Information Circular 8746

Safety Recommendations for Ammonium Nitrate-Based Blasting Agents

Revision of Information Circular 8179

By G. H. Damon, C. M. Mason, N. E. Hanna, and D. R. Forshey

UNITED STATES DEPARTMENT OF THE INTERIOR
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SAFETY RECOMMENDATIONS FOR AMMONIUM NITRATE-BASED BLASTING AGENTS

Revision of Information Circular 8179

by

G. H. Damon,[1] C. M. Mason,[2] N. E. Hanna,[3] and D. R. Forshey[4]

ABSTRACT

Since 1963, Bureau of Mines Information Circular 8179 has served the mining industry as a fundamental safety guide in the field of blasting agents. In the intervening 14 years, many changes have occurred, and this report presents revised and new recommendations which recognize these changes. For example, AN-FO is now supplied mostly premixed, whereas in 1963 much of it was mixed by the blaster; aluminum metal (Al) and other fuels are now often added to AN-FO to increase strength, and flake aluminum powder is used as a sensitizer in water gels; and water gels or slurries that are now extensively used were just coming into practical use in 1963. To provide the widest possible margin of safety, some of the Bureau's recommendations are more stringent than existing regulations.

INTRODUCTION

The use of ammonium nitrate (AN) as an ingredient in blasting compositions is not new. In 1867, Ohlsson and Norrbin patented Ammoniakkrut (4, 30),[5] consisting of ammonium nitrate, either alone or in mixtures with charcoal, sawdust, naphthalene, picric acid, nitroglycerin, or nitrobenzene. Since that time ammonium nitrate has been used continuously as an ingredient in dynamite and blasting agent formulations. Although it is an important ingredient of commercial explosives, ammonium nitrate is not classed for transportation purposes as an explosive (10), but as an oxidizing material.

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[5] Underlined numbers in parentheses refer to references preceding the appendixes at the end of this report.

The industrial development of ammonia dynamite, in which ammonium nitrate admixed with various fuels was sensitized by varying percentages of a high explosive such as nitroglycerin, represented a phase in obtaining explosive power from ammonium nitrate. In 1935, a new product, Nitramon,[6] represented another step in the development of a blasting agent based on the explosive decomposition of ammonium nitrate.

The development of Akremite (20) (a mixture of prilled AN and carbon black) in 1955 brought to the attention of the mining industry and others the basic principles and advantages of using fuel-sensitized ammonium nitrate mixtures, prepared at or near the site of use, as low-cost blasting agents. Industry responded with enthusiasm, promptly adopting the concept and adapting it to a wide variety of uses.

The Bureau of Mines has followed these developments as time progressed and has done extensive research in certain areas (3, 9, 21, 23-24, 33, 39-48). Excellent reviews of the field have been prepared by Cook (1), Robinson (32), and Dick (5-6). More general information on blasting agents and blasting may be found in references 2, 7, 11, 18, and 19. The Bureau's interest is twofold: Safety in preparation, storage, transportation, and use of explosive materials; and the potential for continued reductions in the cost of blasting operations in all types of mining and other uses of explosives. Because of this interest, the Bureau, from the inception of the new developments in blasting agents, advised the industry on safe practices in the use of these materials. The first publication was IC 7988, which appeared in 1960 (36), concurrent with Manual Sheet A-10 published by the Manufacturing Chemists Association (22). This was followed by IC 8179, published in 1963 (35).

In the intervening years, the Bureau, the chemical and explosives industries, and others have followed the development of blasting agents closely, and various organizations have developed new recommendations for handling blasting agents. For example, the National Fire Protection Association has issued several publications (25, 28-29) that give recommendations for the manufacture, storage, transportation, and use of ammonium nitrate and ammonium nitrate-based blasting agents. The Institute of the Makers of Explosives has issued suggested standards for the safe use of blasting agents (12, 14-17).

In 1963, the basic "blasting agent"[7] was prilled ammonium nitrate (AN) to which had been added approximately 6 percent fuel oil (FO) such as No. 2 diesel fuel; this was known to the industry as AN-FO. In the last 14 years the strength of AN-FO has been increased by the addition of aluminum powder, and its density has been changed by the addition of carbonaceous material, such as bagasse, or ferrophosphorus. A wide range of explosive materials known as water gels or slurries has been developed for use where the water resistance or bulk strength of AN-FO is not satisfactory.

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[6]Reference to specific trade names is made for identification only and does not inply endorsement by the Bureau of Mines.

[7]Blasting agent is defined under "Definitions."

Early in the development of AN-FO, the ready availability of the components, AN prills and diesel fuel oil, together with the ease of formulation, made it possible for the blaster himself to prepare AN-FO in small batches at the site. This led to poor mixes, which often resulted in poor blasting performance; present practice is that established manufacturers of explosive materials now supply most of the AN-FO premixed. Onsite formulation is practiced only at certain large operations, usually open pit. A similar situation exists for water-gel or slurry explosive materials; material is prepared and packaged by a recognized manufacturer or premixed (or partially mixed) at a plant near the blasting site and trucked to the site for down-hole delivery.

AN-FO and water-gel blasting agents have unique safety characteristics when compared with the conventional nitroglycerin-based explosives so long used in the industry. Additionally, the economic advantage of blasting agents is a factor of importance to the mining industry. As a result, in 1975, 90 percent of all blasting done in the United States was done with AN-based blasting agents (34).

Although blasting agents are considered safer than dynamites, they are explosive in nature and should be handled with the respect normally given high explosives. Both AN-FO and water gels can be made (or possibly become) cap sensitive, and the product is then classed as an explosive. This publication presents recommendations designed to provide the best possible safety without making operations so burdensome as to lose the basic advantage of lower costs. Recommendations for preparation, storage, transportation, and use of blasting agents based on ammonium nitrate are included. The term "should" is deliberately chosen to emphasize that these are recommendations rather than regulations.

DEFINITIONS

Ammonium nitrate (AN).--A chemical compound represented by the formula NH_4NO_3. AN used in the manufacture of blasting agents usually contains small percentages of anticaking agents or phase-change modifiers.

