the gates are locked, and the area aound the lot is posted with warning signs.

The watchman must be made aware of the class of explosives in each vehicle,

and of its dangers. He must have been trained in measures and procedures to be followed to protect the public. A motor vehicle capable of moving those trailers loaded with explosives must be kept in good operating condition at all times. The vehicle must be available to the watchman, who will have been trained and will have authority to use it. The vehicle must be parked at least 25 feet from the nearest explosives trailer.

If a large number of vehicles containing explosives are to be parked, more than one lot should be provided. The lots should be separated as far as is practicable to reduce the concentration of explosives. Artificial barricades must be erected between lots not sufficiently protected by natural barricades or separation distance. The barricade should be high enough so that a line drawn from the top of any trailer in one lot to the top of any trailer in another lot will pass through it.

Except for minor repairs, no repair work can be performed on any vehicle parked on the lot. The cargo must be removed and the vehicle taken from the lot before any repairs involving cutting, welding, operation of vehicle engine, or electrical repairs can be performed. No explosives are to be transferred from one vehicle to another on the lot except in necessity or emergency.

Vehicle Parking

Motor vehicles may be admitted for parking after passing, at minimum, an inspection which includes checks for hot tires, hot wheel bearings, hot brakes, fuel leakage, oil leakage, accumulations of oil or grease, and checks of the electrical system and any violations of ICC equipment interchange rules. These or any other apparent physical damage to the vehicle which could cause or contibute to fire must be corrected before the vehicle can be admitted to the lot. Vehicles must be maintained in the same condition as required on the highway, including placarding.

Self-propelled vehicles containing explosive materials must be parked 25 feet from any other vehicles containing explosives, and they must be situated where they can be easily removed from the lot in case of emergencies. Spacing of not less than 5 feet shall be maintained between all other parked vehicles so that any vehicle can be removed without moving any other vehicle. Where possible, vehicles loaded with commerical explosives should be parked on separate lots from vehicles containing military explosives. When the trailers have been properly situated on the lot, the tractor must be immediately disconnected and removed from the lot.

No vehicles transporting other hazardous materials shall be parked on an explosives interchange lot unless the materials are compatible with explosives (for example, ammonium nitrate and nonflammable compressed gases). In case of emergency, where vehicles loaded with other hazardous materials are brought into an explosives interchange lot, such vehicles should be parked at a location well separated from the vehicles carrying explosives.

Less-than-truck-load lots

A temporary storage facility conforming to the construction of a Type 1 magazine may be provided. If blasting caps or other detonators are to be stored, then a second, separate magazine is required for them. The magazines must be at least 50 feet from structures on adjacent property or from any potential fire hazard. An area at the loading dock may be designated for temporary storage of explosives in a trailer provided it is not near any fire hazard.

Explosives brought to the terminal to await shipment must be kept in a temporary storage facility until loaded. Explosives delivered by a connecting carrier may be kept in the carrier at the specially designated area of the loading dock, or the trailer may be parked in an isolated area of the terminal, or the explosives may be unloaded into a magazine for temporary storage. Explosives may not be kept either on the lot or in temporary storage longer than 72 hours unless they are in a proper magazine located in accordance with the American Table of Distances (Appendix B). Authorized terminal personnel must be in the vicinity of temporarily stored explosives.

MAGAZINE OPERATIONS

The magazine must be in the charge of a competent person 21 years or older, who is responsible for the enforcement of safety procedures. The safety rules should be posted on the interior of the magazine door. The magazine must be locked at all times except during the placement and removal of explosive materials and during inspections. Inspections should take place at least every 3 days to check for unauthorized entry or illegal removal of the explosives.

No smoking, matches, open flames, spark-producing devices or gun (except a gun worn by a guard) is permitted within 50 feet of any explosives storage facility. The area around a magazine must be kept clear of brush, dry grass, and other combustibles for 25 feet, and of rubbish for 50 feet. No other combustible materials may be stored within 50 feet of a magazine. The property around a Type 1 magazine and outdoor Types 2, 4, and 5 magazines must be posted with warning signs which say "EXPLOSIVES KEEP OFF". The letters should be 3 inches high and 1/2 inch wide. Access roads to magazines must also be posted. The signs should be situated in such a way as to minimize the possibility that a bullet which is shot at a sign might hit the magazine.

Good housekeeping procedures must be followed at all times. Corresponding grades and brands of explosives should be stored together so that their marks show. This makes it easier to count and check supplies. Different kinds of explosive materials should be segregated from one another. For instance, black powder should be grouped separately from other explosives. The stores should be laid flat with the top sides up. They should be piled in a stable manner, not higher than 6 feet. Nitroglycerin may be placed on shelves no more than 54 inches above the floor, in a single tier. The closures should be loosened to permit venting, and retightened when the vessels are moved. Explosive materials must be kept from contact with

masonry, steel or other ferrous metal by means of a nonsparking lattice or equivalent lining, mastic, or paint. The oldest stock should always be removed and used first.

Wooden or damaged containers should not be unpacked or repacked inside a magazine, or within 50 feet of a magazine or other explosives. Only fiberboard containers may be opened inside a magazine. Tools to open explosives containers should be of nonsparking material. A wooden wedge and a fiber, rubber, or wooden mallet are used for opening and closing wooden cases. Metal slitters may be used to open fiberboard. Open containers must be securely closed before being returned to the magazine. No container without a lid may be stored. Metal tools other than non-ferrous conveyors cannot be stored with explosives or detonators. Ferrous metal conveyor stands may be stored in a magazine when the stands are protected with a coat of paint.

The floors should be swept regularly and kept clean and dry. Brooms and other cleaning utensils must not have any metal, spark-producing parts. The sweepings of explosives should be disposed of according to the manufacturers instructions. When explosives have deteriorated to the point of becoming unstable or dangerous, or leaked, an experienced person only must destroy them and their containers in accordance with the manufacturers instructions. An exception is that the uncontaminated contents of broken bags of ammonium nitrate may be salvaged by placing the damaged bag inside a clean, new bag that is then securely tied. Liquid nitroglycerin containers should be inspected once a week for leakage, rust, or warping, and if found, should be destroyed. Standing pools of liquid nitroglycerin must first be absorbed with sawdust that will be burned. Then the floor can be cleaned with a neutralizing solution made of:

1 lb. sodium sulfide (60% commercial), dissolved in
1-1/2 qts. water; to this mixture is added
3-1/2 qts. denatured alcohol, and
1 qt. acetone.

Never add the neutralizing solution to standing pools of nitroglycerin.

If interior repairs to the magazine are necessary, the explosives must be removed and the floors thoroughly cleaned. The explosives must also be removed during exterior repairs if there is a danger of producing sparks. The explosives should be placed in another magazine, or a safe distance away where they will be protected and under guard. They should be returned promptly to the magazine as soon as repairs are completed.

Materials recovered from blasting misfires must be stored separately until proper methods of disposal have been determined. Blasting caps and electric blasting caps must not be saved for reuse. Unused, primed sticks should be disassembled prior to storage. (In California, however, the law provides for a makeup or primer house within which a number of primers not exceeding 2 days usage may be stored. Not more than 100 pounds of other explosive materials may be kept in the same house). Empty boxes and paper and fiber packing materials that have contained explosives shall not be reused. They

should be burned at an approved, outdoor site. No person should be allowed closer than 100 feet after the burning starts. Paper products left around are potentially fatal to livestock.

BLASTING AGENTS AND WATER GELS

Type 5 magazines or other magazines that are waterproof can contain blasting agents. Any magazine used to store blasting agents must not have drains or piping into which molten materials could flow and be confined in case of fire. A bullet resistant magazine is not required for water gels of DOT classification B.

Bulk storage bins for blasting agents should be adequately supported and braced to withstand all loads and impacts from load movement and accidental vehicle contact with supports. Bins and supports should be constructed of compatible materials. The area around bins should be kept clean and picked up. Weeds and other combustible materials must be kept cleared within 25 feet of the bins. Storage material spilled on the ground must be promptly cleaned up.

The discharge gate of bulk bins must close tightly to prevent leakage. The gate should be locked when unattended. Loading manways or access hatches should be hinged or otherwise attached and be designed to lock. Electrically driven conveyors must conform to the National Electrical Code. They should be constructed to minimize damage from corrosion.

Semi-trailers or full trailer vans and tanks used for on-site or highway transportation are suitable for temporary storage of blasting agents and water gels. Trailers must be kept locked except to load or remove stores. Locks shall conform to those required on a Type 5 magazine. Trailers used for temporary storage must be parked in accordance with the American Table of Distances (Appendix B).

Under no circumstances may caked oxidizers be loosened by blasting.

Ammonium Nitrate

Ammonium nitrate (AN) and ammonium nitrate-fuel oil (ANFO) mixtures need special care in storing because of their combined flammable and explosive properties. There are special federal and state regulations pertaining to AN and ANFO, and these should be consulted as the following information is intended to reflect the more common regulations only.

Permits -- The National Fire Protection Association suggest that a permit be required to store more than 1,000 lbs. of AN, that the storage facility and the site be approved for the storage of more than 60 tons of AN, and that approval of large quantities of AN in storage be subject to fire and explosion hazards, including exposure to toxic vapors, and the proximity of residences, places of public assembly, schools, hospitals, railroads, and public highways. Use of a building not conforming to specifications may be approved if it is not a hazard to life or adjoining property.

Separation -- AN should be kept in a separate building or separated by at least 1 hour fire-resistance rating walls from organic chemicals, acids and other corrosives, materials requiring blasting during processing or handling, compressed flammable gasses, or other flammable or combustible materials. These include animal fats, baled cotton, baled rags, baled scrap paper, bleaching powder, burlap or cotton bags, caustic soda, coke, charcoal, cork, camphor, excelsior, fibers, fish oils, fish meal, foam rubber, hay, lubricating oil, linseed oil, other oxidizable or drying oils, naphthalene, oakum, oiled clothing or paper, oiled textiles, paint, straw, sawdust, wood shavings, vegetable oils, fibers of any kind, etc. Separation walls need extend only to the underside of the roof. Sills and curbs may be required to prevent mixing of materials during fire. Flammable liquids and light fuel oils may only be kept on the same premises with AN if such storage complies with NFPA 30-1973, Flammable and Combustible Liquids Code and if sills and curbs are provided. Liquified petroleum gas may only be stored with AN if conforming to NFPA 58-1974, Standard for the Storage and Handling of Liquified Petroleum Gases. Under most circumstances AN should not be stored with sulfur or finely divided metals. Within a magazine, ANFO must be kept physically separate from explosives, safety fuse, or detonating cord so the fuel oil will not contaminate them.

Storage Construction -- Any building used to store AN must be of one story unless otherwise approved. It should have no basement unless the basement is open on one side. The building must have good ventilation or be self-ventilating in case of fire. Buildings must be kept dry and free of water seeping through the roof, walls, and floor. The wall on the exposed side of a building within 50 feet of a combustible building, forest, piles of combustible material, and similar fire hazards must be of fire resistant material or be free standing. Roof coverings will be Class C or better as described in NFPA 203M-1970, Manual on Roof Coverings. All floorings shall be of noncombustible materials or protected against impregnation by AN, and the floors must not have open drains, traps, tunnels, pits, or pockets into which molten AN could flow and be contained during a fire. Provisions must be made to prevent unauthorized entrance to AN storage areas.

In areas where lightning storms are prevalent, lightning protection should be provided in accordance with NFPA 78-1975, Lightning Protection Code. This book details installation of lightning protection equipment and grounds for different types and locations of structures. Electrical installations shall conform to NFPA 70-1975, National Electrical Code for ordinary locations. They should be designed to withstand corrosion. Electric lamps must be located or guarded in such a manner that they will not come into contact with bags of AN or other combustible materials.

Fire Protection -- Unless otherwise approved, no more than 2,500 tons of bagged AN can be stored in a building or structure not equipped with a sprinkler system. Protection may be required in any case if the location of the building or presence of other stored materials present a hazard. Sprinklers must be of approved type and installed according to NFPA 13-1975, Standard for Installation of Sprinkler Systems. For instance, the pressure and flow must be approved, branch lines should carry no more than 6 sprinklers per side, each sprinkler should protect 90 feet. Suitable fire

control devices shall be provided throughout the warehouse and at loading and unloading areas. Water supplies and fire hydrants must be available as required by the location of the warehouse. Any of the above requirements may be waived if the location is remote enough. For detailed information on fire protection measures see NFPA 14-1974, Standard for the Installation of Standpipe and Hose Systems; NFPA 24-1973, Standard for Outside Protection; and NFPA 10-1975, Standard for the Installation; Maintenance, and Use of Portable Fire Extinguishers.

Containers -- Bulk storage of AN may be in piles or bins in warehouses, or in separate bin-like structures. Bags and containers must comply with ICC specifications. Bulk storage structures should not exceed 40 feet in height unless they are of noncombustible materials or unless adequate fire-fighting facilities are provided. To avoid corrosion of bins and the resulting contamination of AN, do not use galvanized iron, copper, lead, or zinc for bin construction unless protected. Aluminum and wooden bins must be protected from AN impregnation. Steel or wood can be protected by sodium silicate, epoxy, or polyvinyl chloride coatings. Bulk bins must be kept clean and free of contaminants. There may be any number of compartments or bins. Dividers must be of tight construction.

When storing ANFO in bulk bins, venting must be provided to equalize internal and external pressures. If ladders are necessary to get to the bins, ladder cages should be provided. There should be catwalks and railings to fill hatches and appurtenances needing inspection. The bins should be bullet resistant.

Operations -- Containers of AN must not be accepted for storage when their temperature exceeds 54.4°C (130°F). Bags of AN should not be stored within 30 inches of magazine walls and partitions. The height and depth of piles of AN are limited by the pressure-setting tendency of the product. However, the height and width of piles of AN must not be more than 20 feet. The length of piles should not exceed 50 feet, unless the building is noncombustible or is equipped with automatic sprinklers. At no time should the piles come closer than 36 inches to the roof or support beams. Piles of AN must be separated by aisles at least 3 feet wide. A minimum of 1 service lane should be maintained at 4 feet in width. Requirements for pile sizes and aisles may be waived when storage facilities are located in remote areas, although approval must be obtained first.

Older piles and bins of AN must be used first to minimize caking. All materials should be moved out periodically to prevent this problem. Dynamite, other explosives and blasting agents must never be used to break up or loosen caked AN.

Internal combustion motor vehicles, lift trucks, and conveyors must not remain unattended unless parked in a specially provided area that will prevent the spread of fire, in case of vehicle fire. Trucks, tractors, platform lift trucks and other specialized industrial trucks used within a warehouse shall conform to the requirements of GS (gas powered), LPS (liquid petroleum gas), or DS (diesel) with exhaust, fuel and electrical systems safeguarded or EE (electric) with the electric system fully enclosed

designated units. The units are fully described in NFPA 505-1975, Standard for the Use, Maintenance and Operation of Powered Industrial Trucks. Hollow spaces (conveyor rollers, hollow screw conveyor shafts) must be avoided in AN handling equipment, where AN could collect and be confined under sufficient pressure to become a source of explosion during fire.

All entrances to commercial warehouses must be posted with durable signs reading "AMMONIUM NITRATE". The background and lettering must be of contrasting colors, and the letters should be at least 2 inches high. Storage bins or piles must also be clearly identified with the signs.

Fire Fighting -- The mass of AN must be kept cool. The fire must be extinguished promptly by applying large volumes of water as fast as possible. If the fire reaches massive proportions, evacuate fire fighting personnel. Provide as much ventilation as possible to dissipate decomposition products and the heat of reaction. Approach the fire from upwind to avoid the AN fumes, which are toxic. Use self contained breathing apparatus of a type approved by the U.S. Bureau of Mines (see 30 CFR 11.70-11.85).

After the fire, loose and contaminated, unsalvagable AN should be buried, or dumped in water where permissible. Residue remaining after sweeping should be hosed. Flushing and scrubbing should be thorough to remove the residue. Wet bags should be dried, then burned outdoors.

USE

Safety in the use of explosives depends, in large part, on the people involved in the blasting operation. Those who are assigned blasting operations should be carefully chosen, should have intelligence and common sense, and should be trained in the use of explosives. In addition to courses on the safe handling of explosives, on the job training is important. Any on-the-job training, however, should be supervised by an experienced blaster until the trainee is capable of working safely without supervision.

Information on explosives use was derived primarily from the Institute of Makers of Explosives publications and the California Administrative Code.

PERMITS

The Federal government has no permit requirements for users or blasters. Some states and municipalities, however, require permits. All jurisdictional permit requirements should be checked before using explosives. Generally, as described by the Institute of Makers of Explosives Publication No. 3, for those cases where a permit is required "No person shall be in possession of explosive materials or conduct an operation or activity requiring the use of explosive materials or perform or supervise the loading and firing of explosive materials without obtaining the proper permit." Every person who conducts such an operation shall obtain the permit and be responsible for the results or consequences of any loading or firing of explosive materials and shall permit the loading and firing to be performed only by an individual possessing a permit to blast.

An applicant for a blaster's permit must generally demonstrate adequate training and experience in the use of explosive materials and must pass a qualifying examination to determine competence. A blaster must be able to understand and give written and oral orders, be in good physical condition and not addicted to narcotics or intoxicants, be qualified by reason of training, knowledge, or experience, in the field of transporting, storing, handling, and use of explosives, and have a working knowledge of state and local laws and regulations. In some jurisdictions, i.e., District of Columbia and Florida, a blaster's examination is required. The user's permit must be posted at each place of operation and the blaster's permit must be carried by the permit holder during the blasting operation.

Permit holders are subject to restrictions and any permit may be denied or revoked. The state application permit should be carefully read and regulations followed.

Recordkeeping is a very important part of the permit process. All recordkeeping regulations should be strictly adhered to. Records must be kept for each blast. All of the explosives, blasting agents, and blasting

supplies used in a blast must be recorded and all returned explosives noted, and a running inventory of all stored explosives and blasting agents must be maintained. Records must be kept for at least 5 years and should follow a format similar to that on the following page.

A&B # 6A

DEPARTMENT OF MINES AND MINERALS
Division of Explosives and Blasting
P.O. Box 680
Lexington, Kentucky 40501
Phone 254-0367

REPORT OF BLASTING OPERATIONS

NAME OF COMPANY _____ ADDRESS _____
NAME OR LOCATION OF JOB _____
DATE: _____ TIME OF BLAST _____ AM _____ PM _____
TYPE(S) OF CHARGE: _____
BURDEN AND SPACING _____
DEPTH AND DIAMETER OF HOLE: Diameter _____ Number _____ Depth _____
Diameter _____ Number _____ Depth _____
DEPTH OF STEMMING _____ TYPE _____
TYPE DETONATION: Electric ( ), Detonation cord ( ), Fuse ( ).
DELAY TYPE(S) _____ CAP TYPE(S) _____ PRIMER TYPE(S) _____

HOLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DELAY FROM 1st HOLE OR CAP NO.																				
LBS. IN HOLE																				

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

DISTANCE FROM NEAREST DWELLINGS, BUILDINGS _____ HIGHWAYS OR RAILROADS _____
OTHER POSSIBLE HAZARDS: Overhead wires _____ Underground pipes _____ Others _____
TYPE OF TERRAIN: Hilly _____ Flat _____ Underground _____ Other _____
TYPE OF STRATA: Slate _____ Shale _____ Sandstone _____ Limestone _____ Other _____
WAS MAT USED? Yes ___ No ___ Type Mat _____ Weight of mat used _____
WAS MAT WEIGHED? Yes ___ No ___ Other precautions _____
CONDITION OF WEATHER: Dry _____ Foggy _____ Clear _____ Rain ___ Snow ___ Cloudy ___
Seismograph records where required:

a. Name of person and firm analyzing the seismograph record _____

b. Seismograph reading _____

NAME (Blaster) _____
Blasters License Number _____
Blasters License issued by: Department of Mines & Minerals, Division of Explosives & Blasting
Draw rough diagram of job on reverse side.

SIGNATURE _____
POSITION _____

RECORDS MUST BE KEPT AT LEAST FIVE YEARS

GENERAL BLASTING PROVISIONS

Anyone known to be under the influence of alcohol shall not be allowed on the job. Horseplay and scuffling must be absolutely prohibited. In addition, no smoking, matches, or fire or flame producing devices should be allowed on the site.

Explosives can be toxic when ingested or contacted with the skin. Hand must be washed thoroughly before eating, drinking or smoking. Clean non-static producing gloves and clothing, i.e., coveralls, should be worn when handling explosives; wash with soap and water following handling.

When there may be exposure to falling objects, personnel must wear protective hats or caps. All work should be well planned. At least 2 men should be present at each blasting site.

Every blast site should have adequate first aid material available and personnel trained in first aid procedures present. Adequate rescue equipment must be immediately available. Where there appears to be any possibility of fire, fire protection must be provided, i.e., water supply with adequate pressure and chemical, automatic chemical or water extinguishers. If a fire cannot be controlled, the area must be evacuated. If during any loading cycle an uncontrolable fire is observed in the vicinity, all personnel should be evaculated.

Haulage to the blast area is usually by the operator's trucks on his own roads. These access roads should be well-maintained and the haulage equipment should be especially selected and maintained for explosives haulage. Vehicles must conform to the DOT regulations outlined under TRANSPORTATION.

Dynamite and detonators must, of course, be kept separate in suitable containers and should be stored separately near the shot area. Explosives or blasting agents in the blast area should be distributed in piles of a quantity and spacing that accidental explosion of one pile cannot cause sympathetic detonation of all piles. It is much safer to have a few larger piles widely spaced than many smaller piles close together.

The use of an axe, bar, hammer, pick, or other iron or steel implement to punch holes in or open containers of dynamite, black powder, blasting caps, electric blasting caps, or detonators is prohibited. A wooden, rubber, rawhide, fiber, copper, zinc, or babbit mallet and wooden wedge should be used.

When explosives in excess of the immediate requirements are removed from a magazine and delivered in the vicinity of a blasting operation, they shall be kept in an approved Class II portable magazine (See STORAGE). Such a magazine or building must be kept securely locked (2 locks of case-hardened steel not easily accessible to vandals) to be opened only by an authorized person. A distance of at least 50 feet should be maintained between the portable magazine and the work in progress.

Any explosives that are damaged or deteriorated shall not be used and any empty containers or paper and fiber packing materials which previously contained explosive materials must be returned to a magazine for pick-up and removal to an approved site to be destroyed by burning. Under no conditions should explosive materials be abandoned.

If explosives freeze, advice must be secured from the manufacturer before using or attempting to thaw. Frozen explosives should generally be destroyed in the prescribed manner. Exposure to weather damages most kinds of explosives; keep them cool and dry. No attempt should be made to reclaim or use water-soaked blasting caps, electric blasting caps, or other explosives even if dried out. Water decreases the sensitivity of blasting agents and increases the output of toxic fumes on detonation. If water cannot be removed from holes, water-resistant explosives must be used.

Whenever possible, surface blasting operations should be conducted during daylight hours, but in all cases, jurisdictional regulations should be checked. If the blasting is to be done in the vicinity of public utility lines such as gas, electric, telephone, or steam, the blaster must notify the utility representative at least 24 hours prior to blasting. In all blasting operations, the maximum peak particle velocity of the ground motion in any direction shall not exceed 2 inches/second at the immediate location of any dwelling, house, public building, school, church, commercial or institutional building. Only electric blasting caps shall be used for blasting operations in congested areas, especially near highways. In such cases, the area shall be covered before firing with a blast mat to prevent fragments from being thrown. When any building is exposed to air or ground vibrations, a seismograph should be used to record and document vibrations.

