AP-42 Section 11.6
Reference 9
Report Sect. 4
Reference 2

H529-4

EMISSION TESTING REPORT

ETB TEST NUMBER 71-MM-03

FINAL

FINAL

Emissions From
Wet Process Cement Kiln
And Clinker Cooler

IDEAL CEMENT COMPANY
SEATTLE, WASHINGTON

FINAL

FINAL

Project Officer
Clyde E. Riley

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Research Triangle Park, North Carolina 27711

PREFACE

The work reported herein was conducted by the Roy F. Weston Company, pursuant to a task order issued by the Environmental Protection Agency (EPA), under the terms of EPA Contract Number CPA 70-132 Task Order 1. Mr. G. E. Benson served as the Project Engineer and directed the Weston field team consisting of Messrs. H. F. Schiff, B. W. Cowan, and L. W. Johnson. Mr. Schiff and Mr. Cowan performed the pollutant analyses at the Weston laboratories. Roy F. Weston submitted to EPA a draft document from which EPA personnel prepared the final report (Test No. 71-MM-03)

Approved:
Environmental Protection Agency

Gene W. Smith
Chief, Metallurgical and Mechanical Section
Emission Testing Branch

FINAL

March 29, 1972

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FINAL

ACKNOWLEDGMENTS

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E. F. Gilardi, Senior Project Manager	Concept Technology Division
F. L. Cross, Air Pollution Consultant	Concept Technology Division
G. E. Benson, Project Engineer	Concept Technology Division
H. F. Schiff, Assistant Project Scientist	Concept Technology Division
B. W. Cowan, Technician	Concept Technology Division
L. W. Johnson, Technician	Concept Technology Division

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F. Bauer, Plant Manager	
R. Owens, Supervisor	Quality Control
R. J. Castelli, Environmental Specialist	Denver Office

The following staff members of EPA-OAP have participated in the planning and execution of this project and/or preparation of this report:

C. E. Riley, Technician	Emission Testing Branch
P. K. York, Chemical Engineer	Source Control Branch
J. Bazes, Chemical Engineer	Emission Testing Branch

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SUMMARY

The Office of Air Programs of the Environmental Protection Agency contracted with Roy F. Weston, Inc. to conduct OAP particulate sampling tests in the duct from the clinker cooler and in the kiln stack at the Seattle, Washington plant of the Ideal Cement Company. Three sampling runs were conducted at the clinker cooler duct and two simultaneous runs were conducted at the kiln stack.

The clinker cooler particulate emissions, which were controlled by a baghouse **dust** collector, were 42, 46, and 56 lbs/hr. The measured particulate concentrations were 0.0513, 0.0571, and 0.0698 gr/scf, respectively (particulate emission catch of front half of train).

The kiln emissions, which were controlled by an electrostatic precipitator, were 85.9 and 94.0 lbs/hr. The particulate concentrations were 0.0935 and **.1064** gr/scf (particulate emission catch of front half of train).

The isokinetic sampling ratios were between 89.9 and 105.7 percent.

A summary of the particulate emissions data is presented in the following Tables 1 and 2. The complete summary results of the test may be found in Tables 3 and 4.

TABLE 1

SUMMARY OF PARTICULATE DATA FOR CLINKER COOLER

Run number	1	2	3
Date	3-18-71	3-19-71	3-19-71
Percent Excess Air	NA	NA	NA
Percent Isokinetic	105.7	105.3	101.9
Stack Flow Rate-SCFM* dry	95,699	94,971	94,100
Stack Flow Rate-ACFM wet	108,307	105,121	104,555
Volume of Dry Gas Sampled SCF*	105.39	104.21	100.03
Feed Rate - tons/hr	103.4	102.8	104.9
Particulates			
Probe, Cyclone, & Filter Catch			
mg	351.0	386.0	453.3
gr/SCF* dry	0.0513	0.0571	0.0698
gr/CF @Stack Conditions	0.0453	0.0516	0.0628
lbs/hr	42.0	46.4	56.3
lbs/ton feed	0.406	0.452	0.536
Total Catch			
mg	374.3	400.6	462.7
gr/SCF* dry	0.0547	0.0592	0.0712
gr/CF @Stack Conditions	0.0483	0.0534	0.0641
lbs/hr	44.8	48.2	57.4
lbs/ton feed	0.433	0.468	0.547
% Impinger Catch	6.22	3.49	2.03

* 70°F, 29.92" Hg
NA--Not Applicable.

TABLE 2

SUMMARY OF PARTICULATE DATA FOR KILN STACK

Run Number	1	2
Date	3-24-71	3-24-71
Percent Excess Air	67.8	67.8
Percent Isokinetic	93.5	89.9
Stack Flow Rate - SCFM* dry	107,179	103,085
Stack Flow Rate - ACFM wet	286,431	288,505
Volume of Dry Gas Sampled - SCF*	39.69	36.68
Feed Rate - tons/hr	101.7	101.7
<u>Particulates</u>		
<u>Probe, Cyclone, & Filter Catch</u>		
mg	241	253.5
gr/SCF* dry	0.0935	0.1064
gr/CF @Stack Conditions	0.0350	0.0380
lbs/hr	85.9	94.0
lbs/ton feed	0.844	0.924
<u>Total Catch</u>		
mg	262	281.8
gr/SCF* dry	0.1016	0.1183
gr/CF @Stack Conditions	0.0380	0.0422
lbs/hr	93.4	104.4
lbs/ton feed	0.918	1.027
% Impinger Catch	8.01	10.04

* $70^{\circ}F$, 29.92" Hg

INTRODUCTION

Under the Clean Air Act, as amended, the Environmental Protection Agency is charged with the establishment of performance standards for new installations or modifications of existing installations in stationary source categories which may contribute significantly to air pollution. A performance standard is a standard for emissions of air pollutants which reflects the best emission reduction systems that have been adequately demonstrated (taking into account economic considerations).

The development of realistic performance standards requires accurate data on pollutant emissions within the various source categories. In the cement industry, eight plants exhibiting well controlled operation have been selected for the emissions testing program. This report presents the particulate emissions data for the Seattle, Washington plant of the Ideal Cement Company.

Between March 15 and March 25, 1971, Roy F. Weston, Inc. conducted particulate source sampling at the following locations within the plant:

1. Outlet duct from the clinker cooler baghouse collector.
2. Stack from the kiln electrostatic precipitator.

The clinker cooler performs the function described by its name; i.e., cools the clinker (the main constituent of cement) which is discharged from the kiln. The kiln acts to calcine the raw materials (which are fed to the kiln in the form of a slurry) in a wet process operation.

The following sections of this report include (1) a process description, (2) a discussion of the testing procedure and results, (3) an abstract of the report, (4) analytical procedures and results, and (5) sample calculations.

PROCESS DESCRIPTION

Clay, crushed limestone and silica sand are brought to the plant by barge from British Columbia and Post Angles, Washington. These materials are ground and blended in a rotating ball mill to a slurry.

The blended slurry is fed into the upper end of a sloping (3/8 inch per foot), slowly revolving (one revolution per minute) kiln. This gas-fired kiln is 500 ft. long, 15 1/2 ft. in diameter at the feed end and tapered to 14 ft. at the discharge end with refractory lining encased in a steel cylinder. Fuel consumption is approximately 1,240 cu. ft. of gas per barrel of cement produced. During passage through the kiln, the raw materials are heated to a temperature of about 2800°F to produce the element hydraulic calcium silicates, known in the trade as "clinker". This marble-sized clinker material is then discharged from the lower end of the kiln at temperatures exceeding 2000°F and fed immediately into air-quenching cooler units which reduce the temperature of the material to about 150°F. From these coolers, the newly-formed clinker material is conveyed to a storage silo.

A small amount of gypsum (4.45% by weight) is added to the clinker material and this mixture is fed into the finish grinding mill. The mixture leaving the grinding mill is fed to an air separator or classifier where the coarse material is returned to the mill and the finished cement (90% through 325 mesh screen) is pneumatically pumped to storage silos. Present plant production is approximately 2,500,000 barrels of cement per year.

The control equipment of interest in this report consists of two Mikro-Pulsaire baghouse collectors (parallel) on the clinker cooler and a Buell electrostatic precipitator on the kiln (see Figures 1 and 2).

