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DETERMINATION OF SAFE MOISTURE CONTENT FOR TRANSPORT OF NAIRNE CALCINES.

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C O N T E N T S.

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1. SUMMARY.

Following a request from the Department of Shipping and Fuel, the safe moisture content for the shipping of Nairne pyrite residues was determined.

Shaking tests, conducted under two different methods, indicated that the material can be safely shipped at a moisture content up to twelve (12) per cent. of the wet weight of the material.

2. INTRODUCTION.

A request was received from the Deputy Director of Lighthouses and Navigation in South Australia for advice on the safe moisture content of Nairne pyrite residues for carriage by sea.

The critical moisture content is defined as the moisture content at which, under conditions of continuous vibration, free moisture becomes visible on the surface. Above this point the mass can become fluid and move in the hold.

3. MATERIAL EXAMINED.

A sample of calcines from the roasting of Nairne pyrite concentrates was obtained from Sulphuric Acid Limited. This material contained 8.4 per cent. moisture. A sizing of this material is shown below.

Fraction. B.S.S. Mesh.	Weight Percent.	Cumulative Weight Per Cent.
- 36 + 52	0.6	0.6
- 52 + 72	1.9	2.5
- 72 + 100	11.4	13.9
- 100 + 150	12.6	26.5
- 150 + 200	15.9	42.4
- 200 + 300	10.9	53.3
- 300 + 40 microns	4.7	58.0
- 40 + 28 "	10.0	68.0
- 28 + 20 "	9.7	77.7
- 20 + 16 "	5.5	83.2
- 16 + 10 "	3.2	86.4
- 10 "	13.6	-
	100.0	

A sample of pyrite concentrate was also obtained for comparison with the calcines and to determine the effectiveness of the testing procedure.

4. EQUIPMENT USED.

(a) ROTAP Screening Machine. This machine is used in routine screening tests and imparts a rotary motion to a nest of screens. A tapping mechanism is also provided. A strong consolidating action is therefore imparted to the test sample.

(b) Vibrating Box. A steel box 12" x 6" x 6" was attached to a electromagnetic vibrating feeder. This machine was controlled to produce a strong vibrating action in the test sample. No tapping action is superimposed on to the vibrating action in this method.

The condition of the surface of the sample could be observed continuously.

5. RESULTS.

5.1 Method of Testing - ROTAP.

Batches of Nairne calcines of various moisture content were placed individually in the container of the Rotap screening machine and shaken and tapped for various periods. The material was examined at regular intervals so that the approximate times for the various changes in the test sample could be determined.

Critical moisture content was taken as the point where free moisture became visible on the surface of the material under test.

5.2 Testing of Nairne Calcines.

Several tests were carried out varying the moisture, retention time and amount of sample.

The conditions and results of these tests are set out in Table 1.

Each sample was prepared by adding the required amount of water to the sample of calcines and then mixing in a mortar. Great care was taken to see that the size of the particles was not reduced during mixing. The mixed material was then placed in the screen pan and shaken in the Rotap. On completion of the test the sample was dried

and weighed to determine the residual moisture content. Loss of moisture took place during the tests, which are arranged in the table in order of increasing residual moisture.

Table 1.

Test No.	Calculated Moisture Per cent.	Measured Moisture Percent.	Retention Time (mins.)	Description
1	-	8.4	60	Material as received. Shaking of this material produced no consolidation or balling. 500 grm. sample.
2	13.2	10.1	111	30 c.c. of water per 500 grms. The material balled easily. No free moisture visible. 500 grm. sample.
3	11.9	10.2	60	20 c.c. of water added per 500 grms. Material on shaking acted in a similar manner to that stated in Test 1. 500 grm. sample.
4	14.3	12.8	30	35 c.c. of water added per 500 grms. Material rolled into balls. No sign of free moisture.
			60	Balls increased in size and material sticking to the side of the container. No sign of free moisture. 2000 grm. sample.
5	14.4	13.1		35 c.c. of water per 500 grms. Material noticeably damp, but friable when placed in the container.
			30	Balls formed, which appeared to glisten, i.e., free moisture present on the surface.
			60	Free water increased. Taken as being in the region of the critical moisture content. 500 grm. sample.
6	15.2	13.5		40 c.c. of water per 500 grms. Material was noticeably damp when placed in the container.
			5	Balling freely.
			10	Free moisture on the surface of the balls.
			44	Whole mass wet and sticky. Taken as being above the critical moisture content. 500 grm. sample.
7	14.4	13.5	120	35 c.c. of water per 500 grms. Balling occurred but free moisture was not noticed. 1,000 grm. sample.

Test No.	Calculated Moisture Per cent.	Measured Moisture Per cent.	Retention Time (mins.)	Description.
8	15.0	14.9		40 c.c. of water per 500 grms. Material noticeably damp, but friable.
			2	Large balls formed; these appeared on the surface. Taken as above the critical moisture content. 2,000 grm. sample.
9	16.0	15.8		50 c.c. of water per 500 grms. After mixing with the water the calcines appeared damp, but only loosely compacted.
			2	Shaking for this length of time produced large balls with free moisture visible on the surface. This mixture was taken to be well above the critical moisture content. 500 grm. sample.

