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.

(4.)

CAMPBELL & ASSOCIATES, INC.
CONSULTING ENGINEERS
701 EAST FOURTH STREET
CHATTANOOGA, TN 37403
615-267-9718

JOHN F. GERM, P.E.
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VICE PRESIDENT

MAY 1988
RECEIVED
11:13a.m.

May 26, 1988

Mr. Wayne Cropp, Director
Chattanooga-Hamilton County Air
Pollution Control Bureau
3511 Rossville Boulevard
Chattanooga, TN 37407

Reference #19

Dear Wayne:

SUBJECT: ERLANGER MEDICAL CENTER - INCINERATOR & BAGHOUSE, SOUTH UNIT
STACK EMISSION TESTING - C&A #86-138

On May 12, 1988, we forwarded you a copy of Almega Corporation's report on the stack emission testing for the South Unit which was performed on April 21-22, 1988. As noted in our letter, repetition #3 was omitted since the data had been taken by the Air Pollution Control Bureau and had not been forwarded to The Almega Corporation. It is my understanding that a member of your staff was concerned about an incomplete report and requested that Table 1 be reworked to include the data from the test #3.

Please find enclosed, replacement sheets for Table 1. The data that is included in run 3 is as received from Pat Patrick of your office on May 23, 1988.

I trust this is the final information which your office needs in order to issue full operating permits for Erlanger Medical Center. I would, again, call your attention to the letter which was previously forwarded to you from Basic Environmental Engineering, Inc., dated April 25, 1988 concerning permit conditions. I would appreciate the opportunity to discuss these with you prior to your issuing the permit so that we can have as clear an understanding on the operation of the system as possible.

The lab data should go into Appendix "K".

Should you have any questions concerning this, please do not hesitate to contact me.

Very truly yours,

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

JFG/db

Encl.

The Almega Corporation

SUMMARY OF EMISSION TEST DATA

TABLE: 1

PLANT: Erlanger Medical Center, Chattanooga, Tennessee

LOCATION: South Incinerator Stack

OPERATORS: B. W. Jackson and E. Aynsley, Ph.D.

TEST DATE: April 21, 1988

REPETITION #:	1	2	3	5†
TEST TIME:	11:05-12:08PM	12:50-1:55PM	2:15-3:18PM	4:40-5:43PM
STACK GAS				
Temperature, average °F	206.1	206.4	210.6	200.7
Velocity average fps	35.03	34.65	85.83	35.58
Volume flow x 10^6 scfh db	0.2579	0.2606	0.2595	0.2644
acfm	6,195	6,129	6,338	6,293
Orsat % CO_2	6.9	6.0	5.4	4.8
% O_2	11.7	12.9	13.8	13.6
CO_2% from gas*	2.105	2.083	2.092	2.053
CO_2 correction factor*	2.503	3.064	3.628	4.368
*see Appendix K				
Moisture %	10.18	8.193	11.01	10.08
PARTICULATE SAMPLE				
Time, mins.	60	60	60	60
Volume scf db	44.433	44.299	44.148	44.930
Particulates collected, mg.				
Filter	4.8	0.0	‡ 3.3+	3.1
Washings	28.9	13.0	‡19.1+	5.8
Total	33.7	13.0	‡22.4+	8.9
Isokinetic Ratio, I%	95.74	94.44	94.54	94.43
INCINERATOR FEED lbs/test	1,227	1,048	1,145	1,051
PARTICULATE				
Concentration grains/dscf				
as measured	0.01170	0.004528	‡0.007829	0.003057
corrected to 12% CO_2	0.02929	0.01387	‡0.02840	0.01335
Emissions lbs/hr	0.4313	0.1686	‡0.2903	0.1155
HYDROGEN CHLORIDE				
Concentration ppm	225.6	527.7	486.9	734.2
Emissions lbs/hr	5.516	13.04	11.98	18.40

† Run 4 rejected.
‡ Samples transferred to CHCAPCB April 21, 1988.
+ As received by phone from Pat Patrick, CHCAPCB on May 23, 1988.

SAMPLE HANDLED BY CHCAPCB

The Almega Corporation

INFORMATION RECEIVED BY PHONE FROM PAT PATE CHCAPCB ON 5/23/88

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger — STACK NUMBER: _____

LOCATION: Chattanooga, Tn. — RUN NUMBER: R3

DATE: 4/21/88 — RELATIVE HUMIDITY: 50 %

ACETONE DENSITY (Pa): 0.7870 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0085 mg/g

ACETONE RINSE VOLUME (Vaw) 150 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 _____ GROSS WT. _____ mg

TIME OF WEIGHING _____

DATE OF WEIGHING _____ GROSS WT. _____ mg

TIME OF WEIGHING _____

AVERAGE GROSS WT. 20.1 mg

LESS BLANK RESIDUE (Wa) 1.0 mg

TARE WT. _____ mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 19.1 mg

DATE OF WEIGHING _____ GROSS FILTER WT. _____ mg

TIME OF WEIGHING _____

DATE OF WEIGHING _____ GROSS FILTER WT. _____ mg

TIME OF WEIGHING _____

AVERAGE GROSS WT. _____ mg

FILTER TARE WT. _____ mg

WEIGHT OF PARTICULATE ON FILTER 3.3 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 19.1 mg

TOTAL WEIGHT OF PARTICULATE 22.4 mg

REMARKS: _____

INITIALS OF ANALYST [signature]

CAMPBELL & ASSOCIATES, INC.
CONSULTING ENGINEERS
701 EAST FOURTH STREET
CHATTANOOGA, TN 37403
615-267-9718

JOHN F. GERM, P.E.
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WYLIE W. GROSS, JR.
VICE PRESIDENT

May 12, 1988

Mr. Wayne Cropp, Director
Chattanooga-Hamilton County Air Pollution
Control Bureau
3511 Rossville Boulevard
Chattanooga, TN 37407

Dear Wayne:

SUBJECT: ERLANGER MEDICAL CENTER - INCINERATOR & BAGHOUSE, SOUTH UNIT
STACK EMISSION TESTING - C&A PROJECT #86-238

Please find enclosed, a copy of the Almega Corporation's report on the stack emission testing for the South Unit performed on April 21-22, 1988. Almega is an independent testing agency which performed the test on the North Unit. The report would indicate that the unit met the requirements as outlined in the Consent Decree on Tests 1, 2 and 5 with the Bureau having the data on Test #3, so those numbers are not available to us for this report. Table 2 indicates the test which was run on April 22, 1988 at 2,000° would still meet the requirements as outlined in the Consent Decree. Please note that under Test 4 where the baghouse was completely bypassed that the emissions were satisfactory, but that the concentration corrected to 12% CO_2 was above the .08 grains as stipulated in the Consent Decree. This is the test run which I contacted you about so that we could see what the performance of the baghouse was.

I would also call your attention to the letter which I had previously forwaded to you from Basic Environmental Engineering, Inc. dated April 25, 1988 concerning permit conditions. I think that there are several good points outlined in the letter which I would appreciate your review and having the opportunity to discuss these with you prior to the issuance of any final permits.

Thank you very much for your cooperation in this matter.

Very truly yours,

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

JFG/db

Encl.

CAMPBELL & ASSOCIATES, INC.
CONSULTING ENGINEERS
701 EAST FOURTH STREET
CHATTANOOGA, TN 37403
615-267-9718

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

APR 1988
RECEIVED
4:18 p.m.

April 20, 1988

Mr. J. Wayne Cropp, Director
Chattanooga-Hamilton County Air
Pollution Control Bureau
3511 Rossville Boulevard
Chattanooga, TN 37407

Dear Wayne:

SUBJECT: ERLANGER MEDICAL CENTER - INCINERATOR & BAGHOUSE, NORTH UNIT
STACK EMISSION TESTING - C&A PROJECT #86-238

Please find enclosed a copy of the Almega Corporation report on the stack emission testing for the North Unit performed on March 23-24, 1988. The testing was performed by an independent agency and as has previously been reported to you, the results were excellent. The report indicates that the North Unit did, in fact, meet all of the requirements as outlined in the Consent Decree, and furthermore, on Tests 5 and 6, met the requirements under more adverse conditions which were required by the specifications.

We would appreciate your review of this report and if you find it acceptable, we would appreciate a permit being issued to operate the North Unit as we have previously discussed.

Should you need additional information on this, we would appreciate your contacting us so that we may send it to you as soon as possible.

Very truly yours,

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

JFG/db

Encl.

cc: Mr. Tom Cowan, Vice-President of Support Services, Erlanger Medical Center, 975 East Third Street, Chattanooga, TN 37403, w/enclosure.

THE ALMEGA CORPORATION

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

MAY 1988
RECEIVED

ERLANGER MEDICAL CENTER
BASIC MODEL 1250
INCINERATOR AND BAGHOUSE
SOUTH UNIT
STACK EMISSION TESTING
APRIL 21 AND 22, 1988
THE ALMEGA CORPORATION PROJECT I-6299
THE ALMEGA CORPORATION REPORT I-6299-2

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

May 6, 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
South Unit
Stack Emission Testing
April 21 and 22, 1988
The Almega Corporation Project I-6299
The Almega Corporation Report I-6299-2

Gentlemen:

INTRODUCTION

A series of stack emission tests were conducted on Erlanger's South Unit, Basic Model 1250 incinerator and dry lime injector baghouse at the Erlanger Medical Center in Chattanooga, Tennessee on April 21 and 22, 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 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. Additionally, carbon monoxide and nitrogen oxide emission testing was performed on both days.

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

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 south incinerator unit at the Erlanger Medical Center in Chattanooga, Tennessee was conducted on April 21 and 22, 1988.

The 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 23¼ 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 CO_2, O_2 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, prefilter glassware washings and filter particulates as detailed in Method 5.

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 and 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 and analysis was also conducted. Specifically, four two-liter grab NO_x samples were taken following Method 7 (Ref. 1) included in Appendix H for each test repetition.

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.

The following test schedule was followed:

Thursday 21 April

Conduct four complete test repetitions for all parameters at 1800°F combustion temperature.

Friday 22 April

Conduct four complete test repetitions for all parameters at 2000°F combustion temperature. The last test repetition was conducted with the baghouse bypassed, thus simulating the baghouse inlet conditions.

SUMMARY OF TEST FINDINGS

Findings of this test series are summarized in Tables 1 and 2 for the April 21 and 22 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, April 21, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO_2 Correction Factor Calculations

L	April 22, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO_2 Correction Factor Calculations
M	April 21 and 22, 1988, Runs 1 to 5 and Runs 1 to 4 respectively, Hydrogen Chloride and Chlorine Laboratory Analyses and Calculations
N	April 21 and 22, 1988, Runs 1 to 5 and Runs 1 to 4 respectively, Nitrogen Oxide Sampling and Analysis Data and Calculations
O	April 21 and 22, 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:

Zone	Residence Time (Seconds)	Reynolds No.
A	0.15	36900
B	0.65	45300
C	0.288	57200
D	1.01	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 South Incinerator Unit and recently installed dry lime injection baghouse at Erlanger Medical Center in Chattanooga, Tennessee on April 21 and 22, 1988.

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

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: South Incinerator Stack

OPERATORS: B. W. Jackson and E. Aynsley, Ph.D.

TEST DATE: April 21, 1988

REPETITION #:	1	2	3	5†
TEST TIME:	11:05-12:08PM	12:50-1:55PM	2:15-3:18PM	4:40-5:43PM
STACK GAS				
Temperature, average °F	206.1	206.4	210.6	200.7
Velocity average fps	35.03	34.65	85.83	35.58
Volume flow x 10^6 scfh db	0.2579	0.2606	0.2595	0.2644
acfm	6,195	6,129	6,338	6,293
Orsat % CO_2	6.9	6.0	5.4	4.8
% O_2	11.7	12.9	13.8	13.6
CO_2% from gas*	2.105	2.083	2.092	2.053
CO_2 correction factor*	2.503	3.064	3.628	4.368
*see Appendix K				
Moisture %	10.18	8.193	11.01	10.08
PARTICULATE SAMPLE				
Time, mins.	60	60	60	60
Volume scf db	44.433	44.299	44.148	44.930
Particulates collected, mg.				
Filter	4.8	0.0	‡	3.1
Washings	28.9	13.0	‡	5.8
Total	33.7	13.0	‡	8.9
Isokinetic Ratio, I%	95.74	94.44	94.54	94.43
INCINERATOR FEED lbs/test	1,227	1,048	1,145	1,051
PARTICULATE				
Concentration grains/dscf				
as measured	0.01170	0.004528	‡0.007823	0.00305
corrected to 12% CO_2	0.02929	0.01387	‡0.02840	0.01335
Emissions lbs/hr	0.4313	0.1686	‡0.2903	0.1155
HYDROGEN CHLORIDE				
Concentration ppm	225.6	527.7	486.9	734.2
Emissions lbs/hr	5.516	13.04	11.98	18.40

† Run 4 rejected.

‡ Samples transferred to CHCAPCB April 21, 1988.

The Almega Corporation

TABLE 1 (continued)

REPETITION #:	1	2	3	5
CHLORINE				
Concentration ppm	- - - All none detected:		less than 0.6 - - -	
Emissions lbs/hr	- - - All none detected:		less than 0.02 - -	
OPACITY %				
Range	0 to 0	0 to 0	0 to 0	0 to 0
Average	0	0	0	0
CARBON MONOXIDE				
Concentration ppm	25	20	20	30
NITROGEN OXIDES (as NO_2)				
Concentration ppm	160.7	84.50	124.3	127.6
	131.4	144.7	120.3	92.47
	111.8	155.1	79.96	93.39
	111.6	93.02	88.96	105.7
Average	128.9	119.3	103.4	104.8
Emissions lbs/hr	4.949	2.630	3.854	4.030
	4.045	4.503	3.732	2.919
	3.443	4.826	2.477	2.948
	3.435	2.895	2.756	3.337
Average	3.968	3.713	3.205	3.309

The Almega Corporation

SUMMARY OF EMISSION TEST DATA

TABLE: 2

PLANT: Erlanger Medical Center, Chattanooga, Tennessee

LOCATION: South Incinerator Stack

OPERATORS: B. W. Jackson and e. Aynsley, Ph.D.

TEST DATE: April 22, 1988

REPETITION #:	1	2	3	4 Bypass Baghouse
TEST TIME:	9:45-10:45AM	11:00-1:01PM	1:12-2:12PM	2:23-3:23PM
STACK GAS				
Temperature, average °F	198.1	199.4	208.2	273.8
Velocity average fps	36.82	35.58	38.42	39.88
Volume flow x 10^6 scfh db	0.2749	0.2653	0.2817	0.2677
acfm	6,513	6,294	6,796	7,055
Orsat % CO_2	5.0	7.9	8.1	7.2
% O_2	13.3	10.0	9.9	10.9
CO_2% from gas*	1.819	1.885	1.775	2.429
CO_2 correction factor*	3.772	1.995	1.897	2.515
*see Appendix L				
Moisture %	9.806	9.773	10.10	9.626
PARTICULATE SAMPLE				
Time, mins.	60	60	60	30 in 60†
Volume scf db	47.629	46.062	49.046	26.954
Particulates collected, mg.				
Filter	7.9	14.5	14.8	72.6
Washings	10.9	15.2	15.3	58.6
Total	18.8	29.7	30.1	131.2
Isokinetic Ratio, I%	96.26	96.45	96.72	95.91

INCINERATOR FEED see Appendix P	Time:	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00
	lbs:	611	949	845	645	725	1,201	1,113	1,278

PARTICULATE			Loader jammed		
Concentration grains/dscf					
as measured	0.006091	0.009949	0.009470	0.07511	
corrected to 12% CO_2	0.02298	0.01985	0.01797	0.1889	
Emissions lbs/hr	0.2393	0.3772	0.3812	0.2873	2.573
HYDROGEN CHLORIDE					
Concentration ppm	399.0	395.4	521.7	907.1	
Emissions lbs/hr	10.40	9.944	13.93	23.02	

† short run, high train vacuum

TABLE 2 (continued)

REPETITION #:	1	2	3	4
CHLORINE				
Concentration ppm	- - - All none detected: less than 0.6 - - -			
Emissions lbs/hr	- - - All none detected: less than 0.02 - - -			
OPACITY %				
Range	0 to 0	0 to 0	0 to 0	0 to 0
Average	0	0	0	0
CARBON MONOXIDE				
Concentration ppm	- - - All none detected: less than 5 - - -			
NITROGEN OXIDES (as NO_2)				
Concentration ppm	89.38	77.40	85.66	146.3
	94.83	96.53	89.23	96.19
	105.3	95.59	81.08	74.80
	96.94	71.70	95.47	81.65
Average	96.61	85.30	87.86	99.74
Emissions lbs/hr	2.933	2.452	2.882	4.677
	3.112	3.059	3.000	3.073
	3.455	3.027	2.727	2.391
	3.181	2.271	3.211	2.610
Average	3.170	2.702	2.955	3.188

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, April 21, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO_2 Correction Factor Calculations
L	April 22, 1988, Runs 1 to 4, Particulate Field Data Calculations, Laboratory Weights, Chain-of-Custody and CO_2 Correction Factor Calculations

APPENDICES

M	April 21 and 22, 1988, Runs 1 to 5 and Runs 1 to 4 Respectively, Hydrogen Chloride and Chlorine Laboratory Analyses and Calculations
N	April 21 and 22, 1988, Runs 1 to 5 and Runs 1 to 4 Respectively, Nitrogen Oxide Sampling and Analysis Data and Calculations
O	April 21 and 22, 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

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 Enviromental Engineering Model 1250 incinerators and heat recovery system to burn hospital normal, infectous, 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 day standard cubic foot of filterable particulate matter emission; and

(b) Not to exceed 0.1 pounds fo filterable particulate matter emission per 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 1800°F 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 pressed 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).

(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, Appendis 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 convience. Should you have any questions please do not hesitate to contact me.

Very truly yours,

John F. Germ, . 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 ^{o}F
velocity fps
moisture % vol/vol
volume flow acfm and scfh db
Orsat CO_2, O_2 and N_2 % vol/vol
total particulate concentration grains/scf and corrected to 12% CO_2
total particulate emission rate lb/hr

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

Method #	Title
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% CO_2 as required for comparison with applicable codes. This correction factor requires allowance be made for the contribution of CO_2 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:

(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.

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:

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.

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 By

Eric Aynsley, Ph.D.
President

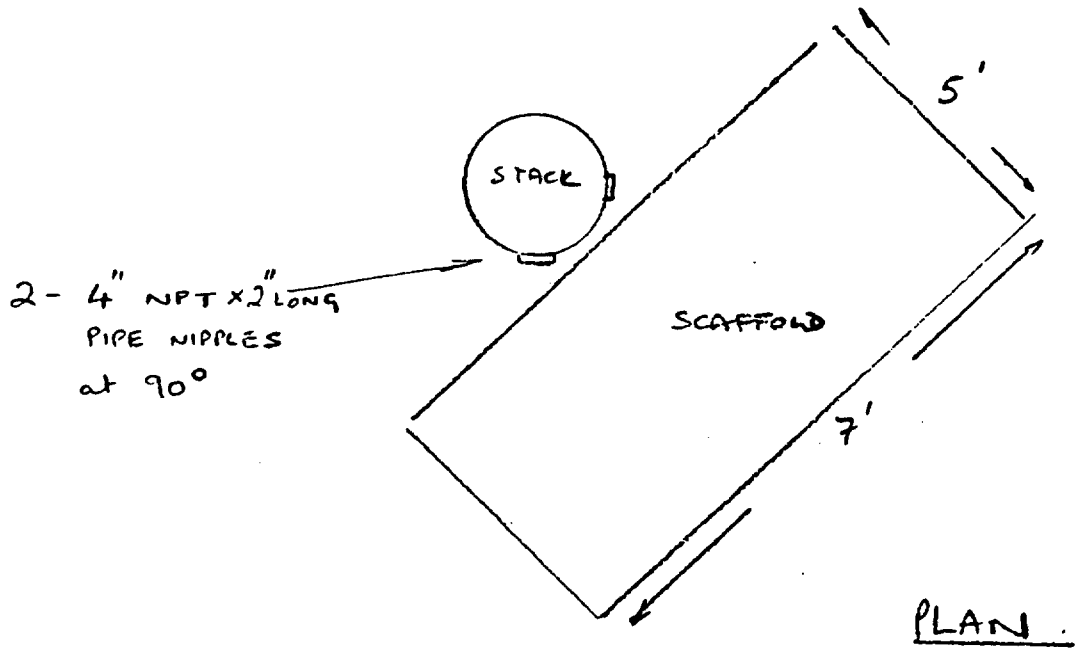
EA:dml

Enclosures

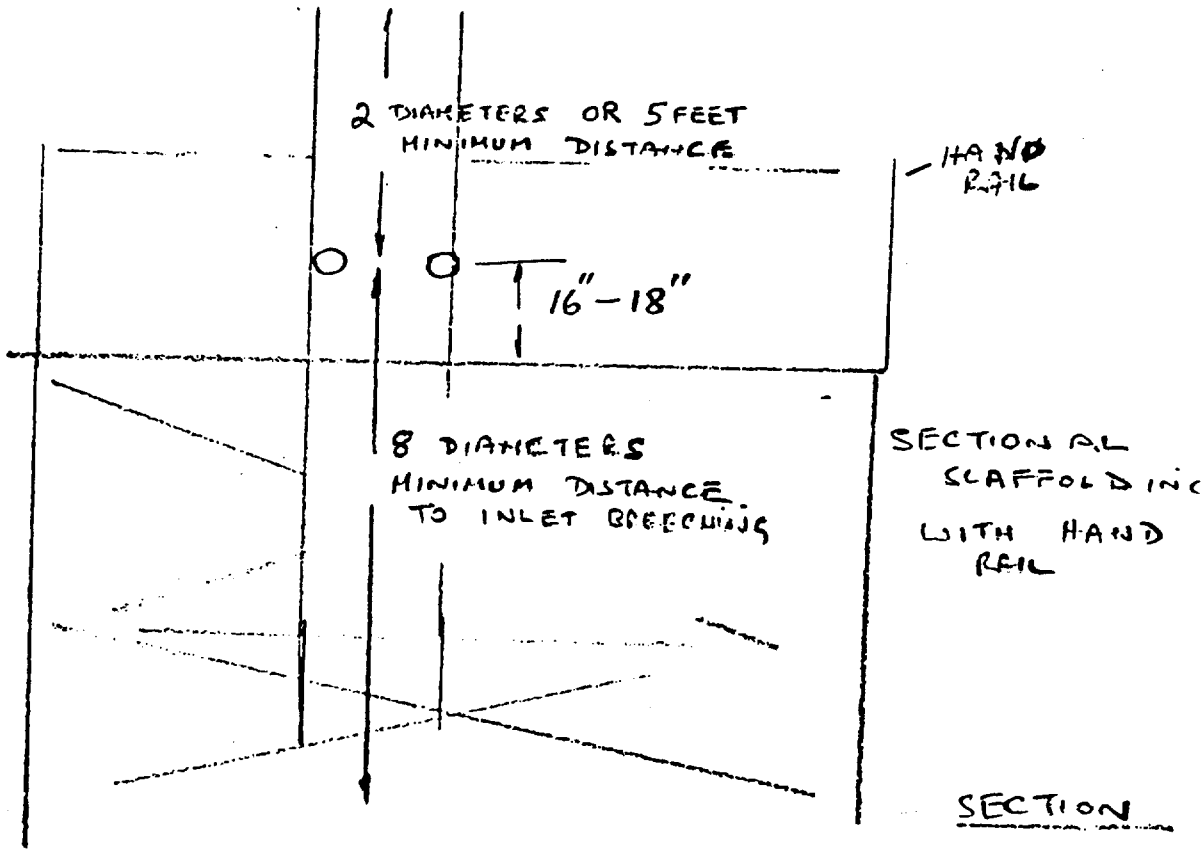
References:
1. Title 40: Code of Federal Regulations
2. Barbeito M.S. et al J. app. Microbiology 16 - 490-495 - 1968
3. Barbeito M.S. et al J. med. Primatol 6 - 264-273 - 1977

The Almega Corporation

SCHEMATIC OF STACK SAMPLING LOCATION



PLAN.



SECTION

DETERMINATION OF CHLORINE AND HYDROCHLORIC ACID IN STACK GAS

SOLUTIONS AND REAGENTS:

1. Distilled-deionized water (DI H_2O Chloride Free)

2. Alkaline arsenite solution
(1.0 N NaOH + 0.1N $NaAsO_2$: Dissolve 40 grams of NaOH and 6.5 gm $NaAsO_2$ in DI H_2O and dilute to 1000 ml with DI H_2O)

3. Alkaline aresenite solution
(2.5 N NaOH and 0.5 N $NaAsO_2$: Dissolve 100 gm of NaOH and 32.5 gm of $NaAsO_2$ in DI H_2O and dilute to 1000 ml with DI H_2O)

4. Ferris alum indicator
(Dissolve 28.0 gm of ferric ammonium sulfate $FeNH_4(SO_4)_2.12\ H_2O$ in 70 ml of hot DI H_2O. Cool and filter. Add 10 ml of concentrated HNO_3 and dilute to 100 ml with DI H_2O)

5. Nitric acid 8.0 N
(Add 100 ml of concentrated HNO_3 to 100 ml of DI H_2O. Boil until colorless and store in a glass bottle)

6. Silver Nitrate solution 0.1N*
(Dissolve 17.0 gm of $AgNO_3$ 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 NH_4CNS in DI H_2O and dilute to 1000 ml with DI H_2O. Standardize this against the $AgNO_3$ solution using Volhard)

8. Sodium Chloride 0.1N*
(Dissolve 5.846 gm of dried NaCl in DI H_2O and dilute to 1000 ml with DI H_2O)

9. Reagent Nitrogenzene

10. Starch solution (I_2 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 I_2 crystals in 25 gm of iodate free KI and 100 ml with DI H_2O. When completely in solution, dilute to 1000 ml with DI H_2O. Store in an amber bottle)

12. Sodium bicarbonate (Reagent grade $NaHCO_3$)

* 0.01 -- Normal solutions may need to be prepared for HCl and Cl_2 concentrations of less than 1000 ppm.

Sampling Train:

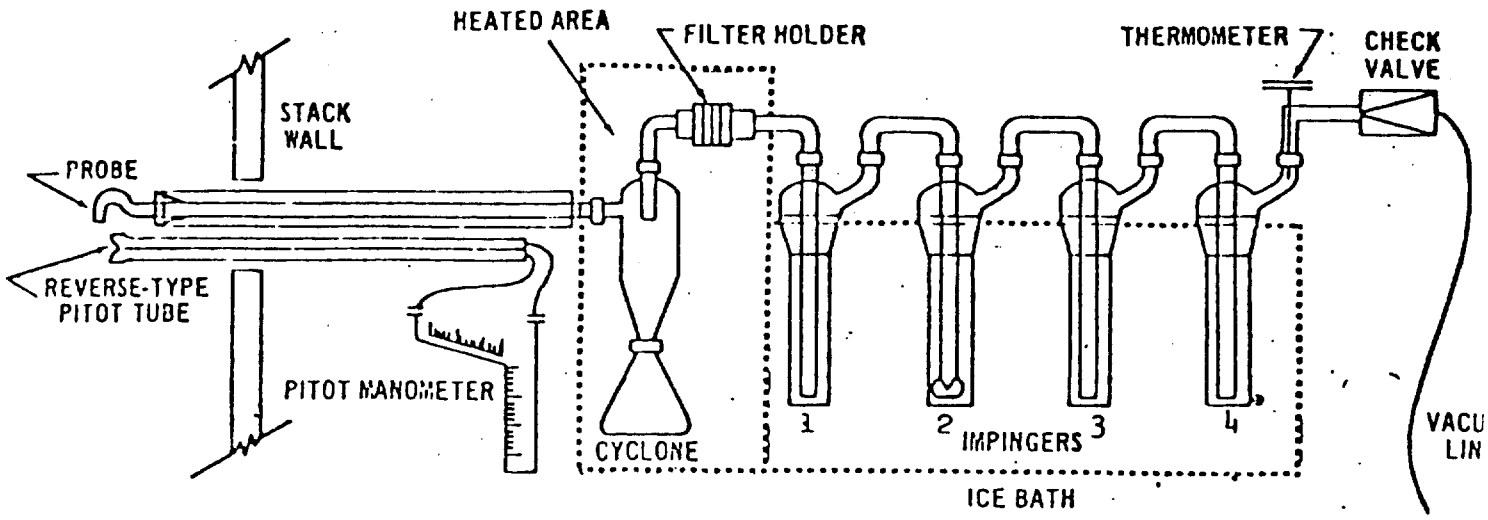


FIGURE II-18

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 H_2O 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 Cl_2 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 Cl_2. 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 I_2 solution where HCl and Cl_2 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 I_2 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 ammononium 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 NH_4CNS solution, as determined previously be titration against standard $AgNO_3$ solution, using ferric alum as an indicator, calculate the net volume of $AgNO_3$ required for precipitation of the chloride.

Calculations:

[(ml $AgNO_3$ x N $AgNO_3$) - (ml NH_4CNS x N NH_4CNS)] x 0.036 = 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 ($NaHCO_3$) 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 I_2 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

[(ml arsenite solution in aliquot x N $NaASO_2$) - (ml I_2 solution x N I_2)] x 0.035 = gms Cl_2 in aliquot

$$0.035 \left[\frac{100\ ml_a\ N_A}{ml_s} - ml_I\ N_I \right] \frac{ml_s}{ml_a} = \text{gm } Cl_2 \text{ in sample}$$

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

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 G. SHUTTLE, P.E.
VICE PRESIDENT
WYLIE 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

CHATTANOOGA-HAMILTON COUNTY HOSPITAL AUTHORITY

ERLANGER MEDICAL CENTER

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

Baroness Erlanger Hospital

T. C. Thompson
Children's Hospital
Medical Center

Willie D. Miller Eye Center

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.

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 in

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,latm,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 contractural 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.

temperature °F
velocity fps
moisture % vol/vol
volume flow acfm and scfh db
Orsat CO_2, O_2 and N_2 % vol/vol
total particulate concentration grains
corrected to 12 % CO_2
total particulate emission rate lb/hr
hydrogen chloride concentrations, lbs/
hydrogen chloride emission rate, lb/hr

The following USEPA (Ref. 1) methods v

Method #	Title
1	Sample and Velocity Trave Sources
2	Determination of Stack Ga Volumetric Flow Rate (Typ
3	Gas Analysis for Carbon D Excess Air and Dry Molecu
4	Determination of Moisture Approximate Method
5	Determination of Particul Stationary Sources
9	Visual Determination of the Emissions from Stationary S

It should be noted that:

(1) Hydrogen chloride emissions will be d and reaction in sodium acetate soluti the Method 5 train. Analysis will be ion electrode method.

(2) Method 5 particulate emissions as mea dard cubic foot (grains/dscf) will be required for comparison with applicab factor requires allowance be made for from the auxiliary natural gas fuel. performing this allowance is to know fired during each test: this require cated gas meter in the gas line to th

(3) A certified observer will be used for servations.

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:

(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.

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.

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

M. R. Jackson

Meryl R. Jackson
Vice-President

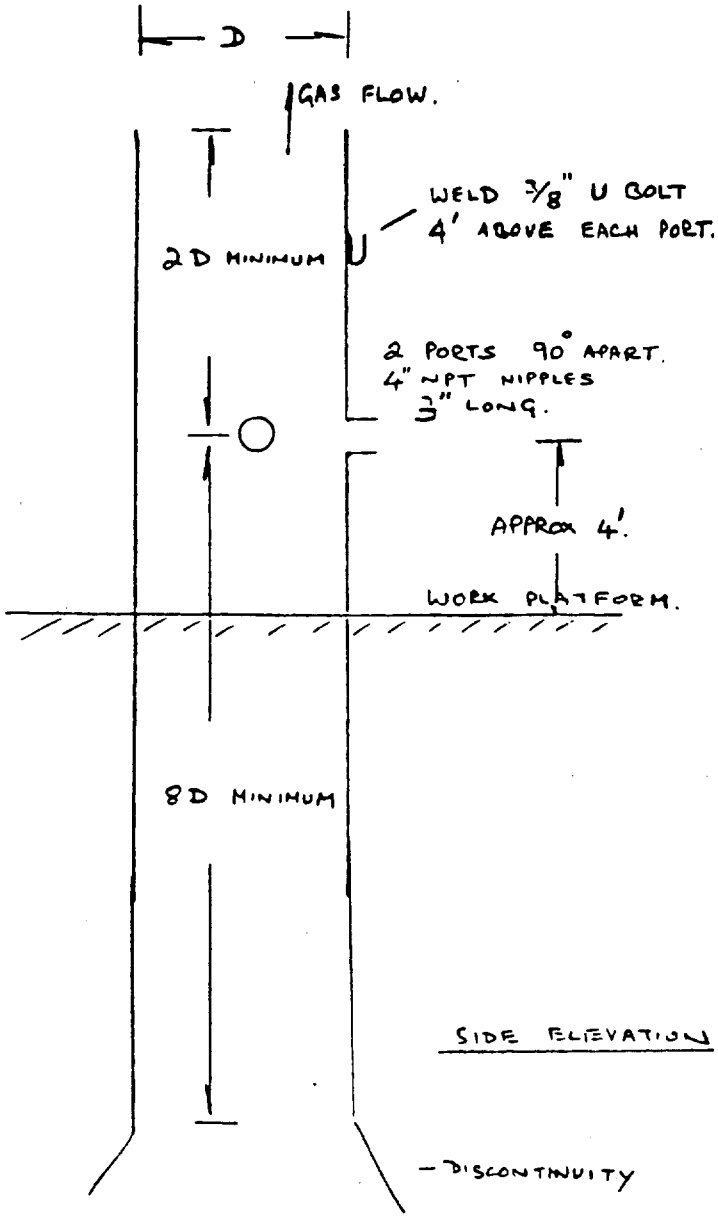
MRJ:dml

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

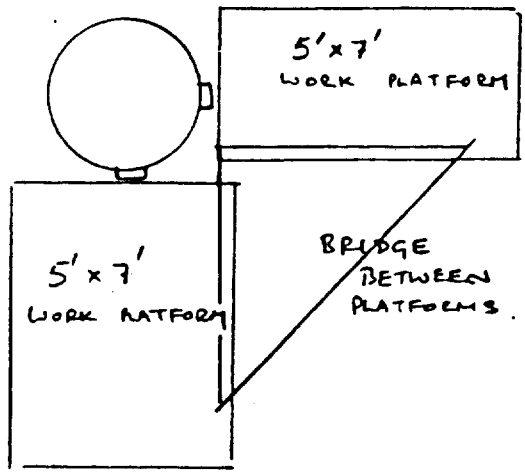
The Almega Corporation



SIDE ELEVATION

IF IT IS NOT POSSIBLE TO LOCATE PORTS AT 2D DOWN AND 8D UP STACK LOCATE 80% OF STRAIGHT LENGH OF STACK

DO NOT LOCATE CLOSER THAN 1/2 D TO TOP OR 2D TO BOTTOM OF STACK.



PLAN VIEW FOR TEMPORARY WORK PLATFO

SKETCH OF REQUIREMENTS FOR TEMPORARY STACK TEST PLATFORMS.

The Almega Corporation

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

March 28, 1988

Mr. John Germ
Campbell & Associates
701 East Fourth Street
Chattanooga, Tennessee 37403

Dear John:

Subject: Project Suggestion
Measurement of
Acid Gas Removal Efficiencies
Hospital Incinerator Lime Injection
Baghouse System
Erlanger Medical Center
TAC File #I-6299

Purpose of this brief Project Suggestion is to put my thoughts on paper for your consideration following the testing of the North Unit at Erlanger last week.

The combination dual incinerator and lime injection baghouse system being started up at Erlanger Medical Center is extremely advanced and probably one of the first lime injection baghouse systems on an incinerator and especially a hospital waste incinerator.

Having spent the last twenty years involved in full time testing of air pollution control systems in the U.S. I was very impressed last Wednesday at the way this system was just "plugged in, switched on and placed faultlessly (almost!) on-line" and the complete agency witnessed tests were completed. I feel that all concerned in the selection, specification, design, installation and start up are to be highly complimented.

However, and now comes the plug for additional test work, I think it would be in the interests of all concerned to determine the acid gas removal efficiencies of this baghouse system. Specifically, there will be a significant reduction in hydrogen chloride (and any free chlorine), nitrogen oxides and sulfur oxides: additionally many other PICs (products of incomplete combustion such as dioxin and furan) will also be removed.

It seems to me it would be in the interests of all concerned, especially Erlanger Medical Center, John Basic, BACT and Allied Mechanical Contractors to know this information: maybe even Chattanooga-Hamilton County APCD will be willing to share in the costs of data acquisition?

