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WATER-BEARING EXPLOSIVE CONTAINING PROTEIN AND NITROGEN-BASE SALT

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ABSTRACT OF THE DISCLOSURE

Water-bearing explosives containing inorganic oxidizing salt, fuel, thickener, proteinaceous material soluble in the water-bearing explosive and nitrogen-base salt.

BACKGROUND OF THE INVENTION

This invention relates to water-bearing explosive compositions and, more particularly, to such compositions containing inorganic oxidizing salt, fuel, proteinaceous material, nitrogen-base salt and thickener.

Water-bearing explosives have found wide acceptance in recent years. These products typically comprise an oxidizing component, usually predominantly ammonium nitrate, and a fuel component dispersed or dissolved in an aqueous medium which is normally thickened or gelled. The high strength, high velocity, water-bearing explosives used where premium performance is required generally contain a major amount of high explosive, for example, TNT. Furthermore, use of the aforementioned water-bearing explosives has been successful but not entirely satisfactory. Water-bearing explosives in the form of a slurry or gely harden on storage. Hardening detrimentally affects, among other things, the sensitivity and reliability of detonation of the explosive composition. The addition of certain proteinaceous materials to such explosive compositions, as disclosed in applicant's recently issued Pat. 3,400,026, has substantially reduced hardening in water-bearing explosive compositions after long periods of storage and/or even after it remains in the borehole at low temperatures for a number of days before being detonated. Although such protein-containing explosive products have resulted in a significant advance in the explosive field and their performance on the range is quite satisfactory, a need still exists for high strength, water-bearing explosive compositions, especially foamed compositions, that can be reliably detonated under the most adverse conditions encountered in the field and, if foamed, retain their foamed structure, are highly brisant and yet, may, but need not, contain explosive sensitizers.

SUMMARY OF THE INVENTION

The present invention provides an improvement in water-bearing explosive compositions comprising inorganic oxidizing salt, fuel, thickener and water, the improvement comprising said explosive composition containing:

(a) At least about 0.001%, preferably at least about 0.01%, based on the weight of the total composition, proteinaceous material of which at least about 10% of the proteinaceous material added is soluble in the explosive composition of pH 3 to 10, and

(b) From 3 to 90%, based on the weight of the total composition, of at least one nitrogen-base salt of an inorganic oxidizing acid and a base selected from the group consisting of (1) acyclic nitrogen bases having no more than two hydrogen atoms bonded to the basic nitrogen and up to three carbon atoms per basic nitrogen, and (2) phenylamines, said nitrogen-base salt having an oxygen balance more positive than —150%.

The combination of proteinaceous material with nitrogen-base salt results in water-bearing explosive compositions having exceptional physical and chemical properties. The compositions are soft and pliable after long periods of storage, even after they remain in a borehole for days or weeks under adverse conditions of low temperature. The compositions are highly brisant, have high detonation velocity, can be produced in a wide range of densities and, therefore, are particularly useful under hard shooting conditions. The explosives, when foamed, retain their foamed structure during pumping and while they remain in a borehole. Quite surprisingly, it appears that the nitrogen-base salt also functions as a foam stabilizer and this has the added advantage of requiring only small amounts of protein and nitrogen-base salt to produce a foamed, highly brisant, sensitive, water-bearing explosive.

The proteinaceous material used in the explosive composition is any protein or protein derivative, such as those obtained by hydrolysis, amidation, acylation or other chemical reaction applied to a protein. Simple proteins are preferred and especially albuments, hydrolyzed milk protein, and extracted collagen. Since the nitrogen-base salt functions in combination with the proteinaceous material as a stabilizing agent, among other things, when foamed slurry explosives are made, excellent results have been obtained when no more than only about 0.001%, preferably 0.01 to 0.1%, proteinaceous material is added to the explosive composition.

Another essential ingredient of the explosive composition is the nitrogen-base salt which is a salt of an amine. The nitrogen-base salt comprises at least one salt of an inorganic oxidizing acid, preferably nitric acid, and a base selected from the group consisting of acyclic nitrogen bases having no more than two hydrogen atoms bonded to the basic nitrogen and up to 3 carbon atoms per basic nitrogen, and phenylamine. The amount of nitrogen-base salt incorporated in the slurry explosive is from about 3 to 90%, preferably 5 to 40%, and most preferably 10 to 25%, based on the weight of the total composition, and said salt has an oxygen balance more positive than about —150%.