Blasting agent.[8]--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 a No. 8 blasting cap when unconfined (25, 35). This includes AN-FO and related mixtures, water gels (slurries), nitrocarbonitrates, etc.

[8] Some difference of opinion has arisen over the definition of a blasting agent. Some authorities favor the omission from the definition of the phrase "and in which none of the ingredients are classified as an explosive." However, recent incidents with blasting agents and their ingredients, as well as a number of potential safety factors, make us hesitate to alter a definition which has been used successfully for many years. Therefore, we believe it is in the interest of safety to retain the original definition until such time as definite solutions can be obtained for the many safety problems.

Blasting cap (No. 8).--Any commercial instantaneous detonator containing a pentaerythritol tetranitrate (PETN) base charge of standard weight.[9]

Cap-sensitive explosive material.--Any material (compound or mixture) as mixed and packaged that can be initiated to detonation by a No. 8 blasting cap (detonator) when unconfined.

Detonator.--Any device containing a detonating charge that is used for initiating detonation of an explosive. The term includes, but is not limited to, electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuse, and detonating-cord delay connectors.

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, cap-sensitive water gels (slurries), black powder, pellet powder, initiating explosives, detonators, safety fuse, squibs, detonating cord, igniter cord, and igniters.

The term includes any material determined to be within the coverage of 18 U.S.C., Chapter 40, Importation, Manufacture, Distribution, and Storage of Explosive Materials,[10] and includes any material classified as an explosive in the regulations of the U.S. Department of Transportation (DOT).[11]

Explosive material.--Explosives, blasting agents, water gels (slurries), and detonators.

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[9]Federal standards specify that a No. 8 cap having a PETN base charge must contain a minimum nominal average of 0.4 gram of the explosive. Most, if not all, No. 8 blasting caps (detonators) manufactured in this country meet or exceed this standard. The original test cap containing 2 grams of a mixture of 80 percent mercury fulminate and 20 percent potassium chlorate is no longer manufactured in this country.

[10]A list of explosives determined to be within the coverage of 18 U.S.C., Chapter 40, is issued at least annually by the Director of the Bureau of Alcohol, Tobacco, and Firearms, U.S. Department of the Treasury (38).

[11]Classification of explosives described in the regulations of the U.S. Department of Transportation (10) is as follows:

Class A explosives.--Possessing detonating or otherwise maximum hazard, such as dynamite, desensitized nitroglycerin, lead azid, fulminate of mercury, black powder, blasting caps and detonating primers. (NOTE.--For purposes of transportation, DOT classifies 1,000 or fewer blasting caps as a Class C explosive.)

Class B explosives.--Possessing flammable hazard, such as propellants (including some smokeless propellants) and most photographic flash powders.

Class C explosives.--Includes certain types of manufactured articles which contain Class A or Class B explosives, or both, as components but in restricted quantities.

Forbidden or not acceptable explosives.--Explosives which are forbidden or not acceptable for transportation by common carriers by rail freight, rail express, highway, or water, in accordance with the regulations of the Department of Transportation.

Fuel.--A substance that may react with the oxygen in the air or with the oxygen yielded by an oxidizer to produce combustion.

Highway.--Any public street, public alley, or public road.

Inhabited buildings.--A building or structure regularly used in whole or part as a place of human habitation. The term "inhabited building" shall also mean any church, school, store, railway passenger station, airport terminal for passengers, and any other building or structure where people are accustomed to congregate or assemble, but excluding any building or structure occupied in connection with the manufacture, transportation, storage, and use of explosive materials.

Magazine.--Any building or structure, other than an explosives manufacturing building, approved for the storage of explosive materials. See appendix C.

Motor vehicle.--In this publication, motor vehicle means any self-propelled vehicle, truck, tractor, semitrailer, or truck-full trailer used for the transportation of freight over public highways.

Nitro-carbo-nitrate.--A type of blasting agent currently defined by the U.S. Department of Transportation as a mixture consisting substantially of inorganic nitrates and carbonaceous material in which none of the ingredients are explosives as defined by DOT, and which, as packaged for shipment, cannot be detonated by means of a No. 8 test blasting cap.

Oxidizer.--A substance such as a nitrate that yields oxygen readily to stimulate the combustion of organic matter or other fuel.

Propellant.--An explosive material that normally functions by deflagration and is used for propulsion purposes. Under the current regulations of the U.S. Department of Transportation, propellants may be classified as Explosives (Class A) or Explosives (Class B) depending on their susceptibility to detonation. Black powder includes black powder propellant.

Railway.--Any steam, electric, diesel electric, or other railroad or railway that carries passengers for hire on the particular line or branch in the vicinity where explosives are stored or where explosives manufacturing buildings are situated.

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; hose of not more than 2 megohms' resistance over its entire length and of not less than 5,000 ohms' resistance per foot meets the requirements. Wire-countered hose may not be used for this purpose (31, 35).

Water gel (slurry).--Any of a wide variety of materials used for blasting that contain water in sufficient quantities to insure a continuous phase and high proportions of ammonium nitrate and other oxidizers, some of which are in solution. Two broad classes of water gels are (1) those that contain a

material classed as an explosive such as TNT and are classed as explosives and (2) those that may be either a blasting agent or an explosive depending on their cap sensitivity. Water gels may be premixed at a plant or mixed at the site immediately before delivery into the borehole.[12]

SENSITIVITY CHANGES

The bulk density of ammonium nitrate prills may range from less than 0.8 gram per cubic centimeter (g/cm^3) to about 1 g/cm^3. Particle sizes may range from 4 to 7 mesh to 90 percent through 100 mesh (crushed prills). Additionally, it should be noted that ammonium nitrate prills tend to disintegrate physically, producing fines, when their temperature passes 90° F, a solid-phase transition point. Temperature fluctuations through the solid phase transition point could easily occur many times during storage or transport. When mixed with oil, the resulting finely divided, low-density product (AN-FO) is much more sensitive to initiation to detonation. Low-density (0.6-g/cm^3) products may be cap sensitive (24, 47-48).