In addition, special precautions are necessary in areas close to structures, railways, or highways to prevent damage by earth vibration, air blasts, or thrown fragments. To ensure the safety of the public and the workers, the blaster must use warning precautions including warning signals, flags, barricades, or signs. Precautions should also be taken to prevent the accidental discharge of electric blasting caps from current induced by radios, radio transmitters, lightning and power lines. Some of these precautions include:

- Supervision of blasting operations and removal of personnel from the blasting area during the approach and progress of electrical, dust, or snow storms.

- Ensure that mobile radio transmitters which are less than 100 feet from the blasting operation are deenergized and locked. When necessary to perform blasting operations at lesser distances, detonating type fuse shall be used.

- Post signs on all adjacent roads warning against the use of mobile radio transmitters.

- Clear the area within 1000 ft of the blast.

Blasting agents are generally less sensitive than other explosives but they should be handled with the same care and respect. In use they are combined with a cap-sensitive explosive; the entire charge, therefore, should be accorded the respect due the most sensitive element.

PREPARATIONS FOR BLASTING

Drilling

Good drilling practices are essential and necessary for safe blasting operations. Poorly drilled shot patterns can cause cut-offs, fly rock, and poor blasting results. All of the drill holes must be sufficiently large for free insertion of the explosive materials. Mudcapping is permitted only where the safety of the workers is endangered by drilling; if mudcapping is necessary, the least amount of explosives to produce the desired result should be used; in no case should more than 10 lbs of explosive be used.

Tamping

Tamping should only be done with wood rods without exposed metal parts. Plastic tamping poles should not be used because some are too soft for physical abuse, some are too hard, some are flammable, some absorb nitroglycerin and some generate hazardous accumulations of static electricity. Non-sparking metal (i.e. brass) connectors may be used for jointed poles.

In addition:

- Do not use excessive pounding to force explosives into blocked holes
- Do not tamp the primer stick
- Do not use any technique that generates heat, friction, galvanic current, or impact.

The end of the pole must be kept from becoming frayed or accumulating a mixture of grit and dynamite which would make the dynamite more sensitive to impact. A hard rubber plug or disc can be used on the end of the tamper.

Loading

Prior to delivery of explosives for loading, all holes should be checked for depth and clearance and all necessary redrilling done. The drilling equipment should be removed 100 ft from the loading area, all personnel cleared from the blast area and all stemming material placed in a safe location. Only personnel directly involved with loading should be at the site. Primers, detonators, explosives, and detonating fuses shall be kept in magazines until all the holes are drilled; then they can be delivered to the loading site and stacked on the ground near the loading zone. If power lines or trailing cables of any electrical equipment are within 15 feet of any holes to be loaded, materials shall not be placed near the hole until

power lines, cables, etc., are removed or deenergized. No combustion engine should be operated wiithin 100 feet of the blasting zone.

The right explosive and priming system should be used for the job. The initiator should be properly imbedded in the primer so that it cannot fall out.

It is important not to load any hole except those to be fired in the next round and to return all unused explosives to the authorized magazine prior to the final hook-up and firing. The boreholes should be rechecked prior to loading; any obstruction should be removed with a tamping pole or other suitable device. Drill holes which have contained explosives or blasting agents should not be deepened. No loading operation shall be conducted within 25 feet of a drilling operation. No vehicle traffic shall be permitted over loaded holes.

Care must be taken not to load hot holes which may result from springing shots, from underground fires in coal stripping, or from a hot, broken drill steel or bit. The safest procedure is not to load the borehole until one hour after it is drilled. If loading must be done immediately after drilling, the hole temperature should be carefully monitored. No explosives should be loaded if temperatures are in excess of 150° F. Since there is always a question whether the observed temperature is the hottest, it may be wise to cool the hole with water if the explosive to be used has adequate water resistance.

Using Detonating Cord

Large diameter bore holes are often initiated with detonating cord. The basic procedure for loading large diameter boreholes with 50 grain detonating cord is as follows:

- Check borehole with mirror or tape to make certain it is clear to full depth.
- Attach detonating cord to the first cartridge or primer loaded into the borehole.
- Insert rod or spindle through axial hole of the detonating cord spool to facilitate handling.
- Ascertain that the cartridge is actually down to the bottom of the borehole. If not, and if safely possible, pull the cartridge or primer back out of the hole and clean the bore hole out.
- After the first cartridge is loaded, cut the detonating cord from the spool. If the spool is left connected to the hole, it may detonate on the surface propagating to other explosives.
- Allow 3 feet or more of detonating cord to protrude from the hole to compensate for slumping of the first cartridge deeper into the hole.

- o Draw detonating cord taut and hold at one side of the hole so that it cannot be broken by, and does not interfere with, subsequent loading.

- o After loading, fasten the end of the cord at the top of the hole by tying it around a rock, other heavy object or a piece of wood longer than the diameter of the hole to prevent kicking it or pulling it into the borehole.

When use of detonating cord would cause severe air blast, trunk lines can be covered by 5-6 inches of loose earth. A double trunkline or loop system shall be used in detonating cord blasting. Trunklines in multiple row blasters shall make one or more complete loops, with crossties between loops at intervals not over 200 feet. All detonating cord knots shall be tight and all connections shall be at right angles to the trunk lines. When connecting sections of detonating cord together:

- o Make certain that the cut ends are free of water, oil, or other foreign material. Cut ends of cord pick up moisture but penetration is generally less than 8-12 inches so place all connections or detonators at least 12 inches from the exposed open end to be sure of positive initiation.

- o Make all connections at right angles. Sharp angles can cause the cord to cut itself off.

- o Do not kink, bend, scrape, or leave slack in the detonator cord, trunklines, or borehole downlines or uplines.

- o Make all detonating cord knots tight and in contact. Loose knots may fail to transmit the detonation wave.

- o Make sure every borehole has two paths by which detonation can reach it and cross-ties between the trunklines at frequent enough intervals to provide positive detonation. Cross-ties are insurance against trunkline cut-offs due to ground movement or flying debris from the shots which fire earlier in the shot's delay sequence.

- o Always cut off excess cord after tying-in to prevent excess from detonating across the trunkline and cutting it off.

- o Keep the shot pattern clear of boxes, box lines, explosives, etc, so that trunkline layout is visible.

- o When using several detonating cord downlines, uplines, or trunklines make sure they do not cross; one cord may detonate prior to another severing it and causing it to fail.

Pneumatic Loading

Construction of Air Loaders -- All bulk explosives shall not be loaded into

any air loader that is constructed of copper, copper alloys, or zinc unless the loader is constructed so that such incompatible materials do not come into contact with the bulk explosive. The vessel that is pressurized shall be designed and constructed for a maximum allowable working pressure of at least 125 lbs/sq. in. (psi) No explosives shall be loaded into any air loader constructed wholly or in part of ferrous metal. Stainless steel, however, may be used.

Air Loader Equipment -- When a pressure loader is being used or an explosive is being loaded, a 20-mesh screen, an air trap, or a filter shall be installed in the air supply line adjacent to the loader. An air pressure reducing regulator of standard manufacture shall also be installed in the air supply line and shall be a part of the loader assembly for a pressure-type loader. An air pressure relieving safety valve of adequate capacity and an adequate pressure gauge shall be installed in the air supply line between the air pressure reducing regulator and the pressure vessel of the air loader.

There shall be no valve between the pressure vessel and the pressure relieving device.

Air Temperature and Pressure -- The temperature of the air supplied to the loader shall not exceed 150°F and the air pressure shall not exceed 50 psi when explosives are being loaded. The air pressure relieving safety value shall be set to open at a pressure not to exceed 55 psi. When a blasting agent such as a water gel is being loaded, the safe loading pressure shall not exceed 110 psi.

Control of Static Electricity and Safety Currents -- There shall be no continuous electrical path from the discharge end of the loading tube through the loading tube, the loading line, the air loader, and to ground. The loading tube shall be static dissipating and shall be at least 2 feet longer than the deepest hole loaded. Generally, metal air loaders resting directly on the ground are sufficiently grounded, but in non-conductive rock or earth an auxiliary ground shall be provided by metal straps or cables of at least #8 American Wire Gauge connected to ground rods. If it is necessary, the ground rods can be driven into water-filled holes. The total resistance from the discharge end of the loading tube to ground shall not exceed 2 megohms. Pneumatic loading equipment shall not be grounded to water lines, air lines, rails or other permanent electrical grounding systems.

The loading tube and loading hose, if one piece, shall be either of a distinctive design or identified at least every 18 inches that it is static dissipating. No loading operations, of course, shall be performed during the approach or progress of an electrical storm.

Operation -- The air supply line shall be thoroughly blown out before it is attached to the air loader. All material poured into a pressure-type air loader shall be passed through a screen having openings not larger than 1/2 inch. Air loaders when used to blow or force stemming into loaded holes shall be thoroughly cleaned before and after such use. Stemming shall consist of clean, fine clay, sand, or crushed rock screening. Use of leaves and trash is prohibited.

Priming

Failure to use adequate priming results in poor performance and can cause quantities of toxic gases to be generated when the charge is fired. Primer assemblies shall be made up only as required for each round of blasting; they shall be assembled at least 50 feet from any magazine.

Primer assemblies which contain a blasting cap, electric blasting cap or delay electric blasting cap shall not be handled by persons who have previously been operating pneumatic loading devices unless that person has grounded himself to bleed off any static charges.

Other safety precautions for handling primers include:

- Handling with the realization that their potential for doing damage is greater than either the detonator or the explosives when separated. They are more sensitive because of the presence of the blasting cap and more destructive because of the total weight of the explosives.

- Assembling the primers at the start of the loading operation to reduce exposure time to hazards of fire, impact, electricity and mishandling.

- Facilitating make-up of the primer at the workplace by the use of a powder punch for cartridged explosives.

- Capping fuses in a central capping house and bringing them to the blast area in an approved container.

Blasting Cap and Safety Fuse

Cap and fuse should only be used by supervised, trained, experienced, and skilled blasters where a long delay time between the detonating of individual holes will not create a problem. The inexperienced blaster can be exposed to hazards of early detonation or misfired holes.

Blasting caps and electric blasting caps may explode prematurely when exposed to spark, heat, shock, or friction. They should not be handled roughly, probed, connected to electric sources, or used as a toy. No blasting cap shall be inserted in the explosives without first making a hole in the cartridge for the blasting cap with a wooden or non-ferrous metal punch. Do not attempt to remove dirt from a blasting cap. Insure that no blasting caps get into the hands of children.

Assembly -- Before uncoiling the fuse be sure that it is warm and flexible; 45°F is minimum. The fuse ends, which have been exposed to the air should be cut off a minimum of one inch. The lengths of fuse should not be wound around small diameter pegs or nails because sharp bends can cause breaks in the water-proofing coat. Fuse length should be sufficient to reach from the primer to the collar plus additional length outside of the hole. The minimum length is 3 feet to allow the blaster sufficient time to reach a place of safety.

Fuse should be cut squarely and inserted in the cap immediately. Slanting cuts may cause folding of the tapered ends and blocking of the end spit when inserted in the cap; it also prevents proper seating of the fuse against the charge in the cap. Shears or scissors are poor fuse cutters because they squeeze or crush the fuse. A fuse cutter should have a smooth, sharp blade to avoid smearing the waterproofing material over the powder strain which could result in misfires.

Fuse should not be handled roughly; the powder can be lost after cutting. Fuse should never be twisted into place or seated with force or violence. All blasting caps must be crimped to the fuse with a crimper. Crimping by use of a knife or teeth is prohibited. All crimps must be made not more than 3/8 inch from the open end of the cap. Crimping more than 3/8 inch could prematurely initiate the cap.

Lighting the Safety Fuse -- Fuse burns at the core not at its cover. Ignition should be practiced until the "ignition spit" - the jet of flame which indicates the core is ignited - is recognized. Two persons should always be present when lighting fuse - one to light and one to observe. All fuses should not be depended on to burn at 120 seconds/yd.

The explosive charge should be in place before the fuse is lighted. Lighting of the fuse before placing the primer in position in the drill hole is prohibited. No unused cap or short-capped fuse shall be placed into any hole to be blasted. The "drop fuse" method of dropping or pushing a primer or any explosive with a lighted fuse attached is forbidden. If the charge does not detonate, do not return to the blast area for at least one hour.

Unintended blasts can be caused by cutting fuse too short, trying to light too many fuses, loss of time in overcoming unexpected difficulty in lighting fuses, or underestimating the time needed to reach adequate shelter. A blaster loses control of the blast area as soon as the first fuse is lighted.

Igniter Cord

Igniter cord is simple to use and increases the safety of cap and fuse firing, but certain potential hazards should be avoided:

- Igniter cord is subject to ignition by open flame, sparks, friction, or sharp blow; connectors can be ignited by heavy impact such as falling rocks.

- Igniter cord must not be used as a subsititute for safety fuse.
- It must not be used where open flame is prohibited.
- It should not be cut with a sharp knife or cutting pliers; an approved cord cutter should be used
- The spool should be placed in the open when cutting off the required lengths; do not carry igniter cord in pockets.

Electric Firing

The internal construction of electric blasting caps varies by manufacturer, as a result they may not be compatible in the same blasting circuit. Electric blasting caps of different manufacturers must never be used in the same blast; nor should blasting caps of different delay periods be used. A dangerous misfire is almost certain to result.

Electric blasting caps shall be kept in the original container or in a closed metal box lined with a soft material such as wood or sponge rubber. Coils and folds in the wires of electric blasting caps should not be straightened out until ready for use.

The blasting machine or blasting switch must be directly under the control of the blaster. It must be locked while not in use with the blaster in possession of the key and must never be taken to the blast site until the loading and wiring is completed.

Lead wires should never be laid out until the blast circuit is completely wired and unnecessary personnel are removed to a safe location. After the lead wires are laid out, they should be checked with a blaster's galvanometer for continuity of circuit. They should also be visibly inspected for cuts and abrasions in insulation.

The lead line must be shunted before the other end of the line is connected to the blasting circuit. After the final connections, the resistance of the entire circuit should be tested with a blaster's galvanometer or blasting ohmeter. The calculated resistance of the entire circuit must always agree with the reading on the instrument or no attempt should be made to fire the blast. If the proper readings are not obtained, reshunt the lead lines before returning to the blast area. Never allow the bare ends of the circuit or lead line to come into contact with the ground or metallic objects. Support on stones, stumps or other nonconductive material so that only the insulated parts of the wires touch the ground. Connectors should be insulated with tape where they cannot be held off the ground or when connections are covered by stemming in the blast holes.

When the instrument readings confirm the calculated resistance, the blasting machine or switch can be unlocked and the lead lines connected for the firing. After the blast, the blasting machine should be disconnected and returned to the storage area. Never leave the blasting machine or switch unguarded or unanttended while unlocked.

Connecting wire should never be reused; it is subject to damage from the blast and should be considered expendable. Only a test instrument specifically designed for blasting circuits should be used. Batteries in the test instruments should not be changed in the presence of electric blasting caps and only batteries specified by the manufacturer should be used in the instrument. Never use car batteries or flashlight batteries.

Bus lines used to connect individual series in parallel offers advantages in simplicity but can result in uneven current distribution and can cause failures in one or more series. If it is absolutely necessary to use bus wires, the maximum allowable resistance of one bus wire should not exceed the total resistance of all the electric blasting caps in the blast divided by 1,000.

The minimum current for commercial electric blasting caps is 0.25 amperes (250 milliamperes). The Institute of Makers of Explosives (IME) established the maximum safe current that could flow through a cap without hazard of initiation as 1/5 of the minimum firing current or 0.05 amperes (50 milliamperes). Electric blasting must not be conducted in areas where extraneous currents are greater than 0.05 amperes.

Lightning generates about 20,000 amperes. Blasting on land and water, and in some underground operations should be suspended and all personnel evacuated when lightning storms are in the vicinity. Insulated foil covers over shunted leg wires of electric blasting caps provide defense against stray current. The foil covers should not be removed until the loading operation is completed and caps are ready to be connected.

When blasting near high voltage or power transmission lines:

- Assure that electric blasting cap leg wires or lead lines do not connect power lines. Personnel may be electrocuted when a cap leg wire or leading wire is thrown by the blast over live power lines. The shot point should not be closer than the distance equal to the length of the leading wire plus the length of both leg wires.

- Check for stray ground current. Overhead power lines can induce currents in blasting circuits. If stray or induced currents above 50 milliamperes are detected, or if the shot point cannot be relocated to insure that blast wiring will not be thrown over power lines, detonating cord with MS convertors, or cap and fuse should be used.

When conducting electric blasting operations near radio frequency energy sources observe the following safe practices:

- When electric blasting operations are conducted at fixed locations, such as a quarry or mine, make sure that there are no radio frequency transmitting antennae closer than recommended by Institute of Makers of Explosives Publication No. 20 - Safety Guide

for the Prevention of Radio Frequency Radiation Hazards in the Use of Electric Blasting Caps.

- Post signs at all approaches warning to turn off 2-way radios.

- Keep mobile transmitters in the "off" position near blasting areas and place adequate signs adjacent to the site .

- Determine if directional radar attennae which project powerful beams over long distances, operate near the blast site. Determine also if electric blasting can be done safely. Blasting machines must be tested at least monthly by procedures recommended by the manufacturer or supplier to ensure performance at rated capacity, and a record of these tests must be kept.

BLASTING PRECAUTIONS

Loaded holes shall be guarded until the blast is fired. In addition, a plan must be developed to clear the blast area of men and equipment. Never assume that the blast area is clear; make certain that it is clear:

- Post guards to block all access roads to the blast area. They must be posted at a sufficient distances to be safe from all fly rock. They must be informed when to stop all traffic. Some special guards may be necessary to prevent curious passers-by on foot from walking too close to the blast site.

- Observe for loose high walls that are out of the blast area but present a hazard because of vibrations.

Low flying aircraft should be informed of the blasting time. No one should be allowed within 1000 ft of the blast unless protected and the blaster must be in a safe position to fire the blast. Also, the person in charge of the blast shall ensure that all loose explosives around the hole have been cleared away to prevent premature explosion.

POST-FIRING INSPECTION

The blast area should not be entered less than 15 minutes after the blast; the waiting period allows time for the fumes to dissipate. Then a blaster and a knowledgeable helper should examine the field. No all clear should be sounded until the entire field has been checked and any misfires corrected by firing or removal.

Misfires

Misfires with any explosive should be treated the same as for dynamite. Before re-entering the blasting area, however, the blaster shall make sure that the area is free of the reddish-brown fumes which indicate a toxic concentration of nitrogen dioxide gas.

Except in the case of simultaneous firing or firing with millisecond delay electric blasting caps, the total number of explosions in every blast shall be counted by the licensed blaster. If the total number counted is less than the number that were to be fired, a report shall be made to the foreman and no one shall enter the area for at least one hour (15 minutes if fired by power squib or electric current).

The largest percentage of blasting accidents are due directly or indirectly to misfires. There is great importance in the proper preparation of shots, of not returning too soon after a misfire, and close examination for unexploded shots. Handling a misfire is the most hazardous duty any blaster is called on to perform; he shall proceed with every caution.

It is usually possible to prevent misfires by the use of high-grade explosives and blasting supplies, testing each electric blasting cap with a galvonometer before loading and before and after tamping, and by using 2 or more electric blasting caps in each charge. Adoption of electric blasting will decrease misfires and prevent hangfires.

Investigation of a misfire should include a search for broken wires, faulty connections or short circuits. Proper repairs should be made and leading wires reconnected and the blasting machine again used. Many failures result from poor connections, or connections being in contact with wet ground or other conductive materials. They can also be caused by lack of care in making up primers and loading holes. Additional primer or charge should never be placed a few inches away from misfired holes in an attempt to shoot the misfired charge. The second charge may not detonate the misfired one, but may scatter the unexploded material including the cap. The stemming can be washed or blown out of a misfired hole and another primer put in. Never drill within 10 ft of a misfired hole.

Destroying Explosives

The preferred method for destroying dynamite and detonating cord is by burning which should always be conducted on the assumption that an explosion may take place. A sight should be chosen far enough away from dwellings, railroad, highway, or other place where people may assemble to eliminate the possibility of injury to persons or damage to property. Explosives should be burned at distances not less than these specified in the American Table of Distances (Appendix B).

Only one type of explosive should be destroyed at a time. Dynamite, detonating cord, and safety fuse must be examined carefully to make certain there are no detonators. Water gels should be disposed of by shooting. Explosives should never be covered over by any materials as a means of disposal. The Institute of Makers of Explosives (420 Lexington Ave, N.Y., N.Y. 10017) and the manufacturer will provide assistance for explosives destruction.

BLACK POWDER BLASTING

The use of black powder is not recommended, but if it is used the following rules must be applied:

- Inexperienced men will be closely supervised.
- Blaster and helper will not carry matches or other sources of ignition.
- Blaster and helper shall wear shoes with no exposed metal.
- All persons not connected with the loading operation should be kept at least 500 feet away.
- No bonfires or other open flames shall be allowed with 500 feet of any black powder.
- Holes shall not be loaded while compressors, shovels, trucks, tractors, or sources of ignition are within 100 feet.
- Only bagged powder shall be used. It shall not be brought from the magazine until after the holes are sprung.
- Black powder shall not be used underground.
- Containers shall not be opened in or within 50 feet of any magazine, within any building in which a fuel-fired or exposed element electric heater is in operation, where electrical or incandescent-particle sparks could result in power ignition.
- Granular powder shall be transferred from containers only by pouring. Spills of granular powder shall be cleaned up promptly with non-sparking equipment; contaminated powder shall be put into a container of water and disposed of promptly after the granules have disintegrated, or flush spill area with copious amounts of water to completely disintegrate granules.
- Keep containers of powder securely closed.
- Dispose of misfires by washing the stemming and powder charge from the boreholes; remove and dispose of the initiator as a damaged explosive. Boreholes of shots that fire but fail to break, or fail to break properly shall not be recharged for at least 12 hours.

UNDERGROUND BLASTING

General

All of the precautions for surface blasting apply also to underground blasting. Including, of course, the insistence that every employee observe

and obey every rule, regulation, and order and that all unsafe conditions be reported. In addition, all employees shall be given frequent accident prevention training. There are other special precautions necessary for undergroung blasting.

Explosives for underground use should be classified according to the volume of oxygen and of carbon monoxide and hydrogen sulfide produced by a test explosion of a standard cartridge (A standard cartridge is 1 1/4 inches in diameter by 8 inches long). The required tests shall be made in a Bichel Gauge according to the standard procedure of the U.S. Bureau of Mines. The value of CO and H_2S should be expressed in terms of cubic feet per standard cartridge:

Fume Class 1 - less than 0.16 cubic feet
Fume Class 2 - 0.16 - 0.33 cubic feet
Fume Class 3 - 0.33 - 0.67 cubic feet

The fume class for underground use shall be clearly marked on the case in letters not less than 1/4 inch high; underground explosives shall comply with the requirements for Fume Class 1.

In underground operations, the level of toxic fumes and gases will be measured and proper ventilation provided. Never use an explosive in a coal mine that is not labelled "Permissible Explosives Approved by the United States Bureau of Mines" on every cartridge. Holes shall not be drilled, charged, or fired where methane gas can be detected at 1.0 percentum or more.

No explosives shall be transported on underground locomotives, but may be transported in a mine car or in a truck. No one but the train crew, driver, or powder man shall be allowed to ride. One empty car with insulated couplings or an insulated bar shall be interposed between the locomotive and the powder car.

In sinking a shaft or winze, no other material shall be carried on any cage, ship, or bucket on which dynamite and detonators are handled and only those crew members needed for blasting may travel with such explosives or remain on the bottom while explosives are lowered. Explosives shall not be lowered into the tunnel on the same conveyance with detonators or primers. Where electric haulage is used, all rail bonds shall be properly maintained and all rails and pipelines cross-bonded and grounded.

