AP-42 Section Number: 1.3

Reference Number: 13

Title: Emission Test Reports, Docket No. OAQPS-78-1, Category II-I-257 through 265

Office of Air Quality Planning and Standards

US EPA

1972

OAQPS-78-1
76/5-II-I 261

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24
4/93 Ref 21

Emission Test Report

Steel Point Station Stack No. 1

Steam Generator Nos. 1-6

1923

The United Illuminating Company
Steel Point Station
43 East Main Street
Bridgeport, Connecticut
06608

Approved by:

E. W. Somerville
Vice President, Engineering and Planning

Submitted by:

M. R. McCraven
Director of Environmental Engineering

Emission Test Report

Steel Point Station Stack No. 1
Steam Generator Nos. 1-6
(Ref. "Intent to Test" Form Number 720059)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis

and by

York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Epstein
J. Jasko

Prepared by:

J. S. Sombati: ____________________
Development and Test Laboratory Supervisor

J. W. Hotchkiss ____________________
Assistant Mechanical Engineer

Checked by:

J. F. Crowe ____________________
Chief Mechanical Engineer

Test Results

Steel Point Station Steam Generator
Nos. 1-6

Test Conducted On
November 13 and 14, 1973

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on the United Illuminating Company Steel Point Station Steam Generator Nos. 1-6, stack No. 1, located in Bridgeport, Connecticut. Testing was conducted on November 13 and 14, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Particulate emission test No. 3 was not completed on this source due to a steam leak in Boiler No. 5 which started midway through test No. 2. In telephone conversation, on November 14, 1973, with Mr. Carl Dodge of the State of Connecticut Department of Environmental Protection, the test would be accepted as valid.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for item numbers III, IV, V, VI, VII, VIII, IX, X, XI, XII, and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new Source Test Guidelines and Procedures, (received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATOR NOS. 1, 2, 3, 4, 5, 6

STACK NO. 1

Component	Sampling Duration		Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
	Minutes per point	Total test time			
1) NO_X		15 min	3	0.28 lb/10^6 BTU	Dynascience Model P-101 NO_X Analyzer
2) Particulates	5	100	3	0.09 lb/10^6 BTU	Method 5*
3) Moisture	5	100	3	9.7%	Method 4*
4) Gas Analysis		15 min	3	42% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	1/2	15 min	3	0.12" H_2O to 0.34" H_2O **	Method 2*

* Federal Register, Vol. 36, No. 247, December 23, 1971
** Range of S-type Pitot - Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATOR NOS. 1, 2, 3, 4, 5, 6

STACK NO. 1

Test	1	2	3	Average
Date	11/13/73	11/14/73	11/14/73	
Stack Flow, ACFM	306,897	288,252	296,381	297,177
Stack Flow, SCFM	141,886	126,730	124,858	131,158
Stack Flow, lb/hr	656,572	588,408	578,164	607,715
% Excess O_2 at Test Point	8.50	8.29	8.47	8.42
Particulate Emissions				
gr/SCF	0.010	0.026	0.057	0.031
lb/hr	12.6	28.3	60.7	33.9
lb/MBTU	0.03	0.07	0.16	0.09
Nitrogen Oxide Emissions				
ppm	114	120	114	116
lb/hr	115.7	108.8	101.8	108.8
lb/MBTU	0.30	0.28	0.27	0.28

part: $\frac{33.9 \text{ lb/hr}}{2.721 \times 10^3 \text{ gal/hr}} = 12.4 \frac{\text{lb}}{10^3 \text{ gal}}$ | .37% sulfur

NOx: $\frac{109 \text{ lb/hr}}{2.721 \times 10^3 \text{ gal/hr}} = 40 \frac{\text{lb}}{\text{hr}}$

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATOR NOS. 1, 2, 3, 4, 5, 6

STACK NO. 1

Test	1	2	3
Date	11/13/73	11/14/73	11/14/73
Oil Flow (Total) gal/hr	2651	2808	2719
Heat Input (Total), MBTU/hr	386.7	395.6	383.0
Stack Gas Temperature ^{o}F	625.8	626.5	618.5
Gas Density, lb/ft^3	0.038	0.038	0.038

TABLE IV

FUEL OIL ANALYSIS

STEAM GENERATOR NOS. 1, 2, 3, 4, 5, 6

STACK NO. 1

Test	1	2	3
Date	11/13/73	11/14/73	11/14/73
	Composition (% by Weight)		
Carbon	85.93	86.06	86.06
Hydrogen	12.78	12.75	12.75
Nitrogen	<0.1	<0.1	<0.1
Ash	0.020	0.017	0.017
Sulfur	0.39	0.36	0.36
Specific Gravity	0.900	0.892	0.892
BTU/lb	19,458	18,959	18,959
BTU/gal	145,876	140,872	140,872

1. Sampling Train Information
(Ref. Item VIII, "Intent To Test" Form)

a. Schematic diagram and description of sampling train:

See Appendix A

b. Media type used to determine gas stream components:

1. Nitrogen Oxides: Dynascience Model P-101 NO_X Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. Nitrogen Oxides: Stainless steel tube.

2. Particulates: See Appendix A.

3. Flue Gas Analysis: Stainless steel tube

4. Probe cleaning method: See Appendix A.

2. Field Data Sheets
(Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. Description of Operation
(Ref. Item X, "Intent To Test" Form)

The operation tested was Steel Point Station Steam Generator Nos. 1, 2, 3, 4, 5, and 6, stack No. 1, Registration Number St. Pt. 1-6, stack 1, having a total BTU/hr rating of 388.4 MBTU (averaged over test period), burning No. 6 residual fuel oil at an average rate of 2726 gal/hr for all six boilers, and having a gas flow of 297,177 ACFM average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission sampling was performed in the stack 150 feet above the stack foundation (7 stack diameters above the breeching inlet and 2 stack diameters down from the top). Emission sampling was performed

4. <u>Sampling Area Description</u> (Cont'd.)

using four - 4" diameter sampling ports spaced 90° apart on the stack circumference. A total of twenty sampling points (5 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 12'-7" I.D.

a. Stack Configuration:

See Appendix A

b. Sampling Port Location:

See Appendix A

c. Sampling Point Position:

See Appendix A

5. <u>Stack and Vent Description</u>
(Ref. Item XII, "Intent To Test" Form)

Six Babcock and Wilcox Three Drum Sterling Boilers discharge flue gas into a common breeching which enters the stack approximately 60 feet above the stack foundation. These boilers do not have any precipitators connected to the flue gas ducts.

6. <u>Operational Parameters</u>
(Ref. Item XIII, "Intent To Test" Form)

Electric utility steam generators burning No. 6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

The test port locations and the number of points samples were calculated from the guidelines in the Federal Register, Volume 36, Number 247, December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature and velocity over the cross-sectional area of each stack. (See Figures 1 to 4.)

2. Velocity and Temperature

Velocity was determined by pitot tube in accordance with EPA Method 2. An "S"-Type Pitot Tube (2) and thermocouple (3) are rigidly attached to the sampling probe (See Figure 5). A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques.

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 5. The stainless steel, button-hook type probe tip (1) was equipped with a 5/8 inch diameter fitting connected by a stainless steel coupling (2) with asbestos packing to the probe. The probe (3) consisted of 1/2 inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 300°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the balljoint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (4) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (5) which is thermostatically maintained at 250-300°F to prevent water condensation. Attached to the heated box was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a 1/2 inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger (11) the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (ΔP in inches water)
5. Desired pressure drop across orifice (ΔH in inches of water)
6. Actual pressure drop across orifice (ΔH in inches of water)
7. Dry gas temperature (°F) gas meter inlet
8. Dry gas temperature (°F) gas meter outlet
9. Vacuum pump gauge reading (in. Hg)
10. Filter box temperature (°F).
11. Dry gas temperature (°F) at the discharge of last impinger.
12. Stack temperature (°F)

The relationship of Δ P reading with the Δ H reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δ P and Δ H could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. Basic Laboratory Procedure

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with an Infra-Red Heat Lamp and the beaker weighed again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

7. Calibration of Sampling Equipment

The equipment used on this assignment was calibrated one week prior to field testing and recalibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

TEST TEAM

Robert S. Epstein
John Jasko

Prepared By: Robert J. Larkin
Test Engineer

Reviewed By: Robert S. Epstein
Project Director

Approved By: Roy S. Egdall
Manager-Engineering Services

York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.08	.11	.727	.853
.19	.27	.704	.839
.45	.66	.682	.826
.64	.91	.703	.839
.72	1.01	.713	.844

$$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$$

Pitot Tube # 14

F_s = .84

F_{std} = 1.00

Calibrated by D. [signature]

Date 11/5/73

REPORT NO. Y-S278-1

Oil O/C

Quick Connects Ok Valves O/C

eters ok

est Meter

ometers O/C

s O/C

rical Check - Amphenol O/C

c O/C

m Gauge ok

Check at 27" hg. - O/C CI

ks

al each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. S 1563 P_b 29.9

ice	CF_w	CF_d	T_W	IT_d	OT_d	T_d Avg.	Time t
.5	5	5.15	67	85	75	80	12.73
.0	5	5.06	67	85.5	77.6	87.5	90.12
.0	10	10.16	68	88.8	79.5	84.1	13.2
.0	10	10.03	68	89.0	79.6	8[illegible]3	93.06
.0	10	10.05	68	92.8	80.3	8[illegible].5	7.67
.0	10						

ulate Y & $H_@$ at man. 2.0

Y =

$$Y = \frac{CF_w\ P_b\ (T_d\ avg. + 460)}{CF_d\ (P_b + 0.147(\ T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)\ (\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)} \left(\frac{(T_w + 460)t}{CF_w}\right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)} \left((\quad + 460)t\right)^2$$

Tolerances

Y = 0.99 - 1.00 - 1.01

$\Delta H_@$ = 1.6 - 1.84 - 2.1

Calibration Calculations Meter and Pump Box

Date 11/5/73 Box No. 51563

ΔH@	Man.	H@
$@ = \frac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\frac{(T_w + 460)t}{CF_w}\right)^2$		
$@ = \frac{0.01585}{29.9\ (75 + 460)} \left(\frac{(67 + 460)\ 12.72}{5}\right)^2$	.5	1.78
$H@ = \frac{0.0317}{29.9\ (77.6 + 460)} \left(\frac{(67 + 460)\ 90.12}{5}\right)^2$	1.0	1.77
$H@ = \frac{0.0634}{29.9\ (79.5 + 460)} \left(\frac{(68 + 460\ 13.2}{10}\right)^2$	2.0	1.90
$\Delta H@ = \frac{0.1268}{29.9\ (79.6 + 460)} \left(\frac{(68 + 460)\ 93.06}{10}\right)^2$	4.0	1.89
$\Delta H@ = \frac{0.1902}{29.9\ (80.3 + 460)} \left(\frac{(68 + 460\ 7.67}{10}\right)^2$	6.0	1.93
$\frac{0.2536}{}\ \left(\frac{(\_\_ + 460)}{}\right)$	8.0	

Y	Man.	Y
$Y = \frac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ P_b + \frac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$	Man.	Y
$Y = \frac{5 \times 29.9\ (80 + 460)}{5.15\ (29.9 + 0.0368)\ (67 + 460)}$	.5	.993
$Y = \frac{5 \times 29.9\ (81.5 + 460)}{5.06\ (29.9 + 0.0737)\ (67 + 460)}$	1.0	1.01
$Y = \frac{10 \times 29.9\ (84.1 + 460)}{10.16\ (29.9 + 0.147)\ (68 + 460)}$	2.0	1.00
$Y = \frac{10 \times 29.9\ (84.3 + 460)}{10.03\ (29.9 + 0.294)\ (68 + 460)}$ 29.9	4.0	1.01
$Y = \frac{10 \times 29.9\ (86.5 + 460)}{10.05\ (29.9 + 0.431)\ (68 + 460)}$ 29.9	6.0	1.0
$Y = \frac{\_\_ \times \_\_\ (\_\_ + 460)}{\_\_\ (\_\_ + 0.588)\ (\_\_ + 460)}$	8.0	

Y-8278-1

FIELD DATA

YORK RESEARCH CORPORATION — QUALITY CONTROLLED

PLANT UI - Steel Pt. Rgpt.
DATE 11/13/73
SAMPLING LOCATION Stack #1
SAMPLE TYPE Particulate
RUN NUMBER 1
OPERATOR JJ R/E
AMBIENT TEMPERATURE 45
BAROMETRIC PRESSURE 30.05
STATIC PRESSURE, (P_s) - 3.6 " H_2O
FILTER NUMBER (s) E1-276

PROBE LENGTH AND TYPE 100" S.S.
NOZZLE I.D. .3125
ASSUMED MOISTURE, % 10.0
SAMPLE BOX NUMBER N.A.
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 250
HEATER BOX SETTING 250
REFERENCE Δp .38

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 6 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET $(T_{m\,in})$, °F	OUTLET $(T_{m\,out})$, °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	1151	348.646									
A1	6	1157	352.21	.24	1.20	1.20	620	58	58	4	255	< 70
2	12	1203	356.09	.26	1.29	1.29	625	69	61	4	220	
3	18	1209	359.49	.26	1.29	1.29	625	63	63	4	300	
4	24	1215	363.46	.24	1.20	1.20	625	76	65	4	250	
5	30	1221	366.333	.21	1.04	1.04	625	82	67	4	250	
B1	36	1307	370.29	.30	1.50	1.50	635	83	78	5	260	
2	42	1313	374.25	.31	1.53	1.53	635	83	79	5	270	
3	48	1319	378.63	.30	1.50	1.50	625	86	78	5	250	
4	54	1325	382.38	.30	1.50	1.50	630	84	79	4.5	300	
5	60	1331	385.936	.28	1.41	1.41	635	64	66	4.5	250	
C1	66	1512	389.67	.29	1.45	1.45	620	62	64	4	250	
2	72	1518	393.41	.29	1.45	1.45	625	70	66	4	260	
3	78	1524	397.11	.28	1.41	1.41	625	76	68	4	290	
4	84	1530	401.05	.28	1.41	1.41	625	50	70	4	300	
5	90	1536	404.428	.24	1.20	1.20	625	53	70	4	300	
D1	96	1611	408.14	.26	1.38	1.38	630	66	68	3.5	300	
2	102	1622	411.55	.26	1.38	1.38	630	70	68	3.5	295	
3	108	1628	415.32	.29	1.45	1.45	630	55	68	4	300	
4	114	1634	418.74	.23	1.05	1.05	630	78	70	4	295	
5	120	1640	422.026	.21	1.00	1.00	635	77	70	4	300	

COMMENTS:

7-0210-1

FIELD DATA

YORK RESEARCH CORPORATION — QUALITY CONTROLLED

PLANT UT- Steel Pt. Bgpt.
DATE 11/14/73
SAMPLING LOCATION Stack #1
SAMPLE TYPE Particulate
RUN NUMBER 2
OPERATOR T.T RSE
AMBIENT TEMPERATURE 57
BAROMETRIC PRESSURE 29.86
STATIC PRESSURE, (P_s) - .36 "H_2O
FILTER NUMBER (s) FL-324

PROBE LENGTH AND TYPE 100" S.S.
NOZZLE I.D. .3125
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER NA
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 250
HEATER BOX SETTING 250
REFERENCE Δp .18

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 6 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	0919	422.156									
D 1	6	0925	425.62	.24	1.10	1.10	620	65	65	5	250	<70
2	12	0931	429.13	.26	1.27	1.27	630	73	67	5		
3	18	0937	432.55	.26	1.27	1.27	630	75	68	5		
4	24	0943	435.92	.24	1.10	1.10	625	81	70	5		
5	30	0949	438.829	.17	.55	.55	625	84	73	5		
C 1	36	1031	443.34	.26	1.27	1.27	625	66	68	5.5		
2	42	1037	445.83	.26	1.27	1.27	625	73	68	5.5		
3	48	1043	449.29	.26	1.27	1.27	625	78	70	5.5		
4	54	1049	453.63	.21	1.03	1.03	625	78	70	5		
5	60	1055	455.589	.15	.77	.77	620	80	73	5		
B 1	66	1131	459.03	.26	1.27	1.27	635	68	68	5.5		
2	72	1137	462.71	.27	1.35	1.35	630	74	69	6		
3	78	1143	466.21	.26	1.27	1.27	630	80	70	6		
4	84	1149	469.46	.30	.97	.97	635	84	74	5		
5	90	1155	472.212	.13	.65	.65	625	82	74	4.5		
A 1	96	1231	476.14	.28	1.35	1.35	630	73	70	6.5		
2	102	1237	479.54	.26	1.25	1.28	630	76	70	6.5		
3	108	1243	483.44	.26	1.17	1.17	630	80	73	6		
4	114	1249	486.58	.22	.97	.97	630	80	74	5.5		
5	120	1255	489.438	.16	.73	.73	625	80	74	5		

ES-041

COMMENTS:

1-8210-1
FIELD DATA

PLANT UI - Steel Pt Bgpt
DATE 11/14/73
SAMPLING LOCATION stack #1
SAMPLE TYPE Particulate
RUN NUMBER 3
OPERATOR JI BEF
AMBIENT TEMPERATURE 75
BAROMETRIC PRESSURE 29.83
STATIC PRESSURE, (P_s) - .36 " H_2O
FILTER NUMBER (s) FL-446

PROBE LENGTH AND TYPE 100" S.S.
NOZZLE I.D. .3125
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER NA
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 250
HEATER BOX SETTING 250
REFERENCE Δp .38

SCHEMATIC OF TRAVERSE POINT LAYOUT

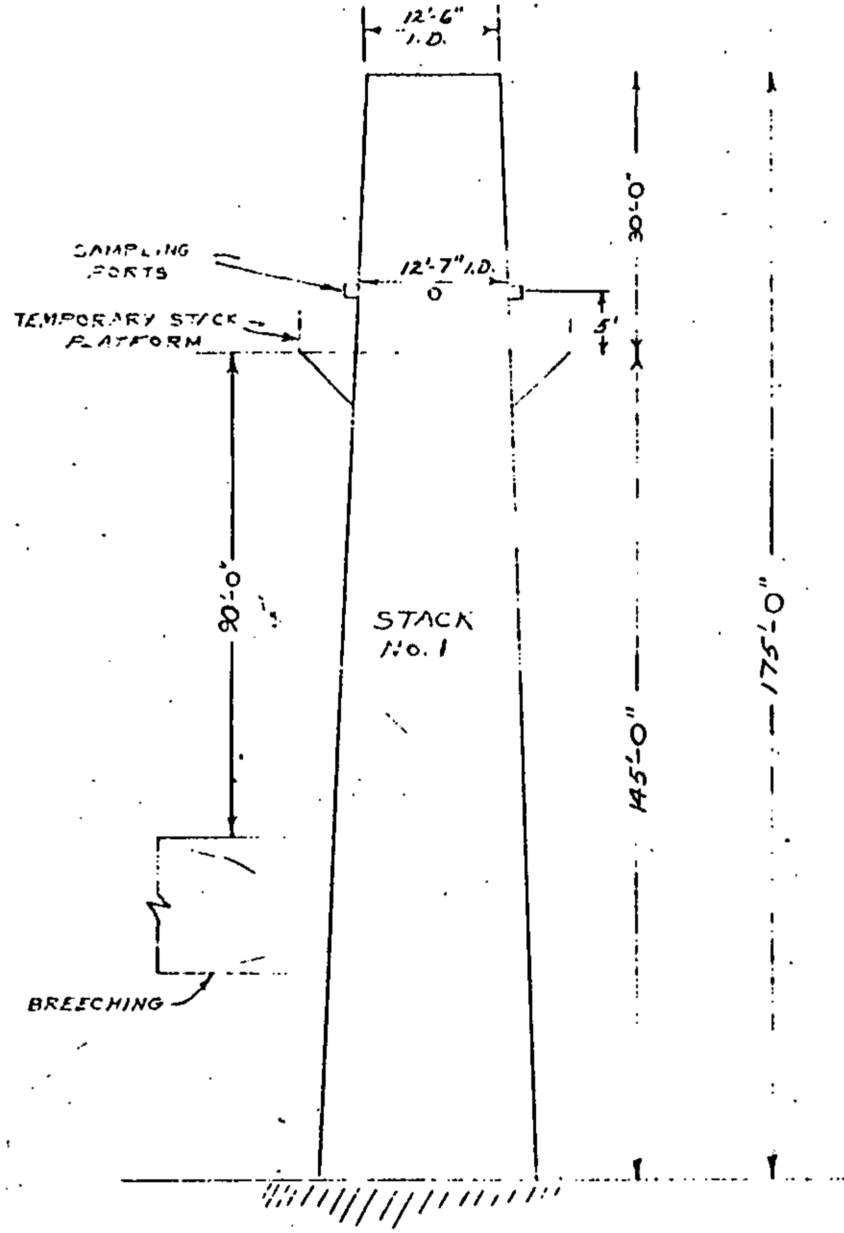
READ AND RECORD ALL DATA EVERY 6 MINUTES

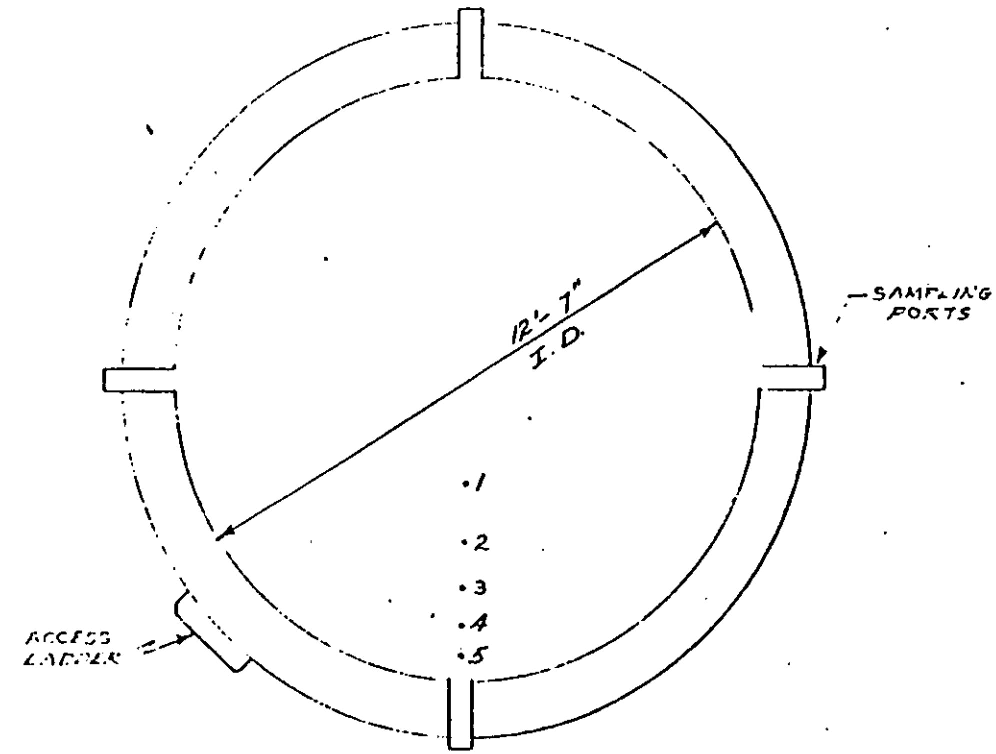
TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	1441	496.487									
A1	6	1447	500.17	.34	1.18	1.18	630	71	71	11	250	< 70
2	12	1453	503.54	.35	1.31	1.31	630	72	71	8		
3	18	1459	507.15	.37	1.30	1.30	630	80	72	8		
4	24	1505	510.53	.33	1.11	1.11	635	76	76	8		
5	30	1511	513.630	.18	.88	.88	635	78	77	7		
B1	36	1546	517.54	.34	1.68	1.68	615	75	75	10		
2	42	1552	521.39	.31	1.57	1.57	610	80	76	10		
3	48	1558	525.10	.28	1.32	1.32	610	83	77	10		
4	54	1604	528.40	.30	.92	.92	610	86	79	25		
5	60	1610	531.062	.12	.55	.55	600	86	80	6		

test stopped due to steam leak

COMMENTS:

ES-041





TRAVERSE POINT No.	DISTANCE FROM WALL
5	3.6"
4	11.8"
3	21.0"
2	32.5"
1	49.3"

REVISED

THE UNITED ILLUMINATING CO.
NEW HAVEN, CONN.
STACK CONFIGURATION AND SAMPLING POINT LOCATION
STACK No. 1
STEEL POINT STATION

DRAWN BY P.L.O. DATE 3-29-74
TRACED BY ______ DATE ______
APPROVED BY J.W.H. DATE 4-1-74
SCALE NONE DRAWING NO. 27272-72

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

TEST 1

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number Steel Point Stack 1 Date Nov 13, 1973

Boiler Number Boilers 1, 2, 3, 4, 5, 6 Time

Plant Location Steel Point Station, 43 E Main St, Bpt. Conn.

