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| AP42 Section: | 11.20 |
| Reference: | 4 |
| Title: | Emission Test Report: Arkansas Lightweight Aggregate Corporation, West Memphis, Arkansas, EMB Report 80-LWA-2, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1981. |

United States
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Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

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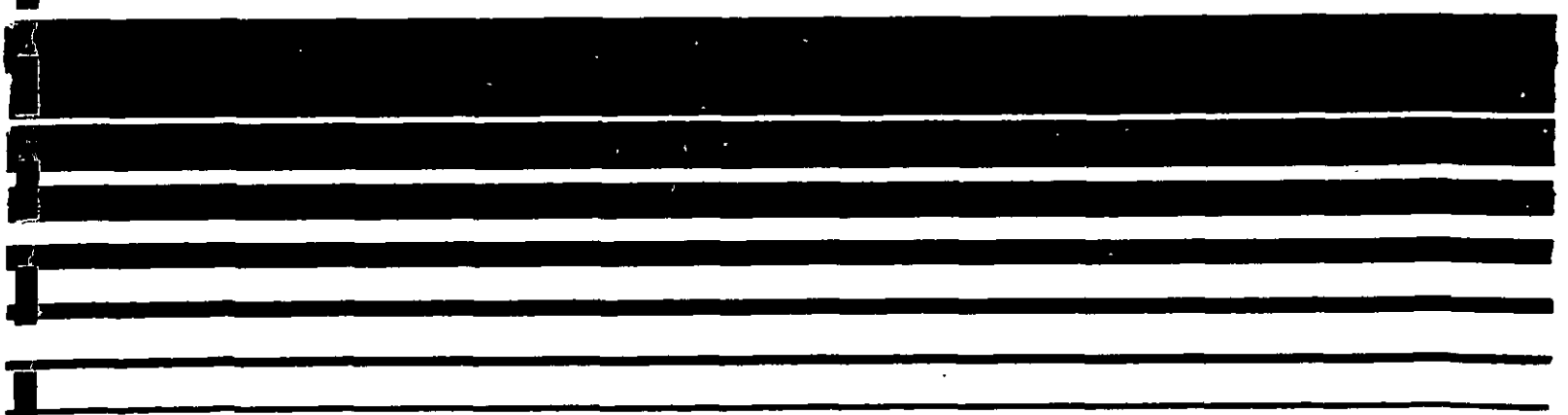
AP-42 Section 11.20
Reference 4
Report Sect. 4
Reference 2

Air

EPA

# Lightweight Aggregate

# Emission Test Report Arkansas Lightweight Aggregate Corporation W. Memphis, Arkansas



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Research Triangle Park NC 27711

EMB Report 80-LWA-2
May 1981

Air

EPA

# Lightweight Aggregate

# Emission Test Report Arkansas Lightweight Aggregate Corporation W. Memphis, Arkansas

° EMISSION TEST REPORT °

# METHOD DEVELOPMENT AND TESTING FOR CLAY, SHALE, AND SLATE AGGREGATE INDUSTRY: Arkansas Lightweight Aggregate Corporation, West Memphis, Arkansas, ESED 80/12

By

PEDCo Environmental, Inc.
11499 Chester Road
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Contract No. 68-02-3546
Work Assignment No. 1
PN 3530-1

EPA Task Manager
Frank Clay

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EMISSION MEASUREMENT BRANCH
EMISSION STANDARDS AND ENGINEERING DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

May 1981

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# SECTION 1

# INTRODUCTION

During the week of October 20, 1980, PEDCo Environmental personnel conducted an emission sampling program at Arkansas Lightweight Aggregate Corporation's West Memphis, Arkansas, facility. The purpose of this test program was to provide data to assess the need for New Source Performance Standards (NSPS) emission limits for selected processes in the lightweight aggregate industry and, if warranted, to develop such limits.

This plant was selected for testing for the following reasons:

1. The plant is one of the best controlled coal-fired lightweight aggregate plants that use wet scrubbers and dry cyclones for emission control; and
2. The arrangement of pollution control devices on process equipment appears to be representative of future plants.

Comprehensive testing was conducted on two specific sources as detailed below:

- Coal-fired rotary kiln whose emissions are controlled by a settling chamber and medium-energy wet scrubber and,
- Reciprocating grate clinker cooler whose emissions are controlled by a dry multicyclone.

Particulate concentrations and mass emission rates were measured at the final exit stacks serving the kiln and clinker

cooler by U.S. Environmental Protection Agency (EPA) Method 5.* Flue gas flow rates, temperature, moisture content, and composition [oxygen ($O_2$), carbon dioxide ($CO_2$), and carbon monoxide (CO)] were measured in conjunction with the particulate test runs. Sulfur dioxide ($SO_2$) concentrations and mass emission rates were measured at the inlet to and outlet from the wet scrubber serving the kiln by EPA Method 6.* Nitrogen oxide ($NO_x$) concentration in the flue gas exiting the scrubber was also determined by EPA Method 7.* In addition, the particle size distribution of particulate matter exiting the kiln and clinker cooler control devices was determined.

Representative samples of the kiln feed material (clay) and the coal used to fire the kiln were collected during each particulate test for determination of sulfur content, moisture, density, and ash content (coal only). Samples of scrubber water influent and effluent were collected for trace metal analysis. Though not specified in the test plan, samples of the final aggregate product and dust captured by the clinker cooler multicyclone were also collected and analyzed for sulfur.

Visible emission observations were made for each exit stack during the particulate tests by EPA Method 9.† Additionally, a visible determination of fugitive dust emissions from the kiln seals (charging and product discharge) was made during each particulate test by proposed EPA Method 22.§

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

† Federal Register, Vol. 39, No. 219, November 12, 1974.

§ Federal Register, Vol. 45, No. 224, November 18, 1980.

Mr. Jeff Shuler [Midwest Research Institute (MRI)] monitored process operation throughout the test period. Mr. Frank Clay, EPA Task Manager, observed the test series.

# SECTION 2

# PROCESS OPERATION

The process operation and summary of data monitored during the test period are presented below. Data was collected by personnel from MRI.

Arkansas Lightweight Aggregate Corporation employs a pulverized coal-fired rotary kiln for the production of lightweight aggregate from surface-mined clay. The kiln operation is continuous, 24 hours per day, 7 days per week except for required maintenance. Kiln capacity is approximately 680 megagrams (Mg) per 24-hour day (750 tons per day). The kiln is fired with pulverized coal, and small amounts of natural gas are used for temperature control. Exhaust gases from the feed end of the kiln are treated by a settling chamber followed by a medium-energy scrubber (Fuller/Dracco type CAA, Size 92).

The other major process equipment on this production line is a reciprocating grate clinker cooler. Particulate emissions from the clinker cooler are controlled by a dry multiclone.

Tables 2-1 and 2-2 summarize the production and process data monitored during the test period.

TABLE 2-1. PROCESS DATA FOR EMISSION TEST AT ARKANSAS LIGHTWEIGHT AGGREGATE PLANT, WEST MEMPHIS, ARKANSAS: OCTOBER 20-23, 1980; ESED PROJECT 80/12; MRI PROJECT 4659-L

Production report, Monday, October 20

| | First shift | Second shift | Third shift | 24-h Total |
|---|---|---|---|---|
| Coal input, tons | 0 | 11.65 | 16.90 | 28.55 |
| Gas input, MCF* | 509 | 205 | 55 | 769 |
| Clay input, tons | 278.7 | 298.8 | 317.0 | 894.5 |
| Product output, $yd^3$ | 317.7 | 340.6 | 361.4 | 1019.7 |

Product density (average composite): 33 $lb/ft^3$

Production report, Tuesday, October 21

| | First shift | Second shift | Third shift | 24-h Total |
|---|---|---|---|---|
| Coal input, tons | 18.81 | 17.99 | 17.56 | 54.36 |
| Gas input, MCF | 36 | 29 | 45 | 110 |
| Clay input, tons | 317.7 | 317.2 | 317.4 | 952.3 |
| Product output, $yd^3$ | 362.2 | 361.6 | 361.8 | 1085.6 |

Product density (average composite): 33 $lb/ft^3$

*Million cubic feet.

(continued)

TABLE 2-1 (continued)

Production report, Wednesday, October 22

| | First shift | Second shift | Third shift | 24-h Total |
|---|---|---|---|---|
| Coal input, tons | 17.76 | 18.44 | 16.85 | 53.05 |
| Gas input, MCF | 19 | 10 | 36 | 65 |
| Clay input, tons | 313.3 | 316.8 | 315.7 | 945.8 |
| Product output, $yd^3$ | 357.2 | 361.2 | 359.9 | 1078.3 |

39.4 tph

Product density (average composite): 33 $lb/ft^3$

Production report, Thursday, October 23

| | First shift | Second shift | Third shift | 24-h Total |
|---|---|---|---|---|
| Coal input, tons | 17.80 | NA | NA | NA |
| Gas input, MCF | 29 | NA | NA | NA |
| Clay input, tons | 313.3 | NA | NA | NA |
| Product output, $yd^3$ | 357.2 | NA | NA | NA |

Product density (average composite): 33 $lb/ft^3$

NA=Not applicable; testing was completed before second shift began, therefore, only first shift data were collected.

~~39.8~~ 38.8 tph
39.5 tph
Kiln & cooler tests were on 10/21 & 10/22.

TABLE 2-2. PROCESS DATA-EPA METHOD 5; TUESDAY, OCTOBER 21

| | Elapsed time (min) | Air to coal mill (°F) | Air from coal mill (°F) | Kiln back end temp. (°F) | Kiln front end temp. (°F) | Kiln firing hood draft (in. water) | Scrubber ID fan draft (in. water) |
|---|---|---|---|---|---|---|---|
| Test No. 1 Start-9:23 a.m. | | | | | | | |
| | 0 | 395 | 172 | 715 | 1566 | -0.05 | 6.4 |
| | 15 | 375 | 162 | 716 | 1576 | -0.05 | 6.4 |
| | 30 | 360 | 158 | 714 | 1569 | -0.04 | 6.4 |
| | 45 | 370 | 158 | 723 | 1569 | -0.04 | 6.4 |
| | 60 | 405 | 165 | 725 | 1577 | -0.05 | 6.4 |
| | 75 | 407 | 162 | 725 | 1580 | -0.05 | 6.4 |
| | 90 | 390 | 155 | 729 | 1582 | -0.05 | 6.4 |
| | 105 | 410 | 165 | 727 | 1576 | -0.04 | 6.4 |
| | 120 | 430 | 170 | 727 | 1580 | -0.04 | 6.4 |
| | 135 | 425 | 173 | 726 | 1575 | -0.04 | 6.4 |
| Test No. 2 Start-2:05 p.m. | | | | | | | |
| | 0 | 420 | 166 | 728 | 1582 | -0.05 | 6.4 |
| | 15 | 410 | 160 | 729 | 1592 | -0.04 | 6.4 |
| | 30 | 420 | 166 | 722 | 1595 | -0.04 | 6.4 |
| | 45 | 420 | 166 | 730 | 1600 | -0.05 | 6.4 |
| | 60 | 410 | 164 | 726 | 1598 | -0.05 | 6.4 |
| | 75 | 405 | 162 | 724 | 1602 | -0.04 | 6.4 |
| | 90 | 430 | 170 | 725 | 1605 | -0.05 | 6.4 |
| | 105 | 410 | 165 | 727 | 1616 | -0.04 | 6.4 |
| | 120 | 425 | 168 | 724 | 1605 | -0.05 | 6.4 |
| | 135 | 410 | 166 | 732 | 1610 | -0.05 | 6.4 |

(continued)

TABLE 2-2 (continued). PROCESS DATA-EPA METHOD 5; WEDNESDAY, OCTOBER 22

| | Elapsed time (min) | Air to coal mill (°F) | Air from coal mill (°F) | Kiln back end temp. (°F) | Kiln front end temp. (°F) | Kiln firing hood draft (in. water) | Scrubber ID fan draft (in. water) |
|---|---|---|---|---|---|---|---|
| Test Nos. 3 and 4* | | | | | | | |
| Start-10:20 a.m. | | | | | | | |
| | 0 | 425 | 176 | 722 | 1560 | -0.05 | 6.4 |
| | 15 | 415 | 172 | 720 | 1555 | -0.05 | 6.4 |
| | 30 | 430 | 177 | 725 | 1556 | -0.04 | 6.4 |
| | 45 | 440 | 182 | 721 | 1550 | -0.05 | 6.4 |
| | 60 | 405 | 174 | 716 | 1530 | -0.04 | 6.4 |
| | 75 | 445 | 184 | 718 | 1525 | -0.04 | 6.4 |
| | 90 | 435 | 182 | 717 | 1537 | -0.04 | 6.4 |
| | 105 | 445 | 186 | 711 | 1517 | -0.04 | 6.4 |
| | 120 | 440 | 183 | 704 | 1512 | -0.02 | 6.4 |
| | 135 | 450 | 182 | 706 | 1513 | -0.04 | 6.4 |
| | 150 | 445 | 181 | 708 | 1520 | -0.06 | 6.4 |
| | 165 | 415 | 175 | 703 | 1510 | -0.05 | 6.4 |
| | 180 | 445 | 180 | 712 | 1542 | -0.04 | 6.4 |

*Conducted simultaneously.

(continued)

TABLE 2-2 (continued). PROCESS DATA-EPA METHOD 6; THURSDAY, OCTOBER 23

| | Elapsed time (min) | Air to coal mill (°F) | Air from coal mill (°F) | Kiln back end temp. (°F) | Kiln front end temp. (°F) | Kiln firing hood draft (in. water) | Scrubber ID fan draft (in. water) |
|---|---|---|---|---|---|---|---|
| | -95 | 420 | 185 | 711 | 1526 | -0.05 | 5.8 |
| | -35 | 460 | 190 | 706 | 1520 | -0.05 | 6.0 |
| | -20 | 415 | 178 | 710 | 1527 | -0.05 | 6.0 |
| Start-10:20 a.m. | 0 | 437 | 182 | 715 | 1552 | -0.05 | 6.0 |
| | 20 | 405 | 170 | 713 | 1540 | -0.05 | 6.0 |
| | 40 | 380 | 165 | 711 | 1532 | -0.05 | 6.2 |
| | 60 | 405 | 174 | 708 | 1517 | -0.04 | 6.2 |
| | 80 | 395 | 173 | 704 | 1497 | -0.05 | 6.2 |
| | 100 | 405 | 174 | 705 | 1522 | -0.05 | 6.2 |
| | 120 | 410 | 170 | 706 | 1530 | -0.02 | 6.2 |
| | 140 | 420 | 174 | 709 | 1620 | -0.04 | 6.3 |
| | 160 | 430 | 178 | 708 | 1622 | -0.05 | 6.3 |
| | 180 | 450 | 184 | 705 | 1620 | -0.06 | 6.3 |
| | 200 | 450 | 186 | 704 | 1624 | -0.05 | 6.3 |
| | 220 | 440 | 180 | 701 | 1610 | -0.04 | 6.3 |
| | 240 | 460 | 185 | 705 | 1614 | -0.04 | 6.4 |
| | 260 | 465 | 187 | 702 | 1593 | -0.05 | 6.4 |
| | 280 | 455 | 184 | 703 | 1539 | -0.05 | 6.4 |
| | 300 | 415 | 172 | 699 | 1542 | -0.05 | 6.4 |
| | 320 | 415 | 171 | 702 | 1554 | -0.05 | 6.4 |
| | 340 | 410 | 168 | 703 | 1551 | -0.05 | 6.4 |
| | 360 | 400 | 165 | 707 | 1656 | 0.00 | 6.4 |
| | 375 | 400 | 164 | 710 | 1636 | -0.05 | 6.4 |

# SECTION 3

# SUMMARY OF RESULTS

This section details results obtained from the emission sampling program. All emission samples and plume observation data were collected simultaneously from the kiln and clinker cooler exhaust stacks. Results are reported separately for each source. It should be noted that the scrubber serving the kiln experienced feedwater pump malfunction during the second particulate and particle size test runs; the malfunction resulted in a fluctuation in scrubber water level throughout this period. A discussion of the effects that this malfunction may have had on the test results is contained in Section 6 of this report.

