ENERGY CONSERVATION POTENTIAL
OF PORTLAND CEMENT
PARTICLE SIZE DISTRIBUTION CONTROL
PHASE III --
IMPROVED CONTROL OF THE FINISH GRINDING PROCESS
IN CEMENT MANUFACTURE

CTL Contract CR7913-4330

FIRST QUARTERLY REPORT
FOR THE PERIOD
January 1, 1985 - March 31, 1985

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Technical Progress Report
1 January 1985 - 30 March 1985

Phase III
Energy Savings by Improved Control of the Finish Grinding Process in Cement Manufacture

I. OBJECTIVE AND SCOPE

The main objective of Phase III is to develop practical economic methods of controlling the particle size distribution of portland cements using existing or modified mill circuits with the principal aim of reducing electrical energy requirements for cement manufacturing.

The work of Phase III, because of its scope, will be carried out in 10 main tasks, some of which will be handled simultaneously.

Task 1 will acquire suitable clinker and gypsum, characterize both materials, and deliver 40-50 tons clinker and 2-3 tons gypsum to each of two subcontractors, Allis-Chalmers (A-C) Corporation at Oak Creek, WI and Kennedy Van Saun (KVS) at Danville, PA. Half of the clinker and gypsum delivered to Allis-Chalmers will be crushed to -10 mesh and delivered to Construction Technology Laboratories (CTL) at Skokie, IL for use in subsequent tasks.

Task 2 will utilize the crushed clinker and gypsum in the CTL closed circuit pilot ball mill to establish baseline conditions. This task will provide matrix and test plans for the subsequent tasks involving grinding operations at CTL, A-C, and KVS. Instruments and feeders will be calibrated and checked.
Task 3 will utilize the CTL pilot ball mill to determine if changes in mill operating parameters can affect particle size distribution so as to produce a controlled cement that will save grinding energy and also provide good performance.

Task 4 will study the performance of a high efficiency air classifier relative to production of the kind of controlled particle size distribution cement that was developed in Phases I and II of this project. This task includes purchase and erection of specified classifier equipment.

Task 5 will study the effects of gypsum on the performance of the grinding operation and particularly its effects on air classification.

Task 6 will study use of semi-air swept grinding technology to arrive at some optimum set of operating parameters that will produce a controlled particle size distribution cement.

Task 7 will handle data developed by prior tasks and will integrate the information into a mathematical model designed to establish operating parameters which will lead to particle size distribution control and energy savings.

Task 8 involves the A-C pilot roller mill which will develop data leading to optimum operating conditions required to produce controlled particle size distribution cements.

Task 9 will select cement samples from the most promising operations and perform standard cement and mortar tests.
Task 10 manages the project and provides required reports and technology transfer.

II. SUMMARY OF PROGRESS

Task 1
The project was initiated by obtaining clinker and gypsum samples from two different cement plant sources. Chemical, physical, and microscopic analyses were performed on each sample and the source was selected. Purchase orders were issued for the acquisition and transportation of the clinker and gypsum. The clinker and gypsum were delivered to A-C and KVS according to plan. Clinker and gypsum were crushed to -10 mesh by A-C as required, and shipped to CTL. Further chemical analysis and physical tests were performed, and the gypsum requirement was established.

Task 2
Calibration of the mill feeder was carried out and watthour meters were checked and adjusted. Mill power drawn by the empty mill was obtained. Several sampling ports were installed in the circuit. All test matrices were completed and approved by the project manager.

Task 6
A test matrix was developed by Dr. L. G. Austin and approved by the project manager. Calibration of Dr. Austin's particle analyzer, a Leeds and Northrup Microtrac, has been calibrated...
to agree with the CTL SediGraph 5000E. Some work has begun on determining the breakage rates of the clinker supplied.

III. DETAILED PROGRESS

JANUARY 1 TO MARCH 31, 1985

Task 1: Acquisition, Characterization, and Distribution of Materials.

Subtasks 1(a), (b): Specifications were developed for procurement of clinker and gypsum. Two sources of clinker were examined. The first source of clinker did not meet specifications based on tests run at CTL. The second source from Lone Star Industries plant at Greencastle, Indiana, met specifications. Results of analyses compared to specifications are shown in Table 1.

