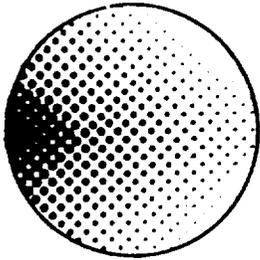


Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources*. AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

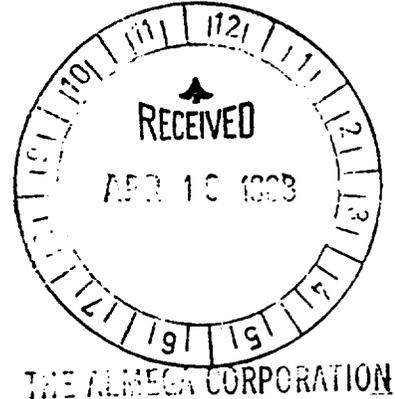


Chattanooga – Hamilton County Air Pollution Control Bureau

3511 Rossville Boulevard • Chattanooga, Tennessee 37407 • (615) 867-4321

Reference #25

April 14, 1988



Mr. Bernard Jackson
The Almega Corporation
607C Country Club Drive
Bensenville, Illinois 60106

Reference: Chattanooga-Hamilton County Hospital Authority
Stack Test of March 23, 1988

Dear Mr. Jackson:

In regard to our telephone conversation of April 11, 1988,
enclosed are copies of the following:

- 1) Chain of Custody Form
- 2) Run #1 Sample Analysis

If I can be of further assistance, please contact me at
867-4321.

Sincerely,

James J. Weyler
Associate Engineer

JJW/fg

Enclosures

Test performed on Chattanooga-Hamilton County Hospital Authority's North Basic Model 1250 incinerator by Almega Inc. on March 23, 1958. The test was observed by Jim Weyler.

Probe Wash - 250 ml
Run 1

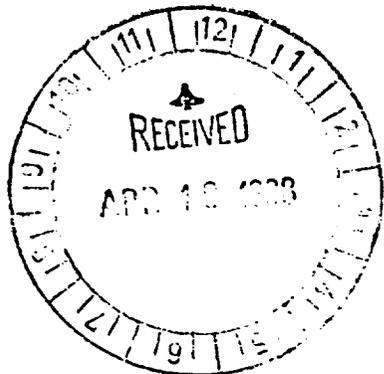
Final Wt. 107.9438 gms
Initial Wt. 107.9309 gms
Difference 0.0129 gms

Filter # 359

Final Wt. 0.6226 gms
Initial Wt. 0.6235 * gms
Difference -0.0009 gms

Acetone Blank - 100 ml

Final Wt. 67.6487 gms
Initial Wt. 67.6484 gms
Difference 0.0003 gms



THE ALMEGA CORPORATION

* negative difference probably due to loss of filter material, filter was torn on edges.

CHAIN OF CUSTODY FORM

Plant Chattanooga - Hamilton County Hospital Authority Source NORTH Basin Model 1250 Incinerator
Date Sampled 2/22/88 Test # 1 Run # 1

SAMPLE RECOVERY

Container #	Description (if filter, then give filter #)
<u>Filter 259</u>	<u>259</u>
<u>Plu Run 1</u>	<u>prob. blank</u>
<u>acetone blank</u>	<u>acetone blank</u>

Person Engaged in Sample Recovery:

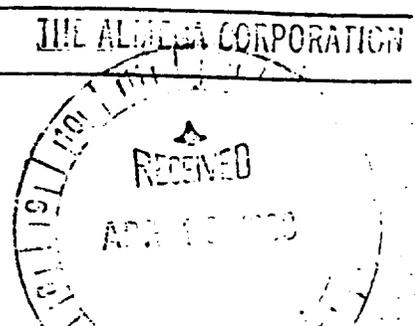
Signature and Title [Signature] TESTER
Recovery Location ON SITE
Date & Time of Recovery AFTER TEST

Sample(s) Recipient, upon Recovery if not Recovery Person

Signature [Signature]
Date & Time of Receipt 2/22/88 6:45 PM
Sample Storage automobile

Laboratory Person Receiving Sample

Signature & Title D. Nancy Pui
Date & Time of Receipt 3-24-88 8:06 a.m.
Sample Storage Lab Hood



The ALMEGA CORPORATION

607 C Country Club Drive
Bensenville, Illinois 60106
Phone: (312) 595-0175

ERLANGER MEDICAL CENTER
BASIC MODEL 1250
INCINERATOR AND BAGHOUSE
NORTH UNIT
STACK EMISSION TESTING
MARCH 23 AND 24, 1988
THE ALMEGA CORPORATION PROJECT I-6299

PREPARED FOR:

Campbell & Associates
701 East Fourth Street
Chattanooga, Tennessee 37403

THE ALMEGA CORPORATION

607 C Country Club Drive
Bensenville, Illinois 60106
Phone: (312) 595-0175

April 13, 1988

Campbell & Associates
701 East Fourth Street
Chattanooga, Tennessee 37403

Attention: Mr. John F. Germ, P.E.
President

Subject: Erlanger Medical Center
Basic Model 1250
Incinerator and Baghouse
North Unit
Stack Emission Testing
March 23 and 24, 1988
The Almega Corporation Project I-6299

Gentlemen:

INTRODUCTION

A series of stack emission tests were conducted on Erlanger's North Unit, Basic Model 1250 incinerator and dry lime injector baghouse at the Erlanger Medical Center in Chattanooga, Tennessee on March 23 and 24, 1988.

Stack emission test methods followed those detailed in Title 40: Code of Federal Regulations (Title 40: CFR) (Ref. 1) as required by Chattanooga-Hamilton County Air Pollution Control Bureau (CHCAPCB).

Emission testing was conducted by L. Damasius and E. Aynsley, Ph.D. of The Almega Corporation using an Andersen Samplers EPA Method 5 style sampling train. Visible emissions observations were made by Mr. B. W. Jackson, a certified opacity reader.

Purpose of this test series was to determine degree of compliance with particulate and visible emission codes and to measure hydrogen chloride and chlorine emissions for a chamber temperature of not less than 1800°F as required by CHCAPCB: this was repeated the next day at a chamber temperature of 2000°F as required by Erlanger and additional carbon monoxide and nitrogen oxide emission testing included.

Representatives of Erlanger Medical Center, Allied Mechanical, BACT Engineering, Basic Environmental, Campbell & Associates and Mr. Jim Weyler of CHCAPCB were present during the tests.

The ALMEGA CORPORATION

Campbell & Associates
Page Two

This report summarizes the test methods, procedures and findings of the two-day test series. Attached as appendices is a complete documentation of all test procedures, field test and laboratory analysis data, calculation summaries and equipment calibrations.

SUMMARY OF TEST METHODS

Emission testing of the baghouse exhaust stack associated with the north incinerator unit at the Erlanger Medical Center in Chattanooga, Tennessee was conducted on March 23 and 24, 1988.

This baghouse is a BACT Engineering, Inc. dry lime injection baghouse retrofitted in the Basic 1250 incinerator at the Erlanger Medical Center.

A complete description of the incinerator and test purpose and program is included in Appendix A as detailed in the related project correspondence.

Emission testing was conducted using an Andersen Samplers, Inc. USEPA Method 5 sampling train following the procedural requirements as detailed in Title 40: Code of Federal Regulations (Ref. 1).

Testing was conducted using the two ports at rooftop level set into this 23 $\frac{1}{4}$ inch I.D. stack exhausting the dry lime injection baghouse.

The selection and location of the sampling points for this stack test followed Method 1 (Ref. 1) included in Appendix B. This test location is some 14 ft. 6 in. up (7.48 diameters) this stack. Consequently, testing was conducted for 5 minutes at each of 12 points, six points on each of two diameters.

The gas velocity was determined using an S type pitot tube and followed Method 2 (Ref. 1) included in Appendix C.

Integrated exhaust gas Orsat samples were taken following Method 3 (Ref. 1) included in Appendix D for determination of CO₂, O₂ and molecular weight.

The exhaust gas moisture was determined following Method 4 (Ref. 1) included in Appendix E.

Particulate concentration and emission rate was determined following Method 5 (Ref. 1) included in Appendix F. The gas velocity, moisture determination and Orsat sampling were conducted simultaneously with the particulate emission testing.

The particulate catch included the front-half nozzle, probe, pre-filter glassware washings and filter particulates as detailed in Method 5.

The ALMEGA CORPORATION

Campbell & Associates
Page Three

Hydrogen chloride and chlorine were determined by replacing the water in the impingers of the above Method 5 train with a solution of 0.5N sodium arsenite + 2.5N sodium hydroxide.

A Pyrex glass-lined stainless steel sampling probe and 5/16 inch I.D. nominal stainless steel sampling nozzle was used for all the above combination particulate, HCl and chlorine sampling tests which were one hour test repetitions.

Nitrogen oxide sampling was requested on the first day of testing, March 23: the equipment was shipped to the site; arriving that night and used the next day. Specifically, four, two-liter grab NO_x samples were taken following Method 7 (Ref. 1) included in Appendix H.

Visible emissions observations were made by a certified visual emissions observer following Method 9 (Ref. 1) included in Appendix I.

Carbon monoxide concentrations were determined on the integrated Orsat gas samples for all runs following Method 10 (Ref. 1) included in Appendix J as requested on the first test day.

The following test schedule was followed:

Tuesday 22 March

Test personnel on-site and set up: no testing

Wednesday 23 March

Conduct four complete test repetitions for all parameters (except NO_x) at 1800°F combustion temperature.

Thursday 24 March

Conduct two only complete test repetitions for all parameters, including NO_x, at 2000°F combustion temperature.

SUMMARY OF TEST FINDINGS

Findings of this test series are summarized in Tables 1 and 2 for the March 23 and 24 test series respectively.

The related field test data, calculations and laboratory analyses and calibrations are included in the listed Appendices:

Appendix

Content

K	Permit Special Conditions, Emissions Pre-Test Agreement, March 23, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO ₂ Correction Factor Calculations
---	--

THE ALMEGA CORPORATION

Campbell & Associates
Page Four

<u>Appendix</u>	<u>Content</u>
L	March 24, 1988, Runs 5 and 6, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO ₂ Correction Factor Calculations
M	March 23 and 24, 1988, Runs 1 to 6, Hydrogen Chloride and Chlorine Laboratory Analyses and Calculations
N	March 24, 1988, Runs 5 and 6, Nitrogen Oxide Sampling and Analysis Data and Calculations and all CO Analysis Data
O	March 23 and 24, 1988, Opacity Observations and Certifications
P	Incinerator Operational Details and Including Charging Schedule, Primary and Secondary Stage Temperatures, Incinerator Logs and Gas Consumption
Q	Detailed Incinerator Description, Residence Time and Reynolds Numbers, Calculations and Turbulent Flow Determination
R	Equipment Calibrations

The calculated residence times and Reynolds Numbers for the turbulent flow determination, detailed in Appendix Q, are summarized below for the four zones:

<u>Zone</u>	<u>Residence Time</u> Seconds	<u>Reynolds No.</u>
A	0.15	36900
B	0.65	45300
C	0.283	57200
D	<u>1.01</u>	51000
Total: 2.098		

Turbulent flow conditions exist at Reynolds Nos. greater than 3000.

CONCLUSION

A series of stack emission tests were performed on the North Incinerator Unit and recently installed dry lime injection baghouse at Erlanger Medical Center in Chattanooga, Tennessee on March 23 and 24, 1988.

THE ALMEGA CORPORATION

Campbell & Associates
Page Five

Emission testing followed EPA methods as detailed in 40: CFR (Ref. 1) as required by CHCAPCB.

This report summarizes the test methods, procedures and findings of this test series: attached as Appendices A thru R is a complete documentation of test protocol, procedures, field test and laboratory analysis data, calculations and incinerator operational details.

The Almega Corporation is pleased to have been of service.

Respectfully submitted,

THE ALMEGA CORPORATION

Eric Aynsley ²

Eric Aynsley, Ph.D.
President

EA:dml

Enclosures

THE ALMEGA CORPORATION

SUMMARY OF EMISSION TEST DATA

TABLE:	1			
PLANT:	Erlanger Medical Center, Chattanooga, Tennessee			
LOCATION:	North Incinerator Stack			
OPERATORS:	L. Damasius, B. W. Jackson and E. Aynsley, Ph.D.			
TEST DATE:	March 23, 1988			
REPETITION #:	1	2	3	4
TEST TIME:	10:46-11:52AM	12:50-1:53PM	2:25-3:30PM	5:30-6:36PM
<u>STACK GAS</u>				
Temperature, average °F	182.3	184.2	191.9	190.4
Velocity average fps	41.25	41.74	42.33	41.44
Volume flow x 10 ⁶ scfh db acfm	0.3221 7,296	0.3275 7,382	0.3270 7,487	0.3204 7,329
Orsat % CO ₂	4.4	4.3	4.3	4.4
% O ₂	15.3	14.0	15.1	15.2
CO ₂ % from gas*	1.411	1.745	1.411	1.986
CO ₂ correction factor* *see Appendix K	4.015	4.697	4.154	4.971
Moisture %	9.71	8.97	9.34	9.48
<u>PARTICULATE SAMPLE</u>				
Time, mins.	60	60	60	60
Volume scf db	55.154	58.300	58.712	56.389
Particulates collected, mg.				
Filter	0	7.25	13.35	8.95
Washings	12.9	6.45	5.8	8.7
Total	12.9	13.70	19.15	17.65
Isokinetic Ratio, I%	93.34	97.02	97.87	95.95
<u>INCINERATOR FEED lbs/test</u>	1,737	1,309	1,324	1,074
<u>PARTICULATE</u>				
Concentration grains/dscf as measured	0.003609	0.003628	0.005033	0.004830
corrected to 12% CO ₂	0.01449	0.01703	0.02091	0.02401
Emissions lbs/hr	0.1661	0.1697	0.2352	0.2211
<u>HYDROGEN CHLORIDE</u>				
Concentration ppm	367.2	175.5	426.4	143.4
Emissions lbs/hr	11.21	5.446	13.22	4.354
<u>CHLORINE</u>				
Concentration ppm	All none detected: less than 0.6			
Emissions lbs/hr	All none detected: less than 0.02			
<u>OPACITY %</u>				
Range	0 to 0	0 to 0	0 to 0	0 to 0
Average	0	0	0	0
<u>CARBON MONOXIDE</u>				
Concentration ppm	8	7	4	5

THE ALMEGA CORPORATION

SUMMARY OF EMISSION TEST DATA

TABLE:	2	
PLANT:	Erlanger Medical Center, Chattanooga, Tennessee	
LOCATION:	North Incinerator Stack	
OPERATORS:	L. Damasius, B. W. Jackson and E. Aynsley, Ph.D.	
TEST DATE:	March 24, 1988	
REPETITION #:	5	6
TEST TIME:	11:55AM-1:02PM	1:10PM-2:12PM
<u>STACK GAS</u>		
Temperature, average °F	191.0	184.6
Velocity average fps	46.30	47.28
Volume flow x 10 ⁶ scfh db acfm	0.354	0.366
Orsat % CO ₂	8.189	8.363
% O ₂	4.6	4.0
CO ₂ % from gas*	13.6	15.05
CO ₂ correction factor*	2.529	1.986
*see Appendix K	5.794	5.701
Moisture %	9.82	9.61
<u>PARTICULATE SAMPLE</u>		
Time, mins.	60	60
Volume scf db	64.820	65.985
Particulates collected, mg.		
Filter	4.95	12.0
Washings	8.1	1.8
Total	13.05	13.8
Isokinetic Ratio, I%	99.79	98.24
<u>INCINERATOR FEED</u> lbs/test	1,172	1,058
<u>PARTICULATE</u>		
Concentration grains/dscf as measured	0.003107	0.003227
corrected to 12% CO ₂	0.01800	0.01840
Emissions lbs/hr	0.1572	0.1689
<u>HYDROGEN CHLORIDE</u>		
Concentration ppm	633.0	801.0
Emissions lbs/hr	21.25	27.81
<u>CHLORINE</u>		
Concentration ppm	None detected: less than 0.55	
Emissions lbs/hr	None detected: less than 0.018	
<u>OPACITY %</u>		
Range	0 to 0	0 to 0
Average	0	0
<u>CARBON MONOXIDE</u>		
Concentration ppm	15	50
<u>NITROGEN OXIDES</u> as NO ₂		
Concentration ppm	67.3	93.3
	96.8	102.8
	85.1	79.10
	114.4	98.09
Average:	90.9	93.3
Emissions lbs/hr	2.844	4.076
	4.090	4.493
	3.598	3.458
	4.837	4.288
Average:	3.842	4.079

NOx only
measured
during
test: 5 + 6

THE ALMEGA CORPORATION

REFERENCE

- 1 Title 40: Code of Federal Regulations

APPENDICES

- A Project Description and Related Correspondence
- B Method 1 -- Sample and Velocity Traverses for Stationary Sources
- C Method 2 -- Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
- D Method 3 -- Gas Analysis for Carbon Dioxide, Excess Air and Dry Molecular Weight
- E Method 4 -- Determination of Moisture Content in Stack Gases
- F Method 5 -- Determination of Particulate Emissions from Stationary Sources
- G Determination of Chlorine and Hydrochloric Acid in Stack Gas - Texas Air Control Board Method
- H Method 7 -- Determination of Nitrogen Oxide Emissions from Stationary Sources
- I Method 9 -- Visual Determination of the Opacity of Emissions from Stationary Sources
- J Method 10 -- Determination of Carbon Monoxide Emissions from Stationary Sources
- K Permit Special Conditions, Emissions Pre-Test Agreement, March 23, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO₂ Correction Factor Calculations
- L March 24, 1988, Runs 5 and 6, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO₂ Correction Factor Calculations

THE ALMEGA CORPORATION

APPENDICES

- M March 23 and 24, 1988, Runs 1 to 6, Hydrogen Chloride and Chlorine Laboratory Analyses and Calculations
- N March 24, 1988, Runs 5 and 6, Nitrogen Oxide Sampling and Analysis data and Calculations and all CO Analysis Data
- O March 23 and 24, 1988, Opacity Observations and Certifications
- P Incinerator Operational Details and Including Charging Schedule, Primary and Secondary Stage Temperatures, Incinerator Logs and Gas Consumption
- Q Detailed Incinerator Description, Residence Time and Reynolds Numbers, Calculations and Turbulent Flow Determination
- R Equipment Calibrations

The ALMEGA CORPORATION

APPENDIX A

PROJECT DESCRIPTION AND RELATED CORRESPONDENCE



CAMPBELL &
ASSOCIATES, INC.
CONSULTING ENGINEERS

701 EAST FOURTH STREET
CHATTANOOGA, TN 37403
615-267-9718

JOHN F. GERM, P.E.
PRESIDENT
PAUL R. MITCHELL, P.E.
SENIOR VICE PRESIDENT
FRED E. KEITH, P.E.
VICE PRESIDENT-SECRETARY
RONALD G. SHUTTLE, P.E.
VICE PRESIDENT
WYLIE W. GROSS, JR.
VICE PRESIDENT

January 30, 1987

Mr. Eric Aynsley Ph.D., President
The Almega Corporation
607-C Country Club Drive
Bensenville, Illinois 60106

Dear Dr. Aynsley:

Our client Erlanger Medical Center is in the process of upgrading their two Basic Environmental Engineering Model 1250 incinerators and heat recovery system to burn hospital normal, infectious, hazardous and pathological waste. Your firm tested these incinerators in January 1984 and issued your report indicating compliance with these original contract documents.

The incinerator must meet the following conditions while destroying pathological waste:

- (a) Not to exceed .08 grains per dry standard cubic foot of filterable particulate matter emission; and
- (b) Not to exceed 0.1 pounds of filterable particulate matter emission per 100 pounds of material charged into any Basic Model 1250 incinerator; and
- (c) Not to cause, suffer, allow on permit a visible emission; and
- (d) To maintain a minimum temperature of 1800⁰F in the secondary chamber (Step II) at all times during operation except during start-up and shut-down of the equipment as long as no uncombusted materials (other than clean-burning wood) are present in the primary chamber; and
- (e) To provide for a minimum residence time of one (1) second for the gas streams in the secondary (Stage II) chambers.

The following methods and procedures shall be employed in determining compliance with emission limitations.

- (1) Sample and Velocity Traverses for Stationary Sources, EPA test reference method 1 (Title 40, Code of Federal Regulations, Part 60, Appendix A - July 1, 1985).
- (2) Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube), EPA test reference method 2 (Title 40, Code of Federal Regulations, Part 60, Appendix A - July 1, 1985).

Page 2

Mr. Eric Aynsley Ph.D. President
The Almega Corp.
January 30, 1987

- (3) Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight, EPA test reference method 3 (Title 40, Code of Federal Regulations, Part 60, Appendix A - July 1, 1985).
- (4) Determination of Particulate Emissions from Stationary Sources, EPA test reference method 5 (Title 40, Code of federal Regulations, Part 60, Appendix A - July 1, 1985).
- (5) Visual Determination of the Opacity of Emissions from Stationary Sources, EPA test reference method 9 (Title 40, Code of Federal Regulations, Part 60, Appendix A - July 1, 1985), and the provisions of Section 4-25, Rule 7.4, the Ordinance, shall supplant the said averaging provisions for the purposes of determining compliance with Paragraph (c) above.

The bureau is also requesting thirty (30) day written notice prior to conducting of any test to demonstrate compliance. It is anticipated the design will be complete by April 16, with construction to be completed April 1, 1988 and testing started on April 11, 1988.

We would like to ascertain your interest in performing the compliance test in accordance with the above criteria and procedures. If you are interested we would request you provide us with a written proposal for your services.

We would appreciate hearing from you at your earliest convenience. Should you have any questions please do not hesitate to contact me.

Very truly yours,



John F. Germ, P. E.
CAMPBELL & ASSOCIATES, INC.

JG/lc

THE ALMEGA CORPORATION

607 C Country Club Drive
Bensenville, Illinois 60106
Phone: (312) 595-0175

February 5, 1987

Campbell & Associates, Inc.
701 East Fourth Street
Chattanooga, Tennessee 37403

Attention: Mr. John Germ, P.E.

Subject: Erlanger Basic Incinerator
Stack Particulate and Other Emission Tests
Budget Estimates
The Almega Corporation Proposal #P87-109

Gentlemen:

INTRODUCTION

This proposal is submitted in response to your recent request and will serve to confirm and elaborate upon our recent discussions.

The purpose of this proposal is to detail a particulate and other possible stack emissions evaluation test to be conducted on the outlet of the new Basic pathological incinerator located at the Erlanger Medical Center in Chattanooga, Tennessee.

Included with this proposal are sections covering proposed test program, required facilities, guarantee, time and cost estimates and related experience in stack and air pollution control equipment collector efficiency testing.

PROPOSED PROGRAM

It is proposed to collect emissions from the effluent gas of the incinerator following a test protocol promulgated and approved by USEPA and Chattanooga-Hamilton County Air Pollution Control Bureau to determine particulate emissions and hydrogen chloride if required.

The following exhaust gas data will be determined at the stack:

temperature °F
velocity fps
moisture % vol/vol
volume flow acfm and scfh db
Orsat CO₂, O₂ and N₂ % vol/vol
total particulate concentration grains/scf and corrected
to 12% CO₂
total particulate emission rate lb/hr

THE ALMEGA CORPORATION

Campbell & Associates, Inc.
Page Two

The following USEPA (Ref. 1) methods will be followed:

<u>Method #</u>	<u>Title</u>
1	Sample and Velocity Traverses for Stationary Sources
2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
3	Gas Analysis for Carbon Dioxide, Excess Air and Dry Molecular Weight
4	Determination of Moisture in Stack Gases Approximate Method
5	Determination of Particulate Emissions from Stationary Sources
9	Visual Determination of the Opacity of Emissions from Stationary Sources

It should be noted that:

- (1) Hydrogen chloride and chlorine emissions can be determined by absorption and reaction in alkaline sodium arsenite solution in the back-half of the Method 5 train. This method follows that published in Texas Air Control Board's Sampling Procedures Manual, Revised July 1985.
- (2) Method 5 particulate emissions as measured in grains/dry standard cubic foot (grains/dscf) will be corrected to 12% CO₂ as required for comparison with applicable codes. This correction factor requires allowance be made for the contribution of CO₂ from the auxiliary natural gas fuel. The most accurate way of performing this allowance is to know exactly the volume of gas fired during each test: this requires installation of a dedicated gas meter in the gas line to the incinerator.
- (3) A certified observer will be used for the Method 9 opacity observations.
- (4) In the event Chattanooga-Hamilton County APCB require demonstration of pathogen destruction this can also be included. It is suggested that the general procedures of Barbeito (Ref. 2 and 3) be used. Specifically vials of *Bacillus subtilis* var. *niger* (*globigii*) are placed in the primary chamber on the waste prior to incineration.

Stack exhaust gas samples will be taken following the USEPA Method 5 procedure for particulates using a separate sampling train. This train is necessary since:

THE ALMEGA CORPORATION

Campbell & Associates, Inc.
Page Three

- (1) the above Method 5 particulate train operation, clean up, recovery and analysis procedures are not compatible with this spore
- (2) the hivol train used by Barbeito will most probably burn up as a result of the anticipated high stack exhaust gas temperatures of this incinerator
- (3) a water cooled glass lined probe will be used to quench the gas sample otherwise the collected material will be subjected to the high temperatures of the flue gas for the duration of the test

In order to determine spore destruction efficiency a known number of spores in 1% agar will be diluted with water and applied to the waste charge prior to incineration. Spores collected in the probe and on the filter of the Method 5 train will be recovered in water. The total number will be determined by incubation and counting.

At the conclusion of the test series a report will be submitted. This report will summarize the test methods and findings of the test series. Attached as appendices will be a complete documentation of all test and analytical methods, field data, and calculation summaries.

It is our policy that this report is the property of the sponsoring client. The Almega Corporation will not supply any information to any other parties without the prior written approval of the sponsoring client.

REQUIRED FACILITIES

Certain facilities are required to be made available to conduct this test series. It is understood that the client will make these available. These facilities include:

1. Incinerator operation throughout the test series.
2. Incinerator operational details and burning rates throughout the test series.
3. Provide suitable stack sampling locations, sampling ports and scaffolding. Specifically two four inch diameter holes, set at 90° to each other will have to be cut into the stack to be tested. A sketch is attached to this proposal.
4. Provide electric power (110 volts AC) domestic type outlet near to the stack sampling location.
5. Install a dedicated gas meter in the gas line to the incinerator.

The ALMEGA CORPORATION

Campbell & Associates, Inc.
Page Four

6. A supply of cooling water at the stack test location for the water cooled probe of the spore sampling train.
7. Provision of radios for communication between the incinerator and stack test location if this is deemed necessary.
8. Access and close parking for one vehicle during the testing.

GUARANTEE

For a complete formal, agency witnessed, stack emission compliance test The Almega Corporation guarantees that the test as conducted and detailed in the final report will be acceptable in format to the appropriate agencies. It is, however, the responsibility of the sponsoring client to:

- (i) notify appropriate agency personnel of the proposed tests,
- (ii) obtain agency approval of the proposed test methods before the tests, and
- (iii) invite agency personnel to witness the tests

The necessity of informing regulatory personnel prior to the tests and obtaining approval of the test methods cannot be over emphasized. In the event that unapproved emission tests are performed or not witnessed and the data shows compliance with applicable codes then regulatory personnel may not accept the data.

Additional assistance may be provided by Almega if requested to prepare detailed test protocols which may be required by the CHCAPCB.

TIME AND COST ESTIMATES

This test program can normally be scheduled within two weeks of receipt of authorization to proceed depending upon schedules at that time. It is understood testing is tentatively scheduled for April 1988.

Test personnel will arrive on-site the day prior to testing to set up, install and check out test equipment for the test the following day. The complete three repetition test series will be conducted over typically eight to ten hours of continuous plant operations the next day.

Typical budget estimate costs to conduct this test series, as detailed above, and submit the final report are detailed below:

The ALMEGA CORPORATION

Campbell & Associates, Inc.
Page Five.

Particulate, Methods 1, 2, 3, 4 & 5.....	\$2,750.00
HCl, Texas ACB Method, add-on.....	\$ 500.00
Opacity, Method 9.....	\$ 550.00
Biological destruction.....	approximately \$2,500.00

The above costs include all equipment set-up and calibration, travel and subsistence, field testing, laboratory analysis, data reduction, preparation and submission of three copies of the final report.

The final report will be available within typically two to three weeks of completion of on-site testing depending on subsequent analysis required.

Additional time needed for test protocol development or due to plant schedules or breakdowns will be charged additionally.

No charge is made for bad weather delays.

Terms are net 30 days.

Certificates of contractor liability and workman's compensation insurance are available upon request. A copy of Almega's Stack Testing, Standard Terms and Conditions is attached and is made a part of this proposal.

PREVIOUS EXPERIENCE

The Almega Corporation is based in Bensenville next to Chicago's O'Hare Airport and specializes in providing industrial and governmental clients services in the areas of stack emission and air sampling, monitoring and analysis.

Currently we have offices in the Philadelphia-New Jersey and New Orleans areas and also representatives in Washington, D.C., Indianapolis and Little Rock.

Almega's staff have had a wide variety of experience in stack emission testing and efficiency testing of air pollution control equipment over the last twenty years: testing services have and are currently being performed for clients both nationwide and at other locations in Europe, the Middle East and the Far East.

THE ALMEGA CORPORATION

Campbell & Associates, Inc.
Page Six

Typical services offered and experience gained include:

- . Stack emission sampling for both compliance and emissions optimization for a full spectrum of contaminants varying from particulates through all inorganic species to total hydrocarbons and individual species ranging to total organic chlorides, PCB and dioxins.
- . Air pollution control equipment efficiency testing for problem definition studies to equipment specification and acceptance testing.
- . OSHA in-plant air contaminant surveys for determination of employee exposures and TLV determinations.
- . Ambient air monitoring projects for the usual particulates, sulfur oxides, etc. through to more recent monitoring of air toxics.
- . Air dispersion modelling for determination of downwind ground level concentrations and more recently plume impact studies.

CONCLUSION

Based upon more than a decade of intensive experience in incinerator air contaminant, stack emission and air pollution control equipment collector efficiency testing we are confident a highly successful and timely project will be conducted.

References can be supplied upon request.

In the event you should have any further questions please feel free to call.

Respectfully submitted,

THE ALMEGA CORPORATION

Eric Aynsley ^{SA}

Eric Aynsley, Ph.D.
President

EA:dml

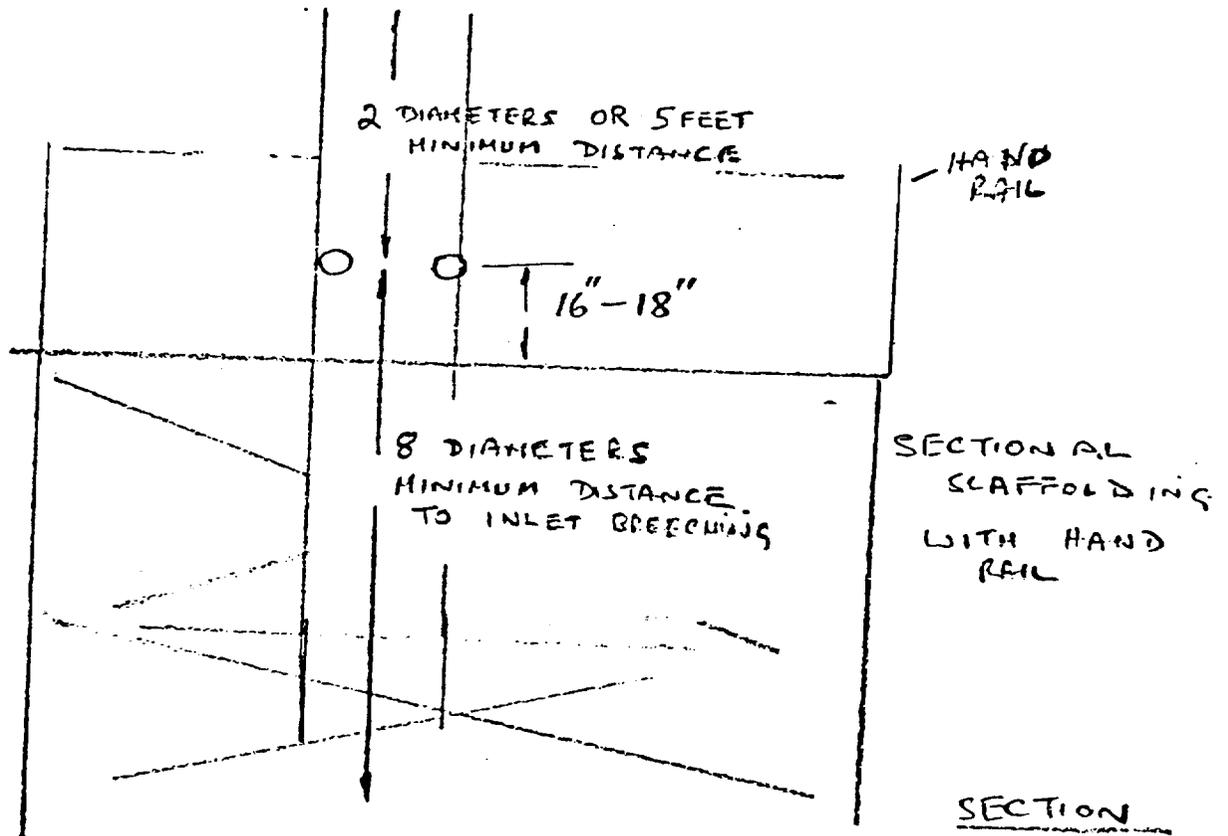
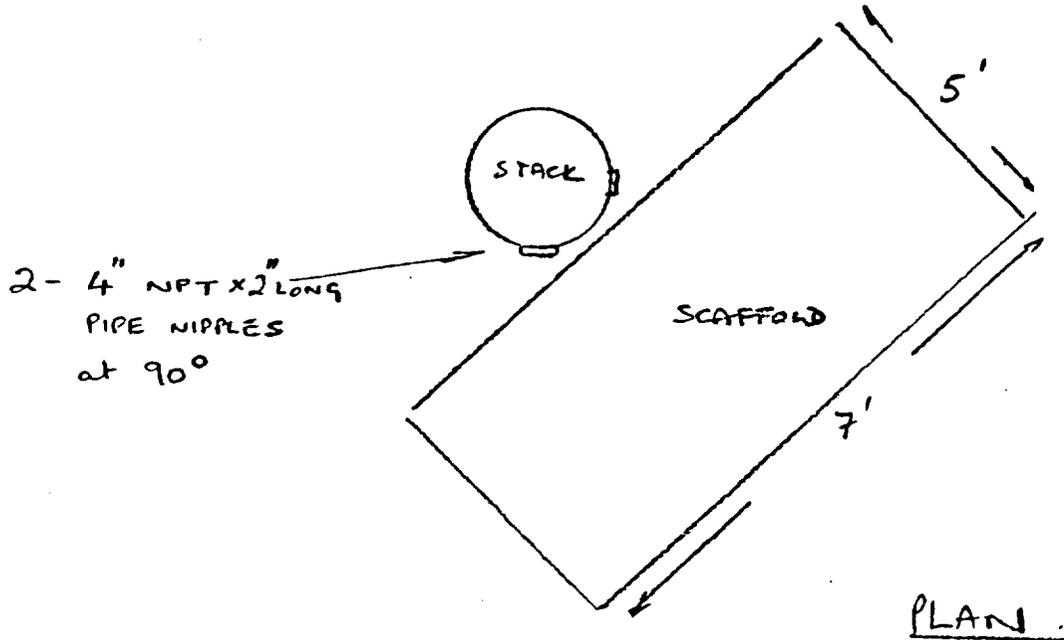
Enclosures

References:

1. Title 40: Code of Federal Regulations
2. Barbeito M.S. et al J. app. Microbiology 16 - 490-495 - 1968
3. Barbeito M.S. et al J. med. Primatol 6 - 264-273 - 1977

The ALMEGA CORPORATION

SCHEMATIC OF STACK SAMPLING LOCATION



DETERMINATION OF CHLORINE AND HYDROCHLORIC ACID IN STACK GAS

SOLUTIONS AND REAGENTS:

1. Distilled-deionized water (DI H₂O Chloride Free)
2. Alkaline arsenite solution
(1.0 N NaOH + 0.1N NaAsO₂: Dissolve 40 grams of NaOH and 6.5 gm NaAsO₂ in DI H₂O and dilute to 1000 ml with DI H₂O)
3. Alkaline arsenite solution
(2.5 N NaOH and 0.5 N NaAsO₂: Dissolve 100 gm of NaOH and 32.5 gm of NaAsO₂ in DI H₂O and dilute to 1000 ml with DI H₂O)
4. Ferris alum indicator
(Dissolve 28.0 gm of ferric ammonium sulfate FeNH₄(SO₄)₂·12 H₂O in 70 ml of hot DI H₂O. Cool and filter. Add 10 ml of concentrated HNO₃ and dilute to 100 ml with DI H₂O)
5. Nitric acid 8.0 N
(Add 100 ml of concentrated HNO₃ to 100 ml of DI H₂O. Boil until colorless and store in a glass bottle)
6. Silver Nitrate solution 0.1N*
(Dissolve 17.0 gm of AgNO₃ in water and dilute to 1000 ml. Store in an amber bottle. Standardize this against 0.1N NaCl solution using Volhard)
7. Ammonium Thiocyanate 0.1N*
(Dissolve 8 gm of NH₄CNS in DI H₂O and dilute to 1000 ml with DI H₂O. Standardize this against the AgNO₃ solution using Volhard)
8. Sodium Chloride 0.1N*
(Dissolve 5.846 gm of dried NaCl in DI H₂O and dilute to 1000 ml with DI H₂O)
9. Reagent Nitrogenzene
10. Starch solution (I₂ indicator):
Make a paste of 1 gm soluble starch in cold water. Dilute to 100 ml with boiling water.
11. Standard iodine solution
(Dissolve 12.69 gm of reagent grade I₂ crystals in 25 gm of iodate free KI and 100 ml with DI H₂O. When completely in solution, dilute to 1000 ml with DI H₂O. Store in an amber bottle)
12. Sodium bicarbonate (Reagent grade NaHCO₃)

* 0.01 -- Normal solutions may need to be prepared for HCl and Cl₂ concentrations of less than 1000 ppm.

Sampling Train:

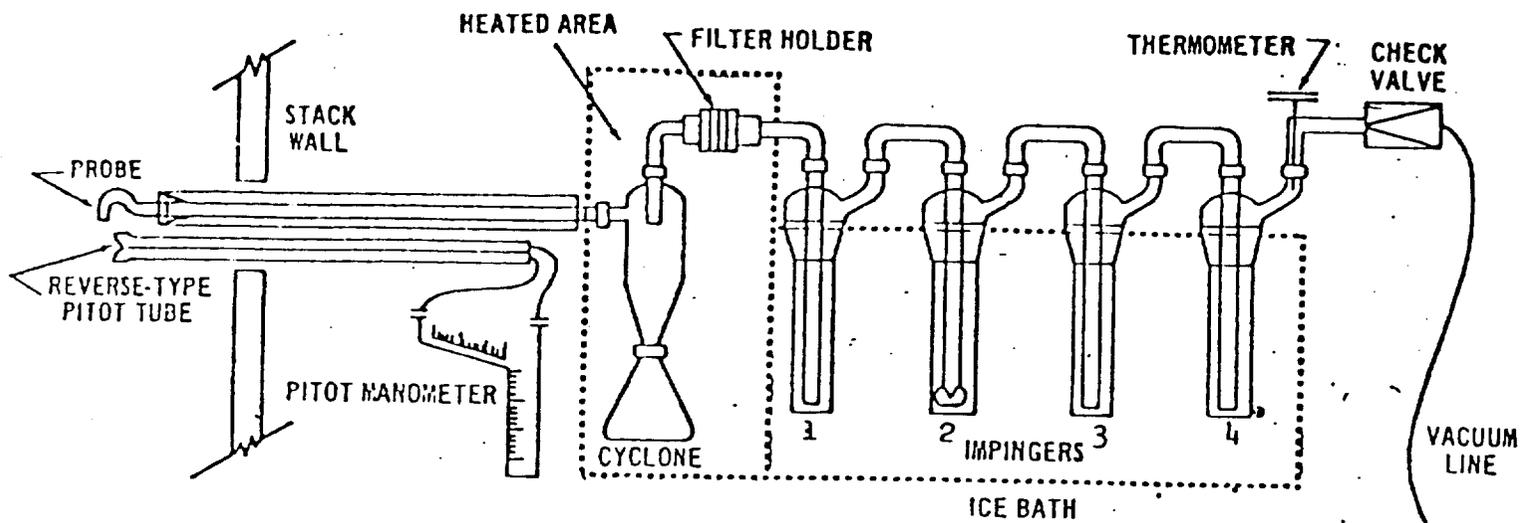


FIGURE II-18

1. Impinger (1) and (2) each to contain 100 ml of standard alkaline arsenite solution. Measure accurately with 100 ml volumetric pipette. If the water content of the gas stream is low, add 100 ml of DI H₂O to each impinger. Weigh and label each.
2. Impinger (3) is dry. Impinger (4) to be filled 1/2 to 3/4 with silica gel. Weigh and label each.

SAMPLING PROCEDURE:

Sample for approximately 20 minutes at a sampling rate of 0.5 to 1.0 cubic feet per minute. (For concentrations of HCl or Cl₂ of 1000 ppm or less, use the weaker solution of alkaline arsenite).

1. When sampling is completed, allow train to cool. Remove collected materials from probe and cyclone by rinsing with distilled water and collect washings in a one liter polyethylene bottle.
2. Dry and weigh all impingers and log weights. The weight increase is water and absorbed HCl and Cl₂. Transfer the contents of impingers (1) and (2) into separate clean polyethylene bottles. Wash out the impingers with DI water being careful not to spill anything, and add the washings from impinger (1) to the bottle with the catch from impinger (1) etc. A polyethylene wash bottle is convenient for washing the impinger tip and tube. (The excess sodium arsenite must be titrated with I₂ solution where HCl and Cl₂ are both present in the same stream. Spillage or loss of any solution will cause high results). Carefully label each bottle for impinger number, test number, date, etc.
3. At the laboratory dilute the solution in each bottle to an exact, known volume with DI water. Be sure to rinse the bottle with DI water. Titrate total chlorides using the Volhard Chloride Titration Method. Titrate the excess sodium arsenite by titrating with I₂ solution. (The aliquot size needed for best accuracy can be determined by trying a small aliquot).

PROCEDURE A: Analysis of Hydrogen Chloride

Pipet an aliquot of the sample into a 250 ml Erlenmeyer flask. Add 25 ml of water, 5 ml of 8 N nitric acid and swirl to mix. Depending on chloride content, add 0.1 N or 0.01 N silver nitrate from a buret until the silver chloride formed begins to coagulate. When coagulation occurs, add an additional 5 ml of silver nitrate. Add 3 ml of nitrobenzene and 2 ml of ferric indicator. Shake or stir vigorously to coat all precipitated silver chloride with nitrobenzene. Back-titrate with 0.1 N or 0.01 N ammonium thiocyanate until the first appearance of the reddish-brown Fe(CNS)₆₋₃ complex. A blank determination for chloride in the absorbing reagent should be run simultaneously and subtracted from the sample results. From the titer of NH₄CNS solution, as determined previously by titration against standard AgNO₃ solution, using ferric alum as an indicator, calculate the net volume of AgNO₃ required for precipitation of the chloride.

Calculations:

$$[(\text{ml AgNO}_3 \times \underline{N} \text{ AgNO}_3) - (\text{ml NH}_4\text{CNS} \times \underline{N} \text{ NH}_4\text{CNS})] \times 0.036 = \text{grams of HCl in aliquot.}$$

(A blank titration should be conducted containing the same amount of unused alkaline arsenite absorbing solution. Subtract this value (if any) from final results).

PROCEDURE B: Analysis of Hydrogen Chloride in the Presence of Chlorine

Pipet an aliquot of the sample into a 250 ml Erlenmeyer flask and proceed with the Volhard titration for total chlorides as described under Procedure A. A blank determination for chloride in the absorbing reagent (alkaline-arsenite reagent) should be run simultaneously and subtracted from the sample results. Calculate the total grams of chloride as above but with a factor of 0.035 rather than 0.036.

Pipet another aliquot of the sample into a 250 ml Erlenmeyer flask. Add a few drops of phenolphthalein indicator, neutralize carefully with concentrated hydrochloric acid and cool. Add sufficient solid sodium bicarbonate (NaHCO₃) to neutralize any excess hydrochloric acid, then add 2 to 3 g more. Add 2 ml of starch indicator and titrate with 0.1 N iodine solution to the blue endpoint. For the reagent blank, determine the number of ml of 0.1 N I₂ required to titrate 25 ml of alkaline-arsenite absorbing reagent, as described above.

Calculations:

ml Arsenite solution in aliquot = ml aliquot x 100 ÷ sample volume

$$[(\text{ml arsenite solution in aliquot} \times \underline{N} \text{ NaASO}_2) - (\text{ml I}_2 \text{ solution} \times \underline{N} \text{ I}_2)] \times 0.035 = \text{gms Cl}_2 \text{ in aliquot}$$

$$0.035 \frac{100 \text{ ml}_a \text{ N}_A}{\text{ml}_s} - \text{ml}_I \text{ N}_I \frac{\text{ml}_s}{\text{ml}_a} = \text{gm Cl}_2 \text{ in sample}$$

$$\text{gm HCl in sample} = \frac{36}{35} [\text{gm total chloride in sample} - \text{gm chlorine in sample}]$$

Reference:

Atmospheric Emissions from Hydrochloric Acid Manufacturing Processes,
U.S. Department of Health, Education and Welfare, Public Health Service,
National Air Pollution Control Administration, Durham, N.C., pp. 38-39,
1969, Publication No. AP-54.



**CAMPBELL &
ASSOCIATES, INC.**

CONSULTING ENGINEERS

701 EAST FOURTH STREET
CHATTANOOGA, TN 37403
615-267-9718

JOHN F. GERM, P.E.
PRESIDENT
PAUL R. MITCHELL, P.E.
SENIOR VICE PRESIDENT
FRED E. KEITH, P.E.
VICE PRESIDENT-SECRETARY
RONALD O. SHUTTLE, P.E.
VICE PRESIDENT
WYLLIE W. GROSS, JR.
VICE PRESIDENT

April 20, 1987

Dr. Eric Aynsley, Ph. D., President
The Almega Corporation
607-C Country Club Drive
Densenville, IL 60106

Dear Dr. Aynsley:

SUBJECT: ERLANGER MEDICAL CENTER - STACK PARTICULATE & OTHER EMISSIONS TEST
ALMEGA CORPORATION PROPOSAL #P87-109 - C&A #86-238

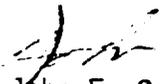
Thank you very much for your proposal of February 5, 1987 in response to our request. We have finished the design on the modifications for the two (2) Basic Model 1250 Incinerators at Erlanger Medical Center and have included in the specifications and the drawings, the items outlined on Page 3 and 4 of your proposal. Since this test will be for both incinerators, we have only included one gas meter which serves the incinerator building. This will allow us the measure the gas for each incinerator with only one incinerator operating, and then if required for both incinerators with both incinerators operating. It is our current intention to place one incinerator on line and have it completely tested prior to the beginning of any construction on the modifications on the second incinerator.

Please verify your proposal on Page 5 that this is for both incinerators.

We are enclosing, for your review, a set of the contract documents and would appreciate your reviewing them and forwarding to us any comments which you may have. It is our intention to have this project competitively bid with the documents being sent to the contractors on May 4, 1987. We would appreciate any review comments you have prior to that time.

Thank you very much for your interest in this project. We look forward to working with you toward the successful conclusion of this project.

Very truly yours,


John F. Germ, P. E.
CAMPBELL & ASSOCIATES, INC.

JFG/db



**ERLANGER
MEDICAL CENTER**

975 E. Third Street
Chattanooga, Tennessee
37403
(615) 778-7000

November 19, 1987

Dr. Eric Aynsley, Ph.D.
The Almega Corporation
607-C Country Club Drive
Bensenville, IL 60106

Dear Dr. Aynsley:

SUBJECT: ERLANGER MEDICAL CENTER - STACK
PARTICULATE AND OTHER EMISSIONS TESTS - ALMEGA
CORPORATION'S PROPOSAL #P87-109 DATED FEBRUARY 5,
1987, TO CAMPBELL & ASSOCIATES, INC. - C&A #86-238

Erlanger Medical Center is pleased to advise you that we wish to accept the referenced proposal subject to the deletion of paragraph 4 on page 2, subparagraphs 1, 2, and 3 on page 3, and the biological destruction quotation on page 5.

Since two incinerator systems are involved in this project, we understand that testing will be in two phases. Performance testing will be made in accordance with the specifications prepared by our consulting engineering firm, Campbell & Associates, Inc. These specifications have been forwarded to you for your use and review. Emissions tests will be made in accordance with your proposal and the consent decree requirements as outlined in the specifications.

I have enclosed for your review an emissions pre-test agreement which is being proposed by the Chattanooga-Hamilton County Air Pollution Control Bureau. After your review, please forward any comments you may have to John Germ of Campbell & Associates, Inc.

John Germ will serve as your contact point for these tests. As such, all invoices should be charged to Campbell & Associates, Inc., 701 East Fourth Street, Chattanooga, Tennessee 37403. They will assume payment for your firm's charges.

Baroness Erlanger Hospital

T. C. Thompson
Children's Hospital
Medical Center

Willie D. Miller Eye Center

Mr. Eric Aynsley, Ph.D.
November 19, 1987
Page 2

We look forward to receiving your revised proposal. Upon completion of its signature process, Mr. Germ will be in touch with you concerning the timing and scheduling of the applicable tests.

Sincerely,



Thomas E. Cowan
Vice-President, Support Services

Enclosures

cc: John Germ, Campbell & Associates, Inc.

EMISSIONS PRE-TEST AGREEMENT

Preamble

A source sampling test of _____ will be conducted to demonstrate compliance with all applicable provisions of the Chattanooga Air Pollution Control Ordinance and will be conducted by _____. The test will be conducted for _____. The test shall be observed by representatives of the Chattanooga-Hamilton County Air Pollution Control Bureau (Bureau) and shall be conducted under maximum representative operating conditions. Failure to meet the test conditions specified herein or include all necessary information in the final report shall constitute sufficient basis for the Bureau's rejection of the test results and/or the final report.

Minimum Test Requirements

A. Process Requirements:

1. Normal process weight (permitted process weight):
2. Process parameters:
 - A. Raw material requirements:
 - B.
 1. For process equipment, the proposed process weight for each run and method of determination shall be:
 2. Allowable deviations:
 3. Alternatives if process weight does not meet desired process weight:
 - C.
 1. For fuel burning equipment, the heat input for each run and method(s) of determination shall be:
 2. Allowable deviations:
 3. Alternative if heat input does not meet desired heat input:

4. Soot blowing shall be performed during each test run if the fuel-burning equipment is equipped with such capability.

D. 1. For incinerator installations, the charge rate for each run and the method of determination shall be:

2. Allowable deviation:

3. Alternative if charge rate does not meet desired charge rate:

3. What testing methods are to be used?

B. Compliance Test Requirements:

1. The source sampling test shall be conducted with what equipment:

2. Copies of all notes, tables, field documents, tare weights of filters, and calculations shall be exchanged between the representatives of the company and the control agencies prior to test completion.

3. Any and all test reports shall be submitted to the Bureau regardless of the results of the test.

4. For particulate matter tests, unless otherwise noted herein, the Bureau will be provided with the filter and washings from one test run of its choice along with pre-weights and acetone blanks. The analysis of this will be completed in the Bureau laboratory, and handling of the sample will be protected by a written chain of custody. The Bureau will assume all responsibility for the samples once in its custody, and the results will be given to the test team for inclusion in the final report after the results obtained by the test team are given to the Bureau. The run analyzed by the Bureau will be considered the same as the other two runs and the results averaged as normally required by EPA Reference Method 5.

If the Bureau loses, damages, or otherwise alters or destroys the sample, the stack emission rate will be determined on the basis of the two remaining runs, and the Bureau will certify that the run from which the sample was obtained was properly completed.

5. Visible Emissions Evaluations shall be conducted for all applicable tests. Such evaluations shall be conducted by certified observers representing _____.
- The results of such evaluations shall be included in the final report.

C. Test Report

The test report shall consist of the following sections, as a minimum:

1. Introduction
2. Summary of results
 - A. Stack Diameter
 - B. Stack Gas Velocity
 - C. Stack Gas Flow Rate (scfm)
 - D. Emission listed in pounds per hour (pph) and grains per standard cubic foot (g/scf), (68F, 1atm, dry gas)
 - E. Allowable emission rate in pph and g/dscf
 - F. Yearly emissions for all pollutants sampled, listed in tons/year
 - G. Percent isokinetic of test
 - H. Process weight during test
 - I. Other pertinent results
3. Conclusions
4. Emission Source Description
 - A. APCB permit number
 - B. Process description and equipment

- C. Control equipment
- D. Exhaust description
- 5. Sampling Protocol
 - A. Methodology
 - B. Analytical Procedures
- 6. Appendices
 - A. Velocity Profile Diagram
 - B. Sample Calculations
 - C. Description of sampling procedure and laboratory procedure (signed)
 - D. Copy of field data sheets (signed by tester)
 - E. Schematic diagram of sampling site showing distance to upstream and downstream disturbances
 - F. Identification of regulations applicable to source
 - G. Calibration data to include the most recent data and results of calibration for all equipment used in the test. (RE: Dry gas meter before and after each test and orifice before each test.)

FAILURE TO INCLUDE ANY OF THE ABOVE INFORMATION IS ADEQUATE GROUNDS FOR REJECTION OF THE COMPLIANCE TEST UNLESS THE DIRECTOR HAS APPROVED SUCH OMISSION IN WRITING PRIOR TO THE TEST OR HEREIN.

D. Physical Condition of Testing

1. The source sampling test will begin at _____ on _____.
2. Representatives of local, state, and federal air pollution agencies shall be permitted to observe the source sampling test and shall be given prompt admittance to the test site during the test.
3. A company representative shall be assigned to the test site.
4. A lead representative shall be appointed to represent _____, the testing and/or consulting firm(s) and the Bureau.

The lead representatives shall be:

All field decisions shall be made by and between these respective persons.

This document is not a contractual agreement but constitutes the source test conditions which were negotiated on _____, between representatives of the Bureau and _____.

This information is set forth in written form to insure that all appropriate parties understand the minimum test conditions. The signature of each representative party signifies that he has read the document and will, to the best of his knowledge and ability, comply with the terms of the pre-test agreement.

(company representative)

(date)

(consultant)

(date)

(test consultant)

(date)

(Bureau)

(date)

The ALMEGA CORPORATION

607 C Country Club Drive
Bensenville, Illinois 60106
Phone: (312) 595-0175

December 4, 1987

Erlanger Medical Center
975 E. Third Street
Chattanooga, Tennessee 37403

Attention: Mr. Thomas E. Cowan
Vice-President, Support Services

Subject: Erlanger Incinerator
Stack Emission Tests
The Almega Corporation Proposal #P87-241

Gentlemen:

INTRODUCTION

This proposal is submitted in response to your recent letter and will serve to confirm the modifications to our Proposal #P87-109 dated February 5, 1987.

The purpose of this proposal is to detail a stack emissions test to be conducted on two modified pathological incinerators located at the Erlanger Medical Center in Chattanooga, Tennessee.

Included with this proposal are sections covering proposed test program, required facilities, guarantee, time and cost estimates and related experience in stack and air pollution control equipment collector efficiency testing.

PROPOSED PROGRAM

It is proposed to collect emissions from and determine visual emissions to the effluent gas of each incinerator following a test protocol promulgated and approved by USEPA and Chattanooga-Hamilton County Air Pollution Control Bureau to determine particulate and hydrogen chloride emission rates.