Explosives may be transferred to an explosives car which is fully enclosed and lined with non-sparking material and may contain two separate compartments. It is preferable to transport underground during off-shift hours; if that is not feasible explosives haulage should precede or follow the transportation of personnel.

All personnel shall be removed from area where the blast might break through to an area of stable roof and rib condition and all areas where the ventilation system may carry smoke and gases should be protected. Employees shall not be permitted to retire to a dead-end drift or cross cut in

selecting shelter from fly rock and blasting gases. A warning shall be sounded when the blast is about to be fired and guards shall be posted at all entries to the blasting area.

Before explosives or detonators are delivered to the tunnel face, all power current must be cut off within 50 feet of the face. Explosives must not be placed where they may be struck by a vehicle. In some operations, miners may carry their daily supply either directly from surface magazines or from an underground distribution point. It is preferable to transport explosives underground during off-shift hours, but if that is not possible, haulage should precede or follow transportation of personnel.

Where miners do their own blasting temporary storage may be provided close-by in separate covered, locked, wooden boxes. The explosives must be kept in the container and the boxes separated by at least 10 feet.

Care should be used in placement and drilling of holes. Roof, face, ribs and timber should be tested before drilling. Bore holes should not be drilled beyond the back of the cut or cutting shot, nor into solid ribs, roof, or floor. Where solid shooting is necessary, depending shots are prohibited. To prevent blown-out or windy shots, all portions of the bore holes where the height of the coal permits, shall have a burden in all directions of at least 18 inches before being fired. Test for methane before drilling.

Other precautions when drilling include:

- Inspecting the face for undetonated explosives prior to any drilling and inspecting and washing out any bootleg holes.
- Never collaring the drill in a bootleg hole.
- Drilling to the required depth; a round will only pull to the depth of the shallowest hole.
- When drilling a burn round, all holes must be parallel.
- Cleaning all holes after drilling with water or air before loading. Standing to one side of the hole to avoid flying rocks.

Use of a fuse with nominal burning rate of less than one foot in 40 seconds is prohibited. The minimum fuse length for all blasts except boulder blasts shall be 7 feet. The burning rate of every shipment of fuse shall be determined and the burning rate posted in a conspicuous location. No man shall "spit" more than 15 fuses in a round of shots except when using water-resistant or waterproof ignitacord. Double priming with fuse is prohibited. At least 2 men shall be present at each location where cap and fuse blasting is done.

Lighting of the fuse before placing the primer is prohibited. Carbide lights shall not be used to light fuse. Firing "mudcaps" or "adobe shots" is extremely hazardous and should not be allowed underground.

Electric Blasting

Only electric or delay electric blasting caps shall be used in the following operations:

- In sinking shafts or winzes or driving raises over 50 feet high except in such raises ignitacord may be used with cap and fuse.
- In cutting shaft stations.
- In drifts, crosscuts, storage pockets and pump sumps where there is not enough protection for the men from flying rock or concussion.

Never attempt to use a blasting machine or test instrument that is not in proper operating condition. No alterations or repairs to the blasting machine circuits should be attempted in the field; electrical discharge from blasting machines can be fatal.

In underground operations there shall be a "lighting" gap of at least 5 feet in the firing system ahead of the main firing switch; that is, between the switch and the source of power. This gap shall be bridged by a flexible jumper cord just before firing the blast.

In mines where shooting is done on shift all shots or series of shots shall be fired promptly after charging. Never return to the blast area until all smoke and gases have cleared; in any case not less than 15 minutes.

Misfire

When safely possible, refire a misfired hole. Otherwise attempt to insert a new primer after removing stemming with a jet of water; compressed air should not be used to remove explosives from misfires.

UNDERWATER BLASTING

In underwater blasting, loading tubes and casings of dissimilar metals shall not be used because of possible electric transient currents from galvanic action of the metals and water. Only water resistant blasting caps and detonating cords shall be used.

No blast shall be fired while any vessel is closer than 1500 feet; those on board vessels or crafts moored or anchored shall be notified before the blast is fired. No blast shall be fired while any swimming or diving operations are in progress in the vicinity of the blasting area.

Blasting flags shall be displayed. When more than one charge is placed underwater, a float device shall be attached to an element of each charge in such a manner that it will be released by the firing.

BLASTING IN EXCAVATION WORK UNDER COMPRESSED AIR

Detonators and explosives shall not be stored in tunnels, shafts, or

caissons. Detonators and explosives for each round shall be taken directly from the magazine to the blasting zone and loaded. Leftovers will be removed from the working chamber before the connecting wires are connected.

When the detonators or explosives are brought into an air lock, no employee except the powderman, blaster, lock tender and employees necessary for carrying shall be permitted to enter the air lock. No other materials, supplies, or equipment shall be locked through with the explosives. Detonators and explosives shall be taken separately into the pressure working chambers.

All metal pipes, rails, airlocks, and steel tunnel lining shall be electrically bonded together, and grounded at or near the portal or shaft, and such pipes and rails shall be cross-bonded together at not less than 1,000 foot intervals throughout the length of tunnel. Each low air supply pipe shall be grounded at the delivery end.

FIELD MIXING

Blasting agents are now generally mixed prior to delivery to the blast site but where on-site field mixing is necessary, the recommendations in this chapter should be followed. In all cases a field mixing operator must have a manufacturing license from the Bureau of Alcohol, Tobacco, and Firearms. (See MANUFACTURING)

COMPOSITION OF MIXTURES

The sensitivity of all mixed agents shall be determined by means of a No. 8 test blasting cap; this shall be done after every change in formulation. All ingredients shall be measured or proportioned to insure control of sensitivity and oxygen balance. Ninety-four percent ammonium nitrate and six percent fuel oil by weight is the optimum mix. Excess oil desensitizes the initiating elements and prime charge and too little oil reduces the chance of proper initiation and increases the yield of toxic gases.

No crude oil, crankcase oil, other hydrocarbon liquid fuel with flash point lower than that of No. 2 diesel fuel oil, or 110°F minimum, or peroxides or chlorides shall be used. Crude oil and crankcase drainings may contain low flashpoint constituents or gritty particles which could increase the sensitivity of the blasting agent and more volatile fuels such as gasoline, kerosene, or No. 1 diesel fuel offer no significant advantage and tend to increase the possibility of vapor explosion and fire. Powdered ammonium nitrate, high explosives, smokeless propellant, peroxides, chlorates, or perchlorates shall not be used unless approved. Solid fuel additions such as carbon black and ground coal can be used but they are not to be mixed in the field. Unusual compositions shall not be attempted except under the supervision of trained personnel; stability and other safety tests may be required.

MIXING

Liquid fuels must be stored in separate tanks with shut-off valves; solid fuels shall be stored in separate containers until mixed. The storage of all blasting agents and prilled, grained, or granulated ammonium nitrate shall be as described under STORAGE. Liquid ammonium nitrate shall be stored in tank cars, tank trucks, or permanent tanks in a safe location. Metal powders such as aluminum shall be kept dry and shall be stored in containers or bins which are moisture resistant or weathertight. Spills or leaks which may contaminate combustible material must be cleaned up immediately.

Not more than one day's production of blasting agents shall be permitted in, or near, the mixing area. Large quantities must be stored in magazines. The mixing area shall be located away from inhabited buildings, passenger railways, and public highways in accordance with the American Table of

Distances (Appendix B). Smoking or open flame shall not be permitted within 50 feet of any mixing area.

Mixing blasting agents in the borehole by pouring oil onto previously loaded ammonium nitrate is not acceptable. It is an inefficient method which causes misfires and production of toxic fumes.

The mixing and transfer equipment must be compatible with blasting agents. The mixer must minimize friction heating and compaction and have outboard gears and bearings protected from accumulation of dust.

All electric power must be furnished by cable from an outside source or by a self-contained motor generator. A self contained power source shall be located at the end of the storage container opposite the blasting agent discharge point. It must have an adequate capacity for the expected loads and be equipped with overload protection devices. All electric motors, electrically operated proportioning devices, and equipment must be electrically bonded.

Each mixer unit shall be equipped with an Underwriter's Laboratory approved fire extinguisher, 4BC or equivalent, to use for fires not involving blasting agents or explosives. Pumps or conveyors that could overheat blasting agents shall not be used.

A warning sign shall be posted on front, sides, and rear of the mixing unit. The sign shall read "EXPLOSIVES" in red letters at least 4 inches high, with a 5/8 inch stroke, on a white background.

Sensitized blasting agents shall not be pulverized or crushed. All unused explosives shall be returned to the proper storage magazine upon completion of loading operations. Any empty oxidizer bags shall be disposed of daily by burning in the open at a safe distance from buildings or combustible materials.

Blasting agents intended for use underground shall be carefully compounded in an oxygen-balanced mixture to minimize production of toxic fumes. Mixing shall not be done underground.

All loading and mixing equipment shall be cleaned frequently to insure against accumulation of ingredients and always before any open flame work is performed on the unit. Blasting agents and water gels must be removed from the truck before services or repair.

MIXING VEHICLES

The body of a bulk mixing vehicle shall be constructed of noncombustible materials. All moving parts of the mixing system shall be designed to prevent heat build-up. Shafts or axles which contact the product shall have outboard bearings with one inch minimum clearance between the bearings and the outside of the product container. Particular attention shall be paid to the clearances of all moving parts.

The operator of a bulk mixing vehicle shall be trained in the safe operation of the vehicle and its mixing, and conveying equipment. The employer must assure that the operator is familiar with the commodities being delivered and the procedures for handling emergency situations. No person shall smoke, carry matches, or other flame producing device, or carry any firearms while in or about bulk vehicles effecting mixing.

No in-transit mixing of materials shall be performed. Caution shall be exercised in the movement of the vehicle in the blasting area.

GLOSSARY

ALL-FIRE: The minimum energy which must be applied to a bridgewire circuit to reliably ignite the surrounding explosive material under specified conditions.

AMERICAN TABLE OF DISTANCES (ALSO KNOWN AS QUANTITY DISTANCE TABLES): The American Table of Distances for Storage of Explosives as revised and approved by the Institute of Makers of Explosives, June 5, 1964.

AMMONIUM NITRATE: Chemical compound represented by the formula NH_4NO_3.

AN-FO: An abbreviation for ammonium nitrate and fuel oil mixture.

ARTICICIAL BARRICADE: An artificial mound or revetted wall of earth of a minimum thickness of three feet.

BARRICADE: A natural or artificial barrier that will effectively screen a magazine, building, railway, or highway from the effects of an explosion in a magazine or building containing explosives.

BLAST: The brief and rapid movement of air or fluid away from center of outward pressure, as in an explosion; the pressure accompanying this movement.

BLAST AREA: The area in which explosives loading and blasting operations are being conducted.

BLASTER: A person qualified by reason of training, knowledge, or experience to fire or detonate explosives in blasting operations.

BLAST: A method loosening, moving, or shattering masses of solid matter by use of explosive compounds.

BLASTING AGENT: Any material or mixture, consisting of a fuel and oxidizer, intended for blasting, not otherwise classified as an explosive and in which none of the ingredients are classified as an explosive, provided that the finished product, as mixed and packaged for use or shipment, cannot be detonated by means of a No. 8 test blasting cap when unconfined.

BLASTING CAP: A small tube closed at one end and loaded with an explosive train normally initiated by safety fuse or electrical energy and used to initiate high explosives.

BLASTING MAT: A heavy mat of woven rope, steel wire, or chain, or a mat improvised from timber, poles, brush or other materials, placed over loaded holes, tending to minimize the amount of rock and other debris that might be thrown into the air.

BLASTING OPERATION: The use of explosives in the blasting of stone, rock, ore, or any other natural formation, or in any construction or demolition work.

BLOCK HOLING: The breaking of boulders by firing a charge of explosives that has been loaded in a drill hole.

BOOSTER: An explosive device to augment the initiating component of an explosive train to cause detonation or deflagration of the main explosive charge.

BOOTLEG: Partial drill holes remaining from a previous blast.

BREAKAWAY CONSTRUCTION: A general term which applies to the principle of purposely providing a weak wall so that the explosive effects can be directed and minimized.

BRISANCE: The shattering effect of an explosive.

BULK MIX: A mass of explosive or blasting agent 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, blasting agents, or ingredients for explosive materials in bulk form for mixing and/or loading directly into blast holes.

BULLET-RESISTANT MAGAZINE: When used in reference to the construction of a magazine, bullet-resistant means that the side walls and doors of a magazine are resistant to penetration of a 150 grain full metal case projectile fired from a standard .30-06 caliber rifle having a nominal muzzle velocity of 2,700 feet per second.

BULLET-SENSITIVE EXPLOSIVE MATERIAL: Means any explosive material that can be detonated by a bullet fired from a standard .30-06 caliber rifle having a nominal muzzle velocity of 2,700 feet per second when the bullet is fired from a distance of 75 to 100 feet.

BUNKERING: Filling as with coal or oil.

BUS WIRE: An expendable wire, used in parallel or series, in parallel circuits, to which are connected the leg wires of electric blasting caps.

CAP CRIMPERS: Tool used to connect fuse to blasting caps.

CAP-SENSITIVE EXPLOSIVE MATERIAL: Any explosive material that can be detonated by means of a No. 8 test blasting cap when unconfined.

CAP-SENSITIVITY TEST: A simple method of measuring the initiation sensitiv- ity of a blasting agent. A one quart, cylindrical, cardboard carton of the type commonly used for bulk ice cream, is filled with the blasting agent to be tested and packed to the approximate shipping package

density. A commercial No. 8 blasting cap is inserted into the center of the blasting agent through a hole in the top of the carton. The charge is then placed on soft ground in an isolated area with adequate protection for personnel and the blasting cap fired. If a crater is formed in the soft ground of sufficient size to indicate that any part of the blasting agent detonated, the material is cap-sensitive and must be treated as a high explosive.

CAST PRIMER OR BOOSTER: A cast or pressed block of solid high explosive (i.e., not nitroglytcerin sensitized) which is normally used to detonate insensitive or non-cap-sensitive explosives.

CHARGE: A quantity of explosive that is to be detonated.

CHARGE WEIGHT: The weight in pounds of an explosive charge.

CLASS A EXPLOSIVES: Possessing detonating or otherwise maximum hazard; such as dynamite, nitroglycerin, picric acid, lead azide, fulminate of mercury, black powder, blasting caps, and detonating primers.

CLASS B EXPLOSIVES: Possessing flammable hazard, such as propellant explosives (including some smokeless propellants), photographic flash-powders, and some special fireworks.

CLASS C EXPLOSIVES: Include certain types of manufactured articles which contain Class A or Class B explosives, or both, as components but in restricted quantities.

CLASS I MAGAZINE: Permanent structures for the storage of more than 50 lbs (100lbs in some states) of explosives.

CLASS II MAGAZINE: Portable storage for less than 50 lbs (100 lbs in some states) of explosives.

COMBUSTION: An exothermic chemical reaction which liberates heat and usually produces high temperature gases and light.

CONNECTING WIRE: An insulated expendable wire used between electric blasting caps and the leading wires or between the bus wire and the leading wires.

DEFLAGRATION: Propagating thermal decomposition that proceeds in the material at less than sonic velocity and may or may not develop hazardous pressures.

DELAY ELECTRIC BLASTING CAP: An electric blasting cap with a timing element interposed between the ignition bead and the detonating compound.

DELAY PERIOD: A time separation of eight (8) or more milliseconds between detonation of subcharges.

DETONATING CORD: A flexible cord containing a center core of high explosives used to detonate other explosives with which it comes in contact.

DETONATING CORD MILLISECOND DELAY CONNECTORS: Non-electric short interval (millisecond) delay devices for use in delaying blasts which are surface initiated by 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: Propagating thermal decomposition that proceeds at supersonic velocity in the material accompanied by the development of a shock wave in the decomposing material.

DETONATION TIME: The time at which the detonation is initiated.

DETONATOR: Any device containing a detonating charge that is used for initiating detonation in an explosive, including but not limited to electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses, and detonating cord delay connectors.

DUD: An explosive device that has failed to initiate as intended.

EED (ELECTRO-EXPLOSIVE DEVICE): Any cartridge, squib, igniter, etc., which is initiated electrically.

ELECTRIC BLASTING CAP: A blasting cap designed for and capable of detonation by means of an electric current.

ELECTRIC DELAY BLASTING CAPS: Caps designed to detonate at a predetermined period of time after energy is applied to the ignition system.

EXPLOSION: A rapid chemical reaction with the generation of high temperature and usually a large quantity of gas.

EXPLOSIVE: Any chemical compound mixture, or device, the primary or common purpose of which is to function by explosion; the term includes, but is not limited to, dynamite, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, and igniters.

EXPLOSIVE MATERIALS: Explosives, blasting agents and detonators.

EXPLOSIVE REACTION: Both deflagration and detonation.

EXPLOSIVE TRAIN: A series of explosives elements arranged in order of decreasing sensitivity and increasing power output.

EXPLOSIVES INTERCHANGE LOT: The specific area of an explosives motor vehicle terminal on which motor vehicles loaded with explosives are parked.

EXPLOSIVES LESS-THAN-TRUCK-LOAD LOT: A designated area of a motor truck facility where less than truck loads of explosives may be held for transfer from one vehicle to another for continuance in transportation.

EXPLOSIVES MOTOR VEHICLE TERMINAL: A designated area where motor vehicles transporting explosives may be parked pending further movement in transportation.

FIRING TRAIN: A series of steps by which a small amount of intitiating energy is progressively built-up to the large amount of energy which is required to detonate a relatively insensitive main charge high explosive.

FIRING WIRE: Wire which connects the power source to a blasting circuit. Also SHOOTING LINES.

FORBIDDEN OR NOT ACCEPTABLE EXPLOSIVES: Explosives which are forbidden or not acceptable for transportation by common, contract, or private carriers by rail freight, rail express, highway, or water in accordance with the regulations of the U.S. Department of Transportation.

FUSE: An igniting device in the form of a cord consisting of a flexible fabric tube and a core of black powder.

FUSE LIGHTERS: Special devices for the purpose of igniting safety fuse.

GRAIN: A single piece of solid propellant regardless of size or shape.

HANG FIRE: An undesired delay in the functioning of an explosive device after initiating energy is applied.

HIGH EXPLOSIVES: Explosives which are characterized by a very high rate of reaction and high pressure development.

IGNITER: A pyrotechnic device specifically designed to initiate burning of a fuel mixture or a propellant.

IGNITION SPIT: A jet of flame which shoots from the end of the fuse when the powder ignites; it signals that the fuse is lit and burning.

INCOMPATIBLE MATERIAL: Those materials that when mixed with oxidizing materials can cause hazardous reactions or decomposition of the oxidizer.

INERT: Description of condition of a munition or component thereof which contains no explosive, pyrotechnic, or chemical agent.

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.

INHABITED BUILDING DISTANCE: The minimum distance which may be expected to protect buildings or structures from structural damage from blast effect or an uncontrolled explosion. This distance does not provide protection against glass breakage, but does provide protection from missiles.

INHIBITOR: A material applied to the surface of propellant grains to prevent burning on the coated surface.

INITIATION: The first action in the first element of an explosive train.

INITIATOR: The primary stimulus component in all explosive and pyrotechnic devices.

INTRALINE DISTANCE: Minimum distance permitted between any two buildings within one operating line.

LEAD: A column of high explosive used as one component of an explosive train.

LEADING WIRE: An insulated wire used between the electric power source and the electric blasting cap circuit.

LEG WIRES: Short wires attached to electric blasting caps.

LICENSED MANUFACTURER: A manufacturer licensed to engage in the business of manufacturing explosive materials for purposes of sale or distribution or for his own use.

LICENSED MANUFACTURER-LIMITED: A manufacturer licensed to engage in the business of manufacturing explosive materials for his own use and not for sale or distribution.

LICENSEE. Any licensed importer, manufacturer, or dealer.

LOW EXPLOSIVES: Explosives which are characterized by deflagration or a low rate of reaction and the development of low pressures.

MAGAZINE: Any building or structure other than an explosives manufacturing building, designed and/or approved for the storage of explosive materials.

MAGAZINE DISTANCE: The minimum distance permitted between any two storage magazines which is expected to prevent a propagation of an explosion from one magazine to another from blasts.

MANUFACTURER: Any person engaged in the business of manufacturing explosive materials for purpose of sale or distribution or for his own use.

MANUFACTURER-LIMITED: Any person engaged in the business of manufacturing explosive materials for his own use and not for sale or distribution.

MANUFACTURER'S MARK: The mark placed on each carton of and each individual

piece of explosive by the manufacturer to identify the manufacturer and the location, date, and shift of manufacture.

MANUFACTURING PLANTS: Those facilities where explosive materials are produced and stored.

MASS DETONATION (MASS EXPLODE): When a unit of explosive material explodes and causes all or a substantial part of the remaining material to detonate or explode.

MISFIRE: Failure of an explosive device to fire after initiating energy is applied.

MIXING BUILDING: Any building used primarily for mixing and blending explosive compositions.

MUD-CAPPING (ALSO BULLDOZING, ADOBE BLASTING, OR DOBYING): The blasting of boulders by placing a quantity of explosives against a rock, boulder, or other object without confining the explosives in a drill hole.

MULTIPLE GRAIN: An assembly of solid propellant grains inside an explosive device.

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 or building containing explosives when the trees are bare of leaves.

NEUTRAL BURNING: The burning of a propellant grain in such a manner that the exposed surface area remains constant as burning progresses.

NITRO-CARBO-NITRATE OXIDIZER: A substance such as a nitrate that yields oxygen readily to stimulate the combustion of organic matter or other fuel.

NO-FIRE: The maximum energy level which can be applied to an EED for a given period without igniting or degrading the surrounding explosive material.

NO. 8 TEST BLASTING CAP: A blasting cap containing two grams of a mixture of 80% mercury fulminate and 20% potassium chlorate, or a cap of equivalent strength.

NON-ELECTRIC DELAY DEVICE: A detonator with an integral delay element used in conjunction with, and capable of being initiated by a detonating impulse or signal from, detonating cord.

NON-ELECTRIC DELAY BLASTING CAP: A blasting cap with an integral delay element in conjunction with and capable of being detonated by a detonation impulse or signal from miniaturized detonating cord.

NONPROCESS BUILDING: Office buildings, warehouses, and other plant buildings where no explosive compositions are processed or stored.

OXIDIZER OR OXIDIZING MATERIAL: A substance, such as a nitrate, that readily yields oxygen or other oxidizing substances to stimulate the combus- tion of organic matter or other fuel.

PERMANENT BLASTING WIRE: A permanently mounted insulated wire used between the electric power source and the electric blasting cap circuit.

PERMITTEE. Any user of explosives for lawful purpose, who has obtained a user permit.

PLACARDS: Signs placed on vehicles transporting explosive materials or oxidizers indicating the nature of the cargo.

POWDER: An explosive in the form of powder or small granules.

PRIMACORD: See Detonating Cord.

PRIMARY BLASTING: The blasting operation by which the original rock formation is dislodged from its natural location.

PRIMARY EXPLOSIVE: A sensitive explosive, one of the first elements in an explosive train.

PRIME (PRIMER MIXTURE): An explosive mixture containing a sensitive explosive, usually the first element in an explosive train.

PRIMER: A cartridge or container of explosives whose purpose is to initiate the main explosive charge.

PROCESS BUILDING: Any mixing building; any building in which explosive composition is pressed or otherwise prepared for finishing and assembling; or any finishing and assembling building.