The sensitivity of water gels (slurries) varies with temperature, and this factor should be considered in transporting and using the product. Some blasting-agent-type slurries may become cap sensitive at higher ambient temperatures, and others may fail to initiate or propagate at low temperatures. Evaporation of water from water gels or the segregation of components may change the sensitivity and propagation characteristics of the resulting blasting agents.

SENSITIVITY TESTS

It is advisable, in the interest of simplicity and uniformity to establish a simple yardstick of blasting agent sensitivity--one that can be employed by operators, blasting foremen, and safety engineers alike. Each of the following tests should be performed according to, and should follow the safety procedures specified in, the reference document describing the test procedure. This will insure test standardization as well as user protection. No sensitivity test should be considered reliable when performed at less than 70° F since temperatures as high as 130° F may be encountered in transportation and in the field.

Cap-Sensitivity Test

The Bureau suggests that all compositions be regularly and routinely tested for sensitivity. One method meeting requirements of simplicity and general availability is that of cap sensitivity (23). This test determines the ability of a blasting cap to initiate detonation. Here, a commercial No.8

[12]Water gels are manufactured to have varying degrees of sensitivity to initiation. Under the current regulations of the U.S. Department of Transportation, water gels may be classified as Explosives (Class A), Propellant Explosives (Class B), or oxidizing materials (10). In the present trade parlance, water gel and slurry are interchangeable terms for the same material.

blasting cap is recommended because of the general unavailability of "test blasting caps." The test is simple: Put the explosive material into a 1-quart cylindrical paper carton approximately 3-3/8 inches in minimum diameter and 6-3/8 inches deep (8.6-cm diameter by 16.2-cm deep)[13] at its approximate packaged density, and fully insert a No. 8 detonator. Place the prepared charge on soft ground in an isolated area provided with an amply safeguarded spot for the shotfirer and others, and fire the detonator. If a crater is formed, the composition tested is considered cap sensitive and must be treated as an explosive and handled with the care normally given to dynamite and comparable explosives.

Projectile Impact Test

An alternate method, much more selective, is the projectile impact test developed by the Bureau of Mines (23). This more complex test has been widely applied by Watson, Hay, and Becker (46, 48) to a large number of ammonium nitrate-sensitized compositions, and data have been made available to the industry for comparison.

Bullet Impact Test

A bullet impact test, while not as discriminating as the projectile impact test used by the Bureau, is also a practical test for estimating the sensitivity of explosive materials. In essence, the material as packaged for shipment or use is fired at from a distance not to exceed 100 feet using a high-powered rifle and load. A 30-06 caliber rifle using a 150-grain full-metal-case projectile having a nominal muzzle velocity of 2,700 feet per second may be used for this test (17, 25). If the explosive material detonates, it should be treated as an explosive (48). Other types of ammunition, in particular those used with the 220 Swift and the 300 Weatherby-Magnum rifles, have been demonstrated to provide a more stringent test than the 30-06 (24).

FIRE HAZARDS

One of the most important considerations in the safe storage of blasting agents based on ammonium nitrate is the prevention of fire. Under some conditions ammonium nitrate fires can develop into a detonation (8, 42).

It is important to make a definite distinction between ammonium nitrate and mixtures of ammonium nitrate with sensitizing agents and fuels such as fuel oil or aluminum metal. The fire and explosion hazards of these two classes of material are different; the mixtures present the greater hazard, in both ease of initiation of detonation and blast energy. If ammonium nitrate is stored near or with explosives or blasting agents, reasonable safety considerations (17, 29) suggest that isolation distances be established for the aggregate lot. Water-gel (slurry) blasting agents, because of their high water content, would appear to be less of a fire hazard than dry blasting agents. However, at present, there are inadequate data and field experience

[13]Paper or plastic 1-quart cartons of approximately the same dimensions may be more readily available and are equally satisfactory.

to permit any general conclusions concerning this point, and water-gel (slurry) blasting agents should be treated in the same manner as the other blasting agents with regard to fire.

FIGHTING FIRES

Ammonium Nitrate

In the absence of nearby stores of sensitizing agents such as fuel oils, unconfined, limited-area fires in even large quantities of ammonium nitrate can be fought with copious amounts of water. However, massive fires may present a substantial explosion hazard, and firefighting efforts on these should be abandoned unless water can be applied by remote control. Water acts solely as a cooling agent. Ammonium nitrate, an oxidizing material, does not need atmospheric oxygen for reaction. Consequently, ammonium nitrate fires cannot be smothered, and chemical extinguishing agents are essentially ineffective.

The decomposition of ammonium nitrate in a fire situation produces voluminous amounts of toxic oxides of nitrogen. Personnel should not remain in areas where appreciable quantities of brown nitrogen dioxide (NO_2) fumes are produced or accumulate.

After extinction of the fire, the loose and contaminated unsalvageable ammonium nitrate should be buried or dumped in water where permitted by State or local authorities. Any residue that cannot be removed by sweeping should be washed with water. Flushing and scrubbing of all areas should be very thorough to insure the dissolving of all residue. Wet and dry empty bags should be removed and disposed of in a safe manner.

Blasting Agents (AN-FO and Other Dry Blasting Agents)

When not confined, incipient fires in fuel-oil-sensitized ammonium nitrate can be fought with copious amounts of water. Here again, the water acts only to cool the burning mass to temperatures below the autodecomposition range. When fires develop beyond the incipient stage, handling the situation becomes more difficult. In this case, it is recommended that firefighting efforts be abandoned and the area evacuated, in anticipation of a possible explosion, according to the distance tables in appendix A. For example, a fire at Norton, Va., in a mixhouse containing about 30 tons of AN-FO and 20 tons of ammonium nitrate resulted in a violent explosion after burning for approximately 30 minutes (42). The fact that there were no fatalities or serious injuries can no doubt be attributed to the prompt action taken by the Norton fire marshal, who realized the seriousness of the situation and evacuated the area rather than attempting to fight the fire. Another example illustrating this point was a fire originating in a bulk ammonium nitrate warehouse near Pryor, Okla. (8). About 25 minutes after the fire was discovered, an explosion occurred in the bulk ammonium nitrate storage building. Fortunately, there were no deaths or major injuries because no workmen or firefighters were in the immediate vicinity of the explosion. The Bureau believes

that such established fires should be fought with water only by means of a remotely controlled system. When stocks of ammonium nitrate and AN-FO are stored close to each other, the explosive yield of a fire in either material should be based on the weight of the AN-FO plus one-half the weight of the ammonium nitrate.