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 Cl_2, 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

CHAIN OF CUSTODY FORM

Plant Chattanooga - Hamilton County Hospital Authority Source Boric Model 1250 South

Date Sampled 4/21/88 Test # 1 Run # 2

SAMPLE RECOVERY

Container #	Description (if filter, then give filter #)
520	Filter #520 tare 558.9
PW	probe wash
AP	acetone blank

Person Engaged in Sample Recovery:

Signature and Title [signature] Administration Manager

Recovery Location On Site

Date & Time of Recovery 4/21/88 3:15 pm

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

Signature [signature]

Date & Time of Receipt 4/21/88 4:20 PM

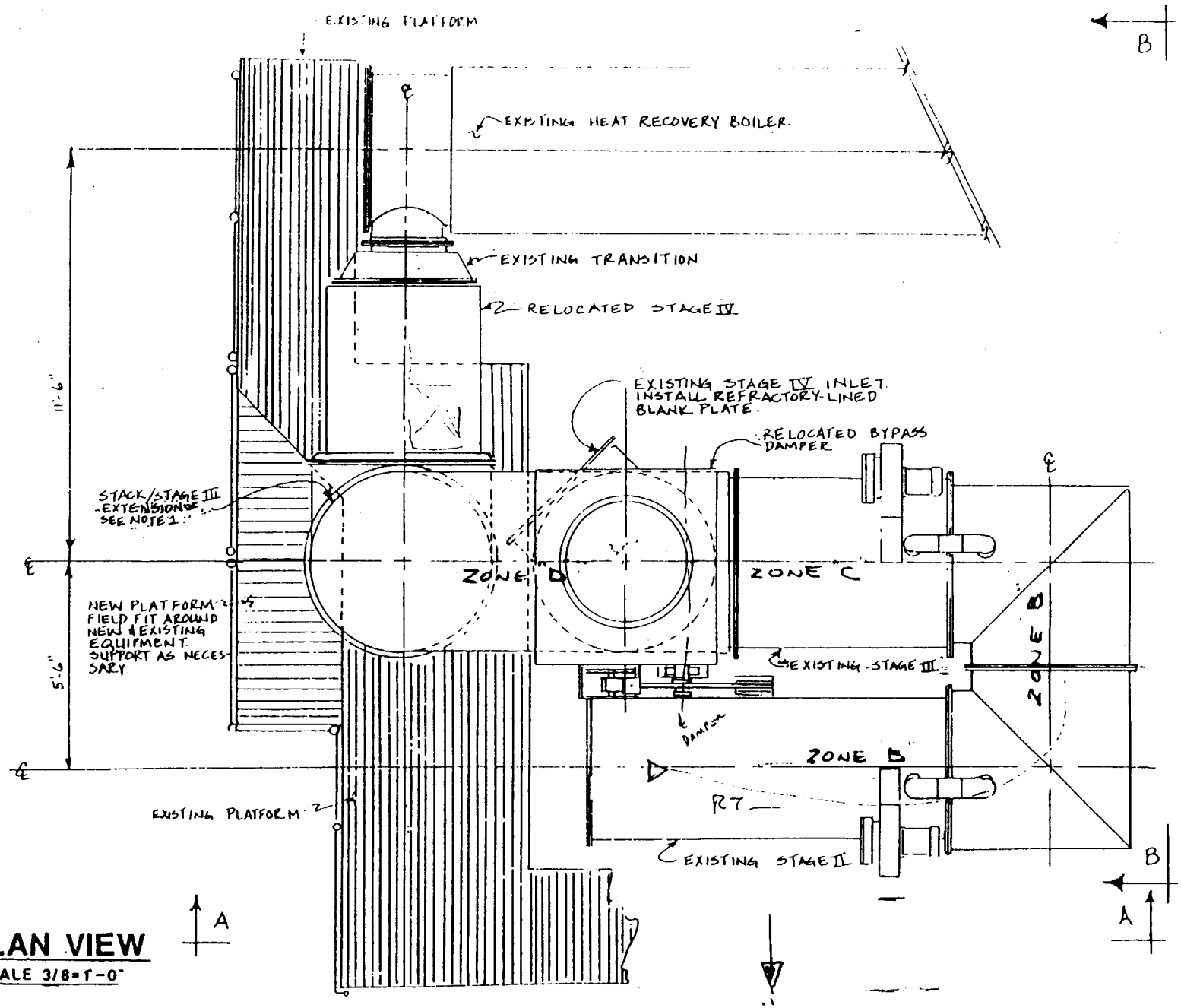
Sample Storage automobile

Laboratory Person Receiving Sample

Signature & Title

Date & Time of Receipt

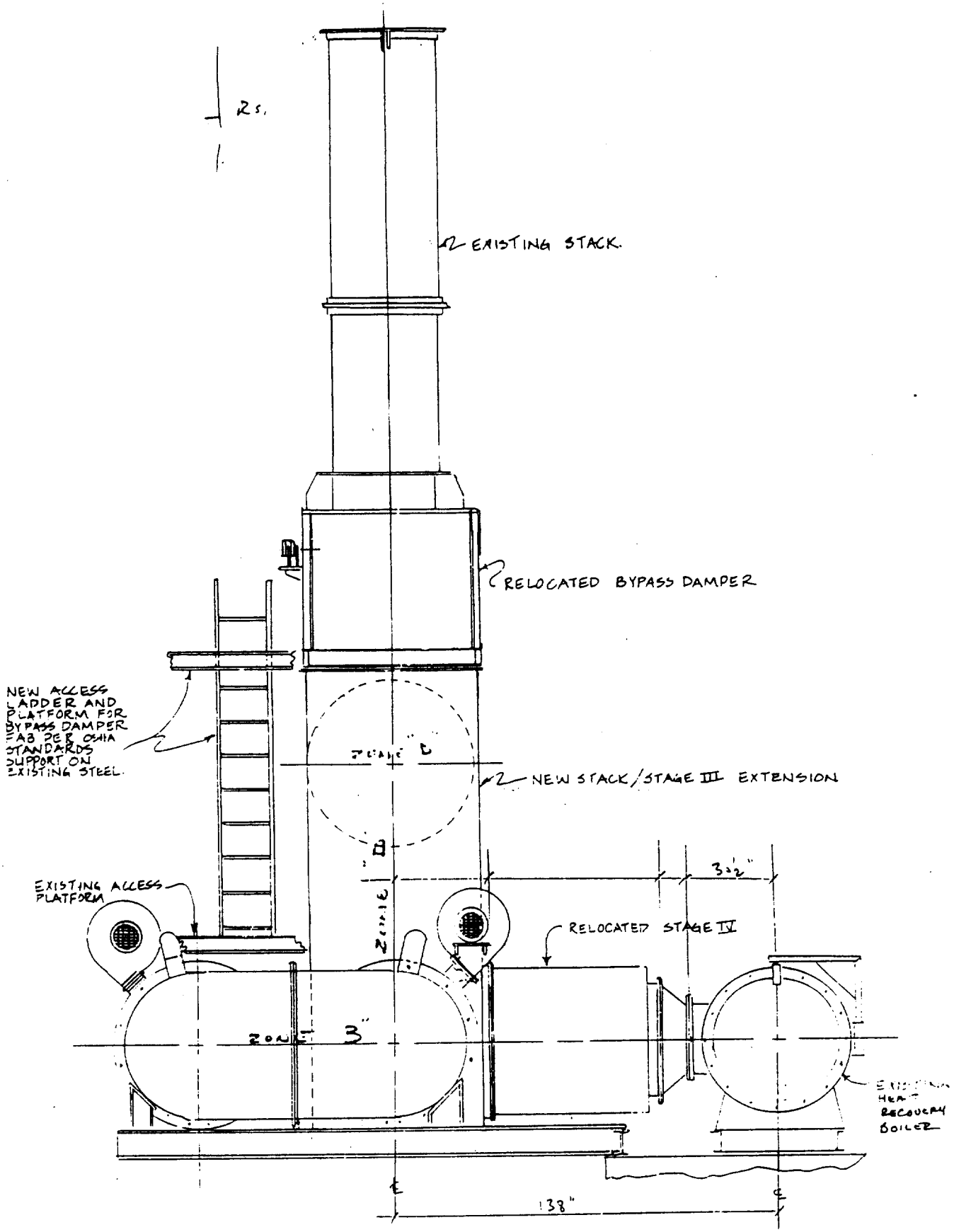
Sample Storage



PLAN VIEW

SCALE 3/8"=1'-0"

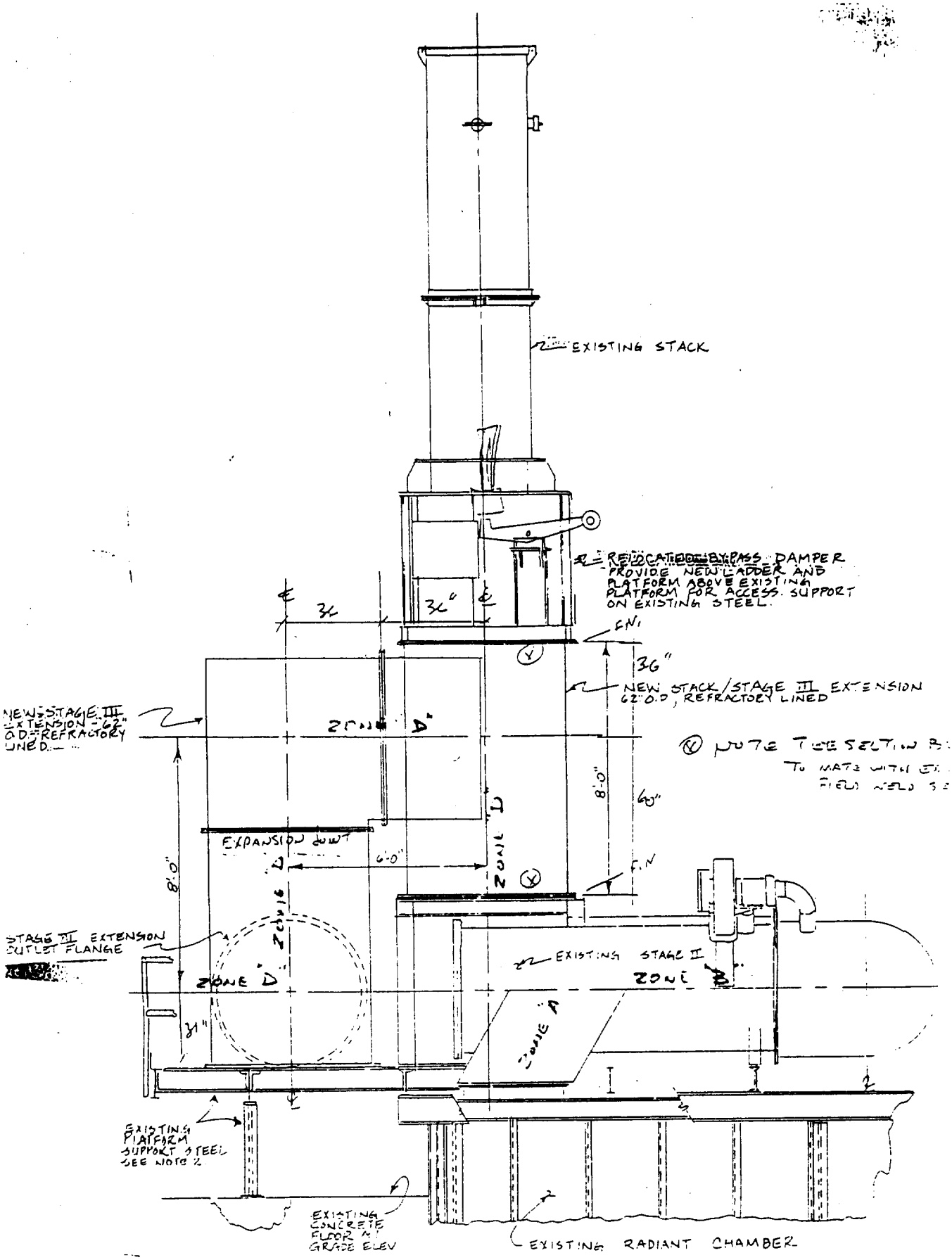
BASIC MODEL 1250



SECTION "B-B"

SCALE 3/8"=1'-0"

BASE MODEL 1250



SECTION "A-A"

SCALE 3/8-1-0"

BASIC MODEL 125

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.

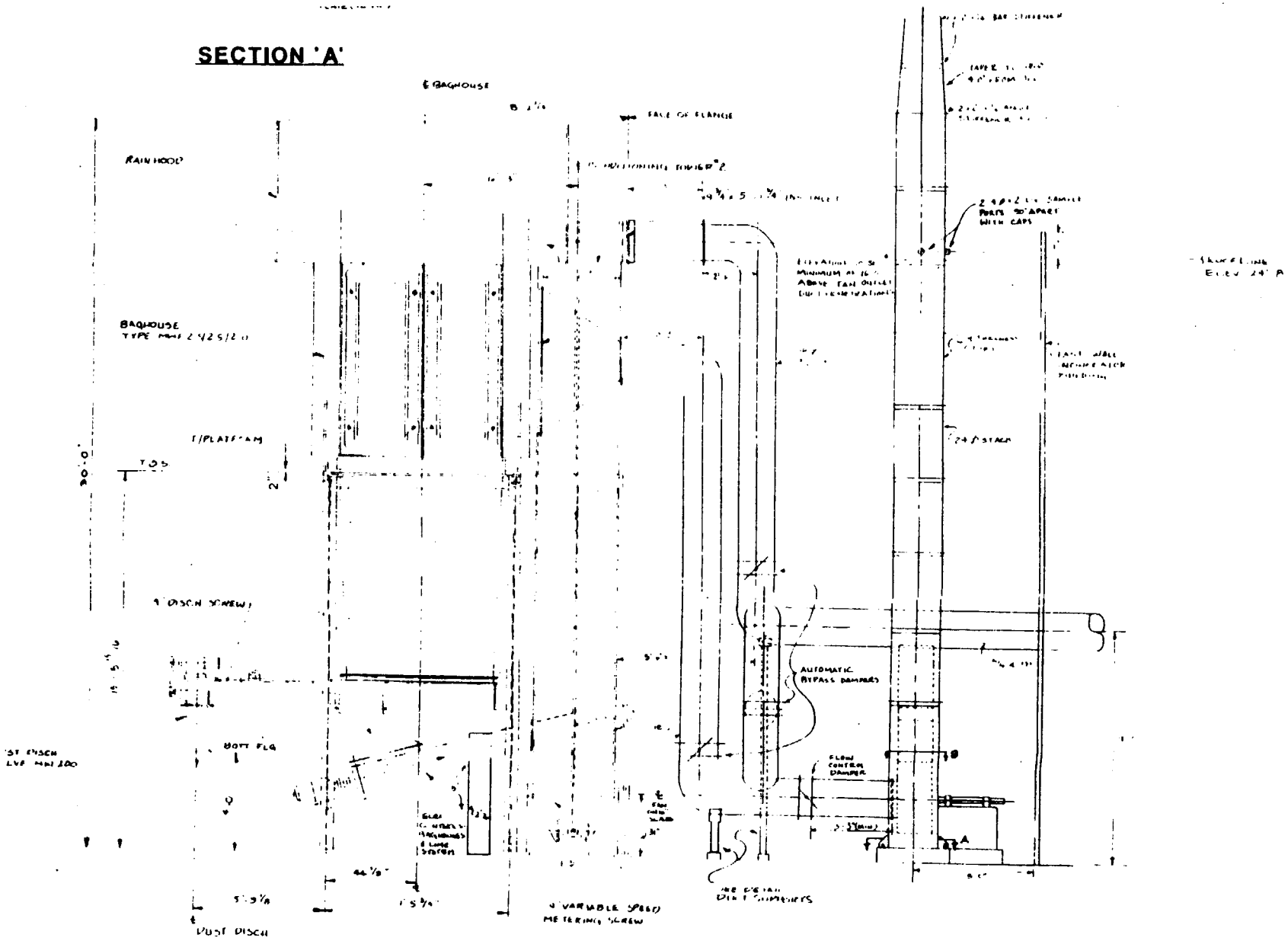
To avoid costly shutdowns to de-slag a boiler, Stage 4 mixing zone is added which conditions the high temperature gases down to a controlled temperature of 1400°F. This is accomplished by recirculating a controlled quantity of flue gas at the lower exhaust temperatures and thoroughly blending it with 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.

ERLANGER MEDICAL CENTER

CAMPBELL & ASSOCIATES INC., Consulting Engineers / 701 E. 4th Street Chattanooga Tennessee 37403



ELEVATION – BAG HOUSE UNIT 2

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 m^2 (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.

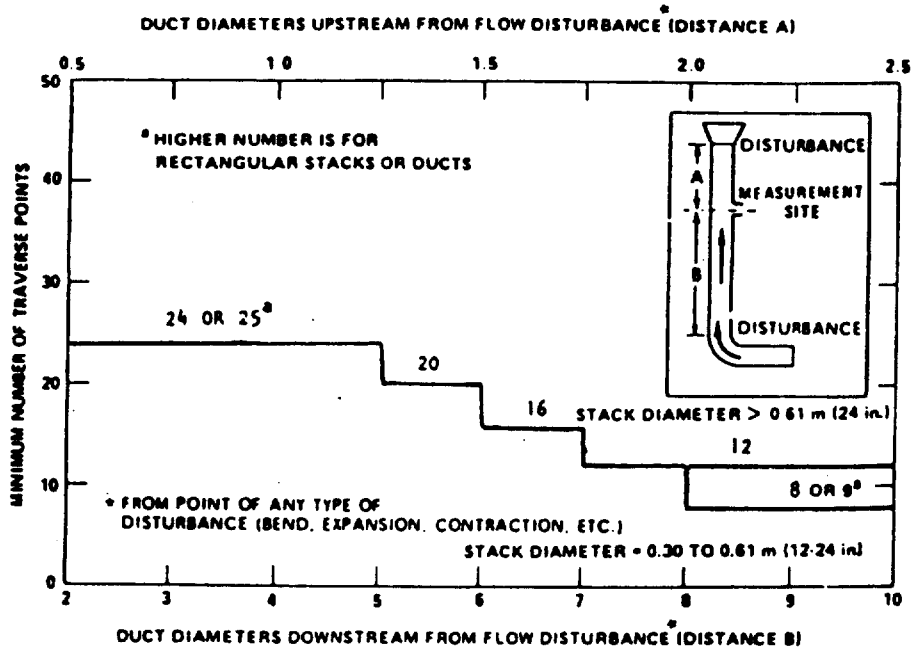


Figure 1-1. Minimum number of traverse points for particulate traverses.

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

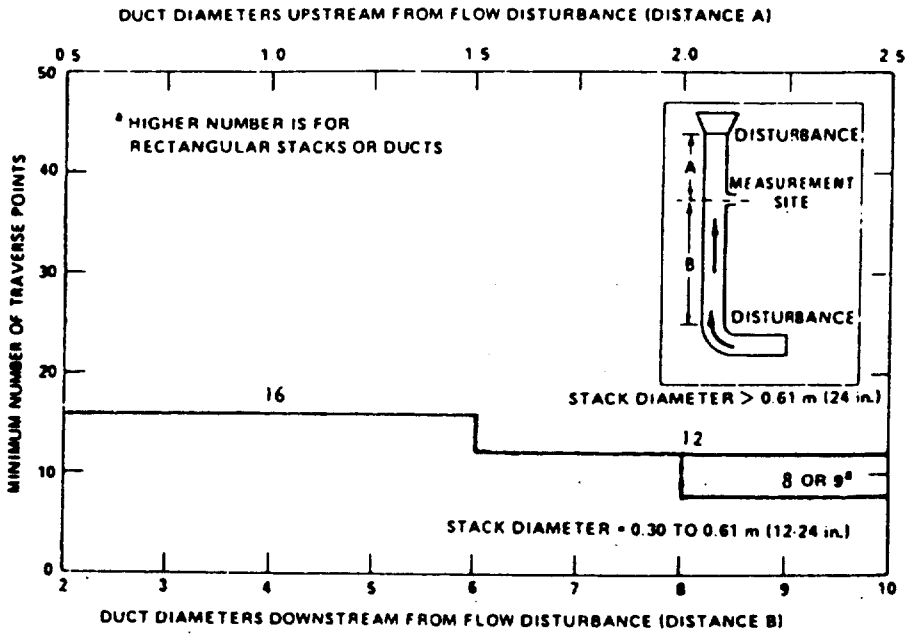


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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

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.

TRAVERSE POINT	DISTANCE % of diameter
1	4 4
2	14 7
3	29 5
4	70 5
5	85 3
6	95 6

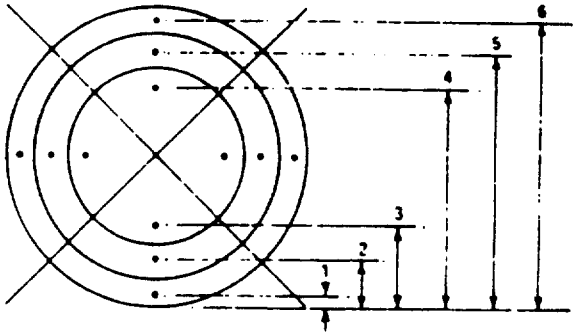


Figure 1 3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

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	68.5	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

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										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

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.

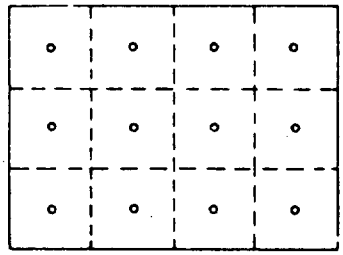


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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 ±90° 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 α 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°.

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 ½ 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.) H_2O 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 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 = arc cosine [(cosine Y_i)(cosine P_i)] 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:

$$\bar{R} = \frac{\Sigma R_i}{n} \qquad \text{Eq. 1-3}$$

Where:

$\bar{R}$ = Average resultant angle, degree.

n = Total number of traverse points.

2.5.4.3 Calculate the standard deviations:

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

Eq. 1-4

Where:

S_θ = Standard deviation, degree.

2.5.5 The measurement location is acceptable if $\bar{R} < 20°$ and $S_\theta < 10°$.

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 ±2° 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° 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.

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APPENDIX C

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

THE ALMEGA CORPORATION

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 (Stauscheibe 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_t, Figure 2-2b) be between 0.48 and 0.95 centimeter (3/16 and 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.

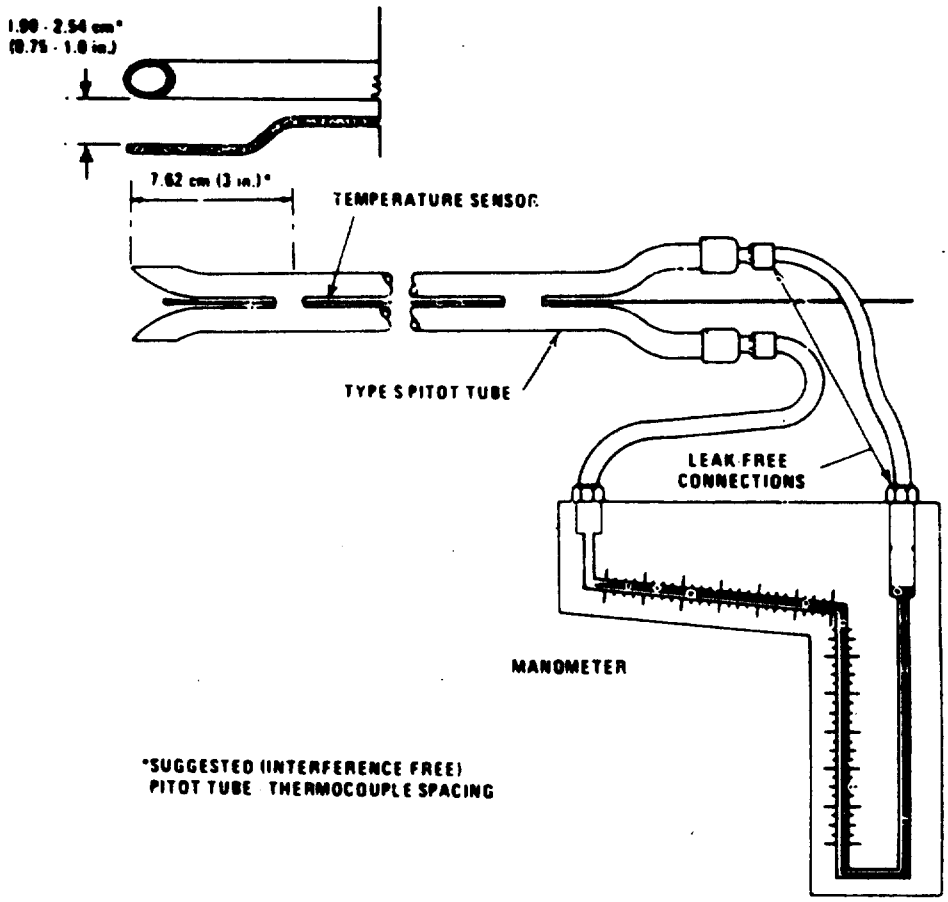


Figure 2-1. Type S pitot tube manometer assembly.

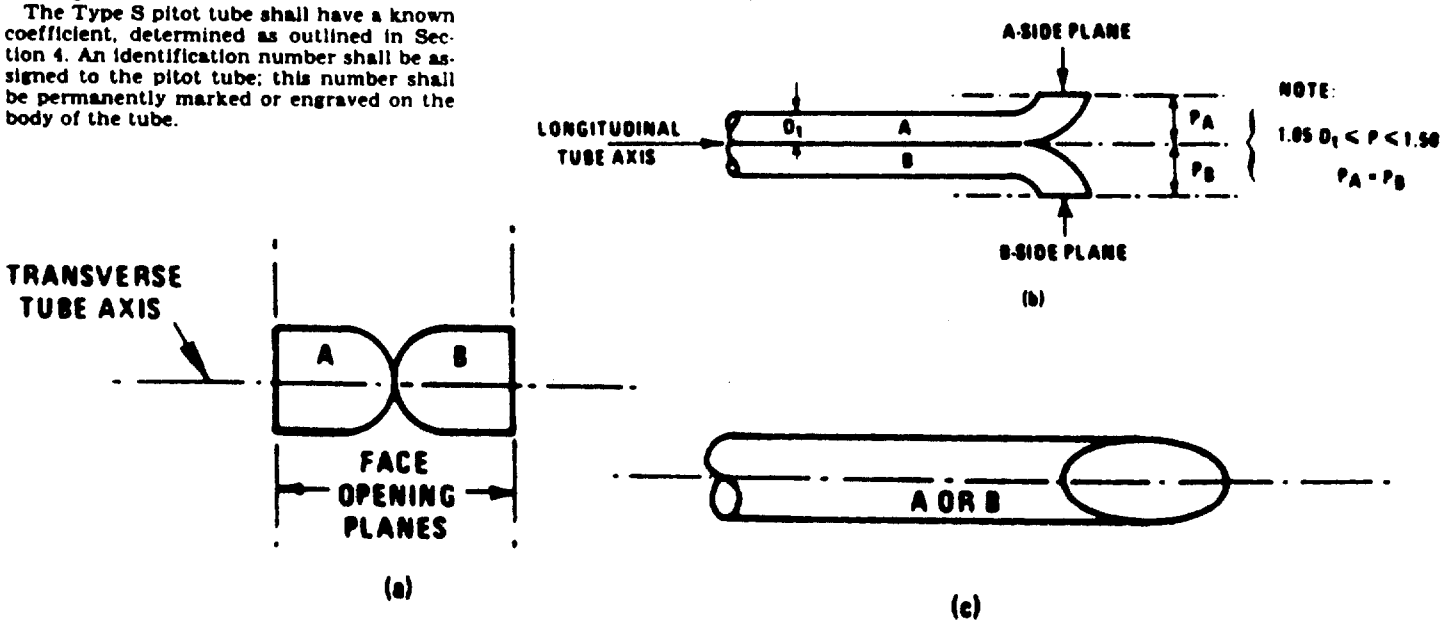


Figure 2-2. Properly constructed Type S pitot tube, shown in: (a) end view; face opening planes perpendicular to transverse axis; (b) top view; face opening planes parallel to longitudinal axis; (c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.

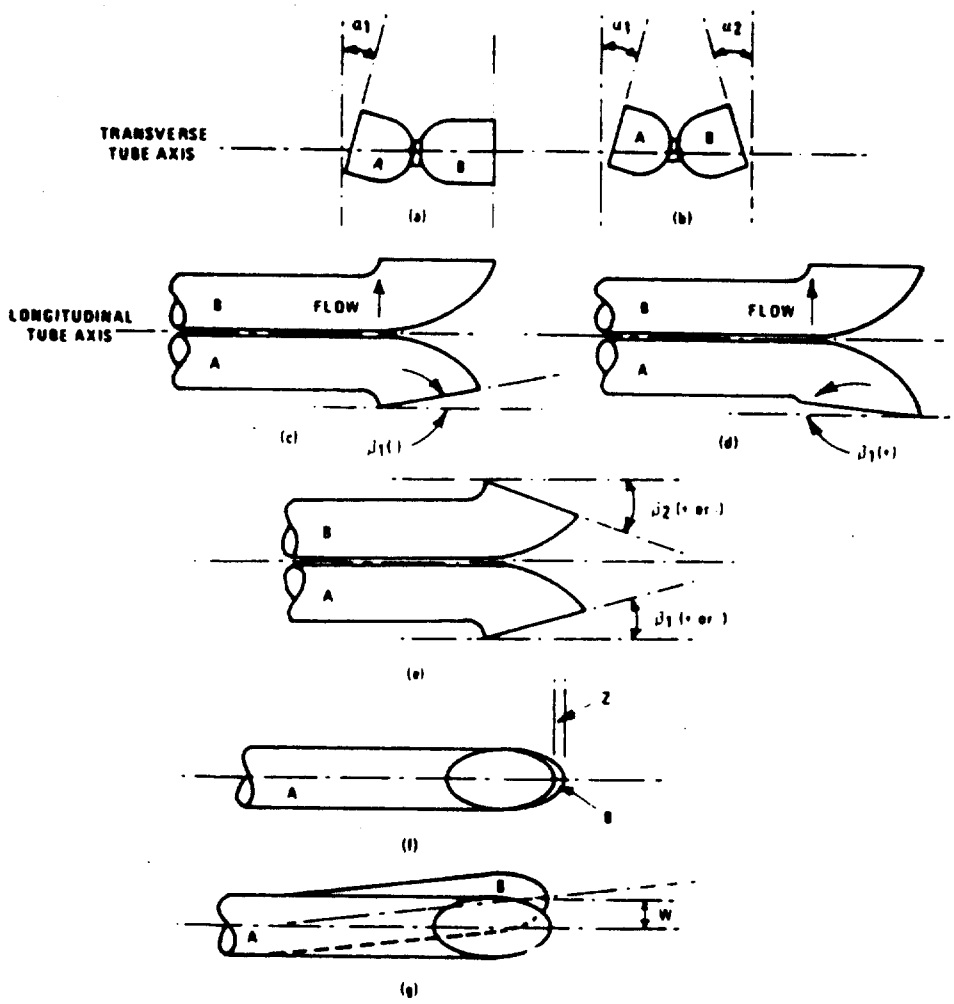


Figure 2-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of Cp(s) so long as $\alpha 1$ and $\alpha 2 < 10°$, $\beta 1$ and $\beta 2 < 5°$, $z < 0.32$ cm (1/8 in.) and $w < 0.08$ cm (1/32 in.)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

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. H_2O divisions on the 0-to 1-in. inclined scale, and 0.1-in. H_2O 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.) H_2O. 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.) H_2O; (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.) H_2O; (3) for traverses of fewer than 12 points, more than one Δp reading is below 1.3 mm (0.05 in.) H_2O. 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 H_2O (in. H_2O).

n = Total number of traverse points.

K = 0.13 mm H_2O when metric units are used and 0.005 in. H_2O 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 Pilot 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

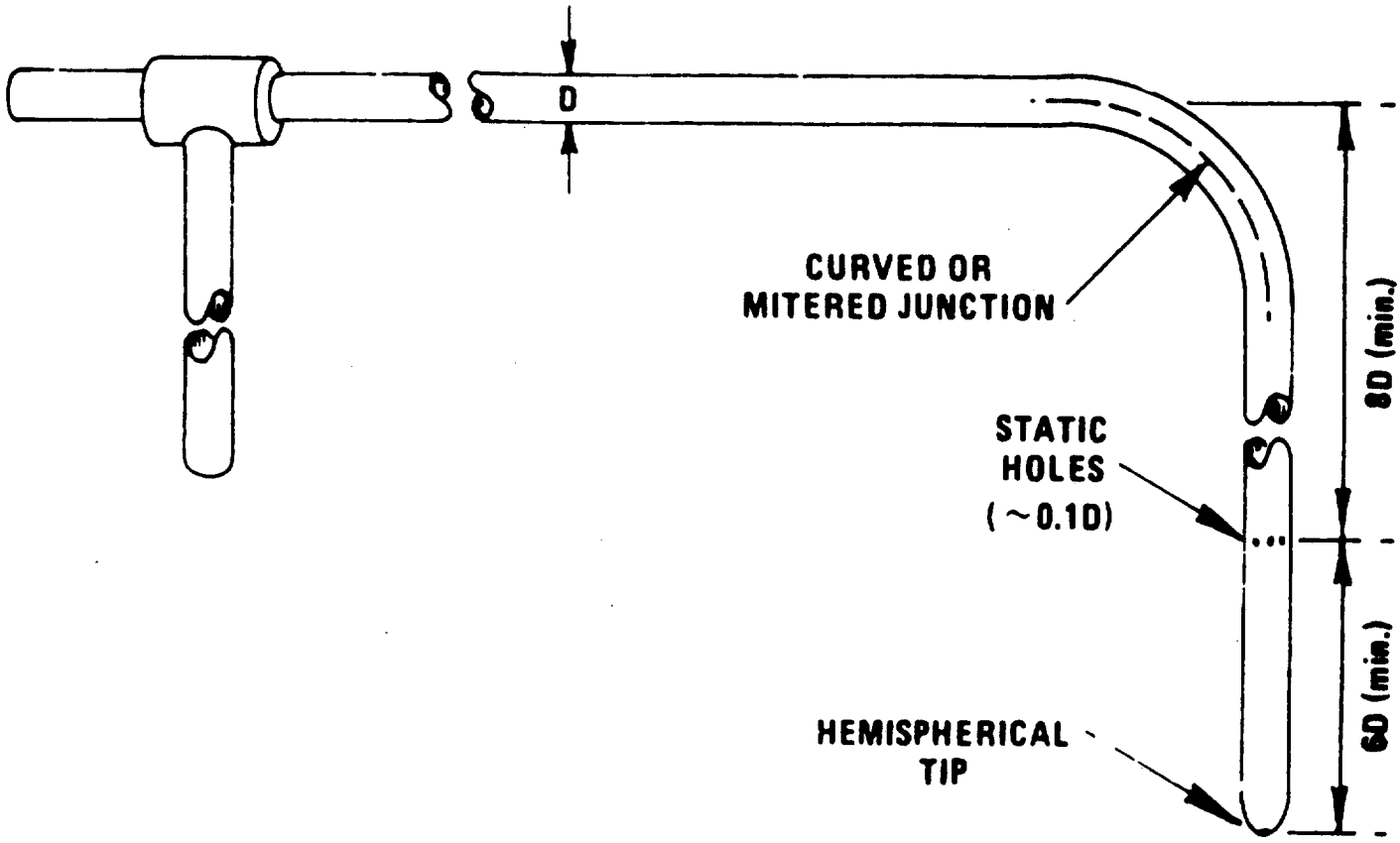


Figure 2-4. Standard pitot tube design specifications.

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 H_2O (0.005 in. H_2O). For multivelocity calibrations, the gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in. H_2O) for Δp values between 1.3 and 25 mm H_2O (0.05 and 1.0 in. H_2O), and to the nearest 1.3 mm H_2O (0.05 in. H_2O) for Δp values above 25 mm H_2O (1.0 in. H_2O). A special, more sensitive gauge will be required to read Δp values below 1.3 mm H_2O [0.05 in. H_2O] (see Citation 18 in Section 6).

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

PLANT ______________________

DATE ______________ RUN NO. ______________

STACK DIAMETER OR DIMENSIONS, m(in.) ______________

BAROMETRIC PRESSURE, mm Hg (in. Hg) ______________

CROSS SECTIONAL AREA, $m^2(ft^2)$ ______________

OPERATORS ______________

PITOT TUBE I.D. NO. ______________

AVG. COEFFICIENT, C_p = ______________

LAST DATE CALIBRATED ______________

SCHEMATIC OF STACK CROSS SECTION

Traverse Pt. No.	Vel. Hd., Δp mm (in.) H_2O	Stack Temperature		P_g mm Hg (in. Hg)	$\sqrt{\Delta p}$
		t_s, °C (°F)	T_s, °K (°R)		
		Average			

Figure 2-5. Velocity traverse data.

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 conducted; 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.

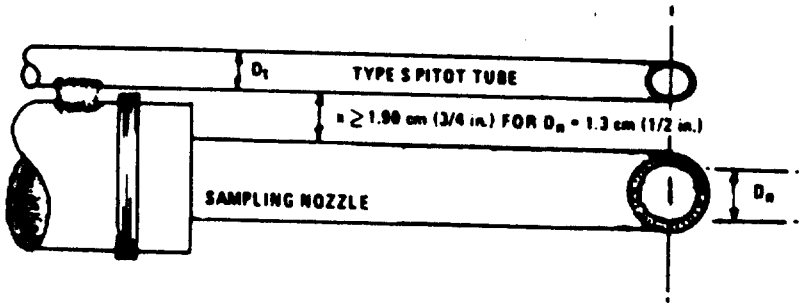
4. *Calibration*

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.