Example calculations are contained in Appendix A. Field and laboratory data sheets are contained in Appendices B and C. Appendix D details the sampling and analytical procedures used during this test program. Equipment calibration procedures and results are contained in Appendix E.

## 3.1 ROTARY KILN EXHAUST

Particulate and particle size tests were conducted on the kiln exhaust immediately after the pollution abatement system, which consisted of a settling chamber followed by a wet scrubber. Visible emission observations were also performed during each

particulate test run. In addition, $SO_2$ tests were simultaneously conducted before and after the wet scrubber. Nitrogen oxide tests were conducted at the scrubber outlet simultaneously with the $SO_2$ tests.

Particulate sampling and analytical procedures followed EPA Method 5* except that an ether-chloroform extraction was performed on the impinger contents to determine condensible organic and inorganic fractions. Particle size sampling and analytical procedures followed those described in "Procedures Manual for Inhalable Particulate Sampler Operation," recently developed by Southern Research Institute for EPA.[1] Visible emission observations were conducted by EPA Method 9.† Sulfur dioxide sampling and analytical procedures followed EPA Method 6* except that large impingers were used instead of the midget impingers specified by EPA Method 6. Nitrogen oxide sampling and analytical procedures followed EPA Method 7.*

### 3.1.1 Flue Gas Conditions and Particulate Emissions

Summaries of the measured flue gas and particulate emission data from the kiln exhaust are presented in Tables 3.1-1 and 3.1-2. Volumetric flow rates are expressed in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions. Flow rates corrected to standard conditions [20°C and 760 mm Hg (68°F and 29.92 in. Hg)] are expressed as dry standard cubic meters per hour (dscmh) and dry standard cubic

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

† Federal Register, Vol. 39, No. 219, November 12, 1974.

TABLE 3.1-1. SUMMARY OF FLUE GAS CONDITIONS - KILN EXHAUST SCRUBBER OUTLET

| Run No. | Date (1980) | Flue gas flow | | | | Temperature | | Moisture, % | $O_2$,[c] % | $CO_2$,[c] % | CO,[c] % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Metric | | English | | | | | | | |
| | | acmh[a] | dscmh[b] | acfh[a] | dscfh[b] | °C | °F | | | | |
| SOP-1 | 10/21 | 154,157 | 97,717 | 5,443,963 | 3,450,833 | 78 | 173 | 24.0 | 14.0 | 5.7 | 0 |
| SOP-2 | 10/21 | 148,096 | 99,438 | 5,229,943 | 3,511,597 | 67 | 153 | 22.1 | 14.7 | 5.0 | 0 |
| SOP-3[d] | 10/22 | 138,546 | 88,453 | 4,892,190 | 3,123,661 | 81 | 177 | 23.0 | 15.1 | 4.4 | 0 |
| SOP-4[d] | 10/22 | 152,016 | 95,804 | 5,368,349 | 3,383,256 | 81 | 177 | 24.0 | 15.1 | 4.4 | 0 |
| Average | | 148,204 | 95,353 | 5,233,736 | 3,367,337 | 77 | 170 | 23.3 | 14.7 | 4.9 | 0 |
| | | | | | 3,339,505 | | | | 14.96 | | |

[a] Flue gas flow in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions.

[b] Flue gas flow in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh). Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg).

[c] Orsat analysis of integrated bag samples.

[d] Sampling conducted simultaneously.

TABLE 3.1-2. SUMMARY OF PARTICULATE EMISSION DATA - KILN EXHAUST SCRUBBER OUTLET

| Run No. | Date (1981) | Concentration[a] | | | | | | Mass emission rate[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Filterable | | Condensible | | | | Filterable | | Condensible | | | |
| | | | | Organic | | Inorganic | | | | Organic | | Inorganic | |
| | | mg/dscm | gr/dscf | mg/dscm | gr/dscf | mg/dscm | gr/dscf | kg/h | lb/h | kg/h | lb/h | kg/h | lb/h |
| SOP-1[c] | 10/21 | 495.9 | 0.2167 | 3.0 | 0.0013 | 305.5 | 0.1334 | 48.5 | 106.8 | 0.30 | 0.66 | 29.9 | 65.8 |
| SOP-2 | 10/21 | 325.4 | 0.1422 | 3.0 | 0.0013 | 337.8 | 0.1476 | 32.4 | 71.3 | 0.30 | 0.65 | 33.6 | 74.1 |
| SOP-3[d] | 10/22 | 775.5 | 0.3388 | 5.6 | 0.0024 | 322.7 | 0.1410 | 68.6 | 151.2 | 0.49 | 1.10 | 28.5 | 62.9 |
| SOP-4[d] | 10/22 | 882.3 | 0.3855 | 3.3 | 0.0014 | 237.7 | 0.1039 | 84.5 | 186.3 | 0.32 | 0.70 | 22.8 | 50.2 |
| Average | | 661.1 | 0.2888 | 4.0 | 0.0017 | 299.4 | 0.1308 | 61.8 | 136.3 | 0.37 | 0.82 | 28.3 | 62.4 |

[a]Concentration expressed as milligrams per dry standard cubic meter and grains per dry standard cubic foot. Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg).

[b]Mass emission rate expressed as kilograms per hour and pounds per hour.

[c]Excluded from average. See p. 3-5.

[d]Samples collected simultanteously.

feet per hour (dscfh). Particulate concentrations are reported in milligrams per dry standard cubic meter (mg/dscm) and grains per dry standard cubic foot (gr/dscf). Emission rates are expressed in kilograms per hour (kg/h) and pounds per hour (lb/h). The product of the concentration and the volumetric flow rate is the mass emission rate. The filterable particulate data in Table 3.1-2 represent material collected in the sample probe and on the filter, both of which were heated to approximately 121°C (250°F). The condensible organic and inorganic fractions represent material that condensed out or was trapped in the impinger section of the sample train at a temperature of approximately 20°C (68°F).

The volumetric flow rate averaged 95,353 dscmh (3,367,337 dscfh) at an average temperature of 77°C (170°F). The moisture content averaged 23.3 percent; and the oxygen, carbon dioxide, and carbon monoxide contents averaged 14.7, 4.9, and 0.0 percent, respectively. Because the gas stream appeared saturated and contained water droplets, two moisture determinations were made: the first involved calculations based on the water collected in the sampling trains, and the second involved psychrometric calculations. In each case, the lower value was used as the correct moisture content according to EPA Method 4.*

Filterable particulate concentration averaged 661 mg/dscm (0.289 gr/dscf) with a corresponding average mass emission rate of 61.8 kg/h (136.3 lb/h). Results from Run SOP-1 were excluded from the average because of a nonisokinetic sampling condition.

* Federal Register, Vol. 42, No. 160, August 18, 1977.

The organic and inorganic concentrations averaged 4.0 mg/dscm (0.0017 gr/dscf) and 299 mg/dscm (0.131 gr/dscf) with corresponding average mass emission rates of 0.37 kg/h (0.82 lb/h) and 28.3 kg/h (62.4 lb/h).

### 3.1.2 Particle Size Distribution

A total of nine particle size samples were collected from the scrubber outlet during the particulate test runs. The first test was a preliminary run and is not considered representative; therefore, it is not included in the overall data averages. Sampling and analytical procedures followed those described in "Procedures Manual for Inhalable Particulate Sampler Operation," developed by Southern Research Institute (SRI) for EPA.[1] Data obtained from the particulate test runs were combined with sampling data to obtain average flow rates, moisture content, and gas composition.

Data were reduced by computer programs in "A Computer-Based Cascade Impactor Data Reduction System," developed by SRI for EPA.[2] Individual computer printouts for each test and brief descriptions of each program used are contained in Appendix A of this report.

Figures 3.1-1 and 3.1-2 present the average distribution curve for each set of four samples collected. Individual data points for each test were plotted manually. The distribution curve was plotted manually and represents the best-fit average curve for the specified number of test runs. All particle size results are based on aerodynamic diameters and unit density (1 g/cc).

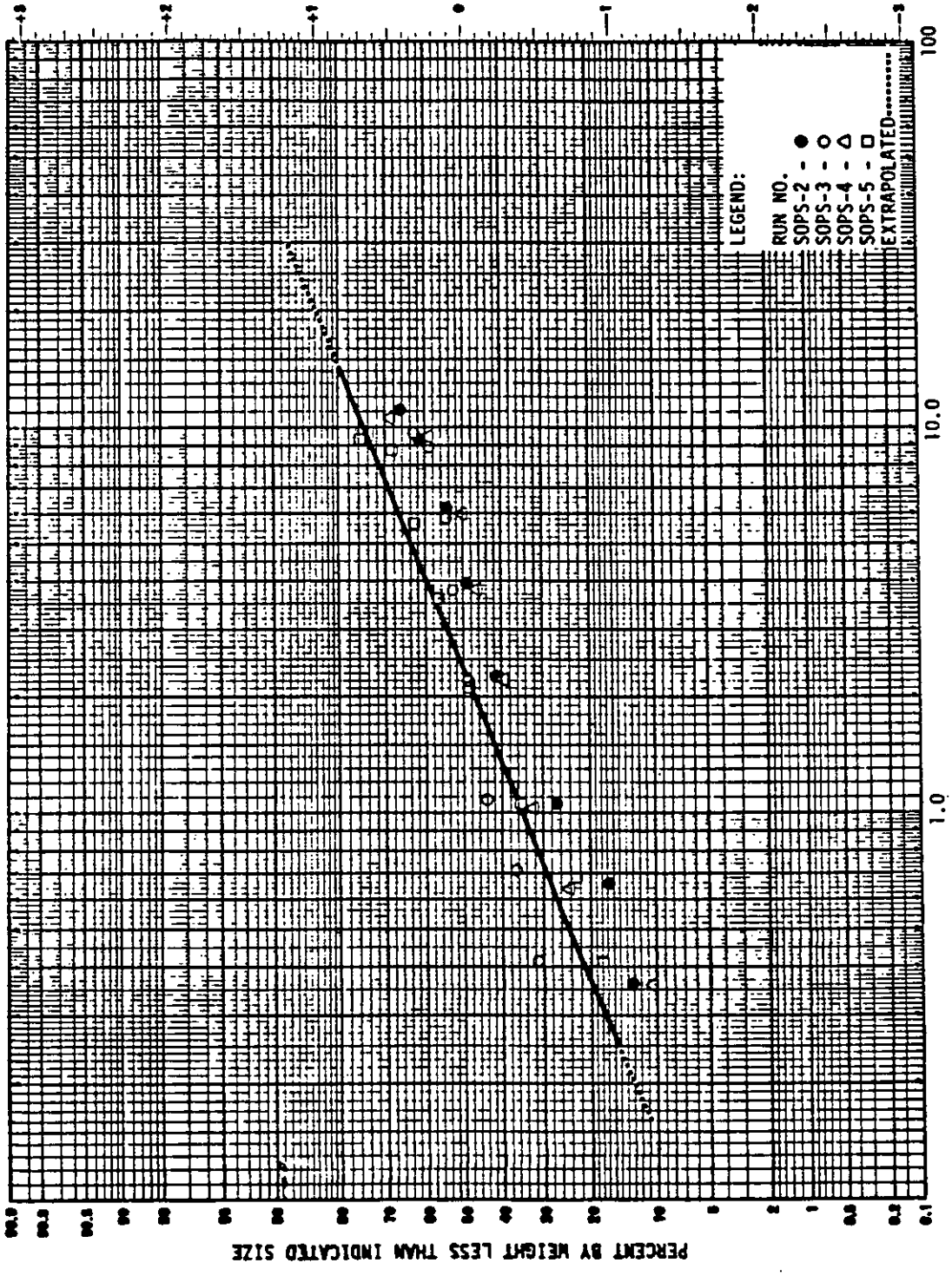


Figure 3.1-1. Particle size distribution for Runs SOPS-2 through SOPS-5 - kiln exhaust.

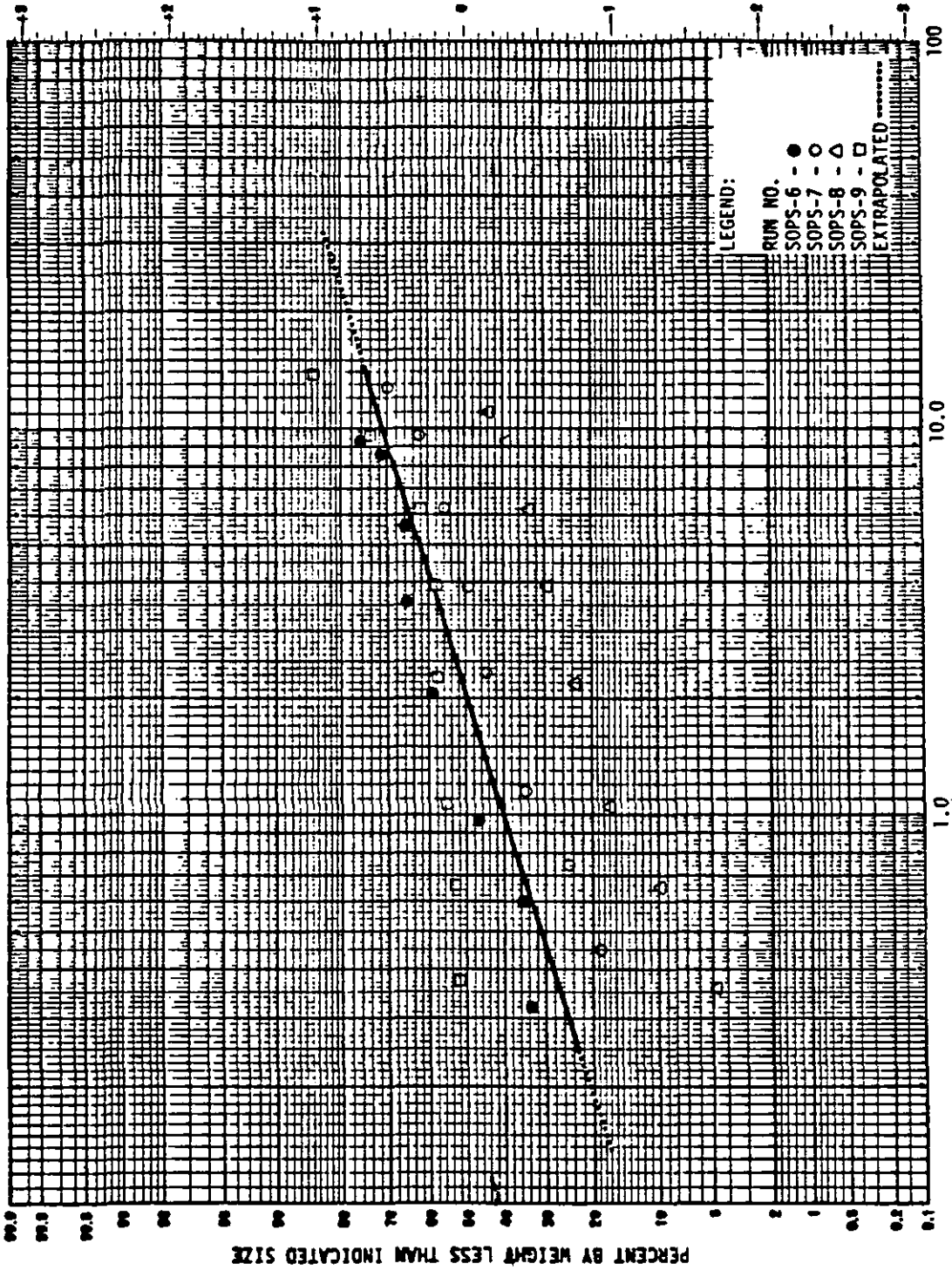


Figure 3.1-2. Particle size distribution for Runs SOPS-6 through SOPS-9 - kiln exhaust.

Samples SOPS-2 through SOPS-5 were collected during the first and second particulate test runs. Scrubber operation problems occured midway through the second particulate test, but did not seem to affect the particle size results as evidenced by the data point distribution for these runs. The data show that 50 percent of the particles by weight were less than 2.4 microns in diameter.

Samples SOPS-6 through SOPS-9 were collected during the third particulate test. The data point distribution for these runs indicate that 50 percent of the particles by weight were less than 2.1 microns in diameter.