Water Gels (Slurries)

Water gels classed as explosives should be treated the same as explosives when involved in a fire. Water gels classed as blasting agents require treatment similar to dry blasting agents such as AN-FO. However, fires involving water gels should be approached with care even by knowledgeable firefighters. Loaded pump trucks and bulk trucks that are not involved in the fire may be removed from the area if this can be done in the very early stages of the fire. Once the fire becomes established, the immediate areas should be evacuated and the fire allowed to burn out unless it can be fought by remote control.

Explosives

If high explosives are present in a fire involving either or both ammonium nitrate or blasting agents, they should be removed from the danger area if this can be done promptly and safely. However, if this is impossible or the explosives are already aflame, the entire area should be evacuated in anticipation of detonation, and the fire should be allowed to burn.

UNDERGROUND APPLICATIONS

The economic advantage of using blasting agents, as demonstrated in almost every aboveground blasting application, has led to their adoption in underground noncoal mines. This trend was advanced by the development of compositions sensitive enough to assure complete propagation in small-hole blasting and of pneumatic loading equipment that provided a simple means for charging the boreholes. Additional safety precautions, listed as recommendations 108 through 120, should be observed when using these agents underground. It should be noted that blasting agents were never approved by the Bureau of Mines, and are not now approved by the Mining Enforcement and Safety Administration, for use in underground coal mines.

RECOMMENDATIONS COVERING AMMONIUM NITRATE AND AMMONIUM NITRATE-BASED BLASTING AGENTS

The following recommendations for preparing, storing, and transporting ammonium nitrate-based blasting agents and for using them in blasting operations are based on the most reliable information available to date. In many cases, rather restrictive recommendations have been chosen to emphasize that these are recommendations, rather than regulations or inflexible requirements. All Federal, State, and local laws and regulations applicable to obtaining, owning, transporting, storing, handling, and using explosive materials should be obeyed in addition to the recommendations listed.

Storage of Ammonium Nitrate

1. Ammonium nitrate should be stored in accordance with recommendations of the National Fire Protection Association (29).

2. The following factors should be considered in judging the adequacy of a site for a storage building: Maximum amount of intended storage, congestion of the area, firefighting facilities, local regulations, toxic fume hazards in event of fire, etc.

3. The storage building should be dry and well ventilated.

4. The storage building floor and handling areas should be of noncombustible material [14] or protected against impregnation by ammonium nitrate, and the design should be such as to eliminate open drains, traps, tunnels, pits, or pockets into which any molten ammonium nitrate could flow and be confined in the event of fire.

5. Ammonium nitrate should not be accepted for storage when the temperature of the ammonium nitrate exceeds 130° F.

6. Storage buildings should be constructed of noncombustible or fire-resistant materials. Since only a limited degree of fire protection is provided by conventional sprinkler systems, it is desirable for such a building to be equipped for fire protection with an adequate-capacity, automatic water-deluge system.

7. If ammonium nitrate is stored in the same building with a blasting agent, the total weight of the blasting agent plus one-half the weight of the ammonium nitrate should be considered as blasting agent, and the building should be isolated from inhabited buildings, passenger railroads, and public highways in accordance with the American Table of Distance for Storage of Explosives (appendix A).

8. If ammonium nitrate is stored with explosives, only a properly constructed explosives magazine should be used. The total weight of the explosive plus one-half the weight of the ammonium nitrate should be the determining factor in establishing the location of the magazine in accordance with the American Table of Distances for Storage of Explosives (appendix A).

9. Smoking and open flames should not be permitted within 50 feet of any storage building containing ammonium nitrate.

10. Explosive materials must not be used to break up or loosen caked ammonium nitrate.

11. Separation sufficient to prevent contamination should be maintained between stores of ammonium nitrate and combustible and flammable liquids such as gasoline, kerosine, solvents, and fuel oils.

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[14] Wood treated with fire retardants should not be considered noncombustible.

12. Unattended motor vehicles such as forklifts, tractors, and cargo conveyors should not be parked near stores of ammonium nitrate. Belt conveyors used for bulk transfer of ammonium nitrate should be of such construction as to minimize penetration of AN into the rollers (idlers). Accumulation of AN under and around the conveyor should not be permitted.[15]

Manufacture of Blasting Agents

Composition

13. No liquid fuel with a flashpoint lower than that of No. 2 diesel fuel oil (125° F [52° C] minimum or legal) should be used. More volatile fuels, such as gasoline, kerosine, or No. 1 diesel fuel, are not recommended because they offer no advantage in blasting and would increase the hazard of a vapor explosion or fire.

14. The addition of an oil-soluble dye to the fuel oil produces a colored product that is advantageous in promoting safety. The color aids primarily in distinguishing between a mixed product and unprocessed ammonium nitrate and also provides an indication of the distribution of the oil throughout the mix.

15. The fuel oil content of AN-FO should be approximately 6.0 percent by weight, which yields a nearly oxygen-balanced composition. If other fuels are substituted for fuel oil, oxygen-balanced composition should be maintained to assure the minimum production of toxic fumes (33, 41, 45).[16] An oil content of 6±0.5 percent provides a mixture which gives near-optimum results.

16. If solid fuels are used, they should be chosen to minimize dust explosion hazards. Aluminum powder smaller than 200 mesh is a known dust explosion hazard.

17. Metal dusts, sulfur, perchlorates, or explosive substances (such as nitroglycerin or other high explosives) should not be used to sensitize ammonium nitrate unless the strict standards of normal explosive plant operations are met. Nitrites, peroxides, and chlorates should never be used in blasting agent formulations.

18. Other unusual compositions should not be attempted except under the supervision of competent personnel able to evaluate the possibility of new hazards in the operation and equipped to determine the sensitivity of the resulting compositions. The compatibility of ingredients should be determined before any new compositions are prepared.