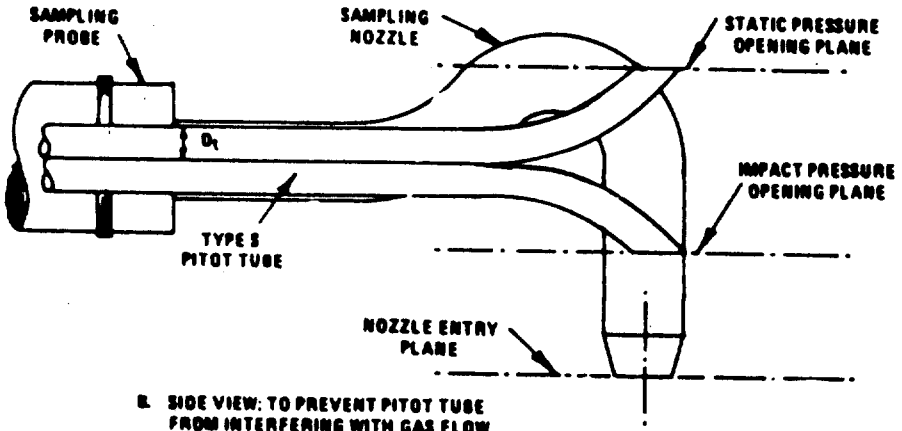
After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-2b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 in.) and if P_A and P_B are equal and between 1.05 and 1.50 D_t, 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_t, P_A, and P_B 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.



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.

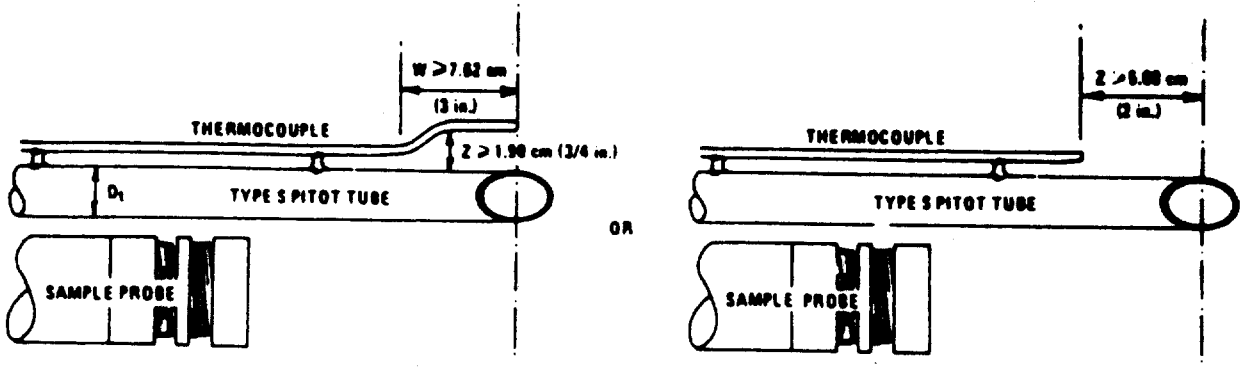


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

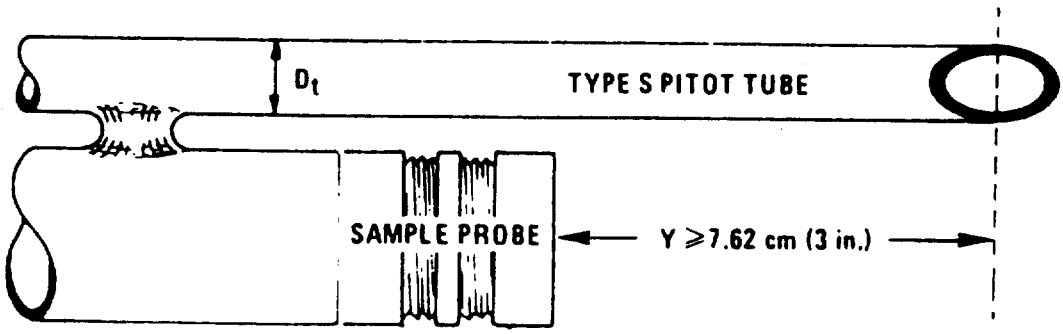


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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:

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:

$$D_e = \frac{2LW}{(L+W)} \qquad \text{Eq. 2-1}$$

Where:
D_e = 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:

4.1.3.1 Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary.

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.

The Almega Corporation

PITOT TUBE IDENTIFICATION NUMBER: _____ **DATE:** _____

CALIBRATED BY: _____

	"A" SIDE CALIBRATION			
RUN NO.	Δp_{std} cm H_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	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_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	DEVIATION $C_{p(s)} - \bar{C}_p$(B)
1				
2				
3				
		$\bar{C}_p$ (SIDE B)		

$$\text{AVERAGE DEVIATION} = \sigma\text{(A OR B)} = \frac{\sum_{1}^{3} \left| C_{p(s)} - \bar{C}_p\text{(A OR B)} \right|}{3} \quad \text{MUST BE} \leq 0.01$$

$$\left| \bar{C}_p\text{ (SIDE A)} - \bar{C}_p\text{ (SIDE B)} \right| \quad \text{MUST BE} \leq 0.01$$

Figure 2-9. Pitot tube calibration data.

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:

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}}$$

Equation 2-2

Where:

$C_{p(s)}$ = Type S pitot tube coefficient

$C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 2.7.1 to 2.7.5 of this method.

Δp_{std} = Velocity head measured by the standard pitot tube, cm H_2O (in. H_2O)

Δp_s = Velocity head measured by the Type S pitot tube, cm H_2O (in. H_2O)

4.1.4.2 Calculate $\bar{C}_p$ (side A), the mean A-side coefficient, and $\bar{C}_p$ (side B), the mean B-side coefficient; calculate the difference between these two average values.

4.1.4.3 Calculate the deviation of each of the three A-side values of $C_{p(s)}$ from $\bar{C}_p$ (side A), and the deviation of each B-side value of $C_{p(s)}$ from $\bar{C}_p$ (side B). Use the following equation:

$$\text{Deviation} = C_{p(s)} - \bar{C}_p\text{(A or B)}$$

Equation 2-3

4.1.4.4 Calculate δ, the average deviation from the mean, for both the A and B sides of the pitot tube. Use the following equation:

$$\sigma\text{ (side A or B)} = \frac{\sum_{1}^{3} \left| C_{p(s)} - \bar{C}_p\text{(A or B)} \right|}{3}$$

Equation 2-4

4.1.4.5 Use the Type S pitot tube only if the values of δ (side A) and δ (side B) are less than or equal to 0.01 and if the absolute value of the difference between $\bar{C}_p$ (A) and $\bar{C}_p$ (B) is 0.01 or less.

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

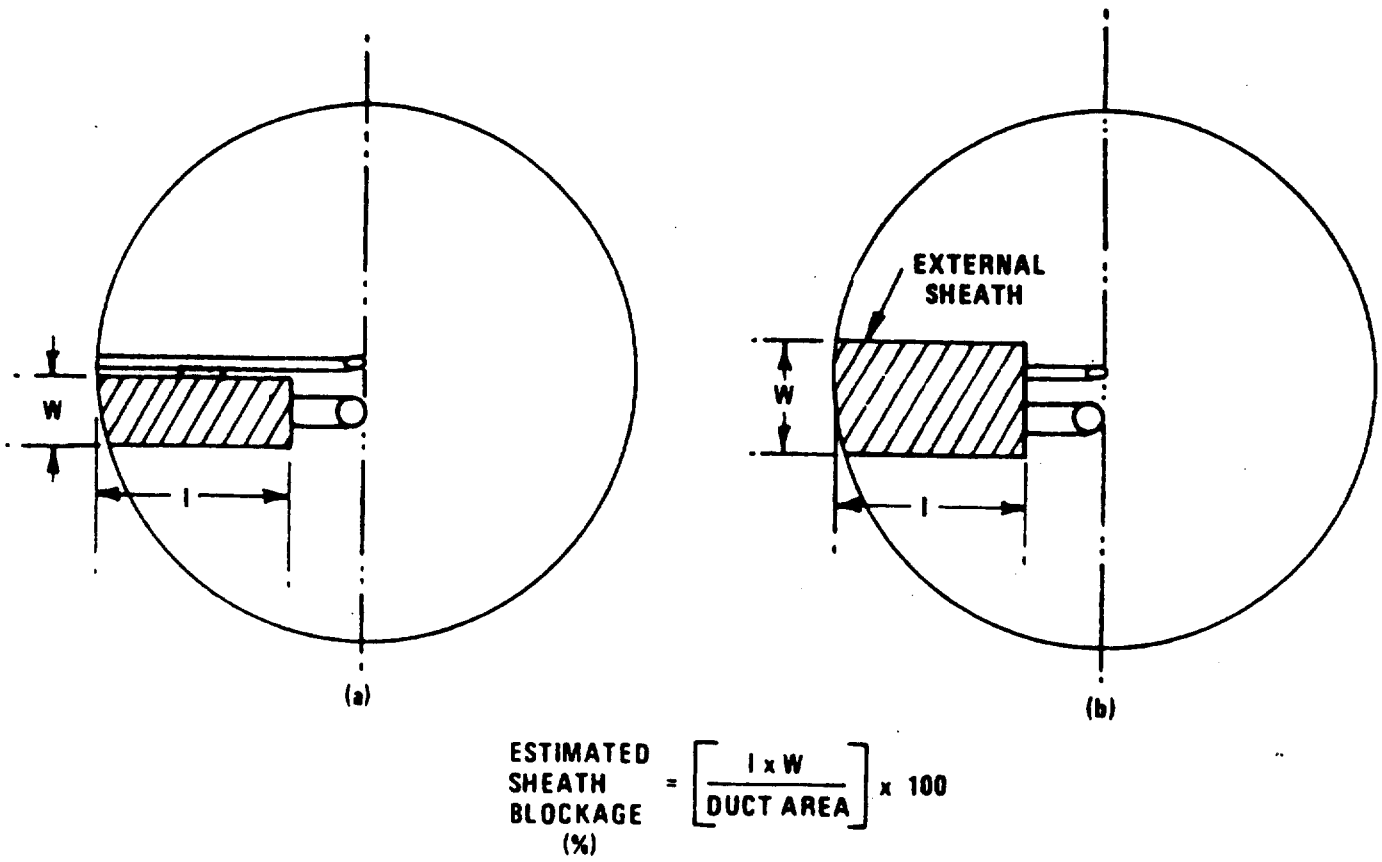


Figure 2-10. Projected-area models for typical pitot tube assemblies.

4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., C_p (side A) and C_p (side B), will be valid, so long as either: (1) the isolated pitot tube is used; or (2) the pitot tube is used with other components (nozzle, thermocouple, sample probe) in an arrangement that is free from aerodynamic interference effects (see Figures 2-6 through 2-8).

4.1.5.1.2 For Type S pitot tube-thermocouple combinations (without sample probe), select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The coefficients so obtained will be valid so long as the pitot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 2-6 and 2-8).

4.1.5.1.3 For assemblies with sample probes, the calibration point should be located at or near the center of the duct; however, insertion of a probe sheath into a small duct may cause significant cross-sectional area blockage and yield incorrect coefficient values (Citation 9 in Section 6). Therefore, to minimize the blockage effect, the calibration point may be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical blockage, as determined by a projected-area model of the probe sheath, is 2 percent or less of the duct cross-sectional area for assemblies without external sheaths (Figure 2-10a), and 3 percent or less for assemblies with external sheaths (Figure 2-10b).

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzle separation distance fails to meet the specification illustrated in Figure 2-6a), the value of $C_{p(t)}$ depends upon the amount of free-space between the tube and nozzle, and therefore is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (>0.635 cm or ¼ in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

4.1.5.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (δ) value of 0.01 or less (see Section 4.1.4.4).

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

4.1.6.1.1 When a Type S pitot tube (isolated tube or assembly) is used in the field, the appropriate coefficient value (whether assigned or obtained by calibration) shall be used to perform velocity calculations. For calibrated Type S pitot tubes, the A side coefficient shall be used when the A side of the tube faces the flow, and the B side coefficient shall be used when the B side faces the flow; alternatively, the arithmetic average of the A and B side coefficient values may be used, irrespective of which side faces the flow.

4.1.6.1.2 When a probe assembly is used to sample a small duct (12 to 36 in. in diameter), the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of $C_{p(t)}$. Consult Citation 9 in Section 6 for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 12 inches (Citation 16 in Section 6).

4.1.6.2 Recalibration.

4.1.6.2.1 Isolated Pitot Tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot face openings are still aligned within the specifications illustrated in Figure 2-2 or 2-3, it can be assumed that the baseline coefficient of the pitot tube has not changed. If, however, the tube has been damaged to the extent that it no longer meets the specifications of Figure 2-2 or 2-3, the damage shall either be repaired to restore proper alignment of the face openings or the tube shall be discarded.

4.1.6.2.2 Pitot Tube Assemblies. After each field use, check the face opening alignment of the pitot tube, as in Section 4.1.6.2.1; also, remeasure the intercomponent spacings of the assembly. If the intercomponent spacings have not changed and the face opening alignment is acceptable, it can be assumed that the coefficient of the assembly has not changed. If the face opening alignment is no longer within the specifications of Figures 2-2 or 2-3, either repair the damage or replace the pitot tube (calibrating the new assembly, if necessary). If the intercomponent spacings have changed, restore the original spacings or recalibrate the assembly.

4.2 Standard pitot tube (if applicable). If a standard pitot tube is used for the velocity traverse, the tube shall be constructed according to the criteria of Section 2.7 and shall be assigned a baseline coefficient value of 0.99. If the standard pitot tube is used as part of an assembly, the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

4.3 Temperature Gauges. After each field use, calibrate dial thermometers, liquid-filled bulb thermometers, thermocouple-potentiometer systems, and other gauges at a temperature within 10 percent of the average absolute stack temperature. For temperatures up to 405° C (761° F), use an ASTM mercury-in-glass reference thermometer, or equivalent, as a reference; alternatively, either a reference thermocouple and potentiometer (calibrated by NBS) or thermometric fixed points, e.g., ice bath and boiling water (corrected for barometric pressure) may be used. For temperatures above 405° C (761° F), use an NBS-calibrated reference thermocouple-potentiometer system or an alternate reference, subject to the approval of the Administrator.

If, during calibration, the absolute temperatures measured with the gauge being calibrated and the reference gauge agree within 1.5 percent, the temperature data taken in the field shall be considered valid. Otherwise, the pollutant emission test shall either be considered invalid or adjustments (if appropriate) of the test results shall be made, subject to the approval of the Administrator.

4.4 Barometer. Calibrate the barometer used against a mercury barometer.

5. *Calculations*

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

5.1 Nomenclature.

A = Cross-sectional area of stack, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.

C_p = Pitot tube coefficient, dimensionless.

K_p = Pitot tube constant,

$$34.97 \frac{m}{sec}\left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{ft}{sec}\left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{1/2}$$

for the English system.

M_d = Molecular weight of stack gas, dry basis (see Section 3.6) g/g-mole (lb/lb-mole).

M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

$= M_d(1 - B_{ws}) + 18.0\ B_{ws}$

Eq. 2-5

P_{bar} = Barometric pressure at measurement site, mm Hg (in. Hg).

P_g = Stack static pressure, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

$= P_{bar} + P_g$

Eq. 2-6

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

Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).

t_s = Stack temperature, °C (°F).

T_s = Absolute stack temperature, °K, (°R).

$= 273 + t_s$ for metric.

Eq. 2-7

$= 460 + t_s$ for English.

Eq. 2-8

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

v_s = Average stack gas velocity, m/sec (ft/sec).

Δp = Velocity head of stack gas, mm H_2O (in. H_2O).

3,600 = Conversion factor, sec/hr.

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

5.2 Average Stack Gas Velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

Equation 2-9

5.3 Average Stack Gas Dry Volumetric Flow Rate.

$$Q_{sd} = 3,600(1 - B_{ws}) v_s A \left(\frac{T_{std}}{T_{s\ (avg)}}\right)\left(\frac{P_s}{P_{std}}\right)$$

Eq. 2-10

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APPENDIX D

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

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 (CO_2), percent oxygen (O_2), and, if necessary, percent carbon monoxide (CO). If a dry molecular weight determination is to be made, either an Orsat or a Fyrite [1] 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 CO_2 and O_2 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 CO_2, O_2, CO, and nitrogen (N_2) 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 CO_2 or O_2 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 O_2, CO_2, CO, and N_2 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 O_2, CO_2, CO, and N_2, 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 cm^3/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 H_2O (2 to 4 in. H_2O). 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 H_2O (2 to 4 in. H_2O) 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.

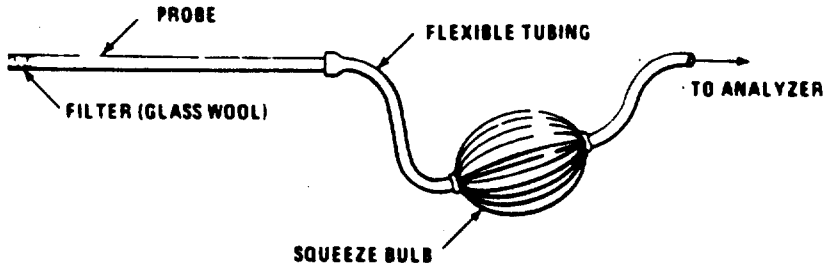

Figure 3-1. Grab sampling train.

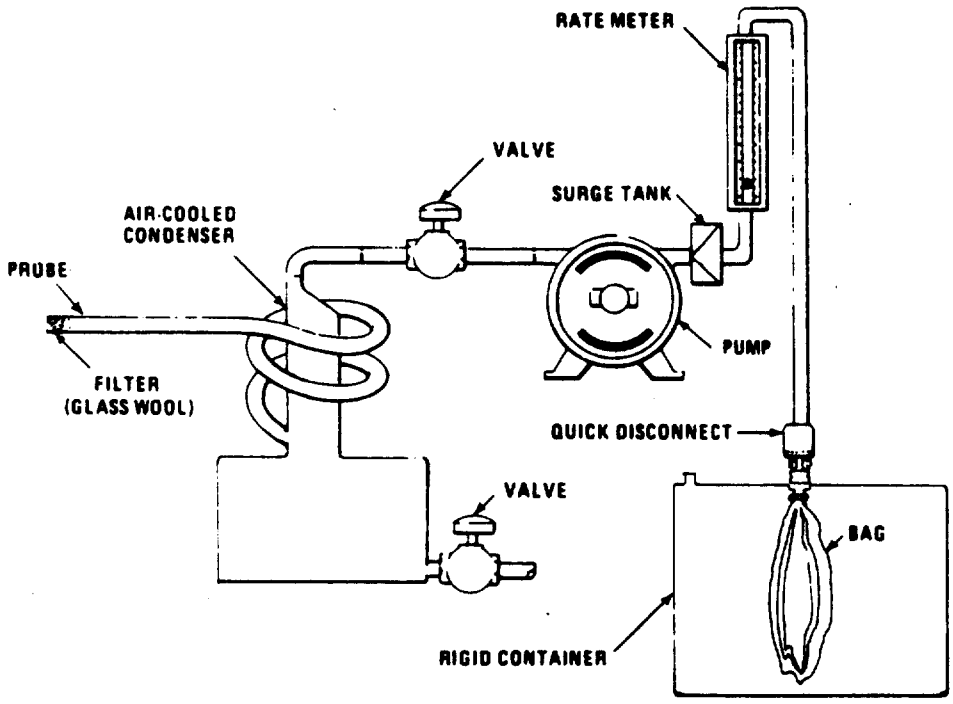

Figure 3-2. Integrated gas-sampling train.

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

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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 CO_2 (less than 4.0 percent) or high O_2 (greater that 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 and Orsat analyzer is used, it is recommended that the analyzer be leaked-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 CO_2 and percent O_2. Determine the percentage of the gas that is N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 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 ft^3) of sample 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 CO_2 and percent O_2 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 N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 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 throught 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 CO_2 and percent O_2 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 CO_2 or percent O_2. 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 CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; and (3) calculate percent excess air as outlined in Section 6.2.

TIME	TRAVERSE PT.	Q 1pm	% DEV.[a]
	AVERAGE		

[a] $\%\ DEV = \left(\frac{Q - Q\ avg}{Q\ avg}\right) 100$ (MUST BE ≤ 10%)

Figure 3-3. Sampling rate data.

Reprinted from CFR Title 40 dated July 1980
pages 310 - 315

4.1.4 To insure complete absorption of the CO_2, O_2, 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 in 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 CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 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 lengh of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft^3) 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 CO_2 or percent O_2 (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-check (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 CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, 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 CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three of four) should be make 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 CO_2, repeat the analytical procedure until the results of any three analyses differ by no more that (a) 0.3 percent by volume when CO_2 is greater than 4.0 percent or (b) 0.2 percent by volume when CO_2 is less than or equal to 4.0 percent. Average the three acceptable values of percent CO_2 and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when O_2 is less than 15.0 percent or (b) 0.2 percent by volume when O_2 is greater than or equal to 15.0 percent. Average the three acceptable values of percent O_2 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 an after the analysis. Note: Although in most instances only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 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 throughly 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 menicus 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 regreased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. *Calculations*

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).
%EA = Percent excess air.
$\%CO_2$ = Percent CO_2 by volume (dry basis).
$\%O_2$ = Percent O_2 by volume (dry basis).
%CO = Percent CO by volume (dry basis).
$\%N_2$ = Percent N_2 by volume (dry basis).
0.264 = Ratio of O_2 to N_2 in air, v/v.
0.280 = Molecular weight of N_2 or CO, divided by 100.
0.320 = Molecular weight of O_2 divided by 100.
0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (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 O_2 and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) 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

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

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*

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APPENDIX E

DETERMINATION OF MOISTURE CONTENT IN STACK GASES

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 H_2O 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 ±1° 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 pyschrometric 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 particular 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 (½ inch) ID glass tube extending to about 1.3 cm (½ 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-

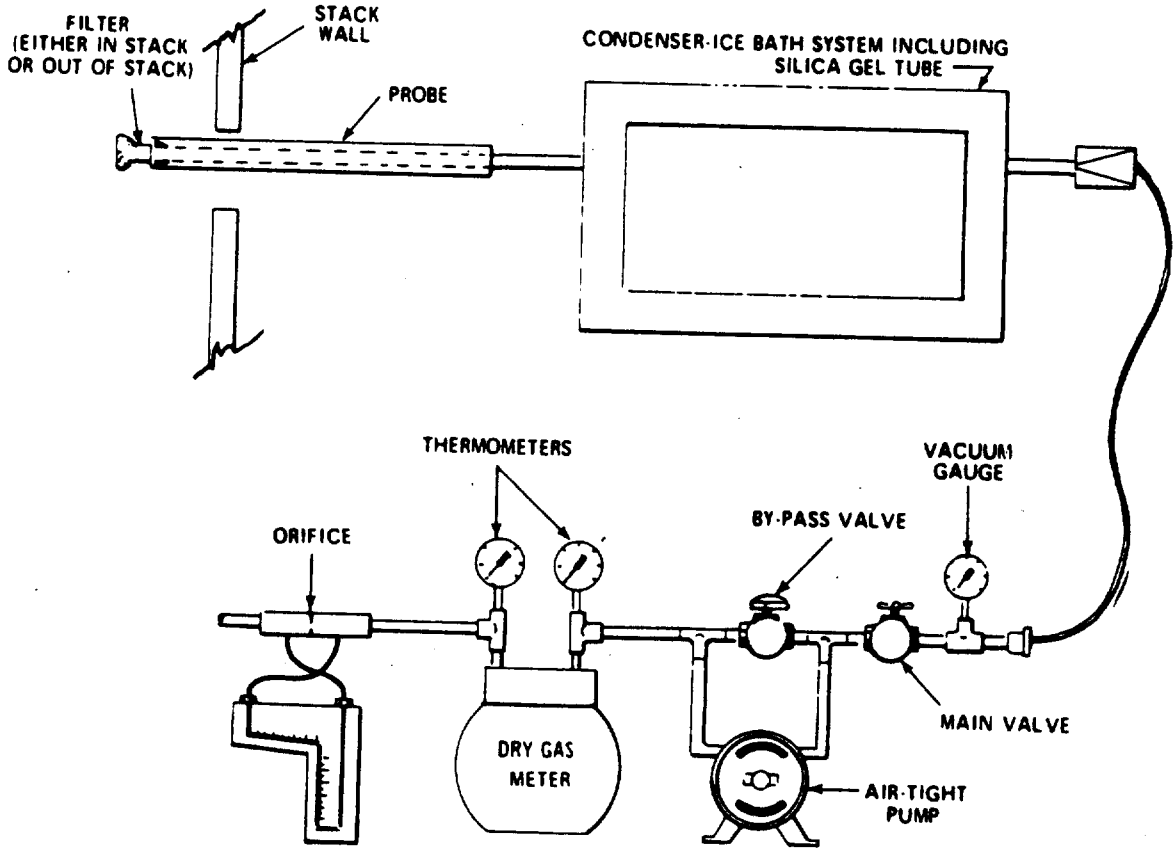

Figure 4-1. Moisture sampling train-reference method

Reprinted from CFR Title 40 dated July 1980
pages 315 - 325

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

Alternatively, any system may be used ubject to the approval of the Administra- or) that cools the sample gas stream and lows measurement of both the water that has been condensed and the moisture leaving the condenser, each to within 1 ml or 1

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 ondenser and using Dalton's law of partial ressures, or (2) passing the sample gas ream through a tared silica gel (or equivalent desiccant) trap, with exit gases kept below 20° C (68° F), and determining the eight gain.

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

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

2.1.4 Metering System. This system includes a vacuum gauge, leak-free pump, hermometers capable of measuring temrature to within 3° C (5.4° F), dry gas eter 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 mpling rate and determining sample gas olume, may be used, subject to the approval of the Administrator.

2.1.5 Barometer. Mercury, aneroid, or other barometer capable of measuring atospheric pressure to within 2.5 mm Hg .1 in. Hg) may be used. In many cases, the arometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the bsolute barometric pressure) shall be requested and an adjustment for elevation difrences 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 00 ft) elevation increase or vice versa for evation decrease.

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

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

2.2.1 Unless otherwise specified by the Administrator, a minimum of eight traverse oints shall be used for circular stacks aving diameters less than 0.61 m (24 in.), a inimum of nine points shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minium of twelve traverse points shall be used all other cases. The traverse points shall 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 adjurt 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 5. 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.

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

Figure 4-3. Analytical data - reference method.

2.3.1 Nomenclature.

B_{ws} = 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_m = 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_m = Absolute temperature at meter, °K (°R).

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

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

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

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

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

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

V_f = Final volume of condenser water, ml.

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

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

W_i = 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.

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

Equation 4-1

where:
$K_1 = 0.001333$ m³/ml for metric units
$= 0.04707$ ft³/ml for English units

2.3.3 Volume of water vapor collected in silica gel.

$$V_{w\,g\,(std)} = \frac{(W_f - W_i)RT_{std}}{P_{std}M_w} = K_2(W_f - W_i)$$

Equation 4-2

where:
$K_2 = 0.001335$ m³/g for metric units
$= 0.04715$ ft³/g for English units

2.3.4 Sample gas volume.

$$V_{m\,(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)} = K_1 Y \frac{V_m P_m}{T_m}$$

Equation 4-3

where:
$K_3 = 0.3858$ °K/mm Hg for metric units
$= 17.64$ °R/in. Hg for English units

NOTE.—If the post-test lead rate (Section 2.2.6) exceeds the allowable rate, correct the value of V_m in Equation 4-3, as described in Section 6.3 of Method 5.

2.3.5 Moisture Content.

$$B_{w\,s} = \frac{V_{w\,c\,(std)} + V_{w\,g\,(std)}}{V_{w\,c\,(std)} + V_{w\,g\,(std)} + V_{m\,(std)}}$$

Equation 4-4

NOTE.—In saturated or moisture droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one using a value based upon the saturated conditions (see Section 1.2), and another based upon the results of the impinger analysis. The lower of these two values of B_{ws} shall be considered correct.

2.3.6 Verification of constant sampling rate. For each time increment, determine the ΔV_m. Calculate the average. If the value for any time increment differs from the average by more than 10 percent, reject the results and repeat the run.

3. *Approximation Method*

The approximation method described below is presented only as a suggested method (see Section 1.2).

3.1 Apparatus.

3.1.1 Probe. Stainless steel glass tubing, sufficiently heated to prevent water condensation and equipped with a filter (either in-stack or heated out-stack) to remove particulate matter. A plug of glass wool, inserted into the end of the probe, is a satisfactory filter.

3.1.2 Impingers. Two midget impingers, each with 30 ml capacity, or equivalent.

3.1.3 Ice Bath. Container and ice, to aid in condensing moisture in impingers.

PLANT _____
LOCATION _____
OPERATOR _____
DATE _____
RUN NO. _____
AMBIENT TEMPERATURE _____
BAROMETRIC PRESSURE _____
PROBE LENGTH m(ft) _____

SCHEMATIC OF STACK CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min	STACK TEMPERATURE °C (°F)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), mm(in.) H_2O	METER READING GAS SAMPLE VOLUME m^3 (ft^3)	ΔV_m m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
						INLET ($T_{m_{in}}$), °C (°F)	OUTLET ($T_{m_{out}}$), °C (°F)	
TOTAL						Avg.	Avg.	
AVERAGE						Avg.		

Figure 4-2. Field moisture determination-reference method.

3.1.4 Drying Tube. Tube packed with new or regenerated 6- 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 ft^3) 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_{ws} = Approximate proportion, by volume, of water vapor in the gas stream leaving the second impinger, 0.025.

B_{ws} = 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_m = 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) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.

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

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

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

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

Y = Dry gas meter calibration factor.

3.3.2 Volume of water vapor collected.

where:

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

Equation 4-5

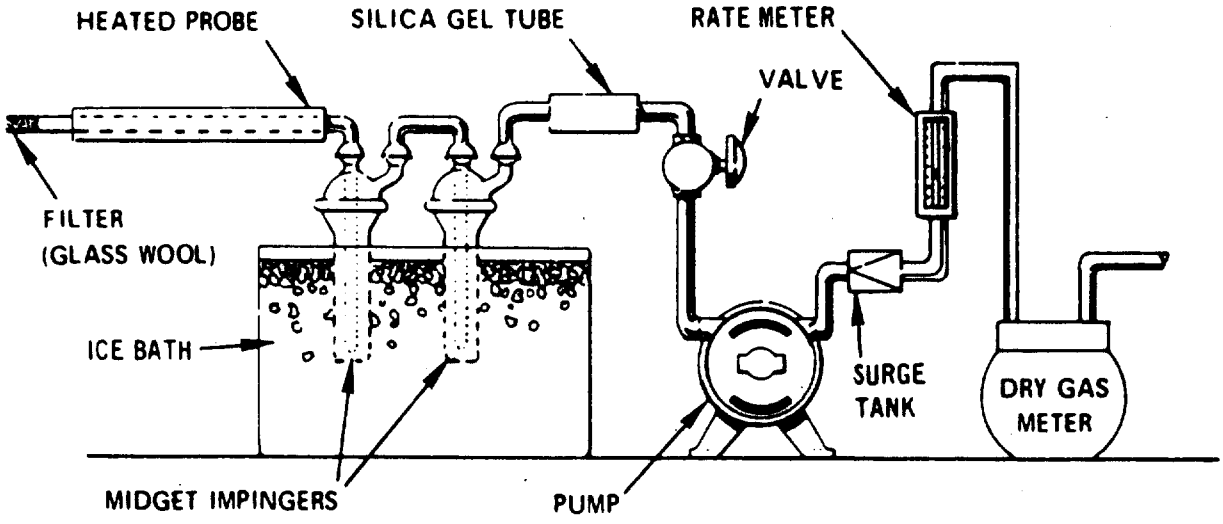

Figure 4-4. Moisture-sampling train - approximation method.

Reprinted from CFR Title 40 dated July 1980
pages 315 - 325

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.

$K_1 = 0.001333$ m³/ml for metric units
$= 0.04707$ ft³/ml for English units.

3.3.3 Gas volume.

$$V_{m(std)} = V_m \left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right) = K_2 \frac{V_m P_m}{T_m}$$

Equation 4-6

where:
$K_2 = 0.3858$ °K/mm Hg for metric units
$= 17.64$ °R/in. Hg for English units.

3.3.4 Approximate moisture content.

$$B_{ws} = \frac{V_{wc}}{V_{wc} + V_{m(std)}} + B_{wm} = \frac{V_{wc}}{V_{wc} + V_{m(std)}} + (0.025)$$

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.

Reprinted from CFR Title 40 dated July 1980

pages 315 - 325

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 ± 14 C (248±25° 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.

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 (⅛ to ½ in.)—or larger if higher volume sampling trains are used—inside diameter (ID) nozzles in increments of 0.16 cm (1/16 in.). Each nozzle shall be calibrated according 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±14 C (248±25° 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° 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° F), and for quartz it is 1,500° C (2,732° F).

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

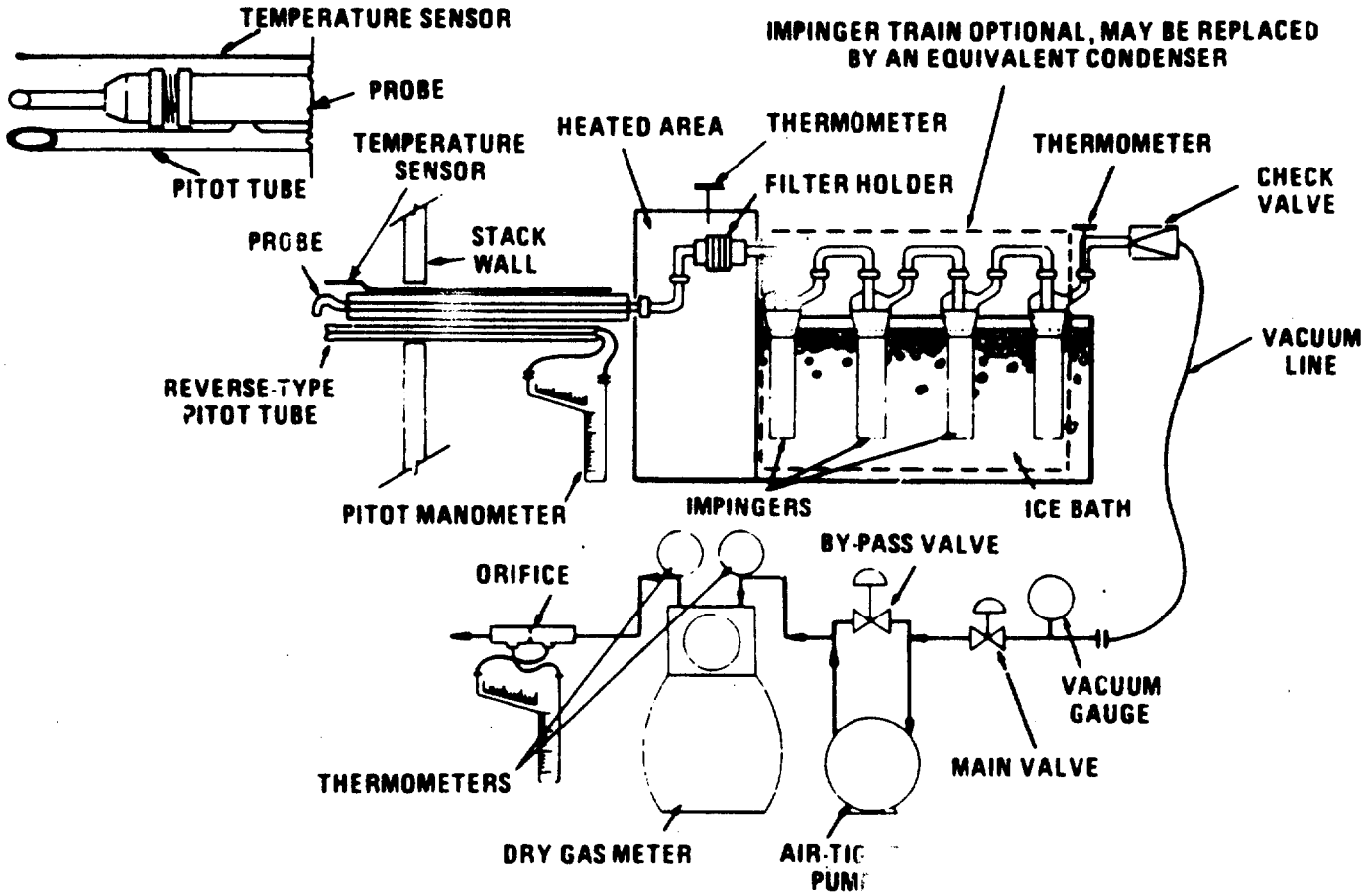

Figure 5-1. Particulate-sampling train

60-113 O—80——22

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±5.6° C (68±10° 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 differental 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 property 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-fr direct mechanical connection. Mark t probe with heat resistant tape or by son other method to denote the proper distan into the stack or duct for each samplin point.

Set up the train as in Figure 5-1, using (necessary) a very light coat of silicon grease on all ground glass joints, greasin only the outer portion (see APTD-0576) t avoid possibility of contamination by th silicone grease. Subject to the approval c the Administrator, a glass cyclone may b used between the probe and filter holde when the total particulate catch is expecte to exceed 100 mg or when water droplets ar 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 prete leak-check is recommended, but not r quired. If the tester opts to conduct the pr test leak-check, the following procedur shall be used.

