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PERFORMANCE OF TABLES IN CLEANING ALASKA COALS

By M. R. Geer, Michael Sokaski, and P. S. Jacobsen

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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UNITED STATES DEPARTMENT OF THE INTERIOR
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CONTENTS

ILLUSTRATIONS

TABLES

PERFORMANCE OF TABLES IN CLEANING ALASKA COALS[1]

by

M. R. Geer,[2] Michael Sokaski,[3] and P. S. Jacobsen[4]

INTRODUCTION AND SUMMARY

Information on the performance of coal-cleaning equipment is necessary to provide a basis for evaluating the performance of existing plants and projecting that of new plants. Performance data can contribute greatly to the wise selection and effective use of coal-washing equipment.

The Bureau of Mines has published information on the performance of several commercial plants, as well as of some laboratory-scale equipment,[5] (2-9, 11, 12, 17-19, 21-25) from time to time for a number of years. A more intensive program to provide such information for all the principal types of cleaning equipment is underway. The present evaluation of table performance is part of this program.

A total of twelve performance tests was made in two Alaska plants, both of which are in the Matanuska Valley field. The five coals cleaned in these plants cover a wide range in washability. Some of the tests involved sampling the table products incrementally over a full shift of operation to show average performance. In others, single-increment zone samples were collected that could be combined as desired to show the influence of changing the cut point between washed coal and refuse.

The separation between coal and impurity in the sizes coarser than 20-mesh generally was reasonably sharp, as detonated by error areas of 50 to 60 and probable errors of about 0.100. In the intermediate size range, 20- to 48-mesh, elimination of heavy impurity generally was satisfactory, but coal was lost in the refuse. In the finest fraction, 48- to 200-mesh, the separation between coal and impurity was far less sharp. Efficiency also was

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influenced by size, sometimes exceeding 99 percent for the coarser material but dropping significantly with decrease in particle size. Thus the proportion of extreme fines in the feed to tables has an important bearing on the overall cleaning results.

As with most cleaning devices, sharpness of separation increased as the density of separation decreased. However, any reduction in the density of separation of coals of this type results in a relatively large sacrifice in efficiency.

The amount of heavy impurity (sink at 1.80 specific gravity) in the table feed ranged from 18 to 29 percent. As impurity content increased, efficiency dropped. In fact, efficiency correlates more closely with impurity content than with the amount of near-gravity (±0.10) material in the feed, which is an index that is used widely to show relative difficulty of washing.

ACKNOWLEDGMENTS

This investigation was conducted at the Seattle Coal Research Laboratory of the Bureau of Mines, which functions in cooperation with the School of Mineral Engineering of the University of Washington. The authors are indebted to officials and operating personnel of the Evan Jones Coal Co. and the Mrak Coal Co., in whose plants the test work was done, for their assistance in the fieldwork.

DESCRIPTION OF COALS AND PLANTS

Table 1 shows specific-gravity analyses of the one coal tested in the Mrak plant and the three coals tested in the Evan Jones plant. The coal from the No. 5 bed is by far the most difficult of the group to clean. It contains almost as much impurity heavier than 1.80 specific gravity as float at 1.30; it also contains considerable material of intermediate density. All the other coals contain less heavy impurity and somewhat less material of intermediate density and are therefore more amenable to treatment.

In both plants the raw coal is wet-screened at 1/4-inch; the oversize goes to the coarse-coal circuit, and the undersize comprises the table feed. In neither plant is the feed deslimed or thickened; that is, all the water used in screening is used for push water to the tables. Raw-coal storage at both plants is limited to a few truckloads. Table-washed coal in the Evan Jones plant is recovered by a screw-type classifier, cyclones, and a vibrating screen; in the Mrak plant a settling tank and vibrating screen are used. These flowsheets are more or less typical of many small-tonnage plants and some large ones.

TABLE 1. - Specific-gravity analyses of coals[1]

Bed	Specific gravity	Weight-percent	Ash, percent	Cumulative	
				Weight-percent	Ash, percent
Mrak....................	Under 1.30	56.1	2.9	56.1	2.9
	1.30 to 1.40	15.8	11.7	71.9	4.8
	1.40 to 1.50	4.7	24.5	76.6	6.0
	1.50 to 1.60	2.5	34.6	79.1	6.9
	1.60 to 1.70	2.0	43.5	81.1	7.8
	1.70 to 1.80	1.4	50.9	82.5	8.6
	Over 1.80	17.5	79.3	100.0	21.0
No. 5..................	Under 1.30	30.9	2.0	30.9	2.0
	1.30 to 1.40	19.7	10.1	50.6	5.2
	1.40 to 1.50	7.7	23.1	58.3	7.5
	1.50 to 1.60	5.1	33.7	63.4	9.6
	1.60 to 1.70	4.2	42.4	67.6	11.7
	1.70 to 1.80	3.5	49.7	71.1	13.5
	Over 1.80	28.9	74.4	100.0	31.1
7B Lower..............	Under 1.30	52.0	1.7	52.0	1.7
	1.30 to 1.40	18.6	7.2	70.6	3.1
	1.40 to 1.50	5.1	20.4	75.7	4.3
	1.50 to 1.60	3.2	32.9	78.9	5.5
	1.60 to 1.70	2.9	41.8	81.8	6.8
	1.70 to 1.80	2.2	48.7	84.0	7.9
	Over 1.80	16.0	69.8	100.0	17.8
7C.....................	Under 1.30	49.5	1.5	49.5	1.5
	1.30 to 1.40	13.1	7.9	62.6	2.8
	1.40 to 1.50	3.7	20.8	66.3	3.8
	1.50 to 1.60	2.6	33.5	68.9	5.0
	1.60 to 1.70	2.8	42.8	71.7	6.4
	1.70 to 1.80	2.7	50.0	74.4	8.0
	Over 1.90	25.6	77.3	100.0	25.8

[1] 3- to 200-mesh.

The feed rate in the Evan Jones plant ranged from 5.5 to 8.5 tons per hour per table, disregarding the solids finer than 200-mesh. Each deck of the double-deck table in the Mrak plant was fed at 8.5 tons per hour. The water-coal ratios (considering both push and dressing water) are shown in the following tabulation:

Test:	Ratio of water to coal
9 to 11...............	2.5
12..................	3.3
1 to 3................	3.6
4 to 6................	3.9
7 and 8...............	5.0

In both plants, the amount of water required for screening rather than ideal table adjustment dictated the amount of water used. In most tests the water-coal ratio was somewhat greater than that recommended by the manufacturer.