PROCESSING PLANTS: Those facilities not on the premises of manufacturing plants where oxidizers are packaged, mixed or blended.

PROGRESSIVE BURNING: Burning of a propellant grain in such a manner that the exposed surface area increases as burning progresses.

PROPAGATION FIRING: The simultaneous exploding of unconnected and unprimed explosives when placed in close proximity and fired by one cartridge and one cap.

REGRESSIVE BURNING: Burning of a propellant grain in such a manner that the surface area decreases as burning progresses.

RESTRICTED BURNING GRAIN: A solid propellant grain in which certain surfaces are restricted or inhibited to provide particular burning characteristics.

REVETTED: Barricaded.

SAFETY FUSE: A flexible cord containing an internal burning medium by which fire is conveyed at a continuous and uniform rate for the purpose of firing blasting caps. A burning rate of 120 seconds/yd is standard for commercial safety fuse in the U.S.

SCALED DISTANCE: The actual distance in feet provided by the square root of the maximum charge weight per delay period, in pounds.

SCALING LAW: A formula which permits calculating some explosive effect based on data obtained from a similar but different size article.

SCREEN TYPE BARRICADE: Any of several barriers for containing embers and debris from fires and deflagration in process buildings that could cause fires and explosions in other buildings.

SECONDARY BLASTING: The reduction of oversize material by the use of explosives to the demension required for handling, including mudcapping and blockholing.

SECONDARY EXPLOSIVE: A high explosive which is relatively insensitive to heat and shock.

SEMICONDUCTIVE HOSE: A hose with 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.

SENSITIVITY: The characteristic of an explosive component which expresses its susceptibility to initiation by externally applied energy.

SHAFT: A vertical or steeply inclined excav-tion or opening within a mine used as a means of establishing connections between any given number of levels for the purpose of service and/or ventilation.

SHAPED CHARGES: An explosive charge with a lined cavity specifically designed to produce a high velocity cutting or piercing jet.

SHELF LIFE: The storage time during which an explosive item remains servicable.

SHOOTING LINES: See FIRING WIRE.

SPECIAL INDUSTRIAL EXPLOSIVES MATERIALS: Shaped materials and sheet forms and various other extrusions, pellets and packages of high explosives, which include dynamite, TNT,* PETN*, RDX,* and other similar compounds used for high-energy-rate forming, expanding and shaping in metal fabrication, and for dismemberment and quick reduction of scrap metal.

*Trinitrotoluene, pentaerythritoltetranitrate, cyclotrimethylenetrinitramine.

SPRINGING: The creation of a pocket in the bottom of a drill hole by the use of a moderate quantity of explosives in order that larger quantitites of explosives may be inserted therein.

SQUIB: A device containing a small quantity of ignition compound in contact with a bridge wire.

SQUIB SWITCH (EXPLOSIVE SWITCH): An electric switch operated by a squib or pressure cartridge.

STABILITY: The ability of an explosive material to retain its original properties without degradation when exposed to various environmental conditions over a period of time.

STAR GRAIN: A solid propellant grain with an internal star-shaped cross section.

STEMMING: A suitable inert noncombustible material or device used to confine or separate explosives in a drill hole, or to cover explosives in mudcapping.

STORAGE CUTOFF: Storage in the same building or area but physically separated from incompatible materials by partitions or walls or when contained in a fixed tank.

STORAGE DETACHED: Storage, either in the open or in a separate building, located away from all structures except those housing operations related directly to the production of the stored materials.

STORAGE SEGREGATED: Storage in the same room but physically separated by space from incompatible materials, using sills or curbs to maintain spacing, or by using intervening storage of nonhazardous, compatible materials.

STORAGE FARM: A tract of land properly segregated and used for the storage of explosives in excess of 50,000 pounds in one or more magazines.

SUBCHARGE: A quantity of explosive or equivalent that is to be detonated within a period of less than eight (8) milliseconds.

SUSTAINER GRAIN: A propellant or pyrotechnic grain used in a pressure cartridge or igniter to sustain burning.

SYMPATHETIC DETONATION (IGNITION): The explosion of a second charge or device caused by nearby detonation (ignition) of another.

TUBULAR GRAIN: A solid propellant grain in the form of a tube.

TWO-COMPONENT EXPLOSIVES: Any two inert components which, when mixed, become capable of detonation by a No. 6 blasting cap, and shall be classified as a Class "A" explosive when so mixed.

TYPE 1 MAGAZINE: A permanent magazine for the storage of explosive materials that are sensitive to initiation by a No. 8 test blasting cap and will mass detonate, such as dynamite and non-electric blasting caps. Type 1 magazines are bullet-resistant, fire-resistant, theft-resistant, and weather-resistant.

TYPE 2 MAGAZINE: A portable or mobile mazazine for outdoor or indoor storage of explosive materials that are sensitive to initiation by a No. 8 test blasting cap and will mass detonate, such as dynamite or non-electric blasting caps. Type 2 magazines are bullet-resistant, fire-resistant, theft-resistant, and weather-resistant except that magazines for indoor storage need not be bullet-resistant.

TYPE 3 MAGAZINE: A portable magazine for the temporary storage of explosive materials while attended. An example is a "day box" at the site for blasting operations. Type 3 magazines are bullet-resistant, fire-resistant, theft-resistant, and weather-resistant.

TYPE 4 MAGAZINE: A permanent, portable or mobile magazine for storage of explosive materials that do not detonate when initiated by a No. 8 test blasting cap, such as blasting agents, certain water gels, smokeless powder, and black powder, or explosive materials that will not mass detonate such as electric blasting caps having leg wires at least 4' long. Type 4 magazines are fire-resistant, theft-resistant, and weather-resistant.

TYPE 5 MAGAZINE: A permanent, portable or mobile magazine for the storage of explosive materials that do not detonate when initiated by a No. 8 blasting cap, such as blasting agents and certain water gels. Type 5 magazines include tanks, tank trailers, tank trucks, semitrailers, bulk trailers, bulk trucks and bins. Type 5 magazines are theft-resistant and outdoor Type 5 magazines are also weather-resistant.

USER-LIMITED PERMIT: A user permit valid only for a single purchase transaction, a new permit being required for a subsequent purch se transaction.

USER PERMIT: A permit issued to a person authorizing him (1) to acquire for his own use explosive materials from a licensee in a State other than the State in which he resides or from a foreign country, and (2) to transport explosive materials so acquired in interstate or foreign commerce.

WATER GELS (SLURRIES): A wide variety of materials used for blasting. As manufactured, they have varying degrees of sensitivity to initiation. They usually contain substantial proportions of water and ammonium nitrate, some of which are in solution in the water. Some are sensitized by a material classified as an explosive, but some contain no ingredient classified as an explosive but may be sensitized with metals such as aluminum or with other fuels.

WINZE: See SHAFT.

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APPENDIX A

CHEMICAL HAZARDS AND PRECAUTIONS

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APPENDIX A

Abbreviations

S: Synonyms

U: Uses

CH: Combustion Hazard

TH: Toxic Hazard

HS: Handling and Storage Precautions

FP: Fire Precautions

HP: Hygienic Practices

SL: Handling Spills and Leaks

TLV: Threshold Limit Value

Acetaldehyde

S: Acetic aldehyde, aldehyde, ethanal, ethyl aldehyde

U: Manufacture of pentaerythritol tetranitrate (PETN)

CH: Extremely volatile. Vapor may travel considerable distance to source of ignition. Forms explosive peroxides on contact with air

TH: TLV 100 ppm (180 mg/m^3). Irritates eyes, skin, lungs. Produces headache, bronchitis, pulmonary edema, dermatitis, and albuminuria. Central nervous system narcotic.

HS: Store in cool, dark area under nitrogen or other inert gas. Wear rubbber gloves and coveralls. Use self contained breathing apparatus

FP: Fight fires using CO_2, dry chemical, or alcohol foam, extinguisher

HP: Adequate ventilation and frequent gargling. In case of contact irrigate eyes and contaminated skin with water. Stomach wash followed by saline catharsis if swallowed.

SL: Wipe up spill with absorbant material, evaporate in hood, burn absorbant.

Acetic Acid

S: Ethanoic acid, methanecarboxylic acid, vinegar acid

U: Nitrocellulose manufacture

CH: Forms explosive mixture in air. Dangerous in contact with oxidizers, especially chromic acid, nitric acid, and sodium peroxide

TH: TLV 10 ppm (25 mg/m^3). Blackening, hyperkeratosis, and fissuring of skin. Conjunctivitis, corneal erosion, iritis. Attacks skin easily. Pain in mouth, pharynx, esophagus, and stomach. Vomiting, hematemisis, diarrhea with blood, laryngitis, bronchitis, pulmonary edema, pneumonia, cardiovascular collapse, albuminurea, hematuria if swallowed.

HS: Adequate ventilation. Store outdoors or in detached area away from combustible or oxidizing materials. Expands at freezing point ($17^{o}C$) and may break glass containers. Handle wearing chemical goggles, chemical cartridge respirator, and rubber protective clothing

HP: Adequate ventiliation. In case of contact wash eyes with water, skin with soap and water. If swallowed take magnesia, chalk, lime, or whiting in water. Do not induce vomiting.

FP: Fight fires using CO_2, dry chemical, alcohol foam, or water spray or mist extinguisher. Use water to keep containers cool.

SL: Cover spills with soda ash or sodium bicarbonate, add water, neutralize, and flush into wastewater system with excess water

Acetic Anhydride

S: Acetyl oxide, acetic oxide

U: Nitrocellulose manufacture

CH: Moderate fire risk. Will react violently on contact with water or steam, especially in the presence of mineral acids.

TH: TLV 5 ppm (20 mg/m^3). Irritates and corrodes tissue, particularly eyes and upper respiratory tract. Produces corneal necrosis, burning

stomach pain, nausea and vomiting. Systemic effects can be avoided by noting early symptoms; burning nose and throat, and coughing. Delayed toxic action can cause severe eye damage.

HS: Store away from food, oxidizing agents, and sources of ignition. Wear rubber gloves, protective clothing, and self contained breathing apparatus.

FP: Fight fires using CO_2, dry chemical, or alcohol foam extinguisher.

HP: Use adequate ventilation. Gargle often. Persons with diseases of the eyes, skin, or lungs should not be exposed. In case of contact, wash eyes with water, skin with soap and water. If swallowed, take magnesia, chalk, lime, or whiting in water. Do not induce vomiting.

SL: Cover spills with soda ash or sodium bicarbonate, add water, neutralize, and flush into wastewater system with excess water.

Acetone

S: Dimethylketone, B-ketopropane, 2-propanone

U: Pentaerythritol tetranitrate (PETN), sodium methylene diisonitramine manufacture

CH: Reacts vigorously with oxidizers. Severe fire and explosion hazard.

TH: TLV 1000 ppm (2400 mg/m^3). Produces conjunctivitis, corneal erosion, headache, weariness, nausea, gastritis, vomiting, lethargy, paralysis. Has a de-fatting action on skin.

HS: Eliminate all ignition sources. Unload tank cars by top pump or siphon using nitrogen with an eduction pipe at 25 psi or less. Do not ship together with explosives, foods, oxidizable materials,

organic peroxides, toxicants, or radioactive materials. Wear rubber gloves, rubber aprons, chemical goggles, self contained breathing apparatus or hose mask with blower, full mask face piece

FP: Fight fires using CO_2, dry chemical, or alcohol foam extinguisher.

HP: Use adequate ventilation. In case of contact, wash eyes with water, skin with soap and water. Stomach wash followed by saline catharsis if swallowed.

SL: Wipe up spills with paper, evaporate in a hood, burn paper.

Acetylene

S: Ethyne, ethine

U: Cuprous acetylide manufacture

CH: Highly flammable and explosive. Reacts vigorously with oxidizers. Unstable under high pressure and will explode if subjected to heat.

TH: Asphyxiant. Produces dizziness, headache, nausea, cyanosis, central nervous system irritation, collapse, and coma.

HS: Do not store near copper, silver, mercury, halogens, organic peroxides, explosives, toxicants, or radioactive materials. Keep in cool, well ventilated place in well grounded containers. Keep away from ignition sources and protect from lightning and static electricity.

FP: Stop acetylene gas flow. Use water to cool exposed containers. Fight fire using CO_2, water spray, or dry chemical extinguisher.

HP: Use adequate ventilation. In case of exposure, remove person(s) from contaminated area, administer artificial respiration and oxygen.

SL: In case of gas leakage, maintain gas level below 2.5% (lower explosive limit) by forced ventilation. Remove leaking container to an open area.

Aluminum Powder

U: Explosives

CH: Flammable when contacting fire. May explode with liberation of hydroogen in contact with water, acids, or alkalis. Hazardous reaction with metal oxides

TH: Chronic dust inhalation may produce dermatitis, bronchial asthma, anorexia, shortness of breath, cough, gastrointestinal pain, pulmonary fibrosis.

HS: protect from moisture. Keep away from CCl_4, CS_2, halogens, acids, and alkalis. Keep away from sources of ignition. Wear heavy gloves, safety glasses, coveralls.

FP: Cover fire with sand or other inert smothering solid. Do not use water.

HP: Use adequate ventilation. Include chest x-ray in regular medical examination.

Ammonia

U: Dinitroglycerine, ammonium nitrate, ethylene dinitramine, azides, cuprous acetylide manufacture

CH: Flammable gas. Increased fire hazard in the presence of combustible materials. Forms explosive fulminating compounds with silver oxide or mercury. Forms explosive compounds with halogens and chlorates.

TH: TLV 25 ppm (18 mg/m^3). Severely irritating to eyes, mucous membranes, and skin, with deep erosion. Produces visual disorder, corneal and conjunctival ulcers, corneal and lenticular opacities, dyspnea, heachache, salivation, nausea, vomiting, cough, breathing problems, bronchitis, hemoptysis, pulmonary edema, fit of the glottis, suffocation.

HS: Store outdoors or in detached area. If stored indoors, location should be cool and well ventilated. Keep away from fire hazards, oxidizing agents, halogens, acids, direct sunlight. Wear face shield, chemical cartridge respirator, rubber boots and gloves.

FP: Stop ammonia gas flow, use water to cool exposed containers. Fight fire using CO_2, dry chemical, or water spray extinguisher.

HP: In case of contact wash eyes with water followed by several drops of olive oil, wash skin with soap and water. Provide victim with oxygen. Persons with eye or pulmonary disease should not be exposed. If ammonia water is swallowed give large amounts of 1% acetic acid, 1:4 vinegar:water, 1% citric acid, or lemon juice. Do not induce vomiting.

SL: Neutralize spills with HCl. Mop up residual and flush into waste water system with excess water.

Ammonium Dihydrogen Phosphate

S: Ammonium acid phosphate, ammonium biphosphate, monobasic ammonium phosphate

U: Nitrocellulose manufacture

CH: Nonflammable

TH: Nontoxic

Ammonium Hydroxide

S: Ammonium hydrate, aqua ammonia, ammonia water

U: Dinitroglycerine, ammonium nitrate, ethylene dinitramine, azide manufacture

CH: Nonflammable

H: Produces corneal and conjunctival ulcers, corneal and lenticular cloudiness, burns of skin and mucosa, headache, nausea, vomiting, breathing difficulties, cough, blood spitting, bronchitis, pulmonary edema.

HS: Do not fill glass, plastic, or rubber stoppered bottles to brim. Store in cool place. Do not store near concentrated inorganic acids or halogens. Wear rubber gloves, general purpose gas mask, and face shield.

HP: Use adequate ventilation. Persons with eye and pulmonary disease

should not be exposed. In case of contact, wash eyes with water then olive oil, wash skin with soap and water. Supply oxygen, and use positive breathing apparatus is necessary. (See Ammonia)

SL: Neutralize with dilute HCl. Mop up and dispose of into waste water.

Ammonium Nitrate

U: Dinitroglycerine, nitrocellulose, guanidine nitrate, RDX, HMX manufacture.

CH: Self igniting in mixtures with easily oxidized materials. Exhibits explosive decomposition. Will emit highly toxic oxides of nitrogen when heated to decomposition. Explodes when mixed with zinc powder and water.

TH: Slightly toxic

HS: Protect containers against physical damage. Store in well ventilated, noncombustible buildings equipped with automatic sprinklers. All floor drains and recesses should be plugged or eliminated to prevent entrapment of molten nitrate during fire. Store away from organic material, flammable liquids, corrosive liquids, acids, chlorates, sulfur, powdered metals, charcoal, and saw-dust. Store on wooden pallets or clean concrete or similar floor covered with plastic, or other waterproof sheets. Bags of ammonium nitrate should be stored at least 30 inches from walls, and 36 inches from eaves and support beams. Stacks should be no greater than eight feet wide and seven feet tall. All sources of flame, heat or sparks should be kept at least 50 feet away. No smoking within 50 feet. Dispose of empty bags properly and promptly. Wear rubber gloves and chemical goggles.

FP: Deluge with water in early stage of fire taking caution not to splatter molten nitrate. When large quantities of ammonium nitrate

are involved in advanced or massive fires, control efforts should be confined to further exposures; fire fighting personnel should secure hose nozzles in fixed position or set up unmanned turrets and withdraw to a safe location. If ammonium nitrate is contaminated with oil, charcoal, or other combustible or sensitizing material there is increased chance of explosion. In this instance, surrounding area should be evacuated.

SL: Sweep into beaker, dilute with water, add soda ash, neutralize with HCl, and drain into sewer.

Ammonium Perchlorate

U: Explosives

CH: Strong oxidizer, shock sensitive. Highly ignitible when combined with combustible materials, or zinc powder and moisture. Forms explosive mixtures with ammonium sulfate, or ammonium nitrate and metal powders.

TH: Strong skin irritant

HS: Store away from strong acids, combustible materials, metal powders, and sources of ignition. Wear rubber gloves, a face shield, a body shield and coveralls.

FP: In early stages of fire spray water from behind protective barrier. In advanced fires, evacuate area. Spray fire exposed containers with water to keep cool.

HP: In case of contact irrigate eyes for at least 15 minutes. Wash skin with soap and water.

SL: Cover with weak reducing agents (e.g. sodium thiosulfate, or bisulfites or ferrous salts in dilute H_2SO_4), transfer to a large container of water, neutralize, and drain into sewer with abundant water.

Ammonium Picrate

S: Ammonium picronitrate, ammonium carbazoate

U: Explosives

CH: Readily explodes with heat or shock

TH: Produces conjunctivitis, rhinitis, papule, and erythematous dermatitis.

HS: Protect from heat and physical damage. Store in explosion proof warehouse. Wear gas mask and safety glasses.

FP: Fight fires from explosion safe location. If a fire starts in the vicinity of ammonium picrate, spray containers with water to prevent temperature rise.

HP: Preclude allergic persons from exposure. In case of contact irrigate eyes with water, wash skin with soap and water. If swallowed, stomach wash followed by saline catharsis.

Ammonium Sulfate

U: Nitrocellulose manufacture

CH: Nonflammable

TH: May cause minor acute irritation

Aniline

S: Aminobenzene, phenylamine

U: Hexyl manufacture

CH: Flammable, vapor forms explosive mixtures with air. May ignite by violent reaction with nitric acid.

TH: TLV 5 ppm skin (19 mg/m^3). Highly toxic when absorbed through skin, inhaled, or swallowed. Acutely produces headache, dizziness, neurosis, shortness of breath, rapid heartbeat, nausea, abdominal pain, pain in joints, cyanosis, convulsion, fainting, methemoglobinemia, anoxemia, hemolysis of red blood cells, immature or stippled red blood cells, liver damage, and jaundice. Chronically produces digestive disease, kidney inflammation, dizziness, headache, insomnia, ringing in ears, neuralgia, conjunctivitis, rashes, decrease in visual capacity, papillomatous bladder growths.

HS: Keep all operations as enclosed as possible. Store in cool, dry, well ventilated area, preferably outdoors or detached or isolated. Do not store near oxidizing materials. Frequently inspect containers for leaks. Wear chemical safety goggles, impervious protective cloththing, including boots and gloves, self contained breathing apparatus with full face mask, and safety hat.

FP: Fight fires using alcohol foam, CO_2, or dry chemical extinguisher. Use water to keep fire exposed containers cool.

HP: Discontinue exposure and remove all clothing promptly. Wash skin with soap and water (including ear canals and under finger and toe nails.) Stomach wash if swallowed, followed by saline catharsis.

SL: Cover spill with 9:1 sand:soda ash mixture. Transfer to paper carton

and burn cautiously in an open furnace or in a furnace with an after burner and scrubber.

Barium Chlorate

U: Baratol, baronal manufacture

CH: May ignite when mixed with combustible materials

TH: Toxic when ingested. Symptoms uncertain but may include severe abdominal pain, vomiting, dyspnea, rapid pulse, paralysis of arm and leg, and cyanosis. Other symptoms include dermatitis and irritation of the eyes, nose, throat, and skin.

HS: Wear rubber gloves, a face shield, and coveralls.

FP: Flood fire with water from a safe distance. Wear a full body shield.

HP: In case of contact wash eyes with water, skin with soap and water. Stomach wash followed by saline catharsis if swallowed. Give two tablespoons magnesium sulfate (epsom salts) in warm water.

SL: Cover spills with weak reducing agents (e.g. sodium thiosulfate, or bisulfites or ferrous salts in dilute H_2SO_4), transfer to a container of water, neutralize with soda ash, and flush down drain with large amounts of water.

Benzaldehyde

S: Benzoic aldehyde

U: Nitrocellulose manufacture

CH: Ignites on slight heating

TH: Moderately toxic by ingestion. Causes CNS depression in small doses, convulsions in higher doses. High vapor concentration produces narcosis. Local contact may cause contact dermatitis.

HS: Keep containers closed and store in a cool, dark place. Wear rubber gloves, self contained breathing apparatus, and overalls.

FP: Fight fires using foam, CO_2, dry chemical, or water spray extinguisher.

SL: Wipe up spills with absorbent material, evaporate under a hood, and burn absorbent material.

Benzene

S: Benzol, coal naphtha, phenylhydride, cyclohexatriene

U: Nitrobenzenes, picrates manufacutre

CH: Dangerously flammable. May travel considerable distance to ignition source

TH: TLV 10 ppm (30 mg/m^3). Highly toxic. Locally benzene has a comparatively strong irritative effect producing erythema and burning to edema and blistering. Acute systemic effects produce euphoria, excitement, headache, dizziness, incoherent speech, narcosis, CNS stimulation followed by depression, confusion, pressure over forehead, tightening of leg muscles, respiratory irritation, pulmonary edema, gastrointestinal irritation with vomiting and colic,

and death via respiratory paralysis. Chronic systemic effects are somewhat vague and include fatigue, headache, dizziness, nausea, loss of appetite, weight loss, weakness, pallor, nosebleeds, bleeding gums, nervousness, irritability, epistaxis, petechiae, purpura, menorrhagia, and menstrual disorders. Benzene is a recognized carcinogen of blood forming tissues. Bone marrow may be hypo or hyperplastic, or normal. Aplastic anemia, leucopenia, macrocytosis, reticulocytosis, thrombocytopenia, hemolysis, high color index, prolonged bleeding time may be present. Myeloid leukemia has been noted.

HS: Protect containers against physical damage. Store outdoors or in detached areas. Indoor storage should be in a standard flammable liquid storage room. Use spark resistant tools. Wear chemical safety goggles, face shield, self contained breathing apparatus, and rubber protective clothing.

FP: Fight fires with foam, CO_2, or dry chemical, extinguisher. Use water spray to keep exposed containers cool.