Table 1.1

Clinker Analyses

(wt %)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Greencastle</th>
<th>C3S</th>
<th>C2S</th>
<th>C3A</th>
<th>C4AF</th>
<th>Free Lime</th>
<th>MgO</th>
<th>Alkali sulfate</th>
<th>Alkali aluminate</th>
<th>SO3</th>
<th>Free water</th>
<th>-50 mesh</th>
<th>Bond Grindability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td></td>
<td>55-65</td>
<td>15-25</td>
<td>8-12</td>
<td>5-8</td>
<td>&lt;1.5</td>
<td>&lt;2.0</td>
<td>Trace</td>
<td>Trace</td>
<td>0.5-2.0</td>
<td>&lt;0.5</td>
<td>-</td>
<td>13-18</td>
</tr>
<tr>
<td>Greencastle</td>
<td></td>
<td>55-60</td>
<td>18-22</td>
<td>9-11</td>
<td>6-8</td>
<td>&lt;0.5</td>
<td>1.0</td>
<td>Trace</td>
<td>None</td>
<td>1.9</td>
<td>None</td>
<td>Not complete</td>
<td>17.5</td>
</tr>
</tbody>
</table>

construction technology laboratories
Optimum SO$_3$ was determined for the Greencastle clinker using ASTM Designation: C563-84, Standard Test Method for Optimum SO$_3$ in Portland Cement. This test is used to develop the proper addition level of gypsum for a particular clinker. It was found that the clinker required about 3.5% SO$_3$. The clinker SO$_3$ was determined to be 1.9% which, by subtraction, allows an addition of 1.6% SO$_3$ from the gypsum. Since the gypsum contains 40.3% SO$_3$, then the amount of gypsum required on a mass basis for optimum is 4%. This information was transmitted to both subcontractors for their processing needs.

Microscopic analyses were performed on polished sections of selected clinkers to determine the nature of the clinker phases, size of crystals, and other items relative to prediction of overall performance and grindability of the material.

**Table 1.2**

**Microscopic Analysis of Greencastle Clinker**

1. Periclase (MgO) - none observed.
2. Free lime-randomly scattered; round crystals and clusters; (maximum 1%).
3. Aluminate - large C$_3$A masses; (maximum 15%).
4. Ferrite - typical lath form crystals, medium dull; (4-6%).
5. Alite - euhedral to subhedral; wide size range; average size = 50 $\mu$m; (50%).
6. Belite - nests of loosely packed crystals: 
   generally wide lamellae: average size = 31 μm: (25%).

7. Alkali sulfate-trace amounts observed.

   While the clinker is relatively porous with fairly large crystals of alite and belite, it nevertheless falls inside a range of typical parameters.

   The Bond Grindability test is not complete at this writing, but a comparative grindability test conducted by CTL on the Greencastle clinker indicates that it is somewhat harder to grind than an average clinker.

   The delivered gypsum was analyzed for SO₃ content, which was determined to be 40.45%. Microscopic analysis and X-ray diffraction analysis indicated the material to be mainly gypsum with small amounts of silica and carbonates.

   **Subtask 1(c):** As called for in the Statement of Work, the clinker and gypsum were shipped to Allis-Chalmers Corporation (A-C) Test Center in Oak Creek, Wisconsin and to Kennedy Van Seem Corporation (KVS) at Danville, Pennsylvania. Each company received half the clinker delivered in covered trucks. Clinker was loaded into the trucks by front end loader at the cement plant on an alternating basis to provide blending and mixing. The clinker was stored in a silo so that drawing down the silo through the spout provided initial mixing. Unloading, conveying, and storing clinker at the destinations continued the mixing process. Gypsum was shipped by truck from United States Gypsum Co.'s Shoals, Indiana mines to A-C and KVS.
Subtask 1(d): A-C crushed half the clinker and half the gypsum delivered to the Oak Creek facility so that the crushed product was nominally -10 mesh material. This crushed material was placed in plastic lined steel drums and delivered to CTL at Skokie, Illinois, where it is stored for further processing.

Task 2: Ball Mill Baseline Tests

Subtask 2(a): A matrix and test plan was prepared and will be provided in the plan package to be mailed to the DOE contracting office.