SAMPLING AND TEST PROCEDURE

Two types of performance tests were made. In one test, samples of the feed, washed coal, and refuse were collected in increments over a shift of plant operation. In the other test, single simultaneous zone samples were collected with special sample launders that divided the side of the table into six equal zones of 33 inches and the end of the table into two zones of 44 inches each. These zone samples were later combined as desired for laboratory examination.

Regardless of type, all samples included both the solids and the water discharged by the table. The samples were wet-screened at 48-mesh immediately, and the oversize was dried to minimize degradation of the shale. An aliquot portion of the material finer than 48-mesh was wet-screened at 200-mesh, and the material coarser than 48-mesh was rescreened dry at 20-mesh in preparation for the float-and-sink examination. Material coarser than 20-mesh was tested in zinc chloride solutions at each 0.1 interval in specific gravity from 1.30 to 1.80. The 20- to 48- and 48- to 200-mesh fractions were tested at the same densities in organic solutions. Each density fraction obtained was analyzed for ash content.

Only the amount and ash content of the 200-mesh to 0 material was determined. The circulating water in both plants contain so much suspended clay, which contaminated the 200-mesh to 0 fraction of the samples, that including this size in the examination would have clouded the performance picture. The amount of minus 200-mesh material in the feed samples (including contaminating solids from the water) ranged from 9 to 24 percent, and the average ash content of this material exceeded 50 percent.

EVALUATION OF RESULTS

Table 2 identifies the individual tests and provided comparisons based on some of the more widely used performance criteria. Additional criteria and information on individual size groups are given in the tables in the appendix.

All of the various performance criteria used have been discussed in the literature (15) and therefore will merely be defined. Recovery efficiency, called organic efficiency in Europe and widely known as Fraser and Yancey efficiency in this country, is the ratio, expressed in percent, of the yield of washed coal to that of float coal of the same ash content shown to be present in the feed (composite or reconstituted) by specific-gravity analysis.

Ash error is the difference in ash content, expressed in percent, between the washed coal and a float coal at a yield equaling that of the washed coal. Yield error is the difference between the yield of washed coal and the float-coal yield at the same ash content. The float-coal yield and ash are derived from the specific gravity-analysis of the composite feed.

TABLE 2. - Identification of tests and summary of principal performance data

Test	Plant	Bed	Type of sample	Zones to washed coal	Ash, percent			Yield, percent	Efficiency, percent	±0.10	Specific gravity of separation	Error area
					Feed	Washed coal	Refuse					
1......	Evan Jones	7B lower	Zone	1-6	17.8	7.3	59.4	79.8	96.4	5.0	1.715	81
2......	do.	do.	do.	1-3	17.8	6.0	48.5	72.2	90.1	6.6	1.562	74
3......	do.	do.	do.	1-2	17.8	5.3	34.5	57.1	72.9	10.5	1.458	70
4......	do.	7C	do.	1-6	21.5	6.9	67.0	75.7	97.1	4.7	1.700	82
5......	do.	do.	do.	1-2	21.5	5.8	51.6	65.7	86.4	5.2	1.570	81
6......	do.	do.	Shift	-	23.6	5.8	63.3	69.1	94.4	4.5	1.613	76
7......	do.	do.	Zone	1-6	25.8	6.1	64.5	66.4	93.3	5.5	1.620	82
8......	do.	do.	do.	1-2	25.8	5.2	52.7	56.8	81.8	6.2	1.511	72
9......	do.	5	Shift	-	31.1	18.7	70.0	75.7	94.0	7.8	1.967	102
10......	do.	5	Zone[1]	1-6	34.8	20.4	74.1	73.1	94.9	8.7	1.964	99
11......	do.	5	do.[1]	1-2	34.8	16.0	64.4	61.1	88.0	7.7	1.826	122
12......	Mrak	Mrak	Shift	-	21.0	9.3	70.7	81.1	97.0	3.6	1.687	107

[1] 3- to 48-mesh.

Misplaced material is the sink in the washed coal and the float in the refuse at the specific gravity of separation, expressed as a percentage of the feed.

All of the foregoing are classed as dependent criteria, because they are affected directly by the difficulty of the separation.

The specific gravity of separation is read from the distribution curve at the 50-percent ordinate and is the specific gravity of material that is divided equally between washed coal and refuse.

Error area and probable error, relating to the sharpness of the separation between washed coal and refuse, are determined from the distribution curve, which is a plot showing what proportion of each density fraction of the raw coal was recovered in the washed product. Error area is the area between this distribution curve and one representing perfect separation; the curves are plotted to a fixed scale. Probable error is one-half of the density interval in which the curve passes between the ordinated representing 25- and 75-percent recovery in the washed product. Both of these criteria are regarded as substantially independent of the density composition of the raw coal; therefore, they are the most useful of the various criteria in comparing the cleaning of dissimilar coals.

Imperfection also relates to sharpness of separation and is regarded by some as less affected by density of separation than are error area and probable error. Numerically, imperfection is the quotient of probable error divided by the density of separation minus one.

All of these criteria are tabulated for the individual tests in the appendix.

Dependent Criteria

Table 3 shows all the dependent performance criteria for the tests, grouped by whether the split between washed coal and refuse was made at the corner or on the side of the table. This group divides the tests, with a few exceptions, into high and low densities of separation. In the high-density group, the recovery efficiency ranged from 93 to 97 percent and in the low-density group from 73 to 90 percent. The values for yield error parallel those for efficiency because these two criteria are related arithmetically. The values for ash error and misplaced material, on the other hand, deviate somewhat from efficiency in ranking individual tests.

The efficiencies for these tests are comparable with those reported by other investigators (10, 13, 36). The index used most frequently to indicate difficulty of separation is the amount of material within ±0.10 of the specific gravity of separation (13). Gandrud (10) generalized that a well-operated table should provide an efficiency of at least 95 percent if the amount of ±0.10 material in the feed did not exceed 10 percent, recognizing, however, that the density of the separation and the size composition of the feed modified the relationship between efficiency and near-gravity material.