After the sampling train has been assem bled, turn on and set the filter and prob heating systems at the desired operatin temperatures. Allow time for the tempera tures to stabilize. If a Viton A O-ring o other leak-free connection is used in assem bling the probe nozzle to the probe liner leak-check the train at the sampling site b plugging the nozzle and pulling a 380 mm Hg (15 in. Hg) vacuum.

NOTE.—A lower vacuum may be used, pro vided that it is not exceeded during the test

If an asbestos string is used, do not con nect the probe to the train during the leak check. Instead, leak-check the train by firs plugging the inlet to the filter holde (cycone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediate ly above). Then connect the probe to th train and leak-check at about 25 mm Hg (in. Hg) vacuum; alternatively, the prob may be leak-checked with the rest of th sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in exces of 4 percent of the average sampling rate o 0.00057 m³/min (0.02 cfm), whichever is less are unacceptable.

The following leak-check instructions fo the sampling train described in APTD-057 and APTD-0581 may be helpful. Start th pump with bypass valve fully open an coarse adjust valve, completely closed. Par tially open the coarse adjust valve an slowly close the bypass valve until the de sired vacuum is reached. Do not reverse di rection of bypass value; this will cause wate to back up into the filter holder. If the de sired 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 th probe, filter holder, or cyclone (if applica ble) and immediately turn off the vacuum pump. This prevents the water in the im pingers from being forced backward into th filter holder and silica gel from being en trained 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 unecessary, 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

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 surface 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 occured 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

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 01.025 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 m ^{3}/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 m ^{3}/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 atached 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.

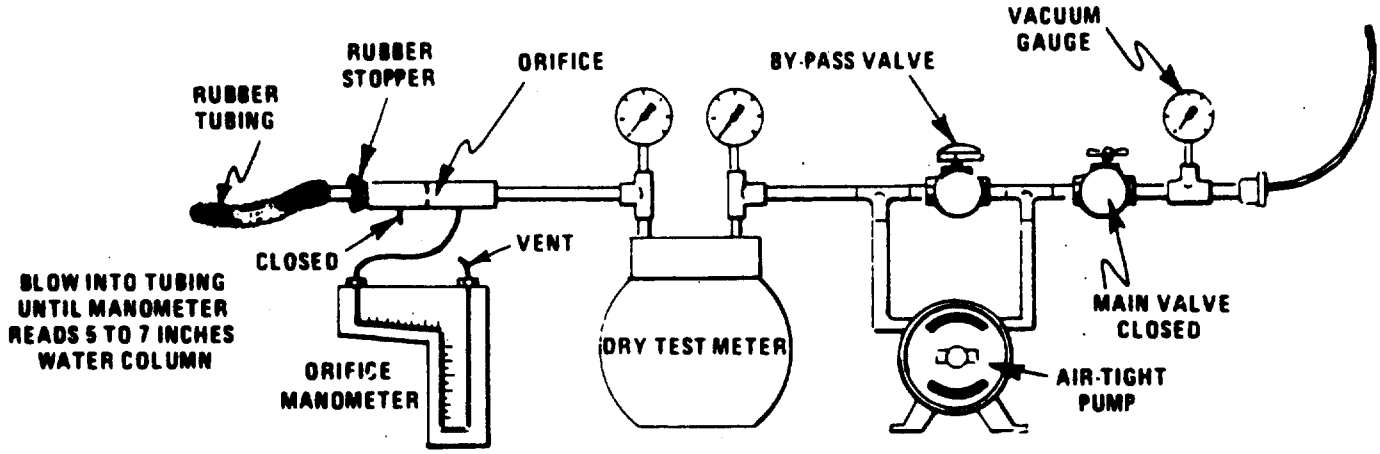

Figure 5-4. Leak check of meter box.

where:

$K_4 = 0.003454$ mm Hg – m^3/ml – °K for metric units.

$= 0.002669$ in. Hg – ft^3/ml – °R for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_{m(std)} P_{std} 100}{T_{std} V_s \theta A_n P_s 60 (1 - B_{ws})}$$

$$= K_4 \frac{T_s V_{m(std)}}{P_s V_s A_n \theta (1 - B_{ws})}$$

Equation 5-8

where:

$K_4 = 4.320$ 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*

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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 H_2O Chloride Free)

2. Alkaline arsenite solution
(1.0 N NaOH + 0.1N $NaAsO_2$: Dissolve 40 grams of NaOH and 6.5 gm $NaAsO_2$ in DI H_2O and dilute to 1000 ml with DI H_2O)

3. Alkaline aresenite solution
(2.5 N NaOH and 0.5 N $NaAsO_2$: Dissolve 100 gm of NaOH and 32.5 gm of $NaAsO_2$ in DI H_2O and dilute to 1000 ml with DI H_2O)

4. Ferris alum indicator
(Dissolve 28.0 gm of ferric ammonium sulfate $FeNH_4(SO_4)_2.12\ H_2O$ in 70 ml of hot DI H_2O. Cool and filter. Add 10 ml of concentrated HNO_3 and dilute to 100 ml with DI H_2O)

5. Nitric acid 8.0 N
(Add 100 ml of concentrated HNO_3 to 100 ml of DI H_2O. Boil until colorless and store in a glass bottle)

6. Silver Nitrate solution 0.1N*
(Dissolve 17.0 gm of $AgNO_3$ 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 NH_4CNS in DI H_2O and dilute to 1000 ml with DI H_2O. Standardize this against the $AgNO_3$ solution using Volhard)

8. Sodium Chloride 0.1N*
(Dissolve 5.846 gm of dried NaCl in DI H_2O and dilute to 1000 ml with DI H_2O)

9. Reagent Nitrogenzene

10. Starch solution (I_2 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 I_2 crystals in 25 gm of iodate free KI and 100 ml with DI H_2O. When completely in solution, dilute to 1000 ml with DI H_2O. Store in an amber bottle)

12. Sodium bicarbonate (Reagent grade $NaHCO_3$)

* 0.01 -- Normal solutions may need to be prepared for HCl and Cl_2 concentrations of less than 1000 ppm.

Sampling Train:

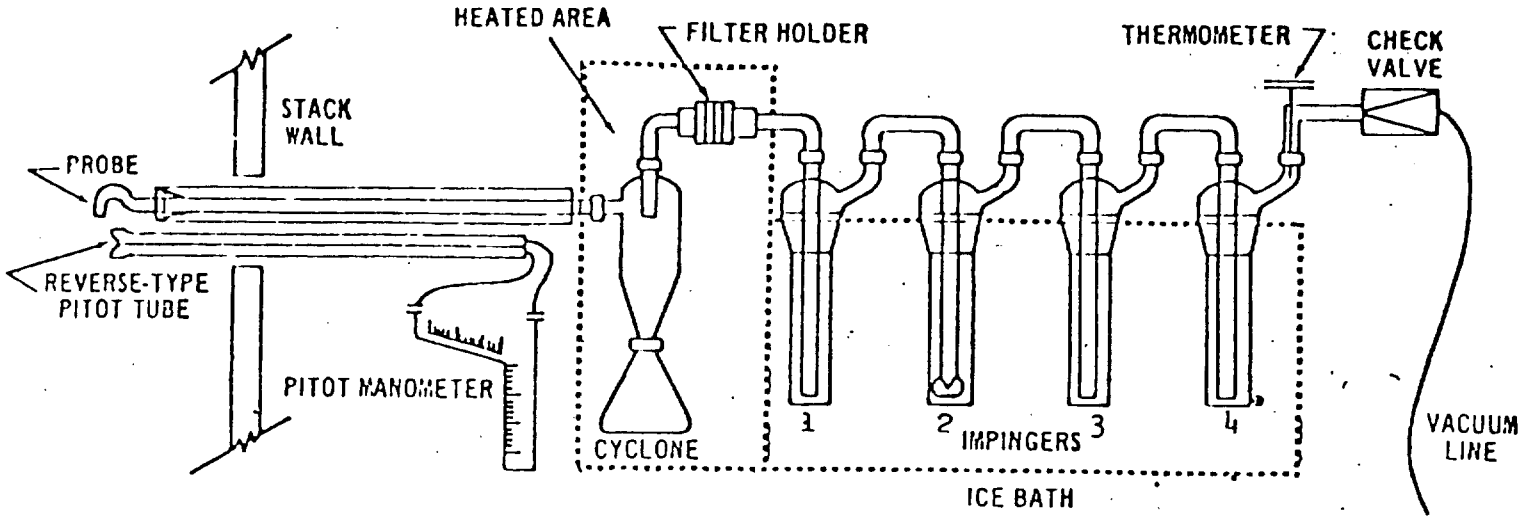

FIGURE II-18

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 H_2O 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 Cl_2 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 Cl_2. 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 I_2 solution where HCl and Cl_2 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 I_2 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 ammononium 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 NH_4CNS solution, as determined previously be titration against standard $AgNO_3$ solution, using ferric alum as an indicator, calculate the net volume of $AgNO_3$ required for precipitation of the chloride.

Calculations:

[(ml $AgNO_3$ x N $AgNO_3$) - (ml NH_4CNS x N NH_4CNS)] x 0.036 = 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 ($NaHCO_3$) 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 I_2 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

[(ml arsenite solution in aliquot x N $NaASO_2$) - (ml I_2 solution x N I_2)] x 0.035 = gms Cl_2 in aliquot

$$0.035 \quad \frac{100\ ml_a\ N_A}{ml_s} - ml_I\ N_I \quad \frac{ml_s}{ml_a} = \text{gm } Cl_2 \text{ in sample}$$

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

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.

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 NO_2) 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 Teflon [1] 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).

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

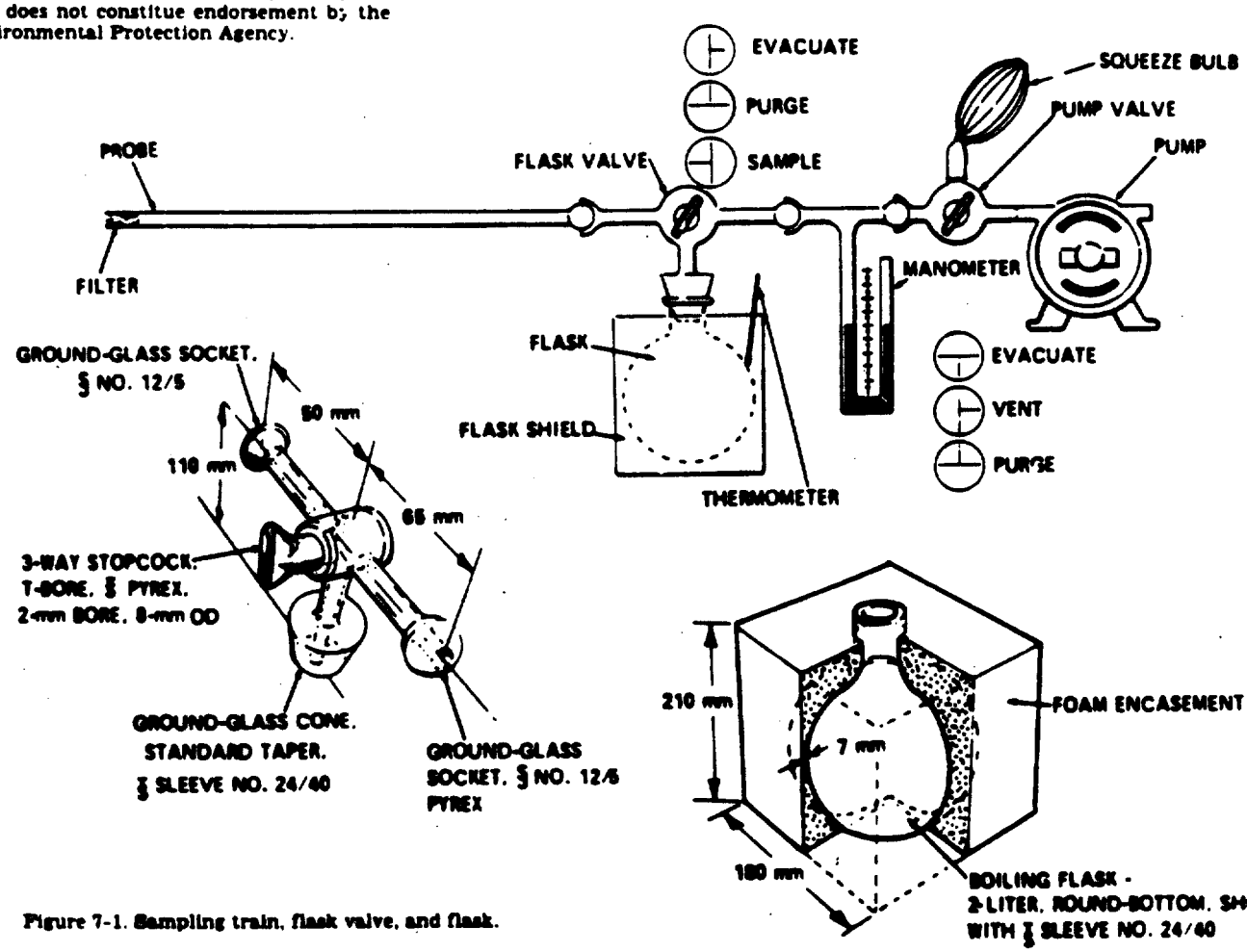

Figure 7-1. Sampling train, flask valve, and flask.

Reprinted from CFR Title 40 dated July 1980

pages 347 - 352

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 μg NO_2 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_c. Add 0.0 ml, 2 ml, 4 ml, 6 ml., and 8 ml of the KNO_3 working standard solution (1 ml = 100 μg NO_2) 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:

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

Equation 7-1

where:

K_c = Calibration factor
A_1 = Absorbance of the 100-μg NO_2 standard
A_2 = Absorbance of the 200-μg NO_2 standard
A_3 = Absorbance of the 300-μg NO_2 standard
A_4 = Absorbance of the 400-μg NO_2 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_2, 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_c = Spectrophotometer calibration factor.
m = Mass of NO_2 as NO_2 in gas sample, μg.
P_f = Final absolute pressure of flask, mm Hg (in. Hg).
P_i = 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, °K (°R).
T_i = Initial absolute temperature of flask, °K (°R).
T_{std} = Standard absolute temperature 293° K (528° R)
V_{sc} = Sample volume at standard conditions (dry basis), ml.
V_f = Volume of flask and valve, ml.
V_a = Volume of absorbing soluton, 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.

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

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

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 μg NO_2 per sample.

$$m = 2\,K_c\,AF$$

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.

$$C = K_2\,\frac{m}{V_{sc}}$$

Equation 7-4

where:

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

$$= 6.243 \times 10^{-5}\ \frac{\text{lb/scf}}{\mu\text{g/ml}}\ \text{for English units}$$

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Reprinted from CFR Title 40 dated July 1980
pages 347 - 352

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[1] 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

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

Reprinted from CFR Title 40 dated July 1980

pages 360 - 367

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.

FIGURE 9-2 OBSERVATION RECORD PAGE ___ OF ___

COMPANY _____ OBSERVER _____
LOCATION _____ TYPE FACILITY _____
TEST NUMBER _____ POINT OF EMISSIONS _____
DATE _____

Hr.	Min.	Seconds 0	15	30	45	STEAM PLUME (check if applicable) Attached	Detached	COMMENTS
	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							

APPENDIX J

DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

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 (H_2O) and carbon dioxide (CO_2) are 3.5 percent H_2O per 7 ppm CO and 10 percent CO_2 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 H_2O per 25 ppm CO and 10 percent CO_2 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 Pyrex[1] 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 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 80 to 90 liters (2 to 3 ft^3). 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.

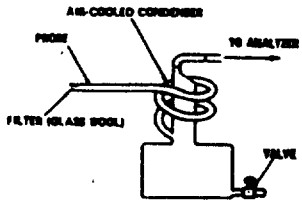


Figure 10-1. Continuous sampling train.

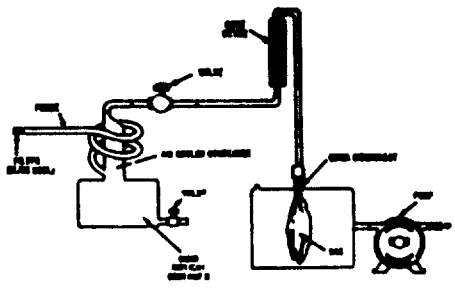


Figure 10-2. Integrated gas sampling train.

5.3.5 CO_2 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 (N_2) for instrument span, prepurified grade of N_2 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.

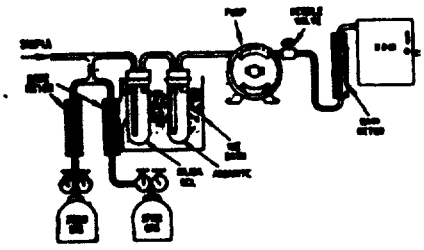


Figure 10-3. Analytical equipment.

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 § 7.2 and 8). CO_2 content of the gas may be determined by using the Method 3 integrated sample procedure (36 FR 24886), or by weighing the ascarite CO_2 removal tube and computing CO_2 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. CO_2 content of the gas may be determined by using the Method 3 integrated sample procedures (36 FR 24886), or by weighing the ascarite CO_2 removal tube and comput-

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

ing CO_2 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 N_2 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 CO_2 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.

$$C_{CO\ stack} = C_{CO\ NDIR}(1 - F_{CO_2})$$

Eq. 10-1

Where:

$C_{CO\ stack}$ = Concentration of CO in stack, ppm by volume (dry basis).

$C_{CO\ NDIR}$ = Concentration of CO measured by NDIR analyzer, ppm by volume (dry basis).

F_{CO_2} = Volume fraction of CO_2 in sample, i.e., percent CO_2 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

ADDENDA

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_2O—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 milliamps 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 reading 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.

APPENDIX K

PERMIT SPECIAL CONDITIONS, EMISSIONS PRE-TEST AGREEMENT, APRIL 21, 1988, RUNS 1 TO 4, PARTICULATE FIELD DATA CALCULATIONS, LABORATORY WEIGHTS, CHAIN-OF-CUSTODY AND CO_2 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, CL_2, 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% CO_2 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.

EMISSIONS PRE-TEST AGREEMENT

Preamble

A source sampling test of the Basic Model 1250 Incinerator/Boiler System (South 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 charge 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 five (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 one (1) to twelve (12) percent carbon dioxide for products of combustion, and two (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 o fits 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 responsiblity 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 (pph) and grains per standard cubic foot (g/scf), (68°F, 1 atm, dry gas)
   - E. Allowable emission rate in pounds per 100 pounds charge
   - F. Percent isokinetic of test
   - G. Process weight during test
   - H. Secondary chamber volume
   - I. Secondary chamber gas glow 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 11 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 at 9:00 a.m. on April 21, 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.

(company representative)	4-21-88 (date)
(consultant)	4-21-88 (date)
(test consultant)	4/21/88 (date)
(Bureau)	4/21/88 (date)

The Almega Corporation

PARTICULATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER SOUTH INCINERATOR
SOURCE: CHATTANOOGA TN
REPETITION NO:
TEST DATE: 21 APRIL 88

	Run 1	2	3	
ENGLISH UNITS (29.92in. Hg 68°F)				
Volume of sample at standard conditions on dry basis	44.148			
$V_{mstd} = [17.64]\, V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$	= 44.433	44.259		44.93
$Y =$ 0.9834	107	54	116	107
Volume of water vapor in sample at standard conditions				
$V_{wstd} = [0.04707 \frac{cu.ft.}{ml}]\, V_{lc}$	= 5.037	3.954	5460	5.037
$V_{lc} =$ _____ ml.				
Fractional moisture content of stack gas	.108	.08193	.1101	.1008
$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	=			
Particle concentration in stack gas on dry basis				
$c's = [0.01543 \frac{gr}{mg}] [\frac{M_n}{V_{mstd}}]$ CORRECTED TO 12% CO2	= 0.01170	0.004528		0.00305
$= 2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$	= 0.02929	0.01387		0.0133
	x 10^{-6} lbs/dscf			
Stack gas volume flow rate on dry basis				
$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)avg \cdot P_{std}}\right]$	= .2579	.2666	.2595	.2644
(A_s= 2.948 sq.ft. V_s= ft/sec)	x 10^6dscf/hr			
Process rate or BTU rating	P_w INCINERATOR CHARGE lbs = 1227	1048	1145	1051
Emission rate				
Q_s c's	= 0.4313	0.1686		0.115
	lbs/hr			
$\frac{Q_s c's}{P_w}$	= _____ lbs/			
Isokinetic sampling rate				
$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.^oR} V_{lc}\right) + \frac{V_m}{T_m} Y \left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\Theta V_s P_s A_n}\right]$				
(A_n = .005809 sq.ft.)	= 96.74	94.44	94.54	94.43

The Almega Corporation

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER SOUTH INCINERATOR
SOURCE:
REPETITION NO:
TEST DATE: CHATTANOOGA TN 21 APRIL 88

	Run 1	2	3	5
Dry molecular weight of stack gas				
$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$	29.57	29.48	29.42	29.3 lb/lb-mol
Molecular weight of stack gas, wet basis				
$M_s = M_d\ (1-B_{ws}) + 18\ B_{ws}$	28.29	28.54	28.16	28.17 lb/lb-mol
Pitot tube coefficient				
C_p (from calibration curve)	.84			
Average velocity head of stack gas, inches H_2O				
$(\sqrt{\Delta p})$ avg.	.5437	.5390	.5519	.552
Average absolute stack gas temperature	°F 206.1	206.4	210.6	200.7
(T_s) avg. = ____ °F + 460	°R 666.1	666.4	670.6 °R	660.7
Absolute stack gas pressure				
$P_s = P_b$ + (Static Pressure/13.6)	29.15	29.15	29.14	29.15 in. Hg
Stack gas velocity				
(V_s) avg. = (85.49) C_p $(\sqrt{\Delta p})$ avg $\sqrt{\frac{(T_s)\text{ avg.}}{P_s\ M_s}}$	35.03	34.65	35.83	35.58 ft/sec.
Stack gas volume flow rate				
$60\ V_s\ A_s$	6195	6129	6338	6293 acfm
Stack gas volume flow rate, dry basis				
$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\text{ avg} \cdot P_{std}}\right]$				x 10^6 dscf/

PARTICULATE FIELD DATA

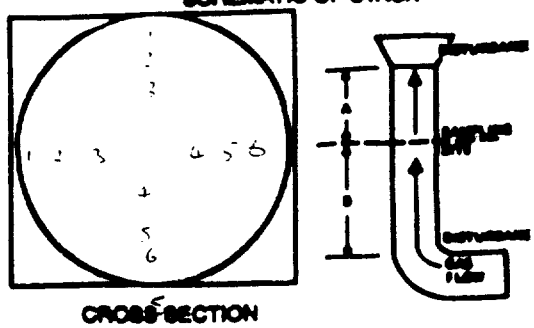
PLANT RANGER MEDICAL CENTER
DATE 21 APRIL 88
LOCATION CHATTANOOGA TN
OPERATOR ERIC AYNSLEY
STACK NO. SOUTH UNIT
RUN NO. I
SAMPLE BOX NO. 1
METER BOX NO. 6
METER $\Delta H_@$ 1.766
Y_d .9834
TIME START = 11:05

AMBIENT TEMPERATURE 62
BAROMETRIC PRESSURE 29.11
ASSUMED MOISTURE, % 9
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .312
STACK DIAMETER, in. 23 1/4
PROBE HEATER SETTING 725 F
HEATER BOX SETTING ~ 250 F
ΔCp FACTOR .84
FILTER NO. 329
FILTER TARE WEIGHT 622.3 mg

12 POINT | SINGLE POINT

NORTH

SCHEMATIC OF STACK



PRE TEST LEAK CHECKS

METER ND @ 26 in Hg
PITOTS ✓ 0 @ 1 in H_2O
ORSAT OK

P #	θ	Static Pressure (+) - in H_2O	Ts °F	ΔP in H_2O	$\sqrt{\Delta P}$	ΔH in H_2O	Vm @ °F	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
E 1	5	47	205	.34		.71	57.9	91	85	235	72	2
2	5		205	.33		.94	52.3	92	86	240	67	2
3	5		206	.27		.79	46.2	93	87	245	61	2
4	5	.54	207	.36		1.05	30.7	95	89	250	65	2
5	5		206	.35		1.04	65.2	97	92	250	64	2
6	5		207	.26		.76	69.1	99	94	255	64	2
E 1	5		206	.29		.86	73.1	102	96	250	64	2
2	5	.43	206	.31		.91	77.2	102	98	250	65	2
3	5		206	.31		.91	81.5	105	99	255	64	2
4	5		207	.26		.76	85.1	107	102	260	65	2
5	5	.47	207	.29		.86	89.1	107	103	255	65	2
6	5		206	.29		.86	93.20	108	104	255	65	2
Av	60	.4775	206.1		.5737	.8708	48.712		57.1			

Time ends = 12:08

POST TEST LEAK CHECKS

METER ND @ 12 in Hg
PITOTS ✓ 0 @ 1 in H_2O
ORSAT OK

Eric Aynsley
ERIC AYNSLEY

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	167	126	2		217
SODIUM ARSENITE INITIAL	100	100	-	55	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					107

~25 ppm

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1	INT	6.9	11.7		
2					
3					
4					

PARTICULATE FIELD DATA

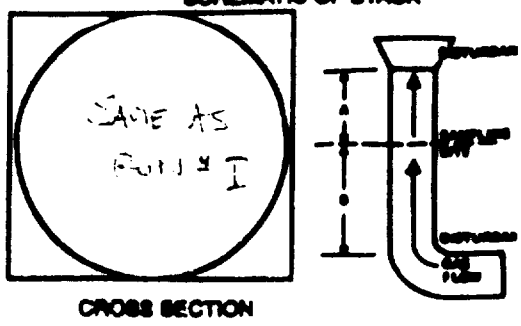
4/21 2

PLANT SHAIKER MEDICAL CENTER
DATE 21 APRIL 88
LOCATION CHATTANOOGA TN
OPERATOR ERIC AYNSLEY
STACK NO. SOUTH UNIT
RUN NO. 2
SAMPLE BOX NO. 2
METER BOX NO. 6
METER $\Delta H_@$ 2.66
Y_d .9534
TIME START 12:20

AMBIENT TEMPERATURE 73
BAROMETRIC PRESSURE 29.11
ASSUMED MOISTURE, % 9
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .312
STACK DIAMETER, in. 23.6
PROBE HEATER SETTING 325 F
HEATER BOX SETTING ~ 325 F
ΔCp FACTOR .84
FILTER NO. 523
FILTER TARE WEIGHT 578.3 mg
12 POINTS / 5 MINS

NORTH

SCHEMATIC OF STACK



CROSS SECTION

PRE TEST LEAK CHECKS
METER N/S @ 17 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

P #	θ	Static Pressure (SP) - in H_2O	Ts °F	ΔP in H_2O	$\sqrt{\Delta P}$	ΔH in H_2O	Vm ft³	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
1	5	.47	195	.31		.95	91.35	102	105	240	68	2
2	5		195	.30		.90	02.55	104	103	245	66	2
3	5		202	.31		.95	7.85	106	103	250	65	2
4	5		209	.24		.71	11.6	107	104	255	66	2
5	5	.50	209	.23		.70	15.35	109	105	250	66	2
6	5		209	.25		.74	19.2	110	106	245	65	2
1	5	.49	210	.33		.98	23.6	112	106	255	66	3
2	5		211	.34		1.—	28.1	113	106	260	65	3
3	5		209	.32		.97	32.45	115	107	255	65	3
4	5	.48	209	.32		.97	36.8	116	108	250	65	3
5	5		209	.27		.80	40.8	117	108	245	65	3
6	5		210	.28		.82	44.909	118	109	240	65	3
Av	60	.485	206.4		.5390	.8742	49.744		108.3			

Time ends 1:55

POST TEST LEAK CHECKS
METER .011 @ 12 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

Eric Aynsley

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	152	118			2.4
INITIAL	100	100	-	56	20
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					54

Sodium Arsenite

×20

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1	INIT	6.0	12.9		
2					
3					
4					

PARTICULATE FIELD DATA

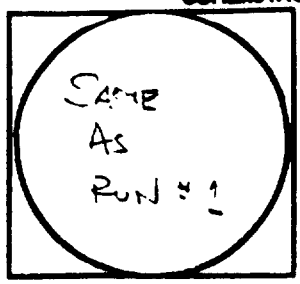
4/21 3

PLANT ERLANGER MEDICAL CENTER
DATE 21 APR 88
LOCATION CHATTANOOGA TN
OPERATOR ERIC AYNSLEY
STACK NO. SOUTH UNIT
RUN NO. 3
SAMPLE BOX NO. 1
METER BOX NO. 6
METER $\Delta H_@$ .7566
Y_d .9834
TIME START = 2:15

AMBIENT TEMPERATURE 76
BAROMETRIC PRESSURE 29.11
ASSUMED MOISTURE, % 10
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .312
STACK DIAMETER, in. 23.4
PROBE HEATER SETTING 250 F
HEATER BOX SETTING 325 F
ΔC_p FACTOR .84
FILTER NO. 530
FILTER TARE WEIGHT 558.9 mg
12 Points @ 5 Mins

NORTH

SCHEMATIC OF STACK



CROSS SECTION

PRE TEST LEAK CHECKS
METER ND @ 21 in Hg
PITOTS 0 @ 1 in Hg
ORSAT OK

P #	θ	Static Pressure (+) in H_2O	Ts °F	ΔP in H_2O	$\sqrt{\Delta P}$	ΔH in H_2O	Vm ft³ 45.975	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
1	5	.43	212	.31		.92	50.225	110	111	235	67	2
2	5		212	.34		1.05	54.75	111	110	240	66	2
3	5		209	.32		.93	59.15	113	111	240	66	2
4	5	.46	209	.31		.92	63.45	114	111	235	65	2
5	5		210	.27		.82	67.5	115	111	230	65	2
6	5		211	.29		.84	71.55	117	112	230	65	2
1	5		207	.27		.82	75.6	119	113	230	"	2
2	5	.43	208	.28		.84	79.65	121	115	225	64	2
3	5		211	.31		.91	84—	123	117	—	—	2
4	5		212	.32		.93	88.05	125	118	"	65	2
5	5		213	.32		.93	92.85	127	120	"	—	2
6	5	.46	214	.33		.94	96.25	129	121	230	66	2
Av	60	.445	210.6		.5519	.9042	50.277		116.4			

Time ends = 2:18

POST TEST LEAK CHECKS
METER ND @ 13 in Hg
PITOTS 0 @ 1 in Hg
ORSAT ✓

Eric Aynsley
ERIC AYNSLEY

	VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL		153	118	—		213
INITIAL		100	100	-	50	200
LIQUID COLLECTED						
TOTAL VOLUME COLLECTED						116

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2	
1	INTD	5.4	13.8	ND		80.8
2						
3						
4						

PARTICULATE FIELD DATA

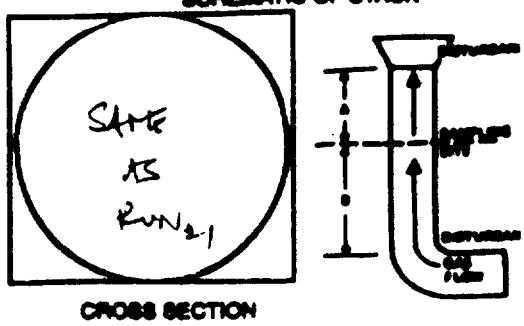
4/M 5

PLANT ERLANGER MEDICAL
DATE 21 APRI - 88
LOCATION CHATTANOOGA TN
OPERATOR ERL AYNSLEY
STACK NO. SOUTH UNIT
RUN NO. 5
SAMPLE BOX NO. 2
METER BOX NO. 6
METER $\Delta H_@$ .7566
Y_d .9834
TIME START = 4:40

AMBIENT TEMPERATURE 78
BAROMETRIC PRESSURE 29.11
ASSUMED MOISTURE, % 9
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .32
STACK DIAMETER, in. 23 1/4
PROBE HEATER SETTING 250 F
HEATER BOX SETTING 225 F
ΔCp FACTOR .84
FILTER NO. 432
FILTER TARE WEIGHT 556.7 mg

NORTH

SCHEMATIC OF STACK



CROSS SECTION

PRE TEST LEAK CHECKS
METER NO @ 20 in Hg
PITOTS OK @ 1 in H_2O
ORSAT OK

12 POINTS @ 5 MIN EACH

P #	θ	Static Pressure (-) in H_2O	Ts °F	ΔP in H_2O	$\sqrt{\Delta P}$	ΔH in H_2O	Vm @ R°	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
5 1	5	46	203	.31		1.3	11 -	112	110	235	65	2
1	5		205	.33		1.4	15.45	114	111	240	64	2
3	5		200	.27		1.1	19.55	116	113	245	63	2
4	5		197	.30		1.23	23.85	119	114	240	63	2
5	5	.49	200	.30		1.21	27.15	122	116	245	64	2
6	5		199	.29		1.15	31.4	123	116	240	62	2
6 1	5		201	.27		1.1	35.55	125	116	240	63	2
2	5	.47	203	.28		1.15	39.7	126	116	235	63	2
3	5		202	.29		1.2	43.9	126	116	235	64	2
4	5		200	.30		1.25	48.2	127	116	230	65	3
5	5	.49	199	.36		1.45	53	126	115	235	66	4
6	5		199	.37		1.45	57.829	126	115	✓	66	4
Av	(60)	(.4775)	(200.7)		(.5523)	(1.249)	(51.274)		(118.1)			

Time ends = 5:48

POST TEST LEAK CHECKS
METER NO @ 18 in Hg
PITOTS OK @ 1 in H_2O
ORSAT OK

ERL AYNSLEY

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	179	138			214
INITIAL	100	100	-	56	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					107

ORSAT MEASUREMENT	TIME	CO_2	O_2	ppm CO	N_2
1	11:45	4.8	13.6	~30	81.6
2					
3					
4					

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger
STACK NUMBER: South Unit
LOCATION: Challenger, Tn
RUN NUMBER: R1
DATE: [illegible]21
RELATIVE HUMIDITY: [illegible] %
ACETONE DENSITY (Pa): 0.78[illegible]8 g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g
ACETONE RINSE VOLUME (Vaw) _____ ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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.

#240

DATE OF WEIGHING 4/25 GROSS WT. 96231.3 mg
TIME OF WEIGHING 1200
DATE OF WEIGHING 4/26 GROSS WT. 96231.6 mg
TIME OF WEIGHING 0700
AVERAGE GROSS WT. 96231.5 mg
LESS BLANK RESIDUE (Wa) — mg
TARE WT. 96202.6 mg
WEIGHT OF PARTICULATE IN ACETONE RINSE 28.9 mg

#329

DATE OF WEIGHING 4/25 GROSS FILTER WT. 627.0 mg
TIME OF WEIGHING 1200
DATE OF WEIGHING 4/26 GROSS FILTER WT. 627.2 mg
TIME OF WEIGHING 0700
AVERAGE GROSS WT. 627.1 mg
FILTER TARE WT. 622.3 mg
WEIGHT OF PARTICULATE ON FILTER 4.8 mg
WEIGHT OF PARTICULATE IN ACETONE RINSE 28.9 mg
TOTAL WEIGHT OF PARTICULATE 33.7 mg

REMARKS: _____

INITIALS OF ANALYST CRT

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger
STACK NUMBER: South Unit
LOCATION: Chattanooga, Tn
RUN NUMBER: R2
DATE: 4/21
RELATIVE HUMIDITY: [illegible] %
ACETONE DENSITY (Pa): [illegible] g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓
ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g
ACETONE RINSE VOLUME (Vaw) _____ ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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.

J241

DATE OF WEIGHING 4/25 GROSS WT. 100272.8 mg
TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS WT. 100273.2 mg
TIME OF WEIGHING 0700

AVERAGE GROSS WT. 100273.0 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 100260.0 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 13.0 mg

#523

DATE OF WEIGHING 4/25 GROSS FILTER WT. 578.3 mg
TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS FILTER WT. 578.3 mg
TIME OF WEIGHING 0700

AVERAGE GROSS WT. 578.3 mg

FILTER TARE WT. 578.3 mg

WEIGHT OF PARTICULATE ON FILTER 0.0 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 13.0 mg

TOTAL WEIGHT OF PARTICULATE 13.0 mg

REMARKS: _____

INITIALS OF ANALYST [illegible]

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Eclipse
STACK NUMBER: [illegible]
LOCATION: Chattanooga, Tn.
RUN NUMBER: R5
DATE: 4/25
RELATIVE HUMIDITY: [illegible] %
ACETONE DENSITY (Pa): [illegible] g/ml
LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓
ACETONE BLANK RESIDUE CONCENTRATION (Ca) [illegible] mg/g
ACETONE RINSE VOLUME (Vaw) _____ ml
BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = [illegible] 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.

