Air Classification Of Portland Cement

Performed For:
Puerto Rican Cement Co.

Performed By:
Buell Division of Fisher-Klosterman
Pilot Classification Test Laboratory

1. Objective

The objective of this program was to produce commercial grade (Type I) Portland Cement from existing cement plant finish grinding mill discharge. The client's specifications for the commercial grade cement were:

Blaine air permeability - 4300 cm^2/gram

Wet sieve - 96.0% passing 325 mesh

2. Purpose

The purpose of performing this program was a request by the client to investigate an improvement of the classification efficiency of existing plant air classification equipment, in the interest of increasing plant production of cement product and reducing plant process (grinding, classifying, transport) energy consumption.

3. Process Background

Based upon plant process data, process recirculation load (separator tailings rate separator fines rate, or rejects product), was computed to be 393% at 325 mesh, and 341% at 200 mesh, for a typical mill discharge/existing separator feed particle size analysis of 48l7% passing 325 mesh. Because of unknown data credibility, recirculation is assumed to be the average of the two computed values, or 367%. Based upon the assumed recirculation load, the separation product yield was computed to be 21.4%. This value may be compared to the reported test results of air classifier fine fraction product yield.

4. Test Facilities

Laboratory pilot classification tests were performed using a Marsulex Environmental Technologies (MET) Centrifugal Air Classifier Model C-18-9. The classifier was operated at a nominal rating classifying air flow of 900 ACFM of ambient air. The classifier was operated through a range of cutpoint operating conditions which were created by variation of the classifier fine product discharge orifice ratio, and the use of secondary classifying air. The coarsest cutpoint operation was produced by a 0.65 orifice ratio (largest possible size which produces minimum classifier pressure drop) while employing increasing amounts of secondary air. The finest cutpoint operating condition was produced by a 0.30 orifice ratio (smallest typical commercial size which creates increased classifier pressure drop) and without use of any secondary air. A test condition with a 0.65 orifice ratio, and without secondary air employed, approached the finest cutpoint operation. Feed material (existing plant finish grinding mill discharge) was elevated and conveyed to the classifier inlet by the primary classify8ng air flow (900 CFM total classifier air flow less secondary classifier air flow, expressed as % of total).

Classifier feed material rates of ~ 2 TPH and ~ 1 TPH were investigated. Although both rates are within the operating range of the laboratory C-18-9 classifier, a purpose of investigating different rates was to determine the impact of feed rate upon classification efficiency. The classifier coarse fraction (corresponding to present plant separator tailings) was directly collected by gravity in a hopper beneath the classifier.

The classifier fine fraction product (corresponding to present plant separator fines) was pneumatically conveyed from the air classifier to a high efficiency cyclone collector and collected in a hopper beneath the cyclone. The described classifier system air flow was operated as induced draft by a blower located downstream of the cyclone. In consideration of the high efficiency performance of the cyclone, the reported test results assume nil particulate escape from the cyclone.

Particle size analyses of test results have been reported by three procedures.

Classifier feed material and both coarse and fine fractions of all tests were analyzed by wet 325 mesh sieve procedure, in accordance with the provisions of ASTM Procedure C430-83. The sieves used for these analyses were 5 inches in diameter with stainless steel woven mesh and frames. These sieves were calibrated by NBS Standard Reference Material 114L. An adjustment of the ASTM procedure was used for both the calibration as well as the test determinations, in consideration of the 5 inch diameter sieve, relative to the specified 2 inch diameter. A larger amount of sample ~ 6 grams > 1 gram standard, and a longer wash time ~ 6 minutes > 1 minute standard was the test procedure employed.

All classifier fine fraction products were analyzed by the Blaine Air Permeability Apparatus, in accordance with the provisions of ASTM Procedure C204-84. Prior to performing any test analyses, the apparatus was calibrated in precise accordance with ASTM C204-84, using NBS Standard Reference Material 114L.

Previous experience using the Blaine apparatus has shown that the ASTM procedure is highly empirical and applicable only to near specification grade Portland Cement. Different materials or significantly off specification (superior as well as inferior) do not fit the parameters of the procedure for preparing the compacted bed of material. Also, the term "ordinary thumb pressure" was fund to be ambiguous.