Gandrud's rule-of-thumb generalization is overoptimistic for the present group of tests because only three have efficiencies exceeding 95 percent, and only one contained more than 10-percent of ± 0.10 material.

TABLE 3. - Comparison of dependent criteria, percent

Test	Washed-coal split	Yield	±0.10	Efficiency	Yield error	Ash error	Misplaced material
1...........	Corner	79.8	5.0	96.4	3.0	1.0	5.8
4...........	do.	75.7	4.7	97.1	2.3	1.2	5.3
6...........	do.	69.1	4.5	94.4	4.1	1.8	6.5
7...........	do.	66.4	5.5	93.3	4.8	2.1	7.6
9...........	do.	75.7	7.8	94.0	4.8	2.4	10.8
[1] 10...........	do.	73.1	8.7	94.9	3.9	2.4	10.7
12...........	do.	81.1	3.6	97.0	2.5	1.5	5.9
2...........	Side	72.2	6.6	90.1	7.9	2.6	10.3
3...........	do.	57.1	10.5	72.9	21.2	3.4	22.7
5...........	do.	65.7	5.2	86.4	10.3	3.2	12.4
8...........	do.	56.8	6.2	81.8	12.6	3.1	14.3
[1] 11...........	do.	61.1	7.7	88.0	8.3	4.8	13.3

[1] 3- to 48-mesh.

Figure 1 illustrates the approximate nature of the correlation between efficiency and ±0.10. The points exhibit considerable scatter, indicating clearly that factors other than near-gravity material have a bearing on efficiency.

The data in table 3 suggest that both efficiency and yield error are related to the yield of washed coal. Figure 2 shows the relation between efficiency and yield for the present tests and also for those in the references (10, 13, 26). Both the present data and those of the other investigators show that efficiency correlates better with yield than with amount of near-gravity material. Moreover, figure 2 demonstrates that the efficiencies found in the present investigation are conformable with those found in other plants.

The dependence of efficiency on yield is not illogical. Some proportion of the heavy impurity (sink at 1.80 specific gravity) in the feed always reports in the clean product; as the amount of such impurity in the feed increases, more impurity enters the washed coal and thus impares efficiency. Also, as the bed of impurity on the table increases, the chances for mechanical entrapment and loss of fine coal are greater. Thus the table is unable to operate as efficiently with dirty feeds as with cleaner ones.

The inability of the table to cope effectively with unusually dirty feeds is illustrated by the results obtained in tests 9, 10, and 11 on the No. 5 bed. When the cleaner coals were treated in the Evan Jones plant, only a small part of the impurity heavier than 1.80 entered the washed coal when the split between coal and refuse was made at the corner of the table, whereas in treating the No. 5 coal, about 35 percent of the 3- to 20-mesh sink at 1.80

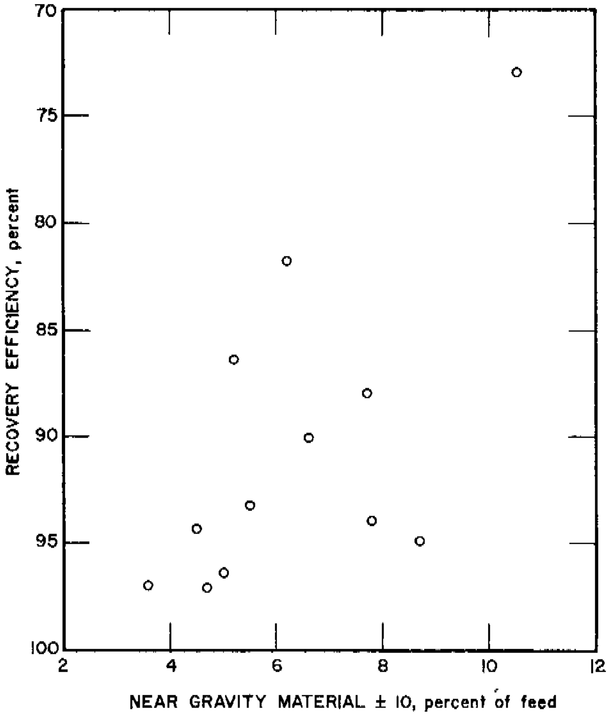

FIGURE 1. - Relation Between Recovery Efficiency and Amount of Near-Gravity Material.

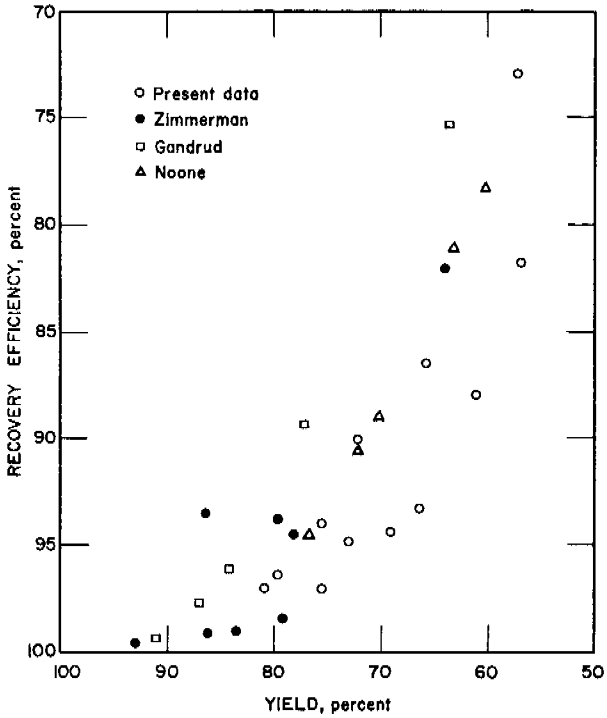

FIGURE 2. - Relation Between Recovery Efficiency and Yield.

specific gravity reported in the cleaned product. Most of this coarse impurity that contaminated the washed coal was discharged in zones 3 and 4. However, even in test 11, in which zones 1 and 2 comprised the washed coal, nearly 13 percent of the coarse sink at 1.80 specific gravity was included in the washed product.