Subtask 2(b): Watthour meters are installed on the pilot mill set-up. One watthour meter reads the total power of the system and a second reads the power of the mill itself. By subtraction, the power of the classifier and the transport system can be determined. An ammeter is used to determine changes in load on the classifier. All watthour meters and ammeters have been checked for accuracy using a standard instrument. The watthour meters were recently sent to the factory for routine maintenance and calibration.

Because we have not received authorization to purchase a mass flow device for measuring the circulating load, we have installed a slide gate on the circulating load conveyor so that this part of the process can be measured by timed weighing.

A standard ball charge will be used for the baseline production runs. The ball charge will be 35% volume loading.
consisting of about 30% 1-1/2-in. balls, 30% 1-1/4-in. balls, 25% 1-in. balls, and 15% 3/4-in. balls. Percent volume loading is determined by calculating the volume of the ball charge compared to the volume of the inside of the mill. The use of 35% volume loading reflects current practice in many cement plants and also is the middle loading of the experimental runs in Task 3.

**Task 3: Effects of Changes in Ball Charge.**

A minor amount of work was accomplished on inventorizing ball sizes and quantities and calculating mill charges as to total weight and size consistency. Final decision on mill charges will be deferred until the baseline runs are complete, using the standard charge described above.

**Task 6: Semi-Air Swept Milling**

**Subtask 6(a):** The test plan and matrix was completed and approved by the project manager. Some breakage rate studies have been started but no data are available yet. The L&N Microtrac particle size analyzer at Pennsylvania State University, where Dr. L. G. Austin is conducting the laboratory portion of this task, has been calibrated to agree with cement fineness standards. Cement fineness standards and the particle size distribution analysis of the standards were produced at CTL using a SediGraph 5000E particle analyzer. Calibration of the Microtrac to the SediGraph will allow coordination of data as cement grinding proceeds.
Task 8: Roller Mill Investigation

Subtask 8(a): The matrix for the proposed test series has been developed and approved by the project manager.

Subtask 8(b): Preliminary work has begun on the main portion of this task. Roller mill feed is being prepared. A new separator part for modifying the pilot roller mill is on order from Germany and delivery is expected by the end of April.

IV. PLAN FOR FUTURE WORK

The project was delayed about 1 month because the original clinker source, which we had checked out several months prior to start of the program, was no longer of acceptable quality. Thus, another source in the same general geographic location had to be located, price quotes obtained, testing performed, and transportation arranged.

We anticipate that the total project will still meet the completion schedule despite the initial delay. There is no change contemplated in the work program.

There are, however, two changes in equipment, which we have requested per our letter to Ms. T. A. Hart, Contracting Officer, dated February 6, 1985. This request involved a change in the type of high efficiency classifier proposed, and the addition of a gamma-ray device to continuously monitor the mass flow of the circulating load.

Our existing classifier is a C-E Raymond turbo separator which is typical of the type installed in the cement industry. In our original proposal, we had the concept of installing a
secondary classifier to handle tailings from the C-E Raymond separator and in this way reduce the amount of undersized material returning to the mill for further grinding. At the time of the original proposal, C-E Raymond had not developed their retrofit kit which allows the separator to run at high efficiencies. Since the C-E Raymond retrofit represents only one piece of process equipment, its operation promises to be much simpler and more stable than if we were to install the two-stage classification scheme originally envisaged. Control of cement grinding mills to constant particle size distribution is difficult, but the use of two-stage classification makes matters worse. Furthermore, it would be well to demonstrate a technique to cement manufacturers which would allow relatively easy conversion of their turbo separators to high efficiency machines, and it is believed that the C-E Raymond retrofit development will do just that.

The mass flow meter for measuring circulating load will allow us to avoid trying to control the mill circuit by multiple sampling and fineness analysis which, at best, produces questionable results. We believe that a much more definitive set of data can be derived with the use of a mass flow device. The gamma-ray meter can be installed easily without dismantling or redesigning the existing equipment, and can be just as easily removed if needed elsewhere.