THE ALMEGA CORPORATION

Erlanger Medical Center
Page Two

temperature °F
velocity fps
moisture % vol/vol
volume flow acfm and scfh db
Orsat CO₂, O₂ and N₂ % vol/vol
total particulate concentration grains/scf and
corrected to 12 % CO₂
total particulate emission rate lb/hr
hydrogen chloride concentrations, lbs/dscf, ppm
hydrogen chloride emission rate, lb/hr

The following USEPA (Ref. 1) methods will be followed:

<u>Method #</u>	<u>Title</u>
1	Sample and Velocity Traverses for Stationary Sources
2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
3	Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight
4	Determination of Moisture in Stack Gases Approximate Method
5	Determination of Particulate Emissions from Stationary Sources
9	Visual Determination of the Opacity of Emissions from Stationary Sources

It should be noted that:

- (1) Hydrogen chloride emissions will be determined by absorption and reaction in sodium acetate solution in the back-half of the Method 5 train. Analysis will be performed by a specific ion electrode method.
- (2) Method 5 particulate emissions as measured in grains/dry standard cubic foot (grains/dscf) will be corrected to 12% CO₂ as required for comparison with applicable codes. This correction factor requires allowance be made for the contribution of CO₂ from the auxiliary natural gas fuel. The most accurate way of performing this allowance is to know exactly the volume of gas fired during each test: this requires installation of a dedicated gas meter in the gas line to the incinerator.
- (3) A certified observer will be used for the Method 9 opacity observations.

The ALMEGA CORPORATION

Erlanger Medical Center
Page Three

The program will be undertaken in two phases. One incinerator will be tested in each phase. It is not anticipated that both phases will occur simultaneously.

At the conclusion of each test phase a report will be submitted. This report will summarize the test methods and findings of the test series. Attached as appendices will be a complete documentation of all test and analytical methods, field data and calculation summaries.

It is our policy that this report is the property of the sponsoring client. The Almega Corporation will not supply any information to any other parties without the prior written approval of the sponsoring client.

REQUIRED FACILITIES

Certain facilities are required to be made available to conduct this test series. It is understood that the client will make these available. These facilities include:

1. Incinerator operation throughout the test series.
2. Incinerator operational details and burning rates throughout the test series.
3. Provide suitable stack sampling locations, sampling ports and scaffolding. Specifically two four inch diameter holes, set at 90° to each other will have to be cut into the stack to be tested. A sketch is attached to this proposal.
4. Provide electric power (110 volts AC) domestic type outlet near to the stack sampling location.
5. Install a dedicated gas meter in the gas line to each incinerator.
6. Provision of radios for communication between the incinerator and stack test location if this is deemed necessary.
7. Access and close parking for one vehicle during the testing.

GUARANTEE

For a complete formal, agency witnessed, stack emission compliance test The Almega Corporation guarantees that the test as conducted and detailed in the final report will be acceptable in format to the appropriate agencies. It is, however, the responsibility of the sponsoring client to:

The ALMEGA CORPORATION

Erlanger Medical Center
Page Four

- (i) notify appropriate agency personnel of the proposed tests,
- (ii) obtain agency approval of the proposed test methods before the tests, and
- (iii) invite agency personnel to witness the tests

The necessity of informing regulatory personnel prior to the tests and obtaining approval of the test methods cannot be over emphasized. In the event that unapproved emission tests are performed or not witnessed and the data shows compliance with applicable codes then regulatory personnel may not accept the data.

Additional assistance may be provided by Almega if requested to prepare detailed test protocols which may be required by the CHCAPCB.

TIME AND COST ESTIMATES

This test program can normally be scheduled within two weeks of receipt of authorization to proceed with each test phase depending upon schedules at that time. It is understood testing is tentatively scheduled for April 1988.

Test personnel will arrive on-site the day prior to testing to set up, install and check out test equipment for the test the following day. The complete three repetition test series will be conducted over typically eight to ten hours of continuous plant operations the next day.

The costs to conduct the test series, as detailed above, and submit the final reports are detailed below:

Particulate, Methods 1, 2, 3, 4 & 5	\$2,750.00
HCl	\$ 500.00
Opacity, Method 9	\$ 550.00

The above costs include all equipment set-up and calibration, travel and subsistence, field testing, laboratory analysis, data reduction, preparation and submission of three copies of the final report.

The final report will be available within typically two to three weeks of completion of on-site testing.

Additional time needed for test protocol development or due to plant schedules or breakdowns will be charged additionally.

The ALMEGA CORPORATION

Erlanger Medical Center
Page Five

No charge is made for bad weather delays.

Terms are net 20 days.

Certificates of contractor liability and workman's compensation insurance are available upon request. A copy of Almega's Stack Testing, Standard Terms and Conditions is attached and is made a part of this proposal.

PREVIOUS EXPERIENCE

The Almega Corporation is based in Bensenville next to Chicago's O'Hare Airport and specializes in providing industrial and governmental clients services in the areas of stack emission and air sampling, monitoring and analysis.

Currently we have offices in the Philadelphia-New Jersey and New Orleans areas and also representatives in Washington, D.C., Indianapolis and Little Rock.

Almega's staff have had a wide variety of experience in stack emission testing and efficiency testing of air pollution control equipment over the last twenty years: testing services have and are currently being performed for clients both nationwide and at other locations in Europe, the Middle East and the Far East.

Typical services offered and experience gained include:

- . Stack emission sampling for both compliance and emissions optimization for a full spectrum of contaminants varying from particulates through all inorganic species to total hydrocarbons and individual species ranging to total organic chlorides, PCB and dioxins.
- . Air pollution control equipment efficiency testing for problem definition studies to equipment specification and acceptance testing.
- . OSHA in-plant air contaminant surveys for determination of employee exposures and TLV determinations.
- . Ambient air monitoring projects for the usual particulates, sulfur oxides, etc. through to more recent monitoring of air toxics.
- . Air dispersion modelling for determination of downwind ground level concentrations and more recently plume impact studies.
- . Testing underground storage tanks.

The ALMEGA CORPORATION

Erlanger Medical Center
Page Six

CONCLUSION

Based upon more than a decade of extensive experience in incinerator air contaminant, stack emission and air pollution control equipment collector efficiency testing we are confident a highly successful and timely project will be conducted.

References can be supplied upon request.

In the event you should have any further questions please feel free to call.

Respectfully submitted,

THE ALMEGA CORPORATION *g*

M. R. Jackson

Meryl R. Jackson
Vice-President

MRJ:dml

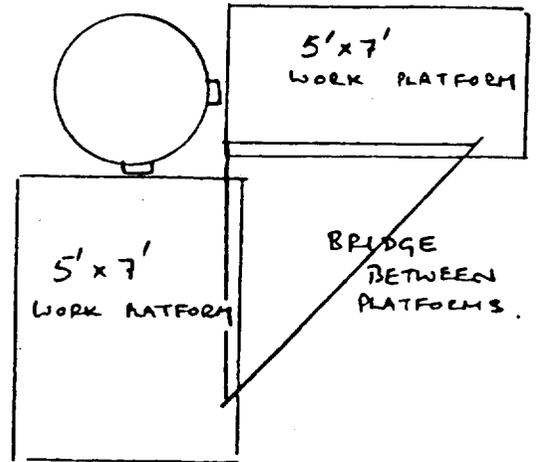
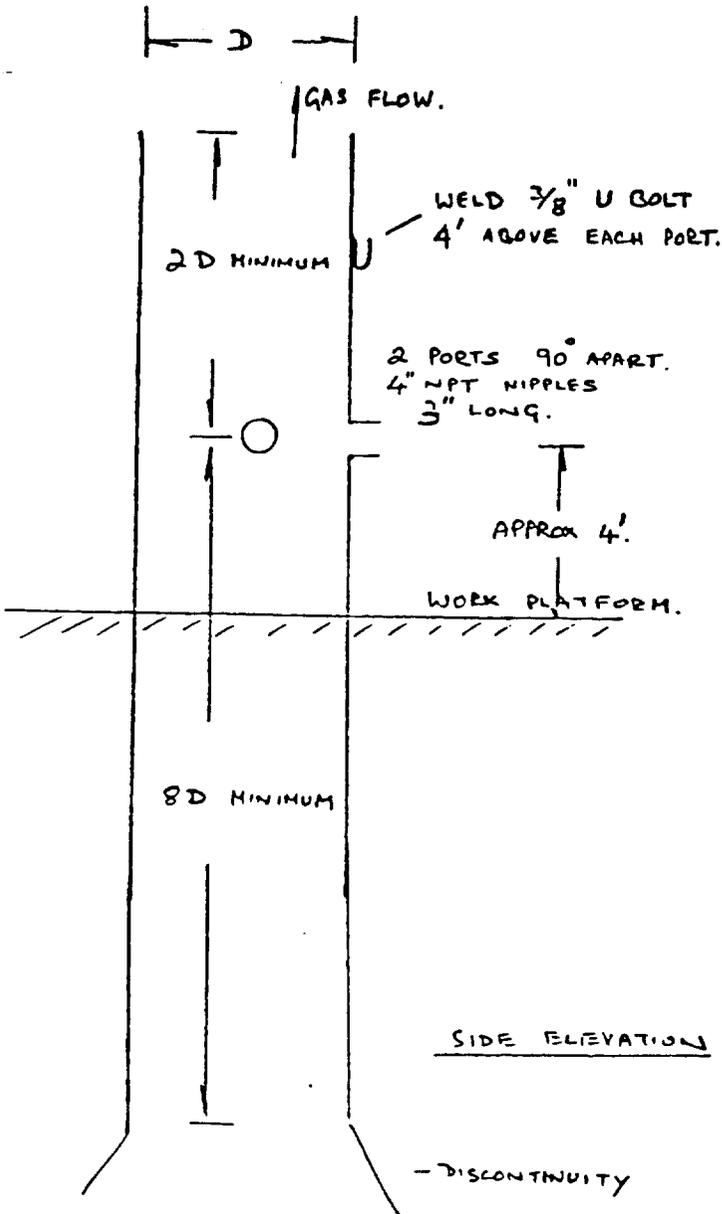
Enclosures

Reference:

1. Title 40: Code of Federal Regulations

cc: Mr. John Germ, P.E.
Campbell & Associates, Inc.
701 East Fourth Street
Chattanooga, Tennessee 37403

The ALMEGA CORPORATION



PLAN VIEW FOR
TEMPORARY WORK PLATFORM

IF IT IS NOT POSSIBLE TO LOCATE
 PORTS AT 2D DOWN AND 8D
 UP STACK LOCATE 80% OF
 STRAIGHT LENGTH OF STACK
 DO NOT LOCATE CLOSER THAN
 $\frac{1}{2} D$ TO TOP OR 2D TO
 BOTTOM OF STACK.

SKETCH OF REQUIREMENTS
FOR TEMPORARY STACK
TEST PLATFORMS.

The ALMEGA CORPORATION

Campbell & Associates
Page Two

Budget estimate costs to determine baghouse inlet and outlet nitrogen and sulfur oxides, and possibly also total hydrocarbons, carbon dioxide, and/or oxygen and carbon monoxide using a series of continuous emission monitors and inlet and outlet hydrogen chloride and chlorine using manual test methods when the south unit two-day test series are performed are around \$10,000.00. Offset against this would be the current costs for two (2) days of HCl and Cl₂, CO and NO_x testing of \$2,800.00 for the stack outlet only.

By way of copies to John Basic, Erlanger, BACT and Allied Mechanical Contractors, I solicit your comments.

Sincerely yours,

THE ALMEGA CORPORATION

Eric Aynsley

Eric Aynsley, Ph.D.
President

EA:dml

cc: Mr. John Basic
Basic Environmental Engineering, Inc.
21W161 Hill Street
Glen Ellyn, Illinois 60137

Mr. Mickey Raines
Erlanger Medical Center
975 E. Third Street
Chattanooga, Tennessee 37403

Mr. Ted Metz
BACT Engineering, Inc.
11 W. College Drive, Suite K
Arlington Heights, Illinois 60004

Mr. Roy Roach
Allied Mechanical Contractors, Inc.
5001 Calhoun Avenue
Chattanooga, Tennessee 37407



**BASIC
ENVIRONMENTAL**

ENGINEERING, INC. *the modern
incinerator people*

TELEX II (TWX)-5101000115 BASIC UD
EASYLINK-62871698
TELEFAX-(312) 469-3167

21W161 Hill Street • Glen Ellyn, Illinois 60137 • (312)469-5340

April 5, 1988

The Almega Corporation
Attn: Eric Aynsley
607C Country Club Drive
Bensenville, IL 60106

RE: Residence time calculations on
Model 1250 for Erlanger Medical
Center

Dear Dr. Aynsley:

Enclosed are three 8-1/2" x 11" sketches of the reburn tunnel system of the BASIC Model 1250 at Erlanger Medical Center in Chattanooga, TN.

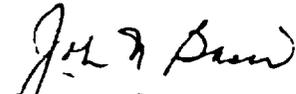
I am enclosing the calculations of the post main chamber residence time. Also enclosed is a process flow description.

The gas velocities for each zone at the reburn are calculated. In addition to the general flow velocity through the passageway, we wish to point out that the excess air is introduced into the passageway in concentric rings of air jets mounted at 45° to the flow and at 45° tangentially to the flow.

There are over 144, 5/8" diameter jets that feed excess air from 3" S.P. H₂O to 11" S.P. H₂O (confidential matter). These add extra turbulences not calculated in the agency's formula.

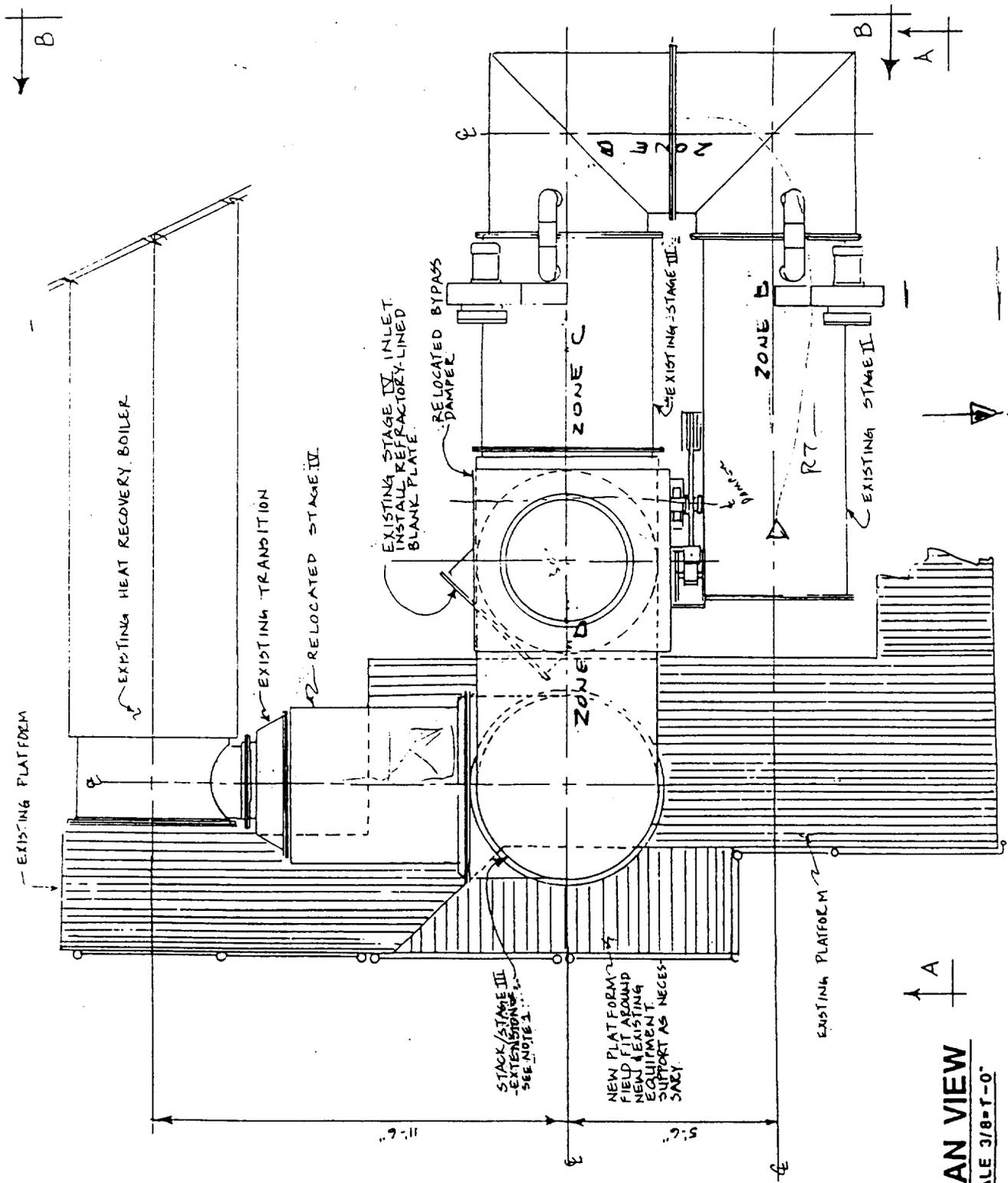
Very truly yours,

BASIC ENVIRONMENTAL ENGINEERING, INC.


John N. Basic, Sr.
President

JNB:ld

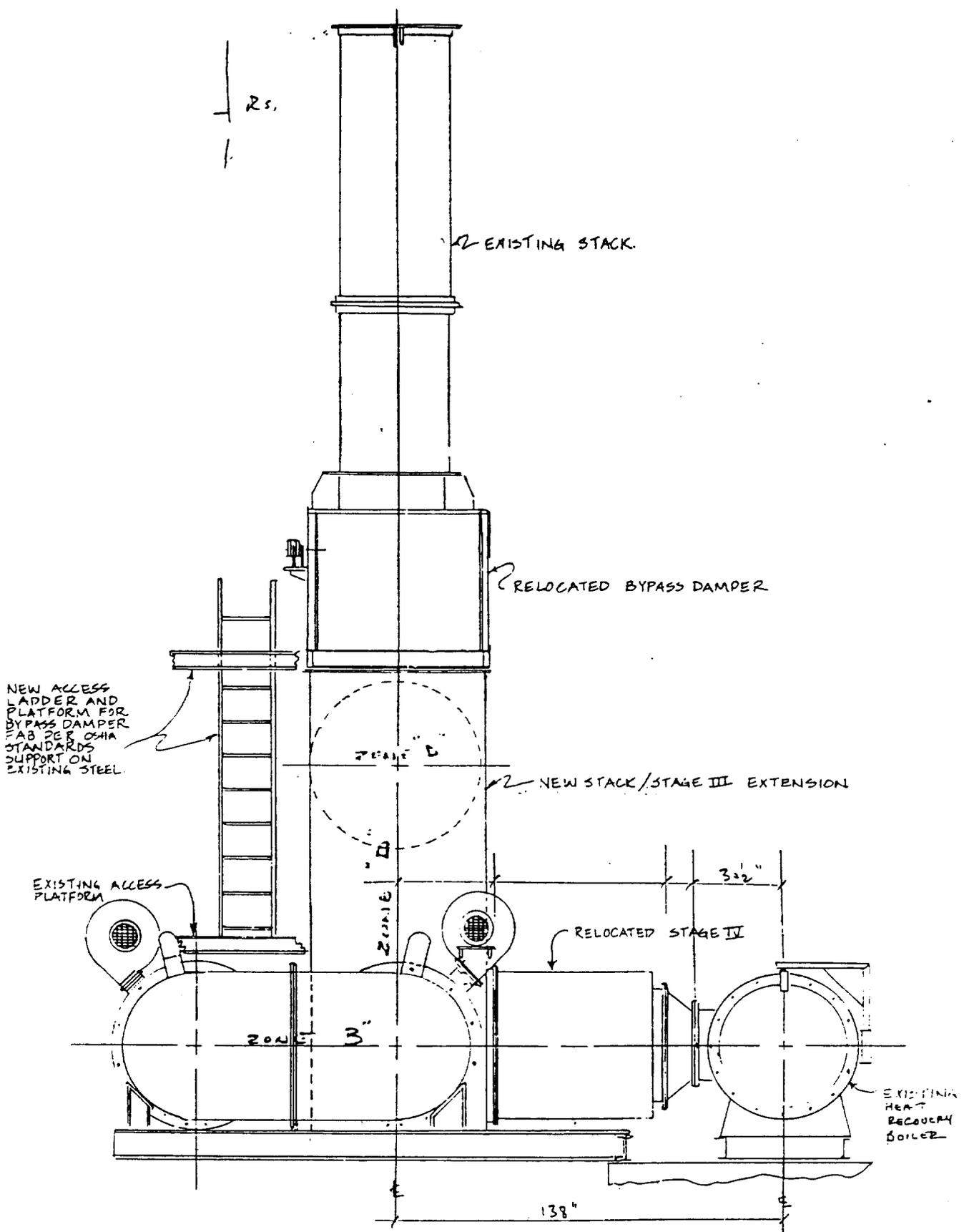
Encls.



PLAN VIEW
SCALE 3/8"=1'-0"

STACK/STAGE III
-EXTENSION-
SEE NOTE 1.

NEW PLAT FORM
FIELD FIT AROUND
NEW EXISTING
EQUIPMENT
SUPPORT AS NECESS-
SNEY.



SECTION "B-B"
 SCALE 3/8"=1'-0"

BASIC MODEL 1250

PROCESS FLOW DESCRIPTION

Bulk waste materials without any size preparation are loaded into the hopper of the loader feeder. An electric motor powered ram pushes this material into the main chamber where the waste fuel is ignited and starts the burning process.

The waste is contained on a refractory covered hearth floor which has a cross section shaped like two sets of stairs facing the center of the hearth. Air is forced into the weldment which forms the hearth and this combustion air is directed to the waste fuel through nozzles exiting through the risers of the steps. This entire chamber is considered the first stage of burning and air is kept at a near stoichiometric level.

The Pulse Hearth(TM) itself is what moves the material slowly and gently through this first stage without any moving parts such as grates or rams required inside this high temperature zone. The Pulse Hearth(TM) is suspended at four points outside the furnace from a fixed steel frame and thus, when given a forward thrust from an external pneumatic device, swings forward and slightly upward and then returns to its original position. The "pulsing" action gently disturbs the fuel bed and moves it forward one to several inches (depending on the strength of the thrust) with each pulse. Since the strength and frequency of the pulse can be varied and controlled, it lends itself to burning a wide variety of materials ranging from municipal and pathological wastes to whole rubber tires.

The non-combustibles (ash, wire, metal, glass, cans, etc.) are eventually discharged at the end of the hearth into a wet ash pit which serves as an air seal and quencher of the hot ash. Coupled to the pit is an inclined trough which also contains a four wheeled carriage and perforated steel plow blade for removing the ash. When traveling down the incline, the blade is in the "open" position. When the blade is at the bottom of the "J" shaped pit, it is rotated through an arc by an air cylinder so that it can "grab" the ash and carry it up the inclined trough as the carriage is pulled up by a cable and winch. At its top position the blade reverts to the "open" position so that all the ash drops out through the trough opening into a receiving container.

The first stage radiant combustion chamber is part of a steam generating system, and has a chamber which is constructed as a membrane waterwall boiler with a top header, ceiling and sidewall tubes and two bottom headers. Energy is absorbed primarily from radiation and can be as much as 35% of the total waste energy input.

The gases which exit from this first stage are not completely combusted due to the lack of excess air. Particulate levels are very low and of very small size (less than 100 microns) due to the low vertical gas velocity at all parts of the chamber as a result of primary air control and the rectangular geometry of the chamber. The gases and particulate enter a two stage reburn tunnel system where the necessary excess air to complete the combustion and particle destruction takes place.

The excess air is delivered to the interior burning area through a double shell construction, so that the outer plenum serves as an air preheater. The preheated air is sent to internal distributor tubes, called Thermal Exciters, designed so that the air jets which they contain will impart a cyclonic pattern while mixing with the gas from the first stage. The extremely high turbulence created permits a highly efficient use of the air thus achieving complete combustion at low excess air quantities. Residence time in these two stages can be from one to two seconds.

If introduction of exceedingly wet materials in Stage 1 causes temperatures in the second and third stage to be too low for total combustion, then an auxiliary fuel burner is brought into play to raise the temperature to the desired setpoint. These temperatures are generally over 1400°F. and can be as high as 2000°F. for some materials.

Since the system is designed to handle a wide range of waste streams, there is a distinct danger of slagging the heat convection boiler with heavy metal oxides, chlorides and other salts which tend to vaporize above 1400°F. and then condense out and slag on "cold" boiler tube surfaces.

To avoid costly shutdowns to de-slag a boiler, Stage 4 mixing zone is added which conditions the high temperature gases down to a controlled temperature of 1400°F. This is accomplished by recirculating a controlled quantity of flue gas at the lower exhaust temperatures and thoroughly blending it with the higher temperature Stage 3 gases to produce a 1400°F. gas stream without stratification. In this way the troublesome metal oxides, chlorides, etc. are maintained in a particulate state. Though they may deposit on the boiler tubes as particles, they can easily be removed by using conventional sootblowers without having to shut down the entire system.

After Stage 4 the entire mass of gas enters the boiler watertube unit and economizer. On many industrial waste applications no additional equipment is needed for emission control, but on more troublesome materials, scrubbers or baghouses may be needed to meet EPA compliance.

As a final safety device, ahead of the heat convection boiler and Stage 4, an emergency relief damper is added in the event of sudden loss of feedwater or draft, so as to prevent any damage to the operator or the equipment. Under these emergency conditions gases are diverted to atmosphere rather than continuing through the heat recovery boiler train.

The ALMEGA CORPORATION

APPENDIX B

SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

The ALMEGA CORPORATION

1. Principle and Applicability

1.1 Principle. To aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source, a measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. A traverse point is then located within each of these equal areas.

1.2 Applicability. This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling (see Section 2.4), (2) a stack is smaller than about 0.30 meter (12 in.) in diameter, or 0.071 m² (113 in.²) cross-sectional area, or (3) the measurement site is less than two stack or duct diameters downstream or less than a half diameter upstream from a flow disturbance.

The requirements of this method must be considered before construction of a new facility from which emissions will be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Administrator, U.S. Environmental Protection Agency.

2. Procedure

2.1 Selection of Measurement Site. Sampling or velocity measurement is performed at a site located at least eight stack or duct diameters downstream and two diameters

upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame. If necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and a half diameter upstream from any flow disturbance. For a rectangular cross section, an equivalent diameter (D_e) shall be calculated from the following equation, to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{L+W}$$

where L = length and W = width.

An alternative procedure is available for determining the acceptability of a measurement location not meeting the criteria above. This procedure, determination of gas flow angles at the sampling points and comparing the results with acceptability criteria, is described in Section 2.5.

2.2 Determining the Number of Traverse Points.

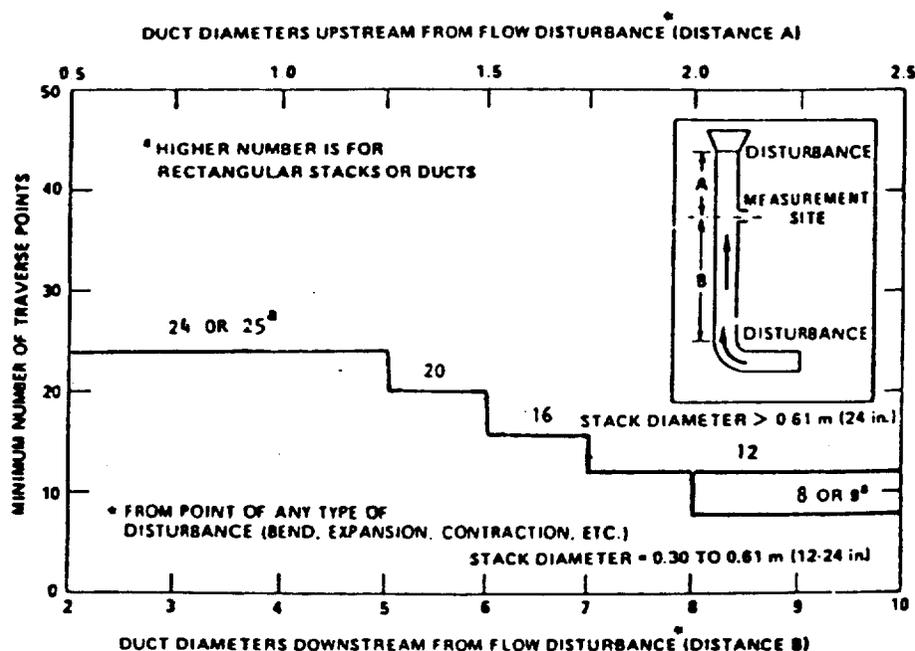


Figure 1-1. Minimum number of traverse points for particulate traverses.

THE ALMEGA CORPORATION

2.2.1 Particulate Traverses. When the eight- and two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 0.30 and 0.61 meter (12-24 in.); (3) nine, for rectangular stacks with equivalent diameters between 0.30 and 0.61 meter (12-24 in.).

When the eight- and two-diameter criterion cannot be met, the minimum number of traverse points is determined from Figure 1-1. Before referring to the figure, however, determine the distances from the chosen measurement site to the nearest upstream and downstream disturbances, and divide each distance by the stack diameter or equivalent diameter, to determine the distance in terms of the number of duct diameters. Then, determine from Figure 1-1 the minimum number of traverse points that

corresponds: (1) to the number of duct diameters upstream; and (2) to the number of diameters downstream. Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks, the number is one of those shown in Table 1-1.

TABLE 1-1. CROSS-SECTION LAYOUT FOR RECTANGULAR STACKS

Number of traverse points	Matrix layout
9	3x3
12	4x3
16	4x4
20	5x4
25	5x5
30	6x5
36	6x6
42	7x6
49	7x7

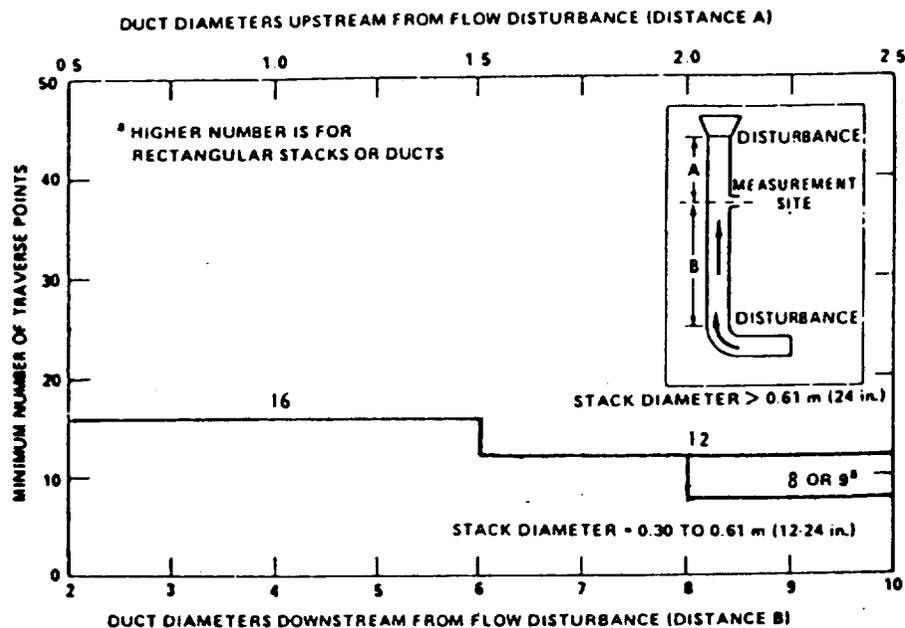


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

2.2.2 Velocity (Non-Particulate) Traverses. When velocity or volumetric flow rate is to be determined (but not particulate matter), the same procedure as that for particulate traverses (Section 2.2.1) is followed,

except that Figure 1-2 may be used instead of Figure 1-1.

2.3 Cross-sectional Layout and Location of Traverse Points.

2.3.1 Circular Stacks. Locate the traverse points on two perpendicular diameters according to Table 1-2 and the example shown

THE ALMEGA CORPORATION

In Figure 1-3. Any equation (for examples, see Citations 2 and 3 in the Bibliography) that gives the same values as those in Table 1-2 may be used in lieu of Table 1-2.

For particulate traverses, one of the diameters must be in a plane containing the greatest expected concentration variation, e.g., after bends, one diameter shall be in the plane of the bend. This requirement becomes less critical as the distance from the disturbance increases; therefore, other diameter locations may be used, subject to approval of the Administrator.

In addition for stacks having diameters greater than 0.61 m (24 in.) no traverse points shall be located within 2.5 centimeters (1.00 in.) of the stack walls; and for stack diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located

within 1.3 cm (0.50 in.) of the stack walls. To meet these criteria, observe the procedures given below.

2.3.1.1 Stacks With Diameters Greater Than 0.61 m (24 in.). When any of the traverse points as located in Section 2.3.1 fall within 2.5 cm (1.00 in.) of the stack walls, relocate them away from the stack walls to: (1) a distance of 2.5 cm (1.00 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger. These relocated traverse points (on each end of a diameter) shall be the "adjusted" traverse points.

Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording the data.

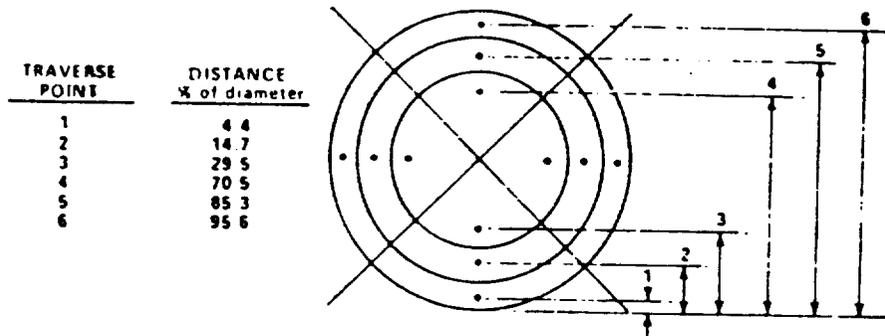


Figure 1.3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

TABLE 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter—											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	66.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9

The ALMEGA CORPORATION

TABLE 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS—Continued
(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter—											
	2	4	6	8	10	12	14	16	18	20	22	24
19										96.1	91.3	86.8
20										96.7	94.0	89.5
21											96.5	92.1
22											96.8	94.5
23												96.8
24												96.8

2.3.1.2 Stacks With Diameters Equal to or Less Than 0.61 m (24 in.). Follow the procedure in Section 2.3.1.1, noting only that any "adjusted" points should be relocated away from the stack walls to: (1) a distance of 1.3 cm (0.50 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger.

2.3.2 Rectangular Stacks. Determine the number of traverse points as explained in Sections 2.1 and 2.2 of this method. From Table 1-1, determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in Figure 1-4.

If the tester desires to use more than the minimum number of traverse points, expand the "minimum number of traverse points" matrix (see Table 1-1) by adding the extra traverse points along one or the other or both legs of the matrix; the final matrix need not be balanced. For example, if a 4x3 "minimum number of points" matrix were expanded to 36 points, the final matrix could be 9x4 or 12x3, and would not necessarily have to be 6x6. After constructing the final matrix, divide the stack cross-section into as many equal rectangular, elemental areas as traverse points, and locate a traverse point at the centroid of each equal area.

The situation of traverse points being too close to the stack walls is not expected to arise with rectangular stacks. If this problem should ever arise, the Administrator must be contacted for resolution of the matter.

2.4 Verification of Absence of Cyclonic Flow. In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling; in these instances, the presence or absence of cyclonic flow at the sampling location must be determined. The following techniques are acceptable for this determination.

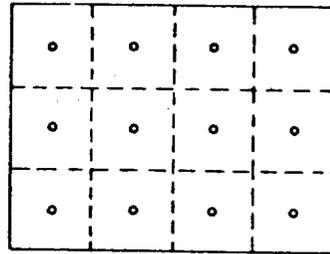


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

Level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure (Δp) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to $\pm 90^\circ$ yaw angle), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. After the null technique has been applied at each traverse point, calculate the average of the absolute values of α ; assign a values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of α is greater than 20°, the overall flow condition in the stack is unacceptable and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate sample and velocity traverses.

The alternative procedure described in Section 2.5 may be used to determine the rotation angles in lieu of the procedure described above. The limit of acceptability for the average value of α would remain 20°.

The ALMEGA CORPORATION

2.5 Alternative Measurement Site Selection Procedure. This alternative applies to sources where measurement locations are less than 2 equivalent stack or duct diameters downstream or less than 1/4 duct diameter upstream from a flow disturbance. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow-sensing probe is used to measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

NOTE: Both the pitch and yaw angles are measured from a line passing through the traverse point and parallel to the stack axis. The pitch angle is the angle of the gas flow component in the plane that INCLUDES the traverse line and is parallel to the stack axis. The yaw angle is the angle of the gas flow component in the plane PERPENDICULAR to the traverse line at the traverse point and is measured from the line passing through the traverse point and parallel to the stack axis.

2.5.1 Apparatus.

2.5.1.1 Directional Probe. Any directional probe, such as United Sensor Type DA Three-Dimensional Directional Probe, capable of measuring both the pitch and yaw angles of gas flows is acceptable. (NOTE: Mention of trade name or specific products does not constitute endorsement by the U.S. Environmental Protection Agency.) Assign an identification number to the directional probe, and permanently mark or engrave the number on the body of the probe. The pressure holes of directional probes are susceptible to plugging when used in particulate-laden gas streams. Therefore, a system for cleaning the pressure holes by "back-purging" with pressurized air is required.

2.5.1.2 Differential Pressure Gauges. Inclined manometers, U-tube manometers, or other differential pressure gauges (e.g., magnehelic gauges) that meet the specifications described in Method 2, § 2.2.

NOTE: If the differential pressure gauge produces both negative and positive readings, then both negative and positive pressure readings shall be calibrated at a minimum of three points as specified in Method 2, § 2.2.

2.5.2 Traverse Points. Use a minimum of 40 traverse points for circular ducts and 42 points for rectangular ducts for the gas flow angle determinations. Follow § 2.3 and Table 1-1 or 1-2 for the location and layout of the traverse points. If the measurement location is determined to be acceptable according to the criteria in this alternative procedure, use the same traverse point number and locations for sampling and velocity measurements.

2.5.3 Measurement Procedure.

2.5.3.1 Prepare the directional probe and differential pressure gauges as recommended by the manufacturer. Capillary tubing or surge tanks may be used to dampen pressure fluctuations. It is recommended, but not required, that a pretest leak check be conducted. To perform a leak check, pressurize or use suction on the impact opening until a reading of at least 7.6 cm (3 in.) H₂O registers on the differential pressure gauge, then plug the impact opening. The pressure of a leak-free system will remain stable for at least 15 seconds.

2.5.3.2 Level and zero the manometers. Since the manometer level and zero may drift because of vibrations and temperature changes, periodically check the level and zero during the traverse.

2.5.3.3 Position the probe at the appropriate locations in the gas stream, and rotate until zero deflection is indicated for the yaw angle pressure gauge. Determine and record the yaw angle. Record the pressure gauge readings for the pitch angle, and determine the pitch angle from the calibration curve. Repeat this procedure for each traverse point. Complete a "back-purge" of the pressure lines and the impact openings prior to measurements of each traverse point.

A post-test check as described in § 2.5.3.1 is required. If the criteria for a leak-free system are not met, repair the equipment, and repeat the flow angle measurements.

2.5.4 Calculate the resultant angle at each traverse point, the average resultant angle, and the standard deviation using the following equations. Complete the calculations retaining at least one extra significant figure beyond that of the acquired data. Round the values after the final calculations.

2.5.4.1 Calculate the resultant angle at each traverse point:

$$R_i = \text{arc cosine} \{(\text{cosine } Y_i)(\text{cosine } P_i)\} \quad \text{Eq. 1-2}$$

Where:

R_i = Resultant angle at traverse point i , degree.

Y_i = Yaw angle at traverse point i , degree.

P_i = Pitch angle at traverse point i , degree.

2.5.4.2 Calculate the average resultant for the measurements:

$$R = \frac{\sum R_i}{n} \quad \text{Eq. 1-3}$$

Where:

R = Average resultant angle, degree.

n = Total number of traverse points.

THE ALMEGA CORPORATION

2.5.4.3 Calculate the standard deviations:

$$S_s = \sqrt{\frac{\sum_{i=1}^n (R_i - \bar{R})^2}{(n-1)}}$$

Eq. 1-4

Where:

S_s = Standard deviation, degree.

2.5.5 The measurement location is acceptable if $R_s < 20^\circ$ and $S_s < 10^\circ$.

2.5.6 Calibration. Use a flow system as described in Sections 4.1.2.1 and 4.1.2.2 of Method 2. In addition, the flow system shall have the capacity to generate two test-section velocities: one between 365 and 730 m/min (1200 and 2400 ft/min) and one between 730 and 1100 m/min (2400 and 3600 ft/min).

2.5.6.1 Cut two entry ports in the test section. The axes through the entry ports shall be perpendicular to each other and intersect in the centroid of the test section. The ports should be elongated slots parallel to the axis of the test section and of sufficient length to allow measurement of pitch angles while maintaining the pitot head position at the test-section centroid. To facilitate alignment of the directional probe during calibration, the test section should be constructed of plexiglass or some other transparent material. All calibration measurements should be made at the same point in the test section, preferably at the centroid of the test-section.

2.5.6.2 To ensure that the gas flow is parallel to the central axis of the test section, follow the procedure in Section 2.4 for cyclonic flow determination to measure the gas flow angles at the centroid of the test section from two test ports located 90° apart. The gas flow angle measured in each port must be $\pm 2^\circ$ of 0° . Straightening vanes should be installed, if necessary, to meet this criterion.

2.5.6.3 Pitch Angle Calibration. Perform a calibration traverse according to the manufacturer's recommended protocol in 5° increments for angles from -60° to $+60^\circ$ at one velocity in each of the two ranges specified above. Average the pressure ratio values obtained for each angle in the two flow ranges, and plot a calibration curve with the average values of the pressure ratio (or other suitable measurement factor as recommended by the manufacturer) versus the pitch angle. Draw a smooth line through the data points. Plot also the data values for each traverse point. Determine the differences between the measured data values and the angle from the calibration

curve at the same pressure ratio. The difference at each comparison must be within 2° for angles between 0° and 40° and within 3° for angles between 40° and 60° .

2.5.6.4 Yaw Angle Calibration. Mark the three-dimensional probe to allow the determination of the yaw position of the probe. This is usually a line extending the length of the probe and aligned with the impact opening. To determine the accuracy of measurements of the yaw angle, only the zero or null position need be calibrated as follows. Place the directional probe in the test section, and rotate the probe until the zero position is found. With a protractor or other angle measuring device, measure the angle indicated by the yaw angle indicator on the three-dimensional probe. This should be within 2° of 0° . Repeat this measurement for any other points along the length of the pitot where yaw angle measurements could be read in order to account for variations in the pitot markings used to indicate pitot head positions.

3. Bibliography

- Determining Dust Concentration in a Gas Stream. ASME Performance Test Code No. 27. New York, 1957.
- Devorkin, Howard, et al. Air Pollution Source Testing Manual. Air Pollution Control District. Los Angeles, CA November 1963.
- Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases. Western Precipitation Division of Joy Manufacturing Co. Los Angeles, CA. Bulletin WP-50. 1968.
- Standard Method for Sampling Stacks for Particulate Matter. In: 1971 Book of ASTM Standards, Part 23. ASTM Designation D-2928-71. Philadelphia, PA 1971.
- Hanson, H. A., et al. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. USEPA, ORD, ESRL, Research Triangle Park, NC. EPA-600/2-76-170, June 1976.
- Entropy Environmentalists, Inc. Determination of the Optimum Number of Sampling Points: An Analysis of Method 1 Criteria. Environmental Protection Agency, Research Triangle Park, NC. EPA Contract No. 68-01-3172, Task 7.
- Hanson, H.A., R.J. Davini, J.K. Morgan, and A.A. Iversen. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA-600/2-76-170. June 1976. 350 p.
- Brooks, E.F., and R.L. Williams. Flow and Gas Sampling Manual. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA-600/2-76-203. July 1976. 93 p.
- Entropy Environmentalists, Inc. Traverse Point Study. EPA Contract No. 68-02-3172. June 1977. 19 p.
- Brown, J. and K. Yu. Test Report: Particulate Sampling Strategy in Circular Ducts. Emission Measurement Branch, Emission Standards and Engineering Division. U.S. Environmental Protection Agency, Research Triangle Park, NC. 27711. July 31, 1980. 12 p.
- Hawksley, P.G.W., S. Badzioch, and J.H. Blackett. Measurement of Solids in Flue Gases. Leatherhead, England, The British Coal Utilisation Research Association, 1961. p. 129-133.
- Knapp, K.T. The Number of Sampling Points Needed for Representative Source Sampling. In: Proceedings of the Fourth National Conference on Energy and the Environment, Theodore, L., et al. (ed.). Dayton, Dayton Section of the American Institute of Chemical Engineers. October 3-7, 1976. p. 563-568.
- Smith, W.S. and D.J. Grove. A Proposed Extension of EPA Method 1 Criteria. "Pollution Engineering." XV (8):36-37. August 1983.
- Gerhart, P.M. and M.J. Dorsey. Investigation of Field Test Procedures for Large Fans. University of Akron, Akron, OH. (EPRI Contract CS-1651). Final Report (RP-1649-5) December 1980.
- Smith, W.S. and D.J. Grove. A New Look at Isokinetic Sampling—Theory and Applications. "Source Evaluation Society Newsletter." VIII (3):19-24. August 1983.

The ALMEGA CORPORATION

APPENDIX C

**DETERMINATION OF STACK GAS VELOCITY
AND VOLUMETRIC FLOW RATE
(TYPE S PITOT TUBE)**

The ALMEGA CORPORATION

METHOD 2—DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

1. Principle and Applicability

1.1 Principle. The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube.

1.2 Applicability. This method is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow.

This procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 2.1. Also, the method cannot be used for direct measurement in cyclonic or swirling gas streams; Section 2.4 of Method 1 shows how to determine cyclonic or swirling flow conditions. When unacceptable conditions exist, alternative procedures, subject to the approval of the Administrator, U.S. Environmental Protection Agency, must be employed to make accurate flow rate determinations; examples of such alternative procedures are: (1) to install straightening vanes; (2) to calculate the total volumetric flow rate stoichiometrically, or (3) to move to another measurement site at which the flow is acceptable.

2. Apparatus

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

2.1 Type S Pitot Tube. The Type S pitot tube (Figure 2-1) shall be made of metal tubing (e.g. stainless steel). It is recommended that the external tubing diameter (dimension D , Figure 2-2b) be between 0.48 and 0.95 centimeters ($\frac{1}{4}$ and $\frac{3}{8}$ inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B , Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

The Type S pitot tube shall have a known coefficient, determined as outlined in Section 4, an identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube.

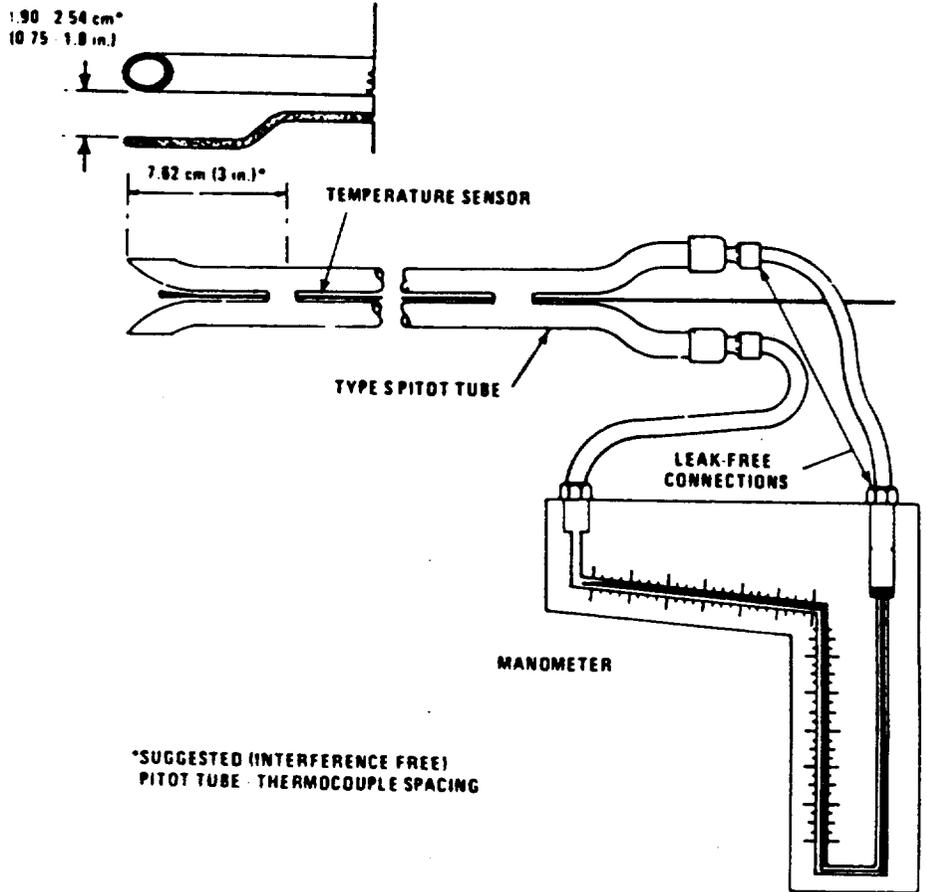


Figure 2-1. Type S pitot tube manometer assembly.

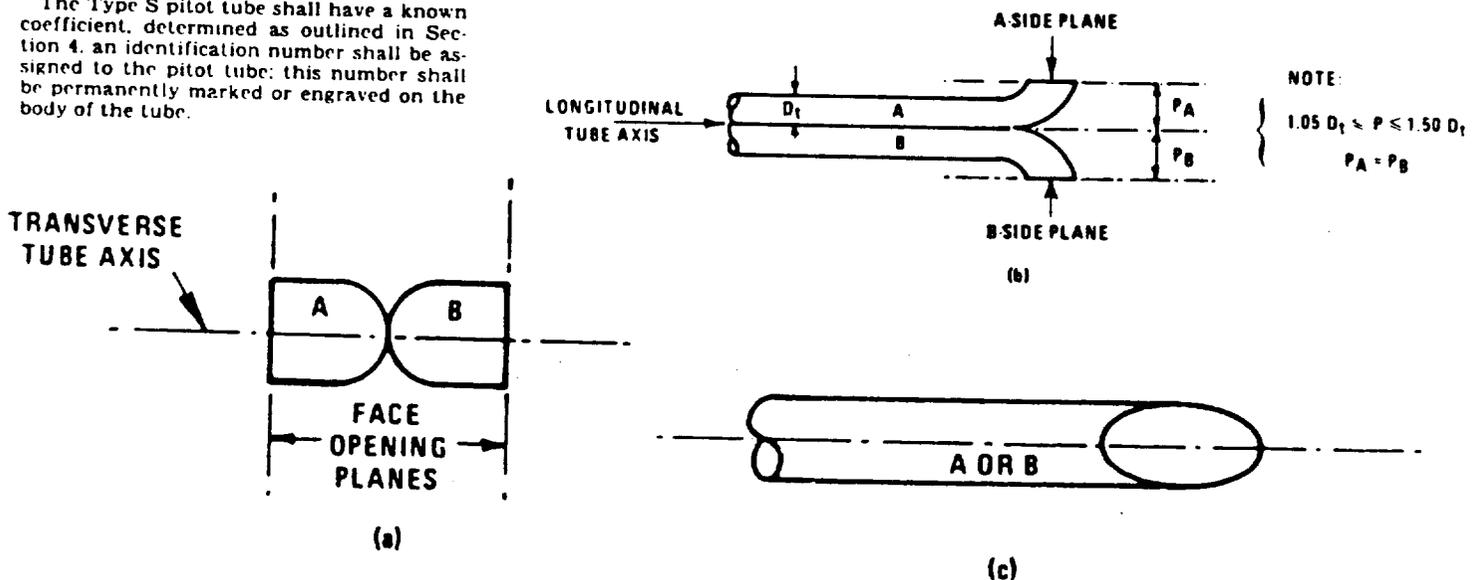


Figure 2-2. Properly constructed Type S pitot tube, shown in (a) end view, face opening planes perpendicular to transverse axis; (b) top view, face opening planes parallel to longitudinal axis; (c) side view, both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.64 may be assigned to pitot tubes constructed this way.

THE ALMEGA CORPORATION

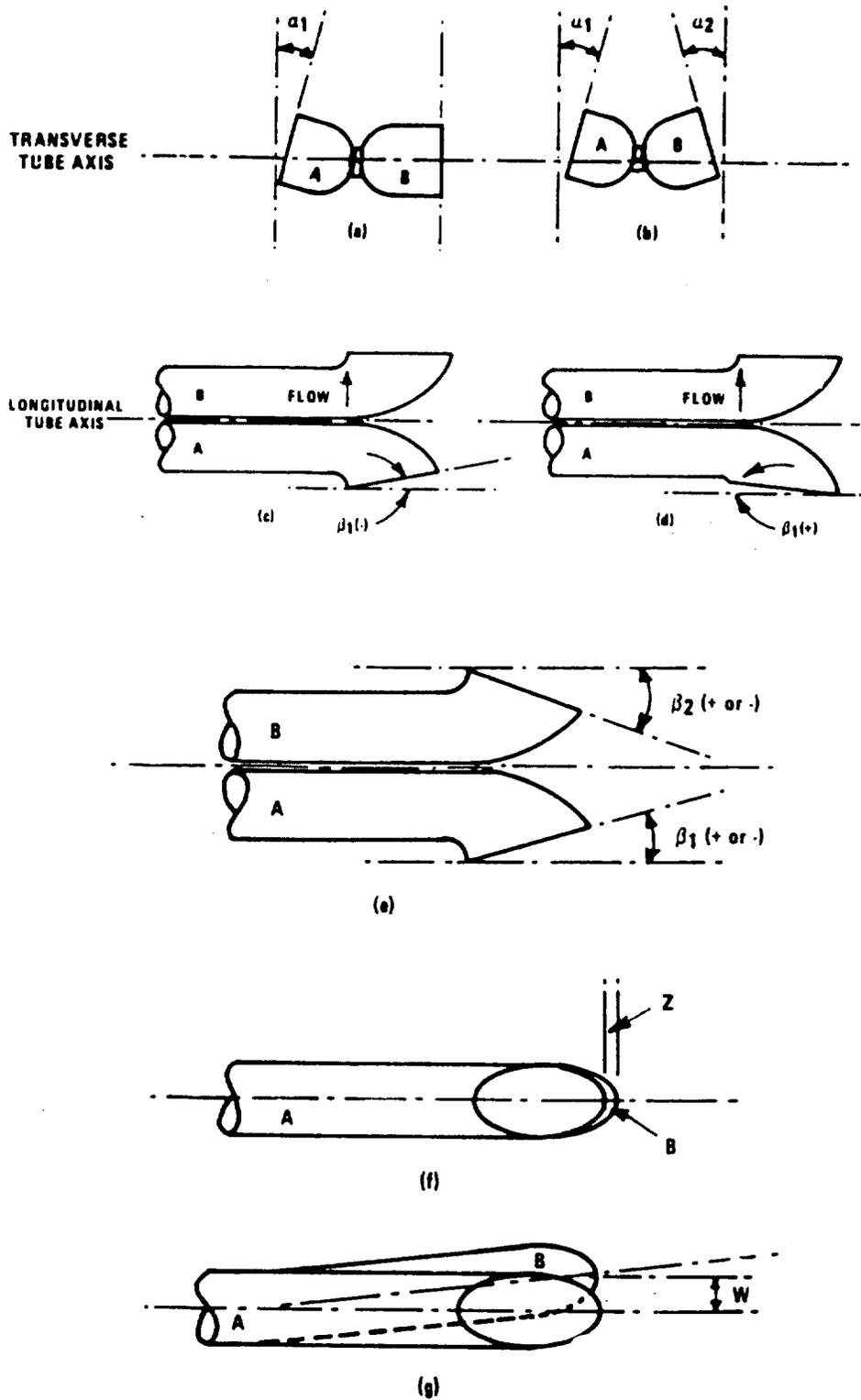


Figure 2-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of $C_p(s)$ so long as α_1 and $\alpha_2 < 10^\circ$, β_1 and $\beta_2 < 5^\circ$, $z < 0.32 \text{ cm}$ (1/8 in.) and $w < 0.08 \text{ cm}$ (1/32 in.) (citation 11 in Section 6).