J242

DATE OF WEIGHING 4/25 GROSS WT. 99958.8 mg
TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS WT. 99959.1 mg
TIME OF WEIGHING 0700

AVERAGE GROSS WT. 99959.0 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 99953.2 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 5.8 mg

#532

DATE OF WEIGHING 4/25 GROSS FILTER WT. 559.7 mg
TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS FILTER WT. 559.9 mg
TIME OF WEIGHING 0700

AVERAGE GROSS WT. 559.8 mg

FILTER TARE WT. 556.7 mg

WEIGHT OF PARTICULATE ON FILTER 3.1 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 5.8 mg

TOTAL WEIGHT OF PARTICULATE 8.9 mg

REMARKS: _____

INITIALS OF ANALYST CRT

The Almega Corporation

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

J239

BLANK ANALYTICAL DATA FORM

PLANT Erlanger

Sample Location South Unit

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 4/25 1200 Gross wt 116408.1 mg

Date and time of wt 4/26 0700 Gross wt 116408.2 mg

Average gross wt 116408.2 mg

Tare wt 116408.2 mg

Weight of blank (m_a) 0.0 mg

$$C_a = \frac{m_a}{V_a P_a} = \frac{(\ 0.0\ )}{(\ 200\ )\ (\ 0.7858\ )} = 0.0 \text{ mg/g}$$

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 4/21/88 + 4/22/88

Sample Number	Number of Container	Description of Samples
R1 Filter	R1 F	Filter for particulates
1 PW	R1 PW	Probe wash for particulates
1 Impl	R1 IMP1	} Impingers for Hcl & Cl
1 Imp 2	R1 IMP2	
R2 Filter	R2 F	Filter for particulates
2 PW	R2 PW	Probe wash for particulates
2 Impl	R2 IMP1	} Impingers for Hcl & Cl
2 Imp 2	R2 IMP2	
R4 Filter	R4 F	Filter for particulates
4 PW	R4 PW	Probe wash for particulates
4 Impl	R4 IMP1	} Impingers for Hcl & Cl
4 Imp 2	R4 IMP2	
R3 IMP 1+2	R3 IMP 1+2	Impingers for Hcl & Cl.
Acetone blank	Acetone blank	

Person responsible for samples B. W. JACKSON Time 5:00 PM Date 4/22/88

Sample Number	Relinquished by:	Received by:	Time	Date	Reason for Change of Custody
R1 F					
R1 PW					
R1 Impl					
R1 Imp 2					
R2 F					
R2 PW					LABORATORY
R2 Impl					
R2 Imp 2			5:00 PM	4/25/88	ANALYSES
R4 F					
R4 PW					
R4 Impl					
R4 Imp 2					
R3 Impl					
R3 Imp 2					
Acetone blank					

CHAIN OF CUSTODY FORM

Plant Chattanooga - Hamilton County Hospital Authority Source Boric Model 1250 South

Date Sampled 4/21/88 Test # 1 Run # 2

SAMPLE RECOVERY

Container #	Description (if filter, then give filter #)
520	Filter #520 tare 558.9
PW	probe wash
AP	acetone blank

Person Engaged in Sample Recovery:

Signature and Title [signature] Administration Manager

Recovery Location On Site

Date & Time of Recovery 4/21/88 3:15 pm

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

Signature [signature]

Date & Time of Receipt 4/21/88 4:20 PM

Sample Storage automobile

Laboratory Person Receiving Sample

Signature & Title

Date & Time of Receipt

Sample Storage

THE ALMEGA CORPORATION

ERLANGER: SOUTH UNIT

CALCULATION OF CO_2 CORRECTION FACTORS

Run	Gas Meter final - initial	Cubic Feet Gas Used	Gas Used dscf/hr Average	$Q_s \times 10^6$ Stack Gas Flow dscfh	% CO_2 in Stack Gas From Gas Use %	CO_2 Correction Factor 12/CO_2 measured - CO_2 from gas use
April 21						
1	372467*	*from Erlanger Waste Incinerator Plant Log (in 7 hours)	5429	0.2579	2.105	12/(6.9 - 2.105) = 2.503
2	- 372429* / 38		5429	0.2606	2.083	12/(6.0 - 2.083) = 3.064
3	x 1000/7		5429	0.2595	2.092	12/(5.4 - 2.092) = 3.628
4	= 5429					
5			5429	0.2644	2.053	12/(4.8 - 2.053) = 4.368
April 22						
1	(9:45 - 10:45) +	time+ 8/9	6000+	0.2749	1.819	12/(5.0 - 1.819) = 3.772
		9/10	5000			
2	(11:00 - 1:01) +	10/11	5000	0.2653	1.885	12/(7.9 - 1.885) = 1.995
		11/12	5000			
3	(1:12 - 2:12) +	12/1	5000	0.2817	1.775	12/(8.1 - 1.775) = 1.897
		1/2	5000			
		2/3	5000			
4	(2:23 - 3:23) +	3/4	8000	0.2677	2.429	12/(7.2 - 2.429) = 2.515

See Appendix P

APPENDIX L

APRIL 22, 1988, RUNS 1 TO 4, PARTICULATE FIELD DATA CALCULATIONS, LABORATORY WEIGHTS, CHAIN-OF-CUSTODY AND CO_2 CORRECTION FACTOR CALCULATIONS

The Almega Corporation

PARTICULATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER
SOURCE: SOUTH INCINERATOR
REPETITION NO: CHATTANOOGA TN
TEST DATE: 22. APRIL 88

	RUN 1	2	3	4 BYPASS BAGHOUSE
ENGLISH UNITS (29.92in. Hg 68°F)				
Volume of sample at standard conditions on dry basis				
$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$	= 47.629	46.062	49.046	26.954
γ = .9834	110	106	117	61
Volume of water vapor in sample at standard conditions				
$V_{wstd} = \left[0.04707 \frac{cu.ft.}{ml}\right] V_{1c}$	= 5.178	4.989	5.507	2.871
V_{1c} = _____ ml.				
Fractional moisture content of stack gas				
$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	= .09806	.09773	.1010	.09626
Particle concentration in stack gas on dry basis				
$c's = \left[0.01543 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{mstd}}\right]$	= .006091	.009949	.009470	.07511
$- 2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$	= _____			$\times 10^{-6}$ lbs/dscf
Stack gas volume flow rate on dry basis				
$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)avg \cdot P_{std}}\right]$	= .2749	.2653	.2817	.2677
(A_s= 2.948 sq.ft. V_s= ft/sec)				$\times 10^6$ dscf/hr
Process rate or BTU rating P_w	= _____			
Emission rate Q_s c's	= .2393	.3772	.3812	2.873
$\frac{Q_s\ c's}{P_w}$	= _____			lbs/
Isokinetic sampling rate				
$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.°R} V_{1c}\right) + \frac{V_m}{T_m}\gamma\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\theta V_s P_s A_n}\right]$				
(A_n = .0005309 sq.ft.)	= 96.26	96.45	96.72	95.91

The Almega Corporation

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER
SOURCE: CHATTANOOGA TN SOUTH INCINERATOR
REPETITION NO:
TEST DATE: 22-APRIL-88

	Run 1	2	3	4
Dry molecular weight of stack gas $M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$	29.33	29.66	29.69	29.59 lb/lb-mole
Molecular weight of stack gas, wet basis $M_s = M_d\ (1-B_{ws}) + 18\ B_{ws}$	28.22	28.52	28.51	28.48 lb/lb-mole
Pitot tube coefficient C_p (from calibration curve)	.84	.84	.84	.8
Average velocity head of stack gas, inches H_2O $(\sqrt{\Delta p})$ avg.	.5728	.5962	.59[illegible]	.5558
Average absolute stack gas temperature (T_s) avg. = ____ °F + 460	°R 658.1	659.4	668.2 °R	733.8
Absolute stack gas pressure $P_s = P_b + (\text{Static Pressure}/13.6)$	29.09	29.10	29.10	29.10 in. Hg
Stack gas velocity (V_s) avg. $= (85.49)\ C_p\ (\sqrt{\Delta p})$ avg $\sqrt{\frac{(T_s)\text{ avg.}}{P_s\ M_s}}$	36.82	35.58	38.42	39.88 ft/sec.
Stack gas volume flow rate $60\ V_s\ A_s$	6513	6294	6796	7055 acfm
Stack gas volume flow rate, dry basis $Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\text{ avg} \cdot P_{std}}\right]$				x 10^6 dscf/[illegible]

111.5984 @ 30

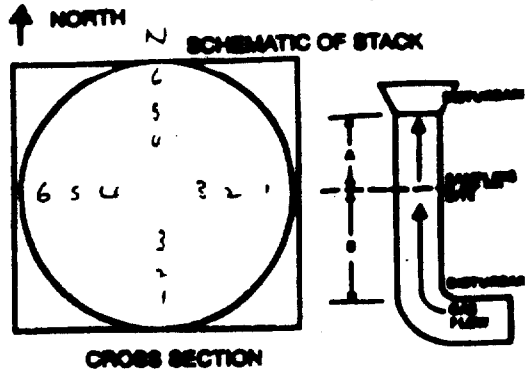
4/22 1

PARTICULATE FIELD DATA

PLANT ERLANGER M.C.
DATE 22 · APRIL · 88
LOCATION CHATTANOOGA TN
OPERATOR ERIC AYNSLEY
STACK NO. SOUTH UNIT
RUN NO. 1
SAMPLE BOX NO. 1
METER BOX NO. 6
METER $\Delta H_@$ .7566
Y_m .9834
TIME START = 9:45 AM

AMBIENT TEMPERATURE 72
BAROMETRIC PRESSURE 29.06
ASSUMED MOISTURE, % 10
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .312
STACK DIAMETER, in. 23 1/4
PROBE HEATER SETTING 250°F
HEATER BOX SETTING ±25°F
ΔCp FACTOR .84
FILTER NO. 528
FILTER TARE WEIGHT 555.1 mg

12 POINTS / 5 MINS



PRE TEST LEAK CHECKS
METER ND @ 21 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

P #	θ	Static Pressure (+) - in H_2O	Ts °F	ΔP in H_2O	√ΔP	ΔH in H_2O	Vm R^2 58.742	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
E 1	5	.47	194	.31		.78	63-	93	92	255	69	2
2	5		195	.34		1.08	67.5	97	94	250	67	2
3	5		197	.37		1.18	72.2	104	97	250	65	2
4	5		197	.36		1.13	76.85	107	99	255	64	2
5	5		198	.34		1.08	81.35	114	103	250	64	2
6	5		198	.33		1.05	85.75	119	107	245	64	2
N 1	5	.46	199	.32		.98	90.05	122	107	240	64	2
2	5		199	.31		1-	94.65	124	108	240	65	2
3	5		199	.31		1-	99.05	125	110	-	-	2
4	5		200	.32		1.05	3.5	127	111	-	-	2
5	5		200	.32		1.05	8.0	127	112	245	66	2
6	5		201	.31		1-	12.454	128	113	-	60	3
Av	60	.465	198.1		.5728	1.048	53.712		110.			

Time ends = 10:45

POST TEST LEAK CHECKS
METER .003 @ 21 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

Eric Aynsley

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	178	185			213
SODIUM ARSENITE FINAL	100	100	-	56	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					

ND<5

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1	INT'D	5.0	13.3		
2					
3					
4					

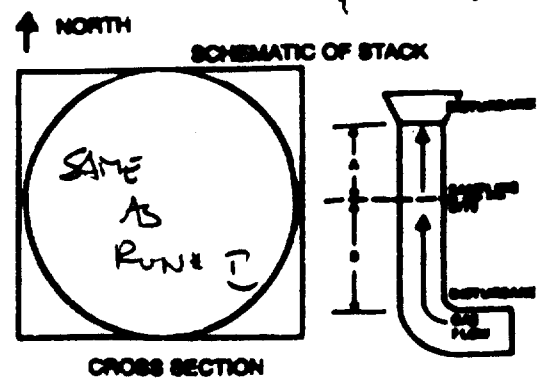
81.7

4/12 2

PARTICULATE FIELD DATA

PLANT ERLANGER M C
DATE 22. APRIL 88
LOCATION CHATANOOGA TN
OPERATOR ERIC AYNSLEY
STACK NO. SOUTH
RUN NO. 2
SAMPLE BOX NO. 2
METER BOX NO. 6
METER $\Delta H_@$ .7566
Y_m .9834
TIME START = 11:00A

AMBIENT TEMPERATURE 75
BAROMETRIC PRESSURE 29.06
ASSUMED MOISTURE, % 10
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 .312
STACK DIAMETER, in. 23 1/4
PROBE HEATER SETTING 250°F
HEATER BOX SETTING ± 25°F
ΔC_p FACTOR .84
FILTER NO. 499
FILTER TARE WEIGHT 576.7 mg



PRE TEST LEAK CHECKS

METER .009 @ 22 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

P #	θ	Static Pressure (+) in H_2O	Ts °F	ΔP in H_2O	√ΔP	ΔH in H_2O	Vm R^3 13.288	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
E 1	5	.52	197	.30		.94	17.6	120	118	225	70	5
2	5		197	.31		.96	22—	122	120	230	67	6
3	5		198	.33		1.02	26.55	125	121	235	66	6
4	5		198	.31		.96	30.95	127	122	240	66	6
5	5		198	.28		.86	35.15	128	123	—	66	6
6	5	⊕	199	.32		1.07	39.6	128	122	—	66	7
M 1	5		200	.28		.86	43.8	107	110	235	70	7
2	5	.51	200	30		.94	48.15	112	113	240	60	7
3	5		201	.34		1.1	52.75	119	116	240	61	7
4	5		201	.32		1—	57.25	119	111	240	61	8
5	5		202	.31		.96	61.65	122	113	—	—	—
6	5		202	.31		.96	66.05	123	113	—	62	8
Av	60	.515	199.4		.5558	.9692	52.767		119.9			

Time ends = 1:01

⊕ OFF ~60 MINS

POST TEST LEAK CHECKS

METER .002 @ 12 in Hg
PITOTS 0 @ 1 in H_2O
ORSAT OK

Eric Aynsley
ERIC AYNSLEY

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	174	117	—		715
[illegible]	100	100	—	56	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					106

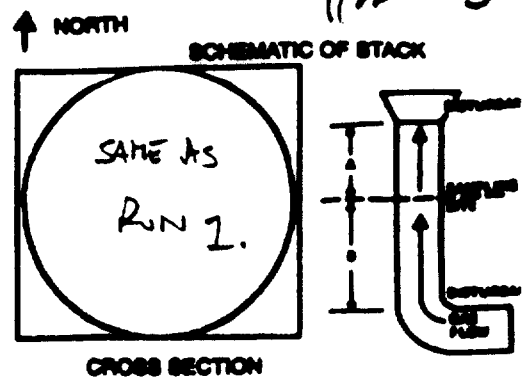
ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1	INT 8	7.9	10.0	ND<5	82.1
2					
3					
4					

4/22 3

PARTICULATE FIELD DATA

PLANT: ERLANGER M.C.
DATE: 22. APRIL. 88
LOCATION: CHATTANOOGA TN
OPERATOR: ERIC AYNSLEY
STACK NO.: SOUTH
RUN NO.: 3
SAMPLE BOX NO.: 1
METER BOX NO.: 6
METER ΔH@: .7566
Y: .9834
TIME START: 1:12

AMBIENT TEMPERATURE: 82
BAROMETRIC PRESSURE: 29.06
ASSUMED MOISTURE, %: 10
PROBE LENGTH, in.: 30
NOZZLE DIAMETER, in.: 5/16 .312
STACK DIAMETER, in.: 23"4
PROBE HEATER SETTING: 250 F
HEATER BOX SETTING: – 325 F
ΔCp FACTOR: .84
FILTER NO.: 458
FILTER TARE WEIGHT: 609.3 mg



PRE TEST LEAK CHECKS
METER: ND @ 20 in Hg
PITOTS: 0 @ 1 in H2O
ORSAT: OK

P #	θ	Static Pressure (+) in H2O	Ts °F	ΔP in H2O	√ΔP	ΔH in H2O	Vm ft³ 66.151	Tm Inlet °F	Tm Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
E 1	5	.57	206	.33		1.05	70.7	121	117	240	67	2
2	5		208	.35		1.09	75.4	125	119	245	65	2
3	5		208	.36		1.13	80.1	127	120	✓	63	2
4	5		208	.34		1.07	84.7	128	121	✓	✓	2
5	5		207	.32		1.05	89.25	128	122	–	64	3
6	5		207	.33		1—	93.85	129	121	250	✓	3
N 1	5		207	.36		1.15	98.65	130	121	245	–	3
2	5		208	.37		1.17	3.45	130	121	–	✓	4
3	5	.53	209	.38		1.21	8.3	131	122	–	–	4
4	5		209	.34		1.07	12.9	131	122	250	65	4
5	5		210	.39		1.25	17.85	130	123	245	65	5
6	5		211	.40		1.29	122.86	130	122	–	60	5
Av	60	.55	208.2		.5962	1.128	56.715		124.6			

Time ends: 2:12

POST TEST LEAK CHECKS
METER: ND @ 21 in Hg
PITOTS: 0 @ 1 in H2O
ORSAT: OK –

Eric Aynsley

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	172	127	2		216
EDDY AYNSLEY INITIAL	155	100	–	56	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					117

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1	INT	8.1	9.9		
2					
3					
4					

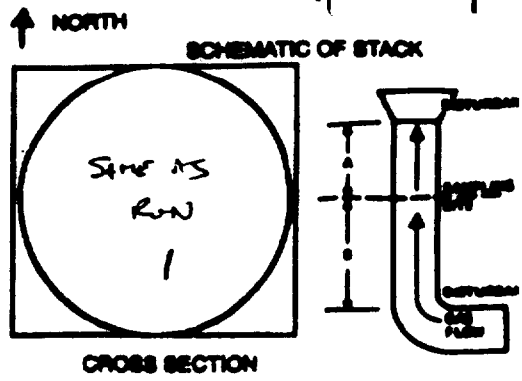
NO < 6

82

PARTICULATE FIELD DATA

PLANT ZRANGER MK
DATE 22. APRIL · 88
LOCATION CHATTANOOGA TN
OPERATOR ERIC
STACK NO. SOUTH: PSH, BYPASSED
RUN NO. 4
SAMPLE BOX NO. 2
METER BOX NO. 6
METER Δ$H_@$ ·7566
Y_d ·9834
TIME START - 2·23

AMBIENT TEMPERATURE 83
BAROMETRIC PRESSURE 29.26
ASSUMED MOISTURE, % 10
PROBE LENGTH, in. 30
NOZZLE DIAMETER, in. 5/16 ·312
STACK DIAMETER, in. 28'4
PROBE HEATER SETTING 250 F
HEATER BOX SETTING ·250 F
ΔC_p FACTOR ·84
FILTER NO. 498
FILTER TARE WEIGHT 517.9 mg



PRE TEST LEAK CHECKS
METER ·003 @ 26 in Hg
PITOTS ✓ @ 1 in H_2O
ORSAT OK.

P #	θ	Static Pressure (+) (−) in H_2O	T_s °F	Δp in H_2O	$\sqrt{\Delta p}$	Δh in H_2O	V_m ft³ 73.101	T_m Inlet °F	T_m Outlet °F	Oven Temp. °F	Imp. Outlet Temp. °F	Vacuum (in Hg)
E 1	5		285	·33		1·25	27.4	122	117	245	69	7
2	5		271	·35		1·30	31.8	124	119	250	67	8
3	5		273	·36		1·35	36.4	125	120	"	66	8
4	5	·48	274	·35		1·3	40.8	127	121	"	65	8
5	5		270	·35		1·3	45.25	128	122	245	65	9
6	5		271	·35		1·3	49.7	129	121	240	68	10
N 1	~5		272	·36		1·4	54.20	131	124	245	69	10
2			272	·36								
3			271	·35								
4			274	·33								
5			277	·34								
6			275	·35								
Av	~35	·48	273.8		.5901	1.314	31.101		123.6			

Time ends - 3:23

POST TEST LEAK CHECKS
METER 2 @ 21 in Hg
PITOTS ✓ @ 1 in Hg
ORSAT OK

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	135	117	2		207
INITIAL	100	100	-	0	200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED					7

ORSAT MEASUREMENT

	TIME	CO_2	O_2	CO	N_2
1	INIT	9·2	10·9	<0·5	79.9
2					
3					
4					

⊖ OFF: SILICA GEL ? PLUGGED?

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger STACK NUMBER: South Unit

LOCATION: Chattanooga, TN RUN NUMBER: R1

DATE: 4/22/88 RELATIVE HUMIDITY: 50 %

ACETONE DENSITY (Pa): 0.7852 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g

ACETONE RINSE VOLUME (Vaw) _____ ml

BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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 4/25 GROSS WT. 90762.8 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS WT. 90763.0 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 90762.9 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 90752.0 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 10.9 mg

528

DATE OF WEIGHING 4/25 GROSS FILTER WT. 563.2 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS FILTER WT. 562.7 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 563.0 mg

FILTER TARE WT. 555.1 mg

WEIGHT OF PARTICULATE ON FILTER 7.9 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 10.9 mg

TOTAL WEIGHT OF PARTICULATE 18.8 mg

REMARKS: _____

INITIALS OF ANALYST CAT

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Enlarger — STACK NUMBER: South Unit

LOCATION: Chattanooga, Tn. — RUN NUMBER: R2

DATE: 4/22/88 — RELATIVE HUMIDITY: 50 %

ACETONE DENSITY (Pa): 0.7858 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g

ACETONE RINSE VOLUME (Vaw) _____ ml

BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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.

J244

DATE OF WEIGHING 4/25 — GROSS WT. 100131.4 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 — GROSS WT. 100131.6 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 100131.5 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 100116.3 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 15.2 mg

#499

DATE OF WEIGHING 4/25 — GROSS FILTER WT. 591.0 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 — GROSS FILTER WT. 591.3 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 591.2 mg

FILTER TARE WT. 576.7 mg

WEIGHT OF PARTICULATE ON FILTER 14.5 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 15.2 mg

TOTAL WEIGHT OF PARTICULATE 29.7 mg

REMARKS: _____

INITIALS OF ANALYST CRT

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Falcon STACK NUMBER: South Unit

LOCATION: Chattanooga, Tn. RUN NUMBER: R3

DATE: 4/22/88 RELATIVE HUMIDITY: 50 %

ACETONE DENSITY (Pa): 0.7858 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g

ACETONE RINSE VOLUME (Vaw) _____ ml

BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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.

J245

DATE OF WEIGHING 4/25 GROSS WT. 96800.4 mg

TIME OF WEIGHING 0700

DATE OF WEIGHING 4/26 GROSS WT. 96800.7 mg

TIME OF WEIGHING 1200

AVERAGE GROSS WT. 96800.6 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 96785.3 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 15.3 mg

#458

DATE OF WEIGHING 4/25 GROSS FILTER WT. 624.2 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS FILTER WT. 624.0 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 624.1 mg

FILTER TARE WT. 609.3 mg

WEIGHT OF PARTICULATE ON FILTER 14.8 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 15.3 mg

TOTAL WEIGHT OF PARTICULATE 30.1 mg

REMARKS: _____

INITIALS OF ANALYST ORT

The Almega Corporation

PARTICULATE ANALYTICAL DATA FORM

COMPANY: Erlanger STACK NUMBER: South Unit

LOCATION: Chattanooga, Tn. RUN NUMBER: R4

DATE: 4/22/88 RELATIVE HUMIDITY: 50 %

ACETONE DENSITY (Pa): 0.791 g/ml

LIQUID LEVEL MARKED AND CONTAINER SEALED? ✓

ACETONE BLANK RESIDUE CONCENTRATION (Ca) 0.0 mg/g

ACETONE RINSE VOLUME (Vaw) _____ ml

BLANK RESIDUE IN ACETONE RINSE (Wa) = Ca.Vaw.Pa = 0.0 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.

J246

DATE OF WEIGHING 4/25 GROSS WT. 100767.1 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS WT. 100767.6 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 100767.4 mg

LESS BLANK RESIDUE (Wa) — mg

TARE WT. 100708.8 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 58.6 mg

#1498

DATE OF WEIGHING 4/25 GROSS FILTER WT. 650.7 mg

TIME OF WEIGHING 1200

DATE OF WEIGHING 4/26 GROSS FILTER WT. 650.3 mg

TIME OF WEIGHING 0700

AVERAGE GROSS WT. 650.5 mg

FILTER TARE WT. 577.9 mg

WEIGHT OF PARTICULATE ON FILTER 72.6 mg

WEIGHT OF PARTICULATE IN ACETONE RINSE 58.6 mg

TOTAL WEIGHT OF PARTICULATE 131.2 mg

REMARKS: _____

INITIALS OF ANALYST _____

The Almega Corporation

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

J239

BLANK ANALYTICAL DATA FORM

PLANT Erlanger

Sample Location South Unit

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 4/25 1200 Gross wt 116408.1 mg

Date and time of wt 4/26 0700 Gross wt 116408.2 mg

Average gross wt 116408.2 mg

Tare wt 116408.2 mg

Weight of blank (m_a) 0.0 mg

$$C_a = \frac{m_a}{V_a P_a} = \frac{(\ 0.0\ )}{(\ 200\ )\ (0.7858)} = 0.0 \text{ mg/g}$$

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 4/21/88 + 4/22/88

Sample Number	Number of Container	Description of Samples
R1 Filter	R1 F	Filter for particulates
1 PW	R1 PW	Probe wash for particulates
1 Imp 1	R1 IMP1	Impingers for Hcl & Cl
1 Imp 2	R1 IMP2	
R2 Filter	R2 F	Filter for particulates
2 PW	R2 PW	Probe wash for particulates
2 Imp 1	R2 IMP1	Impingers for Hcl & Cl
2 Imp 2	R2 IMP2	
R4 Filter	R4 F	Filter for particulates
4 PW	R4 PW	Probe wash for particulates
4 Imp 1	R4 IMP1	Impingers for Hcl & Cl
4 Imp 2	R4 IMP2	
R3 IMP 1+2	R3 IMP 1+2	Impingers for Hcl & Cl.
Acetone blank	Acetone blank	

Person responsible for samples B.W. Jackson Time 5:00 pm Date 4/22/88

Sample Number	Relinquished by:	Received by:	Time	Date	Reason for Change of Custody
R1 F					
R1 PW					
R1 Imp 1					
R1 Imp 2					
R2 F					
R2 PW					LABORATORY
R2 Imp 1			5:00 pm	4/25/88	
R2 Imp 2					ANALYSES
R4 F					
R4 PW					
R4 Imp 1					
R4 Imp 2					
R3 Imp 1					
R3 Imp 2					
Acetone blank					

THE ALMEGA CORPORATION

ERLANGER: SOUTH UNIT

CALCULATION OF CO_2 CORRECTION FACTORS

Run	Gas Meter final - initial	Cubic Feet Gas Used	Gas Used dscf/hr Average	$Q_s \times 10^6$ Stack Gas Flow dscfh	% CO_2 in Stack Gas From Gas Use %	CO_2 Correction Factor 12/CO_2 measured - CO_2 from gas use
April 21						
1	372467*	*from Erlanger Waste Incinerator Plant Log (in 7 hours)	5429	0.2579	2.105	12/(6.9 - 2.105) = 2.503
2	-		5429	0.2606	2.083	12/(6.0 - 2.083) = 3.064
3	372429*/38 x 1000/7		5429	0.2595	2.092	12/(5.4 - 2.092) = 3.628
4	= 5429					
5			5429	0.2644	2.053	12/(4.8 - 2.053) = 4.368
April 22						
1	(9:45 - 10:45) +	time+ 8/9	6000+	0.2749	1.819	12/(5.0 - 1.819) = 3.772
		9/10	5000			
2	(11:00 - 1:01) +	10/11	5000	0.2653	1.885	12/(7.9 - 1.885) = 1.995
		11/12	5000			
3	(1:12 - 2:12) +	12/1	5000	0.2817	1.775	12/(8.1 - 1.775) = 1.897
		1/2	5000			
		2/3	5000			
4	(2:23 - 3:23) +	3/4	8000	0.2677	2.429	12/(7.2 - 2.429) = 2.515

See Appendix P

APPENDIX M

APRIL 21 AND 22, 1988, RUNS 1 TO 5 AND
RUNS 1 TO 4 RESPECTIVELY, HYDROGEN
CHLORIDE AND CHLORINE LABORATORY
ANALYSES AND CALCULATIONS

The Almega Corporation

HCl
~~PARTICULATE~~ CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER SOUTH INCINERATOR
SOURCE: CHATTANOOGA 21 APRIL 88
REPETITION NO: TN RUN1 2 3 5
TEST DATE:

ENGLISH UNITS
(29.92in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$$

$Y = 0.9834$

= 44.433 44.299 44.148 44. dscf.

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{cu.ft.}{ml}\right] V_{lc}$$

= _____ scf.

V_{lc} = _____ ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

= _____

Particle concentration in stack gas on dry basis

ppm 228.6 527.7 486.9 734.2

$$c's = \left[0.01543 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{mstd}}\right]$$

= _____ grains/dscf.

$$2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$$

= _____ x 10^{-6} lbs/dscf

Stack gas volume flow rate on dry basis

$$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}}\right]$$

= .2579 .2606 .2595 x 10^6 dscf/hr .264

(A_s= sq.ft. V_s= ft/sec)

Process rate or BTU rating P_w = _____

Emission rate

Q_s c's = 5.516 13.04 11.98 18.40 lbs/hr

$$\frac{Q_s\ c's}{P_w}$$

= _____ lbs/

Isokinetic sampling rate

$$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.^\circ R} V_{lc}\right) + \frac{V_m Y}{T_m}\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\theta V_s P_s A_n}\right]$$

(A_n = sq.ft.)

= _____

The Almega Corporation

HCl

~~PARTICULATE~~ CALCULATION SUMMARY

SOUTH INCINERATOR

COMPANY: ERLANGER MEDICAL CENTER
SOURCE: CHATTANOOGA TN
REPETITION NO:
TEST DATE: 22 APRIL - 88

	RUN 1	2	3	4
	ENGLISH UNITS (29.92in. Hg 68°F)			BYPASS BACKUP

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$$

$Y = .9834$

= 47.629 46.062 49.046 dscf. 26.9

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{cu.ft.}{ml}\right] V_{lc}$$

= _____ scf.

V_{lc} = _____ ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

= _____

Particle concentration in stack gas on dry basis

RPM

399.0 395.4 521.7 907.1

$$c's = \left[0.01543 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{mstd}}\right]$$

= _____ grains/dscf.

$$- 2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$$

= _____ x 10^{-6} lbs/dscf

Stack gas volume flow rate on dry basis

$$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}}\right]$$

= .2749 .2653 .2817 .267 x 10^6 dscf/hr

(A_s= sq.ft. V_s= ft/sec)

Process rate or BTU rating P_w = _____

Emission rate

Q_s c's = 10.40 9.944 13.93 23.0 lbs/hr

$\frac{Q_s\ c's}{P_w}$ = _____ lbs/

Isokinetic sampling rate

$$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.{}^\circ R} V_{lc}\right) + \frac{V_m Y}{T_m}\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\theta V_s P_s A_n}\right]$$

(A_n = sq.ft.)

= _____ %

Γ Ion

HCl ~~analysis~~ by ion specific electrode

(Orion 601A Analyzer + Electrode) **DATA SHEET**

Run	mv	log C	conc. mg/l	V_s	mg Cl^- impinger	mg HCl impinger		mg HCl sample	
~~Lab~~ Blank	~~+296~~								
1 ppm Std	+299	0							
10 ppm Std	+267	1							
50 ppm Std	+231	1.699							
100 ppm Std	+217	2							
500 ppm Std	+178	2.699							
1000 ppm Std	+161	3							
10,000 ppm Std	+107	4							
100,000 ppm Std	+38	5							
Field Blank	+278			0.2l					
4/21									
R1 Imp 1	+140		2039	0.2l	408	419		431	
Imp 2	+222		59	0.2l	12	12			
R2 Imp 1	+120		4828	0.2l	966	993		1005	
Imp 2	+222		59	0.2l	12	12			
R3 Imp 1	+122		4429	0.2l	886	911		924	
Imp 2	+220		65	0.2l	13	13			
R5 Imp 1	+116		5737	0.2l	1147	1180		1418	
Imp 2	+199		160	0.2l	231	238			

Exhaust

HCl Analysis by ion specific electrode
(Orion 601A Analyzer + Electrode)

DATA SHEET

Run	mv	----	conc. mg/l	V_s	mg Cl^- impinger	mg HCl impinger		mg HCl Sample	
4/22									
R1 Imp 1	~~+125~~		3892	0.2 l	778	800		817	
Imp 2	+215		80	0.2 l	16	17			
R2 Imp 1	+126		3728	0.2 l	746	767		783	
Imp 2	+216		77	0.2 l	15	16			
R3 Imp 1	+118		5263	0.2 l	1052	1082		1100	
Imp 2	+213		88	0.2 l	18	18			
R4 Imp 1	+119		5041	0.2 l	1008	1037		1051	
Imp 2	+219		68	0.2 l	14	14			

The Almega Corporation

~~EPA 2~~
PARTICULATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER SOUTH INCINERATOR
SOURCE: CHATTANOOGA
REPETITION NO: 21 APRIL 88
TEST DATE: TN RUN 1 2 3

ENGLISH UNITS
(29.92in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$$

$Y = 0.9834$

= 44.433 44.299 44.148 44 dscf.

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{cu.ft.}{ml}\right] V_{lc}$$

= _____ scf.

V_{lc} = _____ ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

= _____

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{mstd}}\right]$$

= _____ grains/dscf.

$$= 2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$$

ppm ALL NONE DETECTED

= _____ x 10^{-6} lbs/dscf

<0.6

Stack gas volume flow rate on dry basis

$$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}}\right]$$

= .2579 .2606 .2595 .26 x 10^6 dscf/hr

(A_s = sq.ft. V_s = ft/sec)

Process rate or BTU rating P_w = _____

Emission rate

Q_s c's = ALL NONE DETECTED <.002 lbs/hr

$\frac{Q_s\ c's}{P_w}$ = _____ lbs/

Isokinetic sampling rate

$$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.{}^\circ R} V_{lc}\right) + \frac{V_m}{T_m} Y \left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\theta V_s P_s A_n}\right]$$

(A_n = sq.ft.)

= _____ %

The Almega Corporation

PARTICULATE CALCULATION SUMMARY

COMPANY: ERLANGER MEDICAL CENTER — SOUTH INCINERATOR
SOURCE:
REPETITION NO: CHATTANOOGA TN
TEST DATE: 22 APRIL - 88

	RUN 1	2	3	4
	ENGLISH UNITS (29.92in. Hg 68°F)			BYPR BACKH

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right]$$

$Y = .9834$

= 47.629 46.062 49.046 dscf. 26.

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{cu.ft.}{ml}\right] V_{lc}$$

$V_{lc} =$ _____ ml.

= _____ scf.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

= _____

Particle concentration in stack gas on dry basis

$$c's = \left[0.01543 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{mstd}}\right]$$

= _____ grains/dscf.

PPM ALL NONE DETECTED

$$- 2.205\ 10^{-6} \frac{M_n}{V_{mstd}}$$

= <0.6 x 10^{-6} lbs/dscf

Stack gas volume flow rate on dry basis

$$Q_s = 3600\ (1-B_{ws})\ V_s A_s \left[\frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}}\right]$$

= .2749 .2653 .2817 .267 x 10^6 dscf/hr

(A_s= sq.ft. V_s= ft/sec)

Process rate or BTU rating P_w = _____

ALL NONE DETECTED

Emission rate

Q_s c's = <0.02 lbs/hr

$\frac{Q_s\ c's}{P_w}$ = _____ lbs/

Isokinetic sampling rate

$$I = \left(1.667 \frac{min}{sec}\right) T_s \left[\frac{\left(0.002669 \frac{in.Hg.cu.ft.}{ml.{}^\circ R} V_{lc}\right) + \frac{V_m Y}{T_m}\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{\Theta V_s P_s A_n}\right]$$

(A_n = sq.ft.)

= _____ %

COMPANY: Erlanger

DATE: 4/21 - 4/22

LOCATION: Chattanooga, Tn

SOURCE: South Unit

TITRATION DATA FOR: Cl_2

DATA SHEET

RUN NUMBER	V_s	V_{a_1}	V_{t_1}	V_{a_2}	V_{t_2}	V_{a_3}	V_{t_3}	mg Cl_2	$V_{t_{avg}}$
Ytd									
R1 Imp 1	200 ml	5ml	11.85	5ml	11.86			ND	
Imp 2	200 ml	5ml	11.80	5ml	11.89			ND	
R2 Imp 1	200 ml	5ml	11.87	5ml	11.86			ND	
Imp 2	200 ml	5ml	11.81	5ml	11.85			ND	
R3 Imp 1	200 ml	5ml	11.86	5ml	11.80			ND	
Imp 2	200 ml	5ml	11.86	5ml	11.86			ND	
R4 Imp 1	200 ml	5ml	11.84	5ml	11.84			ND	
Imp 2	200 ml	5ml	11.89	5ml	11.89			ND	
Blank	200 ml	5ml	47.22	5ml	47.22			ND	

Titrant Standardization Data: 0.010N I_2 Soln Used. (Factor Confirmed)

Standard: _____ $V_{a_{std}}$: _____ ml

Normality: _____ $V_{t_1 std}$: _____ ml

Date of certification: _____ $V_{t_2 std}$: _____ ml

Titrant: _____ $V_{t_{avg\ std}}$: _____ ml

$$N_{titrant} = \frac{(N_{std})(V_{a_{std}})}{(V_{t_{avg\ std}})}$$

$N_{titrant}$ = 0.010 N

COMPANY: Eclaque

DATE: 4/21 - 4/22

LOCATION: Chattanooga, Tn.

