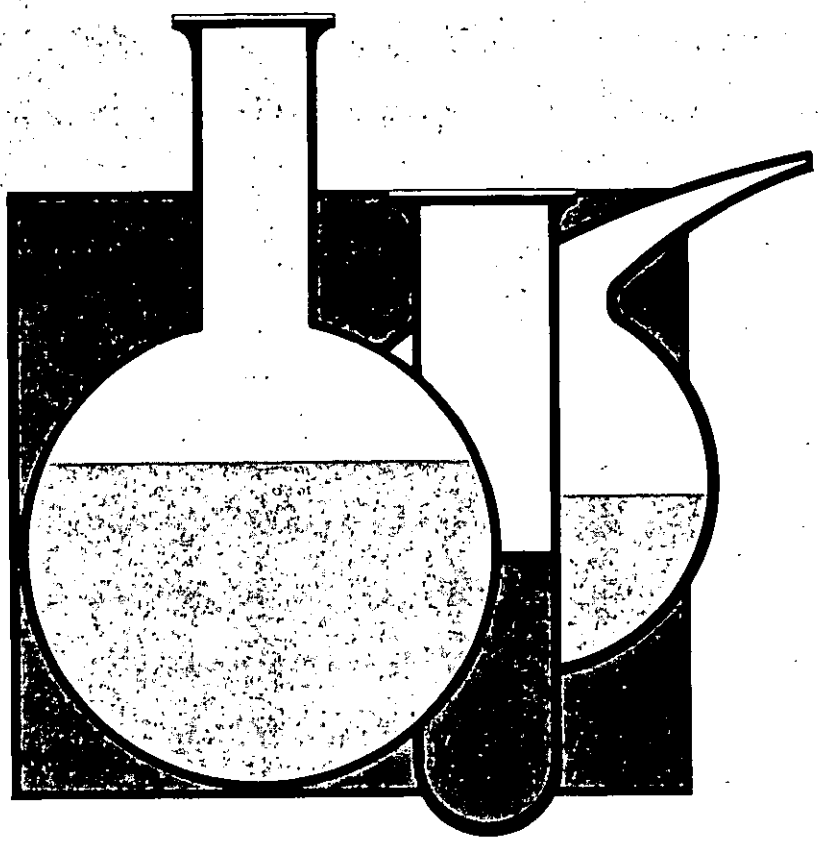
AP42 Section:	11.3
Reference:	16
Title:	Sulfur Dioxide Emission Tests Conducted On The #20 Tunnel Kiln In Mooresville, IN, For General Shale Products Corporation, Guardian Systems, Inc., Leeds, AL, December 2, 1986.

AP-42 Section 11.3
Reference 16

GUARDIAN SYSTEMS INC.

P.O. Box 300
Leeds, Alabama 35094
205/699-6647



Test Report

SULFUR DIOXIDE EMISSION TESTS

CONDUCTED ON THE

#20 TUNNEL KILN

IN

MOORESVILLE, INDIANA

FOR

GENERAL SHALE PRODUCTS CORPORATION

ON

DECEMBER 2, 1986

Approved by: Tom Lotz

Tom Lotz
Director
Field Services Division

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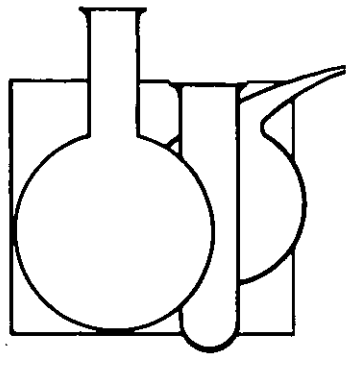
Introduction



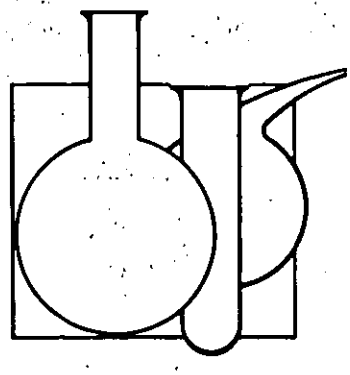
I. INTRODUCTION AND PROCESS DESCRIPTION

On December 2, 1986, Guardian Systems, Inc. performed a series of Sulfur Dioxide Emissions tests on the #20 Tunnel Kiln System of General Shale Products Corporation located near Mooresville, Indiana. This unit has two stack, one is a dryer stack (round stack) and the other is the kiln exhaust stack (brick stack). These two stacks were sampled simultaneously and the results summed to determine the total sulfur dioxide emissions from this source. These tests were conducted in accordance to the rules and regulations expressed in the Code of Federal Regulations, Title 40, Section 60, Reference Methods 1-4 and 6 as amended.

Individual bricks are formed and stacked onto kiln cars. The cars are inserted on a regular basis into a long, continuous-fired tunnel kiln. As one car is discharged another is inserted. This provides a constant moving mass inside the kiln. Cars are pushed through the kiln at a slow, methodical pace. (see **Plant Operational Data** for complete process information). By means of a coal firing process, heat is increased in each chamber until the total firing is complete. As the car continues through the kiln from the main firing zone the temperatures are reduced to provide necessary cooling.

Mr. Dave McNees, Corporate Representative, and Mr. Alvin Hall, Plant Superintendent represented General Shale Products Corporation. Mr. Vic P. Windle represented the Indiana State Board of Health. Mr. Tom Lotz, Mr. Greg Karstens and Mr. Chuck Turner, of Guardian Systems, Inc. performed these tests.

Test Results



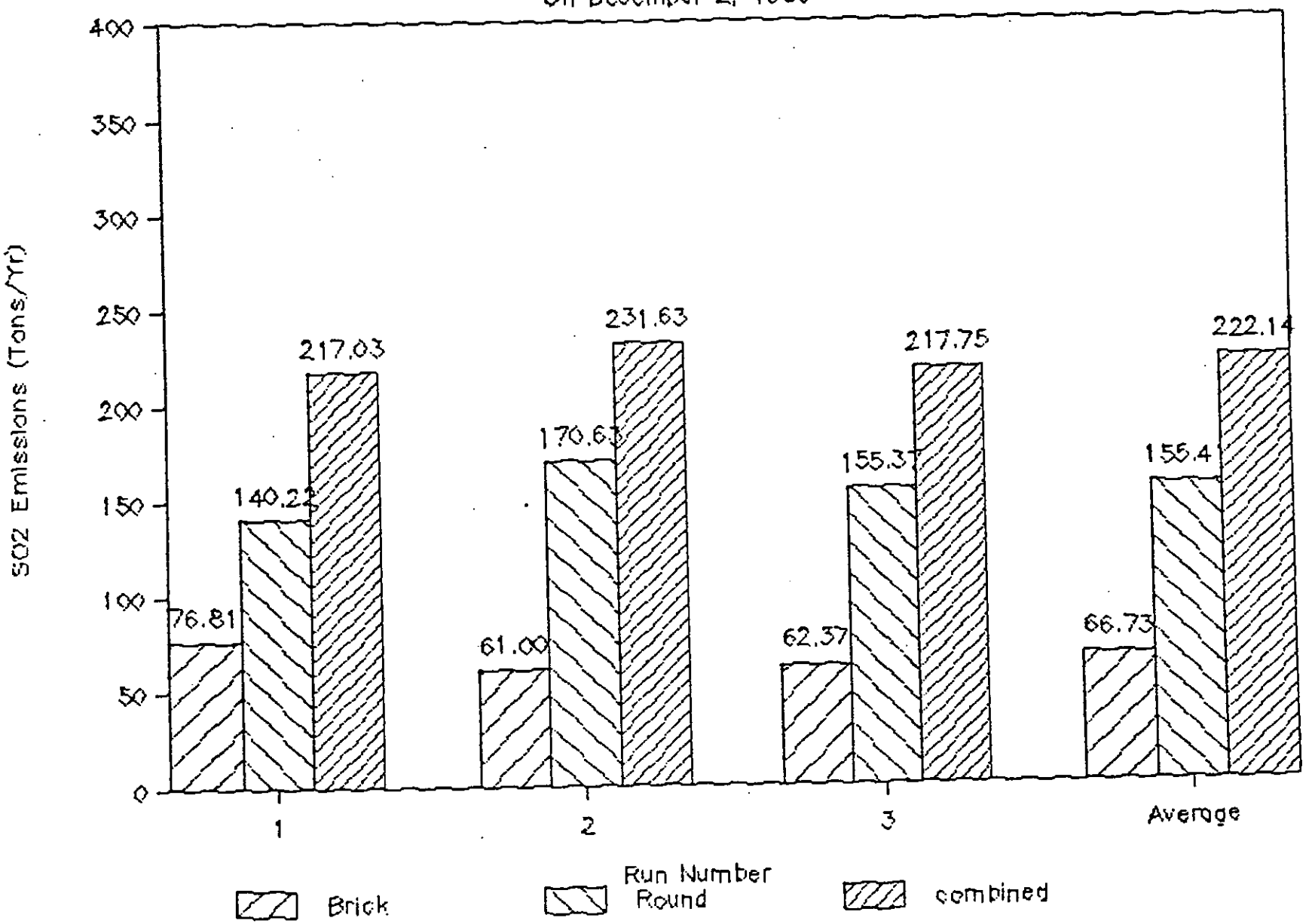
II. SUMMARY OF TEST RESULTS

The individual results from the Brick and Round Kiln stacks can be found in the following pages. Below is a summary of the combined sulfur dioxide emissions from the #20 Tunnel Kiln on December 2, 1986.

Test #1	Brick	Round	Total
Sulfur Dioxide Emissions, lbs/hour	17.54	32.01	49.55
Sulfur Dioxide Emissions, tons/year	76.81	140.22	217.03
Test #2			
Sulfur Dioxide Emissions, lbs/hour	13.93	38.96	52.89
Sulfur Dioxide Emissions, tons/year	61.00	170.63	231.63
Test #3			
Sulfur Dioxide Emissions, lbs/hour	14.24	35.47	49.71
Sulfur Dioxide Emissions, tons/year	62.37	155.37	217.75
Average Sulfur Dioxide Emissions, Tons/year			222.14

GENERAL SHALE CORPORATION

On December 2, 1986



Graph 1

G U A R D I A N * S Y S T E M S * I N C O R P O R A T E D
P.O. BOX 300
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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Brick Stk	Brick Stk	Brick Stk	Brick Stk
Time	1050-1235	1337-1453	1530-1640	1050-1650
Stack Temperature, F	159	157	155	157
Moisture Content, %	7.55	8.66	10.74	8.84
Oxygen Content, %	17.00	17.00	17.00	17.00
Carbon Dioxide Content, %	3.00	3.00	3.00	3.00
Stack Velocity, f/s	9.60	8.69	9.32	9.20
Volumetric Flow, ACFM	5,402	4,886	5,245	5,176
Volumetric Flow, DSCFM	4,250	3,810	4,010	4,028
Concentration SO2 #/CF	6.88E-05	6.09E-05	5.92E-05	6.30E-05
Concentration SO2 #/Hr	17.54	13.93	14.24	15.23
Concentration SO2 Tons/Yr	76.81	61.00	62.37	66.73

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	1-A	1-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Brick	Brick	Brick
Time	1050-1110	1215-1235	1050-1235
Total volume sampled, cf	0.621	0.620	
Meter correction MCF	1.0995	1.0995	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	47	51	
		Sample Recovery	
	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	7.40	6.85	
Vol of blank, ml	0.25	0.25	
		Worksheet Information	
	SO2	SO2	
Vm	0.683	0.682	
Pbar	29.85	29.85	
Tm	507	511	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	7.4	6.9	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			4,250
		Calculations	
Vol std, Cf	0.7091	0.7024	
Concentration SO2, #/DSCF	7.12E-05	6.63E-05	6.88E-05
mg/DSCM	1140.5	1062.8	1101.6
ppm	422.0	393.2	407.6
#/hr	18.15	16.92	17.54

