

ment whereby heat is supplied without contact of the fuel with the dust to be treated.

In case the dust is to be sold directly to the fertilizer trade such a process would have the advantage of yielding a product with its water-soluble potash more concentrated than in the original dust, for not only is the recombined potash liberated by this procedure but the total weight of the material is diminished. This diminution of weight may be attributed to loss of water, of carbon dioxide, and of any carbonaceous matter in the dust. If, however, the preparation of potash salts is aimed at, it is possible that for dusts behaving like the Alpha dust digestion under steam pressure, as mentioned above, would be the preferable method of treatment since in the latter method there is no volatilization of potash and the yield of water-soluble potash on the basis of the total original potash is consequently greater. This volatilization apparently commences at about 900°. As stated before, the temperatures of the Alpha dust very likely were considerably above those indicated by the pyrometer and relatively greater volatilization of potash in this dust at a given temperature may be easily explained on this assumption.

To ascertain the effect of time of heating on the two dusts, samples were ignited at 1000° for 20, 40 and 60 minutes. The results obtained are shown in Table IV.

TABLE IV—THE EFFECT ON WATER-SOLUBLE AND TOTAL POTASH CONTENT OF VARIATIONS IN DURATION OF IGNITION. TEMPERATURE 1000°

	SECURITY DUST			ALPHA DUST		
	20 min.	40 min.	60 min.	20 min.	40 min.	60 min.
ON BASIS OF ORIGINAL DUST						
Loss in weight.....	7.06	7.32	7.37	15.15	15.52	15.80
Total potash.....	11.33	11.19	11.06	6.12	5.97	5.89
Water-soluble potash....	10.60	10.62	10.58	5.02	5.15	4.89
ON BASIS OF PRODUCT						
Total potash.....	12.19	12.07	11.94	7.21	7.07	7.00
Water-soluble potash....	11.41	11.46	11.42	5.92	6.10	5.81

It is apparent from inspection of this table that for the periods considered ignition of the dust for a longer period than 20 minutes has no decided effect on the ratio of water-soluble to total potash in the material.

#### SUMMARY

I—Dusts from cement mills using coal as fuel have considerable proportions of their potash content in a form not readily water-soluble.

II—Ignition of such dusts in an oxidizing atmosphere at temperatures of 600–1100° converts the “recombined” potash into a readily water-soluble form.

III—For the periods considered (20 to 60 minutes) time of ignition apparently has little effect on the water-soluble potash content of the resultant product.

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#### EFFECT OF COAL ASH ON THE LIBERATION AND NATURE OF CEMENT MILL POTASH

By N. S. POTTER, JR., AND R. D. CHEESMAN

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In all articles thus far published relating to potash as a by-product in the manufacture of cement, no consideration has been given to the potash content of the coal used in burning and its attendant effects. It is the purpose of this paper to point out the effect the coal ash has upon the liberation of potash in the

kilns and upon the nature of the so-called “treater dust” collected.

The potash collected from the kiln stack gases where coal is used for burning appears in practically two forms, water-soluble potash and the insoluble or slowly soluble potash. The insoluble potash has been attributed to two causes: the potash in the unburned or partly calcined raw material carried over mechanically in the gases and to a recombination of the volatilized potash with the finely divided ash particles of the coal.

R. J. Nestell and E. Anderson in their paper, “The Nature of Cement Mill Potash,”<sup>1</sup> state that “the most important differences in the potash material from coal-fired and oil-fired kilns, as shown by the analyses given, lie in the relative amounts of soluble and insoluble K<sub>2</sub>O, and in the wide variation in potash concentration in the lighter fractions of dust obtained from kilns using these two different forms of fuel. In the dust from the oil-fired and coal-fired kilns previously referred to, where in the first case the per cent of insoluble K<sub>2</sub>O was 0.56 and in the second case 4.55 per cent, it seems safe to assume that the amount of mechanically carried-over raw material was practically the same, consequently the difference noted in the amount of siliceous material shown cannot be due to a greater amount of calcined raw mix in one case. The only other source of siliceous material is the ash from the coal used as fuel. Since this ash, coming as it does from finely powdered coal, must be in a state of extremely fine subdivisions, approaching that of a true fume, it is reasonable to suppose that part of this ash would be collected among the lighter portions of dust. Since approximately 9 lbs. of coal ash are introduced into the kiln per barrel of clinker burned, if only one-half this amount is carried out with the gases, it would still be sufficient to effect appreciably the composition of the collected dust, as the amount of dust caught per barrel of clinker produced is only about 20 lbs. Consequently it is probable that the considerable amount of insoluble potash shown to be present in the dust from the coal-fired kilns is in reality due to a combination of the volatilized potash with the finely divided incandescent particles of siliceous coal ash.”