The tables were not readjusted when the feed was changed from the cleaner beds to the dirtier No. 5 bed. Removal of sink at 1.80 specific gravity might have been improved if either the end elevation or the cross slope had been decreased or if the stroke had been lengthened; however, all these measures tend to move the clean coal farther toward the end of the table and therefore might not have improved overall performance. Thus the comparison between operation on the No. 5 coal and the cleaner beds clearly illustrates what happens to table performance during periods of dirty feed, and may be indicative of the results to be expected with unusually dirty feed even under optimum table adjustments.

Under fixed adjustments the table appears to be capable of stratifying and eliminating only so much heavy impurity. When the amount of impurity exceeds this critical value, the proportion entering the washed coal increases sharply. This is illustrated in the following tabulation of sink at 1.80 specific gravity:

In feed, tons per hour:	Reporting in washed coal, percent
1.41....................	2.7
1.37....................	3.4
2.47....................	26.8

Sharpness of Separation

In table 4 the individual table tests are compared in terms of the three criteria used to measure the sharpness of the separation between coal and impurity. In a general way, error area, probable error, and imperfection all rank the tests in about the same order of sharpness. However, notable exceptions occur. For example, tests 1, 2, and 3 comprise a series in which zone samples are combined to give progressively lower densities of separation. Error area shows a steady improvement in sharpness of separation as density of separation decreases. Probable error, in contrast, indicates that the test at lower density was the least sharp of the group.

TABLE 4. - Comparison of sharpness-of-separation criteria

Test	Washed-coal split	Specific gravity of separation	Error area	Probable error	Imperfection
1..............	Corner	1.715	81	0.121	0.169
4..............	do.	1.700	82	.122	.174
6..............	do.	1.613	76	.125	.204
7..............	do.	1.620	82	.137	.221
9..............	do.	1.967	102	-	-
10..............	do.	1.964	99	-	-
12..............	do.	1.687	107	.198	.288
2..............	Side	1.562	74	.101	.180
3..............	do.	1.458	70	.127	.277
5..............	do.	1.570	81	.129	.226
8..............	do.	1.511	72	.112	.219
11..............	do.	1.826	122	.236	.286

Note that imperfection varies over fully as wide a range as either error area or probable error. Imperfection is widely used in Europe and is generally regarded as being a constant for a given type of equipment operating under comparable conditions of adjustment and loading. Thus imperfection would have been expected to be constant for tests 1, 2, and 3.

The distribution curves for the 3- to 20-mesh size generally were regular in form, with both tails approaching the axes. The curves for the intermediate size, 20- to 48-mesh, were distinctly poorer; the low-density segments mostly did not approach the axis closely. The curves for the 48- to 200-mesh material were distinctly irregular; generally the high-density segment was displaced from the axis. The composite curves for the 3- to 200-mesh coal were generally inferior to those characterizing cyclones, jigs, and dense-medium cleaning. Therefore, the various criteria of sharpness of separation probably are not as significant and reliable for tables as they are for most other cleaning methods. Tromp (14) suggested that the distribution curve for tables does not take the usual form because tabling represents a series of retreatment steps occurring at each riffle.

Because the criteria of sharpness of separation has limited significance, examination of the complete distribution data is even more important in evaluating table operation than with some other types of cleaning devices.

Density of Separation

Except for the high-ash slimes discharged principally next to the head-motion end, ash content along the side and around the end of a table increases progressively. Thus the ash content of the washed coal, and the density of separation, can be adjusted simply by changing the position of the split between washed coal and refuse. Tests 1, 2, and 3 show the effect of progressively moving the position of the splitter from the corner of the table toward the head-motion end. As shown in the following tabulation, in test 1, with the entire side of the table representing washed coal, a product analyzing 7.3 percent ash was obtained at a yield of 79.8 percent.

	Test		
	1	2	3
Zones to washed coal....................	1-6	1-3	1-2
Yield..........................percent	79.8	72.2	57.1
Ash in washed coal...............do...	7.3	6.0	5.3
Efficiency.......................do...	96.4	90.1	72.9
±0.10............................do...	5.0	6.6	10.5
Specific gravity of separation.........	1.715	1.562	1.458
Error area............................	81	74	70
Probable error........................	.121	.101	.127

In test 2, with only the first three zones constituting the washed coal, a reduction in ash content of 1.3 percentage points occurred, but the yield dropped to 72.2 percent. This reduction in yield represented a decline in efficiency from 96.4 to 90.1 percent. In test 3, with only the first two zones constituting the washed coal, the yield was reduced to only 57.1 percent, and the efficiency was reduced to 72.9 percent. Thus, with coals of this type, operating at a specific gravity as low as 1.46 entails a drastic reduction in efficiency. The modest increase in amount of near-gravity material with decrease in density in this series of tests could hardly account for the drastic decrease in efficiency. Thus these data show that the ±0.10 criteron is not always a reliable indication of the efficiency to be expected in tabling.

As pointed out earlier, when some cleaning devices are used, the sharpness of separation between coal and impurity tend to increase as the density of separation decreases. If error area is used to evaluate sharpness of separation, the present data indicate that the same relationship holds for tables, although the improvement in sharpness of separation with decrease in density is modest.

Influence of Size Composition

Tables, like all other cleaning devices, are unable to effect as sharp a separation between coal and impurity in the finer portions of the feed as in the coarse material. Table 5 shows the average distribution data by individual size groups for all the cleaning trials. A distinct impairment in sharpness of separation with decrease in particle size is evident. Neither the recovery of coal nor the removal of impurity is as good in the smaller sizes as in the coarser material.