HP: Use adequate ventiliation. Sample atmosphere weekly. Determine urinary inorganic sulfates monthly. Complete blood count monthly; if WBC is below 5,000 or RBC is below 4,000,000 on two successive examinations, individual should be removed from exposure. Individuals with a history or evidence of blood disorders should not be exposed. In case of contact, flush eyes with water, wash skin with soap and water. Stomach wash if swallowed followed by saline catharsis. Artificial respiration or oxygen if needed. Do not give adrenaline as a respiratory stimulant.

SL: Absorb spills on paper, evaporate in a hood, then burn paper

n-Butylformate

U: Nitrocellulose solvent

CH: Combustible fire hazard, explosive range between 1.7 and 8% in air. Reacts with oxidizers.

TH: Irritates eyes, skin, and respiratory tract. Vapor narcotic in high concentrations.

HS: Store away from sources of ignition. Wear chemical safety goggles, chemical cartridge respirator, and coveralls.

FP: Fight fires using alcohol foam, foam, CO_2, or dry chemical extinguisher.

HP: Use adequate ventilation. In case of contact, flush eyes with water, wash skin with soap and water.

SL: Wipe up spills with paper, evaporate in a hood, and burn paper.

Calicum Carbonate

S: Calcite, aragonite

U: Glycerol dinitrate manufacture

CH: Nonflammable

TH: Nontoxic

HS: Remove residue from body or clothing

Calcium Hydroxide

S: Calcium hydrate, slaked lime, lime hydrate

U: Picrates, PETN manufacture

CH: Nonflammable

TH: Dust may irritate skin eyes, and mucosa, and cause dermatitis

HS: Keep containers tightly sealed, wear rubber gloves, large size face mask.

HP: In case of contact, flush eyes or skin with copious amounts of warm water.

SL: Sweep into large bucket, neutralize with dilute HCl, flush down drain with abundant water.

Calcium Nitrate

U: Nitrocellulose manufacture

CH: Reacts with reducing materials

TH: Large amounts may cause dizziness, abdominal cramps, vomiting, bloody diarrhea, weakness, convulsions, collapse, some indication of increased cancer incidence. (see Potassium, Sodium Nitrate)

Camphor

S: 2-camphanone, gum camphor, 1,7,7-trimethylbicyclo(2,2,1)-2-heptanone, laurel camphor

U: Explosives binder

CH: Flammable and explosive vapor. Explosive limit 0.6 to 3.5% in air

TH: TLV 2 ppm (12 mg/m^3). Causes headache, dizziness, convulsions, nausea, excitation, stomach ache, paralysis, mania. Can be fatal. Local irritant.

HS: Store away from fire sources. Wear rubber gloves, face mask, protective clothing.

FP: Spray fire with water to cool below flash point.

HP: Use adequate ventilation. In case of contact flush eyes with water, wash skin with soap and water. If swallowed flush stomach using emetic or stomach tube.

SL: Sweep spillage onto paper. Burn paper.

Carbon Black

U: Gunpowder manufacture

CH: Dust may cause an explosion

TH: Can cause dust irritation of eyes, conjunctivitis, corneal hypoplasia, eczema of the eyelids, bronchitis, and pneumatotumor.

HS: Wear safety glasses and a chemical cartridge respirator.

HP: Persons with pulmonary diseases should not be exposed. In case of contact, flush eyes with water.

Carbon Tetrachloride

S: Tetrachloromethane, perchloromethane

U: Nitrocellulose manufacure

CH: Not flammable. When heated to a high temperature, produces phosgene.

TH: TLV 10 ppm (65 mg/m^3). Narcotic action resembles that of chloroform. Acute affects include irritation of eyes, nose and throat, headache, dizziness, nausea, vomiting, hematemisis, abdominal cramps, diarrhea, nervousness, dyspnea, cyanosis, oliguria, proteinuria, hematuria, jaundice, hepatomegaly, optic neuritis, unconciousness, coma, ventricular fibrillation. Chronic effects include dermatitis, anorexia, nausea, vomiting, abdominal pain, apathy, confusion, headache, dizziness, fatigue, restrictions of visual fields, diminished visual acuity, weight loss, jaundice, renal damage, kidney damage, liver damage, and uremia. Suspected carcinogen. Alcoholics particularly susceptable to liver damage.

HS: Protect containers from damage. Store in cool, dry, well ventilated place away from potential fire hazards. Protect against direct sunlight. Wear vinyl gloves, chemical goggles, and a chemical cartridge respirator.

HP: Physical examinations of exposed persons every 6 months including liver and kidney function studies. Individuals with liver, kidney or CNS diseases, and alcoholics, should not be exposed. In case of contact wash eyes with water, skin with soap and water. Stomach wash, if swallowed, followed by saline catharsis.

SL: Wipe up with paper, evaporate in a hood, burn paper.

Chloroform

S: Trichloromethane

U: Nitrocellulose

CH: Will liberate phosgene on contact with high heat.

TH: TLV 50 ppm (240 mg/m^3). Produces irritation of conjunctiva, dilation of pupils, reduced light reaction, reduced intraocular pressure, irritation of skin and mucosa, excitement, nervousness, delirium, staggering, unconsciousness, shortness of breath, vomiting, appetite loss, diuresis, narcosis, damage to heart and liver and kidneys, profound toxemia, loss of reflexes and sensation and consciousness, possible hepatitis, paralysis, and cardiac and respiratory failure. Suspected carcinogen.

HS: Protect containers from physical damage. Keep containers closed and store in a cool, dark, dry place. Wear safety glasses, self contained breathing apparatus, and rubber gloves.

HP: Use adequate ventilation. Annual checkup for all exposed persons, including studies of liver and kidney function. Persons with diseases of the liver, kidney, or CNS should not be exposed. In case of contact wash eyes with water, skin with soap and water. If swallowed, treat with emetics or stomach syphon, friction, cold douche, fresh air, rubefaction, artificial respiration

SL: Absorb on paper, evaporate in a hood, burn paper.

Chlorohydrin

S: α-chlorohydrin, 1-chloropane-2,3-diol,glyceryl-α-chlorohydrin

U: Chlorohydrin dinitrate manufacture

CH: Nonflammable

HS: Wear neoprene gloves, protective plastic clothing, and self contained breathing apparatus.

HP: In case of contact immediately wash skin thoroughly with soap and water. Immediately remove contaminated clothing.

SL: Cover spill with soda ash, mix, spray with water, scoop into a bucket of water and let stand for two hours. Neutralize with dilute HCl and flush down drain with abundant water.

Copper

U: Copper acetylide, copper azide manufacture

CH: Nonflammable

TH: Slightly toxic, nose and throat irritant, produces gastroenteric symptoms with vomiting and inflammation, metal fume fever, dermatitis.

HS: Wear gloves, goggles, overalls.

HP: Stomach wash, if swallowed, followed by saline catharsis.

Cyanamide

S: Carbodiimide, cyanogenamide, hydrogencyanamide, carbimide

U: Guanidine explosives manufacture

CH: Slight fire hazard

TH: Strongly irritating and caustic. Raises pulse and respiration rates, lowers blood pressure. Irritates mucosa, causes severe dermatitis on moist skin, flushing of the face, headache, dizziness, gasping, and rapid throbbing of the heart.

FP: Fight fires using CO_2 or dry chemical extinguishers.

HS: Store in a cool dark place. Liquid is made up to pH 4 using phosphoric, sulfuric, or boric acid. Wear long rubber gloves, self contained breathing apparatus, and overalls

SL: Sweep spill onto a paper sheet. Burn paper.

HP: If swallowed, stomach wash followed by saline catharsis.

Diacetone Alcohol

S: 4-hydroxy-4-methyl-2-pentanone, diketone alcohol

U: Nitrocellulose solvent

CH: Highly flammable

TH: TLV 50 ppm (240 mg/m^3). Narcotic in high concentration. Irritates eyes and mucosa. Causes anemia and kidney and liver lesions.

HS: Wear rubber gloves, face shield, chemical cartridge respirator, and overalls.

SL: Absorb on paper, evaporate in a hood, burn paper.

FP: Fight fires using alcohol foam, CO_2, or dry chemical extinguisher.

Dicyandiamide

S: Cyanoguanidine

U: Guanidine nitrate manufacture

TH: Causes respiratory and pulse increase, lowers blood presure. Dizziness, toxicity uncertain.

Diethyl Carbonate

S: Ethylcarbonate, carbonic ether

U: Nitrocellulose solvent

CH: Flammable

TH: TLV 25 ppm (77 mg/m^3). Irritates eyes and respiratory tract.

HS: Wear rubber gloves, face shield, and multipurpose canister mask.

FP: Fight fires using foam, CO_2, or dry chemical extinguisher.

HP: Use adequate ventilation. In case of contact flush eyes with water, wash skin with soap and water.

SL: Absorb onto paper, evaporate in a hood, burn paper.

Diethylene Glycol

S: 2,2-dihydroxydiethyl ether, diglycol, ethylene diglycol

U: Diethylene glycol dinitrate manufacture

CH: Flammable

TH: Causes nausea, vomiting, epigastric, diarrhea, cyanosis, drowsiness, fatigue, coma, pulmonary edema, albuminuria, oliguria, uremia. Suspected bladder carcinogen.

HS: Wear rubber gloves, face shield, and all purpose cartridge mask.

FP: Fight fires using alcohol foam, water spray, CO_2, or dry chemical extinguisher. Water or foam may cause frothing. Spray containers with water to keep cool.

HP: Stomach wash, if swallowed, followed by saline catharsis. Artificial respiration and oxygen. Persons with diseases of the kidneys, liver, or nervous system should not be exposed.

SL: Absorb with paper, evaporate in hood, burn paper.

Diethylene Glycol Monobutyl Ether

S: Butyl ether, 2-(2-butoxyethoxy)ethanol, butyl carbitol

U: Nitrocellulose solvent

CH: Flammable

TH: Weakly toxic

HS: Protect containers against physical damage, separate from sources of ignition and oxidizers. Outdoors or detached storage is preferred. Use standard combustible storage room for indoor storage. Wear safety glasses, gas mask, and rubber gloves.

FP: Fight fires using alcohol foam, CO_2, or dry chemical extinguisher. Keep containers cool using water spray.

HP: In case of contact flush eyes with water. If swallowed, stomach wash followed by saline catharsis.

SL: Absorb with paper, evaporate in a hood, burn paper.

Diethyl Ether

S: Ethyl ether, diethyl oxide

U: Solvent for nitrocellulose, gunpowder

CH: Highly flammable. May travel considerable distance to ignition source. Can ignite by static electricity. On long standing or exposure to sunlight it forms peroxides that may explode spontaneously.

TH: TLV 400 ppm (1200 mg/m^3) acute symptoms include conjunctivitis, respiratory tract irritation, defatting dermatitis, headache, dizziness, anorexia, nausea, vomiting, paralysis, albuminuria. Chronic symptoms include headache, dizziness, weakness, appetite loss, nausea, psychic disturbances. Causes CNS disturbances by inhalation and skin absorption. Skin and mucosa irritant.

HS: Ignites easily by contact with nitric or fuming sulfuric acids, or by mixing with liquid oxygen or liquid air, resulting in an explosion hazard. Protect containers against damage. Detached or outdoor storage is preferred. Indoor storage should be in a standard flammable liquid storage room. Protect against static electricity, lightning, and direct sunlight. For large quantity storage rooms, protect with automatic sprinkler systems and total flooding CO_2

systems. The floors of the storage room should be conductive to ground out static charges. Wear chemical goggles, chemical cartridge respirator, rubber gloves, and conductive, nonsparking shoes. Protective clothing should be of a type unaffected by ether. Water soluble protective creams, lanolin, or petrolatums may be used to reduce skin contact hazard.

FP: Fight fires using alcohol foam, CO_2, or dry chemical extinguisher. Keep containers cool using water spray.

HP: Use adequate ventilation. Persons with kidney diseases should not be exposed. In case of contact flush eyes with water, wash skin with soap and water. If swallowed, stomach wash followed by saline catharsis.

SL: Absorb with paper, evaporate in a hood, burn paper.

Diethyl Phthalate

S: DEP

U: Nitrocellulose plasticizer

CH: Slightly flammable

TH: Produces conjunctivitis, corneal necrosis, respiratory tract irritation, dizziness, nausea, excema. Narcotic in high concentrations. Irritates eyes and mucosa.

HS: Store in a cool well-ventilated place away from heat, sparks, or strong oxidizers. Wear safety glasses, rubber gloves, face shield, and all-purpose canister mask.

FP: Fight fires using water spray, dry chemical, CO_2, or foam extinguisher.

HP: Use adequate ventilation. In case of contact flush eyes with water, and wash skin with water. If swallowed, stomach wash followed by saline catharsis.

SL: Absorb on paper, evaporate in hood, burn paper.

Diisobutyl Ketone

S: Sec-diisopropyl acetone, isovalerone, 2,-6-dimethyl-4-heptanone

U: Nitrocellulose solvent

CH: Flammable

TH: TLV 25 ppm (150 mg/m^3). Causes eye, nose and throat irritation, headache, dizziness, nausea, vomiting. Narcotic in high concentrations causing CNS depression and narcosis.

HS: Store away from sources of ignition, oxidizers, and direct sunlight. Wear safety glasses, chemical cartridge respirator, face shield, and overalls.

FP: Fight fires using CO_2 or dry chemical extinguisher.

HP: Use adequate ventilation. In case of contact, flush eyes with water, wash skin with soap and water. If swallowed, stomach wash followed by saline catharsis.

SL: Absorb on paper, evaporate in a hood, burn paper.

Diisopropyl Ether

S: Isopropyl ether, 2-isopropoxy propane.

U: Nitrocellulose solvent

CH: Vapor is heavier than air, and may travel considerable distance to ignition source. Forms spontaneously explosive peroxides in contact with air, sunlight, or on long standing.

TH: Irritant. Causes CNS depression, respiratory tract irritation, defatting dermatitis, headache, dizziness, appetite loss, nausea, vomiting, languor, narcosis.

HS: Protect containers against physical damage. Outdoor or detached storage is preferred. If stored indoor, store in standard combustible liquid storage room or cabinet, separate from other combustibles, and protected from sunlight, lightning, and static. For large quantity storage room, equip with automatic sprinkler system and total flooding CO_2 system. Wear rubber gloves, self contained breathing apparatus, strong and large face shield, and overalls.

FP: Fight fires using alcohol foam, foam, dry chemical, or CO_2 extinguisher. Use water spray to keep containers cool.

HP: Use adequate ventilation. In case of contact flush eyes with water, wash skin with soap and water.

SL: Absorb with paper, evaporate in a hood, burn paper.

N,N-Dimethylaniline

S: DMA, dimethyl phenylamine

U: Tetryl manufacture

CH: Flammable

TH: TLV 5 ppm (25 mg/m^3). Highly toxic (See Aniline). CNS depressant. Causes headache, weakness, cyanosis, tremors, dizziness, tonic and chronic convulsions, increased pulse and respiration, paralysis, respiratory slowing, death from respiratory failure.

HS: Wear rubber gloves, rubber boots, air respirator. Do not expose skin.

FP: Fight fires using foam, CO_2, or dry chemical extinguisher.

HP: Use adequate ventilation. Enforce sanitation, wash work clothes daily, periodically check coworkers for cyanosis symptoms. Do not expose persons with anemia or heart and lung disease. In case of exposure, remove all clothing, wash all skin with water, including inside of ears and nail beds.

SL: Cover spill with 9:1 sand:soda ash, burn residue carefully in an outdoor furnace or furnace equipped with an afterburner and scrubber.

2,4 Dinitrochlorobenzene

U: Hexyl, picrates manufacture

CH: Flammable, explosive range in air 1.9 to 22%. May be exploded by shock or heat in sealed container.

TH: Toxic by skin absorption, swallowing, inhalation. Primary irritant, skin sensitizer.

HS: Protect containers from damage, store away from strong oxidizing or reducing materials. Storage area should have automatic sprinkler. Wear self contained breathing apparatus.

FP: Fight fires using water, dry chemical, or CO_2 extinguisher. Fire-fighting should be done from a protected location or by automatic equipment due to explosion hazard, if fighting requires approach to fire, surrounding area should be evacuated.

HP: In case of contact wash skin with soap and water. Remove clothes and wash or burn.

SL: Cover spills with sodium bicarbonate or 9:1 sand:soda ash. Burn in outdoor furnace.

Diphenylamine

S: Phenylaniline, DPA, anilinobenzene

U: Explosives stabilizer

CH: Slightly flammable

TH: TLV 10 mg/m^3. Slightly less toxic than aniline. Similar symptoms include eczema, tachycardia, hypertension. Recognized carcinogen. (See Aniline)

HS: Store in a cool, dark place. Wear safety glasses, mechanical filter respirator, rubber gloves, and rubber clothing.

HP: Use adequate ventilation. In case of contact flush eyes with water, wash skin with soap and water. Wash clothes with soap and water, or dispose of by burning. Burn shoes if contaminated.

SL: Cover spill with 9:1 sand:soda ash, mix, burn in furnace

Ethanol

S: Ethyl alcohol

U: Ethylnitrate, fulminates, sodium methylene diisonitramine manufacture

CH: Very flammable

TH: TLV 1000 ppm (1900 mg/m^3). Can cause eye and respiratory tract irritation, headache, dizziness, drowsiness, mental confusion, fatigue, anorexia, nausea, tremor, narcosis.

HS: Protect containers from damage. Use underground storage tanks for large quantities. Store small amounts in the original shipping containers, either outside the building, or indoors in a cool, well ventilated room. Store away from all possible ignition sources. Do not store near perchlorates, peroxides, chromic acid, or nitric acid. All precautions for the elimination of static electricity should be taken. Wear chemical goggles, chemical cartridge respirator, rubber gloves, and rubber boots.

FP: Fight fire using alcohol foam, dry chemical, or CO_2 extinguisher. Keep containers cool with water spray.

HP: Exposed persons should have a periodic checkup including signs of chronic mucous membrane irritation and alcoholism. In case of contact, irrigate eyes with water. If swallowed, stomach wash followed by saline catharsis.

Ethyl Acetate

S: Acetic ether, acetic ester, acetic acid ethyl ester.

U: Solvent for nitrocellulose, manufacture of smokeless powders.

CH: Dangerous fire and explosion hazard

TH: TLV 400 ppm (1400 mg/m^3). Mildly toxic. Irritates mucosa, eyes, gums, respiratory tract, mild narcotic, can cause conjunctivitis, corneal clouding, dermatitis, "polishers keratitis," tracheitis, congestion of liver and kidneys, secondary anemia, leucocytosis, cloudy swelling, fatty degeneration of the viscera.

HS: Keep containers tightly closed and store in cold, well ventilated areas away from sources of ignition. Wear safety glasses, butyl rubber gloves, face shield, and general purpose breathing apparatus.

FP: Fight fires using alcohol foam, dry chemical, or CO_2 extinguisher. Keep containers cool with water spray.

HP: Use adequate ventilation. In case of contact, flush eyes with water, wash skin with soap and water.

SL: Wipe up spills with paper, evaporate in a hood, burn paper.

Ethyl Chlorocarbonate

S: Ethyl chloroformate

U: Ethylene dinitramine manufacture

CH: Flammable

TH: Irritation and burns of eyes, skin, and respiratory tract

HS: Store away from oxidizing agents. Produces toxic and corrosive fumes on contact with water. Wear safety glasses, gas mask, rubber gloves, apron and boots.

HP: Use adequate ventilation. In case of contact, deluge eyes with water, wash skin with soap and water.

SL: Absorb spills with paper, evaporate in a hood, burn paper.

Ethylene

S: Ethene

U: Nitroglycol manufacture

CH: Highly flammable, forms an explosive mixture with air between 3.1 and 3.2%.

TH: Slightly toxic. Causes paralysis and heart malfunction at high concentrations.

HS: Protect containers against physical damage. Outdoor or detached

storage is preferred. If stored indoor, use a fireproof, well ventilated area isolated from any sources of ignition. Do not ship with explosives, poisons, radioactive materials, or organic peroxides. Wear self-contained breathing apparatus.

FP: Turn off source of gas. Keep container cool with water spray.

HP: Use adequate ventilation. In case of contact administer oxygen or artificial respiration.

SL: By forced ventilation keep concentration in air below explosive mixture. Remove tank or cylinder to an open area.

Ethylene Diamine

S: EDA, 1,2-diaminoethane, 1,2-ethane diamine.

U: Ethylene dinitramine manufacture

CH: Moderate fire hazard

TH: TLV 10 ppm (25 mg/m^3). Irritant to eyes, respiratory tract, skin. Causes vesicular dermatitis, skin burns, headache, dizziness, shortness of breath, nausea, vomiting, asthmatic breathing.

HS: Protect containers from damage. Wear safety glasses, butyl rubber gloves, face shield, general purpose breathing apparatus.

FP: Fight fires using alcohol foam, water spray, CO_2 or dry chemical extinguisher. Wear fully protective clothing.

HP: Use adequate ventilation. Persons with skin diseases or who have

become sensitized should not be exposed. In case of contact flush eyes with water, wash skin with soap and water. If swallowed, stomach wash followed by saline catharsis.

SL: Cover spills with sodium bisulfite, sprinkle with water, pour into drain with excess water.

Ethylene Glycol

S: Ethylene alcohol, glycol, 1,2-ethane diol

U: Nitroglycol manufacture

CH: Flammable

TH: Slightly toxic by skin or mucous membrane exposure, but mildly toxic by swallowing. Estimated fatal dose is 100 ml. Symptoms include conjunctivitis, nausea, vomiting, abdominal pain, weakness, mydriasis, cyanosis, tremor, convulsion, areflexia, narcosis, coma, albuminuria, hematuria, anuria, lymphocytosis, kidney damage.

HS: Store in resin coated stainless steel or aluminum containers. Keep containers tightly closed. Store away from oxidizers and flame. Wear safety glasses, rubber gloves, face shield, general purpose respiratory apparatus.

FP: Fight fire using alcohol foam, water spray, foam, CO_2 or dry chemical extinguisher.

HP: Annual medical checkup should include liver and kidney function tests. Persons with diseases of the liver, kidney, lungs or CNS

should not be exposed. In case of contact flush eyes with water, wash skin with soap and water. If swallowed, stomach wash followed by saline catharsis.

SL: Wipe up spills with paper, evaporate in a hood, burn paper.

Ethylene Glycol Dinitrate*

U: Nitroglycerine antifreeze

CH: Highly flammable, explosive

TH: TLV 0.2 ppm. Highly toxic (See Nitroglycerine).

HS: Wear butyl rubber gloves, self contained breathing apparatus.

FP: (See Nitroglycerine)

HP: Clean clothes immediately with detergent, or incinerate.

SL: Cover spill with sodium bisulfite, sprinkle water, flush down drain with excess water.

*see Nitroglycerine for additional information

Ethyl Oxalate

S: Diethyl oxalate, diethyl ethanedioate, oxalic and diethyl ester, oxalic ether

U: Nitrocellulose solvent

CH: Flammable

TH: Toxic, produces general ill feeling

HS: Store in a cool place away from fire sources. Wear a gas mask.

FP: Fight fires using foam, CO_2, or dry chemical extinguisher.

HP: Annual physical examination should include a complete blood count.

SL: Absorb on paper, evaporate in a hood, burn paper.

Formaldehyde

S: Methanal, oxomethane, oxymethylene, methylene oxide, formalin, methyl aldehyde

U: Pentaerythritol tetranitrate (PETN) manufacture

CH: Flammable. Explosive range in air 7 to 73%.