3.1.3 Sulfur Dioxide

Table 3.1-3 presents a summary of results for $SO_2$ tests conducted simultaneously before and after the wet scrubber. Concentrations are reported in parts per million by volume (ppm), milligrams per dry standard cubic meter (mg/dscm), and pounds per dry standard cubic foot (lb/dscf). Mass emission rates are reported in kilograms per hour (kg/h) and pounds per hour (lb/h). The outlet mass emission rates were calculated from the measured concentrations and the average outlet flow rate measured during the particulate test runs [95,353 dscmh (3,367,337 dscfh)]. The inlet mass emission rates were calculated from the measured concentrations and the average outlet flow rate corrected for excess air for each individual test run. Analysis was conducted on site by EPA Method 6.*

* Federal Register, Vol. 42, No. 160, August 18, 1977.

TABLE 3.1-3. SUMMARY OF SULFUR DIOXIDE RESULTS - KILN EXHAUST SCRUBBER INLET AND OUTLET

| Test No. | Run No. | Date (1980) | Sample location | Concentration[a] | | | Mass emission rate,[b] | | Temperature | | Moisture, % | $CO_2$, % | $O_2$, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ppm | mg/dscm | lb/dscf x $10^{-5}$ | kg/h | lb/h | °C | °F | | | |
| 1 | SIS-2 | 10/23 | Scrubber inlet | 306 | 804 | 5.02 | 64.1 | 141.4 | 232 | 450 | 21 | 5.2 | 13.6 |
| | SIS-3 | | | 371 | 976 | 6.09 | 80.0 | 176.3 | 232 | 450 | 18 | 5.2 | 13.8 |
| | Average | | | 338 | 890 | 5.56 | 72.1 | 158.9 | 232 | 450 | 20 | 5.2 | 13.7 |
| 2 | SIS-4 | 10/23 | Scrubber inlet | 353 | 927 | 5.79 | 76.0 | 167.5 | 227 | 440 | 16 | 4.8 | 13.8 |
| | SIS-5 | | | 349 | 918 | 5.73 | 73.9 | 162.9 | 227 | 440 | 13 | 4.8 | 13.2 |
| | Average | | | 351 | 923 | 5.76 | 75.0 | 165.2 | 227 | 440 | 15 | 4.8 | 13.5 |
| 3 | SIS-6 | 10/23 | Scrubber inlet | 344 | 905 | 5.65 | 72.8 | 160.5 | 227 | 440 | 14 | 5.4 | 13.2 |
| | SIS-7 | | | 331 | 871 | 5.44 | 70.2 | 154.7 | 227 | 440 | 12 | 5.4 | 13.2 |
| | Average | | | 338 | 888 | 5.55 | 71.5 | 157.6 | 227 | 440 | 13 | 5.4 | 13.2 |
| 1 | SOS-1 | 10/23 | Scrubber outlet | 197 | 517 | 3.23 | 49.4 | 108.9 | 60 | 140 | 16 | 4.0 | 14.8 |
| | SOS-2 | | | 163 | 428 | 2.67 | 40.8 | 90.0 | 60 | 140 | 19 | 4.0 | 14.8 |
| | Average | | | 180 | 473 | 2.95 | 45.1 | 99.5 | 60 | 140 | 18 | 4.0 | 14.8 |
| 2 | SOS-3 | 10/23 | Scrubber outlet | 191 | 501 | 3.13 | 47.8 | 105.4 | 62 | 144 | 19 | 3.6 | 14.8 |
| | SOS-4 | | | 182 | 479 | 2.99 | 45.7 | 100.7 | 61 | 143 | 19 | 3.6 | 14.4 |
| | Average | | | 187 | 490 | 3.06 | 46.8 | 103.0 | 62 | 144 | 19 | 3.6 | 14.6 |
| 3 | SOS-5 | 10/23 | Scrubber outlet | 188 | 493 | 3.08 | 47.0 | 103.6 | 61 | 143 | 19 | 4.2 | 14.4 |
| | SOS-6 | | | 184 | 482 | 3.01 | 46.0 | 101.5 | 61 | 143 | 19 | 4.2 | 14.4 |
| | Average | | | 186 | 488 | 3.05 | 47.0 | 102.6 | 61 | 143 | 19 | 4.2 | 14.4 |

[a]Concentration in parts per million by volume, milligrams per dry standard cubic meter, and pounds per dry standard cubic foot.

[b]Emission rate in kilograms per hour and pounds per hour.

Sulfur dioxide concentration at the inlet to the wet scrubber averaged 900 mg/dscm (342 ppm; $5.62 \times 10^{-5}$ lb/dscf) with a corresponding average mass emission rate of 72.9 kg/h (160.6 lb/h). Flue gas temperature averaged 229°C (445°F) with oxygen and carbon dioxide contents averaging 13.5 and 5.1 percent. Moisture content averaged 15.7 percent and was determined gravimetrically by weighing each impinger in the sample trains to the nearest 0.1 gram before and after each test.

Sulfur dioxide concentration at the scrubber exit stack averaged 483 mg/dscm (184 ppm; $3.02 \times 10^{-5}$ lb/dscf) with a corresponding average mass emission rate of 46.1 kg/h (101.7 lb/h). Flue gas temperature averaged 61°C (143°F) with an average moisture content of 18.4 percent determined gravimetrically. Oxygen and carbon dioxide contents averaged 14.6 percent and 3.9 percent.

The isopropanol fraction of the sample train, normally discarded per EPA Method 6, was retained in order to investigate possible ammonium sulfite interference with the $SO_2$ analytical procedure. Selected samples from both the inlet and the outlet sample trains were analyzed by ion chromatography for sulfates ($SO_4^=$) and sulfites ($SO_3^=$). Concentrations of both species were found to be at or below the detectable limits of the analytical method. These data indicate that ammonium sulfite is not present in sufficient quantity to cause a bias in the measured $SO_2$ fraction.

### 3.1.4 Nitrogen Oxides

Table 3.1-4 summarizes nitrogen oxides emission data. Three tests, consisting of four grab samples each, were conducted on the kiln exhaust scrubber outlet. Concentrations are reported in milligrams per dry standard cubic meter (mg/dscm), parts per million by volume (ppm), and pounds per dry standard cubic foot (lb/dscf). Emission rates are reported in kilograms per hour (kg/h) and pounds per hour (lb/h), and were calculated from the average flue gas flow rate measured during the particulate test runs corrected to standard conditions.

Nitrogen oxide concentrations averaged 400 mg/dscm (209 ppm; $0.250 \times 10^{-4}$ lb/dscf) with a corresponding mass emission rate of 38.1 kg/h (84.0 lb/h).

### 3.1.5 Kiln Exhaust Visible Emissions

Visible emissions surveys were conducted at the kiln scrubber outlet during each particulate test. Condensed water vapor was present in the kiln outlet plume; therefore, visible emissions were observed beyond the point in the plume where the steam dissipated.

Visible emissions were read in 6-minute sets throughout each particulate test. Table 3.1-5 contains a summary of visible emissions for the kiln outlet. Opacities during Test 1 ranged from 5 to 40 percent, with an average of 19 percent for all sets. During Test 2, opacities ranged from 5 to 85 percent, with an average of 27 percent for all sets. Scrubber operation problems occurred several times during Test 2, during which there were

TABLE 3.1-4. SUMMARY OF NITROGEN OXIDE EMISSION DATA - KILN EXHAUST SCRUBBER OUTLET

| Run No. | Sample No. | Date (1980) | Concentration[a] | | | Mass emission rate[b] | |
|---|---|---|---|---|---|---|---|
| | | | ppm | mg/dscm | lb/dscf x $10^{-4}$ | kg/h | lb/h |
| 1 | SONO-1A | 10/23 | 199 | 381 | 0.238 | 36.3 | 80.1 |
| | SONO-1B | | 216 | 415 | 0.259 | 39.5 | 87.1 |
| | SONO-1C | | 217 | 415 | 0.259 | 39.6 | 87.3 |
| | SONO-1D | | 216 | 415 | 0.259 | 39.5 | 87.1 |
| | Average | | 212 | 406 | 0.254 | 38.7 | 85.4 |
| 2 | SONO-2A | 10/23 | 210 | 402 | 0.251 | 38.3 | 84.5 |
| | SONO-2B | | 210 | 402 | 0.251 | 38.3 | 84.3 |
| | SONO-2C | | 186 | 356 | 0.222 | 33.9 | 74.6 |
| | SONO-2D | | 188 | 359 | 0.224 | 34.2 | 75.5 |
| | Average | | 199 | 380 | 0.237 | 36.2 | 79.7 |
| 3 | SONO-3A | 10/23 | 222 | 426 | 0.266 | 40.6 | 89.4 |
| | SONO-3B | | 204 | 389 | 0.243 | 37.2 | 81.9 |
| | SONO-3C | | 219 | 420 | 0.262 | 39.9 | 88.1 |
| | SONO-3D | | 219 | 418 | 0.261 | 39.9 | 88.0 |
| | Average | | 216 | 413 | 0.258 | 39.4 | 86.9 |

[a]Concentration of $NO_x$ as nitrogen dioxide ($NO_2$) in parts per million by volume (ppm), milligrams per dry standard cubic meter (mg/dscm), and pounds per dry standard cubic foot (lb/dscf).

[b]Emission rate in kilograms per hour and pounds per hour.

TABLE 3.1-5. SUMMARY OF VISIBLE EMISSIONS DATA
- KILN EXHAUST

| Test 1 | | | | Test 2 | | | | Test 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Set No. | Time | Average % Opacity | Range | Set No. | Time | Average % Opacity | Range | Set No. | Time | Average % Opacity | Range |
| KSVE-1A | 0926-0932 | 12 | 5-25 | KSVE-2A | 1413-1419 | 19 | 10-30 | KSVE-3A | 1023-1029 | 27 | 10-35 |
| KSVE-1B | 0952-0958 | 16 | 10-25 | KSVE-2B | 1433-1439 | 55 | 5-85 | KSVE-3B | 1047-1053 | 23 | 15-30 |
| KSVE-1C | 1014-1020 | 22 | 10-30 | KSVE-2C | 1514-1520 | 25 | 20-30 | KSVE-3C | 1119-1125 | 21 | 15-25 |
| KSVE-1D | 1038-1044 | 16 | 10-20 | KSVE-2D | 1533-1537 | 31 | 20-40 | KSVE-3D | 1136-1142 | 30 | 20-35 |
| KSVE-1E | 1100-1106 | 21 | 15-30 | KSVE-2E | 1607-1613 | 21 | 15-30 | KSVE-3E | 1154-1200 | 23 | 15-30 |
| KSVE-1F | 1122-1128 | 27 | 15-40 | KSVE-2F | 1617-1623 | 22 | 15-25 | KSVE-3F | 1225-1231 | 25 | 20-30 |
| | | | | KSVE-2G | 1637-1643 | 19 | 15-25 | KSVE-3G | 1315-1321 | 32 | 25-40 |

excursions in opacity. Opacities observed during Test 3 ranged from 10 to 40 percent, with an average of 26 percent for all sets.

## 3.2 CLINKER COOLER EXHAUST

Particulate and particle size tests as well as visible emission observations were conducted on the exit stack of the dry multicyclone serving emissions from the reciprocating grate clinker cooler. Particulate sampling and analytical procedures followed EPA Method 5* except that an ether-chloroform extraction was performed on the impinger contents to determine condensible organic and inorganic content. Particle size sampling and analytical procedures followed those described in "Procedures Manual for Inhalable Particulate Sampler Operation," recently developed for EPA by Southern Research Institute.[1] Visible emission observations were made by EPA Method 9.† Concentration and mass emission rate data are expressed in units identical to those used in Section 3.1 of this report.

### 3.2.1 Flue Gas Conditions and Particulate Emissions

Summaries of the measured flue gas and particulate emission data from the clinker cooler exhaust are presented in Tables 3.2-1 and 3.2-2.

The filterable particulate data reported in Table 3.2-2 represent matter collected in the sample probe and on the filter,

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

† Federal Register, Vol. 39, No. 219, November 12, 1974.

TABLE 3.2-1. SUMMARY OF FLUE GAS CONDITIONS - CLINKER COOLER CYCLONE EXHAUST

| Run No. | Date (1980) | Flue gas flow | | | | Temperature | | Moisture, % | $O_2$,[c] % | $CO_2$,[c] % | CO,[c] % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Metric | | English | | | | | | | |
| | | acmh[a] | dscmh[b] | acfh[a] | dscfh[b] | °C | °F | | | | |
| CCP-1 | 10/21 | 38,079 | 30,545 | 1,344,737 | 1,078,683 | 85 | 186 | 2.2 | 17.6 | 2.3 | 0.0 |
| CCP-2 | 10/21 | 40,928 | 32,143 | 1,445,353 | 1,135,100 | 96 | 204 | 1.5 | 20.6 | 0.0 | 0.0 |
| CCP-3[d] | 10/22 | 39,426 | 31,983 | 1,392,315 | 1,129,466 | 85 | 185 | 1.2 | 19.9 | 0.9 | 0.0 |
| CCP-4[d] | 10/22 | 38,329 | 30,462 | 1,353,552 | 1,075,745 | 88 | 190 | 2.5 | 19.9 | 0.9 | 0.0 |
| Average | | 39,191 | 31,283 | 1,383,989 | 1,104,749 | 89 | 191 | 1.9 | 18.8 | 1.6 | 0.0 |

[a]Flue gas flow in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions.

[b]Flue gas flow in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh). Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg).

[c]Orsat analysis of integrated bag samples.

[d]Sampling conducted simultaneously.

TABLE 3.2-2. SUMMARY OF PARTICULATE EMISSION DATA - CLINKER COOLER CYCLONE EXHAUST

| Run No. | Date (1981) | Concentration[a] | | | | | | Mass emission rate[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Filterable | | Condensible | | | | Filterable | | Condensible | | | |
| | | | | Organic | | Inorganic | | | | Organic | | Inorganic | |
| | | mg/dscm | gr/dscf | mg/dscm | gr/dscf | mg/dscm | gr/dscf | kg/h | lb/h | kg/h | lb/h | kg/h | lb/h |
| CCP-1 | 10/21 | 246.5 | 0.1077 | 1.35 | 0.0006 | 0.98 | 0.00040 | 7.5 | 16.6 | 0.04 | 0.09 | 0.030 | 0.070 |
| CCP-2 | 10/21 | 180.4 | 0.0778 | 1.52 | 0.0007 | 0.11 | 0.00003 | 5.8 | 12.8 | 0.05 | 0.11 | 0.004 | 0.008 |
| CCP-3[c] | 10/22 | 107.6 | 0.0470 | 1.05 | 0.0005 | 0.94 | 0.00040 | 3.4 | 7.6 | 0.03 | 0.07 | 0.030 | 0.070 |
| CCP-4[c] | 10/22 | 167.9 | 0.0733 | 2.22 | 0.0010 | 3.85 | 0.00170 | 5.1 | 11.3 | 0.07 | 0.15 | 0.120 | 0.260 |
| Average | | 175.6 | 0.0764 | 1.54 | 0.0007 | 1.48 | 0.00060 | 5.5 | 12.1 | 0.05 | 0.11 | 0.050 | 0.100 |

[a]Concentration expressed as milligrams per dry standard cubic meter and grains per dry standard cubic foot. Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg).

[b]Mass emission data expressed as kilograms per hour and pounds per hour.

[c]Samples collected simultaneously.

both of which were heated to approximately 121°C (250°F). The condensible organic and inorganic fractions represent material that condensed out or was trapped in the impinger section of the sample train at a temperature of approximately 20°C (68°F).

The volumetric flow rate averaged 31,283 dscmh (1,104,749 dscfh) at an average temperature of 89°C (191°F). The moisture content averaged 1.9 percent; and oxygen, carbon dioxide, and carbon monoxide contents averaged 18.8, 1.6, and 0.0 percent, respectively.

Filterable particulate concentrations averaged 175.6 mg/dscm (0.076 gr/dscf) with a corresponding mass emission rate of 5.5 kg/h (12.1 lb/h). The condensible organic and inorganic concentrations averaged 1.5 mg/dscm (0.0007 gr/dscf) each with a corresponding mass emission rate of 0.05 kg/h (0.105 lb/h).

