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FUEL RESEARCH INSTITUTE

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TECHNICAL MEMORANDUM

NO. 9 OF 1977

CALCULATED BOILER CORROSION FACTORS FOR SOME SOUTH AFRICAN COAL PRODUCT SAMPLES

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PROJECT	:	2.8 INORGANIC CONSTITUENTS (INCLUDING MINERALS) IN COAL
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TITLE	:	CALCULATED BOILER CORROSION FACTORS FOR SOME SOUTH AFRICAN COAL PRODUCT SAMPLES
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SECTION	:	CHEMISTRY

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SYNOPSIS

Corrosion factors for boilers were calculated for some South African coal product samples using Borio's formula in which the "accessible" alkalies were replaced by the total alkalies from the ash analysis.

INTRODUCTION

In a report by the Office of Coal Research (US Department of Interior), work by Borio et al (1968) is quoted in which they concluded that the corrosion rate in boilers could be related to the chemical composition of the coal used. They found that the composition of the alkalies, as measured by an acid leaching process, affected the corrosion rate. The alkaline earth minerals, e.g. calcite and dolomite tended to reduce the corrosion rate. Coals could thus be made less corrosive by adding calcite or dolomite. Coals with very low iron contents also tended to be less corrosive.

It was thought that complex alkali-iron-sulphates were responsible for most of the high temperature corrosion and that variation in the sodium-potassium ratio would affect the melting point of these complex sulphates in an ash deposit. The inhibiting effect of calcium and magnesium was due to their ability to tie up sodium and potassium in the form of double salts, of the type $K_2SO_4.2CaSO_4$, hence rendering them unavailable for reaction to form the complexes $K_3Fe(SO_4)_3$ and $Na_3Fe(SO_4)_3$.

Computer studies were carried out and the best equation relating the parameters was found to be:

$$\text{Corrosion} = 5{,}96 + 5{,}07 \left(\frac{Na_2O}{K_2O}\right) - 0{,}42\ (CaO + MgO)$$

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where sodium and potassium oxides as determined by acid extraction are expressed as ppm on a coal basis and calcium and magnesium oxides are expressed as percentages on an ash basis.

CORROSION FACTORS FOR SOUTH AFRICAN COALS

Corrosion factors calculated from coal ash analyses given in the 45th and 46th Annual Reports of the Fuel Research Board are presented in Table 1. Although many of the colliery products are not used for the generation of steam, they have been included in order to determine the probable range of corrosiveness of South African coals.

It must be noted that values for "accessible" sodium and potassium as determined by Borio et al by acid leaching, are not available and the total alkalies in the coal ash were used in the calculation instead. The sulphur content of South African coals is also very much lower, in general, than the sulphur content of the coal on which Borio et al's work was done. How this would affect the data is not known.

DISCUSSION

Bearing in mind the limitation to the data discussed above, it is interesting to note that the variation in corrosion factors for South African coals is numerically of the same order as those published for some American coals (O'Gorman and Walker (1972) pp87 and 88).

Coal products from the Witbank area should cause average corrosion (corrosion factor 4-8) or less than average corrosion (less than 4). The high alkaline earth content of one product resulted in a negative corrosion factor of 0,3. The generally lower alkaline earth content of the No. 5 Seam resulted in slightly higher corrosion factors (5 to 6) although they were still in the "average" corrosion range.

Where they were not inhibited by correspondingly high alkaline earth contents, the corrosion factors for the Natal products tended to be higher where the sodium:potassium ratio was higher. None of the corrosion factors were higher than 10, however.

The high sodium/potassium ratios of products from the Vereeniging-Sasolburg coalfield resulted in the highest corrosion factors calculated for any of the coals. The corrosion values varied from 11 to 19 which is well above the upper limit of 8 for average corrosion.

Since it is not known to what extent, or if at all, these calculated corrosion factors reflect conditions encountered in actual boiler practice in South Africa, comment is invited from coal users.

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REFERENCES

Borio, R W; Hensel, R P; Ulmer, R C; Wilson E B and Leonard, J W. (1968): Study of means for eliminating corrosiveness of coal to high temperature surfaces of steam generating units - II. Combustion, February 1968, 12 - 20.

Forty-fifth and Forty-sixth Annual Reports of the Fuel Research Board.

O'Gorman, J V and Walker, P L (1972): Mineral matter and trace elements in US coals. Office of Coal Research, US Department of Interior Research and Development. Report No. 61. Interim Report No. 2. 81 - 90.