The ALMEGA CORPORATION

A standard pitot tube may be used instead of a Type S, provided that it meets the specifications of Sections 2.7 and 4.2; note, however, that the static and impact pressure holes of standard pitot tubes are susceptible to plugging in particulate-laden gas streams. Therefore, whenever a standard pitot tube is used to perform a traverse, adequate proof must be furnished that the openings of the pitot tube have not plugged up during the traverse period; this can be done by taking a velocity head (Δp) reading at the final traverse point, cleaning out the impact and static holes of the standard pitot tube by "back-purging" with pressurized air, and then taking another Δp reading. If the Δp readings made before and after the air purge are the same (± 5 percent), the traverse is acceptable. Otherwise, reject the run. Note that if Δp at the final traverse point is unsuitably low, another point may be selected. If "back-purging" at regular intervals is part of the procedure, then comparative Δp readings shall be taken, as above, for the last two back purges at which suitably high Δp readings are observed.

2.2 Differential Pressure Gauge. An inclined manometer or equivalent device is used. Most sampling trains are equipped with a 10-in. (water column) inclined-vertical manometer, having 0.01-in. H₂O divisions on the 0-to 1-in. inclined scale, and 0.1-in. H₂O divisions on the 1- to 10-in. vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of Δp values as low as 1.3 mm (0.05 in.) H₂O. However, a differential pressure gauge of greater sensitivity shall be used (subject to the approval of the Administrator), if any of the following is found to be true: (1) the arithmetic average of all Δp readings at the traverse points in the stack is less than 1.3 mm (0.05 in.) H₂O; (2) for traverses of 12 or more points, more than 10 percent of the individual Δp readings are below 1.3 mm (0.05 in.) H₂O; (3) for traverses of fewer than 12 points, more than one Δp reading is below 1.3 mm (0.05 in.) H₂O. Citation 18 in Section 6 describes commercially available instrumentation for the measurement of low-range gas velocities.

As an alternative to criteria (1) through (3) above, the following calculation may be performed to determine the necessity of using a more sensitive differential pressure gauge:

$$T = \frac{\sum_{i=1}^n \sqrt{\Delta p_i} + K}{\sum_{i=1}^n \sqrt{\Delta p_i}}$$

where:

Δp_i = Individual velocity head reading at a traverse point, mm H₂O (in. H₂O).

n = Total number of traverse points.

K = 0.13 mm H₂O when metric units are used and 0.005 in. H₂O when English units are used.

If T is greater than 1.05, the velocity head data are unacceptable and a more sensitive differential pressure gauge must be used.

NOTE.—If differential pressure gauges other than inclined manometers are used (e.g., magnehelic gauges), their calibration must be checked after each test series. To check the calibration of a differential pressure gauge, compare Δp readings of the gauge with those of a gauge-oil manometer at a minimum of three points, approximately representing the range of Δp values in the stack. If, at each point, the values of Δp as read by the differential pressure gauge and gauge-oil manometer agree to within 5 percent, the differential pressure gauge shall be considered to be in proper calibration. Otherwise, the test series shall either be voided, or procedures to adjust the measured Δp values and final results shall be used subject to the approval of the Administrator.

2.3 Temperature Gauge. A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge, capable of measuring temperature to within 1.5 percent of the minimum absolute stack temperature shall be used. The temperature gauge shall be attached to the pitot tube such that the sensor tip does not touch any metal; the gauge shall be in an interference-free arrangement with respect to the pitot tube face openings (see Figure 2-1 and also Figure 2-7 in Section 4). Alternate positions may be used if the pitot tube-temperature gauge system is calibrated according to the procedure of Section 4. Provided that a difference of not more than 1 percent in the average velocity measurement is introduced, the temperature gauge need not be attached to the pitot tube; this alternative is subject to the approval of the Administrator.

2.4 Pressure Probe and Gauge. A piezometer tube and mercury- or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) Hg is used. The static tap of a standard type pitot tube or one leg of a Type S pitot tube with the face opening planes positioned parallel to the gas flow may also be used as the pressure probe.

2.5 Barometer. A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the

absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm (0.1 in.) Hg per 30-meter (100 foot) elevation increase or vice-versa for elevation decrease.

2.6 Gas Density Determination Equipment. Method 3 equipment, if needed (see Section 3.6), to determine the stack gas dry molecular weight, and Reference Method 4 or Method 5 equipment for moisture content determination; other methods may be used subject to approval of the Administrator.

2.7 Calibration Pitot Tube. When calibration of the Type S pitot tube is necessary (see Section 4), a standard pitot tube is used as a reference. The standard pitot tube shall, preferably, have a known coefficient, obtained either (1) directly from the National Bureau of Standards, Route 270, Quince Orchard Road, Gaithersburg, Maryland, or (2) by calibration against another standard pitot tube with an NBS-traceable coefficient. Alternatively, a standard pitot tube designed according to the criteria given in 2.7.1 through 2.7.5 below and illustrated in Figure 2-4 (see also Citations 7, 8, and 17 in Section 6) may be used. Pitot tubes designed according to these specifications will have baseline coefficients of about 0.99 ± 0.01.

2.7.1 Hemispherical (shown in Figure 2-4), ellipsoidal, or conical tip.

2.7.2 A minimum of six diameters straight run (based upon D , the external diameter of the tube) between the tip and the static pressure holes.

2.7.3 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90 degree bend.

2.7.4 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration.

2.7.5 Ninety degree bend, with curved or mitered junction.

2.8 Differential Pressure Gauge for Type S Pitot Tube Calibration. An inclined manometer or equivalent is used. If the single-velocity calibration technique is employed (see Section 4.1.2.3), the calibration differential pressure gauge shall be readable to the nearest 0.13 mm H₂O (0.005 in. H₂O). For multivelocity calibrations, the gauge shall be readable to the nearest 0.13 mm H₂O (0.005 in. H₂O) for Δp values between 1.3 and 25 mm H₂O (0.05 and 1.0 in. H₂O), and to the nearest 1.3 mm H₂O (0.05 in. H₂O) for Δp values above 25 mm H₂O (1.0 in. H₂O). A special, more sensitive gauge will be required to read Δp values below 1.3 mm H₂O (0.05 in. H₂O) (see Citation 18 in Section 6).

The ALMEGA CORPORATION

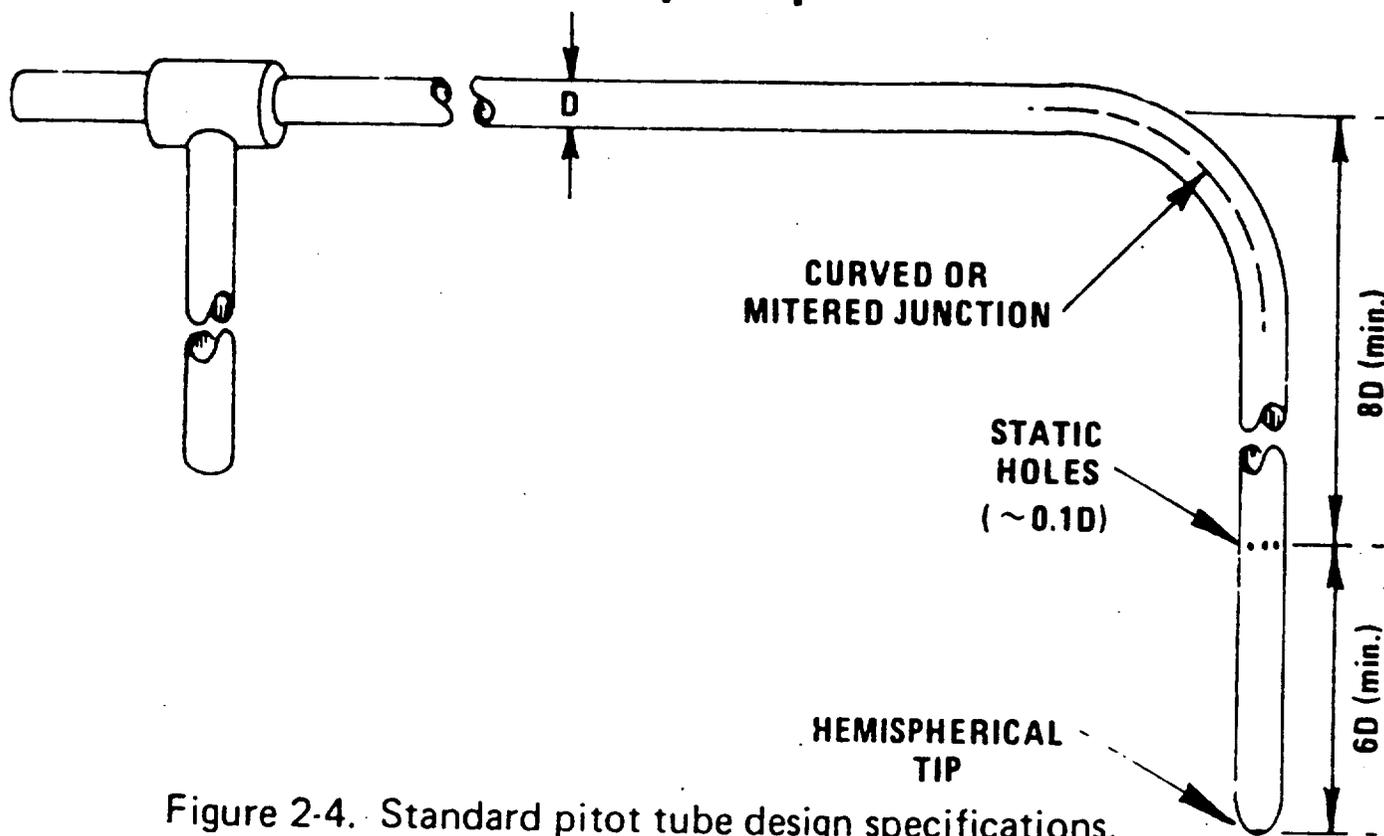


Figure 2-4. Standard pitot tube design specifications.

3. Procedure

3.1 Set up the apparatus as shown in Figure 2-1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen Δp fluctuations. It is recommended, but not required, that a pretest leak-check be conducted, as follows: (1) blow through the pitot impact opening until at least 7.6 cm (3 in.) H_2O velocity pressure registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (2) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3 in.) H_2O . Other leak-check procedures, subject to the approval of the Administrator may be used.

3.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record all necessary data as shown in the example data sheet (Figure 2-5).

3.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of Δp values encountered (see Section 2.2). If it is necessary to change to a more sensitive gauge, do so, and remeasure the Δp and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in Section 3.1 above, to validate the traverse run.

3.4 Measure the static pressure in the stack. One reading is usually adequate.

3.5 Determine the atmospheric pressure.

3.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2 , O_2 , CO , and N_2 , use Method 3. For processes emitting essentially air, an analysis need not be con-

ducted; use a dry molecular weight of 29.0. For other processes, other methods, subject to the approval of the Administrator, must be used.

3.7 Obtain the moisture content from Reference Method 4 (or equivalent) or from Method 5.

3.8 Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimensions rather than using blueprints.

4. Calibration

4.1 Type S Pitot Tube. Before its initial use, carefully examine the Type S pitot tube in top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figure 2-2 or 2-3. The pitot tube shall not be used if it fails to meet these alignment specifications.

After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D , Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_1 and P_2 , Figure 2-2b). If D is between 0.48 and 0.95 cm ($3/16$ and $3/8$ in.) and if P_1 and P_2 are equal and between 1.05 and 1.50 D , there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, or (2) a baseline (isolated tube) coefficient value of 0.84 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 4.1.1).

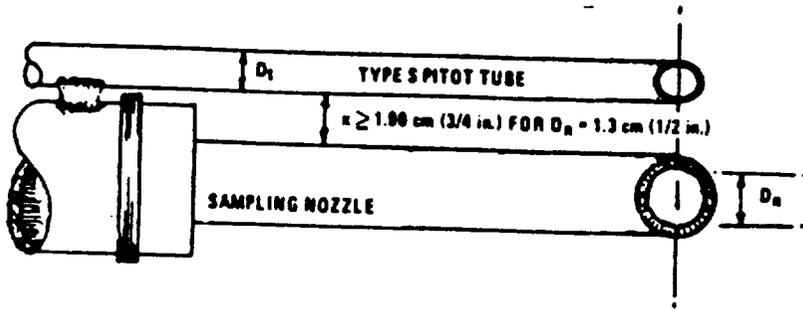
If D , P_1 , and P_2 are outside the specified limits, the pitot tube must be calibrated as outlined in 4.1.2 through 4.1.5 below.

4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Citation 9 in Section 6); therefore an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-6 through 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm ($3/16$ and $3/8$ in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-6 through 2-8 shall be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

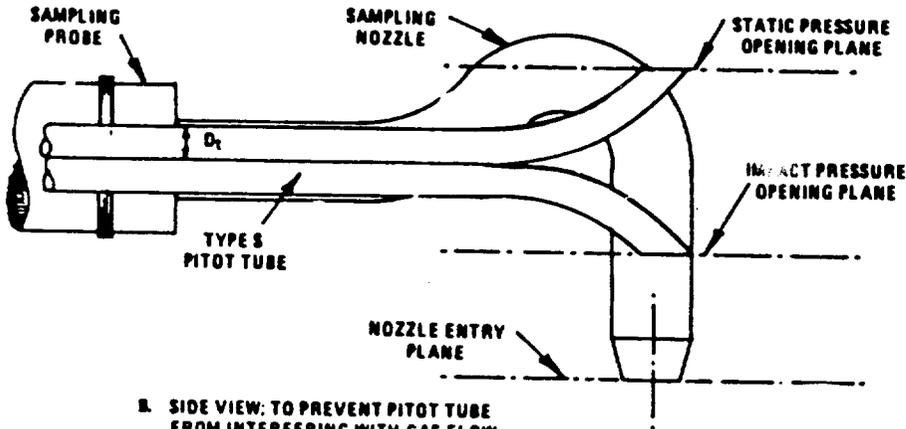
NOTE.—Do not use any Type S pitot tube assembly which is constructed such that the impact pressure opening plane of the pitot tube is below the entry plane of the nozzle (see Figure 2-6b).

4.1.2 Calibration Setup. If the Type S pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be done in a flow system having the following essential design features:

The ALMEGA CORPORATION



A. BOTTOM VIEW: SHOWING MINIMUM PITOT-NOZZLE SEPARATION.



B. SIDE VIEW: TO PREVENT PITOT TUBE FROM INTERFERING WITH GAS FLOW STREAMLINES APPROACHING THE NOZZLE, THE IMPACT PRESSURE OPENING PLANE OF THE PITOT TUBE SHALL BE EVEN WITH OR ABOVE THE NOZZLE ENTRY PLANE.

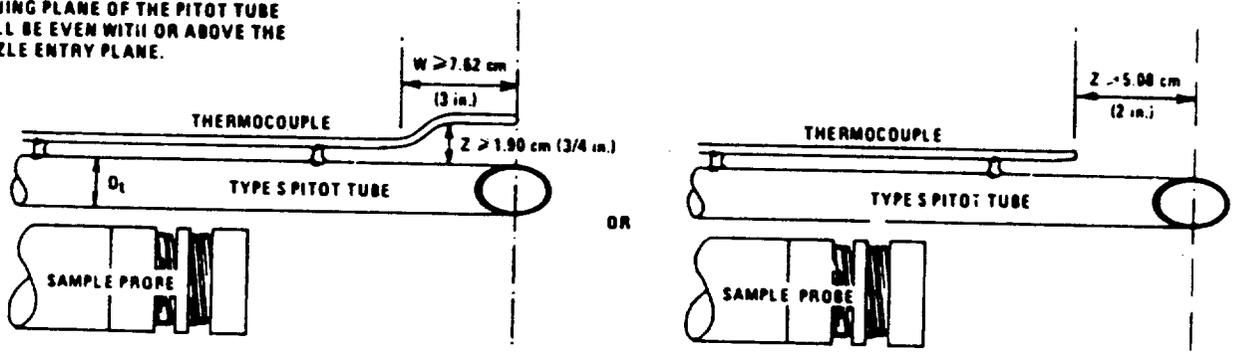


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

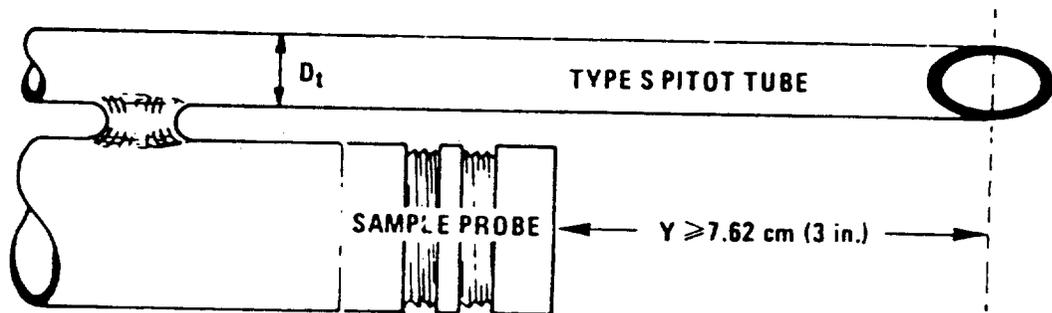


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

THE ALMEGA CORPORATION

THE ALMEGA CORPORATION

4.1.2.1 The flowing gas stream must be confined to a duct of definite cross-sectional area, either circular or rectangular. For circular cross-sections, the minimum duct diameter shall be 30.5 cm (12 in.); for rectangular cross-sections, the width (shorter side) shall be at least 25.4 cm (10 in.).

4.1.2.2 The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation, to determine the number of duct diameters:

$$D = \frac{2LW}{L+W}$$

Equation 2-1

where:

D = Equivalent diameter

L = Length

W = Width

To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section," the site must be located at least eight diameters downstream and two diameters upstream from the nearest disturbances.

NOTE.—The eight- and two-diameter criteria are not absolute; other test section locations may be used (subject to approval of the Administrator), provided that the flow at the test site is stable and demonstrably parallel to the duct axis.

4.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3,000 ft/min) will generally be valid to within ± 3 percent for the measurement of velocities above 305 m/min (1,000 ft/min) and to within ± 5 to 6 percent for the measurement of velocities between 180 and 305 m/min (600 and 1,000 ft/min). If a more precise correlation between C_p and velocity is desired, the flow system shall have the capacity to generate at least four distinct, time-invariant test-section velocities covering the velocity range from 180 to 1,525 m/min (600 to 5,000 ft/min), and calibration data shall be taken at regular velocity intervals over this range (see Citations 9 and 14 in Section 6 for details).

4.1.2.4 Two entry ports, one each for the standard and Type S pitot tubes, shall be cut in the test section; the standard pitot entry port shall be located slightly downstream of the Type S port, so that the standard and Type S impact openings will lie in the same cross-sectional plane during calibration. To facilitate alignment of the pitot tubes during calibration, it is advisable that the test section be constructed of plexiglas or some other transparent material.

4.1.3 Calibration Procedure. Note that this procedure is a general one and must not be used without first referring to the special considerations presented in Section 4.1.5. Note also that this procedure applies only to single-velocity calibration. To obtain calibration data for the A and B sides of the Type S pitot tube, proceed as follows:

4.1.3.2 Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type S entry port.

4.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.5.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.4 Read Δp_{std} and record its value in a data table similar to the one shown in Figure 2-9. Remove the standard pitot tube from the duct and disconnect it from the manometer. Seal the standard entry port.

4.1.3.5 Connect the Type S pitot tube to the manometer. Open the Type S entry port. Check the manometer level and zero. Insert and align the Type S pitot tube so that its A side impact opening is at the same

point as was the standard pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.6 Read Δp_s and enter its value in the data table. Remove the Type S pitot tube from the duct and disconnect it from the manometer.

4.1.3.7 Repeat steps 4.1.3.3 through 4.1.3.6 above until three pairs of Δp readings have been obtained.

4.1.3.8 Repeat steps 4.1.3.3 through 4.1.3.7 above for the B side of the Type S pitot tube.

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

4.1.4 Calculations.

4.1.4.1 For each of the six pairs of Δp readings (i.e., three from side A and three from side B) obtained in Section 4.1.3 above, calculate the value of the Type S pitot tube coefficient as follows:

PITOT TUBE IDENTIFICATION NUMBER: _____ DATE: _____

CALIBRATED BY: _____

"A" SIDE CALIBRATION				
RUN NO.	Δp_{std} cm H ₂ O (in. H ₂ O)	Δp_s cm H ₂ O (in. H ₂ O)	$C_p(s)$	DEVIATION $C_p(s) - \bar{C}_p(A)$
1				
2				
3				
			\bar{C}_p (SIDE A)	

"B" SIDE CALIBRATION				
RUN NO.	Δp_{std} cm H ₂ O (in. H ₂ O)	Δp_s cm H ₂ O (in. H ₂ O)	$C_p(s)$	DEVIATION $C_p(s) - \bar{C}_p(B)$
1				
2				
3				
			\bar{C}_p (SIDE B)	

$$\text{AVERAGE DEVIATION} = \sigma(A \text{ OR } B) = \frac{\sum_{i=1}^3 |C_p(s) - \bar{C}_p(A \text{ OR } B)|}{3} \leftarrow \text{MUST BE } \leq 0.01$$

5. Vennard, J. K. *Elementary Fluid Mechanics*. New York. John Wiley and Sons, Inc. 1947.
6. *Fluid Meters—Their Theory and Application*. American Society of Mechanical Engineers, New York, N.Y. 1959.
7. *ASHRAE Handbook of Fundamentals*. 1972. p. 208.
8. *Annual Book of ASTM Standards*, Part 26. 1974. p. 648.
9. Vollaro, R. F. Guidelines for Type S Pitot Tube Calibration. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at 1st Annual Meeting, Source Evaluation Society, Dayton, Ohio, September 18, 1975.)
10. Vollaro, R. F. A Type S Pitot Tube Calibration Study. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. July 1974.
11. Vollaro, R. F. The Effects of Impact Opening Misalignment on the Value of the Type S Pitot Tube Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. October 1976.
12. Vollaro, R. F. Establishment of a Baseline Coefficient Value for Properly Constructed Type S Pitot Tubes. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.
13. Vollaro, R. F. An Evaluation of Single-Velocity Calibration Technique as a Means of Determining Type S Pitot Tubes Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. August 1975.
14. Vollaro, R. F. The Use of Type S Pitot Tubes for the Measurement of Low Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.
15. Smith, Marvin L. Velocity Calibration of EPA Type Source Sampling Probe. United Technologies Corporation, Pratt and Whitney Aircraft Division, East Hartford, Conn. 1975.
16. Vollaro, R. F. Recommended Procedure for Sample Traverses in Ducts Smaller than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976.
17. Ower, E. and R. C. Pankhurst. *The Measurement of Air Flow*, 4th Ed., London, Pergamon Press. 1966.
18. Vollaro, R. F. A Survey of Commercially Available Instrumentation for the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park N.C. November 1976. (Unpublished Paper)
19. Gnyp, A. W., C. C. St. Pierre, D. S. Smith, D. Mozzon, and J. Steiner. An Experimental Investigation of the Effect of Pitot Tube-Sampling Probe Configurations on the Magnitude of the S Type Pitot Tube Coefficient for Commercially Available Source Sampling Probes. Prepared by the University of Windsor for the Ministry of the Environment, Toronto, Canada. February 1975.

Reprinted from CFR Title 40 dated July 1980
pages 290-310

Reprinted from CFR Title 40 dated July 1980
pages 290-310

The ALMEGA CORPORATION

APPENDIX D

GAS ANALYSIS FOR CARBON DIOXIDE,
OXYGEN, EXCESS AIR AND
DRY MOLECULAR WEIGHT

THE ALMEGA CORPORATION

4.1.4 To insure complete absorption of the CO₂, O₂, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.1.5 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. **NOTE.**—Since this single-point, grab sampling and analytical procedure is normally conducted in conjunction with a single-point, grab sampling and analytical procedure for a pollutant, only one analysis is ordinarily conducted. Therefore, great care must be taken to obtain a valid sample and analysis. Although in most cases only CO₂ or O₂ is required, it is recommended that both CO₂ and O₂ be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.2 Single-Point, Integrated Sampling and Analytical Procedure.

4.2.1 The sampling point in the duct shall be located as specified in Section 4.1.1.

4.2.2 Leak-check (mandatory) the flexible bag as in Section 2.2.6. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (mandatory) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of a least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum shall remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

4.2.3 Sample at a constant rate, or as specified by the Administrator. The sampling run must be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft³) of sample gas. Smaller volumes may be collected, subject to approval of the Administrator.

4.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. For emission rate correction factor determination, analyze the sample within 4 hours after it is taken for percent CO₂ or percent O₂ (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-checked (see Section 5) before the analysis. If excess air is desired, proceed as follows: (1) within 4 hours after the sample is taken, analyze it (as in Sections 4.2.5 through 4.2.7) for percent CO₂, O₂, and CO; (2) determine the percentage of the gas that is N₂ by subtracting the sum of the percent CO₂, percent O₂, and percent CO from 100 percent; (3) calculate percent excess air, as outlined in Section 6.2.

4.2.5 To insure complete absorption of the CO₂, O₂, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.2.6 Repeat the analysis until the following criteria are met:

4.2.6.1 For percent CO₂, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when CO₂ is greater than 4.0 percent or (b) 0.2 percent by volume when CO₂ is less than or equal to 4.0 percent. Average the three acceptable values of percent CO₂ and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O₂, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when O₂ is less than 15.0 percent or (b) 0.2 percent by volume when O₂ is greater than or equal to 15.0 percent. Average the three acceptable values of percent O₂ and report the results to the nearest 0.1 percent.

4.2.6.3 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than 0.3 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.7 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. **NOTE:** Although in most instances only CO₂ or O₂ is required, it is recommended that both CO₂ and O₂ be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.3 Multi-Point, Integrated Sampling and Analytical Procedure.

4.3.1 Both the minimum number of sampling points and the sampling point location shall be as specified in Section 3.3.1 of this method. The use of fewer points than specified is subject to the approval of the Administrator.

4.3.2 Follow the procedures outlined in Sections 4.2.2 through 4.2.7, except for the following: Traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

5. Leak-Check Procedure for Orsat Analyzers

Moving an Orsat analyzer frequently causes it to leak. Therefore, an Orsat analyzer should be thoroughly leak-checked on site before the flue gas sample is introduced into it. The procedure for leak-checking an Orsat analyzer is:

5.1.1 Bring the liquid level in each pipette up to the reference mark on the capillary tubing and then close the pipette stopcock.

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette and then close the manifold stopcock.

5.1.3 Record the meniscus position.

5.1.4 Observe the meniscus in the burette and the liquid level in the pipette for movement over the next 4 minutes.

5.1.5 For the Orsat analyzer to pass the leak-check, two conditions must be met.

5.1.5.1 The liquid level in each pipette must not fall below the bottom of the capillary tubing during this 4-minute interval.

5.1.5.2 The meniscus in the burette must not change by more than 0.2 ml during this 4-minute interval.

5.1.6 If the analyzer fails the leak-check procedure, all rubber connections and stopcocks should be checked until the cause of the leak is identified. Leaking stopcocks must be disassembled, cleaned, and re-

greased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. Calculations

6.1 Nomenclature.

M_a = Dry molecular weight, g/g-mole (lb/lb-mole).

%EA = Percent excess air.

%CO₂ = Percent CO₂ by volume (dry basis).

%O₂ = Percent O₂ by volume (dry basis).

%CO = Percent CO by volume (dry basis).

%N₂ = Percent N₂ by volume (dry basis).

0.264 = Ratio of O₂ to N₂ in air, v/v.

0.280 = Molecular weight of N₂ or CO, divided by 100.

0.320 = Molecular weight of O₂, divided by 100.

0.440 = Molecular weight of CO, divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O₂, CO, and N₂ (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%EA = \left[\frac{\%O_2 - 0.5\%CO}{0.264\%N_2 - (\%O_2 - 0.5\%CO)} \right] 100$$

Equation 3-1

NOTE.—The equation above assumes that ambient air is used as the source of O₂ and that the fuel does not contain appreciable amounts of N₂ (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N₂ are present (coal, oil, and natural gas do not contain appreciable amounts of N₂) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas

$$M_a = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

Equation 3-2

NOTE.—The above equation does not consider argon in air (about 0.9 percent, molecular weight of 37.7). A negative error of about 0.4 percent is introduced. The tester may opt to include argon in the analysis using procedures subject to approval of the Administrator.

7. Bibliography

1. Altshuler, A. P. Storage of Gases and Vapors in Plastic Bags. International Journal of Air and Water Pollution. 6:75-81. 1963.

2. Conner, William D. and J. S. Nader. Air Sampling with Plastic Bags. Journal of the American Industrial Hygiene Association. 25:291-297. 1964.

3. Burrell Manual for Gas Analysts. Seventh edition. Burrell Corporation. 2223 Fifth Avenue, Pittsburgh, Pa. 15219. 1951.

4. Mitchell, W. J. and M. R. Midgett. Field Reliability of the Orsat Analyzer. Journal of Air Pollution Control Association 26:491-495. May 1976.

5. Shigehara, R. T., R. M. Neulicht, and W. S. Smith. Validating Orsat Analysis Data from Fossil Fuel-Fired Units. Stack Sampling News. 4(2):21-26. August, 1976.

The ALMEGA CORPORATION

APPENDIX E

DETERMINATION OF MOISTURE CONTENT IN STACK GASES

The ALMEGA CORPORATION

1. Principle and Applicability

1.1 Principle. A gas sample is extracted from a stack, by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analyzed for percent carbon dioxide (CO₂), percent oxygen (O₂), and, if necessary, percent carbon monoxide (CO). If a dry molecular weight determination is to be made, either an Orsat or a Fyrite¹ analyzer may be used for the analysis; for excess air or emission rate correction factor determination, an Orsat analyzer must be used.

1.2 Applicability. This method is applicable for determining CO₂ and O₂ concentrations, excess air, and dry molecular weight of a sample from a gas stream of a fossil-fuel combustion process. The method may also be applicable to other processes where it has been determined that compounds other than CO₂, O₂, CO, and nitrogen (N₂) are not present in concentrations sufficient to affect the results.

Other methods, as well as modifications to the procedure described herein, are also applicable for some or all of the above determinations. Examples of specific methods and modifications include: (1) a multi-point sampling method using an Orsat analyzer to analyze individual grab samples obtained at each point; (2) a method using CO₂ or O₂ and stoichiometric calculations to determine dry molecular weight and excess air; (3) assigning a value of 30.0 for dry molecular weight, in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Administrator, U.S. Environmental Protection Agency.

2. Apparatus

As an alternative to the sampling apparatus and systems described herein, other sampling systems (e.g., liquid displacement) may be used provided such systems are capable of obtaining a representative sample and maintaining a constant sampling rate, and are otherwise capable of yielding acceptable results. Use of such systems is subject to the approval of the Administrator.

2.1 Grab Sampling (Figure 3-1).

2.1.1 Probe. The probe should be made of stainless steel or borosilicate glass tubing and should be equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other materials inert to O₂, CO₂, CO, and N₂ and resistant to temperature at sampling conditions may be used for the probe; examples of such material are aluminum, copper, quartz glass and Teflon.

2.1.2 Pump. A one-way squeeze bulb, or equivalent, is used to transport the gas sample to the analyzer.

2.2 Integrated Sampling (Figure 3-2).

2.2.1 Probe. A probe such as that described in Section 2.1.1 is suitable.

2.2.2 Condenser. An air-cooled or water-cooled condenser, or other condenser that will not remove O₂, CO₂, CO, and N₂, may be used to remove excess moisture which would interfere with the operation of the pump and flow meter.

2.2.3 Valve. A needle valve is used to adjust sample gas flow rate.

2.2.4 Pump. A leak-free, diaphragm-type pump, or equivalent, is used to transport sample gas to the flexible bag. Install a small surge tank between the pump and rate meter to eliminate the pulsation effect of the diaphragm pump on the rotameter.

2.2.5 Rate Meter. The rotameter, or equivalent rate meter, used should be capable of measuring flow rate to within ± 2 percent of the selected flow rate. A flow rate range of 500 to 1000 cm³/min is suggested.

2.2.6 Flexible Bag. Any leak-free plastic (e.g., Tedlar, Mylar, Teflon) or plastic-coated aluminum (e.g., aluminized Mylar) bag, or equivalent, having a capacity consistent with the selected flow rate and time

length of the test run, may be used. A capacity in the range of 55 to 90 liters is suggested.

To leak-check the bag, connect it to a water manometer and pressurize the bag to 5 to 10 cm H₂O (2 to 4 in. H₂O). Allow to stand for 10 minutes. Any displacement in the water manometer indicates a leak. An alternative leak-check method is to pressurize the bag to 5 to 10 cm H₂O (2 to 4 in. H₂O) and allow to stand overnight. A deflated bag indicates a leak.

2.2.7 Pressure Gauge. A water-filled U-tube manometer, or equivalent, of about 28 cm (12 in.) is used for the flexible bag leak-check.

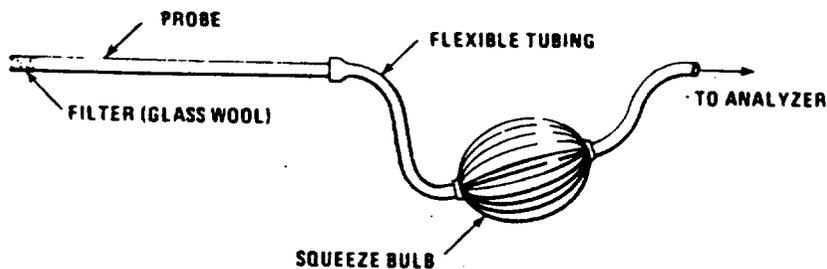


Figure 3-1. Grab sampling train.

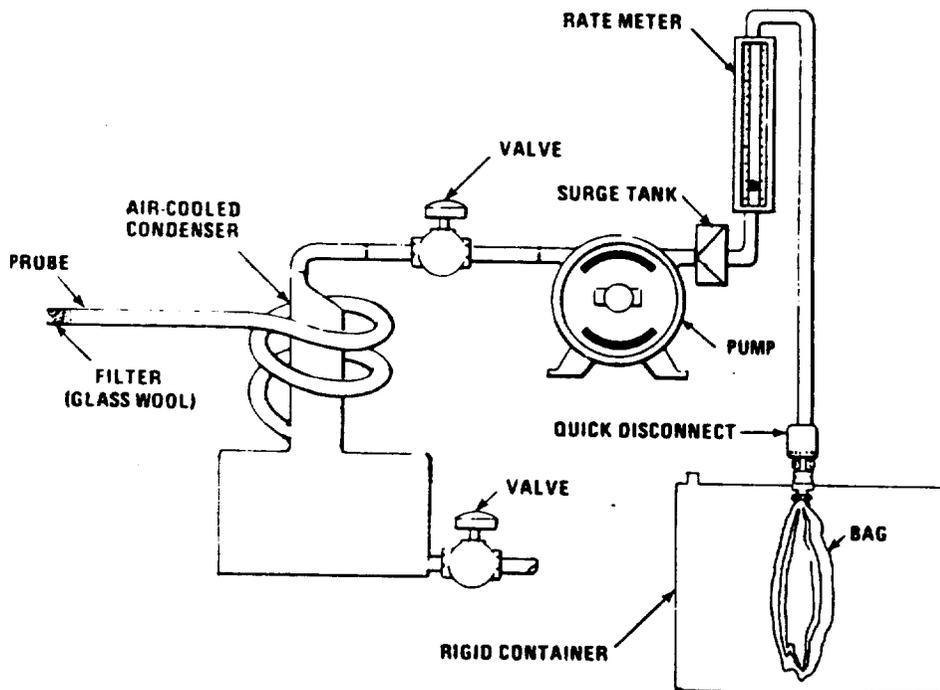


Figure 3-2. Integrated gas sampling train.

¹Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

The ALMEGA CORPORATION

2.2.8 Vacuum Gauge. A mercury manometer, or equivalent, of at least 760 mm Hg (30 in. Hg) is used for the sampling train leak-check.

2.3 Analysis. For Orsat and Fyrite analyzer maintenance and operation procedures, follow the instructions recommended by the manufacturer, unless otherwise specified herein.

2.3.1 Dry Molecular Weight Determination. An Orsat analyzer or Fyrite type combustion gas analyzer may be used.

2.3.2 Emission Rate Correction Factor or Excess Air Determination. An Orsat analyzer must be used. For low CO₂ (less than 4.0 percent) or high O₂ (greater than 15.0 percent) concentrations, the measuring burette of the Orsat must have at least 0.1 percent subdivisions.

3. Dry Molecular Weight Determination

Any of the three sampling and analytical procedures described below may be used for determining the dry molecular weight.

3.1 Single-Point, Grab Sampling and Analytical Procedure.

3.1.1 The sampling point in the duct shall either be at the centroid of the cross section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

3.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. If an Orsat analyzer is used, it is recommended that the analyzer be leak-checked by following the procedure in Section 5; however, the leak-check is optional.

3.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer and immediately analyze it for percent CO₂ and percent O₂. Determine the percentage of the gas that is N₂ and CO by subtracting the sum of the percent CO₂ and percent O₂ from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.1.4 Repeat the sampling, analysis, and calculation procedures, until the dry molecular weights of any three grab samples differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (lb/lb-mole).

3.2 Single-Point, Integrated Sampling and Analytical Procedure.

3.2.1 The sampling point in the duct shall be located as specified in Section 3.1.1.

3.2.2 Leak-check (optional) the flexible bag as in Section 2.2.6. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (optional) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum should remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

3.2.3 Sample at a constant rate. The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 30 liters (1.00 ft³) of sample gas is recommended; however, smaller volumes may be collected, if desired.

3.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO₂ and percent O₂ using either an Orsat analyzer or a Fyrite-type combustion gas analyzer. If an Orsat analyzer is used, it is recommended that the Orsat leak-check described in Section 5 be performed before this determination; however, the check is optional. Determine the percentage of the gas that is N₂ and CO by subtracting the sum of the percent CO₂ and percent O₂ from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.2.5 Repeat the analysis and calculation procedures until the individual dry molecular weights for any three analyses differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

3.3 Multi-Point, Integrated Sampling and Analytical Procedure.

3.3.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used for all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to approval of the Administrator.

3.3.2 Follow the procedures outlined in sections 3.2.2 through 3.2.5, except for the following: traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

4. Emission Rate Correction Factor or Excess Air Determination

NOTE.—A Fyrite-type combustion gas analyzer is not acceptable for excess air or emission rate correction factor determination, unless approved by the Administrator. If both percent CO₂ and percent O₂ are measured, the analytical results of any of the three procedures given below may also be used for calculating the dry molecular weight.

Each of the three procedures below shall be used only when specified in an applicable subpart of the standards. The use of these procedures for other purposes must have specific prior approval of the Administrator.

4.1 Single-Point, Grab Sampling and Analytical Procedure.

4.1.1 The sampling point in the duct shall either be at the centroid of the cross-section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

4.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. Leak-check the Orsat analyzer according to the procedure described in Section 5. This leak-check is mandatory.

4.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer. For emission rate correction factor determination, immediately analyze the sample, as outlined in Sections 4.1.4 and 4.1.5, for percent CO₂ or percent O₂. If excess air is desired, proceed as follows: (1) immediately analyze the sample, as in Sections 4.1.4 and 4.1.5, for percent CO₂, O₂, and CO; (2) determine the percentage of the gas that is N₂ by subtracting the sum of the percent CO₂, percent O₂, and percent CO from 100 percent; and (3) calculate percent excess air as outlined in Section 6.2.

TIME	TRAVERSE PT.	Q lpm	% DEV. ^a
AVERAGE			

$${}^a \% \text{ DEV} = \left(\frac{Q \cdot Q_{\text{avg}}}{Q_{\text{avg}}} \right) 100 \quad (\text{MUST BE } \leq 10\%)$$

Figure 3-3. Sampling rate data.

The ALMEGA CORPORATION

1. Principle and Applicability

1.1 Principle. A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined either volumetrically or gravimetrically.

1.2 Applicability. This method is applicable for determining the moisture content of stack gas.

Two procedures are given. The first is a reference method, for accurate determinations of moisture content (such as are needed to calculate emission data). The second is an approximation method, which provides estimates of percent moisture to aid in setting isokinetic sampling rates prior to a pollutant emission measurement run. The approximation method described herein is only a suggested approach; alternative means for approximating the moisture content, e.g., drying tubes, wet bulb-dry bulb techniques, condensation techniques, stoichiometric calculations, previous experience, etc., are also acceptable.

The reference method is often conducted simultaneously with a pollutant emission measurement run; when it is, calculation of percent isokinetic, pollutant emission rate, etc., for the run shall be based upon the results of the reference method or its equivalent; these calculations shall not be based upon the results of the approximation method, unless the approximation method is shown, to the satisfaction of the Administrator, U.S. Environmental Protection Agency, to be capable of yielding results within 1 percent H₂O of the reference method.

NOTE.—The reference method may yield questionable results when applied to saturated gas streams or to streams that contain water droplets. Therefore, when these conditions exist or are suspected, a second determination of the moisture content shall be made simultaneously with the reference method, as follows: Assume that the gas stream is saturated. Attach a temperature sensor (capable of measuring to $\pm 1^\circ\text{C}$ (2°F)) to the reference method probe. Measure the stack gas temperature at each traverse point (see Section 2.2.1) during the reference method traverse; calculate the average stack gas temperature. Next, determine the moisture percentage, either by: (1) using a psychrometric chart and making appropriate corrections if stack pressure is different from that of the chart, or (2) using saturation vapor pressure tables. In cases where the psychrometric chart or the saturation vapor pressure tables are not applicable (based on evaluation of the process), alternate methods, subject to the approval of the Administrator, shall be used.

2. Reference Method

The procedure described in Method 5 for determining moisture content is acceptable as a reference method.

2.1 Apparatus. A schematic of the sampling train used in this reference method is shown in Figure 4-1. All components shall be maintained and calibrated according to the procedure outlined in Method 5.

2.1.1 Probe. The probe is constructed of stainless steel or glass tubing, sufficiently heated to prevent water condensation, and is equipped with a filter, either in-stack (e.g., a plug of glass wool inserted into the end of the probe) or heated out-stack (e.g., as described in Method 5), to remove particulate matter.

When stack conditions permit, other metals or plastic tubing may be used for the probe, subject to the approval of the Administrator.

2.1.2 Condenser. The condenser consists of four impingers connected in series with ground glass, leak-free fittings or any similarly leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with a 1.3 centimeter ($\frac{1}{2}$ inch) ID glass tube extending to about 1.3 cm ($\frac{1}{2}$ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator.

The first two impingers shall contain known volumes of water, the third shall be empty, and the fourth shall contain a known weight of 6- to 16-mesh indicating type silica gel, or equivalent desiccant. If the silica gel has been previously used, dry at 175°C (350°F) for 2 hours. New silica gel may be used as received. A thermometer, ca-

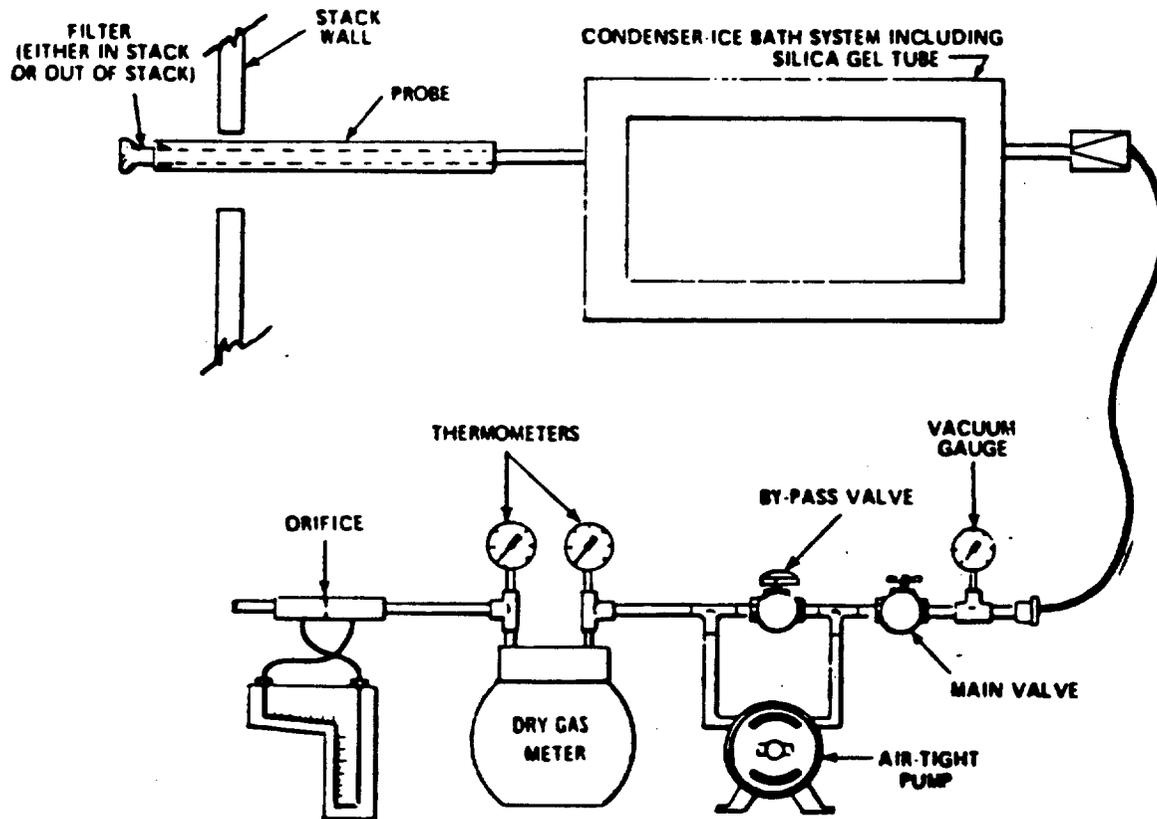


Figure 4-1. Moisture sampling train-reference method

The ALMEGA CORPORATION

pable of measuring temperature to within 1° C (2° F), shall be placed at the outlet of the fourth impinger, for monitoring purposes.

Alternatively, any system may be used (subject to the approval of the Administrator) that cools the sample gas stream and allows measurement of both the water that has been condensed and the moisture leaving the condenser, each to within 1 ml or 1 g. Acceptable means are to measure the condensed water, either gravimetrically or volumetrically, and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures, or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap, with exit gases kept below 20° C (68° F), and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump, to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

2.1.3 Cooling System. An ice bath container and crushed ice (or equivalent) are used to aid in condensing moisture.

2.1.4 Metering System. This system includes a vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3° C (5.4° F), dry gas meter capable of measuring volume to within 2 percent, and related equipment as shown in Figure 4-1. Other metering systems, capable of maintaining a constant sampling rate and determining sample gas volume, may be used, subject to the approval of the Administrator.

2.1.5 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.6 Graduated Cylinder and/or Balance. These items are used to measure condensed water and moisture caught in the silica gel to within 1 ml or 0.5 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. These balances are suitable for use here.

2.2 Procedure. The following procedure is written for a condenser system (such as the impinger system described in Section 2.1.2) incorporating volumetric analysis to measure the condensed moisture, and silica gel and gravimetric analysis to measure the moisture leaving the condenser.

2.2.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine points shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used in all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to the approval of

the Administrator. Select a suitable probe and probe length such that all traverse points can be sampled. Consider sampling from opposite sides of the stack (four total sampling ports) for large stacks, to permit use of shorter probe lengths. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point. Place known volumes of water in the first two impingers. Weigh and record the weight of the silica gel to the nearest 0.5 g, and transfer the silica gel to the fourth impinger; alternatively, the silica gel may first be transferred to the impinger, and the weight of the silica gel plus impinger recorded.

2.2.2 Select a total sampling time such that a minimum total gas volume of 0.60 scm (21 scf) will be collected, at a rate no greater than 0.021 m³/min (0.75 cfm). When both moisture content and pollutant emission rate are to be determined, the moisture determination shall be simultaneous with, and for the same total length of time as, the pollutant emission rate run, unless otherwise specified in an applicable subpart of the standards.

2.2.3 Set up the sampling train as shown in Figure 4-1. Turn on the probe heater and (if applicable) the filter heating system to temperatures of about 120° C (248° F), to prevent water condensation ahead of the condenser; allow time for the temperatures to stabilize. Place crushed ice in the ice bath container. It is recommended, but not required, that a leak check be done, as follows: Disconnect the probe from the first impinger or (if applicable) from the filter holder. Plug the inlet to the first impinger (or filter holder) and pull a 380 mm (15 in.) Hg vacuum; a lower vacuum may be used, provided that it is not exceeded during the test. A leakage rate in excess of 4 percent of the average sampling rate or 0.00057 m³/min (0.02 cfm), whichever is less, is unacceptable. Following the leak check, reconnect the probe to the sampling train.

2.2.4 During the sampling run, maintain a sampling rate within 10 percent of constant rate, or as specified by the Administrator. For each run, record the data required on the example data sheet shown in Figure 4-2. Be sure to record the dry gas meter reading at the beginning and end of each sampling time increment and whenever sampling is halted. Take other appropriate readings at each sample point, at least once during each time increment.

2.2.5 To begin sampling, position the probe tip at the first traverse point. Immediately start the pump and adjust the flow to the desired rate. Traverse the cross section, sampling at each traverse point for an equal length of time. Add more ice and, if necessary, salt to maintain a temperature of less 20° C (68° F) at the silica gel outlet.

2.2.6 After collecting the sample, disconnect the probe from the filter holder (or from the first impinger) and conduct a leak check (mandatory) as described in Section 2.2.3. Record the leak rate. If the leakage rate exceeds the allowable rate, the tester shall either reject the test results or shall correct the sample volume as in Section 6.3 of Method 8. Next, measure the volume of the moisture condensed to the nearest ml. Determine the increase in weight of the silica gel (or silica gel plus impinger) to the nearest 0.5 g. Record this information (see example data sheet, Figure 4-3) and calculate the moisture percentage, as described in 2.3 below.

2.3 Calculations. Carry out the following calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation.

	INITIAL: VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
DIFFERENCE		

Figure 4.3. Analytical data - reference method.

2.3.1 Nomenclature.

B_w = Proportion of water vapor, by volume, in the gas stream.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_w = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m³)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft³)/(lb-mole) (°R) for English units.

T_w = Absolute temperature at meter, °K (°R).

T_{std} = Standard absolute temperature, 293° K (528°R).

V_d = Dry gas volume measured by dry gas meter, dcm (dcf).

ΔV_w = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).

$V_{d,std}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w,cond}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).

$V_{w,imp}$ = Volume of water vapor collected in silica gel corrected to standard conditions, scm (scf).

V_c = Final volume of condenser water, ml.

V_i = Initial volume, if any, of condenser water, ml.

W_i = Final weight of silica gel or silica gel plus impinger, g.

W_o = Initial weight of silica gel or silica gel plus impinger, g.

Y = Dry gas meter calibration factor.

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

2.3.2 Volume of water vapor condensed.

$$V_{w,cond} = \frac{(V_f - V_i) \rho_w R T_{std}}{P_{std} M_w} = K_1 (V_f - V_i) \quad \text{Equation 4.1}$$

THE ALMEGA CORPORATION

3.1.4 **Drying Tube.** Tube packed with new or regenerated 8- to 16-mesh indicating-type silica gel (or equivalent desiccant), to dry the sample gas and to protect the meter and pump.

3.1.5 **Valve.** Needle valve, to regulate the sample gas flow rate.

3.1.6 **Pump.** Leak-free, diaphragm type, or equivalent, to pull the gas sample through the train.

3.1.7 **Volume Meter.** Dry gas meter, sufficiently accurate to measure the sample volume within 2%, and calibrated over the range of flow rates and conditions actually encountered during sampling.

3.1.8 **Rate Meter.** Rotameter, to measure the flow range from 0 to 3 lpm (0 to 0.11 cfm).

3.1.9 **Graduated Cylinder.** 25 ml.

3.1.10 **Barometer.** Mercury, aneroid, or other barometer, as described in Section 2.1.5 above.

3.1.11 **Vacuum Gauge.** At least 760 mm Hg (30 in. Hg) gauge, to be used for the sampling leak check.

3.2 **Procedure.**

3.2.1 Place exactly 5 ml distilled water in each impinger.

Leak check the sampling train as follows: Temporarily insert a vacuum gauge at or near the probe inlet; then, plug the probe inlet and pull a vacuum of at least 250 mm Hg (10 in. Hg). Note, the time rate of change of the dry gas meter dial; alternatively, a rotameter (0-40 cc/min) may be temporarily attached to the dry gas meter outlet to determine the leakage rate. A leak rate not in excess of 2 percent of the average sampling rate is acceptable.

NOTE.—Carefully release the probe inlet plug before turning off the pump.

3.2.2 Connect the probe, insert it into the stack, and sample at a constant rate of 2 lpm (0.071 cfm). Continue sampling until the dry gas meter registers about 30 liters (1.1 ft³) or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure, and dry gas meter readings as required by Figure 4-5.

3.2.3 After collecting the sample, combine the contents of the two impingers and measure the volume to the nearest 0.5 ml.

3.3 **Calculations.** The calculation method presented is designed to estimate the moisture in the stack gas; therefore, other data, which are only necessary for accurate moisture determinations, are not collected. The following equations adequately estimate the moisture content, for the purpose of determining isokinetic sampling rate settings.

3.3.1 Nomenclature.

B_{wv} = Approximate proportion, by volume of water vapor in the gas stream leaving the second impinger, 0.028.

B_w = Water vapor in the gas stream, proportion by volume.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_a = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter.

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m³)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft³)/(lb-mole) (°R) for English units.

T_a = Absolute temperature at meter, °K (°R).

T_{std} = Standard absolute temperature, 293° K (528° R).

V_f = Final volume of impinger contents, ml.

V_i = Initial volume of impinger contents, ml.

V_d = Dry gas volume measured by dry gas meter, dcm (def).

V_{dstd} = Dry gas volume measured by dry gas meter, corrected to standard conditions, dscm (dscf).

V_{wvstd} = Volume of water vapor condensed, corrected to standard conditions, scm (scf).

ρ_w = Density of water, 0.9982 g/ml (0.02201 lb/ml).

Y = Dry gas meter calibration factor.

3.3.2 Volume of water vapor collected, where:

$$V_{wv} = \frac{(V_f - V_i) \rho_w R T_{std}}{P_{std} M_w} \\ = K_1 (V_f - V_i)$$

Equation 4-5

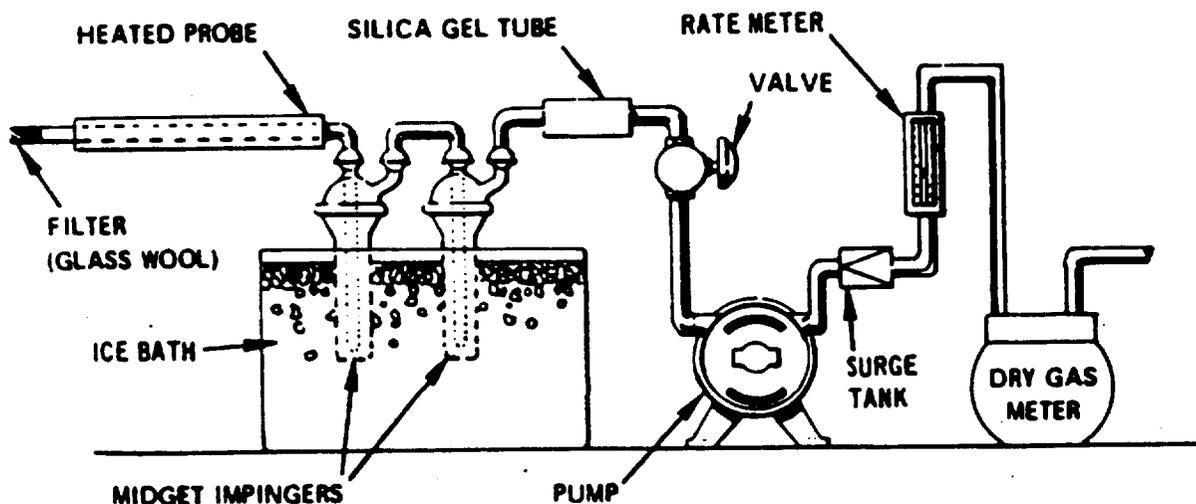


Figure 4-4. Moisture-sampling train - approximation method.