### 3.2.2 Particle Size Distribution

A total of nine samples were collected from the clinker cooler cyclone exhaust. The first test was a preliminary run and is not considered representative; therefore, it is not included in the overall data averages. The sampling and analytical procedures as well as the data reduction technique are the same as those described in Section 3.1.2 and Appendix A of this report.

Figures 3.2-1 and 3.2-2 present the distribution curves for each set of four samples collected. Individual data points for each test were plotted manually. The distribution curve was plotted manually and represents the best-fit average curve for the specified number of test runs. All particle size results are based on aerodynamic diameters and unit density (1 g/cc).

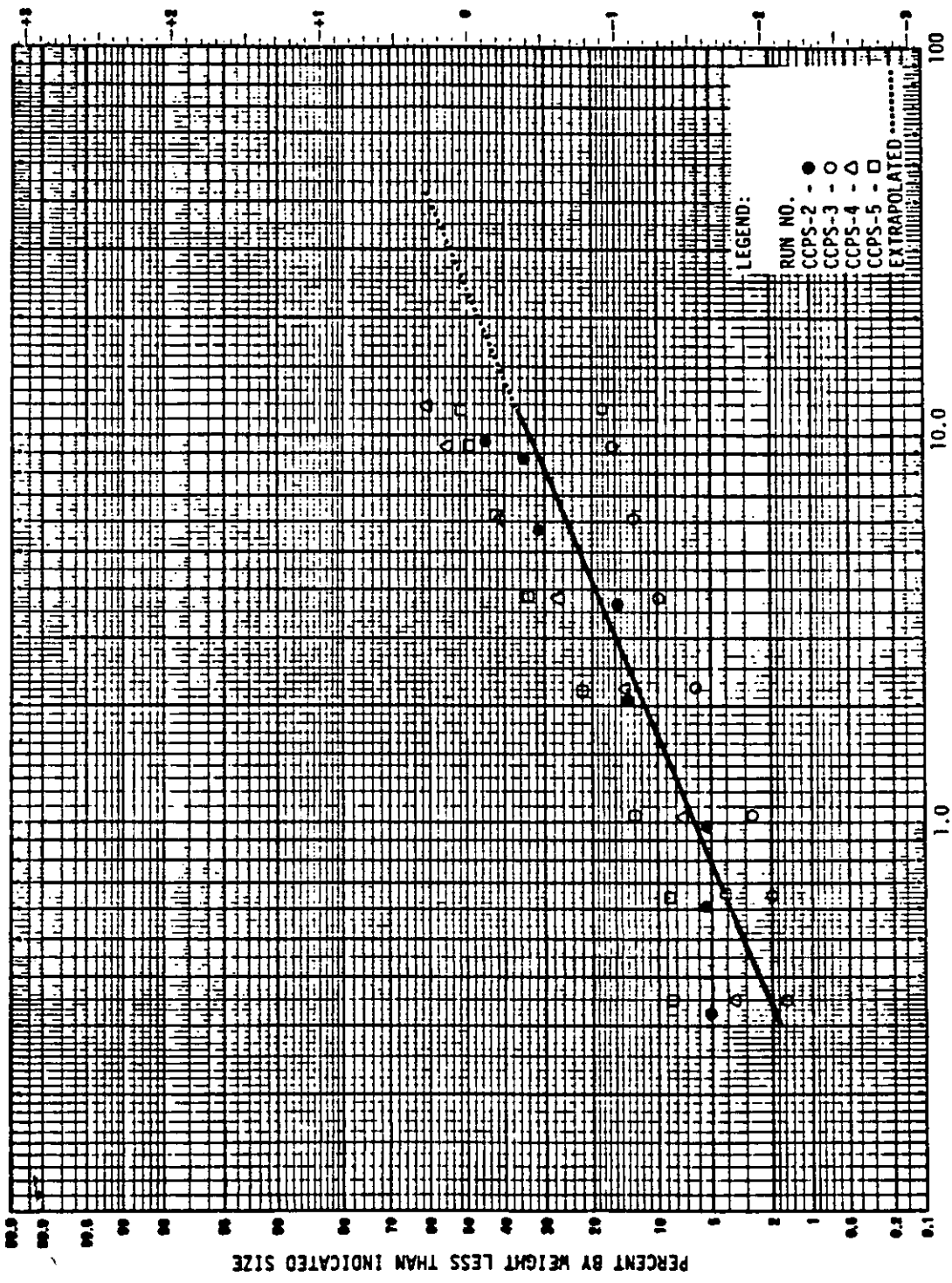



Figure 3.2-1. Particle size distribution for Runs CCPS-2 through CCPS-5 - clinker cooler exhaust.

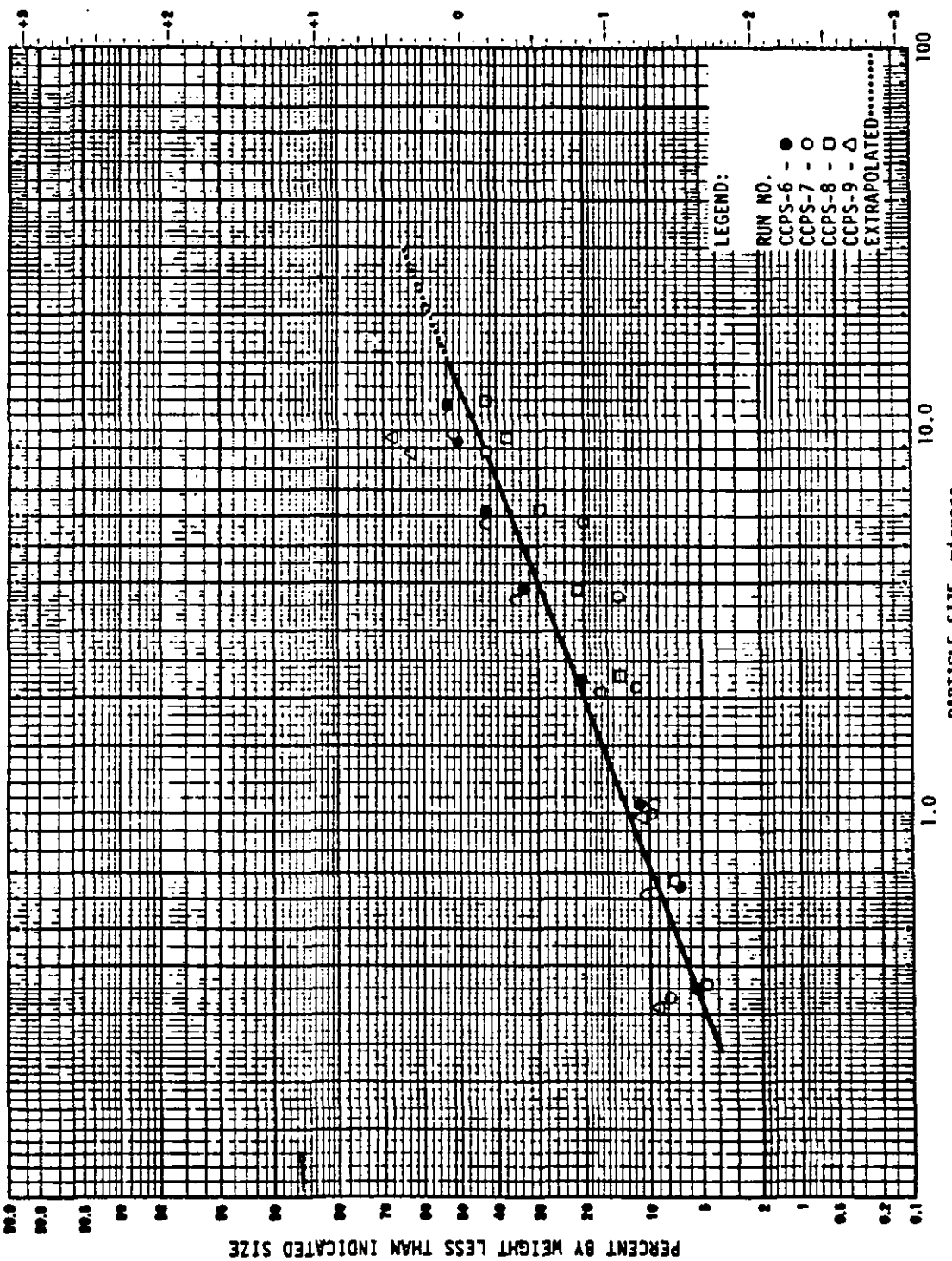



Figure 3.2-2. Particle size distribution for Runs CCPS-6 through CCPS-9 - clinker cooler exhaust.

Samples CCPS-2 through CCPS-5 were collected during the first and second particulate test runs. The data point distribution indicates that 50 percent of the particles by weight were less than 24 microns in diameter.

Samples CCPS-6 through CCPS-9 were collected during the third particulate test and show that 50 percent of the particles by weight were less than 13 microns in diameter.

### 3.2.3 Clinker Cooler Exhaust Visible Emissions

Visible emissions surveys were conducted at the clinker cooler outlet during each particulate test. Visible emissions were read in 6-minute sets throughout each particulate test. Table 3.2-3 contains a summary of visible emissions for the clinker cooler outlet. Opacities during Test 1 ranged from 5 to 30 percent, with an average of 16 percent for all sets. During Test 2, opacities ranged from 10 to 30 percent, with an average of 18 percent for all sets. Opacities observed during Test 3 ranged from 5 to 25 percent, with an average of 12 percent for all tests.

## 3.3 PROCESS SAMPLES

Table 3.3-1 summarizes results from the analysis of process samples collected during the particulate test runs. Clay and coal samples were collected at approximately 20-minute intervals during each particulate test. Clay samples were collected from the kiln feed conveyor and coal samples after the pulverizer but before the kiln. In addition, single samples of the final product and dust captured by the clinker cooler multicyclone were

TABLE 3.2-3. SUMMARY OF VISIBLE EMISSIONS DATA
- CLINKER COOLER EXHAUST

| Test 1 | | | | Test 2 | | | | Test 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Set No. | Time | Average % Opacity | Range | Set No. | Time | Average % Opacity | Range | Set No. | Time | Average % Opacity | Range |
| CCVE-1A | 0937-0943 | 8 | 5-15 | CCVE-2A | 1423-1429 | 22 | 20-30 | CCVE-3A | 1036-1042 | 8 | 5-15 |
| CCVE-1B | 1001-1007 | 12 | 5-30 | CCVE-2B | 1443-1449 | 19 | 15-25 | CCVE-3B | 1056-1102 | 8 | 5-15 |
| CCVE-1C | 1022-1028 | 17 | 10-25 | CCVE-2C | 1459-1505 | 17 | 10-20 | CCVE-3C | 1127-1133 | 9 | 5-15 |
| CCVE-1D | 1046-1052 | 16 | 10-25 | CCVE-2D | 1523-1529 | 22 | 15-30 | CCVE-3D | 1144-1150 | 17 | 10-25 |
| CCVE-1E | 1108-1114 | 20 | 15-25 | CCVE-2E | 1545-1551 | 16 | 15-20 | CCVE-3E | 1202-1208 | 14 | 10-20 |
| CCVE-1F | 1131-1137 | 22 | 15-25 | CCVE-2F | 1557-1603 | 15 | 10-20 | CCVE-3F | 1233-1239 | 13 | 10-15 |
| | | | | CCVE-2G | 1629-1635 | 16 | 10-20 | CCVE-3G | 1256-1302 | 12 | 10-15 |

TABLE 3.3-1. SUMMARY OF PROCESS SAMPLE ANALYSIS

| Particulate Run No. | Date (1980) | Sample type | Density, g/ml | Moisture, % | Ash, % dry basis | Sulfur, % dry basis |
|---|---|---|---|---|---|---|
| 1 | 10/21 | Coal | 1.14 | 3.51 | 9.04 | 1.92[a] |
| | | Clay | 2.49 | 21.65 | - | 2.19[b] |
| 2 | 10/21 | Coal | 1.00 | 3.24 | 9.21 | 1.64[a] |
| | | Clay | 2.57 | 19.34 | - | 2.12[b] |
| 3 Duplicate trains | 10/22 | Coal | 1.09 | 2.94 | 8.27 | 1.48[a] |
| | | Clay | 2.34 | 24.00 | - | 2.13[b] |
| 2 | 10/21 | Final product | - | - | - | 1.63[b] |
| | | Clinker cooler hopper catch | - | - | - | 1.57[b] |

[a] ASTM D3177.

[b] ASTM D2234.

collected during the second particulate test in order to determine the sulfur content.

The clay analytical data was characterized by an average sulfur content of 2.15 percent and an average moisture content of 21.7 percent. The coal analytical data were characterized by an average sulfur content of 1.68 percent and an average ash content of 8.84 percent. The sulfur contents of the final product and the multicyclone hopper catch were 1.63 percent and 1.57 percent; these results indicate that a substantial part of the sulfur in the raw clay remains as such.

Table 3.3-2 summarizes results from the trace metal analysis performed on scrubber influent and effluent water samples, which were collected during the particulate test runs. All results are reported in parts per million (ppm) by volume. Table 3.3-3 summarizes results of the trace metal analysis performed on the solid fraction, which was filtered from the water samples. Results are reported in parts per million by volume and, in some cases, percent by weight.

## 3.4 FUGITIVE EMISSIONS FROM THE KILN

Fugitive emissions surveys were conducted to determine the magnitude of any leaks around the kiln seals. These surveys were conducted during each particulate test using the procedure of Draft EPA Method 22.*

Three fugitive surveys were conducted for 15 minutes, at each end of the kiln during each particulate test. During each of the three particulate tests, no fugitive emissions were observed from either end of the rotary kiln.

*Federal Register, Vol. 45, No. 224, November 18, 1980.

