United States Patent Office 3,574,011 Patented Apr. 6, 1971

3,574,011

AQUEOUS SLURRIED EXPLOSIVE OF IMPROVED POURABILITY CONTAINING A POLYACRYLAMIDE THICKENER AND SODIUM PERCHLORATE

Herbert K. Knight, Jr., Flanders, N.J., assignor to Hercules Incorporated, Wilmington, Del.

No Drawing. Continuation-in-part of application Ser. No. 694,097, Dec. 28, 1967. This appplication Dec. 16, 1968, Ser. No. 784,210

Int. Cl. C06b 11/00

U.S. Cl. 149—70 20 Claims

ABSTRACT OF THE DISCLOSURE

Inorganic oxidizer salt explosive compositions of the aqueous slurry type having improved low temperature flow properties are provided, which contain a polyacrylamide thickener system in combination with 50–90 weight percent total aqueous phase, sodium perchlorate as at least 75 percent of the total inorganic oxidizer salt, and said aqueous phase containing said sodium perchlorate dissolved therein in a weight ratio to water of from 1:1 to 1.5:1.

This application is a continuation-in-part of my copending application, Ser. No. 694,097, filed Dec. 28, 1967 now U. S. Pat. 3,442,729.

This invention relates to improved pourable aqueous slurry explosive compositions of the inorganic oxidizer salt type in which sodium perchlorate is at least a major proportion of the inorganic oxidizer salt component, and the thickener component is of the polyacrylamide type. In one aspect this invention relates to explosive compositions, above described, which exhibit improved flowability at ambient winter temperatures as low as —20° F. and lower, and which have improved sensitivity, density and energy characteristics advantageously applied to loading at high loading density values, particularly under the above described temperature conditions.

Inorganic oxidizer salt explosive compositions of the aqueous slurry type have been extensively utilized in recent years. These compositions comprise an inorganic oxidizer salt, water, a sensitizer, and a thickening agent in amount at least sufficient to impart consistency to the slurry to prevent settling of the ingredients. Exemplary of these compositions are those disclosed and claimed in U.S. Pat. 3,235,425 and others.

Dependent on such variables as choices of thickener component, degree of cross-linking, if any, of the thickener, concentration of inorganic salt, fuels, sensitizer, and the like, the extent of flowability of the slurry may be varied. In substantially all instances choice of thickener, in pourable slurries, has been the determining factor and it has always been present in at least an amount sufficient to cause all ingredients to be suspended in the slurry, but to still permit sufficient fluidity to enable the slurry to be pumped, or alternatively bagged in sufficiently flowable form for emplacement in the borehole at a suitable loading density.

Pourability of slurries of the type above described is of course of major importance to the handling and emplacement of the explosive at maximum loading density. However, at temperatures, say, in the order of 30° F. and lower, the inorganic oxidizer salt component often undergoes crystallization to cause the slurry to set up to a solid and thereby become nonpourable, even at temperatures above those at which the water component would normally freeze.

Although various inorganic oxidizer salts, and mixtures thereof, have been utilized as the inorganic oxidizer salt component, ammonium nitrate and ammonium nitrate/sodium nitrate mixtures have been utilized as such in substantially all instances, albeit sometimes in admixture with other alkali metal and alkalin earth metal salts including perchlorates, other nitrates, and the like. In some instances the latter type salts have been used in absence of ammonium nitrate. However, these slurries have shown unsatisfactory pourability characteristics at winter temperatures. Indeed, in some instances the crystallization, or solidification, has taken place at temperatures of from 30–60° F., and higher, dependent upon the particular system. For example, at about 30° F., a slurry comprising, on a weight basis, about 50 percent ammonium nitrate, 15 percent sodium nitrate, 16 percent water, 18 percent sensitizer and 1.0 percent guar gum (with or without being crosslinked) will undergo crystallization of the oxidizer salt to cause solidification of the slurry, albeit the solidification is significantly above that of the freezing point of water in that particular system.