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	2-A	2-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Brick	Brick	Brick
Time	1337-1357	1433-1453	1337-1453
Total volume sampled, cf	0.633	0.628	
Meter correction MCF	1.0995	1.0995	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	52	54	
		Sample Recovery	
	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	6.38	6.40	
Vol of blank, ml	0.25	0.25	
		Worksheet Information	
	SO2	SO2	
Vm	0.696	0.690	
Pbar	29.85	29.85	
Tm	512	514	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	6.4	6.4	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			3,810
		Calculations	
Vol std, Cf	0.7158	0.7074	
Concentration SO2, #/DSCF	6.05E-05	6.14E-05	6.09E-05
mg/DSCM	968.7	983.4	976.1
ppm	358.4	363.9	361.2
#/hr	13.82	14.03	13.93

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	3-A	3-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Brick	Brick	Brick
Time	1530-1550	1620-1640	1530-1640
Total volume sampled, cf	0.909	0.820	
Meter correction MCF	1.0995	1.0995	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	53	51	

Sample Recovery

	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	9.00	7.90	
Vol of blank, ml	0.25	0.25	

Worksheet Information

	SO2	SO2	
Vm	0.999	0.902	
Pbar	29.85	29.85	
Tm	513	511	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	9.0	7.9	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			4,010

Calculations

Vol std, Cf	1.0259	0.9290	
Concentration SO2, #/DSCF	6.02E-05	5.81E-05	5.92E-05
mg/DSCM	964.8	931.4	948.1
ppm	357.0	344.6	350.8
#/hr	14.49	13.99	14.24

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Round Stk	Round Stk	Round Stk	Round Stk
Time	1045-1225	1335-1450	1530-1640	1045-1640
Stack Temperature, F	124	126	128	126
Moisture Content, %	10.44	10.52	9.22	9.98
Oxygen Content, %	17.00	17.00	17.00	17.00
Carbon Dioxide Content, %	3.00	3.00	3.00	3.00
Stack Velocity, f/s	71.01	71.33	71.69	71.33
Volumetric Flow, ACFM	30,118	30,252	30,404	30,254
Volumetric Flow, DSCFM	24,256	24,258	24,651	24,404
Concentration SO2 #/CF	2.20E-05	2.68E-05	2.40E-05	2.42E-05
Concentration SO2 #/Hr	32.01	38.96	35.47	35.48
Concentration SO2 Tons/Yr	140.22	170.63	155.37	155.41

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	1-A	1-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Round	Round	Round
Time	1045-1105	1205-1225	1045-1225
Total volume sampled, cf	0.462	0.471	
Meter correction MCF	1.1259	1.1259	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	47	50	
		Sample Recovery	
	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	1.10	2.80	
Vol of blank, ml	0.25	0.25	
		Worksheet Information	
	SO2	SO2	
Vm	0.520	0.530	
Pbar	29.85	29.85	
Tm	507	510	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	1.1	2.8	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			24,256
		Calculations	
Vol std, Cf	0.5402	0.5475	
Concentration SO2, #/DSCF	1.11E-05	3.29E-05	2.20E-05
mg/DSCM	178.0	526.8	352.4
ppm	65.8	194.9	130.4
#/hr	16.17	47.86	32.01

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	2-A	2-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Round	Round	Round
Time	1335-1355	1430-1450	1335-1450
Total volume sampled, cf	0.484	0.447	
Meter correction MCF	1.1259	1.1259	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	51	52	
		Sample Recovery	
	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	2.50	2.10	
Vol of blank, ml	0.25	0.25	
		Worksheet Information	
	SO2	SO2	
Vm	0.545	0.503	
Pbar	29.85	29.85	
Tm	511	512	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	2.5	2.1	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			24,258
		Calculations	
Vol std, Cf	0.5615	0.5176	
Concentration SO2, #/DSCF	2.83E-05	2.52E-05	2.68E-05
mg/DSCM	453.2	404.3	428.8
ppm	167.7	149.6	158.6
#/hr	41.18	36.73	38.96

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Outlet SO2 Input Parameters for General Shale Products Corporation

Run Number	3-A	3-B	Average
Date	12-02-86	12-02-86	12-02-86
Location	Round	Round	Round
Time	1530-1550	1620-1640	1530-1640
Total volume sampled, cf	0.873	0.906	
Meter correction MCF	1.1259	1.1259	
Sampling Time, minutes	20.0	20.0	
Barometric Pressure, in Hg	29.85	29.85	
Sample Temperature, F	52	53	
		Sample Recovery	
	SO2	SO2	
Norm of titrant	0.0100	0.0100	
Vol of sample, ml	100.0	100.0	
Vol titrated, ml	10.0	10.0	
Vol of titrant, ml	4.80	2.65	
Vol of blank, ml	0.25	0.25	
		Worksheet Information	
	SO2	SO2	
Vm	0.983	1.020	
Pbar	29.85	29.85	
Tm	512	513	
Vsoln	100.0	100.0	
Va	10.0	10.0	
Vt	4.8	2.7	
Vtb	0.3	0.3	
N	0.0100	0.0100	
Volumetric Flow, DSCFM			24,651
		Calculations	
Vol std, Cf	1.0109	1.0470	
Concentration SO2, #/DSCF	3.18E-05	1.62E-05	2.40E-05
mg/DSCM	509.1	259.3	384.2
ppm	188.4	95.9	142.2
#/hr	47.01	23.94	35.47

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Computer Input Paramters for General Shale Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Brick Stk	Brick Stk	Brick Stk	Brick Stk
Time	1010-1015	1315-1320	1520-1525	1010-1525
Barometric Pressure, in Hg	29.85	29.85	29.85	29.85
Static Pressure, in H20	-0.030	-0.030	-0.031	-0.030
Meter Volume, CF	0.882	0.808	0.650	
Meter Correction factor, MCF	1.0995	1.0995	1.0995	
Meter Volume (Corrected)	0.970	0.888	0.715	2.573
Stack Temperature, F	159	157	155	157
Meter Temperature, F	53	53	53	53
Meter Pressure, in H20	0.00	0.00	0.00	0.00
Sqr Velocity Pressure	0.156	0.141	0.151	0.149
Mg of Water Collected	1727.5	1838.0	1875.1	5440.6
% Oxygen	17.00	17.00	17.00	17.00
% Carbon Dioxide	3.00	3.00	3.00	3.00
% Carbon Monoxide	0.00	0.00	0.00	0.00
Stack Area, Sq ft	9.375	9.375	9.375	9.375
Pitot Correction Factor	0.842	0.842	0.842	0.842

G U A R D I A N * S Y S T E M S * I N C O R P O R A T E D
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Computed Velocity Results for General Shale Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Brick Stk	Brick Stk	Brick Stk	Brick Stk
Time	1010-1015	1315-1320	1520-1525	1010-1525
1. Stack Pressure				
Inches Hg	29.85	29.85	29.85	29.85
Millimeters Hg	758.13	758.13	758.13	758.13
2. Meter Pressure				
Inches Hg	29.85	29.85	29.85	29.85
Millimeters Hg	758.19	758.19	758.19	758.19
3. Meter Volume				
Dry Std Cubic Feet	0.996	0.912	0.734	2.642
Dry Std Cubic Meters	0.028	0.026	0.021	0.075
4. Water Volume				
Std Cubic Feet	0.081	0.087	0.088	0.256
Std Cubic Meters	0.002	0.002	0.002	0.007
5. Moisture Content, %	7.55	8.66	10.74	8.84
6. Molecular Weight Dry	29.16	29.16	29.16	29.16
7. Molecular Weight Wet	28.32	28.19	27.96	28.17
8. Stack Velocity				
Feet per Second	9.60	8.69	9.32	9.20
Meters per Second	2.93	2.65	2.84	2.80
9. Volumetric Flow				
Actual Cubic Ft per minute	5,402	4,886	5,245	5,176
Actual Cubic M per second	2.55	2.31	2.48	2.44
10. Volumetric Flow				
Dry Std Cubic Ft per minute	4,250	3,810	4,010	4,028
Dry Std Cubic M per minute	2.01	1.80	1.89	1.90
12. Excess Air, %	412.62	412.62	412.62	412.62

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Computer Input Paramters for General Shale Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Round Stk	Round Stk	Round Stk	Round Stk
Time	955-1000			1010-1525
Barometric Pressure, in Hg	29.85	29.85	29.85	29.85
Static Pressure, in H2O	-1.250	-1.250	-1.260	-1.253
Meter Volume, CF	0.520	0.596	0.725	
Meter Correction factor, MCF	1.1259	1.1259	1.1259	
Meter Volume (Corrected)	0.585	0.671	0.816	2.073
Stack Temperature, F	124	126	128	126
Meter Temperature, F	47	51	53	50
Meter Pressure, in H2O	0.00	0.00	0.00	0.00
Sqr Velocity Pressure	1.179	1.182	1.189	1.183
Mg of Water Collected	1506.4	1727.9	1807.6	5041.9
% Oxygen	17.00	17.00	17.00	17.00
% Carbon Dioxide	3.00	3.00	3.00	3.00
% Carbon Monoxide	0.00	0.00	0.00	0.00
Stack Area, Sq ft	7.069	7.069	7.069	7.069
Pitot Correction Factor	0.842	0.842	0.842	0.842

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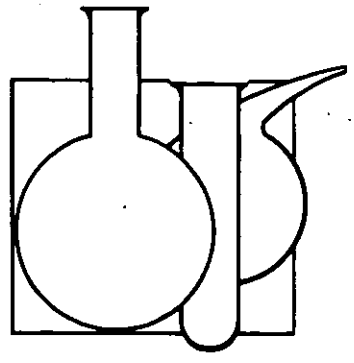
Computed Velocity Results for General Shale Corporation

Run Number	1	2	3	Average
Date	12-02-86	12-02-86	12-02-86	12-02-86
Location	Round Stk	Round Stk	Round Stk	Round Stk
Time	955-1000			1010-1525
1. Stack Pressure				
Inches Hg	29.76	29.76	29.76	29.76
Millimeters Hg	755.86	755.86	755.84	755.85
2. Meter Pressure				
Inches Hg	29.85	29.85	29.85	29.85
Millimeters Hg	758.19	758.19	758.19	758.19
3. Meter Volume				
Dry Std Cubic Feet	0.608	0.692	0.838	2.140
Dry Std Cubic Meters	0.017	0.020	0.024	0.061
4. Water Volume				
Std Cubic Feet	0.071	0.081	0.085	0.237
Std Cubic Meters	0.002	0.002	0.002	0.007
5. Moisture Content, %	10.44	10.52	9.22	9.98
6. Molecular Weight Dry	29.16	29.16	29.16	29.16
7. Molecular Weight Wet	27.99	27.99	28.13	28.05
8. Stack Velocity				
Feet per Second	71.01	71.33	71.69	71.33
Meters per Second	21.65	21.74	21.85	21.74
9. Volumetric Flow				
Actual Cubic Ft per minute	30,118	30,252	30,404	30,254
Actual Cubic M per second	14.22	14.28	14.35	14.28
10. Volumetric Flow				
Dry Std Cubic Ft per minute	24,256	24,258	24,651	24,404
Dry Std Cubic M per minute	11.45	11.45	11.64	11.52
12. Excess Air, %	412.62	412.62	412.62	412.62

Sampling & Analytical Procedures



III. SAMPLING AND ANALYTICAL PROCEDURES

General

All sampling and analytical procedures for the determination of Sulfur Dioxide Emission rates were conducted in strict adherence with the Code of Federal Regulations, Title 40, Section 60, Methods 1-4, and 6, as amended. The equipment used in this test series was calibrated before and after these tests (See Calibrations). All samples were taken as close as possible to the centroid of each duct. The velocity was determined before each series of sulfur dioxide tests. The sulfur dioxide concentration was determined for each test by extracting a gas sample from the stack. The sulfuric acid mist (including sulfur trioxide) and sulfur dioxide were separated, and the sulfur dioxide fraction was measured by barium-thorin titration method.