The length of time required to manufacture these water-bearing explosives is substantially less than the time required to formulate like water-bearing explosives. The process of the present invention comprises blending an inorganic oxidizing salt, e.g. ammonium nitrate, with proteinaceous material, e.g. egg albumen, in a slurry. If a foamed product is desired, the nitrogen-base salt and proteinaceous material are added to the mix and the mixture agitateed, with or without the addition of gas, e.g., air, until foaming occurs. Explosives, when added, can be incorporated in the composition before or after foaming. Thickener is added alone or admixed with an additional amount of inorganic oxidizing salt and the mixture allowed to hydrate. Fuels such as sulfur and carbon are added during hydration and the thickened mixture aids in dispersing these relatively fine solids. If desired, a solid inorganic oxidizing salt, e.g., ammonium nitrate prills, can be added during the hydration period. Subsequent to hydration, and just prior to packaging or pumping the explosive, a crosslinking agent is added to thicken the water-bearing explosive which is then packaged or pumped to a borehole. Such combination of ingredients can be blended with the oxidizing fuel within a fraction of the time normally required for mixing known water-bearing explosives. The combination of proteinaceous material and nitrogen-base salt need only be added in very small quantities, and yet the resulting water-bearing explosive compositions have, among other things, premium explosive performance, sensitivity and high brisance associated with high explosive sensitized water-bearing slurry explosives. Since only small amounts of proteinaceous material

and nitrogen-base salt are needed to produce the desired effects, the combination of ingredients react to produce a synergistic effect on the amount of protein needed in the composition. Water-bearing explosive compositions of the present invention have velocities exceeding 3000 meters per second, can be foamed to form low density, e.g., about 0.7 to 1.4 g./cc., explosives and still can be reliably detonated.

PREFERRED EMBODDIMENTS OF THE INVENTION

The water-bearing explosive compositions of the present invention comprise inorganic oxidizing salt, proteinaceous material that the soluble in the aqueous explosive composition of pH 3 to 10, nitrogen-base salt and thickening agent. The proteinaceous material, which includes both protein and protein derivatives, used in the present explosive composition must be soluble in the aqueous explosive composition that has a pH of from 3 to 10. By soluble proteinaceous material is meant at least about 10% by weight of the amount of said proteinaceous material added to the aqueous explosive composition dissolves therein and the remainder of the proteinaceous material, if any, is water-dispersible. As mentioned above, at least 0.001% proteinaceous material, preferably at least 0.01%, is incorporated into the water-bearing explosive in order to realize beneficial effects. Although relatively large amounts of proteinaceous material can be incorporated in the explosive composition, no added advantages result from the use of more than about 10%, and usually less than about 3% protein is adequate. Quite surprisingly, due to the presence of the nitrogen-base salt, foamed explosive compositions can be prepared that have detonation velocities of about 3500 m./sec. to 5000 m./sec. in air at about 42° F. when only about 0.01 to 0.1% proteinaceous material is incorporated in the slurry composition. The action of the nitrogen-base salt on the proteinaceous material produces a valuable synergistic effect, thus greatly reducing the cost, among other things, of the water-bearing explosive. Representative proteinaceous materials that are used in the invention include: simple proteins, that is proteins that yield, on complete hydrolysis, chiefly alpha amino acids; conjugated proteins, that is, compounds of a protein with some other molecule or molecules referred to as a prosthetic group; and protein derivatives, i.e., derived proteins, namely products formed by the action of heat or other physical forces, or by hydrolytic agents, such as denatured proteins or peptides. Preferably, the molecular weight of the proteinaceous material is generally within the range of from about 5000 to 200,000 and usually it is not over 100,000.