When performing the apparatus calibration using the 114L standard, it was found that a force on the plunger > 6 Lb., 7 Lbs. Was required to properly compress the bed. This criterion was subsequently applied to all test analyses. The following describes the test procedure employed for determinations:

a. The specific gravity (density) of sample was determined by a Pycnometer procedure. Measured values of tested samples ranged from 2.8159 to 3.1959, but there was no systematic relationship to the variations, and an average value of 2.9765 was used for all samples to minimize the scatter of the Blaine values. Note, although the ASTM procedure described use of a density (specific gravity) value of 3.15 for the 114L standard sample material, a GEESI specific gravity determination of this material gave a similar value of 2.9798. The ASTM 3.15 value was used for the apparatus calibration.

b. By trial and error and subsequent experience, the quantity of sample was determined which would form a compacted bed at a force of > 6lb., 7Lbs. In performing these experiments, an initial force of 2 Lbs. was placed on the cell plunger. Force was increased in increments of 1 LB. If the plunger contacted the top of the cell before use of 7 Lb. force, more sample was required. If the plunger did not contact the top of the cell at use of 7 Lb. force, less sample was required. These experiments were not performed incrementally. Each bed preparation employed a freshly prepared quantity of test sample in accordance with C204-84.

c. The porosity of the prepared sample bed, E, was determined by computation using the equation: $W = PV (1-E)$

d. The Blaine value was computed by use of Equation 6. This equation allows for variation of bed porosity E, relative to a standard calibration value of 0.500. When performing the computations, the value of constant b was assumed to be 0.9 consistent with Portland Cement.

5. Discussion of Test Results

Two series of classification tests were performed. Tests 1 through 6 were performed at a classifier feed rate of ~ 2 TPH, while Tests 7 through 12 performed at a feed rate of ~ 1 TPH.

The attached Table I summarizes the results of the ~ 2 TPH feed rate tests. Test data is tabulated from left to right in order of decreasing (finer) cutpoint. Accordingly, Test 2 represents the test condition which produced the greatest amount of fine fraction product yield while Test 6 produced the finest product. Likewise, Table II summarizes the results of the ~ 1 TPH feed rate tests, also tabulated in order of decreasing cutpoint.

Each of these tabulations include the following pertinent data of test operating conditions and test results:

a. Classifier Operation:

- Classifier Feed Rate, TPH
- Classifier Fine Product Discharge Orifice Ratio
- % Secondary Classifying Air

b. 2. Fine Fraction Product

- % yield
- % -325 Mesh (Wet)
- Blaine Value
- Blaine Determination Bed Porosity

c. Coarse Fraction Rejects:

- % Yield
- % -325 Mesh (Wet)

d. Reconstructed Feed:

- % -325 Mesh (Wet)

The later value, computed from the classifier fraction yields and analyses, was very consistent in comparison to the as-received feed material, attesting to the validity of sampling and analysis.

It is noteworthy that the finest product obtained by the ~ 2 TPH tests, Test 6, 15.71% product yield, did not attain the desired 4300 Blaine value, but did attain the desired 96% passing 325 mesh wet sieve. Also, the Blaine porosity values increased with increasing product fineness, but the finest product porosity was < 0.500.

The results of tests performed at the ~1 TPH feed rate condition are more favorable. Test 9 (32.38% product yield), Test 8 (18.57% yield) and Test 7 (17.22% yield) all satisfied the 96% passing 325 mesh objective. Test 8 came close to satisfying the 4300 Blaine objective and Test 7 greatly exceeded the Blaine objective.

It is interesting to note that the Blaine bed porosity for test 8 was very close to 0.500, and the porosity for Test 7 was greater than 0.500. This attests to the empirical nature of the Blaine procedure. When samples which were close to specification Blaine were analyzed, the modified Blaine procedure produced a porosity which confirmed the 0.500 desired value.

Also attached are graphs which illustrate pertinent tests results.