METHOD 1

This method was used to determine the number of sampling points and the required matrix for velocity determination. The dimensions of the stacks (see **Figures 1 & 2**) indicated that 16 points would be required for the velocity traverses on both stacks. We measured 20 points (4 x 5 matrix) on the brick stack and 16 points (8 per diameter) on the round stack. Verification of absence of cyclonic flow was not determined because cyclonic flow did not seem to exist from either stack exhaust.

METHOD 2

Velocity measurements were taken using a S type pitot tube and 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.* To measure the low flow on the brick stack a micromanometer, having 0.001 in. H_20 divisions on the 0 to 0.25 inclined scale, was used.

METHOD 3

Gas analysis for CO_2, O_2, and N_2 by difference was performed by using the grab sample technique once during each velocity test and analyzed with a Fyrite Gas Analyzer (0-20% scale with 0.5% divisions).

METHOD 4

Moisture content of the stack gases was determined during the velocity measurement for each test by weighing the increase in weight of the silica gel.

METHOD 6

Sampling Techniques

The SO_2 determinations were made by utilizing the sample train in **Figure 3.** Initial and final leak checks of the sampling system as outlined in Method 6 were performed and recorded on the data sheets **(See Field Data).** The sampling probe was placed at the sampling point and the sample was taken for 20 minutes at approximately 1.0 liter/minute.

The stack gases were drawn through a heated probe to prevent condensation which contained a glass wool plug to remove particulate matter. The gases were then scrubbed through a series of midget impingers placed in an ice bath to maintain a maximum exit temperature of 68^0F. This temperature was also recorded on the data sheets. The scrubbed gases then entered a silica gel tube to remove moisture. The clean gases then passed through the dry gas meter where the gas flow and temperature were measured.

The first impinger, with glass wool in the top to prevent carry over, contained approximately 15 ml of 80% IPA (for SO_3 removal), the second and third approximately 15 ml of a 3% hydrogen peroxide solution and the fourth blank. For the first three determinations a fifth impinger was added to prove the collection efficiency of the sampling train and contained approximately 15 ml of a 3% hydrogen peroxide solution.

After the sampling was complete, the system was purged by drawing ambient air through the system for fifteen minutes at the average flow rate used for sampling. The cleanup data was recorded on **Method 8 Sample Recovery and Integrity Data** and is located in the Field Data Section of this report. The collection system was transported to the field lab where the contents of the second and third impingers were combined with the rinsing of the connecting glassware and the fourth impinger and place in a clearly marked 100 ml volumetric flask. The contents of the first impinger was discarded. The contents of the fifth impinger (for the first three tests only) and the rinsing of the connecting glassware was placed in a clearly marked 100 ml volumetric flask for analysis.

Analysis

All titrations were performed on jobsite. The Barium Perchlorate was initially standarized in our laborabory in Birmingham. The titer used for this test was again standarized against 0.0200N Sulfuric Acid and the normality was determined to be 0.0100N. A blank was determined for the hydrogen peroxide.

Each container was brought to 100 ml volume and 10 ml was titrated for SO_2 content using the Barium Perchlorate titrant until duplicate titrations agreed within 0.1 ml. For runs 1A, 1B, and 2A, the back half or fifth impinger was titrated to determine the collection efficiency of the sampling train. No SO_2 was found in any of these, indicating a 100% collection efficiency for the sampling train. This data is recorded on the **Sulfur Dioxide Analytical Data.** Additionally one EPA known standard from Lot # 585, and two(2) unknown EPA stardards were prepared and titrated with the following results:

Sample Number	Measured Concentration	Actual Concentration	Relative Error	Type
9405	213.5 mg/DSCM	221.2 mg/DSCM	-3.61%	Known
3430	1632 mg/DSCM	1630 mg/DSCM	-0.12%	Unknown
1363	2456 mg/DSCM	2430 mg/DSCM	-1.07%	Unknown

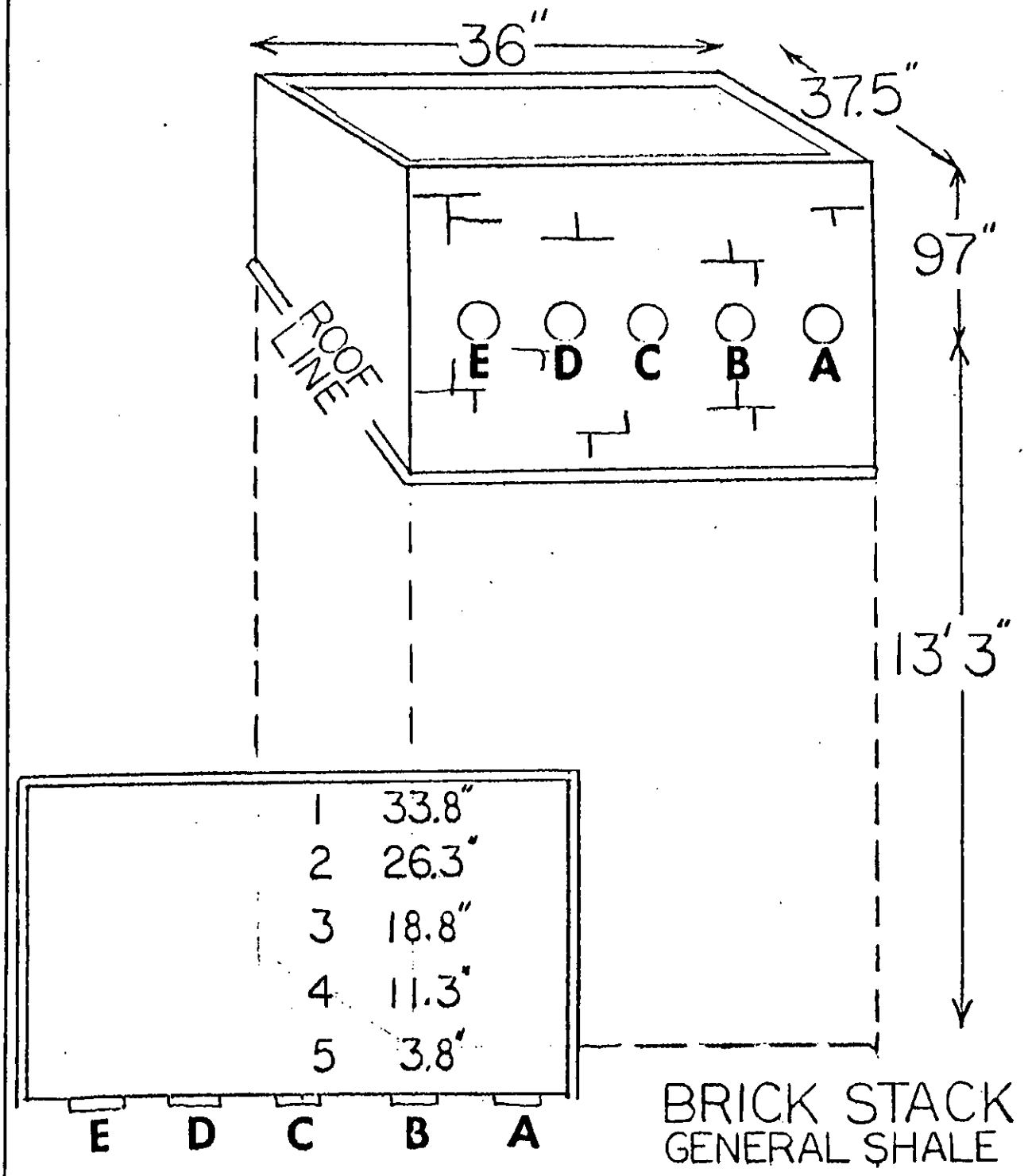
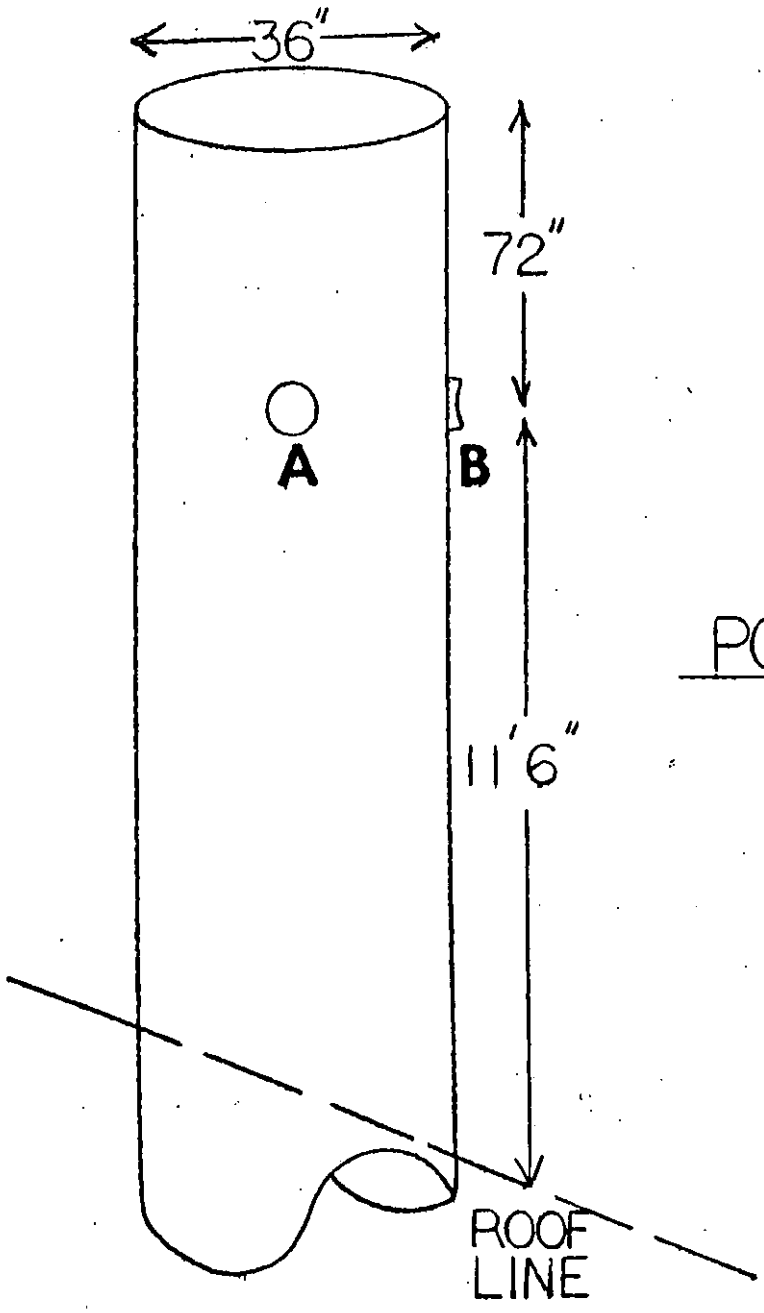
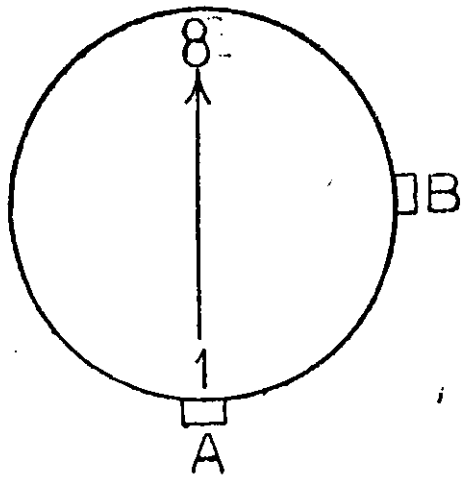