SOURCE: South Unit

TITRATION DATA FOR: Cl_2

DATA SHEET

RUN NUMBER	V_s	V_{a_1}	V_{t_1}	V_{a_2}	V_{t_2}	V_{a_3}	V_{t_3}	mg Cl_2	$V_{t_{avg}}$
4/22									
R1 Trip 1	200ml	5ml	11.84	5ml	11.85			ND	
Trip 2	200ml	5ml	11.85	5ml	11.81			ND	
R2 Trip 1	200ml	5ml	11.96	5ml	11.87			ND	
Trip 2	200ml	5ml	11.83	5ml	11.86			ND	
R3 Trip 1	200ml	5ml	11.87	5ml	11.87			ND	
Trip 2	200ml	5ml	11.86	5ml	11.87			ND	
R4 Trip 1	200ml	5ml	11.89	5ml	11.84			ND	
Trip 2	200ml	5ml	11.89	5ml	11.85			ND	

Titrant Standardization Data: 0.010N In Soln Used (Fisher Certified)

Standard: _____ $V_{a_{std}}$: _____ ml

Normality: _____ $V_{t_{1\,std}}$: _____ ml

Date of certification: _____ $V_{t_{2\,std}}$: _____ ml

Titrant: _____ $V_{t_{avg\ std}}$: _____ ml

$$N_{titrant} = \frac{(N_{std})(V_{a_{std}})}{(V_{t_{avg\ std}})}$$

$N_{titrant}$ = 0.010N

APPENDIX N

APRIL 21 AND 22, 1988, RUNS 1 TO 5 AND RUNS 1 TO 4 RESPECTIVELY, NITROGEN OXIDE SAMPLING AND ANALYSIS DATA AND CALCULATIONS

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 1

Date: 21 APRIL 88

	1	2	3	4
Flask #:	1	2	28	16
Sample Time:	11:15	11:30	11:45	12:00

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$ — 1689 | 1899 | 1803 | 1825

P_{bar} 29.4

T_i 75°F

Vf =	2118	2062	2013	2074	ml
Pf =	25.54	29.60	29.34	28.15	in
Tf =	530	530	530	530	°R
Pi =	1.31	1.61	2.01	1.41	in
Ti =	535	535	535	535	°R

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$ — 519.1 | 477.1 | 385 | 389.3

$K_c = 954.2$

Kc =	954.2	954.2	954.2	954.2
A =	.272	.250	.202	.204
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db — 19.19 | 15.69 | 13.35 | 13.32

ppm = C · 8.376 (as NO_2) — 160.7 | 131.4 | 111.8 | 111.6 / Av 128.9

Nitrogen Oxide Emissions

lbs/hr = C · Qs

Qs = 8.3579 x 10^6 dscfh — 4.949 | 4.046 | 3.443 | 3.435 / 3.968

$lbs/10^6$ BTU = $\frac{C \cdot Qs}{BTU}$ — | | | /

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ENLARGER MEDICAL CENTRE

Sample Location: SOUTH UNIT

Repetition: 2

Date: 21 APRIL 88

	5	6	7	8
Flask #:	5	6	35	17
Sample Time:	12.55	1.10	1.25	1.40

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$ | 1795 | 1807 | 1628 | 1695

P_{bar} 29.11

Vf =	2072	2069	2059	2075	ml
Pf =	28.24	29.44	25.94	26.14	in
Tf =	530	530	530	530	^oR
Pi =	1.91	2.91	1.91	1.31	in
Ti =	535	535	536	536	^oR

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$ | 290.1 | 500 | 482.7 | 301.5

Kc =	954.2	954.2	954.2	954.2
A =	.152	.262	.253	.158
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db | 10.09 | 17.28 | 18.52 | 11.11 | Av 119.3

ppm = C·8.376 (as NO_2) | 84.50 | 144.7 | 155.1 | 93.02

Nitrogen Oxide Emissions

lbs/hr = C·Qs

Qs = 0.2606 x 10^6 dscfh | 2.630 | 4.503 | 4.826 | 2.895 | 3.712

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$ | | | | |

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: SUTTER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 3

Date: 21 APRIL 88

	9	10	11	12
Flask #:	33	25	23A	18
Sample Time:	1:15	1:30	1:45	2:00

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$

	1854	1583	1872	1784

Vf =	2131	2087	2126	2064	ml
Pf =	28.44	25.64	29.44	28.46	in
Tf =	530	530	530	530	°R
Pi =	2.01	2.61	2.71	2.21	in
Ti =	536	537	537	537	°R

P_{bar} 29.11

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$

	440.8	364.5	286.3	303.4

Kc =	954.2	954.2	954.2	954.2
A =	.231	.191	.150	.159
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db

	14.85	14.38	9.547	10.62

ppm = C · 8.376 (as NO_2)

	124.3	120.4	79.96	88.96 / 103.4

Nitrogen Oxide Emissions

lbs/hr = C · Qs

Qs = 0.2595 x 10^6 dscfh

	3.854	3.732	2.477	2.756 / 3.205

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 4

Date: 21. APRIL. 88

	13	14	15	16
Flask #:	22	15	14	21
Sample Time:	4:05	4:20	4:40	5:00

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$

	1806	1813	1848	1803	
Vf =	2076	2070	2093	2059	m
Pf =	28.54	29.02	29.33	28.92	i
Tf =	530	530	530	530	c
Pi =	2.11	2.41	2.51	2.31	i
Ti =	537	537	537	536	c

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$

	440.8	320.6	330.2	364.5
Kc =	954.2	954.2	954.2	954.2
A =	.231	.168	.173	.191
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db

ppm = C·8.376 (as NO_2)

	15.24	11.04	11.15	12.62
	127.6	92.47	93.39	105.7 / 104

Nitrogen Oxide Emissions

lbs/hr = C·Qs

Qs = 0.2644 x 10^6 dscfh

	4.030	2.919	2.948	3.337 / 3.33

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$

BTU = _____ x 10^6 BTU/hr

	____	____	____	____

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 1

Date: 22 APRIL 88

	1	2	3	4
Flask #:	72	9	12	7
Sample Time:	9:55	10:12	10:27	10:40

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$

	1764	1747	1763	1606	
Vf =	2088	2069	2087	2049	ml
Pf =	26.74	26.64	26.74	25.64	in
Tf =	530	530	530	530	°R
Pi =	1.06	.96	1.06	1.81	in
Ti =	533	533	523	534	°R

$P_{bar\ init}$ 29.06

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$

	301.5	316.8	355.0	297.7
Kc =	954.2	954.2	954.2	954.2
A =	.158	.166	.186	.156
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db

$ppm = C \cdot 8.376$ (as NO_2)

	10.67	11.32	12.87	11.57
	89.38	94.83	105.3	96.94 / 96.61

Nitrogen Oxide Emissions

lbs/hr = C·Qs

Qs = 0.2949 x 10^6 dscfh

	2.933	3.112	3.466	3.181 / 3.170

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 2

Date: 22. APRIL. 88

	5	6	7	8	
Flask #:	34	334	31	29	
Sample Time:	11:05	11:20	12:30	12:45	
			diff ~60 mins		
Sample Volume (Standard Dry Conditions) $V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$	1921	1561	1827	1865	
Vf =	2083	2090	2078	2113	ml
Pf =	29.24	24.64	29.24	29.04	in
Tf =	530	530	530	530	^oR
Pi =	1.21	1.96	2.56	2.26	in
Ti =	537	538	542	543	^oR

P_{bar} 29.06

Total µg NO_2 Per Sample
$m = 2\ K_c\ Af$

	284.4	288.0	334.0	255.7
Kc =	954.2	954.2	954.2	954.2
A =	.149	.151	.175	.134
F =	1	1	1	1

Nitrogen Oxide Concentration
$C = 62.43 \times 10\text{-}6\left[\frac{m}{V_s}\right]$ lbs/scf db

	9.241	11.53	11.41	8.560
ppm = C·8.376 (as NO_2)	77.40	96.53	95.59	71.70 / 85.30

Nitrogen Oxide Emissions
lbs/hr = C·Qs
Qs = 0.2653 x 10^6 dscfh

	2.452	3.059	3.027	2.271 / 2.702

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$

	____	____	____	____

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 3

Date: 22 APRIL 88

Flask #:	4	10	3	11
Sample Time:	1:15	1:30	1:50	2:05

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$

	1771	1812	1809	1756	
Vf =	2095	2077.52	2101.76	2103.78	m
Pf =	27.37	28.29	27.85	26.96	i
Tf =	530	530	530	530	o
Pi =	1.71	1.81	1.71	1.61	i
Ti =	543	543	543	543	o

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$

	290.1	369.2	280.5	320.6
Kc =	954.2	954.2	954.2	954.2
A =	.152	.162	.147	.168
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db

ppm = C·8.376 (as NO_2)

	10.23	10.65	9.680	11.40
	85.66	89.23	81.08	95.47 / 87.8

Nitrogen Oxide Emissions

lbs/hr = C·Qs

Qs = 0.3817 x 10^6 dscfh

	2.882	3.000	2.727	3.211 / 2.95

$lbs/10^6$ BTU = $\frac{C \cdot Qs}{BTU}$

BTU = _____ x 10^6 BTU/hr

The Almega Corporation

NITROGEN OXIDE CALCULATION FORM

Company: ERLANGER MEDICAL CENTER

Sample Location: SOUTH UNIT

Repetition: 4

Date: 22 APRIL 88

	9	10	11	
Flask #:	32	30	13	92
Sample Time:	2:25	2:40	2:50	3:05

Sample Volume (Standard Dry Conditions)

$V_{sc} = 17.64\ (Vf - 25)\left[\frac{Pf}{Tf} - \frac{Pi}{Ti}\right]$

	1644	1660	1761	1772	
Vf =	2086	2093	2090	2057	ml
Pf =	25.64	25.84	27.44	28.11	in
Tf =	530	530	530	530	^oR
Pi =	1.71	1.76	1.86	1.96	in
Ti =	543	543	543	543	^oR

29.06

Total µg NO_2 Per Sample

$m = 2\ K_c\ Af$

	460.0	305.3	251.9	276.7
Kc =	954.2	954.2	954.2	954.2
A =	.241	.160	.132	.145
F =	1	1	1	1

Nitrogen Oxide Concentration

$C = 62.43 \times 10^{-6}\left[\frac{m}{V_{sc}}\right]$ lbs/scf db

	17.47	11.48	8.931	9.749
ppm = C·8.376 (as NO_2)	146.3	96.19	74.80	81.65

AV 99.71

Nitrogen Oxide Emissions

lbs/hr = C·Qs

Qs = 02677 x 10^6 dscfh

	4.677	3.073	2.391	2.610

AV 3.188

lbs/10^6 BTU = $\frac{C \cdot Qs}{BTU}$

	____	____	____	____

BTU = _____ x 10^6 BTU/hr

APPENDIX O

APRIL 21 AND 22, 1988, OPACITY
OBSERVATIONS AND CERTIFICATIONS

Form 4500-114
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: 4/5/88
Expiration Date: 10/5/88
Certified By: Joe Perez

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LUYSC DWR

LOCATION CHATTANOOGA

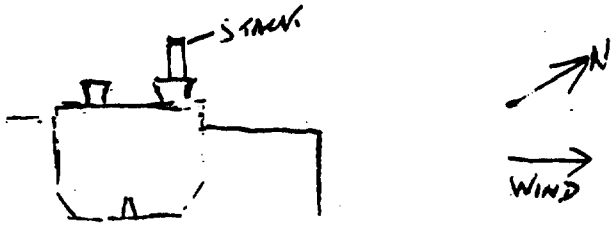
EMISSION POINT NAME BASIC 1250 INCINERATOR STACK - SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT 88

CLOCK TIME: INITIAL 11 : 05 (A.M./P.M.) FINAL 12 : 05 (A.M./P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	200'	200'
Direction to Discharge	E	E
Height of Observation Point	GROUND	GROUND
Background Description	WHITE CLOUD	CLEAR BLUE SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	0-5	0-5
Ambient Temperature	66°F	65°F
Sky Conditions	PARTLY CLOUDY	PARTLY CLOUDY
Plume Description		
Color	NONE	NONE
Distance Visible		

Diagram of Observer and Emission Point



MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOUISVILLE DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC INCINERATOR 1250 SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL _____ : _____ A.M./P.M. FINAL 12 : 05 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	See page 1	
Plume Description		
Color		
Distance Visible		

Diagram of Observer and Emission Point

See page 1

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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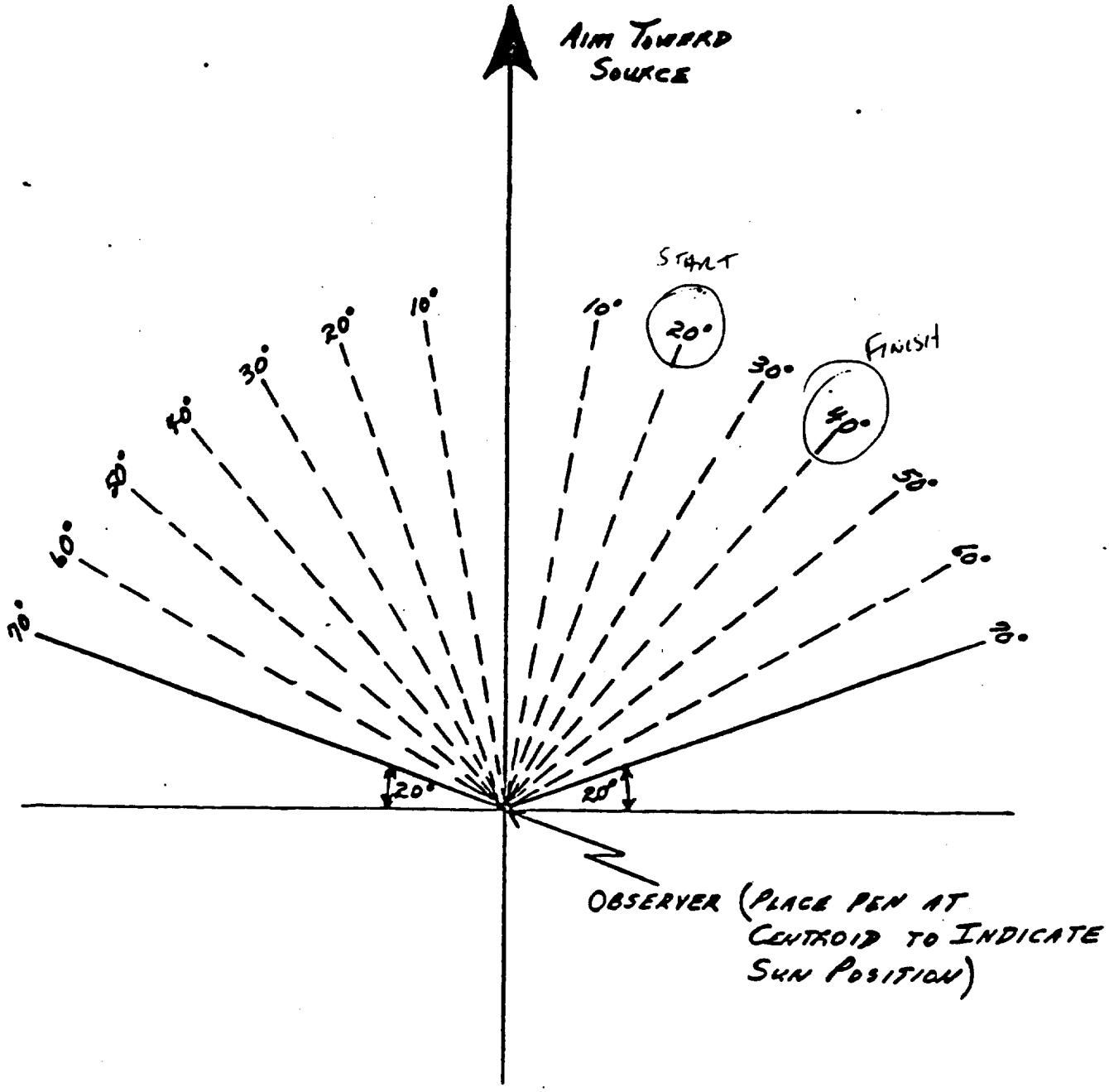
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4-21-88
RUN N°: 1
START TIME: 11:05 AM
FINISH TIME: 12:05 PM



VISIBLE EMISSIONS EVALUATION RECORD

PAGE 1 OF 2
RUN 2

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOCAL DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

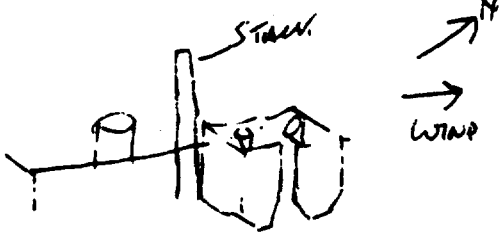
OBSERVER B. W. JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL 12 : 50 A.M. (P.M.) FINAL 1 : 50 A.M. (P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	300'	300'
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		
Ambient Temperature		
Sky Conditions	PARTLY CLOUDY	PARTLY CLOUDY
Plume Description		
Color	NONE	NONE
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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



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PAGE 1 OF 2
RUN 2

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. 6056 DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL ____ : ____ A.M./P.M. FINAL 1 : 50 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 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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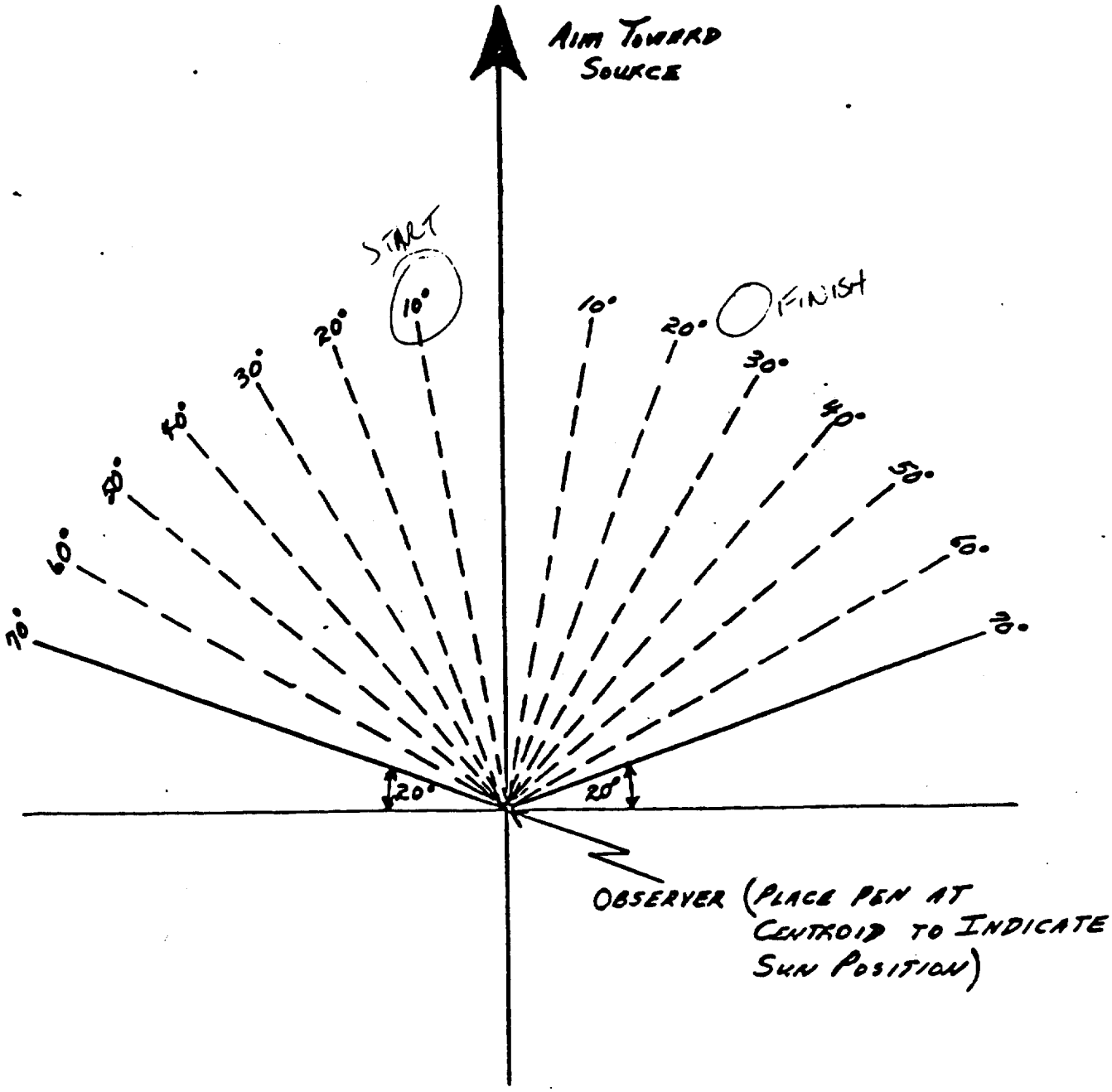
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/21/98
RUN N°: 2
START TIME: 12 50 PM
FINISH TIME: 1.50 AM



Page 1 of 2
Run 3

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY Erlanger Medical Center REGISTRATION NO. Lease DNR

LOCATION Chattanooga

EMISSION POINT NAME Basic 1250 Incinerator South Unit HEIGHT OF DISCHARGE POINT 28'

OBSERVER R.W. Jackson CERTIFICATION EXPIRATION DATE Oct/88

CLOCK TIME. INITIAL 2 : 15 A.M./P.M. FINAL 3 : 15 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge	200'	200'
Direction to Discharge	N	N
Height of Observation Point	Ground	Ground
Background Description	Blue Sky	Blue Sky
Weather Conditions		
Wind Direction	NW	NW
Wind Speed	0-5	0-5
Ambient Temperature	70°F	70°F
Sky Conditions	Partly Cloudy	Partly Cloudy
Plume Description	None	None
Color		
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			
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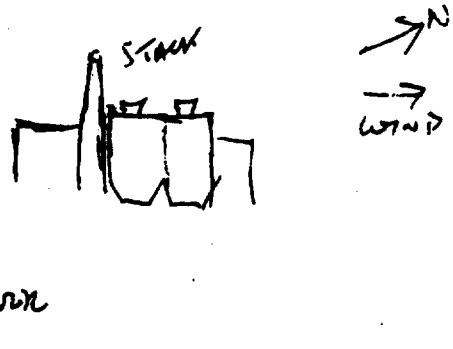
11	0	0	0	0			
12	0	0	0	0			
13	0	0	0	0			
14	0	0	0	0			
15	0	0	0	0			
16	0	0	0	0			
17	0	0	0	0			
18	0	0	0	0			
19	0	0	0	0			
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point



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Page 1 of 2
Run 3

Page 2 of 2
Run 3

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. [illegible]

LOCATION CHATTANOOGA

EMISSION POINT NAME [illegible] INCINERATOR 1250 SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL ____ : ____ A.M./P.M. FINAL 3 : 15 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	See page 1	
Plume Description	✓	
Color		
Distance Visible		

Diagram of Observer and Emission Point

See page 1

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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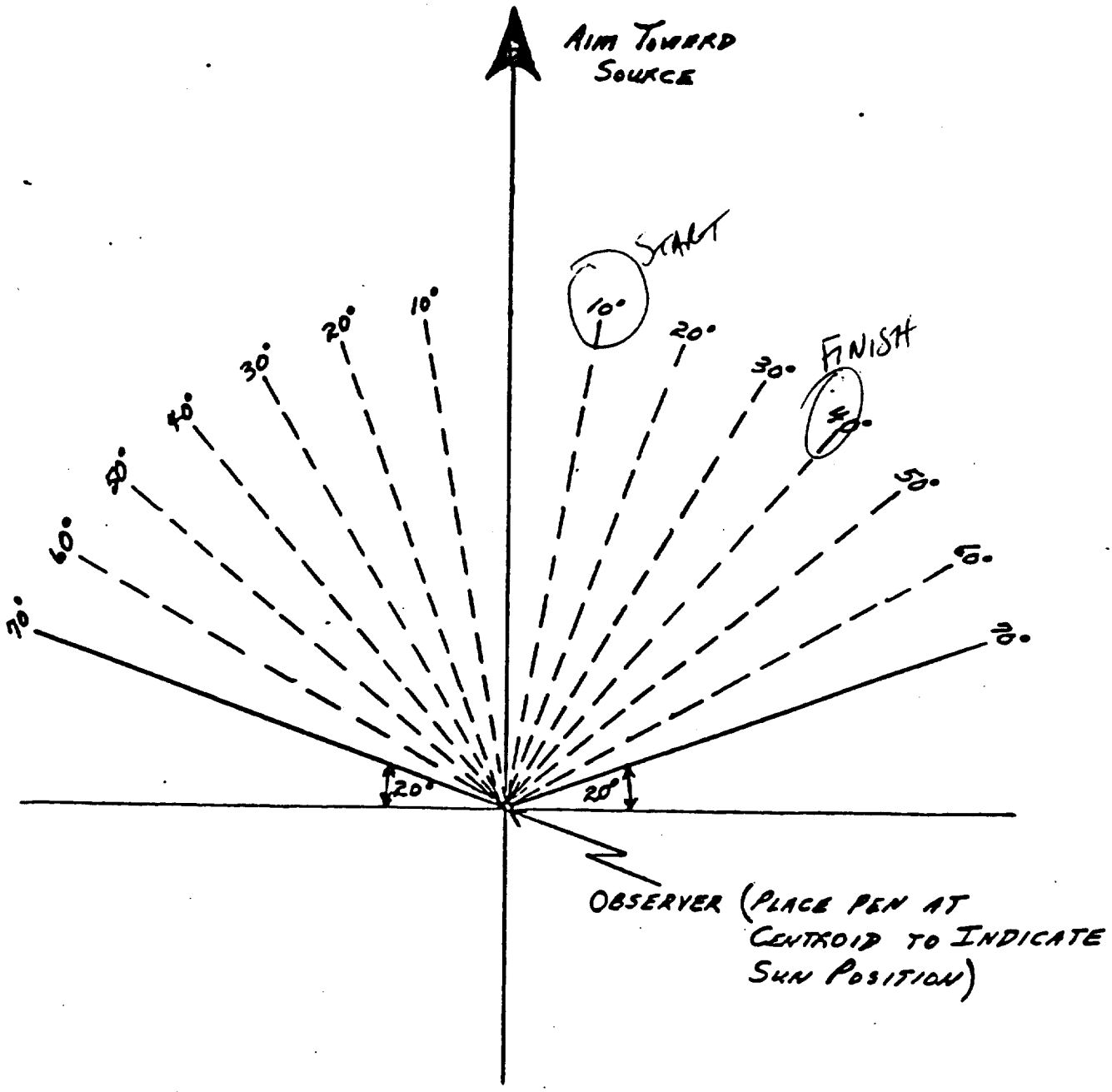
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/21/88
RUN N°: 3
START TIME: 2:15 PM
FINISH TIME: 3:15 PM



PAGE 1 OF 2

RUN 5 (RAN FOR SCRUBBED)

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. 0056 DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATION SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL 4:40 A.M./(P.M.) FINAL 5:40 A.M.(P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	250'	250'
Direction to Discharge	E	E
Height of Observation Point	GROUND	GROUND
Background Description	BLUE SKY	BLUE SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	0-5	0-5
Ambient Temperature	75°F	75°F
Sky Conditions	PARTLY CLOUDY	PARTLY CLOUDY
Plume Description		
Color	NONE	NONE
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			
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18	0	0	0	0			
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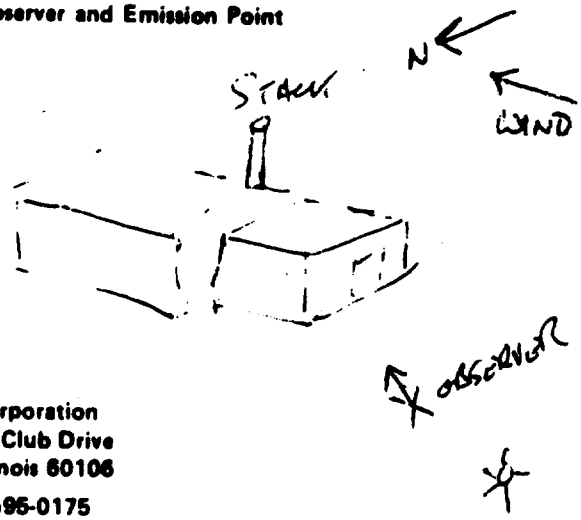
20	0	0	0	0			
21	0	0	0	0			
22	0	0	0	0			
23	0	0	0	0			
24	0	0	0	0			
25	0	0	0	0			
26	0	0	0	0			
27	0	0	0	0			
28	0	0	0	0			
29	0	0	0	0			

Diagram of Observer and Emission Point



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PAGE 1 OF 2
RUN 5

Page 2 of 2
Run 5
(Run 4 scrubber)

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/21/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WBSC DAOR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER R W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL ____ : ____ A.M./P.M. FINAL 5 : 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

Diagram of Observer and Emission Point

See Page 1

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			
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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			

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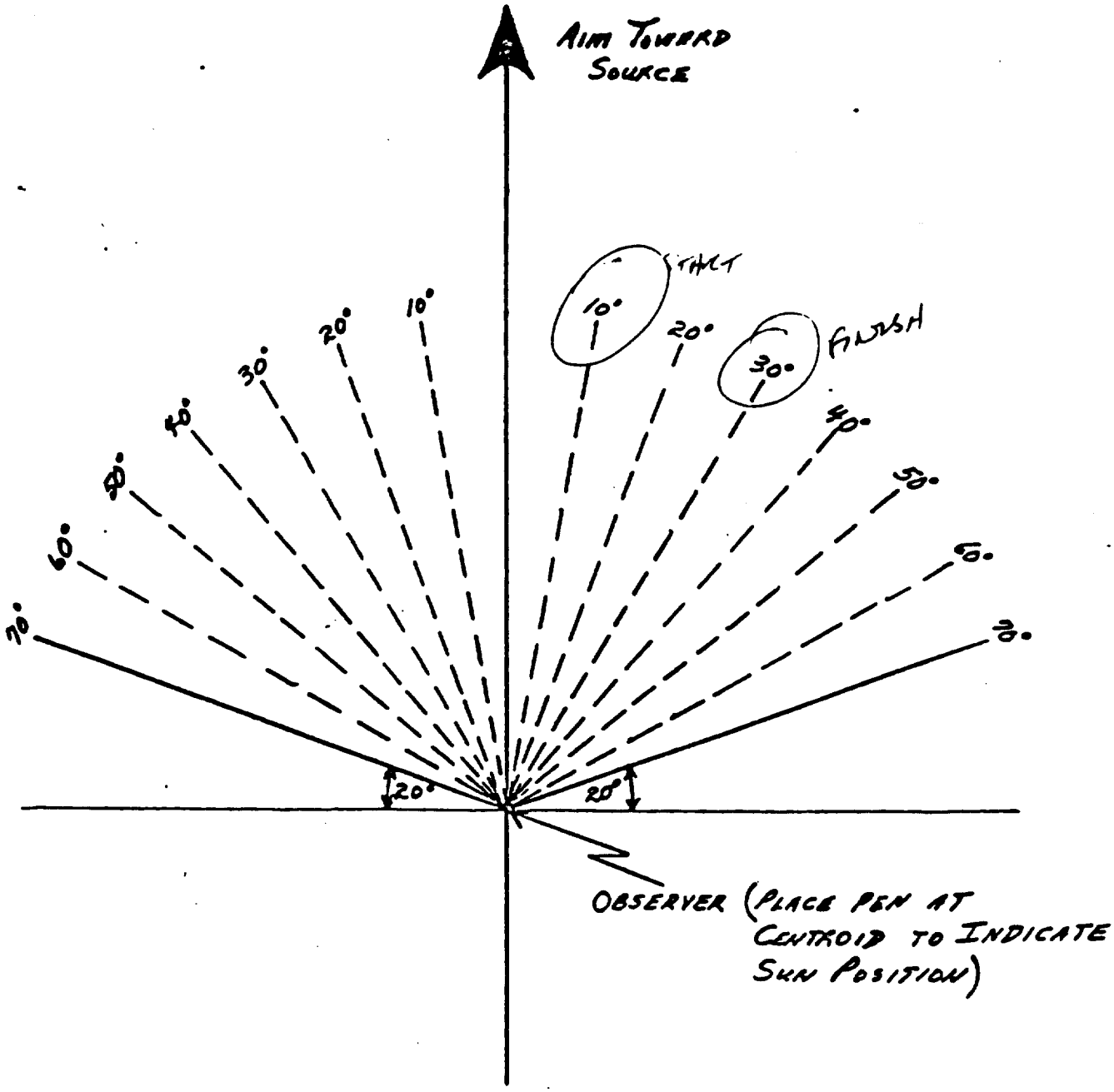
Page 2 of 2
Run 5

COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/21/89
RUN N°: 5 (RUN 4 SCRUBBED)
START TIME: 4:40PM
FINISH TIME: 5:40PM



RUN 6

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. MUSC DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC INCINERATOR 1250 SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

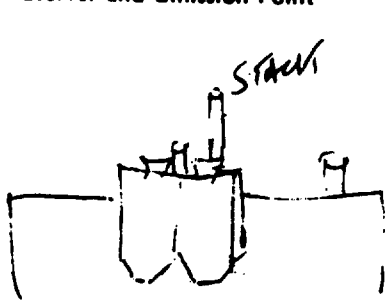
OBSERVER Ben JACKSON CERTIFICATION EXPIRATION DATE OCT/88

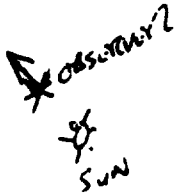
CLOCK TIME: INITIAL 9 : 45 (A.M./P.M.) FINAL 10 : 45 (A.M./P.M.)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	150'	150'
Direction to Discharge	W	W
Height of Observation Point	GROUND	GROUND
Background Description	BLUE SKY	BLUE SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	0-5	0-5
Ambient Temperature	67°F	69°F
Sky Conditions	PARTLY CLOUDY	PARTLY CLOUDY
Plume Description		
Color	NONE	NONE
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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





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VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. 60SC DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL _____ : _____ A.M./P.M. FINAL 10 : 45 (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

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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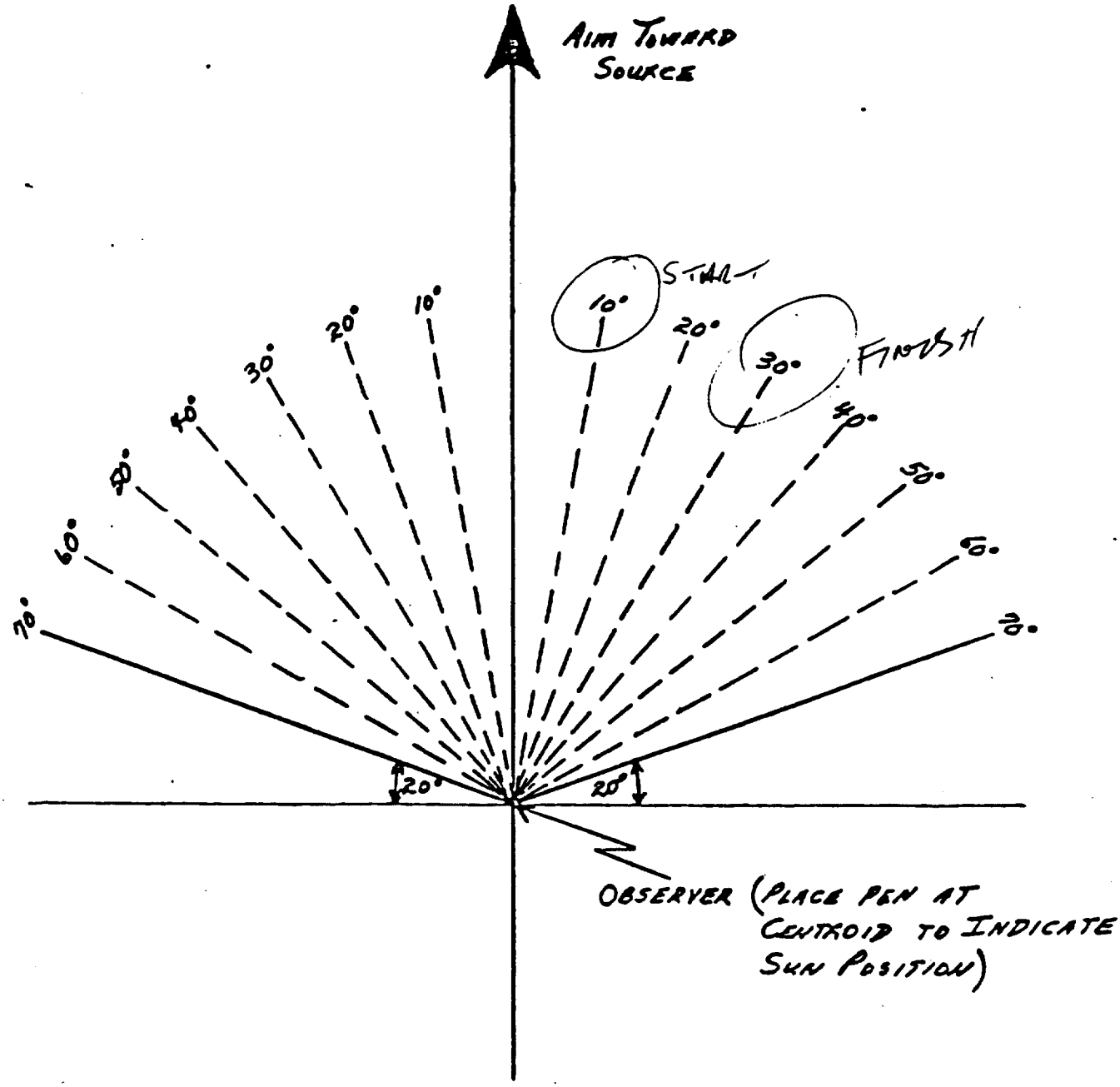
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/22/88
RUN N°: 6
START TIME: 9:45
FINISH TIME: 10:45