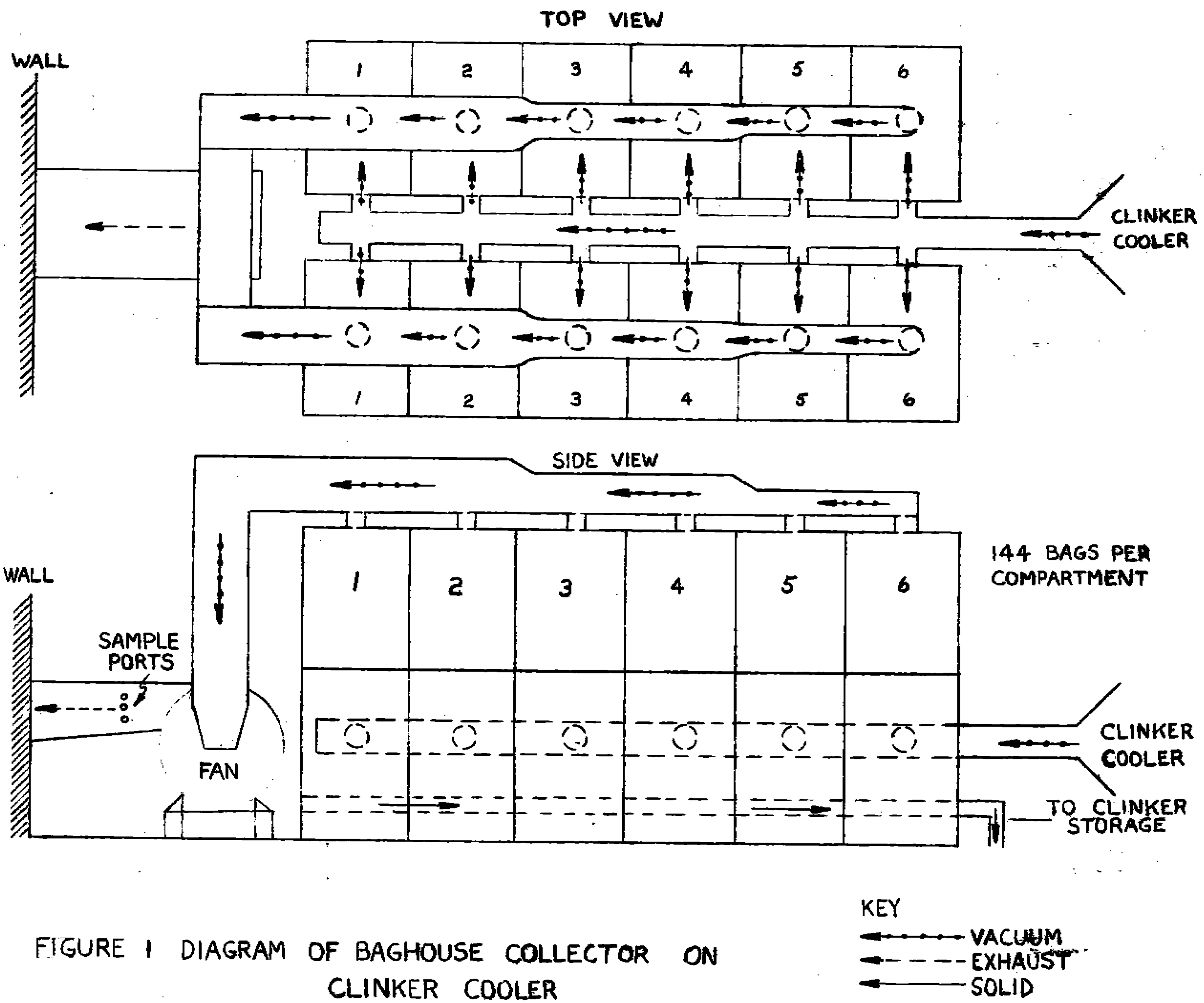


FIGURE 1 DIAGRAM OF BAGHOUSE COLLECTOR ON CLINKER COOLER

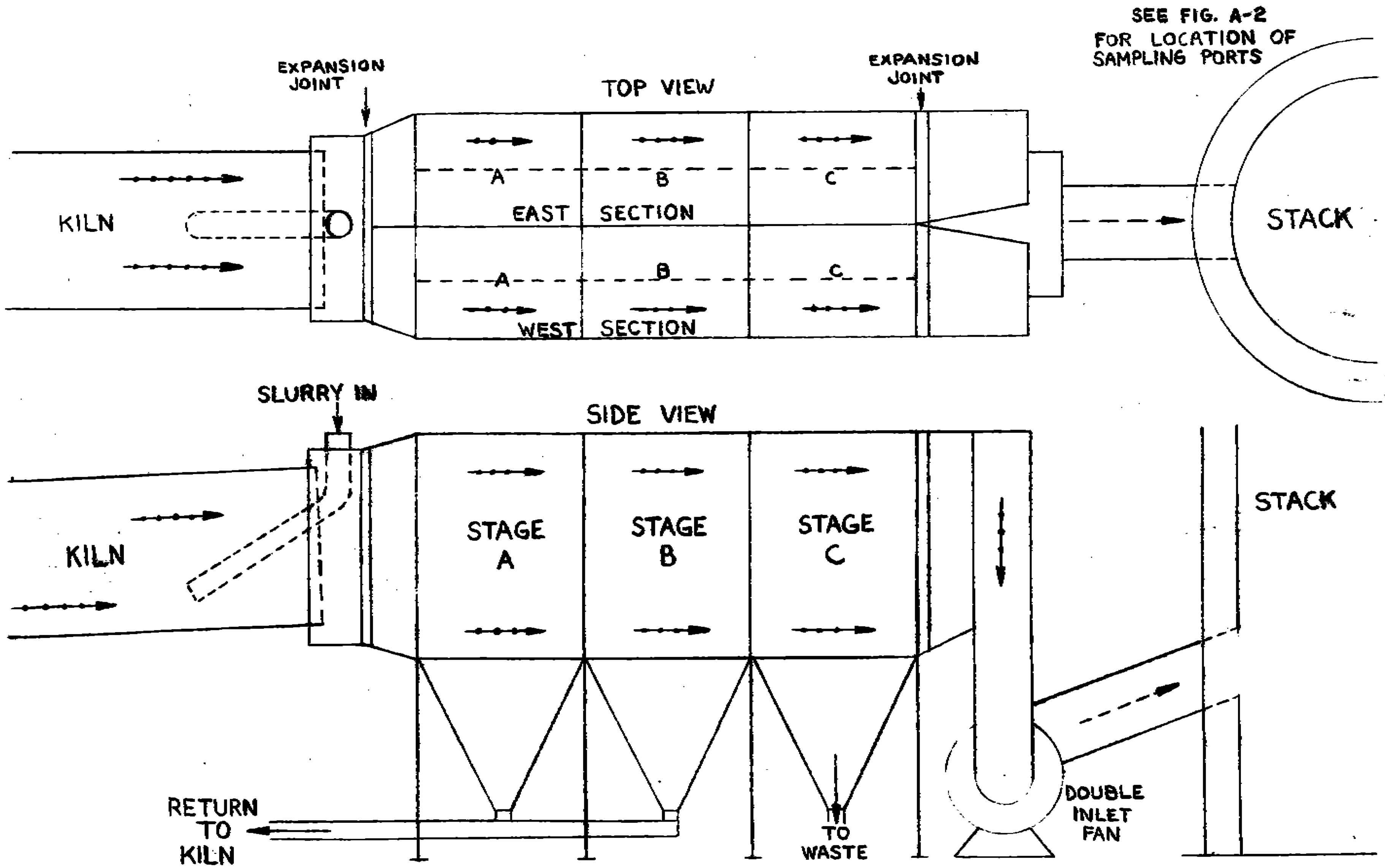


FIGURE 2 DIAGRAM OF ELECTROSTATIC PRECIPITATOR ON KILN

KEY
VACUUM
EXHAUST
SOLID

The baghouse collectors consist primarily of a series of cylindrical filter elements enclosed in a dust-tight housing. The felted filter media is "Nomex" which is heat resistant for temperatures as high as 425^{o}F and is supported on a stainless steel wire frame. Dust laden air is admitted to the housing and clean air withdrawn from inside the filter cylinders. As dust particles accumulate on the filter elements, periodic cleaning is accomplished by introduction of a momentary jet of high pressure air through a venturi mounted above each filter cylinder. A continuous flow of air through the collector is maintained, since only a fraction of the total filter area is cleaned at one time. The particulate matter falls during the cleaning cycle to the hopper below where the material is removed by a screw conveyor.

These Mikro-Pulsaire collectors are designed to operate with a pressure drop of 7 in. of water and have 864 filter bags per unit that are 4 1/2 in. in diameter x 8 ft. long. Each collector has six compartments and is 16 ft. tall x 36 ft. long x 13 ft. wide with a 60^{o} hopper below. Each collector is designed for a performance of 99.99+ percent efficiency with a gas volume of 62,500 ACF at 350^{o}F. The collection surface area is 8,040 square feet, which gives an air to surface ratio of 7.79 CFM/ft^{2}. The approximate installed cost of both baghouses was $425,000 in 1966. Annual bag usage is about 50 bags ($12.00 each) and labor and maintenance is approximately $600.00.

The electrostatic precipitator is of the horizontal flow type and consists of two sections with three treatment stages in each **section** This unit is designed for a performance of 99.83 percent efficiency with an inlet loading of 12 gr/ACF at 700^{o}F and an outlet loading of 0.02 gr/ACF and a gas volume to the **precipitator** of 400,000 ACFM containing 30-40 percent water. The collection surface area is 151,200 square feet which gives an air-to-surface ratio of 2.64 CFM/ft^2. The linear gas velocity is 5.28 feet per second and the residence time is 8.5 seconds. The particle drift velocity is 0.281 feet per second. There are 35 gas passages per section and each passage is 9 inches wide, 24 feet high, and 45 feet long. The precipitator contains a total of 3,990 emitting electrodes constructed of stainless steel. The approximate cost of installation in 1966 was $2,325,000.00 and the annual operating cost is about $10,400.00.

DISCUSSION OF TESTING AND RESULTS

Schematic drawings of the sampling locations are shown in Appendix A. The clinker cooler duct was not an ideal sampling location, however, it was the only available location. A temperature-controlled damper was located approximately four feet in front of the sampling ducts. Immediately preceding the damper was the fan. Three sampling runs of 144 minutes duration were conducted in the duct from the clinker cooler baghouse.

Sampling was conducted at a total of 36 points--12 points at each of three sampling ports. No sampling problems occurred. The isokinetic sampling rates were 105.7, 105.3 and 101.9 percent for the three runs.

Sampling was conducted in the kiln stack 150 feet above grade. Two simultaneous particulate runs were conducted. Sampling was done at 12 points--three points at each of four ports located 90^o apart. The sampling trains were operated at ports 180^o apart.

Tests at the kiln stack were begun on March 16 but discontinued due to sampling equipment difficulties. OAP type unitized trains were obtained and sampling at the kiln stack was begun again on March 23. Heavy rainfall made sampling difficult. The sampling platform and equipment were electrified and several members of the sampling crew received shocks. The electrical shocks and the rain forced abortion of the sampling after five minutes of the tests. With the concurrence of the OAP observer, the tests were continued on March 24 at the point where they had been discontinued.

Two simultaneous one-hour duration runs were completed between 11:30 a.m. and 5:30 p.m. The sampling was extremely difficult to complete. The sampling ports were below the stack platform top railing, and two ports were further blocked by vertical members of the stack platform railing. The port locations made necessary the use of two different lengths of probe to sample the three points at each port. Operating two trains simultaneously caused further problems due to coordination. Anything that delayed the sampling with one train also delayed the other. The stack platform width was approximately 30 inches around the stack. The sampling equipment and the four sampling platforms erected at ports cluttered the platform and made movement around the stack difficult. Winds with velocities of 40 and 50 mph made it difficult to retain heat in the sampling boxes.

When changing probes and moving the sampling boxes inside and outside the railing and from port to port, the box temperatures decreased quickly. Fifteen to twenty minutes were necessary to reheat the boxes after the sampling at almost every point. After completion of the two simultaneous particulate sampling runs, no further sampling was conducted at the kiln stack. For details of the sampling procedure see Appendix B. Data sheets and notes recorded in the field are presented in Appendix C.

The kiln stack emissions which were controlled by an electrostatic precipitator were 93.4 and 104.4 lbs/hr. The particulate concentrations were 0.1016 and 0.1183 gr/scf. The isokinetic sampling rates were 93.5 and 89.9 percent.

A complete summary of all particulate testing data is presented in Tables 3 and 4. According to the Federal Register, "Standards of Performance for New Stationary Sources", (December 23, 1971), the standards for particulate emissions, in terms of lbs. per ton of feed to the kiln, for cement plants are based upon measurement of the weight of particulate matter collected in the probe, cyclone and filter section. At the time of testing the Ideal, Seattle Plant (March 1971), these standards had not been officially established. Thus, emissions data were obtained measuring (a) the weight of particulates collected by the probe, cyclone and filter alone and (b) measuring the total weight of particulates collected (to include the impinger catch). These are reported for both schemes in Tables 3 and 4. A sample calculation is presented in Appendix E in which the data for run No. 1 of the clinker cooler are utilized.

Particulate samples were recovered from the sampling train and analyzed for ~~the elements Sb, As, Be, Cd, Cr, Cu,~~ Fe, Pb, Mn, Ni, ~~Sr,~~ V, and Zn. Details of the sample recovery procedure as well as the results of the subsequent analyses are presented in Appendix D.

Nitrogen oxides and carbon monoxide grab sampling was to be conducted simultaneously with the particulate sampling. During trial runs of NO_x sampling, a stream of water was pulled into the sample flask with the stack gas stream. This and other equipment difficulties, together with a test crew member's illness, made NO_x and CO sampling impossible.

TABLE 3
PARTICULATE EMISSIONS DATA FOR CLINKER COOLER

Run No.		1	2	3
Test Date		3-18-71	3-19-71	3-19-71
D_n	Sampling nozzle diameter, in.	0.189	0.189	0.189
T_t	Net time of test, min.	144	144	144
P_b	Barometric pressure, in. Hg absolute	30.23	29.88	29.92
P_m	Average Orifice pressure drop, in. H_2O	1.30	1.29	1.27
V_m	Volume of dry gas sampled, ft^3 at meter conditions	103.81	104.06	101.92
T_m	Average gas meter temperature, °F	68.7	69.8	81.2
$V_{m_{std}}$	Volume of dry gas sampled at standard conditions*, SCF	105.39	104.21	100.03
V_w	Total H_2O collected in impingers and silica gel, ml	12	10	8
$V_{w_{gas}}$	Volume of water vapor collected at standard conditions*, SCF	0.57	0.47	0.38
% M	% Moisture in the stack gas by volume	0.54	0.45	0.38
M_d	Mole fraction of dry gas	0.99	0.99	0.99
% CO_2		0.03	0.03	0.03
% O_2		20.95	20.95	20.95
% CO		<1	<1	<1
% N_2		78.0	78.0	78.0
% EA	Excess Air Percent	-	-	-
MW_d	Molecular weight of stack gas, dry basis	29.0	29.0	29.0
MW	Molecular weight of stack gas, wet basis	28.9	28.9	28.9
C_p	Pitot tube coefficient	0.85	0.85	0.85
ΔP_s	Average velocity head of stack gas, in. H_2O	1.23	1.19	1.17
T_s	Average stack temperature, °F	141	121	124
N_p	Net sampling points	36	36	36
P_{st}	Static pressure of stack gas in. Hg	0.05	0.05	0.05
P_s	Stack gas pressure in. Hg absolute	30.28	29.93	29.97
V_s	Stack gas velocity at stack conditions fpm	4012	3894	3873
A_s	Stack area, in.^{2}	3888	3888	3888
Q_s	Dry stack gas volumetric flow rate at standard conditions* SCFM	95,699	94,971	94,100
Q_a	Stack gas volumetric flow rate at stack conditions, ACFM	103,307	105,121	104,555
% I	Percent isokinetic	105.7	105.3	101.9

* 70°F, 29.92 in. Hg

TABLE 3 (Concluded)