Wm. H. Ross, in his paper on “The Extraction of Potash from Silicate Rocks—II,”<sup>2</sup> also states that “the slowly soluble combination is explained on the ground that during the burning of the cement part of the volatilized potash undergoes a recombination with the silicates in the dust.”

The following is taken from an article on “The Recovery of Water-Soluble Potash as a By-product in the Cement Industry,”<sup>3</sup> “The insoluble potash represents the combinations occurring in the original silicates of the raw mix which is carried over mechanically in the dust before being subjected to a sufficiently high temperature to bring about decomposition. The form of combination which is slowly soluble in water is supposed to be due to a recombination of the volatilized potash with the silicates in the dust. In

<sup>1</sup> THIS JOURNAL, 9 (1917), 646.

<sup>2</sup> *Ibid.*, 9 (1917), 467.

<sup>3</sup> *Ibid.*, 9 (1917), 1035.

some plants where coal is used for burning, the extent to which the potash occurs in the "recombined" form may be considerable, while in certain other plants where oil is used for fuel this combination of the potash is present in comparatively small amount." Thus it is evident that the potash content of the coal ash has been quite neglected.

Analyses of the ash from the coal burned in the kiln, Table I, bring out the fact that the potash content of the ash is considerable and to such an extent that it must be taken seriously into consideration in figuring liberation and potash balances. The samples taken for analyses represent a week's composite of the daily averages of coal going into the kiln. Being compelled to buy coal upon the open market due to the coal situation, it was impossible to differentiate the sources relative to the mines furnishing the coal. Work along the line of determining the potash content of the ash of coal from different mines throughout the country is now in progress and the results obtained will be published in due time.

TABLE I—K<sub>2</sub>O CONTENT OF KILN COAL ASH

SAMPLE	Per cent K <sub>2</sub> O
Week ending Oct. 29, 1917.....	5.22
Week ending Nov. 5, 1917.....	4.54
Week ending Nov. 12, 1917.....	4.85
Week ending Nov. 17, 1917.....	4.75

The average potash content figures close to 5 per cent. As the coal consumption at the different cement plants throughout the country varies greatly, ranging from 80 lbs. coal per barrel to 250 lbs., it is apparent that the potash entering with the coal is considerable. Assuming the ash content to average 10 per cent and using the above figures, it is evident that the potash introduced by the coal lies between 0.4 lb. and 1.25 lbs. per barrel of clinker. Due to the very finely divided state of these ash particles and the velocity of the gases in the kiln, but a very small percentage of the ash is deposited in the kilns, nearly all passing out with the gases. The per cent being deposited in the kiln is undoubtedly higher in mills using the wet process where the ash particles have a tendency to cling to the wet slurry. In order to observe this effect of the ash upon the nature of the materials in the kiln, samples of the material were taken at intervals of 10 ft. throughout the length of the kiln. The effect upon the K<sub>2</sub>O content of the materials is shown graphically in Fig. I.

Curve I takes into consideration the actual K<sub>2</sub>O as determined by analyses assuming the original material (slurry) to be previously calcined.

Curve II shows the actual K<sub>2</sub>O in these different samples.

Curve III attempts to show the K<sub>2</sub>O content of the samples as it would be on the basis of K<sub>2</sub>O content of slurry entering the kiln and taking into consideration the actual loss attained at the different intervals as shown by chemical analyses, disregarding any additions of K<sub>2</sub>O from other sources.

Curve IV shows the K<sub>2</sub>O content at the different intervals calculated on the assumption that the material had been previously calcined and no volatilization of K<sub>2</sub>O in the kiln or addition of K<sub>2</sub>O from other sources.

Comparing Curves II and III it is clearly shown that the K<sub>2</sub>O content of the slurry is effected appreciably from some other source. This source is either the K<sub>2</sub>O in the ash from the coal or the K<sub>2</sub>O as fume in the gases. Due to the very physical nature of the K<sub>2</sub>O from these two causes it is safe to assume that the K<sub>2</sub>O in the ash is the principal contaminator.