Sampling Point Location Stack.

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	9.00	8.87			8.935	44/100	3.9314
CO, % Vol (dry)	0.00	0.00			0.00	28/100	+0.00
O_2, % Vol (dry)	8.45	8.55			8.50	32/100	+2.720
N_2, % Vol (dry)	82.55	82.58			82.565	28/100	+23.1182
					Avg. molecular wt. of dry stack gas =		29.77

TEST 2

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number Steel Point Stack 1 Date Nov 14, 1973

Boiler Number Boilers 1, 2, 3, 4, 5, 6 Time

Plant Location Steel Point Station, 43 E Main St, Bpt. Conn

Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	9.75	9.50	9.62		9.6233	44/100	4.234
CO, % Vol (dry)	0.00	0.00	0.00		0.00	28/100	+ 0.00
O_2, % Vol (dry)	8.24	8.34	8.29		8.29	32/100	+ 2.653
N_2, % Vol (dry)	82.01	82.16	82.09		82.0866	28/100	+ 22.984
						Avg. molecular wt. of dry stack gas =	29.87

TEST 3

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number Steel Point stack 1 Date Nov 14, 1973

Boiler Number Boilers 1, 2, 3, 4, 5, 6. Time 3:30 PM

Plant Location Steel Point Station, 43 E. Main St, Bpt. Conn

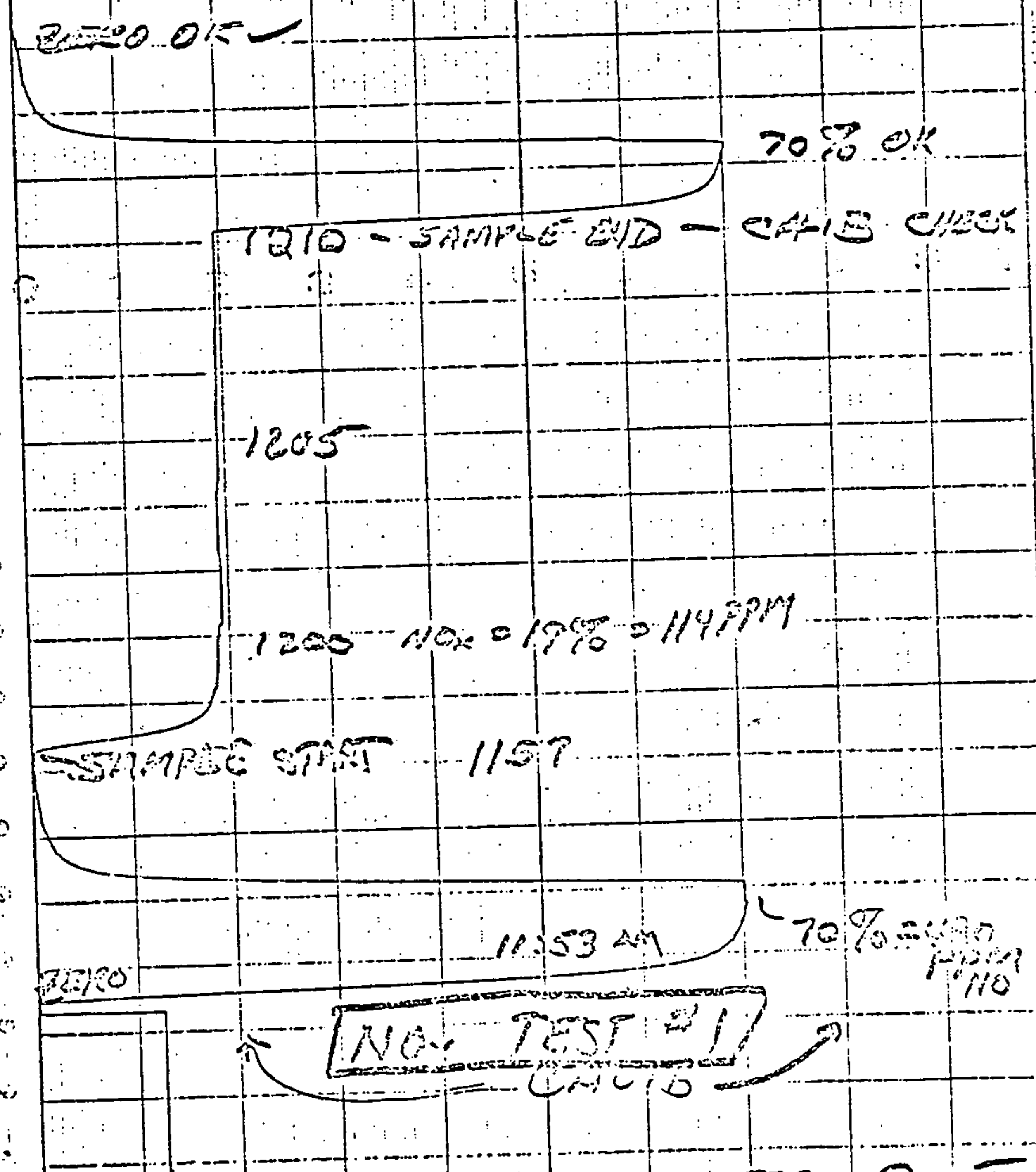
Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole (dry)
CO2, % Vol (dry)	9.25	8.93	8.93		9.0366	44/100	3.9761
CO, % Vol (dry)	0.00	0.00	0.00		0.00	28/100	+ 0.00
O2, % Vol (dry)	8.33	8.54	8.54		8.47	32/100	+ 2.7104
N2, % Vol (dry)	82.42	82.53	82.53		82.4933	28/100	+ 23.0981

Avg. molecular wt. of dry stack gas = 29.79

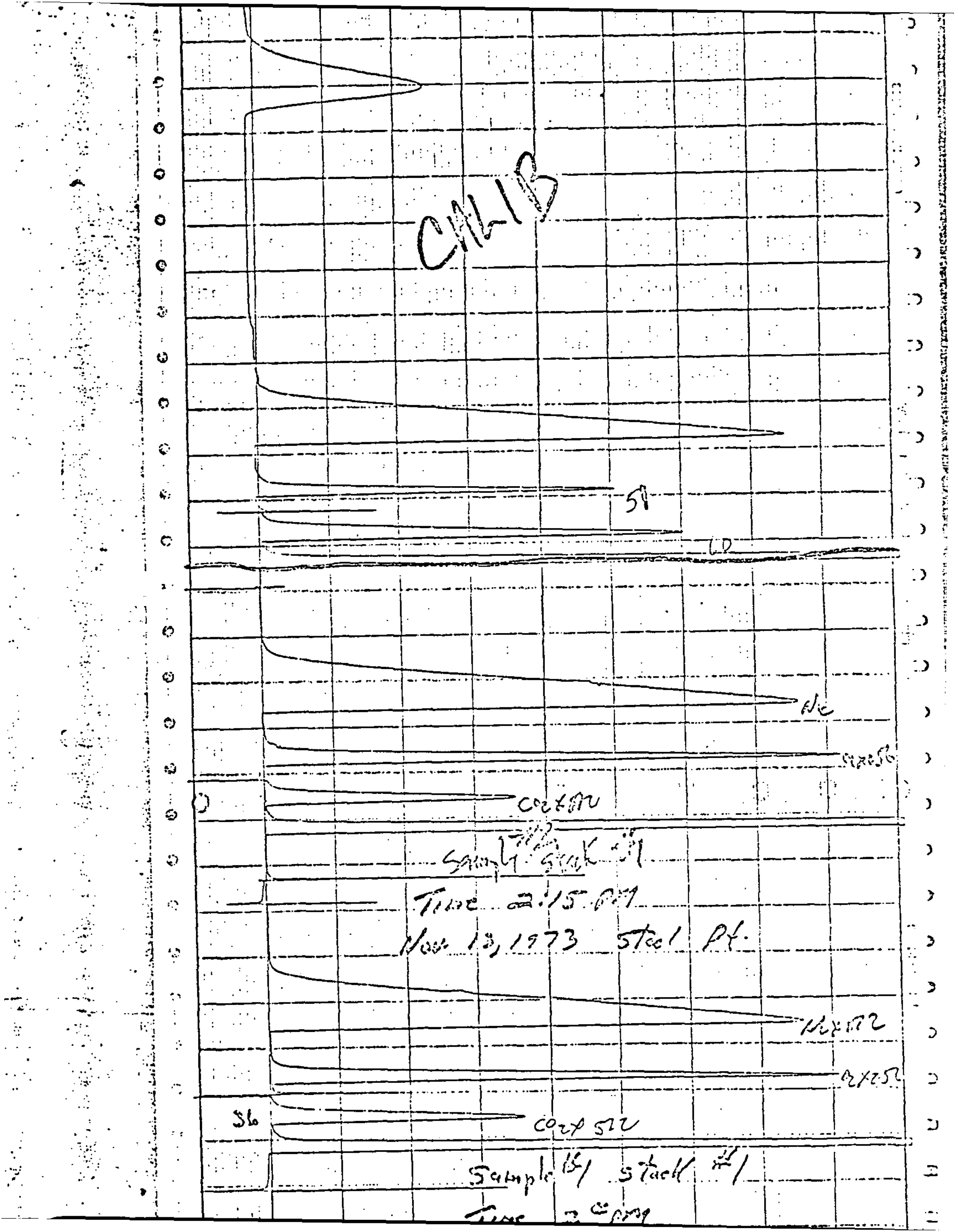
TEST NO. 1

Steel Point Station
Stack No 1
Test No 1
11/13/73



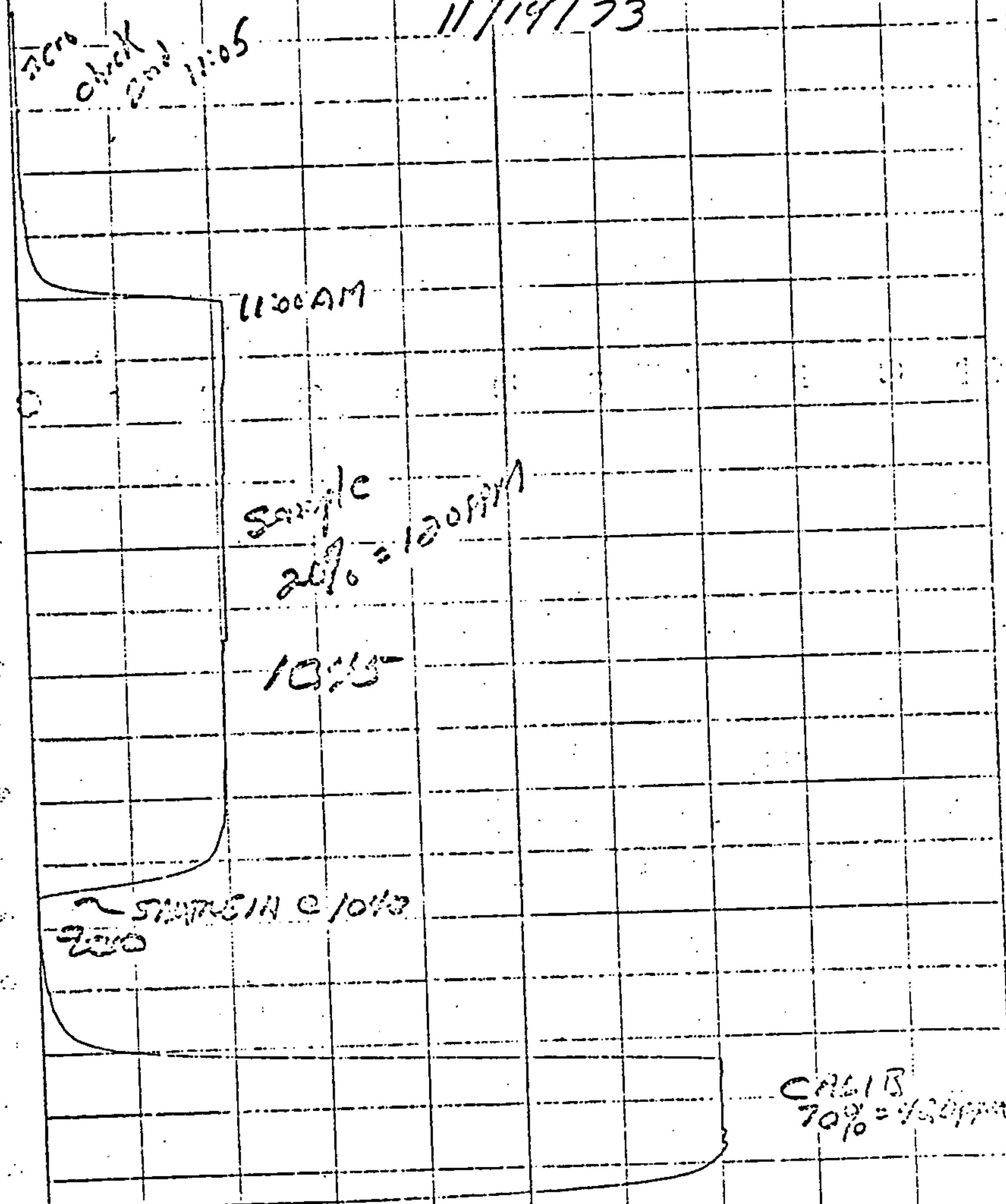
STEEL POINT
STACK #1

11-13-73

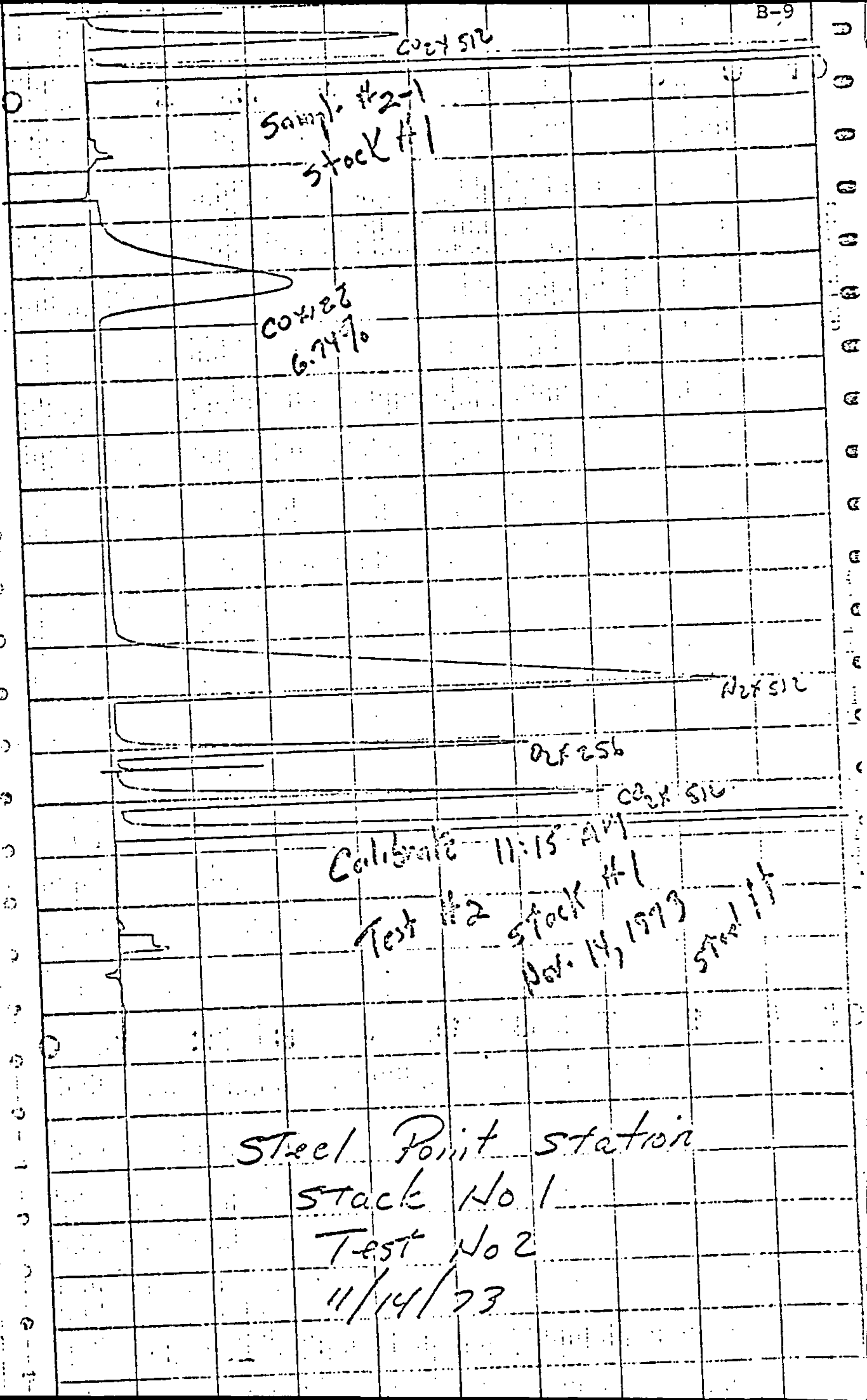

CALIB
Time 2:15 PM
Nov 13, 1973 Steel Pt.