36"
37.5"
97"
ROOF LINE
E
D
C
B
A
13' 3"
1 33.8"
2 26.3"
3 18.8"
4 11.3"
5 3.8"
E D C B A
BRICK STACK
GENERAL SHALE

Figure 1

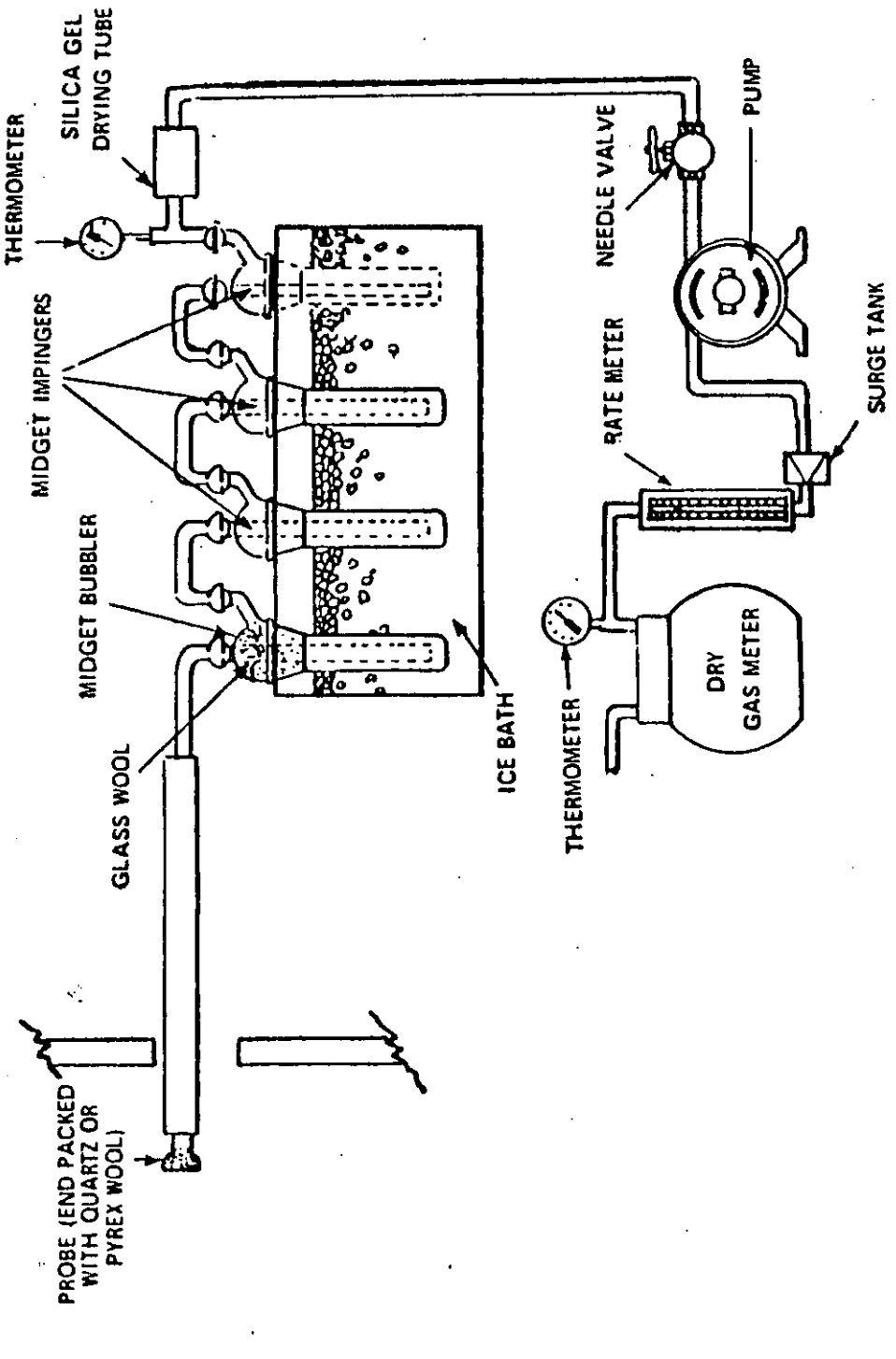




POINTS	DISTANCE
1	1.2"
2	3.8"
3	7.0"
4	11.6"
5	24.4"
6	29.0"
7	32.2"
8	34.8"

ROUND STACK
GENERAL SHALE

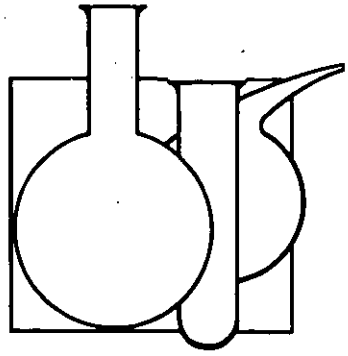
Figure 2



Method 6 Sampling Train

Figure 3

Field Data



NOMENCLATURE FOR SO_2

C_{so2} = Concentration of sulfur dioxide, dry basis corrected to standard conditions, mg/dscm (lb/dscf)

C_{ppm} = Concentration of sulfur dioxide, dry std. conditions, ppm

N = Normality of barium perchlorate titrant, milliequivalents/ml

P_{bar} = Barometric pressure at the exit orifice of the dry gas meter, mm Hg (in. Hg).

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

T_m = Average dry gas meter absolute temperature, °K (°R).

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

V_a = Volume of sample aliquot titrated, ml.

V_m = Dry gas volume measured by the dry gas meter, dcm (dcf)

$V_{m(std)}$ =Sample volume at standard conditions (dry basis), ml.

V_{soln} = Total volume in which the sulfur dioxide sample is contained, 100ml.

V_t = Volume of barium perchlorate titrant used for the sample, ml. (average or replicate titrations)

V_{tb} = Volume of barium perchlorate titrant used for the blank, ml.

Y = Dry gas meter calibration factor

32.03 = Equivalent weight of sulfur dioxide

EQUATIONS FOR SO_2

$$V_{m(std)} = V_m \times Y \times (T_{std}/T_m) \times (P_{bar}/P_{std})$$
$$= K_1 \times Y \times (V_m) \times (P_{bar}/T_m)$$

$$C_{so2} = K_2 \times (V_t - V_{tb}) \times (N) \times (V_{soln}/V_a) / (V_{m(std)})$$

If C_{so2} is in Metric units then:

$$C_{ppm} = C_{so2} \times 0.37$$

Where: $K_1 = 17.64 \quad \frac{^\circ R}{\text{in Hg}}$ for English units

$K_2 = 7.061 \times 10^{-5}$ lb/meq. for English units

PLANT NAME General Shale — CITY Mooresville

SAMPLE LOCATION Brick Stack — DATE 12/2/86

OPERATOR Turner — SAMPLE NO. Run 1-6

BAROMETRIC PRESSURE mm Hg (in Hg) 29.85 — PROBE LENGTH m(ft) 2'

PROBE MATERIAL glass — PROBE HEATER SETTING @ 40%

METER BOX NO. #2 714045 — METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 45° — SAMPLE POINT LOCATION Port C for Run 1-6

INITIAL LEAK CHECK < 20 cc/min for Run #1, #2, #3 — SAMPLE PURGED (min) 15 min/charcoal for Run 1-6

FINAL LEAK CHECK < 20 cc/min for Run #1, #2, #3 — REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vml (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
Run #1	20 min 1050		1 lpm	785.800 - 786.421		46, 46, 47, 47, 47	46, 46, 47, 47, 47
Run #2	20 min 1215		1 lpm	787.684 - 788.309		51, 51, 51, 51, 51	52, 52, 52, 52, 52
Run #3	20 min 1337		1 lpm	788.605 - 789.238		52, 52, 52, 53, 53	51, 53, 54, 53, 53
Run #4	20 min 1433		1 lpm	790.237 - 790.865		54, 54, 54, 54, 54	54, 54, 54, 54, 54
Run #5	20 min 1530		1.5 lpm	791.012 - 791.721		53, 53, 54, 53, 53	55, 55, 55, 54, 53
Run #6	20 min 1620		1.5 lpm	792.905 - 793.725		51, 51, 51, 51	50, 50, 50, 50
Total		Total		ΔVm avg.	Max. Dev.	Avg.	Max. Temp.

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$

Run #1	Run #2	Run #3
786.104	787.850	788.765
786.221	788.025	788,920
786.310	788,160	789.100
Run #4	**Run #5**	**Run #6**
790.390	791.200	793.140
790.600	791.540	793.350
790.749	791.700	793.520

#5 moisture 786.795 — 1 lpm — 26 min
Finish 787.677

#2 moisture 789.395 — 1 lpm — 25 min
790,203

Field sampling data sheet

#4 moisture 792.215 — 1.5 lpm — 15 min
792.865

GUARDIAN SYSTEMS INC

PLANT NAME: LG&N SHALE — CITY: MOORESVILLE IND

SAMPLE LOCATION: ROUND STACK — DATE: 12-2-86

OPERATOR: KARSTENS — SAMPLE NO.: #1A

BAROMETRIC PRESSURE mm Hg (in Hg): 29.85 — PROBE LENGTH m(ft): 3'

PROBE MATERIAL: GLASS — PROBE HEATER SETTING: 40%

METER BOX NO.: 4 — METER CALIBRATION FACTOR (Y):

AMBIENT TEMP. °C: 40° — SAMPLE POINT LOCATION: "A" SIDE

INITIAL LEAK CHECK: ✓ at 10" — SAMPLE PURGED (min): 15 MINUTES

FINAL LEAK CHECK: ✓ at 10" — REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vmi (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20 ~~18~~	1045-1105		1 LPM	~~96.280~~ 96.004		47 F	47 F
0 ~~20~~ 18			1 LPM	~~96.112~~		47	46
5 ~~18~~			"	96.112 ~~96.210~~		47	46
10 ~~28~~			"	96.216		48	46
15			"	96.312		47	46
20			"	96.424		48	46
				.420			
Total		Total		Δ Vm avg.	Max. Dev.	Avg.	Max. Temp.
				1.9493		47	
				.462			

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$

Gcl. #3 @ 1LPM

22 MIN START 96.565

FINISH 97.085

Field sampling data sheet

GUARDIAN SYSTEMS INC

PLANT NAME GEN SHALE CITY MOORESVILLE IND

SAMPLE LOCATION ROUND STACK DATE 12-2-86

OPERATOR KARSTENS SAMPLE NO. #1 B

BAROMETRIC PRESSURE mm Hg (in Hg) 29.85 PROBE LENGTH m(ft) 3

PROBE MATERIAL GLASS PROBE HEATER SETTING 40%

METER BOX NO. #4 METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 42° SAMPLE POINT LOCATION POINT A

INITIAL LEAK CHECK GOOD AT 10" SAMPLE PURGED (min) 15MIN

FINAL LEAK CHECK REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vml (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20MIN	1205-1225		1 LPM				
0			"	97.173		50	47
5			"	97.245		50	47
10			"	97.394		50	48
15			"	97.508		49	47
20			"	97.601		49	47
				.428			
Total		Total		Δ Vm avg.	Max. Dev.	Avg.	Max. Temp.
				.471		50	

