a potassium salt, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate;

wherein the PSAN prill is explosive grade and has a bulk density less than 0.9 kg/L.

[0002b] In another aspect of the present disclosure, there is provided an emulsion explosive blend comprising an emulsion explosive and the PSAN prill disclosed herein blended with the emulsion explosive.

[0002c] In a further aspect of the present disclosure, there is provided a method of preparing a phase-stabilized ammonium nitrate (PSAN) prill, the method comprising:

forming a PSAN solution comprising a potassium salt and ammonium nitrate; and

crystallizing the PSAN solution to form a PSAN prill, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate, and

wherein the PSAN prill is explosive grade and has a bulk density less than 0.9 kg/L.

[0002d] In another aspect of the present disclosure, there is provided a method of increasing the hardness of a phase-stabilized ammonium nitrate (PSAN) prill, the method comprising:

forming a PSAN solution comprising a potassium salt and ammonium nitrate; and

crystallizing the PSAN solution to form a PSAN prill, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate.

[0002e] In a further aspect of the present disclosure, there is provided a method of making an emulsion explosive, the method comprising:

melting PSAN prill into a liquor, the liquor comprising:

ammonium nitrate; and

a potassium salt, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate; and

forming the liquor into a discontinuous oxidizer phase of an emulsion.

[0002f] In another aspect of the present disclosure, there is provided an emulsion explosive comprising:

a discontinuous oxidizer phase comprising:

ammonium nitrate and between 0.5 mole percent (mol%) to 5 mol% potassium ions based on the ammonium ions of the ammonium nitrate wherein the potassium ions are derived from at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate; and

a continuous fuel phase.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The embodiments disclosed herein will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings.

Table 3. Crush testing data – standard LDAN vs Prill A

Sample	Average Crush Strength (kg) Initial (0 cycles)	Average Crush Strength (kg) 20 cycles	%Change from Initial Average Crush Strength (20 cycles)	Average Crush Strength (kg) 40 cycles	%Change from Initial Average Crush Strength (40 cycles)	Average Crush Strength (kg) 50 cycles	%Change from Initial Average Crush Strength (50 cycles)
Std LDAN Prill	0.98	0.174	-82.2	0.05	-94.9	Unable to Crush – sample is dust	
Prill A Prill	0.68	0.87	27.9	0.94	38.2	0.783	15.1
Sample	Average Crush Strength (kg) Initial (0 cycles)	Average Crush Strength (kg) 60 cycles	%Change from Initial Average Crush Strength (60 c, des)	Average Crush Strength (kg) 80 cycles	%Change from Initial Average Crush Strength (80 cycles)	Average Crush Strength (kg) 100 cycles	%Change from initial Average Crush Strength (100 cycles)
Std LDAN Prill (ex MBH)	0.98	Unable to Crush – sample is dust		Unable to Crush – sample is dust		Unable to Crush – sample is dust	
Prill A Prill	0.68	0.826	21.5	0.722	6.2	0.814	19.7
Sample	Average Crush Strength (kg) Initial (0 cycles)	Average Crush Strength (kg) 120 cycles	%Change from Initial Average Crush Strength (120 cycles)	Average Crush Strength (kg) 140 cycles	%Change from Initial Average Crush Strength (140 cycles)	Average Crush Strength (kg) 150 cycles	%Change from Initial Average Crush Strength (150 cycles)
Std LDAN Prill	0.98	Unable to Crush – sample is dust		Unable to Crush – sample is dust		Unable to Crush – sample is dust	
Prill A Prill	0.68	0.810	19.1	0.854	25.6	0.892	31.2
Sample	Average Crush Strength (kg) Initial (0 cycles)	Average Crush Strength (kg) 160 cycles	%Change from initial Average Crush Strength (160 cycles)	Average Crush Strength (kg) 180 cycles	%Change from Initial Average Crush Strength (180 cycles)	Average Crush Strength (kg) 200 cycles	%Change from Initial Average Crush Strength (200 cycles)
Std LDAN Prill	0.98	Unable to Crush – sample is dust		Unable to Crush – sample is dust		Unable to Crush – sample is dust	
Prill A Prill	0.68	0.853	25.4	0.886	30.3	0.832	22.4

[0095] The crush testing data shown in Table 3 and FIG. 19 demonstrate that the standard LDAN product was significantly degraded after 20 thermal cycles, and

and ANFO using Prill A. Each of these pipes were 75 mm in internal diameter, and approximately 0.5 m in length. The charge weight for each pipe was approximately 2 kg. A #12 strength MS electric detonator and a 400 g Trojan NBU pentolite booster were used to initiate each of the pipes. Velocity of Detonation (VoD) was measured for each of the charges. A Handitrap II™ VoD recorder was used, fitted with 300Ω probes, to measure velocity of detonation. VoD results are seen in Table 4. All pipes detonated were fully consumed during each blast, indicating complete detonation of all products. Test blasting of the Prill A prill (as ANFO) demonstrated that the Prill A and the standard LDAN were successfully detonated under the same conditions, with acceptable VoD's observed for both products.