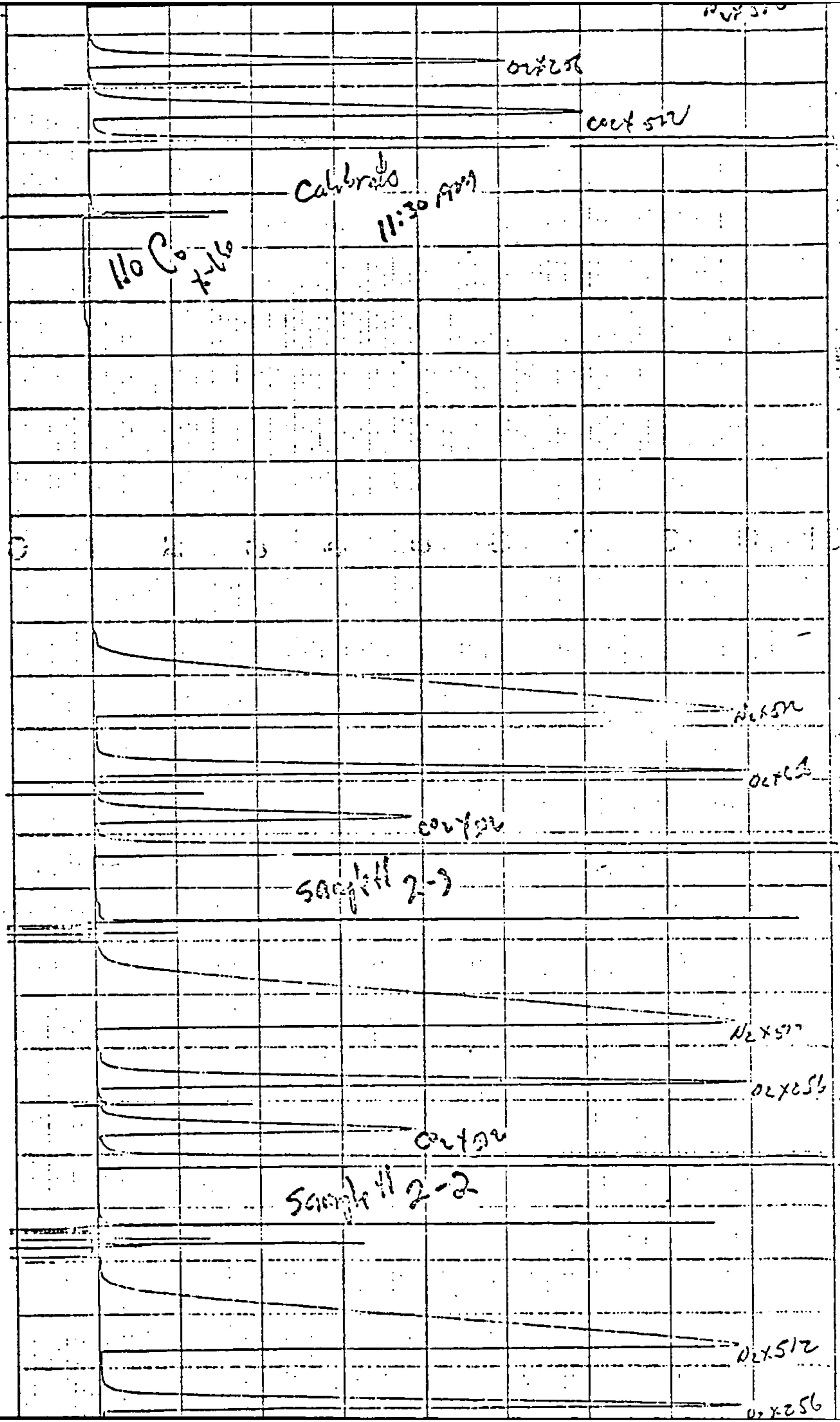
TEST NO. 2

Steel Point Station
Stack No 1
Test No 2
11/14/73

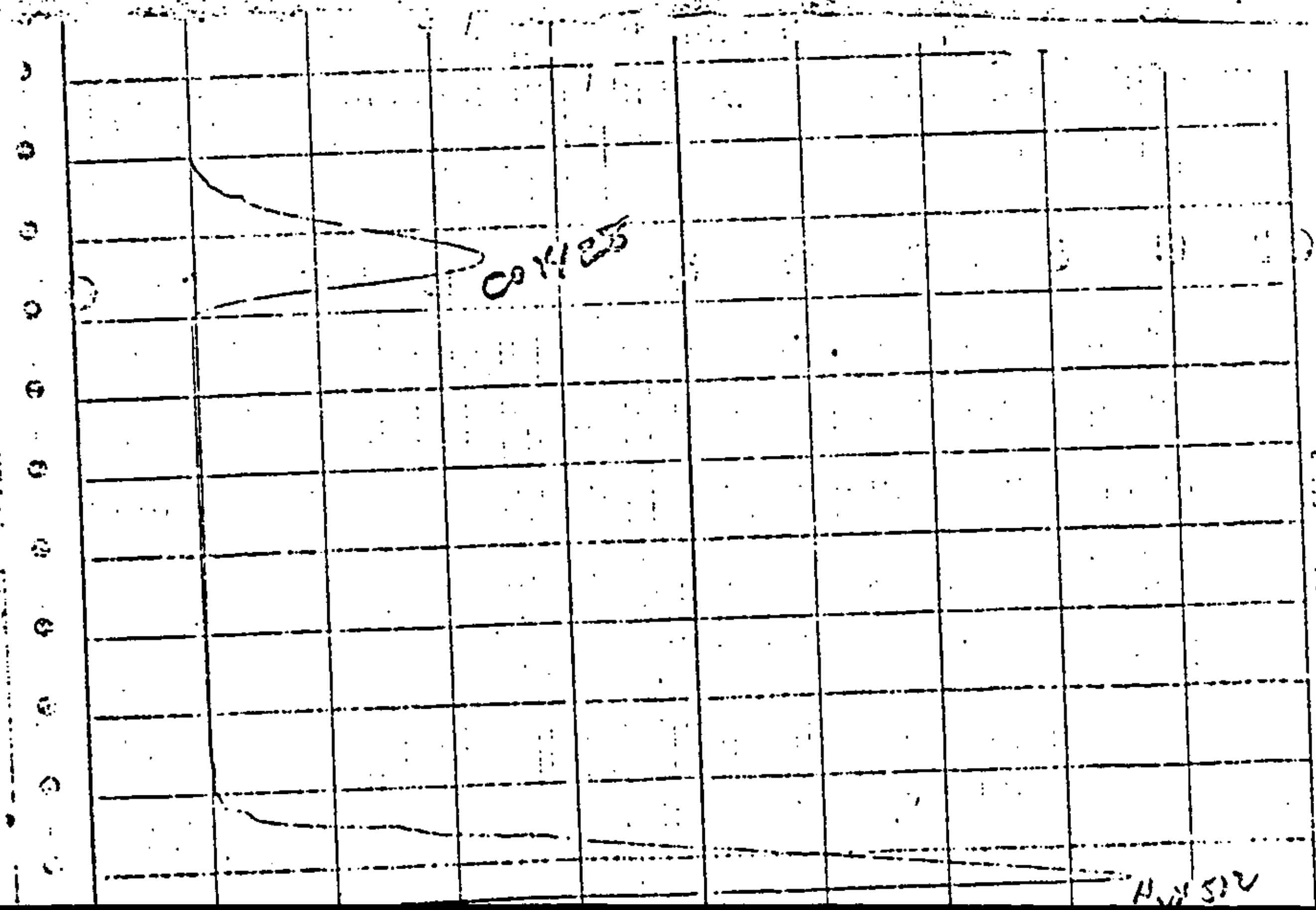


NOx Test #2
Nov. 14, 1973
St. Pt. Stack 1

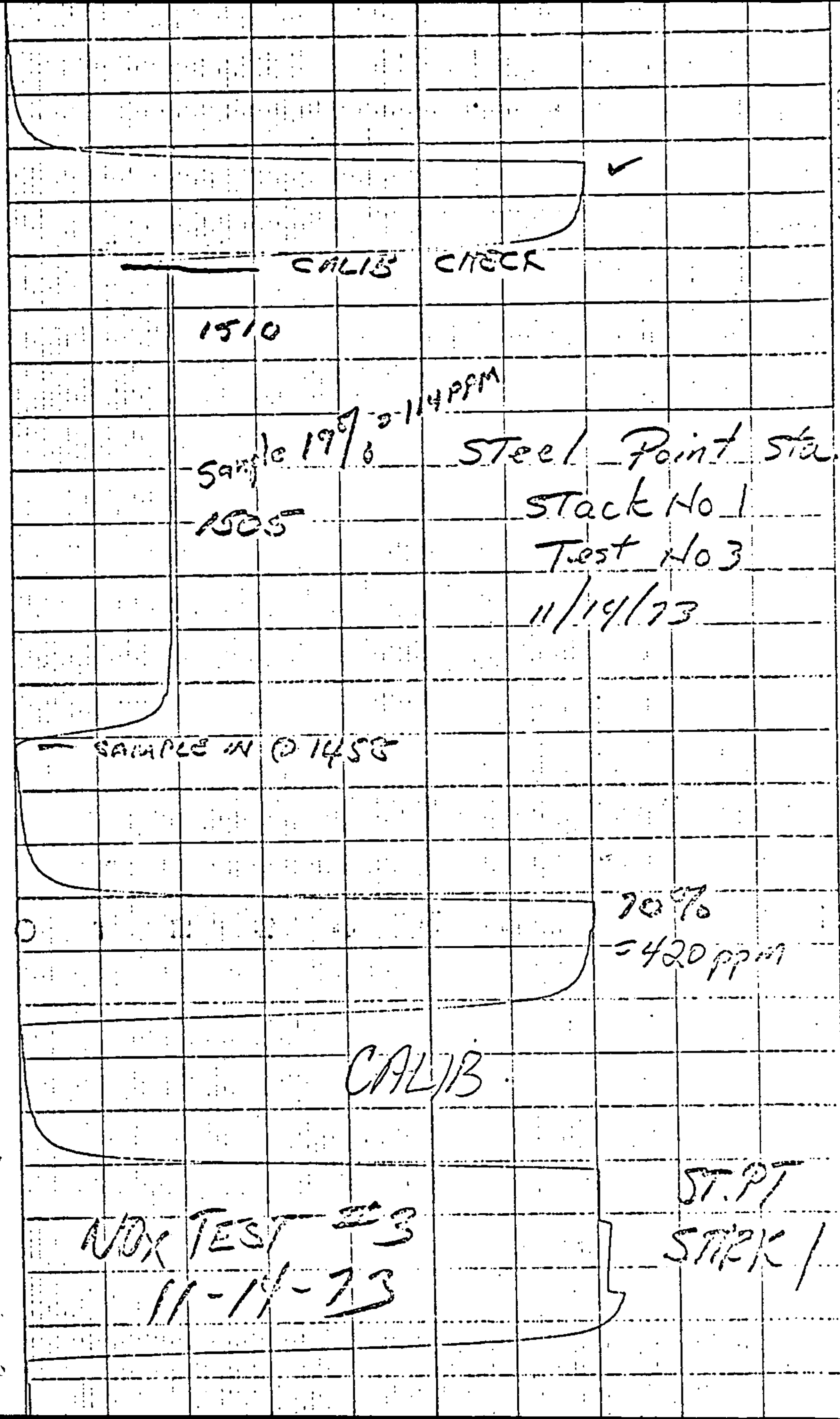

CO2 x 512
Sample #2-1
Stack #1
CO2 x 8
6.74%
N2 x 512
O2 x 256
CO2 x 512
Calibrate 11:15 AM
Test #2 Stack #1
Nov. 14, 1973
Steel Pt
Steel Point station
Stack No 1
Test No 2
11/14/73



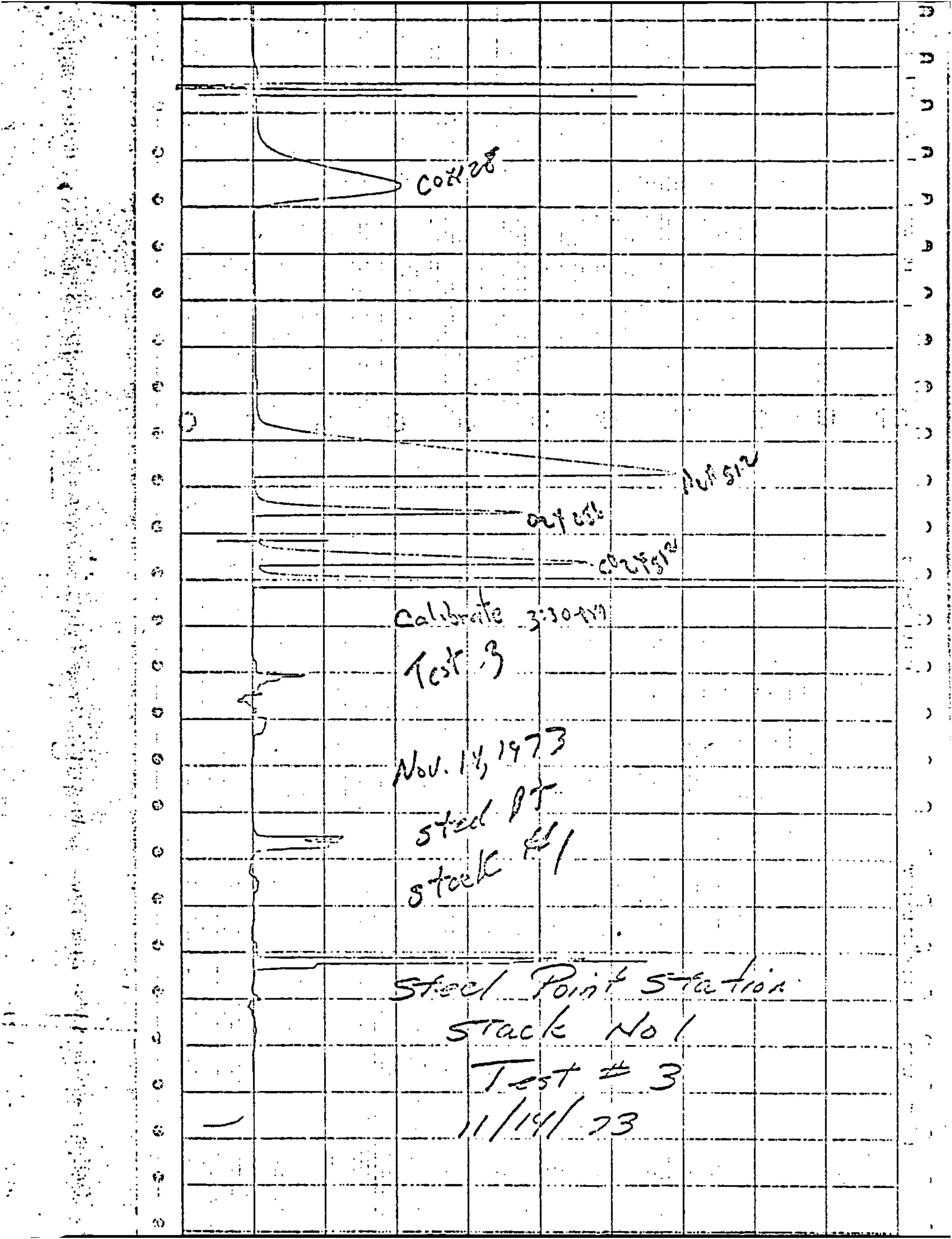
Calibratio
11:30 AM
No Co
Sample # 2-3
Sample # 2-2
N2 x 512
O2 x 256

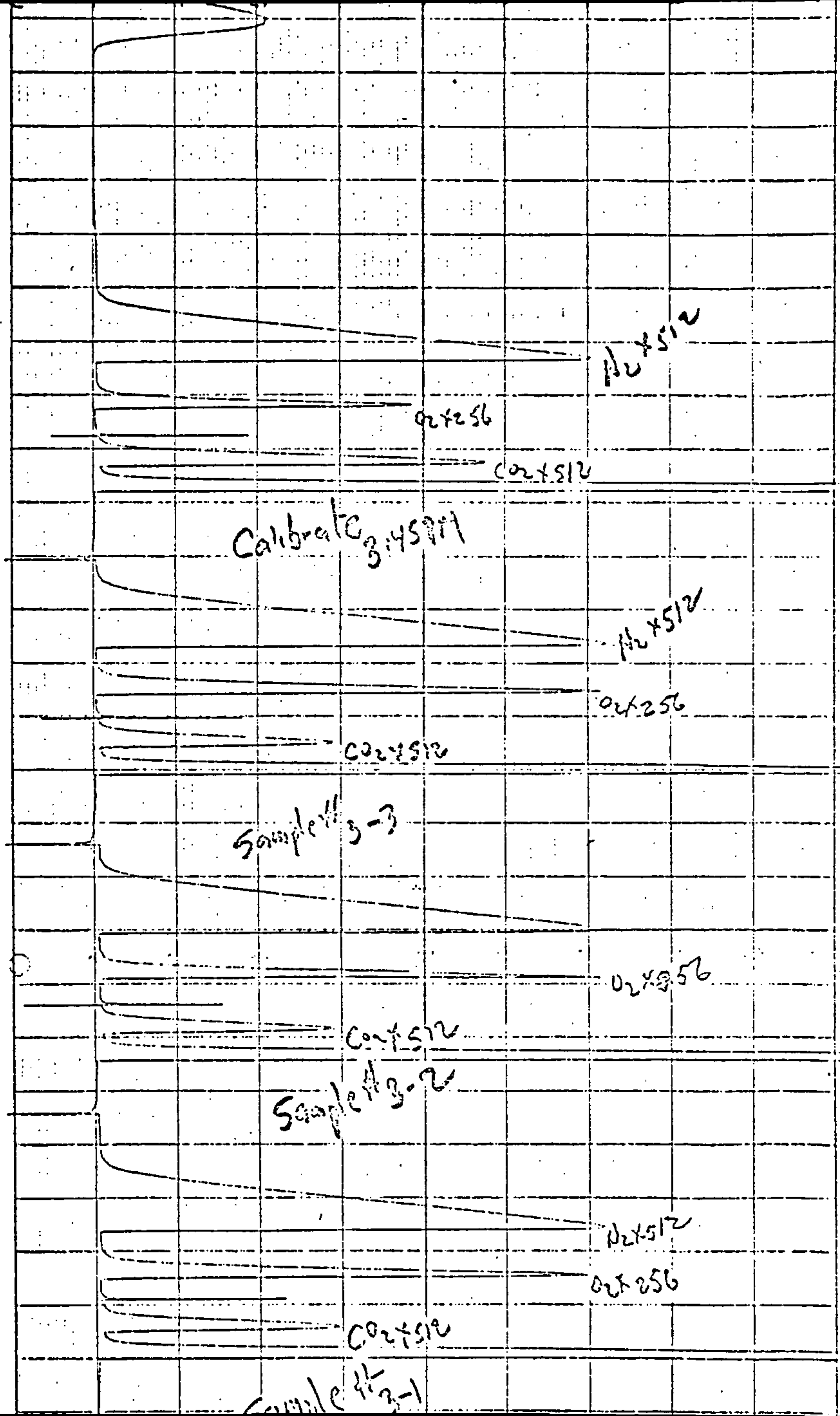


TEST NO. 3



CALIB CHECK
1510
Sample 19% = 114 PPM
1505
Steel Point Sta
Stack No 1
Test No 3
11/19/73
SAMPLE IN @ 1458
70% = 420 ppm
CALIB
NOx TEST #3
11-19-73
ST. PT
STK 1


Calibrate 3:30 PM
Test 3
Nov. 14, 1973
Steel PT
stack #1
Steel Point Station
Stack No 1
Test # 3
11/14/73



N2 x 512
O2 x 256
CO2 x 512
Calibrate 3:45 PM
N2 x 512
O2 x 256
CO2 x 512
Sample #3-3
O2 x 256
CO2 x 512
Sample #3-2
N2 x 512
O2 x 256
CO2 x 512
Sample #3-1

APPENDIX C

BOILER OPERATING DATA

Date Nov 13, 1973

Stack Identification Number STACK #1

Boiler Number 1-6 LP

Plant Location STMA POINT

TEST #1

BAROM. 30.05

Parameters	1113	1221	1356	1511	1659		
Gross Load (MW)							
Net Load (MW)							
Fuel Flow (gal/hr) oil meter (gal)	57118	55126	[illegible]	62603	67404		
Steam-Flow (lb/hr) 9th oil flow #1	435	435	425	425	440		
~~Feed-Water-Flow (lb/hr)~~ " 2	420	430	410	430	460		
Air-Flow " 3	385	[illegible]	420	375	400		
Excess Air (%) " 4	430	425	380	415	430		
Excess O2 (%) " 5	370	370	420	355	380		
Soot Blowing " 6	405	395	425	410	380		
Boiler Inlet Feed Water Temp (°F)							
Boiler Exit Steam Press. (psig)	210	210	210	215	220		
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig) FAN DUCT PRESS	5.9	5.9	5.8	6.2	7.3		
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							

Condenser Pressure (in-Hg)

BOILER OPERATING DATA

Stack Identification Number Sl. #1

Boiler Number 1-6

Plant Location Steel

Date Nov. 14, 1973

TEST #2

BAROMETER 29.86

Parameters	0838	0953	1132	1307		
Gross Load (MW)						
Net Load (MW)						
Fuel Flow (gal/hr) oil meter	105868	109405	114053	115456		
Steam Flow (lb/hr) oil [illegible] #1	370	[illegible]	380	465		
~~Feed Water Flow (lb/hr)~~ #2	470	[illegible]	[illegible]	[illegible]		
#3	430	410	430	410		
Air Flow #4	410	430	410	430		
Excess Air (%) #5	425	470	[illegible]	470		
Excess O2 (%) #6	460	385	460	380		
Soot Blowing						
Boiler Inlet Feed Water Temp (°F)						
Boiler Exit Steam Press. (psig)	210	[illegible]	210	210		
Boiler Exit Steam Temp (°F)						
Reheat Inlet Steam Press. (psig) [illegible]	[illegible]	6.0	[illegible]	6.3		
Reheat Inlet Steam Temp (°F)						
Reheat Exit Steam Press. (psig)						
Reheat Exit Steam Temp (°F)						

BOILER OPERATING [illegible]

Date May 14, 1973

TEST 3

Stack Identification Number STACK #1

Boiler Number 1-6 LP

Plant Location STEEL [illegible] [illegible] 21,82

Parameters	1435	1537	1633					
Gross Load (MW)								
Net Load (MW)	122572	125483	127920					
Fuel Flow (gal/hr) OIL METER 1	415	4[illegible]	S					
~~Steam Flow (lb/hr)~~ OIL FLOW gph 2	430	480	h					
~~Feed Water Flow (lb/hr)~~ 3	410	410	ut					
~~Air Flow~~ 4	420	420	down					
~~Excess Air (%)~~ 5	450	380						
Excess O2 (%) 6	376	375	tubes					
Soot Blowing			blown					
Boiler Inlet Feed Water Temp (OF)	210	210						
Boiler Exit Steam Press. (psig)								
Boiler Exit Steam Temp (OF)								
Reheat Inlet Steam Press. (psig) INDUCT PRESS	6.3	1.2						
Reheat Inlet Steam Temp (OF)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp (OF)								

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{\circ}R}{in.Hg.}\right) \quad Vm \quad \left(\frac{Pbar + \frac{\Delta H}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= 17.71 \frac{^{\circ}R}{in.Hg.} \quad 73.430\ ft^3 \quad \left(\frac{30.05\ In.Hg. + \frac{1.322\ in.\ H_2O}{13.6}}{532.0\ ^{\circ}R}\right)$$

$$= 73.693\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{ft^3}{M}\right) \quad Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{ft^3}{M}\right) \quad 95.6\ ml$$

$$= 4.531\ ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

$$= \frac{4.531\ ft^3}{4.531\ ft^3 + 73.693\ ft^3}$$

$$= .0579 \times 100\% = 5.6\%$$

4. Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (8.93) + 0.32\ (8.50) + 0.28\ (82.57) + 0.28\ (0.00)$$

$$= 29.77\ \text{lb/lb-mole}$$

5. Molecular Weight (wet)

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 29.77\ (1-.056) + 18\ (.056)$$

$$= 29.11\ \text{lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}} \left(\frac{Ts}{Ps \times Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.84)\ (.514) \left(\frac{1085.8}{30.02 \times 29.11}\right)^{1/2}$$

$$= 41.15\ \text{F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A_s \times 60\ \text{sec/min}$$

$$= 41.15 \times 124.3\ \text{ft}^2 \times 60\ \text{sec/min}$$

$$= 306{,}897\ \text{ACFM}$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ A_s \left(\frac{Tstd}{Ts}\right) \left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.056)\ (41.15)\ (124.3) \left(\frac{530}{1085.8}\right) \left(\frac{30.02}{29.92}\right)$$

$$= 141{,}886\ \text{SCFM}$$

9. Gas Volumetric Flow Rate, lb/hr

$$W\hat{s} = Qs \times \frac{60\ \text{min}}{\text{hr}} \times \frac{Md}{386\ ft^3}$$

$$= 141{,}886\ \text{SCFM} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{29.77\ \text{lb/lb-mole}}{386\ ft^3}$$

$$= 656{,}572\ \text{lb/hr}$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154\ \frac{gr.}{mg.}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154\ \frac{gr.}{mg.}\right) \frac{49.60\ mg.}{73.693\ ft^3}$$

$$= 0.0103\ \text{gr/SCF}$$

11. Particulate Concentrations. lb/ft^3

$$Cs = \frac{\left(\frac{1}{453600}\ \frac{lb.}{mg.}\right)}{Vmstd}\ Mn \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600}\ \frac{lb.}{mg.}\right)}{73.693\ ft^3}\ 49.60\ mg.$$

$$= 1.48 \times 10^{-6}\ \text{lb/SCF}$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60\ \text{min}}{\text{hr}}$$

$$= (1.48 \times 10^{-6}\ \text{lb/SCF})\ (141{,}886\ \text{SCFM})\quad 60\ \frac{\text{min}}{\text{hr}}$$

$$= 12.60\ \text{lb/hr}$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{12.60 \text{ lb/hr}}{386.7 \times 10^6 \text{ BTU/hr}}$$

$$= 0.033 \text{ lb/MBTU}$$

14. % Isokinetic Sampling

$$I = \frac{\overline{Ts}\ (1.667\ \frac{\text{min}}{\text{sec}}) \left((0.00267)\ Vlc + \frac{Vm}{Tm} \left(Pbar + \frac{\overline{\Delta H}}{13.6} \right) \right)}{\Theta\ Vs\ Ps\ An}$$

eq. 5-6

$$I = \frac{1085.8\ (1.667) \left((0.00267)\ (95.6) + \frac{73.43}{532.0} \left(30.05 + \frac{1.322}{13.6} \right) \right)}{(120)\ (41.15)\ (30.02)\ (5.324 \times 10^{-4})}$$

$$= 101.3\%$$

15. NO_X Concentrations, lb/hr

$$\text{lb/hr} = \text{ppm} \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{114}{10^6} \times \frac{46 \text{ lb/lb-mole}}{29.77 \text{ lb/lb-mole}} \times 656{,}572\ \frac{\text{lb}}{\text{hr}}$$

$$= 115.7 \text{ lb/hr}$$

16. NO_X Concentrations, lb/MBTU

$$\text{lb/MBTU} = \frac{\text{lb/hr}}{\text{Heat Input}}$$

$$= \frac{115.7 \text{ lb/hr}}{386.7 \times 10^6 \text{ BTU/hr}}$$

$$\text{lb/MBTU} \quad \frac{0.299 \text{ lb}}{10^6 \text{ BTU}}$$

17. Stack Pressure (Absolute) in.Hg.

$$Ps = Pb + \frac{Pd}{13.6} = 30.05 + \frac{(-0.36)}{13.6} = 30.02 \text{ in.Hg.}$$