Assuming that authorization to procure these two items is forthcoming shortly, we will order and install them as rapidly as possible. However, since there is a delivery time lag of at least two months for both items, we must move rapidly in this area to comply with the milestone plan.
### Matrix of Tests

**Task 2: Baseline Power Determination**

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. Target Blaine, m²/kg</th>
<th>No. of Tests</th>
<th>Actual Blaine Detms., m²/kg</th>
<th>Sedigraph Runs</th>
<th>Grinding Energy, kWh</th>
<th>Mill Mass Flow Rate, wt/hr</th>
<th>Sieve Analysis of Feed, 10-200 mesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinker + Gypsum</td>
<td>250</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td>350</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>400</td>
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<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>Clinker only</td>
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<td>3</td>
<td>3</td>
<td>1</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td>300</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subtotals</td>
<td>8</td>
<td>8</td>
<td>24</td>
<td>24</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

* 35% volume loading for these experiments
* 70% of critical speed for these experiments \( N_c \)
## Matrix of Tests

**Task 3: Effect of Changes in Ball Charge, Volume Loading, and Mill Speed**

<table>
<thead>
<tr>
<th>Classifier Type</th>
<th>Ball Charge Distribution</th>
<th>Volume Loading, %</th>
<th>Mill Speeds, No.</th>
<th>No. of Runs</th>
<th>No. of No-Load Tests</th>
<th>Blaine, m²/kg</th>
<th>SediGraph Runs</th>
<th>Compressive Strength at 3, 7, 28 days, psi*</th>
<th>Time of Set, hr:min</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>3</td>
<td>25</td>
<td>3 (60, 70, 80 rpm)</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>35</td>
<td>&quot;</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>45</td>
<td>&quot;</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>27</td>
<td>9</td>
<td>27</td>
<td>27</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

* samples selected based on particle size distribution.
Matrix of Tests

Task 4: Effect of Changes in Ball Charge and Mill Speed

<table>
<thead>
<tr>
<th>Classifier Type</th>
<th>Ball Charge Distribution No. of Types</th>
<th>Volume Loading, %</th>
<th>Mill Speeds, No. of Runs</th>
<th>No. of No-Load Tests</th>
<th>Blaine, m²/kg. No. of Runs</th>
<th>Sedi-Graph, No. of Runs</th>
<th>Compressive Strength at 3,7 &amp; 28d, psi</th>
<th>Time of Set, hr:min</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>3</td>
<td>35</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(60, 70, &amp; 80 rpm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Matrix of Tests

## Task 5: Effect of Gypsum

### a) Preparation of Clinker/Gypsum Blends

<table>
<thead>
<tr>
<th>Blend Clinker/Gypsum</th>
<th>Blaine</th>
<th>SediGraph</th>
<th>$SO_3$</th>
<th>Grinding Energy, kWh</th>
<th>No-Load Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>50/50</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30/70</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Subtotals:</strong></td>
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<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

### b) Preparation of Cements of Different Surface Areas using Clinker/Gypsum Blends

<table>
<thead>
<tr>
<th>Approx. Clinker Blaine, $m^2/kg$</th>
<th>Clinker/Gypsum Blends</th>
<th>Blaine, No. of runs ($m^2/kg$)</th>
<th>SediGraph No. of Runs</th>
<th>$SO_3$, No. of Runs (wt %)</th>
<th>Compressive Strength at 3, 7 &amp; 28 d (psi)</th>
<th>Time of Set hr:min</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>50/50</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>250</td>
<td>50/50</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>300</td>
<td>50/50</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>350</td>
<td>50/50</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Subtotals:</strong></td>
<td><strong>4</strong></td>
<td><strong>4</strong></td>
<td><strong>8</strong></td>
<td><strong>8</strong></td>
<td><strong>8</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

* from Task 2 data
Matrix of Tests

Task 5: Effect of Gypsum

c) Preparation of Cements by Blending Clinker/Gypsum Blends in Pilot Mill
Loaded Originally with Clinker

<table>
<thead>
<tr>
<th>Materials</th>
<th>Blaine, No. of runs (m²/kg)</th>
<th>SediGraph No. of Runs</th>
<th>SO₃ No. of Runs (wt %)</th>
<th>Compressive Strength at 3, 7 &amp; 28d (psi)</th>
<th>Time of Set No. of Runs (hr:min)</th>
<th>Grinding Energy No. of Runs (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinker from Ball Mill</td>
<td>Clinker/Gypsum Blend Ratio Added After Ball Mill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50/50</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30/70</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
MATRIX OF TESTS
ALLIS-CHALMERS CORP.

construction technology laboratories
Portland Cement Association  
5420 Old Orchard Road  
Skokie, Illinois 60077

Attention: Mr. Stewart W. Tresouthick, Director  
Chemical/Physical Research Department

Subject: Clinker Grinding Roller Mill Test Matrix  
Reference: Energy Savings by Improved Control of the Finish  
Grinding Process in Cement Manufacture

Dear Stew:

We are enclosing for your approval the test matrix which you requested at the  
meeting held in your office on February 13, 1985.