The appreciable rise in the K<sub>2</sub>O content of the slurry at 115 ft. as shown in Curve II is probably only a local condition due to the peculiar construction in our kilns at this point. I-beams about 15 ft. in length

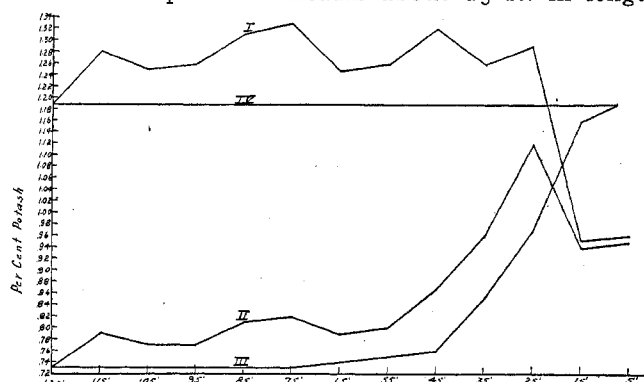


FIG. I—DISTANCE FROM BURNING END OF KILN

I—Actual K<sub>2</sub>O, supposing no loss on ignition.

II—Actual K<sub>2</sub>O in samples.

III—Theoretical K<sub>2</sub>O, supposing no contamination from ash on volatilization of K<sub>2</sub>O.

IV—Theoretical K<sub>2</sub>O figured to no loss on ignition basis, non-volatilization of K<sub>2</sub>O and no adulteration from ash.

are attached to the interior wall of the kiln. These are spaced at intervals of 3 ft. and lie parallel to the axis of the kiln. The kiln in rotating lifts the slurry at this point to approximately the top of the kiln where it drops back through the gases to the floor of the kiln. This very readily acts as a filter causing considerable of the fine dust particles to deposit with the wet slurry.

TABLE II—CHEMICAL ANALYSES

Distance from Front of Kiln Ft.	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	S	Loss on Ignition
5	22.68	3.89	6.29	61.75	3.51	1.16	0.05	2.25
15	22.41	3.67	5.95	60.54	3.54	1.14	0.06	4.90
25	20.34	3.29	6.23	56.09	3.23	1.41	0.07	12.05
35	19.74	3.59	6.99	53.97	3.21	1.04	0.17	19.11
45	16.22	3.22	3.96	42.70	2.65	1.05	0.04	32.10
55	14.82	2.62	4.14	40.17	2.66	0.76	0.32	37.15
65	14.12	2.39	3.27	39.47	2.75	0.54	0.52	37.40
75	14.00	2.39	4.15	38.66	2.63	0.19	0.58	38.36
85	14.34	2.39	3.91	38.87	2.40	0.16	0.10	38.77
95	13.92	2.32	4.06	38.76	2.50	0.29	0.22	38.80
105	14.02	2.32	3.36	39.27	2.70	0.21	0.30	39.05
115	14.38	2.02	4.12	38.56	2.55	0.31	0.43	39.01
125	13.82	2.24	4.26	38.97	2.66	0.21	0.39	38.96
Ash	41.63	8.77	33.09	15.23	1.67	....	....	...

The ash deposit with the slurry is further demonstrated by chemical analyses.

Table II shows the chemical analyses of the different samples as taken throughout the kiln and also the ash analyses of the coal used at that time.

As the velocity of the kiln gases is quite high these ash particles will be exposed to the intense heat of the firing zone of the kiln but a fraction of a minute, possibly not more than a few seconds. Further, the very nature of combustion being exothermic precludes the possibility of a very high temperature being attained by the ash particles. Such being the case there should be practically no volatilization of the potash in the ashes from the coal in the kilns.

TABLE III—SOLUBILITY TESTS ON COAL ASH FOR  $K_2O$   
Sample Heated to Glow over Meker Burner for 1 Hour  
Total  $K_2O$  in Ash, 4.47 Per cent

HOW TREATED	Sol. $K_2O$ Per cent $H_2O$ in Sample
Washed on filter paper.....	0.10
$1/2$ hour boil.....	0.16
1 hour boil.....	0.23
2 hours boil.....	0.23
4 hours boil.....	0.23
7 hours boil.....	0.25
10 hours boil.....	0.28
15 hours boil.....	0.28
24 hours boil.....	0.25

Samples of kiln coal ash containing 4.47 per cent  $K_2O$  were heated to a glow for approximately one hour over the Meker burner. This showed no volatilization. Two gram samples of this ash were then boiled vigorously for different periods up to 24 hrs. to determine whether this could be made water-soluble upon boiling. Table III shows that after 1 hour's boiling there is no increase in water-soluble  $K_2O$ . This water-soluble is so small as to be negligible. While this does not reproduce the kiln condition exactly it is quite evident that at the temperature attained by the ash in passing through the kiln and for the period to which it is subjected to this temperature, no potash of the ash will be volatilized.