18. Nozzle Area (ft^2)

$$An = \pi D^2/4 = 0.785\ (0.3125/12)^2 = 5.324 \times 10^{-4}\ ft^2$$

19. Stack Area (ft^2)

$$As = \pi D^2/4 = 0.785\ (151\ /12)^2 = 124.3\ ft^2$$

20. Heat Input, MBTU

Sp. Gr. x 8.33 lb/gal x BTU/lb x gal/hr

0.900 x 8.33 x 19,458 x 2651 = 386.7 MBTU

21. Gas Density, lb/ft^3

$$\text{Gas Density} = \frac{\text{mol wt gas}}{386\ ft^3}\ (md) \times \frac{Tstd}{Ts} \times \frac{Pbar}{Pstd}$$

$$= \frac{29.77}{386} \times \frac{530\ ^{\circ}R}{1085.8} \times \frac{30.05}{29.92} = 0.0378\ lb/ft^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

'est No. Steel Point #1 No. Runs 2-1/2

'ame of Firm The United Illuminating Company

,ocation of Plant 43 East Main Street, Bridgeport, Connecticut

'ype of Plant Steam Generating Station

'ontrol Equipment None

;ampling Point Locations Stack

'ollutants Sampled Particulates, Nitrogen Oxides

'ime of Particulate Test:

Run No. 1	Date 11/13/73	Begin 11:51	End 16:40
Run No. 2	Date 11/14/73	Begin 9:19	End 12:55
Run No. 3	Date 11/14/73	Begin 14:41	End 16:33

PARTICULATE EMISSION DATA

un No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole\text{-}^{o}R}\right)^{1/2}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.84	0.84	0.84	
$\sqrt{\overline{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.514	0.478	0.488	
$\bar{Ts}$ = Average stack temp., ^{o}R	1085.8	1086.5	1078.5	
Pb = Barometric pressure, "Hg Abs.	30.05	29.86	29.82	
Pd = Gas duct pressure, "H_2O	-0.36	-0.36	-0.36	
Ps = Absolute stack gas pressure, inches Hg	30.02	29.83	29.79	
Bws = % moisture in stack gas, by volume	5.6	9.6	13.9	
Md = Molecular weight of stack gas, dry	29.77	29.87	29.79	
Ms = Molecular weight of stack gas	29.11	28.73	28.15	

Vs =	Stack gas velocity, F.P.S.	41.15	38.65	39.74	
% CO_2		8.93	9.62	9.04	
% O_2		8.50	8.29	8.47	
% CO		0.00	0.00	0.00	
% N_2		82.57	82.09	82.49	
Vlc =	Total volume of liquid collected in impingers and silica gel, ml.	95.6	150.6	115.7	
Vm =	Volume of dry gas sampled at meter conditions, FT^3	73.430	67.272	34.580	
Vstd =	Volume of dry gas sampled at STP, FT^3	73.693	66.877	34.087	
Tm =	Average dry gas meter temp., ^oR	532.0	533.4	537.3	
$\overline{\Delta H}$ =	Average pressure drop across orifice, inches H_2O	1.322	1.112	1.179	
θ =	Total Sampling Time, min.	120	120	60	
Dn =	Nozzle dia., inches	0.3125	0.3125	0.3125	
An =	Nozzle area, $FT^2 \times 10^{-4}$	5.324	5.324	5.324	
I =	% of isokinetic sampling	101.3	102.7	106.2	
Qs =	Stack gas volume at STP (SCFM)	141,886	126,730	124,858	131,158
Qa =	Stack gas volume at stack conditions (ACFM)	306,897	288,252	296,381	297,177
Ws =	Stack gas mass flow lbs/hr	656,572	588,408	578,164	607,715
Mp =	Particulate-probe, washings, mg	-	-	-	
Mf =	Particulate-filter (mg)	-	-	-	
Mn =	Particulate-total (mg)	49.60	113.10	127.20	
C's =	Particulate Concentrations gr/scf	0.010	0.026	0.057	0.031
Cw =	Particulate total emission lb/hr	12.6	28.3	60.7	33.9
Er =	Particulate emission rate, lb/106 BTU	0.033	0.072	0.158	0.088
C =	NO, concentrations, PPM	114	120	114	116
Cn =	NO, $lb/10^6 BTU$	0.30	0.28	0.27	0.28

OAQPS - 78-1

II-I-262

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref 21

EMISSION TEST REPORT

Stack No. B.H.S. 1

Steam Generator No. 1

1957

.004 gr/SCF
15% CO2

The United Illuminating Company
Bridgeport Harbor Station
10 Henry Street
Bridgeport, Connecticut
06604

Approved by:

E.W. Somerville ____________________
Vice President, Engineering and Planning

Submitted by:

M.R. McCraven ____________________

Stack No. B.H.S. 1
Steam Generator No. 1
(Ref. "Intent to Test" Form Number 720049)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Personnel Present

J. Sombati
J. Hotchkiss
J. Macknis
T. McAlee

Prepared by:

J.S. Sombati
Development & Testing Laboratory Supervisor

J.W. Hotchkiss
Assistant Mechanical Engineer

Checked by:

D.W. Hoskinson
Chief Mechanical Engineer

TEST RESULTS

Steam Generator No. 1

Tests Conducted On

April 12, 13, 16, 1973

Introduction

Emission tests for particulate and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company Bridgeport Harbor Station Steam Generator No. 1 located in Bridgeport, Connecticut. Testing was conducted on April 12, 13 and 16, 1973.

Source sampling was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. These tests were conducted on the stack four diameters downstream of the breeching inlet.

The primary contaminants tested for were particulates and nitrogen oxides. Tests were also conducted to determine stack gas velocity, moisture content and flue gas analysis. The procedures used in determining these various parameters, except for flue gas analysis and nitrogen oxides, are those found in the above mentioned Federal Register. Flue gas analysis was performed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph, and nitrogen oxide emissions were found by using a Dynascience Model P-101 NO_x Analyzer.

This test report includes the information required for Items III, IV, V, VI, VII, VIII, IX, X, XI, XII and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the DEP's new Source Test Guidelines and Procedures, (received April 3, 1973).

1. Sampling Train Information
(Ref. Item VIII "Intent to Test" Form)

a.) Schematic diagram of Sampling Train:

See Figure 1

Sampling Train used:

Research Appliance Corporation Stacksamplr Model 2343-5, Serial No. 1399, purchased April 4, 1972.

b.) Media type used to determine gas stream components:

NO_x: Dynascience Model P-101 NO_x analyzer

Particulates: Reeve Angel 900AF 11 CM diameter glass fiber filter

Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c.) Sampling tube:

Preliminary Moisture: Heated pyrex tube

NO_x: Stainless steel tube

Particulates: 12 foot stainless steel tube

Flue Gas Analysis: Stainless steel tube

d.) Probe cleaning method:

The probe was first washed with acetone, after which two to three pre-weighed gun patches were pushed through the probe, followed by another washing of the probe with acetone.

2. Field Data Sheets
(Ref. Item IX "Intent to Test" Form)

See Appendix C

3. Description of Operations
(Ref. Item X "Intent to Test" Form)

The operation tested was Bridgeport Harbor Station Steam Generator 1, Registration Number B.H.S. 1, Stack 1, having a BTU/hr rating of 895 x 10^6 (averaged over test period), burning No. 6 residual fuel oil at an average rate of 6277 gal/hr, and having a gas flow of 263,335 ACFM, average for test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI "Intent to Test" Form)

Emission sampling was performed in the stack 43'-3" above the breeching inlet and 126'-6" down from the top of the stack. Sampling was done through two 4" diameter sampling ports spaced 90° apart on the stack circumference. Eighteen sampling points per port were used in the test for particulates. The diameter of the stack at the sampling location was found to be 8'-6".

a.) Stack Configuration

See Figure 2

b.) Sampling Port Location

See Figure 2

c.) Sampling Point Positions

See Figure 3

5. Stack and Vent Descriptions
(Ref. Item XII "Intent to Test" Form)

Connected to this boiler is a Research-Cottrell electrostatic precipitator having an estimated collection efficiency of 75% when burning No. 6 residual fuel oil. The precipitator outlet duct connects into the 201' stack at elevation 55'-3".

6. Operational Parameters
(Ref. Item XIII "Intent to Test" Form)

Electric utility steam generator burning No. 6 residual fuel oil and having rated capacities as registered.

Table 1

Summary of Test Results

Steam Generator No. 1

Component	Sampling Duration: minutes per point	Sampling Duration: total test time	Number of tests (Minimum of 3)	Measured Concentrations	Method Employed to Determine Concentration i.e., material balance, emission factor, reference, (specify) etc
NO_x		10 min.	3	0.19 lb/10^6 BTU	Dynascience Model P-101
Particulates	5	180 min.	3	0.006 lb/10^6 BTU	Method 5*
Moisture	5	180 min.	3	9.8	Method 4*
Gas Analysis		10 min.	3	32% Excess Air	AID Model 512 Portable Gas Chromatograph
Velocity	½	30 min.	3	1.1" to 2.0" H_2O	Method 2*

*Federal Register, Vol. 36, No. 247, December 23, 1971

Table II

Summary of Results

Steam Generator No. 1

	Test 1	Test 2	Test 3	Average
Date	4/12/73	4/13/73	4/16/73	
Stack Flow, ACFM	266,811	261,580	261,614	263,335
Stack Flow, SCFM	171,038	171,145	169,546	170,576
Stack Flow, lb/hr	797,853	801,544	788,784	796,060
% Excess O_2 @ Test Point	5.05	5.89	7.99	6.31
Particulate Emissions				
gr/SCF	0.003	0.002	0.006	0.004
lb/hr	3.9	3.3	8.2	5.1
lb/MBTU	0.004	0.004	0.009	0.006
Nitrogen Oxide Emissions				
PPM	234	219	167	207
lb/MBTU	0.21	0.20	0.15	0.19

Correction f: 1.457

part: $5.1 \frac{lb}{hr} \times \frac{1 hr}{6.27\times10^3 gal}$ $0.8 \frac{lb}{10^3 gal}$ | 0.4

$0.19 \times 1.457 = 0.29$.

NO_X: $0.19 \frac{lb}{10^6 Btu} \times \frac{143{,}000{,}000 Btu}{10^3 gal} = 27 \frac{lb}{10^3 gal}$

Table III

Average Boiler Operating Data For Test Periods

Steam Generator No. 1

	Test 1	Test 2	Test 3
Date	4/12/73	4/13/73	4/16/73
Gross Load MW	89.5	88.6	89.4
Steam Flow lb/hr	658,000	652,000	656,000
Oil Flow, gal/hr	6343	6257	6231
Heat Rate, MBTU/hr	906.4	891.7	887.8
Stack Gas Temp. ^{o}F	285.5	275.0	286.6
Gas Density, lb/ft^3	0.055	0.057	0.056
Additive Rate ("CHESSCO")	2000:1	2000:1	2000:1

TABLE IV(a)

Analysis Of
Representative Fuel Oil Sample

FUEL ENGINEERING COMPANY

FUEL TESTING DEPARTMENT

TEST REPORT

April 27, 1973
DATE

254979
REPORT NUMBER

Your P.O. No.

API Gravity @60°F	27.3
Specific Gravity @60°F	0.8911
Sulfur	0.44%
Heating Value	19255 BTU per Pound
	142895 BTU per Gallon

On Sample Marked Unit #1, Oil-HDR
10:15 A.M.
4/12/73

Sample Taken by You Us

Received from United Illuminating Company
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. J. Sombati

Fuel Engineering Company of New York

by: H.O. Courtney

TABLE IV(b)

Ultimate Analysis Of Representative Fuel Oil Sample

FUEL ENGINEERING COMPANY

May 5, 1973
DATE

FUEL TESTING DEPARTMENT

TEST REPORT

254978
REPORT NUMBER

Your P.O. No.

On Sample Marked Unit #1 Oil-HDR 11:30 A.M. 4/13/73

Sample Taken by You / Us

Ultimate:

Carbon	84.93%
Hydrogen	12.65%
Sulfur	0.43%
Nitrogen	0.18%
Ash	0.036%
Oxygen	1.77%
BTU per Pound	19257
BTU per Gallon	142521

Received from United Illuminating Co.
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. J. Sombati

Fuel Engineering Company of New York

by: Howard O Courtney / HB

TABLE IV(c)

Analysis Of

Representative Fuel Oil Sample

FUEL ENGINEERING COMPANY

April 27, 1973
DATE

FUEL TESTING DEPARTMENT

254980
REPORT NUMBER

TEST REPORT

API Gravity @60°F 27.5
Specific Gravity @60°F 0.8899
Sulfur 0.46%
Heating Value 19226 BTU per Pound
142484 BTU per Gallon

Your P.O. No.

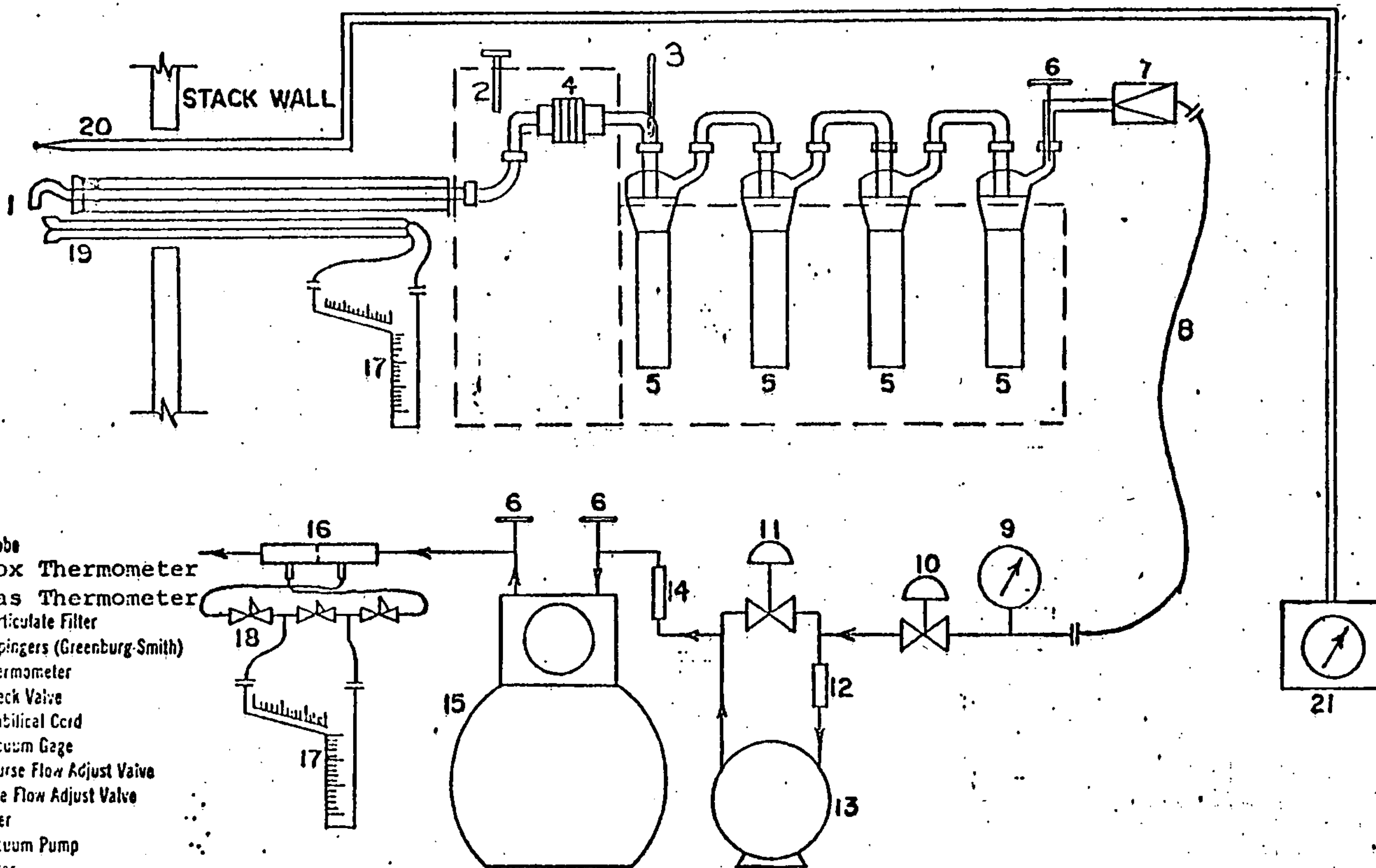
On Sample Marked Oil Sample For Test #3 BUS #1
1:00 P.M. From Unit #2 HDR Discharge
4/17/73
Sample Taken by You Us

Received from United Illuminating Company
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. J. Sombati

Fuel Engineering Company of New York

by: H.O. Courtney

RAC "STAKSAMPLR" SAMPLING TRAIN SCHEMATIC



1) Probe
2) Box Thermometer
3) Gas Thermometer
4) Particulate Filter
5) Impingers (Greenburg-Smith)
6) Thermometer
7) Check Valve
8) Umbilical Cord
9) Vacuum Gage
10) Course Flow Adjust Valve
11) Fine Flow Adjust Valve
12) Oiler
13) Vacuum Pump
14) Filter
15) Dry Gas Meter
16) Orifice Tube
17) Incline Manometer
18) Solenoid Valves
19) Pitot
20) Thermocouple
21) Leeds & Northrup 8595-2 I.C. Temperature Potentiometer

THE UNITED ILLUMINATING COMPANY
TYPICAL SAMPLING TRAIN
FIGURE 1

UNITED ILLUMINATING CO
BPT. HARBOR STA
UNIT # 1
STACK CONFIGURATION
SAMPLING PORT LOCATION

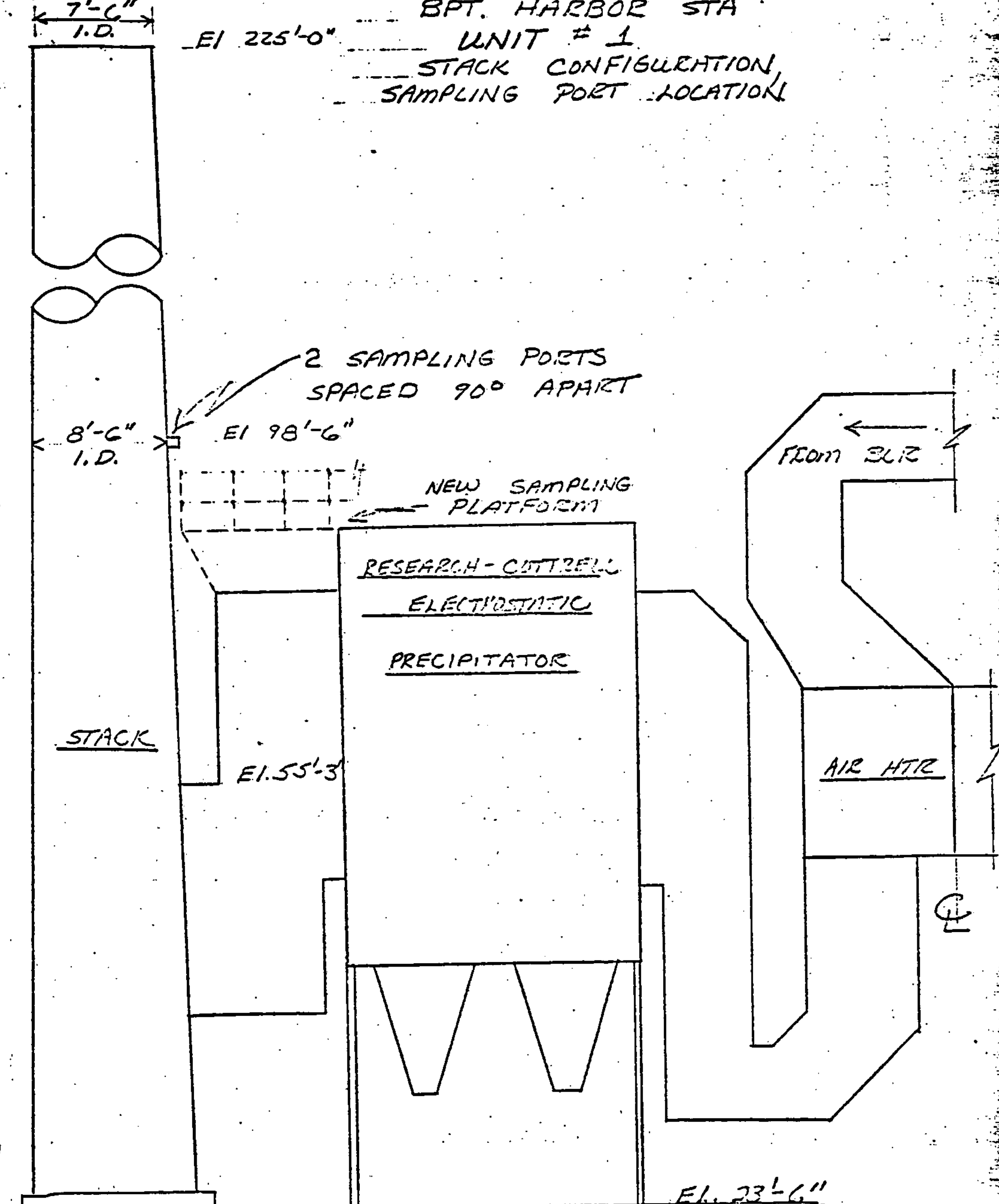


FIGURE 2

SAMPLING POINT POSITIONS

(STACK DIA. CROSS-SECTION)

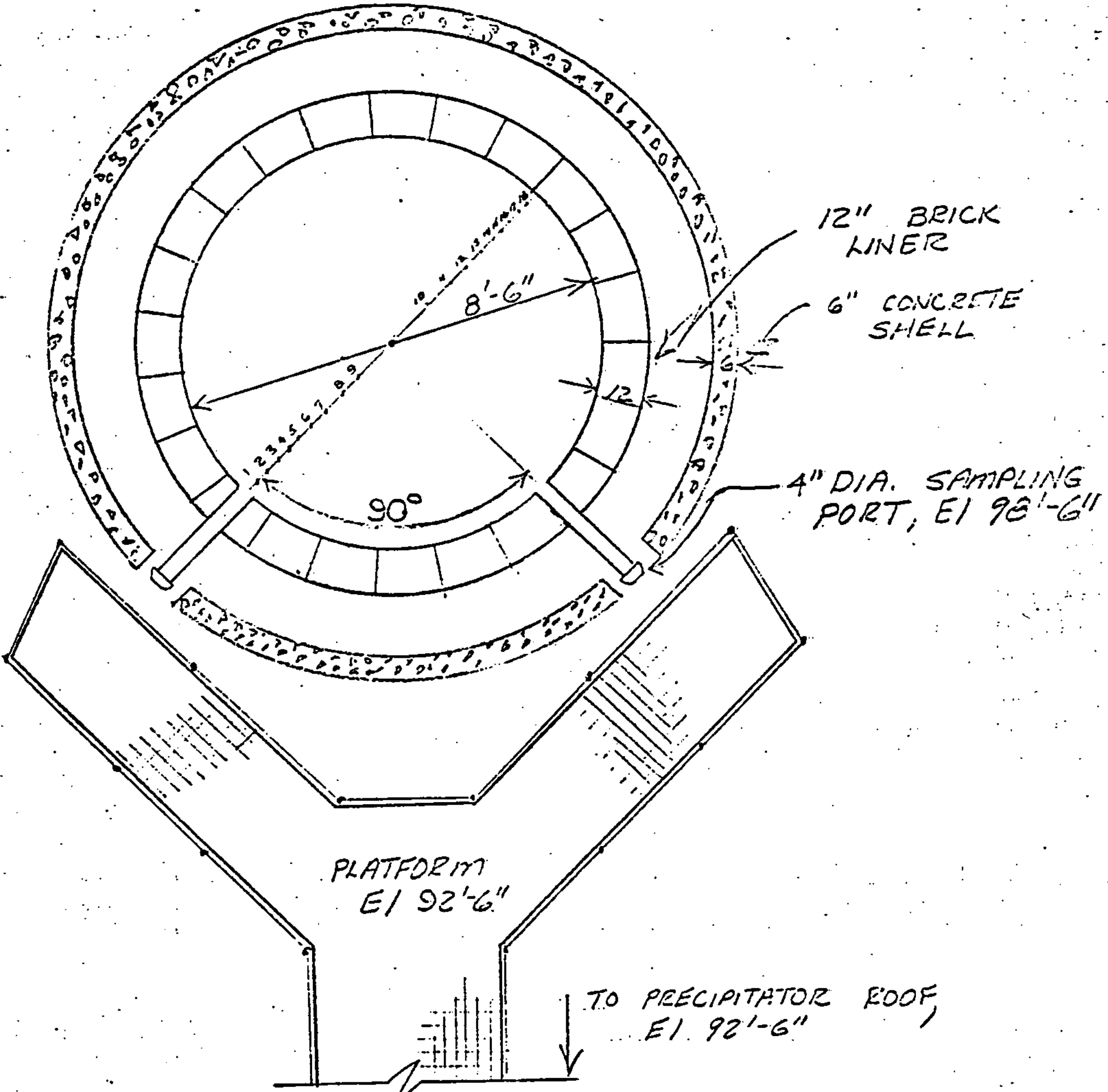


FIGURE 3-A

B.H.S. UNIT #1

Sampling Point Positions

Stack Diameter: 8'-6" = 102"

Pipe Length: 36"

POINT	FACTOR	DISTANCE	DISTANCE + PIPE LENGTH
1	1.4	1.4"	37.4"
2	4.4	4.5"	40.5"
3	7.5	7.7"	43.7"
4	10.9	11.1"	47.1"
5	14.6	14.9"	50.9"
6	18.8	19.2"	55.2"
7	23.6	24.1"	60.1"
8	29.6	30.2"	66.2"
9	38.2	39.0"	75.0"
10	61.8	63.0"	99.0"
11	70.4	71.8"	107.8"
12	76.4	77.9"	113.9"
13	81.2	82.8"	118.8"
14	85.4	87.1"	123.1"
15	89.1	90.9"	126.9"
16	92.5	94.4"	130.4"
17	95.6	97.5"	133.5"
18	98.6	100.6"	136.6"

Figure 3-B

Bridgeport Harbor Station Unit No. 1
Test 1
April 12, 1973

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, Dated December 23, 1971.