The ALMEGA CORPORATION

LOCATION _____ COMMENTS _____
 TEST _____
 DATE _____
 OPERATOR _____
 BAROMETRIC PRESSURE _____

CLOCK TIME	GAS VOLUME THROUGH METER. (Vm). m ³ (ft ³)	RATE METER SETTING m ³ /min. (ft ³ /min.)	METER TEMPERATURE. °C (°F)

Figure 4-5. Field moisture determination - approximation method.

$K_1 = 0.001333 \text{ m}^3/\text{ml}$ for metric units
 $= 0.04707 \text{ ft}^3/\text{ml}$ for English units.

3.3.3 Gas volume.

$$V_{m(Std)} = V_m \left(\frac{P_m}{P_{Std}} \right) \left(\frac{T_{Std}}{T_m} \right)$$

$$= K_1 \frac{V_m P_m}{T_m}$$

Equation 4-6

where:

$K_1 = 0.3858 \text{ }^\circ\text{K}/\text{mm Hg}$ for metric units
 $= 17.64 \text{ }^\circ\text{R}/\text{in. Hg}$ for English units

3.3.4 Approximate moisture content.

$$B_{v,c} = \frac{V_{v,c}}{V_{v,c} + V_{m(Std)}} + B_{v,m}$$

$$= \frac{V_{v,c}}{V_{v,c} + V_{m(Std)}} + (0.025)$$

Equation 4-7

4. Calibration

4.1 For the reference method, calibrate equipment as specified in the following sections of Method 5: Section 5.3 (metering system); Section 5.5 (temperature gauges); and Section 5.7 (barometer). The recommended leak check of the metering system (Section 5.6 of Method 5) also applies to the reference method. For the approximation method, use the procedures outlined in Section 5.1.1 of Method 6 to calibrate the metering system, and the procedure of Method 5, Section 5.7 to calibrate the barometer.

5. Bibliography

1. Air Pollution Engineering Manual (Second Edition). Danielson, J. A. (ed.). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. Publication No. AP-40. 1973.
2. Devorkin, Howard, et al. Air Pollution Source Testing Manual. Air Pollution Control District, Los Angeles, Calif. November, 1963.
3. Methods for Determination of Velocity, Volume Dust and Mist Content of Gases. Western Precipitation Division of Joy Manufacturing Co., Los Angeles, Calif. Bulletin WP-50. 1968.

The ALMEGA CORPORATION

APPENDIX F

DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES

The ALMEGA CORPORATION

1. Principle and Applicability

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a temperature in the range of $120 \pm 14^\circ \text{C}$ ($248 \pm 25^\circ \text{F}$) or such other temperature as specified by an applicable subpart of the standards or approved by Administrator, U.S. Environmental Protection Agency, for a particular application. The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources.

2. Apparatus

2.1 Sampling Train. A schematic of the sampling train used in this method is shown in Figure 5-1. Complete construction details are given in APTD-0581 (Citation 2 in Section 7); commercial models of this train are also available. For changes from APTD-0581 and for allowable modifications of the train shown in Figure 5-1, see the following subsections.

¹Mention of trade names or specific product does not constitute endorsement by the Environmental Protection Agency.

The operating and maintenance procedures for the sampling train are described in APTD-0576 (Citation 3 in Section 7). Since correct usage is important in obtaining valid results, all users should read APTD-0576 and adopt the operating and maintenance procedures outlined in it, unless otherwise specified herein. The sampling train consists of the following components:

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be 30° and the taper shall be on the outside to preserve a constant internal diameter. The probe nozzle shall be of the button-hook or elbow design, unless otherwise specified by the Administrator. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other materials of construction may be used, subject to the approval of the Administrator.

A range of nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm ($\frac{1}{8}$ to $\frac{1}{2}$ in.)—or larger if higher volume sampling trains are used—inside diameter (ID) nozzles in increments of 0.16 cm ($\frac{1}{16}$ in.). Each nozzle shall be calibrated ac-

ording to the procedures outlined in Section 5.

2.1.2 Probe Liner. Borosilicate or quartz glass tubing with a heating system capable of maintaining a gas temperature at the exit end during sampling of $120 \pm 14^\circ \text{C}$ ($248 \pm 25^\circ \text{F}$), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. (The tester may opt to operate the equipment at a temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not usually monitored during sampling, probes constructed according to APTD-0581 and utilizing the calibration curves of APTD-0576 (or calibrated according to the procedure outlined in APTD-0576) will be considered acceptable.

Either borosilicate or quartz glass probe liners may be used for stack temperatures up to about 480°C (900°F) quartz liners shall be used for temperatures between 480 and 900°C (900 and $1,650^\circ \text{F}$). Both types of liners may be used at higher temperatures than specified for short periods of time, subject to the approval of the Administrator. The softening temperature for borosilicate is 820°C ($1,508^\circ \text{F}$), and for quartz it is $1,500^\circ \text{C}$ ($2,732^\circ \text{F}$).

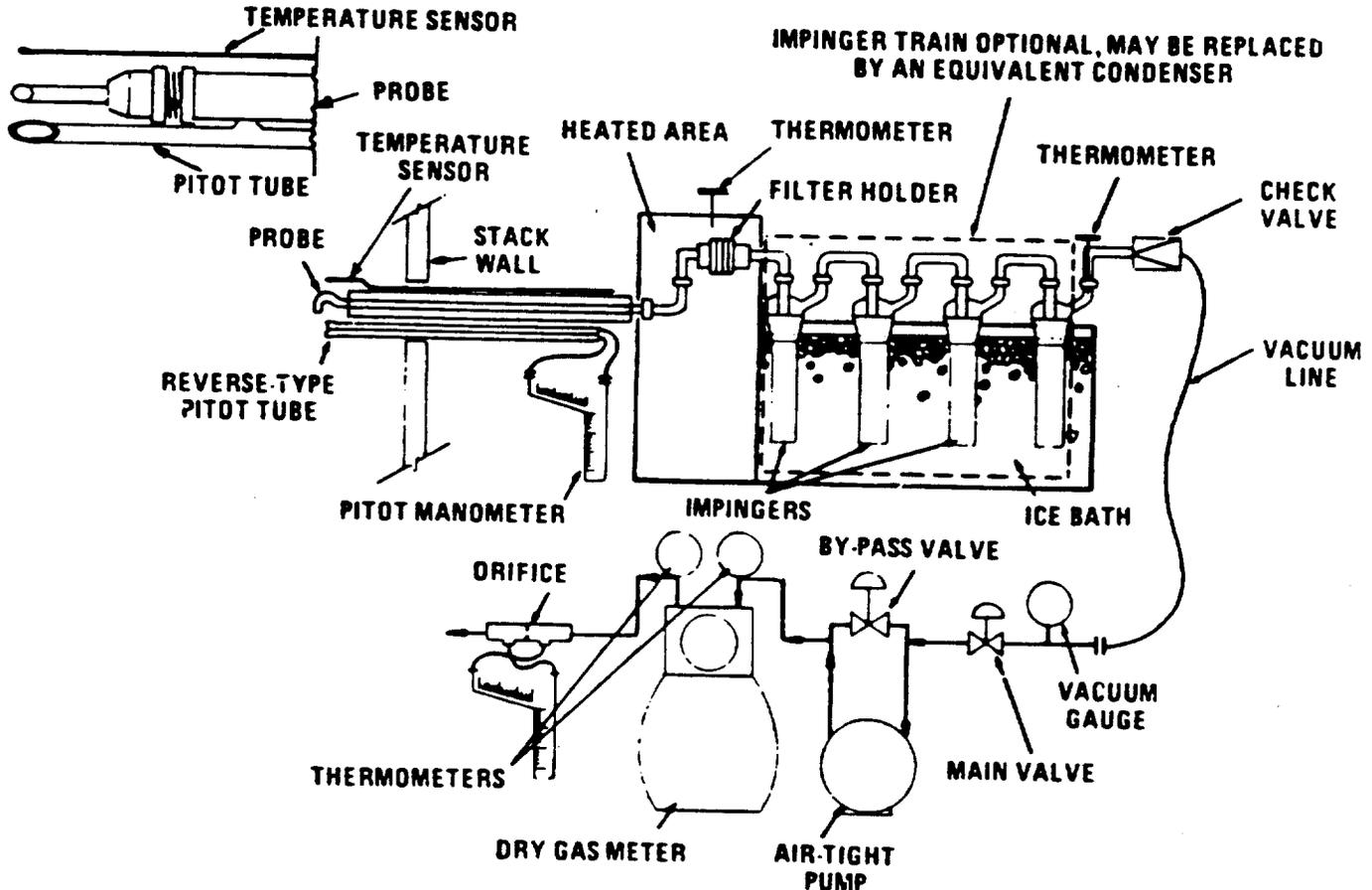


Figure 5-1. Particulate-sampling train

60-111 (0-80)-22

The ALMEGA CORPORATION

Whenever practical, every effort should be made to use borosilicate or quartz glass probe liners. Alternatively, metal liners (e.g., 316 stainless steel, Incoloy 825,¹ or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot Tube. Type S, as described in Section 2.1 of Method 2, or other device approved by the Administrator. The pitot tube shall be attached to the probe (as shown in Figure 5-1) to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see Method 2, Figure 2-8b) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of Method 2.

2.1.4 Differential Pressure Gauge. Inclined manometer or equivalent device (two), as described in Section 2.2 of Method 2. One manometer shall be used or velocity head (Δp) readings, and the other, for orifice differential pressure readings.

2.1.5 Filter Holder. Borosilicate glass, with a glass frit filter support and a silicone rubber gasket. Other materials of construction (e.g., stainless steel, Teflon, Viton) may be used, subject to approval of the Administrator. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached immediately at the outlet of the probe (or cyclone, if used).

2.1.6 Filter Heating System. Any heating system capable of maintaining a temperature around the filter holder during sampling of $120 \pm 14^\circ \text{C}$ ($248 \pm 25^\circ \text{F}$), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. Alternatively, the tester may opt to operate the equipment at a temperature lower than that specified. A temperature gauge capable of measuring temperature to within 3°C (5.4°F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling. Heating systems other than the one shown in APTD-0581 may be used.

2.1.7 Condenser. The following system shall be used to determine the stack gas moisture content: Four impingers connected in series with leak-free ground glass fittings or any similar leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with 1.3 cm ($\frac{1}{2}$ in.) ID glass tube extending to about 1.3 cm ($\frac{1}{2}$ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator. The first and second impingers shall contain known quantities of water (Section 4.1.3), the third shall be empty, and the fourth shall contain a known weight of silica gel, or equivalent desiccant. A thermometer, capable of measuring temperature to within 1°C (2°F) shall be placed at the outlet of the fourth impinger for monitoring purposes.

Alternatively, any system that cools the sample gas stream and allows measurement of the water condensed and moisture leaving the condenser, each to within 1 ml or 1 g

may be used, subject to the approval of the Administrator. Acceptable means are to measure the condensed water either gravimetrically or volumetrically and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures; or (2) passing the sample has stream through a tared silica gel (or equivalent desiccant) trap with exit gases kept below 30°C (88°F) and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

NOTE.—If a determination of the particulate matter collected in the impingers is desired in addition to moisture content, the impinger system described above shall be used, without modification. Individual States or control agencies requiring this information shall be contacted as to the sample recovery and analysis of the impinger contents.

2.1.8 Metering System. Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3°C (5.4°F), dry gas meter capable of measuring volume to within 2 percent, and related equipment, as shown in Figure 5-1. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 2 percent may be used, subject to the approval of the Administrator. When the metering system is used in conjunction with a pitot tube, the system shall enable checks of isokinetic rates.

Sampling trains utilizing metering systems designed for higher flow rates than that described in APTD-0581 or APDT-0576 may be used provided that the specifications of this method are met.

2.1.9 Barometer. Mercury aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg). In many cases the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.10 Gas Density Determination Equipment. Temperature sensor and pressure gauge, as described in Sections 2.3 and 2.4 of Method 2, and gas analyzer, if necessary, as described in Method 3. The temperature sensor shall, preferably, be permanently attached to the pitot tube or sampling probe in a fixed configuration, such that the tip of the sensor extends beyond the leading edge of the probe sheath and does not touch any metal. Alternatively, the sensor may be attached just prior to use in the field. Note, however, that if the temperature sensor is attached in the field, the sensor must be placed in an interference-free arrangement with respect to the Type S pitot tube openings (see Method 2, Figure 2-7). As a second alternative, if a difference of not more than

1 percent in the average velocity measurement is to be introduced, the temperature gauge need not be attached to the probe or pitot tube. (This alternative is subject to the approval of the Administrator.)

2.2 Sample Recovery. The following items are needed.

2.2.1 Probe-Liner and Probe-Nozzle Brushes. Nylon bristle brushes with stainless steel wire handles. The probe brush shall have extensions (at least as long as the probe) of stainless steel, Nylon, Teflon, or similarly inert material. The brushes shall be properly sized and shaped to brush out the probe liner and nozzle.

2.2.2 Wash Bottles—Two. Glass wash bottles are recommended; polyethylene wash bottles may be used at the option of the tester. It is recommended that acetone not be stored in polyethylene bottles for longer than a month.

2.2.3 Glass Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for acetone washes, 500 ml or 1000 ml. Screw cap liners shall either be rubber-backed Teflon or shall be constructed so as to be leak-free and resistant to chemical attack by acetone. (Narrow mouth glass bottles have been found to be less prone to leakage.) Alternatively, polyethylene bottles may be used.

2.2.4 Petri Dishes. For filter samples glass or polyethylene, unless otherwise specified by the Administrator.

2.2.5 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. Any of these balances is suitable or use here and in Section 2.3.4.

2.2.6 Plastic Storage Containers. Airtight containers to store silica gel.

2.2.7 Funnel and Rubber Policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.

2.2.8 Funnel. Glass or polyethylene, to aid in sample recovery.

2.2 Analysis. For analysis, the following equipment is needed.

2.3.1 Glass Weighing Dishes.

2.3.2 Desiccator.

2.3.3 Analytical Balance. To measure to within 0.1 mg.

2.3.4 Balance. To measure to within 0.5 g.

2.3.5 Beakers. 250 ml.

2.3.6 Hygrometer. To measure the relative humidity of the laboratory environment.

2.3.7 Temperature Gauge. To measure the temperature of the laboratory environment.

3. Reagents

3.1 Sampling. The reagents used in sampling are as follows:

3.1.1 Filters. Glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (<0.05 percent penetration) on 0.3-micron dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM standard method D 2986-71. Test data from the supplier's quality control program are sufficient for this purpose.

3.1.2 Silica Gel. Indicating type, 6 to 16 mesh. If previously used, dry at 175°C (350°F) for 2 hours. New silica gel may be used as received. Alternatively, other types of desiccants (equivalent or better) may be used, subject to the approval of the Administrator.

THE ALMEGA CORPORATION

3.1.3 Water. When analysis of the material caught in the impingers is required, distilled water shall be used. Run blanks prior to field use to eliminate a high blank on test samples.

3.1.4 Crushed Ice.

3.1.5 Stopcock Grease. Acetone-insoluble, heat-stable silicone grease. This is not necessary if screw-on connectors with Teflon sleeves, or similar, are used. Alternatively, other types of stopcock grease may be used, subject to the approval of the Administrator.

3.2 Sample Recovery. Acetone-reagent grade, <0.001 percent residue, in glass bottles—is required. Acetone from metal containers generally has a high residue blank and should not be used. Sometimes, suppliers transfer acetone to glass bottles from metal containers; thus, acetone blanks shall be run prior to field use and only acetone with low blank values (<0.001 percent) shall be used. In no case shall a blank value of greater than 0.001 percent of the weight of acetone used be subtracted from the sample weight.

3.3 Analysis. Two reagents are required for the analysis:

3.3.1 Acetone. Same as 3.2.

3.3.2 Desiccant. Anhydrous calcium sulfate, indicating type. Alternatively, other types of desiccants may be used, subject to the approval of the Administrator.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. All the components shall be maintained and calibrated according to the procedure described in APTD-0576, unless otherwise specified herein.

Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in the impinger or sampling holder just prior to train assembly.

Check filters visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using numbering machine ink. As an alternative, label the shipping containers (glass or plastic petri dishes) and keep the filters in these containers at all times except during sampling and weighing.

Desiccate the filters at $20 \pm 5.6^\circ \text{C}$ ($68 \pm 10^\circ \text{F}$) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight, i.e., 0.5 mg change from previous weighing; record results to the nearest 0.1 mg. During each weighing the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity above 50 percent. Alternatively (unless otherwise specified by the Administrator), the filters may be oven dried at 105°C (220°F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Procedures other than those described, which account for relative humidity effects, may be used, subject to the approval of the Administrator.

4.1.2 Preliminary Determinations. Select the sampling site and the minimum number of sampling points according to Method 1 or as specified by the Administrator. Determine the stack pressure, temperature, and

the range of velocity heads using Method 2; it is recommended that a leak-check of the pitot lines (see Method 2, Section 3.1) be performed. Determine the moisture content using Approximation Method 4 or its alternatives for the purpose of making isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in Method 2, Section 3.6; if integrated Method 3 sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the particulate sample run.

Select a nozzle size based on the range of velocity heads, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size. Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of Method 2).

Select a suitable probe liner and probe length such that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of probes.

Select a total sampling time greater than or equal to the minimum total sampling time specified in the test procedures for the specific industry such that (1) the sampling time per point is not less than 2 min (or some greater time interval as specified by the Administrator), and (2) the sample volume taken (corrected to standard conditions) will exceed the required minimum total gas sample volume. The latter is based on an approximate average sampling rate.

It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid timekeeping errors. The sampling time at each point shall be the same.

In some circumstances, e.g., batch cycles, it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas sample volumes. In these cases, the Administrator's approval must first be obtained.

4.1.3 Preparation of Collection Train. During preparation and assembly of the sampling train, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin.

Place 100 ml of water in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

Using a tweezer or clean disposable surgical gloves, place a labeled (identified) and weighed filter in the filter holder. Be sure that the filter is properly centered and the gasket properly placed so as to prevent the sample gas stream from circumventing the filter. Check the filter for tears after assembly is completed.

When glass liners are used, install the selected nozzle using a Viton A O-ring when stack temperatures are less than 260°C (500°F) and an asbestos string gasket when temperatures are higher. See APTD-0576 for details. Other connecting systems using either 316 stainless steel or Teflon ferrules may be used. When metal liners are used,

install the nozzle as above or by a leak-free direct mechanical connection. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

Set up the train as in Figure 5-1, using (if necessary) a very light coat of silicone grease on all ground glass joints, greasing only the outer portion (see APTD-0576) to avoid possibility of contamination by the silicone grease. Subject to the approval of the Administrator, a glass cyclone may be used between the probe and filter holder when the total particulate catch is expected to exceed 100 mg or when water droplets are present in the stack gas.

Place crushed ice around the impingers.

4.1.4 Leak-Check Procedures.

4.1.4.1 Pretest Leak-Check. A pretest leak-check is recommended, but not required. If the tester opts to conduct the pretest leak-check, the following procedure shall be used.

After the sampling train has been assembled, turn on and set the filter and probe heating systems at the desired operating temperatures. Allow time for the temperatures to stabilize. If a Viton A O-ring or other leak-free connection is used in assembling the probe nozzle to the probe liner, leak-check the train at the sampling site by plugging the nozzle and pulling a 380 mm Hg (15 in. Hg) vacuum.

Note.—A lower vacuum may be used, provided that it is not exceeded during the test.

If an asbestos string is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first plugging the inlet to the filter holder (cyclone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediately above). Then connect the probe to the train and leak-check at about 25 mm Hg (1 in. Hg) vacuum; alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in excess of 4 percent of the average sampling rate or $0.00057 \text{ m}^3/\text{min}$ (0.02 cfm), whichever is less, are unacceptable.

The following leak-check instructions for the sampling train described in APTD-0576 and APTD-0581 may be helpful. Start the pump with bypass valve fully open and coarse adjust valve, completely closed. Partially open the coarse adjust valve and slowly close the bypass valve until the desired vacuum is reached. Do not reverse direction of bypass valve; this will cause water to back up into the filter holder. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak-check as shown below and start over.

When the leak-check is completed, first slowly remove the plug from the inlet to the probe, filter holder, or cyclone (if applicable) and immediately turn off the vacuum pump. This prevents the water in the impingers from being forced backward into the filter holder and silica gel from being entrained backward into the third impinger.

4.1.4.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 4.1.4.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no

THE ALMEGA CORPORATION

When the stack is under significant negative pressure (height of impinger stem), take care to close the coarse adjust valve before inserting the probe into the stack to prevent water from backing into the filter holder. If necessary, the pump may be turned on with the coarse adjust valve closed.

When the probe is in position, block off the openings around the probe and porthole to prevent unrepresentative dilution of the gas stream.

Traverse the stack cross-section, as required by Method 1 or as specified by the Administrator, being careful not to bump the probe nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the portholes; this minimizes the chance of extracting deposited material.

During the test run, make periodic adjustments to keep the temperature around the filter holder at the proper level; add more ice and, if necessary, salt to maintain a temperature of less than 20° C (68° F) at the condenser/silica gel outlet. Also, periodically check the level and zero of the manometer.

If the pressure drop across the filter becomes too high, making isokinetic sampling difficult to maintain, the filter may be replaced in the midst of a sample run. It is recommended that another complete filter assembly be used rather than attempting to change the filter itself. Before a new filter assembly is installed, conduct a leak-check (see Section 4.1.4.2). The total particulate weight shall include the summation of all filter assembly catches.

A single train shall be used for the entire sample run, except in cases where simultaneous sampling is required in two or more separate ducts or at two or more different locations within the same duct, or, in cases where equipment failure necessitates a change of trains. In all other situations, the use of two or more trains will be subject to the approval of the Administrator.

Note that when two or more trains are used, separate analyses of the front-half and (if applicable) impinger catches from each train shall be performed, unless identical nozzle sizes were used on all trains, in which case, the front-half catches from the individual trains may be combined (as may the impinger catches) and one analysis of front-half catch and one analysis of impinger catch may be performed. Consult with the Administrator for details concerning the calculation of results when two or more trains are used.

At the end of the sample run, turn off the coarse adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check, as outlined in Section 4.1.4.3. Also, leak-check the pitot lines as described in Method 2, Section 3.1; the lines must pass this leak-check, in order to validate the velocity head data.

4.1.6 Calculation of Percent Isokinetic. Calculate percent isokinetic (see Calculations, Section 6) to determine whether the run was valid or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source conditions, consult with the Administrator for possible variance on the isokinetic rates.

4.2 Sample Recovery. Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Allow the probe to cool.

When the probe can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent losing or gaining particulate matter. Do not cap off the probe tip tightly while the sampling train is cooling down as this would create a vacuum in the filter holder, thus drawing water from the impingers into the filter holder.

Before moving the sample train to the cleanup site, remove the probe from the sample train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the filter inlet where the probe was fastened and cap it. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line is used between the first impinger or condenser and the filter holder, disconnect the line at the filter holder and let any condensed water or liquid drain into the impingers or condenser. After wiping off the silicone grease, cap off the filter holder outlet and impinger inlet. Either ground-glass stoppers, plastic caps, or serum caps may be used to close these openings.

Transfer the probe and filter-impinger assembly to the cleanup area. This area should be clean and protected from the wind so that the chances of contaminating or losing the sample will be minimized.

Save a portion of the acetone used for cleanup as a blank. Take 200 ml of this acetone directly from the wash bottle being used and place it in a glass sample container labeled "acetone blank."

Inspect the train prior to and during disassembly and note any abnormal conditions. Treat the samples as follows:

Container No. 1. Carefully remove the filter from the filter holder and place it in its identified petri dish container. Use a pair of tweezers and/or clean disposable surgical gloves to handle the filter. If it is necessary to fold the filter, do so such that the particulate cake is inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers which adhere to the filter holder gasket, by using a dry Nylon bristle brush and/or a sharp-edged blade. Seal the container.

Container No. 2. Taking care to see that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by washing these components with acetone and placing the wash in a glass container. Distilled water may be used instead of acetone when approved by the Administrator and shall be used when specified by the Administrator; in these cases, save a water blank and follow the Administrator's directions on analysis. Perform the acetone rinses as follows:

Carefully remove the probe nozzle and clean the inside surface by rinsing with acetone from a wash bottle and brushing with a Nylon bristle brush. Brush until the acetone rinse shows no visible particles, after which make a final rinse of the inside sur-

face with acetone.

Brush and rinse the inside parts of the Swagelok fitting with acetone in a similar way until no visible particles remain.

Rinse the probe liner with acetone by tilting and rotating the probe while squirting acetone into its upper end so that all inside surfaces will be wetted with acetone. Let the acetone drain from the lower end into the sample container. A funnel (glass or polyethylene) may be used to aid on transferring liquid washes to the container. Follow the acetone rinse with a probe brush. Hold the probe in an inclined position, squirt acetone into the upper end as the probe brush is being pushed with a twisting action through the probe; hold a sample container underneath the lower end of the probe, and catch any acetone and particulate matter which is brushed from the probe. Run the brush through the probe three times or more until no visible particulate matter is carried out with the acetone or until none remains in the probe liner on visual inspection. With stainless steel or other metal probes, run the brush through in the above prescribed manner at least six times since metal probes have small crevices in which particulate matter can be entrapped. Rinse the brush with acetone, and quantitatively collect these washings in the sample container. After the brushing, make a final acetone rinse of the probe as described above.

It is recommended that two people be used to clean the probe to minimize sample losses. Between sampling runs, keep brushes clean and protected from contaminations.

After ensuring that all joints have been wiped clean of silicone grease, clean the inside of the front half of the filter holder by rubbing the surfaces with a Nylon bristle brush and rinsing with acetone. Rinse each surface three times or more if needed to remove visible particulate. Make a final rinse of the brush and filter holder. Carefully rinse out the glass cyclone, also (if applicable). After all acetone washings and particulate matter have been collected in the sample container, tighten the lid on the sample container so that acetone will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether or not leakage occurred during transport. Label the container to clearly identify its contents.

Container No. 3. Note the color of the indicating silica gel to determine if it has been completely spent and make a notation of its condition. Transfer the silica gel from the fourth impinger to its original container and seal. A funnel may make it easier to pour the silica gel without spilling. A rubber policeman may be used as an aid in removing the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, follow the procedure for container No. 3 in Section 4.3.

Impinger Water. Treat the impingers as follows: Make a notation of any color or film in the liquid catch. Measure the liquid which is in the first three impingers to within ± 1 ml by using a graduated cylinder or by weighing it to within ± 0.5 g by using a balance (if one is available). Record the

The ALMEGA CORPORATION

volume or weight of liquid present. This information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Note, Section 2.1.7).

If a different type of condenser is used, measure the amount of moisture condensed either volumetrically or gravimetrically.

Whenever possible, containers should be shipped in such a way that they remain upright at all times.

4.3 Analysis. Record the data required on a sheet such as the one shown in Figure 5-3. Handle each sample container as follows:

Container No. 1. Leave the contents in the shipping container or transfer the filter and any loose particulate from the sample container to a tared glass weighing dish. Desiccate for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg. For purposes of this Section, 4.3, the term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of desiccation time between weighings.

Alternatively, the sample may be oven dried at 105° C (220° F) for 2 to 3 hours, cooled in the desiccator, and weighed to a constant weight, unless otherwise specified by the Administrator. The tester may also opt to oven dry the sample at 105° C (220° F) for 2 to 3 hours, weigh the sample, and use this weight as a final weight.

Container No. 2. Note the level of liquid in the container and confirm on the analysis sheet whether or not leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in this container either volumetrically to ±1 ml or gravimetrically to ±0.5 g. Transfer the contents to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

Container No. 3. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field.

"Acetone Blank" Container. Measure acetone in this container either volumetrically or gravimetrically. Transfer the acetone to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

NOTE.—At the option of the tester, the contents of Container No. 2 as well as the acetone blank container may be evaporated at temperatures higher than ambient. If evaporation is done at an elevated temperature, the temperature must be below the boiling point of the solvent; also, to prevent "bumping," the evaporation process must be closely supervised, and the contents of the beaker must be swirled occasionally to maintain an even temperature. Use extreme care, as acetone is highly flammable and has a low flash point.

Plant _____

Date _____

Run No. _____

Filter No. _____

Amount liquid lost during transport _____

Acetone blank volume, ml _____

Acetone wash volume, ml _____

Acetone blank concentration, mg/mg (equation 5-4) _____

Acetone wash blank, mg (equation 5-5) _____

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL			
Less acetone blank			
Weight of particulate matter			

	VOLUME OF LIQUID WATER COLLECTED	
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
LIQUID COLLECTED		
TOTAL VOLUME COLLECTED		g° ml

* CONVERT WEIGHT OF WATER TO VOLUME BY DIVIDING TOTAL WEIGHT INCREASE BY DENSITY OF WATER (1g/ml).

$$\frac{\text{INCREASE, g}}{1 \text{ g/ml}} = \text{VOLUME WATER, ml}$$

Figure 5-3. Analytical data.

The ALMEGA CORPORATION

6. Calculations

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

6.1 Nomenclature

- A_s = Cross-sectional area of nozzle, m^2 (ft^2).
- B_w = Water vapor in the gas stream, proportion by volume.
- C_a = Acetone blank residue concentration, mg/g .
- c = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, $g/dscm$ ($g/dscf$).
- i = Percent of isokinetic sampling.
- L_m = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to $0.0057 m^3/min$ ($0.02 cfm$) or 4 percent of the average sampling rate, whichever is less.
- L_o = Individual leakage rate observed during the leak check conducted prior to the i^{th} component change ($i=1, 2, 3, \dots, n$), m^3/min (cfm).
- L_p = Leakage rate observed during the post-test leak check, m^3/min (cfm).
- m_a = Total amount of particulate matter collected, mg .
- M_w = Molecular weight of water, $18.0 g/g\text{-mole}$ ($18.0 lb/lb\text{-mole}$).
- m_s = Mass of residue of acetone after evaporation, mg .
- P_{at} = Barometric pressure at the sampling site, $mm\ Hg$ ($in. Hg$).
- P_s = Absolute stack gas pressure, $mm\ Hg$ ($in. Hg$).
- P_{std} = Standard absolute pressure, $760\ mm\ Hg$ ($29.92\ in. Hg$).
- R = Ideal gas constant, $0.06236\ mm\ Hg\text{-}m^3/K\text{-}g\text{-mole}$ ($21.85\ in. Hg\text{-}ft^3/R\text{-}lb\text{-mole}$).
- T_m = Absolute average dry gas meter temperature (see Figure 5-2), $^{\circ}K$ ($^{\circ}R$).
- T_s = Absolute average stack gas temperature (see Figure 5-2), $^{\circ}K$ ($^{\circ}R$).
- T_{std} = Standard absolute temperature, $293^{\circ}K$ ($528^{\circ}R$).
- V_a = Volume of acetone blank, ml .
- V_w = Volume of acetone used in wash, ml .
- V_{liq} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml .
- V_m = Volume of gas sample as measured by dry gas meter, dcm ($dscf$).
- $V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, $dscm$ ($dscf$).
- $V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).
- v = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).
- W_a = Weight of residue in acetone wash, mg .
- Y = Dry gas meter calibration factor.
- ΔH = Average pressure differential across the orifice meter (see Figure 5-2), $mm\ H_2O$ ($in. H_2O$).
- ρ_a = Density of acetone, mg/ml (see label on bottle).

ρ_w = Density of water, $0.9982\ g/ml$ ($0.002201\ lb/ml$).

- θ = Total sampling time, min .
- θ_1 = Sampling time interval, from the beginning of a run until the first component change, min .
- θ_2 = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min .
- θ_n = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min .
- 13.6 = Specific gravity of mercury.
- 60 = Sec/min .
- 100 = Conversion to percent.

6.2 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).

6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions ($20^{\circ}C$, $760\ mm\ Hg$ or $68^{\circ}F$, $29.92\ in. Hg$) by using Equation 5-1.

$$V_{m(std)} = V_m \left(\frac{T_{std}}{T_m} \right) \left[\frac{P_{std} + \frac{\Delta H}{13.6}}{P_{at}} \right]$$

$$= K_1 V_m \left(\frac{T_{std}}{T_m} \right) \left[\frac{P_{std} + \frac{\Delta H}{13.6}}{P_{at}} \right]$$

Equation 5-1

where:

- $K_1 = 0.3858\ ^{\circ}K/mm\ Hg$ for metric units
- $= 17.64\ ^{\circ}R/in. Hg$ for English units

NOTE.—Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_m . If L_p or L_o exceeds L_m , Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m in Equation 5-1 with the expression:

$$V_m - (L_p - L_o)\theta$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m in Equation 5-1 by the expression:

$$\left[V_m - (L_1 - L_n)\theta_1 - \sum_{i=2}^n (L_i - L_n)\theta_i - (L_p - L_n)\theta_p \right]$$

and substitute only for those leakage rates (L_o or L_p) which exceed L_m .

6.4 Volume of water vapor.

$$V_{w(std)} = V_{m(std)} \left(\frac{\rho_w}{M_w} \right) \left(\frac{H T_{std}}{P_{std}} \right) = K_2 V_{m(std)}$$

Equation 5-2

where:

- $K_2 = 0.001333\ m^3/ml$ for metric units
- $= 0.04707\ ft^3/ml$ for English units.

6.5 Moisture Content.

$$B_w = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

Equation 5-3

NOTE.—In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of B_w shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.3 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is $\pm 1^{\circ}C$ ($2^{\circ}F$).

6.6 Acetone Blank Concentration.

$$C_a = \frac{m_a}{V_a \rho_a}$$

Equation 5-4

6.7 Acetone Wash Blank.

$$W_a = C_a V_w \rho_a$$

Equation 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from containers 1 and 2 less the acetone blank (see Figure 5-3). NOTE.—Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

$$c = (0.001\ g/mg) (m_a / V_{m(std)})$$

Equation 5-6

6.10 Conversion Factors:

From	To	Multiply by
scf	m^3	0.02832
g/n°	g/n°	15.43
g/n°	g/n°	$2.205 \cdot 10^{-3}$
g/n°	g/m^3	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

$$I = \frac{100 T_s [K_2 V_{w(std)} + (V_{m(std)} T_m) (P_{std} + \frac{\Delta H}{13.6})]}{60 \theta v_s P_s A_s}$$

Equation 5-7

The ALMEGA CORPORATION

5. Calibration

Maintain a laboratory log of all calibrations.

5.1 Probe Nozzle. Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Make three separate measurements using different diameters each time, and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

5.2 Pitot Tube. The Type S pitot tube assembly shall be calibrated according to the procedure outlined in Section 4 of Method 2.

5.3 Metering System. Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in APTD-0576. Instead of physically adjusting the dry gas meter dial readings to correspond to the wet test meter readings, calibration factors may be used to mathematically correct the gas meter dial readings to the proper values. Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect

leakages within the pump, for these cases the following leak-check procedure is suggested: make a 10-minute calibration run at 0.0057 m³/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volumes; divide the difference by 10, to get the leak rate. The leak rate should not exceed 0.00057 m³/min (0.02 cfm).

After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test). With the vacuum set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and the inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in APTD-0576.

Alternative procedures, e.g., using the orifice meter coefficients, maybe used, subject to the approval of the Administrator.

NOTE.—If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

5.4 Probe Heater Calibration. The probe heating system shall be calibrated before its initial use in the field according to the procedure outlined in APTD-0576. Probes constructed according to APTD-0581 need not be calibrated if the calibration curves in APTD-0576 are used.

5.5 Temperature Gauges. Use the procedure in Section 4.3 of Method 2 to calibrate in-stack temperature gauges. Dial thermometers, such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

5.6 Leak Check of Metering System Shown in Figure 5-1. That portion of the sampling train from the pump to the orifice meter should be leak checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Figure 5-4) Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

5.7 Barometer. Calibrate against a mercury barometer.

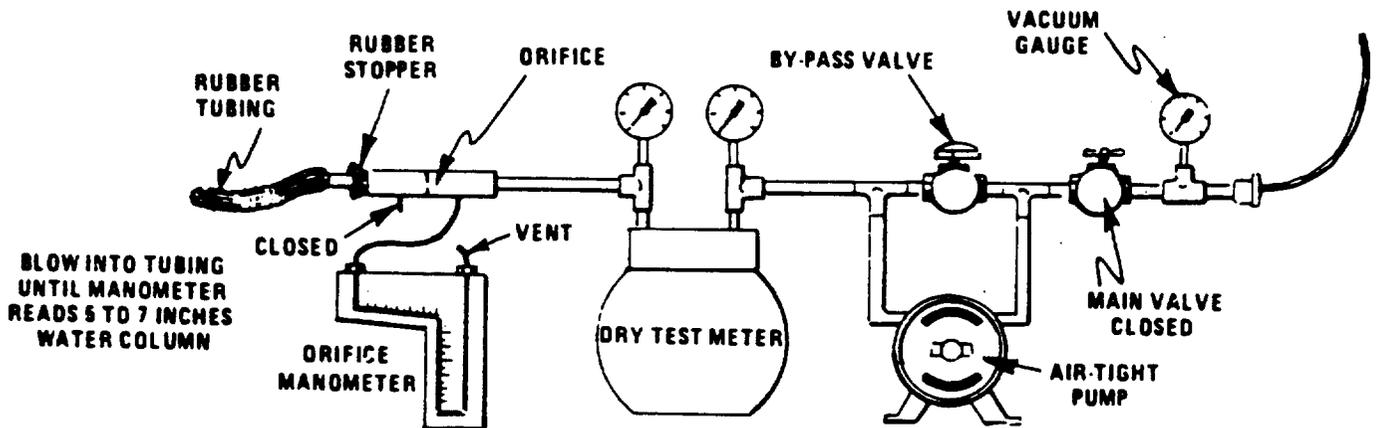


Figure 5-4. Leak check of meter box.

THE ALMEGA CORPORATION

where:

$K = 0.003454$ mm Hg - m³/ml - °K for metric units.
 $= 0.002669$ in. Hg - ft³/ml - °R for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_m (s.c.) P_{std} 100}{T_{std} V_s \theta A_s P_s 60 (1 - B_{s,c})}$$

$$= K \frac{T_s V_m (s.c.)}{P_s V_s A_s \theta (1 - B_{s,c})}$$

Equation 5-8

where:

$K = 4.320$ for metric units
 $= 0.09450$ for English units.

6.12 Acceptable Results. If 90 percent $I < 110 <$ percent, the results are acceptable.

If the results are low in comparison to the standard and I is beyond the acceptable range, or, if I is less than 90 percent, the Administrator may opt to accept the results.

Use Citation 4 to make judgments. Otherwise, reject the results and repeat the test.

7. Bibliography

1. Addendum to Specifications for Incinerator Testing at Federal Facilities. PHS, NCAPC, Dec. 6 1967.
2. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Environmental Protection Agency, Research Triangle Park, N.C. APTD-0581. April 1971.
3. Rom, Jerome J. Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment. Environmental Protection Agency, Research Triangle Park, N.C. APTD-0576. March, 1972.
4. Smith, W. S., R. T. Shigehara, and W. F. Todd. A method of Interpreting Stack Sampling Data. Paper Presented at the 63d Annual Meeting of the Air Pollution Control Association, St. Louis, Mo. June 14-19, 1970.
5. Smith, W. S., et al. Stack Gas Sampling Improved and Simplified With New Equipment. APCA Paper No. 67-119. 1967.
6. Specifications for Incinerator Testing at Federal Facilities. PHS, NCAPC. 1967.
7. Shigehara, R. T. Adjustments in the EPA Nomograph for Different Pitot Tube Coefficients and Dry Molecular Weights. Stack Sampling News 2:4-11, October, 1974.
8. Vollaro, R. F. A Survey of Commercially Available Instrumentation For the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch. Research Triangle Park, N.C. November, 1976 (unpublished paper).
9. Annual Book of ASTM Standards, Part 26. Gaseous Fuels; Coal and Coke; Atmospheric Analysis. American Society for Testing and Materials. Philadelphia, Pa. 1974. pp. 617-622.

The ALMEGA CORPORATION

APPENDIX G

**DETERMINATION OF CHLORINE
AND HYDROCHLORIC ACID IN STACK GAS
TEXAS AIR CONTROL BOARD METHOD**

DETERMINATION OF CHLORINE AND HYDROCHLORIC ACID IN STACK GAS

SOLUTIONS AND REAGENTS:

1. Distilled-deionized water (DI H₂O Chloride Free)
2. Alkaline arsenite solution
(1.0 N NaOH + 0.1N NaAsO₂: Dissolve 40 grams of NaOH and 6.5 gm NaAsO₂ in DI H₂O and dilute to 1000 ml with DI H₂O)
3. Alkaline arsenite solution
(2.5 N NaOH and 0.5 N NaAsO₂: Dissolve 100 gm of NaOH and 32.5 gm of NaAsO₂ in DI H₂O and dilute to 1000 ml with DI H₂O)
4. Ferris alum indicator
(Dissolve 28.0 gm of ferric ammonium sulfate FeNH₄(SO₄)₂.12 H₂O in 70 ml of hot DI H₂O. Cool and filter. Add 10 ml of concentrated HNO₃ and dilute to 100 ml with DI H₂O)
5. Nitric acid 8.0 N
(Add 100 ml of concentrated HNO₃ to 100 ml of DI H₂O. Boil until colorless and store in a glass bottle)
6. Silver Nitrate solution 0.1N*
(Dissolve 17.0 gm of AgNO₃ in water and dilute to 1000 ml. Store in an amber bottle. Standardize this against 0.1N NaCl solution using Volhard)
7. Ammonium Thiocyanate 0.1N*
(Dissolve 8 gm of NH₄CNS in DI H₂O and dilute to 1000 ml with DI H₂O. Standardize this against the AgNO₃ solution using Volhard)
8. Sodium Chloride 0.1N*
(Dissolve 5.846 gm of dried NaCl in DI H₂O and dilute to 1000 ml with DI H₂O)
9. Reagent Nitrogenzene
10. Starch solution (I₂ indicator):
Make a paste of 1 gm soluble starch in cold water. Dilute to 100 ml with boiling water.
11. Standard iodine solution
(Dissolve 12.69 gm of reagent grade I₂ crystals in 25 gm of iodate free KI and 100 ml with DI H₂O. When completely in solution, dilute to 1000 ml with DI H₂O. Store in an amber bottle)
12. Sodium bicarbonate (Reagent grade NaHCO₃)

* 0.01 -- Normal solutions may need to be prepared for HCl and Cl₂ concentrations of less than 1000 ppm.

Sampling Train:

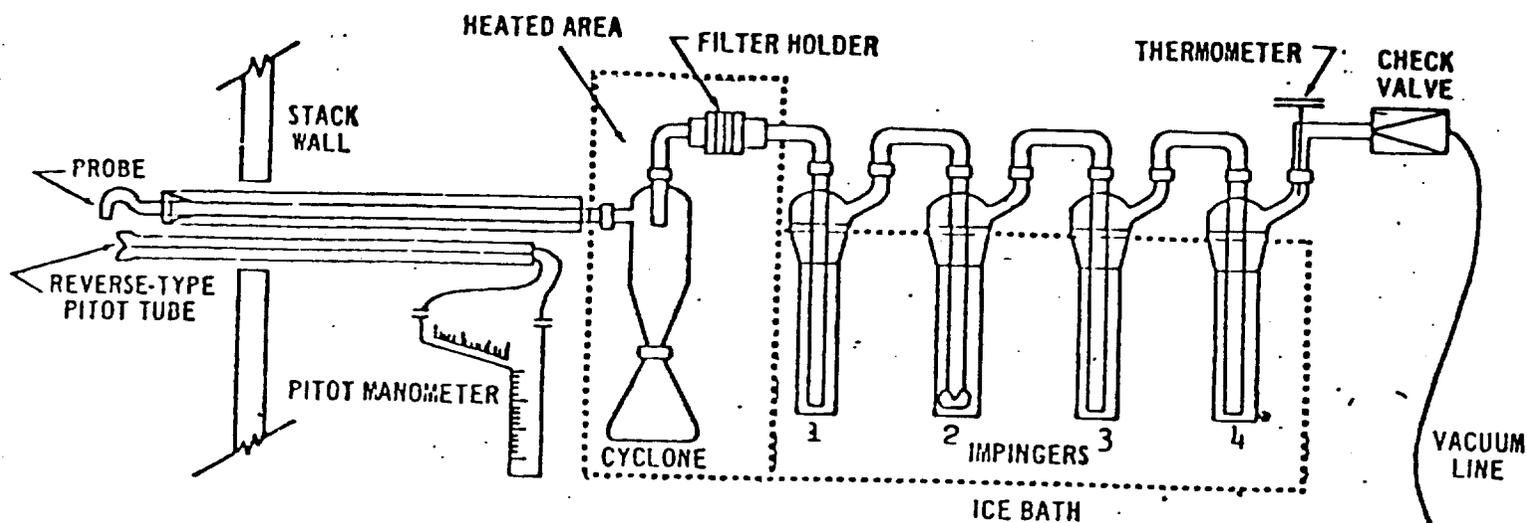


FIGURE II-18

1. Impinger (1) and (2) each to contain 100 ml of standard alkaline arsenite solution. Measure accurately with 100 ml volumetric pipette. If the water content of the gas stream is low, add 100 ml of DI H₂O to each impinger. Weigh and label each.
2. Impinger (3) is dry. Impinger (4) to be filled 1/2 to 3/4 with silica gel. Weigh and label each.

SAMPLING PROCEDURE:

Sample for approximately 20 minutes at a sampling rate of 0.5 to 1.0 cubic feet per minute. (For concentrations of HCl or Cl₂ of 1000 ppm or less, use the weaker solution of alkaline arsenite).

1. When sampling is completed, allow train to cool. Remove collected materials from probe and cyclone by rinsing with distilled water and collect washings in a one liter polyethylene bottle.
2. Dry and weigh all impingers and log weights. The weight increase is water and absorbed HCl and Cl₂. Transfer the contents of impingers (1) and (2) into separate clean polyethylene bottles. Wash out the impingers with DI water being careful not to spill anything, and add the washings from impinger (1) to the bottle with the catch from impinger (1) etc. A polyethylene wash bottle is convenient for washing the impinger tip and tube. (The excess sodium arsenite must be titrated with I₂ solution where HCl and Cl₂ are both present in the same stream. Spillage or loss of any solution will cause high results). Carefully label each bottle for impinger number, test number, date, etc.
3. At the laboratory dilute the solution in each bottle to an exact, known volume with DI water. Be sure to rinse the bottle with DI water. Titrate total chlorides using the Volhard Chloride Titration Method. Titrate the excess sodium arsenite by titrating with I₂ solution. (The aliquot size needed for best accuracy can be determined by trying a small aliquot).

PROCEDURE A: Analysis of Hydrogen Chloride

Pipet an aliquot of the sample into a 250 ml Erlenmeyer flask. Add 25 ml of water, 5 ml of 8 N nitric acid and swirl to mix. Depending on chloride content, add 0.1 N or 0.01 N silver nitrate from a buret until the silver chloride formed begins to coagulate. When coagulation occurs, add an additional 5 ml of silver nitrate. Add 3 ml of nitrobenzene and 2 ml of ferric indicator. Shake or stir vigorously to coat all precipitated silver chloride with nitrobenzene. Back-titrate with 0.1 N or 0.01 N ammonium thiocyanate until the first appearance of the reddish-brown Fe(CNS)₆₋₃ complex. A blank determination for chloride in the absorbing reagent should be run simultaneously and subtracted from the sample results. From the titer of NH₄CNS solution, as determined previously by titration against standard AgNO₃ solution, using ferric alum as an indicator, calculate the net volume of AgNO₃ required for precipitation of the chloride.

Calculations:

$[(\text{ml AgNO}_3 \times \underline{N} \text{ AgNO}_3) - (\text{ml NH}_4\text{CNS} \times \underline{N} \text{ NH}_4\text{CNS})] \times 0.036 = \text{grams of HCl in aliquot.}$
(A blank titration should be conducted containing the same amount of unused alkaline arsenite absorbing solution. Subtract this value (if any) from final results).

PROCEDURE B: Analysis of Hydrogen Chloride in the Presence of Chlorine

Pipet an aliquot of the sample into a 250 ml Erlenmeyer flask and proceed with the Volhard titration for total chlorides as described under Procedure A. A blank determination for chloride in the absorbing reagent (alkaline-arsenite reagent) should be run simultaneously and subtracted from the sample results. Calculate the total grams of chloride as above but with a factor of 0.035 rather than 0.036.

Pipet another aliquot of the sample into a 250 ml Erlenmeyer flask. Add a few drops of phenolphthalein indicator, neutralize carefully with concentrated hydrochloric acid and cool. Add sufficient solid sodium bicarbonate (NaHCO₃) to neutralize any excess hydrochloric acid, then add 2 to 3 g more. Add 2 ml of starch indicator and titrate with 0.1 N iodine solution to the blue endpoint. For the reagent blank, determine the number of ml of 0.1 N I₂ required to titrate 25 ml of alkaline-arsenite absorbing reagent, as described above.

Calculations:

$\text{ml Arsenite solution in aliquot} = \text{ml aliquot} \times 100 \div \text{sample volume}$

$[(\text{ml arsenite solution in aliquot} \times \underline{N} \text{ NaASO}_2) - (\text{ml I}_2 \text{ solution} \times \underline{N} \text{ I}_2)] \times 0.035 = \text{gms Cl}_2 \text{ in aliquot}$

$0.035 \frac{100 \text{ ml}_a \underline{N}_A}{\text{ml}_s} - \text{ml}_I \underline{N}_I \frac{\text{ml}_s}{\text{ml}_a} = \text{gm Cl}_2 \text{ in sample}$

$\text{gm HCl in sample} = \frac{36}{35} [\text{gm total chloride in sample} - \text{gm chlorine in sample}]$

Reference:

Atmospheric Emissions from Hydrochloric Acid Manufacturing Processes,
U.S. Department of Health, Education and Welfare, Public Health Service,
National Air Pollution Control Administration, Durham, N.C., pp. 38-39,
1969, Publication No. AP-54.

The ALMEGA CORPORATION

APPENDIX H

DETERMINATION OF NITROGEN OXIDE EMISSIONS FROM STATIONARY SOURCES

The ALMEGA CORPORATION

1. Principle and Applicability

1.1 Principle. A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the nitrogen oxides, except nitrous oxide, are measured colorimetrically using the phenoldisulfonic acid (PDS) procedure.

1.2 Applicability. This method is applicable to the measurement of nitrogen oxides emitted from stationary sources. The range of the method has been determined to be 2 to 400 milligrams NO_x (as NO₂) per dry standard cubic meter, without having to dilute the sample.

2. Apparatus

2.1 Sampling (see Figure 7-1). Other grab sampling systems or equipment, capable of measuring sample volume to within ± 2.0 percent and collecting a sufficient sample volume to allow analytical reproducibility to within ± 5 percent, will be considered acceptable alternatives, subject to approval of the Administrator, U.S. Environmental Protection Agency. The following equipment is used in sampling:

2.1.1 Probe. Borosilicate glass tubing, sufficiently heated to prevent water condensation and equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Stainless steel or Teflon³ tubing may also be used for the probe. Heating is not necessary if the probe remains dry during the purging period.

2.1.2 Collection Flask. Two-liter borosilicate, round bottom flask, with short neck and 24/40 standard taper opening, protected against implosion or breakage.

2.1.3 Flask Valve. T-bore stopcock connected to a 24/40 standard taper joint.

2.1.4 Temperature Gauge. Dial-type thermometer, or other temperature gauge, capable of measuring 1° C (2° F) intervals from -5 to 50° C (25 to 125° F).

2.1.5 Vacuum Line. Tubing capable of withstanding a vacuum of 75 mm Hg (3 in. Hg) absolute, pressure, with "T" connection and T-bore stopcock.

2.1.6 Vacuum Gauge. U-tube manometer, 1 meter (36 in.), with 1-mm (0.1-in.) divisions, or other gauge capable of measuring pressure to within ± 2.5 mm Hg (0.10 in. Hg).

2.1.7 Pump. Capable of evacuating the collection flask to a pressure equal to or less than 75 mm Hg (3 in. Hg) absolute.

2.1.8 Squeeze Bulb. One-way.

2.1.9 Volumetric Pipette. 25 ml.

2.1.10 Stopcock and Ground Joint Grease. A high-vacuum, high-temperature chlorofluorocarbon grease is required. Halocarbon 25-5S has been found to be effective.

2.1.11 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg). In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute

barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase, or vice versa for elevation decrease.

2.2 Sample Recovery. The following equipment is required for sample recovery:

2.2.1 Graduated Cylinder. 50 ml with 1-ml divisions.

2.2.2 Storage Containers. Leak-free polyethylene bottles.

2.2.3 Wash Bottle. Polyethylene or glass.

2.2.4 Glass Stirring Rod.

2.2.5 Test Paper for Indicating pH. To cover the pH range of 7 to 14.

2.3 Analysis. For the analysis, the following equipment is needed:

2.3.1 Volumetric Pipettes. Two 1 ml, two 2 ml, one 3 ml, one 4 ml, two 10 ml, and one 25 ml for each sample and standard.

2.3.2 Porcelain Evaporating Dishes. 175- to 250-ml capacity with lip for pouring, one for each sample and each standard. The Coors No. 45006 (shallow-form, 195 ml) has been found to be satisfactory. Alternatively, polymethyl pentene beakers (Nalge No. 1203, 150 ml), or glass beakers (150 ml) may be used. When glass beakers are used, etching of the beakers may cause solid matter to be present in the analytical step; the solids should be removed by filtration (see Section 4.3).

³Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

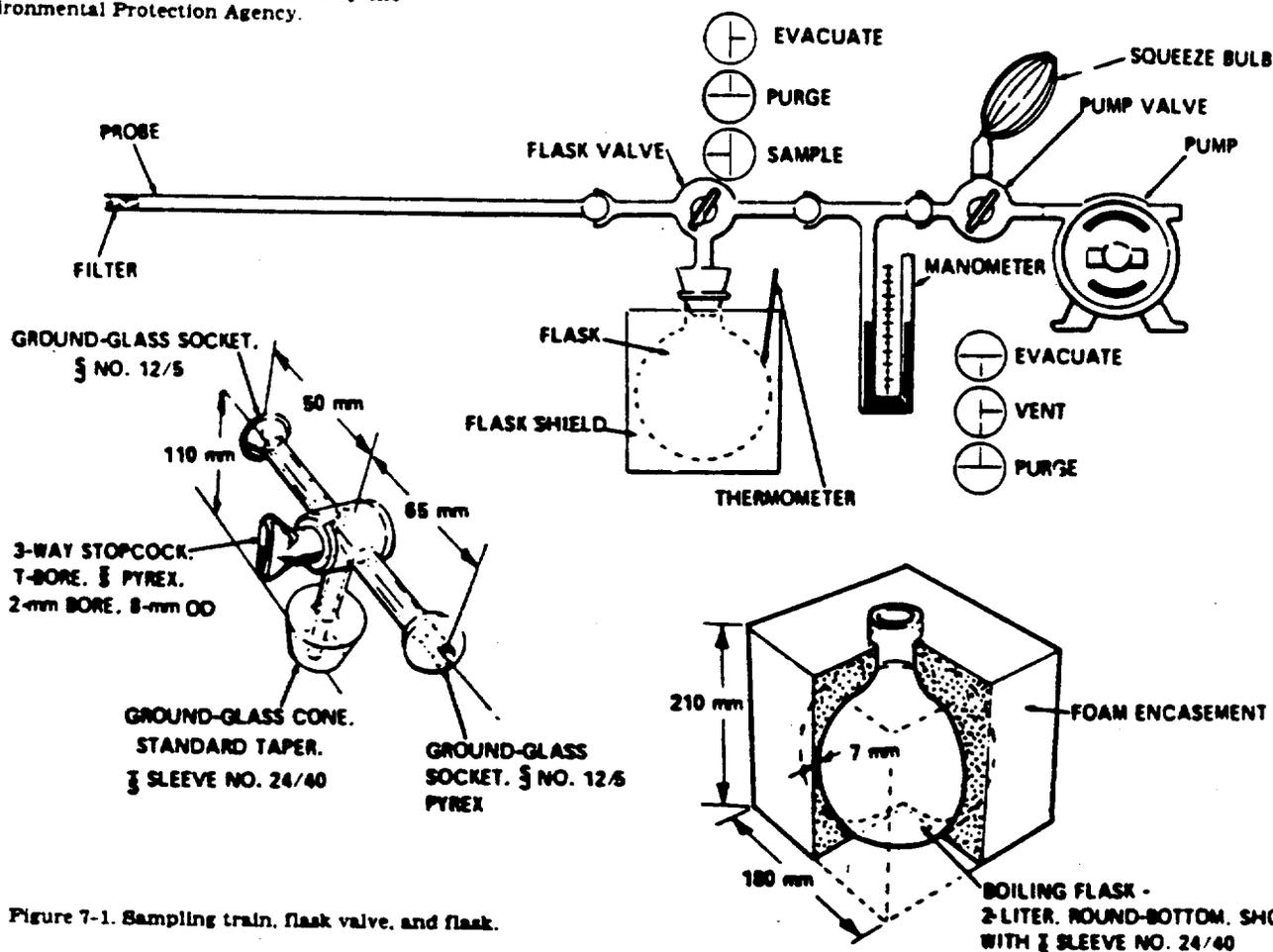


Figure 7-1. Sampling train, flask valve, and flask.

