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# SLURRY BLASTING AGENT CONTAINING NON-EXPLOSIVE LIQUID FUEL

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This invention relates to explosive compositons, and more particularly to blasting agents in aqueous slurry form containing inorganic chlorates and non-explosive liquid fuels. By the term "chlorates," where not otherwise limited, it is intended to include perchlorates. This application is a continuation in part of our application Serial No. 52,369, filed August 29, 1960 and now abandoned.

The art has long recognized that sodium chlorate or other inorganic chlorates and perchlorates are effective oxidants and should find utility in blasting explosives. However, prior art attempts to utilize chlorates have not been commercially practicable because the chlorates and perchlorates in dry form are often very hazardous, being very sensitive under some conditions to shock, friction and heat. According to the present invention, blasting agents are provided utilizing chlorates which are very much safer to manufacture, handle and utilize in blasting operations than compositions of the prior art.

Accordingly, it is a principal object of this invention to provide inorganic chlorate-containing blasting agents, especially those based on sodium chlorates which are relatively insensitive to shock, impact, friction and heat.

It is a further object of the invention to produce and use a chlorate-based blasting agent in slurry form which is inexpensive and safe to handle but which may be dependably detonated by inexpensive boosters.

Among the further objects of the invention is the provision of blasting agents which may be used both in large and small diameter bore holes and which are safe and dependable for use in wet, dry or even in water-containing boreholes.

Other objects and advantages of the invention will be apparent to those skilled in the art.

The blasting agents of the invention comprises a slurry of solid oxidant, which oxidant is selected from the group consisting of inorganic chlorates, including perchlorates and mixtures of such inorganic chlorates with inorganic nitrates, especially ammonium nitrate, such mixtures containing up to 70 percent by weight of the mixture of the inorganic or ammonium nitrate. The solid oxidant is in greater proportions than can be dissolved in the amount of water used, and hence includes granular particles suspended in an aqueous suspending medium. Such medium is selected from the group consisting of aqueous solutions of water-soluble, non-explosive liquid fuels and aqueous dispersions of water-dispersible, non-explosive, non-water soluble liquid fuels. The slurry contains by weight about 70 to 90 percent of the oxidant, 5 to 20 percent of liquid fuel and 1 to 10 percent water.

The slurry may optionally contain a finely divided non-water soluble solid fuel, such as coal or the like, or it may contain a metallic powder which serves as a fuel, such as aluminum.

The liquid fuels utilized in the slurry are non-explosive per se. They may be either water soluble or water dispersible. Examples of water-soluble fuels are the lower aliphatic alcohols, such as methyl, ethyl and isopropyl alcohols, polyhydric alcohols such as ethylene glycol, diethylene glycole and glycerol, and ketones, such as acetone and methyl ethyl ketones. Water-dispersible liquid fuels include hydrocarbons, such as kerosene, fuel oil and



the like. The water-dispersible fuels, which of course are not water soluble, must be dispersed in the water to yield a stable dispersion or emulsion, which is accomplished in known fashion by the use of emulsifying agents, preferably anionic emulsifying agents such as alkaryl sulfonates, long-chain aliphatic sulfates and the like. Many suitable dispersing agents are available such as the "Spans" and "Tweens" of Atlas Powder Company, which are derived from polyhydric alcohols, and the "Pluronics" of Wyandotte Chemicals. The "soluble oils" utilized in agricultural sprays which contain emulsifying agents of various well known types may be used. One preferred example of a water-dispersible fuel is a mixture of No. 2 fuel oil and commercial tall oils, which may be emulsified with a suitable emulsifier, such as an alkaryl sulfonate or an alcohol sulfate, or one of the other materials just mentioned.

The operative proportional ranges of ingredients yielding safe and dependable blasting agents are as defined above. Preferably, the amounts of the various ingredients are adjusted within the range specified to yield a mobile, pourable slurry which has approximately a zero oxygen balance. As indicated, an amount of finely divided solid fuel, such as coal, may be added to achieve the optimum oxygen balance. The oxygen balance need not always be zero but is preferably within ±10 percent.

The particle sizes of the chlorates or perchlorates used in the slurry blasting agents of this invention are not critical. Screen sizes ranging from 20 to 150 mesh have been used with essentially equivalent results. The screen analysis of a typical grade of sodium chloride used in the examples herein is as follows:

| Mesh size: | Percent |
|---|---|
| +20 standard Tyler Mesh | 0.2 |
| −20+28 standard Tyler Mesh | 17.7 |
| −28+35 standard Tyler Mesh | 45.6 |
| −35+48 standard Tyler Mesh | 23.0 |
| −48+65 standard Tyler Mesh | 6.6 |
| −65+100 standard Tyler Mesh | 3.3 |
| −100 standard Tyler Mesh | 3.6 |

Examples of other inorganic chlorates which have been found useful in the invention are potassium chlorate and ammonium perchlorate. Sodium and potassium perchlorates can be used and mixtures of any two or more of these can be substituted for the simple compounds. Sodium perchlorate is particularly desirable because of price.