TABLE 3.3-2. SUMMARY OF TRACE METAL ANALYSIS - SCRUBBER WATER SAMPLES

| Element | Test No. 1 effluent-ppm | Test No. 2 effluent-ppm | Test No. 3 effluent-ppm | Composite influent-ppm |
|---|---|---|---|---|
| Al | 240 | 250 | 370 | 0.37 |
| Sb | <0.032 | <0.032 | <0.032 | <0.032 |
| As | <0.057 | <0.057 | <0.057 | <0.057 |
| Ba | 0.096 | 0.10 | 0.15 | 0.69 |
| Be | <0.0005 | <0.0005 | <0.0005 | <0.0005 |
| Bi | <0.05 | <0.05 | <0.05 | <0.05 |
| B | 16 | 17 | 23 | 0.21 |
| Cd | 0.080 | 0.080 | 0.080 | <0.008 |
| Ca | 610 | 630 | 570 | 71 |
| Cr | 0.16 | 0.16 | 0.14 | <0.001 |
| Co | 0.43 | 0.49 | 0.62 | <0.006 |
| Cu | 0.096 | 0.093 | 0.049 | <0.001 |
| Au | <0.03 | <0.03 | <0.03 | <0.03 |
| In | <0.05 | <0.05 | <0.05 | <0.05 |
| Fe | 0.71 | 0.50 | 0.70 | <0.008 |
| Pb | <0.084 | <0.084 | <0.084 | <0.084 |
| Li | 0.54 | 0.57 | 0.86 | 0.003 |
| Mg | 190 | 210 | 260 | 26 |
| Mn | 57 | 66 | 80 | 0.012 |
| Ag | <0.03 | <0.03 | <0.03 | <0.03 |
| Mo | 0.11 | 0.11 | 0.11 | 0.015 |
| Ni | 0.94 | 1.1 | 1.4 | 0.022 |
| P | 0.50 | 0.94 | 0.96 | 0.27 |
| Pz | <0.03 | <0.03 | <0.03 | <0.03 |
| K | 69 | 76 | 100 | 6.2 |
| Sc | <0.08 | <0.08 | <0.08 | <0.08 |
| Si | 170 | 160 | 180 | 13 |
| Ag | <0.001 | <0.001 | <0.001 | <0.001 |
| Na | 51 | 56 | 77 | 13 |
| Su | 3.2 | 3.1 | 3.8 | 0.52 |
| Te | <0.1 | <0.1 | <0.1 | <0.1 |
| Tl | <0.1 | <0.1 | <0.1 | <0.1 |
| Sn | <0.12 | <0.12 | <0.12 | <0.12 |
| Ti | 0.18 | 0.18 | 0.096 | <0.005 |
| U | <0.06 | <0.06 | <0.06 | <0.06 |
| V | 0.13 | 0.14 | 0.056 | <0.003 |
| W | <0.03 | <0.03 | <0.03 | <0.03 |
| Y | 0.52 | 0.54 | 0.64 | <0.002 |
| Zn | 1.1 | 1.1 | 1.3 | 0.007 |

TABLE 3.3-3. SUMMARY OF TRACE METAL ANALYSIS - SOLID SAMPLES (ppm except as indicated)

| Elements | Test No. 1 | Test No. 2 | Test No. 3 |
|---|---|---|---|
| Al | 4.9% | 4.9% | 4.7% |
| Sb | <8 | <8 | <8 |
| As | <14 | <14 | <14 |
| Ba | 660 | 660 | 660 |
| Be | <0.12 | <0.12 | <0.12 |
| Bi | <13 | <13 | <13 |
| B | 3.2% | 3.2% | 3.2% |
| Cd | 1.7 | 1.5 | 1.5 |
| Ca | 1.2% | 1.2% | 1.4% |
| Cr | 69 | 66 | 54 |
| Co | 50 | 42 | 37 |
| Au | <8 | <8 | <8 |
| In | <13 | <13 | <13 |
| Fe | 5.5% | 5.1% | 5.3% |
| Pb | 65 | 60 | 63 |
| Li | 68 | 72 | 65 |
| Mg | 5900 | 5800 | 4900 |
| Mn | 350 | 290 | 360 |
| Hg | <8 | <8 | <8 |
| Mo | 21 | 27 | 26 |
| Ni | 420 | 401 | 360 |
| P | 480 | 420 | 460 |
| Pt | <8 | <8 | <8 |
| K | 1.5% | 1.5% | 1.3% |
| Se | <20 | <20 | <20 |
| Ag | <0.5 | <0.5 | <0.5 |
| Na | 4.2% | 4.4% | 4.3% |
| Sr | 80 | 83 | 80 |
| Te | <25 | <25 | <25 |
| Tl | <25 | <25 | <25 |
| Sn | <50 | <50 | <50 |
| Ti | 3900 | 3900 | 3300 |
| U | <15 | <15 | <15 |
| V | 160 | 140 | 137 |
| W | <8 | <8 | <8 |
| Y | 3.3 | 1.8 | 2.3 |
| Zn | 180 | 150 | 130 |

# SECTION 4

# SAMPLE LOCATIONS AND TEST METHODS USED

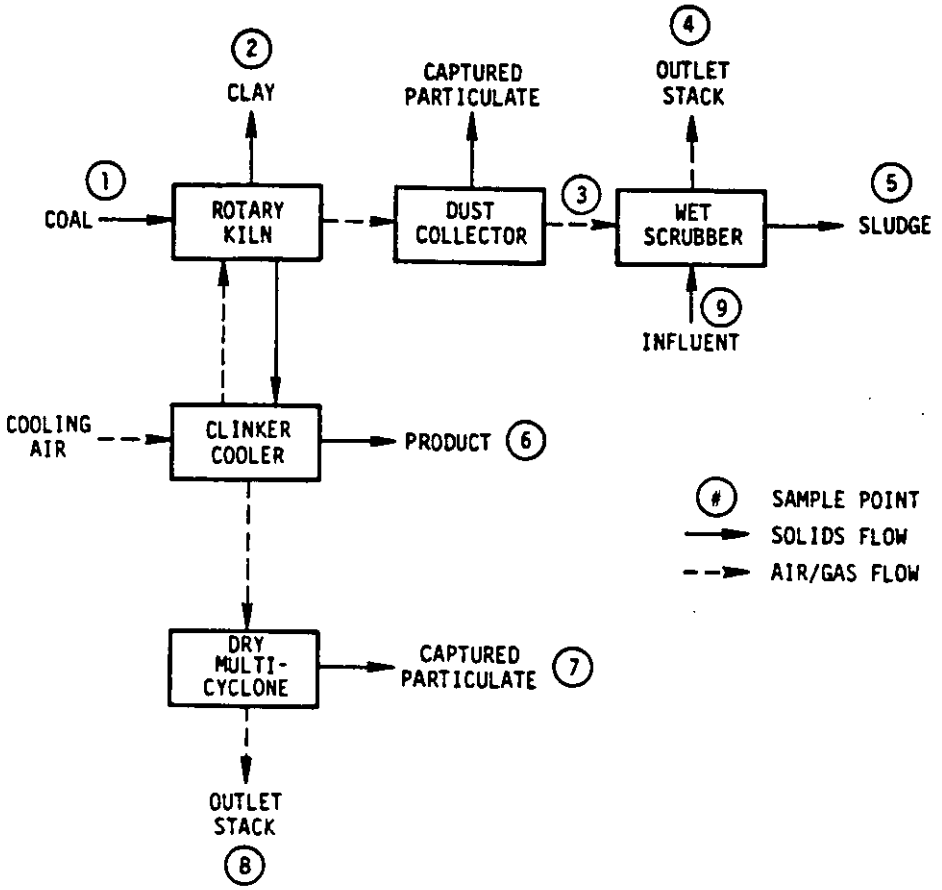
Figure 4-1 is a simplified process flow sheet depicting the sample locations and type of testing conducted at each site. The following is a description of the sample locations used to conduct sampling for particulate, sulfur dioxide and nitrogen oxide emissions, and particle size distribution.

## 4.1 CLINKER COOLER MULTICYCLONE OUTLET

Particulate concentration and particle size distribution were measured at the multicyclone outlet as shown in Figure 4.1-1. Two sample ports, 90 degrees off center, were located 7.1 duct diameters downstream and 1.8 duct diameters upstream from the nearest flow disturbances in the round stack, the inside diameter (I.D.) of which was 1.22 meters (4 ft). Twenty-four traverse points, twelve per port, were used to traverse the cross-sectional area of the stack for the particulate test runs. Each point was sampled for 5 minutes, and total test time was 120 minutes.

## 4.2 KILN EXHAUST SCRUBBER OUTLET

Particulate, sulfur dioxide, and nitrogen oxide concentrations as well as particle size distribution were measured at the kiln exhaust outlet as shown in Figure 4.2-1. Two sample ports,

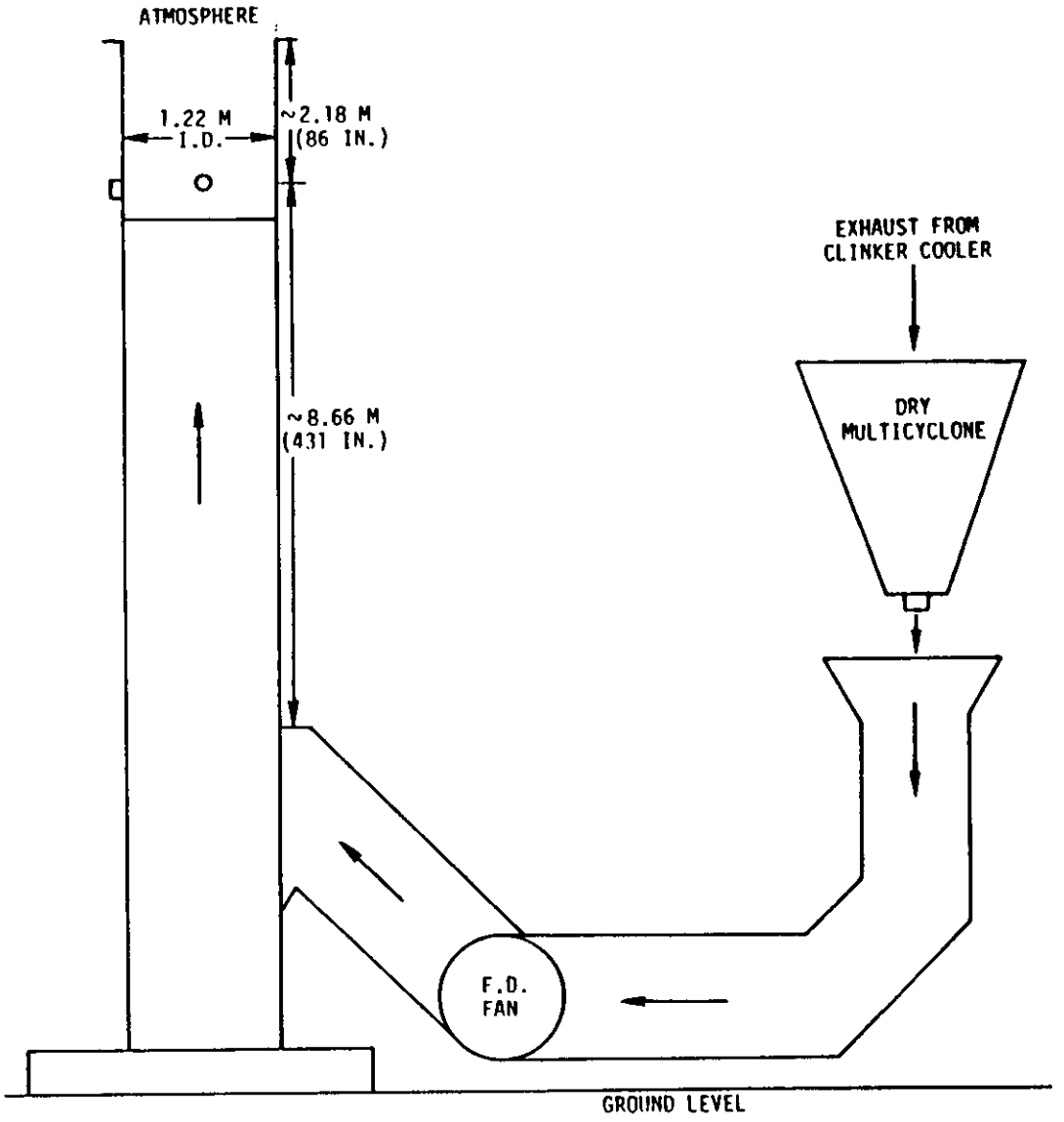



| SAMPLE TYPE | SAMPLE POINTS | NO. OF SAMPLES | TEST METHOD |
|---|---|---|---|
| PARTICULATE | 4,8 | 4 | EPA 5 |
| $SO_2$ | 3,4 | 3 | EPA 6 |
| PARTICLE SIZE | 4,8 | 18 | IMPACTOR |
| OPACITY | 4,8 | 3 | EPA 9 |
| FUGITIVE DUST | KILN SEALS | 3 | EPA 22 |
| $NO_x$ | 4 | 12 | EPA 7 |
| RAW MATERIAL | 1,2 | 24 | -[a] |
| TRACE METALS | 5,9 | 3 | I-CAP[b] |

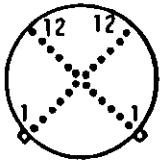
[a] Coal samples: sulfur content; density, percent moisture; and percent ash.
Clay samples: sulfur content; density and percent moisture.
Sulfur analysis by Method: ASTM D3177 and ASTM D2234.

[b] I-CAP - Induction Capture Plasma and Atomic Absorption Spectrophotometry.

Figure 4-1. Process flow sheet and sampling plan for Arkansas Lightweight Aggregate Corporation.




CROSS-SECTION




1.22 M (48") I.D.
6.99 CM (2 3/4")
NIPPLE LENGTH

| TRAVERSE POINT NUMBER | TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES) |
|---|---|
| 1 | 3.75 |
| 2 | 5.97 |
| 3 | 8.41 |
| 4 | 11.25 |
| 5 | 14.75 |
| 6 | 19.84 |
| 7 | 33.66 |
| 8 | 38.75 |
| 9 | 42.25 |
| 10 | 45.09 |
| 11 | 47.53 |
| 12 | 49.74 |

Figure 4.1-1. Clinker cooler multicyclone outlet.

| TRAVERSE POINT NUMBER | TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (INCHES) |
|---|---|
| 1 | 5.0 |
| 2 | 5.90 |
| 3 | 7.20 |
| 4 | 8.7 |
| 5 | 10.2 |
| 6 | 11.8 |
| 7 | 13.5 |
| 8 | 15.4 |
| 9 | 17.6 |
| 10 | 20.0 |
| 11 | 23.0 |
| 12 | 27.5 |
| 13 | 39.5 |
| 14 | 43.9 |
| 15 | 46.9 |
| 16 | 49.4 |
| 17 | 51.5 |
| 18 | 53.5 |
| 19 | 55.2 |
| 20 | 56.8 |
| 21 | 58.3 |
| 22 | 59.7 |
| 23 | 61.1 |
| 24 | 63.0 |

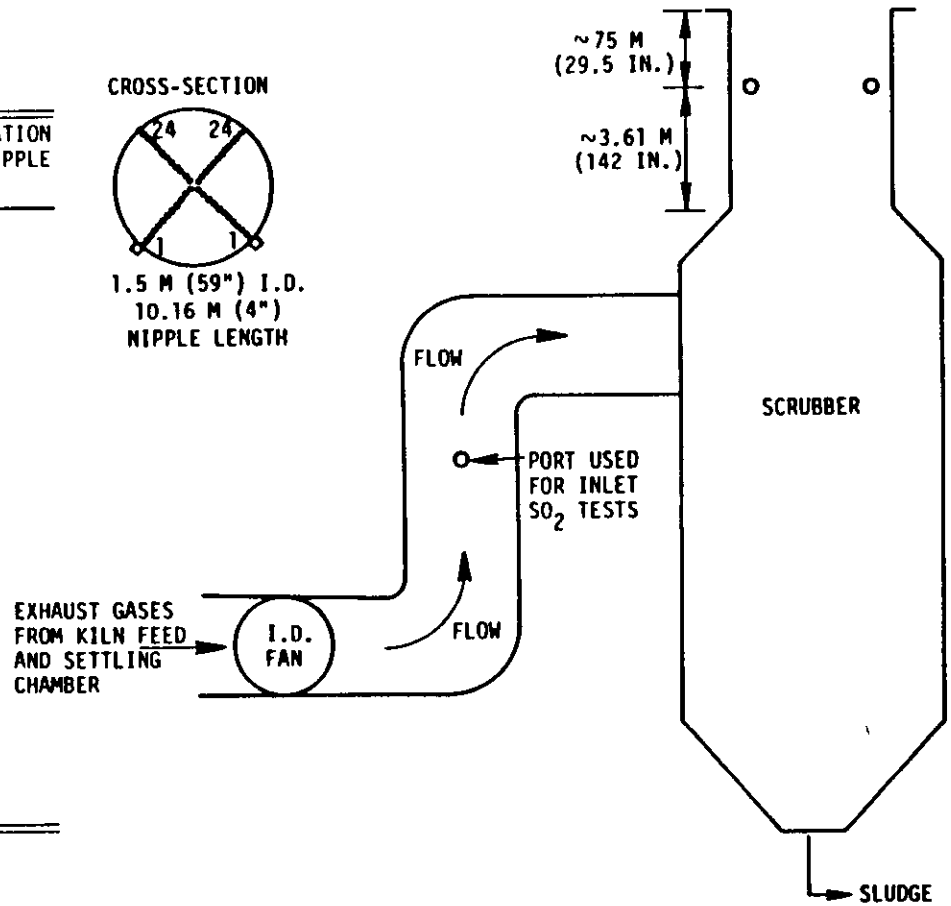



Figure 4.2-1. Kiln exhaust scrubber outlet.

90 degrees off center, were located 2.4 duct diameters downstream and 0.5 duct diameters upstream from the nearest flow disturbances in the round stack, the I.D. of which was 1.5 meters (4.9 ft). Forty-eight traverse points, twenty-four per port, were used to traverse the cross-sectional area of the stack for the particulate test runs. Each point was sampled for 2.5 minutes, and total test time was 120 minutes.

Sulfur dioxide and nitrogen oxide sampling were conducted at constant sampling rates by placing the probe tip near the center of the stack. The test and analytical procedures used are described briefly below.