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$

Field sampling data sheet

GUARDIAN SYSTEMS inc

PLANT NAME GEN SHALE CITY MOORESVILLE, IND

SAMPLE LOCATION ROUND STACK DATE 12-2-86

OPERATOR KIARSTENS SAMPLE NO. 2A

BAROMETRIC PRESSURE mm Hg (in Hg) 29.85 PROBE LENGTH m(ft) 3'

PROBE MATERIAL GLASS PROBE HEATER SETTING 450

METER BOX NO. 4 METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 44° SAMPLE POINT LOCATION PORT "A"

INITIAL LEAK CHECK GOOD AT 10" SAMPLE PURGED (min) 15 MIN

FINAL LEAK CHECK REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vml (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20 MIN	1335-1355		1 LPM				
0	|		"	98.045		51	50
5	|		"	98.160		50	49
10	|		"	98.278		50	50
15	|		"	98.395		51	49
20	+		"	98.485		52	49
Total		Total		ΔVm avg.	Max. Dev.	Avg.	Max. Temp.
				.440		51	

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$ .484

GCL # 6 ON TUBE
3 ON TUBING

TIME 25 MIN START 98.636
FINISH 99.232

Field sampling data sheet

GUARDIAN SYSTEMS INC

PLANT NAME GEN SHALE CITY MORGANVILLE IND

SAMPLE LOCATION ROUND STACK DATE 12-2-86

OPERATOR KARUNS SAMPLE NO. 2B

BAROMETRIC PRESSURE mm Hg (in Hg) 29.85 PROBE LENGTH m(ft) 3'

PROBE MATERIAL CLASS PROBE HEATER SETTING 40%

METER BOX NO. 4 METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 4.4° SAMPLE POINT LOCATION PORT "A"

INITIAL LEAK CHECK GOOD AT 10" SAMPLE PURGED (min) 15 MIN

FINAL LEAK CHECK REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vml (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20	1430-1450						
0			1 LPM	99.245		53	51
5			"	99.321		52	50
10			"	99.462		53	49
15			"	99.572		52	49
20			"	99.692		52	49
Total		Total		ΔVm avg.	Max. Dev.	Avg.	Max. Temp.
				.447		52	

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$ .997 / .491

Field sampling data sheet

GUARDIAN SYSTEMS INC

PLANT NAME GEN SHALE CITY MOORESVILLE IND

SAMPLE LOCATION ROUND STACK DATE 12-2-86

OPERATOR KITTENS SAMPLE NO. 3A

BAROMETRIC PRESSURE mm Hg (in Hg) 29.85 PROBE LENGTH m(ft) 3'

PROBE MATERIAL GLASS PROBE HEATER SETTING 40%

METER BOX NO. 4 METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 46° SAMPLE POINT LOCATION PORT "A"

INITIAL LEAK CHECK 6000 AT 10" SAMPLE PURGED (min) 15 MIN

FINAL LEAK CHECK REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vml (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20 MIN	1530-1550		1.5 LPM	99.793		54	54
0	"		"	100.042		52	52
5	"		"	100.221		52	46
10	"		"	100.425		52	49
15	"		"			52	49
20	⊥		"	100.666			
Total		Total		ΔVm avg.	Max. Dev.	Avg.	Max. Temp.
				.873		52	

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$

Field sampling data sheet

GUARDIAN SYSTEMS INC

PLANT NAME EGN SHALE — CITY MORGANSVILLE IND

SAMPLE LOCATION ROUND STACK — DATE 12-2-86

OPERATOR KARSTENS — SAMPLE NO. 3B

BAROMETRIC PRESSURE mm Hg (in Hg) 29.95 — PROBE LENGTH m(ft) 3'

PROBE MATERIAL GLASS — PROBE HEATER SETTING 40%

METER BOX NO. 4 — METER CALIBRATION FACTOR (Y)

AMBIENT TEMP. °C 48° — SAMPLE POINT LOCATION POINT "A"

INITIAL LEAK CHECK GOOD @ 10" — SAMPLE PURGED (min) 15 MIN

FINAL LEAK CHECK — REMARKS:

Sampling Time (min)	Clock Time (24 hr)	Sample Volume l(ft³)	Sample flow rate setting lpm (cfm)	Sample volume metered Δ Vmi (ft³)	Percent Deviation % (±)	Dry gas meter temp. °C (°F)	Impinger temperature °C (°F)
20 MIN	1620-1640		1.5 LPM	103,050			
0				~~101.573~~		53	51
5			"	~~101.~~		52	50
10			"	103.479		53	50
15			"	103.702		53	50
20	—		"	103.956		55	50
Total		Total		ΔVm avg.	Max. Dev.	Avg.	Max. Temp.
						53	

±) Percent deviation (%) = $\left| \frac{\Delta V_m - \Delta V_m \text{ avg.}}{\Delta V_m \text{ avg.}} \right| \times 100$

Gel # 1 (ON column)

TIME 16 MIN — START 100.862 — FINISH

Field sampling data sheet

GUARDIAN SYSTEMS INC

METHOD 6

SULFUR DIOXIDE ANALYTICAL DATA

PLANT Canal Shale DATE 12-2-86

SAMPLE LOCATION AS Meter ANALYST Tom Lotz

NORMALITY OF BARIUM PERCHLORATE

1 20.2 ml .0095 N

2 20.1 ml .0100 N .0100 N

3 20.1 ml .0100 N

Run No.	Sample No.	Total Volume of Sample	Sample Aliquot	Volume of Titrant V_t, ml		
				1st Titration	2nd Titration	Average
NA	SA 9405	100	10	1.6	1.7	1.65
NA	A02864	100	10	5.5	5.4	5.45
NA	A-23604	100	10	5.4	5.5	5.45
NA	A03430	100	10	10.9	11.0	10.95
IA	IA Back Front	100	10	7.4	7.4	7.4
IA	IA Back Back	100	10	.25	.20	.225

1630

Blank Analysis - Volume of titrant 1st titration .20

2nd titration .30

Average .25

1st titration / 2nd titration = 0.99 to 1.01 or 1st titration - 2nd titration = 0.2 ml

Signature of Analyst Tom Lotz

Signature of Reviewer or Supervisor

METHOD 6

SULFUR DIOXIDE ANALYTICAL DATA

PLANT Coal Shale DATE 12-2-86

SAMPLE LOCATION Control ANALYST Tom Lott

NORMALITY OF BARIUM PERCHLORATE

1 20.2 ml .0099 N
2 20.1 ml .0100 N .0100 N
3 20.1 ml .0100 N

Run No.	Sample No.	Total Volume of Sample	Sample Aliquot	Volume of Titrant V_t, ml		
				1st Titration	2nd Titration	Average
1A	Rail Back	100	10	0.1	0.1	0.1
1A	Rail Front	100	10	1.1	1.1	1.1
N/A	FA A01363	100	10	16.35	16.35	16.35
1B/A	Rail Front	100	10	2.8	2.8	2.8
1B	Rail Back	100	10	0.1	0.1	0.1
1B	Rail Back	100	10	0.3	0.2	0.25

2-30

Blank Analysis - Volume of titrant 1st titration .20
2nd titration .30
Average .25

1st titration / 2nd titration = 0.99 to 1.01 or 1st titration - 2nd titration = 0.2 ml

Signature of Analyst Tom Lott

Signature of Reviewer or Supervisor

METHOD 6

SULFUR DIOXIDE ANALYTICAL DATA

PLANT Coal Fired DATE 12-2-86

SAMPLE LOCATION Acid ANALYST Tom Lotz

NORMALITY OF BARIUM PERCHLORATE

1 20.2 ml .0099 N

2 20.1 ml .0100 N .0100 N

3 20.1 ml .0100 N

Run No.	Sample No.	Total Volume of Sample	Sample Aliquot	Volume of Titrant V_t, ml		
				1st Titration	2nd Titration	Average
1B	BRICK FRONT	100	10	6.9	6.8	6.85
2A	Rand Front	100	10	2.5	2.5	2.5
2A	Rand Back	100	10	0.2	0.2	0.2
2A	Brick Back	100	10	0.2	0.2	0.2
2A	Brick Front	100	10	6.4	6.35	6.38
2B	Brick Rand Spike	100	10	6.45	6.35	6.4

Blank Analysis - Volume of titrant 1st titration .2

2nd titration .3

Average .25

1st titration / 2nd titration = 0.99 to 1.01 or 1st titration - 2nd titration = 0.2 ml

Signature of Analyst Tom Lotz

Signature of Reviewer or Supervisor

METHOD 6

SULFUR DIOXIDE ANALYTICAL DATA

PLANT Coal Stack DATE 12-1-80

SAMPLE LOCATION Boiler ANALYST Ian Lott

NORMALITY OF BARIUM PERCHLORATE

1 20.2 ml .0099 N

2 20.1 ml 0.100 N .0101 N

3 20.1 ml 0.100 N

Run No.	Sample No.	Total Volume of Sample	Sample Aliquot	Volume of Titrant V_t, ml		
				1st Titration	2nd Titration	Average
2A	Coal Stack	100	10	2.1	2.1	2.1
3A	Coal Stack	100	10	4.5	4.8	4.8
3A	Coal Stack	100	10	9.0	9.0	9.0
3B	Coal Stack	100	10	2.6	2.7	2.65
3B	Coal Stack	100	10	7.5	7.5	7.5

Blank Analysis - Volume of titrant 1st titration 0.2

2nd titration 0.3

Average 0.25

1st titration / 2nd titration = 0.99 to 1.01 or 1st titration - 2nd titration = 0.2 ml

Signature of Analyst Ian Lott

Signature of Reviewer or Supervisor

NOMENCLATURE

ACF - Actual Cubic Feet

ACFM - Actual Cubic Feet per minute

ACM - Actual Cubic Meters

ACMS - Actual Cubic Meters per second

An - Cross sectional area of nozzle, (ft^2)

As - Area of Stack, (ft^2)

Bws - Water vapor in the gas stream, proportion by volume (dimensionless)

Ca - Acetone blank residue concentration, mg/g

c_a - Particulate Concentration, ACF

CFM - Cubic feet per minute

Cp - Pitot tube coefficient, (dimensionless)

c_s - Particulate Concentration, grains/DSCF

Cso_2 - Concentration of sulfur dioxide (dry basis) corrected to standard conditions, lb/DSCF

C_{12} - Particulate concentration (c_s adjusted to 12% excess air), grains/DSCF

C_{50} - Particulate concentration (c_s adjusted to 50% excess air), grains/DSCF

DSCF - Dry Standard Cubic Feet

DSCFM - Dry Standard Cubic Feet per minute

DSCM - Dry Standard Cubic Meters

DSCMS - Dry Standard Cubic Meters per second

EA - Excess Air, %

I - Isokinetic Sampling, %

Km - Orifice Correction Factor, (dimensionless)

Kp - Pitot tube constant, 85.49 $\left[\frac{(lb/lb\text{-}mole)(in.\ Hg)}{(^{o}R)\ (in.\ H_2O)}\right]$ 1/2

La - Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.02 CFM or 4 percent of the average sampling rate, whichever is less.

Li - Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change ($i = 1,2,3,...n$), CFM.

Lp - Leakage rate observed during the post test leak check, $ft^3/min.$ (cfm).

Ma - Mass of residue of acetone after evaporation, mg.

Md - Molecular weight of stack gas; dry basis, lb/lb-mole.

Mn - Total amount of particulate matter collected, mg.

Ms - Molecular weight of stack gas; wet basis, lb/lb-mole.