TABLE 5. - Average distribution data, percent

Specific-gravity interval	Screen size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
-0.70	99.5	-	95.1	-
.65	99.3	-	91.9	-
.60	99.1	-	89.3	-
.55	98.6	-	87.3	-
.50	96.5	-	85.4	-
.45	97.3	-	83.8	95.9
.40	96.6	96.7	86.9	96.0
.35	96.7	94.0	84.2	95.1
.30	94.7	87.8	79.9	91.9
.25	91.4	88.1	77.4	87.9
.20	86.3	83.7	71.2	82.5
.15	80.4	77.5	65.9	76.5
.10	72.4	69.3	60.9	69.5
- .05	61.8	59.8	55.2	60.4
0	50.0	50.0	50.0	50.0
± .05	39.0	41.4	45.2	39.6
.10	28.4	34.0	41.3	29.3
.15	20.2	27.5	38.1	21.4
.20	16.2	22.1	34.5	16.6
.25	9.6	17.9	31.1	13.5
.30	7.7	14.7	28.6	9.8
.35	6.1	12.4	26.3	8.3
.40	5.0	10.7	24.3	7.2
.45	3.3	9.4	22.5	6.3
.50	2.4	8.3	20.9	5.7
.55	1.9	7.5	18.0	5.2
.60	1.3	6.4	16.6	5.0
.65	.7	5.1	14.1	3.9
.70	.6	4.7	10.3	3.1
.75	.4	4.2	-	-
.80	-	4.0	-	-
.85	-	3.5	-	-

Because sharpness of separation decreases as particle size decreases, the recovery efficiency in the 20- to 48-mesh size was lower than in the 3- to 20-mesh size in every test. In some tests the efficiency in the 48- to 200-mesh size was still lower, but in other tests the minimum efficiency was in the intermediate size. Efficiency reflects primarily loss of coal, and generally this loss was highest in the intermediate size range. This probably reflects the fact that the finest coal particles, those below perhaps 65-mesh, are largely entrained in the dressing water and carried to the side of the table, whereas some of the intermediate-size coal particles are mechanically entrapped in the refuse.

Both yield error and misplaced material exhibited about the same trend as efficiency; that is, they generally show the poorest result in the intermediate rather than finest size range. In contrast, in all the tests, ash error increased progressively as particle size decreased.

The magnitude of the decrease in sharpness of separation with decrease in particle size and the consequent impairment in efficiency highlight the importance of the size composition of table feed and its effect on overall table performance. Treatment of the finer sizes is so inferior to that of the material coarser than 20-mesh, that the proportion of finer material in the feed has an important bearing on table operation. This fact is recognized by many operators, and in a number of the more modern preparation plants material finer than 100-mesh is removed from the table feed. In a few of the most recent plants material finer than 48-mesh is removed for separate treatment in flotation cells.

In all the present cleaning tests, the minimum density of separation occurred in the 20- to 48-mesh range. In some tests the density of the separation in the 48- to 200-mesh was higher than that in the 3- to 20-mesh material, but in others it was not.

PREDICTION OF CLEANING RESULTS

With dense-medium units, including the dense-medium cyclone, and jigs, the performance of a new cleaning plant can be projected with considerable accuracy by using the distribution curves representing operation of similar equipment under comparable conditions (16). The amount of detailed performance data on table operation available has not been sufficient to determine whether the same technique could be used in predicting table results. The variation in distribution data for the present group of tests, when expressed on a basis of equal density difference as in table 5, suggests that such predictions of table performance would be far less accurate than that for dense-medium cleaning, and probably distinctly less reliable than the predictions that can be made for jig operation. Thus the average distribution factors shown in table 5 should be used with due caution in predicting table performance on other coals. In view of the marked decrease in sharpness of separation with decrease in particle size, the use of the appropriate distribution curves for individual size components of the feed would materially enhance the accuracy of the predicted results.

Most investigators have concluded that the distribution curves for dense-medium cleaning and jig operation are substantially independent of the density composition of the raw coal. The present data do not demonstrate that this is true for table operation, and until more data are available, the validity of such an assumption is open to question.

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APPENDIX. - SUMMARY OF PERFORMANCE

TABLE A-1. - Test No. 1, 7B lower bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed..........................percent	75.5	16.5	8.0	100.0
Washed coal....................do...	79.8	13.4	6.8	100.0
Refuse.........................do...	58.4	28.6	13.0	100.0
Ash:				
Feed...........................do...	16.1	21.6	26.3	17.8
Washed coal....................do...	7.1	5.6	12.3	7.3
Refuse.........................do...	64.1	51.2	55.1	59.4
Yield of washed coal...........do...	84.4	64.9	67.4	79.8
Theoretical yield..............do...	84.8	74.0	78.6	82.8
Recovery efficiency............do...	99.5	87.7	85.8	96.4
Yield error....................do...	0.4	9.1	11.2	3.0
Ash error......................do...	0.2	2.7	6.7	1.4
Misplaced material, percent of feed:				
Washed coal........................	1.2	3.2	7.4	1.8
Refuse.............................	1.9	8.3	9.5	4.0
Total..............................	3.1	11.5	16.9	5.8
Near gravity material ± 0.10, percent of feed............................	5.0	8.3	4.5	5.0
Distribution, percent to washed coal:				
Under 1.30.........................	99.8	92.4	90.3	97.9
1.30 to 1.40.......................	99.6	81.0	86.3	96.7
1.40 to 1.50.......................	97.2	57.9	75.0	90.0
1.50 to 1.60.......................	90.1	36.7	60.9	79.8
1.60 to 1.70.......................	73.0	23.3	52.6	64.5
1.70 to 1.80.......................	46.8	12.5	47.1	42.2
Over 1.80..........................	3.7	4.4	22.2	6.3
Specific gravity of separation........	1.738	1.488	1.682	1.715
Error area............................	63	79	144	81
Probable error........................	0.098	0.127	0.331	0.121
Imperfection..........................	0.133	0.260	0.485	0.169

TABLE A-2. Test No. 2, 7B lower bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed.......................percent	75.5	16.5	8.0	100.0
Washed coal.................do...	80.2	12.6	7.2	100.0
Refuse......................do...	63.3	26.6	10.1	100.0
Ash:				
Feed........................do...	16.1	21.6	26.3	17.8
Washed coal.................do...	5.4	5.7	12.6	6.0
Refuse......................do...	50.9	41.0	51.8	48.5
Yield of washed coal........do...	76.6	55.0	65.0	72.2
Theoretical yield...........do...	80.9	74.2	79.0	80.1
Recovery efficiency.........do...	94.7	74.1	82.3	90.1
Yield error.................do...	4.3	19.2	14.0	7.9
Ash error...................do...	1.4	3.9	8.0	2.6
Misplaced material, percent of feed:				
Washed coal..........................	1.7	4.1	7.3	2.4
Refuse...............................	5.5	16.7	12.1	7.9
Total................................	7.2	20.8	19.4	10.3
Near gravity material ± 0.10, percent of feed............................	6.7	13.2	4.4	6.6
Distribution, percent to washed coal:				
Under 1.30...........................	96.6	77.5	87.4	92.7
1.30 to 1.40.........................	92.0	70.6	79.4	88.8
1.40 to 1.50.........................	81.4	47.4	72.2	76.3
1.50 to 1.60.........................	57.1	30.6	60.9	53.3
1.60 to 1.70.........................	27.9	20.9	52.6	28.2
1.70 to 1.80.........................	9.8	12.5	47.1	13.5
Over 1.80............................	0.9	4.4	22.2	4.6
Specific gravity of separation.......	1.574	1.437	1.695	1.562
Error area...........................	61	86	153	74
Probable error.......................	0.086	0.143	0.364	0.101
Imperfection.........................	0.150	0.327	0.524	0.180