OBSERVER (PLACE PEN AT CENTROID TO INDICATE SUN POSITION)

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. NON DAER

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATION SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

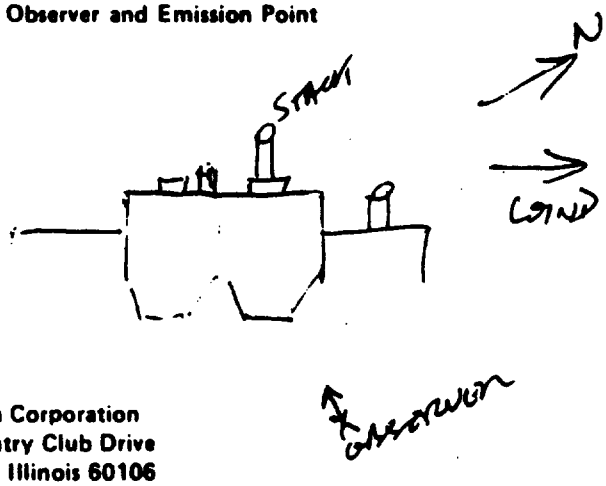
OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL 11 00 FINAL 1 00 AM (PM)

	INITIAL	FINAL
Observer Location		
Distance to Discharge	200'	200'
Direction to Discharge	W	W
Height of Observation Point	GROUND	GROUND
Background Description	BLUE SKY	BLUE SKY
Weather Conditions		
Wind Direction	SW	SW
Wind Speed	0-5	0-5
Ambient Temperature	73°F	76°F
Sky Conditions	PARTLY CLOUDY	PARTLY CLOUDY
Plume Description		
Color	NONE	NONE
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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	TEST STOPPED 1130		
29	0	0	0	0	LOADER PROBLEM		

Diagram of Observer and Emission Point



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PAGE 2 OF 2
RUN 7

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO WPSC DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL ____ : ____ A.M./P.M. FINAL 1 00 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	See Page 1	
Plume Description		
Color		
Distance Visible		

Diagram of Observer and Emission Point

See Page 1

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) Detached	Attached	Distance
0	0	0	0	0	PLUME WITH EAR AT 12:23		
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			

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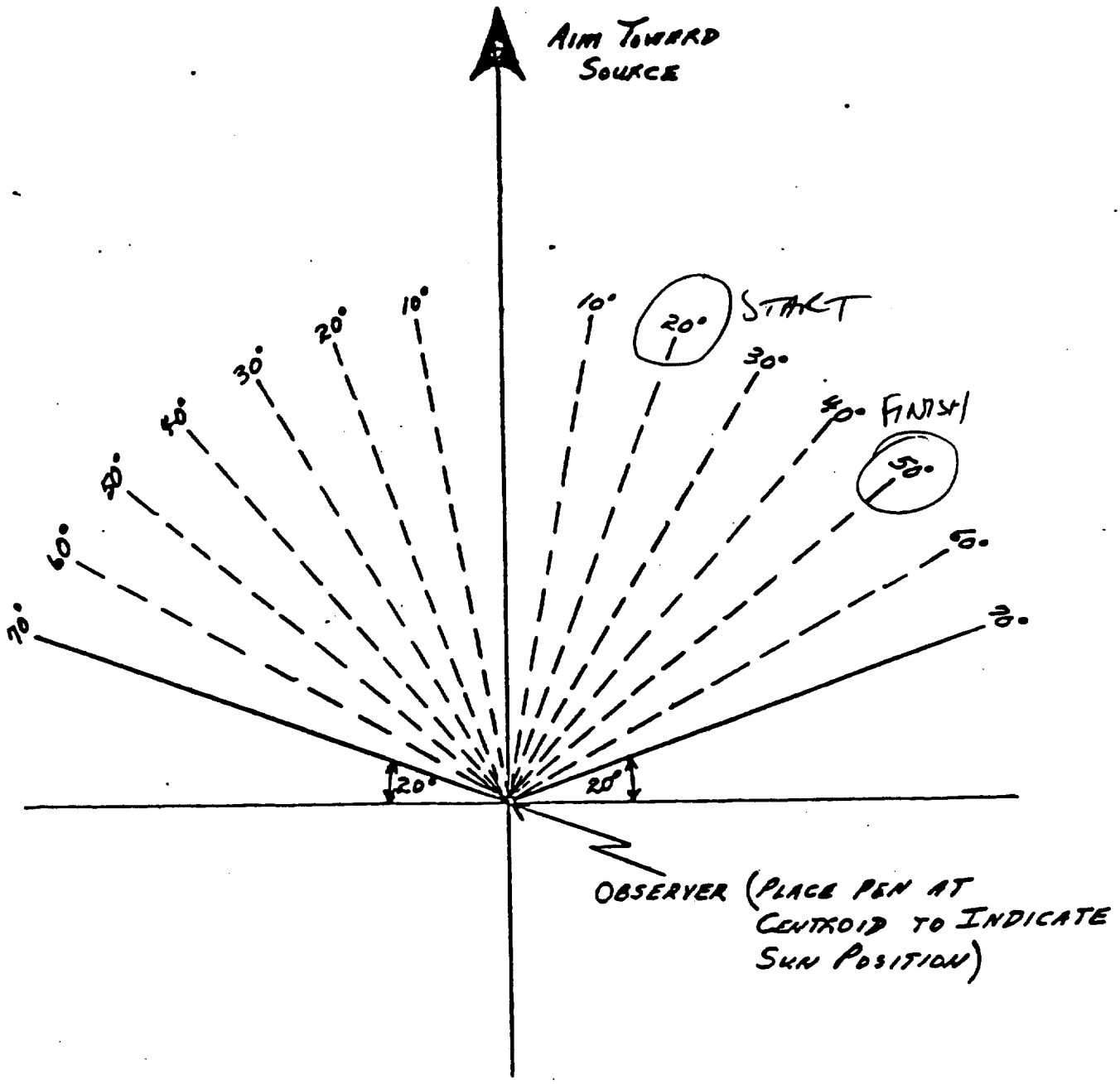
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/22/88
RUN Nº: 7
START TIME: 11:00 AM
FINISH TIME: 1:00 PM



VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WASTE DNR

LOCATION CHATTANOOGA

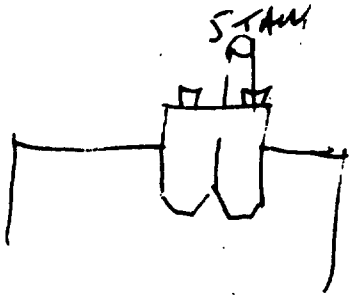
EMISSION POINT NAME BOILER 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME INITIAL 1:12 A.M./P.M. FINAL 2:12 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge	300'	300'
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	0-5	0-5
Ambient Temperature	80°F	82°F
Sky Conditions	CLEAR	CLEAR
Plume Description		
Color	NONE	NONE
Distance Visible		

Diagram of Observer and Emission Point



MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOCAL DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER R.W. JACKSON CERTIFICATION EXPIRATION DATE OCT/89

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 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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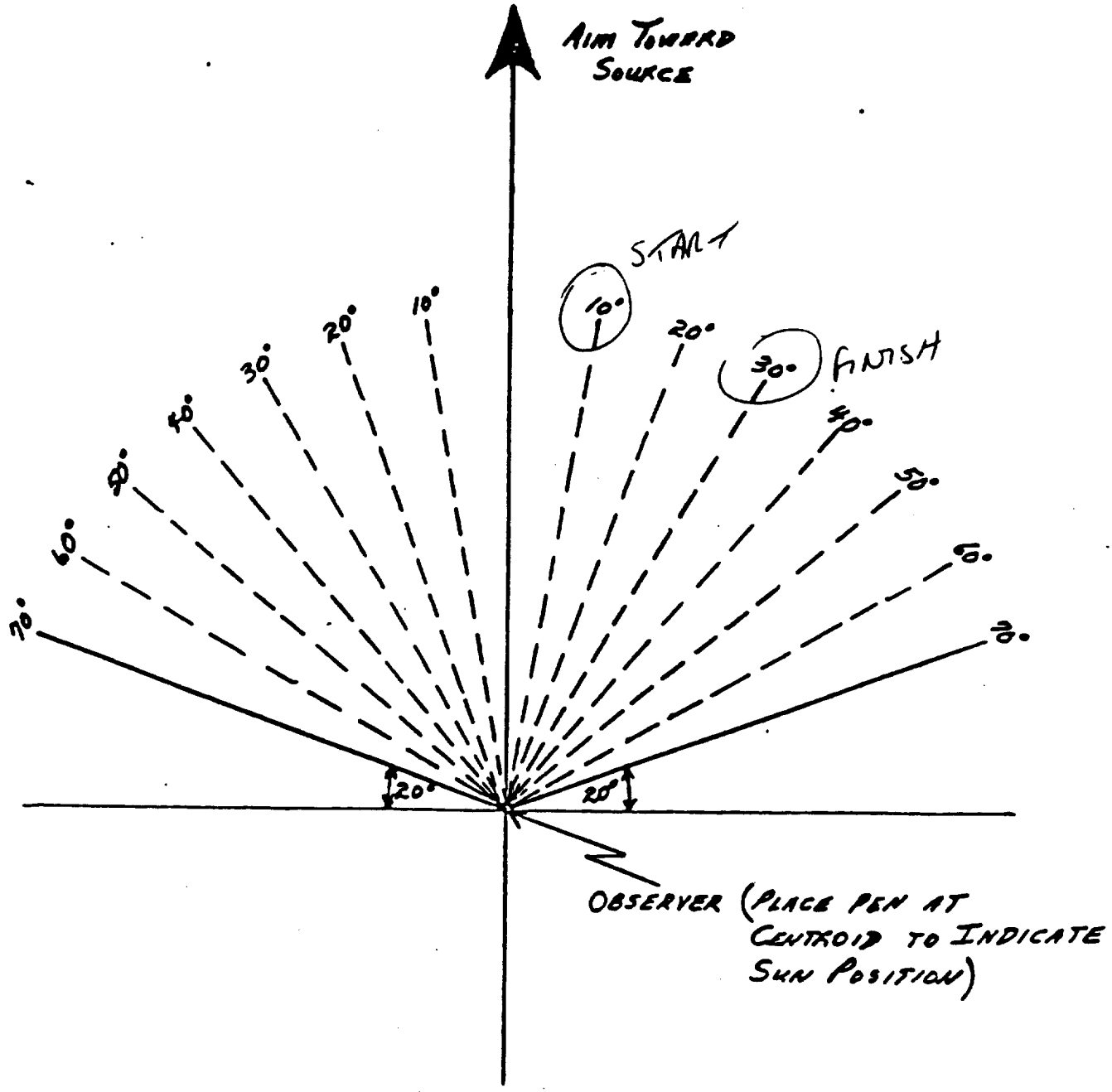
COMPANY: ERLANGER MEDICAL CENTER
TEST DATE: 4/22/88
RUN N°: 8
START TIME: 1:12 PM
FINISH TIME: 2:12 PM



Page 1 of 2
Run 9

VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. WOSC DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC 1250 INCINERATOR SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

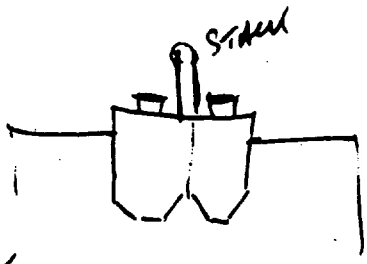
OBSERVER BW JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL 2 : 23 A.M./P.M. FINAL 3 : 23 A.M./P.M.

	INITIAL	FINAL
Observer Location		
Distance to Discharge	300'	300'
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	0-5	0-5
Ambient Temperature	78°F	78°F
Sky Conditions	CLEAR	CLEAR
Plume Description		
Color	NONE	
Distance Visible		

MIN.	SECONDS 0	15	30	45	STEAM PLUME (Check if Applicable) 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
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VISIBLE EMISSIONS EVALUATION RECORD

DATE 4/22/88

COMPANY ERLANGER MEDICAL CENTER REGISTRATION NO. LOCAL DNR

LOCATION CHATTANOOGA

EMISSION POINT NAME BASIC INCINERATOR 1250 SOUTH UNIT HEIGHT OF DISCHARGE POINT 28'

OBSERVER B W JACKSON CERTIFICATION EXPIRATION DATE OCT/88

CLOCK TIME: INITIAL _____ : _____ A.M./P.M. FINAL 3 : 23 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 0	15	30	45	STEAM PLUME (Check if Applicable) 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			

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APPENDIX P

INCINERATOR OPERATIONAL DETAILS
AND INCLUDING CHARGING SCHEDULE,
PRIMARY AND SECONDARY STAGE
TEMPERATURES, INCINERATOR LOGS
AND GAS CONSUMPTION

ERLANGER MEDICAL CENTER - WASTE INCINERATOR PLANT LOG

UNIT (circle one) N (S)

DATE: 4-21-88

TIME/OPERATOR	EXHAUST TEMP.	STAGE 3 TEMP.	STAGE 2 TEMP.	STAGE 1 TEMP.	STAGE 1 DRAFT	GAS READING	STEAM PRESS.	STEAM FLOW	BOXES LOADED	REMARKS
Oper: G/B										
Midnight	314.2	1609	1979	858	-06	372352	170	5232	0	- CURE RETRACTOR
1:00 a.m.	312.4	1604	1918	857	-06	372360	168	4403	0	
2:00 a.m.	316.6	1613	1979	854	-05	372368	170	5276	0	
3:00 a.m.	314.2	1611	1974	856	-05	372376	170	4802	0	
4:00 a.m.	312.4	1607	1962	855	05	372383	171	5130	0	
5:00 a.m.	312.4	1565	1867	855	-06	372390	170	5035	0	
6:00 a.m.	314.1	1556	1817	856	-06	372396	170	5200	0	
7:00 a.m.	313.6	1633	1969	1095	-05	372402	170	5838	[illegible]8	197# START LOAD @ 6:35 AM
Oper: H/L										
8:00 a.m.	313.4	1649	1866	1288	-.01	372414	172	7500	22	542 LBS
9:00 a.m.	312.1	1594	1813	1123	-.00	372419	169	5495	22	533 LBS
10:00 a.m.	313.7	1657	1959	1214	-.04	372424	172	6772	26	765 LBS.
11:00 a.m.	319.1	1673	1911	1469	-.07	372429	173	7992	34	965 LBS.
Noon	318.5	1688	1950	1589	-.06	372434	173	8000	44	1104 LBS.
1:00 p.m.	321.1	1635	1895	1399	-.07	372439	173	7738	28	784 LBS
2:00 p.m.	320.2	1645	1893	1436	-.05	372444	173	7526	33	1050 lbs.
3:00 p.m.	321.3	1651	1931	1418		372449	174	8000	30	1155 lbs.
Oper: A-S										
4:00 p.m.	325.1	1682	1995	1489	.03	372457	174	8000	26	824 LB
5:00 p.m.	325.7	1670	1999	1491	.07	372461	175	8000		
6:00 p.m.	325.2	1660	1910	1499	.02	372467	176	7604	28	920 LB
7:00 p.m.	331.4	1661	1902	1487	.02	372473	178	8000	28	957 LB
8:00 p.m.	328.6	1658	1905	1519	.07	372478	174	8000	26	1042 #
9:00 p.m.	329.9	1648	1911	1442	.07	372484	174	8000	26	1043 #
10:00 p.m.	253.0	1623	1879	1357	.06	372489	166	2530	20	710# REPAIR ID FAN BELTS
11:00 p.m.	320.2	[illegible]	1926	[illegible]	-06	372493	170	6406	10	+ 408# BAGHOUSE

OPERATORS:
3rd Shift: Guffey / Blankenship
1st Shift: HECK / LOY
2nd Shift: ADAMS / SMITH

WEATHER	TEMP.	CLEAR	CLOUDY	RAIN	FOG	SNOW
3rd Shift Start	60	✓				
1st Shift Start	52	✓				
2nd Shift Start						

MAINTENANCE PERFORMED:
3rd Shift:
1st Shift:
2nd Shift:

4/21/88 GAS USE
11 AM 372429
6PM 372467
38 x 1000 / 7 = 5429 cubic ft / hr AVERAGE

Flame Failure Stage II 4:02 AT

LOW WATER 10:15 BACK UP 10:22

ERLANGER MEDICAL CENTER - WASTE INCINERATOR PLANT LOG

UNIT (circle one) N (5)

DATE: 4-22-88

TIME/OPERATOR	EXHAUST TEMP.	STAGE 3 TEMP.	STAGE 2 TEMP.	STAGE 1 TEMP.	STAGE 1 DRAFT	GAS READING	STEAM PRESS.	STEAM FLOW	BOXES LOADED	REMARKS
Oper: G-B										
Midnight	320.2	1625	1900	1297	-.07	372502	172	7326	27	669 lbs
1:00 a.m.	327.5	1613	1898	1160	-.06	372509	171	6279	15	621 lbs
2:00 a.m.	327.5	1625	1900	1114	-.07	372516	171	6731	17	761 lbs
3:00 a.m.	323.5	1631	1891	1159	-.06	372522	171	6435	16	698 lbs
4:00 a.m.	322.3	1619	1907	1123	-.01	372527	170	5907	17	476 lbs
5:00 a.m.	326.1	1606	1835	1127	-.06	372533	170	6146	17	577 lbs.
6:00 a.m.	321.7	1614	1867	1034	-.06	372539	170	6217	17	405 lbs
7:00 a.m.	326.9	1602	1901	1021	-.06	372545	170	6175	17	452 lbs
Oper: A-H										
8:00 a.m.	325.8	1627	1896	1250	-.06	372551	171	6592	20	522 lbs.
9:00 a.m.	330.2	1671	2068	1177	-.05	372557	172	7022	22	611 lbs
10:00 a.m.	326.7	1767	2051	1271	-.05	372562	174	7919	30	949 lbs
11:00 a.m.	331.9	1784	2064	1248	-.06	372567	175	8000	28	845 lbs
Noon	331.7	1756	2040	1289	-.03	372572	172	7902	15	645 lbs ← LOADED SAMMEL
1:00 p.m.	327.1	1818	2109	1435	-.04	372577	174	8003	21	725 lbs
2:00 p.m.	335.6	1827	2041	1502	-.01	372582	175	7997	34	1201 lbs
3:00 p.m.	338.0	1787	2064	1515	-.00	372587	173	7855	37	1163 lbs
Oper: AB										
4:00 p.m.	337.5	1610	1876	1159	-.02	372595	170	6180	35	1278 #
5:00 p.m.	335.7	1621	1871	1058	-.04	372607	170	6014	18	393 # PILED ON GRATE-TH
6:00 p.m.	340.9	1619	1871	891	-.03	372614	170	5850	0	0 COOL DOWN
7:00 p.m.	330.0	947	1819	792	-.14	372620	166	1760	0	0
8:00 p.m.	333.6	540	396	486	-.14	372620	165	1000	0	0
9:00 p.m.	325.3	374	292	395	-.15	372620	126	980	0	0
10:00 p.m.	321.7	305	240	362	-.15	372620	108	962	0	0
11:00 p.m.										

OPERATORS:
3rd Shift: Huffy Hankerson
1st Shift: Ahmis / Beck
2nd Shift: ADAMS / SMITH

WEATHER	TEMP.	CLEAR	CLOUDY	RAIN	FOG	SNOW
3rd Shift Start	65	✓				
1st Shift Start	66	✓				
2nd Shift Start		✓				

TEST BURN 4·21·88

SOUTH INCINERATOR TEST BURN #1

TIME	CHARGE	Total
11:05 AM	90 LBS.	
11:10 AM	61 LBS	151 lbs
11 15 AM	66 LBS	217 lbs
11:20 AM	94 LBS	57 PATH 311
11 25	50 LBS	361 LBS
11:30	90 LBS	451 LBS
1 34	138 LBS	53 PATH 589
11 38	48 LBS	637 lbs
1 42	139 LBS	776 LBS
1 46	98 LBS	874 LBS
1 50	83 LBS	957 LBS
11 54	65 LBS	1022 LBS
11 58	49 LBS	1071 LBS
12 02	88 LBS	1159 LBS
12:06	68 LBS	1227 LBS
12 10	57 LBS	1284 LBS
12:14	44 LBS	1328 LBS
12 19	115 lb	1443 lbs
12 23	62 lb	1505 lb
12 27	75 lb	1580 lb
12 31	76 lb	1656 lb
12:34	65 lb	1721 lb
12 37	48 lb	1769 lb
12 41	47 lb	1816 lb
12 48	42	1858 lb

SOUTH INCINERATOR TEST BURN #2

Time	Charge	Total
12:55	85 lb	85 lbs
1:00	71 lb	156 lb
1:04	91 lb	247 lb
1:08	75 lb	321 lb 30 PATH
1:12	72 lbs	393 lbs.
1:16	102	495 lbs
1:20	105	600 lbs
1:24	73	673 lbs
1:31	70	24 PATH 743 lbs
1:34	85 lbs.	828 lbs.
1:38	54 lbs	882 lbs.
1:43	73 lbs	955 lbs
1:47	48 lbs	1003 lbs.
1:52	44 lbs	1048 lbs ✓
1:56	47 lbs	1094 lbs.
2:00	43 lbs	1137 lbs.
2:04	63 lbs	1200 lbs
2:08	69 lbs	1269 lbs
2:12	58 lbs	1327 lbs

SOUTH INCINERATOR TEST BURN #3

Time	Charge	Total
2:17	30 lbs	
2:21	95 lb 6 PATH	125
2:25	58 lbs	183
2:29	88 lbs	271
2:34	116 lbs	387
2:38	94 lbs	481
2:42	86 lbs	567
2:46	89 lb	655
2:50	75 lb 44 AM	730
2:54	116	846
2:58	76	922
3:02	46	968
3:07	76	1044
3:11	52	1096
3:15	49	1145 ✓
3:19	35	1180
3:24	55	1235
3:28	104	1339
3:33	125	1464
3:37	92	1556
3:42	85	1641
3:45	75	1716
3:50	69	1775
3:54	67	1852

TEST #4

TIME	Charge	Total
4:02	80	80
4:06	80	160
4:11	80	240

TEST #5

TIME	CHARGE	TOTAL
4:44	82	82
4:48	101	183
4:53	90	273
4:57	71	344
5:02	84	428
5:06	89	517
5:10	83	610
5:15	83	693
5:19	79	772
5:24	72	844
5:30	78	922
5:37	64	986
5:40	75	1061 1051 ✓
5:44	59	1120

4/21	1988	1047	1864	1904	1975	1939	1900
4/21	1988	1052	1839	1859	1754	1920	1839
4/21							
	1988	1057	1828	1909	1933	1884	1840
4/21	1988	1102	1909	1930	1873	1888	1972
4/21	1988	1107	1923	1888	1864	1934	1936
4/21	1988	1112	1889	1870	1964	1936	1867
4/21	1988	1117	1874	1934	1926	1896	1864
4/21	1988	1122	1950	2011	2011	1949	1878
4/21	1988	1127	1976	1974	1960	1888	1858
4/21	1988	1132	1958	1969	1906	1858	1907
4/21	1988	1137	1939	1907	1913	1923	1958
4/21	1988	1142	1960	1927	1933	2043	2056
4/21	1988	1147	1973	1958	2039	2034	1989
4/21	1988	1152	1940	1982	1982	1944	1945
4/21	1988	1157	1957	1922	1967	1954	1961
4/21	1988	1202	2005	1995	1955	1937	1979
4/21	1988	1207	1980	1937	1929	1944	1986
4/21	1988	1212	1960	1914	1926	2065	2020
4/21	1988	1217	1904	1888	1973	2020	1961
4/21	1988	1222	1922	1997	2089	1982	1937
4/21	1988	1227	2047				
4/21	1988	1228					
4/21	1988	1223	2134				
4/21	1988	1229					
4/21	1988	1229					
4/21	1988	1229	2048				
4/21	1988	1230	1929	1929	2030	2023	1960
4/21	1988	1235	1918	1937	1926	1903	1897
4/21	1988	1240	1922	1915	1911	1907	1911
4/21	1988	1245	1933	1917	1892	1884	1900
4/21	1988	1250	1903	1879	1880	1908	1896
4/21	1988	1255	1875	1891	1922	1916	1903
4/21	1988	1300	1896	1908	1920	1914	1894
4/21	1988	1305	1883	1902	1904	1884	1881
4/21	1988	1310	1902	1947	1959	1926	1937
4/21	1988	1315	1944	1928	1910	1912	1917
4/21	1988	1320	1897	1890	1906	1945	1935
4/21	1988	1325	1912	1890	1889	1902	1899
4/21	1988	1330	1875	1918	1963	1941	1907
4/21	1988	1335	1980	2063	1966	1897	1895
4/21	1988	1340	1934	1971	1924	1903	1922
4/21	1988	1345	1937	1922	1907	1950	1959
4/21	1988	1350	1928	1910	1939	1967	1932
4/21	1988	1355	1907	1918	1956	1939	1911
4/21	1988	1400	1922	2028	1994	1920	1900
4/21	1988	1405	1918	1890	1877	1906	1918
4/21	1988	1410	1894	1892	1893	1894	1902
4/21	1988	1415	1906	1877	1928	2002	1894
4/21	1988	1420	1908	1917	1927	1922	1907
4/21	1988	1425	1902	1918	1887	1891	1894
4/21	1988	1430	1931	1924	1918	1888	1900
4/21	1988	1435	1905	1888	1902	1917	1924
4/21	1988	1440	1922	1908	1914	1918	1907
4/21	1988	1445	1919	1931	1889	2014	1950
4/21	1988	1450	1892	1894	1912	1901	1881
4/21	1988	1455	1888	1917	1945	1923	1916
4/21	1988	1500	1932	1960	1945	1921	1961
4/21	1988	1505	1990	1926	1901	1953	1991

SECONDARY TEMPS

#1

#2

#3

4/21/1988	1510	1938	1906	1937	2015	1971
4/21/1988	1515	1914	1906	1933	1934	1915
4/21/1988	1520	1904	1934	1958	1937	1915
4/21/1988	1525	1948	1998	1951	1903	1911
4/21/1988	1530	1953	1964	1921	1911	1956
4/21/1988	1535	1973	1953	1933	1966	1983
4/21/1988	1540	1956	1925	1936	1950	1950
4/21/1988	1545	1951	1956	1969	1933	1982
4/21/1988	1550	1956	1952	1976	[illegible]	[illegible]
4/21/1988	1555	1953	[illegible]	[illegible]	[illegible]	1995
4/21/1988	[illegible]	2005	[illegible]	1924	1922	1955
[illegible]	[illegible]	1970	1930	1942	2071	2013
[illegible]	[illegible]	1907	1892	1960	2013	1964
4/21/1988	1615	1920	1949	1949	1935	1923
4/21/1988	1620	1947	1974	1952	1912	1936
4/21/1988	1625	2065	2038	1977	1933	1952
4/21/1988	1630	1968	1938	1919	1921	1961
4/21/1988	1635	1966	1933	1983	2014	1959
4/21/1988	1640	1927	1939	1943	1918	1911
4/21/1988	1645	1933	1997	1958	1909	1907
4/21/1988	1650	1985	1979	1923	1899	1907
4/21/1988	1655	1911	1909	1895	1930	1999
4/21/1988	1700	1988	1937	1917	1918	1927
4/21/1988	1705	1929	1904	1903	1906	1898
4/21/1988	1710	1902	1901	1906	1915	1898
4/21/1988	1715	1884	1907	1925	1918	1891
4/21/1988	1720	1900	1928	1931	1910	1893
4/21/1988	1725	1892	1901	1892	1885	1903
4/21/1988	1730	1903	1888	1901	1911	1920
4/21/1988	1735	1908	1907	1894	1916	1968
4/21/1988	1740	1963	1938	1917	1976	2015
4/21/1988	1745	1960	1916	1922	1963	1986
4/21/1988	1750	1931	1930	1989	1970	1937
4/21/						

5

The Almega Corporation

PRIMARY

Stage 1 Temp, 5 mins.

Test #1			Test #2					
10:30	-	1115	12:55	-	1344	3:30	-	1481
10:35	-	1240	1:00	-	1352	3:35	-	1494
10:40	-	1335	1:05	-	1410	3:40	-	1504
10:45	-	1403	1:10	-	1383	3:45	-	1496
10:50	-	1417	1:15	-	1446	3:50	-	1552
10:55	-	1458	1:20	-	1445	3:55	-	1535
11:00	-	1469	1:25	-	1430	4:00	-	1500
11:05	-	1541	1:30	-	1370	4:05	-	1500
11:10	-	1531	1:35	-	1418	4:10	-	1490
11:15	-	1453	1:40	-	1522	4:15	-	
11:20	-	1481	1:45	-	1476	4:20	-	
11:25	-	1466	1:50	-	1458	4:25	-	1493
11:30	-	1481	1:55	-	1473	4:30	-	1590
11:35	-	1480	2:00	-	1436	4:35	-	
11:40	-	1489	2:05	-	1495	4:40	-	1567
11:45	-	1513	2:10	-	1394	4:45	-	1477
11:50	-	1644	2:15	-	1374	4:50	-	1508
11:55	-	1598	2:20	-	1489	4:55	-	1479
12:00	-	1568	2:25	-	1492	5:00	-	1511
12:05	-	1609	2:30	-	1473	5:05	-	1494
12:10	-	1554	2:35	-	1492	5:10	-	1477
12:15	-	1512	2:40	-	1432	5:15	-	1494
12:20	-	1577	2:45	-	1437	5:20	-	1497
12:25	-	1545	2:50	-	1507	5:25	-	1525
12:30	-	1636	2:55	-	1440	5:30	-	1450
12:35	-	1632	3:00	-	1444	5:35	-	1436
12:40	-	1494	3:05	-	1512	5:40	-	1455
12:45	-	1474	3:10	-	1517	5:45	-	1486
12:50	-	1413	3:15	-	1518	5:50	-	
			3:20	-	1477	5:55	-	
			3:25	-	1500	6:00	-	

CHATTANOOGA-HAMILTON COUNTY HOSPITAL AUTHORITY

ERLANGER MEDICAL CENTER

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

RECEIVED
MAY 06 1988
THE ALMEGA CORPORATION

May 3, 1988

Mr. Bernard W. Jackson
Administrative Manager
The Almega Corporation
607 Country Club Drive
Bensenville, IL 60106

Dear Mr. Jackson:

Enclosed for your information, as requested, is a copy of the Waste Incinerator Plant Log for Friday, April 22, 1988, along with a copy of the computer print-out.

If you have any questions or require additional information concerning this matter, please let me know.

Sincerely,

Millard L. Raines/bc

Millard L. Raines
Central Energy Plant Manager

/bc

Attachments
INCRT422.DOC/MR

Baroness Erlanger Hospital

T. C. Thompson
Children's Hospital
Medical Center

Willie D. Miller Eye Center

4/22/1988	705	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4/22/1988	710	[illegible]	1857			
4/22/1988	712	1902	1924	1878		
4/22/1988	715	1861	1899	1933	1911	1871
4/22/1988	720	1885	1928	1907	1874	1882
4/22/1988	725	1930	1911	1878	1882	1967
4/22/1988	730	1950	1904	1873	1897	1906

Secondary temps

4/22/1988	735	1875	1896	1975	1949	1903
4/22/1988	740	1884	1900	1915	1884	1879
4/22/1988	745	1908	1896	1872	1897	1901
4/22/1988	750	1927	1946	1927	1894	1877
4/22/1988	755	1898	1900	1864	1897	1915
4/22/1988	800	1873	1878	1926	1902	1868
4/22/1988	805	1911	1918	1890	1872	1886
4/22/1988	810	1881	1874	1896	1883	1873
4/22/1988	815	1918	1924	1891	1869	1932
4/22/1988	820	1958	1926	1884	1890	1952
4/22/1988	825	1944	1901	1862	1902	1915
4/22/1988	830	1866	1871	1922	1930	1895
4/22/1988	835	1865	1916	1917	1874	1879
4/22/1988	840	1925	1895	1863	1911	1933
4/22/1988	845	1945	1918	1888	1871	1930
4/22/1988	850	1915	1868	1884	1930	1945
4/22/1988	855	1972	1995	2015	2047	2069
4/22/1988	900	2056	2042	2034	2032	2030
4/22/1988	905	2025	2039	2032	2029	2064
4/22/1988	910	2073	2050	2043	2035	2026
4/22/1988	915	2032	2056	2055	2061	2086
4/22/1988	920	2097	2073	2043	2025	2048
4/22/1988	925	2058	2069	2073	2065	2060
4/22/1988	930	2062	2056	2050	2047	2036
4/22/1988	935	2035	2060	2068	2069	2057
4/22/1988	940	2060	2077	2057	2043	2064
4/22/1988	945	2062	2062	2060	2061	2056
4/22/1988	950	2053	2056	2051	2042	2036
4/22/1988	955	2031	2027	2053	2081	2047
4/22/1988	1000	2021	2028	2039	2051	2062
4/22/1988	1005	2056	2061	2059	2040	2039
4/22/1988	1010	2062	2063	2041	2038	2054
4/22/1988	1015	2074	2047	2033	2047	2080
4/22/1988	1020	2054	2028	2031	2057	2065
4/22/1988	1025	2037	2029	2039	2054	2051
4/22/1988	1030	2050	2046	2040	2045	2043
4/22/1988	1035	2029	2037	2067	2042	2026
4/22/1988	1040	2041	2057	2047	2053	2067
4/22/1988	1045	2028	2029	2043	2078	2077
4/22/1988	1050	2036	2038	2044	2045	2037
4/22/1988	1055	2027	2039	2056	2041	2024
4/22/1988	1100	2038	2047	2024	[illegible]	[illegible]
4/22/1988	1105	2036	2020	2031	2058	2054
4/22/1988	1110	2031	2020	[illegible]	2021	2019
4/22/1988	1115	2016	2013	2009	[illegible]	2009
4/22/1988	1120	2009	2008	2006	2005	2008
4/22/1988	1125	2001	1998	[illegible]	2025	2074
4/22/1988	1130	2056	[illegible]	[illegible]	2042	[illegible]
4/22/1988	1135	2020	2016	2007		

#1

#2

2035	2034	2033	2017				
4/22/1988	1235	2057	2132	2114	2063	2045	
4/22/1988	1240	2042	2031	2040	2055	2051	
4/22/1988	1245	2054	2074	2040	2023	2053	
4/22/1988	1250	2070	2054	2047	2065	2058	
4/22/1988	1255	2047	2083	2107	2069	2050	
4/22/1988	1300	2054	2087	2040	2054	2109	
4/22/1988	1305	2100	2070	2067	2064	2058	
4/22/1988	1310	2084	2080	2042	2043	2059	
4/22/1988	1315	2072	2043	2043	2114	2137	
4/22/1988	1320	2100	2130	2149	2076	2055	
4/22/1988	1325	2084	2068	2035	2047	2052	
4/22/1988	1330	2058	2084	2091	2017	2006	
4/22/1988	1335	2037	2057	2003	2017	2038	
4/22/1988	1340	2058	2069	2045	2056	2062	
4/22/1988	1345	2055	2061	2056	2067	2071	
4/22/1988	1350	2047	2065	2096	2131	2105	
4/22/1988	1355	2105	2098	2043	2036	2049	
4/22/1988	1400	2065	2049	2049	2056	2076	
4/22/1988	1405	2054	2055	2065	2047	2051	
4/22/1988	1410	2042	2031	2047	2079	2074	
4/22/1988	1415	2039	2043	2064	2058	2039	
4/22/1988	1420	2047	2054	2049	2043	2053	
4/22/1988	1425	2065	2043	2044	2055	2058	
4/22/1988	1430	2054	2073	2060	2047	2071	
4/22/1988	1435	2122	2099	2065	2056	2065	
4/22/1988	1440	2069	2094	2069	2060	2057	
4/22/1988	1445	2062	2069	2081	2056	2052	
4/22/1988	1450	2070	2058	2052	2071	2100	
4/22/1988	1455	2111	2089	2130	2137	2077	
4/22/1988	1500	2078	2078	2051	2061	2077	
4/22/1988	1505	2073	2047	2054	2092	2089	
4/22/1988	1510	2049	2047	2064	2096	2084	
4/22/1988	1515	2104	2094	2069	2060	2088	
4/22/1988	1520	2079	2052	2060	2069	2012	
4/22/1988	1525	2012	2054	2081	2048	2040	
4/22/1988	1530	2054	2062	2049	2009	1709	
4/22/1988	1535	1852	1882	1910	1891	1874	
4/22/1988	1540	1870	1896	1899	1881	1869	
4/22/1988	1545	1886	1888	1879	1871	1876	
4/22/1988	1550	1884	1866	1869	1885	1869	
4/22/1988	1555	1863	1884	1873	1860	1875	
4/22/1988	1600	1876	1887	1872	1905	1900	
4/22/1988	1605	1869	1872	1906	1892	1860	
4/22/1988	1610	1869	1891	1877	1860	1884	
4/22/1988	1615	1888	1869	1874	1908	1899	
4/22/1988	1620	1872	1881	1893	1879	1869	
4/22/1988	1625	1892	1893	1895	1927	1941	
4/22/1988	1630	1939	1917	1901	1893	1878	
4/22/1988	1635	1869	1893	1896	1878	1862	
4/22/1988	1640	1887	1893	1861	1869	1882	
4/22/1988	1645	1863	1862	1879	1870	1859	

#1

#3

#4

4/22/1988	1700	1871	1981	1861	1863	1879
4/22/1988	1705	1867	1958	1870	1873	1955
4/22/						
1988	1710	1858	1866	1871	1864	1956
4/22/1988	1715	1862	1875	1870	1859	1869
4/22/1988	1720	1880	1860	1858	1869	1883
4/22/1988	1725	1897	1906	1875	1859	1878
4/22/1988	1730	1877	1856	1862	1874	1863
4/22/1988	1735	1954	1862	1869	1870	1854
4/22/1988	1740	1857	1863	1869	1871	1862
4/22/1988	1745	1858	1859	1858	1858	1856
4/22/1988	1750	1854	1852	1850	1848	1846
4/22/1988	1755	1842	1839	1834	1830	1860
4/22/1988	1800	1871	1854	1841	1834	1832
4/22/1988	1805	1866	1868	1850	1838	1829
4/22/1988	1810	1852	1863	1854	1841	1832
4/22/1988	1815	1842	1866	1858	1844	1832
4/22/1988	1820	1836	1862	1856	1842	1828
4/22/1988	1825	1846	1859	1847	1832	1835
4/22/1988	1830	1858	1853	1836	1823	1849
4/22/1988	1835	1851	1836	1828	1851	1853
4/22/1988	1840	1839	1827	1850	1854	1839
4/22/1988	1845	1827	1847	1851	1837	1828
4/22/1988	1850	1848	1848	1832	1832	1852
4/22/1988	1855	1846	1828	1835	1854	1845
4/22/1988	1900	1819	1720	1590	1467	1359
4/22/1988	1905	1263	1181	1109	1046	991
4/22/1988	1910	941	897	858	823	791
4/22/1988	1915	763	737	714	693	673
4/22/1988	1920	655	638	623	608	593
4/22/1988	1925	584	572	562	551	542
4/22/1988	1930	533	525	517	510	503
4/22/1988	1935	497	491	484	479	473
4/22/1988	1940	467	462	458	453	449
4/22/1988	1945	445	441	437	433	431
4/22/1988	1950	426	423	[illegible]	415	413
4/22/1988	1955	409	[illegible]	403	400	398
4/22/1988	2000	396	393	390	387	384
4/22/1988	2005	381	379	377	374	372
4/22/1988	2010	369	367	365	362	361
4/22/1988	2015	358	356	354	352	350
4/22/1988	2020	348	346	344	343	340
4/22/1988	2025	339	337	335	333	332
4/22/1988	2030	330	329	328	327	326
4/22/1988	2035	325	324	324	323	322
4/22/1988	2040	320	320	318	317	316
4/22/1988	2045	314	313	311	309	308
4/22/1988	2050	306	305	304	302	301
4/22/1988	2055	299	298	296	295	294
4/22/1988	2100	292	290	289	288	286
4/22/1988	2105	286	284	283	282	281
4/22/1988	2110	279	278	278	276	275

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. H_2O to 11" S.P. H_2O (confidential matter). These add extra turbulences not calculated in the agency's formula.