Graph "A" illustrates the relationship of fraction yields and fraction fineness expressed as the % passing 325 mesh sieve. For example, a ~1 TPH interpolated case corresponding to a fine fraction product of 96% passing 325 mesh, produced results of: 40.5% fine fraction product yield, 59.5% coarse fraction yield, coarse fraction fineness if 29.8% passing 325 mesh, and a resulting recirculation load of 147%.

Graph "B" illustrates the predictable effect of the use of secondary classifying air to control the classifier cutpoint. Since all but one test of each test series was performed using a 0.65 orifice ratio, the graph is limited to this test data. It is expected that tests performed with a different orifice ratio (o.30) would produce similar characteristics.

It is interesting to note that the data for the two test series (~2 TPH and ~1 TPH) are indistinguishable in regard to product yield. However, Graph "A" illustrated that there is a significant difference of product and reject fineness, relative to yield.

Graph "C" illustrates the relationship between product yield and product fineness expressed as the Blaine value. As was the case illustrated by Graph "A", there is a significant difference between the characteristics for ~2 TPH and ~1 TPH classifier operation. Based upon an interpolated ~1 TPH characteristic, a 4300 Blaine value is attainable with a product yield of 18.5% (81.5% coarse fraction yield) and results in a 441% recirculating load.

Graph "D" illustrates the relationship between product fineness determined by 325 mesh wet sieve and the Blaine value. Test results are shown plotted for both the ~2 TPH and ~1 TPH test series.

It is noteworthy that the data of the two test series plot as separate and different characteristics. It is not understood why there are two apparent different characteristics. It would seem that the relationship of the two fineness measurements should be constant, independent of the mechanism used to create the product.

6. Conclusions

Based upon the results of these Laboratory Pilot Classification Tests, there are two conclusions:

a. The program product objective cannot be attained by Classifier operation at the ~2 TPH feed rate, but product requirements for both the 325 mesh particle size and Blaine Value requirements can be achieved at ~1 TPH classifier operation.

b. Test results obtained at the ~1 TPH feed rate operating condition, are comparable, or better than the performance of the existing separator process.

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Laboratory Pilot Classification of Portland Cement							
Table I - Summary of Test Results C-18-9 Classifier, 900 CFM Classifying Air, ~2 TPH Feed Rate							
Test No.	2	3	4	5	1	6	Average
Orifice Ratio	0.65	0.65	0.65	0.65	0.65	0.30	--
Feed Rate, TPH	1.980	2.085	2.100	2.055	1.920	2.100	2.040
% Sec. Air	24.0	16.3	13.1	9.0	0	0	--
% Yield	90.91	52.52	38.57	31.39	22.66	15.71	--
Fine Fraction							
% -325 Mesh Sieve	63.66	80.43	89.88	91.50	95.34	97.36	--
Blaine, Sq.Cm/Gram	1893	2222	2773	2989	3449	3902	--
Blaine Bed Porosity	0.4173	0.4173	0.4530	0.4530	0.4708	0.4887	--
Coarse Fraction							
% Yield	9.09	47.48	61.63	68.61	77.34	84.29	--
% -325 Mesh Sieve	--	28.28	36.38	40.22	42.44	48.74	--
Recon. Feed							
% -325 Mesh Sieve	--	55.67	57.01	56.32	54.42	56.38	55.96
Original Feed							
% -325 Mesh Sieve							54.76
Recirculation Load, %	10.0	90.4	159.8	218.6	341.3	536.5	

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Laboratory Pilot Classification of Portland Cement							
Table II - Summary of Test Results C-18-9 Classifier, 900 CFM Classifying Air, ~1 TPH Feed Rate							
Test No.	2	3	4	5	1	6	Average
Orifice Ratio	0.65	0.65	0.65	0.65	0.65	0.30	--
Feed Rate, TPH	1.070	1.110	1.070	1.050	1.050	1.132	1.080
% Sec. Air	17.7	15.2	13.6	9.0	0	0	--
Fine Fraction							
% Yield	55.14	49.55	41.12	32.38	18.57	17.22	--
% -325 Mesh Sieve	87.28	92.96	95.22	97.85	98.89	99.31	--
Blaine, Sq.Cm/Gram	2456	2902	3197	3585	4177	4651	--
Blaine Bed Porosity	0.4351	0.4530	0.4709	0.4798	0.5066	0.5244	--
Coarse Fraction							
% Yield	44386	50.45	58.88	67.62	81.43	82.78	--
% -325 Mesh Sieve	17.67	21.30	30.45	36.15	42.98	47.67	--
Recon. Feed							
% -325 Mesh Sieve	56.06	56.81	57.08	56.12	53.36	56.56	56.00
Original Feed							
% -325 Mesh Sieve							54.76
Recirculation Load, %	81.4	101.8	143.2	208.8	438.5	480.7	