## 4.3 VELOCITY AND GAS TEMPERATURE

A Type S pitot tube and an inclined draft gauge manometer were used to measure the gas velocity. Velocities were measured at each sampling point across the duct to determine an average value according to the procedures outlined by EPA Method 2.* The temperature at each sampling point was measured with a thermocouple and potentiometer.

## 4.4 MOLECULAR WEIGHT

Flue gas composition was determined by EPA Method 3.* A bag sample was collected during each particulate, sulfur dioxide, and nitrogen oxide test run. The bag contents were analyzed with an Orsat Gas Analyzer.

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

## 4.5 PARTICULATE

The test procedure used to measure particulate grain loading at each final exit stack was EPA Method 5.* All tests were conducted isokinetically by traversing the cross-sectional area of the stack and regulating the sample flow rate relative to the flue gas flow rate as measured by the pitot tube attached to the sample probe. The sampling train used for each test consisted of a heated, glass-lined probe; a heated glass fiber filter (Gelman Type AE) with a diameter of 87 mm (3 in.); and a series of Greenburg-Smith impingers. An acetone rinse of the nozzle, probe, and filter holder portions of the sample train was made at the end of each test. The acetone rinse and the particulate caught on the filter media were dried at room temperature, desiccated to a constant weight, and weighed on an analytical balance. Total filterable particulate matter was determined by adding these two values. The contents of the impinger section of the sampling train were recovered and analyzed for organic and inorganic content by ether-chloroform extraction.

## 4.6 SULFUR DIOXIDE

The test procedure used was EPA Method 6* except for the replacement of the midget impingers with a series of Greenburg-Smith impingers. A heated, glass-lined probe preceded the series of impingers. A plug of glass wool was placed in the tip of the probe as well as in the connecting glassware between the first

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

and second impingers. Each inlet and outlet test consisted of two 30-minute runs. Each sampling train was purged with ambient air for 15 minutes after the completion of each test. Contents of the second and third impingers (3% hydrogen peroxide) were measured, and analyses for sulfur dioxide content were conducted on site with the barium-thorin titration method. Contents of the first impinger (80% isopropanol) were recovered and shipped to the laboratory for the purpose of investigating possible ammonia interference.

## 4.7 NITROGEN OXIDE

Sampling and analytical procedures used followed EPA Method 7.* Three tests consisting of four grab samples taken at approximately 15-minute intervals were conducted on the scrubber exit stack. Samples were obtained and shipped to the laboratory for analysis.

## 4.8 PARTICLE SIZE DISTRIBUTION

Particle size samples were obtained with an Andersen 2000 Mark III Source Cascade Impactor. This is an in-stack, multi-stage cascade impactor that has a total of eight stages with particle size cutoffs ranging nominally from 0.5 to 15 microns, followed by a backup filter stage. Substrates for the Andersen were glass fiber filters, each 64 mm (2.5 in.) in diameter. A constant sampling rate was maintained through the test period. Sampling rates were set for isokinetic sampling as long as the

* Federal Register, Vol. 42, No. 160, August 18, 1977.

sample rate did not exceed the recommended flow rate for the impactor (0.70 acfm).

A total of nine impactor runs were conducted at each outlet sampling site. Sampling point locations for each stack were located as shown in Figure 4.8-1. At least two impactor runs were conducted at each sampling point. The procedures used followed those recommended in "Procedures Manual for Inhalable Particulate Sampler Operation," recently developed for EPA by the Southern Research Institute.[1]

## 4.9 PROCESS SAMPLES

Samples of the coal and clay fed to the kiln were collected at approximately 20-minute intervals during the particulate sampling. Coal samples were collected after the pulverizer just prior to entering the kiln. Clay samples were collected from the kiln feed conveyor belt. Coal samples were analyzed for sulfur content, density, moisture content, and percent ash. Clay samples were analyzed for sulfur content, density, and percent moisture.

In addition to the coal and clay, composite samples of the influent and effluent from the kiln wet scrubber were collected and analyzed for trace metal content. Samples of the final aggregate product and dust captured by the clinker cooler multicyclone were also collected and analyzed for sulfur content.

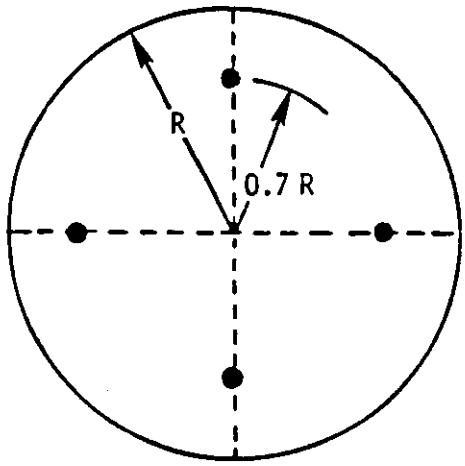


Figure 4.8-1. Particle size sampling points for circular stack.

# SECTION 5

# QUALITY ASSURANCE

Routine quality control procedures for standard reference methods were followed throughout this test series. These included but were not limited to the following:

- Calibration of gas meters, thermocouples and potentiometers, pressure gauges, thermometers, and pitot tubes.
- Use of designated equipment.
- Sample train leak checks.
- Train configuration and calculation checks.

Detailed calibration procedures and results for equipment used during this test series are contained in Appendix E of this report.

In addition, the following quality assurance procedures were implemented to insure valid, reproducible data.

## 5.1 PARTICULATE

During the third particulate test, duplicate EPA Method 5 trains were run simultaneously on each stack. The results of these tests are presented in Table 5.1-1. Results from the tests conducted on the kiln exhaust show good correlation and reproducibility, considering the entire sampling system.

The reliability of the analytical method used to analyze the filters for particulate and particle size tests was checked by

TABLE 5.1-1. COMPARATIVE PARTICULATE RESULTS

| Run No. | Date (1981) | Sample location | Filterable concentration | | Condensible concentration | | | | Total concentration[a] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Inorganic | | Organic | | | |
| | | | mg/dscm | gr/dscf | mg/dscm | gr/dscf | mg/dscm | gr/dscf | mg/dscm | gr/dscf |
| CCP-3 | 10/22 | Clinker cooler exhaust | 107.6 | 0.047 | 0.94 | 0.0004 | 1.1 | 0.0005 | 109.6 | 0.0479 |
| CCP-4 | | | 167.8 | 0.073 | 3.90 | 0.0017 | 2.2 | 0.0010 | 173.9 | 0.0757 |
| SOP-3 | 10/22 | Kiln exhaust | 775.5 | 0.3388 | 322.6 | 0.141 | 4.6 | 0.0024 | 1103.6 | 0.4822 |
| SOP-4 | | | 882.3 | 0.3855 | 237.7 | 0.104 | 3.3 | 0.0014 | 1123.0 | 0.4909 |

[a] Total concentration is the sum of the filterable and condensible concentration.

resubmitting sets of filters, preweighed in the lab, for replicate analysis. Table 5.1-2 summarizes the results of a blank filter analysis. The results of the blank filter analysis show good data reproducibility from an analytical standpoint.

## 5.2 SULFUR DIOXIDE

Audit solutions prepared by EPA were used to check the analytical procedure and reagents prior to onsite sample analysis. The results of the analytical audit conducted onsite are presented below:

| Audit sample lot No. | Audit solution concentration, ppm | Measured concentration, ppm | Percent difference |
|---|---|---|---|
| 0680-1 | 85.9 | 86 | +0.1 |
| 0680-3 | 429.5 | 426 | -0.8 |

In addition, calculations relating the theoretical quantity of $SO_2$ generated from the combustion of pulverized coal to the quantity of $SO_2$ measured at the scrubber inlet show good correlation.

## 5.3 NITROGEN OXIDE

Audit solutions prepared by EPA were used to check the analytical procedure and reagents prior to laboratory analysis. The results of the analytical audit are presented in Table 5.3-1.

TABLE 5.1-2. EXAMPLE BLANK FILTER ANALYSIS

| Sample type and filter number | Original tare weight, mg | Blank weight, mg | Net weight, mg |
|---|---|---|---|
| Particulate - 87-mm Gelman AE | | | |
| # 0002003 | 357.6 | 358.2 | +0.6 |
| # 0002011 | 359.7 | 359.9 | +0.2 |
| Particle size - 64-mm Reeve Angel 934 AH | | | |
| K-83 | 143.1 | 144.1 | +1.0 |
| N-06 | 140.6 | 140.9 | +0.3 |
| K-85 | 132.3 | 132.3 | 0.0 |
| N-92 | 134.7 | 134.6 | -0.1 |
| K-07 | 144.6 | 145.1 | +0.5 |
| N-98 | 137.4 | 138.0 | +0.6 |
| K-67 | 132.0 | 132.8 | +0.8 |
| N-44 | 134.6 | 135.0 | +0.4 |
| B-25 | 180.6 | 181.1 | +0.5 |

TABLE 5.3-1. $NO_x$ ANALYTICAL AUDIT RESULTS

| Sample No. | Audit concentration, mg $NO_2$/dscm | Measured concentration, mg $NO_2$/dscm | Difference, % |
|---|---|---|---|
| 1293 | 99.54 | 101.2 | +1.7 |
| 3251 | 796.31 | 772.8 | -3.0 |
| 4535 | 248.79 | 245.4 | -1.4 |

# SECTION 6

# DISCUSSION OF RESULTS

Overall, the sampling program was executed as planned and no major problems occurred with either test equipment or sampling activities. In addition, the process operation was characterized as normal throughout the test period by plant personnel and the NSPS contractor.

The feedwater pump serving the kiln exhaust scrubber malfunctioned during the second particulate test and periodically throughout the third test. This malfunctioning probably decreased the overall particulate removal efficiency of the scrubber and thus significantly increased particulate concentrations and emission rates. Both the particulate and the visible emission results from the source support this conclusion.

Because no obvious malfunctions or process modifications occurred with the clinker cooler and/or its control device, the particulate and particle size data appear representative of emissions from the source. It should be noted that the organic concentration measured in the back half of the EPA Method 5 sample trains from both sources was negligible.

The $SO_2$ results obtained from tests conducted at the inlet to the kiln exhaust scrubber are compatible with theoretical calculations of the quantity of $SO_2$ generated from the combustion of coal. Analyses of the final product and the catch from the

clinker cooler multicyclone hopper indicate that a large percentage of sulfur in the clay feed material remains in the clay as it is processed. Therefore, it is reasonable to conclude that $SO_2$ emissions from this source are caused primarily by the combustion of pulverized coal in the kiln.

Initially, $NO_x$ concentrations were expected to be negligible. The test data, however, show that $NO_x$ emissions are potentially significant and are generated from the combustion of coal in the kiln.

## REFERENCES


1. Southern Research Institute. Procedures Manual for Inhalable Particulate Sampler Operation. Prepared for EPA under Contract No. 68-02-3118. November 1979.

2. Southern Research Institute. A Computer-Based Cascade Impactor Data Reduction System. Prepared for EPA under Contract No. 68-02-2131. March 1978.

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Ref. 4 (AP-42)
4-2

# Emission Test Report
# Review Checklist

Reviewer: Brian Shroger
Review Date: April 24, 1992

## A. Background Information

1. Facility name: Arkansas Lightweight Aggregate Corporation
   Location: W. Memphis, Arkansas
2. Source category: Lightweight Aggregate Production
3. Test date: Week of October 20, 1980
4. Test sponsor: EPA/EMB
5. Testing contractor: PEDCo Environmental, Inc.
6. Purpose of test: To provide data to assess the need for NSPS emission limits for selected processes in the LWA industry and, if warranted, to develop such limits.
7. Pollutants measured

   (PM) (PM-10) (CO) ($SO_2$) ($NO_x$) VOC Pb ($CO_2$)

   Others (list): PS

8. Process overview: On an attached page provide a block diagram of the unit operations and associated air pollution control systems at the facility. Identify process tested with letters from the beginning of the alphabet (A, B, C, etc.) and APC systems with letters from end of alphabet (V, W, X, etc.). Also identify test locations with Arabic numerals (1,2,3, ...). Using the ID symbols from that sketch complete the table below that identifies processes or unit operations tested.

| Test ID | Process | Process ID | Emissions tested | | APCD (controlled emissions only) |
|---|---|---|---|---|---|
| | | | Uncontrolled | Controlled | |
| 1 | Heating | A | | ✓ | Medium Energy Scrubber |
| 2 | Heating | A | ✓ | | |
| 3 | Heating | A | | ✓ | Scrubber |
| 4 | Cooling | B | | ✓ | Dry Multicyclone |
| | (Kiln fired w/coal) | | | | |
| | | | | | |

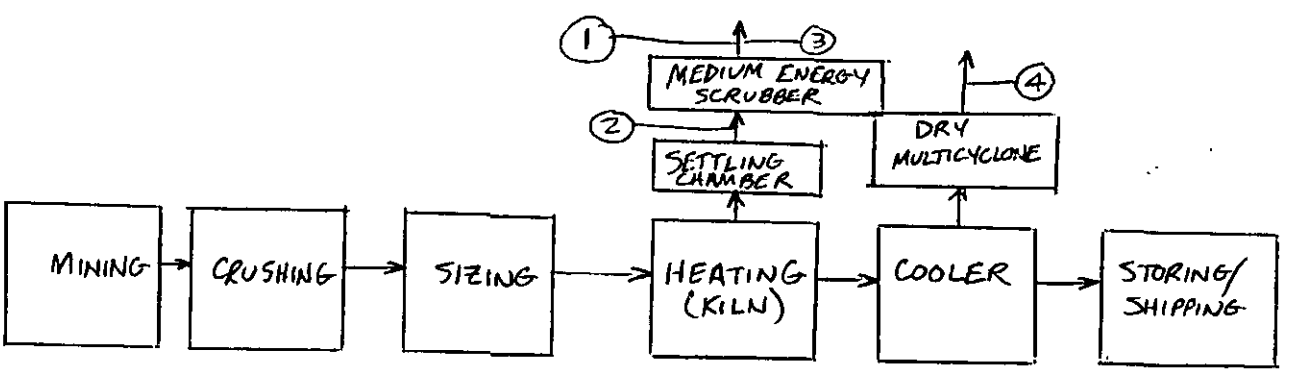
B. Process Information

1. Provide a brief narrative description of the process. With as much detail as possible, (e.g., if a furnace or conveyor system is used, identify the type of unit) describe the equipment used for those operations tested. (Note: If process description provided in test report is adequate, attach copy or reproduce here.)

Arkansas Lightweight Aggregate Corporation employs a pulverized coal-fired rotary kiln for the production of lightweight aggregate from surface-mined clay. The kiln operation is continuous, 24 hours per day, 7 days per week except for required maintenance. Kiln capacity is approximately 680 megagrams (Mg) per 24-hour day (750 tons per day). The kiln is fired with pulverized coal, and small amounts of natural gas are used for temperature control. Exhaust gases from the feed end of the kiln are treated by a settling chamber followed by a medium-energy scrubber (Fuller/Dracco type CAA, Size 92).

The other major process equipment on this production line is a reciprocating grate clinker cooler. Particulate emissions from the clinker cooler are controlled by a dry multiclone.

Tables 2-1 and 2-2 summarize the production and process data monitored during the test period.