The particle size of the ammonium nitrate (or other inorganic nitrate) in those compositions wherein it may replace up to 70 percent by weight of the chlorate is also not critical. Prilled ammonium nitrate having a mesh size of 6 to 14 mesh may be used as well as fine, 35 to 50 mesh ammonium nitrate. Mixtures of the prilled and fine ammonium nitrates may also be used.

A simple and effective composition is a pourable liquid slurry wherein an approximately 50–50 mixture of a chlorate and ammonium nitrate is used as the oxidizer, between 1 and 10 percent of water, based on the composition is used, and the liquid fuel is first mixed with the water and the oxidizer added thereto. As liquid fuel ethylene glycol is very satisfactory. The proportions of liquid to oxidizer are such that the oxidizer is not nearly dissolved but the slurry has a consistency about like that of Portland cement grout. A typical material may include about 84 percent oxidizer, 5 percent water and 10 percent glycol, plus ½ percent each of alkali (sodium carbonate) and guar gum. Sodium chlorate is the preferred chlorate with ammonium perchlorate being second choice. Sodium nitrate may be substituted for part but preferably not all of the ammonium nitrate.

The slurry blasting agents of the invention have high density, in the range of about 1.4 to 1.8. The slurries are essentially void-free and air-free and they require no

special manipulation or additives to control the density. The blasting agents prepared according to the present invention provide high maximum available energy and, because of their high density, they possess high bulk strength, namely, the product of their density and maximum available energy.

The hazard sensitivity, e.g. to heat, of the slurry blasting agents is satisfactorily low. Thus, differential thermal analyses of compositions of this invention reveal that the temperature of first exothermic reaction is generally upwards of 160° C. and explosion does not occur until at least 225° C. has been reached. Additionally, the impact sensitivity of the blasting agents of the invention is well below that of most blasting explosives now in use, such as ammonium nitrate-fuel oil mixtures.

The blasting agents of this invention may be dependably detonated by relatively inexpensive boosters of high brisance, such as pentolite, RDX, and the like. Generally, such boosters contain from about 80 to 400 grams or more of pentolite or its equivalent. The booster and fuse may be simply lowered into the borehole containing the slurry and thereafter fired.

The slurry blasting agents of the invention may be safely manufactured, stored and shipped, and hence may be prepared in a processing plant and transported to the blasting site. Alternatively, the slurries may be prepared on the site, if desired. In most cases, a satisfactory pourable slurry is obtained on mere admixture of the components, without an inert, or relatively inert thickening agent, but a hydrophillic colloid such as guar gum, starch and the like may be added in small amounts, if desired, to control or increase the viscosity of the slurry.

The following examples illustrate desirable properties of the blasting agents of this invention, in which all parts and percentages are by weight. Obviously, many other examples could be given.

It is desirable to prevent premature decomposition of the chlorate slurries, in storage for example, which may be done by the addition of a small amount on the order of about 1 percent by weight of an alkali, such as sodium carbonate, sodium hydroxide, KOH, and the like. The presence of an alkaline medium stabilizes the oxidizer and prevents decomposition of chlorate in the slurry.

## EXAMPLE I

The following experimental results were obtained with the compositions having ingredients in the parts by weight indicated:

| Composition | A | B | C | D |
|---|---|---|---|---|
| Sodium chlorate | 40 | 56 | 84 | 81.3 |
| Ammonium nitrate prill | 40 | 24 | | |
| Ethylene glycol | 17 | 19 | 17 | 17 |
| Water | 3 | 1 | 2 | 1.7 |
| Density | 1.5 | 1.64 | 1.7 | 1.67 |
| Critical diameter, inches | 5 | 5 | 5 | 5 |

All of the above were pourable slurries having no voids or air spaces. Detonation was accomplished with 160-gram pentolite boosters.

## EXAMPLE II

The following slurries using alcohols were prepared with the results as indicated. Detonation was accomplished with 160-gram pentolite boosters. Percentages by weight are indicated.

| Composition | A | B | C |
|---|---|---|---|
| Sodium chlorate | 61.9 | 63.3 | 66.6 |
| Ammonium nitrate prills | 17 | 7.7 | 8.4 |
| Alcohol (type) | [1] 14.6 | [2] 13 | [3] 5 |
| Water | 6.5 | 5 | 9 |
| Coal 15 mesh | | 11 | 11 |
| Density | 1.66 | 1.67 | 1.67 |
| Size for consistent detonation (diameter x length in inches) | 5 x 60 | 4 x 36 | 4 x 36 |

[1] Isopropyl. [2] Methyl. [3] Ethyl.



A preferred liquid non-explosive fuel ingredient for the blasting agents of the invention is one prepared from a mixture of 40 to 60 percent No. 2 fuel oil and 60 to 40 percent tall oil. The following example illustrates such a composition (parts by weight).