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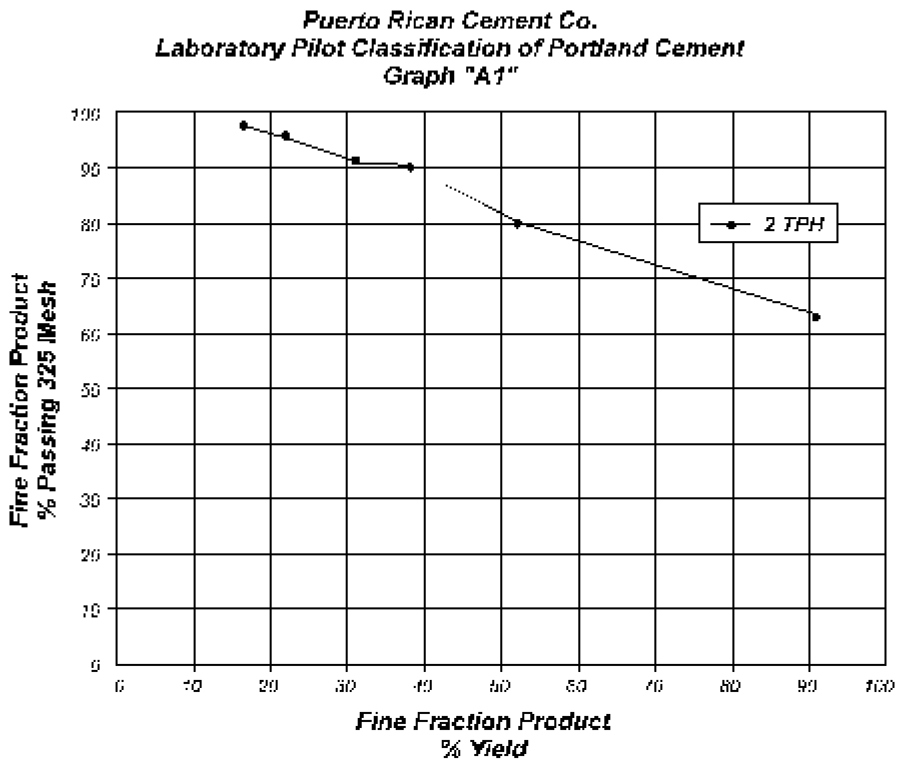