Inasmuch as winter temperatures in the order of 0–10° F., and lower, are often encountered during blasting operations, and pourability of conventional ammonium nitrate slurries under those conditions is substantially nil, various routes to improved pourability have been proposed and involve choice of thickener, the use of additive materials, and the like. Thus, in each of U.S. Pats. 3,097,120; 3,097,121; 3,321,344; 3,341,383; and 3,355,336, and in the above identified parent application, are defined certain polyacrylamide type thickener systems for pourable slurries.

This invention is concerned with slurry type explosives, above described, having improved low temperature flowability, among other improved properties, as result of choice of inorganic oxidizer salt component in combination with a polyacrylamide type thickener.

In accordance with the invention, inorganic oxidizer salt explosives of the aqueous slurry type having improved low-temperature flowability are provided, which contain a polyacrylamide type thickener component, from 50 to 90 weight percent total aqueous phase, and sodium perchlorate as at least 75 weight percent of the oxidizer salt component; and said aqueous phase containing said sodium perchlorate dissolved therein in a weight ratio to water of from 1:1 to 1.5:1. The invention is based on my discovery that when utilizing a polyacrylamide type thickener system, and the inorganic oxidizer salt component is at least 75 weight percent sodium perchlorate, and the sodium perchlorate is present in sufficient amount to form a solution with the aqueous phase as described, salting out, i.e. crystallization of inorganic oxidizer salt, is markedly reduced at temperatures in the order of —20° F. and lower to preclude solidification, or setting up, of the slurry to a nonpourable form.

In preferred practice, the slurry compositions of the invention comprise, on a weight basis, from 15 to 40 percent water and from 15 to 50 percent sodium perchlorate, together with the polyacrylamide type thickener and a suitable sensitizer. Generally, the amount of sensitizer is at least 5 percent and does not exceed 50 percent and the amount of thickener is in the range of from about 0.05 to 5 percent, more often in the order of from 0.5 to 2.0 percent. However, the proportion of the now-preferred thickener component, polymers I and II of my present application described hereinafter, is generally within the range of from 0.4 to 1.5, and preferably 0.8 to 1.2 weight percent.

The pourable compositions of the invention are in most instances insensitive to detonating action of a commercial No. 8 blasting cap but detonatable by conventional "booster" charges of PETN (pentaerythritol tetranitrate), RDX (cyclotrimethylenetrinitramine), Pentolite (PETN-TNT), tetryl, Composition B (RDX-TNT), and

the like. One booster advantageously employed is a dispersion of a crystalline high explosive, e.g., PETN or RDX, in a plastic carrier such as described in U.S. Pat. 2,965,466 and which is detonated by either a commercial blasting cap or detonating fuse.

Any of the various known sensitizer materials for inorganic oxidizer salt blasting compositions of the aqueous slurry type, above described, can be utilized as such, in the compositions of the invention. Exemplary of now preferred sensitizer components are smokeless powder as disclosed and claimed in the above said U.S. 3,235,425 and TNT and/or particulate aluminum as disclosed and claimed in the above said U.S. 2,930,685. Other suitable sensitizers include particulate magnesium-aluminum alloys, and high explosives such as PETN, RDX, tetryl, Composition B, nitromannite, and the like.

Water-soluble organic compounds, e.g., glycols such as ethylene glycol, and saccharides such as ordinary granulated sugar, or water insoluble carbonaceous fuels such as fuel oil, ground coal and the like, are often added to the formulation as supplementary fuel components, generally in an amount of less than 15 weight percent of the total slurry. The total energy of the slurry explosive composition is often increased by the addition of various solid energizers such as aluminum, ferrosilicon, ferrophosphorus, silicon, and the like, generally in a total amount less than about 20 weight percent. In all events, the total amount of solid energizer, or fuel material, is limited so as to be less than that which would adversely affect flow properties of the final slurry composition.