PARTICULATE EMISSIONS DATA FOR CLINKER COOLER

Run No.		1	2	3
T_c	Unit Feed Rate-Tons/hr	103.4	102.8	104.9
m_f	Particulate - probe, cyclone and filter, mg	351.0	386.6	453.3
m_t	Particulate - total, mg	374.3	400.6	462.7
I_c	% impinger catch	6.22	3.49	2.03
C_{an}	Particulate - probe, cyclone, and filter, gr/SCF*	0.0513	0.0571	0.0698
C_{ao}	Particulate - total, gr/SCF*	0.0547	0.0592	0.0712
C_{at}	Particulate - probe, cyclone, and filter, gr/cf at stack conditions	0.0453	0.0516	0.0628
C_{au}	Particulate - total, gr/cf at stack conditions	0.0483	0.0534	0.0641
C_{aw}	Particulate - probe, cyclone, and filter, lb/hr.	42.0	46.4	56.3
C_{ax}	Particulate - total, lb/hr.	44.8	48.2	57.4
P_{tf}	Particulate - probe, cyclone, and filter, lb/ton feed	0.406	~~0.0452~~ 0.452	0.536
P_{tt}	Particulate - total, lb/ton feed	0.433	0.468	0.547

*70°F, 29.92 in. Hg, dry basis

TABLE 4

PARTICULATE EMISSIONS DATA FOR KILN STACK

Run No.		1	2
Test Date		3-24-71	3-24-71
D_n	Sampling nozzle diameter, in.	0.5	0.5
T_t	Net time of test, min.	60	60
P_b	Barometric pressure, in. Hg absolute	29.79	29.79
P_m	Average Orifice pressure drop, in. H_2O	1.23	1.72
V_m	Volume of dry gas sampled, ft^3 at meter conditions	38.80	35.39
T_m	Average gas meter temperature, °F	57.0	50.9
$V_{m_{std}}$	Volume of dry gas sampled at standard conditions*, SCF	39.69	36.68
V_w	Total H_2O collected in impingers and silica gel, ml	347	356
$V_{w_{gas}}$	Volume of water vapor collected at standard conditions*, SCF	16.45	16.87
% M	% Moisture in the stack gas by volume	29.3	31.5
M_d	Mole fraction of dry gas	0.71	0.68
% CO_2		17.0	17.0
% O_2		8.0	8.0
% CO		< 1	< 1
% N_2		75.0	75.0
% EA	Excess Air Percent	67.8	67.8
MW_d	Molecular weight of stack gas, dry basis	31.04	31.04
MW	Molecular weight of stack gas, wet basis	27.22	27.00
C_p	Pitot tube coefficient	0.85	0.85
ΔP_s	Average velocity head of stack gas, in. H_2O	0.081	0.082
T_s	Average stack temperature, °F	542	545
N_p	Net sampling points	12	12
P_{st}	Static pressure of stack gas in. Hg	0.02	0.02
P_s	Stack gas pressure in. Hg absolute	29.81	29.81
V_s	Stack gas velocity at stack conditions fpm	1382	1392
A_s	Stack area, in.^{2}	29,850	29,850
Q_s	Dry stack gas volumetric flow rate at standard conditions* SCFM	107,179	103,085
a	Stack gas volumetric flow rate at stack conditions, ACFM	286,431	288,505
% I	Percent isokinetic	93.5	89.9

* 70°F, 29.92 in. Hg

TABLE 4 (Concluded)

PARTICULATE EMISSIONS DATA FOR KILN STACK

Run No.		1	2
T_c	Unit Feed Rate-Tons/hr	~~101.7~~ 101.7	101.7
m_f	Particulate - probe, cyclone and filter, mg	241	253.5
m_t	Particulate - total, mg	262	281.8
I_c	% impinger catch	8.01	10.04
C_{an}	Particulate - probe, cyclone, and filter, gr/SCF*	0.0935	0.1064
C_{ao}	Particulate - total, gr/SCF*	0.1016	0.1183
C_{at}	Particulate - probe, cyclone, and filter, gr/cf at stack conditions	0.0350	0.0380
C_{au}	Particulate - total, gr/cf at stack conditions	0.0380	0.0422
C_{aw}	Particulate - probe, cyclone, and filter, lb/hr.	85.9	94.0
C_{ax}	Particulate - total, lb/hr.	93.4	104.4
P_{tf}	Particulate - probe, cyclone, and filter, lb/ton feed	0.844	0.924
P_{tt}	Particulate - total, lb/ton feed	0.918	1.027

*70°F, 29.92 in. Hg, dry basis

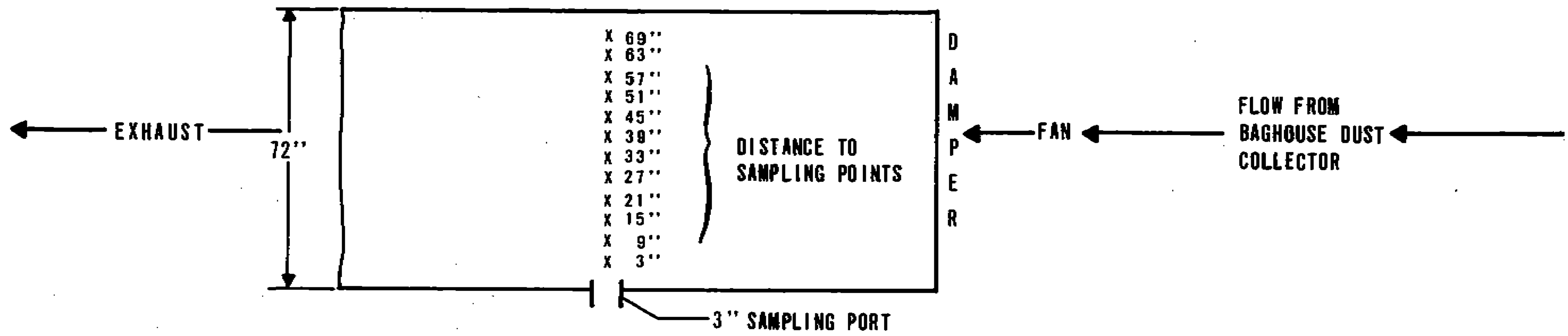
ABSTRACT

This source sampling report is one of nine studies concerning particulate and gaseous emissions from selected cement plants at various locations. The objectives of this study were to evaluate air pollution control equipment performance and efficiencies and to determine emission constituents typical of the cement industry. Schematics of test locations, field and processed data, and descriptions of sampling and laboratory analytical procedures have been included as part of the evaluation.

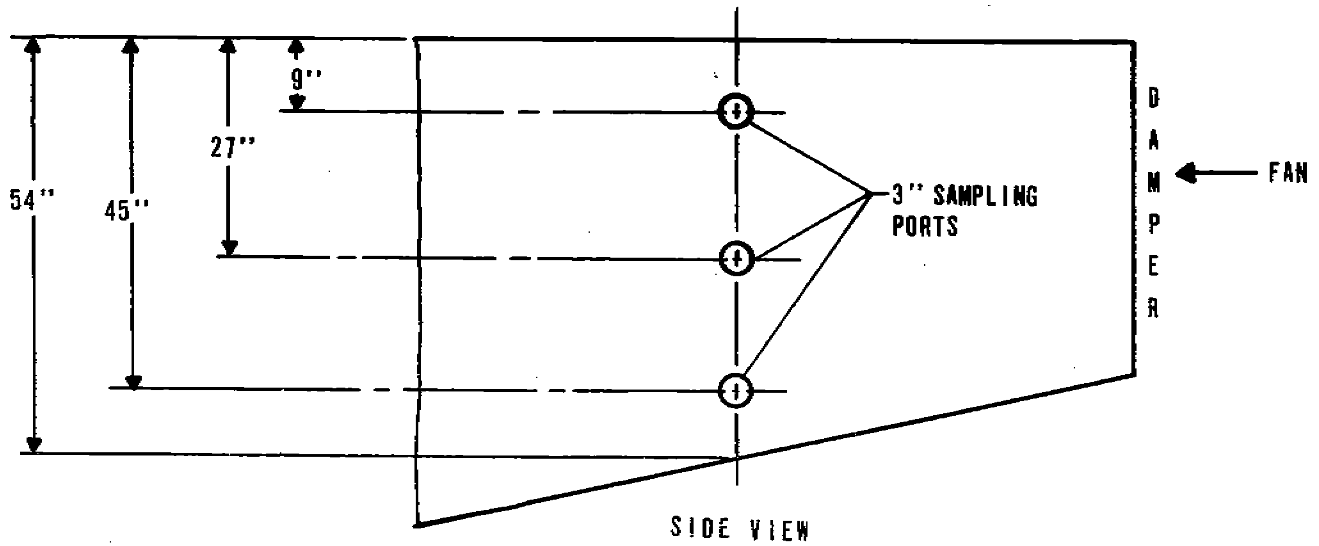
APPENDIX A

SCHEMATICS OF TEST LOCATIONS

FIGURE A-1
IDEAL CEMENT COMPANY
SEATTLE, WASHINGTON
SCHEMATIC OF CLINKER COOLER EXHAUST DUCT



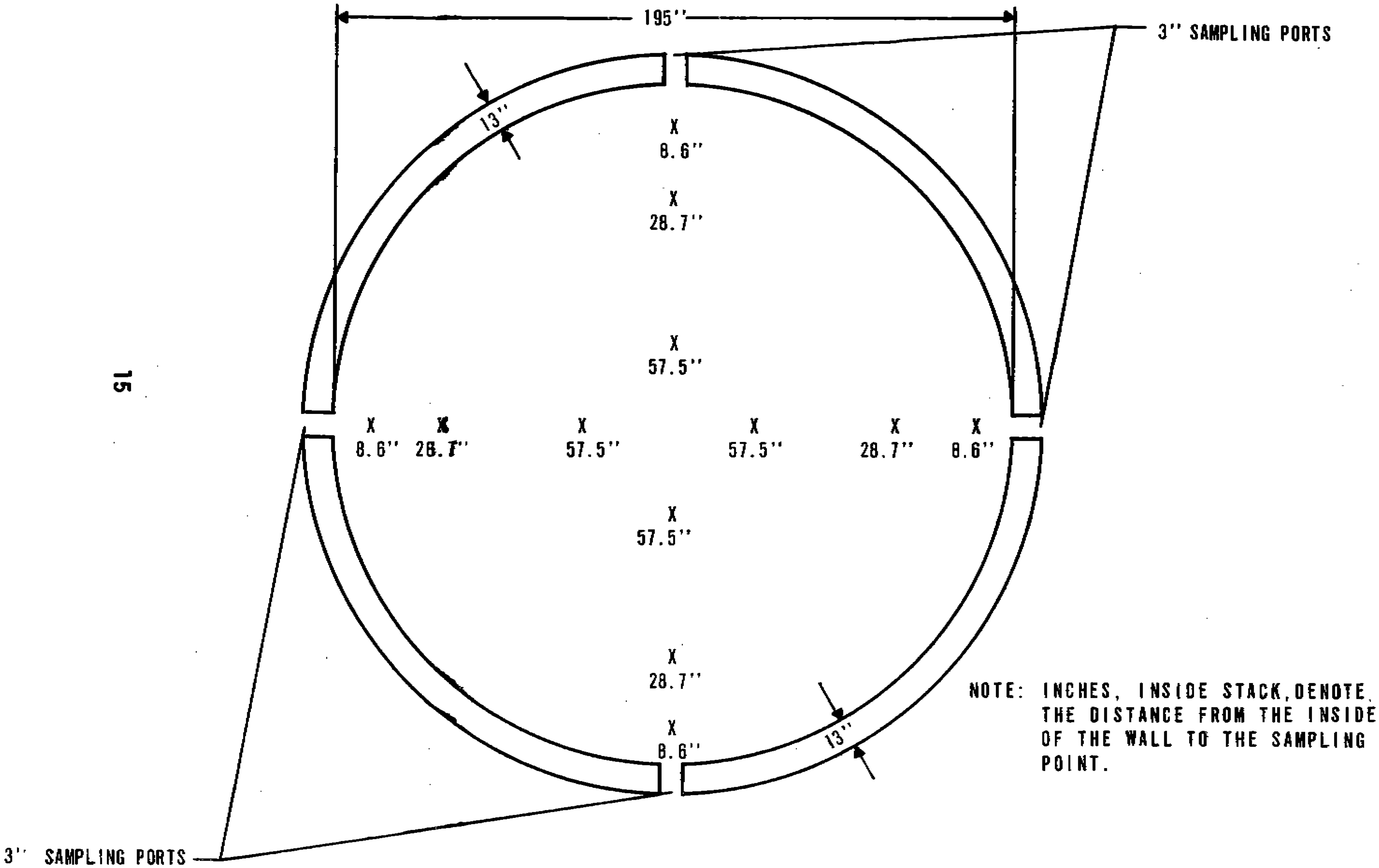
TOP VIEW



SIDE VIEW

FIGURE A-2
IDEAL CEMENT COMPANY
SEATTLE, WASHINGTON

SCHEMATIC OF KILN STACK CROSS-SECTION



APPENDIX B

SAMPLING PROCEDURES

The particulate sampling train used by Roy F. Weston, Inc. is shown in Figure B-1. A glass or nonreactive metal probe with button hook nozzles (whose size depended on the velocity of the gases) headed the train. The equipment following the probe consisted of a glass cyclone and flask (for certain runs a glass cyclone by-pass was used), a pre-weighed glass fiber filter, and four Greenberg-Smith impingers. The impingers were placed in an ice bath, while the preceding glass pieces were contained in a hot box maintained at a temperature of 240°F. The first impinger was modified by breaking off the glass tip, the second was unmodified, and the third and fourth were modified. The first two impingers each contained 100 ml of distilled water, the third was empty, and the fourth contained a pre-weighed quantity of silica gel. A leakless vacuum pump, a dry gas meter, and a calibrated orifice measured with an inclined manometer completed the train.