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[15] The origin of the fire resulting in the explosion of ammonium nitrate in Pryor, Okla., was not determined; however, ignitions originating in an unattended payloader or on the belt conveyor are considered to be possible causes (8).

[16] Close control of the composition is necessary for use in underground operations.

19. The cap sensitivity of a composition should be determined at regular intervals and after every change in proportion, character of ingredients, mixing, or packaging.

Fixed Location Mixing Plants

20. Blasting agents should be mixed, transported, and stored with the same care as is used with explosives.

21. Buildings or other facilities used for mixing blasting agents should be located, with respect to inhabited buildings, passenger railroads, and public highways, in accordance with the American Table of Distances for Storage of Explosives (appendix A) and the Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives or Blasting Agents (appendix B).

22. Buildings should be of noncombustible material and construction.

23. Floors in mixing plants should be of concrete or other nonabsorbent materials. Floor drains, traps, tunnels, pits, or pockets, in which molten material could flow in case of a fire, should be eliminated.

24. Magazine separation distances based on the Table of Recommended Separation Distances of Ammonion Nitrate and Blasting Agents From Explosives or Blasting Agents (appendix B) should be used to locate the mixing plant with respect to the permanent storage area for blasting agents.

25. A mixing plant should be laid out so that daily operation stocks of unprocessed ammonium nitrate and finished products are physically separated from the area or areas in which mixing or packaging operations are conducted.

26. No more than 1 day's production of blasting agent should be permitted in the mixing and packaging plant.

27. Fuel oil and other combustible materials (fuels) should be stored in a separate, isolated building or in outside tanks to minimize contact between molten ammonium nitrate and fuel in the event of fire. Shutoff valves should be provided at all tanks.

28. Ammonium nitrate solutions used in the preparation of water gels (slurries) may be stored in tank trucks or fixed tanks without quantity or distance limitations.

29. Heat should be provided exclusively from a source outside the building. However, space heaters that do not depend on combustion processes within the heating unit may be satisfactory if they are suitably located overhead to provide minimum clearances of 30 inches from raw materials and finished products. The space heaters must also meet the requirements of the most recent edition of the National Electrical Code for the specific type of hazard encountered (26).

30. All electric switches, controls, motors, and lights--if located in the blasting agent storage area--should conform to the requirements of the most recent edition of the National Electrical Code (26); otherwise, they should be outside the buildings. The frame of the mixer and all other equipment that may be used should be electrically bonded together and be provided with a continuous electrical path to ground.

31. The design of the mixer should minimize the possibility of frictional heating, compaction, and especially confinement. Bearings and gears should be protected against the accumulation of product dust and should preferably be of the outboard type.

32. Mixing and packaging equipment should be constructed of materials compatible with the fuel oil-ammonium nitrate composition. Zinc and chromium should be avoided because of their tendency to promote or accelerate decomposition of ammonium nitrate. Copper is also unsatisfactory because of corrosion problems.

33. An automatic water-deluge system with adequate capacity may be used to protect the mixing and packaging areas as well as any stocks of ammonium nitrate and blasting agent that may be in the plant.

34. Personnel limits should be established, posted, and enforced while operations involving blasting agents are underway in the mixing house.

35. Smoking, matches, open flames, spark-producing devices, and firearms (except firearms carried by guards when authorized) should not be permitted inside any building or facility used for the mixing of blasting agents or within 50 feet of such building or facility.

36. No cutting or welding should be done in the mixing or storage building while any AN-FO or ammonium nitrate is present in the building. The equipment and the area involved should be washed free of ammonium nitrate and other residues before any welding or cutting operations are conducted. Where feasible, the equipment should be removed from the building for repairs.

37. The floors and equipment of the mixing and packaging room should be cleaned frequently to prevent accumulation of ammonium nitrate or fuel oil and other carbonaceous materials. The entire mixing and packaging plant should be cleaned regularly to prevent excessive accumulation of dust.

38. Discarded empty ammonium nitrate bags should be disposed of daily in a safe manner, such as by burning in an isolated area.

39. The area surrounding a mixhouse should be kept free of rubbish, dry grass, or other combustible materials for not less than 50 feet in all directions.

40. Both equipment and handling procedures should be designed to prevent the introduction of foreign objects or materials.

41. Mixers, pumps, valves, and related equipment should be designed to permit regular and periodic flushing, cleaning, dismantling, and inspection.

42. All electric motors and generators should be provided with suitable overload protection devices. Electrical generators, motors, proportioning devices, and all other electrical enclosures should be electrically bonded. The grounding conductor to all such electrical equipment should be effectively bonded to the service-entrance ground connection and to all equipment ground connections in a manner that provides a continuous path to ground (26).

43. A daily visual inspection should be made of the mixing, conveying, and electrical equipment to establish that it is in good operating condition. A program of systematic maintenance should be conducted on a regular schedule. The recommendations in respect to conveyor belts should be observed in the mixing plants. (See recommendation 12.)

Storage of Blasting Agents

Magazines

44. Blasting agents, when stored separately from explosives, should be stored in either a type 5 (25) magazine (appendix C) or one of higher classification (lower number) except as specified in recommendation 45.

45. Semitrailer or full-trailer vans used for highway transportation of the AN-FO or water-gel compositions are satisfactory for storing these materials temporarily, provided the vans are theft resistant and are located in accordance with the American Table of Distances for Storage of Explosives (appendix A) with respect to inhabited buildings, passenger railways, and public highways and according to the Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives or Blasting Agents (appendix B) with respect to one another.

46. All storage facilities should be well-ventilated areas, posted with proper warning signs, and should be kept locked at all times except during the placement and removal of the blasting agents.

47. When blasting agents and explosives are stored in the same magazine, the entire mass should be treated as an explosive (25, 38).

48. The interior of buildings used for storing blasting agents should be kept clean and free of debris and empty containers.

49. Combustible materials (including flammable liquids), corrosive acids, chlorates, nitrites, or similar materials should not be kept in any structure used for storing blasting agents.

50. Smoking and open flames should not be permitted in or within 50 feet of storage buildings or vans containing blasting agents.