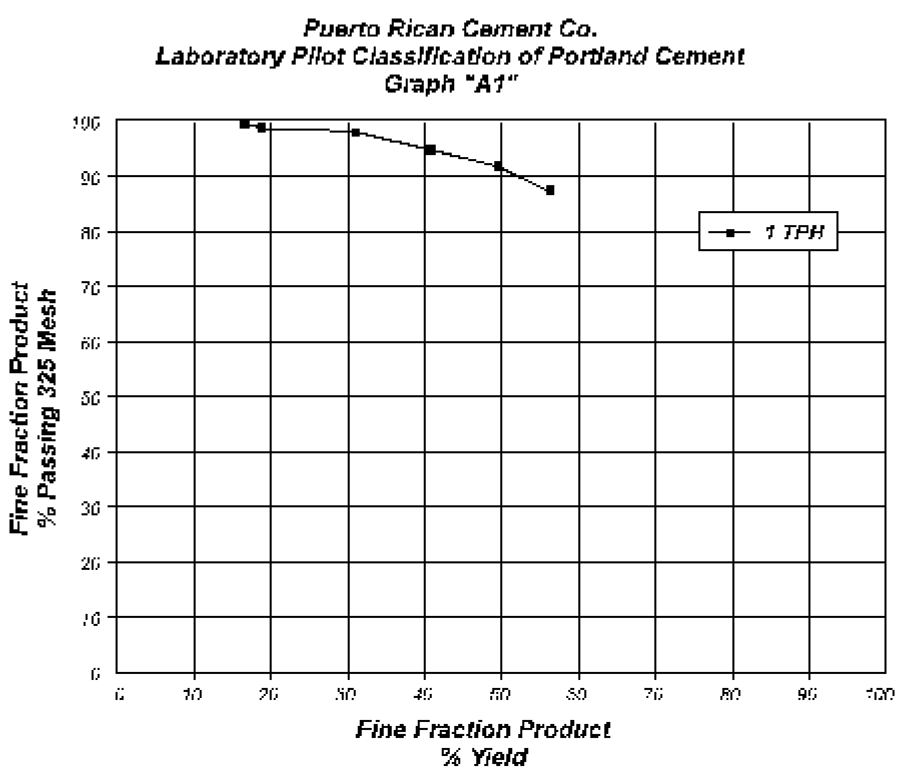

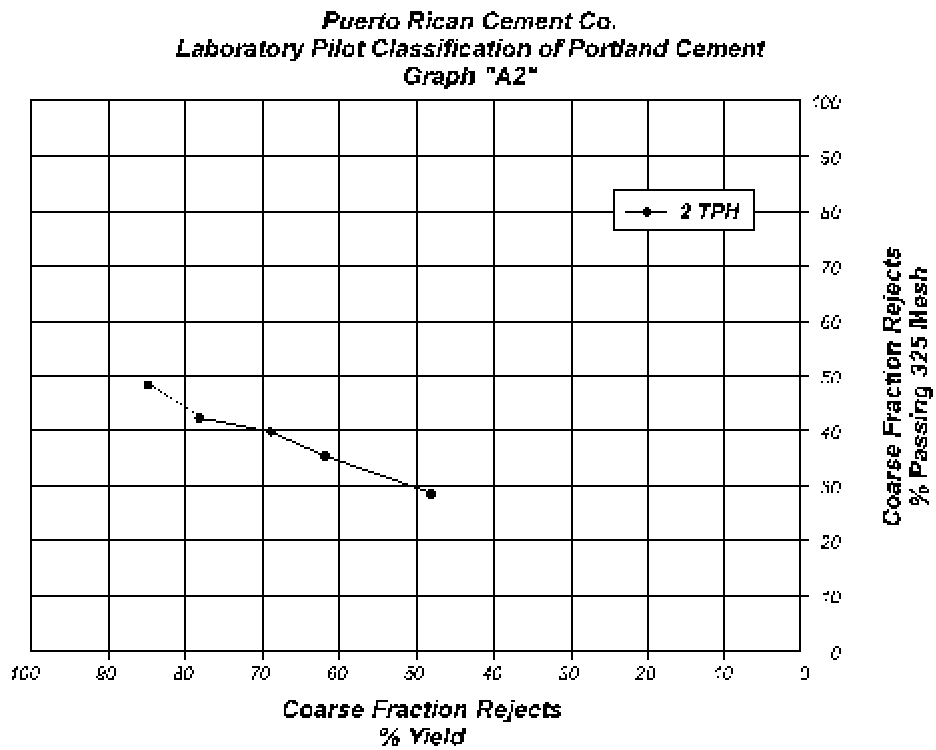
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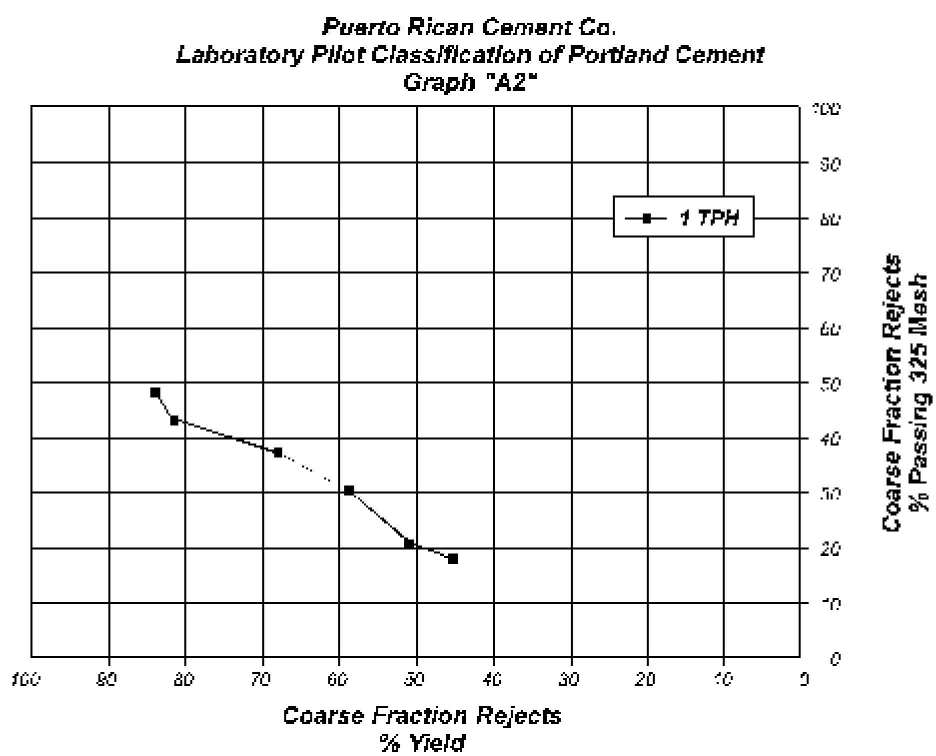