Illustrative of the polyacrylamide type thickener component of the compositions of the invention are those set forth in the various patents, and the parent application, above referred to. Thus, in U.S. 3,097,120, slurries are disclosed in which the choice of thickener is from about 0.1 to about 5 weight percent of a polyacrylamide having an apparent molecular weight of about 1 million to 25 million and a hydrolyzed free acid content of from about 0.1 to about 8 percent, together with from about 0.01 to about 0.5 weight percent of an inorganic polyvalent metal salt cross-linking agent for the polyacrylamide; in U.S. 3,097,121 slurries are disclosed in which the choice of thickener component is from about 0.5 to about 5 weight percent of a polyacrylamide having an apparent molecular weight of at least 100,000 together with from about 0.05 to about 0.5 weight percent of a polyvalent metal inorganic salt cross-linking agent for the polyacrylamide, the polyacrylamide in preferred practice containing at least 2000 acrylamide units; in U.S. 3,321,344 are disclosed slurries in which the thickener component is from 0.05 to about 2 percent of a polyacrylamide having an apparent molecular weight of from about 1 million to 25 million and a hydrolyzed free acid content of from about 0.1 to about 8 weight percent, together with from 0.01 to about 0.5 percent of an inorganic polyvalent metal salt cross-linking agent, and additionally from about 1 to 15 weight percent each of urea and sodium chloride to further promote the slurry pourability; in U.S. 3,341,383 are disclosed slurries in which the thickener component is 0.1 percent to about 5 percent by weight of a partially hydrolyzed acrylamide polymer having a degree of hydrolysis such that 15 to 40 percent of the monomeric units therein have been converted to the hydrolyzed form, and the polymer having a molecular weight such that a 1 percent solution of the polymer in distilled water will have a viscosity in the range of 1500 to 7000 centipoises at 25° C.—the partially hydrolyzed acrylamide polymer having, preferably, (1) a degree of hydrolysis such that about 22 percent of the monomeric units therein are converted to the hydrolyzed form, (2) a viscosity of about 4000 centipoises, and (3) being also optionally associated with a cross-linked guar gum in a guar gum to polymer weight ratio of from 1:3 to 3:1, the guar gum preferably comprising 98 percent guar and 2 percent pyroantimonate as the cross-linker therefor; and in U.S. 3,355,336 are disclosed water-bearing explosives in which the thickening agent is a combination of cross-linked galactomannan and polyacrylamide, the weight ratio of the latter to former being from 0.1:1 to 10:1—and preferably (1) the galactomannan being guar gum in a polyacrylamide to guar gum ratio of 1:1 to 5:1 (2) the slurry containing from 0.1 to 0.5 percent guar gum and from 0.2 to 1 percent polyacrylamide, (3) the combination being cross-linked (based on the weight of the guar gum) with from 0.5 to 3 percent of alkali metal dichromate and 2 to 10 percent of potassium antimony tartrate, and (4) the polyacrylamide having a molecular weight of about 3 million to 15 million and a pH in a 1 percent by weight solution in water of from about 6 to 8.

A now preferred thickener component is that disclosed in my copending parent application Ser. No. 694,097, above referred to, which is a combination of polymers I and II and a polymer I to polymer II weight ratio within the range of 10:1 to 1:1. The polymer I is a partially hydrolyzed acrylamide polymer having a degree of hydrolysis such that 15 to 40 percent of the monomeric units therein have been converted to the hydrolyzed form, and the polymer having a molecular weight such that a 1 percent solution of the polymer in distilled water will have a viscosity in the range of 1500 to 7000 centipoises at 25° C.; and said polymer II being formed by copolymerizing acrylamide with at least one acrylate of the group consisting of ammonium and alkali metal acrylates, in an acrylamide to total acrylate weight ratio within the range of 40:1 to 2:1 in an aqueous solvent medium containing from 30 to 65 weight percent water and selected from the group consisting of water-tertiary butanol, water-acetone, and water-tertiary butanol-acetone, at a temperature of 0–60° C., and cross-linking the resulting polymer as an ingredient of said thickener component, preferably in situ in preparation of the slurry explosive, by action of from 0.001 to 0.1 percent of a polyvalent metal salt-cross-linking agent therefor, based on the weight of the finished slurry explosive.