TH: TLV 2 ppm (3 mg/m^3). Highly toxic. Locally produces conjunctivitis, corneal burns, brownish skin discoloration, dermatitis, hives, pustulovesicular eruption. Inhalation produces rhinitis, smell loss, pharyngitis, laryngospasm, tracheitis, bronchitis, pulmonary edema, cough, chest constriction, difficult breathing, headdache, weakness, rapid heart beat, inflammation of stomach and intestine. Suspected lung carcinogen. Ingestion produces burning in mouth and esophagus, abdominal pain, dizziness, violent vomiting and diarrhea leading to collapse, unconsciousness, jaundice, albuminuria, hematuria, anuria, acidosis, convulsions.

HS: Protect containers from damage. Do not store near oxidizing or alkaline materials, indoor storage areas should have floors pitched toward a trapped drain, or storage should be in curbed retention areas. Store between 16 and 35°C in a well ventilated area away from flames. Storage areas should be provided with automatic sprinklers. Storage tanks should be grounded to discharge static. Wear chemical goggles, chemical cartridge respirator or airline mask, and rubber protective clothing.

FP: Fight fires using CO_2, dry chemical, foam, alcohol foam, or water spray extinguisher.

HP: Use adequate ventilation. Frequent medical examinations for signs of skin irritation. In case of contact, flush eyes with water, wash skin with soap and water. If swallowed, stomach wash with 1% ammonium carbonate, followed by saline catharsis.

SL: Absorb onto paper, evaporate in a hood, burn paper.

Glycerin

S: Glycerol, 1,2,3-propanetriol, trihydroxypropane

U: Nitroglycerine, glycerine mononitrate, dinitroglycerine, glycidol nitrate manufacture

CH: Flammable, may explode in the presence of a strong oxidizer such as dichromate, chlorate, or permanganate.

TH: Relatively nontoxic. Irritates eyes and respiratory tract, causes insommia, vomiting, nausea, diarrhea, fever, hemoglobinuria, convulsion, paralysis when swallowed.

HS: Keep container closed.

FP: Fight fires using water, dry chemical, alcohol foam, or CO_2 extinguisher.

HP: In case of contact irrigate eyes with water, wash skin with soap and water. Stomach wash if swallowed, followed by saline catharsis.

SL: Absorb on paper, evaporate in a hood, burn paper.

Hexamethylene Tetramine

S: HMTA, methylenamine, hexamine, urotropin, formamine, metramine

U: Hexamethylenetetramine dinitrate, RDX, HMX manufacture

CH: Flammable, moderate fire hazard

TH: Mildly toxic. Produces erythema, itching, scarlatiniform, vesicular lesions, diarrhea, albuminuria, hematuria.

HS: Wear safety goggles, rubber gloves, face protecting board, all purpose gas mask, overalls. May explode in contact with iodoform.

HP: Use adequate ventilation. In case of contact flush eyes with water, wash skin with soap and water. Stomach wash if swallowed, followed by saline catharsis.

SL: Cover spill with sodium bisulfite, wet, pour down drain with abundant water.

n-Hexanol

S: 1-hexyl alcohol, amylcarbinol, 1-hydroxyhexane

U: Nitrocellulose solvent

CH: Flammable

TH: Slightly toxic

HS: Protect containers from damage, store in a cool well ventilated place. Wear rubber gloves, protecting mask, all purpose gas mask.

FP: Fight fires using alcohol foam, dry chemical, or CO_2 extinguisher. Use water spray to keep containers cool.

HP: In case of contact flush eyes with water, wash skin with soap and water.

SL: Absorb on paper, evaporate in a hood, burn paper.

Sec-Hexyl Acetate

S: 1-methylpentyl acetate, 1,3-dimethylbutylacetate, methylbutylcarbinol acetate, 2-hexyl acetate, methylamyl acetate

U: Nitrocellulose solvent

CH: Flammable

TH: TLV 50 ppm (300 mg/m^3). Mild irritant.

HS: Store in a cool place away from sources of ignition. Wear rubber gloves, face shield, self contained respirator.

FP: Fight fires using foam, CO_2, or dry chemical extinguisher.

SL: Absorb on paper, evaporate in a hood, burn paper.

Hydrazine

S: Diamine

U: Azides manufacture

CH: Highly dangerous fire and explosion hazard. Flammable limits 4.7 to 100% in air. Ignites on contact with easily reduced substances such as mercury and copper oxides. Violently explodes when heated.

TH: TLV 1 ppm (1.3 mg/m^3). Highly toxic. Severely irritates skin and mucosa, produces conjunctivitis, corneal necrosis, eczema, blistering dermatitis, irritation of trachea, dizziness, appetite loss, weight loss, nausea, vomiting, liver and red blood cell damage. Suspected carcinogen of lung, nervous system, liver, kidney, hematopoietic organs, breast, subcutaneous tissue.

HS: Store in nitrogen filled closed containers protected from damage in an outdoor or detached location. If indoors, store in a standard flammable liquid storage room isolated from oxidizers such as metal oxides, peroxides, and acids. Water reservoir should be prepared in case of leakage. Keep away from ignition sources. Wear safety glasses, rubber gloves, shoes, and apron, plastic protective clothing, self contained breathing apparatus, body shield.

FP: In case of fire, flood with water. Dry chemical and CO_2 extinguisher may be used to put out the fire, but flooding is necessary to prevent reignition. Alcohol foam is effective on spill fires. In advanced or massive fires, firefighting should be done

from a safe distance or protected location because of extreme explosion hazard.

SL: Recover spilled hydrazine by aspiration. Neutralize in dilute sulfuric acid, pour down drain with abundant water.

Hydrochloric Acid

S: Hydrogen chloride

U: Fulminates manufacture

TH: TLV 5 ppm (7 mg/m^3). Produces conjuctivitis, corneal necrosis, skin irritation, rhinitis, nasoseptic performation, dental erosion, laryngitis, bronchitis, pneumonia, headache, palpitation, irritation of mouth, throat, gullet, stomach, nausea, vomiting, intestinal perforation, chills, fever, shock, kidney inflammation.

HS: Protect containers from damage. Store in a cool, well ventilated place away from oxidizing materials. Wear rubber gloves and self contained breathing apparatus. Ignites ethylene on contact.

HP: In case of contact wash eyes with water, skin with soap and water. If swallowed, give aluminum hydroxide gel or magnesia in large quantities, followed by milk or egg whites. Do not induce vomiting.

SL: Cover with sodium carbonate, add water, neutralize, and pour down drain with abundant water.

Isopropyl Acetate

S: Acetic acid, isopropyl ester

U: Nitrocellulose solvent

CH: Flammable and dangerous fire hazard

TH: TLV 2500 ppm (950 mg/m^3). Moderately toxic. Narcotic in high concentration. Irritates eyes, skin, mucosa. Prolonged exposure results in liver damage.

HS: Store in a standard combustible liquid storage room or cabinet. Wear rubber gloves, face shield, self contained breathing apparatus.

FP: Fight fires using foam, dry chemical or CO_2 extinguisher.

SL: Absorb on paper, evaporate in a hood, burn paper.

Lead

U: Preparation of lead picrate, azide, dinitroresorcinate (as lead nitrate)

TH: TLV 0.15 mg/m^3. Highly toxic suspected carcinogen of lungs and kiddneys, red blood cells become fragile and hemolyze with slight trauma. Tissue damage: lesions of kidneys, liver, male gonads, nervous system. Poisoning can be classified as: alimentary, neuromotor, or encephalic. Alimentary: abdominal discomfort or pain, occasional colic, constipation, diarrhea, appetite loss, metallic taste, nausea and vomiting, lassitude, insomnia, weakness, joint and muscle pain, irritability, headache, dizziness, pallor, lead line on gums, pyorrhea, loss of weight, abdominal tenderness, basophilic stippling, anemia, slight albuminurea, increased urinary excretion. Neuromuscular: weakness (wrist and hand), gastroenteric symptoms, severe joint and muscle pain, headache, dizziness, insomnia, rare paralysis. Encephalopathy: headache, dizziness, somnolescence,

insomnia, increased cerebrospinal pressure, excitation, confusion, mania, stupor regressing to coma (with or without convulsion) often terminating in death. Begins abruptly, characterized by signs of cerebral and meningeal involvement.

HS: Strict control of atmospheric concentation in work area is vital. Use wet method for dust control. Wear mechanical filter respirator

HP: Use adequate ventilation. No smoking or eating in work area. Medical check for exposure (lead in blood and urine) no less frequently than 3 months. Persons with above acceptable levels must end exposure immediately. In case of large exposure contact physician immediately. If swallowed give magnesium sulfate (epsom salts) or sodium sulfate, induce vomiting, then give egg whites mixed with water or milk. There is no known first aid for lead poisoning.

Magnesium

U: Explosives

CH: Powder, thin sheets, chips, turnings are easily ignited and burn with intense heat. Powder forms exposive mixture in air. Finely divided powder may explode on contact with water, oxidizing materials, halogens, and acids.

TH: Irritates mucosa resulting in chronic atrophic nasopharyngitis. Small particles embedded in body tissue liberate hydrogen and produce swelling, vesiculation, necrosis, and ulceration. Inhalation may cause "metal fume fever".

HS: Protect containers from damage. Store powder, chips or shavings in a detached, fire resistant building away from moisture, halogens, acids, or sources of ignition. Wear mechanical respirator.

FP Do not use water, foam, CO_2 or CCl_4 extinguisher. Smother fire with dry graphite or similar dry powder (talc, G-1). Eye damage can result from viewing magnesium fires. Protect eyes and skin from flying particles.

HP: Thoroughly cleanse all wounds.

Magnesium Nitrate

S: Magnesium nitrate hexahydrate

U: Nitrocellulose manufacture

CH: May explode on contact with oxidizable material

TH: Moderately toxic

HS: Protect containers from damage. Store in a cool dry place in a tightly sealed condition. Wooden floor is not acceptable. Do not store near oxidizable materials. Wear rubber gloves, self contained breathing apparatus.

FP: Use abundant water in early state of fire.

SL: Dilute with water, add soda ash, neutralize with HCL, pour down drain with abundant water.

Mercury

S: Quicksilver

U: Picrates, fulminates manufacture

TH: TLV 0.05 mg/m^3. Acute symptoms include burning in mouth and throat, excessive salivation, metallic taste, thirst, shock, cardiac arrhythmias, nausea, vomiting, abdominal pain and cramps, bloody diarrhea, oliguria, hematuria, albuminuria, casts, difficult breathing, cough, fever, restlessness, bronchitis, inflamed lungs. Chronic symptoms include headache, dizziness, constriction of blood vessel disturgance, restlessness, insomnia, irritability, peripheral nerve inflammation, ineffective muscle control, increase in deep-tendon reflex, tremors, increased salivation, gum inflammation with blue line, stomatitis, appetite loss, nausea, vomiting, diarrhea, liver damage, proteinuria, hematuria, anuria, inflammation of the nose, smell loss, cough, fever, mercurialentis (mercuy deposit on anterior and posterior eye lens), constriction of visual fields, blind spots, erythemous papular and vesicular skin lesions.

HS: Keep containers closed. Cover surface of mercury with water to prevent evaporation. Maintain good ventilation.

HP: Maintain meticulous housekeeping and clean up all spills immediately. Sample air frequently. No eating or smoking in work area. Protective clothing with special lockers and bathing facilities. Physical exams of exposed persons at intervals determined by degree of exposure, including mercury in urine, and neurological dysfunction. Persons with kidney, liver, lung or nerve disease should not be exposed. In case of ingestion, flush stomach with 5% sodium formaldehyde sulfoxylate solution, followed by 2% sodium carbonate, finally leaving 250 ml sodium formaldehyde sulfoxylate.

SL: Collect spilled mercury in an aspirator. Cover small amount in in accessible places with calcium polysulfide and excess sulfur.

Methanol

S: Methyl alcohol, wood spirts, wood alcohol, methyl hydroxide

U: Methyl nitrate manufacture

CH: Flammable

TH: TLV 200 ppm (260 mg/m^3). Produces eczyematoid dermatitis, conjunctivitis, euphoria, muscular incoordination, headache, dizziness, nausea, vomiting, cramps, sweating, weakness, tracheitis, bronchitis, narcosis, delirium, coma, respiratory failure, cyanosis, cardiac depression, peripheral neuritis, acidosis, albuminuria, convulsions, constriction of visual fields, decreased visual acuity, dilated and unresponsive pupils, eye pain, photophobia, blindness.

HS: Store in a well ventilated place away from sources of ignition. Large volumes should be stored away from inhabited buildings and structures. Wear chemical goggles or face shield, chemical cartridge respirator, rubber gloves, apron, and boots.

FP: Fight fires using dry chemical, alcohol foam, or CO_2 extinguisher. Use water spray to keep containers cool.

HP: Use adequate ventilation. Medical examination every six months including CNS, vision, kidney, and liver function. If swallowed, stomach wash followed by saline catharsis. Then give 2 tablespoons sodium bicarbonate in water. Persons with diseases of the eye, liver, kidney, or lungs should not be exposed. In case of contact flush eyes with water, wash skin with soap and water. If swallowed, stomach wash with 4% sodium bicarbonate.

SL: Absorb on paper, evaporate in a hood, burn paper.

Methyl Acetate

S: Acetic acid methyl ester

U: Nitrocellulose solvent

CH: Dangerous fire hazard

TH: TLV 200 ppm (610 mg/m^3). Respiratory irritant, narcotic. Produces conjunctivitis, "Polisher's keratitis", headache, dizziness, difficult breathing, pain in side, palpitation, weakness, poor vision, paralysis.

HS: Store in a cool, well ventilated place away from sources of ignition. Wear rubber gloves, face shield, general purpose respirator.

FP: Fight fires using CO_2, dry chemical, or alcohol foam extinguisher. Use water spray to keep containers cool.

HP: Use adequate ventilation. In case of contact flush eyes with water. If swallowed, stomach wash with 4% sodium carbonate followed by saline catharsis.

SL: Absorb on paper, evaporate in a hood, burn paper.

Methyl Cellosolve Acetate

S: Ethylene glycol monomethyl ether acetate

U: Solvent for nitroglycerine

CH: Moderate fire hazard

TH: TLV 25 ppm (120 mg/m^3). Causes eye and respiratory irritation, headache, dizziness, fatigue, nausea, vomiting, delirium, ataxia.

HP: Protect containers from damage. Store in a cool, well ventilated place away from oxidizers or sources of flame. Outdoor or detached storage preferred. If stored indoors, store in a standard flammable liquid storage room. Wear safety glasses and a gas mask.

FP: Fight fires using powder, alcohol foam, CO_2, or dry chemical extinguisher. Use water spray to keep containers cool.

HP: Use adequate ventilation. Annual medical checkup should include complete blood inspection. Persons with blood disorders should not be exposed. In case of contact flush eyes with water, wash skin with soap and water.

SL: Absorb spills on paper, evaporate in a hood, burn paper.

Nitric Acid

S: Aqua fortis, engraver's acid, azotic acid

U: Nitrobenzene, TNT, DNT, picrate, hexyl, nitroglycerine, glycerine mononitrate, glycidol nitrate, dinitroglycerine, chlorohydrin dinitiate, nitrodiglycerine, nitroglycol, diethylene glycol dinitate, methyl nitrate, ethyl nitrate, pentaerythritol tetranitrate (PETN), nitrocellulose, hexamethylenetetramine dinitrate, ethylene dinitramine, tetryl, RDX, HMX, fulminates manufacture

CH: Noncombustible but dangerously reactive with many materials. Reacts explosively with metallic powders, carbides, hydrogen sulfide and turpentine. Increases flammability of combustible, organic and readily oxidizable materials; can cause spontaneous ignition of some materials.

TH: TLV 2 ppm (5 mg/m^3). Conjunctivitis, corneal ulcer, yellow discoloration of skin, severe burns with necrosis, dental erosion, cough, sneeze, chest pain, bronchitis, bronchopneumonia, yellow discoloration of teeth, mouth, and throat; stomachache, nausea, vomiting blood, oliguria, anuria, albuminuria, casts, circulatory collapse.

HS: Protect containers against physical damage. Keep separate from metallic powders, carbides, hydrogen sulfide, turpentine, organic acids, and all combustible, organic or other readily oxidizable materials. Provide good ventilation and avoid direct sunlight. Wear rubber gloves, self contained breathing apparatus. Body protective shield should be ready at any time. May ignite or explode on contact with nitric acid and the following: alcohol, acetylene, ammonia, amines, NO_2, sugars, turpentine, oil, paper, wood, cloth, thiophene, HI, H_2S, H_3P, H_2Se, organics, flammable materials.

HP: Requires proper ventilation and clothing for protection. Those suffering from diseases of lungs and kidney should avoid contact. In case of contact fully rinse eyes with water. Polluted bodily portions should be fully washed by 5% solution of sodium bicarbonate, or soap and water. Burns should be treated with a cloth immersed in a saturated solution of potassium thiosulfate. If swallowed, orally administer calcium hydroxide, aluminium hydroxide, or magnesium oxide (alkalis that might generate carbon dioxide inviting the perforation of intestines should be avoided).

SL: Cover with sodium carbonate or an equal mixture of soda ash and slaked lime. After mixing, add water to form a slurry.

Nitric Oxide

S: Mononitrogen monoxide, nitrogen monoxide

U: Sodium methylene diisonitramine manufacture

CH: Noncombustible, but supports combustion

TH: TLV: 25 ppm (30 mg/m^3). Edema, a slight cough, fatigue, nausea, choking, headache, inability to breathe deeply, loss of appetite, constipation, general bodily weakness.

HS: Wear long rubber gloves, safety goggles, self-contained breathing apparatus.

HP: Adequate ventilation

SL: Flow into a mixed solution of caustic soda and slaked lime. Place cylinder in hood, dilute with water after leak stops, neutralize, pour down drain with abundant water.

Nitrogen Dioxide

S: Nitrogen peroxide, dinitrogen tetroxide

U: Nitrocellulose manufacture

CH: Noncombustible, but extremely strong oxidizing agent. May cause fire in contact with clothing and other combustible materials.

TH: TLV: 5 ppm (9 mg/m^3). Local: conjunctivitis, edema of eyelids, corneal ulceration, yellow-brown discoloration of the skin, hair and teeth, irritation of skin. Acute: (may be delayed for 24 hours). Respiratory: Chest pain, difficult breathing, cough with yellow sputum or blood, cyanosis, fever, asthmatic breathing, increased respiratory rate, tracheobronchitis, bronchopneumonia, pulmonary

edema. Central nervous system: headache, dizziness, weakness, defective control of muscles, delirium, unconsciousness, fits. Gastrointestinal: acid taste, nausea, vomiting, abdominal pain. Circulatory: increased pulse rate, decreased blood pressure, cardiac arrhythmias, collapse. Chronic inhalation: headache, insomnia, ulcers of nose and mouth, lack of appetite, indigestion, dental erosion, weakness, chronic bronchitis, emphysema.

HS: Protect containers against physical damage. Keep separate from combustible organic or other readily oxidizable materials. Transport facilities should be located outdoors. Since extremely corrosive when wet, proper materials for construction of the facilities are necessary. May ignite or explode on contact with combustible materials (potasium, phosphorus, sulfur, carbon, etc.), organic materials (hydrocarbons, etc.). Wear chemical goggles, gas mask or airline respirator, rubber gloves and protective clothing.

HP: No silo should be entered for 7 days after filling. Physical examinations of exposed personnel annually, with special attention to teeth and respiratory tract, including chest x-ray. Preclude from exposure those individuals with cardiac and pulmonary diseases. In case of contact irrigate eyes with water, wash contaminated areas of body with soap and water. Hospitalize exposed individual and observe vital signs carefully, and at hourly intervals. Absolute rest will be necessary.

FP: Use water to keep fire exposed containers cool. If it is necessary to stop the flow of gas, use water spray to direct escaping gas away from persons effecting the shut-off.

SL: Cover with sodium bicarbonate or an 1:1 mixture of soda ash and slaked lime. After mixing, spray with water from an atomizer with great precaution. Transfer slowly into a large container of water. Neutralize and drain into a sewer with sufficient water.

Nitrous Oxide

S: Laughing gas, dinitrogen monoxide, hyponitrous acid, anhydride, factitious gas

U: Azides manufacture

CH: Supports combustion

TH: Anesthetic, low toxicity

HS: Store away from sources of ignition or heat. Keep away from explosives, poisons, radioactive materials, organic peroxides, hydrogen. Wear rubber gloves, safety glasses, self contained breathing apparatus.

SL: Flow leakage into a solution of caustic soda and slaked lime.

Oleum*

S: Fuming sulfuric acid

U: (See Sulfuric Acid)

CH: Very reactive oxidizing agent. Can react on contact with powdered combustible materials. Reacts violently with water and organic materials. Extremely hazardous in contact with many materials, especially carbides, chlorates, fulminates, nitrates, picrates, metal powders.

TH: (See Sulfuric Acid)

HS: Protect container from damage and water. Wear rubber gloves, body shield, self contained breathing apparatus, coveralls.

FP: Smother fires with dry chemical. Use water with utmost caution due to evolution of heat, and splattering.

HP: Use adequate ventilation. Persons with pulmonary disease should not be exposed. In case of contact wash eyes with water, skin with soap and water. If swallowed, give alumnumn hydroxide gel or magnesia in large amounts. Do not induce vomiting.

SL: Cover with sodium carbonate.
* See Sulfuric Acid for additional information.

Perchloric Acid

S: Dioxinium perchlorate, hydronium perchlorate, hydrogen perchlorate

U: Perchlorate explosives manufacture

CH: 60 to 72% perchloric acid solutions may explode on contact with organics. Strong dehydrating agents may convert the acid to the unstable anhydride.

TH: Irritates eyes, respiratory tract, burns skin, GI tract, cornea, cough, nausea, vomiting, chronic skin rash if sensitized.

HS: Store away from all flammable and combustible materials, organic materials, strong dehydrating agents, oxidizing and reducing agents. Storage room should have no flammable material, including shelves and flooring. Strong containers with enough inert organic material to absorb leakage. Protect containers against damage and freezing. Electrical equipment and wiring in the area must be of the water tight type. Wear rubber gloves, chemical goggles.

FP: In case of fire assume organic materials are involved and may be

explosive. Fight fire with water spray but use caution in approaching.

HP: Remove sensitized persons from exposure. Provide adequate ventilation. Medical checkup annually. In case of contact wash eyes with water, skin with soap and water. If swallowed, give aluminum hydroxide gel or magnesia in large amounts. Do not induce vomiting.

SL: In case of spills, cover with weak reducing agent (e. g., sodium thiosulfate, or bisulfites or ferrous salts in dilute H_2SO_4). Transfer to water, neutralize, flush down drain with abundant water. Pass gas leakages through a sodium bisulfite/sodium bicarbonate solution.

Phenanthrene

U: Explosives manufacture

CH: Slightly flammable

TH: Photosensititizes skin, carcinogenic

HS: Wear rubber gloves, face shield, all purpose cannister mask, coveralls.

Phenol

S: Carbolic acid, hydroxybenzene, phenilic acid, phenyl hydroxide

U: Picrates manufacture

CH: Highly flammable, forms explosive mixtures with air

TH: TLV 5 ppm ($19mg/m^3$). Local: produces conjunctival burns, corneal necrosis, severe skin burns. Gastrointestinal: burns mouth, pharynx, gastrointestinal tract, performation of intestinal tract is possible, nausea, vomiting, abdominal pain, jaundice, difficult breathing, cough, cyanosis, pulmonary edema. CNS: headache, dizziness, visual disturbances, weakness, sweating, tremors and convulsions, unconsciousness. Genitourinary: oliguria, anuria, albuminuria, casts, red and white blood cells in urine. Chronic: headache, cough, fatigue and weakness, anorexia (lack of appetite), nausea, vomiting, insommia, nervousness, loss of weight, pallor, partial paralysis, ochronosis, albuminuria.