As is evident from the above and the specific examples that follow, the particular source of proteinaceous material is not critical. Whether the protein is naturally occurring or is a derivative is immaterial, provided it is soluble to the extent indicated in the explosive composition and remains soluble during storage. Representative simple proteins that are used in the invention are albumens such as ovalbumin and lactalbumin, occurring respectively, in egg white and milk; globulins such as ovoglobulin and lactoglobulin, conjugated proteins such as the glycoprotein musin. Representative protein derivatives that are incorporated into the explosive composition are partially hydrolyzed milk protein and extracted collagen derivatives. Other suitable naturally occurring animal and vegetable proteins that can be used in the explosive compositions are, for example, cottonseed protein, fishmeal protein, soybean and nonfat milk solids. Especially suitable proteinaceous materials that are used, in combination with the nitrogen-base salt, are albumin, extracted collagen and soybean protein. Examples of some specific commercially available proteinaceous materials, soluble to the extent indicated, that can be used in the invention are fluid colloids 2225 and 2226 and colloid 5V (dry) manufactured by Swift & Co., which are extracted and

refined proteins of a collagen source, having a molecular weight of at least 2,000 and a pH of about 6, N–Z amines which are pancreatic digests of casein and manufactured by Sheffield Chemical. A large number of protein derivatives are commercially available, and with consideration as to their solubility and preferably at least a minimum degree of observable foamability, when added to the slurry and agitated, such proteins and derivatives thereof are applicable for use in the present aqueous explosive compositions. Of those described, egg albumin is especially preferred due to its wide range of solubility and its exceptional ability both in producing and maintaining a foamed structure. For ease of handling, dry powdered egg whites manufactured by Henningson & Co. are particularly suitable for incorporation in the explosive compositions of the present invention. Preferably, the proteinaceous material is foamable, i.e., the volume of the explosive composition is increased at least 5%, and generally not more than about 50%, when agitated with said material. However, it should be understood that although a foamed composition is preferable, it is not absolutely necessary. Even if the explosive composition is not foamed or if foaming action of the proteinaceous material on the explosive composition is kept at a minimum by, for example, minimal agitation of ingredients, the proteinaceous materials, in combination with the nitrogen-base salts, are still found to improve the properties of aqueous blasting agents so that they are soft and pliable, highly brisant and capable of detonation at low temperatures. Yet, the foaming action produced by the combination of the proteinaceous material and nitrogen-base salt when sufficiently agitated, as described herein, or by any of the conventional agitation methods used in the manufacture of water-bearing explosive compositions, serves to introduce and entrain small bubbles of a gas, commonly air, in the gel structure, thus making the explosive composition especially sensitive to detonation. It is believed that the proteinaceous material functions as an effective foaming agent for the water-bearing explosive composition and the nitrogen-base salt functions as a foam stabilizer. The dimensions of the gas bubbles in the foamed slurry explosive are small, e.g., generally they have a diameter not larger than about 3.5 mm. and are substantially uniformly distributed throughout the composition so as to preclude any discontinuities which might result in failures in detonation. The foaming which results from the agitation or turbulent mixing of the proteinaceous material in the explosive composition precludes the necessity of introducing an additional gas into the composition or even to forego the use of more expensive high speed mixers. It is understood, however, that any of these supplementary methods for introducing air or other gas into the compositions, as well as the use of low-density fuels which serve to lower the product density to a desired level, can be employed in formulating the explosive compositions of this invention. When the explosive composition is foamed usually about 5 to 50%, and preferably about 10 to 40%, by volume of the composition comprises gas, e.g., air, entrained in small cavities or bubbles. Densities of explosive compositions, both foamed and nonfoamed, are about from 0.7 to 2.0 g./cc. and preferably about from 0.8 to 1.4 g./cc. the density tailored, to some extent, on the contemplated use of the explosive composition. The nitrogen-base salts employed in this invention can be derived from inorganic bases such as hydrazines but preferably they are derived from amines, especially aliphatic amines and phenyl amines. Phenyl amines, as used herein, refers to compounds having one carbocyclic aromatic ring to which is bonded at least one, and preferably one or two, primary amino groups. Salts of primary, secondary and tertiary amines meeting the aforementioned requirements can be used and the base moiety can bear substituents other than carbon, hydrogen and the base nitrogen that are inert with the system. Excellent explosive properties and stability of foamed compositions of the products of this in-

vention result particularly when salts of saturated aliphatic amines of up to three carbons are used. The oxidizing acid moiety can be that of any of the strong inorganic oxidizing acids, preferably mineral acids, such as, for example, salts of nitric, nitrous, chloric, and perchloric acids. Those acids having an oxygen balance of at least about +10% are preferred. Nitrates are particularly preferred because of their ready availability and excellent sensitizing effect.