TABLE A-3. - Test No. 3, 7B lower bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	75.5	16.5	8.0	100.0
Washed coal...................do...	80.1	12.4	7.5	100.0
Refuse........................do...	69.4	21.9	8.7	100.0
Ash:				
Feed..........................do...	16.1	21.6	26.3	17.8
Washed coal...................do...	4.3	6.1	13.5	5.3
Refuse........................do...	33.9	33.2	40.9	34.5
Yield of washed coal...........do...	60.5	42.9	53.4	57.1
Theoretical yield..............do...	77.9	75.0	80.4	78.3
Recovery efficiency............do...	77.7	57.2	66.4	72.9
Yield error....................do...	17.4	32.1	27.0	21.2
Ash error......................do...	2.3	4.9	11.2	3.4
Misplaced material, percent of feed:				
Washed coal......................	2.2	6.7	8.0	2.7
Refuse...........................	17.5	25.0	21.9	20.0
Total............................	19.7	31.7	29.9	22.7
Near gravity material ± 0.10, percent of feed............................	13.2	49.3	5.3	10.5
Distribution, percent to washed coal:				
Under 1.30.......................	79.9	60.6	71.7	76.1
1.30 to 1.40.....................	73.0	50.7	57.8	69.5
1.40 to 1.50.....................	52.8	39.5	58.3	51.9
1.50 to 1.60.....................	21.8	26.5	52.2	24.3
1.60 to 1.70.....................	6.2	18.6	47.4	11.1
1.70 to 1.80.....................	2.9	12.5	41.2	7.6
Over 1.80........................	0.5	4.4	20.9	4.1
Specific gravity of separation.......	1.459	1.365	1.588	1.458
Error area........................	56	91	162	70
Probable error....................	0.104	-	-	0.127
Imperfection......................	0.227	-	-	0.277

TABLE A-4. - Test No. 4, 7C bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	78.7	15.1	6.2	100.0
Washed coal..................do...	83.0	11.9	5.1	100.0
Refuse.......................do...	65.0	25.3	9.7	100.0
Ash:				
Feed.........................do...	18.8	29.4	36.0	21.5
Washed coal..................do...	6.2	7.0	17.2	6.9
Refuse.......................do...	68.8	62.3	66.8	67.0
Yield of washed coal.........do...	79.9	59.3	62.2	75.7
Theoretical yield............do...	80.6	66.3	72.2	78.0
Recovery efficiency..........do...	99.1	89.4	86.1	97.1
Yield error..................do...	0.7	7.0	10.0	2.3
Ash error....................do...	0.4	3.4	6.6	1.2
Misplaced material, percent of feed:				
Washed coal..........................	1.4	4.2	10.6	2.3
Refuse...............................	1.9	5.9	5.6	3.0
Total................................	3.3	10.1	16.2	5.3
Near gravity material ± 0.10, percent of feed...........................	4.7	6.2	4.9	4.7
Distribution, percent to washed coal:				
Under 1.30...........................	99.8	94.2	94.1	98.8
1.30 to 1.40.........................	99.2	87.2	92.4	97.8
1.40 to 1.50.........................	93.0	57.9	80.0	86.5
1.50 to 1.60.........................	83.2	45.9	64.7	76.4
1.60 to 1.70.........................	68.1	28.6	66.7	61.7
1.70 to 1.80.........................	42.5	21.1	43.8	38.5
Over 1.80............................	3.7	5.9	23.6	6.5
Specific gravity of separation.......	1.720	1.507	1.698	1.700
Error area...........................	68	93	126	82
Probable error.......................	0.104	0.149	0.280	0.122
Imperfection.........................	0.144	0.294	0.401	0.174

TABLE A-5. - Test No. 5, 7C bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	78.7	15.1	6.2	100.0
Washed coal..................do...	84.1	10.9	5.0	100.0
Refuse.......................do...	68.3	23.2	8.5	100.0
Ash:				
Feed.........................do...	18.8	29.4	36.0	21.5
Washed coal..................do...	4.9	7.2	17.9	5.8
Refuse.......................do...	51.6	49.5	56.2	51.6
Yield of washed coal.........do...	70.2	47.4	52.9	65.7
Theoretical yield............do...	78.1	66.7	72.7	76.0
Recovery efficiency..........do...	89.9	71.1	72.8	86.4
Yield error..................do...	7.9	19.3	19.8	10.3
Ash error....................do...	2.2	5.5	12.9	3.2
Misplaced material, percent of feed:				
Washed coal......................	1.5	5.0	11.6	2.3
Refuse...........................	8.4	15.6	12.6	10.1
Total............................	9.9	20.6	24.2	12.4
Near gravity material ± 0.10, percent of feed............................	4.9	11.2	5.7	5.2
Distribution, percent to washed coal:				
Under 1.30.......................	91.4	77.1	85.0	89.1
1.30 to 1.40.....................	89.0	61.5	62.0	85.2
1.40 to 1.50.....................	75.6	42.1	60.0	69.9
1.50 to 1.60.....................	58.7	37.8	52.9	54.3
1.60 to 1.70.....................	30.2	23.8	53.3	31.3
1.70 to 1.80.....................	12.2	18.4	37.5	14.1
Over 1.80........................	1.2	5.5	22.0	4.5
Specific gravity of separation.......	1.580	1.423	1.567	1.570
Error area........................	69	101	149	81
Probable error....................	0.106	0.170	0.355	0.129
Imperfection......................	0.183	0.402	0.626	0.226