HS: Protect against physical damage. Store in cool, dry, well-ventilated location, away from any areas where the fire hazard may be acute. Outdoor or detached storage is preferred. Wear chemical goggles, self contained breathing apparatus, rubber gloves, aprons, boots.

HP: Adequate ventilation. Physical examinations of exposed personnel annually, including studies of liver and kidney function. Preclude from exposure those individuals with diseases of central nervous system, liver kidney and lungs. In case of contact irrigate eyes with water, wash contaminated areas of body with soap and water. Stomach wash with salt water if swallowed, followed by saline catharsis and introduction of demulcents (protective agents for irritations) before the tube is withdrawn. Do not give oils or alcohol.

FP: Fight fires using water spray, carbon dioxide, dry chemical, or foam.

SL: By forced ventilation, maintain concentration of vapor below the range of explosive mixture.

Phosphoric Acid

U: Nitrocellulose manufacture

TH: TLV 1 mg/m^3. Produces conjunctivitis, burns, irritates trachea, nausea, vomiting, stomachache, diarrhea, acid intoxication, shock.

HS: Wear rubber gloves, self contained breathing apparatus, totally sealed coveralls.

HP: Use proper ventilation. Persons with pulmonary disease should not be exposed. In case of contact wash eyes with water, skin with soap and water. If swallowed, give large amounts of aluminum hydroxide gel or magnesia. Do not induce vomiting.

SL: Cover spills with sodium carbonate.

Phosphorus Pentoxide

S: Phosphoric anhydride, diphosphorus pentoxide

U: Nitrocellulose manufacture

TH: Highly caustic. Corrodes mucosa, severe local irritation.

HS: Wear rubber gloves, body shield, self contained breathing apparatus, overalls.

SL: Cover spills with sodium carbonate.

Picramic Acid

S: Picraminic acid, dinitroaminophenol

U: DDNP, DINOL manufacture

CH: Explosive

TH: Produces liver damage, induced fever, metabolic stimulation. Highly toxic. Skin irritant, produces dermatitis.

Picric Acid

S: Trinitrophenol, picronitric acid, carbazotil acid

U: Picrates manufacture

CH: Highly flammable. Forms explosive compounds with metals.

TH: TLV 0.1 mg/m^3. Produces conjunctivitis, corneal ulcers with yellow tissue discoloration, erythema, papulo-vesicular eruption of skin followed by peeling. Yellow staining of skin, irritation and bleeding of nose, bronchitis, headache, dizziness, nausea, vomiting, epigastric pain, diarrhea, jaundice, albuminuria, casts, anuria, anemia, weakness, fever, muscle pain, unconsciousness.

HS: Protect containers against damage, store in permanent magazine, do not store near lime or organic materials. Wear butyl rubber gloves, protective boots, chemical goggles, self contained breathing apparatus.

FP: Operate fire fighting from an explosion safe location. Use water spray. In advanced or massive fires evacuate area. Keep exposed containers cool.

HP: Persons with liver, kidney, or blood disease should not be exposed. In case of contact wash eyes with water, skin with alcohol, then soap

and water. Wash stomach with 5% sodium bicarbonate, then saline catharsis.

Potassium Chlorate

S: Potcrate.

U: Explosives

CH: Powerful oxidizing material. Forms explosive mixtures with combustible, organic or other easily oxidizable materials. These mixtures are easily ignited by friction or heat.

TH: Nausea, vomiting, abdominal pain, diarrhea, hypotension, abnormally slow pulse, cyanosis, hepatomegaly, jaundice, oliguria, anuria, hemoglobinuria; albumin, red blood cells and casts in a dark brown urine, fits.

HS: Protect containers against damage. Keep separate from combustible, organic or other readily oxidizable materials, acids, ammonium salts, sulfur and flammable vapors. Avoid storage on wood floors. Immediately remove and dispose of any spilled chlorate. Wear rubber gloves, face shield and coverall. May ignite or explode on contact with sulfur, carbon disulfide, organic sulfur, sulfides, red phosphorus, ammonium rhodanate, ammonium rhodanate + copper + alcohol, hydrazine, hydroxylamine, zinc chloride, sugar + ferricyanides, sodium hyposulfite, combustible powders, amines.

HP: Encourage personal cleanliness. Stomach wash if swallowed, followed by saline catharsis.

FP: Flood fire with water.

SL: Cover with weak reducing agent (e.g., sodium thiocyanate, or bisulfites or ferrous salts in dilute sulfuric acid) pour into water, neutralize, pour down drain with abundant water.

Potassium Hydroxide

S: Caustic potash, potassium hydrate

U: Glycerine mononitrate, glycidol nitrate manufacture

TH: Conjunctivitis, corneal burns, deep skin burns, irritation of respiratory tract, inflammation of the lungs, burning in mouth and esophagus, nausea, vomiting, adbominal pain, diarrhea, edema of larynx and subsequent suffocation, mediastinitis, perforation of gastrointestinal tract, cardiovascular collapse, coma.

HS: Store in dry place to prevent corrosion of surface of the drum, absorption of moisture, freezing, etc. For outdoor storage in liquid state, it is advisable to protect with some insulation and heating systems. Wear rubber gloves, big face shield.

HP: In case of contact irrigate eyes with water, wash skin with soap and water. Treat skin burns as usual. If swallowed give large amounts of 1% acetic acid, 1:4 vinegar:water, 1% citric acid, or lemon juice. Do not induce vomiting.

SL: Collect and remove with a broom in a large bucket. Dilute with water and neutralize with dilute HCL. Drain into a sewer with sufficient water.

Potassium Nitrate

S: Saltpeter, niter

U: Nitrocellulose, gunpowder manufacture

TH: Nausea, diarrhea, diuresis, muscular debility, collapse

HS: Avoid contacts with organics, store in a dry place. Also, never put together with inflammable powders or acids. Wear rubber gloves, safety glasses, protective work gowns. May explode on contact with sodium acetate + tartarates, oxalates + citrates, sodium phosphite, sodium hyposulfite, tin, solder, stannates, lead phosphite, lead nitrite.

FP: Use abundant amount of water in early stages of fire. When large quantities are involved in fire, nitrate may fuse or melt. In such condition, application of water may result in extensive scattering of molten material.

SL: Sweep into a beaker. Dilute with sufficient water. Add soda ash. Mix and neutralize with dilute HCl. Drain into the sewer with abundant water.

Potassium Perchlorate

S: Potassium hyperchlorate, peroidin

U: Explosives

CH: Powerful oxidizing material

TH: Irritates skin, eyes, throat and nose. Liberates toxic gases when involved in fire.

HS: Protect against physical damage. Keep away from organic, combustible, readily oxidizable materials, sulfur, aluminium and magnesium. Immediately remove and carefully dispose of any spills. May explode or ignite on contact with hydrazine or the hydrate, hydroxylamine or the salts, combustible materials, organic materials, metallic powders, strong oxiding agent, oxides, arsenic, antimony.

FP: Flood with water. Wear self-contained breathing apparatus.

SL: Cover with weak reducing agents such as sodium thiosulfate, or bisulfites or ferrous salts in dilute sulfuric acid. Transfer to a large container of water and neutralize. Drain into a sewer with abundant water.

Potassium Sulfate

U: Nitrocellulose manufacture

CH: Nonflammable

TH: May cause skin irritation. Strong systemic effects on ingestion.

Resorcinol

S: Resorcin, m-dihydroxybenzene.

U: Lead dinitroresorcinate manufacture

CH: Flammable, forms explosive mixture with air.

TH: Produces skin irritation, conjunctivitis, dermatitis, dizziness, restlessness, palpitation, short breath, drowsiness, profuse sweating, cyanosis, hepatomegaly, juandice, splenomegaly, unconsciouness,

fits, hyperemia, enlargement of regional lymph glands, methemoglobinemia, dyspnea.

HS: Keep away from flame, wear rubber gloves, general purpose breathing apparatus, face shield.

FP: Fight fires using water, CO_2, or dry chemical extinguisher.

TP: Use adequate ventilation. In case of contact wash eyes with water, skin with soap and water, followed by alcohol. Stomach wash, if swallowed, followed by saline catharsis. Do not give oils or alcohol.

SL: Collect onto paper sheet. Burn in a hood

Silver

U: Silver azide manufacture

CH: Flammable dust

TH: TLV 0.01 mg/m^3. Highly toxic. Produces argyria (blue tint of skin, conjunctivae, mucosa), permanent deposits in blood vessel walls, kidneys, testes, pituitary, choroid plexus, nasal mucosa, maxillary antra, trachea, and bronchi. Also produces local argyria.

HS: Wear gloves, safety goggles, coveralls.

HP: Adequate ventilation. No eating or smoking in work area.

Sodium

S: Sodium metal

U: Azides, sodium methylenediisonitramine manufacture

CH: Extremely dangerous in contact with water. Releases hydrogen with sufficient heat to cause explosion or ignition. Ignites spontaneously on contact with air. Burns with explosive spattering.

TH: Severe skin and eye burns. Fumes from burning sodium are highly irritating to skin, eyes, mucosa.

HS: Store away from water or places water may be needed to combat fires. Avoid high temperatures. Store under nitrogen or kerosene. Never store under halogenated hydrocarbons. Large quantities should be stored in isolated fire resistant buildings constructed so that rain or ground water cannot enter. Drums should be stored in a dry place without automatic sprinklers, and water or steam piping must be avoided. Wear leather gloves, face shield, rubber apron, rubber boots.

FP: In case of fire cover flames with graphite, soda ash, powdered sodium chloride or appropriate dry powder. Do not use water, bicarbonate, CO_2, soda acid, or halogenated hydrocarbon extinguishers.

TP: In case of contact wash eyes and skin with water.

SL: Mix with dry sodium carbonate, scatter into a steel pan in a remote outdoor area, cover with scrap wood or paper and burn.

Sodium Bisulfate

S: Sodium acid sulfate, niter cake, sodium hydrogen sulfate, sodium pyrosulfate

U: Nitrocellulose manufacture

CH: Nonflammable

TH: Strongly acidic, irritating (See Sulfuric Acid)

HS: Keep containers tightly closed. Wear rubber gloves, safety glasses.

SL: Sweep into beaker, dilute with water, add soda ash, mix, neutralize, flush down drain with abundant water.

Sodium Carbonate

S: Soda ash, crystal carbonate

U: Hexyl manufacture

CH: Nonflammable

TH: Eye and respiratory irritant, perforates nasal septum, soda ulcers, nausea, vomiting, diarrhea.

SH: Keep containers thightly closed. Wear rubber gloves, safety glasses.

HP: In case of contact wash eyes with water, skin with soap and water. If swallowed, give 1% acetic acid, 1:4 vinegar:water, 1% citric acid, or lemon juice. Do not induce vomiting.

Sodium Chlorate

U: Explosives

CH: Powerful oxidizing material. When involved in fire, containers may be ruptured, followed by evolution of oxygen which supports burning, and fumes of highly toxic ClO_2.

TH: Conjunctivitis, irritation to skin, nausea, vomiting, abdominal pain, diarrhea, cyanosis, albuminuria, anuria, hematuria.

HS: Keep away from any source of ignition, and protect against heat, friction, percussion, and physical damage. May combine explosively with ammonia, antimony sulfide, carbon disulfide, sulfur, sulfides, red phosphorus, hydrazine, hydroxylamine, zinc chloride, sodium hypochlorite, amines. May ignite or evolve ClO_2 on contact with conc H_2SO_4 or conc HNO_3. Wear chemical goggles, rubber gloves, a self contained breathing apparatus and full protective shield.

HP: Extreme cleanliness of the environment and body. In case of contact irrigate eyes with water, wash contaminated areas of body with soap and water. Stomach wash, if swallowed, followed by saline catharsis.

FP: Firefighting should be done from a safe distance with massive amounts of water.

SL: Cover with weak reducing agents such as sodium thiosulfate, or bisulfites or ferrous salts in dilute H_2SO_4. Transfer the slurry into a large container of water and neutralize. Drain into a sewer with abundant water.

Sodium Hydroxide

S: Caustic soda, sodium hydrate, white caustic

U: Nitrobenzenes manufacture

CH: Not combustible. Contact with water may generate enough heat to ignite combustibles. Contact with some metals can generate hydrogen.

TH: TLV 2.0 mg/m^3. Produces conjunctivitis, corneal and deep skin burns, respiratory irritation, lung inflammation, burning in mouth and esophagus, nausea, vomiting, hematemisis, abdominal pain, diarrhea, swelling of larynx and subsequent suffocation, mediastinitis, perforation of GI tract, cardiovascular collapse, coma.

HS: Protect containers from damage or moisture. Store in a dry place away from acids, metals, explosives, organic peroxides, and easily ignitible materials. Wear chemical goggles or full face sheild, mechanical filter respirator, rubber gloves, apron, and boots.

HP: In case of contact wash eyes with water, skin with soap and water. Give 1% acetic acid, 1:4 vinegar:water, 1% citric acid, or lemon juice if swallowed. Do not induce vomiting.

SL: Sweep into bucket, add water, neutralize, pour down drain with abundant water.

Sodium Nitrate

S: Chile saltpeter, cuban niter, natratine, soda niter

U: Nitrocellulose manufacture

CH: Strong oxidizing material. If sodium nitrate is in contact with easily oxidizable substances, violent combustion or explosion may result upon ignition from any source. Increases the flammability of any combustible substance.

TH: Excitement, convulsion, paralysis, diuresis, cyanosis.

HS: Protect against physical damage. Store in dry and cool place away from inflammable organics or easily oxidizable substances. Wooden floors are not acceptable. Wear rubber gloves, safety glasses.

HP: Preclude from exposure those individuals with diseases of kidney and lungs.

FP: Use abundant amount of water in early stages of fire. When large quantities are involved in fire, nitrate may fuse or melt. Under such conditions, application of water may result in extensive scattering of molten material.

SL: Sweep into a beaker. Dilute with sufficient water. Add soda ash. Mix and neutralize. Drain into the sewer with abundant water.

Sodium Nitrite

S: Erinitrit

U: Azides manufacture

CH: Explodes when heated up to 538°C.

TH: TDL oral Human LDL_o 3 mg/kg

HS: Protect containers against physical damage. Outdoor or detached storage is preferred. For indoor storage, an incombustible area should be used. Avoid storage on wooden floor. Wear rubber gloves, safety glasses, coveralls. If working in draft is impossible, wear a gas mask. May react explosively with hydrazine and its hydrates, ammonium halides, ammonium salts, thiocyanates, potassium cyanate, ferricyanides, combustible materials.

HP In case of contact irrigate eyes with water, wash skin with soap and water. Stomach wash, if swallowed, followed by saline catharsis.

FP Spray water when fire is in an early stage or still small. When

large quantities are involved in fires, nitrite may fuse or melt. Under such conditions, application of water may cause extensive scattering of molten material.

SL: Cover with soda ash or sodium bicarbonate. Put in a large beaker, add equal volume of calcium hypochlorite (caution!) Add additional water, and stir. After one hour, dilute further and neutralize. Drain into the sewer with abundant water.

Sodium Perchlorate

U: Explosives

CH: Powerful oxidizer. Readily combustible when mixed with organic materials.

TH: Irritant to skin, eyes, nose, throat.

HS: Keep container closed and protect against damage. Store away from heat, flames, organic or combustible or easily oxidizable material. Immediately clear up spill. (See Potassium Chlorate).

FP: Flood area with water. Wear goggles and self contained breathing apparatus.

HP: In case of contact, irrigate eyes for at least 15 minutes, and consult opthomologist. Wash skin with abundant water.

SL: Cover with weak reducing agents (e. g., sodium thiosulfate, or bisulfites or ferrous salts in dilute sulfuric acid), transfer to a large container of water, neutralize, pour down drain with abundant water.

Sodium Sulfate

U: Nitrocellulose manufacture

CH: Nonflammable

TH: Moderately toxic, caustic

Sodium thiosulfate

S: Sodium hyposulfite, HYPO

U: Nitrobenzenes, picryl sulfide manufacture

TH: Slightly toxic, large quantities may cause diarrhea.

HS: Protect containers from damage. Wear rubber gloves, safety glasses, coveralls.

HP: In case of exposure wash eyes with water, skin with soap and water.

SL: Cover with sodium carbonate or bicarbonate, sweep into large beaker, add water and an equal volume of calcium hypochlorite (caution!) with stirring. After an hour dilute, neturalize, and pour down drain with abundant water.

Starch

U: Nitrostarch manufacture

CH: Dust may be explosive

TH: Causes allergic reactions in some persons. Inhalation can cause irritation.

Styphnic Acid

S: Trinitroresorcinol

U: Styphnates manufacture

CH: Highly explosive

TH: Toxicity unknown. Assumed to be similar to other aromatic nitro compounds.

Sulfur

U: Gunpowder manufacture

CH: Easily ignitible and combustible. Forms explosive mixture with oxidizing agents.

TH: Conjunctivitis, skin inflammation, respiratory irritation

HS: Store in cool, well ventilated room away from chlorates or other oxidizers. Guard against dust aspiration or accumulation. Wear safety goggles, mask, and self contained breathing apparatus.

FP: Fight fires using water spray. Avoid scattering molten sulfur.

HP In case of contact wash eyes with water, skin with soap and water.

Sulfuric Acid

U: Nitrobenzenes, TNT, DNT, picrates, hexyl, nitroglycerine, glycerine mononitrate, glycidol nitrate, chlorohydrin dinitrate, nitrodiglycerine, chlorohydrin dinitrate, nitroglycol, diethylene glycol dinitrate, nitrocellulose, tetryl, RDX, HMX manufacture.

CH: Not flammable but highly reactive and capable of igniting finely divided combustible materials on contact. Reacts violently with water and organic materials with evolution of heat. Extremely hazardous in contact with many materials. Attacks and corrodes many metals by releasing hydrogen.

TH: TLV: 1 mg/m^3. Produces conjunctivitis, corneal necrosis, dermatitis, skin burns, ulceration, irritation of nose and throat, laryngeal edema, bronchitis, pneumonitis, pulmonary edema, dental erosion, shock, anuria, burning in mouth and throat and abdomen, nausea, vomiting of blood and eroded tissue, perforation of gastrointestinal tract, albuminuria, blood and casts in urine.

HS: Protect containers against physical damage and prevent contact with water. Keep separate from carbides, chlorates, fulminates, nitrates, picrates, powdered metal and combustible materials. Wear rubber gloves, chemical goggles, rubber boots and chemical cartridge respirator.

HP: Adequate ventilation. Preclude from exposure those individuals with pulmonary diseases. In case of contact irrigate eyes with water, wash skin with soap and water. If swallowed give aluminum hydroxide gel or magnesia. Do not induce vomiting.

FP: Fire involving small amount of combustibles may be smothered with suitable dry chemical. Use water on combustibles burning in vicinity of this material but use care, as water applied directly to this acid results in evolution of heat and causes splattering.

SL: Cover with sodium carbonate.

Toluene

S: Toluol, methylbenzene, phenylmethane, methacide

U: TNT, DNT manufacture

CH: Flammable. May travel considerable distance to a source of ignition and flash back.

TH: TLV 200 ppm (375 mg/m^3). Dermatitis, bronchitis, pneumonitis, loss of appetite, nausea, vomiting, hepatomegaly, fatigue, weakness, headache, dizziness, incoordination, irritability, partial paralysis, narcosis, conjunctivitis, corneal burns, "Polisher's keratitis" fine vacuolar lesions of cornea.

HS: Protect containers against physical damage. Outdoors or detached or isolated storage is preferable. Indoor storage should be in a standard flammable liquid storage room. Wear chemical goggles, chemical cartridge respirator or self contained breathing apparatus, rubber gloves.

HP: Physical examination of exposed personnel annually, with special attention to eyes and nervous system, and including complete blood count and studies of liver function. Preclude from exposure those individuals with diseases of central nervous system and liver. In case of contact irrigate eyes with water, wash skin with soap and water. An exposed person should be removed immediately to fresh air and kept warm and quiet. If breathing has stopped, artificial respiration should be commenced.

FP: Fight fires using water spray, carbon dioxide, dry chemical, or foam extinguisher.

SL: Absorbed on paper, evaporate in a hood, burn paper.

Tricresyl phosphate

S: TCP, tritolyl phosphate

U: Nitrocellulose plasticizer

CH: Flammable

TH: TLV 0.1 mg/m^3. Nausea, vomiting, abdominal pain, diarrhea. After from 3-28 days, nontender enlargement of parotid glands, cold and sweaty hands and legs, pain and cramping of hands and legs, paraesthesias of extremities, muscular tremor, symmetrical polyneuritis.

HS: Wear safety glasses, gas mask, long sleeve coveralls with tight collar and cuffs, gloves, boots.

HP: Deep breathing after work shift. Weekly cholinesterase determination. Persons with CNS disease should not be exposed. If swallowed, stomach wash followed by saline catharsis. Do not give oils or alcohol.

SL: Absorb with paper, place in plastic bags, burn in furnace or open area.

Triethylene glycol

S: TEG

U: Nitrocellulose solvent

CH: Flammable, forms explosive mixture with air.

HS: Wear rubber gloves, face shield, overalls, gas mask.

FP: Fight fires using water spray, dry chemical, alcohol foam or CO_2 extinguisher. Keep containers cool with water spray.

SL: Absorb on paper, evaporate in a hood, burn paper.

Urea

S: Carbamide

U: Urea nitrate manufacture

TH: Non toxic

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APPENDIX B

American Table of Distances

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TABLE B-1 - QUANTITY-DISTANCE -
INTRALINE SEPARATIONS

Pounds of Explosives		Distance in Feet		Pounds of Explosives		Distance in Feet	
(Over)	(Not Over)	Bar.	Unbar.	(Over)	(Not Over)	Bar.	Unbar.
0	50	30	40	35,000	40,000	310	620
50	100	40	80	40,000	45,000	320	640
100	200	50	100	45,000	50,000	330	660
200	300	60	120	50,000	55,000	340	680
300	400	65	130	55,000	60,000	350	700
400	500	70	140	60,000	65,000	360	720
500	600	75	150	65,000	70,000	370	740
600	700	80	160	70,000	75,000	385	770
700	800	85	170	75,000	80,000	390	780
800	900	90	180	80,000	85,000	395	790
900	1,000	95	190	85,000	90,000	400	800
1,000	1,500	105	210	90,000	95,000	410	820
1,500	2,000	115	230	95,000	100,000	415	830
2,000	3,000	130	260	100,000	125,000	450	900
3,000	4,000	140	280	125,000	150,000	475	950
4,000	5,000	150	300	150,000	175,000	500	1000
5,000	6,000	160	320	175,000	200,000	525	1050
6,000	7,000	170	340	200,000	225,000	550	1100
7,000	8,000	180	360	225,000	250,000	575	1150
8,000	9,000	190	380	250,000	275,000	585	1170
9,000	10,000	200	400	275,000	300,000	600	1200
10,000	15,000	225	450	300,000	325,000	620	1240
15,000	20,000	245	490	325,000	350,000	635	1270
20,000	25,000	265	530	350,000	375,000	650	1300
25,000	30,000	280	560	375,000	400,000	665	1330
30,000	35,000	295	590	400,000	500,000	715	1430

AMERICAN TABLE OF DISTANCES FOR STORAGE OF EXPLOSIVES

As Revised and Approved by The Institute of Makers of Explosives — November 5, 1971

QUANTITY OF EXPLOSIVES		DISTANCES IN FEET							
		Inhabited Buildings		Public Highways Class A to D		Passenger Railways — Public Highways with Traffic Volume of more than 3,000 Vehicles/Day		Separation of Magazines	
Pounds Over	Pounds 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	39	78
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	58	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	68	136
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	1,835	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	1,965	2,000	590	1,180	1,662	2,000	255	510
170,000	180,000	1,990	2,000	600	1,200	1,695	2,000	265	530
180,000	190,000	2,010	2,010	605	1,210	1,725	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

EXPLANATORY NOTES ESSENTIAL TO THE APPLICATION OF THE AMERICAN TABLE OF DISTANCES FOR STORAGE OF EXPLOSIVES

NOTE 1 — "Explosive materials" means explosives, blasting agents, and detonators.