Mw - Molecular weight of water, 18.0 g/g-mole (18.01 lb/lb-mole)

ΔP - Velocity head of stack gas, in. H_2O

Pa - Density of acetone, mg/ml

Pbar - Barometric pressure at the sampling site, in. Hg

Pg - Stack static pressure, in. H_2O

Pm - Meter pressure, in. Hg

PMR - Particulate Mass Rate, lbs per hour

Ps - Absolute stack pressure, in. Hg

Pstd - Standard absolute pressure, 29.92 in. Hg

Pw - Density of water, 0.9982 g/ml (0.002201 lb/ml)

Qa - Volumetric flow rate, ACFM

Qs - Volumetric flow rate, DSCFM

R - Ideal gas constant, 0.06236 mm Hg - $m^3/^oK$-g-mole (21.85 in. Hg-$ft^3/^oR$-lb-mole)

SCF - Standard Cubic Foot

ta - Ambient Temperature, ^oF

tm - Average Temperature of meter, ^oF

t_s - Average Temperature of stack, ^oF

tstd - Standard Temperature, $68^{\circ}F$

NOTE: Capital "T" denotes degrees Rankin

Va - Volume of acetone blank, ml

Vaw - Volume of acetone used in wash, ml

Vlc - Total volume of liquid collected in condenser and silica gel, ml

Vm - Volume of gas sample, as measured by the dry gas meter, ACF

Vmc - Volume of gas sample, corrected for leak, ACF

Vm(std) - Volume of gas sample measured by the dry gas meter, corrected to standard conditions, DSCF

Vn - Volume collected at stack conditions through nozzle, ACF

Vs - Average stack gas velocity, ft/sec.

Vw(std) - Volume of water in the gas sample, corrected to standard conditions, SCF

Wa - Weight of residue in acetone wash, mg

Y - Dry gas meter calibration factor, (dimensionless)

ΔH - Average pressure differential across the calibrated orifice, in. H_2O

ΔH_a - Value of ΔH measured for a specific orifice when operated under the following conditions: 0.75 cfm of dry air (M.W. = 29) at $68^{\circ}F$, 29.92 in. Hg.

$\sqrt{\Delta P}$ - Average of the square roots of the velocity pressure, in. H_2O

Θ - Total sampling time, min.

Θ_1 - Sampling time interval from the beginning of a run until the first component change, min.

Θ_i - Sampling time interval between two successive component changes, beginning with the interval between the first and second changes, min.

Θp - Sampling time interval from the final (n^{th}) component change until the end of the sampling run, min.

$\%CO_2$, $\%O_2$, $\%N_2$, %CO - Number percent (%) by volume (dry basis) of each compound in the stack gas.

EQUATIONS

1. $$P_s = P_{bar} + \frac{P_g}{13.6}$$

2. $$P_m = P_{bar} + \frac{\overline{\Delta H}}{13.6}$$

3. $$V_{m(std)} = V_m Y \left(\frac{Tstd}{Tm}\right) \left[\frac{Pbar + \frac{\overline{\Delta H}}{13.6}}{Pstd}\right]$$

4. $$V_{w(std)} = 0.04707\ V_{lc}$$

5. $$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

6. $$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

7. $$M_s = M_d\ (1 - B_{ws}) + 18(B_{ws})$$

8. $$v_s = K_p C_p\ (\sqrt{\Delta p})\ \text{avg.} \sqrt{\frac{T_s}{M_s P_s}}$$

9. $$Q_a = (v_s)\ (A_s)\ (60)$$

10. $$Q_s = Q_a\ (1 - B_{ws}) \left(\frac{528}{T_s}\right) \left(\frac{P_s}{29.92}\right)$$

11. $$c_s = \left[0.0154\ (Mn/Vmstd)\right]$$

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

13. $$c_{50} = \frac{c_s}{1 - \left[\frac{(1.5)(\%O_2) - 0.133(\%N_2) - 0.75\ (\%CO)}{21}\right]}$$

14. $$c_{12} = c_s \frac{12}{\%\ CO_2}$$

15. $$PMR = (c_s)(Q_s)\left(\frac{60}{7000}\right)$$

16. $$V_n = \frac{T_s}{P_s}\left[(0.002669)(V_{1c}) + \frac{V_m}{T_m}\left(P_{bar} + \frac{\overline{\Delta H}}{13.6}\right)\right]$$

17. $$C_a = (0.0154)(M_n)\ /V_n$$

18. $$I = \frac{100\ V_n}{60\ \Theta\ v_s\ An}$$

19. $$V_{mc} = V_m - (L_p - L_a)\ \Theta$$

20. $$W_a = Ca\ Vaw\ p_a$$

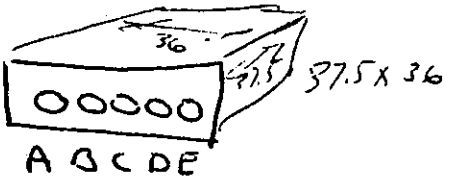
GUARDIAN SYSTEMS INC.
2810 18th Street South
Birmingham, Alabama 35209
205/870-1880

PRELIMINARY VELOCITY TRAVERSE

83

PLANT GEN SHALE
DATE 12-2-86
LOCATION SQUARE STACK (#1 RUN)
STACK I.D.
BAROMETRIC PRESSURE, in. Hg 29.85
STACK PRESSURE, in. H_2O -
PERCENT O_2 17
PERCENT CO_2 3
PITOT CORRECTION FACTOR .84
OPERATORS KARSTENS. FRANKE

-.030 static



SCHEMATIC OF TRAVERSE POINT LAYOUT

1010 - 1015 #1

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A 1	.013	151
2	.015	157
3	.020	158
4	.022	154
B 1	.022	154
2	.021	156
3	.021	157
4	.022	159
C 1	.025	161
2	.025	161
3	.022	162
4	.025	160
D 1	.025	157
2	.024	160
3	.024	161
4	.040	162
E 1	.024	160
2	.023	161
3	.030	161
4	.060	161
AVERAGE	.156	159

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
Vel	9.54	
Acfm	5365	
Dscfm	4338	
AVERAGE		

GUARDIAN SYSTEMS INC.

2810 18th Street South
Birmingham, Alabama
205/870-1

PRELIMINARY VELOCITY TRAVERSE

PLANT General Shale

DATE 12/2/86

LOCATION Brick

STACK I.D. _____

BAROMETRIC PRESSURE, in. Hg 29.85

STACK PRESSURE, in. H_2O static -.030

PERCENT O_2 17

PERCENT CO_2 3

PITOT CORRECTION FACTOR .84

OPERATORS Turner

1315 - 1320

O O O O O
A B C D E

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A 1	.014	152
2	.015	155
3	.020	157
4	.020	158
B 1	.015	152
2	.017	153
3	.016	152
4	.019	153
C 1	.015	150
2	.015	150
3	.017	155
4	.024	159
D 1	.017	155
2	.018	160
3	.021	161
4	.030	166
E 1	.017	160
2	.017	162
3	.030	166
4	.050	167
AVERAGE	.191 ✓	157 ✓

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
8.61		
4.841		
3927		
AVERAGE		

GUARDIAN SYSTEMS INC.

8870 1 8th Street South
Birmingham, Alabama 35209
205/879-1660

PRELIMINARY VELOCITY TRAVERSE

#3

1520-1525

PLANT General Shale

DATE 12/2

LOCATION Brick

STACK I.D.

BAROMETRIC PRESSURE, in. Hg 29.85

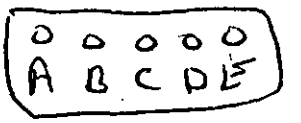
STACK PRESSURE, in. H_2O -.31

PERCENT O_2 17

PERCENT CO_2 3

PITOT CORRECTION FACTOR .84

OPERATORS Turner



SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A 1	.017	146
2	.015	150
3	.017	152
4	.019	154
B 1	.020	150
2	.020	152
3	.020	154
4	.020	155
C 1	.016	152
2	.017	154
3	.019	156
4	.021	159
D 1	.022	156
2	.020	160
3	.025	162
4	.040	160
E 1	.024	160
2	.021	162
3	.031	162
4	.061	163
AVERAGE	.151 ✓	155 ✓

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
9.20		
5176		
4212		
AVERAGE		

GUARDIAN SYSTEMS INC.

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Birmingham, Alabama 35209
205/879-1850

PRELIMINARY VELOCITY TRAVERSE

PLANT GEN SHALE

DATE 12-2-86

LOCATION ROUND STACK

STACK I.D.

BAROMETRIC PRESSURE, in. Hg 29.85

STACK PRESSURE, in. H_2O -1.25

PERCENT O_2 17

PERCENT CO_2 3

PITOT CORRECTION FACTOR .84

OPERATORS KARSTENS-TURNER

1055-1000

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A		
1	1.50	124
2	1.50	124
3	1.40	124
4	1.38	124
5	1.40	124
6	1.42	124
7	1.35	124
8	.92	124
B1	1.55	124
2	1.48	124
3	1.40	124
4	1.36	124
5	1.35	124
6	1.40	124
7	1.49	124
8	1.41	124
	SPARE	
AVERAGE	1.179	124

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
70.12		
25,740		
25,410		
AVERAGE		

GUARDIAN SYSTEMS INC.
2810 18th Street South
Birmingham, Alabama 35209
205/879-1850

PRELIMINARY VELOCITY TRAVERSE

PLANT EEN STATE
DATE 12-2-86
LOCATION ROUND STACK
STACK I.D.
BAROMETRIC PRESSURE, in. Hg 29.85
STACK PRESSURE, in. H_2O -1.25
PERCENT O_2 17
PERCENT CO_2 3
PITOT CORRECTION FACTOR .84
OPERATORS KARSTENS/TURNER

RUN #2

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A1	1.52	125
2	1.50	125
3	1.45	126
4	1.40	126
5	1.33	126
6	1.35	127
7	1.32	127
8	1.21	127
B1	1.42	125
2	1.50	125
3	1.42	126
4	1.38	126
5	1.32	127
6	1.41	127
7	1.47	127
8	1.36	127
AVERAGE	1.382	126

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
70.42		
29F67		
25431		
AVERAGE		

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Birmingham, Alabama 35209
205/879-1850

PRELIMINARY VELOCITY TRAVERSE

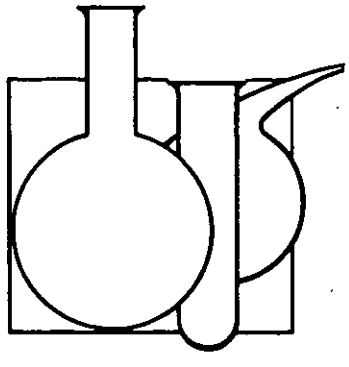
PLANT GEN STEEL
DATE 12-2-86
LOCATION ROUND STACK
STACK I.D. #3
BAROMETRIC PRESSURE, in. Hg 29.85
STACK PRESSURE, in. H_2O -1.26
PERCENT O_2 17
PERCENT CO_2 3
PITOT CORRECTION FACTOR .84
OPERATORS KARLTON / JUENGEL

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), F
A1	1.45	128
2	1.48	129
3	1.50	129
4	1.45	129
5	1.38	129
6	1.39	129
7	1.41	129
8	1.15	129
B1	1.55	127
2	1.52	128
3	1.47	128
4	1.41	128
5	1.30	129
6	1.32	129
7	1.42	128
8	1.44	127
AVERAGE	1.189	128

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
70.96		
30.96		
25.58		
AVERAGE		

Plant Operation Data



PROCESS INFORMATION

PLANT: 20, Mooresville, IN DATE: December 2, 1986

Brick Rate:

Car Schedule	=	34	Minutes =	1.765	Cars/Hour
Car Count	=	3,968	S/S Brick/Car		
Hourly Rate	=	7,002	S/S Brick/Hour		
Brick Weight	=	4.8	Lbs.		
Brick Rate	=	33,611	Lbs./Hour		

Fuel Rate:

Total	=	26.2	Therms/M Brick		
Coal	=	15.61	Tons/Day		
		1,301	Lbs./Hour =	100	% of Btu's
Natural Gas	=	-0-	MCF/Day		
			Cu. Ft./Hour =		% of Btu's

Total Process Weight:

	33,611	Lbs. Brick/Hour
+	1,301	Lbs. Coal/Hour
	34,912	Total Lbs./Hour
	17.46	Tons/Hour

Coal Analysis:

		Avg., Previous 12 Months:
(Report Attached)	Btu/Lb.	14,145
	Sulfur	0.97
	Ash	3.68

Allowable Emissions:

GUARDIAN SYSTEMS, INC.