Twenty-five tons of cement clinker will be crushed to minus 0.375 inch and blended  
with an amount of gypsum specified by the PCA. To assure thorough mixing, the  
gypsum will be crushed and ground to approximately 20 mesh before blending. Five  
tons of the blend will be retained by Allis-Chalmers for subsequent roller mill tests.

Proceeding and independent tests by PCA have suggested that "ideal" ground cement  
products will have size distributions as shown graphically on attached Fig. 1.  
The purpose of the roller mill tests is to vary operating conditions to approach  
or duplicate one or all of the "ideal" size distributions.

It is recognized that the roller mill can impress a certain amount of energy per  
pass (on the clinker bed between roll and table) and the size distribution of the  
particles produced depends on the crushing and the subsequent classification.

To explore the full range of both unit processes, the matrix as shown on Fig. 2  
will be conducted.

The test conducted each day will be at a specific table speed and roll load. Four  
days of tests will be required, each will give 12 individual samples over a range  
of air sweep volumes, classifier speed and classifier by-pass. Each of the 48  
samples will be size analyzed on the Sedigraph and compared to the distributions  
shown in Graph I.

The degree of size distribution agreement will dictate the area of the matrix  
which is most promising for further testing, or modification of the matrix  
composition by revising test conditions to further the chances to achieve the  
program objective.
After PCA completes their evaluation, they will specify mill operating conditions under which up to three (3) tons of product will be made.

The matrix of tests and the production run (runs) of three tons will be carried out under PCA Order No. B35503. In case of scope change, or if additional tests are required, an extension of the present order will be required.

Very truly yours,

[Signature]

Dr. Lida Dinter
Engineer, Process Development
Process Research & Test Center
A-C ENERGY & MINERALS SYSTEMS CO.

LD/em

cc:  R. S. Jermyn
     E. J. Klovers
     D. R. Olson
     G. G. Sulzer
PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION
IDEAL CURVES - CLINKER

Density g/cc LIQUID
Preparation AS FOLLOWS FROM PCA 1979 REPORT

Density g/cc Viscosity cp

DATE 2.14.85
BY L.D
TEMPERATURE "C

RATE START DIA

CUMULATIVE MASS PERCENT

100
90
80
70
60
50
40
30
20
10

1.00 0.80 0.60 0.40 0.20 0.10

EQUIVALENT SPHERICAL DIAMETER, \( \mu m \)

micromeriticsInstrument corporation
CLINKER GRINDING ROLLER MILL TEST MATRIX

- TEST PROCEDURE
  - TABLE SPEED
    - 100%
    - 80%
  - LOAD ON ROLLS
    - 1225 lb/roll
    - 2550 lb/roll
  - AIR SWEEP VOLUME
    - 90%
    - 75%
  - CLASSIFIER SPEED, RPM
    - 1400
    - 900
    - 400
  - CLASSIFIER % BY-PASS
    - 0
    - 50

12 SAMPLES
24 SAMPLES
43 SAMPLES

Fig. 2
MIX OF TESTS
DR. L. G. AUSTIN
(Pennsylvania State Univ.
and
Kennedy Van Saun)

construction technology laboratories
TEST SCHEDULE AT KVS

Ball load J=27% mill volume; U=fractional interstitial ball filling based on formal bulk density of clinker; 80% critical speed.

TEST 1
Calibrate hold-up of mill versus sound level monitor reading. Ball load (J)=27%, 5 levels of hold-up covering range of interstitial filling (U) 0.5 to 2.0.

TEST 2
Batch grinding; U=0.85; 6 grinding times.

TESTS 3/4/5/6
O.C. continuous; mass flow adjusted to maintain U=0.85; 4 levels of production rate as set by air flow rate.

TESTS 7/8/9
O.C. continuous; medium level of air flow rate; mass flow adjusted to give U=0.5, U=1.2, U=1.5.