Representative examples of nitrogen-base salts incorporated in the present explosive include inorganic salts such as hydrazine nitrate, dinitrate, and perchlorate, salts of aliphatic amines such as monomethylamine nitrate, nitrite, chlorate and perchlorate, ethylenediamine dinitrate and diperchlorate, dimethylamine nitrate, trimethylamine nitrate, ethylamine nitrate, propylamine nitrate, ethanolamine nitrate, guanidine nitrate, urea nitrate and salts of phenyl amines such as aniline nitrate, chlorate and perchlorate, p-chloroaniline nitrate and phenylenediamine dinitrate. Of the aforementioned salts saturated aliphatic amine nitrates containing up to three carbon atoms, for example, monomethylamine nitrate, trimethylamine nitrate, ethylenediamine dinitrate and ethanolamine nitrate are particularly preferred because of the case of formulation of explosives therewith and the outstanding explosive properties including velocity and strength of the resulting products. Mixtures of the aforementioned salts can be used as well as mixtures of one or more of such salts with other similar salts having an oxygen balance more positive than —150%, for example, cyclohexylamine nitrate and diethylamine nitrate. Normally, in such salt mixtures, the overall oxygen balance of the salt should be more positive than —150%.

The nitrogen-base salts can be incorporated in the explosives of this invention in substantially pure form; however, they can be provided as a crude reaction mixture of the base substantially neutralized with the oxidizing acid, either formed separately in aqueous medium then blended with the remainder of the constituents of the explosive or formed in situ in the presence of one or more of such constituents.

A characteristic feature of the explosives of this invention is that they require none of the conventional explosive sensitizers or metallic fuels characteristically required for performance in high velocity, high strength water-bearing explosives. Thus, although metals such as finely-divided aluminum or explosives such as trinitrotoluene, pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, smokeless powder or mixtures thereof such as pentolite (PETN/TNT) and composition B (TNT/RDX) can be used as sensitizing components, they are not required.

The total amount of nitrogen-base salt used varies with the particular composition and can range from 3 to 90% by weight of the total composition. In general, the amount of salt decreases as the amount of water used is reduced and as the amount, if any, of auxiliary sensitizer is increased or if a lower strength product is desired. Preferably, about 5 to 40% of nitrogen-base salt is included in the slurry explosive. Depending on its oxygen balance, the amine salts function as sensitizer and, also, are a part of the oxidizing or fuel component, normally the latter. Most importantly, the amine salts function as a sensitizing element and stabilizing agent for the proteinaceous material so that highly brisant, stable foams are produced that remain soft and pliable when small amounts, e.g., about 0.1% of protein, are used.

In its broad aspects the improvement of this invention can be applied to any of the known general types of inorganic salt based water-bearing explosives having a continuous phase comprising water, and the explosives of this invention can contain the conventional ingredients normally employed in such water-bearing explosives in the amounts generally used therein. As the primary oxidizing ingredients, the compositions of this invention usually contain at least about 20% by weight of inorganic oxidizing salt. Examples of inorganic oxidizing salts include ammonium, alkali metal and alkaline earth metal nitrates and perchlorates as well as mixtures of two or more such salts. Examples of such salts are ammonium nitrate, ammonium perchlorate, sodium nitrate, sodium perchlorate, potassium nitrate, potassium perchlorate, magnesium nitrate, magnesium perchlorate and calcium nitrate. Preferably, the aqueous phase in the compositions contains a substantial portion of oxidizing salt, for example, 40 to 70% by weight thereof at room temperature. Inorganic oxidizing salt mixtures containing at least about 50% by weight of ammonium nitrate and at least 5% by weight of sodium nitrate are particularly preferred.