51. The area surrounding a storage facility should be kept free of rubbish, dry grass, or other materials of a combustible nature for not less than 50 feet in all directions.

52. Broken bags or cartridges of blasting agents should be cleaned up and removed from the premises.

53. Blasting agents in bags or in cartridges should be stacked to allow free access by authorized persons and to permit circulation of air between and around stacks. (This does not apply to temporary van storage.)

54. All cartridges, bags, or other containers of blasting agents should be labeled to indicate their contents. If ammonium nitrate bags are used as containers for the mixed blasting agent, they should be relabeled to show their content.

55. Prolonged storage of AN-FO and water-gel blasting agents should be avoided unless it has been demonstrated that segregation or evaporation of the oil does not occur in AN-FO or in the liquid phase in water gels. Stocks of water gels (slurries) which have been in storage for prolonged periods should be checked for sensitivity.

56. One or more natural draft vents should be provided. They should be covered with spark-arresting screens.

Bulk Storage Bins

57. The storage bin should meet the requirements of a type 5 magazine (appendix C) (25) and should be waterproof.

58. The storage bin should be constructed from materials compatible (29) with the product to be stored and built with sufficient strength to withstand the forces arising from product movement within the bin and accidental contact by trucks or other vehicles.

59. The bin discharge gate should be designed to provide a closure tight enough to prevent leakage of the stored product. Provision should also be made so that the gate can be locked.

60. Bin-loading manways or access hatches should be hinged or otherwise attached to the bin and be designed to permit locking.

61. Any electrically driven conveyors for loading or unloading bins should conform to the requirements of the latest edition of the National Electrical Code (26). They should be designed to minimize damage from corrosion and entry of ammonium nitrate or ammonium nitrate mixtures into the rollers.

62. Bins containing blasting agents should be located, with respect to inhabited buildings, passenger railroads, and public highways, in accordance with the American Table of Distances for Storage of Explosives (appendix A).

63. Bins containing blasting agents should be located, with respect to other blasting agent storage and explosive storage, in conformity with the Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives and Blasting Agents (appendix B).

64. Good housekeeping practices should be maintained around any bin containing ammonium nitrate of blasting agents. This includes keeping weeds and other combustible materials cleared within 50 feet of such bins. Accumulation of spilled product on the ground should be avoided.

Transportation

General

65. The regulations of the U.S. Department of Transportation (DOT) (10) governing the transportation of explosive materials over public highways should be considered as the minimum requirement.

66. Vehicles used for transporting blasting agents should be in a safe operating condition and should be driven by competent drivers who have a State driver's license valid for the type of vehicle driven. Drivers should also be familiar with applicable Federal, State, and local regulations and codes. These include the placarding requirments specified by DOT regulations (10).

67. No person should be permitted to ride upon, drive, load, or unload a vehicle containing blasting agents while smoking or under the influence of intoxicants, narcotics, or other dangerous drugs.

68. No matches, firearms, acids, or other corrosive liquids should be carried in the bed or body of any vehicle containing blasting agents.

69. No Class A, B, or C explosive should be carried with blasting agents in the bed or body of the vehicle unless the entire load (10) is given the classification of the explosive.

70. Detonators may be transported with blasting agents only under conditions meeting the requirements of the U.S. Department of Transportation (10). See also the standards proposed by IME (13).

71. Blasting agents should not be transported in any public vehicle carrying passengers for hire.

72. All trucks transporting blasting agents should carry two fire extinguishers having a combined rating of at least 2-A: 10-B: C. Two 15-pound or larger carbon dioxide fire extinguishers or two 4-pound or larger dry chemical extinguishers meet this requirement (27). These extinguishers are effective against ordinary truck fires, but not against fires involving blasting agents. Truck tire fires are difficult to extinguish and often reignite after appreciable lengths of time.

73. The provisions of this section should apply to off-highway private operations, as well as to all public highway movement.

74. The construction of any truck or van used for transporting blasting agents should include a means for low-pressure venting in case the truck and its contents are involved in a fire.

75. Any tarpaulin used to cover the load of blasting agents should be fire resistant.

Bulk Delivery and Mixing

76. The following recommendations for the bulk delivery of blasting agents are in addition to the general recommendations (Nos. 65 to 75).

77. Mobile processing equipment should not be used for mixing blasting agents while on public highways and other public thoroughfares.

78. If an auger is used to deliver the blasting agent from the truck, the shell of the auger should be selected so as to minimize buildup of pressure internally.

79. The body of a vehicle for transporting and mixing blasting agents in the bulk should be constructed of noncombustible materials compatible with ammonium nitrate.

80. Vehicles used to transport bulk, premixed blasting agents on highways should have closed bodies.

81. All moving parts of the mixing system should be designed to prevent a heat buildup. Shafts, axles, and augers which contact the product should have outboard bearings with 1-inch minimum clearance between the bearings and the outside of the product container. Particular attention must be given to the clearances on all moving parts.

82. The operator should be trained in the safe operation of the vehicle together with its mixing, conveying, and related equipment. He should be familiar with the commodities being delivered and the general procedure for handling emergency situations.

83. The transporting of blasting caps (detonators) may be permitted on bulk trucks provided that a special wood- or nonferrous-lined compartment is installed for the caps (13). Such blasting caps must be in shipping containers specified by the U.S. Department of Transportation (10).

84. No person should smoke, carry matches or any flame-producing device, or carry any firearms while in or about bulk vehicles effecting the mixing, transfer, or down-the-hole loading of blasting agents at or near the blasting site.

85. No welding or open flames should be used on or around any part of the delivery equipment unless it has been completely washed down to remove all fuel, oxidizer, and blasting agent.

86. Before welding or repairs to hollow shafts, the shaft should be thoroughly cleaned inside and out and vented with a minimum 1/2-inch-diameter opening.

87. When electric power is supplied by a self-contained motor generator located on the vehicle, the generator should be at a point separate from where the blasting agent is discharged (preferably on the side farthest away).