TESTS 10/11
O.C. continuous; low level of air flow rate; mass flow adjusted to give U=0.5, U=1.2.

TESTS 12/13
O.C. continuous; high level of air flow rate; mass flow adjusted to give U=0.5, U=1.2.

TEST 14
Contingency test.
LABORATORY TESTS AT P.S.U.

TEST SET 1 (8 tests)

Standard S and B determinations in batch 8 inch mill at J=0.3, U=0.85, 80% critical speed, one inch balls. Four starting feed sizes in \sqrt{?} intervals. Duplicates.

TEST SET 2 (4 tests)

Standard S and B in batch 8 inch mill at J=0.3, 80% critical speed, 1" balls, one feed size. U=0.5, 1.2, 1.5, 2.0.

TEST SET 3 (10 tests)

S and B determinations in batch 2 feet diameter mill, J=0.3, U=0.85, 80% critical speed. Two starting feed sizes. Ball sizes 1/2", 3/4", 1", 1 1/2", 2".

TEST SET 4 (2 tests)

Cushioning in batch 2 feet diameter mill. J=0.3, U=0.85, 80% critical speed, 1" balls. Two mixed feed sizes.
## MILESTONE LOG

**Contract:** DE-FC07-81CS40419.A004  
**Period:** 01/03/85 - 12/31/86

**Project:** Improved Control of the Finish Grinding Process in Cement Manufacture [Phase III of Energy Conservation Potential of Portland Cement Particle Size Distribution Control]

<table>
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<th>Milestone</th>
<th>Description</th>
<th>Task</th>
<th>Planned Completion</th>
<th>Actual Completion</th>
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<td>01/03/85</td>
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<td>B</td>
<td>Complete pilot mill baseline tests</td>
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<td>Complete roller mill tests at Allis-Chalmers</td>
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<td>D</td>
<td>Assess ball charge loading and mill speed effects on pilot scale ball mill efficiency</td>
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<td>Complete improved separator performance tests</td>
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<td>F</td>
<td>Complete tests involving energy efficiency of separate grinding and mixing of gypsum</td>
<td>(5)</td>
<td>01/15/86</td>
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<td>G</td>
<td>Complete semi-air swept cement milling tests</td>
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<td>Optimize ball mill circuits by mathematical modeling</td>
<td>(7)</td>
<td>06/30/86</td>
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<tr>
<td>I</td>
<td>Submit draft final report</td>
<td>(10)</td>
<td>09/30/86</td>
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CR7913-4330  
March 1985
**U.S. DEPARTMENT OF ENERGY**

**Assistant Milestone Plan**

**Program/Project Title:** Energy Conservation Potential of Portland Cement Particle Size Control - Phase III: Finish Grinding in Cement Manufacture

**Agency:** Portland Cement Association

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**Program/Project Start Date:**

A004: 1/3/85

**Program/Project Completion Date:**

Dec. 31, 1986

**Comments:**

- ΔC
- ΔD
- ΔE
- ΔF
- ΔG
- ΔH
- ΔI

**12. Signature of DOE Reviewing Representative and Date:**

- [Signature]

- [Date]
1. Program/Project Identification No. DE-FC07-81CS40419.A004
2. Program/Project Title Finish Grinding in Cement Manufacture, Phase III of Energy Conservation
3. Reporting Period 1/3/85 through 3/31/85

4. Name and Address
   Construction Technology Distribution Control
   Laboratories, A Division of the Portland Cement Association
   5420 Old Orchard Road, Skokie, IL 60077
   Potential of Portland Cement Particle Size

5. Program/Project Start Date A004: 1/3/85
6. Completion Date A004: 12/31/86 planned

7. Approach Changes

8. Performance Variances, Accomplishments, or Problems
   Task 1: Due to difficulties in obtaining a suitable clinker source, Task 1 was completed approximately 1 month behind schedule. This has delayed the start of Task 2, which is now about 2-3 weeks behind schedule. Efforts are being made to close this gap.
   Task 2: Extra effort was involved in calibrating power meters for the mill system, which added to delays in Task 2.
   None

9. Open Items
   To date authorization has not been received for purchase of the C-E Raymond air classifier modification and the mass flow measuring device as requested in my