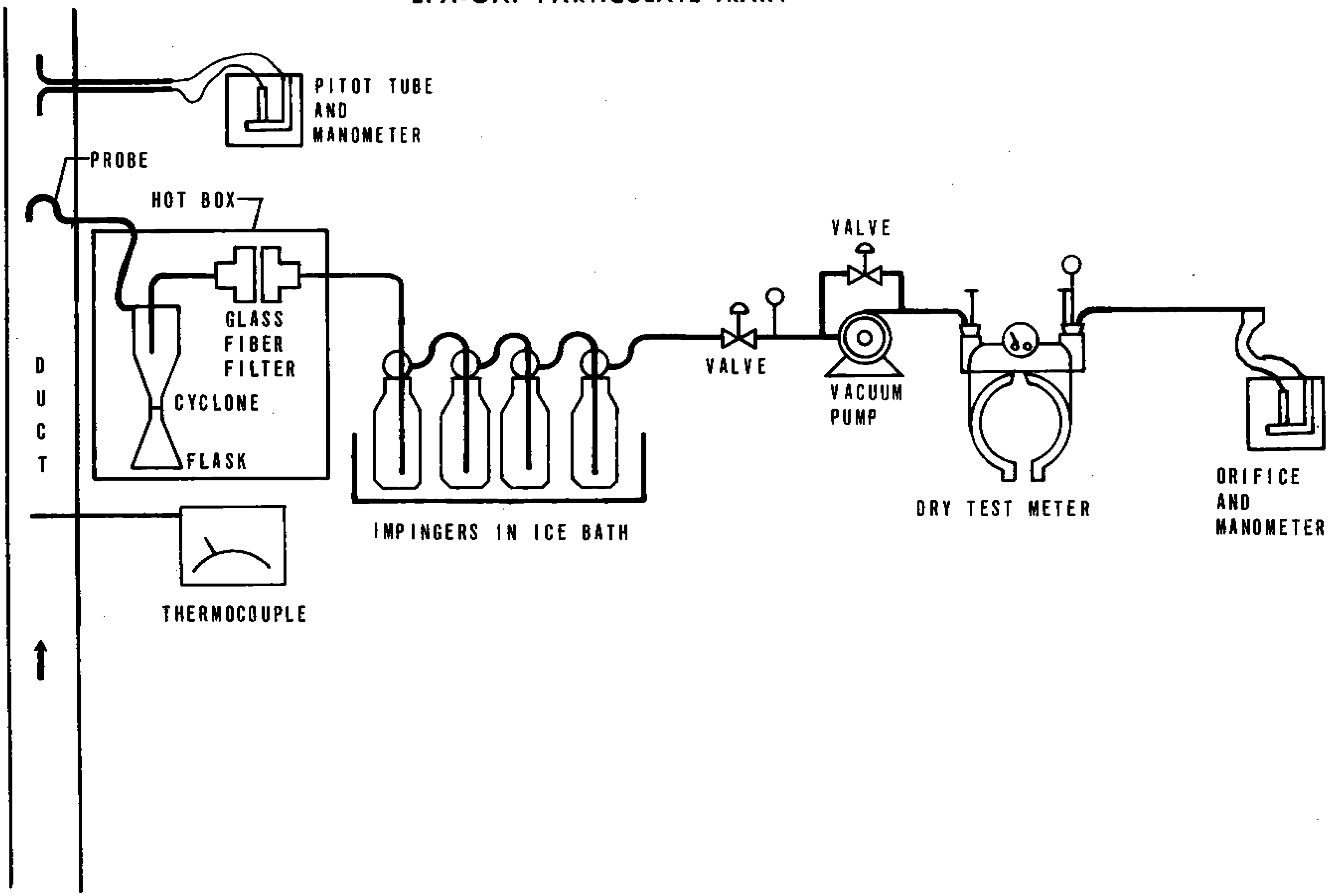
During sampling, gas stream velocities were measured by insertion of a calibrated type "S" pitot tube into the stack beside the particulate sampling probe. A type "K" thermocouple and a direct reading pyrometer measured gas temperatures within the gas flow itself. Temperature measurements were made at the heated cyclone, after the silica gel impinger, and at the inlet and outlet of the dry gas meter. Immediately after positioning on each traverse point, readings were made and sampling were adjusted.

Each sampling location was divided into equal cross-sectional area. The centroid of each area was chosen as a sampling point. The number of sampling points was determined by the configuration of the sampling location (e.g. circular, square, or rectangular) and its distance from bends, constrictions, fans, etc. In general, the closer a sampling location was to a bend constriction, fan, etc., the greater was the number of sampling points used.

After the completion of sampling, the cleanup of the train proceeded as follows: The filter was placed in a Petri dish. The probe, cyclone, flask, and the front half of the filter holder were washed with acetone into a sample bottle. The volume of the first three impingers was measured, and these impingers, the back half of the filter holder, and all connectors were washed first with distilled water and then with acetone. The silica gel was weighed to the nearest tenth of a gram.

FIGURE B.1

EPA-OAP PARTICULATE TRAIN

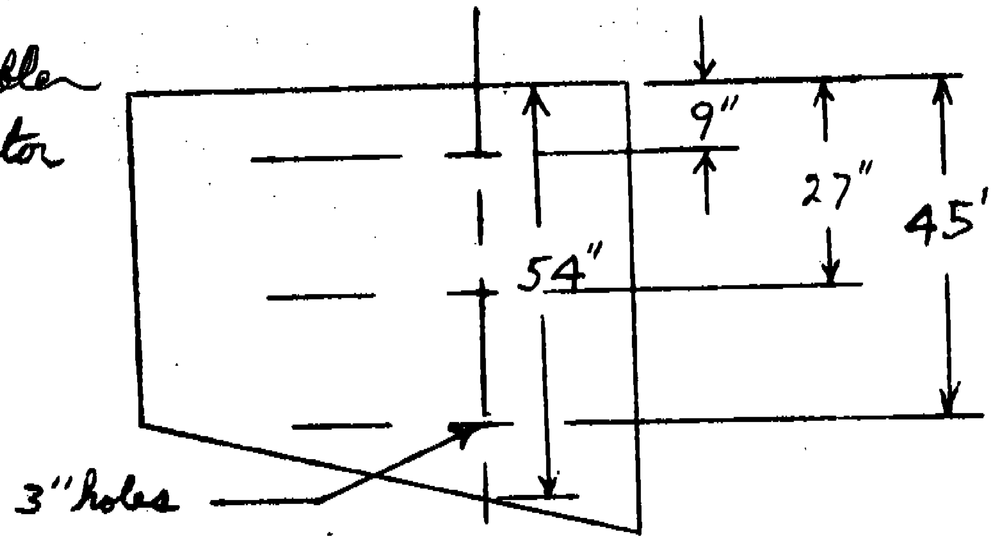


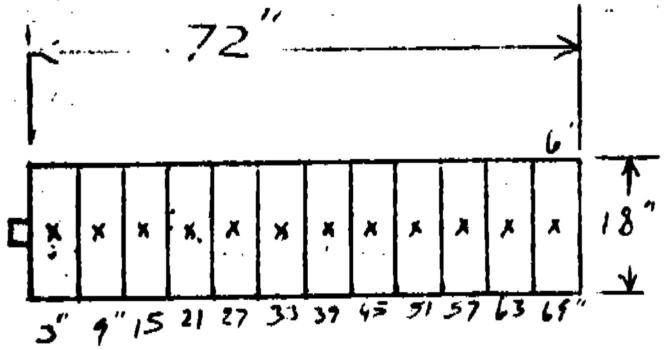
APPENDIX C

FIELD DATA AND NOTES

Clinker Cooler

Seattle
Clinker Cooler
Dust Collector





3 ports
12 sampling areas/port
4 MIN / area
total time/port - 48 MIN
test time - 144 MIN

Probe distance

1. 3"	8. 45"
2. 9"	9. 51"
3. 15"	10. 57"
4. 21"	11. 63"
5. 27	12. 69"
6. 33"	[redacted]
7. 39"	

2 = 9" X 18"

PRELIMINARY FIELD DATA
Stack Geometry

Plant Ideal Cement Seattle

Test No.

Location Clinker Cooler

Date 3-16-71

A. Dist. from inside of far wall to outside of near wall, in., = 74"

B. Wall thickness, in., = 2"

Inside ~~diameter~~ of stack = A-B 72"

Stack Area = 3,888.

Comments: 72" x 54" =

Sketch of stack cross-section showing sampling holes

Calculations:

Point	~~Table for circular stack~~	Dist. from outside of sample port, in.
1		3" + 2" = 5"
2		9" = 11"
3		15" = 17"
4		21" = 23"
5		27" = 29"
6		33" = 35"
7		39" = 41"
8		45" = 47"
9		51" = 53"
10		57" = 59"
11		63" = 65"
12		69" = 71"

Calculator C. E. Riley

NCAP-28 (12/67)

Plant Ideal Cement · Date 3-16-71

Sampling location Clinker Cooler

STACK DATA FOR NOMOGRAPH:

1. Meter ΔH 1.60 in H_2O
2. Avg. meter tempt (ambient + 20° 70 °F
3. Moisture (volume) 3 %
4. Avg. static press. ⊖ .75 in. H_2O X .073 = + .05 in. Hg.
5. Bar. press sampling point 30.23 in.Hg ± .05 (static press in.Hg) = ______ in. Hg.
6. Bar press of meter 30.23 in. Hg.
7. P_s/P_m = 5.______ in. Hg / 6.______ in. Hg = 1.0
8. Avg. stack temperature 110 °F.
9. Avg. stack velocity (ΔP) 1.12 in H_2O.