The polymeric I ingredient above described is that set forth in U.S. Pat. 3,341,383, above referred to and in preferred practice contains from about 20–35 percent of the monomeric units therein converted to the hydrolyzed form, often in the order of about 22 percent together with a polymer viscosity of about 4000 centipoises.

The polymeric II copolymer ingredient, above described, is disclosed in most of the monomeric unit proportions contemplated in practice of this invention in the copending application of Harrison et al., U.S. Ser. No. 594,500, filed Nov. 15, 1966; and in preferred practice has an acrylamide to total acrylate weight ratio not exceeding 20:1 and often within the range of about 6:1 to 12:1, a weight ratio of about 9:1 being advantageously employed in many instances.

The polymeric II ingredient is a copolymer and is prepared by only one known process, i.e., which will produce the polymeric II ingredient having the properties applicable in the present invention. This process is referred to as a precipitation polymerization and comprises polymerizing a solution of acrylamide and acrylate monomers in aqueous tertiary butanol, aqueous acetone or aqueous tertiary butanol-acetone in the substantial absence of air while agitating the solution to give a copolymer product that can be isolated by filtration, the aqueous tertiary butanol and aqueous acetone being solvents for the monomers but nonsolvents for the copolymer product.

Solvent and temperature conditions of this precipitation polymerization process are critical. Thus, the solvent for the monomers must be aqueous tertiary butanol, aqueous acetone, or aqueous tertiary butanol-acetone (i.e., mixtures of water with tertiary butanol or acetone alone or with both). The concentrations of water in said mixtures must be 30 to 65 percent, preferably 45 to 60 percent, by weight of said mixtures. The polymerization reac-

tion temperature must be 0° C. to 60° C., preferably 0° C. to 40° C.

The polymerization may be carried out either in the presence or absence of a polymerization catalyst (initiator), but preferably a polymerization initiator will be used. Both the types and amounts of free radical initiator applicable are well known in this art. Peroxygen compounds are quite suitable, including, e.g., ammonium persulfate, potassium persulfate and hydrogen peroxide. Other free radical initiators include, e.g., α,α'-azo-bis-isbutyronitrile. The peroxygen initiators may be used alone or in combination with activators (also well-known in this art) including, e.g., sodium bisulfite, sodium thiosulfate, tetramethylethylenediamine, thiourea and ferrous chloride, said combination forming a redox system. The amount of initiator usually will not exceed 0.5 percent, preferably is 0.05 to 0.2 percent, 0.05 percent being specifically preferred, by weight of the combined weight of monomers.

Although not necessary, preferably the precipitation polymerization is carried out in the presence of a salt dissolved in the polymerization reaction mixture. By polymerizing in the presence of a salt, or a buffer system comprising one or more salts in combination with another material to complete the buffer system, recovery of the copolymer product is substantially facilitated. These salts and buffer systems include, e.g. (1) alkali metal and ammonium acetates, carbonates, bicarbonates, chlorides, phosphates, sulfates, bisulfates, borates; (2) buffer systems comprising (a) mixtures of weak acid or weak base and their salts including (b) phthalates, citrates, borates, phosphates, acetates, ammonium hydroxide, ammonium acetate, ammonium chloride, (c) specific combinations including mixtures of boric acid-borax, citric acid-sodium acid phosphate, sodium carbonate-sodium bicarbonate, ammonium-ammonium hydroxide, ammonium acetate-ammonium hydroxide; or (3) any combination of (1) and (2).

The amount of salt which may be used for the precipitation is about 0.1 to 2.0 percent, preferably about 0.2 to 0.7 percent, by weight of the reaction mixture. If the amount of salt exceeds about 2.0 percent, usually there is a tendency for the granules of the polymeric product to agglomerate in the polymerization reaction mixture. The manner of adding the salt and the point at which it is added are not critical.