The ALMEGA CORPORATION

2.3.3 Steam Bath. Low-temperature ovens or thermostatically controlled hot plates kept below 70° C (160° F) are acceptable alternatives.

2.3.4 Dropping Pipette or Dropper. Three required.

2.3.5 Polyethylene Policeman. One for each sample and each standard.

2.3.6 Graduated Cylinder. 100 ml with 1-ml divisions.

2.3.7 Volumetric Flasks. 50 ml (one for each sample and each standard), 100 ml (one for each sample and each standard), and one for the working standard KNO₃ solution, and 1000 ml (one).

2.3.8 Spectrophotometer. To measure absorbance at 410 nm.

2.3.9 Graduated Pipette. 10 ml with 0.1-ml divisions.

2.3.10 Test Paper for Indicating pH. To cover the pH range of 7 to 14.

2.3.11 Analytical Balance. To measure to within 0.1 mg.

3. Reagents

Unless otherwise indicated, it is intended that all reagents conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available; otherwise, use the best available grade.

3.1 Sampling. To prepare the absorbing solution, cautiously add 2.8 ml concentrated H₂SO₄ to 1 liter of deionized, distilled water. Mix well and add 6 ml of 3 percent hydrogen peroxide, freshly prepared from 30 percent hydrogen peroxide solution. The absorbing solution should be used within 1 week of its preparation. Do not expose to extreme heat or direct sunlight.

3.2 Sample Recovery. Two reagents are required for sample recovery:

3.2.1 Sodium Hydroxide (1N). Dissolve 40 g NaOH in deionized, distilled water and dilute to 1 liter.

3.2.2 Water. Deionized, distilled to conform to ASTM specification D1193-74, Type 3. At the option of the analyst, the KMNO₃ test for oxidizable organic matter may be omitted when high concentrations of organic matter are not expected to be present.

3.3 Analysis. For the analysis, the following reagents are required:

3.3.1 Fuming Sulfuric Acid. 18 to 18 percent by weight free sulfur trioxide. HANDLE WITH CAUTION.

3.3.2 Phenol. White solid.

3.3.3 Sulfuric Acid. Concentrated, 95 percent minimum assay. HANDLE WITH CAUTION.

3.3.4 Potassium Nitrate. Dried at 105 to 110° C (220 to 230° F) for a minimum of 2 hours just prior to preparation of standard solution.

3.3.5 Standard KNO₃ Solution. Dissolve exactly 2.198 g of dried potassium nitrate (KNO₃) in deionized, distilled water and dilute to 1 liter with deionized, distilled water in a 1,000-ml volumetric flask.

3.3.6 Working Standard KNO₃ Solution. Dilute 10 ml of the standard solution to 100 ml with deionized distilled water. One milliliter of the working standard solution is equivalent to 100 µg nitrogen dioxide (NO₂).

3.3.7 Water. Deionized, distilled as in Section 3.2.2.

3.3.8 Phenoldisulfonic Acid Solution. Dissolve 25 g of pure white phenol in 150 ml concentrated sulfuric acid on a steam bath. Cool, add 75 ml fuming sulfuric acid, and heat at 100° C (212° F) for 2 hours. Store in a dark, stoppered bottle.

4. Procedures

4.1 Sampling.

4.1.1 Pipette 25 ml of absorbing solution into a sample flask, retaining a sufficient quantity for use in preparing the calibration standards. Insert the flask valve stopper into the flask with the valve in the "purge" position. Assemble the sampling train as shown in Figure 7-1 and place the probe at the sampling point. Make sure that all fittings are tight and leak-free, and that all ground glass joints have been properly greased with a high-vacuum, high-temperature chlorofluorocarbon-based stopcock grease. Turn the flask valve and the pump valve to their "evacuate" positions. Evacuate the flask to 75 mm Hg (3 in. Hg) absolute pressure, or less. Evacuation to a pressure approaching the vapor pressure of water at the existing temperature is desirable. Turn the pump valve to its "vent" position and turn the off the pump. Check for leakage by observing the manometer for any pressure fluctuation. (Any variation greater than 10 mm Hg (0.4 in. Hg) over a period of 1 minute is not acceptable, and the flask is not to be used until the leakage problem is corrected. Pressure in the flask is not to exceed 75 mm Hg (3 in. Hg) absolute at the time sampling is commenced.) Record the volume of the flask and valve (V_f), the flask temperature (T_f), and the barometric pressure. Turn the flask valve counterclockwise to its "purge" position and do the same with the pump valve. Purge the probe and the vacuum tube using the squeeze bulb. If condensation occurs in the probe and the flask valve area, heat the probe and purge until the condensation disappears. Next, turn the pump valve to its "vent" position. Turn the flask valve clockwise to its "evacuate" position and record the difference in the mercury levels in the manometer. The absolute internal pressure in the flask (V_i) is equal to the barometric pressure less the manometer reading. Immediately turn the flask valve to the "sample" position and permit the gas to enter the flask until pressures in the flask and sample line (i.e., duct, stack) are equal. This will usually require about 15 seconds; a longer period indicates a "plug" in the probe, which must be corrected before sampling is continued. After collecting the sample, turn the flask valve to its "purge" position and disconnect the flask from the sampling train. Shake the flask for at least 5 minutes.

4.1.2 If the gas being sampled contains insufficient oxygen for the conversion of NO to NO₂, (e.g., an applicable subpart of the standard may require taking a sample of a calibration gas mixture of NO in N₂), then oxygen shall be introduced into the flask to permit this conversion. Oxygen may be introduced into the flask by one of three methods: (1) Before evacuating the sampling flask, flush with pure cylinder oxygen, then evacuate flask to 75 mm Hg (3 in. Hg) absolute pressure or less; or (2) inject oxygen into the flask after sampling; or (3) terminate sampling with a minimum of 50 mm Hg (2 in. Hg) vacuum remaining in the flask, record this final pressure, and then vent the flask to the atmosphere until the flask pressure is almost equal to atmospheric pressure.

4.2 Sample Recovery. Let the flask set for a minimum of 16 hours and then shake the contents for 2 minutes. Connect the flask to a mercury filled U-tube manometer. Open the valve from the flask to the manometer and record the flask temperature (T_f), the barometric pressure, and the difference

between the mercury levels in the manometer. The absolute internal pressure in the flask (P_f) is the barometric pressure less the manometer reading. Transfer the contents of the flask to a leak-free polyethylene bottle. Rinse the flask twice with 5-ml portions of deionized, distilled water and add the rinse water to the bottle. Adjust the pH to between 9 and 12 by adding sodium hydroxide (1 N), dropwise (about 25 to 35 drops). Check the pH by dipping a stirring rod into the solution and then touching the rod to the pH test paper. Remove as little material as possible during this step. Mark the height of the liquid level so that the container can be checked for leakage after transport. Label the container to clearly identify its contents. Seal the container for shipping.

4.3 Analysis. Note the level of the liquid in container and confirm whether or not any sample was lost during shipment; note this on the analytical data sheet. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Immediately prior to analysis, transfer the contents of the shipping container to a 50-ml volumetric flask, and rinse the container twice with 5-ml portions of deionized, distilled water. Add the rinse water to the flask and dilute to the mark with deionized, distilled water; mix thoroughly. Pipette a 25-ml aliquot into the porcelain evaporating dish. Return any unused portion of the sample to the polyethylene storage bottle. Evaporate the 25-ml aliquot to dryness on a steam bath and allow to cool. Add 2 ml phenoldisulfonic acid solution to the dried residue and triturate thoroughly with a polyethylene policeman. Make sure the solution contacts all the residue. Add 1 ml deionized, distilled water and four drops of concentrated sulfuric acid. Heat the solution on a steam bath for 3 minutes with occasional stirring. Allow the solution to cool, add 20 ml deionized, distilled water, mix well by stirring, and add concentrated ammonium hydroxide, dropwise, with constant stirring, until the pH is 10 (as determined by pH paper). If the sample contains solids, these must be removed by filtration (centrifugation is an acceptable alternative, subject to the approval of the Administrator), as follows: filter through Whatman No. 41 filter paper into a 100-ml volumetric flask; rinse the evaporating dish with three 5-ml portions of deionized, distilled water; filter these three rinses. Wash the filter with at least three 15-ml portions of deionized, distilled water. Add the filter washings to the contents of the volumetric flask and dilute to the mark with deionized, distilled water. If solids are absent, the solution can be transferred directly to the 100-ml volumetric flask and diluted to the mark with deionized, distilled water. Mix the contents of the flask thoroughly, and measure the absorbance at the optimum wavelength used for the standards (Section 5.2.1), using the blank solution as a zero reference. Dilute the sample and the blank with equal volumes of deionized, distilled water if the absorbance exceeds 4, the absorbance of the 400 µg NO₂ standard (see Section 5.2.2).

5. Calibration

5.1 Flask Volume. The volume of the collection flask-flask valve combination must be known prior to sampling. Assemble the flask and flask valve and fill with water, to the stopcock. Measure the volume of water to ±10 ml. Record this volume on the flask.

The ALMEGA CORPORATION

5.2 Spectrophotometer Calibration.

5.2.1 Optimum Wavelength Determination. Calibrate the wavelength scale of the spectrophotometer every 6 months. The calibration may be accomplished by using an energy source with an intense line emission such as a mercury lamp, or by using a series of glass filters spanning the measuring range of the spectrophotometer. Calibration materials are available commercially and from the National Bureau of Standards. Specific details on the use of such materials should be supplied by the vendor; general information about calibration techniques can be obtained from general reference books on analytical chemistry. The wavelength scale of the spectrophotometer must read correctly within ± 5 nm at all calibration points; otherwise, the spectrophotometer shall be repaired and recalibrated. Once the wavelength scale of the spectrophotometer is in proper calibration, use 410 nm as the optimum wavelength for the measurement of the absorbance of the standards and samples.

Alternatively, a scanning procedure may be employed to determine the proper measuring wavelength. If the instrument is a double-beam spectrophotometer, scan the spectrum between 400 and 415 nm using a 200 $\mu\text{g NO}$, standard solution in the sample cell and a blank solution in the reference cell. If a peak does not occur, the spectrophotometer is probably malfunctioning and should be repaired. When a peak is obtained within the 400 to 415 nm range, the wavelength at which this peak occurs shall be the optimum wavelength for the measurement of absorbance of both the standards and the samples. For a single-beam spectrophotometer, follow the scanning procedure described above, except that the blank and standard solutions shall be scanned separately. The optimum wavelength shall be the wavelength at which the maximum difference in absorbance between the standard and the blank occurs.

5.2.2 Determination of Spectrophotometer Calibration Factor K_1 . Add 0.0 ml, 2 ml, 4 ml, 6 ml., and 8 ml of the KNO_3 working standard solution (1 ml = 100 $\mu\text{g NO}_x$) to a series of five 50-ml volumetric flasks. To each flask, add 25 ml of absorbing solution, 10 ml deionized, distilled water, and sodium hydroxide (1 N) dropwise until the pH is between 9 and 12 (about 25 to 35 drops each). Dilute to the mark with deionized, distilled water. Mix thoroughly and pipette a 25-ml aliquot of each solution into a separate porcelain evaporating dish. Beginning with the evaporation step, follow the analysis procedure of Section 4.3 until the solution has been transferred to the 100 ml volumetric flask and diluted to the mark. Measure the absorbance of each solution, at the optimum wavelength, as determined in Section 5.2.1. This calibration procedure must be repeated on each day that samples are analyzed. Calculate the spectrophotometer calibration factor as follows:

$$K_1 = 100 \frac{A_1 + 2A_2 + 3A_3 + 4A_4}{A_1^2 + A_2^2 + A_3^2 + A_4^2}$$

Equation 7-1

where:

K_1 = Calibration factor
 A_1 = Absorbance of the 100- $\mu\text{g NO}$, standard
 A_2 = Absorbance of the 200- $\mu\text{g NO}$, standard
 A_3 = Absorbance of the 300- $\mu\text{g NO}$, standard
 A_4 = Absorbance of the 400- $\mu\text{g NO}$, standard

5.3 Barometer. Calibrate against a mercury barometer.

5.4 Temperature Gauge. Calibrate dial thermometers against mercury-in-glass thermometers.

5.5 Vacuum Gauge. Calibrate mechanical gauges, if used, against a mercury manometer such as that specified in 2.1.6.

5.6 Analytical Balance. Calibrate against standard weights.

6. Calculations

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

6.1 Nomenclature.

A = Absorbance of sample.

C = Concentration of NO , as NO_x , dry basis, corrected to standard conditions, mg/dscm (lb/dscf).

F = Dilution factor (i.e., 25/5, 25/10, etc., required only if sample dilution was needed to reduce the absorbance into the range of calibration).

K_1 = Spectrophotometer calibration factor.

m = Mass of NO , as NO_x , in gas sample, μg .

P_i = Final absolute pressure of flask, mm Hg (in. Hg).

P_s = Initial absolute pressure of flask, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

T_f = Final absolute temperature of flask, $^{\circ}\text{K}$ ($^{\circ}\text{R}$).

T_s = Initial absolute temperature of flask, $^{\circ}\text{K}$ ($^{\circ}\text{R}$).

T_{std} = Standard absolute temperature 293 $^{\circ}\text{K}$ (528 $^{\circ}\text{R}$).

V_s = Sample volume at standard conditions (dry basis), ml.

V_f = Volume of flask and valve, ml.

V_a = Volume of absorbing solution, 25 ml.

2 = 50/25, the aliquot factor. (If other than a 25-ml aliquot was used for analysis, the corresponding factor must be substituted).

6.2 Sample volume, dry basis, corrected to standard conditions.

$$V_{s,c} = \frac{T_{std}}{P_{std}} (V_f - V_a) \left[\frac{P_f}{T_f} - \frac{P_i}{T_i} \right]$$

$$= K_1 (V_f - 25 \text{ ml}) \left[\frac{P_f}{T_f} - \frac{P_i}{T_i} \right]$$

Equation 7-2

$$K_1 = 0.3858 \frac{^{\circ}\text{K}}{\text{mm Hg}} \text{ for metric units}$$

$$= 17.64 \frac{^{\circ}\text{R}}{\text{in. Hg}} \text{ for English units}$$

6.3 Total $\mu\text{g NO}_x$ per sample.

$$m = 2 K_1 A F$$

Equation 7-3

Note.—If other than a 25-ml aliquot is used for analysis, the factor 2 must be replaced by a corresponding factor.

6.4 Sample concentration, dry basis, corrected to standard conditions.

$$C = K_2 \frac{m}{V_{s,c}}$$

Equation 7-4

where:

$$K_2 = 10^3 \frac{\text{mg/m}^3}{\mu\text{g/ml}} \text{ for metric units}$$

$$= 6.243 \times 10^{-3} \frac{\text{lb/scf}}{\mu\text{g/ml}} \text{ for English units}$$

7. Bibliography

1. Standard Methods of Chemical Analysis 6th ed. New York, D. Van Nostrand Co., Inc. 1962, Vol. 1, p. 329-330.

2. Standard Method of Test for Oxides of Nitrogen in Gaseous Combustion Products (Phenoldisulfonic Acid Procedure). In: 1968 Book of ASTM Standards, Part 26. Philadelphia, Pa. 1968. ASTM Designation D-1608-60, p. 725-729.

3. Jacob, M. B. The Chemical Analysis of Air Pollutants. New York, Interscience Publisher, Inc. 1960, Vol. 10, p. 351-356.

4. Beatty, R. L., L. B. Berger, and H. H. Schrenk. Determination of Oxides of Nitrogen by the Phenoldisulfonic Acid Method. Bureau of Mines, U.S. Dept. of Interior, R.I. 3687, February 1943.

5. Hamill, H. F. and D. E. Camann. Collaborative Study of method for the Determination of Nitrogen Oxide Emissions from Stationary Sources (Fossil Fuel-Fired Steam Generators). Southwest Research Institute report for Environmental Protection Agency, Research Triangle Park, N.C. October 5, 1973.

6. Hamill, H. F. and R. E. Thomas. Collaborative Study of Method for the Determination of Nitrogen Oxide Emissions from Stationary Sources (Nitric Acid Plants). Southwest Research Institute report for Environmental Protection Agency, Research Triangle Park, N.C. May 8, 1974.

The ALMEGA CORPORATION

APPENDIX I

**VISUAL DETERMINATION OF
THE OPACITY OF EMISSIONS
FROM STATIONARY SOURCES**

The ALMEGA CORPORATION

Many stationary sources discharge visible emissions into the atmosphere; these emissions are usually in the shape of a plume. This method involves the determination of plume opacity by qualified observers. The method includes procedures for the training and certification of observers, and procedures to be used in the field for determination of plume opacity. The appearance of a plume as viewed by an observer depends upon a number of variables, some of which may be controllable and some of which may not be controllable in the field. Variables which can be controlled to an extent to which they no longer exert a significant influence upon plume appearance include: Angle of the observer with respect to the plume; angle of the observer with respect to the sun; point of observation of attached and detached steam plume; and angle of the observer with respect to a plume emitted from a rectangular stack with a large length to width ratio. The method includes specific criteria applicable to these variables.

Other variables which may not be controllable in the field are luminescence and color contrast between the plume and the background against which the plume is viewed. These variables exert an influence upon the appearance of a plume as viewed by an observer, and can affect the ability of the observer to accurately assign opacity values to the observed plume. Studies of the theory of plume opacity and field studies have demonstrated that a plume is most visible and presents the greatest apparent opacity when viewed against a contrasting background. It follows from this, and is confirmed by field trials, that the opacity of a plume, viewed under conditions where a contrasting background is present can be assigned with the greatest degree of accuracy. However, the potential for a positive error is also the greatest when a plume is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of a plume is less and approaches zero as the color and luminescence contrast decrease toward zero. As a result, significant negative bias and negative errors can be made when a plume is viewed under less contrasting conditions. A negative bias decreases rather than increases the possibility that a plant operator will be cited for a violation of opacity standards due to observer error.

Studies have been undertaken to determine the magnitude of positive errors which can be made by qualified observers while reading plumes under contrasting conditions and using the procedures set forth in this method. The results of these studies (field trials) which involve a total of 769 sets of 25 readings each are as follows:

(1) For black plumes (133 sets at a smoke generator), 100 percent of the sets were read with a positive error of less than 7.5 percent opacity; 99 percent were read with a positive error of less than 5 percent opacity.

(2) For white plumes (170 sets at a smoke generator, 168 sets at a coal-fired power plant, 298 sets at a sulfuric acid plant), 99 percent of the sets were read with a positive error of less than 7.5 percent opacity; 95 percent were read with a positive error of less than 5 percent opacity.

The positive observational error associated with an average of twenty-five readings is therefore established. The accuracy of the method must be taken into account when determining possible violations of applicable opacity standards.

1. Principle and applicability.

1.1 Principle. The opacity of emissions from stationary sources is determined visually by a qualified observer.

1.2 Applicability. This method is applicable for the determination of the opacity of emissions from stationary sources pursuant to § 60.11(b) and for qualifying observers for visually determining opacity of emissions.

2. Procedures. The observer qualified in accordance with paragraph 3 of this method shall use the following procedures for visually determining the opacity of emissions:

2.1 Position. The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140° sector to his back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his observations from a position such that his line of vision is approximately perpendicular to the plume direction, and when observing opacity of emissions from rectangular outlets (e.g. roof monitors, open baghouses, noncircular stacks), approximately perpendicular to the longer axis of the outlet. The observer's line of sight should not include more than one plume at a time when multiple stacks are involved, and in any case the observer should make his observations with his line of sight perpendicular to the longer axis of such a set of multiple stacks (e.g. stub stacks on baghouses).

2.2 Field records. The observer shall record the name of the plant, emission location, type facility, observer's name and affiliation, and the date on a field data sheet (Figure 9-1). The time, estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet at the time opacity readings are initiated and completed.

2.3 Observations. Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer shall not look continuously at the plume, but instead shall observe the plume momentarily at 15-second intervals.

2.3.1 Attached steam plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

2.3.2 Detached steam plume. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.

2.4 Recording observations. Opacity observations shall be recorded to the nearest 5 percent at 15-second intervals on an observational record sheet. (See Figure 9-2 for an example.) A minimum of 24 observations shall be recorded. Each momentary observation recorded shall be deemed to represent the average opacity of emissions for a 15-second period.

2.5 Data Reduction. Opacity shall be determined as an average of 24 consecutive observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not be consecutive in time and in no case shall two sets overlap. For each set of 24 observations, calculate the average by summing the opacity of the 24 observations and dividing this sum by 24. If an applicable standard specifies an averaging time requiring more than 24 observations, calculate the average for all observations made during the specified time period. Record the average opacity on a record sheet. (See Figure 9-1 for an example.)

3. Qualifications and testing.

3.1 Certification requirements. To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and an average error not to exceed 7.5 percent opacity in each category. Candidates shall be tested according to the procedures described in paragraph 3.2. Smoke generators used pursuant to paragraph 3.2 shall be equipped with a smoke meter which meets the requirements of paragraph 3.3.

The certification shall be valid for a period of 6 months, at which time the qualification procedure must be repeated by any observer in order to retain certification.

3.2 Certification procedure. The certification test consists of showing the candidate a complete run of 50 plumes—25 black plumes and 25 white plumes—generated by a smoke generator. Plumes within each set of 25 black and 25 white runs shall be presented in random order. The candidate assigns an opacity value to each plume and records his observation on a suitable form. At the completion of each run of 50 readings, the score of the candidate is determined. If a candidate fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test may be administered as part of a smoke school or training program, and may be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

3.3 Smoke generator specifications. Any smoke generator used for the purposes of paragraph 3.2 shall be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output shall display instack opacity based upon a pathlength equal to the stack exit diameter, on a full 0 to 100 percent chart recorder scale. The smoke meter optical design and performance shall meet the specifications shown in

¹For a set, positive error = average opacity determined by observers' 25 observations—average opacity determined from transmissometer's 25 recordings.

The ALMEGA CORPORATION

Table 9-1. The smoke meter shall be calibrated as prescribed in paragraph 3.3.1 prior to the conduct of each smoke reading test. At the completion of each test, the zero and span drift shall be checked and if the drift exceeds ± 1 percent opacity, the condition shall be corrected prior to conducting any subsequent test runs. The smoke meter shall be demonstrated, at the time of installation, to meet the specifications listed in Table 9-1. This demonstration shall be repeated following any subsequent repair or replacement of the photocell or associated electronic circuitry including the chart recorder or output meter, or every 6 months, whichever occurs first.

TABLE 9-1—SMOKE METER DESIGN AND PERFORMANCE SPECIFICATIONS

Parameter	Specification
a Light source	Incandescent lamp operated at nominal rated voltage
b Spectral response of photocell	Photopic (daylight spectral response of the human eye—reference 4.3)
c Angle of view	15° maximum total angle
d Angle of projection	15° maximum total angle

TABLE 9-1—SMOKE METER DESIGN AND PERFORMANCE SPECIFICATIONS—Continued

Parameter	Specification
e Calibration error	$\pm 3\%$ opacity, maximum
f Zero and span drift	$\pm 1\%$ opacity, 30 minutes
g Response time	5 seconds

3.3.1 Calibration. The smoke meter is calibrated after allowing a minimum of 30 minutes warmup by alternately producing simulated opacity of 0 percent and 100 percent. When stable response at 0 percent or 100 percent is noted, the smoke meter is adjusted to produce an output of 0 percent or 100 percent, as appropriate. This calibration shall be repeated until stable 0 percent and 100 percent readings are produced without adjustment. Simulated 0 percent and 100 percent opacity values may be produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

3.3.2 Smoke meter evaluation. The smoke meter design and performance are to be evaluated as follows:

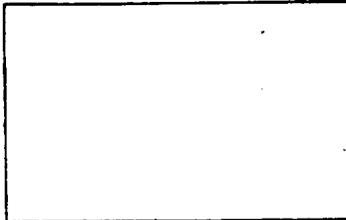
3.3.2.1 Light source. Verify from manufacturer's data and from voltage measurements made at the lamp, as installed, that the lamp is operated within ± 5 percent of the nominal rated voltage.

3.3.2.2 Spectral response of photocell. Verify from manufacturer's data that the photocell has a photopic response; i.e., the spectral sensitivity of the cell shall closely approximate the standard spectral-luminosity curve for photopic vision which is referenced in (b) of Table 9-1.

**FIGURE 9-1
RECORD OF VISUAL DETERMINATION OF OPACITY**

PAGE of

COMPANY _____
 LOCATION _____
 TEST NUMBER _____
 DATE _____
 TYPE FACILITY _____
 CONTROL DEVICE _____



HOURS OF OBSERVATION _____
 OBSERVER _____
 OBSERVER CERTIFICATION DATE _____
 OBSERVER AFFILIATION _____
 POINT OF EMISSIONS _____
 HEIGHT OF DISCHARGE POINT _____

	Initial		Final
CLOCK TIME			
12 OBSERVER LOCATION			
Distance to Discharge			
Direction from Discharge			
Height of Observation Point			
BACKGROUND DESCRIPTION			
WEATHER CONDITIONS			
Wind Direction			
Wind Speed			
Ambient Temperature			
SKY CONDITIONS (clear, overcast, % clouds, etc.)			
PLUME DESCRIPTION			
Color			
Distance Visible			
OTHER INFORMATION			

SUMMARY OF AVERAGE OPACITY

Set Number	Time	Opacity	
	Start--End	Sum	Average

Readings ranged from to % opacity
 The source was/was not in compliance with at the time evaluation was made.

The ALMEGA CORPORATION

FIGURE 9-2 OBSERVATION RECORD

PAGE ___ OF ___

COMPANY _____
 LOCATION _____
 TEST NUMBER _____
 DATE _____

OBSERVER _____
 TYPE FACILITY _____
 POINT OF EMISSIONS _____

3.3.2.3 Angle of view. Check construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15°. The total angle of view may be calculated from: $\theta = 2 \tan^{-1} d/2L$, where θ = total angle of view; d = the sum of the photocell diameter + the diameter of the limiting aperture; and L = the distance from the photocell to the limiting aperture. The limiting aperture is the point in the path between the photocell and the smoke plume where the angle of view is most restricted. In smoke generator smoke meters this is normally an orifice plate.

3.3.2.4 Angle of projection. Check construction geometry to ensure that the total angle of projection of the lamp on the smoke plume does not exceed 15°. The total angle of projection may be calculated from: $\theta = 2 \tan^{-1} d/2L$, where θ = total angle of projection; d = the sum of the length of the lamp filament + the diameter of the limiting aperture; and L = the distance from the lamp to the limiting aperture.

3.3.2.5 Calibration error. Using neutral-density filters of known opacity, check the error between the actual response and the theoretical linear response of the smoke meter. This check is accomplished by first calibrating the smoke meter according to 3.3.1 and then inserting a series of three neutral-density filters of nominal opacity of 20, 50, and 75 percent in the smoke meter pathlength. Filters calibrated within ± 2 percent shall be used. Care should be taken when inserting the filters to prevent stray light from affecting the meter. Make a total of five nonconsecutive readings for each filter. The maximum error on any one reading shall be 3 percent opacity.

3.3.2.6 Zero and span drift. Determine the zero and span drift by calibrating and operating the smoke generator in a normal manner over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

3.3.2.7 Response time. Determine the response time by producing the series of five simulated 0 percent and 100 percent opacity values and observing the time required to reach stable response. Opacity values of 0 percent and 100 percent may be simulated by alternately switching the power to the light source off and on while the smoke generator is not operating.

4. References.

4.1 Air Pollution Control District Rules and Regulations. Los Angeles County Air Pollution Control District, Regulation IV, Prohibitions, Rule 50.

4.2 Weisburd, Melvin I., Field Operations and Enforcement Manual for Air. U.S. Environmental Protection Agency, Research Triangle Park, N.C., APTD-1100, August 1972, pp. 4.1-4.36.

4.3 Condon, E.U., and Odishaw, H., Handbook of Physics, McGraw-Hill Co., N.Y., N.Y., 1958, Table 3.1, p. 6-52.

Hr.	Min.	Seconds				STEAM PLUME (check if applicable)		COMMENTS
		0	15	30	45	Attached	Detached	
	0							
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							
	27							
	28							
	29							

The ALMEGA CORPORATION

APPENDIX J

**DETERMINATION OF CARBON MONOXIDE
EMISSIONS FROM STATIONARY SOURCES**

The ALMEGA CORPORATION

FIGURE 9-2 OBSERVATION RECORD
(Continued)

PAGE ___ OF ___

COMPANY _____
 LOCATION _____
 TEST NUMBER _____
 DATE _____

OBSERVER _____
 TYPE FACILITY _____
 POINT OF EMISSIONS _____

Hr.	Min.	Seconds				STEAM PLUME (check if applicable)		COMMENTS
		0	15	30	45	Attached	Detached	
	30							
	31							
	32							
	33							
	34							
	35	1						
	36							
	37							
	38							
	39							
	40							
	41							
	42							
	43							
	44							
	45							
	46							
	47							
	48							
	49							
	50							
	51							
	52							
	53							
	54							
	55							
	56							
	57							
	58							
	59							

The ALMEGA CORPORATION

METHOD 10

Determination of Carbon Monoxide Emissions from Stationary Sources

1. Principle and Applicability

1.1 Principle. An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a Luft-type nondispersive infrared analyzer (NDIR) or equivalent.

1.2 Applicability. This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

2. Range and Sensitivity

2.1 Range. 0 to 1,000 ppm.

2.2 Sensitivity. Minimum detectable concentration is 20 ppm for a 0 to 1,000 ppm span.

3. Interferences

Any substance having a strong absorption of infrared energy will interfere to some extent. For example, discrimination ratios for water (H₂O) and carbon dioxide (CO₂) are 3.5 percent H₂O per 7 ppm CO and 10 percent CO₂ per 10 ppm CO, respectively, for devices measuring in the 1,500 to 3,000 ppm range. For devices measuring in the 0 to 100 ppm range, interference ratios can be as high as 3.5 percent H₂O per 25 ppm CO and 10 percent CO₂ per 50 ppm CO. The use of silica gel and ascarite traps will alleviate the major interference problems. The measured gas volume must be corrected if these traps are used.

4. Precision and Accuracy

4.1 Precision. The precision of most NDIR analyzers is approximately ± 2 percent of span.

4.2 Accuracy. The accuracy of most NDIR analyzers is approximately ± 5 percent of span after calibration.

5. Apparatus

5.1 Continuous Sample (Figure 10-1).

5.1.1 Probe. Stainless steel or sheathed Pyrex¹ glass, equipped with a filter to remove particulate matter.

5.1.2 Air-Cooled Condenser or Equivalent. To remove any excess moisture.

5.2 Integrated Sample (Figure 10-2).

5.2.1 Probe. Stainless steel or sheathed Pyrex glass, equipped with a filter to remove particulate matter.

5.2.2 Air-Cooled Condenser or Equivalent. To remove any excess moisture.

5.2.3 Valve. Needle valve, or equivalent, to adjust flow rate.

5.2.4 Pump. Leak-free diaphragm type, or equivalent, to transport gas.

5.2.5 Rate Meter. Rotameter, or equivalent, to measure a flow range from 0 to 1.0 liter per min (0.035 cfm).

5.2.6 Flexible Bag. Tedlar, or equivalent, with a capacity of 60 to 90 liters (2 to 3 ft³). Leak-test the bag in the laboratory before using by evacuating bag with a pump followed by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

5.2.7 Pitot Tube. Type S, or equivalent, attached to the probe so that the sampling rate can be regulated proportional to the stack gas velocity when velocity is varying with the time or a sample traverse is conducted.

5.3 Analysis (Figure 10-3).

5.3.1 Carbon Monoxide Analyzer. Nondispersive infrared spectrometer, or equivalent. This instrument should be demonstrated, preferably by the manufacturer, to meet or exceed manufacturer's specifications and those described in this method.

5.3.2 Drying Tube. To contain approximately 200 g of silica gel.

5.3.3 Calibration Gas. Refer to paragraph 6.1.

5.3.4 Filter. As recommended by NDIR manufacturer.

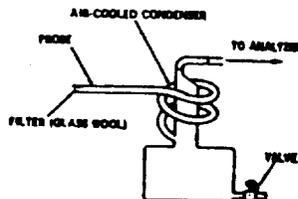


Figure 10-1. Continuous sampling tube.

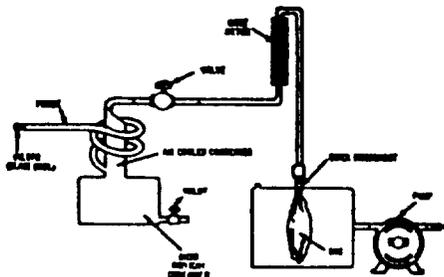


Figure 10-2. Integrated gas sampling tube.

5.3.5 CO₂ Removal Tube. To contain approximately 500 g of ascarite.

5.3.6 Ice Water Bath. For ascarite and silica gel tubes.

5.3.7 Valve. Needle valve, or equivalent, to adjust flow rate.

5.3.8 Rate Meter. Rotameter or equivalent to measure gas flow rate of 0 to 1.0 liter per min (0.035 cfm) through NDIR.

5.3.9 Recorder (optional). To provide permanent record of NDIR readings.

6. Reagents

6.1 Calibration Gases. Known concentration of CO in nitrogen (N₂) for instrument span, prepurified grade of N₂ for zero, and two additional concentrations corresponding approximately to 60 percent and 30 percent span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within ± 2 percent of the specified concentration.

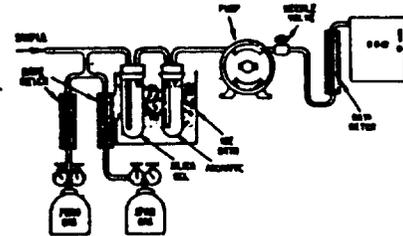


Figure 10-3. Analytical equipment.

6.2 Silica Gel. Indicating type, 6 to 16 mesh, dried at 175° C (347° F) for 2 hours.

6.3 Ascarite. Commercially available.

7. Procedure

7.1 Sampling.

7.1.1 Continuous Sampling. Set up the equipment as shown in Figure 10-1 making sure all connections are leak free. Place the probe in the stack at a sampling point and purge the sampling line. Connect the analyzer and begin drawing sample into the analyzer. Allow 5 minutes for the system to stabilize, then record the analyzer reading as required by the test procedure. (See 17.2 and 8). CO₂ content of the gas may be determined by using the Method 3 integrated sample procedure (36 FR 24886), or by weighing the ascarite CO₂ removal tube and computing CO₂ concentration from the gas volume sampled and the weight gain of the tube.

7.1.2 Integrated Sampling. Evacuate the flexible bag. Set up the equipment as shown in Figure 10-2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are leak free. Sample at a rate proportional to the stack velocity. CO₂ content of the gas may be determined by using the Method 3 integrated sample procedures (36 FR 24886) or by weighing the ascarite CO₂ removal tube and comput-

¹ Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

THE ALMEGA CORPORATION

ing CO₂ concentration from the gas volume sampled and the weight gain of the tube.

7.2 CO Analysis. Assemble the apparatus as shown in Figure 10-3, calibrate the instrument, and perform other required operations as described in paragraph 8. Purge analyzer with N₂ prior to introduction of each sample. Direct the sample stream through the instrument for the test period, recording the readings. Check the zero and span again after the test to assure that any drift or malfunction is detected. Record the sample data on Table 10-1.

8. Calibration

Assemble the apparatus according to Figure 10-3. Generally an instrument requires a warm-up period before stability is obtained. Follow the manufacturer's instructions for specific procedure. Allow a minimum time of 1 hour for warm-up. During this time check the sample conditioning apparatus, i.e., filter, condenser, drying tube, and CO₂ removal tube, to ensure that each component is in good operating condition. Zero and calibrate the instrument according to the manufacturer's procedures using, respectively, nitrogen and the calibration gases.

TABLE 10-1—FIELD DATA

	Comments
Location.....	
Test.....	
Date.....	
Operator.....	
Clock time	Rotameter setting, liters per minute (cubic feet per minute)

9. Calculation

Concentration of carbon monoxide. Calculate the concentration of carbon monoxide in the stack using Equation 10-1.

$$C_{CO \text{ stack}} = C_{CO \text{ NDIR}}(1 - F_{CO_2})$$

Eq. 10-1

Where:

$C_{CO \text{ stack}}$ = Concentration of CO in stack, ppm by volume (dry basis).

$C_{CO \text{ NDIR}}$ = Concentration of CO measured by NDIR analyzer, ppm by volume (dry basis).

F_{CO_2} = Volume fraction of CO₂ in sample, i.e., percent CO₂ from Orsat analysis divided by 100.

10. Bibliography

- 10.1 McElroy, Frank, The Intertech NDIR-CO Analyzer. Presented at 11th Methods Conference on Air Pollution, University of California, Berkeley, CA. April 1, 1970.
- 10.2 Jacobs, M. B., et al., Continuous Determination of Carbon Monoxide and Hydrocarbons in Air by a Modified Infrared Analyzer, J. Air Pollution Control Association, 9(2): 110-114, August 1959.
- 10.3 MSA LIRA Infrared Gas and Liquid Analyzer Instruction Book, Mine Safety Appliances Co., Technical Products Division, Pittsburgh, PA.
- 10.4 Models 215A, 315A, and 415A Infrared Analyzers, Beckman Instruments, Inc., Beckman Instructions 1635-B, Fullerton, CA. October 1967.
- 10.5 Continuous CO Monitoring System, Model A5611, Intertech Corp., Princeton, NJ.
- 10.6 UNOR Infrared Gas Analyzers, Bendix Corp., Ronceverte, WV

APPENDIX

A. PERFORMANCE SPECIFICATIONS FOR NDIR CARBON MONOXIDE ANALYZERS

Range (minimum).....	0-1000 ppm.
Output (minimum).....	0-10mV.
Minimum detectable sensitivity.....	20 ppm.
Rise time, 90 percent (maximum).....	30 seconds.
Fall time, 90 percent (maximum).....	30 seconds.
Zero drift (maximum).....	10% in 8 hours.
Span drift (maximum).....	10% in 8 hours.
Precision (minimum).....	±2% of full scale.
Noise (maximum).....	±1% of full scale.
Linearity (maximum deviation).....	2% of full scale.
Interference rejection ratio.....	CO ₂ -1000 to 1, H ₂ O-500 to 1.

B. Definitions of Performance Specifications.

Range—The minimum and maximum measurement limits.

Output—Electrical signal which is proportional to the measurement; intended for connection to readout or data processing devices. Usually expressed as millivolts or milliamperes full scale at a given impedance.

Full scale—The maximum measuring limit for a given range.

Minimum detectable sensitivity—The smallest amount of input concentration that can be detected as the concentration approaches zero.

Accuracy—The degree of agreement between a measured value and the true value; usually expressed as ± percent of full scale.

Time to 90 percent response—The time interval from a step change in the input concentration at the instrument inlet to a read-

ing of 90 percent of the ultimate recorded concentration.

Rise Time (90 percent)—The interval between initial response time and time to 90 percent response after a step increase in the inlet concentration.

Fall Time (90 percent)—The interval between initial response time and time to 90 percent response after a step decrease in the inlet concentration.

Zero Drift—The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is zero; usually expressed as percent full scale.

Span Drift—The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is a stated upscale value; usually expressed as percent full scale.

Precision—The degree of agreement between repeated measurements of the same concentration, expressed as the average deviation of the single results from the mean.

Noise—Spontaneous deviations from a mean output not caused by input concentration changes.

Linearity—The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

The ALMEGA CORPORATION

APPENDIX K

**PERMIT SPECIAL CONDITIONS, EMISSIONS PRE-TEST
AGREEMENT, MARCH 23, 1988, RUNS 1 to 4,
PARTICULATE FIELD DATA CALCULATIONS,
LABORATORY WEIGHTS, CHAIN-OF-CUSTODY AND CO₂
CORRECTION FACTOR CALCULATIONS**

CHATTANOOGA-HAMILTON COUNTY AIR POLLUTION CONTROL BUREAU

Special Conditions for
Chattanooga-Hamilton County Hospital Authority
Installation Permit No. 0150-50200599-02I

1. Final compliance must be demonstrated by stack testing no later than May 30, 1988, as specified by the Consent Decree entered in Docket #65267 of the Chancery Court for Hamilton County, Tennessee.

Testing shall be conducted for particulate matter, HCL, CL₂, primary chamber temperature, secondary chamber temperature and visible emissions. Additionally, the secondary chamber residence time and a turbulent flow determination shall be provided in the final report. All testing shall be in accordance with methods and procedures specified by the Director, The Chattanooga-Hamilton County Air Pollution Control Bureau. The Director shall be given notice of the proposed testing date at least ten (10) days prior to such testing.

2. Antineoplastic agents which are defined by U.S. EPA as hazardous wastes (40 Code of Federal Regulations 261.33 - U-list) shall not be incinerated in this unit except as residue of antineoplastic agents. "Antineoplastic agents" means chemotherapy drugs or compounds used in the treatment of cancer. "Residue of antineoplastic agents" means the portion of compound that remains in a container or other item (i.e. clothing, tubing, etc.) after all the compound has been removed using the practices commonly employed to remove materials from that type of container, e.g., pouring, pumping, and aspirating; and no more than 2.5 centimeters (one inch) of material remain on the bottom of the container or other item, or no more than 3 (three) percent by weight of the total capacity of the container remains in the container or other item. Except as specified above, no hazardous waste may be incinerated in this unit.
3. The maximum allowable particulate emission rate is 0.080 grains per dry standard cubic foot of exhaust gas corrected to 12% CO₂ and 0.1 pounds per 100 pounds of material charged.
4. A log shall be maintained during hours of incinerator operation and kept on the premises for review by Bureau representatives upon request. The log shall contain at a minimum data reflecting the weight of materials charged and the date and time of charging.
5. There shall be no visible emissions from this incinerator.

6. The secondary chamber (stage 2) shall be operated at a minimum of 1800°F with a residence time of one (1.0) second, provided, however, that this minimum temperature requirement shall not apply during start-up and shut-down of the equipment so long as no uncombusted materials (other than clean burning wood) are present in the primary chamber.
7. A recorder which provides a permanent printed recording of temperatures in the secondary (stage 2) chamber at a frequency of not less than once per minute at all times during operation of the equipment, including start up and shutdown periods, shall be maintained. Temperature records shall be kept at the source for a minimum of two years, and shall be made available for review by Bureau representatives upon request.
8. Each person operating this incinerator must be licensed by the Bureau.
9. This permit does not authorize the incineration of waste generated outside of Hamilton County, Tennessee. The intent to dispose of such waste will require reapplication for an installation permit and may require a public hearing.
10. Compliance with the terms and conditions of this permit shall not relieve this source from compliance with other requirements of local, state or federal law.

Permit # 0150-502-00599-02T

EMISSIONS PRE-TEST AGREEMENT

Preamble

A source sampling test of the Basic Model 1250 Incinerator/Boiler System (North unit) at the Chattanooga-Hamilton County Hospital Authority will be conducted to demonstrate compliance with all applicable provisions of the Chattanooga Air Pollution Control Ordinance (the "Ordinance") and consent decree #65267 of the Chancery Court for Hamilton County, Tennessee and will be conducted by The Almega Corporation. The test will be conducted for particulate matter, chlorine, hydrochloric acid, primary chamber temperature, secondary chamber temperature and visible emissions. Additionally, secondary chamber residence time and turbulent flow determination shall be provided in the final report. The test shall be observed by representatives of the Chattanooga-Hamilton County Air Pollution Control Bureau (Bureau) and shall be conducted under maximum representative operating conditions. Failure to meet the test conditions specified herein or include all necessary information in the final report shall constitute sufficient basis for the Bureau's rejection of the test results and/or the final report.

Minimum Test Requirements

- A. Incineration Requirements
 - 1. Normal incineration rate (permitted incineration rate): 1250 lbs/hr.
 - 2. Incineration parameters:
 - A. Charge material requirements: Type 0-4 waste.
 - B. 1. For incinerators the charge rate for each run and the method of determination shall be: The amount of charged waste shall be weighed to establish a test run charge rate. The test run charge rate shall include waste charged three (3)

minutes prior to starting a test run and all waste charged during the test run excluding waste charged during the last three (3) minutes of the test run.

2. Alternative if charge rate does not meet 80% of permitted incineration rate of 1,250 lbs/hr: Re-permit at test charge rate or retest

C. Primary chamber and secondary chamber temperatures shall be recorded at a minimum of 5 minute intervals throughout the test.

3. What testing methods are to be used: EPA Reference Methods 1-5, 9 (as modified by Section 4-41, Rule 3, the Ordinance), and acceptable methods for hydrochloric acid and chlorine. Test results shall be calculated (1) to twelve (12) percent carbon dioxide for products of combustion, and (2) to standard conditions. In measuring emissions from incinerators, the carbon dioxide produced by combustion of any liquid or gaseous fuels shall be excluded from the calculation to a maximum of twelve (12) percent carbon dioxide. Secondary chamber residence time is to be based on the secondary chamber volume and the secondary chamber flow rate.

B. Compliance Test Requirements:

1. The source sampling test shall be conducted with

what equipment: EPA approved equipment

2. Copies of all notes, tables, field documents, tare weights of filters, and calculations shall be exchanged between the representatives of the company and the control agencies prior to test completion.
3. Any and all test reports shall be submitted to the Bureau regardless of the results of the test.
4. For particulate matter tests, unless otherwise noted herein, the Bureau will be provided with the filter and washings from one test run of its choice along with pre-weights and acetone blanks. The analysis of this will be completed in the Bureau laboratory, and handling of the sample will be protected by a written chain of custody. The Bureau will assume all responsibility for the samples once in its custody, and the results will be given to the test team for inclusion in the final report after the results obtained by the test team are given to the Bureau. The run analyzed by the Bureau will be considered the same as the other two runs and the results averaged as normally required by EPA Reference Method 5. If the Bureau loses, damages, or otherwise alters or destroys the sample, the stack emission rate will be determined on the basis of the two remaining runs, and the Bureau will certify that all three

runs were properly completed.

5. Visible Emissions Evaluations shall be conducted and recorded during the entire period of each test run. Such evaluations shall be conducted by certified observers provided by Chattanooga-Hamilton County Hospital Authority. The results of such evaluations shall be included in the final report.

C. Test Report

The test report shall consist of the following sections, as a minimum:

1. Introduction
2. Summary of results
 - A. Stack Diameter
 - B. Stack Gas Velocity
 - C. Stack Gas Flow rate (SCFM)
 - D. Emission listed in pounds per hour and grain per standard cubic foot (g/scf), (68F, 1 atm, dry gas)
 - E. Allowable emission rate in pounds per 100 pounds charge
 - F. Percent isokinetic of test
 - G. Incineration rate during test
 - H. Secondary chamber volume
 - I. Secondary chamber gas flow rate (ACFM)
 - J. Residence time (seconds)
 - K. Other pertinent results

3. Conclusions
4. Emission Source Description
 - A. APCB permit number
 - B. Process description and equipment
 - C. Control equipment
 - D. Exhaust description
5. Sampling Protocol
 - A. Methodology
 - B. Analytical Procedures
6. Appendices
 - A. Velocity Profile Diagram
 - B. Sample Calculations
 - C. Description of sampling procedure and laboratory procedure (signed)
 - D. Copy of field data sheets (signed by tester)
 - E. Schematic diagram of sampling site showing distance to upstream and downstream disturbances
 - F. Identification of regulations applicable to source
 - G. Calibration data to include the most recent data and results of calibration for all equipment used in the test. (RE: Dry gas meter before and after each test and orifice before each test.)
 - H. Visible Emissions evaluation Certification
 - I. Turbulent flow determination

FAILURE TO INCLUDE ANY OF THE ABOVE INFORMATION IS ADEQUATE
GROUNDS FOR REJECTION OF THE COMPLIANCE TEST.

D. Physical Condition of Testing

1. The source sampling test will begin after 9:00 a.m. on March 23, 1988.
2. Representatives of local, state, and federal air pollution agencies shall be permitted to observe the source sampling test and shall be given prompt admittance to the test site during the test.
3. A company representative shall be assigned to the test site.
4. A lead representative shall be appointed to represent Chattanooga-Hamilton County Hospital Authority, the testing, and/or consulting firm(s), and the Bureau.

The lead representatives shall be:

Stan Grinde -	The Chattanooga-Hamilton County Hospital Authority
Bernard Jackson -	The Almega Corporation
Richard Manning -	Campbell and Associates
Jim Weyler -	Air Pollution Control Bureau

All field decisions shall be made by and between these respective persons.

This document is not a contractual agreement but constitutes the source test conditions which were negotiated on March 18, 1988, between representatives of the Bureau and The Chattanooga-

Hamilton County Hospital Authority.

This information is set forth in written form to insure that all appropriate parties understand the minimum test conditions. The signature of each representative party signifies that he has read the document and will, to the best of his knowledge and ability, comply with the terms of the pre-test agreement.

S.E. Grind
(company representative)

3-22-88
(date)

Richard K. Manning
(consultant)

3/21/88
(date)

Thomas W. Jackson
(test consultant)

3/22/88
(date)

Jim J. Weyler
Bureau

3/21/88
(date)

The ALMEGA CORPORATION

PARTICULATE CALCULATION SUMMARY

COMPANY: EVANSER MURKIN CENTER
 SOURCE: INCUBATOR NORTH UNIT
 REPETITION NO:
 TEST DATE: CHATTANOOGA, TN 23. MARCH. 88

ENGLISH UNITS
 (29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[\frac{17.64}{0.9938} \right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \frac{55.154}{126} \quad \frac{58.300}{122} \quad \frac{58.172}{128.5} \quad \frac{56.389}{125.5} \text{ dscf.}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[\frac{0.04707 \text{ cu. ft.}}{\text{ml}} \right] V_{lc} = \frac{5.931}{17.710} \quad \frac{5.743}{18.5} \quad \frac{6.049}{9.34} \quad \frac{5.907}{14.5} \text{ scf.}$$

$V_{lc} = \text{ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \frac{\text{FURSE nd}}{\text{P.W.} - 12.9} = \frac{12.9}{12.9} = 1$$

Particle concentration in stack gas on dry basis

$$c's = \left[\frac{0.01543 \text{ gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] = \frac{0.003609}{0.01449} \quad \frac{0.003626}{0.01703} \quad \frac{0.005033}{0.02091} \quad \frac{0.004830}{0.02401} \text{ grains/dscf.}$$

$- 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}}$

COLLECTED TO 12% CO₂ (LESS GAS FROM EVAPORERS) grains/dscf

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \frac{.3221}{2948} \quad \frac{.3215}{\text{sq. ft.}} \quad \frac{.3270}{\text{ft/sec}} \quad \frac{.3204}{\text{dscf/hr}}$$

Process rate or BTU rating P_w

Emission rate

$$Q_s \text{ c's} = \frac{0.1661}{0.1697} \quad \frac{0.2352}{\text{lbs/hr}} \quad 0.2211$$

$$\frac{Q_s \text{ c's}}{P_w} = \text{lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{0.002669 \frac{\text{in. Hg. cu. ft.}}{\text{ml. OR}} V_{lc}}{Q V_s P_s A_n} + \frac{V_m Y}{T_m} \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{13.6} \right) \right] = \frac{93.34}{.005412} \quad \frac{97.02}{\text{sq. ft.}} \quad \frac{97.87}{\text{sq. ft.}} \quad 95.95$$

The ALMEGA CORPORATION

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER
 SOURCE: INCINERATOR NORTH UNIT
 REPETITION NO: CHATTANOOGA
 TEST DATE: TN 23. MARCH. 88

Run ① ② ③ ④

Dry molecular weight of stack gas

$$M_d = 0.44 (\%CO_2) + 0.32 (\%O_2) + 0.28 (\%N_2 + \%CO)$$

	29.32	29.25	29.29	29.3
	lb/lb-mole			

Molecular weight of stack gas, wet basis

$$M_s = M_d (1 - B_{ws}) + 18 B_{ws}$$

	28.22	28.24	28.24	28.24
	lb/lb-mole			

Pitot tube coefficient

$$C_p \text{ (from calibration curve)}$$

	.84	.84	.84	.84

Average velocity head of stack gas, inches H₂O.

$$(\sqrt{\Delta p}) \text{ avg.}$$

	.6558	.6625	.6679	.6549

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \text{_____ OF} + 460$$

	.F. 182.3	184.2	191.9	190.4
	.R. 642.3	644.2	651.9	650.4

Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6)$$

	29.66	29.65	29.65	29.65
	in. Hg			

Stack gas velocity

$$(V_s) \text{ avg.} = (85.49) C_p (\sqrt{\Delta p}) \text{ avg} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

	41.25	41.74	42.33	41.4
	ft/sec.			