(1.5) C factor (1) .9 (2)______

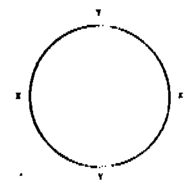
Probe Tip ~~.192~~ ~~.194~~ .189

TIME (24 HR. clock)	SAMPLE POINT	STACK TEMP. °F or °C	MANOM. READING IN. H_2O	VELOCITY HEAD IN. H_2O	VELOCITY ft./sec.
Top	1		1.2		
	2		1.4		
	3		1.2		
	4		1.1		
	5		1.1		
	6		1.2		
	7	105	1.2		
	8		1.1		
	9		1.3		
	10		1.5		
	11		1.7		
	12		1.5		
Middle	1		1.3		
	2		1.3		
	3		1.1		
	4		0.95		
	5		0.82		
	6		0.73		
	7		0.75		
	8		0.89		
	9		1.3		
	10		1.3		
	11		0.98		
	12		1.2		
Bottom	1		0.98		
	2		0.86		
	3		0.73		
	4		0.95		
	5		1.2		
	6	100°F	1.2		
	7		1.3		
	8		1.2		
	9		0.85		
	10		0.83		
	11		0.92		
	12		1.00		

(1.12)

Shutterstrip

Static P = 0.75



POINT	% DISTANCE FROM WALL	DISTANCE FROM WALL INCHES
1		
2		
3		
4		
5		
6		
7		
8		

Area Square ft. ______

Effluent Flow Rate, CFM ______

Effluent Flow Rate, SCFM ______

Operator______

.73
1.7

1.12

Clinker Cooler Dust Collector Duct
Ideal Cement, Seattle, Washington

Sampling Data — Date 3-18 → 3-19

Run	DAV	Pzz	Tzw	Vzc	Tzi	Pzf	Vzb
⊙1	.189	30.23	144	103.809	68.7	1.30	105.39
⊙2	.189	29.88	144	104.055	70.0	1.27	104.16
⊙3	.189	29.92	144	101.920	81.3	1.26	100.02

Moisture

Run	Vce	Vcf	Vcg	Mch	Mcz
1	12	.569	.54	.990	28.89
2	10	.474	.54	.990	28.89
3	8	.379	.38	.996	28.96

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAx
1	3,888	30.28	141	27.24	4006	95,556	105.8
2	3,888	29.93	121	26.29	3889	94,850	105.4
3	3,888	29.97	124	26.17	3864	94,450	101.6

Static press. .05 in. Hg.

PARTICULATE FIELD DATA

Plant: Ideal Cement (Seattle)
Run No.: 1
Location: Clinker Cooler
Date: 3-18-71
Operator: GEB/H.S
Sample Box No.:
Meter Box No.:
Meter ΔH: 1.60
C Factor: 0.9

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

PATHOLOGICAL INCINERATORS- read and record every 5 minutes.

Top
A
Exit ← B ← f2N
C

Start 1320

4 MIN/sampling point

Ambient Temp °F: 50
Bar. Press. "Hg: 30.23
Assumed Moisture %: 3
Heater Box Setting, °F: 250
Probe Tip Dia., In.: .186
Probe Length: 9-10
Probe Heater Setting: 110°
Avg. ΔP: 1.12
Avg.: 1.4

(1) Point	(6) Clock Time	(8) Dry Gas Meter, CF 088.700	(19) Pitot in. H_2O ΔP	Orifice ΔH in H_2O Desired	(59) Orifice ΔH in H_2O Actual	(35) Dry Gas Temp. °F Inlet	(43) Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	(51) Stack Press.	Stack Temp °F	(69) Dist.
A-1	0000	[illegible]	1.9	2.0	2.0	64	56	7.0	250		.05	170	71.
A-2	0004	092.185	1.6	1.36	1.35	74	56	4.0	250			170	65.
A-3	0008	095.35	0.95	0.87	0.87	74	56	2.0	250			170	59.
A-4	0012	097.70	0.95	0.87	0.87	74	57	2.0	250			160	53.
A-5	0016	[illegible]	1.19	1.0	1.00	78	58	3.0	250			152	47.
A-6	0020	102.70	1.10	1.05	1.05	76	58	3.0	245			150	41.
A-7	0024	105.57	1.50	1.52	1.52	78	58	5.0	245			145	35.
A-8	0028	108.41	1.10	1.07	1.07	80	58	4.0	240			145	29.
A-9	0032	110.18	1.40	1.47	1.47	80	58	4.5	240			140	23.
A-10	0036	114.15	1.65	1.71	1.71	82	59	6.5	255			140	17.
A-11	0040	117.54	1.80	1.96	1.96	85	59	7.0	255			140	11.
A-12	0044	120.93	1.60	1.73	1.73	88	59	5.9	255			140	5.
Stop 1406	48	124.300											
B-1 1419	0000	124.300	1.50	1.53	1.53	76	58	5.0	155			140	71.
B-2	0004	127.56	[illegible]	1.21	1.21	76	58	4.2	160			140	65.
B-3	0008	130.55	[illegible]	0.84	0.84	77	58	2.0	165		.05	140	59.

Automatic damper controls flow through duct from [illegible] bag-house area!

(+) Velocity continually changing at each point

Moisture gained 12 gms

Comment	Pt.	Clock Time	Dry Gas Meter, CF	Pitot in. H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Press in. Hg	Stack Temp °F	DIST.
clinker cooler No 1 Test	B-4	0012	133.00	0.75	0.73	0.73	75	58	1.0	175			140	53.
	B-5	0016	135.25	0.65	0.64	0.64	74	58	1.0	185			135	47.
	B-6	0020	137.40	0.70	0.69	0.69	72	58	1.0	190			135	41.
	B-7	0024	139.56	0.75	0.73	0.73	74	58	2.0	190			135	35.
	B-8	0028	141.80	0.85	0.85	0.85	74	58	2.2	200			135	29.
	B-9	0032	144.20	1.20	1.23	1.23	77	58	4.0	205			135	23.
	B-10	0036	147.03	1.60	1.78	1.78	80	59	6.0	210			135	17.
	B-11	0040	150.20	2.00	2.30	2.30	90	58	[illegible]	210			140	11.
	B-12	0044		2.00	2.30	2.30	94	59	8.8	210			140	5.
1501 Stop		48	157.923											
1516	C-1	0000	157.923	1.90	2.03	2.03	67	58	9.0	200			140	71.
	C-2	0004	160.40	1.50	1.52	1.52	82	59	5.2	200			140	65.
	C-3	0008	165.0	1.60	1.89	1.89	82	59	6.0	210			140	59.
	C-4	0012	167.93	1.50	1.52	1.52	85	59	5.5	210			140	53.
	C-5	0016	170.99	1.10	1.07	1.07	86	59	3.0	220			140	47.
	C-6	0020	173.75	1.05	0.99	0.99	92	57	3.0	220			140	41.
	C-7	0024	176.20	1.40	1.45	1.45	82	59	5.0	225			130	35.
	C-8	0028	179.34	1.20	1.21	1.21	84	60	4.0	225			130	29.
	C-9	0032	182.30	1.00	1.00	1.00	84	60	4.0	225			125	23.
	C-10	0036	185.00	0.90	0.89	0.89	80	60	2.5	225			130	17.
	C-11	0040	187.48	0.95	0.90	0.89	80	60	2.8	225			125	11.
	C-12	0044	190.95	0.95	0.98	0.98	80	60	2.5	225			120	5.
1604 end of run			192.509											
						1.30	79.1	58.4					141	
							68.17							

Sheet #1

NAPCA TRAIN DATA

CLIENT: APCO Ideal Cement Seattle
WO. #: 300-18
Bar P. = 29.88
LOCATION: Clinker cooler
DATE: 3/19/71
TEST #: 2
PERSONNEL: APS / LCS / BWS

Transferred to std. sheets 3/24/71

+ Velocity constantly changing due to auto damper

TIME 0914	POSITION	VELOCITY HEAD pitot	GAS METER READING	GAS METER TEMP IN	GAS METER TEMP OUT	ORIFICE HEAD Desired	STACK TEMP	HOTBOX TEMP	Orifice head Actual	VACUUM
0	C1	1.50 +	192.510	58	54	1.53	145	140	1.53	5.0
4	2	0.90 +	195.[illegible]	66	56	0.86	140	150	0.86	4.6
8	3	1.20 +	198.16	69	56	1.18	135	160	1.18	6.0
12	4	1.20 +	200.92	72	55	1.22	135	170	1.22	6.0
16	5	1.25 +	203.[illegible]	76	55	1.3[illegible]	120	180	1.3[illegible]	7.0
20	6	1.30 +	206.[illegible]	80	55	1.38	130	185	1.38	7.0
24	7	1.30 +	2[illegible].31	86	56	1.38	125	185	1.38	7.0
28	8	1.10 +	212.81	88	56	1.12	125	190	1.12	6.0
32	9	1.20 +	216.59	88	56	1.25	120	200	1.25	6.0
36	10	0.95 +	218.[illegible]	86	57	0.96	120	200	0.96	4.8
40	11	0.95 +	220.05	82	57	0.98	115	205	0.98	5.0
44	C 12	0.90 +	223.362	80	56	0.92	115	205	0.92	4.5
1002	Stop	—	226.146			—	—	—	—	
1010 0	B1	1.20 +	226.146	64	54	1.22	115	215	1.22	6.0
4	2	1.00 +	228.92	70	54	1.05	120	220	1.05	5.0
8	3	0.90 +	231.60	74	54	0.93	115	220	0.93	4.5
12	4	0.95 +	234.15	74	54	1.00	110	220	1.00	5.0
16	5	0.85 +	236.75	76	54	0.84	110	220	0.84	4.2
20	6	0.75	239.17	75	54	0.77	110	220	0.77	3.2
24	7	+ 0.90	241.57	74	54	0.95	110	220	0.95	5.0
28	8	+ 1.20	244.01	78	54	1.32	110	220	1.32	7.0
32	9	+ 1.20	246.93	83	55	1.32	110	225	1.32	7.0
36	10	+ 1.10	249.90	85	55	1.15	110	225	1.18	6.[illegible]
40	11	+ 1.10	252.76	88	56	1.18	110	225	1.18	6.[illegible]
44	B 12	+ 1.20	255.45	90	56	1.32	110	225	1.32	7.0
1058 47	Stop	—	258.55			—	—	—	—	
1114 0	A1	+ 1.20	258.559	66	57	1.32	110	225	1.32	6.9
4	2	+ 1.80	261.35	81	58	2.05	110	235	2.05	12.5
8	3	+ 1.50	264.90	92	58	1.75	110	245	1.75	10.0
12	4	+ 1.20	268.28	96	59	1.32	110	245	1.32	[illegible]
16	A 5	+ 1.50	271.28	96	60	1.75	115	245	1.75	9.0
AVERAGES										

C = 0.9

A
outlet N | K/n S
floor

Position #1 allow. wy in

SILICA GEL
SAMPLE NOZZLE SIZE
IMPINGER SOLUTION VOLUMES
STOP
START 2nd

moisture 10 gms

Sheet #2

NAPCA TRAIN DATA

CLIENT Apco Ideal Cement Seattle
WO. # 300-18
+ Velocity constantly changing.
Inlet / Back
U-Kiln [8] Kiln Stack

LOCATION Clinker cooler
DATE 3/11/71
TEST # 2
PERSONNEL LBB / LWJ / BWC
Probe

TIME	POSITION	VELOCITY HEAD pitot	GAS METER READING	GAS METER TEMP IN	GAS METER TEMP OUT	ORIFICE HEAD desired	STACK TEMP	HOTBOX TEMP	Orifice head Actual	Vacuum
20	A 6 +	1.55 +	274.67	100	60	1.69	120	240	1.69	9.5
24	7	1.20 +	277.82	100	60	1.23	125	240	1.23	6.5
28	8	1.20 +	280.79	96	60	1.23	130	240	1.23	6.5
32	9	1.40 +	283.62	97	60	1.50	135	240	1.50	7.5
36	10	1.50 +	286.68	99	60	1.60	135	240	1.60	8.5
40	11	1.80 +	289.80	102	61	1.98	140	240	1.98	10.5
44	A 12	1.50 +	293.33	106	62	1.58	140	240	1.58	9.0
1800 48	end	—	296.565	—	—	—	—			
144			104.055	83.1	56.6		121		1.27	
				70.						

FILTER # Paper was torn!
SILICA GEL #
SAMPLE NOZZLE SIZE
IMPINGER SOLUTION VOLUMES
STOP
START

Sheet #1

NAPCA TRAIN DATA

CLIENT APCO Ideal Cement Seattle
WO. # 300-18
Transferred to std. data sheets 4/22/71
Baro. P. 29.92 ↓
Reading at beginning of point - velocity changes constantly at each point

LOCATION Clinker cooler
DATE 3/19/71
TEST # 3 oper.
PERSONNEL LBB / LWJ / BWC
Probe
Vac.