305 Ashville Road
P.O. Box 300
Leeds, Alabama 35094
205/699-6647

December 10, 1986

Customer: General Shale Products Corp.
P.O. Box 3547 C.R.S.
Johnson City, TN 37601

Control number: 63860

Report to: Mr. David McNees

Sample date: 12/04/86

Sample Mark: Coal Analysis

Sample Number:

LABORATORY REPORT

Parameter	Units		Results
	As Received	Dry Basis	
Moisture, %	4.17		
Ash, %	3.21	3.35	
Sulfur, %	1.00	1.05	
Btu	12,774	13,330	
MAF, Btu		13,792	

Method Reference: "Standard Methods", 15th Ed., 1981
ASTM ANNUAL STANDARDS

Approved by:

Date 12-3-8C

DAILY BURNING REPORT - PLANT #20

Pre-Dryer Supply Temperature 160°

Green Cars at 8:00 A.M. 56

Kiln Schedule 34 Minutes

Cars Burned 16656

Brick Burned 42

Type Brick Burned CHALD.

Kiln Car Bearing Temperature 345°

Car Count 3968

FUEL:

Coal 31220 THERMS 4402 GAS .1700 THERMS .17

Total Therms 4402.17

Total Therms per M 26.51

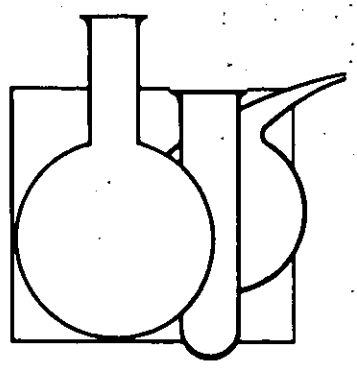
BTU/LBS Product 687

C.W.A. LOW 1.2 HIGH 5.2 AVG. 3.2

KWH/M 108

KWH COST/M #5.99

Calibrations



VI. CALIBRATIONS

Meters

The meters #703039 & #714045 were initially calibrated at a fixed setting 1.0 liter per minute. Upon return to the laboratory from this test the meters were recalibrated at the same flow rate. The recalibration produced a single point MCF which agreed within 5% of the initial value and the initial factor was multiplied by the meter volume to obtain a corrected meter volume.

Pitot Tubes

The S type tubes were calibrated against a standard pitot tube ($C_p = 0.99$) in a wind tunnel with a capacity to generate a test section velocity of approximately 3000 feet/ minute every 6 months. Additionally the pitot tube was measured as to its specifications and alignment. Upon return, the intercomponent spacings and the face opening alignment of the pitot tube assembly were rechecked. If no changes are noticed, it was assumed that the coefficient of the assembly had not changed.

Temperature measurements

All temperature devices shall be calibrated every 6 months against an ASTM mercury-in-glass reference thermometer or a reference thermocouple and potentiometer calibrated by fixed points, e.g., ice bath and boiling water (corrected to barometric pressure). Upon return the stack temperature device was recalibrated within 10% of the average absolute stack temperarure. If the device being tested agrees within 1.5% of the reference device, the temperature data taken in the field shall be considered valid.

Barometric Pressure

An aneroid barometer capable of measuring atmospheric pressure to within 0.1 inches Hg was used. If this device is defective the following alternate method shall be used. 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 0.1 inches Hg per 100 feet elevation increase or vice versa for elevation decrease.

VI. CALIBRATIONS CONTINUED

Specific Test equipment and measurements

The equipment used during these tests was as follows:

	Brick	Round
Meter:	#714045	#703039
Probe:	Collapse 6'	Collapse 6'
Stack Temeperature:	Omega II	Omega III
Average Stack Temp:	157	126
Recalibration Temp:	155	125

Each temperature device was recalibrated. The recalibration temperature for each device agreed exactly with an ASTM mercury-in-glass reference thermometer. The intercomponent spacings and the face opening alignment of the Pitot Tube assembly was rechecked and no changes were noticed.

GUARDIAN SYSTEMS INC
Meter Calibration #714045 w/ pump #2
on 11/21/86

Run Number	1	2	3	Average
Barometric Pres, in Hg	30.19	30.19	30.19	30.19
Set Flow rate l/m rotometer	1.00	1.00	1.00	1.00
Flow rate l/m from dry gas	1.13	1.15	1.15	1.14
Pres Wet Test Meter, in H20	-0.11	-0.08	-0.15	-0.11
Gas Volume Wet Init, CF	0.000	0.000	0.000	0.000
Gas Volume Wet Final, CF	0.589	0.621	0.619	1.829
Gas Volume Dry Init, CF	783.103	783.644	784.214	2350.961
Gas Volume Dry Final, CF	783.644	784.214	784.790	2352.648
Temp Wet Init, C	12.2	12.5	12.6	12.4
Temp Wet Final, C	12.5	12.6	12.8	12.6
Dry Gas Temp Init In, F	62	62	63	62
Dry Gas Temp Final In, F	62	63	63	63
Dry Gas Temp Init Out, F	61	61	62	61
Dry Gas Temp Final Out, F	61	62	62	62
Run Time, sec	900	930	930	2760
Meter Calibration Factor, Y Adjusted to 29.92 and 528	1.1038	1.1049	1.0902	1.0995
Qm	0.0398	0.0406	0.0405	0.0403

SIGNATURE _____

GUARDIAN SYSTEMS INC
Meter Calibration #714045 w/ pump #2
on 12/04/86

Run Number	1	2	3	Average
Barometric Pres, in Hg	30.30	30.30	30.30	30.30
Set Flow rate l/m rotometer	1.00	1.00	1.00	1.00
Flow rate l/m from dry gas	1.13	1.14	1.14	1.14
Pres Wet Test Meter, in H20	-0.12	-0.11	-0.10	-0.11
Gas Volume Wet Init, CF	0.000	0.595	1.195	1.790
Gas Volume Wet Final, CF	0.595	1.195	1.793	3.583
Gas Volume Dry Init, CF	793.937	794.481	795.026	2383.444
Gas Volume Dry Final, CF	794.481	795.026	795.568	2385.075
Temp Wet Init, C	14.7	14.9	14.9	14.8
Temp Wet Final, C	14.9	14.9	15.0	14.9
Dry Gas Temp Init In, F	61	63	64	63
Dry Gas Temp Final In, F	63	64	65	64
Dry Gas Temp Init Out, F	61	63	64	63
Dry Gas Temp Final Out, F	63	64	65	64
Run Time, sec	900	900	900	2700
Meter Calibration Factor, Y Adjusted to 29.92 and 528	1.1005	1.1106	1.1149	1.1087
Previous Y				1.0995
			Difference	-0.83%

SIGNATURE _____

GUARDIAN SYSTEMS INC
Meter Calibration #703039 w/ pump #4
on 11/26/86

Run Number	1	2	3	Average
Barometric Pres, in Hg	29.95	29.95	29.95	29.95
Set Flow rate l/m rotometer	1.00	1.00	1.00	1.00
Flow rate l/m from dry gas	0.92	0.92	0.92	0.92
Pres Wet Test Meter, in H2O	-0.16	-0.16	-0.14	-0.15
Gas Volume Wet Init, CF	0.000	0.000	0.000	0.000
Gas Volume Wet Final, CF	0.488	0.488	0.487	1.463
Gas Volume Dry Init, CF	94.354	94.787	95.220	284.361
Gas Volume Dry Final, CF	94.787	95.220	95.657	285.664
Temp Wet Init, C	18.8	18.8	18.8	18.8
Temp Wet Final, C	18.8	18.8	18.8	18.8
Dry Gas Temp Init In, F	66	68	68	67
Dry Gas Temp Final In, F	68	68	67	68
Dry Gas Temp Init Out, F	66	68	68	67
Dry Gas Temp Final Out, F	68	68	67	68
Run Time, sec	900	900	900	2700
Meter Calibration Factor, Y Asjusted to 29.92 and 528	1.1291	1.1312	1.1176	1.1259
Qm	0.0326	0.0327	0.0326	0.0326

SIGNATURE _____

GUARDIAN SYSTEMS INC
Meter Calibration #703039 w/ pump #4
on 12/04/86

Run Number	1	2	3	Average
Barometric Pres, in Hg	30.30	30.30	30.30	30.30
Set Flow rate l/m rotometer	1.00	1.00	1.00	1.00
Flow rate l/m from dry gas	0.93	0.93	0.94	0.93
Pres Wet Test Meter, in H20	-0.16	-0.15	-0.16	-0.16
Gas Volume Wet Init, CF	0.000	0.488	0.977	1.465
Gas Volume Wet Final, CF	0.488	0.977	1.469	2.934
Gas Volume Dry Init, CF	104.873	105.298	105.727	315.898
Gas Volume Dry Final, CF	105.298	105.727	106.162	317.187
Temp Wet Init, C	14.0	14.1	14.1	14.1
Temp Wet Final, C	14.1	14.1	14.3	14.2
Dry Gas Temp Init In, F	62	63	64	63
Dry Gas Temp Final In, F	63	64	65	64
Dry Gas Temp Init Out, F	62	63	64	63
Dry Gas Temp Final Out, F	63	64	65	64
Run Time, sec	900	900	900	2700
Meter Calibration Factor, Y Adjusted to 29.92 and 528	1.1593	1.1529	1.1458	1.1526
Previous Y				1.1259
			Difference	-2.32%

SIGNATURE _____

PITOT CALIBRATION FORM

Date 10-1-86 Probe # COLLAPSE 6'

Calibrated By G KARSTENS

Nozzle Size NA

SIDE A

Run #	ΔP_{std} (in. H_2O) Standard	$\Delta P(s)$ (in. H_2O) Type "s"	$C_p(s)$	Deviation $C_p(s) - \bar{C}_p(A)$
1	.28	.38	.849	+.004
2	.30	.41	.846	+.001
3	.29	.40	.842	-.003
		$\bar{C}_{p(A)}$	.845	

.84

SIDE B

Run #	ΔP_{std} (in. H_2O) Standard	$\Delta P(s)$ (in. H_2O) Type "s"	$C_p(s)$	Deviation $C_p(s) - \bar{C}_p(B)$
1	.25	.35	.837	-.001
2	.25	.35	.837	-.001
3	.26	.36	.841	+.003
		$\bar{C}_{p(B)}$	.838	

CALCULATIONS

.84

$$C_p(s) = C_{p(std)} \text{ (or 0.99)} \sqrt{\frac{\Delta P_{std}}{\Delta P(s)}}$$

$$\text{Average Deviation} = \frac{\Sigma \left| C_p(s) - \bar{C}_p(A \text{ or } B) \right|}{3}$$