The nitrogen-base salt and the proteinaceous material, alone or together, can provide substantially all of the fuel component. However, generally, it is desirable to include one or more of the conventional fuels as auxiliary fuels. Auxiliary fuel or fuels used in the compositions of this invention can be varied widely, provided that in the composition in which any particular fuel is used, the fuel is stable, that is, prior to detonation, during preparation and storage, the fuel is chemically inert with the system. In addition to the aforementioned explosive sensitizers, examples of fuels are sulfur, carbonaceous nonexplosive fuels such as finely-divided coal and other forms of finely-divided carbon and solid carbonaceous vegetable products such as cornstarch, wood pulp, sugar, ivory nut meal and bagasse. Examples of auxiliary metallic fuels are aluminum and iron, and alloys, of such metals such as aluminum-magnesium alloys, ferrosilicon, ferrophosphorus, as well as mixtures of the aforementioned metals and alloys. Preferably, the total amount of fuel is adjusted so that the total composition has an oxygen balance of about from —25 to +10% and, except for those compositions containing the aforementioned heavier metallic fuels such as ferrophosphorus and ferrosilicon, preferably the oxygen balance is between about —10 and +10%.

As is conventional in water-bearing explosives, the compositions of this invention contain at least about 5% by weight water. The water-bearing compositions to which this invention is directed generally contain less than about 50% by weight water, and preferably, on the order of about 10 to 30% by weight water based on the total composition.

Conventional materials also can be used to thicken or gel the aqueous phase. Of such materials, galactomannans, especially guar gum, are particularly preferred. Usually about from 0.1 to 5% of such galactomannan based on the total weight of composition is employed. Galactomannans also preferably are crosslinked with an oxidizing agent such as an alkali metal dichromate either alone or in combination with a soluble antimony compound.

As previously indicated, the slurry explosive compositions of this invention are preferably prepared by blending proteinaceous material with a concentrated substantially saturated solution of the oxidizing components and nitrogen-base salt. Thickeners are added and, optionally, additives such as auxiliary fuels and sensitizers, e.g. high explosives or smokeless powder, can be blended with the slurry composition. Finally, crosslinking agents are added just prior to packing, in the case of packaged products, and just prior to loading into the borehole, in the case of pump truck products. Alternately, the nitrogen-base salt can be formed in situ in the presence of other ingredients of the explosive, particularly the oxidizing component. With ammonium nitrate-base explosives, preferably the pH is adjusted to about from 4 to 7. Water content can conventionally be controlled by the concentration of the oxidizing acid added to neutralize the nitrogen base.

In the following examples which further illustrate this invention parts and percentages are by weight unless otherwise indicated. In the table, monomethylamine nitrate is indicated as MMAN, JAG 180 designates guar gum, AN is ammonium nitrate, SN is sodium nitrate and FRAN is free running ammonium nitrate.

EXAMPLES 1 TO 7

Water-bearing exposives of the compositions shown in Table I are prepared in a mixer from the materials listed by the following sequence of steps, Ammonium nitrate (75% aqueous solution of ammonium nitrate) is charged to a steam jacketed mixer and heated to 150° to 200° F. The amine nitrate, e.g., monomethylamine nitrate, is added to the ammonium nitrate solution and dissolves therein. Proteinaceous material, e.g., egg albumin, is premixed with sodium nitrate and added to the ammonium nitrate-containing mixture. The mixture is agitated thereby forming a foam. Guar gum is added and the foamed mixture allowed to hydrate for about 3 to 4 minutes at 140 to 150° F. thus forming a thick mass. Sulfur, carbon, sugar, or other optional additives such as aluminum, are added to the foamed mixture during the hydration period. If used, free-running ammonium nitrate or ammonium nitrate prills can be added during the hydration period together with a high explosive sensitizer. After hydration and just prior to packaging or pumping to the borehole, a crosslinking agent, for example 250 cc. of 5% aqueous potassium antimony tartrate per 100 pounds of mix is added to further thicken the slurry exposive.

TABLE I

Examples	1	2	3	4	5	6	7
75% aq. AN	56.0	61.1	63.1	58.15	58.1	55.0	54.0
FRAN	4.0	4.0	3.0	4.0	4.0	4.0	2.0
76% aq. MMAN	13.0	10.0	7.0				
86% aq. MMAN				12.0	12.0	10.0	14.0
SN	16.0	16.0	16.0	15.0	15.0	15.0	15.0
Sugar	2.0		2.0	2.0	2.0	2.0	
Sulfur	5.0	5.0	5.0	5.0	5.0	5.0	2.0
Coal	3.0	3.0	3.0	3.0	3.0	3.0	2.0
Aluminum						5.0	
TNT							10.0
Egg albumen	0.2	0.2	0.1	0.05	0.1	0.1	0.1
JAG 180	0.8	0.8	0.8	0.8	0.8	0.9	0.9
Density	Floats	1.22	1.20	1.12	1.15	1.13	1.28
Velocity, m./sec.	3,544	4,747	4,010	4,010	4,110	4,354	4,482
6" diam, 38–42° F		5,080	4,747				

EXAMPLES 8 TO 17

The procedure described above was repeated with the ingredients listed hereinbelow to form a protein-amine nitrate containing slurry explosive.