TIME	POSITION	VELOCITY HEAD pitot	GAS METER READING	GAS METER TEMP IN	GAS METER TEMP OUT	ORIFICE HEAD desired	STACK TEMP	HOTBOX TEMP	Orifice Head Actual	Vac.
1422			713							
0	A 1	1.50	296.665	70	62	1.68	125	255	1.68	9.5
4	2	1.60	300.16	80	62	1.79	120	255	1.79	10.0
8	3	1.50	303.43	90	63	1.68	115	260	1.68	10
12	4	1.30	306.72	96	64	1.42	120	245	1.42	8
16	5	1.50	309.79	99	64	1.62	135	245	1.62	10
20	6	1.50	312.98	104	64	1.62	125	240	1.62	10
24	7	1.50	316.09	108	65	1.62	126	240	1.62	10
28	8	1.40	319.342	108	66	1.48	125	240	1.48	9
32	9	1.40	322.43	109	66	1.47	120	240	1.47	9
36	10	1.60	325.60	110	66	1.62	120	240	1.62	10
40	11	1.70	328.79	112	67	1.89	120	240	1.89	12.5
44	A 12	1.50	332.15	116	68	1.62	125	240	1.62	10
1510 48	end stop	—	335.462	116	68	—	—	—	—	—
1516 0	B 1	1.40	335.462	96	66	1.49	125	240	1.49	8.5
4	2	1.10	338.40	96	67	1.12	120	240	1.12	6
8	3	1.10	341.16	96	67	1.12	120	240	1.12	6
12	4	0.60	343.57	97	67	0.69	120	240	0.69	4
16	(0.75) 5	0.60	346.14	95	67	0.69	120	240	0.69	4
20	6	0.75	348.35	90	67	0.74	130	240	0.74	4.5
24	7	0.65	350.69	90	66	0.63	135	240	0.63	2.5
28	8	0.65	352.69	86	67	0.63	135	240	0.63	2.5
32	9	1.10	354.80	88	66	1.12	130	240	1.12	6
36	10	1.50	357.44	94	66	1.58	130	240	1.58	10
40	11	1.60	360.60	103	66	1.55	135	240	1.55	9
44	B 12	1.80	363.76	102	68	2.00	135	240	2.00	13
1604 48	Change	—	367.225	102	68	—	—	—	—	
1612 0	C 1	1.30	367.225	86	66	1.38	120	240	1.38	7
4	2	1.10	370.22	90	66	1.12	120	240	1.12	6
8	3	1.20	372.99	96	66	1.23	120	240	1.23	7
12	4	1.10	375.64	100	67	1.13	120	240	1.13	6
16	C 5	1.20	378.60	100	67	1.23	120	240	1.23	7

AVERAGES

Moisture - 8.0 gm

SILICA GEL #
SAMPLE NOZZLE SIZE 0.188
IMPINGER SOLUTION VOLUMES 200
STOP
START
Inlet Clinker Cooler

Sheet #2

NAPCA TRAIN DATA

CLIENT Apco - Ideal Cement Seattle
WO. # 300-18

LOCATION Clinker cooler
DATE 3/19/71
TEST # 3 oper.
PERSONNEL LBB / BWC / LWJ
Probe

TIME	POSITION	VELOCITY HEAD	GAS METER READING	GAS METER TEMP IN	GAS METER TEMP OUT	ORIFICE HEAD desired	STACK TEMP	HOTBOX TEMP	Orifice Head actual	Vacuum
20	C 6	0.93	381.44	98	67	0.92	120	240	0.92	4.5
24	7	1.10	383.96	97	66	1.12	120	240	1.12	6
28	8	1.10	386.66	99	67	1.12	125	240	1.12	6
32	9	0.80	389.38	99	67	0.79	125	240	0.79	4
36	0.45 10	0.48	391.71	94	67	0.44	125	240	0.44	1
40	11	1.38		94	68	1.23	125	240	1.23	7
44	12	0.85	396.29	97	67	0.80	125	240	0.83	4
1701 48	end	—	398.633	—	—	—	—	—	—	
144			101.920	96.5	66.06		124.		1.26	
				81.3						

Clinker Cooler Dust Collector Duct
Ideal Cement, Seattle, Washington

Sampling Data — Date 3-18 3-19

Run	DAY	Paa	Taw	Yac	Tai	Paf	Yab
1	.189	30.23	144	103.809	68.7	1.30	105.39
2	.189	29.88	144	104.055	70.0	1.27	104.16
3	.189	29.92	144	101.920	81.3	1.26	100.02

Moisture

Run	Vce	Vcf	Vcg	Mch	Mca
1	12	.564	.54	.990	28.89
2	10	.474	.54	.990	28.89
3	8	.379	.38	.996	28.96

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAX
1	3,888	30.28	141	27.24	4006	95,556	105.8
2	3,888	29.93	121	26.29	3889	94,850	105.4
3	3,888	29.97	124	26.17	3864	94,450	101.6

Static press. 0.5 in. Hg.

PRELIMINARY FIELD DATA

Stack Geometry

Plant *Ideal Cement Seattle*

Test No. ____________

Location *Kiln Stack*

Date ____________

A. Dist. from inside of far wall to outside of near wall, in., = *208*

B. Wall thickness, in., = *13"*

Inside diameter of stack = A-B *195"*

Stack Area = ____________

Comments: *A = .785 (d^2)*

195

Sketch of stack cross-section showing sampling holes

Calculations:

Point	% Dia. for circular stack	Dist. from outside of sample port, in.
1	4.4	8.6 +13 = 21 5/8
2	14.7	28.7 = 41 3/4
3	29.5	57.5 = 70 1/2
4	70.5	137.5 = 150 1/2
5	85.3	166.3 = 179 3/8
6	95.6	186.4 - 199 3/8

Calculator ____________

NCAP-28 (12/67)

Plant *Ideal Cement* Date *3-24-71*

Sampling location *Kiln Stack Train No 2*

STACK DATA FOR NOMOGRAPH:

1. Meter ΔH *1.78* in H_2O
2. Avg. meter tempt (ambient *30* + 20° *50* °F
3. Moisture (volume) *30* %
4. Avg. static press. ± ____ in. H_2OX.073 = + *.02* in. Hg.
5. Bar. press sampling point *29.70* in.Hg + *29.72* (static press in.Hg) = ____ in. Hg.
6. Bar press of meter *29.70* in. Hg.
7. P_s/P_m = $\frac{5.\_\_\_\_ \text{ in. Hg}}{6.\_\_\_\_ \text{ in. Hg}}$ = *1.0*
8. Avg. stack temperature *500* °F.
9. Avg. stack velocity (ΔP) *.071* in H_2O.

   C factor (1) *.58* (2) ____________

Plant *Ideal Cement* Date *3-24-71*

Sampling location *Kiln Stack Train No. 1*

STACK DATA FOR NOMOGRAPH:

1. Meter ΔH *1.24* in H_2O
2. Avg. meter tempt (ambient *30* + 20° *50* °F
3. Moisture (volume) *30* %
4. Avg. static press. ± *.3* in. H_2OX.073 = + *.02* in. Hg.
5. Bar. press sampling point *29.70* in.Hg ⊕ *.02* (static press in.Hg) = *29.72* in. Hg.
6. Bar press of meter *29.70* in. Hg.
7. P_s/P_m = $\frac{5.\_\_\_\_ \text{ in. Hg}}{6.\_\_\_\_ \text{ in. Hg}}$ = *1.0*
8. Avg. stack temperature *500* °F.
9. Avg. stack velocity (ΔP) *.071* in H_2O.

   C factor (1) *.42* (2) ____________

Kiln Stack, Seattle, Ideal Cement Train No. 1

Sampling Data

Run	DAY	Pzz	Tzw	VAC	Tzi	Pzf	Vzb
1	0.50	29.79	60	38.802	57	1.23	39.694
2	.50						
3	[illegible]						

Moisture

Run	Vce	Vcf	Vcg	Mch	Mbj	Mca
1	347	16.45	29.3	.71	31.04	27.26
2						
3						

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAX
1	29,850	29.81	542	9.03	1378	106,869.	93.8
2							
3							

Static press. - .02 in Hg.
Note - Train No. 1, Run 1 was operating at the same time as Train No. 2, Run 1; each being 180° ports away!
3-24-71 11:30 reading CO_2 - 17% O_2 - 8%

Kiln Stack, Ideal Cement, Seattle Train No. 2

Sampling Data

Run	DAY	Pzz	Tzw	VAC	TAi	Pzf	VAb
1	.50	29.79	60	35.394	51	1.72	36.677
2	.50	"					
3	.50						

Moisture

Run	Vce	Vcf	Vcg	Mch	Mbj	Mca
1	356	16.87	31.5	.69	31.04	27.00
2						
3						

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAX
1	29,850	29.81	545	9.05	1388	104300.	88.8
2							
3							

Static press. - .02 in Hg.
Note - Train No. 1, Run 1 was operating at the same time as Train No. 2, Run 1; each being 180° ports away!
3-24-71 11:30 reading CO_2 - 17% O_2 - 8%

Run No. 1-6 (B)
Location Kiln Stack
Date 3-17-71
Operator [illegible]
Sample Box No.
Meter Box No.
Meter Δ H 1.60
C Factor .52

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

PATHOLOGICAL INCINERATORS-
read and record every 5 minutes.

Ambient Temp °F 45
Bar. Press. "Hg 30.22
Assumed Moisture % 30
Heater Box Setting, °F 250
Probe Tip Dia., In. .500
Probe Length 8 ft
Probe Heater Setting 70
Avg. Δ P .07 Avg. [illegible] 1.32

Point	Clock Time	Dry Gas Meter, CF	Pitot in. H_2O ΔP	Orifice ΔH in. H_2O Desired	Orifice ΔH Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Press In. Hg	Stack Temp °F
N-1		500.896		1.85	1.85	60	62	4	110			515
2		506.2	.05	1.51	1.51	61	59	3	120			
3		508.765										
1												
2												
3		7.87										
1												
2												
3												
1												
2												
3												

Abort due to probe being too cold

No. 1 Filter tare weight 0.1931 g (one filter used)

Plant Ideal, Seattle
Run No. One
Location Kiln Stack
Date start 3/23/71 restart 3/24/71
Operator
Sample Box No.
Meter Box No.
Meter Δ H 1.24
Factor

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

PATHOLOGICAL INCINERATORS-
read and record every 5 minutes

start ~1025 3-23
restart ~1130 3-24

Moisture Total - 347 gms

Ambient Temp °F 50
Bar. Press. "Hg 29.79
Assumed Moisture % 30
Heater Box Setting, °F
Probe Tip Dia., In. 0.50
Probe Length
Probe Heater Setting

(1) Point	(6) Clock Time	(11) Dry Gas Meter, CF	(19) Pitot in. H_2O ΔP	Orifice ΔH Desired	(27) Orifice ΔH Actual	(35) Dry Gas Temp. Inlet	(43) Dry Gas Temp. Outlet	Pump Vacuum (X)	Box Temp (X)	Impinger Temp	(51) Stack Press in. Hg	(59) Stack Temp °F	(60) Dist. from Outside of Sample Port, in.
E-1	0	511.208	.08	1.20	1.20	58	58	10	250		.02	5[illegible]	21.6
E-2	5	514.603	.09	1.33	1.33	50	50	6	260		.02	550	41.7
E-3	10	518.02	.06	0.90	0.90	54	54	7	190	Box temp [illegible]	.02	540	70.5
~~[illegible]~~	~~15~~	~~521.00~~											
N-3	0	521.00	.06	0.90	0.90	57	56	8	190	[illegible] temp	.02	530	70.5
N-2	5	523.68	.10	1.48	1.48	58	56	11	220		.02	540	41.7
N-1	10	527.09	.09	1.33	1.33	57	57	10	185		.02	510	21.6
~~[illegible]~~	~~15~~	~~530.51~~							230			540	
W-1	0	530.51	.08	1.2	1.2	56	56	11	220		.02	540	21.6
W-2	5	533.78	.07	1.05	1.05	53	53	11	250		.02	545	41.7
W-3	10	536.84	.06	0.90	0.90	59	59	8	230		.02	541	70.5
~~[illegible]~~	~~15~~	~~539.70~~											
S-3	0	539.70	.10	1.48	[illegible]	58	58	16	240		.02	550	41.7
S-2	5	543.31	.07	1.05	[illegible]	61	60	10	210		.02	549	70.5
S-1	10	546.39	.13	1.91	1.90	60	60	10	215		.02	550	21.6
~~[illegible]~~	9999	550.01											

Had to shut down twice at N-2 due to trouble with train #2 — hot box temp dropped, water condensed - finally changed filter

Comments: *Sheet lost, data reconstituted

(17/67) 38.802

530 − 200 = 330
330 + 17 = 347

Run One
Kiln stack

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

PATHOLOGICAL INCINERATORS-
read and record every 5 minutes.

after 2'25" shut down on No. 2-3 changed filter. Was saturated w/ H_2O. Hot box heating to only 250-265 max.