Assuming that 90 per cent of this ash in a dry process plant and 75 per cent in a wet plant passes up the flue with the gases the effect of the insoluble  $K_2O$  in the ashes will affect the nature of the treater dust very appreciably.

Due to observations made while assisting in the research work at the Security Cement & Lime Company and to data showing potash balances at different plants at hand, but which we are not at liberty to publish at this time, it is quite evident that the insoluble potash content of the dust collected from the kiln gases is of two sources, that which passes over with the raw material, or partially calcined dust, and that which passes over with the ash from the coal used in burning.

#### CONCLUSIONS

- I— $K_2O$  content of coal ash is considerable.
- II— $K_2O$  content of coal ash must not be disregarded in calculating the liberation in kilns.
- III— $K_2O$  content of coal ash appears in "treater dust" as insoluble  $K_2O$ .
- IV—Taking into consideration the  $K_2O$  content of ash and the  $K_2O$  in raw mix carried over mechanically there is apparently no "recombination" of the volatilized  $K_2O$  with the siliceous ash particles.

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#### TOLUOL RECOVERY AND STANDARDS FOR GAS QUALITY<sup>1</sup>

By R. S. McBRIDE

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The removal of benzol and toluol from gas necessarily reduces the heating value and candle-power of the gas; the amount of reduction depends upon the quantity of these constituents originally in the gas, the thoroughness of washing, and the general character of the gas with respect to other heating and lighting

constituents. In this paper it is intended, *first*, to present a summary of the more important conditions of operation which determine the probable effect of toluol recovery upon the quality of the gas supplied; *second*, to illustrate the method of estimating the probable effect in any particular case; and *third*, to summarize certain general recommendations as to changes in standards that must be made in order that recovery of toluol can be carried out effectively in a large number of localities. In this memorandum, changes of standards are considered only from the standpoint of toluol recovery. No consideration is given to any other factors which might properly in many cases make desirable a change of standards. Such matters would depend upon a number of factors, not within the scope of the present discussions.

#### SUMMARY OF PRESENT STANDARDS OF GAS QUALITY AND GAS COMPANY OPERATING CONDITIONS

Both the heating value and the candle-power of gas are used in this country as a measure of the quality of the product supplied. Usually only one of these two characteristics is prescribed by ordinance or administrative ruling, but in some cases both are fixed. In cases where such standards have not been adopted and the quality of the gas supplied is determined by the local gas company, it is of interest to know what quality of gas is being supplied. This information is presented below; for convenience of consideration the companies are classified according to the standard in force. Data are included for all American gas companies making 500,000,000 cu. ft. or more of coal, water, or oil gas per year and for such other companies as have been recommended to the Ordnance Department for consideration by the Sub-Committee on Coal-Tar By-Products.

I—Gas companies in the following cities are expected to supply gas in compliance with the candle-power requirement as follows:

##### (a) Requirements of 20 candles or higher:

New York City (including the New York Consolidated System, the Brooklyn Union Gas Company, and the King's County Lighting Company), 22 c.-p. (Permission has recently been given to change to a heating value of 650 B. t. u. at the same price or to any lower heating-value standard if a proportionate reduction in price of gas is made.)

Philadelphia, Pa., 22 c.-p., fixed by a franchise contract with the city.

Des Moines, Iowa, 22 c.-p.

Sioux City, Iowa, 21 c.-p.

Omaha, Neb., 23 c.-p. measured at the gas works, or 21.2 c.-p. measured at the city testing station, and 600 B. t. u. heating value.

Charleston, S. C., 20 c.-p. and 600 B. t. u.

East St. Louis, Ill., 20 c.-p. (an old city ordinance requirement) and 565 B. t. u.

Northern Illinois cities supplied by Public Service Company of Northern Illinois, 22 c.-p. (ordinance) and 565 B. t. u. (state standard).

##### (b) Requirements of 18 candles:

Detroit, Mich., 18 c.-p. and 600 B. t. u.

Lansing, Mich., 18 c.-p. and 600 B. t. u. *net* heating value.

Los Angeles, Cal., 18 c.-p. and 600 B. t. u. (most of the gas

<sup>1</sup> Published with permission of the Director, Bureau of Standards.