Any suitable procedure can be utilized in the manufacture of the slurry type compositions of the invention. In accordance with one such procedure, which is directed to preparation of now preferred slurry compositions containing the above described combination of polymers I and II as the thickener component, the required mixture of polymeric I and II ingredients is dispersed in a non-aqueous liquid, generally ethylene glycol and then added to a hot aqueous solution of the inorganic oxidizer salt in an amount to permit sufficient thickening to retain subsequently added ingredients in suspension. After the addition of all ingredients, during which time the mixture is under constant agitation, a suitable cross-linking agent is added such as a polyvalent metal salt. Although the cross-linking agent is preferably the last added ingredient, it can be added at any time during formation of explosive slurry after a portion of each of polymer I and polymer II ingredients is added, preferably after the polymer I and polymer II ingredients are added in their entirety.

Further exemplary of well-known polyvalent metal salt cross-linking agents for the formation of the polymer II ingredient are alum, chromium acetate and ferric citrate. Trivalent metal salt cross-linking agents are generally preferred.

As described in my copending U.S. application Ser. No. 784,211, filed Dec. 16, 1968, a paraffin oil, or other suitable agent is often added to the packaged slurry product, either as an ingredient of the slurry product or to the container inner wall to serve as a release agent to facilitate removal of the product from the package for field use.

The invention is illustrated with reference to the following examples, all formulations being shown on a weight percent basis:

	Example (weight percent)						
	1	2	3	4	5	6	7
Water	22.0	30.4	30.4	31.3	28.0	18.0	20.0
TNT	40.0					35.0	
PETN		10.0	10.0				
Nitrocellulose, densified				19.5	18.0		18.0
Sodium perchlorate	30.0	41.0	41.0	38.5	35.4		
Sodium nitrate					6.4	13.4	18.0
Ammonium nitrate						22.0	38.0
Silicon-iron			5.0				
Aluminum		5.0				5.0	
Ethylene glycol	6.5	12.1	12.2	9.3	10.7	5.0	7.5
Pine oil	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Paraffin oil	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thickener [1]	0.9	0.9	0.8	0.8	0.9	0.9	0.9
Total	100	100	100	100	100	100	100
Density, grams/cc	1.50	1.51	1.47	1.45	1.42	1.41	1.39
2" Funnel Test at 0° F.,[2] seconds	37	29	20	37	70	[3]	[3]
Detonation rate,[4] meters per second:							
3" unconfined		4,450	4,150	4,350		5,000	
2½" unconfined	4,750	4,250	3,850	4,250	4,550		4,750
Underwater energy, ft. lbs./lb	10.4×10^5	9.3×10^5	9.2×10^5	9.4×10^5		8.5×10^5	5.4×10^5

[1] Blend of polymer I and polymer II in polymer I/polymer II wt. ratio of 2.3:1; polymer II is copolymer of acrylamide and sodium acrylate having an acrylamide:sodium acrylate wt. ratio of 9:1. Basic aluminum acetate was cross-linking agent for poylmer II.

[2] Funnel Test—2 liters of slurry is poured into an aluminum funnel having an orifice of 2" diameter. When the orifice is opened to permit flow, the timing is started. When light is visible through the orifice (looking down into the funnel), timing is stopped. The time difference is designated as the flow time.

[3] No flow.

[4] Measured as average detonation velocity over a 20 cm. length, at the end of a 28" long column of explosive. The time for detonation to proceed across the 20 cm. length of explosive was measured electronically with a counter-chronograph.

Examples 1–5, with reference to the funnel tests, illustrate superior pourability of compositions of the invention at 0° F., together with high explosive energy and and sensitivity characteristics shown with reference to successful shots at small diameters.

Examples 6 and 7 illustrate compositions of the prior art similar to those of Examples 1–5 except that they (Examples 6, 7) contain ammonium nitrate and ammonium nitrate-sodium nitrate as the oxidizer salt in lieu of the sodium perchlorate oxidizer salt component of the invention.

Examples 1–5, with reference to the funnel tests, show times of from 20 to 70 seconds, for 2000 cc. of the slurry, at 0° F. to flow through a two-inch orifice. In contrast, Examples 6 and 7 utilizing the same test conditions show no flow of the prior art slurry.