5.3 Testing of Nairne Pyrite Concentrates.

These tests were to determine the effectiveness of the Rotap method and to obtain the critical moisture content of pyrite concentrates. Testing was carried out in a similar manner to that used for the Nairne calcines. Results appear in Table 2.

Table 2.

Rotap Testing of Nairne Pyrite Concentrates.

Test No.	Calculated Moisture Per cent.	Measured Moisture Per cent.	Retention Time (mins.)	Description.
10	-	8.2	20	Material as received. Shaking only tended to ball the material. No free moisture. 1,000 grm. sample.
11	9.6	8.9	44	7.5 c.c. of water per 500 grms. The material balled freely around the edge of the container. Major portion remained compacted in the centre. No free moisture present. 1,000 grm. sample.
12	10.4	10.2		12.5 c.c. of water per 500 grms.
			4	Some balling notice, but these settled into the remainder of the pyrite after 4 minutes.
			14	Finally all settled into a level compact mass. 1,000 grm. sample.

Table 2 (Contd.):

Test No.	Calculated Moisture Per cent.	Measured Moisture Per cent.	Retention Time (mins.)	Description.
13	12.5	10.8		25 c.c. of water per 500 grms.
			0	Sticky mass of concentrates.
			2	Settled down as a tough mass along the base of the container. No free moisture.
			4	Stiff mass. Could be made to move along the base of the container when tilted and lightly tapped with the hand.
			14	Similar to the above.
			44	As before. 1,000 grm. sample.
14	11.3	10.8		17.5 c.c. of water per 500 grms.
			2	Some balling; major portion sets solidly.
			4	Balls subsiding and the whole mass compacted.
			14	All compacted with free water on the surface. 1,000 grm. sample.

5.4 Vibrating Box Testing of Nairne Calcines.

Samples of the calcines, each containing two kilograms of the head sample, were prepared to definite moisture contents in the mortar. These samples were then shaken for four-hour periods. The balls remained in the same place throughout the test period, but rotated about an axis parallel to the plane of the box and perpendicular to the direction of vibration.

Results of these tests are set out in Table 3.

Table 3.

Vibrating Box Testing of Nairne Calcines.

Test No.	Calculated Moisture Per Cent.	Measured Moisture Per Cent.	Retention Time (Hours)	Description.
15	-	7.9	4	Material as received. Material balled slightly; very little packing.
16	11.0	11.2	4	35 c.c. of water per 1,000 grms. Compacted, but only slightly damp to the touch. 2,000 grm. sample.
17	11.9	11.7	4	45 c.c. of water per 1,000 grms. Similar to test 16. 2,000 grm. sample.
18	13.4	12.6	4	60 c.c. of water per 1,000 grms. Similar to tests 16 and 17. 2,000 grm. sample.
19	14.3	13.3	4	70 c.c. of water per 1,000 grms. Compacted, but breaks easily when handled. No noticeable variation in moisture content with depth. 2,000 grm. sample.
20	15.8	14.9	4	85 c.c. of water per 1,000 grms. Similar to test 19. 2,000 grm. sample.
21	16.8	15.4	4	95 c.c. of water per 1,000 grms. Well compacted with uniform moisture content from top to bottom. 2,000 grm. sample.
22	-	15.4	24	95 c.c. of water per 1,000 grms. Same as test 21. No sloppy conditions after extended testing. 2,000 grm. sample.
23	17.8	16.1	1.5	105 c.c. of water per 1,000 grms. Sloppy section appeared after 3 minutes and covered the whole surface area in 20 minutes, set hard after 90 mins. Test terminated at this point. 10 c.c. of free water removed from the surface of the sample. 2,000 grm. sample.

6. DISCUSSIONS AND CONCLUSIONS.

It is likely that the following factors would have an effect on the behaviour of the material during carriage by sea:-

(1) Moisture content.

(2) Sizing analysis.

(3) Mineral composition.

(4) Temperature of material and surroundings.

(5) Ratio of surface area to depth.

(6) Nature and degree of vibration.

The test work reported here refers to the specific sample of calcine provided by Sulphuric Acid Limited. Variation of any of the conditions mentioned could vary the results obtained.

The two methods of consolidation used give different figures for the critical moisture. The Rotap shaking and tapping method is violent and is considered to be greatly in excess of the motion that will be obtained on board ship. The vibrating box method appears to be a closer approach to the motion obtained on an ocean-going cargo ship, in that it would simulate the continuous vibration due to the engines.

The Rotap method indicated a critical moisture content of approximately 13 per cent. Above this figure there is every likelihood of a wet surface developing. The shaking box test indicates the critical moisture to be between 15.4 and 16.1 per cent.

Testing of the Nairne pyrite concentrates indicated a critical moisture content between 9 and 10 per cent. The permissible moisture for sea transporting of this material is 7 per cent., which allows a safety margin of 3 per cent. moisture. Using this figure of 3 per cent. as a guide and considering the more stable properties of the calcines, a limiting moisture content of 12.0 per cent. based on wet weight (i.e., 12 parts by weight of water to 88 parts by weight of calcine) is recommended for the sea transport of the calcine.