88. A positive-action parking brake which will set the wheel brakes on at least one axle should be provided on vehicles equipped with air brakes and should be used during bulk delivery operations. Wheel chocks should supplement parking brakes whenever conditions may require.

89. Vehicle fires involving the transportation of blasting agents should only be fought in the incipient state. If efforts to control the fire appear futile, the area should be evacuated.

Use of Blasting Agents

Blasting Operations--General

90. Explosive materials should be used only by, or under the close supervision of, persons holding the required permits and experienced in handling such hazardous products. No person should be allowed to handle explosive materials while under the influence of intoxicating liquors, narcotics, or other dangerous drugs.

91. Unauthorized or unnecessary personnel should not be present where explosive materials are being handled or used.

92. The relative safety of blasting agents may tempt the blasting crew to disregard normal rules for handling explosives. All normal practices and regulations for the safe handling of explosives should be observed. Smoking should not be tolerated within 50 feet of any loading operation or loaded hole.

93. Jet-pierced holes or holes expanded at the bottom (sprung holes) should not be loaded until they have had adequate time to cool.

94. Excess oil in AN-FO blasting agents should be avoided because it has a desensitizing effect on both the primer charge and the blasting agent and decreases the chance for proper initiation. Hard prills do not absorb oil readily and should be avoided.

95. Before entering a blast area, personnel should make certain that it is completely free of visible reddish-brown fumes, an indication of highly toxic concentrations of nitrogen dioxide gas.

96. Adequate priming should always be employed to guard against misfires, increased toxic fumes, and poor performance. The kind and amount of primer used should be governed by the sensitivity of the blasting agent, hole diameter, and other factors.

97. If there are any misfires while using cap and safety fuse, all persons should remain away from the charge for at least 1 hour. If electric blasting caps are used and a misfire occurs, this waiting period may be reduced to 30 minutes. Misfires should be handled under the direction of the person in charge of the blasting; all fuse and wires should be carefully traced, and search should be made for unexploded charges.

98. During pneumatic loading of blasting agents into blastholes primed with electric blasting caps or other static sensitive systems, operators should provide a positive grounding system to prevent the accumulation of static electricity.

99. Caution should be exercised in the movement of vehicles in the blasting area to avoid driving vehicles, or dragging hoses, over firing lines, cap wires, or explosive materials. In moving the vehicle, the driver should obtain the assistance of a second person to guide his movements.

100. The location chosen for blasting agent transfer from a support vehicle into the borehole loading vehicle should be away from the blasthole site when the boreholes are loaded or in the process of being loaded.

101. Surplus explosive materials should never be abandoned.

102. When blasting is done in congested areas or in close proximity to a structure, railway, highway, or any other installation that may be damaged, the blast should be covered, before firing, with a mat so constructed that it is capable of preventing fragments from being thrown.

103. Persons authorized to prepare explosive charges or conduct blasting operations should use every reasonable precaution, including but not limited to warning signals, flags, barricades, and woven wire mats, to insure the safety of the general public and workmen.

104. Surface blasting operations, except during unusual conditions, should be conducted during daylight hours.

105. Whenever blasting is being conducted in the vicinity of gas, electric, water, fire alarm, telephone, telegraph, and steam utilities, the blaster should notify the appropriate representatives of such utilities at least 24 hours in advance of blasting, specifying the location and intended time of such blasting. Verbal notice should be confirmed with written notice. In an emergency, this time limit may be waived.

106. Due precautions should be taken to prevent accidental discharge of electric blasting caps from current induced by radar, radio transmitters, lightning, adjacent powerlines, dust storms, or other sources of extraneous electricity (14).

107. All blasting operations should be suspended and personnel removed from the blasting area during the approach and progress of an electric storm.

Blasting Operations--Underground Mines (Additional Recommendations)

108. Blasting agents should be excluded from underground coal mining operations. No blasting agent is approved as permissible for such use.

109. Mixing of blasting agents should not be done underground.

110. In small-diameter holes, blasting agents should be loaded so as to provide a continuous column which completely fills the cross section of the borehole.

111. In loading AN-FO and other blasting agents, the potential hazard of static electricity causing premature initiation of the priming charge (containing a detonator) where pneumatic loading is employed should be evaluated in every type of blasting application before it is put into operation, and adequate steps should be taken to eliminate this hazard.[17]

112. Pneumatic equipment used for loading blasting agents should be firmly grounded to dissipate any static charges that may be generated during the loading operation.

113. Water lines, air lines, rails, or the permanent electrical grounding systems should not be used to ground pneumatic loading equipment.

114. Any hose used in connection with a loading machine should be of the semiconductive type, having a total resistance low enough to permit the dissipation of static electricity and high enough to limit the flow of stray electric currents to a safe level.[18] Wire-countered hose should not be used because of the potential hazard from stray electric currents.

115. All loading should be stopped immediately when the presence of static electricity or stray current is detected by a blasting galvanometer or other sensitive current-measuring device. The conditions should be remedied before loading is resumed.

116. Before holes containing water are charged with AN-FO, the water should be thoroughly removed. If water continues to flow into the boreholes, water-resistant explosives or water-resistant blasting agents should be used.

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[17] The hazard from static electricity increases as the relative humidity decreases. See references 21 and 31 for further discussion of the hazards of static electricity.

[18] On the basis of presently available information, it appears that semiconductive hose having a resistance of not less than 5,000 ohms per foot with no more than 2 megohms for the total length is satisfactory.

117. Every reasonable precaution should be exercised to exclude moisture from dry blasting agents. Water decreases the sensitivity of AN-FO mixtures and increases the production of toxic fumes on detonation.

118. Although information on the physiological effect of both ammonium nitrate and fuel oil is limited, the possibility of irritating effects or other health hazards should not be overlooked. Protective equipment such as dust respirators, gloves, and protective clothing should be used where a need is indicated.

119. Positive ventilation of the mine working place should be provided to remove toxic fumes from blasting operations.

120. Following blasting, a place should not be mucked out until the concentration of toxic gases is reduced to a safe level.

Water Gels (Slurries)

121. All safety precautions given for blasting agents and explosives should be observed in the preparation, handling, and use of water gels. However, water gels are prepared in such a wide range of compositions that some additional precautions are necessary.