Stack gas volume flow rate

$$60 V_s A_s$$

	7296	7382	7487	7329
	acfm			

Stack gas volume flow rate, dry basis dscfm (5368) (5459) 5429 5546

$$Q_s = 3,600 (1 - B_{ws}) V_s A_s$$

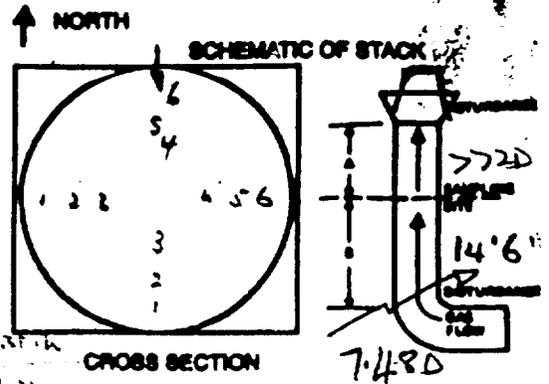
$$\left[\frac{T_{std} \cdot P_s}{(T_s) \text{ avg.} \cdot P_{std}} \right]$$

$$= \text{_____} \times 10^6 \text{ dscf/h}$$

PARTICULATE FIELD DATA

PLANT Erlanger Med. Center
 DATE 3/23/88
 LOCATION Chattanooga, Tenn.
 OPERATOR L. Damascius / Eric Andrews
 STACK NO. North unit
 RUN NO. 1
 SAMPLE BOX NO. 1
 METER BOX NO. 2
 METER # 8964
 Y# 9938
 TIME START - 10:46

AMBIENT TEMPERATURE 55
 BAROMETRIC PRESSURE 29.60
 ASSUMED MOISTURE, % 12
 PROBE LENGTH, in. 30
 NOZZLE DIAMETER, in. 5/16 .315
 STACK DIAMETER, in. 2.3 1/4
 PROBE HEATER SETTING 250°F=25
 HEATER BOX SETTING 250°F=25
 ΔCP FACTOR .84
 FILTER NO. 359
 FILTER TARE WEIGHT 623.5
 12 POINTS / 5 MINS



PRE TEST LEAK CHECKS
 METER MD @ 25 in Hg
 PITOTS 0 @ 1 in H₂O
 ORBAT OK

P	θ	Static Pressure (in Hg)	T _s °F	ΔP in H ₂ O	√ΔP	ΔH in H ₂ O	V _m ft ³ /min	T _m Inlet °F	T _m Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
W1	5	.76	178	.43		1.45	62.58	75	73	225	62	2
2	5		181	.45		1.52	67.34	78	73	230	58	2
3	5	.72	180	.38		1.26	71.92	79	75	235	59	2
4	5		183	.42		1.4	76.65	78	76	235	62	2
5	5		182	.42		1.4	81.38	78	76	235	61	2
6	5		181	.42		1.4	86.11	84	80	235	63	2
N1	5	.80	185	.49		1.55	91.22	85	85	230	67	3
2	5		184	.50		1.55	91.22	85	85	235	67	3
3	5		182	.46		1.52	101.5	85	88	237	67	2
4	5		180	.41		1.4	102.5	84	88	250	66	2
5	5		183	.39		1.3	110.57	84	89	235	66	2
6	5	.75	183	.40		1.37	115.29	85	90	235	67	2
AV	50	.7575	182.5		.6558	1.44	57.360	81.67	91.5			

Time ends - 11:52

POST TEST LEAK CHECKS
 METER MD @ 25 in Hg
 PITOTS 0 @ 1 in H₂O
 ORBAT OK

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA GEL WEIGHT.
	1	2	3	4	
FINAL	175	126	2		220
INITIAL	157	150	-	56	200
LIQUID COLLECTED	78	26	2		20
TOTAL VOLUME COLLECTED					126

ORBAT MEASUREMENT	TIME	CO ₂	O ₂	CO	N ₂
1	6:00	4.6			
2	✓	6.0			
3	✓	5.3			
4	INTD	(4.4)	(15.3)		

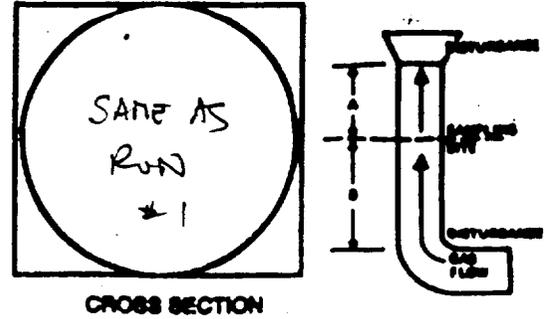
PARTICULATE FIELD DATA

PLANT Erlanger Medical Center
 DATE 3/23/88
 LOCATION Chattanooga, Tenn
 OPERATOR L. Damasio
 STACK NO. North Unit
 RUN NO. 2
 SAMPLE BOX NO. 6
 METER BOX NO. 2
 METER H_2O .8964
 Yr .7738
 TIME START - 12:50

AMBIENT TEMPERATURE 62°F
 BAROMETRIC PRESSURE 29.6
 ASSUMED MOISTURE, % 9
 PROBE LENGTH, in. 30
 NOZZLE DIAMETER, in. 5/16 .315
 STACK DIAMETER, in. 23 3/4
 PROBE HEATER SETTING 250 ± 25°F
 HEATER BOX SETTING 250 ± 25°F
 ΔC_p FACTOR .84
 FILTER NO. 387
 FILTER TAPE WEIGHT 617.5 mg

↑ NORTH

SCHMATIC OF STACK



CROSS SECTION

PRE TEST LEAK CHECKS

METER .016 @ 11 in Hg
 PITOTS 0 @ 1 in Hg
 ORSAT OK

P	θ	Static Pressure in Hg	T ₀ °F	ΔP in Hg	√ΔP	ΔH in Hg	Vm $\frac{R^2}{15.581}$	T _m Inlet °F	T _m Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
W1	5	.80	184	.37		1.4	20.45	90	93	230	65	2
2	5		188	.38		1.39	25.00	90	92	235	66	2
3	5		186	.46		1.55	30.29	91	92	235	66	3
4	5		184	.50		1.76	36.23	89	91	235	67	3
5	5		184	.40		1.48	41.16	90	92	235	67	2
6	5	.75	181	.35		1.15	45.77	91	93	235	66	2
N1	5		180	.66		2.20	52.13	91	94	230	65	3
2	5		182	.49		1.65	57.56	92	94	230	65	2
3	5		186	.51		1.70	63.13	92	95	235	66	2
4	5		186	.39		1.38	68.05	92	95	235	67	2
5	5		184	.40		1.40	72.97	94	96	240	67	2
6	5	.75	185	.38		1.38	77.44	96	99	235	67	2
Av	60	.7525	184.2			1.52	61.861	91.5	93.8			

Time ends - 12:53 (600.2)

Luis Damasio 552.65

POST TEST LEAK CHECKS

METER .019 @ 10 in Hg
 PITOTS 0 @ 1 in Hg
 ORSAT OK

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME =				SILICA GEL WEIGHT.
	1	2	3	4	
FINAL	125	169			226
INITIAL	100	100	-	36	200
LIQUID COLLECTED	25	69	-		26
TOTAL VOLUME COLLECTED					122

ORSAT MEASUREMENT	TIME	CO ₂	O ₂	CO	N ₂
1	INITIAL	0.3	14.0		
2					
3					
4					

The ALMEGA CORPORATION

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger Hose STACK NUMBER: N. Incinerator
LOCATION: Chattanooga Tn RUN NUMBER: 2
DATE: 3/23/88 RELATIVE HUMIDITY: 50 %
ACETONE DENSITY (Pa): 0.7852 g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.004 mg/g
ACETONE RINSE VOLUME (Vaw) 191 ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.6 mg

NOTE: IN NO CASE SHOULD A BLANK RESIDUE 0.01 mg/g OR 0.001 % OF THE WEIGHT OF ACETONE USED BE SUBTRACTED FROM THE SAMPLE WEIGHT.

DATE OF WEIGHING 3/28 GROSS WT. 84455.1 mg
TIME OF WEIGHING 1315
DATE OF WEIGHING 3/29 GROSS WT. 84455.2 mg
TIME OF WEIGHING 0900

AVERAGE GROSS WT. 84455.2 mg

LESS BLANK RESIDUE (Wa) 0.6 mg

TARE WT. 84448.1 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 6.5 mg

DATE OF WEIGHING 3/28 GROSS FILTER WT. 624.6 mg
TIME OF WEIGHING 1317
DATE OF WEIGHING 3/29 GROSS FILTER WT. 624.8 mg
TIME OF WEIGHING 0900

AVERAGE GROSS WT. 624.7 mg

FILTER TARE WT. 617.5 mg

WEIGHT OF PARTICULATE ON FILTER 7.2 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 6.5 mg

TOTAL WEIGHT OF PARTICULATE 13.7 mg

REMARKS: _____

INITIALS OF ANALYST B

The ALMEGA CORPORATION

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Enclosure Hosp STACK NUMBER: N. Inactivation
LOCATION: Chattanooga, TN RUN NUMBER: 3
DATE: 3/23/88 RELATIVE HUMIDITY: 50 %
ACETONE DENSITY (Pa): 0.7878 g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.004 mg/g
ACETONE RINSE VOLUME (Vaw) 274 ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.9 mg

NOTE: IN NO CASE SHOULD A BLANK RESIDUE 0.01 mg/g OR 0.001 % OF THE WEIGHT OF ACETONE USED BE SUBTRACTED FROM THE SAMPLE WEIGHT.

DATE OF WEIGHING 3/28 GROSS WT. 111817.3 mg
TIME OF WEIGHING 1315
DATE OF WEIGHING 3/29 GROSS WT. 111817.0 mg
TIME OF WEIGHING 1400

AVERAGE GROSS WT. 111817.2 mg

LESS BLANK RESIDUE (Wa) 0.9 mg

TARE WT. 111810.5 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 5.8 mg

DATE OF WEIGHING 3/28 GROSS FILTER WT. 630.1 mg
TIME OF WEIGHING 1415

DATE OF WEIGHING 3/29 GROSS FILTER WT. 629.8 mg
TIME OF WEIGHING 1415

AVERAGE GROSS WT. 629.95 mg

FILTER TARE WT. 616.6 mg

WEIGHT OF PARTICULATE ON FILTER 13.35 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 5.8 mg

TOTAL WEIGHT OF PARTICULATE 19.15 mg

REMARKS: _____

INITIALS OF ANALYST B

The ALMEGA CORPORATION

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Emerson Hase STACK NUMBER: N Inco-ite
LOCATION: Chattanooga, Ten. RUN NUMBER: 4
DATE: 3/23/28 RELATIVE HUMIDITY: 50 %
ACETONE DENSITY (Pa): 0.7858 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED?

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.004 mg/g
ACETONE RINSE VOLUME (Vaw) 303 ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 1.0 mg

NOTE: IN NO CASE SHOULD A BLANK RESIDUE 0.01 mg/g OR 0.001 % OF THE WEIGHT OF ACETONE USED BE SUBTRACTED FROM THE SAMPLE WEIGHT.

DATE OF WEIGHING 3/28 GROSS WT. 100603.3 mg
TIME OF WEIGHING 1320
DATE OF WEIGHING 3/29 GROSS WT. 100603.7 mg
TIME OF WEIGHING 0900

AVERAGE GROSS WT. 100603.5 mg

LESS BLANK RESIDUE (Wa) 1.0 mg

TARE WT. 100593.8 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 8.7 mg

DATE OF WEIGHING 3/28 GROSS FILTER WT. 624.9 mg
TIME OF WEIGHING 1323
DATE OF WEIGHING 3/29 GROSS FILTER WT. 625.2 mg
TIME OF WEIGHING 0900

AVERAGE GROSS WT. 625.05 mg

FILTER TARE WT. 616.1 mg

WEIGHT OF PARTICULATE ON FILTER 8.95 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 8.7 mg

TOTAL WEIGHT OF PARTICULATE 17.65 mg

REMARKS: _____

INITIALS OF ANALYST B

The ALMEGA CORPORATION

SAMPLE CHAIN OF CUSTODY RECORD

Plant ERLANGER MEDICAL CENTER, CHATTANOOGA Test Date 3-23-88

Sample Number	Number of Container	Description of Samples
R1 I1	R1 IMP 1	Impinger content for Hcl & cl analysis
R1 I2	R1 IMP 2	" " " " " "
R2 F	R2 FILTER	Filter for drying & weighing
R2 PW	R2 PW	Probe wash for drying & weighing
R2 I1	R2 IMP 1	Impinger content for Hcl & Cl analysis
R2 I2	R2 IMP 2	" " " " " "
R3 F	R3 FILTER	Filter for drying & weighing
R3 PW	R3 PW	Probe wash for drying & weighing
R3 I1	R3 IMP 1	Impinger content for Hcl & cl analysis
R3 I2	R3 IMP 2	" " " " " "
R4 F	R4 FILTER	Filter for drying & weighing
R4 PW	R4 PW	Probe wash for drying & weighing
R4 I1	R4 IMP 1	Impinger content for Hcl & cl analysis
R4 I2	R4 IMP 2	" " " " " "

Person responsible for samples B.W. Jackson Time 6:30pm Date 3/23/88

Sample Number	Relinquished by: <u>B.W. Jackson</u>	Received by: <u>G. TRZUPAK</u>	Time	Date	Reason for Change of Custody
R1 I1			<u>2:30pm</u>	<u>3/25/88</u>	<u>TRANSPORTED FROM TEST LOCATION AT ERLANGER MEDICAL CENTER TO ALMEGA CORP LABORATORY FOR ANALYTICAL PURPOSES</u>
R1 I2					
R2 F					
R2 PW					
R2 I1					
R2 I2					
R3 F					
R3 PW					
R3 I1					
R3 I2					
R4 F					
R4 PW					
R4 I1					
R4 I2					

CHAIN OF CUSTODY FORM

Plant Chattanooga - Hamilton County Hospital Authority Source NORTH Basic Model 1250 Incubator
Date Sampled 2/22/88 Test # 1 Run # 1

SAMPLE RECOVERY

Container #	Description (if filter, then give filter #)
<u>Filter 259</u>	<u>259</u>
<u>PLW Run 1</u>	<u>prob. mark</u>
<u>acetone blank</u>	<u>acetone blank</u>

Person Engaged in Sample Recovery:

Signature and Title [Signature] : TESTER
Recovery Location ON SITE
Date & Time of Recovery AFTER TEST

Sample(s) Recipient, upon Recovery if not Recovery Person

Signature [Signature]
Date & Time of Receipt 2/22/88 6:45 PM
Sample Storage automobile

Laboratory Person Receiving Sample

Signature & Title _____
Date & Time of Receipt _____
Sample Storage _____

The ALMEGA CORPORATION

APPENDIX L

MARCH 24, 1988, RUNS 5 AND 6, PARTICULATE FIELD
DATA CALCULATIONS, LABORATORY WEIGHTS, CHAIN-OF-
CUSTODY AND CO₂ CORRECTION FACTOR CALCULATIONS

The ALMEGA CORPORATION

PARTICULATE CALCULATION SUMMARY

COMPANY: **EMANCER MEDICAL CENTER**
 SOURCE: **INCUBATOR**
 REPETITION NO: **Run 5** **24. MARCH. 88**
 TEST DATE: **Run 6**
NORTH UNIT

CHATANOOGA, A TN

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[\frac{17.64}{Y} \right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \frac{64.82}{150} \text{ dscf.} \quad 65.985$$

$Y = 0.9938$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[\frac{0.04707 \text{ cu.ft.}}{\text{ml}} \right] V_{lc} = \frac{7.061}{\text{scf.}} \quad 7.013$$

$V_{lc} = \text{ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \frac{0.09823}{0.9608} = 0.1033$$

Particle concentration in stack gas on dry basis

$$c's = \left[\frac{0.01543 \text{ gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] \text{ grains/dscf} = \frac{0.003107}{\text{grains/dscf.}} \quad 0.003227$$

$- 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} @ 127.00 \text{ v} = \frac{0.01800}{\text{x } 10^{-6} \text{ lbs/dscf}} \quad 0.01840$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \frac{3541}{\text{x } 10^6 \text{ dscf/hr}} \quad 3662$$

$(A_s = 7.948 \text{ sq.ft.} \quad V_s = \text{ft/sec})$

Process rate or BTU rating P_w

$$\text{Emission rate} = \frac{Q_s c's}{P_w} = \frac{0.1572}{\text{lbs/hr}} \quad 0.1689$$

$$= \frac{Q_s c's}{P_w} = \text{lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{\left(\frac{0.002669 \text{ in.Hg.cu.ft.}}{\text{ml. OR}} V_{lc} \right) + \frac{V_m Y}{T_m} \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{13.6} \right)}{0 V_s P_s A_n} \right] = \frac{99.79}{\text{}} \quad 98.24$$

$(A_n = 0.5 \text{ sq.ft.})$

The ALMEGA CORPORATION

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY:
SOURCE:
REPETITION NO:
TEST DATE:

Run 5

Run 6

Dry molecular weight of stack gas

$$M_d = 0.44 (\%CO_2) + 0.32 (\%O_2) + 0.28 (\%N_2 + \%CO)$$

	29.28	29.24
		lb/lb-mole

Molecular weight of stack gas, wet basis

$$M_s = M_d (1 - B_{ws}) + 18 B_{ws}$$

	28.17	28.16
		lb/lb-mole

Pitot tube coefficient

$$C_p \text{ (from calibration curve)}$$

	0.84	0.84
--	------	------

Average velocity head of stack gas, inches H₂O

$$(\sqrt{\Delta p}) \text{ avg.}$$

	0.7281	0.7473
--	--------	--------

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \text{_____} \text{ OF} + 460$$

	191.0	184.5
	651.0	644.5
		OR

Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6)$$

	29.48	29.49
		in. Hg

Stack gas velocity

$$(V_s) \text{ avg.} = (85.49) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

	46.30	47.28
		ft/sec.

Stack gas volume flow rate

$$60 V_s A_s$$

	889	8363
		acfm

Stack gas volume flow rate, dry basis

dscfm

5902

6103

$$Q_s = 3,600 (1 - B_{ws}) V_s A_s$$

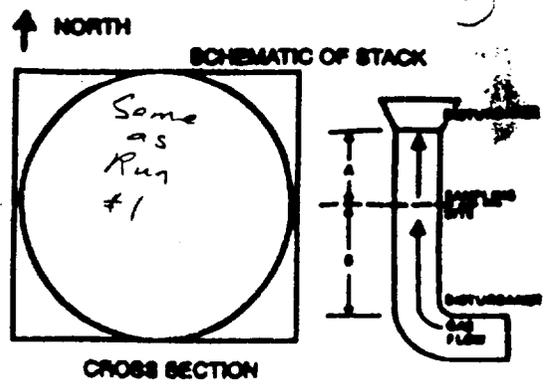
$$\left[\frac{T_{std} \cdot P_s}{(T_s) \text{ avg.} \cdot P_{std}} \right]$$

= _____ x 10⁶ dscf/h

PARTICULATE FIELD DATA

PLANT Erlanger Medical Center
 DATE 3/24/89
 LOCATION Chattanooga Tenn
 OPERATOR L. Domasius
 STACK NO. North Unit
 RUN NO. 5
 SAMPLE BOX NO. 1
 METER BOX NO. 2
 METER # 8964
9938
 TIME START - 11:55

AMBIENT TEMPERATURE 65
 BAROMETRIC PRESSURE 29.24
 ASSUMED MOISTURE, % 9
 PROBE LENGTH, in. 30
 NOZZLE DIAMETER, in. 5/16 .315"
 STACK DIAMETER, in. 23/4
 PROBE HEATER SETTING 350 = 25°F
 HEATER BOX SETTING 250 = 25°F
 ΔC_p FACTOR 0.84
 FILTER NO. 369
 FILTER TARE WEIGHT 618.9 mg
 12 POINTS / 5 MIN.



PRE TEST LEAK CHECK
 METER 01 @ 20 in Hg
 PITOTS 0 @ 1 in H₂O
 ORBAT OK

P	θ	Static Pressure (in Hg)	T ₀ °F	ΔP in H ₂ O	√ΔP	ΔH in H ₂ O	V _m (ft ³ /min)	T _m Inlet °F	T _m Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
W1	5	115	190	.52	.7211	1.8	9.29	93	85	230	64	2
2	5		195	.58	.762	1.9	15.2	92	85	235	64	2
3	5		196	.46	.678	1.6	20.66	92	85	235	64	3
4	5		193	.58	.762	1.85	2.19	93	85	235	63	4
5	5	135	193	.50	.707	1.7	2.27	94	85	240	63	4
6	5		191	.54	.735	1.83	32.27	96	86	240	64	5
N1	5	.87	193	.48	.693	1.65	43.54	96	86	245	64	4
2	5		193	.45	.671	1.61	29.91	90	84	250	64	4
3	5	.35	194	.44	.663	1.5	54.5	91	84	250	65	4
4	5		192	.54	.735	1.82	54.99	92	90	250	65	5
5	5		197	.60	.775	1.9	66.1	94	91	235	65	6
6	5	.16	197	.76	.871	2.38	72.85	96	93	245	64	7
Av	60	1.08	191.0		.728	1.82	69.53	87.4	87.4			

Time ends - 1:02 651.0

L. Domasius 567.4

POST TEST LEAK CHECK
 METER 01 @ 21 in Hg
 PITOTS 0 @ 1 in H₂O
 ORBAT OK

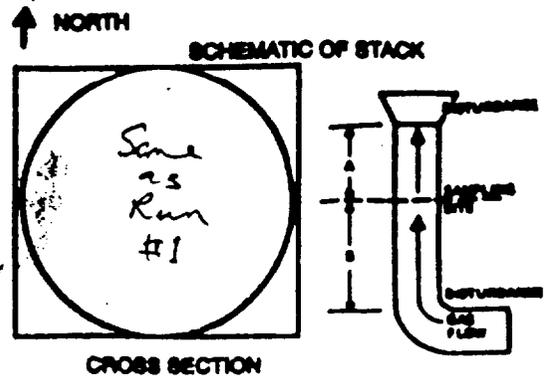
VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME in				SILICA GEL WEIGHT.
	1	2	3	4	
FINAL	186	157			227
INITIAL	100	100		56	200
LIQUID COLLECTED	86	57			27
TOTAL VOLUME COLLECTED					150

ORBAT MEASUREMENT	TIME	CO ₂	O ₂	CO	N ₂
1	INT	4.6	13.6		
2					
3					
4					

PARTICULATE FIELD DATA

PLANT Erlanger
 DATE 3/24/88
 LOCATION Chattanooga Tenn
 OPERATOR L. Damasio
 STACK NO. North Lead
 RUN NO. 6
 SAMPLE BOX NO. 5
 METER BOX NO. 2
 METER & H₂O 6A64
9A38
 TIME START - 1:10

AMBIENT TEMPERATURE 70
 BAROMETRIC PRESSURE 29.4
 ASSUMED MOISTURE, % 9
 PROBE LENGTH, in 30
 NOZZLE DIAMETER, in 5/16 25
 STACK DIAMETER, in 23/4
 PROBE HEATER SETTING 250 ± 25°F
 HEATER BOX SETTING 250 ± 25°F
 ΔCp FACTOR .94
 FILTER NO. 263
 FILTER TARE WEIGHT 629.2



PRE TEST LEAK CHECK

METER .011 @ 21 in Hg
 PITOTS 0 @ 1 in H₂O
 ORSAT

P	θ	Static Pressure P - in Hg	T ₀ °F	ΔP in H ₂ O	√ΔP	ΔH in Hg	V _m ft ³	T _m Inlet °F	T _m Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
W1	5	1.2	188	.50		1.7	72.545	97	96	230	65	2
2	5		180	.60		2.1	84.25	98	95	235	65	3
3	5		182	.68		2.3	90.76	98	97	235	64	3
4	5		184	.62		2.15	86.93	98	94	240	64	3
5	5	1.15	193	.54		2.05	83.00	96	93	240	64	3
6	5		184	.60		1.35	81.00	96	93	235	65	3
W1	5		185	.55		1.9	83.86	97	93	235	65	3
2	5	1.18	185	.50		1.7	84.45	97	94	235	65	2
3	5		184	.52		1.75	85.15	98	95	230	66	2
4	5	1.25	184	.58		2.0	81.14	98	95	230	66	2
5	5		188	.55		1.9	87.00	98	95	230	67	3
6	5		185	.65		2.25	43373	99	96	230	67	3
AV	60	1.2	184.7		.747	1.93	70.828	97.1	94.75			

Time ends - 2:12 6447

Linda Damasio 555.9

POST TEST LEAK CHECK

METER 0.012 @ 17 in Hg
 PITOTS 0 @ 1 in H₂O
 ORSAT OK

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME				SILICA GEL WEIGHT.
	1	2	3	4	
FINAL	202	130			2.17
INITIAL	100	100			2.00
LIQUID COLLECTED	102	30			17
TOTAL VOLUME COLLECTED					149

ORSAT MEASUREMENT	TIME	CO ₂	O ₂	CO	N ₂
1	INT	4.1	15.1		
2	INT	3.9	15.0		
3					
4	AV	<u>4.0</u>	<u>15.05</u>		

The ALMEGA CORPORATION

PARTICULATE ANALYTICAL DATA FORM

COMPANY: ERLANGER HOSPITAL STACK NUMBER: N. Incinerator
LOCATION: Chattanooga, TN. RUN NUMBER: 5
DATE: 3/24/88 RELATIVE HUMIDITY: 50 %
ACETONE DENSITY (Pa): 0.7858 g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED?
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.004 mg/g
ACETONE RINSE VOLUME (Vaw) 298 ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.9 mg

NOTE: IN NO CASE SHOULD A BLANK RESIDUE 0.01 mg/g OR 0.001 % OF THE WEIGHT OF ACETONE USED BE SUBTRACTED FROM THE SAMPLE WEIGHT.

DATE OF WEIGHING 3/28 GROSS WT. 102352.9 mg
TIME OF WEIGHING 1315
DATE OF WEIGHING 3/29 GROSS WT. 102353.1 mg
TIME OF WEIGHING 0905

AVERAGE GROSS WT. 102353.0 mg

LESS BLANK RESIDUE (Wa) 0.9 mg

TARE WT. 102344.0 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 8.1 mg

DATE OF WEIGHING 3/28 GROSS FILTER WT. 624.0 mg
TIME OF WEIGHING 1317
DATE OF WEIGHING 3/29 GROSS FILTER WT. 623.7 mg
TIME OF WEIGHING 1500

AVERAGE GROSS WT. 623.85 mg

FILTER TARE WT. 618.9 mg

WEIGHT OF PARTICULATE ON FILTER 4.95 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 8.1 mg

TOTAL WEIGHT OF PARTICULATE 13.05 mg

REMARKS: _____

INITIALS OF ANALYST _____

The ALMEGA CORPORATION

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger Hosp STACK NUMBER: N. Incinerator
LOCATION: Chattanooga, TN RUN NUMBER: 6
DATE: 3/24/82 RELATIVE HUMIDITY: 50 %
ACETONE DENSITY (Pa): 0.7858 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED?
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.004 mg/g
ACETONE RINSE VOLUME (Vaw) 210 ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.6 mg

NOTE: IN NO CASE SHOULD A BLANK RESIDUE 0.01 mg/g OR 0.001 % OF THE WEIGHT OF ACETONE USED BE SUBTRACTED FROM THE SAMPLE WEIGHT.

DATE OF WEIGHING 3/28 GROSS WT. 104822.0 mg
TIME OF WEIGHING 1320
DATE OF WEIGHING 3/29 GROSS WT. 104822.0 mg
TIME OF WEIGHING 1015

AVERAGE GROSS WT. 104822.0 mg

LESS BLANK RESIDUE (Wa) 0.6 mg

TARE WT. 104819.6 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 1.8 mg

DATE OF WEIGHING 3/28 GROSS FILTER WT. 641.1 mg
TIME OF WEIGHING 1322
DATE OF WEIGHING 3/29 GROSS FILTER WT. 641.3 mg
TIME OF WEIGHING 1515

AVERAGE GROSS WT. 641.2 mg

FILTER TARE WT. 629.2 mg

WEIGHT OF PARTICULATE ON FILTER 12.0 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 1.8 mg

TOTAL WEIGHT OF PARTICULATE 13.8 mg

REMARKS: _____

INITIALS OF ANALYST _____

THE ALMEGA CORPORATION

607 C Country Club Drive
Bensenville, Illinois 60106
Phone: (312) 595-0175

BLANK ANALYTICAL DATA FORM

PLANT ERLANGER HOSP.
Sample Location Chattanooga, Tn.
Relative Humidity 50
Liquid level marked and container sealed
Density of acetone (P_a) 0.7858 g/ml
Blank volume (V_a) 200 ml
Date and time of wt 4/4 0800 Gross wt 96430.0 mg
Date and time of wt 4/4 1600 Gross wt 96430.0 mg
Average gross wt 96430.0 mg
Tare wt 96429.4 mg
Weight of blank (m_a) 0.6 mg

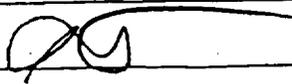
$$C_a = \frac{m_a}{V_a P_a} = \frac{(0.6)}{(200)(0.7858)} = 0.004 \text{ mg/g}$$

Note: In no case should a blank residue greater than 0.01 mg/g or 0.001% of the blank weight be subtracted from the sample weight.

Filters Filter number _____
Date and time of wt _____ Gross wt _____ mg
Date and time of wt _____ Gross wt _____ mg
Average gross wt _____ mg
Tare wt _____ mg
Difference wt _____ mg

Note: Average difference must be less than 15 mg or 2% of total sample weight whichever is greater.

REMARKS _____

Signature of analyst 

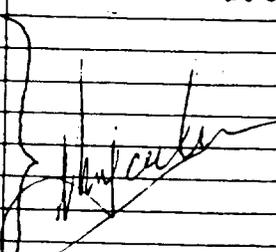
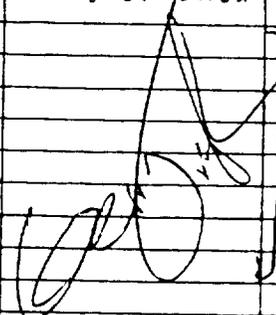
The ALMEGA CORPORATION

SAMPLE CHAIN OF CUSTODY RECORD

Plant ERLANGER MEDICAL CENTER CHATTANOOGA Test Date 3-24-88

Sample Number	Number of Container	Description of Samples
R5 F	R5 FILTER	Filter for drying + weighing
R5 PW	R5 PW	Probe wash for drying + weighing
R5 I1	R5 IMP1	Impinger content for Hcl + cl analysis
R5 I2	R5 IMP2	" " " " " "
R6 F	R6 FILTER	Filter for drying + weighing
R6 PW	R6 PW	Probe wash for drying + weighing
R6 I1	R6 IMP1	Impinger content for HCl + cl analysis
R6 I2	R6 IMP2	" " " " " "

Person responsible for samples B.W. Jackson Time 3:30 PM Date 3/24/88

Sample Number	Relinquished by: B.W. Jackson	Received by: G. TRZUVEK	Time	Date	Reason for Change of Custody
R5 F			2:30pm	3/25/88	TRANSPORTED FROM TEST LOCATION AT ERLANGER MEDICAL CENTER TO ALMEGA CORP LABORATORY FOR ANALYTICAL PURPOSES
R5 PW					
R5 I1					
R5 I2					
R6 F					
R6 PW					
R6 I1					
R6 I2					

THE ALMEGA CORPORATION

CALCULATION OF CO₂ CORRECTION FACTORS

<u>Run</u>	<u>Gas Meter final - initial</u>	<u>Cubic Feet Gas Used °F</u>	<u>Test Lapsed Time mins.</u>	<u>Gas Used dscf</u>	<u>Qs x 10⁶ Stack Gas Flow dscfh</u>	<u>% CO₂ in Stack Gas From Gas Use %</u>	<u>CO₂ Correction Factor 12/CO₂ measured - CO₂ from gas use</u>
1	5	5000	66	4546	0.3221	1.411	12/4.4 - 1.411 = 4.015
2	6	6000	63	5714	0.3275	1.745	12/4.3 - 1.745 = 4.697
3	5	5000	65	4615	0.3270	1.411	12/4.3 - 1.411 = 4.154
4	7	7000	66	6364	0.3204	1.986	12/4.4 - 1.986 = 4.971
5	10	10000	67	8955	0.3541	2.529	12/4.6 - 2.529 = 5.794
6	7	7000	62	6774	0.3662	1.895	12/4.0 - 1.895 = 5.701

THE ALMEGA CORPORATION

CALCULATION OF CO₂ CORRECTION FACTORS

<u>Run</u>	<u>Gas Meter final - initial</u>	<u>Cubic Feet Gas Used °F</u>	<u>Test Lapsed Time mins.</u>	<u>Gas Used dscf</u>	<u>Q_s x 10⁶ Stack Gas Flow dscfh</u>	<u>% CO₂ in Stack Gas From Gas Use %</u>	<u>CO₂ Correction Factor 12/CO₂ measured - CO₂ from gas use</u>
1	5	5000	66	4546	0.3221	1.411	12/4.4 - 1.411 = 4.015
2	6	6000	63	5714	0.3275	1.745	12/4.3 - 1.745 = 4.697
3	5	5000	65	4615	0.3270	1.411	12/4.3 - 1.411 = 4.154
4	7	7000	66	6364	0.3204	1.986	12/4.4 - 1.986 = 4.971
5	10	10000	67	8955	0.3541	2.529	12/4.6 - 2.529 = 5.794
6	7	7000	62	6774	0.3662	1.895	12/4.0 - 1.895 = 5.701

The ALMEGA CORPORATION

APPENDIX M

**MARCH 23 AND 24, 1988, RUNS 1 TO 6,
HYDROGEN CHLORIDE AND CHLORINE
LABORATORY ANALYSES AND CALCULATIONS**

The ALMEGA CORPORATION

HCL

PARTICULATE CALCULATION SUMMARY

COMPANY: ERLANGER
 SOURCE:
 REPETITION NO:
 TEST DATE:

R₁ R₂ R₃ R₄

ENGLISH UNITS
 (29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64 \right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{\hspace{2cm}} \text{ dscf.}$$

$Y = \underline{\hspace{2cm}}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}} \right] V_{lc} = \underline{\hspace{2cm}} \text{ scf.}$$

$V_{lc} = \underline{\hspace{2cm}} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{\hspace{2cm}}$$

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] = \underline{0.2436} \quad \underline{.1164} \quad \underline{.2828} \quad \underline{.09509} \text{ grains/dscf.}$$

$- 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} \times 10^{55} \text{ ppm} = \underline{34.81} \quad \underline{16.63} \quad \underline{40.42} \quad \underline{13.59} \text{ lbs/dscf}$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{\hspace{2cm}} \times 10^6 \text{ dscf/hr}$$

$(A_s = \text{sq. ft.} \quad V_s = \text{ft/sec})$

Process rate or BTU rating $P_w = \underline{\hspace{2cm}}$

Emission rate

$$\frac{Q_s c's}{P_w} = \underline{11.21} \quad \underline{5.446} \quad \underline{13.22} \quad \underline{4.354} \text{ lbs/hr}$$

$$\frac{Q_s c's}{P_w} = \underline{\hspace{2cm}} \text{ lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{\left(0.002669 \frac{\text{in. Hg. cu. ft.}}{\text{ml. OR}} V_{lc} \right) + \frac{V_m Y}{T_m} \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right)}{0 V_s P_s A_n} \right]$$

$(A_n = \text{sq. ft.}) = \underline{\hspace{2cm}}$

The ALMEGA CORPORATION

PARTICULATE CALCULATION SUMMARY

COMPANY:
SOURCE:
REPETITION NO:
TEST DATE:

ERLANZIR

R5

R6

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64 \right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{\hspace{2cm}} \text{ dscf.}$$

$\gamma = \underline{\hspace{2cm}}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{\hspace{2cm}} \text{ scf.}$$

$V_{lc} = \underline{\hspace{2cm}} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{\hspace{2cm}}$$

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] = \underline{.4199} \text{ grains/dscf.} \quad .5313$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{60.00} \times 10^{-6} \text{ lbs/dscf} \quad 75.93$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{\hspace{2cm}} \times 10^6 \text{ dscf/hr}$$

$(A_s = \text{sq.ft.} \quad V_s = \text{ft/sec})$

Process rate or BTU rating $P_w = \underline{\hspace{2cm}}$

Emission rate

$$\frac{Q_s c's}{P_w} = \underline{21.25} \text{ lbs/hr} \quad 27.81$$

$$= \underline{\hspace{2cm}} \text{ lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{0.002669 \text{ in.Hg.cu.ft.} \cdot V_{lc}}{\text{ml.} \cdot \text{OR}} + \frac{V_m \gamma}{T_m} \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{13.6} \right) \right]$$

$(A_n = \text{sq.ft.}) \quad = \underline{\hspace{2cm}}$

ppm (633.0)

(801.9)

rv b. 10/10

HCL Analysis

DATA SHEET

Run #	mV	$\log_{10} \text{conc}$	conc. mg/l	$V_{\text{air}}/V_{\text{air}} \times$ (ml)	actual conc. (mg/l)	V_s (l)	$36.5/35.5 \times$ (HCL/HCL/ANAL)	mg HCL Imps	mg HCL Sample
Stds.									
1 ppm	+285	0							
10 ppm	+240	1							
50 ppm	+222	1.699							
100 ppm	+213	2							
500 ppm	+185	2.699							
1000 ppm	+160	3							
10,000 ppm	+114	4							
Blank	+297	-							
R1 Imp 1	+133		4628	50/55	4210	0.200		865.7	870.8
Imp 2	+232		27	50/55	25	0.200		5.1	
R2 Imp 1	+156		1397	50/52	1343	0.200		276.2	
Imp 2	+165		875	50/55	795	0.200		163.5	439.7
R3 Imp 1	+128		6004	50/58	5176	0.200		1064.3	
Imp 2	+214		68	50/59	58	0.200		11.9	1076.2
R4 Imp 1	+150		1910	50/57	1675	0.200		344.4	
Imp 2	+242		16	50/55	15	0.200		3.1	347.5
R5 Imp 1	+118		10,104	50/60	8420	0.200		1731.4	
Imp 2	+196		174	50/55	158	0.200		32.5	1763.9
R6 Imp 1	+115		11,812	50/54	10,937	0.200		2249.0	
Imp 2	+202		127	50/56	113	0.200		23.2	2272.2

The ALMEGA CORPORATION

PARTICULATE CALCULATION SUMMARY

COMPANY:
SOURCE:
REPETITION NO:
TEST DATE:

ERLANGER

R1 2 3 4

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64 \right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{\hspace{2cm}} \text{ dscf.}$$

$Y = \underline{\hspace{2cm}}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{\hspace{2cm}} \text{ scf.}$$

$V_{lc} = \underline{\hspace{2cm}} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{\hspace{2cm}}$$

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] = \underline{\hspace{2cm}} \text{ grains/dscf.}$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} \cdot 10^{10.85} = \underline{\hspace{2cm}} \times 10^{-6} \text{ lbs/dscf}$$

Stack gas volume flow rate on dry basis

< 0.7 < 0.6 < 0.6 < 0.6

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{\hspace{2cm}} \times 10^6 \text{ dscf/hr}$$

$(A_s = \text{sq.ft.} \quad V_s = \text{ft/sec})$

Process rate or BTU rating $P_w = \underline{\hspace{2cm}}$

Emission rate

$$\frac{Q_s c's}{P_w} = \underline{\hspace{2cm}} \text{ lbs/hr} \quad \text{L.02} \quad \text{L.02} \quad \text{L.02} \quad \text{L.02}$$

$$\frac{Q_s c's}{P_w} = \underline{\hspace{2cm}} \text{ lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{\left(0.002669 \frac{\text{in.Hg.cu.ft.}}{\text{ml.}^{\circ R}} V_{lc} \right) + \frac{V_m Y \left(P_{bar} + \frac{\Delta H}{13.6} \right)}{T_m}}{O V_s P_s A_n} \right]$$

$(A_n = \text{sq.ft.}) = \underline{\hspace{2cm}}$

The ALMEGA CORPORATION

Cl₂ PARTICULATE CALCULATION SUMMARY

COMPANY:
SOURCE:
REPETITION NO:
TEST DATE:

ERLANGER

RS

6

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64 \right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{\hspace{2cm}} \text{ dscf.}$$

Y =

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}} \right] V_{lc} = \underline{\hspace{2cm}} \text{ scf.}$$

V_{lc} = ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{\hspace{2cm}}$$

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[\frac{M_n}{V_{mstd}} \right] = \underline{\hspace{2cm}} \text{ grains/dscf.}$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{\hspace{2cm}} \times 10^{-6} \text{ lbs/dscf}$$

Stack gas volume flow rate on dry basis

<.55 <.55

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{av} \cdot P_{std}} \right] = \underline{\hspace{2cm}} \times 10^6 \text{ dscf/hr}$$

(A_s = sq. ft. V_s = ft/sec)

Process rate or BTU rating P_w

Emission rate

$$Q_s c's = \underline{\hspace{2cm}} \text{ lbs/hr} \quad \text{<.018}$$

$$\frac{Q_s c's}{P_w} = \underline{\hspace{2cm}} \text{ lbs/}$$

Isokinetic sampling rate

$$I = \left(1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[\frac{\left(0.002669 \frac{\text{in. Hg. cu. ft.}}{\text{ml.}^{\circ R}} V_{lc} \right) + \frac{V_m Y}{T_m} \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right)}{Q V_s P_s A_n} \right]$$

(A_n = sq. ft.)

COMPANY: Erlanger

TITRATION DATA FOR: CK2

DATE: _____

LOCATION: Ch. Hanger, TN

DATA SHEET

RUN NUMBER	Vs	Va1	Vt1	Va2	Vt2	Va3	Vt3	Nt	W (L2)
Blank	100 ml	5ml	47.22	5ml	47.22				ND
01 Top 1	200 ml	5ml	11.84	5ml	11.83		11.24		ND
01 Top 2	200 ml	5ml	11.81	5ml	11.81		11.21		ND
02 Top 1	200 ml	5ml	11.84	5ml	11.87		11.86		ND
02 Top 2	200 ml	5ml	11.94	5ml	11.94		11.97		ND
03 Top 1	200 ml	5ml	11.80	5ml	11.79		11.80		ND
03 Top 2	200 ml	5ml	11.90	5ml	11.89		11.90		ND
04 Top 1	200 ml	5ml	11.92	5ml	11.81		11.87		ND
04 Top 2	200 ml	5ml	11.99	5ml	11.85		11.92		ND
05 Top 1	200 ml	5ml	11.82	5ml	11.79		11.81		ND
05 Top 2	200 ml	5ml	11.89	5ml	11.94		11.92		ND
06 Top 1	200 ml	5ml	11.90	5ml	11.91		11.91		ND
06 Top 2	200 ml	5ml	11.91	5ml	11.86		11.89		ND
									ND ~ 15mg

0.01N I2 Soln Used

0.01N I2 Soln Used

The ALMEGA CORPORATION

APPENDIX N

**MARCH 24, 1988, RUNS 5 AND 6,
NITROGEN OXIDE SAMPLING AND ANALYSIS
DATA AND CALCULATIONS AND ALL CO ANALYSIS DATA**

The ALMEGA CORPORATION

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER : CHATTANOOGA TN

Sample Location: NORTH INCINERATOR: STACK

Repetition: 5

Date: 24 MARCH 88

Flask #:

Sample Time:

Sample Volume
(Standard Dry Conditions)

$$V_{sc} = 17.64 (V_f - 25) \left[\frac{P_f - P_i}{T_f - T_i} \right]$$

	1	2	3	4
Flask #:	<u>18</u>	<u>33</u>	<u>7</u>	<u>25</u>
Sample Time:	<u>12:00</u>	<u>12:15</u>	<u>12:30</u>	<u>0:45</u>
Sample Volume	<u>1518</u>	<u>1533</u>	<u>1438</u>	<u>1440</u>

$P_{bar f} = 744 \text{ mm}$

$P_{bar i} = 29.4$

70 F

68 F

VF =	<u>2064</u> ₂₀₇₉	<u>2131</u> ₂₁₀₆	<u>2049</u> ₂₀₂₄	<u>2087</u> ₂₀₆₂	ml
PF =	<u>29.49</u>	<u>29.09</u>	<u>28.58</u>	<u>28.31</u>	in
Tf =	<u>530</u>	<u>530</u>	<u>530</u>	<u>530</u>	OR
Pi =	<u>7.1</u>	<u>7.2</u>	<u>7.2</u>	<u>7.3</u>	intg
Ti =	<u>528</u>	<u>528</u>	<u>528</u>	<u>528</u>	OR

Total $\mu\text{g NO}_2$ Per Sample
 $m = 2 K_c A_f$

<u>195.3</u>	<u>283.7</u>	<u>234.0</u>	<u>315.1</u>
--------------	--------------	--------------	--------------

Kc =

A =

F =

Nitrogen Oxide Concentration

$$C = 62.43 \times 10^{-6} \left[\frac{m}{V_{sc}} \right] \text{ lbs/scf db}$$

$$\text{ppm} = C \cdot 8.376 \text{ (as NO}_2\text{)}$$

<u>8.032</u>	<u>11.55</u>	<u>10.16</u>	<u>13.66</u>
<u>67.3</u>	<u>96.8</u>	<u>85.1</u>	<u>114.4</u>

90.9 pp

Nitrogen Oxide Emissions

$$\text{lbs/hr} = C \cdot Q_s$$

$$Q_s = \underline{0.3541} \times 10^6 \text{ dscfh}$$

$$\text{lbs}/10^6 \text{ BTU} = \frac{C \cdot Q_s}{\text{BTU}}$$

$$\text{BTU} = \underline{\hspace{2cm}} \times 10^6 \text{ BTU/hr}$$

<u>2.844</u>	<u>4.090</u>	<u>3.598</u>	<u>4.837</u>
--------------	--------------	--------------	--------------

3.842
lbs/hr

The ALMEGA CORPORATION

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER : CHATTANOOGA TN

Sample Location: NORTH INCINERATOR: STACK

Repetition: 6

Date: 24-MARCH-88

Flask #:

Sample Time:

Sample Volume
(Standard Dry Conditions)

$$V_{sc} = 17.64 (V_f - 25) \left[\frac{P_f - P_i}{T_f - T_i} \right]$$

$P_{bar_f} = 744 \text{ mm}$

$P_{bar_i} = 29.4$

	5	6	7	8	
#	23A	72	12	9	
	<u>1:00</u>	<u>1:15</u>	<u>1:30</u>	<u>1:45</u>	
VF =	2126 <small>2101</small>	2088 <small>2063</small>	2087 <small>2062</small>	2079 <small>2054</small>	ml
PF =	29.69	28.39	28.58	27.99	in
7.6 TF =	530	530	530	530	°R
PI =	7.5	7.2	6.9	6.7	in
68°F Ti =	528	528	528	528	°R

Total $\mu\text{g NO}_2$ Per Sample
 $m = 2 K_c A_f$

<u>276.4</u>	<u>285.6</u>	<u>224.8</u>	<u>272.7</u>
--------------	--------------	--------------	--------------

Kc =			
A =			
F =			

Nitrogen Oxide Concentration
 $C = 62.43 \times 10^{-6} \left[\frac{m}{V_{sc}} \right] \text{ lbs/scf db}$
ppm = $C \cdot 8.376$ (as NO_2)

<u>11.13</u>	<u>12.27</u>	<u>9.444</u>	<u>11.71</u>
<u>93.3</u>	<u>102.8</u>	<u>79.10</u>	<u>98.09</u>
			AV 93.3

Nitrogen Oxide Emissions

$\text{lbs/hr} = C \cdot Q_s$
 $Q_s = \underline{0.3662} \times 10^6 \text{ dscfh}$

<u>4.076</u>	<u>4.493</u>	<u>3.458</u>	<u>4.288</u>
			AV 4.079

$\text{lbs}/10^6 \text{ BTU} = \frac{C \cdot Q_s}{\text{BTU}}$

BTU = _____ $\times 10^6$ BTU/hr

EHLINGER MEDICAL CENTER

CHATTANOOGA TN

24. MARCH. 88

INCUBATOR + BACTERIA

NORTH UNIT

NOX FIELD TEST DATA

	#	1	2	3	4
Run 5	FLASK #	18/2064	33/2131	7/2049	25/2087
	mls				
	TIME	12 ⁰⁰	12 ¹⁵	12 ³⁰	12 ⁴⁵
$P_b = 29.4$ barometric	P_i	12.3 + 10.0 = 7.1	12.3 + 9.9 = 7.2	12.3 + 9.9 = 7.2	12.3 + 9.8 = 7.3
$T_{Ambient} = 68$		749 mmtHg	739 mmtHg	726 mmtHg	719 mmtHg

* MAX OBTAINABLE ON HI VAC VANE PUMP AFTER AIR FREIGHT SHIPPING TO SITE

	#	5	6	7	8
Run 6	FLASK	23A/2126	72/2088	12/2087	9/2079
	TIME	1 ⁰⁰	1 ¹⁵	1 ³⁰	1 ⁴⁵
	P_i	12.4 + 7.3	12.2 + 10.0	12.3 + 10.2	12.3 + 10.4
	P_f	754 mmtHg	721 mmtHg	726 mmtHg	711 mmtHg

Run 7

$P_b = 744$ mm Hg
 $T_f = 70$ F

* .03937 = P_a



The ALMEGA CORPORATION

DETERMINATION OF TOTAL mg NO₂ PER SAMPLE

Factor m

COMPANY: Erlanger
 DATE: _____
 LOCATION: Chattanooga, TN
 SOURCE: _____

$$m = 2K_c AF$$

$$K_c = \underline{921.2}$$

FLASK #	A	F	m
A ₀	0.000		
A ₁	0.101		
A ₂	0.212		
A ₃	0.339		
A ₄	0.428		
# 72	0.155	1	285.6
# 7	0.127	1	234.0
# 9	0.148	1	272.7
# 12	0.122	1	224.8
# 18	0.106	1	195.3
# 23A	0.150	1	276.4
# 25	0.171	1	315.1
# 33	0.154	1	283.7

The ALMEGA CORPORATION

APPENDIX O

MARCH 23 AND 24, 1988, OPACITY
OBSERVATIONS AND CERTIFICATIONS



Form 4600-114
7-85

State of Wisconsin
Department of Natural Resources
Bureau of Air Management

SMOKE SCHOOL
CERTIFICATION

Name: Bernard Jackson
Certification Site: Milwaukee, WI
Certification Date: 10/13/87
Expiration Date: 4/13/88
Certified By: Joe Perez

The above named was recertified at Milwaukee Wisconsin DNR Smoke School on Tuesday, April 5, 1988.

Signed: Bernard A. Jackson

VISIBLE EMISSIONS EVALUATION RECORD

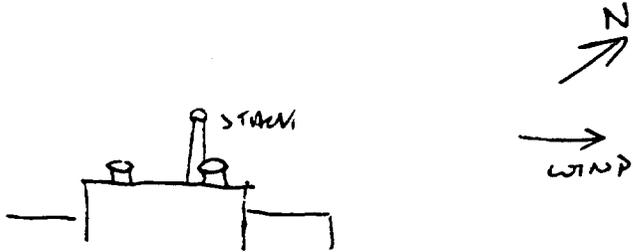
DATE 3/24/88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOX 7-95
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCINERATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME: INITIAL 11:56 A.M. FINAL 1:04 P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge	120'	120'
Direction to Discharge	NW	NW
Height of Observation Point	GROUND	GROUND
Background Description		
	WHITE CLOUD	WHITE CLOUD
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	5-10	5-10
Ambient Temperature	68°F	72°F
Sky Conditions		
	80% CLOUD	80% CLOUD
Plume Description		
Color	NONE	NONE
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point



The Almega Corporation
 107 C Country Club Drive
 Bensenville, Illinois 60106
 Phone: (312) 595-0175

OBSERVER

3-54N

[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3/24/88
 COMPANY ERLANGER Medical Center REGISTRATION NO. Low DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCINERATOR STACK NORTHERN HEIGHT OF DISCHARGE POINT 28'
 OBSERVER Ben Jackson CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME: INITIAL _____ A.M./P.M. FINAL _____ A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description	See page 1	
Weather Conditions	See page 1	
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point
 See page 1

[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3/24/88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WASC DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCINERATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME: INITIAL _____ A.M./P.M. FINAL 1:04 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

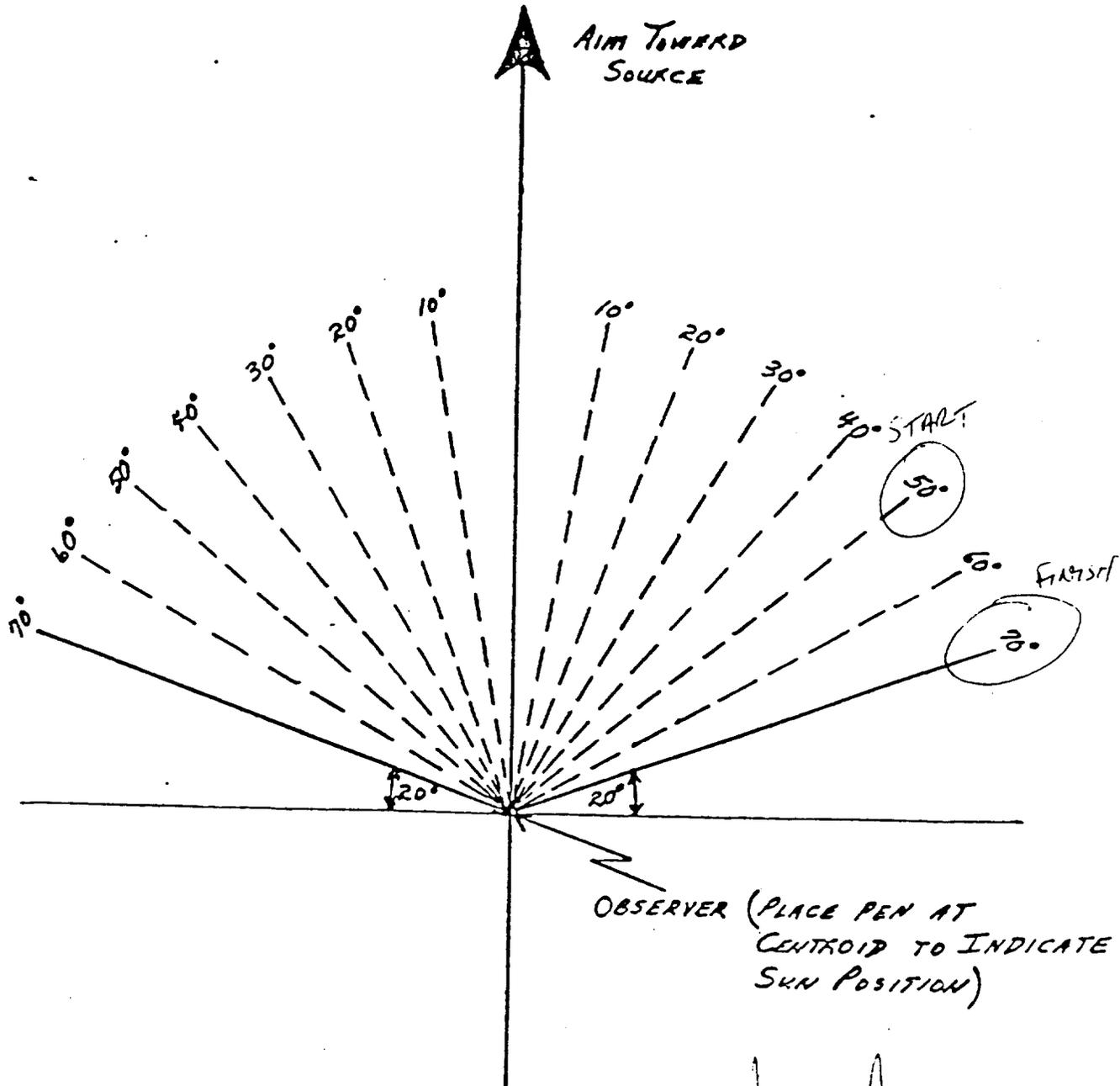
See page 1

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

[Handwritten signature]

Diagram of Observer and Emission Point
See page 1

COMPANY: ERLANGEN MEDICAL CENTER
TEST DATE: 3-24-88
RUN NO: 5
START TIME: 11:56 AM
FINISH TIME: 1:04 PM



[Handwritten signature]

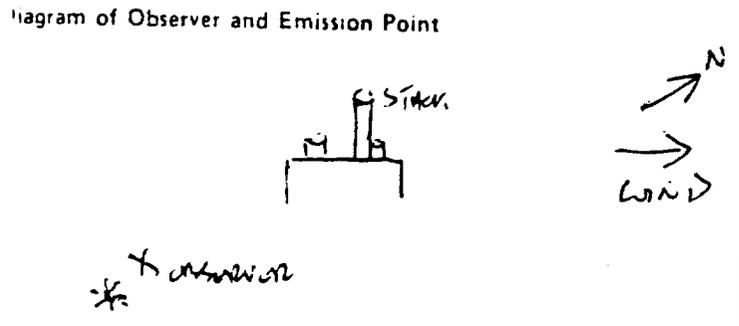
VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-24-88
 COMPANY ERLANGER Medical Center REGISTRATION NO. LDK DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL 1 12 pm A.M./P.M. (P.M.) FINAL 2 12 A.M./P.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	120'	120'
Direction to Discharge	NNW	NNW
Height of Observation Point	GROUND	GROUND
Background Description	Blue Sky	White Cloud
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	5-10	5-10
Ambient Temperature	68°F	68°F
Sky Conditions	80% Cloud	80% Cloud
Plume Description		
Color	NONE	NONE
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			



[Handwritten Signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-24-88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WISC DNR 7.85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCINERATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER B.W. JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL _____ A.M./P.M. FINAL 2 12 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

See Page 1

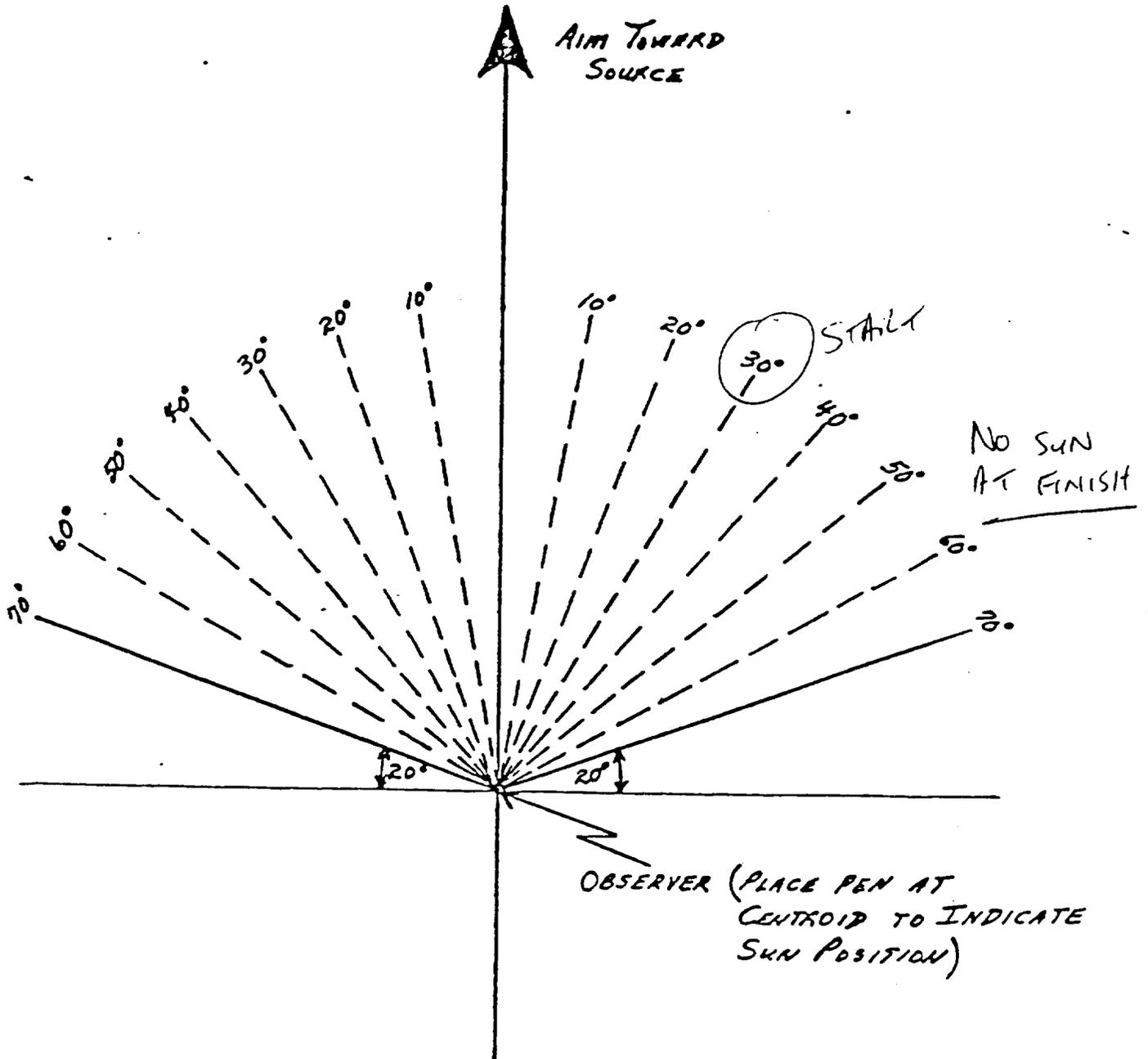
Diagram of Observer and Emission Point

See Page 1

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

[Handwritten Signature]

COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 3-24-88
RUN NO: 6
START TIME: 1:12 PM
FINISH TIME: 2:12 PM



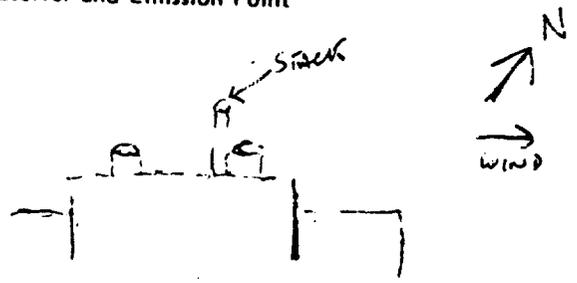
VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER Medical Center REGISTRATION NO. Wisc DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME INCINERATION Stack 1250 North HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE 4-13 88
 CLOCK TIME: INITIAL 10 45 (A)M/P.M. FINAL 11 54 (A)M/P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge	100'	100'
Direction to Discharge	NW	NW
Height of Observation Point	GROUND	GROUND
Background Description	BLUE SKY	BLUE SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	5-10	5-10
Ambient Temperature	68°F	69°F
Sky Conditions	CLEAR	CLEAR
Plume Description		
Color	NONE	NONE
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point



X Observer
OK SUN.