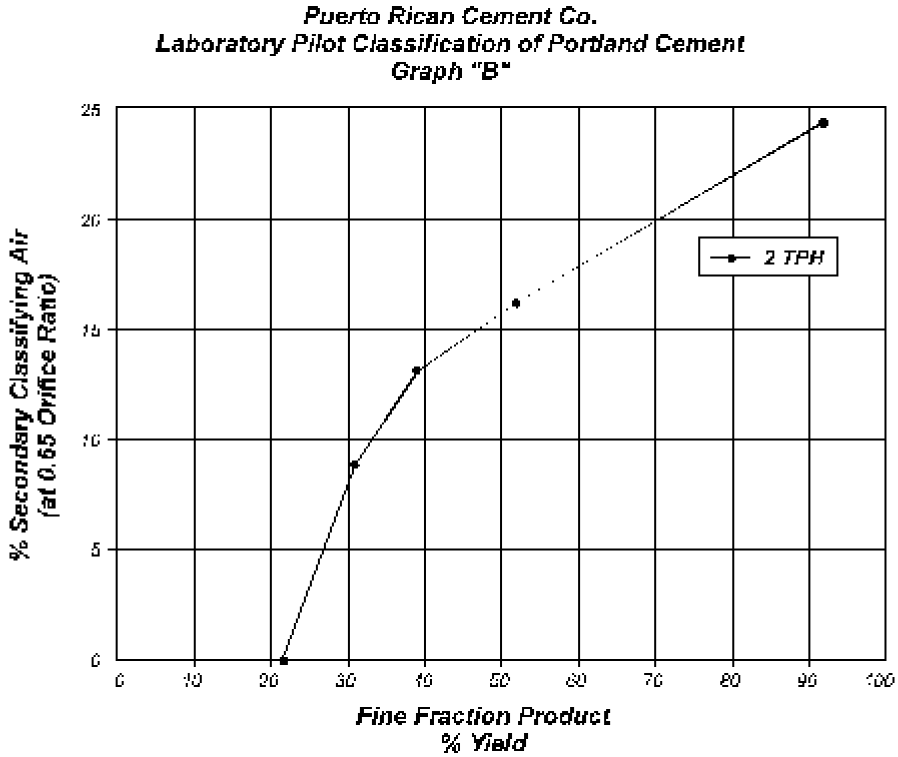
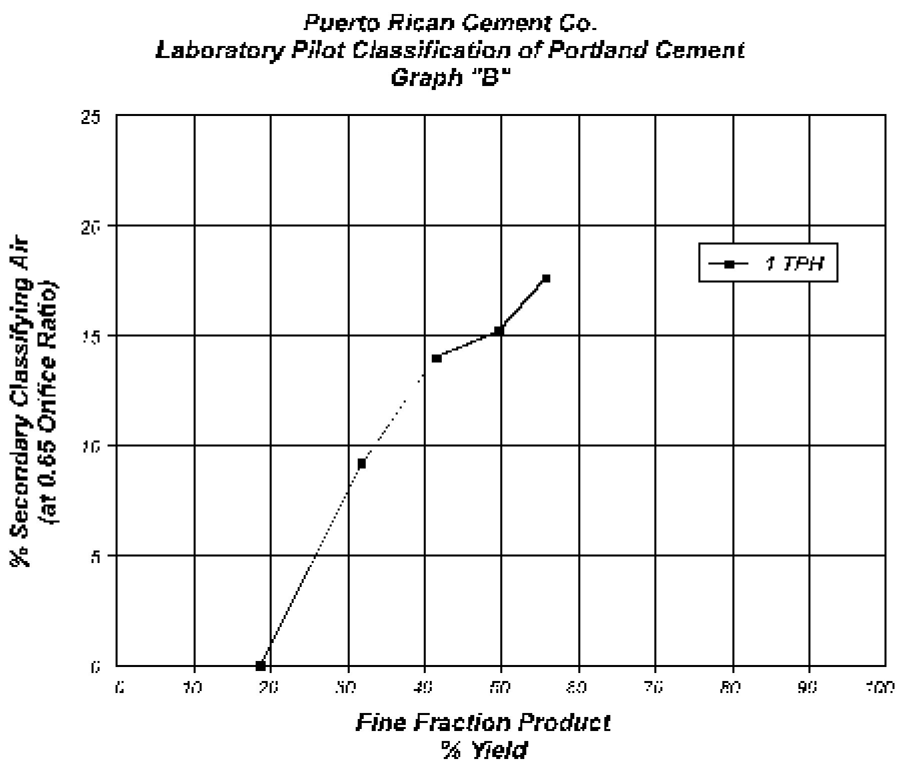
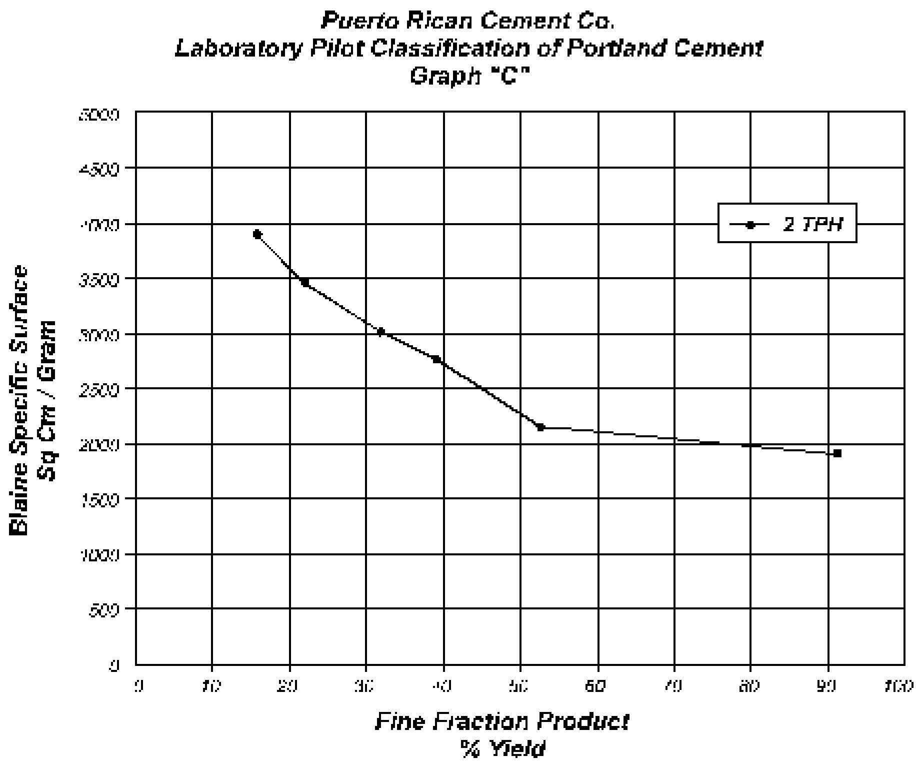
Laboratory Pilot Classification of Portland Cement
Graph "A2"
2 TPH
Coarse Fraction Rejects
% Passing 325 Mesh
Coarse Fraction Rejects
% Yield
100
90
80
70
60
50
40
30
20
10
0