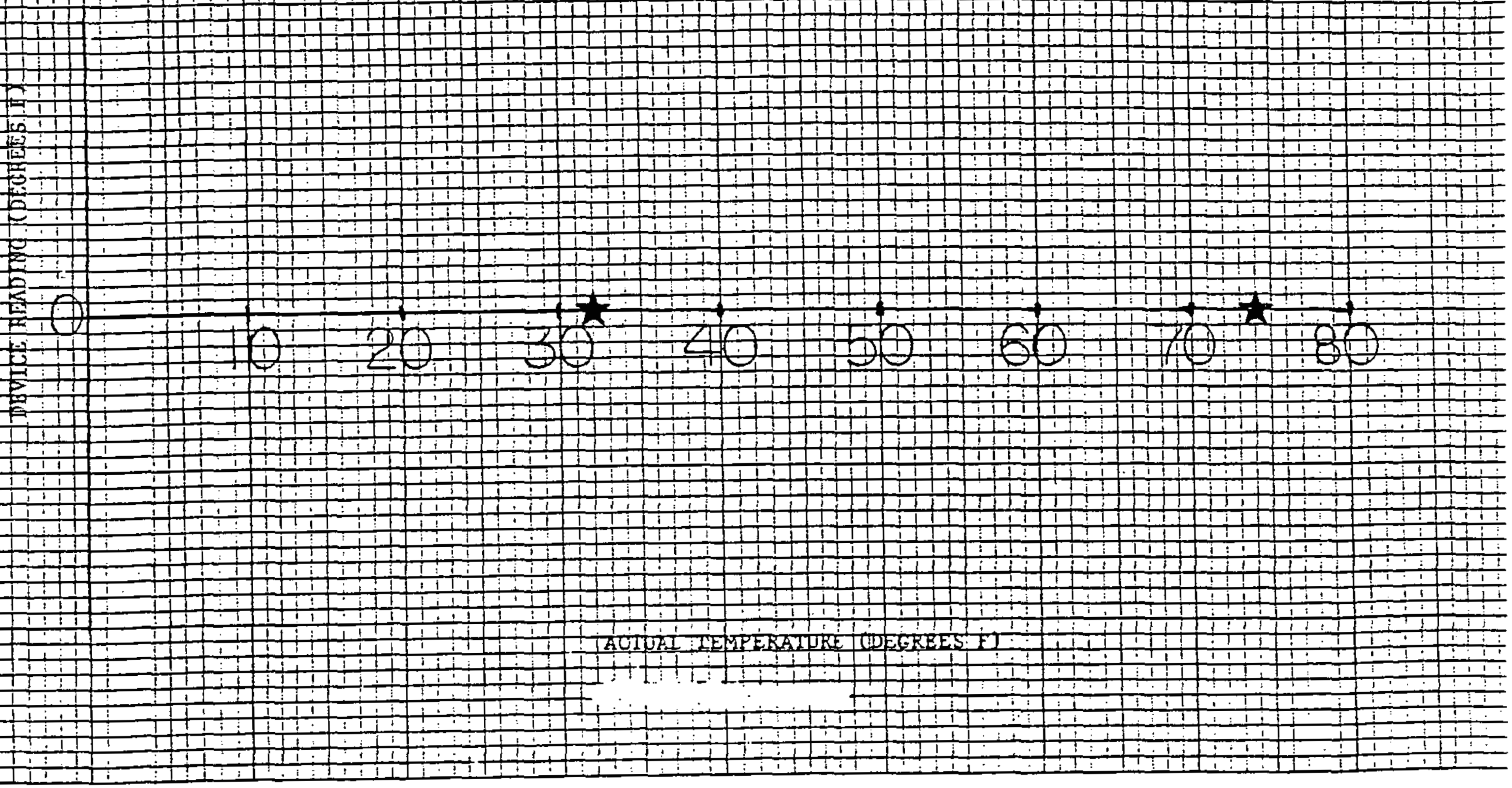
← Must be ≤ 0.01

$$\left| \bar{C}_p(A) - \bar{C}_p(B) \right|$$ ← Must be ≤ 0.01

TEMPERATURE CALIBRATION

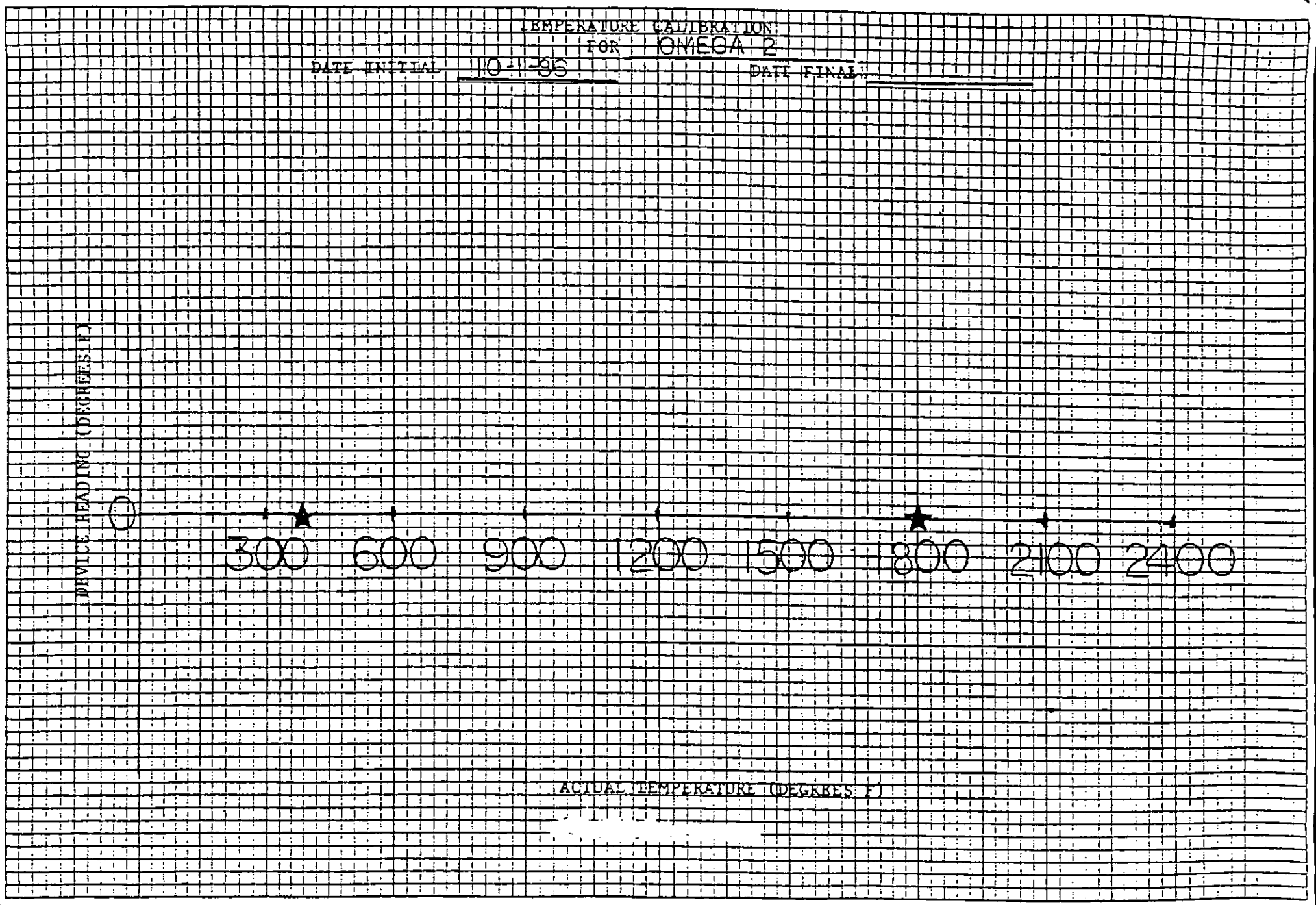
FOR OMEGA 2

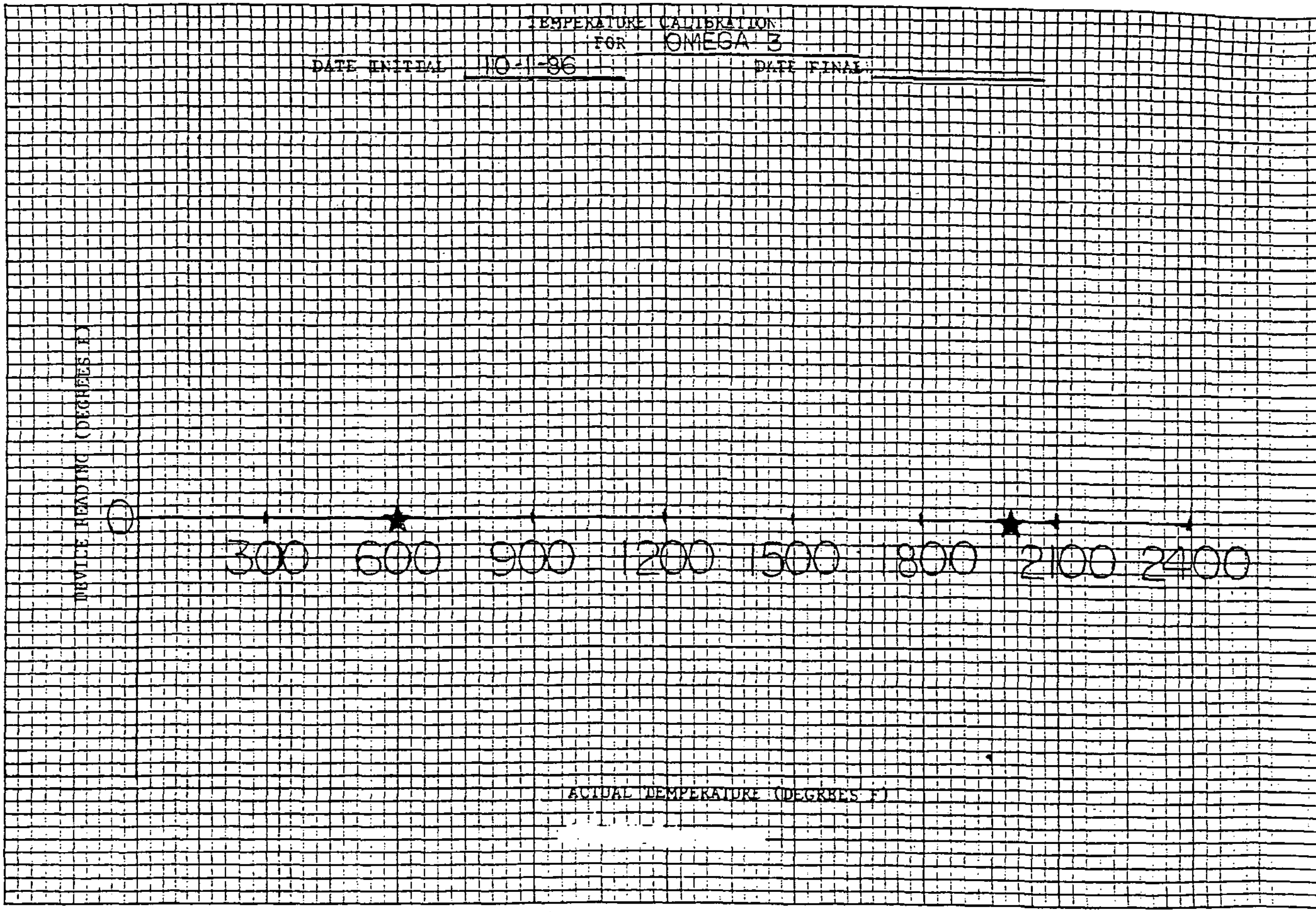
DATE INITIAL 10-11-86 DATE FINAL ____________



TEMPERATURE CALIBRATION
FOR OMEGA 2

DATE INITIAL 10-11-95 DATE FINAL




TEMPERATURE CALIBRATION
FOR OMEGA 3
DATE INITIAL 10-1-96
DATE FINAL
DEVICE READING (DEGREES F)
0
300
600
900
1200
1500
1800
2100
2400
ACTUAL TEMPERATURE (DEGREES F)

TEMPERATURE CALIBRATION
FOR OMEGA 3

DATE INITIAL 10-11-86 DATE FINAL