TABLE A-6. - Test No. 6, 7C bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	79.4	14.0	6.6	100.0
Washed coal..................do...	86.7	10.2	3.1	100.0
Refuse.......................do...	63.1	22.5	14.4	100.0
Ash:				
Feed.........................do...	20.2	30.2	50.3	23.6
Washed coal..................do...	5.4	5.5	19.1	5.8
Refuse.......................do...	65.7	55.3	65.4	63.3
Yield of washed coal...........do...	75.4	50.4	32.4	69.1
Theoretical yield..............do...	77.3	62.4	50.7	73.2
Recovery efficiency............do...	97.5	80.8	63.9	94.4
Yield error....................do...	1.9	12.0	18.3	4.1
Ash error......................do...	0.9	3.2	13.3	1.8
Misplaced material, percent of feed:				
Washed coal........................	1.6	2.8	7.6	2.0
Refuse.............................	2.8	10.6	8.4	4.5
Total..............................	4.4	13.4	16.0	6.5
Near gravity material ± 0.10, percent of feed............................	4.4	11.0	5.6	4.5
Distribution, percent to washed coal:				
Under 1.30.........................	99.0	84.0	76.0	92.6
1.30 to 1.40.......................	95.6	76.0	76.5	92.7
1.40 to 1.50.......................	86.6	44.4	61.9	79.9
1.50 to 1.60.......................	71.2	28.1	37.5	63.0
1.60 to 1.70.......................	48.3	16.7	31.6	42.5
1.70 to 1.80.......................	24.0	8.8	22.2	21.6
Over 1.80..........................	2.3	1.8	8.8	3.1
Specific gravity of separation.......	1.640	1.432	1.500	1.613
Error area...........................	68	71	106	76
Probable error.......................	0.108	0.112	0.166	0.125
Imperfection.........................	0.169	0.259	0.332	0.204

TABLE A-7. - Test No. 7, 7C bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed.........................percent	78.0	15.9	6.1	100.0
Washed coal...................do...	83.3	11.8	4.9	100.0
Refuse........................do...	67.4	24.1	8.5	100.0
Ash:				
Feed..........................do...	24.0	31.1	35.5	25.8
Washed coal...................do...	5.9	5.9	11.4	6.1
Refuse........................do...	68.1	55.3	63.0	64.5
Yield of washed coal............do...	71.0	49.0	53.2	66.4
Theoretical yield...............do...	72.8	63.8	65.5	71.2
Recovery efficiency.............do...	97.5	76.8	81.2	93.3
Yield error.....................do...	1.8	14.8	12.3	4.8
Ash error.......................do...	0.9	4.0	7.9	2.1
Misplaced material, percent of feed:				
Washed coal.........................	1.8	4.0	7.1	2.3
Refuse..............................	3.2	11.5	8.4	5.3
Total...............................	5.0	15.5	12.2	7.6
Near gravity material ± 0.10, percent of feed.............................	5.7	14.2	4.7	5.5
Distribution, percent to washed coal:				
Under 1.30..........................	98.5	82.6	88.7	95.5
1.30 to 1.40........................	96.0	65.0	71.7	91.7
1.40 to 1.50........................	86.3	37.5	64.7	78.3
1.50 to 1.60........................	72.2	27.8	42.9	64.0
1.60 to 1.70........................	48.7	12.5	46.2	44.5
1.70 to 1.80........................	23.7	10.0	33.3	22.9
Over 1.80...........................	1.3	3.8	11.7	2.7
Specific gravity of separation.......	1.641	1.395	1.531	1.620
Error area...........................	66	76	130	82
Probable error.......................	0.104	0.119	0.258	0.137
Imperfection.........................	0.162	0.301	0.486	0.221

TABLE A-8. Test No. 8, 7C bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	78.0	15.9	6.1	100.0
Washed coal..................do...	84.1	11.0	4.9	100.0
Refuse.......................do...	69.9	22.4	7.7	100.0
Ash:				
Feed.........................do...	24.0	31.1	35.5	25.8
Washed coal..................do...	4.7	6.5	12.0	5.2
Refuse.......................do...	54.4	47.0	55.0	52.7
Yield of washed coal...........do...	61.3	39.2	45.3	56.8
Theoretical yield..............do...	70.3	64.8	66.4	69.4
Recovery efficiency............do...	87.2	60.5	68.2	81.8
Yield error....................do...	9.0	25.6	21.1	12.6
Ash error......................do...	2.3	5.2	10.3	3.1
Misplaced material, percent of feed:				
Washed coal.......................	1.8	5.3	7.3	2.2
Refuse............................	9.7	19.2	14.8	12.1
Total.............................	11.5	24.5	22.1	14.3
Near gravity material ± 0.10, percent of feed............................	6.6	59.3	6.1	6.2
Distribution, percent to washed coal:				
Under 1.30........................	88.1	65.1	75.6	83.8
1.30 to 1.40......................	84.7	50.4	54.3	80.1
1.40 to 1.50......................	70.2	32.1	58.8	64.3
1.50 to 1.60......................	45.3	25.0	35.7	41.1
1.60 to 1.70......................	20.2	12.5	38.5	20.6
1.70 to 1.80......................	6.6	10.0	33.3	9.0
Over 1.80.........................	0.6	3.6	10.8	2.1
Specific gravity of separation.......	1.530	1.355	1.465	1.511
Error area........................	63	74	130	72
Probable error....................	0.099	-	0.261	0.112
Imperfection......................	0.187	-	0.561	0.219