122. Unless otherwise stated, water gels (slurries) should be manufactured, stored, transported, and used in the same manner as explosives or blasting agents depending on their composition and sensitivity or classification by the U.S. Department of Transportation.

123. Water gels containing no substance classified as an explosive, but which can be detonated by means specified in the section entitled "Sensitivity Tests" (p. 6), should be considered an explosive and handled in accordance with that classification.

124. Water gels containing no material classified as an explosive and which prove negative in the "Sensitivity Tests" should be considered as a blasting agent. The following recommendations apply to slurry blasting agents.

125. Buildings or other facilities used for mixing water gels should be located with respect to inhabited buildings, passenger railroads, and public highways in accordance with the American Table of Distances for Storage of Explosives (appendix A).

126. In the manufacture of water gels (slurries), all applicable sections of recommendations 13 through 43 should be applied.

127. The compatibility of chemicals should be determined before any new slurry compositions are prepared.

128. Good housekeeping is of primary importance around a water-gel mix plant. Chemical spills should be cleaned up promptly.

129. Peroxides, nitrites, and chlorates should never be used.

130. Water gels (slurries) should be stored in accordance with all applicable provisions of recommendations 44 through 64.

131. Many slurries have poor storage characteristics. Older stocks should be checked for sensitivity before use to avoid misfires (see recommendation 55).

132. Recommendations 65 through 120 provide guidelines for the handling and use of water gels.

133. Since the sensitivity of many slurries varies appreciably with temperature, care should be taken when using other than normal temperatures. At elevated temperatures sometimes encountered in transportation and in the field, non-cap-sensitive slurries may become cap sensitive, and the product should be handled as an explosive. At relatively low temperatures, propagation failures may result in misfires. It is recommended that the user confer with the manufacturer to determine the appropriate composition of the slurry and the required primers for use at abnormally low temperatures.

134. Relatively little is known about the behavior of water gels in massive fires. Therefore, every effort should be made to protect against large-scale fires.

135. Because of the variation in sensitivity with relatively small changes in composition, the user should cooperate closely with the manufacturer to establish proper storage and handling procedures and to determine initiation requirements.

136. Adequate priming should always be employed to prevent misfires, poor performance, and an overall decrease in blasting safety.

RECOMMENDATION COVERING CAP-SENSITIVE COMPOSITIONS

If, during the preparation of a blasting agent, a cap-sensitive composition should be obtained, such a composition is not a blasting agent and should be treated in the same way as dynamite and other explosives in every regard.

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APPENDIX A.--AMERICAN TABLE OF DISTANCES FOR STORAGE OF EXPLOSIVES (12, 25)

(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	110	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

1. Explosive material, see page 4.

2. Explosive, see page 4.

3. Blasting agent, see page 3.

4. Detonator, see page 4.

5. Magazine, see page 5.

6. Barricades means that a building containing explosives is effectively screened from a magazine, building, railway, or highway by a natural or artificial mound of earth at least 3 feet in thickness and of such height that a straight line from the top of any sidewall of the building, or to a point 12 feet above the center of a railway or highway, will pass through such barricade.

7. Inhabited building, see page 5.

8. Railway, see page 5.

9. Highway, see page 5.

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

11. This table applies only to the manufacture and permanent storage of commercial explosives. It is not applicable to transportation of explosives or any handling or temporary storage necessary or incident thereto. It is not intended to apply to bombs, projectiles, or other heavily encased explosives.

12. All types of blasting caps in strengths through No. 8 cap should be rated at 1-1/2 pounds of explosives per 1,000 caps. For strengths higher than No. 8 cap, consult the manufacturer.

13. For quantity and distance purposes, detonating cord of 50 to 60 grains per foot should be calculated as equivalent to 9 pounds of high explosives per 1,000 feet. Heavier or lighter core loads should be rated proportionately.

APPENDIX B.--TABLE OF RECOMMENDED SEPARATION DISTANCES OF AMMONIUM NITRATE AND BLASTING AGENTS FROM EXPLOSIVES OR BLASTING AGENTS* [1] [2]
(16, 28-29, 39-40)

Donor weight		Minimum separation distance of receptor when barricaded[3] (feet)		Minimum thickness of artificial barricades[6] (inches)
Pounds over	Pounds not over	Ammonium nitrate[4]	Blasting agent[5]	
	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

See footnotes on page 30.

*This table appears in Recommended Separation Distances of Ammonium Nitrate and Blasting Agents From Explosives or Blasting Agents, adopted as an NFPA Official Standard (No. 492) in 1968. For a discussion of the derivation of the table and examples of how it is applied to actual storage situations, see reference 28.

[1]These are the 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 distances of explosives or blasting agents, one-half the mass of the ammonium nitrate should be included in the mass of the donor.

[2]For determining the distances to be maintained from inhabited buildings, passenger railways, and public highways, use appendix A, American Table of Distances for Storage of Explosives. Ammonium nitrate, when stored with blasting agents or explosives, may be counted at one-half its actual weight because its blast effect is lower.

[3]When the ammonium nitrate and/or blasting agent is not barricaded, the distances shown in the table should be multiplied by 6. 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 have enclosed the donor. Where storage is in bullet resistant magazines 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 for Storage of Explosives (appendix A) are not required.

[4]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,** and ammonium nitrate failing to pass said test should be stored as a blasting agent.

**U.S. Fertilizer Institute. Report of the Technical Test Group of Ammonium Nitrate Subcommittee of the Fertilizer Institute. Washington, D.C., 1971, 11 pp.

[5]These distances apply to nitro-carbo-nitrates and blasting agents which pass the insensitivity test prescribed in the U.S. Department of Transportation Regulations (10).

[6]Earth, sand dikes, and enclosures filled with the prescribed minimum thickness of earth and 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.

APPENDIX C.--TYPES OF MAGAZINES (17, 25, 38)

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 nonelectric blasting caps. Type 1 magazines are bullet resistant, fire resistant, theft resistant, and weather resistant.

Type 2 magazine.--A portable or mobile magazine 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 nonelectric 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 the 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 feet 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.

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