Orsat 17% CO_2
8% O_2
at 11:30 A.M.

Moisture Total - 356

Ambient Temp °F 50
Bar. Press. "Hg 29.79
Assumed Moisture %
Heater Box Setting, °F
Probe Tip Dia., In. 0.50
Probe Length
Probe Heater Setting

Operator
Sample Box No.
Meter Box No.
Meter Δ H 1.70
Factor

(1) Point	(6) Clock Time	(11) Dry Gas Meter, CF	(19) Pitot ΔP	~~Orifice ΔH Desired~~	(27) Orifice ΔH Actual	(35) Dry Gas Temp. Inlet	(43) Dry Gas Temp. Outlet	~~Pump Vacuum~~	~~Box Temp~~	Impinger Temp	(51) Stack Press	(59) Stack Temp	(60) Dist. from Outside of Sample Port, in.
W-1	0	246.164	.16	3.2	3.2	51	51	16	250		.02	555	21.6
W-3	5	249.5	.08	1.68	1.66	41	42	7	260		.0565	566	70.5
W-2	10	252.4	.10	2.00	2.00	49	49	12	215		.02	560	41.7
S-3	15	255.698	.04	.83	.83	50	51	5	150			510	70.5
S-2	20	257.815	.09	1.85	1.85	51	52	6.5	250			550	41.7
S-1	25	260.340	.07	1.45	1.45	50	51	5.0	240			550	21.6
E-1	30	263.130	.10	2.00	2.00	50	50	2.0	280			550	21.6
E-2	35	266.357	.08	1.61	1.68	51	53	2.0	270			555	41.7
E-3	40	269.343	.05	1.04	1.04	52	53	6.0	265			552	70.5
N-2	45	271.7	.07	1.65	1.65	52	53	9.0	265			552	41.7
N-3	50	274.815	.05	1.04	1.04	52	52	6.0	250			510	70.5
N-1	55	277.45	.10	2.00	2.00	52	52	11.0	2[illegible]		.02	565	21.6
	9999	280.568											

35.802 — two filters weighed together & total tare must be subtracted 545 − 200 = 345

345 + 11 = 356. two filters used

Filter tare weight 1st 0.1964 2nd 0.1946 analyzed by Howard erist

Kiln Stack = , Seattle, Ideal Cement Train No. 1

Sampling Data

Run	DAY	Paa	Tzw	VAC	Tz1	Paf	Vab
1	0.50	29.79	60	38.802	57	1.23	39.694
2	.500						
3	.[illegible]						

Moisture

Run	Vce	Vcf	Vcg	Mch	Mbj	Mca
1	347	16.45	29.3	.71	31.04	27.26
2						
3						

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAX
1	29,850	29.81	542	9.03	1378	106,869.	93.8
2							
3			460				
			1002				

Static press. -.02 in Hg.

Note - Train No. 1, Run 1 was operating at the same time as Train No. 2, Run 1, each being 180° ports away!

3-24-71 11:30 reading CO_2 - 17% O_2 - 8%

analyzed by RFW

Kiln Stack, Ideal Cement, Seattle Train No. 2

Sampling Data

Run	DAV	Paa	Taw	VAC	TAi	Paf	VAb
1	.50	29.79	60	35,394	51	1.72	36,677
2	.50	[illegible]					
3	.50						

Moisture

Run	Vce	Vcf	Vcg	Mch	Mbj	Mca
1	356	16.87	31.5	.69	31.04	27.00
2						
3						

Velocity and Calculation Data

Run	Sdd	Pdi	Tdf	Sde	Vdh	Vdb	IAX
1	29,850	29.81	545	9.05	1388	104,300.	88.8
2							
3							

Static press. - .02 in Hg.
Note- Train No. 1, Run 1 was operating at the same time as Train No. 2, Run 1; each being 180° ports away!
3-24-71 11:30 reading CO_2 - 17% O_2 - 8%

FTS-206-583-0111

PRESURVEY - PROCESS INDUSTRY & POWER PLANTS

NAME OF COMPANY Ideal Cement DATE OF PRESURVEY 2-18-71

ADDRESS 5400 West Marginal Way CITY Seattle STATE Washington

NAME OF CONTACT ~~Jack~~ Fred Bauer TITLE Plant Mgr PHONE 937-8025

PROVIDE FLOW DIAGRAM OF EACH PROCESS TO BE SAMPLED, INCLUDING FEED COMPOSITIONS AND RATES, OPERATING TEMPERATURES AND PRESSURES, PRODUCT RATES, AND PROPOSED SAMPLING SITES:

Process - wet
Kiln fuel - natural gas
Single kiln - yes

Kiln data	temperature	% Moisture	CFM
at stack port	400°F	30-40	40,000
Clinker cooler	~~200-300~~ 180°	3-~~5~~ 2-3	150,000
mill operation	250°	3-5	30,000 50,000

COMMENTS: Plant Capacity - 7200 bbl/day ; 2.6 MM BBL/year

PROVIDE DIAGRAM OF EACH SAMPLING SITE. INCLUDE THE FOLLOWING INFORMATION:

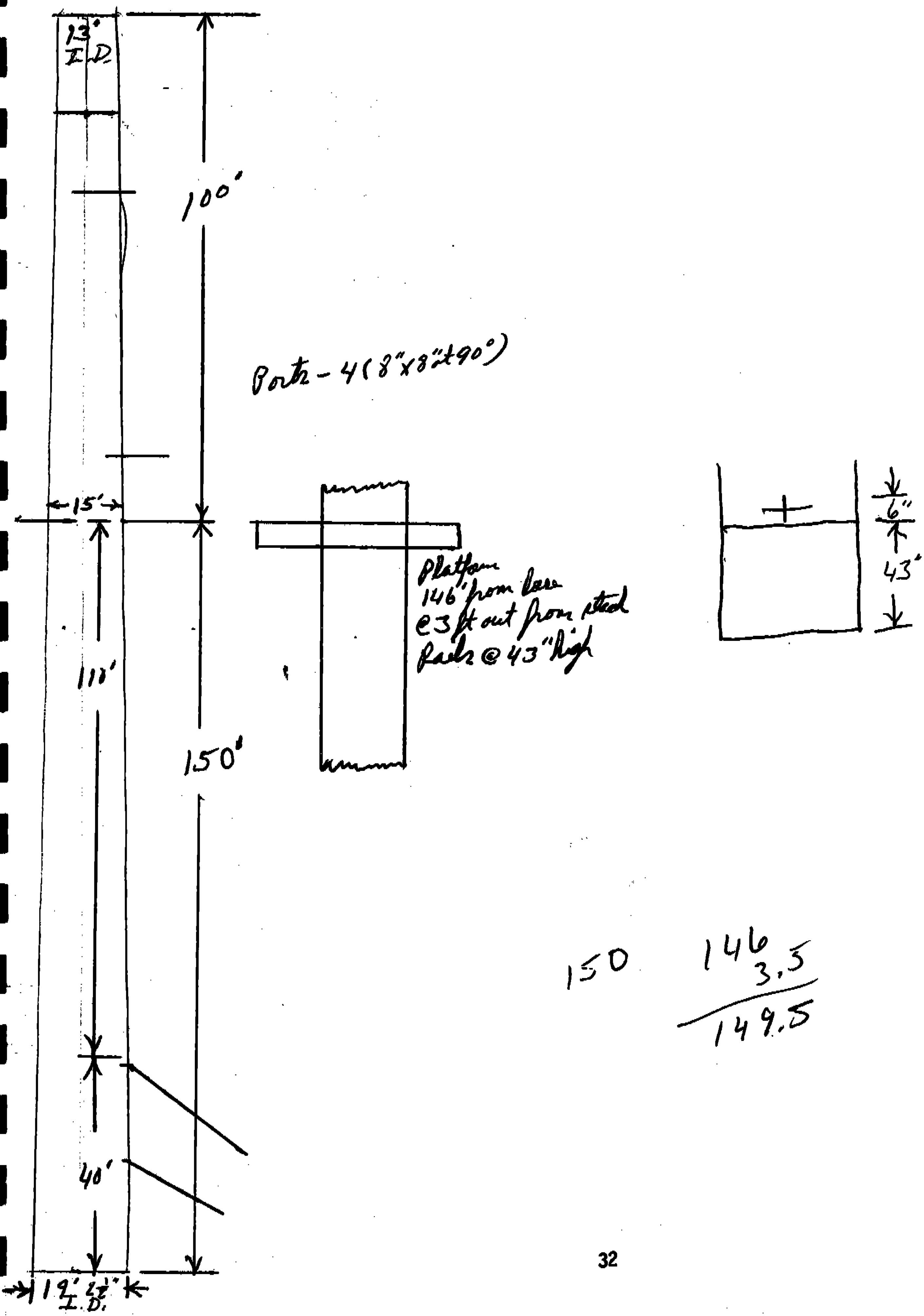
DIMENSIONS TO NEAREST OBSTRUCTION IN ALL DIRECTIONS FROM SAMPLING PORT.

COMPLETE DESCRIPTION OF ALL PORTS INCLUDING ALL DIMENSIONS. DESCRIPTION OF ANY UNUSUAL FEATURES ABOUT ENVIRONMENT; HEIGHT, ODORS, TOXIC CONDITIONS, TEMPERATURE, DUST, ETC.

Inside plant environment - excellent
Outside environment - stack etc. lots of rain!

No ports exist except on kiln stack (see drawing).

Kiln stack



13' I.D.
100'
Ports - 4 (8"x8" @ 90°)
15'
Platform 146' from base @ 3 ft out from stack Rails @ 43" high
6"
43"
111'
150'
40'
19' 2½" I.D.
150
146
3.5
149.5

OPERATING HOURS OF PLANT PERSONNEL 24 hrs./day 7 days/week

OPERATING SCHEDULE FOR EACH PROCESS TO BE SAMPLED same

ARE PROCESSES BATCH OR CONTINUOUS? Continuous

LIST FEED RATES AND COMPOSITION FOR EACH PROCESS

LIST ANY CONTROL EQUIPMENT, INCLUDING SIZE Kiln ESP unit (3 stages); Clinker cooler baghouse; ~~Mill~~ Finish mill baghouses

LIST EXPECTED CONSTITUENTS OF STACK GAS FOR EACH SAMPLING SITE NO_x, particulate

Kiln STACK DATA: HEIGHT 250 WIDTH 19'-13' DIAMETER I.D 19'-13'

O.D. AMOUNT OF INSULATION WALL THICKNESS 24" @

MATERIAL OF CONSTRUCTION Concrete GAS TEMPERATURE @ 400°F

PRESSURE 4-6 in. H_2O WET BULB TEMPERATURE ?

AVERAGE PITOT TUBE READING

DISTANCE TO NEAREST UPSTREAM RESTRICTION 100' TYPE OF RESTRICTION top

DISTANCE TO NEAREST DOWNSTREAM RESTRICTION 110' TYPE OF RESTRICTION entrance duct

ARE PORTS EXISTING? [X] YES, SIZE 8"x8"

[ ] ~~NO, WHO WILL PROVIDE THEM?~~

SCAFFOLDING OR OTHER MEANS OF SUPPORT PRESENT?

☑ YES

☑ NO, WHO WILL PROVIDE IT? plant

SOURCE OF ELECTRICITY AVAILABLE? ☑ YES, MAXIMUM AMPERAGE PER CIRCUIT 20

☐ NO

DISTANCE 150-200 WHO WILL PROVIDE EXTENSION CORDS? contractor & plant

LOCATION OF FUSE BOX

PARKING FACILITIES AVAILABLE FOR TRAILER OR VAN? yes

SIGNATURE REQUIRED ON PASSES? no WAIVERS?

NEARBY RESTAURANTS AND MOTELS lunch - Andy's (@ 2 miles) Vending machine

Motels - Holiday Inn No. 1 Seattle; 206 762 0300

Cheaper → Max - Lyn WE 7-9920

LIST ANY SPECIAL SAFETY EQUIPMENT OR RULES Hard hats

SURVEY BY C. E. Riley

COMMENTS:

Plant is in excellent condition. Plant personnel seems very interested in our testing and want to cooperate to the fullest extent.