Table 4. Velocity of Detonation results

Product	Velocity of Detonation (m/s)	Uncertainty (m/s)
Standard LDAN ANFO	3100	+30
PSAN ANFO	2900	+26

Example 13 – Reactive Ground Testing

[00103] Reactive ground testing using the plant manufactured Prill A prill for ANFO in an inhibited emulsion blend containing potassium nitrate in the oxidizer was performed, to ensure there was no significant difference in inhibition when potassium was present in the prill as well as in the emulsion. Standard emulsion/ANFO blends were used as controls with the same reactive ground samples. Samples were tested at 70°C for 28 days, as per Appendix 3 of the AEISG Code of Practice: Elevated Temperature and Reactive Ground. No exotherms were observed, apart for the internal AN control. The

Claims:

1. A phase-stabilized ammonium nitrate (PSAN) prill comprising:

ammonium nitrate; and

a potassium salt, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate;

wherein the PSAN prill is explosive grade and has a bulk density less than 0.9 kg/L.

2. The PSAN prill of claim 1, wherein the mol% of the potassium ions based on the ammonium ions is from 2 mol% to 5 mol%, 2 mol% to 4 mol%, 2.1 mol% to 4.0 mol%, or 3 mol%.

3. The PSAN prill of claim 1 or claim 2, wherein the PSAN prill has at least 5.7% porosity.

4. The PSAN prill of any one of claims 1–3, further comprising a porosity enhancing agent.

5. The PSAN prill of claim 4, wherein the porosity enhancing agent comprises an interfacial surface modifier, a pore former, or both.

6. The PSAN prill of claim 5, wherein the interfacial surface modifier comprises at least one of an alkyl sulfonate polymer, an alkaline metal salt of naphthalenesulfonic acid, an alkaline metal salt of alkyl sulfonic acid, an alkaline metal salt of polystyrene sulfonic acid, or aluminum sulfate hydrate.

7. The PSAN prill of claim 5 or claim 6, wherein the concentration of the interfacial surface modifier is from 400 ppm to 4,000 ppm, from 400 ppm to 1000 ppm, from 500 ppm to 900 ppm, from 600 ppm to 800 ppm, 700 ppm, 2,000 ppm to 4,000 ppm, from 2,500 ppm to 3,900 ppm, from 3,000 ppm to 3,700 ppm, or 3,500 ppm.

8. The PSAN prill of any one of claims 1-7, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, or potassium sulfate.

9. The PSAN prill of any one of claims 1-8, wherein the PSAN prill substantially lacks a 32 °C crystalline phase change.

10. The PSAN prill of any one of claims 1-9, wherein the PSAN prill substantially lacks an 84 °C crystalline phase change.

11. The PSAN prill of any one of claims 1-10, wherein upon thermal cycling the PSAN prill 50 times, wherein one cycle comprises four hours at 15 °C followed by four hours at 45 °C, the thermal cycled PSAN prill has an average crush strength greater than 0.4 kg, including from 0.4 kg to 2.0 kg, 0.5 kg to 1.5 kg, 0.6 kg to 1.0 kg, or 0.7 kg to 0.9 kg.

12. The PSAN prill of any one of claims 1-11, wherein upon thermal cycling the PSAN prill 20 times, wherein one cycle comprises four hours at 15 °C followed by four hours at 45 °C, an average crush strength of the thermal cycled PSAN prill is greater than an average crush strength of non-thermal cycled control PSAN prill.

13. The PSAN prill of any one of claims 1-12, wherein the shelf life of the PSAN prill is at least two months, at least four months, or at least six months at an average daytime ambient temperature from 30 °C to 50 °C and an average night time temperature of 10 °C to 30 °C.

14. The PSAN prill of any one of claims 1-13, wherein crystal domains of the PSAN prill are more tightly packed and more uniform than the crystal domains of an explosive grade ammonium nitrate prill devoid of potassium and having similar density and porosity to the PSAN prill.

15. The PSAN prill of any one of claims 1-14, wherein the PSAN prill comprises potassium uniformly distributed throughout the prill.

16. An emulsion explosive blend comprising an emulsion explosive and the PSAN prill of any one of claims 1-15 blended with the emulsion explosive.

17. A method of preparing a phase-stabilized ammonium nitrate (PSAN) prill, the method comprising:

forming a PSAN solution comprising a potassium salt and ammonium nitrate; and

crystallizing the PSAN solution to form a PSAN prill, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate, and

wherein the PSAN prill is explosive grade and has a bulk density less than 0.9 kg/L.

18. A method of increasing the hardness of a phase-stabilized ammonium nitrate (PSAN) prill, the method comprising:

forming a PSAN solution comprising a potassium salt and ammonium nitrate; and

crystallizing the PSAN solution to form a PSAN prill, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium

salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate.

19. The method of claim 18, further comprising thermal cycling the PSAN prill 20 times or more.

20. A method of making an emulsion explosive, the method comprising:

melting PSAN prill into a liquor, the liquor comprising:

ammonium nitrate; and

a potassium salt, wherein the PSAN prill comprises from 0.5 mole percent (mol%) to 5 mol% potassium ions of the potassium salt based on the ammonium ions of the ammonium nitrate, wherein the potassium salt comprises at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate; and

forming the liquor into a discontinuous oxidizer phase of an emulsion.

21. An emulsion explosive comprising:

a discontinuous oxidizer phase comprising:

ammonium nitrate and between 0.5 mole percent (mol%) to 5 mol% potassium ions based on the ammonium ions of the ammonium nitrate wherein the potassium ions are derived from at least one of potassium hydroxide, potassium nitrate, potassium sulfate or potassium hydrogen sulfate; and

a continuous fuel phase.