## EXAMPLE III

| | | |
|---|---|---|
| Sodium chlorate | 41.5 | oxidizer. |
| Ammonium nitrate (75% prill-25% fine) | 41.5 | oxidizer. |
| No. 2 fuel oil | 4.5 | Non-explosive liquid fuel. |
| Tall oil | 4.5 | Non-explosive liquid fuel. |
| Water | 9. | |
| Sodium dodecyl benzene sulfonate (dispersant) | 0.05. | |
| Sodium carbonate (alkali stabilizer) | 1. | |
| Density | 1.55. | |
| Performance | Detonated consistently in 5 x 60" charges unconfined using 160 g. pentolite booster. | |

The fuel oil, tall oil, water and emulsifier were agitated until a stable dispersion resulted. The dispersion was then mixed with premixed oxidizer composed of the dry sodium chlorate and ammonium nitrate. A satisfactory stable pourable slurry resulted.

The oxygen balance of sodium chlorate is 0.45. The oxygen balance of a fuel of course is always negative. In order to achieve optimum results, the oxygen balance should be brought as near to zero as is consistent with other essential properties in the composition. Properties such as overall density, available free space for the solid oxidant, etc., need to be considered. The oxygen balance and density of various fuels are tabulated, for comparative purposes:

| | $O^2$ Balance | Density, g./cc. |
|---|---|---|
| No. 2 Fuel Oil | −3.46 | 0.8 |
| 2-nitropropane | −1.35 | 1.0 |
| Dinitrotoluene | −1.145 | 1.28 |
| Nitrobenzene | −1.884 | 1.20 |
| Benzene | −3.08 | 0.88 |

The amount of fuel required for oxygen balance can readily be calculated. The desired oxygen balance is obtained by adjusting the quantity of fuel. The available free space of the solid oxidant is taken into consideration to obtain an essentially void-free composition of relatively high density, usually between 1.4 and 1.8 g./cc.

While the invention has been described in terms of certain examples, they are to be considered illustrative and not limiting. It is intended to cover all modifications and embodiments that would suggest themselves to one skilled in the art, to the extent that they fall within the fair spirit and scope of the invention as defined by the appended claims.

We claim:

1. A blasting agent comprising a slurry of a solid oxidant selected from the group consisting of inorganic chlorates and mixtures of inorganic chlorates and ammonium nitrate containing up to 70 percent by weight of the mixture of ammonium nitrate in an aqueous suspending medium containing a non-explosive liquid fuel selected from the group consisting of lower aliphatic alcohols, polyhydric alcohols, ketones and hydrocarbons, said slurry containing by weight about 70 to 90 percent oxidant, 5 to 20 percent of liquid fuel and 1 to 10 percent water.

2. A blasting agent consisting essentially of a slurry of a solid oxidant selected from the group consisting of sodium chlorate and mixtures of sodium chlorate and ammonium nitrate containing up to 70 percent by weight of the mixture of ammonium nitrate in an aqueous sus-

pending medium containing a non-explosive liquid fuel selected from the group consisting of lower aliphatic alcohols, polyhydric alcohols, ketones and hydrocarbons, said slurry containing by weight about 70 to 90 percent oxidant, 5 to 20 percent of liquid fuel and 1 to 10 percent water.

3. The blasting agent set forth in claim 2 including a finely divided water-insoluble solid fuel suspended in said slurry.

4. The blasting agent set forth in claim 2 wherein said liquid fuel is a lower aliphatic alcohol.

5. The blasting agent set forth in claim 2 wherein said liquid fuel is an aliphatic polyhydric alcohol.

6. The blasting agent set forth in claim 2 wherein said liquid fuel is a fuel oil-tall oil mixture dispersed in the water by means of an anionic emulsifying agent.

7. A blasting agent comprising a slurry of a solid oxidant comprising about 40 to 60 percent by weight of an inorganic chlorate and about 60 to 40 percent by weight of ammonium nitrate in an aqueous suspending medium comprising an aqueous emulsion of oils containing about 40 to 60 percent fuel oil and 60 to 40 percent tall oil by weight, said slurry containing by weight about 70 to 90 percent oxidant, 5 to 20 percent of fuel oil-tall oil mixture and 1 to 10 percent water.

8. The blasting agent set forth in claim 2 including about 1 percent by weight of alkali.

9. A blasting composition in the form of a pourable liquid slurry essentially free of voids and air spaces, said composition comprising a major proportion of an oxidizer selected from the group which consists of an inorganic normally explosive chlorate and a mixture of such chlorate with a normally explosive inorganic nitrate, a liquid component including 1 to 10 percent by weight, based on the total composition, of water, and 5 to 20 percent by weight of a liquid fuel selected from the group which consists of water soluble lower aliphatic alcohols, polyhydric alcohols and ketones, and water insoluble oil with a dispersant.



10. Composition according to claim 9 wherein the liquid fuel is a glycol.

11. Composition according to claim 9 wherein the liquid fuel is a mixture of hydrocarbon fuel oil and tall oil.

12. Composition according to claim 9 to which is added a small proportion of a thickener.

13. Composition according to claim 9 in which the oxidizer is about a 50–50 combination of sodium chlorate and ammonium nitrate.

14. Composition according to claim 9 in which the oxidizer is about a 50–50 combination of ammonium perchlorate and ammonium nitrate.

15. Composition according to claim 9 in which the oxidizer is sodium perchlorate.

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