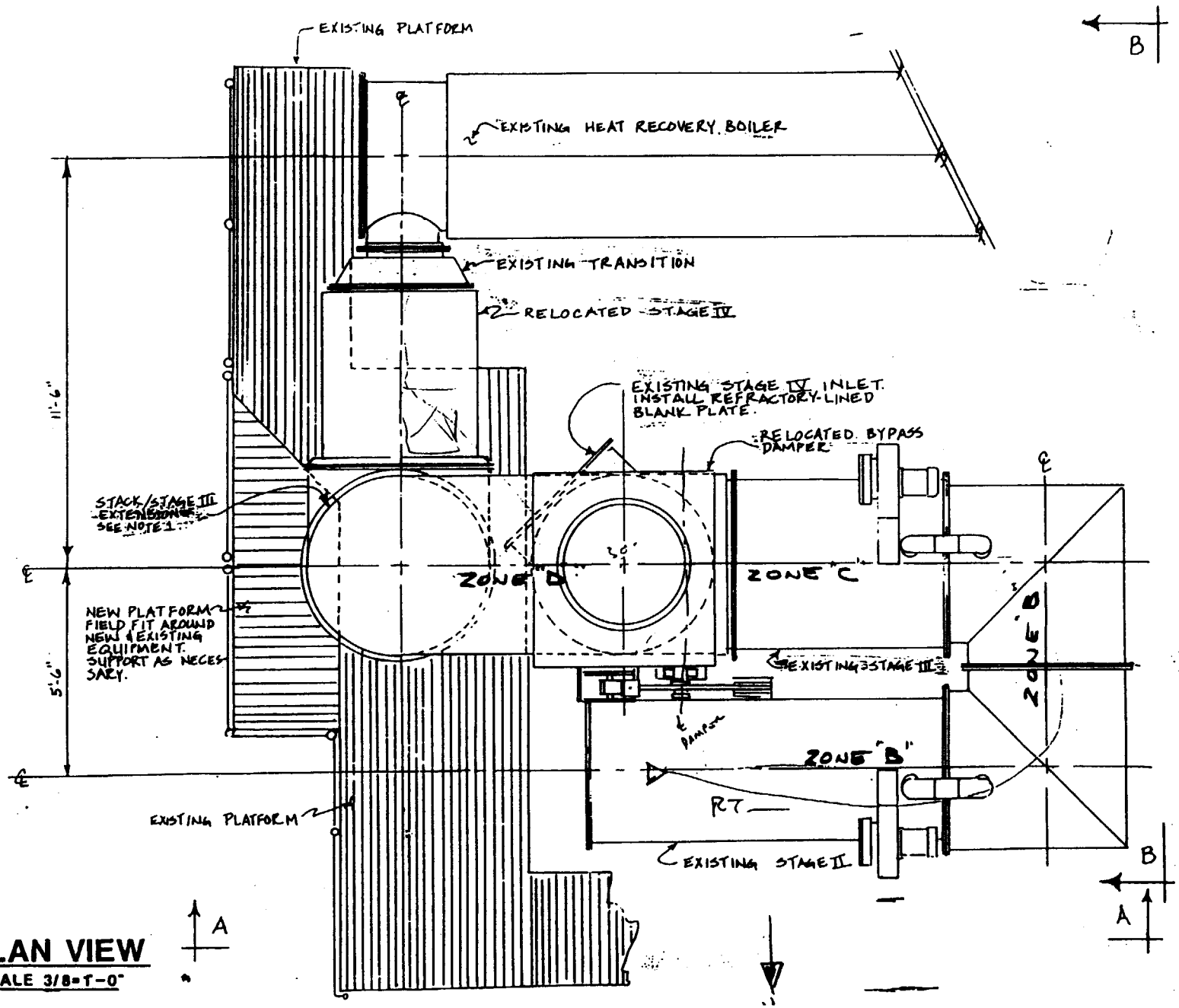
Very truly yours,

BASIC ENVIRONMENTAL ENGINEERING, INC.

John N. Basic, Sr.
President

JNB:ld

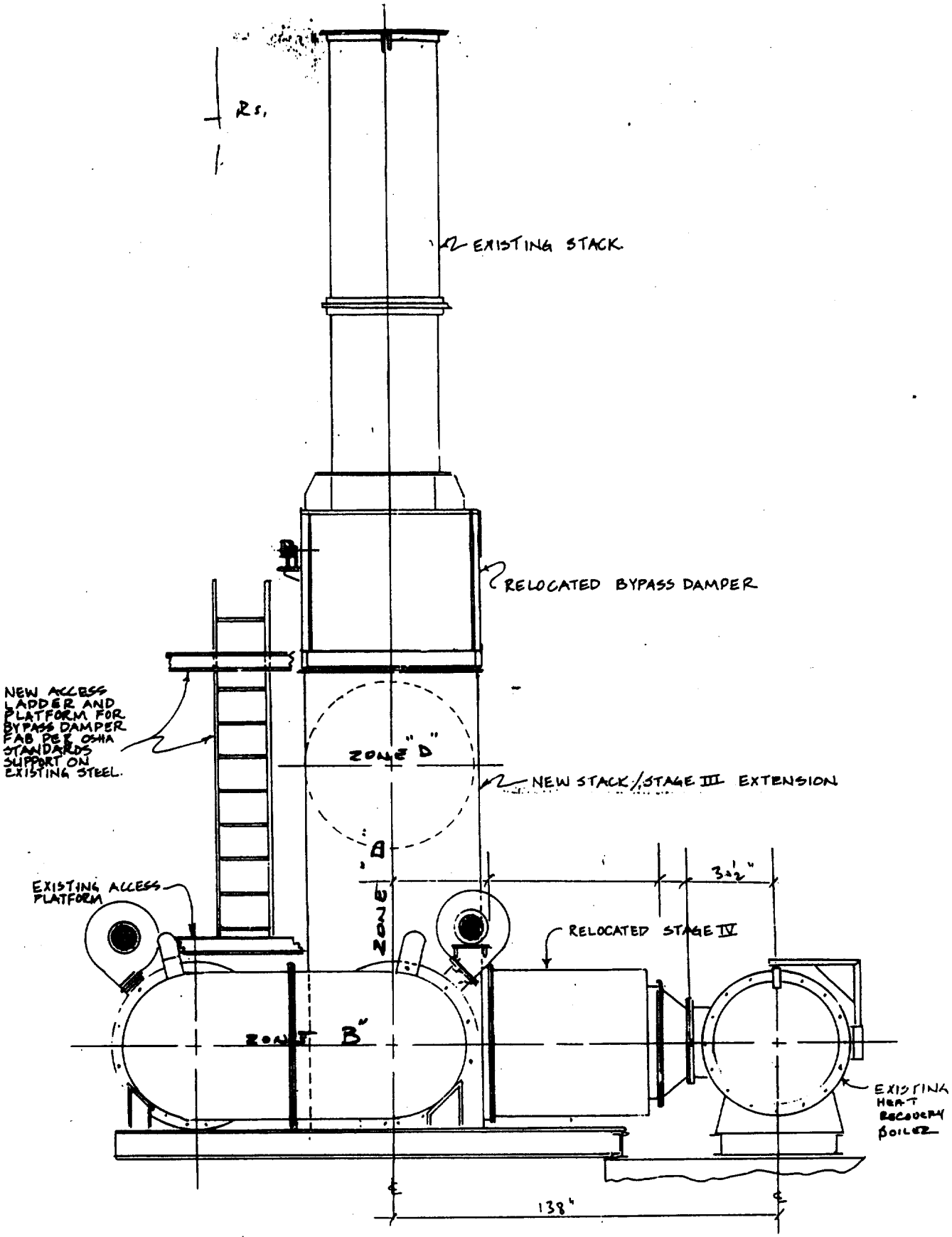
Encls.



PLAN VIEW

SCALE 3/8"=1'-0"

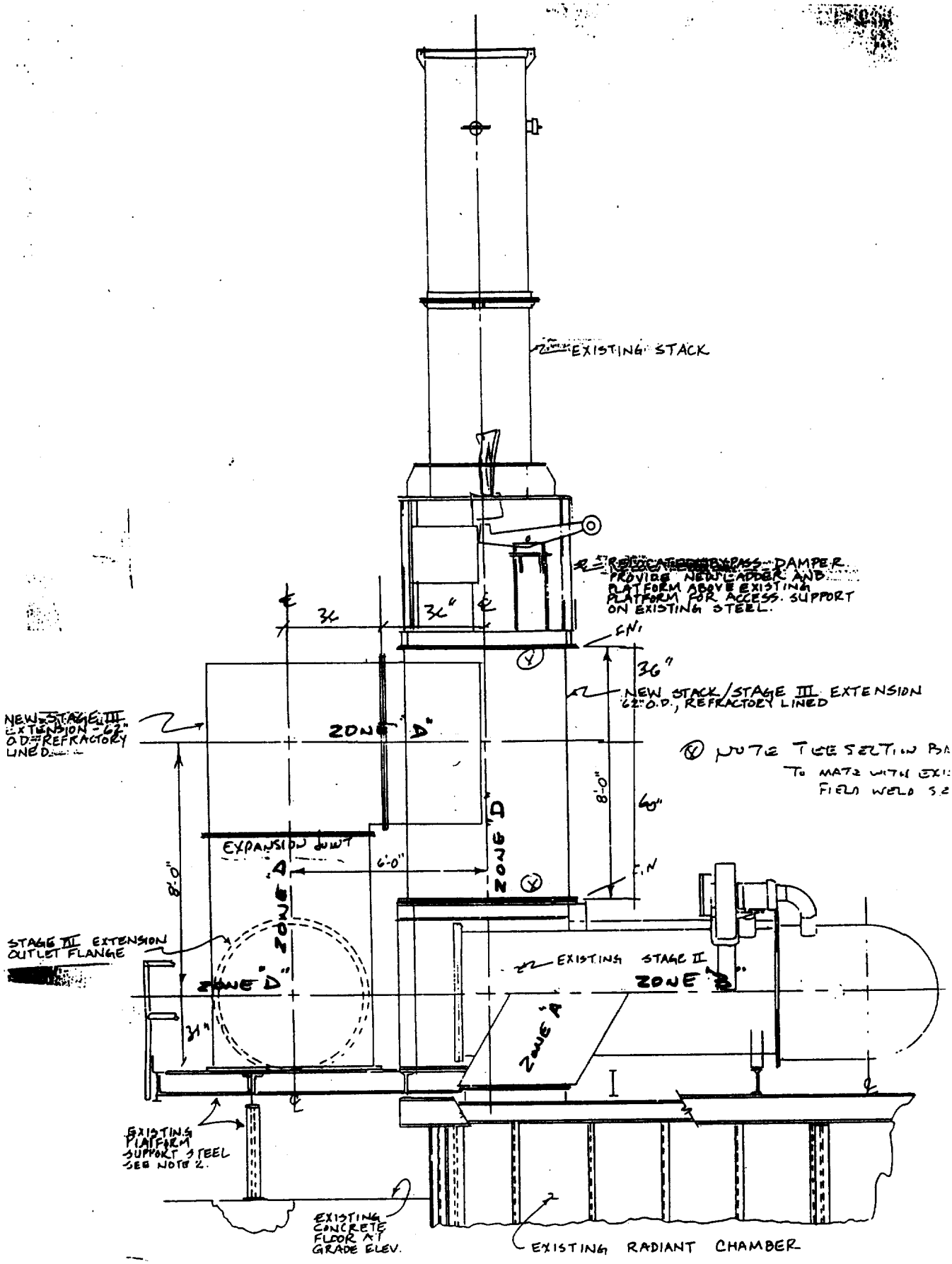
Basic Model 1250



SECTION "B-B"

SCALE 3/8"=1'-0"

Basic Model 1250



SECTION "A-A"

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.

Viscosities of gases

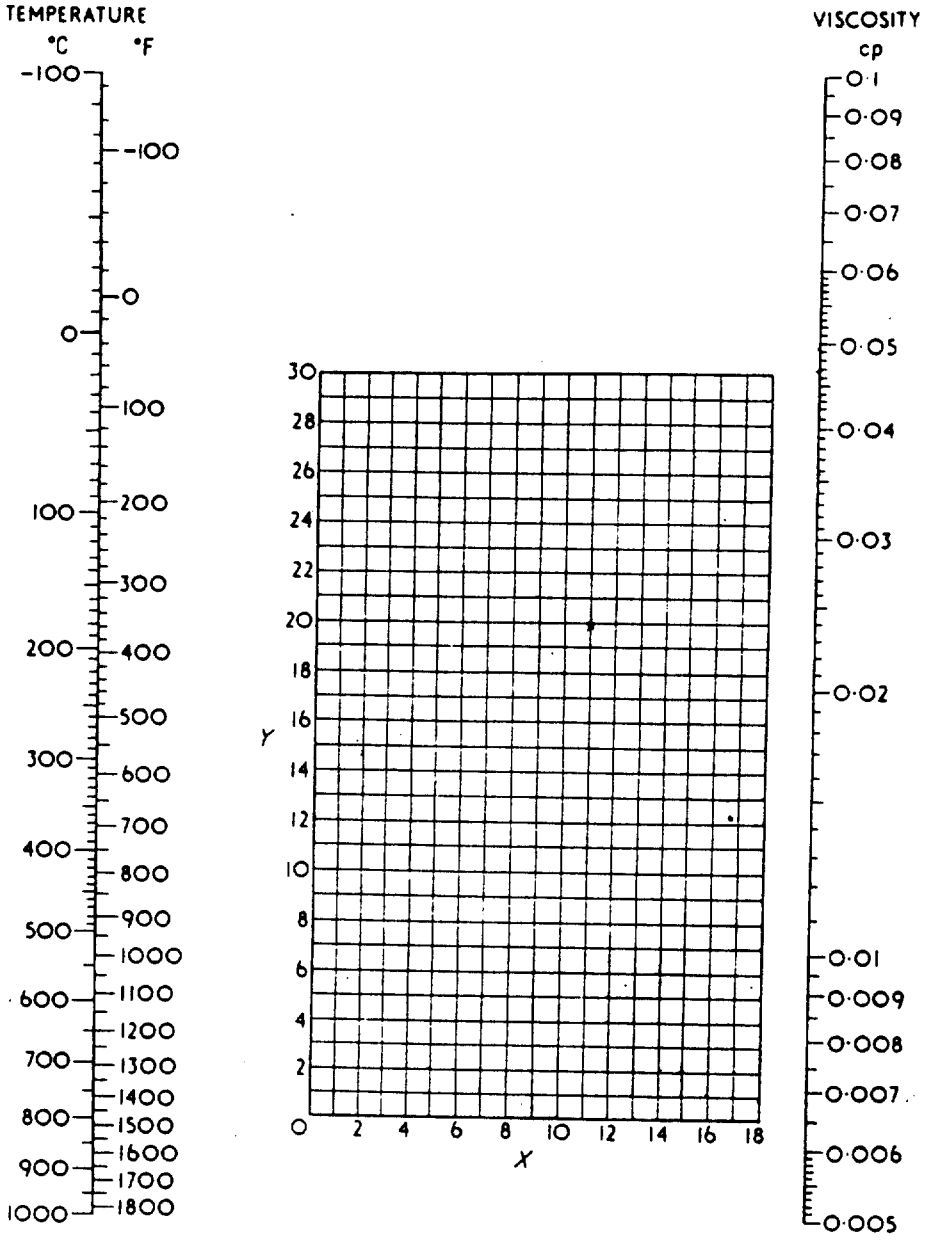


TABLE 8. Viscosities of gases*

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_3F)	10·6	15·1
26	Freon-12 (CCl_2F_2)	11·1	16·0
27	Freon-21 ($CHCl_2F$)	10·8	15·3
28	Freon-22 ($CHClF_2$)	10·1	17·0
29	Freon-113 (CCl_2F-$CClF_2$)	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 in^2 or 4.625 ft^2
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 in^2 or 7.465 ft^2
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 in^2 or 9.16 ft^2
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 in^2 or 11.54 ft^2
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:

$$T = 0.15 + 0.65 + 0.288 + 1.01 \text{ seconds}$$

T = 2.098 seconds

THE ALMEGA CORPORATION

CALCULATION OF REYNOLDS NUMBER (Re)
FOR ZONES A, B, C & D AND TURBULENT FLOW DETERMINATION

$Re = \frac{uD\rho}{\mu}$ where: u = velocity ft/sec

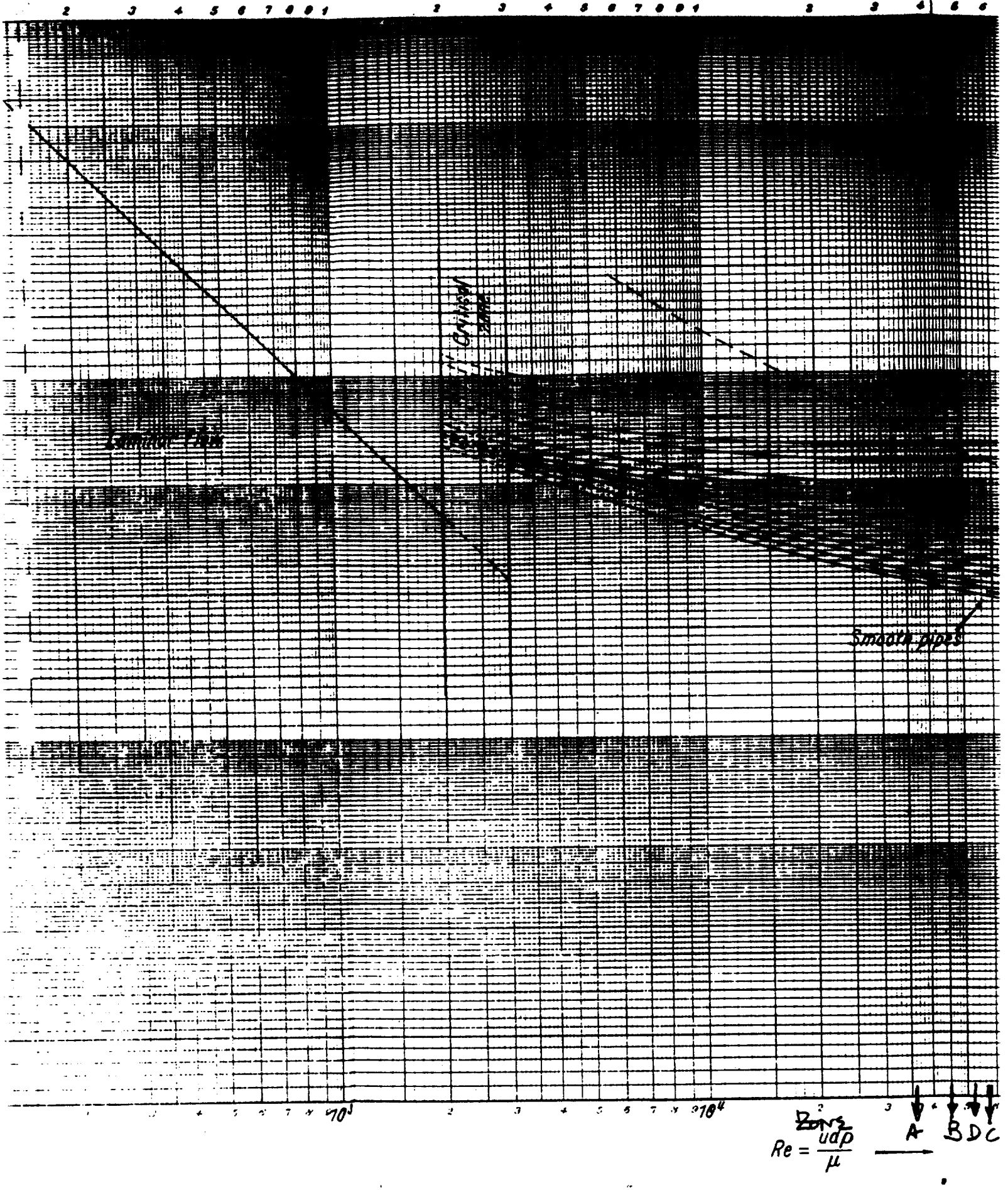
D = characteristic dimension ft

ρ = density lbs/ft^3

μ = viscosity lb/ft sec

Units: Re: $\frac{ft}{sec} \cdot ft \cdot \frac{lbs}{ft^3} \cdot \frac{ft\ sec}{lbs}$ dimensionless

Zone (Temp °F)	Velocity u ft/sec	Characteristic Dimension Diameter D ft	Density (from Table 1 and test data) ρ lbs/ft³	Viscosity (of air: see attached) μ lb/ft sec	Reynolds No. Re Dimensionless
A (1500°F)	22.54	29.1/12	$(\frac{28.24}{386} \times \frac{528}{1960})$	(0.0435 x 0.000672)	36900
B (1800°F)	26.856	37/12	$(\frac{28.24}{386} \times \frac{528}{2260})$	(0.0465 x 0.000672)	45300
C (1800°F)	30.6	41/12	$(\frac{28.24}{386} \times \frac{528}{2260})$	(0.0465 x 0.000672)	57200
D (1800°F)	24.29	46/12	$(\frac{28.24}{386} \times \frac{528}{2260})$	(0.0465 x 0.000672)	51000


Laminar Flow
Smooth pipes
$Re = \frac{udp}{\mu}$
A
B
D
C

APPENDIX R

EQUIPMENT CALIBRATIONS

INTER-LABORATORY STUDY RESULTS

DATE PRINTED: 08/18/87

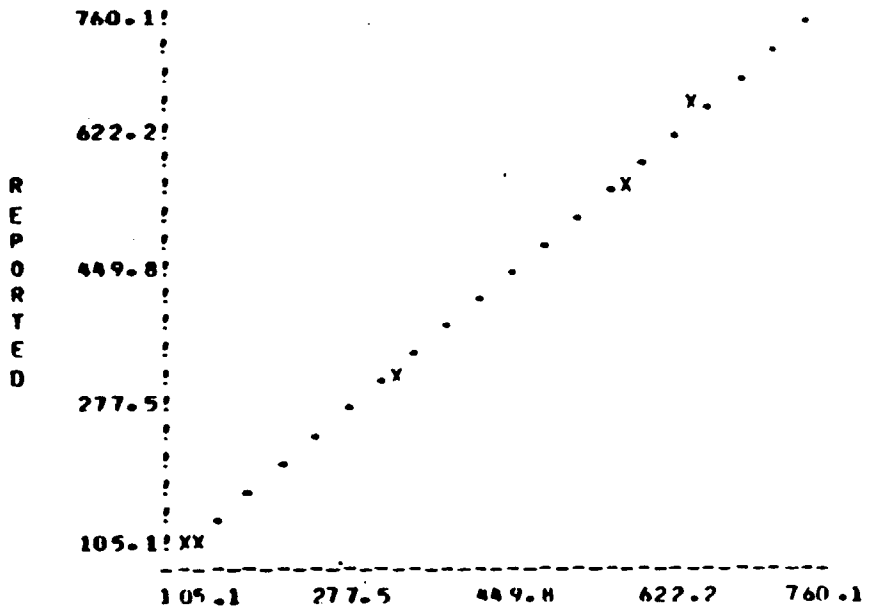
(APRIL 1987)

POLLUTANT - NOX

I2A008
MR. R. TRZUPEK
ALMEGA CORP.
607-C COUNTRY CLUB DR.
BENSENVILLE, IL 60106

UNITS - MILLIGRAMS PER DRY STD CUBIC METER

SAMPLE NUMBER	REPORTED 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	557.8	590.0	-5.53
9371	332.6	329.9	.82



Y = 1.013X -13.778

INTER-LABORATORY STUDY RESULTS

DATE PRINTED: 07/16/86

(APRIL 1986)

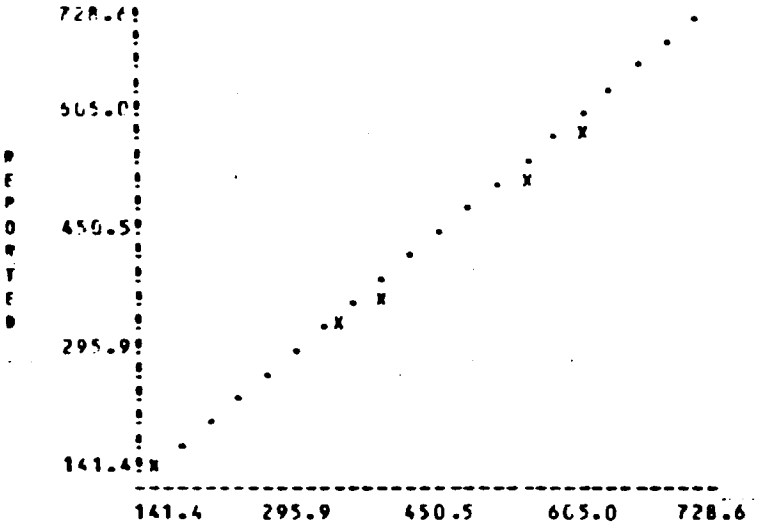
POLLUTANT - NOX

[illegible]
MR. K. TRZUPEK
ALMEGA CORP.
607-C COUNTRY CLUB DR.
BENSENVILLE, IL 60106

UNITS - MILLIGRAMS PER DRY STD CUBIC METER

SAMPLE NUMBER	REPORTED VALUE	EPA VALUE	PERCENT DIFFERENCE
2192	603.0	620.0	-2.74
3044	517.0	555.0	-6.85
5271	126.0	130.0	-3.08
7233	349.0	350.0	-.29
9642	374.0	390.0	-4.10

Avg Difference -3.



Y = .948X +6.026

The Almega Corporation

NO_x FLASKS

FLASK #	VOLUME (ml)
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 2090
34 2083

THE ALMEGA CORPORATION

CALIBRATED BY: HC DATE: 3/11/88 BOX NO.: 6

BAROMETRIC PRESSURE, P_b = 29.260 in. Hg DRY GAS METER NO.: 8734190556

Orifice Manometer Setting ΔH, in. H_2O	Reference Gas Volume Test Meter V_w, ft^3 708.781	Gas Volume Dry Gas Meter V_d, ft^3 94.173	TEMPERATURE: Reference Test Meter t_w, °F	TEMPERATURE: Dry Gas Meter Inlet t_{di}, °F	TEMPERATURE: Dry Gas Meter Outlet t_{do}, °F	TEMPERATURE: Dry Gas Meter Average t_d, °F	Time e, min	Y	ΔH@
0.5	711.946	97.414	65	68	62	65.0	5	0.9753	0.7098
1.0	716.359	101.732	65	70	63	66.5	5	0.9743	0.7281
1.5	721.608	107.313	65	73	65	69.0	5	0.9792	0.7683
2.0	727.579	113.476	65	80	70	75.0	5	0.9824	0.7928
2.5	734.206	120.340	65	90	78	84.0	5	0.9940	0.7812
3.0	741.525	127.916	65	93	80	86.5	5	0.9954	0.7692
								Average: 0.9834	0.7566

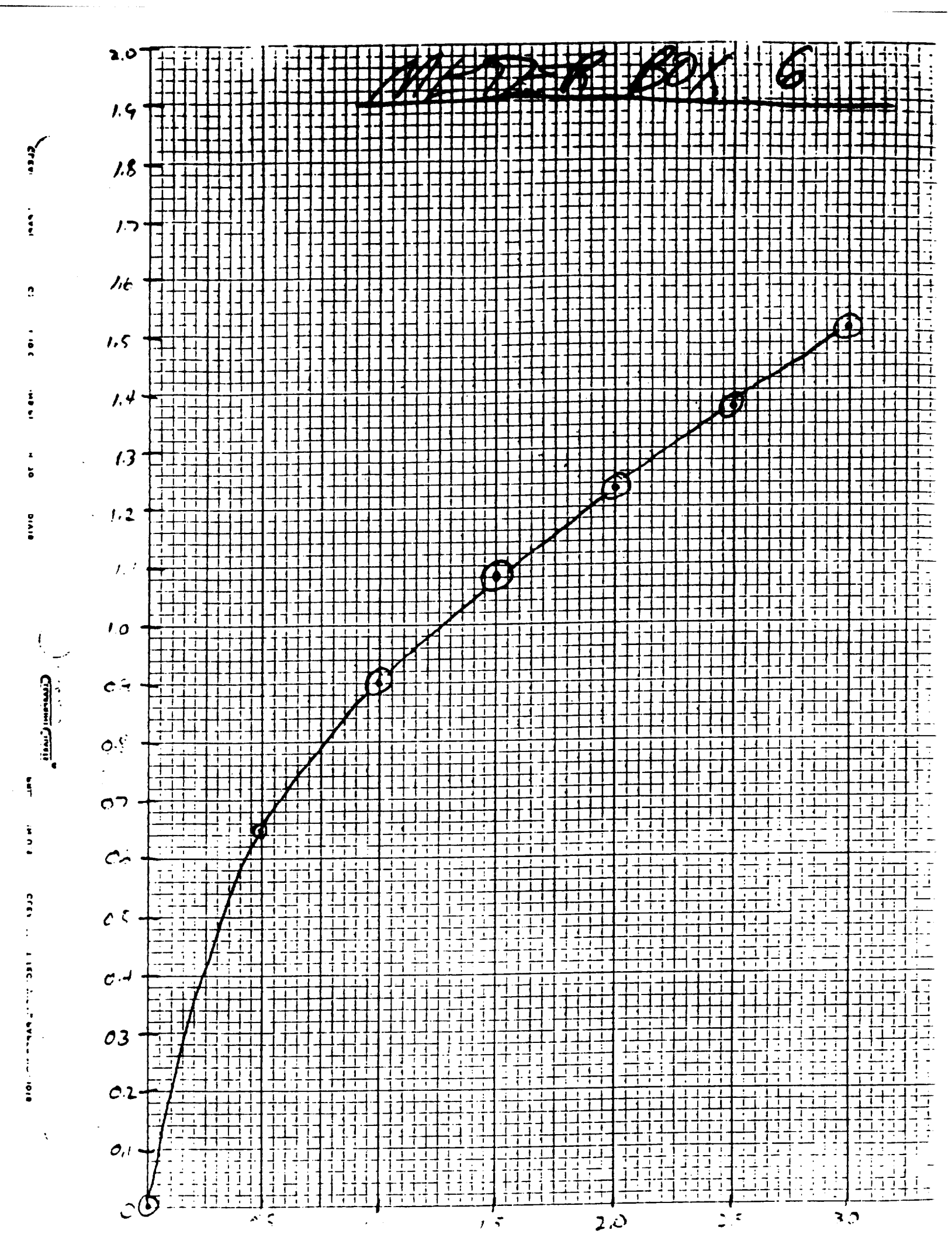
V_w: 3.165, 4.413, 5.249, 6.627, 7.259

V_d: 3.281, 4.519, 5.381, 6.163, 6.864, 7.576

$V_d/5$: 0.6482, 0.9036, 1.076, 1.233, 1.373, 1.515

CALCULATIONS:

ΔH	$\frac{\Delta H}{13.6}$	$\frac{Y}{\frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}}$	$\frac{\Delta H@}{\frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{\theta (t_w + 460)}{V_w}\right]^2}$
0.5	0.03676		
1.0	0.07353		
1.5	0.1103		
2.0	0.1471		
2.5	0.1838		
3.0	0.2206		


2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.0
0.7
0.4
0.3
0.2
0.1
0
2.0
3.0

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

METER BOX 6

DATE 3/26/88 THERMOCOUPLE NUMBER METER IN/METER 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,[c] %
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	132	137	0

[a] Every 50°F for each reference point.

[b] Type of calibration system used.

[c] $\frac{[(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)]}{\text{ref temp, °F} + 460} 100 \leq 1.5\%$

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

SAMPLE BOX 1

DATE 3/26/88 THERMOCOUPLE NUMBER OVEN / IMP. OUT

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, [c] %
OVEN	WATER	151	150	0.2
	WATER	210	209	0.1
	OIL	265	265	0
IMP OUT	WATER ICE	32	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] $\frac{[(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)]}{\text{ref temp, °F} + 460} 100 \leq 1.5\%$

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

SAMPLE BOX 2

DATE 3/26/88 THERMOCOUPLE NUMBER OVEN / IMP OUT

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,[c] %
OVEN	WATER	151	150	0.2
	WATER	210	209	0.1
	OIL	265	265	0
IMP 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] $\frac{[(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)]}{\text{ref temp, °F} + 460}$ 100 $\leq$ 1.5%

Calibrated by: CC
Pitobe number: 38
Date: 3-24-89
Manufacturer: TAC
Effective length: 30

The Almega Corporation

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube Assembly level? ✓ yes _____ no

Pitot tube openings damaged? _____ yes (explain below) ✓ no

α_1 = 1.5 ^{0} (<10^0), α_2 = 5.0 ^{0} (<10^0), β_1 = 4.0 (<5^0),

β_2 = 0 ^{0} (<5^0).

γ = 0 ^{0}, Θ = 2 ^{0}, A = (.25) cm (in.)

z = A sin γ = 0 cm (in.); <0.32 cm (<1/8 in.),

w = A sin Θ = .009 cm (in.); <0.08 cm (<1/32 in.).

P_A .367 cm (in.) P_b .355 cm(in.)

D_t = _____ cm (in.)

Comments: ✓

Calibration required? _____ yes ✓ no

The Almega Corporation

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

DATE 3/26/88 THERMOCOUPLE NUMBER DIGI-SENSE 3

AMBIENT TEMPERATURE 60 °F BAROMETRIC PRESSURE 29.54 in. Hg.

CALIBRATOR LC REFERENCE: MERCURY-IN-GLASS ✓

OTHER _____

REFERENCE POINT NUMBER [a]	SOURCE [b] (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, [c] %
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] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$