2. For each process tested list feedstock materials and products. Indicate if activity factors are for feed (F) rate or product (P) rate.

| Process ID | Feedstock materials | Products | Basis for activity factor | F/P |
|---|---|---|---|---|
| A | Clay | LWA | LWA | P |
| A | Clay | LWA | LWA | P |
| A | Clay | LWA | LWA | P |
| B | Heated, expanded clay (LWA) | LWA | LWA | P |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Basis for data: Pg. 2-1
(Indicate page/table Nos. in test report)

3. For each process or operation tested and each test run note process capacity and operating rate during test.

| Process ID | Capacity | Units | Test run | Process rate | Units |
|---|---|---|---|---|---|
| A | 750 | tons/day prod. | 1 | 20.13 | tons/hr |
| | (31.25 tons/hr) | | 2 | 20.13 | tons/hr |
| | | | 3 | 20 | tons/hr |
| | | | 4 | 20 | tons/hr |
| A | 750 | tons/day prod. | 1 | 19.88 | tons/hr |
| | | | 2 | 19.88 | tons/hr |
| | | | 3 | 19.88 | tons/hr |
| | | | 4 | | |
| A | 750 | tons/day prod | 1 | 19.88 | tons/hr |
| | | | 2 | 19.88 | tons/hr |
| | | | 3 | 19.88 | tons/hr |
| | | | 4 | " | |
| B | 750 | tons/day prod. | 1 | 20.13 | tons/hr |
| | | | 2 | 20.13 | tons/hr |
| | | | 3 | 20 | tons/hr |
| | | | 4 | 20 | tons/hr |

10/20 454
10/21 483
10/22 480
10/23 *477
(FIRST SHIFT ONLY)

Basis for data: Pg 2-1, 2-2, 2-3

C. Air Pollution Control Systems Tested

1. For each air pollution control system pollution control system identified in A.8, note the following

| ID | Type of APCD | Manufacturer | Model No. |
|---|---|---|---|
| X | Settling Chamber? | | |
| Y | Medium-Energy Scrubber | Fuller/Draco | CAA, Size 92 |
| Z | Dry Multicyclone | | |
| | | | |
| | | | |
| | | | |
| | | | |

Note: Be as specific as possible in identifying APCD. For example, indicate "pulse jet fabric filter" rather than simply "fabric filter."

2. For each system identified above, provide a narrative description. For fugitive systems describe capture techniques as well as the removal techniques (use a separate page if necessary)

3. Using the attached parameter list for guidance complete the table below. (Use additional pages as needed.)

| APCD ID | Parameter | Units | Readings | | | |
|---|---|---|---|---|---|---|
| | | | Run 1 | Run 2 | Run 3 | Run 4 |
| X | | | | | | |
| Type of APCD: Settling Chamber | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Y | | | | | | |
| Type of APCD: Medium-Energy Scrubber | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Z | | | | | | |
| Type of APCD: Dry Multiclone | | | | | | |
| | | | | | | |
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| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

D. Sampling and Analysis Methods

1. Complete the following table

| Test location | Pollutant | S & A method | Reference/ conditional method | Deviations noted |
|---|---|---|---|---|
| All | PM, CO, $CO_2$ | Method 5 | (Y)/N | (Y)/N |
| | $SO_2$ | Method 6 | (Y)/N | (Y)/N |
| | $NO_x$ | Method 7 | (Y)/N | Y/(N) |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
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| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |
| | | | Y/N | Y/N |

2. If a method used was not a reference or conditional method, provide a narrative discussion including any data manipulation needed to make results correspond to reference or conditional method results.

3. Describe any deviations identified above.

Particulate sampling and analytical procedures followed EPA Method 5* except that an ether-chloroform extraction was performed on the impinger contents to determine condensible organic and inorganic fractions. Particle size sampling and analytical procedures followed those described in "Procedures Manual for Inhalable Particulate Sampler Operation," recently developed by Southern Research Institute for EPA.[1] Visible emission observations were conducted by EPA Method 9.† Sulfur dioxide sampling and analytical procedures followed EPA Method 6* except that large impingers were used instead of the midget impingers specified by EPA Method 6. Nitrogen oxide sampling and analytical procedures followed EPA Method 7.*

## E. Emission Data Documentation

1. Tabulate the following stack gas data from the test report. (Use additional pages as needed.)

| Test ID | Parameter | Units | Values reported | | | |
|---|---|---|---|---|---|---|
| | | | Run 1 | Run 2 | Run 3 | Run 4 |
| 1 | Stack temperature | °F | 173 | 153 | 177 | 177 |
| | Moisture | % VOL. | 24.0 | 22.1 | 23.0 | 24.0 |
| | Oxygen | % VOL. | 14.0 | 14.7 | 15.1 | 15.1 |
| | Volumetric flow, actual | acfh | 5,443,963 | 5,229,943 | 4,892,190 | 5,368,349 |
| | Volumetric flow, standard | dscfh | 3,450,833 | 3,511,597 | 3,123,661 | 3,383,256 |
| | Percent isokinetic | | | | | |
| | Pollutant concentration: | | | | | |
| | PM-FILTERABLE | gr/dscf | 0.2167 | 0.1422 | 0.3388 | 0.3855 |
| | PM-CONDENS. ORGANIC | gr/dscf | 0.0013 | 0.0013 | 0.0024 | 0.0014 |
| | PM-CONDENS. INORGANIC | gr/dscf | 0.1334 | 0.1476 | 0.1410 | 0.1039 |
| | $CO_2$ | % VOL. | 5.7 | 5.0 | 4.4 | 4.4 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 2 | Stack temperature | °F | 450 | 440 | 440 | |
| | Moisture | % VOL. | 20.0 | 19.0 | 13.0 | |
| | Oxygen | % VOL. | 13.7 | 13.5 | 13.2 | |
| | Volumetric flow, actual | | | | | |
| | Volumetric flow, standard | dscfh * | 3,367,337 | 3,367,337 | 3367,337 | |
| | ~~Percent isokinetic~~ | | | | | |
| | Pollutant concentration: | | | | | |
| | $SO_2$ | lb/dscf | 5.56E-05 | 5.76E-05 | 5.55E-05 | |
| | $CO_2$ | % VOL. | 5.2 | 4.8 | 5.4 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 3 | Stack temperature | °F | 140 | 144 | 143 | |
| | Moisture | % VOL. | 18 | 19 | 19 | |
| | Oxygen | % VOL. | 14.8 | 14.6 | 14.4 | |
| | Volumetric flow, actual | | | | | |
| | Volumetric flow, standard | dscfh * | 3,367,337 | 3,367,337 | 3,367,337 | |
| | Percent isokinetic | | | | | |
| | Pollutant concentration: | | | | | |
| | $SO_2$ | lb/dscf | 2.95E-05 | 3.06E-05 | 3.05E-05 | |
| | $NO_x$ | lb/dscf | 0.254E-04 | 0.237E-04 | 0.258E-04 | |
| | $CO_2$ | % VOL. | 4.0 | 3.6 | 4.2 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

* Average flow rate from particulate tests.

E. Emission Data Documentation

1. Tabulate the following stack gas data from the test report. (Use additional pages as needed.)

| Test ID | Parameter | Units | Values reported | | | |
|---|---|---|---|---|---|---|
| | | | Run 1 | Run 2 | Run 3 | Run 4 |
| 4 | Stack temperature | °F | 186 | 204 | 185 | 190 |
| | Moisture | % VOL. | 2.2 | 1.5 | 1.2 | 2.5 |
| | Oxygen | % VOL. | 17.6 | 20.6 | 19.9 | 19.9 |
| | Volumetric flow, actual | acfh | 1,344,737 | 1,445,353 | 1,392,315 | 1,353,552 |
| | Volumetric flow, standard | dscfh | 1,078,683 | 1,135,100 | 1,129,466 | 1,075,745 |
| | Percent isokinetic | | | | | |
| | Pollutant concentration: | | | | | |
| | Filterable PM | gr/dscf | 0.1077 | 0.0778 | 0.0470 | 0.0733 |
| | Condensible organic PM | gr/dscf | 0.0006 | 0.0007 | 0.0005 | 0.0010 |
| | Condensible inorganic PM | gr/dscf | 0.00040 | 0.00003 | 0.00040 | 0.00170 |
| | CO2 | % VOL. | 2.3 | 0.0 | 0.9 | 0.9 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | Stack temperature | | | | | |
| | Moisture | | | | | |
| | Oxygen | | | | | |
| | Volumetric flow, actual | | | | | |
| | Volumetric flow, standard | | | | | |
| | Percent isokinetic | | | | | |
| | Pollutant concentration: | | | | | |
| | | | | | | |
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| | | | | | | |
| | | | | | | |
| | | | | | | |
| | Stack temperature | | | | | |
| | Moisture | | | | | |
| | Oxygen | | | | | |
| | Volumetric flow, actual | | | | | |
| | Volumetric flow, standard | | | | | |
| | Percent isokinetic | | | | | |
| | Pollutant concentration: | | | | | |
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| | | | | | | |

## 2. Tabulate pollutant mass flux rates

| Test ID | Pollutant | Units | Mass flux rates | | | |
|---|---|---|---|---|---|---|
| | | | Run 1 | Run 2 | Run 3 | Run 4 |
| 1 | Filterable PM | lb/hr | ~~108~~ 8 | 71.3 | 151.2 | 186.3 |
| | Condens. Org. PM | lb/hr | ~~0.66~~ | 0.65 | 1.10 | 0.70 |
| | Condens. Inorg. PM | lb/hr | ~~65~~ 8 | 74.1 | 62.9 | 50.2 |
| | $CO_2$ | *lb/hr | ~~23,814~~ | 20,543 | 16,081 | 17,417 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 2 | $SO_2$ | lb/hr | 158.9 | 165.2 | 157.6 | |
| | $CO_2$ | *lb/hr | 20,487 | 18,911 | 21,275 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 3 | $SO_2$ | lb/hr | 99.5 | 103.0 | 102.6 | |
| | $NO_x$ | lb/hr | 85.4 | 79.7 | 86.9 | |
| | $CO_2$ | *lb/hr | 5,759 | 14,183 | 16,547 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 4 | Filterable PM | lb/hr | 16.6 | 12.8 | 7.6 | 11.3 |
| | Condens. Org. PM | lb/hr | 0.09 | 0.11 | 0.07 | 0.15 |
| | Condens. Inorg. PM | lb/hr | 0.070 | 0.008 | 0.070 | 0.260 |
| | $CO_2$ | *lb/hr | 2903 | 0 | 1,189 | 1,133 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

* DENSITY @ STP = 0.1170 lb/ft3

TEST 1, RUN 1 Anisokinetic Conditions - See pg 3-5

3. Present example emission factor calculations below.

TEST 1

Feed rate, tons/hr
10/20 37.3/20.13
10/21 39.7/19.88
10/22 39.4/20.13

FILTERABLE PM

$$EF = \left(\frac{106.8}{20.13} + \frac{71.3}{20.13} + \frac{151.2}{20} + \frac{186.3}{20}\right) \frac{lb/hr}{tons/hr} \div 4 = \ldots \; lb/ton \text{ produced}$$

Scrubber feedwater pump malfunctioned during 2nd & 3rd particulate test. Throw out these runs!

| PROCESS | POLLUTANT | RUN 1 | RUN 2 | RUN 3 | RUN 4 |
|---|---|---|---|---|---|
| A | Filterable PM | ~~106.8 / 20.13 = 5.31~~ | ~~71.3 / 20.13 = 3.54~~ | ~~151.2 / 20 = 7.56~~ | 186.3 / 20 = 9.32 |
| | Cond. Org. PM | ~~0.66 / 20.13 = 0.0328~~ | ~~0.65 / 20.13 = 0.0323~~ | ~~0.10 / 20 = 0.005~~ | 0.70 / 20 = 0.035 |
| | Cond. Inorg. PM | ~~65.8 / 20.13 = 3.27~~ | ~~74.1 / 20.13 = 3.68~~ | ~~62.9 / 20 = 3.15~~ | 50.2 / 20 = 2.51 |
| | $CO_2$ | ~~23,014 / 20.13 = 1143~~ | 20,543 / 20.13 = 1021 | 16,081 / 20 = 804.1 | 17,417 / 20 = 870.9 |
| A | $SO_2$ | 158.9 / 19.88 = ~~7.99~~ 4.0 | 165.2 / 19.88 = 8.31 4.2 | 157.6 / 19.88 = 7.93 4.0 | 4.1 |
| | $CO_2$ | 20,487 / 19.88 = ~~1031~~ 502 | 18,911 / 19.88 = ~~951.9~~ 468 | 21,275 / 19.88 = ~~1070~~ 526 | ~~4035~~ 441 |
| A | $SO_2$ | 99.5 / 19.88 = 5.01 2.51 | 103.0 / 19.88 = 5.18 2.59 | 102.6 / 19.88 = 5.16 2.58 | 2.56 |
| | $NO_x$ | 85.4 / 19.88 = 4.30 2.15 | 79.7 / 19.88 = 4.01 2.01 | 86.9 / 19.88 = 4.37 2.19 | 2.12 |
| | $CO_2$ | 15,754 / 19.88 = ~~792.7~~ 390 | 14,183 / 19.88 = ~~713.4~~ 351 | 16,547 / 19.88 = ~~832.3~~ 409 | |
| B | Filterable PM | 16.6 / 20.13 = 0.825 0.413 | 12.8 / 20.13 = 0.636 0.319 | 7.6 / 20 = 0.38 0.19 | 11.3 / 20 = 0.565 0.28 0.30 |
| | Cond. Org. PM | 0.09 / 20.13 = 0.00447 0.0024 | 0.11 / 20.13 = 0.00546 0.0027 | 0.07 / 20 = 0.0035 0.0018 | 0.15 / 20 = 0.0075 0.0038 0.0027 |
| | Cond Inorg. PM | 0.07 / 20.13 = 0.00348 0.0017 | 0.0008 / 20.13 = 3.97E-05 1.99 | 0.07 / 20 = 0.0035 0.0018 | 0.26 / 20 = 0.013 .0065 0.0025 |
| | $CO_2$ | 2903 / 20.13 = ~~144.2~~ 71 | 0 / 20.13 = 0 | 1,189 / 20 = ~~59.5~~ 29 | 1,133 / 20 = 56.7 28 43 |

## 4. Tabulate emission factors

| Process | Pollutant | Units | Average emission factor | |
|---|---|---|---|---|
| | | | Uncontrolled | Controlled |
| A | Filterable PM | lb/ton produced | | ~~6.81~~ |
| | Condens. Org. PM | " | | ~~0.0241~~ |
| | Condens. Inorg. PM | " | | ~~3.41~~ |
| | $CO_2$ | " | ~~898.7~~ | |
| | PM10 | lb/ton produced | | ~~4.97~~ |
| | (PM(Filt.) x .73) | | | |
| A | $SO_2$ | lb/ton produced | 8.08 | |
| | $CO_2$ | " | 1017.3 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| A | $SO_2$ | lb/ton produced | | 5.12 |
| | $NO_x$ | " | | 4.23 |
| | $CO_2$ | " | 779.5 | |
| | | | | |
| | | | | |
| | | | | |
| B | Filterable PM | lb/ton produced | | 0.601 |
| | Condens. Org. PM | " | | 0.00523 |
| | Condens. Inorg. PM | " | | 5.00 E-03 |
| | $CO_2$ | " | | 65.1 |
| | PM10 | " | | 0.240 |
| | (PM(Filt.) x .40) | | | |

VOID ONLY 1 GOOD RUN

**ATTACHMENT A**
**APCD PARAMETERS**

| Type of APCD | Parameters |
|---|---|
| Fabric filter | Cleaning mechanism<br>Bag type<br>Cleaning frequency<br>Air to cloth ratio (A/C)<br>Pressure drop<br>Inlet temperature |
| ESP | Type (wet or dry)<br>Number of fields<br>Rapping cycle (if dry)<br>Specific Collection Area (SCA)<br>Particulate resistivity (if known)<br>Spark rate<br>Current and power levels |
| Venturi (or other high energy) scrubber | Pressure drop<br>Liquid/gas (L/G) ratio<br>Mist eliminator type |
| Packed-bed scrubber | Packing depth<br>L/G ratio<br>~~Caustic use (Y/N)~~<br>pH<br>Mist eliminator type |
| Carbon absorber | Bed depth<br>Superficial gas velocity<br>Bed temperature<br>Desorption mechanism (media)<br>Flue-gas moisture<br>Cycle length<br>Time-on-line after breakthrough |