Calculations representative of Test #1.

1) Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{o}R}{inHg}\right) Vm \left(\frac{Pbar + \frac{\Delta H}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{o}R}{inHg}\right) 173.64\ ft^3 \left(\frac{29.94 \text{ in Hg} + \frac{3.56 \text{ in } H_2}{13.6}}{529.1\ ^{o}R}\right)$$

$$= 175.53\ ft^3$$

2) Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{FT^3}{M}\right) Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{FT^3}{M}\right) 403.6\ Ml$$

$$= 19.13\ FT^3$$

3) Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

$$= \frac{19.13\ FT^3}{19.13\ FT^3 + 175.53\ FT^3}$$

$$= .098 \times 100\% = 9.8\%$$

4) Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%\ N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (11.33) + 0.32\ (5.05) + 0.28\ (83.62) + 0.28\ (0.00)$$

$$= 30.01 \text{ lb/lb-mole}$$

5) Molecular Weight (wet)

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 30.01\ (1-.098) + 18\ (.098)$$

$$= 28.83 \text{ lb/lb-mole}$$

6) Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\Delta P}\ \left(\frac{Ts}{Ps\ \ Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (0.783)\ (1.26) \left(\frac{745.5}{29.91 \times 28.83}\right)^{1/2}$$

$$= (85.48)\ (0.783)\ (1.26)\ (0.930)$$

$$= 78.4 \text{ F.P.S.}$$

7) Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A \times 60 \text{ sec/min}$$

$$= 78.4 \times 56.72 \text{ FT}^2 \times 60 \text{ sec/min}$$

$$= 266{,}811 \text{ ACFM}$$

8) Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ A \left(\frac{Tstd}{Ts}\right) \left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.098)\ (78.4)\ (56.72) \left(\frac{530}{745.5}\right)\left(\frac{29.91}{29.92}\right)$$

$$= 171{,}038 \text{ SCFM}$$

9) Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60 \text{ min}}{hr} \times \frac{Md}{386 \text{ FT}^3}$$

$$= 171{,}038 \text{ SCFM} \times \frac{60 \text{ min}}{hr} \times \frac{30.01 \text{ lb/lb-mole}}{386 \text{ FT}^3}$$

$$= 797{,}853 \text{ lb/hr}$$

10) Particulate Concentrations, gr/SCF

$$C's = \left(0.0154 \frac{gr}{mg}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154 \frac{gr}{mg}\right) \frac{30.6 \text{ mg}}{175.53 \text{ FT}^3}$$

$$= 0.003 \text{ gr/SCF}$$

11) Particulate Concentrations, lb/FT^3

$$Cs = \frac{\left(\frac{1}{453600} \frac{lb}{mg}\right) mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600} \frac{lb}{mg}\right) 30.6 \text{ mg}}{175.53 \text{ FT}^3}$$

$$= 0.38 \times 10^{-6} \text{ lb/SCF}$$

12) Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60\ min}{hr}$$

$$= (0.38 \times 10^{-6}\ lb/SCF)\ (171{,}038\ SCFM)\ \frac{60\ min}{hr}$$

$$= 3.9\ lb/hr$$

13) Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{3.9\ lb/hr}{906.4 \times 10^{6}\ BTU/hr}$$

$$= .004\ lb/MBTU$$

14) % Isokinetic Sampling

$$I = \frac{Ts\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\Delta H}{13.6}\right)\right)}{\Theta\ \ Vs\ \ Ps\ \ An}$$

eq. 5-6

$$I = \frac{745.5\ (1.667)\left((0.00267)\ (403.6) + \frac{173.64}{529.1}\left(29.94 + \frac{3.56}{13.6}\right)\right)}{(180)\ (78.4)\ (29.91)\ (0.000325)}$$

$$= 99.54\%$$

15) NO_x Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ (NO)}{Md} \times Ws$$

$$= \frac{234}{10^6} \times \frac{30\ lb/lb\text{-}mole}{30.13\ lb/lb\text{-}mole} \times 797853\ \frac{lb}{hr}$$

$$= 185.9\ lb/hr$$

16) NO$_x$ Concentrations, lb/MBTU

$$\text{lb/MBTU} = \frac{\text{lb/hr}}{\text{Heat Input}}$$

$$= \frac{185.9}{906.4 \times 10^6 \text{ BTU/hr}}$$

$$\text{lb/MBTU} = \frac{0.21 \text{ lb}}{10^6 \text{ BTU}}$$

17) Stack Pressure

$$Ps = Pb - \frac{Pd}{13.6} = 29.94 - \frac{0.40'' \ H_2O}{13.6} = 29.91$$

18) Nozzle Area

$$An = \frac{\pi D^2}{4} = 0.785 \left(\frac{(0.244)}{12}\right)^2 = 3.25 \times 10^{-4} \text{ ft}^2$$

19) Stack Area

$$As = \pi D^2 = .785 \left(\frac{(102)}{12}\right)^2 = 56.7 \text{ FT}^2$$

20) Heat Input: 6343.3 gal/hr x 142,895 BTU/gal = 906.4 MBTU

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

Test No. B.H.S. 1, Stack 1 No. Runs 3

Name of Firm The United Illuminating Company

Location of Plant 10 Henry Street, Bridgeport, Connecticut

Type of Plant Steam Generating Station

Control Equipment Electrostatic Precipitator

Sampling Point Locations Stack

Pollutants Sampled Particulates, Nitrogen Oxides

Time of Particulate Test:

Run No. 1	Date 4/12/73	Begin 1402	End 1719
Run No. 2	Date 4/13/73	Begin 1300	End 1609
Run No. 3	Date 4/16/73	Begin 1326	End 1637

PARTICULATE EMISSION DATA

Run No.	1	2	3	
Kp = 85.48 $\frac{ft}{sec}\left(\frac{lb.}{lb\ mole\text{-}^{o}R}\right)^{1/2}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.783	0.783	0.783	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	1.26	1.25	1.24	
$\overline{Ts}$ = Average stack temp., ^{o}R	745.5	735.0	746.6	
Pb = Barometric pressure, "Hg Abs.	29.94	30.10	30.38	
Pd = Gas duct pressure, "H_2O	-0.40	-0.52	-0.48	
Ps = Absolute stack gas pressure, inches Hg	29.91	30.06	30.35	
Bws = % moisture in stack gas, by volume	9.8	9.7	10.0	
Md = Molecular weight of stack gas, dry	30.01	30.13	29.93	
Ms = Molecular weight of stack gas	28.83	28.95	28.74	

Run No.	1	2	3
Vs = Stack gas velocity, F.P.S.	78.4	76.9	76.9
% CO_2	11.33	11.85	10.09
% O_2	5.05	5.89	7.99
% CO	0.00	0.00	0.00
% N_2	83.62	82.26	81.92
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	403.6	400.5	366.6
Vm = Volume of dry gas sampled at meter conditions, FT^3	173.639	170.381	153.761
Vstd = Volume of dry gas sampled at STP, FT^3	175.53	175.29	154.85
Tm = Average dry gas meter temp., ^oR	529.1	522.5	537.8
ΔH = Average pressure drop across orifice, inches H_2O	3.56	3.46	2.75
θ = Total Sampling Time, min.	180	180	180
Dn = Nozzle dia., inches	0.244	0.244	0.242
An = Nozzle area, FT^2	0.000325	0.000325	0.000318
I = % of isokinetic sampling	99.54	99.37	90.58
Qs = Stack gas volume at STP (SCFM)	171,038	171,145	169,546
Qa = Stack gas volume at stack conditions (ACFM)	266,811	261,580	261,614
Ws = Stack gas mass flow lbs/hr	797,853	801,544	788,784
Mp = Particulate-probe, washings, mg	15.9	14.8	43.7
Mf = Particulate-filter (mg)	14.7	11.1	13.3
Mn = Particulate-total (mg)	30.6	25.9	57.0
C's = Particulate Concentrations gr/scf	0.003	0.002	0.006
Cw = Particulate total emission lb/hr	3.9	3.3	8.2
Er = Particulate emission rate, lb/106 BTU	0.004	0.004	0.009
C = NO, concentrations, PPM	234	219	167
Cn = NO, lb/10^6BTU	0.21	0.20	0.15

APPENDIX C

STACK SAMPLING: HARBOR STATION: UNIT #1

Test #1:

PARTICULATE wgt. ON filter: 14.7 mg

PARTICULATE wgt. IN WASHINGS: 15.9 mg

Total particulate wgt.: 30.6 mg

Test #2:

PARTICULATE wgt. ON filter: 11.1 mg

PARTICULATE wgt. IN WASHINGS: 14.8 mg

Total particulate wgt.: 25.9 mg

Test #3:

PARTICULATE wgt. ON filter: 13.3 mg

PARTICULATE wgt. IN WASHINGS: 43.7 mg

Total particulate wgt.: 57.0 mg

Gas Density

$$\text{Gas Density} = \frac{Md}{386\ FT^3} \times \frac{T_{std}}{T_s} \times \frac{P_{bar}}{P_{std}}$$

1) $$\text{Gas Density} = \frac{30.01}{386} \times \frac{530}{745.5} \times \frac{29.94}{29.92} =$$

$$= 0.055$$

2) $$\text{Gas Density} = \frac{30.13}{386} \times \frac{530}{735.0} \times \frac{30.10}{29.92} =$$

$$= 0.057$$

3) $$\text{Gas Density} = \frac{29.93}{386} \times \frac{530}{746.6} \times \frac{30.38}{29.92} =$$

$$= 0.056$$

Probe Measurements

CALCULATED DISTANCES

STACK DIAMETER = 102" = 8'-6"

1

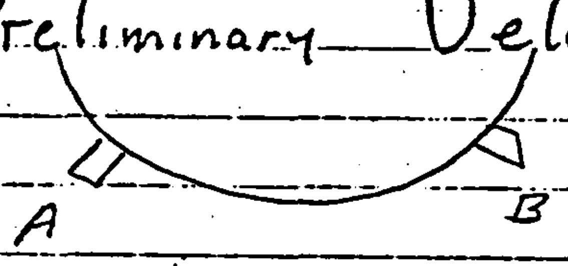
POINT	FACTOR	DISTANCE + NIPPLE	PROBE MARKINGS
1	1.4	1.43 + 36 =	37.4
2	4.4	4.5	40.5
3	7.5	7.7	43.7
4	10.9	11.1	47.1
5	14.6	14.9	50.9
6	18.8	19.2	55.2
7	23.6	24.1	60.1
8	29.6	30.2	66.2
9	38.2	39.0	75.0
10	61.8	63.0	99.0
11	70.4	71.8	107.8
12	76.4	77.9	113.9
13	81.0	82.8	118.8
14	85.4	87.1	123.1
15	89.1	90.9	126.9
16	92.5	94.4	130.4
17	95.6	97.5	133.5
18	98.6	100.6	136.6

37.4 inches is distance from center of pitot tube to first mark on probe, accounting for 36" long sampling port nipple

60-265

244.

Preliminary Velocity Traverse



127 1/2
25 1/2
102"

STACK PRESS -0.75" H_2O

Point	Factor		+ A			B
1	1.4	1.43' 25.5 -	26.9	1.5	1.4	1.3
2	4.4	4.44	30.0	1.4	1.5	1.4
3	7.5	7.55	33.1	1.4	1.3	1.4
4	10.9	11.0	36.5	1.4	1.3	1.5
5	14.6	14.7	40.2	1.4	1.3	1.5
6	18.8	19.0	44.5	1.3	1.3	1.5
7	23.6	23.8	49.3'	1.4	1.3	1.4
8	29.6	29.9	55.4	1.4	1.3	1.4
9	38.2	38.5	64.0	1.6	1.5	1.4
10	61.8	62.3	87.8	1.6	1.5	1.5
11	70.4	71.0	96.5	1.7	1.6	1.6
12	76.4	77.0	102.5	1.7	1.7	1.6
13	81.2	82.0	107.5	1.6	1.7	1.6
14	85.4	86.0	111.5	1.6	1.7	1.5
15	89.1	90.0	115.5	1.6	1.6	1.5
16	92.5	93.4	118.9	1.6	1.6	1.5
17	95.6	96.5	122.0	1.5	1.5	1.4
18	98.6	99.5	125.0	1.5	1.5	1.3

PARTICULATE FIELD DATA

Stack Identification Number 1

Boiler Number 1

Plant Hacker Station

Run No. 1

Location Stack

Date 4-12-73

Operator [illegible]

Meter Δ H 1.82

C Factor .77 .76

Ambient Temp °F 40

Bar. Press. "Hg 29.14 - 29.94

Assumed Moisture % 12

Heater Box Setting, °F 275

Probe Tip Dia., In. .244

Probe Length 12'

Probe Heater Setting 80%

Avg $\sqrt{\Delta P}$ 1.26 Avg. Δ H 3.56

Stack Pressure - 0.40" H_2O

% Isokinetic 99.5

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
1	1402	387.303	1.1	2.6	2.6	55	66	9.5	240	50	1.05	[illegible]
2	1407	[illegible]	1.3	3.0	[illegible]	62	66	9.5	[illegible]	55	1.14	[illegible]
3	[illegible]	395.87	1.3	3.0	[illegible]	[illegible]	[illegible]	9.5	[illegible]	[illegible]	1.14	[illegible]
4	1417	[illegible]	1.3	3.0	3.0	[illegible]	[illegible]	10	260	50	1.14	[illegible]
5	[illegible]	[illegible]	1.4	3.1	3.1	55	[illegible]	10	290	50	1.18	[illegible]
6	[illegible]	409.00	1.35	2.95	[illegible]	54	[illegible]	10	[illegible]	50	1.16	258
7	[illegible]	413.45	1.4	3.1	3.1	52	[illegible]	10	245	[illegible]	1.18	257
8	[illegible]	417.95	1.45	3.15	[illegible]	[illegible]	[illegible]	16	270	[illegible]	1.20	[illegible]
9	[illegible]	[illegible]	1.5	[illegible]	[illegible]	[illegible]	[illegible]	12	[illegible]	[illegible]	1.22	[illegible]
10	[illegible]	[illegible]	1.7	3.8	[illegible]	[illegible]	[illegible]	13.5	[illegible]	50	1.30	[illegible]
11	1452	[illegible]	1.8	3.95	[illegible]	[illegible]	58	14.0	[illegible]	[illegible]	[illegible]	[illegible]
12	1457	[illegible]	1.9	4.2	[illegible]	58	59	15.0	[illegible]	50	1.33	[illegible]
13	1502	[illegible]	2.0	[illegible]	[illegible]	[illegible]	[illegible]	15.5	[illegible]	[illegible]	1.41	[illegible]
[illegible]	[illegible]	447.70	2.0	4.35	4.35	56	61	[illegible]	[illegible]	50	1.41	285
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	1.41	256
16	1517	[illegible]	2.0	4.35	4.35	83	61	[illegible]	[illegible]	[illegible]	1.41	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
17	[illegible]	463.65	1.9	4.2	4.2	[illegible]	61	16	[illegible]	50	1.38	[illegible]
12	[illegible]	468.20	1.7	4.2	[illegible]	[illegible]	[illegible]		[illegible]	50	1.38	[illegible]
stop	[illegible]	[illegible]									1.10	[illegible]
1	1542	[illegible]	1.2	2.6	2.6	[illegible]	57	9	[illegible]	[illegible]	1.18	[illegible]
2	[illegible]	476.44	1.4	3.1	3.1	[illegible]	[illegible]	10	[illegible]	[illegible]	1.18	28[illegible]
3	[illegible]	[illegible]	1.4	3.1	3.1	50	[illegible]	10	[illegible]	[illegible]	1.26	280
4	[illegible]	487.44	1.6	3.5	3.5	[illegible]	57	11	[illegible]	[illegible]	1.30	[illegible]
5	[illegible]	492.20	1.7	3.7	3.7	84	57	13	[illegible]	50	1.30	[illegible]
6	[illegible]	[illegible]	1.7	3.7	3.7	[illegible]	60	13	[illegible]	50	1.30	[illegible]
7	[illegible]	502.16	1.7	3.7	3.7	89	61	13	[illegible]	50	1.30	[illegible]
8	[illegible]	507.10	1.7	[illegible]	3.7	[illegible]	[illegible]	13	[illegible]	50	1.26	[illegible]
9	[illegible]	513.10	1.6	3.5	3.5	50	60	12.5	[illegible]	50	1.30	[illegible]
10	[illegible]	517.00	1.7	3.7	3.7	[illegible]	[illegible]	13	250	50	1.30	[illegible]
11	[illegible]	521.12	1.7	3.7	3.7	[illegible]	57	13	[illegible]	50	1.30	[illegible]
[illegible]	[illegible]	526.20	1.7	3.7	3.7	82	59	13	[illegible]	50	1.30	[illegible]
[illegible]	1649	531.83	1.7	3.7	3.7	78	[illegible]	13	[illegible]	50	1.30	[illegible]
16	[illegible]	[illegible]	1.7	[illegible]	[illegible]	78	59	13	[illegible]	[illegible]	1.34	[illegible]
[illegible]	1659	541.24	1.8	[illegible]	3.7	[illegible]	[illegible]		[illegible]	50	1.30	2[illegible]
[illegible]	1704	546.77	1.7	3.7	3.7	52	57	13	[illegible]	50	1.26	[illegible]
[illegible]	1709	551.79	1.6	3.5	3.5	[illegible]	[illegible]	12	[illegible]	50	1.18	[illegible]
12	1714	556.60	1.4	3.1	3.1	76	59	11	[illegible]			
stop	1717	561.1[illegible]										
		193.639		3.56		80.36	54.77				1.26	285

BHS # 1 TEST 1

WEIGHT OF PARTICULATE COLLECTED
mg

Container Number 16	Final Weight	Tare Weight	Weight Gain
1 Filter 2 Washings Total	.6171	.6318	.0147

VOLUME OF LIQUID WATER COLLECTED
ml

Impinger	1	2	3	4
Final Vol.	292	224	29	
Initial Vol.	100	100	0	
Liquid Collected	192	124	29	58.6 ~~ml~~ g 403.6 ml

Unit 1 4-12-73

RUN # 1

199.5
37.0
162.5
196.1
358.6

233.1
37.0
196.1

22
192
124
29
58.6
403.6

Test #1 : HARBOR 4/23

Filter : (#16) 0.6318
0.6171
0.0147 mg

DISH : (#7) 66.1601
66.1492
0.0109 mg

PATCHES : (#10) 0.3710
0.3689
0.0021

(#9) 0.3719
0.3690
0.0029

WASHINGS : 10.9
2.1
2.9
15.9 mg

TOTAL : 15.9
14.7
30.6 mg

PARTICULATE FIELD DATA

Stack Identification Number ______

Boiler Number 1

Plant BHS

Run No. 2

Location Stack

Date 4-13-73

Operator J Sambati

Meter Δ H 1.82

C Factor .76

Ambient Temp °F 44

Bar. Press. "Hg 30.12 - 30.07

Assumed Moisture % 10

Heater Box Setting, °F 275

Probe Tip Dia., In. .25

Probe Length 12'