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88

COMPANY ERLANNON MATHIA CENTER

REGISTRATION NO. Wisc Dir 7-85

LOCATION CITATIQUOIA

EMISSION POINT NAME 1250 INCUBATOR STACK NORTH

HEIGHT OF DISCHARGE POINT 28'

OBSERVER B. W. JACKSON

CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME: INITIAL _____ A.M./P.M. FINAL _____ A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions	<i>See page 1</i>	
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point

See page 1

[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3 23-88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOSCDNR 7-55
 LOCATION CITAT. AREA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL _____ A.M./P.M. FINAL 11 54 A M P M

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

see page 1

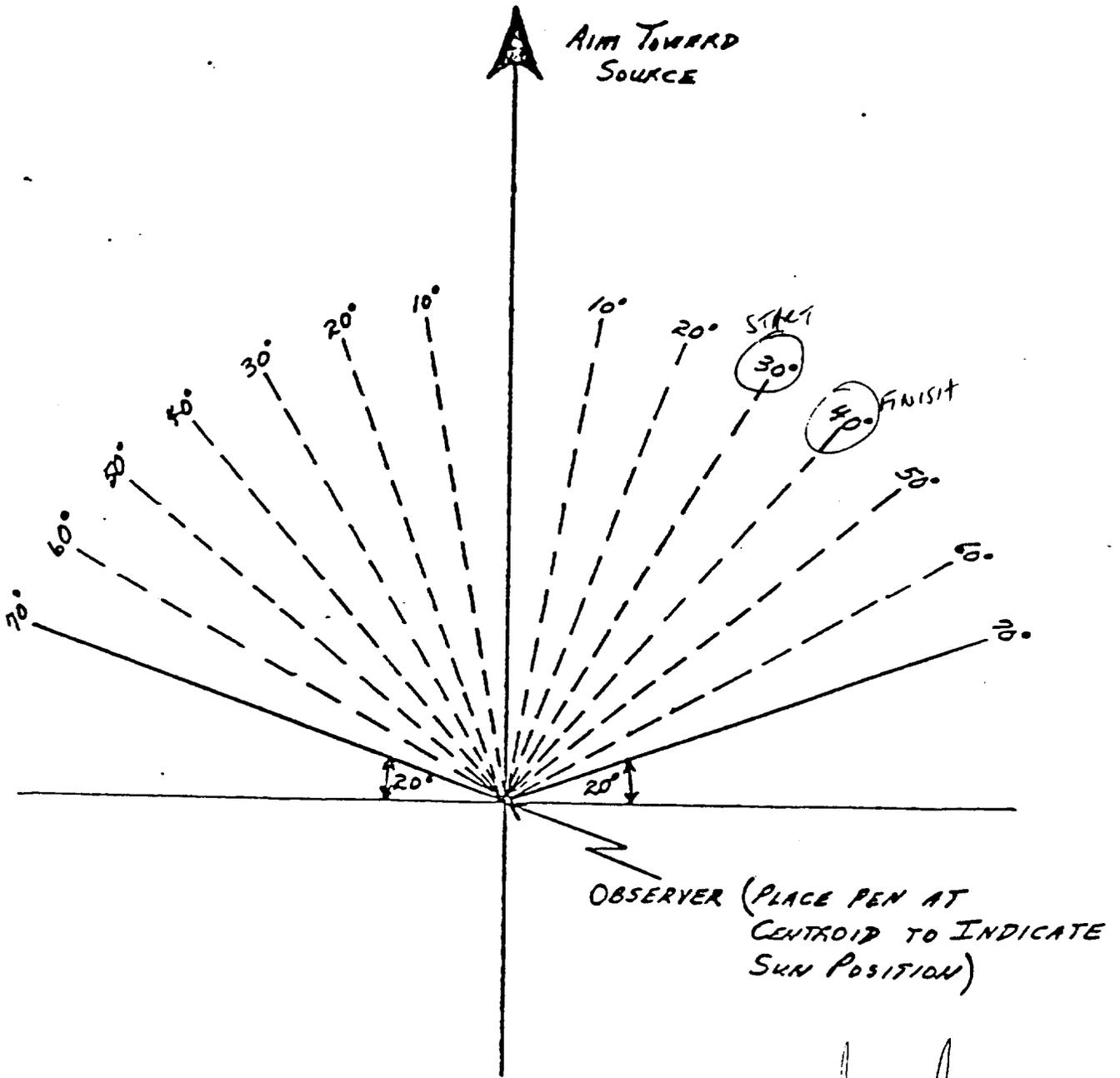
MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

BW Jackson

see page 1

Diagram of Observer and Emission Point

COMPANY: ERLANGEN MEDICAL CONTROL
TEST DATE: 3-23-88
RUN NO: 1
START TIME: 10:45 AM
FINISH TIME: 11:54 AM

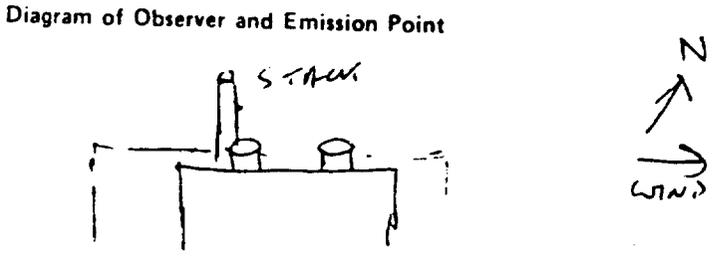


VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER Medical Center REGISTRATION NO. Loss DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER Low Jackson CERTIFICATION EXPIRATION DATE 4-13-88
 CLOCK TIME: INITIAL 12 50 A.M. (P.M.) FINAL 1 53 A.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	120'	120'
Direction to Discharge	NNW	NNW
Height of Observation Point	GROUND	GROUND
Background Description	Blue SKY	Blue SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	5-10	5-10
Ambient Temperature	72°F	72°F
Sky Conditions	CLEAR	CLEAR
Plume Description		
Color	NONE	NONE
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			



The Almaga Corporation
 607 C Country Club Drive
 Bensenville, Illinois 60106
 Phone: (312) 595-0175

[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER Medical Center REGISTRATION NO. Wisc DR-2 7-85
 LOCATION CITATTANOOLA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BO JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME: INITIAL _____ A.M./P.M. FINAL _____ A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions	<i>See Page 1</i>	
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point

See Page 1

[Handwritten Signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-58
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOUISIANA DNR 7-55
 LOCATION CITRANTANOOGA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BO JACKSON CERTIFICATION EXPIRATION DATE 4-13-58

CLOCK TIME INITIAL _____ A.M./P.M. FINAL 1:53 A.M./P.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions	<i>See page 1</i>	
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

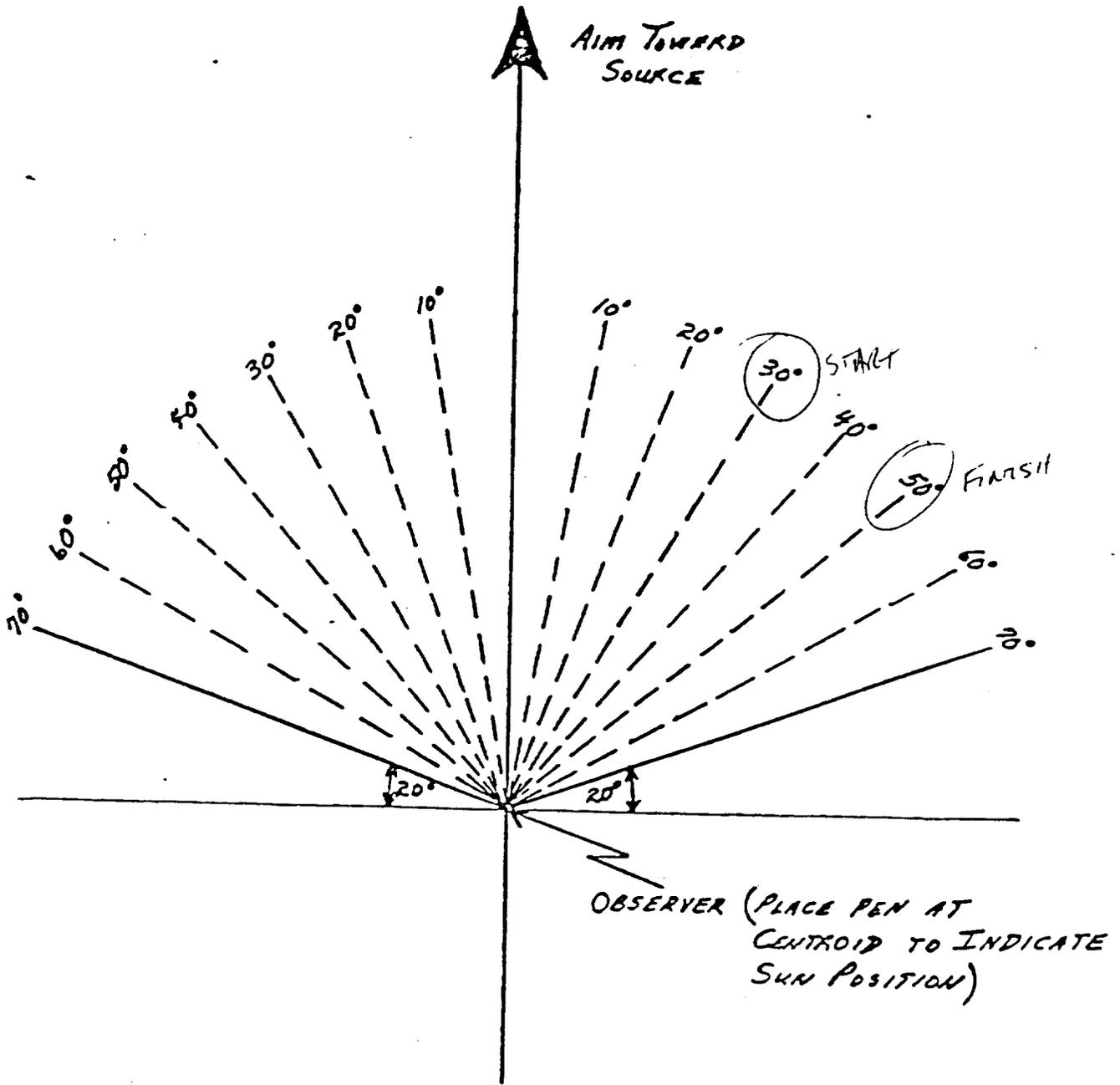
MIN	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

Diagram of Observer and Emission Point

See page 1

[Signature]

COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 3-23-88
RUN NO: 2
START TIME: 12:50 PM
FINISH TIME: 1:53 PM



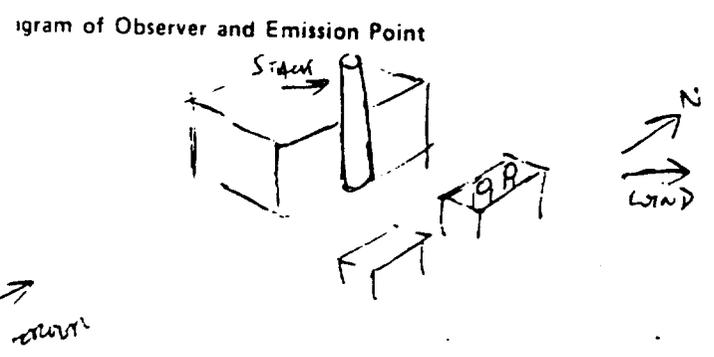
[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER Medical Center REGISTRATION NO. Case DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 SERVER BW JACKSON CERTIFICATION EXPIRATION DATE 4-13-88
 CLOCK TIME INITIAL 2 25 A.M./P.M. (P.M.) FINAL 3 29 A.M./P.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	120'	120'
Direction to Discharge	N	N
Height of Observation Point	GROUND	GROUND
Background Description	Blue Sky	Blue Sky
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	5-10	5-10
Ambient Temperature	75°F	75°F
Visibility Conditions	CLEAR	CLEAR
Plume Description		
Color	None	None
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			



[Handwritten signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88

COMPANY ERLANGER MEDICAL CENTER

REGISTRATION NO. huscma 7-85

LOCATION CHATTANOOGA

EMISSION POINT NAME 1250 INCINERATOR STACK NORTH

HEIGHT OF DISCHARGE POINT 28'

OBSERVER B. W. JACKSON

CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL _____

A.M./P.M.

FINAL 3 29

A.M./P.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

See page 1

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

(Signature)

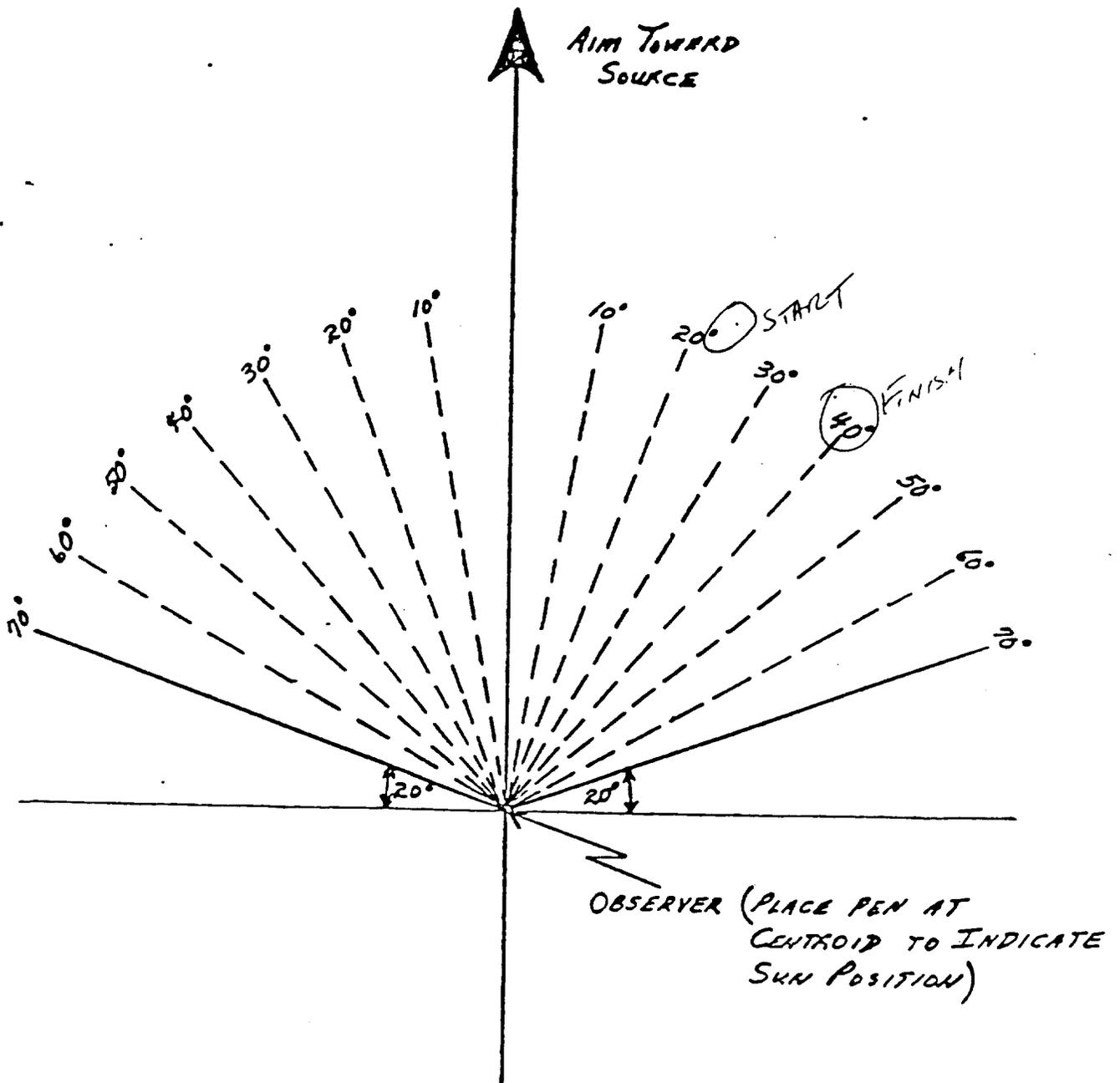
COMPANY: ERLANGEN MEDICAL CENTER

TEST DATE: 3-23-88

RUN NO: 3

START TIME: 2 25 PM

FINISH TIME: 3 29 PM



VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOU DNR 7-85
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCINERATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL _____ A.M./P.M. FINAL _____ A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

See page 1

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	At or near	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

See page 1

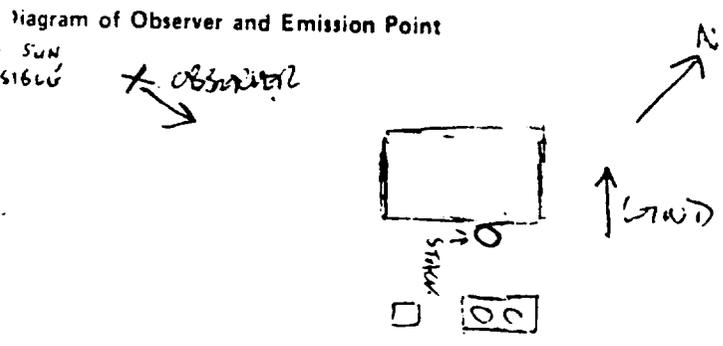
[Signature]

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WDC DNR 7-55'
 LOCATION CHATTANOOGA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 28'
 OBSERVER RW JACKSON CERTIFICATION EXPIRATION DATE 4-13-88
 CLOCK TIME: INITIAL 5:30 A.M./P.M. (P.M.) FINAL 6:40 A.M./P.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	400'	400'
Direction to Discharge	NE	NE
Height of Observation Point	GROUND	GROUND
Background Description	WHITE CLOUD	
Weather Conditions		
Wind Direction	SE	SE
Wind Speed	5-10	5-10
Ambient Temperature	60°F	65°F
Sky Conditions	100% CLOUD	
Plume Description		
Color	NONE	NONE
Distance Visible	/	/

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10	0	0	0	0			
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			



The Almega Corporation
 07 C Country Club Drive
 Bensenville, Illinois 60106
 Phone: (312) 595-0175

VISIBLE EMISSIONS EVALUATION RECORD

DATE 3-23-88
 COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOGG DWR 7-85
 LOCATION CRATTANOCCA
 EMISSION POINT NAME 1250 INCUBATOR STACK NORTH HEIGHT OF DISCHARGE POINT 25'
 OBSERVER B.W JACKSON CERTIFICATION EXPIRATION DATE 4-13-88

CLOCK TIME INITIAL _____ A.M./P.M. FINAL 6:40 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge		
Direction to Discharge		
Height of Observation Point		
Background Description		
Weather Conditions		
Wind Direction		
Wind Speed		
Ambient Temperature		
Sky Conditions		
Plume Description		
Color		
Distance Visible		

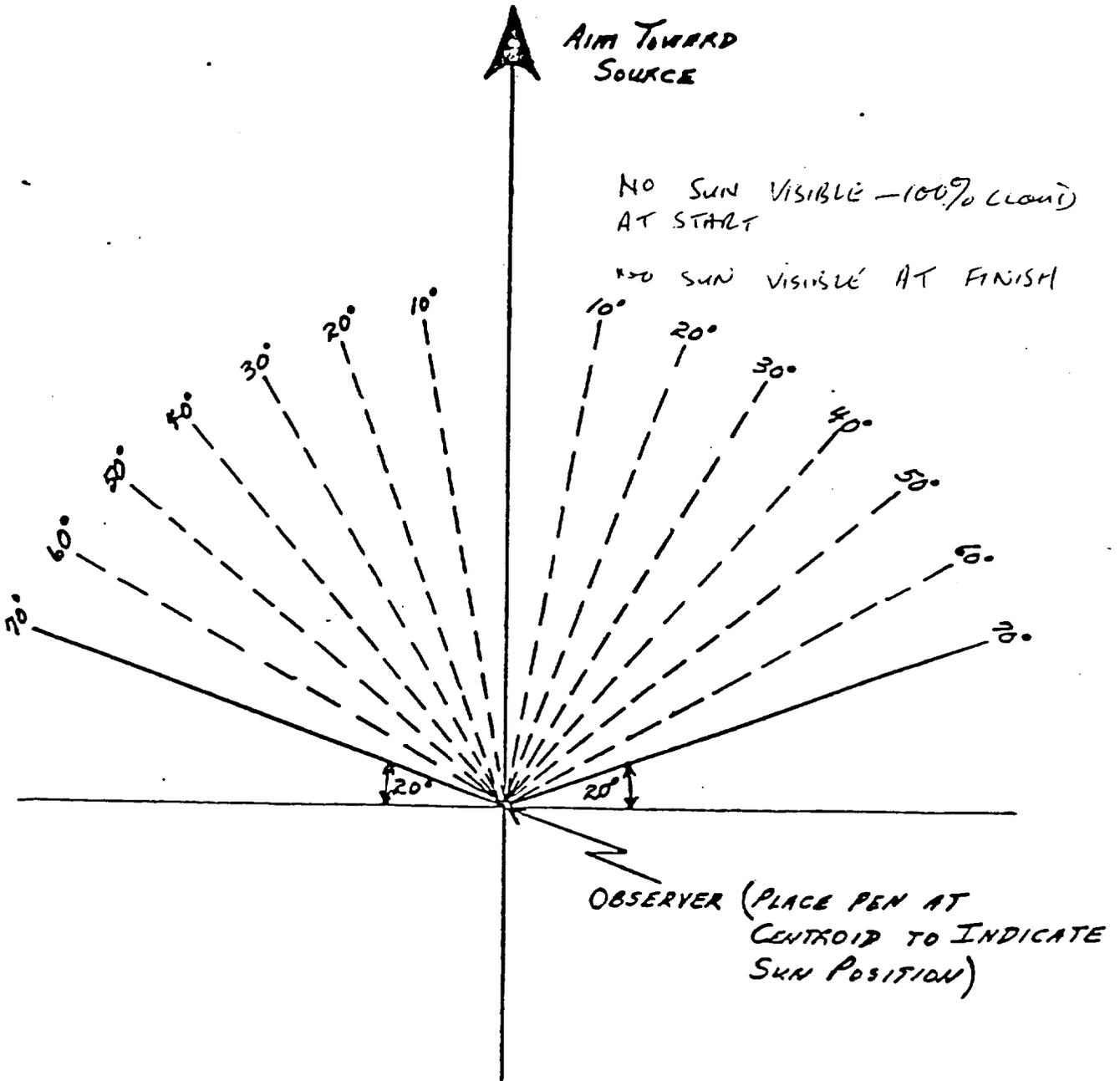
see page 1

MIN.	SECONDS				STEAM PLUME (Check if Applicable)		
	0	15	30	45	Detached	Attached	Distance
0	0	0	0	0			
1	0	0	0	0			
2	0	0	0	0			
3	0	0	0	0			
4	0	0	0	0			
5	0	0	0	0			
6	0	0	0	0			
7	0	0	0	0			
8	0	0	0	0			
9	0	0	0	0			
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

[Handwritten signature]

see page 1

COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 3-23-88
RUN N^o: 4
START TIME: 5:30 PM
FINISH TIME: 6:40 PM



The ALMEGA CORPORATION

APPENDIX P

**INCINERATOR OPERATIONAL DETAILS AND
INCLUDING CHARGING SCHEDULE,
PRIMARY AND SECONDARY STAGE TEMPERATURES,
INCINERATOR LOGS AND GAS CONSUMPTION**

Run # I

charge rate

TIME

CHARGE

Total

10:42

102

10:48

172

10:52

148

10:58

169

11:07

167

11:10

171

11:16

163

11:22

161

11:28

169

11:34

102

11:40

75

11:45

136

11:49

104

11:54

~~102~~ 102

274

422

591

758

929

1092

1253

1422

1524

1599

1735

1839

2041

11:07

KUN #2

<u>TIME</u>	<u>CHARGE</u>		
12:52	96		96
12:58	158	(108 Path)	254
1:04	111		365
1:10	138		503
1:16	161		664
1:22	98		762
1:28	108		870
1:34	115		985
1:39	115		1100
1:44	93		1193
1:49	116		1309
	9		

RUN #3

<u>Time</u>	<u>CHARGE</u>	<u>TOTAL</u>
2:21	93	93
2:27	89	182
2:33	101	283
2:38	187	470
2:43	167	637
2:49	157	794 794
3:13	377	1171
3:17	151	1322

KUN #4

<u>TIME</u>	<u>CHARGE</u>	<u>TOTAL</u>
5:29	94	94
5:58	132	226
6:01	132 212	438
6:06	211	649
6:11	141	790
6:16	140	930
6:23	144	1074

RUN ~~IX~~#5

MARCH 24, 1988

<u>TIME</u>	<u>CHARGE</u>	<u>TOTAL</u>		
11:50	115			
12:01	149	264		
12:06	62	326		
12:12	121	447		
12:18	118	565		
12:29	149	714		
12:30	167	881		
12:38	100	1081		
12:44	87	1168		
12:50	104	1272	1172?	
<hr/>				
12:56	101	1373	Test #	101
1:02	104	1474	6	205
1:08	103	1577		308
1:14	108	1685		416
1:20	115	1800		531
1:26	102	1902		633
1:32	98	2000		731
1:38	104	2104		835
1:44	108	2212		943
1:50	103	2315		1046
1:56	106	2421		1152
2:02	103	2524		1255
2:08	111	2635		1366
2:14	180	2815		1546

STAGE II TEMPERATURES

Page 1

			TIME	TEMPS				
21	25/	1958	850	1961	1987	1994	1914	1915
21	23/	1988	855	1945	1970	1979	1986	1989
21	23/	1988	900	1961	1967	1947	1916	1892
21	23/	1988	905	1918	1960	1978	1977	1965
21	23/	1988	910	1941	1923	1929	1941	1941
21	23/	1988	915	1933	1919	1891	1893	1941
21	23/	1988	920	1973	1985	1984	1979	1954
21	23/	1988	925					

Readings per minute
TEMPS

Stage II Temp.

			TIME	TEMPS				
21	23/	1988	930	1940	1930	1919	1902	1884
21	23/	1988	933	1868	1838	1837	1847	1851
21	23/	1988	935	1872	1878	1850	1847	1837
21	23/	1988	940	1857	1871	1860	1839	1835
21	23/	1988	945	1843	1914	1945	1941	1915
21	23/	1988	950	1889	1866	1846	1929	1978
21	23/	1988	955	1879	1937	1933	1907	1877
21	23/	1988	1000	1877	1892	1941	1980	2006
21	23/	1988	1005	1940	1921	1948	1958	1958
21	23/	1988	1010	1948	1941	1937	1936	1930
21	23/	1988	1015	1942	1958	1965	1958	1947
21	23/	1988	1020	1937	1913	1915	1922	1918
21	23/	1988	1025	1904	1889	1876	1852	1857
21	23/	1988	1030	1877	1879	1871	1862	1839
21	23/	1988	1035	1894	1949	1959	1945	1921
21	23/	1988	1040	1892	1893	1901	1907	1906
21	23/	1988	1045	1897	1878	1877	1884	1882
21	23/	1988	1050	1874	1864	1869	1933	1971
21	23/	1988	1055	1863	1941	1909	1899	1960
21	23/	1988	1100	1931	1972	1942	1904	1914
21	23/	1988	1105	1990	1985	1911	1902	1901
21	23/	1988	1110	1915	1918	1914	1907	1895
21	23/	1988	1115	1930	2008	1925	1904	1918
21	23/	1988	1120	1930	1992	1985	1993	1960
21	23/	1988	1125	1887	1871	1944	1927	1870
21	23/	1988	1130	1859	1882	1913	1949	1915
21	23/	1988	1135	1881	1843	1867	1868	1907
21	23/	1988	1140	1834	1941	1921	1915	1930
21	23/	1988	1145	1865	1914	1919	1956	1925
21	23/	1988	1150	1921	1919	1923	1971	1910
21	23/	1988	1155	1913	1898	1977	1958	1868
21	23/	1988	1200	1920	2013	1935	1892	1874
21	23/	1988	1205	1942	1934	188	1900	1952
21	23/	1988	1210	1931	1889	1913	1946	1928
21	23/	1988	1215	1913	1948	2000	1907	1839
21	23/	1988	1220	1891	1905	1941	1945	1942
21	23/	1988	1225	1932	1939	1923	1922	1921
21	23/	1988	1230	1902	1917	1908	1896	1886
21	23/	1988	1235	1892	1908	1910	1910	1912

#1

2/	23/	1988	1240	1911	1908	1906	1901	1899	
3/	23/	1988	1245	1898	1899	1899	1892	1868	
4/	23/	1988	1250	1841	1828	1843	1847	1854	1842.6
5/	23/	1988	1255	1838	1846	1857	1848	1869	1851.6
6/	23/	1988	1300	1893	1911	1915	1894	1899	1902.4
7/	23/	1988	1305	1924	1943	1945	1922	1906	1928.0
8/	23/	1988	1310	1910	1925	1923	1901	1869	1905.6
9/	23/	1988	1315	1877	1903	1928	1940	1912	1912.0
10/	23/	1988	1320	1945	1976	1862	1798	1981	1912.4
11/	23/	1988	1325	1934	1821	1899	1972	1876	1900.4
12/	23/	1988	1330	1842	1856	1877	1896	1905	1875.2
13/	23/	1988	1335	1900	1877	1873	1892	1911	1891.6
14/	23/	1988	1340	1922	1898	1870	1884	1933	1901.4
15/	23/	1988	1345	1960	1859	1837	1942	1949	1907.0
16/	23/	1988	1350	1873	1886	1893	1915	1943	1891.8
17/	23/	1988	1355	1942	1900	1915	1972	1923	1894.1
18/	23/	1988	1400	1947	1975	1878	1879	1957	
19/	23/	1988	1405	1952	1891	1931	1962	1894	
20/	23/	1988	1410	1919	1966	1895	1896	1948	
21/	23/	1988	1415	1933	1883	1911	1949	1916	
22/	23/	1988	1420	1877	1844	1905	1911	1891	3
23/	23/	1988	1425	1883	1891	1903	1914	1910	1701.4
24/	23/	1988	1430	1900	1963	1958	1872	1869	1913.8
25/	23/	1988	1435	1900	1904	1923	1941	1940	1923.4
26/	23/	1988	1440	1911	1941	1943	1853	1853	1921.6
27/	23/	1988	1445	1932	1933	2042	2103	2000	1999.0
28/	23/	1988	1450	2088	1942	1903	2114	1948	1979.2
29/	23/	1988	1455	1998	1932	-	1877	1901	1912.2
30/	23/	1988	1500	1901	1902	1907	1916	1922	
31/	23/	1988	1505	1901	1902	1907	1916	1922	
32/	23/	1988	1510	1901	1902	1907	1916	1922	
33/	23/	1988	1515	1901	1902	1907	1916	1922	
34/	23/	1988	1520	1901	1902	1907	1916	1922	
35/	23/	1988	1525	1901	1902	1907	1916	1922	
36/	23/	1988	1530	1901	1902	1907	1916	1922	
37/	23/	1988	1535	1901	1902	1907	1916	1922	
38/	23/	1988	1540	1901	1902	1907	1916	1922	
39/	23/	1988	1545	1901	1902	1907	1916	1922	
40/	23/	1988	1550	1901	1902	1907	1916	1922	
41/	23/	1988	1555	1901	1902	1907	1916	1922	
42/	23/	1988	1560	1901	1902	1907	1916	1922	
43/	23/	1988	1565	1901	1902	1907	1916	1922	
44/	23/	1988	1570	1901	1902	1907	1916	1922	
45/	23/	1988	1575	1901	1902	1907	1916	1922	
46/	23/	1988	1580	1901	1902	1907	1916	1922	
47/	23/	1988	1585	1901	1902	1907	1916	1922	
48/	23/	1988	1590	1901	1902	1907	1916	1922	
49/	23/	1988	1595	1901	1902	1907	1916	1922	
50/	23/	1988	1600	1901	1902	1907	1916	1922	
51/	23/	1988	1605	1901	1902	1907	1916	1922	
52/	23/	1988	1610	1901	1902	1907	1916	1922	
53/	23/	1988	1615	1901	1902	1907	1916	1922	
54/	23/	1988	1620	1901	1902	1907	1916	1922	
55/	23/	1988	1625	1901	1902	1907	1916	1922	
56/	23/	1988	1630	1901	1902	1907	1916	1922	
57/	23/	1988	1635	1901	1902	1907	1916	1922	
58/	23/	1988	1640	1901	1902	1907	1916	1922	
59/	23/	1988	1645	1901	1902	1907	1916	1922	
60/	23/	1988	1650	1901	1902	1907	1916	1922	
61/	23/	1988	1655	1901	1902	1907	1916	1922	
62/	23/	1988	1660	1901	1902	1907	1916	1922	
63/	23/	1988	1665	1901	1902	1907	1916	1922	
64/	23/	1988	1670	1901	1902	1907	1916	1922	
65/	23/	1988	1675	1901	1902	1907	1916	1922	
66/	23/	1988	1680	1901	1902	1907	1916	1922	
67/	23/	1988	1685	1901	1902	1907	1916	1922	
68/	23/	1988	1690	1901	1902	1907	1916	1922	
69/	23/	1988	1695	1901	1902	1907	1916	1922	
70/	23/	1988	1700	1901	1902	1907	1916	1922	
71/	23/	1988	1705	1901	1902	1907	1916	1922	
72/	23/	1988	1710	1901	1902	1907	1916	1922	
73/	23/	1988	1715	1901	1902	1907	1916	1922	
74/	23/	1988	1720	1901	1902	1907	1916	1922	
75/	23/	1988	1725	1901	1902	1907	1916	1922	
76/	23/	1988	1730	1901	1902	1907	1916	1922	
77/	23/	1988	1735	1901	1902	1907	1916	1922	
78/	23/	1988	1740	1901	1902	1907	1916	1922	
79/	23/	1988	1745	1901	1902	1907	1916	1922	
80/	23/	1988	1750	1901	1902	1907	1916	1922	
81/	23/	1988	1755	1901	1902	1907	1916	1922	
82/	23/	1988	1760	1901	1902	1907	1916	1922	
83/	23/	1988	1765	1901	1902	1907	1916	1922	
84/	23/	1988	1770	1901	1902	1907	1916	1922	
85/	23/	1988	1775	1901	1902	1907	1916	1922	
86/	23/	1988	1780	1901	1902	1907	1916	1922	
87/	23/	1988	1785	1901	1902	1907	1916	1922	
88/	23/	1988	1790	1901	1902	1907	1916	1922	
89/	23/	1988	1795	1901	1902	1907	1916	1922	
90/	23/	1988	1800	1901	1902	1907	1916	1922	
91/	23/	1988	1805	1901	1902	1907	1916	1922	
92/	23/	1988	1810	1901	1902	1907	1916	1922	
93/	23/	1988	1815	1901	1902	1907	1916	1922	
94/	23/	1988	1820	1901	1902	1907	1916	1922	
95/	23/	1988	1825	1901	1902	1907	1916	1922	
96/	23/	1988	1830	1901	1902	1907	1916	1922	
97/	23/	1988	1835	1901	1902	1907	1916	1922	
98/	23/	1988	1840	1901	1902	1907	1916	1922	
99/	23/	1988	1845	1901	1902	1907	1916	1922	
100/	23/	1988	1850	1901	1902	1907	1916	1922	
101/	23/	1988	1855	1901	1902	1907	1916	1922	
102/	23/	1988	1860	1901	1902	1907	1916	1922	
103/	23/	1988	1865	1901	1902	1907	1916	1922	
104/	23/	1988	1870	1901	1902	1907	1916	1922	
105/	23/	1988	1875	1901	1902	1907	1916	1922	
106/	23/	1988	1880	1901	1902	1907	1916	1922	
107/	23/	1988	1885	1901	1902	1907	1916	1922	
108/	23/	1988	1890	1901	1902	1907	1916	1922	
109/	23/	1988	1895	1901	1902	1907	1916	1922	
110/	23/	1988	1900	1901	1902	1907	1916	1922	
111/	23/	1988	1905	1901	1902	1907	1916	1922	
112/	23/	1988	1910	1901	1902	1907	1916	1922	
113/	23/	1988	1915	1901	1902	1907	1916	1922	
114/	23/	1988	1920	1901	1902	1907	1916	1922	
115/	23/	1988	1925	1901	1902	1907	1916	1922	
116/	23/	1988	1930	1901	1902	1907	1916	1922	
117/	23/	1988	1935	1901	1902	1907	1916	1922	
118/	23/	1988	1940	1901	1902	1907	1916	1922	
119/	23/	1988	1945	1901	1902	1907	1916	1922	
120/	23/	1988	1950	1901	1902	1907	1916	1922	
121/	23/	1988	1955	1901	1902	1907	1916	1922	
122/	23/	1988	1960	1901	1902	1907	1916	1922	
123/	23/	1988	1965	1901	1902	1907	1916	1922	
124/	23/	1988	1970	1901	1902	1907	1916	1922	
125/	23/	1988	1975	1901	1902	1907	1916	1922	
126/	23/	1988	1980	1901	1902	1907	1916	1922	
127/	23/	1988	1985	1901	1902	1907	1916	1922	
128/	23/	1988	1990	1901	1902	1907	1916	1922	
129/	23/	1988	1995	1901	1902	1907	1916	1922	
130/	23/	1988	2000	1901	1902	1907	1916	1922	
131/	23/	1988	2005	1901	1902	1907	1916	1922	
132/	23/	1988	2010	1901	1902	1907	1916	1922	
133/	23/	1988	2015	1901	1902	1907	1916	1922	
134/	23/	1988	2020	1901	1902	1907	1916	1922	
135/	23/	1988	2025	1901	1902	1907	1916	1922	
136/	23/	1988	2030	1901	1902	1907	1916	1922	
137/	23/	1988	2035	1901	1902	1907	1916	1922	
138/	23/	1988	2040	1901	1902	1907	1916	1922	
139/	23/	1988	2045	1901					

3/	23/	1988	1600	1876	1868	1873	1881	1885
3/	23/	1988	1605	1875	1868	1872	1877	1880
3/	23/	1988	1610	1879	1878	1873		1875
3/	23/	1988	1615	1869	1866	18		1877
3/	23/	1988	1615	1869		1877	1880	1880
3/	23/	1988	1620	1871	1862	1851	1889	1843
3/	23/	1988	1625	1877	1869	1869	1878	1883
3/	23/	1988	1630	1881	1844	1840	1880	1883
3/	23/	1988	1635	1881	1831	1879	1872	1868
3/	23/	1988	1640	1882	1847	1854	1875	1873
3/	23/	1988	1645	1884	1854	1845	1838	1851
3/	23/	1988	1650	1839	1872	1879	1851	1839
3/	23/	1988	1655	1846	1860	1834	1841	1851
3/	23/	1988	1700	1839	1840	1836	1840	1839
3/	23/	1988	1705	1854	1831	1837	1907	1879
3/	23/	1988	1710	1837	1837	1907	1892	1854
3/	23/	1988	1715	1828	1850	1898	1881	1858
3/	23/	1988	1720	1844	1869	1877	1918	1961
3/	23/	1988	1725	1888	1864	1853	1841	1876
3/	23/	1988	1730	1897	1882	1925	1983	
3/	23/	1988	1734	1892				
3/	23/	1988	1735	1840	1877	1910	1937	1949
3/	23/	1988	1740	1875	1851	1858	1888	1903
3/	23/	1988	1745	1907	1907	1905	1903	1900
3/	23/	1988	1750	1893	1888	1884	?	?
3/	23/	1988	1753	1881	1879	1876	1874	1870
3/	23/	1988	1758	1888				
3/	23/	1988	1789	1866	1856	1852	1906	?
3/	23/	1988	1803	1903	1836	1911	1892	1921
3/	23/	1988	1808	1933	1903	1868	1858	1936
3/	23/	1988	1813	1975	1856	1805	1954	1994
3/	23/	1988	1818	1987	1902	1899	1988	2031
3/	23/	1988	1823	1988	1896	1931	1966	1911
3/	23/	1988	1828	1941	1936	1893	1911	1937
3/	23/	1988	1833	1944	1879	1972	1934	1847
3/	23/	1988	1838	1879	1905	1870	1879	1817
3/	23/	1988	1843	1933	1941	1863	1852	1901
3/	23/	1988	1848	1902	1898	1961	1919	1832

(4)
 1921.8
 1902.6
 1875.0
 1904.4
 1888.3 ?
 1870.0 ?
 1918.6
 1899.6
 1916.8
 1949.4
 1931.5
 1927.6
 1946.0
 1903.1

1st & 2nd Stage Mentis

- See 11.50 AM

3/	23/	1988	1853	1869	1952	1900	1864	1843
3/	23/	1988	1858	1840	1881	1911	1937	1952
3/	23/	1988	1903	1904	1688	1901	1893	1888
3/	23/	1988	1908	1884	1873	1847	1881	1932
3/	23/	1988	1913	1952	1896	1884	1866	1871
3/	23/	1988	1918	1882	1894	1899	1875	1881
3/	23/	1988	1923	1918	1937	1906	1878	1877
3/	23/	1988	1928	1885	1894	1897	1873	1924
3/	23/	1988	1933	1996	1881	1808	1930	1950
3/	23/	1988	1938	1854	1845	1894	1914	1915
3/	23/	1988	1943	1912	1890	1881	1903	1926
3/	23/	1988	1948	1914	1883	1867	1860	1853
3/	23/	1988	1953	1854	1862	1869	1873	1846
3/	23/	1988	1958	1849	1908	1951	1905	1853
3/	23/	1988	2003	1838	1867	1883	1884	1885
3/	23/	1988	2008	1886	1884	1854	1874	1949
3/	23/	1988	2013	1940	1848	1826	1896	1927
3/	23/	1988	2018	1974	1903	1775	1871	1989
3/	23/	1988	2023	1890	1850	1850	1847	1869
3/	23/	1988	2028	1876	1859	1870	1930	1949
3/	23/	1988	2033	1828	1786	1960	1941	1833
3/	23/	1988	2038	1865	1933	1891	1846	1828
3/	23/	1988	2043	1840	1875	1881	1862	1876
3/	23/	1988	2048	1900	1908	1911	1900	1892
3/	23/	1988	2053	1881	1876	1869	1864	1859
3/	23/	1988	2058	1851	1832	1832	1891	1901
3/	23/	1988	2103	1897	1871	1881	1875	1866
3/	23/	1988	2108	1856	1851	1847	1858	1935
3/	23/	1988	2113	1808	1878	1840	1883	1871
3/	23/	1988	2118	1861	1894	1847	1862	1868
3/	23/	1988	2123	1862	1848	1871	1878	1926
3/	23/	1988	2128	1948	1934	1907	1893	1880
3/	23/	1988	2133	1859	1862	1858	1855	1843
3/	23/	1988	2138	1847	1901	1938	1942	1926
3/	23/	1988	2143	1909	1848	1854	1879	1892
3/	23/	1988	2148	1876	1828	1866	1855	1879
3/	23/	1988	2153	1889	1860	1874	1865	1856
3/	23/	1988	2158	1851	1847	1864	1862	1851
3/	23/	1988	2203	1831	1847	1917	1933	1918
3/	23/	1988	2208	1895	1870	1860	1850	1850
3/	23/	1988	2213	1865	1860	1849	1833	1841
3/	23/	1988	2218	1868	1877	1866	1858	1851
3/	23/	1988	2223	1890	1866	1872	1857	1854
3/	23/	1988	2228	1843	1841	1871	1905	1930
3/	23/	1988	2233	1933	1826	1915	1894	1873
3/	23/	1988	2238	1841	1811	1884	1847	1870

3/	23/	1988	2248	1873	1859	1847	1847	1866
3/	23/	1988	2253	1858	1841	1826	1966	1982
3/	23/	1988	2258	1856	1831	1915	1923	1904
3/	23/	1988	2303	1883	1868	1855	1847	1853
3/	23/	1988	2308	1843	1880	1920	1926	1915
3/	23/	1988	2313	1900	1885	1873	1863	1855
3/	23/	1988	2318	1851	1850	1860	1840	1871
3/	23/	1988	2323	1901	1902	1888	1875	1864

3/	23/	1988	2328	1854	1846	1861	1865	1856
3/	23/	1988	2333	1838	1848	1903	1924	1923
3/	23/	1988	2338	1908	1885	1866	1850	1843
3/	23/	1988	2343	1861	1860	1846	1834	1850
3/	23/	1988	2348	1925	1951	1895	1861	1850
3/	23/	1988	2353	1850	1867	1861	1847	1845
3/	23/	1988	2358	1864	1847	1832	1922	1949
3/	24/	1988	3	1905	1879	1869	1859	1852
3/	24/	1988	8	1847	1863	1862	1849	1828
3/	24/	1988	13	1877	1946	1921	1865	1845
3/	24/	1988	18	1851	1864	1854	1843	1855
3/	24/	1988	23	1862	1847	1820	1913	1951
3/	24/	1988	28	1865	1835	1858	1873	1864
3/	24/	1988	33	1851	1845	1862	1858	1840
3/	24/	1988	36	1824	1892	1930	1908	1881
3/	24/	1988	43	1861	1847	1849	1863	1852
3/	24/	1988	48	1842	1858	1858	1825	1897
3/	24/	1988	53	1946	1928	1897	1873	1851
3/	24/	1988	58	1841	1860	1861	1846	1843
3/	24/	1988	103	1857	1833	1839	1879	1882
3/	24/	1988	108	1866	1848	1843	1862	1858
3/	24/	1988	113	1843	1847	1860	1844	1828
3/	24/	1988	118	1926	1935	1909	1891	1861
3/	24/	1988	123	1845	1851	1863	1853	1840
3/	24/	1988	128	1861	1857	1823	1899	1941
3/	24/	1988	133	1919	1890	1866	1850	1846
3/	24/	1988	138	1864	1861	1847	1847	1855
3/	24/	1988	143	1828	1871	1926	1909	1883
3/	24/	1988	148	1860	1843	1851	1865	1853
3/	24/	1988	153	1841	1856	1852	1835	1883
3/	24/	1988	158	1903	1890	1871	1852	1846
3/	24/	1988	203	1864	1862	1849	1846	1865
3/	24/	1988	208	1845	1828	1917	1933	1911
3/	24/	1988	213	1886	1866	1852	1845	1862
3/	24/	1988	218	1860	1844	1843	1849	1834
3/	24/	1988	223	1856	1882	1877	1852	1848
3/	24/	1988	228	1846	1862	1857	1843	1847
3/	24/	1988	233	1862	1836	1840	1922	1915
3/	24/	1988	238	1887	1862	1842	1846	1862
3/	24/	1988	243	1854	1839	1851	1859	1828
3/	24/	1988	248	1863	1906	1898	1877	1859
3/	24/	1988	253	1843	1851	1862	1847	1835
3/	24/	1988	258	1854	1859	1832	1871	1900
3/	24/	1988	303	1900	1885	1871	1860	1849
3/	24/	1988	308	1850	1866	1861	1847	1845
3/	24/	1988	313	1864	1863	1947	1843	1832
3/	24/	1988	318	1871	1882	1873	1859	1847
3/	24/	1988	323	1853	1866	1852	1834	1907
3/	24/	1988	328	1845	1838	1901	1879	1862
3/	24/	1988	333	1871	1845	1844	1856	1845

3/	24/	1988	343	1867	1831	1843	1862	1863
3/	24/	1988	348	1848	1843	1862	1850	1832
3/	24/	1988	353	1881	1899	1884	1865	1847
3/	24/	1988	358	1842	1863	1861	1844	1844
3/	24/	1988	403	1861	1844	1827	1850	1875
3/	24/	1988	408	1869	1854	1839	1853	1861
3/	24/	1988	413	1843	1840	1859	1859	1828
3/	24/	1988	418	1866	1960	1888	1831	1839
3/	24/	1988	423	1869	1866	1851	1843	1862
3/	24/	1988	428	1859	1842	1830	1837	1884
3/	24/	1988	433	1892	1873	1854	1843	1863
3/	24/	1988	438	1868	1853	1843	1861	1866
3/	24/	1988	443	1834	1854	1943	1941	1915
3/	24/	1988	448	1892	1872	1858	1846	1855
3/	24/	1988	453	1869	1861	1847	1829	1888

3/	24/	1988	456	1922	1873	1858	1884	1872
3/	24/	1988	503	1854	1848	1850	1866	1837
3/	24/	1988	508	1941	1832	1869	1891	1890
3/	24/	1988	513	1881	1831	1833	1851	1847
3/	24/	1988	518	1867	1863	1852	1843	1836
3/	24/	1988	523	1856	1831	1863	1832	1843
3/	24/	1988	528	1880	1833	1847	1841	1865
3/	24/	1988	533	1836	1831	1818	1931	1948
3/	24/	1988	538	1847	1832	1929	1929	1900
3/	24/	1988	543	1873	1884	1842	1838	1838
3/	24/	1988	548	1833	1833	1945	1918	1887
3/	24/	1988	553	1833	1833	1845	1863	1862
3/	24/	1988	558	1833	1834	1855	1830	1842
3/	24/	1988	563	1833	1873	1862	1847	1846
3/	24/	1988	568	1867	1853	1849	1843	1865
3/	24/	1988	573	1852	1824	1907	1938	1917
3/	24/	1988	578	1891	1869	1853	1843	1858
3/	24/	1988	583	1863	1849	1841	1848	1843
3/	24/	1988	588	1862	1839	1859	1847	1847
3/	24/	1988	593	1865	1838	1844	1850	1863
3/	24/	1988	598	1850	1827	1850	1978	1889
3/	24/	1988	603	1830	1902	1944	1831	1831
3/	24/	1988	608	1850	1833	1833	1833	1833
3/	24/	1988	613	183	183	1833	1833	1833
3/	24/	1988	618	1833	1833	1833	1833	1833
3/	24/	1988	623	1833	1833	1833	1833	1833
3/	24/	1988	628	1833	1833	1833	1833	1833
3/	24/	1988	633	1833	1833	1833	1833	1833
3/	24/	1988	638	1833	1833	1833	1833	1833
3/	24/	1988	643	1833	1833	1833	1833	1833
3/	24/	1988	648	1833	1833	1833	1833	1833
3/	24/	1988	653	1833	1833	1833	1833	1833
3/	24/	1988	658	1833	1833	1833	1833	1833
3/	24/	1988	663	1833	1833	1833	1833	1833
3/	24/	1988	668	1833	1833	1833	1833	1833
3/	24/	1988	673	1833	1833	1833	1833	1833
3/	24/	1988	678	1833	1833	1833	1833	1833
3/	24/	1988	683	1833	1833	1833	1833	1833
3/	24/	1988	688	1833	1833	1833	1833	1833
3/	24/	1988	693	1833	1833	1833	1833	1833
3/	24/	1988	698	1833	1833	1833	1833	1833
3/	24/	1988	703	1833	1833	1833	1833	1833
3/	24/	1988	708	1833	1833	1833	1833	1833
3/	24/	1988	713	1833	1833	1833	1833	1833
3/	24/	1988	718	1833	1833	1833	1833	1833
3/	24/	1988	723	1833	1833	1833	1833	1833
3/	24/	1988	728	1833	1833	1833	1833	1833
3/	24/	1988	733	1833	1833	1833	1833	1833
3/	24/	1988	738	1833	1833	1833	1833	1833
3/	24/	1988	743	1833	1833	1833	1833	1833
3/	24/	1988	748	1833	1833	1833	1833	1833
3/	24/	1988	753	1833	1833	1833	1833	1833
3/	24/	1988	758	1833	1833	1833	1833	1833
3/	24/	1988	763	1833	1833	1833	1833	1833
3/	24/	1988	768	1833	1833	1833	1833	1833
3/	24/	1988	773	1833	1833	1833	1833	1833
3/	24/	1988	778	1833	1833	1833	1833	1833
3/	24/	1988	783	1833	1833	1833	1833	1833
3/	24/	1988	788	1833	1833	1833	1833	1833
3/	24/	1988	793	1833	1833	1833	1833	1833
3/	24/	1988	798	1833	1833	1833	1833	1833
3/	24/	1988	803	1833	1833	1833	1833	1833
3/	24/	1988	808	1833	1833	1833	1833	1833
3/	24/	1988	813	1833	1833	1833	1833	1833
3/	24/	1988	818	1833	1833	1833	1833	1833
3/	24/	1988	823	1833	1833	1833	1833	1833
3/	24/	1988	828	1833	1833	1833	1833	1833
3/	24/	1988	833	1833	1833	1833	1833	1833
3/	24/	1988	838	1833	1833	1833	1833	1833
3/	24/	1988	843	1833	1833	1833	1833	1833
3/	24/	1988	848	1833	1833	1833	1833	1833
3/	24/	1988	853	1833	1833	1833	1833	1833
3/	24/	1988	858	1833	1833	1833	1833	1833
3/	24/	1988	863	1833	1833	1833	1833	1833
3/	24/	1988	868	1833	1833	1833	1833	1833
3/	24/	1988	873	1833	1833	1833	1833	1833
3/	24/	1988	878	1833	1833	1833	1833	1833
3/	24/	1988	883	1833	1833	1833	1833	1833
3/	24/	1988	888	1833	1833	1833	1833	1833
3/	24/	1988	893	1833	1833	1833	1833	1833
3/	24/	1988	898	1833	1833	1833	1833	1833
3/	24/	1988	903	1833	1833	1833	1833	1833
3/	24/	1988	908	1833	1833	1833	1833	1833
3/	24/	1988	913	1833	1833	1833	1833	1833
3/	24/	1988	918	1833	1833	1833	1833	1833
3/	24/	1988	923	1833	1833	1833	1833	1833
3/	24/	1988	928	1833	1833	1833	1833	1833
3/	24/	1988	933	1833	1833	1833	1833	1833
3/	24/	1988	938	1833	1833	1833	1833	1833
3/	24/	1988	943	1833	1833	1833	1833	1833
3/	24/	1988	948	1833	1833	1833	1833	1833
3/	24/	1988	953	1833	1833	1833	1833	1833
3/	24/	1988	958	1833	1833	1833	1833	1833
3/	24/	1988	963	1833	1833	1833	1833	1833
3/	24/	1988	968	1833	1833	1833	1833	1833
3/	24/	1988	973	1833	1833	1833	1833	1833
3/	24/	1988	978	1833	1833	1833	1833	1833
3/	24/	1988	983	1833	1833	1833	1833	1833
3/	24/	1988	988	1833	1833	1833	1833	1833
3/	24/	1988	993	1833	1833	1833	1833	1833
3/	24/	1988	998	1833	1833	1833	1833	1833