Note - No ice available on plant site!

APPENDIX D

LABORATORY PROCEDURES

The following is a detailed outline of the laboratory procedure used in determining the weights of particulates and water collected in the various segments of the EPA-OAP sampling train.

All glassware used for evaporation and residue determinations in the following steps was prepared for use by the following procedure. The beakers were first soaked in 40% nitric acid for several hours. They were then washed and rinsed with distilled water followed by oven-drying. After drying, the beakers were desiccated to constant weight and kept in a desiccator until used. Beakers were weighed to ± 0.1 mg.

A. Filter

1.) Preparation

The filters are oven-dried @ 105°C for a minimum of four hours, and then desiccated to constant weight. Filters are weighed to ± 0.1 mg. After weighing, the filters are placed in plastic petri dishes until used.

2.) Particulate weight determination

Filter and any loose particulate matter are transferred to a tared glass weighing dish, and desiccated to constant weight. The weight gain is then recorded.

B. Acetone washings prior to filter

1.) The acetone washings are received in glass bottles and their volume is measured. They are then transferred to the tared beakers prepared as described above.

2.) The acetone washings are allowed to evaporate to dryness at ambient temperature and pressure. The beakers are covered with ribbed cover glasses to facilitate evaporation without allowing dust or other foreign matter into the beakers. When dry, the beakers are desiccated to constant weight. Beakers are weighed to nearest 0.1 mg.

3.) A blank of the acetone (measured amount) is evaporated also as described above. Any residue resulting from this blank is used to correct for the amount of acetone used in the washings. The net weight is the required particulate residue.

C. Impinger water plus water rinsings

1.) The volume of impinger water has been measured in the field and recorded. Final volumes of these samples are measured in the laboratory in order to determine the volume of washings used and to correct for this water using a blank (by the same procedure used in part B-3 above).

2.) At this point an organic extraction of the impinger water is in order. However, this step was omitted since no organic material was considered present.

D. Acetone washings - back

1.) The volume of acetone washings is first measured and then the liquid is transferred to tared beakers (prepared as above) and allowed to evaporate to dryness at ambient temperature and pressure. Upon drying, the beakers are desiccated to constant weight. A blank of the acetone used is also evaporated any corrections due to the acetone are made if necessary. Beakers are weighed to nearest 0.1 mg.

E. Silica gel

1.) Preparation

The silica gel is placed in a wide mouth plastic bottle and capped. The bottle plus silica gel is then weighed to the nearest 0.1 gm.

2.) After sampling, the bottle plus used silica gel is weighed to the nearest 0.1 gm and the weight of water collected is determined.

Results of the sample recovery procedure are presented in Table D-1 wherein total particulate weights are reported for each run. These values were obtained by adding the weights of the probe, cyclone, filter and impinger catches.

An emission spectroscopy analysis was conducted on the particulate samples collected from each stack to determine the concentrations (μg/g) of the following elements: Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sr, V, and Zn. The results of these tests are presented in Table D - 2. In general, of the components tested for, iron was present in the highest proportion (reaching concentrations as high as 3.3%), followed by zinc, strontium and lead.

TABLE D - 1

RESULTS OF SAMPLE RECOVERY PROCEDURE

Description of Sample		Clinker Cooler Run 1	Clinker Cooler Run 2	Clinker Cooler Run 3	Kiln Stack Run 1*	Kiln Stack Run 2
1. Filter	RFW #	1419	1423	1427	----	1430
	Filter #	F56	F65	F67	----	----
	Net wt. gm.	0.0077	0.0297	0.0197	0.159	0.1643
2. Probe, Flask Cyclone Front half Filter holder — Acetone Wash	RFW #	1417	1422	1426	----	1429
	Beaker #	117	122	119	----	110
	Net wt. gm	0.3433	.3569	0.4336	0.082	0.0892
Total (1,2)		351.0	386.0	453.3	241	253.5
3. Impinger H_2O + H_2O wash Imp, conn. back 1/2 filter holder	RFW #	1416	1420	1424	----	Note: Impinger water lost in transit. Value assumed to be that for Run# 1
	Beaker #					
	Net wt. (-blank) gms.	0.0153	0.0047	0.0031	0.021	0.021
4. Impingers, Connectors back 1/2 filter holder — Acetone wash	RFW #	1418	1421	1425	----	1428
	Beaker #	124	104	105	----	111
	Net wt. gm.	0.0080	0.0093	0.0063	----	0.0073
Blanks H_2O	RFW #	1414	1415		----	
	Beaker #	121	120		----	
	Net wt. gm.	0.0024	0.0025	----	0.0023	----
	Sample Volume ml.	420	435		500	
Total Particulates, mg (obtained by adding weights 1,2,3,and 4)		374.3	400.6	462.7	262	281.8

* See TABLE D - 1 (Continued)

TABLE D - 1 (Continued)
ENVIRONMENTAL PROTECTION AGENCY

Reply to Attn of: ETB, DAT   Run #1   *Date:* April 20, 1971

Subject: Particulate Analysis of Samples Collected at Ideal Cement, Seattle, Washington.

To: Gene Riley

Sample	Particulate, Mg	Location
Impinger water	21	Kiln stack
Probe, cyclone, flask & filter holder	82	
Filter	159	
Total	262	
Water blank (Seattle)	2.3 Mg/500 ml	
Water blank (Tijeris)	2.1 Mg/500 ml	

The sample results reflect correction for the blank. The above sample was one of a pair of samples collected simultaneously by Roy Weston Company. They are analyzing the companion sample for comparison with the above results.

Howard Crist

Howard L. Crist
Chemist
Emission Testing Branch
Division of Applied Technology

TABLE D - 2

RESULTS OF EMISSION SPECTROSCOPY ANALYSIS

Sample type	Particulate	Particulate
Sample location and run No.	Clinker Cooler Run # 1	Kiln Run # 1
Sample weight, mg	374.3	262.0
Volume of gas sampled, scf	105.39	39.69
	Concentration, μg/g	
Sb	100	< 110
As	< 192	< 276
Be	2	2
Cd	40	170
Cr	850	100
Cu	500	200
Fe	33,000	15,000
Pb	300	4,000
Mn	400	200
Ni	500	200
Sr	2,000	< 276
V	< 4	60
Zn	4,000	8,000

APPENDIX E

SAMPLE CALCULATIONS

Example: Run No. 1 on Clinker Cooker (for data, see Table 3, page 9)

1. Volume of dry gas sampled at standard conditions: 70°F, 29.92 in. Hg, SCF

$$V_{m_{std}} = \frac{17.7 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)} = \frac{17.7 \times 103.81\left(30.23 + \frac{1.30}{13.6}\right)}{(68.7 + 460)} = 105.39 \text{ SCF}$$

2. Volume of water vapor at 70°F and 29.92 in. Hg, SCF

$$V_{w_{gas}} = 0.0474 \times V_w = 0.0474 \times 12 = 0.57 \text{ SCF}$$

3. Percent moisture in stack gas

$$\% M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}} = \frac{100 \times 0.57}{105.39 + 0.57} = 0.54$$

4. Mole fraction of dry gas

$$M_d = \frac{100 - \%M}{100} = \frac{100 - 0.54}{100} = 0.99$$

5. Average molecular weight of dry stack gas

$$MW_d = \left(\%CO_2 \times \frac{44}{100}\right) + \left(\%O_2 \times \frac{32}{100}\right) + \left[(\%CO + \%N_2) \times \frac{28}{100}\right] =$$

$$\left(0.03 \times \frac{44}{100}\right) + \left(20.95 \times \frac{32}{100}\right) + \left(78 \times \frac{28}{100}\right) = 29.0$$

6. Molecular weight of stack gas

$$MW = MW_d \times M_d + 18\,(1 - M_d) = 29.0 \times 0.99 + 18\,(1 - .99) = 28.9$$

7. Stack gas velocity at stack conditions, fpm

$$V_s = 4{,}360 \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2} =$$

$$4{,}360 \times 27.2 \left[\frac{1}{30.28 \times 28.9}\right]^{1/2} = 4012 \text{ fpm}$$

SAMPLE CALCULATIONS, RUN NO. 1, CLINKER COOLER(Continued)

8. Stack gas volumetric flow rate at standard conditions*, SCFM

$$Q_s = \frac{0.123 \times V_s \times A_s \times M_d \times P_s}{(T_s + 460)} = \frac{0.123 \times 4012 \times 3888 \times 0.99 \times 30.28}{(141 + 460)} = 95{,}699 \text{ SCFM}$$

9. Stack gas volumetric flow rate at stack conditions, ACFM

$$Q_a = \frac{.05645 \times Q_s \times (T_s + 460)}{P_s \times M_d} = \frac{.05645 \times 95{,}699 \times (141 + 460)}{30.28 \times 0.99} = 108{,}307 \text{ ACFM}$$

10. Percent isokinetic

$$\%I = \frac{1{,}032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2} = \frac{1{,}032 \times (141 + 460) \times 105.39}{4012 \times 144 \times 30.28 \times 0.99 \times (0.189)^2} = 105.7\%$$

11. Particulate: probe, cyclone and filter, gr/SCF* Dry Basis

$$C_{an} = 0.0154 \times \frac{m_f}{V_{m_{std}}} = 0.0154 \times \frac{351.0}{105.39} = 0.0513 \text{ gr/SCF}$$

12. Particulate total, gr/SCF* Dry Basis

$$C_{ao} = 0.0154 \times \frac{m_t}{V_{m_{std}}} = 0.0154 \times \frac{374.3}{105.39} = 0.0547 \text{ gr/SCF}$$

13. Particulate: probe, cyclone and filter, gr/CF at stack conditions

$$C_{at} = \frac{17.7 \times C_{an} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0513 \times 30.28 \times 0.99}{(141 + 460)} = 0.0453 \text{ gr/CF}$$

14. Particulate: total, gr/CF at stack conditions

$$C_{au} = \frac{17.7 \times C_{ao} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0547 \times 30.28 \times 0.99}{(141 + 460)} = 0.0483 \text{ gr/CF}$$

15. Particulate: probe, cyclone, and filter, lb/hr

$$C_{aw} = 0.00857 \times C_{an} \times Q_s = 0.00857 \times 0.0513 \times 95{,}699 = 42.0 \text{ lb/hr}$$

16. Particulate: total, lb/hr

$$C_{ax} = 0.00857 \times C_{ao} \times Q_s = 0.00857 \times 0.0547 \times 95{,}699 = 44.8 \text{ lb/hr}$$

17. Particulate: probe, cyclone, and filter, lb/ton feed

$$P_{tf} = \frac{C_{aw}}{T_c} = \frac{42.0}{103.4} = 0.406 \text{ lb/ton feed}$$

18. Particulate: total, lb/ton

$$P_{tt} = \frac{C_{ax}}{T_c} = \frac{44.8}{103.4} = 0.433 \text{ lb/ton feed}$$

* 70°F, 29.92 in. Hg

APPENDIX F

TEST LOG

Table F - 1 presents the actual time during which sampling was conducted.

Table F - 1

Sampling Log

(Clinker Cooler)

Run	Date	Sampling Port	Began	Ended	Elapsed Time (min)
1	3-18-71	A	13:20	14:08	48
		B	14:19	15:07	48
		C	15:16	16:04	48
2	3-19-72	C	09:14	10:02	48
		B	10:10	10:58	48
		A	11:14	12:02	48
3	3-19-71	A	14:22	15:10	48
		B	15:16	16:04	48
		C	16:13	17:01	48
		(Kiln Stack)			
1	3-23-71	E	10:25	10:30	5
1(cont.)	3-24-71	E	10:50	11:00	10
		N	12:30	12:40	10
		N	12:50	12:55	5
		W	14:00	14:05	5
		W	14:15	14:25	10
		S	16:00	16:10	10
		S	16:20	16:25	5

TABLE F - 1 (Continued)

Run	Date	Sampling Port	Began	Ended	Elapsed Time (min)
2	3-23-71	W	10:25	10:30	5
2(cont.)	3-24-71	W	10:50	11:00	10
		S	12:30	12:40	10
		S	12:50	12:55	5
		E	14:00	14:05	5
		E	14:15	14:25	10
		N	16:00	16:10	10
		N	16:20	16:25	5