Probe Heater Setting 70%

Avg. $\sqrt{\Delta P}$ 1.25 Avg. Δ H 3.46

Stack Pressure -0.52" H2O

% Isokinetic ______

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
1	1300	[illegible]	1.15	2.5	2.5	44	41	4	275	50	1.07	[illegible]
2	1305	570.37	1.25	2.7	2.7	60	45	4.2	[illegible]	50	1.12	[illegible]
3	1310	574.52	1.3	2.9	2.9	61	46	4.2	250	50	1.14	265
4	1315	578.71	1.35	3.0	3.0	66	46	4.5	270	50	1.16	[illegible]
5	1320	583.90	1.35	3.0	3.0	65	46	4.5	260	50	1.16	270
6	1325	587.62	1.35	3.0	3.0	70	50	4.7	265	50	1.16	272
7	1330	[illegible]	1.35	3.0	3.0	71	51	4.8	[illegible]	50	1.16	[illegible]
[illegible]	[illegible]	[illegible].42	1.35	[illegible]	3.0	71	52	[illegible]	260	50	1.16	271
[illegible]	[illegible]	600.55	1.5	3.27	3.27	72	[illegible]	4.9	260	50	1.22	271
[illegible]	[illegible]	605.13	1.7	3.8	3.8	74	[illegible]	5.8	260	50	1.30	272
11	[illegible]	610.38	1.7	3.8	3.8	78	55	5.5	260	50	[illegible]	270
12	1355	615.33	1.8	3.9	3.9	74	[illegible]	6.0	[illegible]	50	1.34	[illegible]
13	[illegible]	620.31	1.85	4.0	4.0	72	56	6.2	260	50	1.36	[illegible]
14	[illegible]	[illegible]	1.85	4.0	[illegible]	[illegible]	[illegible]	6.3	[illegible]	50	1.36	273
[illegible]	[illegible]	[illegible]	1.85	[illegible]	4.0	72	55	6.2	260	50	1.36	271
[illegible]	1415	635.62	1.85	4.0	4.0	72	54	6.2	260	50	1.36	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
17	[illegible]	[illegible]0.71	1.7	[illegible]	[illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]	1.30	[illegible]
18	[illegible]	[illegible]	1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.22	[illegible]
[illegible]	[illegible]	[illegible]										
1	[illegible]	[illegible]	1.1	2.4	[illegible]		[illegible]		[illegible]	[illegible]	1.05	[illegible]
2	[illegible]	[illegible]	1.4	3.1	3.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.18	[illegible]
3	[illegible]	[illegible]	1.5	3.25	3.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.22	[illegible]
4	[illegible]	[illegible]	1.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	1.26	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	[illegible]	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.7	[illegible]	[illegible]	[illegible]	54	6.0	[illegible]	[illegible]	1.30	[illegible]
7	[illegible]	[illegible]	1.7	3.8	[illegible]	73	54	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	[illegible]	6.0	[illegible]	[illegible]	1.30	280
[illegible]	[illegible]	[illegible]	1.7	[illegible]	3.8	[illegible]	56	6.0	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.6	3.5	3.5	[illegible]	[illegible]	6.0	[illegible]	50	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	3.8	[illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.7	3.8	3.8	75	56	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.7	[illegible]	[illegible]	[illegible]	57	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	212.56	1.7	[illegible]	[illegible]	[illegible]	57	6.0	250	50	1.30	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.2	250	50	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.5	3.25	3.25	[illegible]	[illegible]	5.5	[illegible]	[illegible]	1.22	[illegible]
[illegible]	[illegible]	232.10	1.4	3.1	3.1	[illegible]	[illegible]	5.5	[illegible]	[illegible]	1.18	[illegible]
STOPS	[illegible]	736.[illegible]										
		170.[illegible]		3.4[illegible]		71.6	53.3				1.25	295

RHS 1, TEST 2, 4/13/73

WEIGHT OF PARTICULATE COLLECTED mg			
Container Number 18	Final Weight	Tare Weight	Weight Gain
1 Filter 2 Washings Total	.6320	.6209	0.0111

VOLUME OF LIQUID WATER COLLECTED ml				
Impinger	1	2	3	4
Final Vol.	323	201	22	454.5
Initial Vol.	100	100	0	400
Liquid Collected	223	101	22	54.5 ml
			TOTAL	400.5

Run #2 4-13-73
Patches ~~2~~ 11,12

TEST #2 : HARBOR 4/23

Filter (#18):

0.6320
0.6209

0.0111 mg

WASHINGS: DISH (#X):

60.9799
60.9714

— 0.0085 mg

PATCHES: (#11)

0.3423
0.3384

0.0039 mg

(#12)

0.3418
0.3394

0.0024

WASHINGS:

8.5
3.9
2.4

14.8 mg

TOTAL:

14.8
11.1

25.9 mg

PARTICULATE FIELD DATA

Stack Identification Number ____________

Boiler Number 1

Plant BHS

Run No. 3

Location Stack

Date 4-16-73

Operator J. Sorrbati

Meter Δ H 1.82

C Factor .78

Ambient Temp °F 64

Bar. Press. "Hg 30.38 - 30.38

Assumed Moisture % 10

Heater Box Setting, °F 300

Probe Tip Dia., In. .242

Probe Length 12'

Probe Heater Setting 85%

Avg. Δ P 1.24 Avg. Δ H 2.75

Stack Pressure −0.13" H_2O

% Isokinetic ____________

Port	Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
A	1	1326	737.03	1.15	2.4	2.4	66	64	16.5	260	50	1.07	[illegible]
	2	1331	740.97	1.25	2.65	2.65	75	64	18.2	250	50	1.12	[illegible]
	3	1336	745.09	1.3	2.75	2.75	88	66	21.0	250	50	1.14	[illegible]
	4	1341	749.[illegible]	1.35	2.8	2.8	92	68	22.5	[illegible]	50	1.16	[illegible]
	5	[illegible]	753.14	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.18	[illegible]
	6	1351	757.17	1.4	[illegible]	[illegible]	91	72	[illegible]	255	50	1.18	[illegible]
	7	1356	762.31	1.4	2.9	2.9	92	72	22.0	261	50	1.15	[illegible]
	8	1401	766.71	1.4	2.9	2.9	92	72	22.2	255	50	1.18	[illegible]
	9	1406	771.04	1.5	3.15	2.9	95	73	22.2	[illegible]	50	1.22	[illegible]
	10	1411	775.[illegible]	1.7	3.6	2.9	94	73	[illegible]	265	50	1.30	[illegible]
	11	[illegible]	777.87	1.75	3.7	[illegible]	[illegible]	72	[illegible]	258	50	1.32	[illegible]
	12	1421	[illegible].93	1.75	3.7	[illegible]	[illegible]	[illegible]	[illegible]	266	50	1.32	[illegible]
	13	1426	78[illegible].57	1.75	3.7	2.8	90	73	22.4	[illegible]	50	1.32	[illegible]
	14	1431	[illegible]	1.8	3.8	2.9	90	73	22.2	[illegible]	50	1.34	[illegible]
	15	[illegible]	797.35	1.8	[illegible]	[illegible]	[illegible]	73	[illegible]	[illegible]	[illegible]	1.34	[illegible]
	16	1441	801.75	1.8	3.8	2.7	90	72	22.0	[illegible]	50	1.34	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
12	1446	[illegible]	1.65	[illegible]	[illegible]	91	72	[illegible]			1.29	[illegible]
12	1451	[illegible]	1.4	[illegible]			72	[illegible]			1.18	[illegible]
	[illegible]	814.89	—	—						—	—	—
1	[illegible]	814.??	1.1	[illegible]					[illegible]		1.05	[illegible]
2	[illegible]	819.3?	[illegible]	2.78	[illegible]	76	[illegible]	[illegible]			1.11	[illegible]
[illegible]	[illegible]	[illegible]	1.1	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.18	[illegible]
[illegible]	[illegible]	[illegible]	1.5	3.1	2.8		[illegible]	[illegible]	[illegible]	[illegible]	1.2?	[illegible]
[illegible]	[illegible]	832.16	1.6	3.4	2.7	[illegible]	69	22.5	300	50	1.26	[illegible]
[illegible]	[illegible]	836.55	1.6	3.4	2.6	55	66	22.5	300	[illegible]	1.26	[illegible]
[illegible]	[illegible]	840.?0	1.6	3.4	2.6	55	[illegible]	22.5	[illegible]	[illegible]	1.26	[illegible]
[illegible]	[illegible]	844.67	1.6	3.4	2.6	56	[illegible]	[illegible]	[illegible]	[illegible]	1.26	[illegible]
[illegible]	[illegible]	[illegible]	1.6	3.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	1.26	[illegible]
[illegible]	[illegible]	853.03	1.7	3.6	[illegible]	56	[illegible]	[illegible]	[illegible]	50	1.30	[illegible]
[illegible]	[illegible]	857.20	1.7	3.6	[illegible]		[illegible]	[illegible]	[illegible]	50	1.30	[illegible]
[illegible]	1502	861.??	1.7	3.6	[illegible]	56	[illegible]	[illegible]	[illegible]	50	1.30	[illegible]
[illegible]	1507	865.58	1.8	3.8	2.6	55	68	22.?	[illegible]	50	1.34	[illegible]
[illegible]	[illegible]	[illegible]	1.7	3.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	1.30	[illegible]
[illegible]	[illegible]	[illegible]	1.8	3.8	[illegible]	[illegible]	[illegible]	[illegible]	270	[illegible]	1.34	[illegible]
[illegible]	[illegible]	878.??	1.7	3.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.30	[illegible]
[illegible]	[illegible]	882.51	1.6	[illegible]	[illegible]	[illegible]	68	22.5	270	50	1.26	[illegible]
[illegible]	[illegible]	886.60	1.25	2.63	2.6	[illegible]	[illegible]	[illegible]	270	60	1.12	270
	[illegible]	890.791										
		155.261		3.26	2.75	56.3	69.3				1.34	[illegible]

BHS 1, TEST 3 4/16/73

WEIGHT OF PARTICULATE COLLECTED
mg

Container Number # 9	Final Weight	Tare Weight	Weight Gain
1 Filter # 2 Washings Total	.6176	.6043	0.0133 g

VOLUME OF LIQUID WATER COLLECTED
ml

Impinger Final Vol. Initial Vol. Liquid Collected	1	2	3	4
	298 100 198	187 100 87	23 0 23	58.6 ml 366.6

Patches 13, 14

TEST 3: HARBOR 1 4/73

FILTER: (#9) 0.6176
0.6043
0.0133 mg

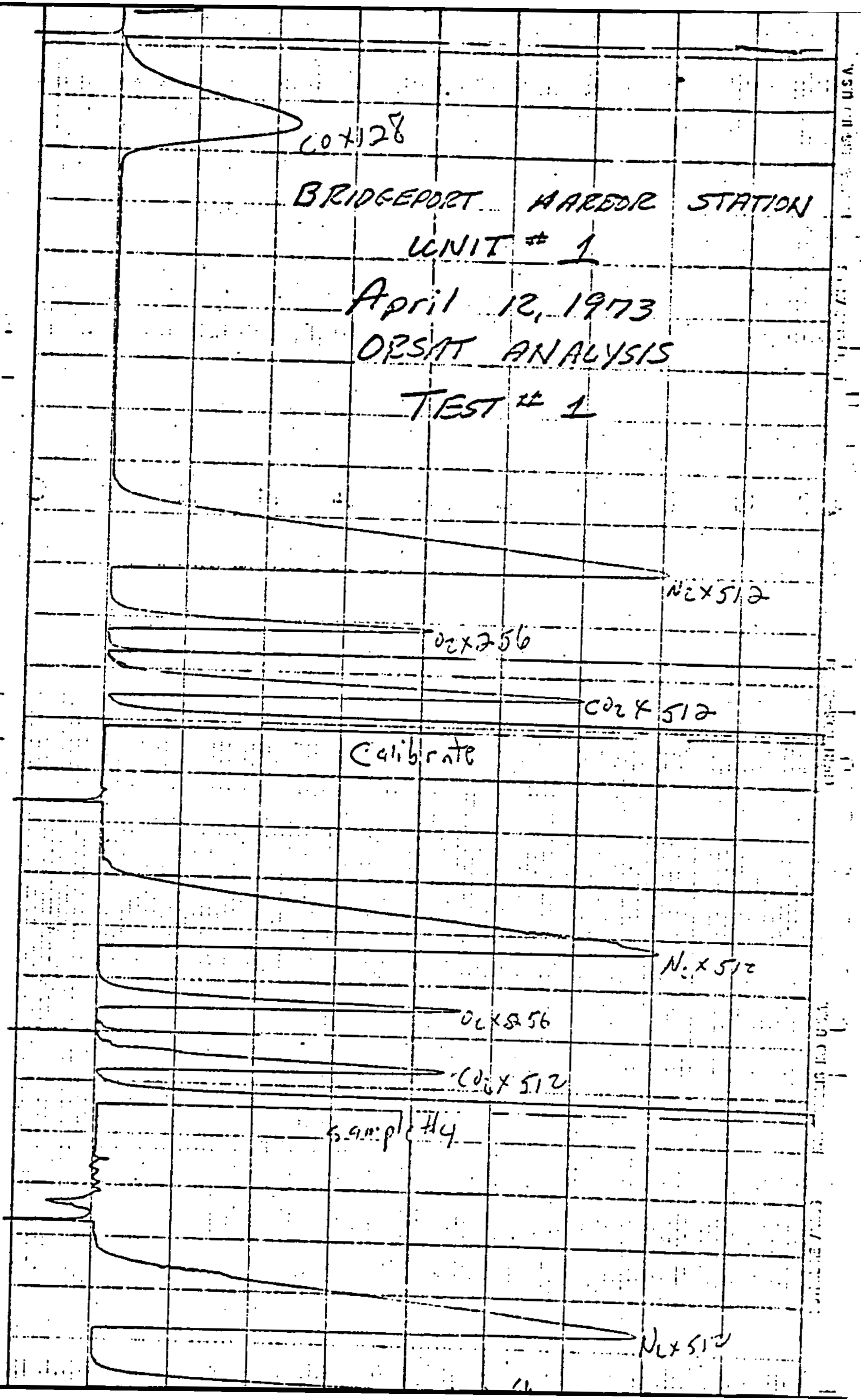
WASHINGS: DISH (#10) 63.1310
63.0998
0.0312 mg

PATCHES: (#13) 0.3597
0.3551
0.0046

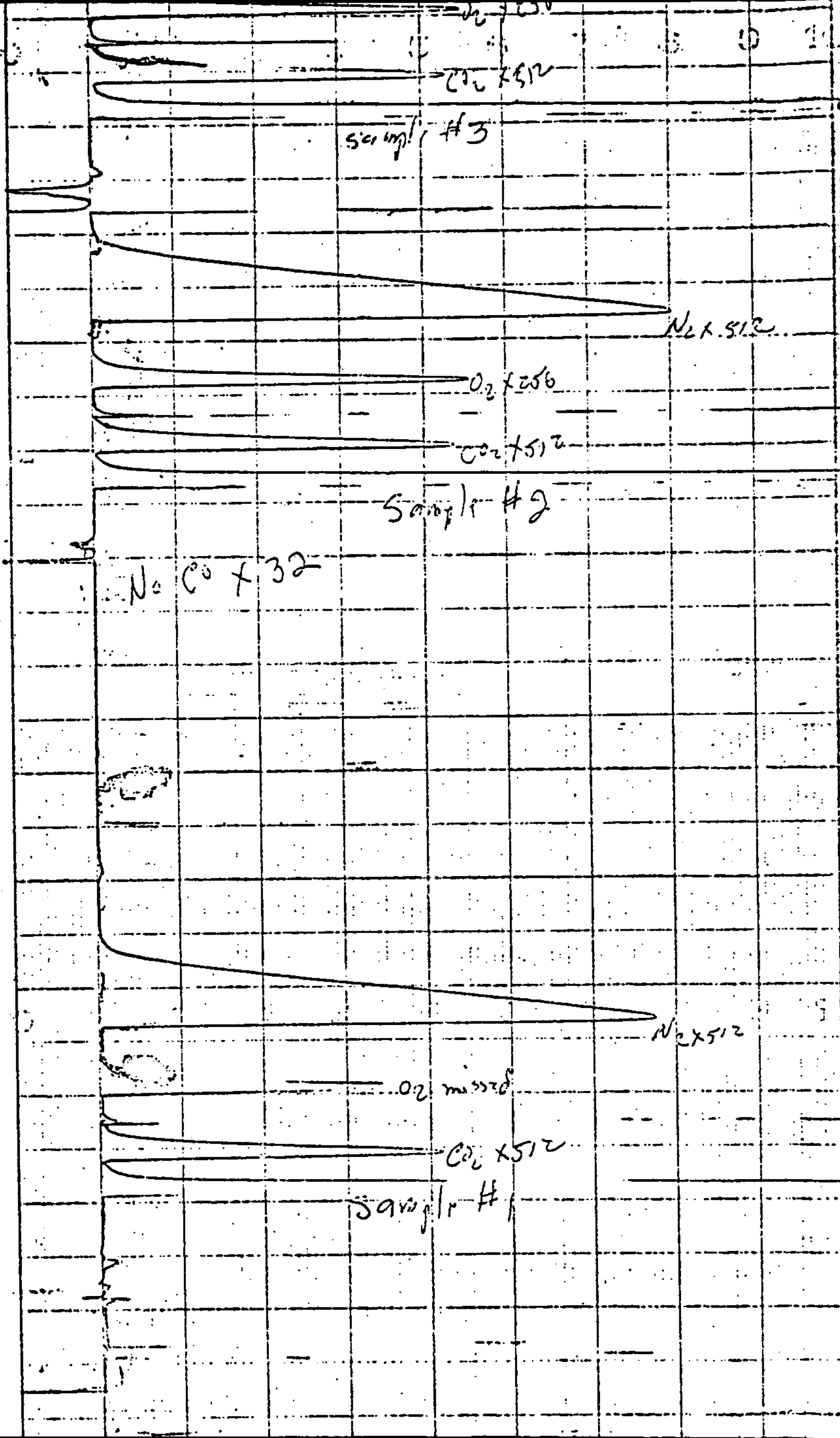
(#14) 0.3512
0.3433
0.0079

WASHINGS: 31.2
4.6
7.9
43.7 mg

TOTAL: 43.7
13.3
57.0



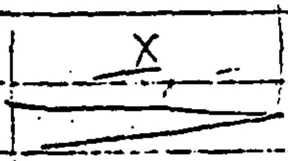
CO x 128
BRIDGEPORT HARBOR STATION
UNIT # 1
April 12, 1973
ORSAT ANALYSIS
TEST # 1
N2 x 512
O2 x 256
CO2 x 512
Calibrate
N2 x 512
O2 x 256
CO2 x 512
sample #4
N2 x 512



CO2 x512
sample #3
N2 x 512
O2 x 256
CO2 x512
Sample #2
No CO x 32
N2 x512
O2 missed
CO2 x512
Sample #1

TEST 1

ORSAT ANALYSIS



14 =

$\frac{3'' \times 25.4 \text{ mm/in}}{2} = \frac{76.2 \text{ mm}}{2}$ [illegible]

$= 1.5 \times 25.4 =$ [illegible]

0 [illegible] 25.4 = 7.2 mm [illegible]

$\frac{16.3}{18} = \frac{y}{14.2}$

$CO_2 = 15.9\%$ 60.0

$CO = 6.6\%$

$O_2 = 4.6\%$ 41.0

$CO_2 : \frac{41.5 + 43.5 + 43.5 + 42.5}{4} = 42.75$

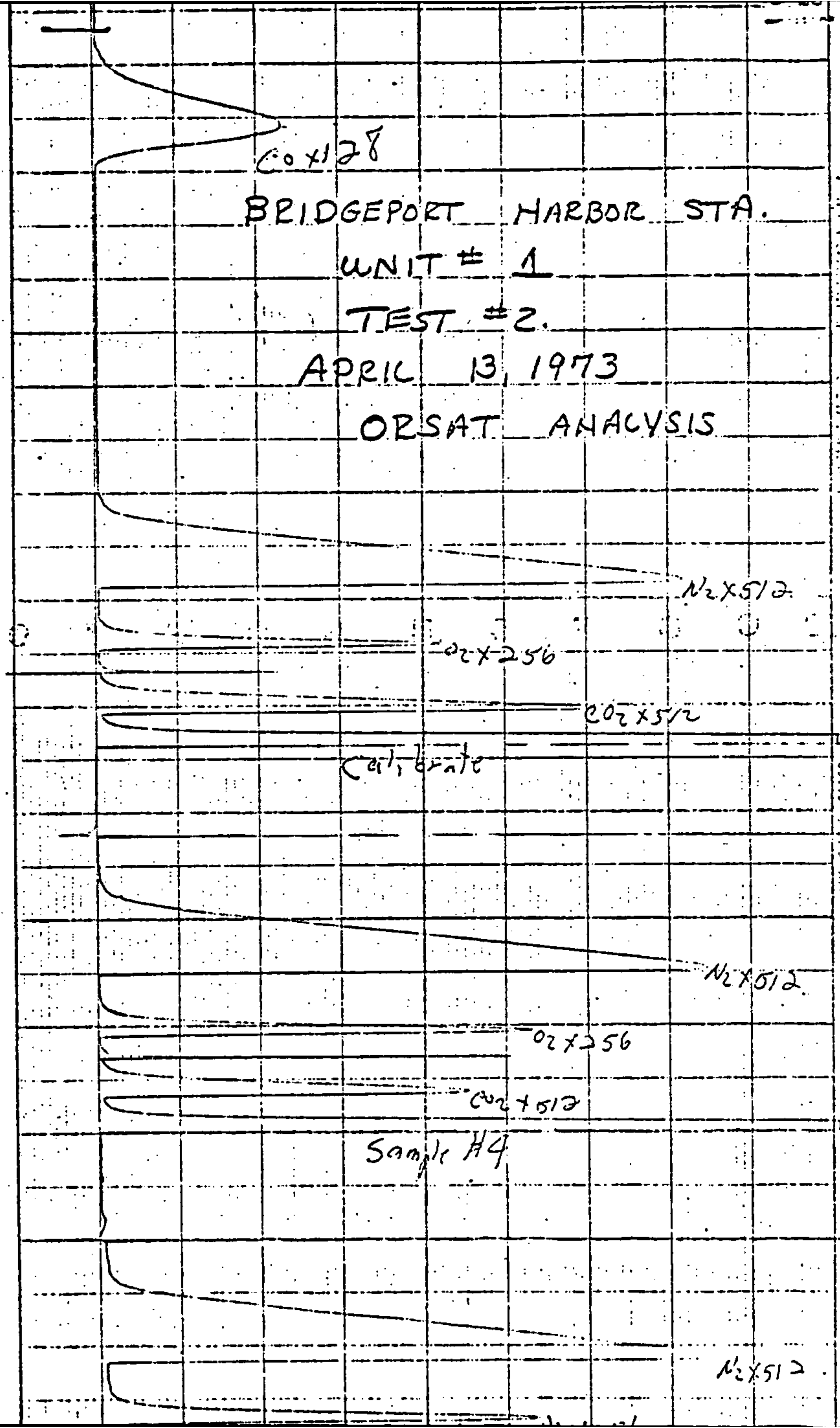
$O_2 : \frac{45.5 + 44.0 + 45.5}{3} = 45.0$