NOTE 2 — "Explosives" means any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion. A list of explosives determined to be within the coverage of "18 U.S.C. 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 Treasury.

NOTE 3 — "Blasting agents" means 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 number 8 test blasting cap when unconfined.

NOTE 4 — "Detonator" means any device containing a detonating charge that is used for initiating detonation in an explosive; the term includes, but is not limited to, electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses and detonating-cord delay connectors.

NOTE 5 — "Magazine" means any building or structure, other than an explosives manufacturing building, used for the permanent storage of explosive materials.

NOTE 6 — "Natural Barricade" means natural features of the ground, such as hills, or timber of sufficient density that the surrounding exposures which require protection cannot be seen from the magazine when the trees are bare of leaves.

NOTE 7 — "Artificial Barricade" means an artificial mound or revetted wall of earth of a minimum thickness of three feet.

NOTE 8 — "Barricaded" means that a building containing explosives is effectually screened from a magazine, building, railway, or highway, either by a natural barricade, or by an artificial barricade of such height that a straight line from the top of any sidewall of the building containing explosives to the eave line of any magazine, or building, or to a point twelve feet above the center of a railway or highway, will pass through such intervening natural or artificial barricade.

NOTE 9 — "Inhabited Building" means a building regularly occupied in whole or in 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 explosives.

NOTE 10 — "Railway" means any steam, electric, or other railroad or railway which carries passengers for hire.

NOTE 11 — "Highway" means any street or public road. "Public Highways Class A to D" are highways with average traffic volume of 3,000 or less vehicles per day as specified in "American Civil Engineering Practice" (Abbett, Vol. 1, Table 46, Sec. 3-74, 1956 Edition, John Wiley and Sons).

NOTE 12 — When two or more storage magazines are located on the same property, eac magazine must comply with the minimum distances specified from inhabited buildings, rai ways, and highways, and, in addition, they should be separated from each other by nc less than the distances shown for "Separation of Magazines," except that the quantity c explosives contained in cap magazines shall govern in regard to the spacing of said ca magazines from magazines containing other explosives. If any two or more magazines ar separated from each other by less than the specified "Separation of Magazines" distance then such two or more magazines, as a group, must be considered as one magazine, an the total quantity of explosives stored in such group must be treated as if stored in single magazine located on the site of any magazine of the group, and must comply wit the minimum of distances specified from other magazines, inhabited buildings, railway and highways.

NOTE 13 — Storage in excess of 300,000 lbs. of explosives in one magazine is general not required for commercial enterprises; however, IME will provide recommendations fc quantities greater than 300,000 lbs. in one magazine upon inquiry.

NOTE 14 — This Table applies only to the manufacture and permanent storage of cor mercial explosives. It is not applicable to transportation of explosives or any handling temporary storage necessary or incident thereto. It is not intended to apply to bomb projectiles, or other heavily encased explosives.

For transportation purposes, the Department of Transportation in Title 49 Transportati CFR Parts 1-199 subdivides explosives into three classes:

Class A — Maximum Hazard
Class B — Flammable Hazard
Class C — Minimum Hazard

NOTE 15 — All types of blasting caps in strengths through No. 8 cap should be rated 1½ lbs. of explosives per 1,000 caps. For strengths higher than No. 8 cap, consult t manufacturer.

NOTE 16 — For quantity and distance purposes, detonating cord of 50 to 60 grains per fc should be calculated as equivalent to 9 lbs. of high explosives per 1,000 feet. Heavier lighter core loads should be rated proportionately.

Table B-3

TABLE OF RECOMMENDED SEPARATION DISTANCES OF AMMONIUM NITRATE AND BLASTING AGENTS FROM EXPLOSIVES OR BLASTING AGENTS[1,6]

Donor Weight		*Minimum Separation Distance of Acceptor when Barricaded[2] (ft.)*		*Minimum Thickness of Artificial Barricades[5] (in.)*
Pounds Over	*Pounds Not Over*	*Ammonium Nitrate[3]*	*Blasting Agent[4]*	
	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	48	173	50
200,000	220,000	52	187	60
220,000	250,000	56	202	60
250,000	275,000	60	216	60
275,000	300,000	64	230	60

Notes to Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents

NOTE 1 — Recommended 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 should be included in the mass of the donor.

NOTE 2 — When the ammonium nitrate and/or blasting agent is not barricaded, the distances shown in the Table shall 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 storage is in bullet-resistant magazines[1] recommended for explosives or where the storage is protected by a bullet-resistant wall, distances and barricade thicknesses in excess of those prescribed in the American Table of Distances are not required.

NOTE 3 — The distances in the Table apply to ammonium nitrate that passes the insensitivity test prescribed in the definition of ammonium nitrate fertilizer promulgated by the Fertilizer Institute;[2] and ammonium nitrate failing to pass said test shall be stored at separation distances determined by competent persons and approved by the authority having jurisdiction.

NOTE 4 — These distances apply to nitrocarbonitrates and blasting agents which pass the insensitivity test prescribed in regulations of the U.S. Department of Transportation and the U.S. Department of the Treasury, Bureau of Alcohol, Tobacco and Firearms.

NOTE 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.

NOTE 6 — For determining the distances to be maintained from inhabited buildings, passenger railways, and public highways, use the Table of Distances for Storage of Explosives in Appendix A of *NFPA 495–1973, Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials.*

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[1]For construction of bullet-resistant magazines see Chapter 3 of *NFPA 495–1973, Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials.*

[2]Definition and Test Procedures for Ammonium Nitrate Fertilizer, Fertilizer Institute, November 1964.

Guide to Use of Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents

2-1 Sketch location of all potential donor and acceptor materials together with the *maximum* mass of material to be allowed in that vicinity. (Potential donors are high explosives, blasting agents, and combination of masses of detonating materials. Potential acceptors are high explosives, blasting agents, and ammonium nitrate.)

2-2 Consider separately each donor mass in combination with each acceptor mass. If the masses are closer than table allowance (distances measured between nearest edges), the combination of masses becomes a new potential donor of weight equal to the total mass. When individual masses are considered as donors, distances to potential acceptors shall be measured between edges. When combined masses within propagating distance of each other are considered as a donor, the appropriate distance to the edge of potential acceptors shall be computed as a weighted distance from the combined masses.

Calculation of weighted distance from combined masses:

Let M_2, M_3 ..... M_n be donor masses to be combined.
M_1 is a potential acceptor mass.
D_{12} is distance from M_1 to M_2 (edge to edge).
D_{13} is distance from M_1 to M_3 (edge to edge), etc.
To find weighted distance $[D_{1(2,3,\ldots.n)}]$ from combined masses to M_1, add the products of the individual masses and distances and divide the total by the sum of the masses thus:

$$D_{1(2,3,\ldots.n)} = \frac{M_2 \times D_{12} + M_3 \times D_{13} \ldots + M_n \times D_{1n}}{M_2 + M_3 \ldots + M_n} \qquad (1)$$

Propagation is possible if either an individual donor mass is less than the tabulated distance from an acceptor or a combined mass is less than the weighted distance from an acceptor.

2-3 In determining the distances separating highways, railroads, and inhabited buildings from potential explosions (*see Appendix A of NFPA 495–1973, Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials*), the sum of all masses which may propagate (i.e., lie at distances less than prescribed in the Table) from *either* individual *or* combined donor masses are included. However, when the ammonium nitrate must be included, only 50 percent of its weight shall be used because of its reduced blast effects.

In applying the American Table of Distances to distances from highways, railroads, and inhabited buildings, distances are measured from the nearest edge of potentially explodable material as prescribed in the American Table of Distances, Note 5. (*See Appendix to NFPA 495–1973, Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials.*)

2-4 When all or part of a potential acceptor comprises Explosives Class A as defined in DOT regulations, storage in bullet-resistant magazines is required. Safe distances to stores in bullet-resistant magazines may be obtained from the intermagazine distances prescribed in the American Table of Distances.

2-5 Barricades must not have line-of-sight openings between potential donors and acceptors which permit blast or missiles to move directly between masses.

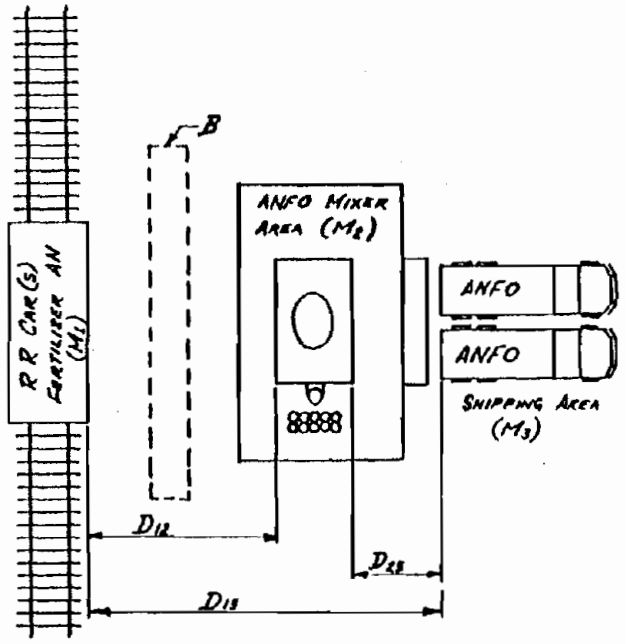

Figure 1.

Example 1 **ANFO Mix Plant (Figure 1)**

M_1 100,000 lbs. Fertilizer AN Frills (maximum)
M_2 2,500 lbs. ANFO (maximum)
M_3 80,000 lbs. ANFO (maximum)

D_{12} 20 ft.
D_{23} 20 ft.
D_{13} 50 ft.

No other stores on site; no barricade exists.

Potential Donor	Potential Acceptor	Distance On Site (ft.)	Table Distance, Minimum Required (ft.)	Propagation Possible?
M_2 (2,500 lbs.)	M_1	20	$9 \times 6 = 54$	Yes
M_3 (2,500 lbs.)	M_2	20	$32 \times 6 = 192$	Yes
M_3 (80,000 lbs.)	M_1	50	$28 \times 6 = 168$	Yes
M_3 (80,000 lbs.)	M_2	20	$101 \times 6 = 606$	Yes

Conclusion:

The maximum amount of blasting agent to be considered for public protection at this site is sum of all masses, reducing Fertilizer AN mass by 50 percent as indicated in Paragraph 23.

$$100{,}000 \times 50\% = 50{,}000$$
$$2{,}500$$
$$80{,}000$$
$$132{,}500 \text{ pounds}$$

In accordance with the American Table of Distances, the required separation distance from an inhabited building (unbarricaded) is 2,000 feet.

Example 2 **ANFO Mix Plant (Figure 1)**

M_1 100,000 lbs. Fertilizer AN Prills (maximum)
M_2 2,500 lbs. ANFO (maximum)
M_3 80,000 lbs. ANFO (maximum)

D_{12} 20 ft.
D_{23} 20 ft.
D_{13} 50 ft.

No other stores on site; a 4-foot-thick earth barricade exists at B (Figure 1).

Potential Donor	Potential Acceptor	Distance On Site (ft.)	Table Distance; Minimum Required (ft.)	Propagation Possible?
M_2 (2,500 lbs.)	M_1	20	9	No
M_3 (2,500 lbs.)	M_2	20	$6 \times 32 = 192$	Yes
M_3 (80,000 lbs.)	M_1	50	28	No
M_3 (80,000 lbs.)	M_2	20	$6 \times 101 = 606$	Yes
Combined $M_2 + M_3$ (82,500 lbs.)	M_1	49*	30	No

Conclusion:

The maximum amount of blasting agent to be considered for public protection at this site is the sum of M_2 plus M_3 or 82,500 pounds. In accordance with the American Table of Distances, the required separation distance from an inhabited building (unbarricaded) is 2,000 feet. If a natural or artificial barricade protects the building, the required distance is 1,730 feet.

*Compute weighted distance to combined mass by equation 1:

$$\frac{2{,}500 \times 20 + 80{,}000 \times 50}{2{,}500 + 80{,}000} = 49 \text{ feet}$$

APPENDIX C

Federal Explosives Storage Requirements

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Federal Explosives Storage Requirements

Following, in table form, are construction, housekeeping and storage requirements for Types 1 through 5 explosives storage facilities. These requirements are the minimum acceptable under Federal law and regulations (27 CFR, Part 181, Subpart J—Storage). In specific instances, variance from a particular requirement or requirements may be granted by the Regional Director.

This section includes (a) a table of the classes of explosives which may be stored in each of the five types of magazines; (b) a table of housekeeping and construction requirements that apply to all types of storage facilities; and (c) tables setting forth in detail the requirements that apply specifically to each of the five types of magazines.

Types of Storage Facilities

(18 USC, Section 842(j)) (27 CFR, Section 181.183)

Storage Type	Classes of Explosive Materials Which May Be Stored Therein
Type 1 (permanent)	High Explosives Low Explosives Blasting Agents
Type 2 (portable)	High Explosives Low Explosives Blasting Agents
Type 3 ("day-box" for temporary storage)	High Explosives Low Explosives Blasting Agents
Type 4	Low Explosives Blasting Agents *Electric Blasting Caps
Type 5	Blasting Agents

*As a result of tests with electric blasting caps, it has been determined that these blasting caps are not subject to sympathetic detonation. Therefore, a Type 4 storage facility meets the necessary requirements for storage of electric blasting caps.

Note: 1. Blasting caps shall not be stored with other explosive materials in the same storage facility.

2. Explosives storage limitations and quantity restrictions are stated in 27 CFR Sections 181.186, 181.188(b), 181.188(c), 181.189, 181.190(b), and 181.193. For tables of distances for high explosives, low explosives, and blasting agents, see 27 CFR Sections 181.198, 181.199, and 181.200, respectively.

Housekeeping and Construction Requirements Common to All Types of Storage Facilities

(18 USC, Section 842(j)) (27 CFR, Sections 181.187, 181.194, and 181.195)

Item	Requirements
Hinges and Hasps	Shall be attached to doors by either Welding, OR Riveting, OR Bolting (nuts on inside of door).
Locks	Each door shall be equipped with either 2 mortise locks, OR 2 padlocks fastened in separate hasps and staples, OR A combination of a mortise lock and a padlock, OR Mortise lock requiring 2 keys to open, OR Three-point lock. Locks shall be five-tumbler proof. Padlocks shall be protected with 1/4" steel caps constructed to prevent sawing or lever action on locks or hasps. Note: Outdoor-mobile storage facilities with one steel, case-hardened, five-tumbler padlock, having at least a 7/16" shackle diameter, have been determined by the Director to meet necessary requirements.
Lighting	No lighting shall be placed or used in a magazine of type 1, 2, 3, or 4 except battery-activated safety lights or battery-activated safety lanterns: Provided, That electrical illumination may be used when explosion-proof fixtures and wiring in rigid conduit are used inside and all electric switches are located outside the magazine.

Item	Requirements
Housekeeping	Storage facilities shall be kept clean, dry, and free of grit, paper, empty packages and containers, and rubbish. Explosive materials shall not be placed directly against interior walls of storage facility. Brooms and other cleaning utensils shall have no spark-producing metal parts. Only tools made of nonsparking materials shall be used in Types 1, 2, 3, and 4 magazines. (Metal slitters may be used for opening fiberboard containers. Metal tools other than nonsparking transfer conveyors shall not be stored in any magazine containing high explosives.) Area surrounding storage facilities shall be kept clear of rubbish, brush, dry grass, or trees for not less than 25 feet in all directions. Any other combustible materials shall be kept a distance of not less than 50 feet from outdoor storage facilities.

Type 1 Storage

(18 USC, Section 842(j)) (27 CFR, Sections 181.187 and 181.197)

A type 1 storage facility shall be a permanent structure: a building, an igloo or Army-type structure, a tunnel, or a dugout; and shall be bullet-resistant, weather-resistant, theft-resistant, and well-ventilated.

Item	Requirements
Masonry Wall	Shall be constructed of either Brick, not less than 6" thick, OR Concrete, not less than 6" thick, OR Tile, not less than 6" thick, OR *Cement block, not less than 6" thick, OR *Cinder block, not less than 6" thick. *Hollow masonry units shall have all hollow spaces filled with well-tamped coarse dry sand or weak concrete.

Type 1 Storage (Continued)

Item	Requirements
Metal Wall	Sectional sheets of one of the following shall be securely fastened to a metal framework: Steel, not less than 14 gauge, OR Aluminum, not less than 14 gauge. Shall be lined with either Brick, OR Solid cement blocks, OR Hardwood, not less than 4" thick, OR Shall have at least 6" sand fill between inner and outer walls.
Wood Wall	Exterior shall be covered with either Iron, not less than 26 gauge, OR Aluminum, not less than 26 gauge. Inner wall shall be constructed to provide not less than 6" between outer and inner walls, space filled with either Coarse dry sand, OR Weak concrete.
Foundations	Shall be constructed of either Brick, OR Concrete, OR Cement block, OR Stone, OR Wood posts (If piers or posts are used, space under buildings shall be enclosed with metal).
Floors	Shall be constructed of nonsparking material. Shall be strong enough to bear weight of maximum quantity to be stored.
Roof	Outer roof (except fabricated metal roofs) shall be covered with either 26-gauge iron, fastened to 7/8" sheathing, OR 26-gauge aluminum fastened to 7/8" sheathing. Where possible for a bullet to be fired directly through roof and into storage facility, magazine shall be protected by either A sand tray, filled with not less than 4" of coarse dry sand, covering the entire ceiling area; except that necessary for ventilation, OR Fabricated metal roof construction of 3/16" plate steel, lined with 4" hardwood (for each additional 1/16" of plate steel, hardwood may be decreased 1").

Type 1 Storage (Continued)

Item	Requirements
Doors	Shall be constructed of 1/4" steel. Shall be lined with 2" of hardwood.
Hinges, Hasps, and Locks	See construction requirements common to all types of facilities.
Interior	Shall be constructed of or covered with a nonsparking material. No sparking metal construction shall be exposed below top of walls in interior. All nails shall be blind-nailed or countersunk.
Ventilation	2" air space shall be left around ceiling and perimeter of floors, except at doorways. Foundation ventilators shall be not less than 4"×6". Vents in foundation, roof, or gables shall be screened and offset.
Ground	Ground around storage facility shall slope away for drainage.
Igloos, Army-Type Structures, Tunnels and Dugouts	Shall be constructed of reinforced concrete, masonry, metal, or a combination of these materials. Shall have an earthmound covering of not less than 24" on the top, sides and rear. Interior walls and floors shall be covered with a nonsparking material. Floor, door, lock, ventilation, exposed metal, and lighting requirements are as stated above.
Lighting	See construction requirements common to all types of facilities.
Housekeeping	See housekeeping requirements common to all types of facilities.

Type 2 Storage

(18 USC, Section 842(j)) (27 CFR, Sections 181.188 and 181.197)

A type 2 storage facility shall be a box, a trailer, a semi-trailer, or other mobile facility. It shall be bullet-resistant, fire-resistant, weather-resistant, theft-resistant, and well ventilated.

Item	Requirements
Hinges, Hasps, and Locks	See construction requirements common to all types of storage facilities.

Type 2 Storage (Continued)

Item	Requirements
Lighting	See construction requirements common to all types of storage facilities.
Housekeeping	See housekeeping requirements common to all types of storage facilities.
Restrictions on Type 2 Outdoor Storage Facilities	
Size	Shall be at least 1 cubic yard in size.
Ground	Outdoor storage facilities shall be supported in such a manner so as to prevent direct contact with the ground. Ground around storage facility shall slope away for drainage.
Construction	Sides, bottoms, tops, and covers or doors shall be constructed of 1/4" steel and lined with 2" of hardwood.
Unattended Storage	Unattended vehicular storage facilities shall have wheels removed or shall be immobilized by kingpin locking devices.
Restrictions On Type 2 Indoor Storage Facilities	
Location	No indoor storage facility for storage of high explosives shall be located in a residence or dwelling. Storage facilities located in a warehouse, or wholesale or retail establishment, shall be provided with substantial wheels or casters to facilitate removal therefrom. No more than two indoor storage facilities shall be located in any one building. Two storage facilities may be kept in the same building only when one is used for storage of blasting caps and the other for storage of other high explosives. Each storage facility shall be located on the floor nearest ground level and within 10 feet of an outside exit. Indoor storage facilities within one building shall be separated by a distance of not less than 10 feet.
Quantity Restrictions	No indoor storage facility shall contain a quantity of high explosives in excess of 50 pounds or more than 5,000 blasting caps.

Type 2 Storage (Continued)

Item	Requirements
Construction	Shall be of either *Wood* (Shall have sides, bottoms, and covers or doors constructed of 2" hardwood and shall be well braced at corners. They shall be covered with sheet metal (not less than 20 gauge). Exposed nails shall be countersunk), OR *Metal* (Shall have sides, bottoms, and covers or doors constructed of 12-gauge metal and shall be lined inside with a nonsparking material. Edges of metal shall overlap sides at least 1").
Cap Boxes	
	Storage facilities for blasting caps in quantities of 100 or less shall have sides, bottoms, and covers constructed of 12-gauge metal, with hinges and hasps attached by welding. One five-tumbler proof lock shall be sufficient for locking purposes.

Type 3 Storage

(18 USC, Section 842(j)) (27 CFR, Sections 181.188(a), 181.189, and 181.197)

A type 3 storage facility shall be a "day-box" or other portable facility. It shall be constructed in the same manner prescribed for type 2 outdoor storage facilities in 181.188(a), except that it may be less than 1 cubic yard in size, and shall be bullet-resistant, fire-resistant, weather-resistant, theft-resistant, and well ventilated.

Item	Requirements
Construction	Doors or covers, sides, bottoms, and tops shall be constructed of 1/4" steel and lined with 2" of hardwood. Edges of metal covers shall overlap sides at least 1".
Hinges, Hasps, and Locks	See housekeeping and construction requirements common to all types of storage facilities.
Ground	Ground around storage facility shall slope away for drainage.

Type 3 Storage (Continued)

Item	Requirements
Unattended Storage	No explosive materials shall be left in storage facility if unattended. Explosive materials must be removed to types 1 or 2 storage facilities for unattended storage.
Lighting	See construction requirements common to all types of storage facilities.
Housekeeping	See housekeeping requirements common to all types of storage facilities.

Type 4 Storage

(18 USC, Section 842(j)) (27 CFR, Sections 181.187(a)(5), (11); 181.190; and 181.197)

A type 4 storage facility may be a building, an igloo or Army-type structure, a tunnel, a dugout, a box, a trailer, or a semitrailer or other mobile facility; and shall be fire-resistant, weather-resistant, and theft-resistant.

Item	Requirements
Construction	Shall be of either Masonry, OR Metal-covered wood, OR Fabricated metal, OR Combinations of these materials.
Doors or Covers	Shall be constructed of either Metal, OR Solid wood covered with metal.
Foundations	Shall be constructed of either Brick, OR Concrete, OR Cement block, OR Stone, OR Wood posts (If piers or posts are used, space under buildings shall be enclosed with metal).
Interior	Shall be lined with nonsparking material. No sparking metal construction shall be exposed below top of walls in interior. All nails shall be blind-nailed or countersunk.