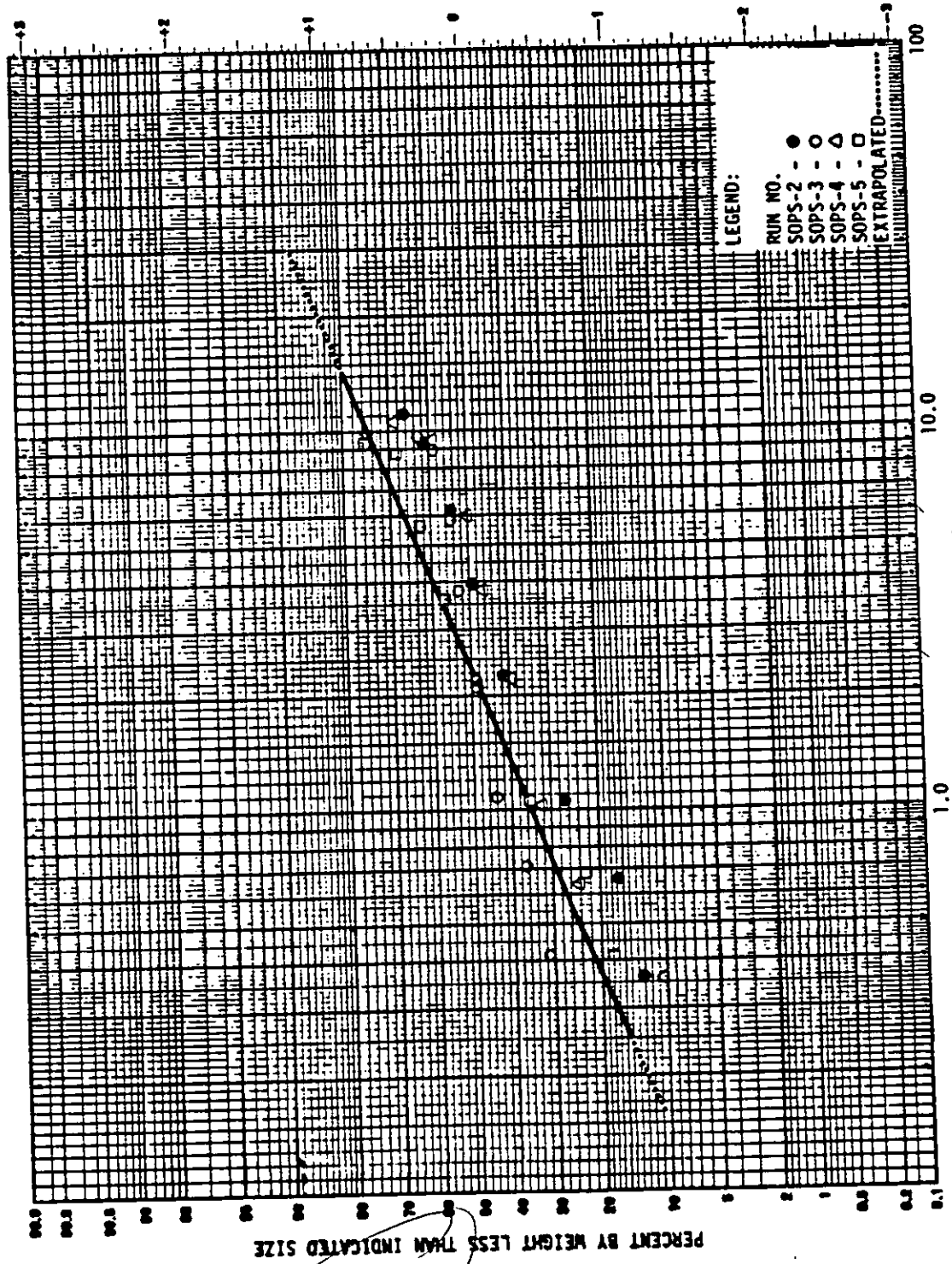



Figure 3.1-1. Particle size distribution for Runs SOPS-2 through SOPS-5 - kiln exhaust.

| SIZE | 1 | 2 | % |
|---|---|---|---|
| 2.5 | 51 | 53 | |
| 6.0 | 67 | 64 | |
| 10.0 | 75 | 71 | |
| 15.0 | 80 | 76 | |
| 20.0 | 84 | 78 | |

AVG
52 %
66 %
73 %
78 %
81 %

PM10 = 75 %

AVERAGE PM10 % FOR SCRUBBER OUTLET

$\frac{75\% + 71\%}{2} = 73\%$

VOID
Particulate Emissions test is no good! (at scrubber outlet)

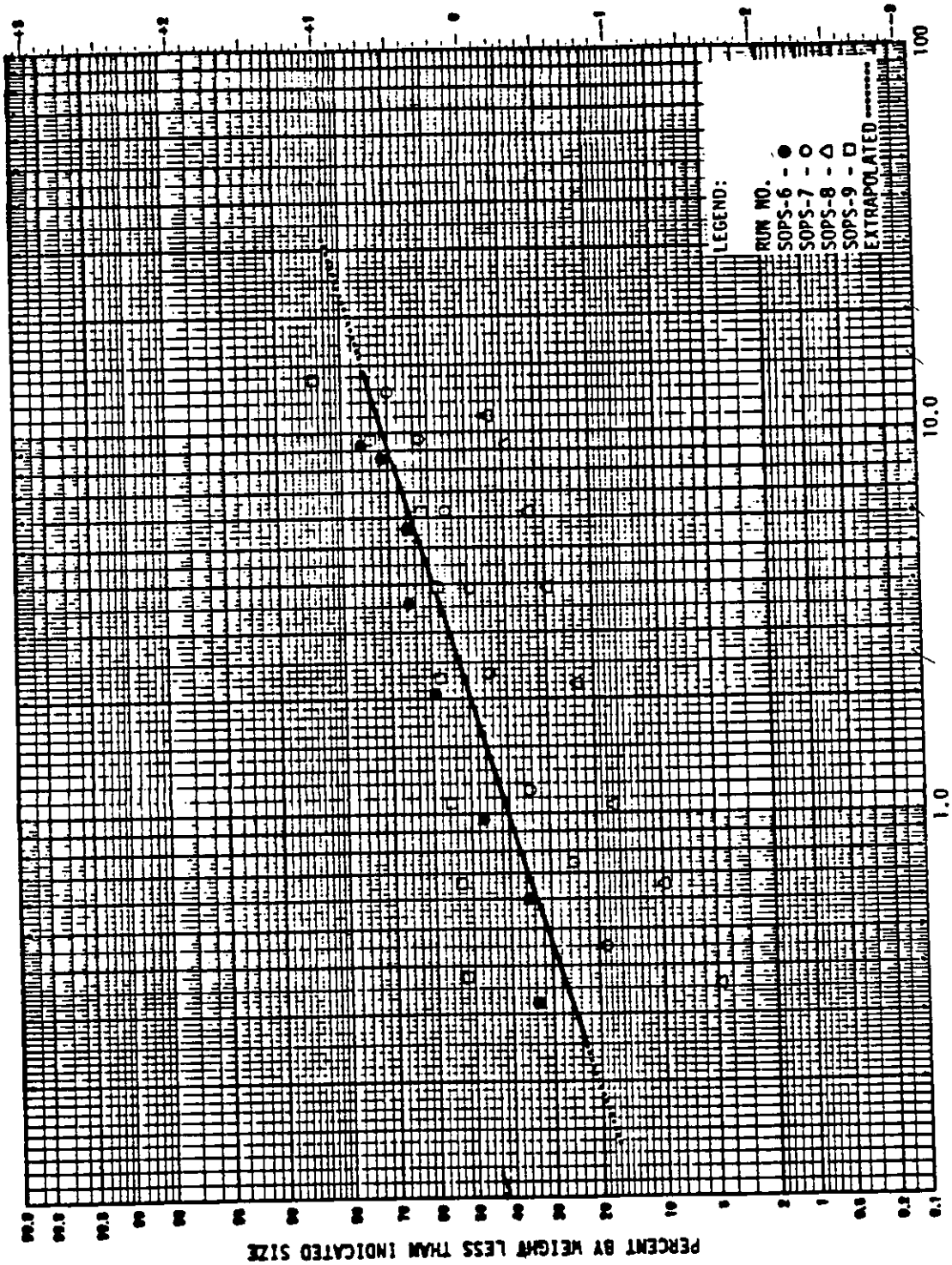
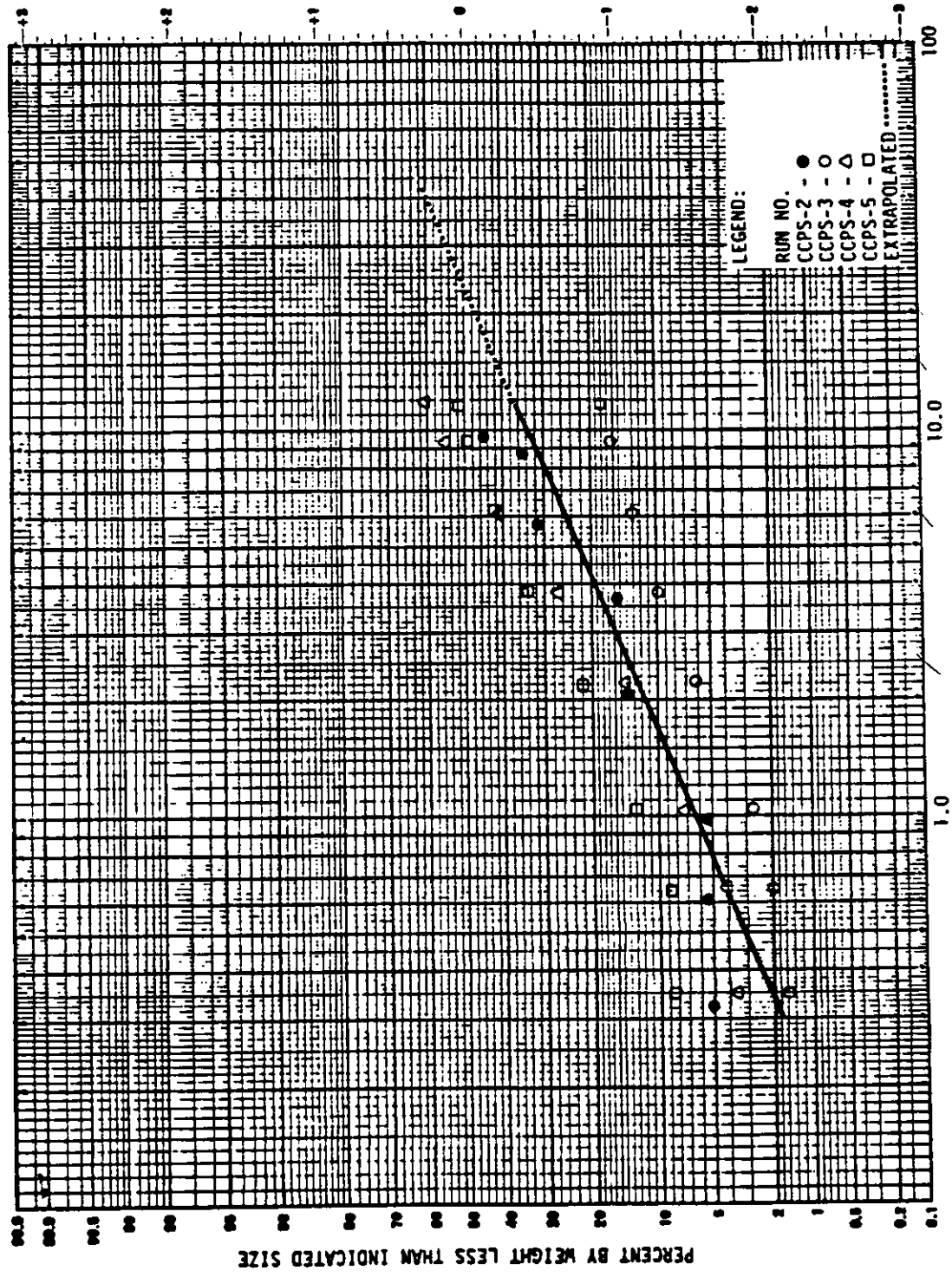



Figure 3.1-2. Particle size distribution for Runs SOPS-6 through SOPS-9 - kiln exhaust.

PM10 = 71%




| SIZE | 1 | 2 | AVG |
|---|---|---|---|
| 2.5 | 14 | 23 | 19 % |
| 6.0 | 25 | 36 | 31 % |
| 10.0 | 34 | 46 | 40 % |
| 15.0 | 42 | 53 | 48 % |
| 20.0 | 47 | 58 | 53 % |

PM10 = 34 %

Figure 3.2-1. Particle size distribution for Runs CCPS-2 through CCPS-5 - clinker cooler exhaust.

AVERAGE PM10 % FOR CLINKER COOLER EXHAUST

$\frac{34\% + 46\%}{2} = 40\%$

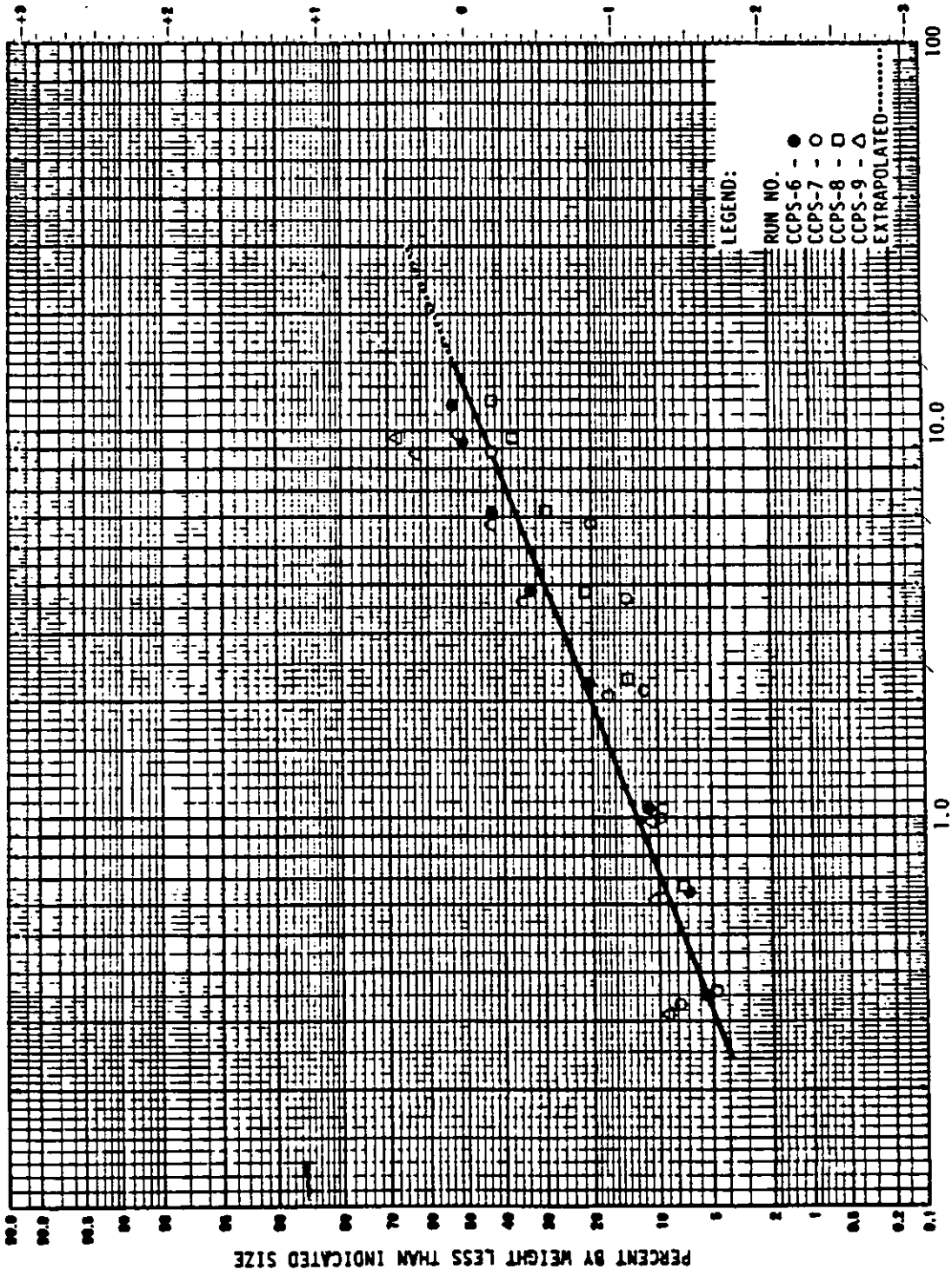



Figure 3.2-2. Particle size distribution for Runs CCPS-6 through CCPS-9 - clinker cooler exhaust.

$PM_{10} = 46\%$