$O_2 \quad \frac{4.6}{4.1} \quad \frac{X}{45} = 5.05 \; O_2$

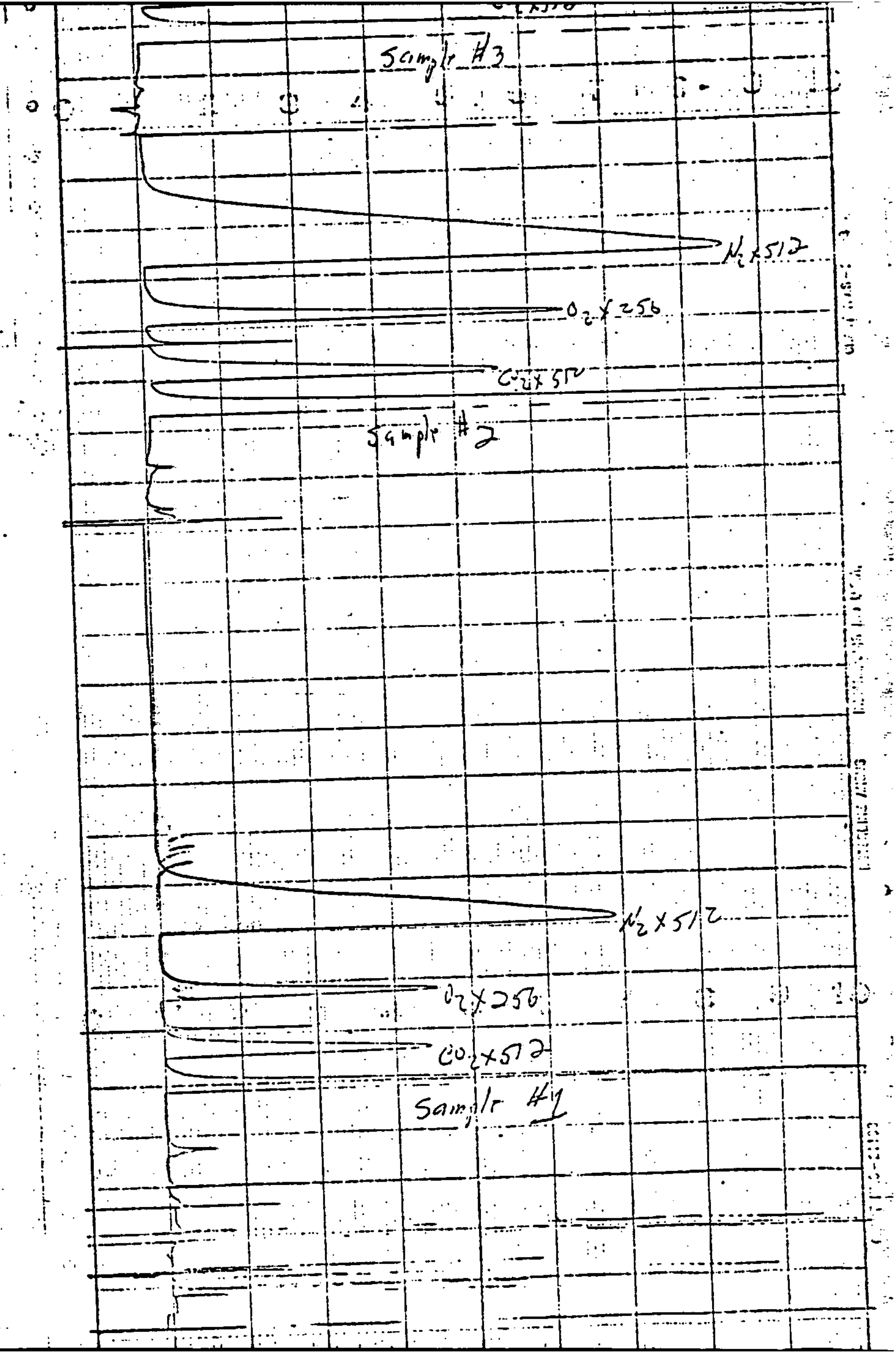
$CO_2 \quad \frac{15.9}{60} = \frac{X}{42.75} = 11.33$

$$\begin{array}{r} 5.05 \\ 11.33 \\ \hline 16.38 \end{array}$$

$N_2 = 83.62$



Co x128
BRIDGEPORT HARBOR STA.
UNIT # 1
TEST #2.
APRIL 13, 1973
ORSAT ANALYSIS
N2 x512
O2 x256
CO2 x512
Calibrate
N2 x512
O2 x256
CO2 x512
Sample #4
N2 x512


Sample #3
$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
Sample #2
$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
Sample #1

BHS. #1

TEST 2

ORSAT ANALYSIS

CALIBRATION

CO_2 : 60 DIVISIONS, 15.9%

O_2 : 41.5 4.6%

TEST DATA: SAMPLES 2, 3, & 4

CO_2: $\frac{44.5 + 45 + 44.5}{3} = 44.67$

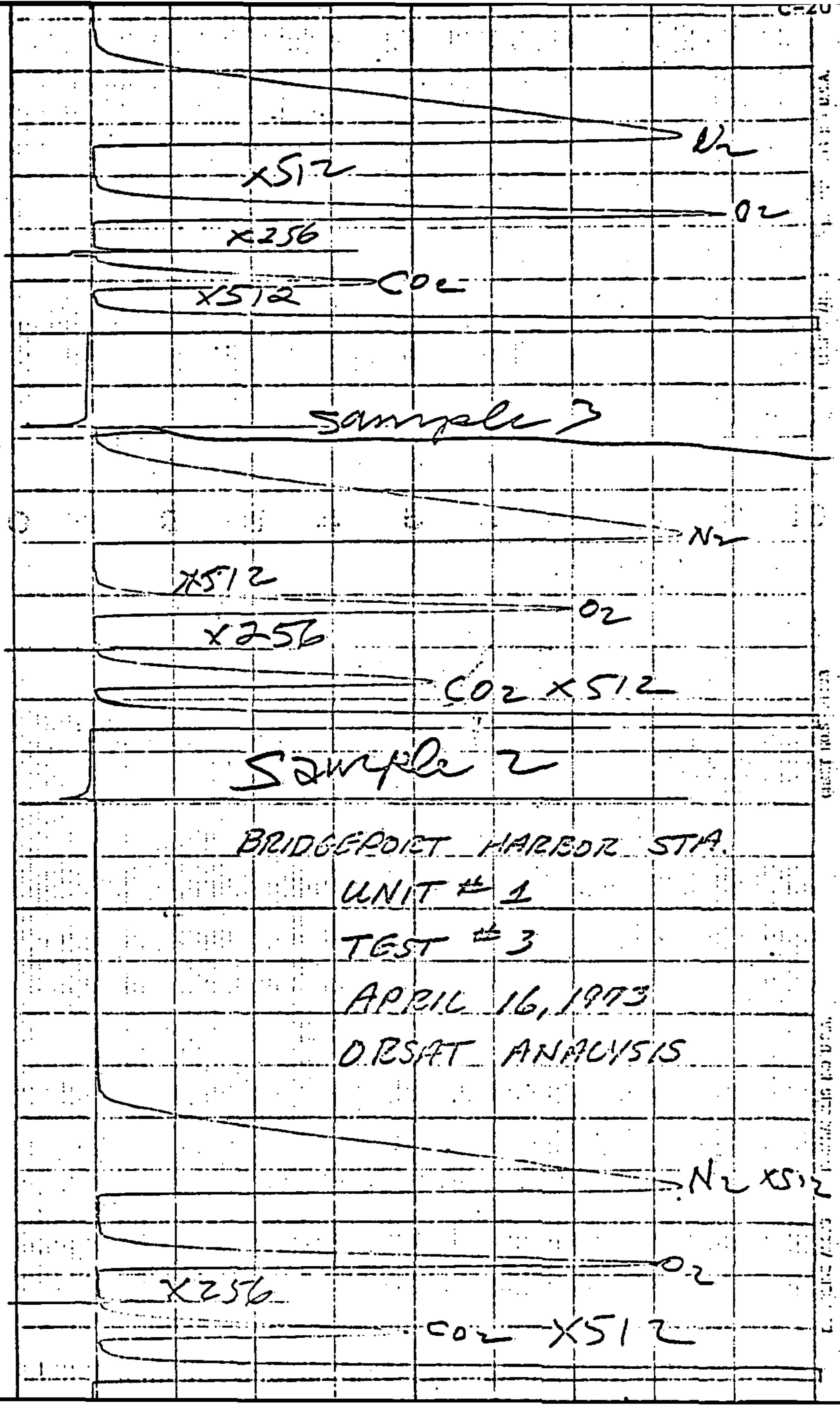
O_2: $\frac{54 + 52.5 + 53}{3} = 53.16$

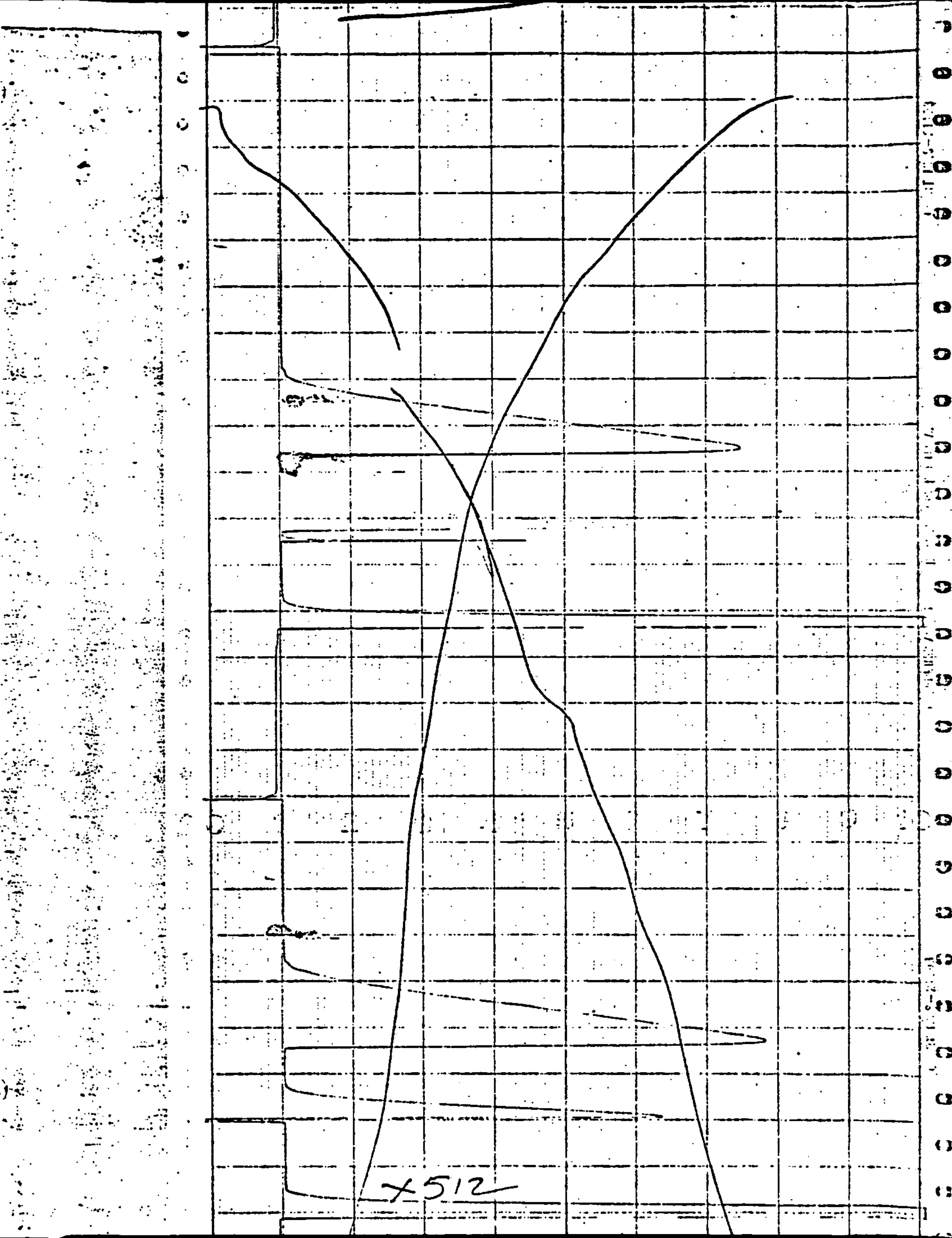
CO_2 $\frac{15.9}{60} = \frac{X}{44.7} = 11.85$

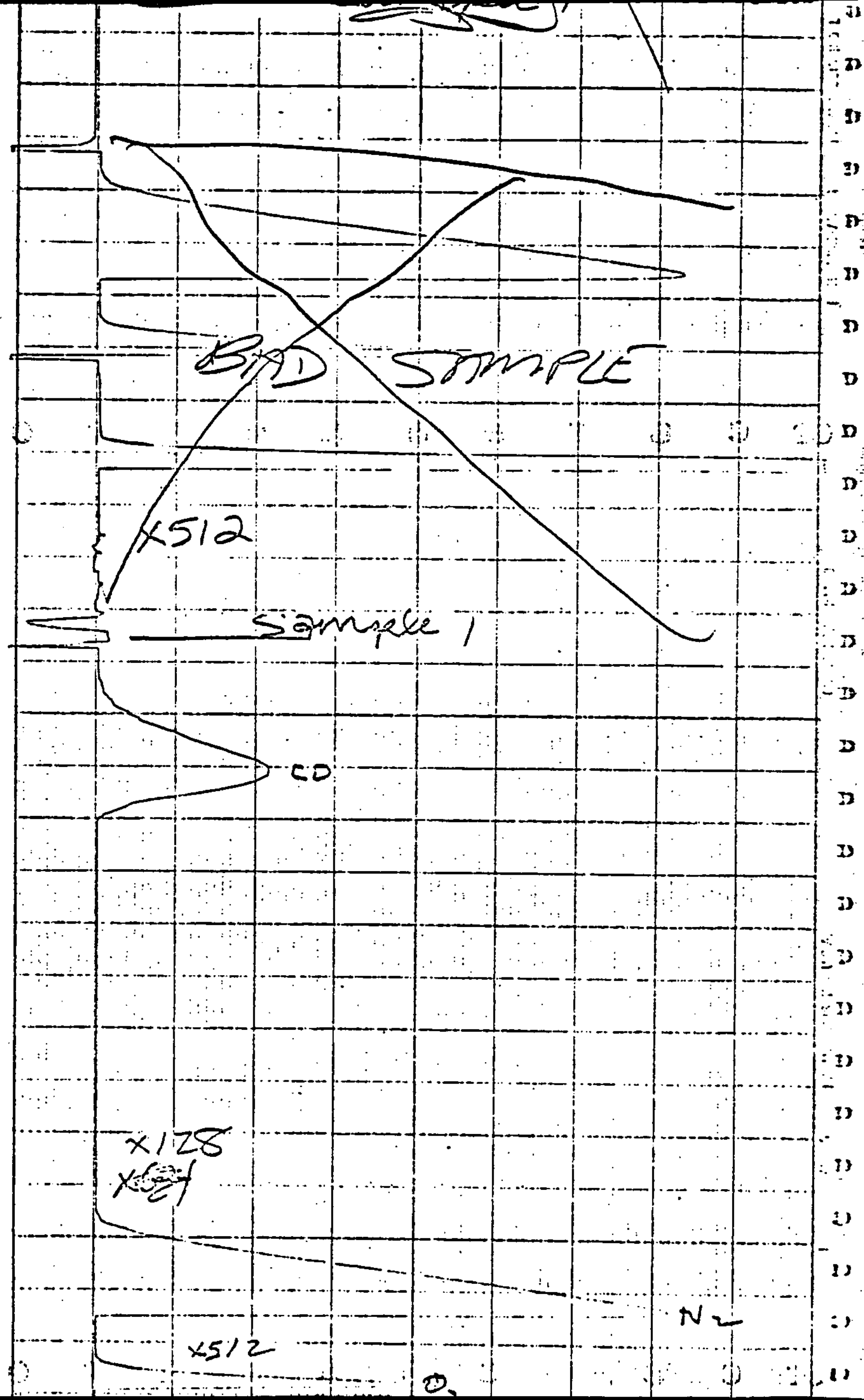
O_2 $\frac{4.6}{41.5} = \frac{X}{53.16} = 5.89$

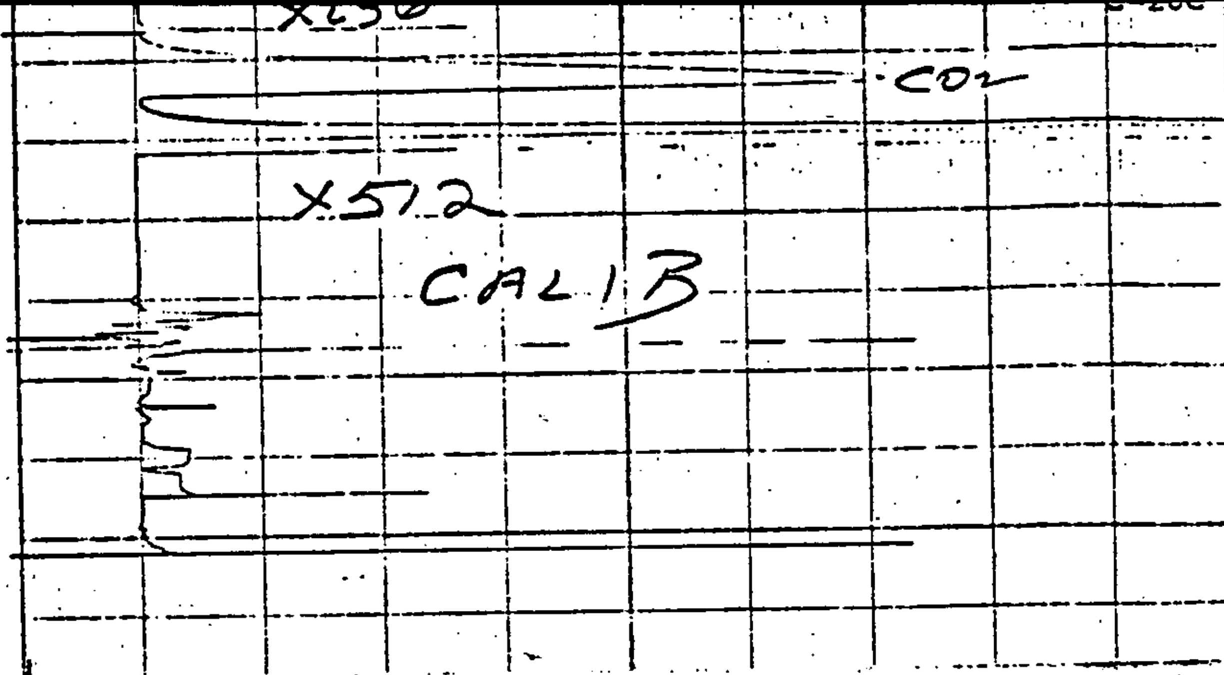
17.74

$N_2 = 100 - 17.74 = 82.26$


C-20
N_2
X512
O_2
X256
CO_2
X512
Sample 3
N_2
X512
O_2
X256
CO_2 X512
Sample 2
BRIDGEPORT HARBOR STA.
UNIT #1
TEST #3
APRIL 16, 1973
ORSAT ANALYSIS
N_2 X512
O_2
X256
CO_2 X512


x512


BAD SAMPLE
X512
Sample 1
CO
X128
N2
x512
O2


CO2
X512
CALIB

BHS # 1

TEST # 3

ORSAT ANALYSIS

CALIBRATION

CO_2	15.9%	61
O_2	4.6%	40

TEST DATA

CO_2 $\quad \dfrac{38.5 + 42 + 35.5}{3} = 38.7$

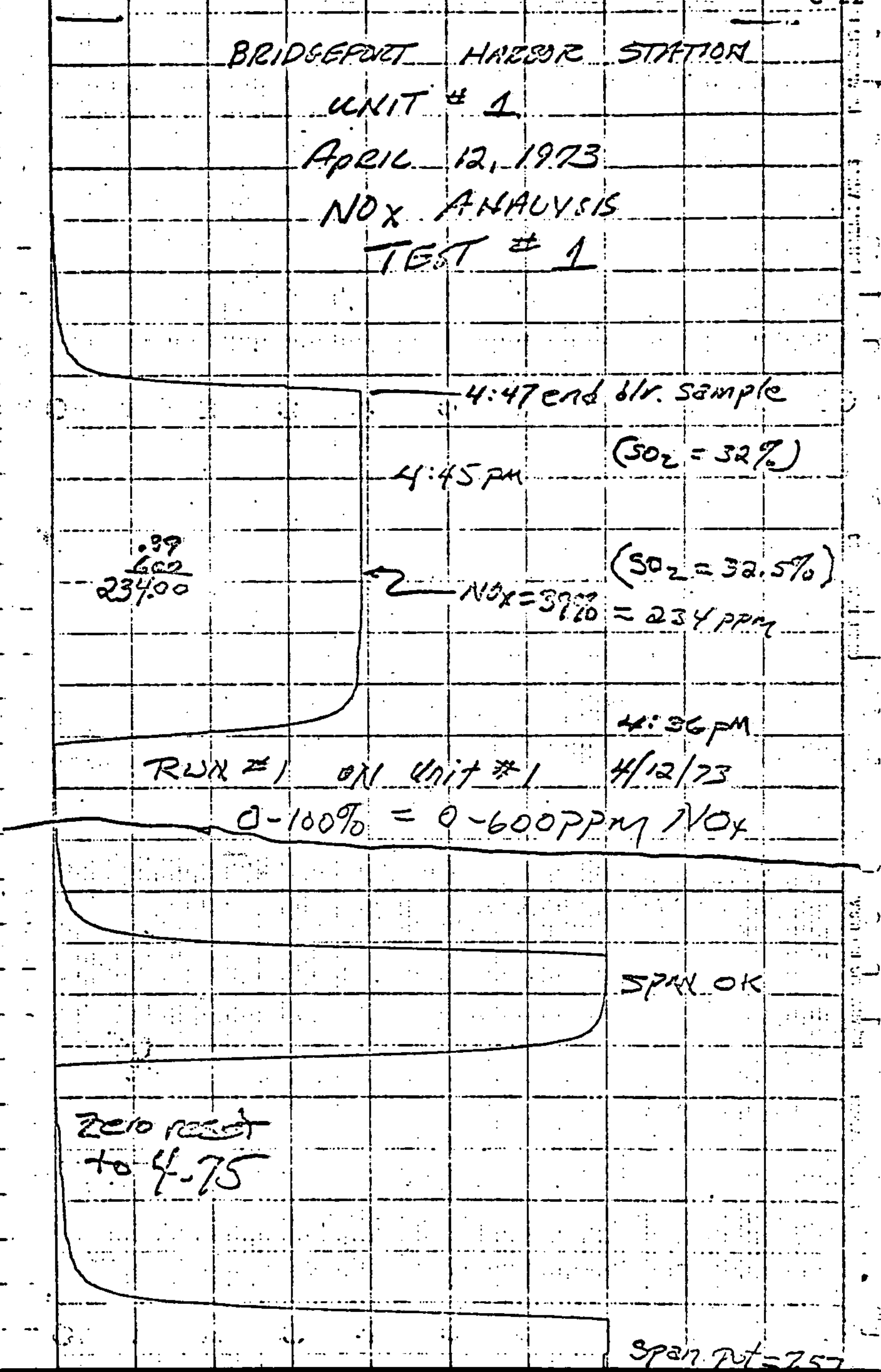
O_2 $\quad \dfrac{70.5 + 59.5 + 78.5}{3} = 69.5$