TABLE II

Examples	8	9	10	11	12	13	14	15	16	17
75% aq. AN	52.0	54.0	56.1	56.1	56.1	58.0	50.0	54.0	50.0	47.05
FRAN	10.0	8.0	4.0	4.0	4.0	4.0	8.0	4.0	8.0	
86% aq. MMAN		6.0					16.0	16.0	16.0	35.0
SN	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Sugar			2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Sulfur	5.0	5.0	3.0	3.0	3.0	3.0	5.0	5.0	5.0	
Coal	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Ethanolamine nitrate			16.0							
Dimethylamine nitrate				16.0						
Trimethylamine nitrate					16.0					
Ethylenediamine dinitrate	14.0	8.0								
Aniline nitrate						14.0				
Egg albumen	0.2	0.2	0.1	0.1	0.1	0.2				0.05
Extracted collagen								0.2		
Hydrolyzed milk protein							0.2			
Soybean protein									0.1	
JAG 180	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9
Velocity, m./sec., 6" diam, 38–42° F	3,628	4,010	3,950	3,850	3,775	3,750	3,925	4,005	3,950	4,916
Lead block depression			2½"	2 9/16"	2¼"	2¾"				
Density	1.10	1.10	1.12	1.12	1.15	1.12	1.10	1.10	1.09	1.33

I claim:

1. In a water-bearing explosive composition comprising inorganic oxidizing salt, fuel, thickener and water, the improvement comprising said explosive composition containing:

(a) at least about 0.001%, based on the weight of the total composition, of proteinaceous material of which at least about 10% of said material is soluble in the explosive composition of pH 3 to 10, and

(b) from 3 to 90%, based on the weight of the total composition, of at least one nitrogen-base salt of an inorganic oxidizing acid and a base selected from the group consisting of (1) acyclic nitrogen bases having no more than two hydrogen atoms bonded to the basic nitrogen and up to three carbon atoms per basic nitrogen, and (2) phenyl amines, said nitrogen-base salt having an oxygen balance more positive than about −150%.

2. An explosive composition of claim **1** foamed.

3. An explosive composition of claim **1** wherein the proteinaceous material is a simple protein.

4. An explosive composition of claim **3** containing at least 0.01% simple protein.

5. An explosive composition of claim **3** wherein the nitrogen-base salt component is a salt of an amine.

6. An explosive composition of claim **5** wherein the nitrogen-base salt component is at least one salt of nitric acid and an amine.

7. An explosive composition of claim **6** wherein said nitrogen-base salt component comprises at least one salt of an aliphatic amine and nitric acid.

8. An explosive composition of claim **7** foamed.

9. An explosive composition of claim **7** wherein said proteinaceous material is an albumen.

10. An explosive composition of claim **9** wherein said nitrogen-base salt component is a saturated aliphatic amine nitrate containing up to three carbon atoms.

11. An explosive composition of claim **10** wherein the albumen is egg albumen.

12. An explosive composition of claim **11** containing 0.01 to 0.1% egg albumen.

13. An explosive composition of claim **12** foamed.

14. A foamed explosive composition of claim **11** wherein the nitrogen-base salt component is monomethylamine nitrate.

15. An explosive composition of claim **14** containing 5 to 40% monomethylamine nitrate.

16. A foamed explosive composition of claim **11** wherein the nitrogen-base salt component is ethylenediamine dinitrate.

17. An explosive composition of claim **16** containing 5 to 40% ethylenediamine dinitrate.

18. A foamed explosive composition of claim **11** wherein the nitrogen-base salt component is trimethylamine nitrate.

19. A foamed explosive composition of claim **11** wherein the nitrogen-base salt component is ethanolamine nitrate.

20. A foamed explosive composition of claim 11 wherein the nitrogen-base salt component is dimethylamine nitrate.

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