Example 5 further demonstrates sodium nitrate as a supplemental oxidizer salt ingredient, i.e. in a proportion not exceeding 25 percent of the total oxidizer salt com-

ponent. At the relatively high content of sodium nitrate, the funnel test required 70 seconds for the measured flow, which demonstrates the limited amount of supplemental oxidizer salt that can be tolerated. Thus, with 6.4 percent sodium nitrate, based on the entire composition, and representing about 15 percent of total oxidizer salt component, with the remainder sodium perchlorate, the flowability, although excellent, was reduced to 70 seconds as compared with 20 to 37 seconds of Examples 1–4.

Examples 1–5 demonstrate energies (ft. lbs./lb.) of 9.2 to 10.4×10^5 as compared with 5.4 to 8.5×10^5 of the prior art compositions, thus demonstrating superior energy properties of the compositions of the invention. Similarly, high densities of 1.42 to 1.52, of Examples 1–5, coupled with the superior pourability and high energy characteristics shown, demonstrate high loading densities of high energy slurry explosives that are provided at low temperatures in accordance with the invention.

When utilizing a supplemental oxidizer salt, the proportion utilized, in a given instance, is dependent on the particular firing conditions. Thus, sodium nitrate, as a supplemental oxidizer salt ingredient is often utilized in an amount up to the permitted maximum (25 percent of the total oxidizer salt component) under temperature conditions of, say, 0–20° F. whereas if ammonium nitrate is so utilized, the proportion thereof is generally limited to in the order of about 5 percent of the total oxidizer salt. Even lesser proportions of divalent oxidizer salts such as calcium perchlorate, barium perchlorate, calcium nitrate, and the like, are generally utilized under such firing conditions. In preferred practice, and particularly at lower temperautre levels, say, in the order of +20 to −20° F., sodium perchlorate is the sole oxidizer salt utilized. On the other hand, when, at temperatures of from 20 to 30° F. and higher, a supplemental oxidizer salt is utilized, selection of the amount of same is less critical. It is thus seen that when referring herein to the use of a supplementary inorganic oxidizer salt in an amount up to 25 percent of the total inorganic oxidizer salt component, it is understood that selection of that amount is made in accordance with the need at hand.

As will be evident to those skilled in the art, various modifications can be made or followed, in the light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

What I claim and desire to protect by Letters Patent is:

1. In an inorganic oxidizer salt explosive composition of the aqueous slurry type, the improvement providing for improved pourability of said slurry composition and comprising a polyacrylamide type thickener component, from 50 to 90 weight percent total aqueous phase, and sodium perchlorate as at least 75 weight percent of the inorganic oxidizer salt component; and said aqueous phase containing said sodium perchlorate dissolved therein in a weight ratio to water of from 1:1 to 1.5:1.

2. A pourable slurry of claim **1** containing said sodium perchlorate as the sole ingredient of said inorganic oxidizer salt component.

3. A pourable slurry of claim **1** containing on a weight basis from 15 to 40 percent water, from 15 to 50 percent of said sodium perchlorate, from 5 to 50 percent sensitizer, and from 0.05 to 5 percent of said thickener.

4. A pourable slurry of claim **3** containing as said thickener from about 0.1 to about 5 weight percent of a polyacrylamide, said polyacrylamide having an apparent molecular weight of from about 1 million to about 25 million and a hydrolyzed free acid content of from about 0.1 to about 8 percent, and cross-linked with an inorganic polyvalent metal salt cross-linking agent therefor.

5. A pourable slurry of claim **3** containing as said thickener from about 0.5 to about 5 weight percent of a polyacrylamide, having an apparent molecular weight of at least 100,000, cross-linked with from about 0.05 to about 0.5 weight percent of a polyvalent metal inorganic salt cross-linking agent therefor.

6. A pourable slurry of claim **3** containing as said thickener from about 0.05 to about 2 percent of a polyacrylamide having an apparent molecular weight of from about 1 million to about 25 million and a hydrolyzed free acid content of from about 0.1 to about 8 weight percent, and cross-linked with from about 0.01 to about 0.5 percent of an inorganic polyvalent metal salt cross-linking agent.