TABLE A-9. - Test No. 9, 5 bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	73.8	18.8	7.4	100.0
Washed coal..................do...	78.3	14.9	6.8	100.0
Refuse.......................do...	59.9	31.1	9.0	100.0
Ash:				
Feed.........................do...	30.1	32.6	37.5	31.1
Washed coal..................do...	19.3	11.7	26.1	18.7
Refuse.......................do...	74.0	63.9	64.2	70.0
Yield of washed coal............do...	80.3	59.9	70.2	75.7
Theoretical yield..............do...	82.2	66.3	80.8	80.5
Recovery efficiency............do...	97.7	90.3	86.9	94.0
Yield error....................do...	1.9	6.4	10.6	4.8
Ash error......................do...	1.2	3.3	6.3	2.4
Misplaced material, percent of feed:				
Washed coal........................	5.0	3.6	9.0	5.2
Refuse............................	4.5	7.5	12.2	5.6
Total.............................	9.5	11.1	21.2	10.8
Near gravity material ± 0.10, percent of feed............................	7.6	7.1	9.6	7.8
Distribution, percent to washed coal:				
Under 1.30......................	99.2	94.0	93.5	97.7
1.30 to 1.40......................	98.7	91.0	90.5	97.1
1.40 to 1.50......................	97.4	79.7	87.3	93.4
1.50 to 1.60......................	95.0	65.5	82.9	89.4
1.60 to 1.70......................	91.2	50.7	76.5	83.6
1.70 to 1.80......................	85.9	36.5	76.9	78.4
Over 1.80......................	34.7	5.5	39.4	29.0
Specific gravity of separation.......	1.991	1.653	2.003	1.967
Error area.........................	92	95	131	102
Probable error.....................	-	0.173	-	-
Imperfection.......................	-	0.265	-	-

TABLE A-10. - Test No. 10, 5 bed

	Size, mesh		
	3 to 20	20 to 48	3 to 48
Screen analysis:			
Feed........................percent	74.0	26.0	100.0
Washed coal..................do...	78.7	21.3	100.0
Refuse.......................do...	61.2	38.8	100.0
Ash:			
Feed.........................do...	34.1	36.8	34.8
Washed coal..................do...	21.5	16.2	20.4
Refuse.......................do...	78.1	67.7	74.1
Yield of washed coal.........do...	77.8	59.9	73.1
Theoretical yield............do...	78.9	66.4	77.0
Recovery efficiency..........do...	98.6	90.2	94.9
Yield error..................do...	1.1	6.5	3.9
Ash error....................do...	0.7	3.9	2.4
Misplaced material, percent of feed:			
Washed coal..........................	8.8	6.9	6.6
Refuse...............................	6.2	5.8	4.1
Total................................	15.0	12.7	10.7
Near gravity material ± 0.10 percent of feed............................	8.8	7.5	8.7
Distribution, percent to washed coal:			
Under 1.30...........................	100.0	97.8	99.4
1.30 to 1.40.........................	99.9	93.2	98.6
1.40 to 1.50.........................	99.8	82.8	95.7
1.50 to 1.60.........................	98.8	67.7	90.4
1.60 to 1.70.........................	97.7	54.0	86.7
1.70 to 1.80.........................	89.8	40.4	76.6
Over 1.80............................	35.4	13.7	29.3
Specific gravity of separation.......	1.983	1.680	1.964
Error area...........................	89	109	99
Probable error.......................	-	0.184	-
Imperfection.........................	-	0.271	-

TABLE A-11. - Test No. 11, 5 bed

	Size, mesh		
	3 to 20	20 to 48	3 to 48
Screen analysis:			
Feed........................percent	74.0	26.0	100.0
Washed coal..................do...	77.9	22.1	100.0
Refuse.......................do...	67.8	32.2	100.0
Ash:			
Feed.........................do...	34.1	36.8	34.8
Washed coal..................do...	15.8	16.5	16.0
Refuse.......................do...	67.1	58.8	64.4
Yield of washed coal.........do...	64.4	51.9	61.1
Theoretical yield............do...	69.7	66.8	69.4
Recovery efficiency..........do...	92.4	77.7	88.0
Yield error..................do...	5.3	14.9	8.3
Ash error....................do...	3.3	8.4	4.8
Misplaced material, percent of feed:			
Washed coal..........................	4.3	7.6	4.0
Refuse...............................	6.7	11.9	9.3
Total................................	11.0	19.5	13.3
Near gravity material ± 0.10, percent of feed............................	7.3	8.5	7.7
Distribution, percent to washed coal:			
Under 1.30........................	94.4	84.0	91.4
1.30 to 1.40......................	92.9	82.6	90.9
1.40 to 1.50......................	90.7	67.8	85.2
1.50 to 1.60......................	84.4	55.4	76.5
1.60 to 1.70......................	79.2	46.0	70.9
1.70 to 1.80......................	66.8	35.1	58.3
Over 1.80........................	12.8	13.0	12.9
Specific gravity of separation.......	1.809	1.613	1.826
Error area...........................	95	124	122
Probable error.......................	0.144	0.232	0.236
Imperfection.........................	0.178	0.378	0.286

TABLE A-12. - Test No. 12, Mrak bed

	Size, mesh			
	3 to 20	20 to 48	48 to 200	3 to 200
Screen analysis:				
Feed........................percent	69.7	11.7	18.6	100.0
Washed coal..................do...	71.2	10.0	18.8	100.0
Refuse.......................do...	63.4	19.1	17.5	100.0
Ash:				
Feed.........................do...	18.3	25.8	27.7	21.0
Washed coal..................do...	7.3	7.0	18.1	9.3
Refuse.......................do...	71.4	67.8	71.9	70.7
Yield of washed coal............do...	82.8	69.1	82.1	81.1
Theoretical yield...............do...	84.0	72.8	86.2	83.6
Recovery efficiency.............do...	98.6	94.9	95.2	97.0
Yield error.....................do...	1.2	3.7	4.1	2.5
Ash error.......................do...	0.5	1.5	2.7	1.5
Misplaced material, percent of feed:				
Washed coal......................	1.4	2.3	7.1	3.0
Refuse...........................	1.9	4.4	5.2	2.9
Total............................	3.3	6.7	12.3	5.9
Near gravity material ± 0.10, percent of feed............................	3.9	5.6	5.1	3.6
Distribution, percent to washed coal:				
Under 1.30.......................	99.7	97.8	99.4	99.4
1.30 to 1.40.....................	98.8	88.6	93.2	97.2
1.40 to 1.50.....................	91.5	69.8	88.0	88.4
1.50 to 1.60.....................	67.2	50.0	84.6	68.9
1.60 to 1.70.....................	44.8	31.8	83.9	54.2
1.70 to 1.80.....................	31.4	18.8	82.4	42.6
Over 1.80........................	2.8	3.5	41.9	13.6
Specific gravity of separation.......	1.629	1.550	2.010	1.687
Error area...........................	79	82	119	107
Probable error.......................	0.138	0.138	-	0.198
Imperfection.........................	0.219	0.251	-	0.288