TABLE 1

CALCULATED BOILER CORROSION FACTORS[x] FOR COAL PRODUCT SAMPLES[xx]

Colliery	Product	Sample No.	$\frac{Na_2O}{K_2O}$ [xxx]	CaO + MgO %	Corrosion factor
WITBANK AREA					
No. 2 Seam					
Albion	Pea	75/576B	0,31	18,7	-0,3
Bank	Pea	76/71B	0,33	7,5	4,5
Delmas	Mixed smalls	75/38D	0,90	8,7	6,9
Douglas[1)]	Pea	76/67B	0,62	7,2	6,1
Eikeboom	Pea	75/208D	0,24	5,8	4,7
Koornfontein	Mixed smalls	75/582A	0,80	13,3	4,4
New Clydesdale	Nut	75/414A	1,40	14,3	7,0
Optimum[1)]	Crushed	76/237A	0,32	4,4	5,7
Springbok	Nut	75/424A	0,62	8,3	5,6
Tavistock	Pea	75/136B	0,48	10,4	4,0
Transvaal Navigation	Pea	75/128B	0,44	8,9	4,4
Van Dyks Drift[1)]	Mixed smalls	75/425B	0,81	10,2	5,8
No. 2 and No. 4 Seams					
Anglo Power (Kriel)[2)]	Crushed	75/553A	1,07	15,4	4,9
Blinkpan[3)]	Mixed smalls	75/144A	0,37	11,6	2,9
Greenside	Pea	76/62B	0,35	11,5	2,9
New Largo	Nut	75/427B	0,22	11,3	2,3
Phoenix	Pea	75/570B	0,34	9,1	3,8
South Witbank[2)]	Pea	75/572D	0,55	10,3	4,4
Tweefontein	Pea	75/418B	0,42	5,9	5,6
Waterpan	Mixed smalls	75/428D	0,64	11,7	4,3
Witbank Consolidated[4)]	Mixed smalls	75/574C	0,28	11,1	2,7
Wolvekrans[1)]	Pea	75/589B	0,23	7,3	4,1

TABLE 1 (CONTD)

Colliery	Product	Sample No.	$\frac{Na_2O}{K_2O}$ xxx	CaO + MgO %	Corrosion factor
No. 5 Seam					
Blesbok	Coking	76/965A	0,11	3,4	5,1
Greenside	Blend coking	75/408D	0,19	9,2	3,0
Kriel	Nut	75/555B	0,33	4,9	5,6
Navigation	Coking	75/569B	0,13	3,6	5,1
Springbok	Coking	76/246C	0,12	1,5	5,9
Springbok Hope	Coking	76/244A	0,15	2,9	5,5
EASTERN TRANSVAAL					
Spitzkop	Pea	75/586B	0,26	8,0	3,9
Union	Pea	75/124B	0,30	7,1	4,5
Usutu (South and East)	Crushed	76/234A	1,00	10,9	6,5
Usutu (West)	Crushed	76/233A	0,51	12,2	3,4
SOUTH RAND AND ORANGE FREE STATE					
Coalbrook No. 2	Mixed smalls	75/45A	2,41	10,8	13,6
Coalbrook No. 3	Crushed	75/559A	3,00	6,4	18,5
Cornelia Bertha I	Pea	75/393A	2,02	9,6	12,2
Cornelia Bertha II	Pea	75/394A	2,12	8,8	13,0
Sigma	13 x 0 mm	75/557B	1,65	7,2	11,3
Springfield (Grootvlei)	Crushed	75/562A	0,66	9,1	5,5
Vierfontein	Mixed smalls	75/202A	0,61	4,7	7,1
NATAL					
Klip River					
Ballengeich	Pea	75/303B	1,26	6,2	9,8
Durban Navigation	Coking	76/680A	0,62	7,2	6,1
Indumeni	Coking	76/683A	1,71	12,6	9,3
Kilbarchan	Mixed smalls	75/55A	0,80	8,0	6,7
Natal Navigation	Coking	76/684A	0,47	2,0	7,5
Newcastle-Platberg	Pea	75/304B	0,40	1,2	7,5
Star	Nut	75/301B	0,62	23,8	-0,9

TABLE 1 (CONTD)

Colliery	Product	Sample No.	$\frac{Na_2O}{K_2O}$ [xxx]	CaO + MgO %	Corrosion factor
Utrecht					
Balgray	Mixed smalls	76/40B	1,53	21,8	4,5
Umgala	Small	76/933A	0,41	16,3	1,2
Utrecht	Pea	75/310B	1,02	18,3	3,4
Zimbutu	Pea	76/934C	0,41	10,1	3,8
Paulpietersburg-Vryheid					
Aloe Anthracite	Mixed duff	8434	0,60	1,3	8,4
Brockwell Anthracite	Mixed smalls	76/44D	0,75	2,8	8,6
Dumbe	Coking	76/223A	0,28	3,0	6,1
Hlobane	Coking	76/691A	0,32	1,3	7,0
Tendega	Coking	76/950A	1,09	4,3	9,7
Vryheid Coronation	Coking	76/946A	0,37	1,8	7,1

NOTES:

[x] 4-8 average corrosion
<4 corrosion less than average
>8 corrosion more than average.

[xx] Ash analyses given in Forty-fifth and Forty-sixth Annual Reports of the Fuel Research Board.

[xxx] Total alkalies in coal ash.

1) Including No. 1 Seam.

2) No. 4 Seam only.

3) No. 4 Seam not always mined.

4) No. 2 Seam not always mined.