Puerto Rican Cement Co.
Laboratory Pilot Classification of Portland Cement
Graph "A2"
1 TPH
Coarse Fraction Rejects
% Passing 325 Mesh
Coarse Fraction Rejects
% Yield
100
90
80
70
60
50
40
30
20
10
0


Puerto Rican Cement Co.
Laboratory Pilot Classification of Portland Cement
Graph "B"
% Secondary Classifying Air
(at 0.65 Orifice Ratio)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100
Fine Fraction Product
% Yield
2 TPH


Puerto Rican Cement Co.
Laboratory Pilot Classification of Portland Cement
Graph "B"
% Secondary Classifying Air
(at 0.65 Orifice Ratio)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100
Fine Fraction Product
% Yield
1 TPH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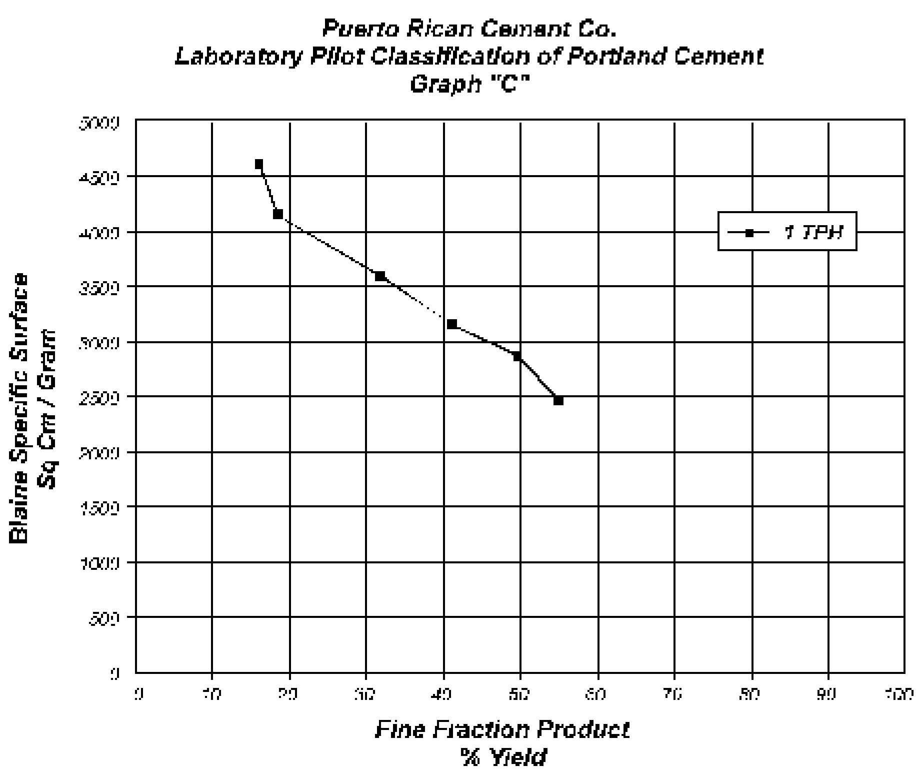
Laboratory Pilot Classification of Portland Cement
Graph "C"
Blaine Specific Surface
Sq Cm / Gram
Fine Fraction Product
% Yield
2 TPH
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
10
20
30
40
50
60
70
80
90
100


Puerto Rican Cement Co.
Laboratory Pilot Classification of Portland Cement
Graph "C"
Blaine Specific Surface
Sq Cm / Gram
Fine Fraction Product
% Yield
1 TPH
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
10
20
30
40
50
60
70
80
90
100

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