3/	24/	1988	823	1840	1910	1975	1876	1853
3/	24/	1988	828	1854	1842	1854	1862	1844
3/	24/	1988	833	1838	1853	1851	1828	1881
3/	24/	1988	838	1926	1936	1932	1915	1891
3/	24/	1988	843	1871	1854	1843	1860	1863
3/	24/	1988	848	1847	1821	1919	1947	1867
3/	24/	1988	853	1839	1863	1877	1869	1857
3/	24/	1988	858	1848	1855	1867	1854	1830
3/	24/	1988	903	1880	1920	1926	1919	1911
3/	24/	1988	908	1896	1881	1866	1854	1850
3/	24/	1988	913	1854	1857	1830	1856	1882
3/	24/	1988	918	1882	1874	1863	1851	1847
3/	24/	1988	923	1866	1884	1980	2074	2069
3/	24/	1988	928	2011	2129	2066	1968	2044
3/	24/	1988	933	2101	2002	2026	2090	2050
3/	24/	1988	938	2030	2092	2042	1995	2058
3/	24/	1988	943	2092	2027	2049	2087	2028
3/	24/	1988	948	2049	2090	2031	2050	2088
3/	24/	1988	953	2020	2021	2118	2054	2001
3/	24/	1988	958	2087	2059	1995	2064	2091
3/	24/	1988	1003	2028	2054	2089	2018	2020
3/	24/	1988	1008	2113	2036	1994	2073	2081
3/	24/	1988	1013	1950	1948	2040	2114	2114
3/	24/	1988	1018	2068	2107	2082	2097	2154
3/	24/	1988	1023	2043	2068	2134	2099	2079

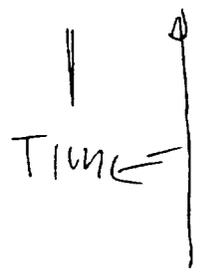
3/	24/	1988	1028	2135	2096	2080	2134	2090
3/	24/	1988	1033	2068	2087	2164	2069	2089
3/	24/	1988	1038	2160	2134	2073	2139	2093
3/	24/	1988	1043	2084	2136	2087	2072	2113
3/	24/	1988	1048	2160	2049	2122	2133	2018
3/	24/	1988	1053	2055	2115	2104	2060	2092
3/	24/	1988	1058	2118	2050	2055	2105	2141
3/	24/	1988	1103	2088	2105	2137	2077	2103
3/	24/	1988	1108	2139	2107	2107	2137	2082
3/	24/	1988	1113	2060	2117	2132	2074	2114
3/	24/	1988	1118	2106	2111	2111	2126	2071
3/	24/	1988	1123	2112	2120			
3/	24/	1988	1128	1277				
3/	24/	1988	1133	1275				
3/	24/	1988	1138	1274	2069	2079	2124	2124
3/	24/	1988	1143	1279	2069	2105	2086	2165
3/	24/	1988	1148	1408	2107	2141	2107	2085
3/	24/	1988	1153	1328				2116
3/	24/	1988	1158	1391	2100	2101	2083	2054
3/	24/	1988	1163	1468	2100	2087	2130	2135
3/	24/	1988	1168	1412				
3/	24/	1988	1173	1406				
3/	24/	1988	1178	1425				
3/	24/	1988	1183	1432				
3/	24/	1988	1188	1437				
3/	24/	1988	1193	1471	2128			
3/	24/	1988	1198	1426	2070			
3/	24/	1988	1203	1417	2133	2119	2064	2085
3/	24/	1988	1208	1371	2124	2091	2142	2105
3/	24/	1988	1213	1425	2139	2136	2080	2142
3/	24/	1988	1218	1416	2072	2096	2144	2135
3/	24/	1988	1223	1474	2107	2089	2088	2182
3/	24/	1988	1228	1176	2061	2108	2189	2050

2124	2091	2142	2105	2068
2139	2136	2080	2142	2111
2072	2096	2144	2135	2107
2107	2089	2088	2182	2073
2061	2108	2189	2050	2052

2104.0
2119.6
2110.8
2109.8
2106.2

(5)

3/24/1988	1230	1504	2036	1986	2067	2153	2067	2066.2
3/24/1988	1235	1519	1978	2044	2146	2110	1984	2079.8
3/24/1988	1240	1523	1893	1849	2009	2205	2080	2099.4
3/24/1988	1245	1501	2004	2139	2112	2037	2114	2079.0
3/24/1988	1250	1521	2117	2020	2115	2118	2029	2089.0
3/24/1988	1255	1510	2102	2129	2031	2117	2118	
3/24/1988	1300	1455	2001	2054	2182	2083	2043	
3/24/1988	1305	1534	2137	2080	2031	2160	2131	
3/24/1988	1310	1515	1994	2032	2173	2065	2051	
3/24/1988	1315	1563	2168	2067	2024	2105	2160	
3/24/1988	1320	1470	2039	2107	2155	2004	2068	2063.0
3/24/1988	1325	1479	2198	2090	2017	2118	2124	2104.8
3/24/1988	1330	1491	1990	2031	2172	2092	2022	2074.6
3/24/1988	1335	1634	2104	2163	2044	2069	2153	2109.4
3/24/1988	1340	1584	2048	2035	2152	2120	2036	2061.4
3/24/1988	1345	1584	2122	2120	2014	2102	2141	2106.6
3/24/1988	1350	1545	2016	2062	2181	2064	2016	2075.2
3/24/1988	1355	1531	2112	2141	2014	2043	2140	2099.8
3/24/1988	1400	1462	2088	2030	2153	2138	2029	2067.8
3/24/1988	1405	1535	2076	2148	2042	2074	2167	2090.0
3/24/1988	1410	1525	2049	2024	2118	2158	2028	2057.6
3/24/1988	1415	1517	2030	2144	2092	2027		2101.4
3/24/1988	1419	1519						2063.7
3/24/1988	1419	1518	2110					2085.3
3/24/1988	1420	1518						
3/24/1988	1420	1518						
3/24/1988	1420	1517						



2ND STAGE
MINUTE READINGS

PRIMARY

THE ALMEGA CORPORATION

GAS METER READINGS

3/24/88

Run 5	End of Test	369,185	
	Start of Test	<u>369,175</u>	
			10,000
Run 6	End of Test	369,192	
	Start of Test	<u>369,185</u>	
			7,000

The ALMEGA CORPORATION

APPENDIX Q

**DETAILED INCINERATOR DESCRIPTION,
RESIDENCE TIME AND REYNOLDS NUMBERS,
CALCULATIONS AND TURBULENT
FLOW DETERMINATION**



**BASIC
ENVIRONMENTAL
ENGINEERING, INC.** *the modern
incinerator people*

TELEX II (TWX)-5101000115 BASIC UD
EASYLINK-62871698
TELEFAX-(312) 469-3167

21W161 Hill Street • Glen Ellyn, Illinois 60137 • (312)469-5340

April 5, 1988

The Almega Corporation
Attn: Eric Aynsley
607C Country Club Drive
Bensenville, IL 60106

RE: Residence time calculations on
Model 1250 for Erlanger Medical
Center

Dear Dr. Aynsley:

Enclosed are three 8-1/2" x 11" sketches of the reburn tunnel system of the BASIC Model 1250 at Erlanger Medical Center in Chattanooga, TN.

I am enclosing the calculations of the post main chamber residence time. Also enclosed is a process flow description.

The gas velocities for each zone at the reburn are calculated. In addition to the general flow velocity through the passageway, we wish to point out that the excess air is introduced into the passageway in concentric rings of air jets mounted at 45° to the flow and at 45° tangentially to the flow.

There are over 144, 5/8" diameter jets that feed excess air from 3" S.P. H₂O to 11" S.P. H₂O (confidential matter). These add extra turbulences not calculated in the agency's formula.

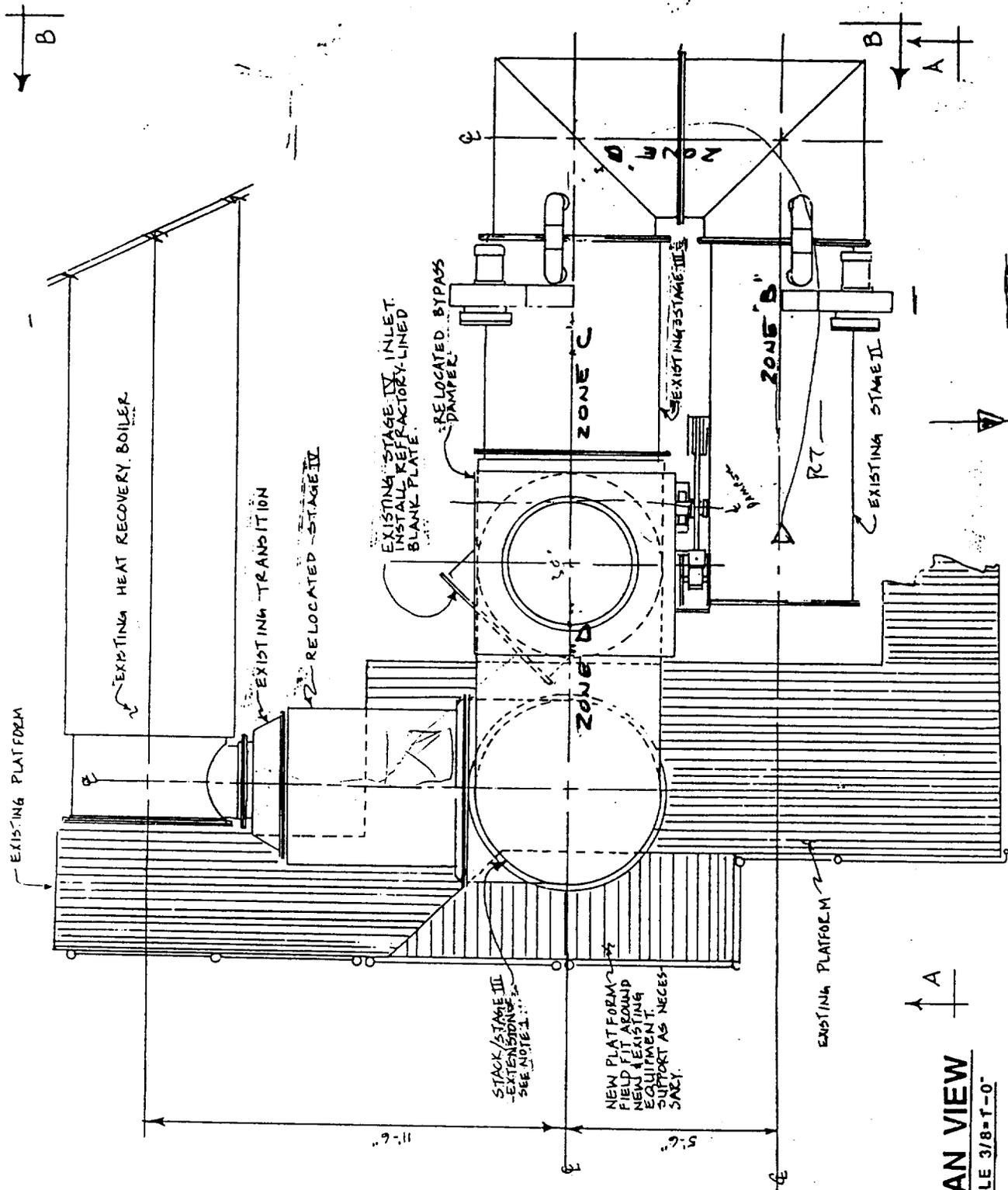
Very truly yours,

BASIC ENVIRONMENTAL ENGINEERING, INC.

John N. Basic, Sr.
President

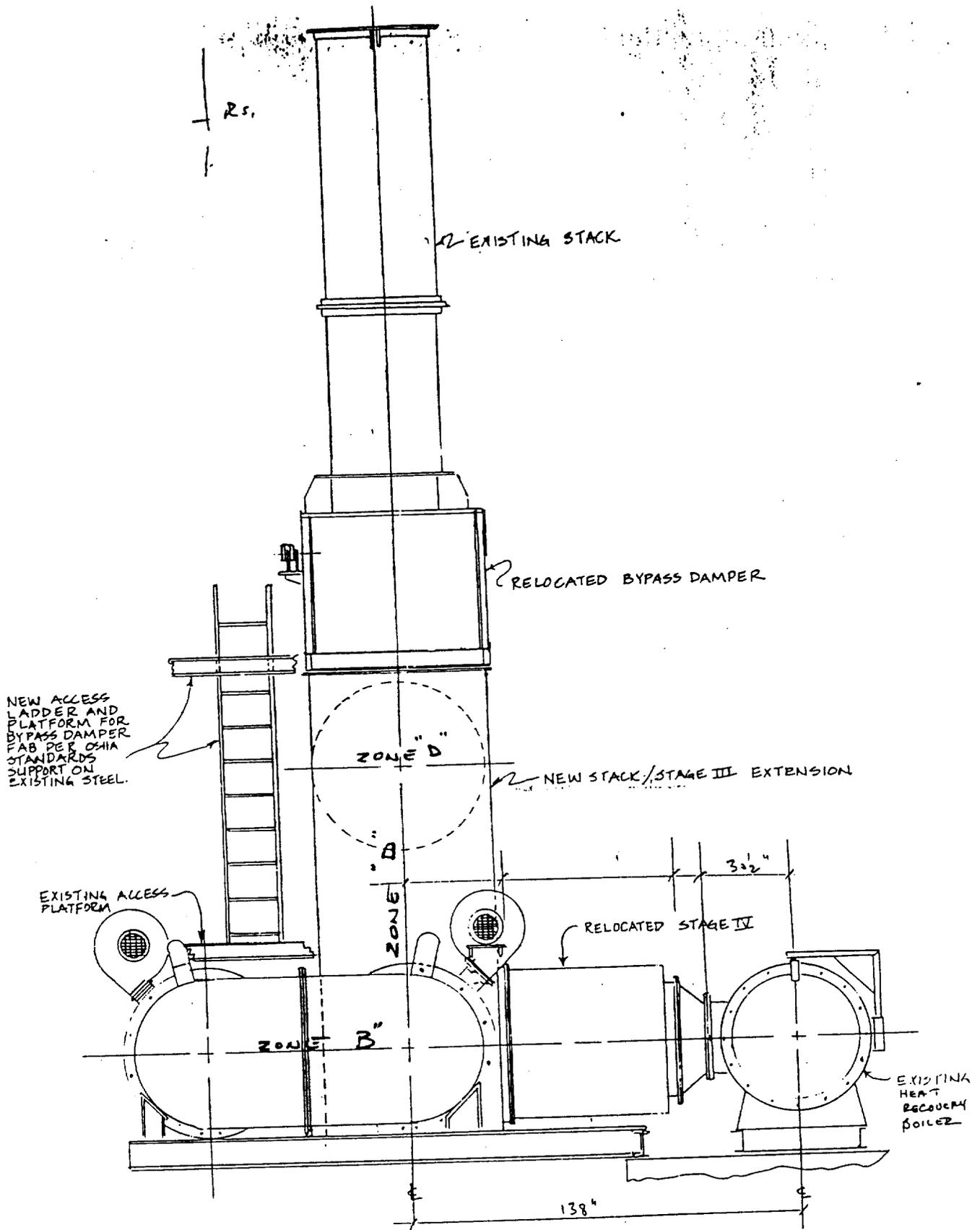
JNB:ld

Encls.



PLAN VIEW
SCALE 3/8"=1'-0"

Basic Model 1250



SECTION "B-B"

SCALE 3/8"=1'-0"

BASIC MODEL 1250

PROCESS FLOW DESCRIPTION

Bulk waste materials without any size preparation are loaded into the hopper of the loader feeder. An electric motor powered ram pushes this material into the main chamber where the waste fuel is ignited and starts the burning process.

The waste is contained on a refractory covered hearth floor which has a cross section shaped like two sets of stairs facing the center of the hearth. Air is forced into the weldment which forms the hearth and this combustion air is directed to the waste fuel through nozzles exiting through the risers of the steps. This entire chamber is considered the first stage of burning and air is kept at a near stoichiometric level.

The Pulse Hearth^(TM) itself is what moves the material slowly and gently through this first stage without any moving parts such as grates or rams required inside this high temperature zone. The Pulse Hearth^(TM) is suspended at four points outside the furnace from a fixed steel frame and thus, when given a forward thrust from an external pneumatic device, swings forward and slightly upward and then returns to its original position. The "pulsing" action gently disturbs the fuel bed and moves it forward one to several inches (depending on the strength of the thrust) with each pulse. Since the strength and frequency of the pulse can be varied and controlled, it lends itself to burning a wide variety of materials ranging from municipal and pathological wastes to whole rubber tires.

The non-combustibles (ash, wire, metal, glass, cans, etc.) are eventually discharged at the end of the hearth into a wet ash pit which serves as an air seal and quencher of the hot ash. Coupled to the pit is an inclined trough which also contains a four wheeled carriage and perforated steel plow blade for removing the ash. When traveling down the incline, the blade is in the "open" position. When the blade is at the bottom of the "J" shaped pit, it is rotated through an arc by an air cylinder so that it can "grab" the ash and carry it up the inclined trough as the carriage is pulled up by a cable and winch. At its top position the blade reverts to the "open" position so that all the ash drops out through the trough opening into a receiving container.

The first stage radiant combustion chamber is part of a steam generating system, and has a chamber which is constructed as a membrane waterwall boiler with a top header, ceiling and sidewall tubes and two bottom headers. Energy is absorbed primarily from radiation and can be as much as 35% of the total waste energy input.

The gases which exit from this first stage are not completely combusted due to the lack of excess air. Particulate levels are very low and of very small size (less than 100 microns) due to the low vertical gas velocity at all parts of the chamber as a result of primary air control and the rectangular geometry of the chamber. The gases and particulate enter a two stage reburn tunnel system where the necessary excess air to complete the combustion and particle destruction takes place.

The excess air is delivered to the interior burning area through a double shell construction, so that the outer plenum serves as an air preheater. The preheated air is sent to internal distributor tubes, called Thermal Exciters, designed so that the air jets which they contain will impart a cyclonic pattern while mixing with the gas from the first stage. The extremely high turbulence created permits a highly efficient use of the air thus achieving complete combustion at low excess air quantities. Residence time in these two stages can be from one to two seconds.

If introduction of exceedingly wet materials in Stage 1 causes temperatures in the second and third stage to be too low for total combustion, then an auxiliary fuel burner is brought into play to raise the temperature to the desired setpoint. These temperatures are generally over 1400°F. and can be as high as 2000°F. for some materials.

Since the system is designed to handle a wide range of waste streams, there is a distinct danger of slagging the heat convection boiler with heavy metal oxides, chlorides and other salts which tend to vaporize above 1400°F. and then condense out and slag on "cold" boiler tube surfaces.

To avoid costly shutdowns to de-slag a boiler, Stage 4 mixing zone is added which conditions the high temperature gases down to a controlled temperature of 1400°F. This is accomplished by recirculating a controlled quantity of flue gas at the lower exhaust temperatures and thoroughly blending it with the higher temperature Stage 3 gases to produce a 1400°F. gas stream without stratification. In this way the troublesome metal oxides, chlorides, etc. are maintained in a particulate state. Though they may deposit on the boiler tubes as particles, they can easily be removed by using conventional sootblowers without having to shut down the entire system.

After Stage 4 the entire mass of gas enters the boiler watertube unit and economizer. On many industrial waste applications no additional equipment is needed for emission control, but on more troublesome materials, scrubbers or baghouses may be needed to meet EPA compliance.

As a final safety device, ahead of the heat convection boiler and Stage 4, an emergency relief damper is added in the event of sudden loss of feedwater or draft, so as to prevent any damage to the operator or the equipment. Under these emergency conditions gases are diverted to atmosphere rather than continuing through the heat recovery boiler train.

CHEMICAL ENGINEERING

VOLUME ONE

FLUID FLOW, HEAT TRANSFER
AND MASS TRANSFER

J. M. COULSON, M.A., Ph.D.

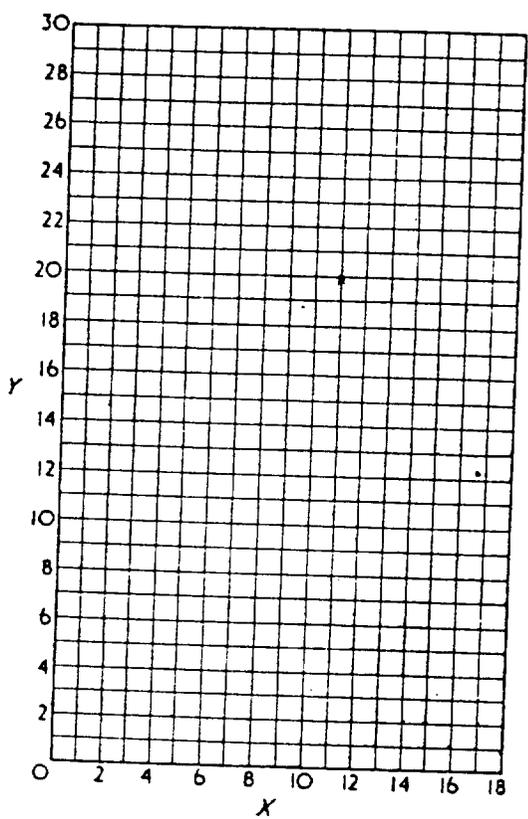
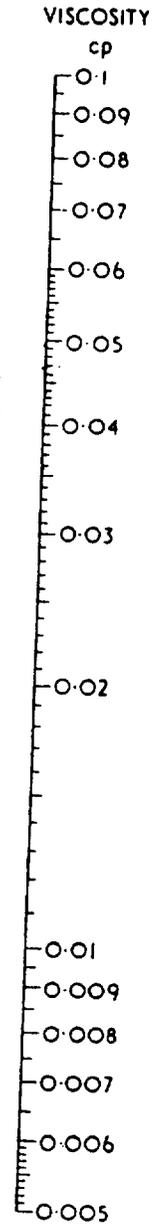
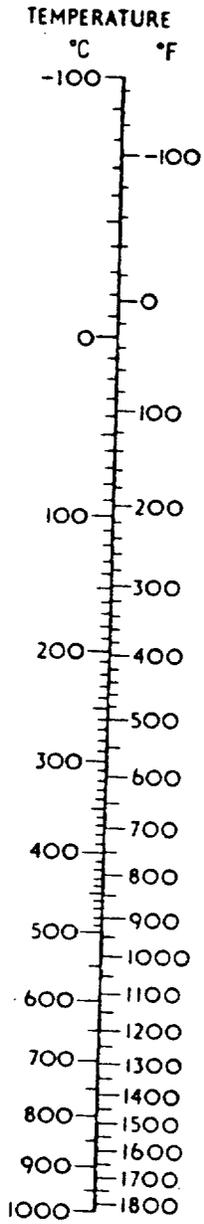
AND

J. F. RICHARDSON, B.Sc., Ph.D.

Imperial College of Science and Technology
London, S.W.7

NEW YORK: MCGRAW-HILL BOOK CO. INC.
LONDON: PERGAMON PRESS LTD.

APPENDIX
Viscosities of gases



APPENDIX

TABLE 8. Viscosities of gases*

Co-ordinates for use with graph on opposite page

No.	Gas	x	y
1	Acetic acid	7.7	14.3
2	Acetone	8.9	13.0
3	Acetylene	9.8	14.9
4	Air	11.0	20.0
5	Ammonia	8.4	16.0
6	Argon	10.5	22.4
7	Benzene	8.5	13.2
8	Bromine	8.9	19.2
9	Butene	9.2	13.7
10	Butylene	8.9	13.0
11	Carbon dioxide	9.5	18.7
12	Carbon disulphide	8.0	16.0
13	Carbon monoxide	11.0	20.0
14	Chlorine	9.0	18.4
15	Chloroform	8.9	15.7
16	Cyanogen	9.2	15.2
17	Cyclohexane	9.2	12.0
18	Ethane	9.1	14.5
19	Ethyl acetate	8.5	13.2
20	Ethyl alcohol	9.2	14.2
21	Ethyl chloride	8.5	15.6
22	Ethyl ether	8.9	13.0
23	Ethylene	9.5	15.1
24	Fluorine	7.3	23.8
25	Freon-11 (CCl ₃ F)	10.6	15.1
26	Freon-12 (CCl ₂ F ₂)	11.1	16.0
27	Freon-21 (CHCl ₂ F)	10.8	15.3
28	Freon-22 (CHClF ₂)	10.1	17.0
29	Freon-113 (CCl ₂ F-CClF ₂)	11.3	14.0
30	Helium	10.9	20.5
31	Hexane	8.6	11.8
32	Hydrogen	11.2	12.4
33	3H ₂ + 1N ₂	11.2	17.2
34	Hydrogen bromide	8.8	20.9
35	Hydrogen chloride	8.8	18.7
36	Hydrogen cyanide	9.8	14.9
37	Hydrogen iodide	9.0	21.3
38	Hydrogen sulphide	8.6	18.0
39	Iodine	9.0	18.4
40	Mercury	5.3	22.9
41	Methane	9.9	15.5
42	Methyl alcohol	8.5	15.6
43	Nitric oxide	10.9	20.5
44	Nitrogen	10.6	20.0
45	Nitrosyl chloride	8.0	17.6
46	Nitrous oxide	8.8	19.0
47	Oxygen	11.0	21.3
48	Pentane	7.0	12.8
49	Propane	9.7	12.9
50	Propyl alcohol	8.4	13.4
51	Propylene	9.0	13.8
52	Sulphur dioxide	9.6	17.0
53	Toluene	8.6	12.4
54	2, 3, 3-trimethylbutane	9.5	10.5
55	Water	8.0	16.0
56	Xenon	9.3	23.0

* (By permission from *Chemical Engineers' Handbook*, by J. H. PERRY. Copyright 1950, McGraw-Hill Book Company Inc.)

To convert to lb/ft-sec. multiply by 0.000672
To convert to lb/ft-hr multiply by 2.42

April 5, 1988

Erlanger Medical Center

Residence Time Calculations in Post-Main Chamber Combustion

ZONE A: Exit tunnel from main chamber
Exit temp = 1500°F.
Exit area = 666 in² or 4.625 ft²
Gas volume = 1660 scfm
Exit length = 3.5 ft.

Find residence time in seconds:

$$1660 \times \frac{(1500 + 460)}{(60 + 460)} \times \frac{1 \text{ min}}{60 \text{ sec}} = 4.25 \times V$$

$$104.26 = 4.25 \times V$$

$$V = 22.54 \text{ ft/sec}$$

$$\text{Time} = \frac{3.5}{22.54 \text{ ft/sec}} = 0.15 \text{ sec.}$$

ZONE B: Zone temp = 1800°F.
Zone area cross section = 1075 in² or 7.465 ft²
Zone gas volume = 1660 scfm + 2/3 1660
Zone passage length = 17.5 ft.

Find residence time in seconds:

$$(1660 + 1106.66) \times \frac{(1800 + 460)}{(60 + 460)} \times \frac{1 \text{ min}}{60 \text{ sec}} = 7.465 \times V$$

$$200.35 = 7.465 \times V$$

$$V = \frac{200.35}{7.465}$$

$$V = 26.856$$

$$\text{Time} = \frac{17.5}{26.856} = 0.65 \text{ sec}$$

ZONE C: Zone temp = 1800°F.
Zone area cross section = 1320 in² or 9.16 ft²
Zone gas volume = 1660 scfm + 2/3 1660 + 2/3 1660
Zone passage length = 8.83 ft.

Find residence time in seconds:

$$(1660 + 1106 + 1106) \times \frac{(1800 + 460)}{(60 + 460)} \times \frac{1 \text{ min}}{60 \text{ sec}} = 9.16 \times V$$

$$280.4 = 9.16 \times V$$

$$V = 30.6$$

$$\text{Time} = \frac{8.83}{30.6} = .288 \text{ sec}$$

ZONE D: Zone temp = 1800°F.
Zone area cross section = 1661 in² or 11.54 ft²
Zone gas volume = 1660 scfm + 2/3 1660 + 2/3 1660
Zone passage length = 24.66 ft

Find residence time in seconds:

$$280.4 = 11.54 \times V$$
$$V = 24.29$$

$$\text{Time} = \frac{24.66}{24.29} = 1.01 \text{ sec}$$

Total post combustion chamber residence time equals:

$$T = 0.15 + 0.65 + 0.288 + 1.01 \text{ seconds}$$

$$\begin{array}{c} \text{+-----+} \\ | T = 2.098 \text{ seconds} | \\ \text{+-----+} \end{array}$$

THE ALMEGA CORPORATION

CALCULATION OF REYNOLDS NUMBER (Re)
FOR ZONES A, B, C & D AND TURBULENT FLOW DETERMINATION

$Re = \frac{u\rho D}{\mu}$ where: u = velocity ft/sec

D = characteristic dimension ft

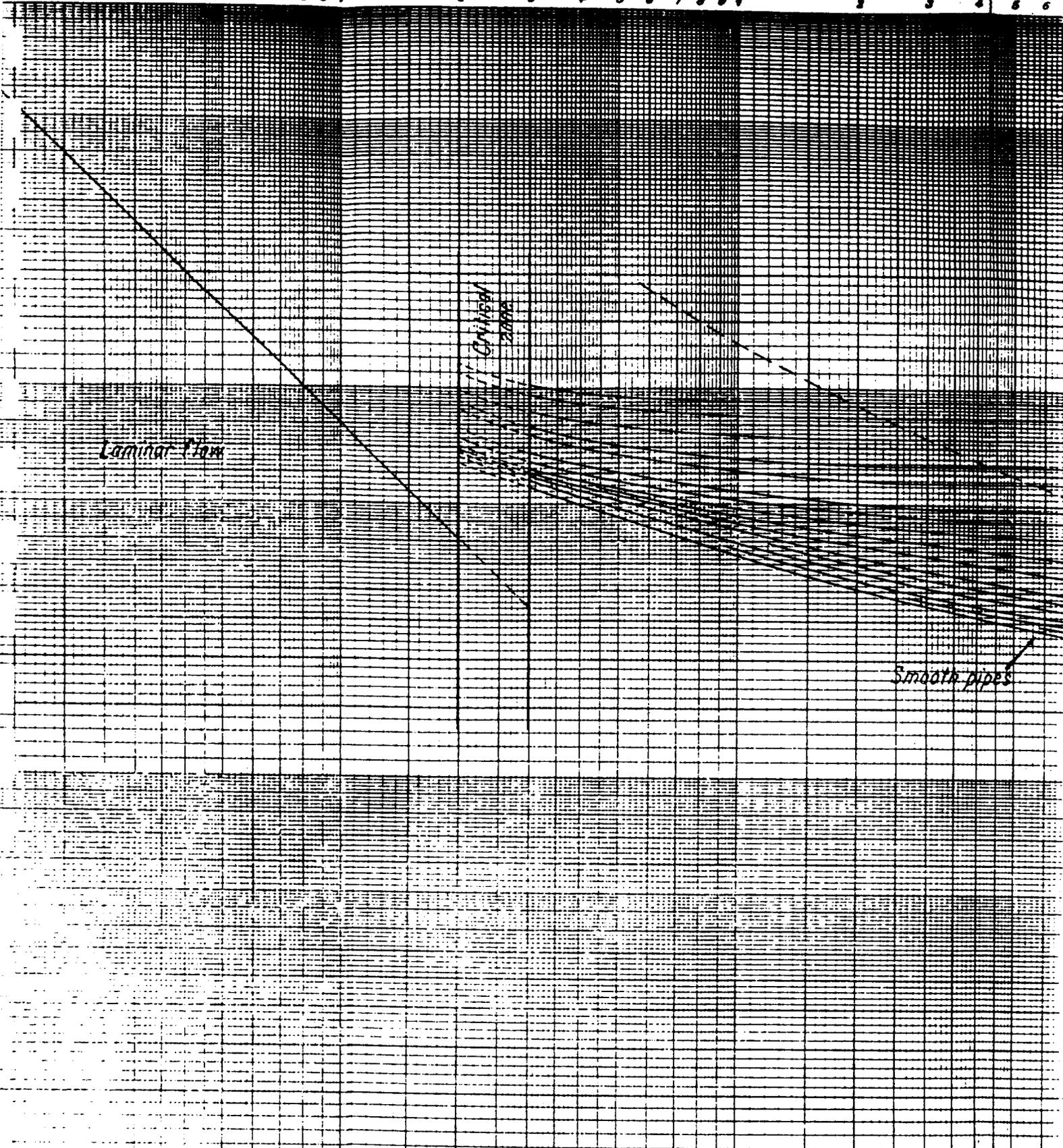
ρ = density lbs/ft³

μ = viscosity lb/ft sec

Units: $Re = \frac{ft}{sec} \cdot \frac{ft}{ft^3} \cdot \frac{lbs}{ft^3} \cdot \frac{ft \cdot sec}{lbs}$ dimensionless

Zone (Temp °F)	Velocity u ft/sec	Characteristic Dimension Diameter D ft	Density (from Table 1 and test data) ρ lbs/ft ³	Viscosity (of air: see attached) μ lb/ft sec	Reynolds No. Re Dimensionless
A (1500°F)	22.54	29.1/12	$\frac{(28.24 \times 528)}{386}$ 1960	(0.0435×0.000672)	36900
B (1800°F)	26.856	37/12	$\frac{(28.24 \times 528)}{386}$ 2260	(0.0465×0.000672)	45300
C (1800°F)	30.6	41/12	$\frac{(28.24 \times 528)}{386}$ 2260	(0.0465×0.000672)	57200
D (1800°F)	24.29	46/12	$\frac{(28.24 \times 528)}{386}$ 2260	(0.0465×0.000672)	51000

2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10 2 3 4 5 6



Laminar flow

Critical
Re = 2300

Smooth pipes

$$Re = \frac{\rho u d \rho}{\mu}$$

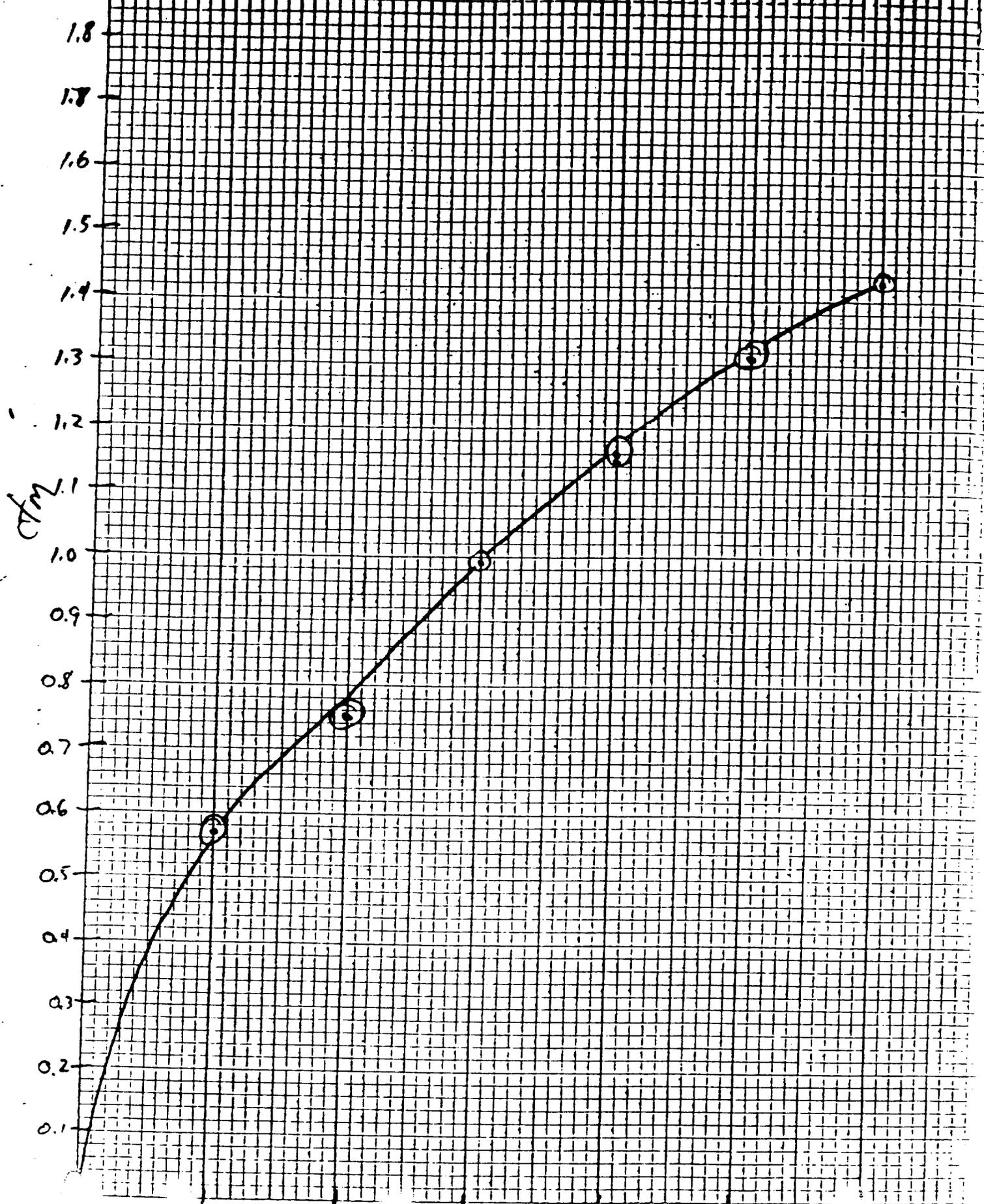
↓ ↓ ↓
A B C

The ALMEGA CORPORATION

APPENDIX R

EQUIPMENT CALIBRATIONS

WATER BOX #2



CHESAPEAKE LABOR CO. CASE 10 X 10 DIVISIONS PER INCH 30 X 30 DIA. PAPER

STRAIGHT IMPRESSION

100% U.M.I. 4 C.T. 1987 100% U.M.I.

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

DATE 2/26/88 THERMOCOUPLE NUMBER METER BOX 2
 AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.59 in. Hg.
 CALIBRATOR HE REFERENCE: MERCURY-IN-GLASS
 OTHER _____

REFERENCE POINT NUMBER ^a	SOURCE ^b (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, ° %
METER IN	WATER & ICE	33	32	0.2
	WATER	85	87	0.4
	WATER	134	135	0.2
METER OUT	WATER & ICE	34	34	0
	WATER	88	90	0.4
	WATER	137	137	0

^a Every 50°F for each reference point.

^b Type of calibration system used.

^c
$$\frac{[(\text{ref temp, } ^\circ\text{F} + 460) - (\text{test thermom temp, } ^\circ\text{F} + 460)]}{\text{ref temp, } ^\circ\text{F} + 460} \times 100 \leq 1.5\%$$

The Almeda Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

SAMPLE BOX 1

DATE 2/26/88 THERMOCOUPLE NUMBER OVEN/DMP. OUT

AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.54 in. Hg.

CALIBRATOR HR REFERENCE: MERCURY-IN-GLASS

OTHER _____

REFERENCE POINT NUMBER ^a	SOURCE ^b (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, ° %
OVEN	WATER	151	150	0.2
	WATER	210	209	0.1
	OIL	265	265	0
DMP OUT	WATER/ICE	34	35	0.2
	WATER	85	86	0.2
	WATER	136	136	0

^a Every 50°F for each reference point.

^b Type of calibration system used.

^c $\frac{[(\text{ref temp, } ^\circ\text{F} + 460) - (\text{test thermom temp, } ^\circ\text{F} + 460)]}{\text{ref temp, } ^\circ\text{F} + 460} \times 100 \leq 1.5\%$

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

DATE 2/26/88 THERMOCOUPLE NUMBER SAMPLE BOX 5 OVEN / IMP. OUT
 AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.54 in. Hg.
 CALIBRATOR He REFERENCE: MERCURY-IN-GLASS
 OTHER _____

REFERENCE POINT NUMBER ^a	SOURCE ^b (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, ° %
OVEN	WATER	150	150	0
	WATER	201	200	0.2
	Oil	253	252	0.1
IMP. OUT	WATER ETC	32	33	0.2
	WATER	85	85	0
	WATER	135	136	0.2

^a Every 50°F for each reference point.

^b Type of calibration system used.

^c
$$\frac{[(\text{ref temp, } ^\circ\text{F} + 460) - (\text{test thermom temp, } ^\circ\text{F} + 460)]}{\text{ref temp, } ^\circ\text{F} + 460} \times 100 \leq 1.5\%$$

The ALMEGA Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

DATE 2/26/88 THERMOCOUPLE NUMBER SAMPLE BOX 6 OVEN / IMP. OUT
 AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.54 in. Hg.
 CALIBRATOR HR REFERENCE: MERCURY-IN-GLASS
 OTHER _____

REFERENCE POINT NUMBER ^a	SOURCE ^b (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, ° %
OVEN	WATER	150	152	0.3
	WATER	200	198	0.3
	OIL	250	251	0.1
IMP. OUT	WATER & ICE	33	35	0.4
	WATER	85	85	0
	WATER	136	135	0.2

^a Every 50°F for each reference point.

^b Type of calibration system used.

^c
$$\frac{[(\text{ref temp, } ^\circ\text{F} + 460) - (\text{test thermom temp, } ^\circ\text{F} + 460)]}{\text{ref temp, } ^\circ\text{F} + 460} \times 100 \leq 1.5\%$$

The ALMEGA CORPORATION

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

DATE 2/26/88 THERMOCOUPLE NUMBER DIGI-SENSE 3
 AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.54 in. Hg.
 CALIBRATOR HC REFERENCE: MERCURY-IN-GLASS
 OTHER _____

REFERENCE POINT NUMBER ^a	SOURCE ^b (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, ° %
THERMO-COUPLE	WATER	60	60	0
	WATER	110	110	0
	WATER	161	160	0.2
	WATER	212	210	0.3

^a Every 50°F for each reference point.

^b Type of calibration system used.

^c
$$\frac{[(\text{ref temp, } ^\circ\text{F} + 460) - (\text{test thermom temp, } ^\circ\text{F} + 460)]}{\text{ref temp, } ^\circ\text{F} + 460} \times 100 \leq 1.5\%$$

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube Assembly level? ✓ yes _____ no

Pitot tube openings damaged? _____ yes (explain below) ✓ no

$\alpha_1 = \underline{1.5}^\circ (<10^\circ)$, $\alpha_2 = \underline{5.0}^\circ (<10^\circ)$, $\beta_1 = \underline{4.0} (<5^\circ)$,

$\beta_2 = \underline{0}^\circ (<5^\circ)$

$\gamma = \underline{0}^\circ$, $\theta = \underline{2}^\circ$, $A = \underline{(25)}$ cm (in.)

$z = A \sin \gamma = \underline{0}$ cm (in.); <0.32 cm ($<1/8$ in.),

$w = A \sin \theta = \underline{0.09}$ cm (in.); <0.08 cm ($<1/32$ in.).

$P_A \underline{.367}$ cm (in.) $P_b \underline{.355}$ cm (in.)

$D_t = \underline{\hspace{2cm}}$ cm (in.)

Comments: OK

Calibration required? _____ yes X no

THE ALMEGA CORPORATION

NOZZLE CALIBRATION DATA FORM

DATE: 3-16-88 CALIBRATED BY: [Signature]

NOZZLE IDENTIFICATION NUMBER	NOZZLE DIAMETER ^a			ΔD ^b mm (in.)	D _{avg} ^c
	D ₁ mm (in.)	D ₂ mm (in.)	D ₃ mm (in.)		
#204	.315	.315	.315	0	.315

Where:

- ^a D_{1,2,3} = Three different nozzle diameters, mm (in.); each diameter must be within (0.025 mm) 0.001 in.
- ^b ΔD = Maximum difference between any two diameters, mm (in.), ΔD ≤ (0.10 mm) 0.004 in.
- ^c D_{avg} = Average of D₁, D₂ and D₃.

The ALMEGA CORPORATION

NO_x FLASKS

<u>FLASK #</u>	<u>VOLUME (ml)</u>
1	2118
2	2062
3	2101
4	2095
5	2072
6	2069
7	2049
8	2077
10	2080
11	2103
12	2087
13	2090
14	2093
15	2070
16	2074
17	2075
18	2064
19	2125
20	2066
21	2059
22	2076
23	2043
23A	2126
24	2059
25	2087
26	2115
27	2076
28	2013
29	2113
33	2131
35	2059
37	2097
72	2088
92	2057

30 - 2093

31 - 2078

32 - 2086

33A - 2097

34 - 2083

INTER-LABORATORY STUDY RESULTS

DATE PRINTED: 07/15/88

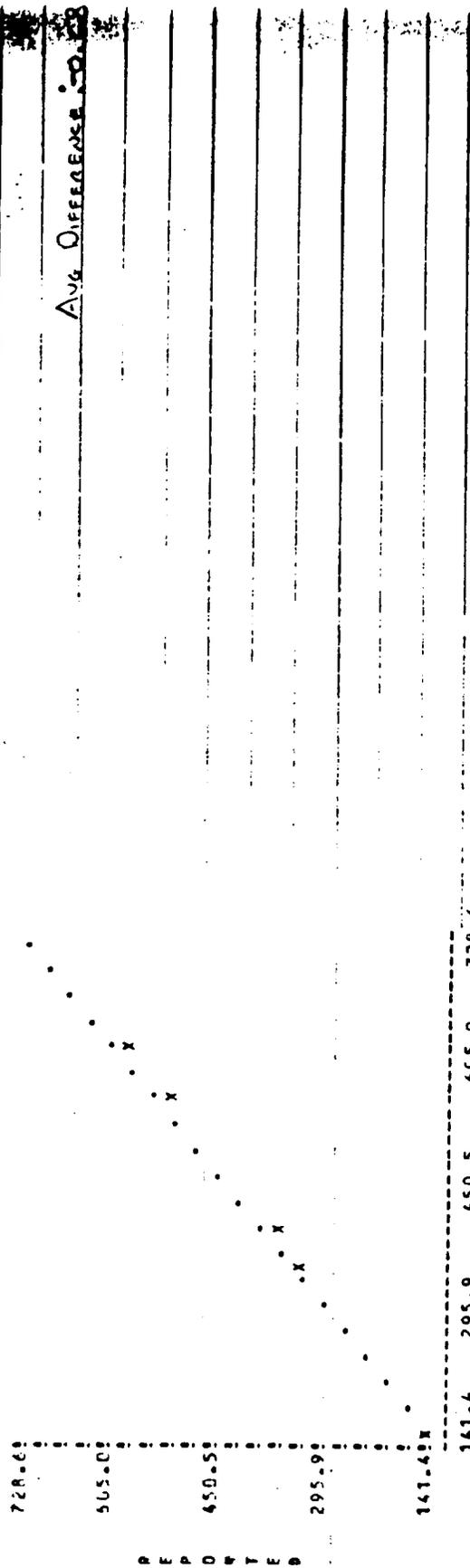
(APRIL 1986)

POLLUTANT - NOX

1200R
 W. K. TRZUPEK
 ALMERA CORP.
 607-C COUNTRY CLUB DR.
 BENSENVILLE, IL 60106

UNITS - MILLIGRAMS PER DRY STD CUBIC METERS

SAMPLE NUMBER	REPORTED VALUE	EPA VALUE	PERCENT DIFFERENCE
21P2	603.0	520.0	-2.76
3044	517.0	555.0	-6.85
5271	126.0	130.0	-3.08
7233	349.0	350.0	-0.29
9062	374.0	390.0	-4.10



EPA RESULTS

V = .948 ± 6.026

INTER-LABORATORY STUDY RESULTS

DATE PRINTED: 06/16/87

(APRIL 1987)

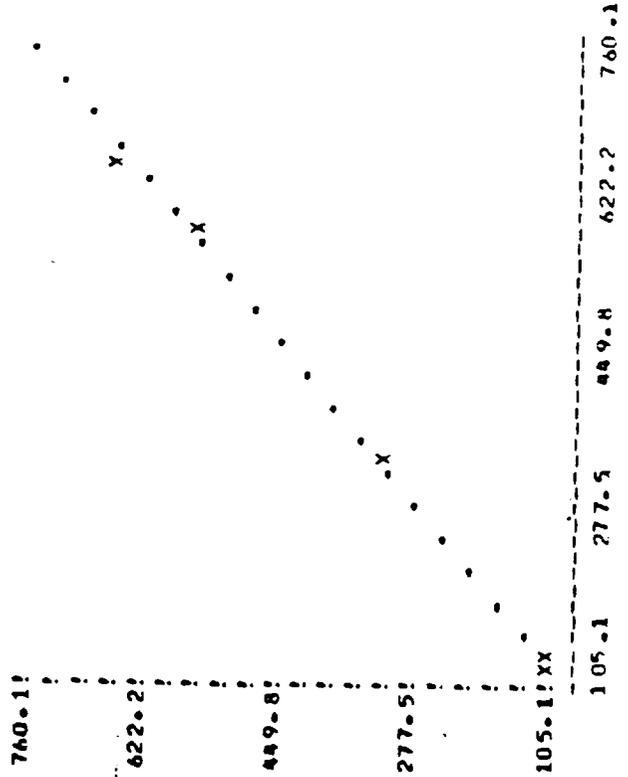
POLLUTANT - NOX

12R008

MR. R. TRZUPEK
ALPHA CORP.
607-C COUNTRY CLUB DR.
BENSenville, IL 60106

UNITS - MILLIGRAMS PER DRY STU CUBIC METER

SAMPLE NUMBER	RECORDED VALUE	EPA VALUE	PERCENT DIFFERENCE
4256	87.9	99.5	-11.66
5277	107.7	125.1	-13.91
6541	663.2	649.5	2.11
8272	557.4	590.0	-5.53
9371	332.6	329.9	.82



AP-42 Emission Factor Development
 Paper Number 34

Type	Facility	Reference	Run	Pollutant	Emission Factor lb/ton	mg/Mg	Quality Rating
3	Chatt-Ham	34	1	Particulate Matter	1.90E-01	9.50E+04	A
3	Chatt-Ham	34	2	Particulate Matter	2.60E-01	1.30E+05	A
3	Chatt-Ham	34	3	Particulate Matter	3.60E-01	1.80E+05	A
3	Chatt-Ham	34	4	Particulate Matter	4.10E-01	2.05E+05	A
3	Chatt-Ham	34	5	Particulate Matter	2.70E-01	1.35E+05	A
3	Chatt-Ham	34	6	Particulate Matter	3.20E-01	1.60E+05	A
3	Chatt-Ham	34	1	Hydrogen Chloride	1.29E+01	6.46E+06	A
3	Chatt-Ham	34	2	Hydrogen Chloride	8.32E+00	4.16E+06	A
3	Chatt-Ham	34	3	Hydrogen Chloride	2.00E+01	9.99E+06	A
3	Chatt-Ham	34	4	Hydrogen Chloride	8.11E+00	4.05E+06	A
3	Chatt-Ham	34	5	Hydrogen Chloride	3.63E+01	1.81E+07	A
3	Chatt-Ham	34	6	Hydrogen Chloride	5.26E+01	2.63E+07	A
3	Chatt-Ham	34	1	Carbon Monoxide	2.16E-01	1.08E+05	A
3	Chatt-Ham	34	2	Carbon Monoxide	2.55E-01	1.27E+05	A
3	Chatt-Ham	34	3	Carbon Monoxide	1.44E-01	7.18E+04	A
3	Chatt-Ham	34	4	Carbon Monoxide	2.17E-01	1.08E+05	A
3	Chatt-Ham	34	5	Carbon Monoxide	6.59E-01	3.29E+05	A
3	Chatt-Ham	34	6	Carbon Monoxide	2.52E+00	1.26E+06	A
3	Chatt-Ham	34	5	Oxides of Nitrogen	6.56E+00	3.28E+06	A
3	Chatt-Ham	34	6	Oxides of Nitrogen	7.71E+00	3.86E+06	A

AP-42 Emission Factor Development
 Paper Number 34

Replicate Charge (#)	PM		HC1		C12		Stack Flow Rate		CO Emissions		CO		NOx	
	Rate (lbs/hr)	Emiss. Factor (lb/ton)	Rate (lbs/hr)	Emiss. Factor (lb/ton)	Rate (lbs/hr)	Emiss. Factor (lb/ton)	Rate (dscfm)	Concen. (ppmv) @ 7% O2	Rate (dscfm)	Concen. (ppmv) as meas.	Emiss. Rate (lbs/hr)	Factor (lb/ton)	Emiss. Rate (lbs/hr)	Factor (lb/ton)
1	1737	0.1661	0.19	11.21	12.91	0	0.00	322100	5368	8.00	5.8137E-07	0.1873	0.21561	
2	1309	0.1697	0.26	5.446	8.32	0	0.00	327500	5458	7.00	5.0869E-07	0.1666	0.25454	
3	1324	0.2352	0.36	13.22	19.97	0	0.00	327000	5450	4.00	2.9068E-07	0.0951	0.14358	
4	1074	0.2211	0.41	4.354	8.11	0	0.00	320400	5340	5.00	3.6335E-07	0.1164	0.21679	
5	1172	0.1572	0.27	21.25	36.26	0	0.00	354000	5900	15.00	1.0901E-06	0.3859	0.65850	3.842 6.55631
6	1058	0.1689	0.32	27.81	52.57	0	0.00	366200	6103	50.00	3.6335E-06	1.3306	2.51531	4.079 7.71078