7. A pourable slurry of claim **3** containing as said thickener, from about 0.1 to about 5 percent by weight of a partially hydrolyzed acrylamide polymer having a degree of hydrolysis such that 15 to 40 percent of the monomeric units therein have been converted to the hydrolyzed form, and the polymer having a molecular weight such that 1 percent solution of the polymer in distilled water will have a viscosity in the range of 1500 to 7000 centipoises at 25° C.

8. A pourable slurry of claim **3** wherein said thickener is a combination of a cross-linked galactomannan and polyacrylamide, the weight ratio of said polyacrylamide to galactomannan being from about 0.1:1 to 10:1.

9. In a pourable slurry of claim **8**, from 0.1 to 0.5 weight percent guar gum as said galactomannan, and from 0.2 to 1 weight percent of said polyacrylamide; said ratio is within the range of from 1:1 to 5:1; said combination is cross-linked (based on the weight of said guar gum) with from 0.5 to 3 percent of an alkali metal dichromate and 2 to 10 percent potassium antimony tartrate; and said polyacrylamide has a molecular weight of from about 3 million to 15 million, and a pH in a 1 weight percent solution in water of from about 6 to 8.

10. A pourable slurry of claim **3** wherein said thickener is a polyacrylamide cross-linked with an inorganic polyvalent metal cross-linking agent.

11. A pourable slurry of claim **10** wherein said polyacrylamide is partially hydrolyzed to thereby have a free acid content.

12. A slurry composition of claim **1** wherein said inorganic oxidizer salt contains sodium nitrate as a supplemental inorganic oxidizer salt.

13. A pourable slurry of claim **3** wherein said thickener component is a combination of polymers I and II in a polymer I to polymer II weight ratio within the range of from 10:1 to 1:1, said polymer I being a partially hydrolyzed acrylamide polymer having a degree of hydrolysis such that 15 to 40 percent of the monomeric units therein have been converted to the hydrolyzed form, and said polymer I having a molecular weight such that a 1 percent solution of same in distilled water will have a viscosity in the range of 1500 to 7000 centipoises at 25° C., and said polymer II being a cross-linked product formed by copolymerizing acrylamide with at least one acrylate selected from the group consisting of ammonium and alkali metal acrylates in an acrylamide to total acrylate weight ratio within the range of from 40:1 to 2:1 in an aqueous solvent medium containing from 30 to 65 percent water and selected from the group consisting of water-tetriary butanol, water-acetone, and water-tertiary butanol-acetone, at a temperature of from 0 to 60° C. and cross-linking the resulting copolymer as an ingredient of said thickener component during the formation of said explosive composition by action of from 0.001 to 0.1 percent of a polyvalent metal salt cross-linking agent therefor, based on the weight of said explosive.

14. A pourable slurry of claim **13** containing from 0.4 to 1.5 weight percent of said thickener component.

15. A pourable slurry of claim **13** wherein said polymer I has a degree of hydrolysis such that from about 20 to

35 percent of the monomeric units therein are converted to the hydrolyzed form.

16. A pourable slurry of claim **15** wherein said polymer I has a degree of hydrolysis such that about 22 percent of the monomeric units therein are converted to the hydrolyzed form, and said viscosity is about 4000 centipoises.

17. A composition of claim **16** wherein said polymer II has an acrylamide to total weight ratio not exceeding about 20:1.

18. A slurry composition of clam **17** wherein said weight ratio is about 9:1.

19. A pourable slurry of claim **18** wherein said acrylate is sodium arcylate.

20. A pourable slurry of claim **18** wherein said acrylate is ammonium acrylate.

References Cited

UNITED STATES PATENTS

3,096,223	7/1963	Cook et al.	149—83X
3,214,308	10/1965	Rice	149—83X
3,355,336	11/1967	Lyerly	149—83X
3,390,029	6/1968	Preckel	149—83X
3,442,729	5/1969	Knight	149—60X
3,473,983	10/1969	Cook et al.	149—83X
3,485,686	12/1969	Jessop et al.	149—83X

BENJAMIN R. PADGETT, Primary Examiner

S. J. LECHERT, JR., Assistant Examiner

U.S. Cl. X.R.

149—40, 41, 42, 44, 83, 84