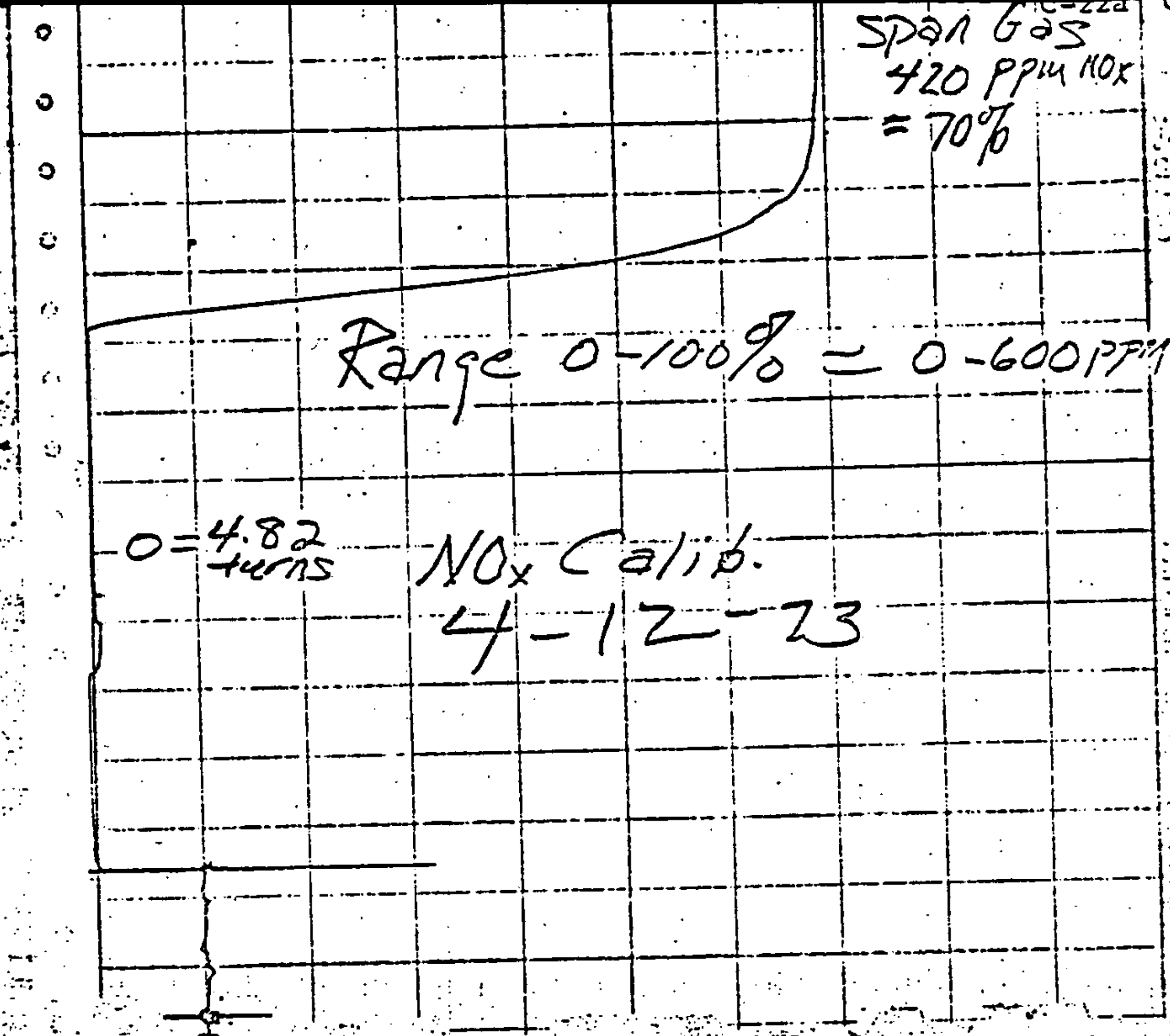
CO_2 $\quad \dfrac{15.9}{61} = \dfrac{X}{38.7} \qquad X = 10.09$

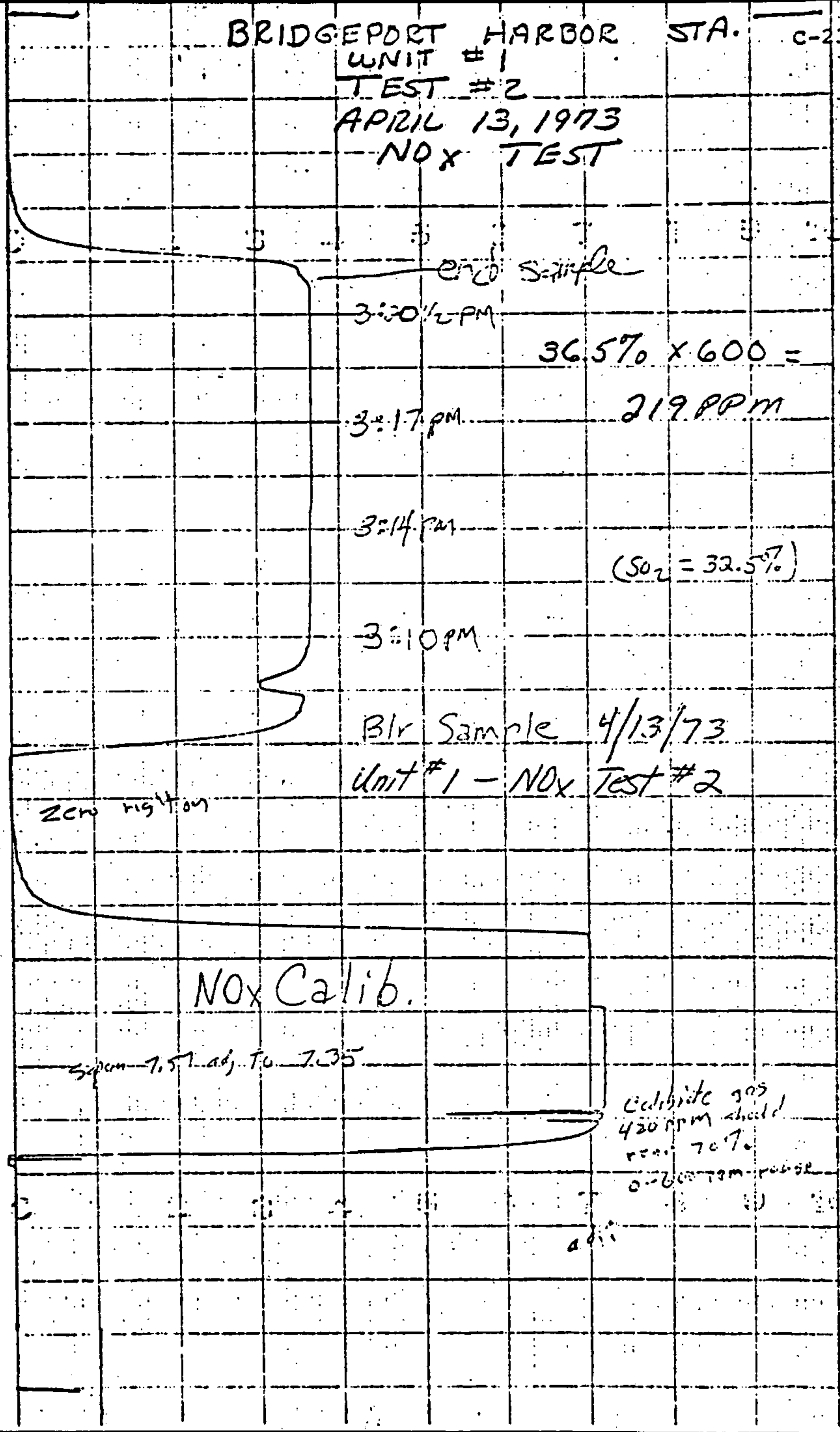
O_2 $\quad \dfrac{4.6}{40} = \dfrac{X}{69.5} \qquad 7.99$

18.08

$N_2 = 100 - 18.08 = 81.92$


BRIDGEPORT HARBOR STATION
UNIT # 1
April 12, 1973
NOx ANALYSIS
TEST # 1
4:47 end blr. sample
(SO_2 = 32%)
4:45 PM
.39
600
234.00
(SO_2 = 32.5%)
NOx = 39% = 234 ppm
4:36 PM
RUN #1 ON Unit #1 4/12/73
0-100% = 0-600PPM NOx
SPAN OK
Zero reset to 4.75
Span pot = 757


Span Gas
420 PPM NOx
= 70%
Range 0-100% = 0-600 PPM
0 = 4.82 turns
NOx Calib.
4-12-23


BRIDGEPORT HARBOR STA.
UNIT #1
TEST #2
APRIL 13, 1973
NOx TEST
end sample
3:20½ PM
36.5% x 600 =
219 PPM
3:17 PM
3:14 PM
(SO_2 = 32.5%)
3:10 PM
Blr Sample 4/13/73
Unit #1 – NOx Test #2
zero rig't on
NOx Calib.
Span 7.57 adj. To 7.35
calibrate gas
420 ppm should
read 70%
0-600 ppm range

recheck calib
4:15pm
26.5%

zero ✓ blr. sample #2 4:09 pm

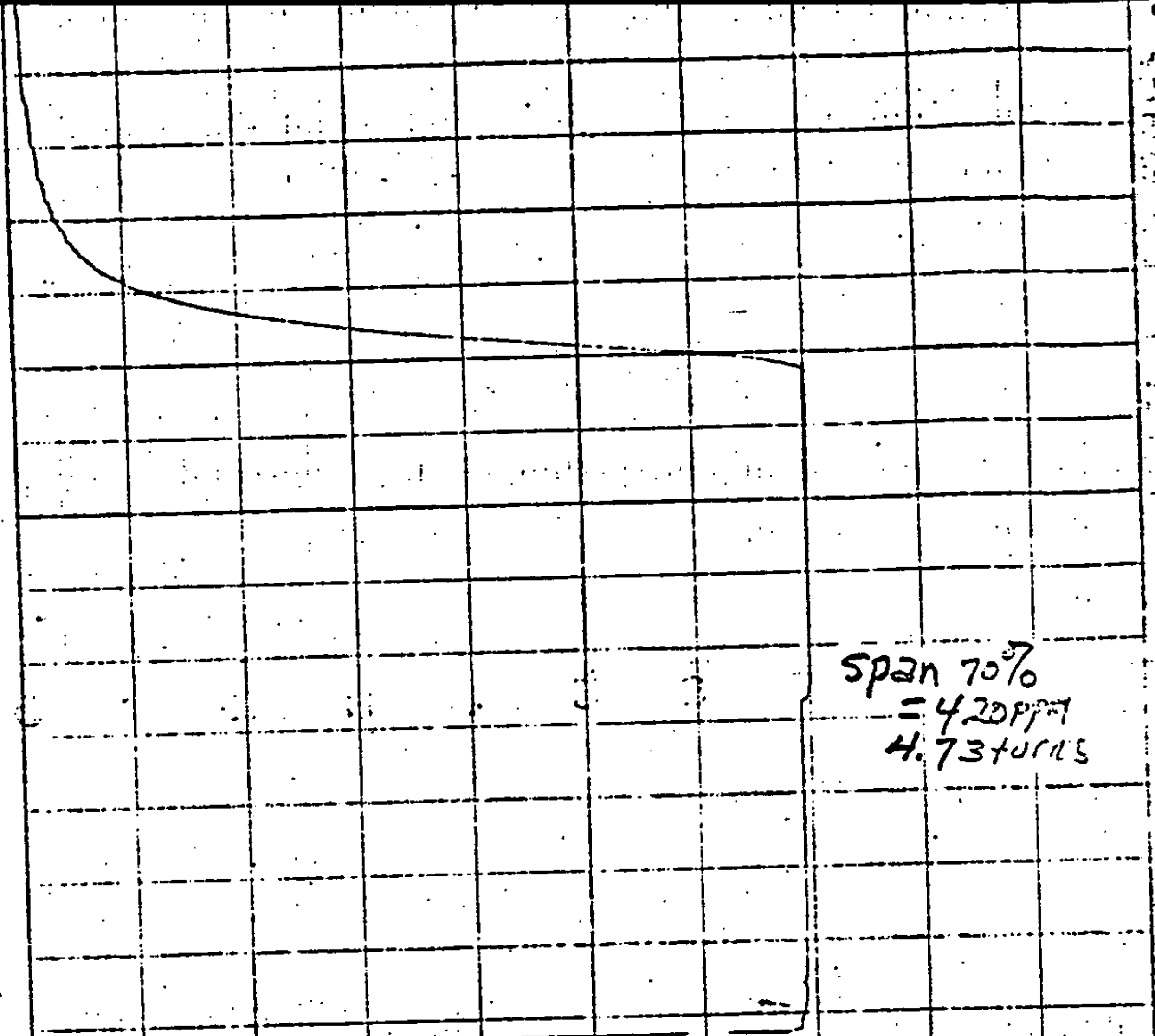
readjust span
4.78

recheck calib
4:00 pm
27.8% NOx on 0-600 ppm scale

27.8% X600 = 167 PPM

blr. sample #1 3:50 pm
4-16-73

BRIDGEPORT HARBOR STA.
UNIT #1
TEST #3
APRIL 16, 1973
NO_x ANALYSIS



— 0 = 4.75 turns CALIB.

4-16-73
NOx Test #3
Harbor Unit 1

BOILER OPERATING CONDITIONS

Stack Identification Number 1

Date 4/12/73.

Boiler Number BRIDGEPORT HARBOR UNIT 1

TEST 1

Plant Location

Parameters	1:45	2:45	4:00	4:45			
Gross Load (MW)	89.5	89.5	89.5	89.5			
Net Load (MW)	1:40	2:40	3:50	4:40			
Fuel Flow (gal/hr)	360,609	366,950	374,352	379,639			
Steam Flow (lb/hr)	658,000	658,000	658,000	658,000			
Feed Water Flow (lb/hr)	658,000	658,000	657,000	658,000			
Air Flow	555,000	555,000	555,000	555,000			
Excess Air (%)							
Excess 02 (%)	1.4%	1.35%	1.35%				
Scot Blowing							
Boiler Inlet Feed Water Temp (OF)	450°	450°	450	450			
Boiler Exit Steam Press. (psig)							
Boiler Exit Steam Temp (OF)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (OF)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (OF)							
Condenser Pressure (in Hg)							

Parameters	1:45	2:45	4:00	4:45			
Cooling Water Temp (^oF)	92	92	94	94			
Boiler Air Inlet Temp (^oF)	525	525	526	526			
Boiler Flue Gas Exit Temp (^oF)	650°	642	643	644			
F.D. Fan Pressure Rise (in H20)	266	270	270	270			
F.D. Fan Current (amps)							
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H20)							
ID Fan Current (amps)							
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (^oF)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (^oF)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (^oF)							
Outlet Temp (^oF)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							

BOILER OPERATING CONDITIONS

TEST 2

Date 4-13-73

Stack Identification Number 1

Boiler Number UNIT 1

Plant Location HARBOR STATION

Parameters	1^00	2^00	4^00				
Gross Load (MW)	88.5	88.6	88.5				
Net Load (MW)	1^00	2^00	4^00				
Fuel Flow (gal/hr)	496,315	502,574	515,095				
Steam Flow (lb/hr)	652,000	652,000	652,000				
Feed Water Flow (lb/hr)	652,000	652,000	650,000				
Air Flow	550,000	550,000	550,000				
Excess Air (%)							
Excess O2 (%)	1.55	1.60	1.65				
Soot Blowing							
Boiler Inlet Feed Water Temp (°F)	450°	450°	450				
Boiler Exit Steam Press. (psig)							
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

Parameters	1	2	[illegible]				
Cooling Water Temp (^oF)	90	90	95				
Boiler Air Inlet Temp (^oF)	502	505	505				
Boiler Flue Gas Exit Temp (^oF)	615	615	620				
F.D. Fan Pressure Rise (in H20)	260	250	265				
F.D. Fan Current (amps)							
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H20)							
ID Fan Current (amps)							
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (^oF)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (^oF)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (^oF)							
Outlet Temp (^oF)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							

BOILER OPERATING CONDITIONS

Stack Identification Number HARBOR - UNIT 1 Date 4-16-73

Boiler Number

Plant Location

Parameters	2^{15}	3^{15}	4^{15}				
Gross Load (MW)	895	875	89.7				
Net Load (MW)	2^{16}	3^{16}					
Fuel Flow (gal/hr)	800,781	806,944	813,243				
Steam Flow (lb/hr)	656,000	656,000	652,000				
Feed Water Flow (lb/hr)	652,000	644,000	645,000				
Air Flow	550,000	548,000	548,000				
Excess Air (%)							
Excess 02 (%)	2.0	1.9					
Soot Blowing							
Boiler Inlet Feed Water Temp (°F)	450°	450	450				
Boiler Exit Steam Press. (psig)							
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
... Pressure (in Hg)							

Parameters	2:45	3:15	4:15				
Cooling Water Temp (°F)	110	110	111				
Boiler Air Inlet Temp (°F)	520	525	522				
Boiler Flue Gas Exit Temp (°F)	634	634	634				
F.D. Fan Pressure Rise (in H2O)	275	274	274				
F.D. Fan Current (amps)							
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H2O)							
ID Fan Current (amps)							
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H2O)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							

Plaint B

OAQPS - 78-1
II-I-263

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref 21

Emission Test Report

Bridgeport Harbor Station Stack No. 2

Steam Generator No. 2

Aug. 1961

The United Illuminating Company
Bridgeport Harbor Station
10 Henry Street
Bridgeport, Connecticut
06604

Approved by:

E. W. Somerville
Vice President, Engineering and Planning

Submitted by:

M. R. McCraven
Director of Environmental Engineering

Emission Test Report

Bridgeport Harbor Station Stack No. 2
Steam Generator No. 2
(Ref. "Intent to Test" Form Number 720050)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Larkin
J. Kittrell

Prepared by:

J. S. Sombati ____________________
Development & Test Laboratory Supervisor

J. W. Hotchkiss ____________________
Assistant Mechanical Engineer

Checked by:

J. F. Crowe ____________________
Chief Mechanical Engineer

Test Results

Bridgeport Harbor Station
Steam Generator No. 2

Test Conducted on
December 11, 1973

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company Bridgeport Harbor Station Steam Generator No. 2, stack No. 2, located in Bridgeport, Connecticut. Testing was conducted on December 11, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new Source Test Guidelines and Procedures, (received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATOR NO. 2

STACK NO. 2

Component	Sampling Duration: Minutes per point	Sampling Duration: Total Test Time	Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
1) NO_x		15 min	3	0.42 lb/10^6 BTU	Dynascience Model P-101 NO_x Analyzer
2) Particulate	5	60 min	3	0.05 lb/10^6 BTU	Method 5*
3) Moisture	5	60 min	3	7.4%	Method 4*
4) Gas Analysis		15 min	3	33% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	1/2	15 min	3	0.45" H_2O to 1.5" H_2O **	Method 2*

* Federal Register, Volume 36, No. 247, December 23, 1971

** Range of S-type Pitot Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATOR NO. 2

STACK NO. 2

Test	1	2	3	Average
Date	12/11/73	12/11/73	12/11/73	
Stack Flow, ACFM	584,901	628,201	617,552	610,218
Stack Flow, SCFM	406,382	427,969	426,971	420,441
Stack Flow, lb/hr	1,905,784	2,005,689	2,000,348	1,970,607
% Excess O_2 at Test Point	6.57	6.66	6.69	6.64
Particulate Emissions				
gr/SCF	0.030	0.020	0.022	0.024
lb/hr	104.85	71.90	81.98	86.24
lb/MBTU	0.06	0.04	0.05	0.05
Nitrogen Oxide Emission				
ppm	255	252	246	251
lb/hr	741.0	771.1	751.0	754.4
lb/MBTU	0.41	0.43	0.42	0.42

part: $86.2 \frac{lb}{hr} \times \frac{1\ hr}{12.3 \times 10^3\ gal} = 7 \frac{lb}{10^3\ gal}$ -.35 % S

NO_x: $754 \frac{lb}{hr} \times \frac{1\ hr}{12,300\ gal} \approx 61 \frac{lb}{10^3\ gal}$

(60% ...

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATOR NO. 2

STACK NO. 2

Test	1	2	3
Date	12/11/73	12/11/73	12/11/73
Steam Flow lb/hr	140 MW 1,325,000	1,325,000	1,325,000
Oil Flow gal/hr	12,257	12,280	12,263
Heat Input, MBTU/hr	1805.3	1808.7	1806.2
Stack Gas Temperature ^oF	250	250	250
Gas Density, lb/ft^3	0.058	0.058	0.058

TABLE IV

FUEL OIL ANALYSIS

STEAM GENERATOR NO. 2

STACK NO. 2

Test	1	2	3
Date	12/11/73	12/11/73	12/11/73
	Composition (% by Weight)		
Carbon	86.10	86.10	86.10
Hydrogen	12.61	12.61	12.61
Nitrogen	0.1	0.1	0.1
Ash	0.019	0.019	0.019
Sulfur	0.348	0.348	0.348
Specific Gravity	0.909	0.909	0.909
BTU/lb	19,452	19,452	19,452
BTU/gal	147,290	147,290	147,290

1. <u>Sampling Train Information</u>
(Ref. Item VIII, "Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_X: Dynascience Model P-101 NO_X Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. Nitrogen Oxides: Stainless steel tube

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube

d. Probe Cleaning Method:

See Appendix A

2. <u>Field Data Sheets</u>
(Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. <u>Description of Operation</u>
(Ref. Item X, "Intent To Test" Form)

The operation tested was Bridgeport Harbor Station steam generator No. 2, stack No. 2, Registration Number BHS2, stack 2, having a total BTU/hr rating of 1806.7 MBTU/hr (averaged over the test period), burning No. 6 residual fuel oil at an average rate of 12,267 gal/hr, and having a gas flow of 610,218 ACFM, average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission sampling was performed in the stack 170 feet above the stack foundation (8 stack diameters above the breeching inlet and 6 stack diameters down from the top). Emission sampling was performed using four - 4" diameter sampling ports, spaced 90° apart on the stack circumference. A total of twelve sampling points (3 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 12'-10-3/4" I.D.

a. Stack Configuration:

See Appendix A.

b. Sampling Port Location:

See Appendix A.

c. Sampling Point Position:

See Appendix A.

5. Stack and Vent Description
(Ref. Item XII, "Intent To Test" Form)

One Babcock and Wilcox Cyclone fired Radiant Reheat Boiler discharges flue gas through two breechings into the stack. Attached to the outlet of the boiler is a Research-Cottrell electrostatic precipitator, having an estimated collection efficiency of 60% when burning No. 6 residual fuel oil.

6. Operational Parameters
(Ref. Item XIII, "Intent To Test" Form)

Electric utility steam generators burning No. 6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

The test port locations and the number of points sampled were calculated from guidelines in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature, and velocity over the cross-sectional area of each stack (See Figures 1-4).

2. Velocity and Temperature

Velocity was determined in accordance with Guidelines in Method 2 of the Federal Register. A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques (See Figure #6).

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe on Unit 2 and a fifteen (15) foot probe on Unit 3, heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 5. The stainless steel, button-hook type sampling nozzle (1), Type "S" pitot tube (2), and thermocouple (3), extended from the sampling end of the probe, which consisted of ½ inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 250°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the ball-joint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (5) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (4) which is thermostatically maintained at a minimum temperature of 250°F to prevent water condensation. Attached to the heated box with tygon tubing was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a ½ inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger (10) modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (ΔP in inches water)
5. Desired pressure drop across orifice (ΔH inches water)
6. Actual pressure drop across orifice (ΔH in inches water)
7. Dry gas temperature (°F) gas meter inlet
8. Dry gas temperature (°F) gas meter outlet.
9. Vacuum pump gauge reading (in. Hg).

10. Filter box temperature (°F)
11. Dry gas temperature (°F) at the discharge of last impinger
12. Stack temperature (°F)

The relationship of ΔP reading with the ΔH reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between ΔP and ΔH could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. BASIC LABORATORY PROCEDURE

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III and VI of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with an Infra-Red Heat Lamp and the beaker weighed again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

CALIBRATION

The equipment used on this assignment was calibrated one week prior to field testing and re-calibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

TEST TEAM

Robert J. Larkin
James R. Kittrell

Prepared By:

Robert J. Larkin
Test Engineer

Reviewed By:

Robert S. Epstein
Project Director

Approved By:

Roy S. Egdall
Manager Engineering Services

11/5/73 REPORT NO. Y-8278-3

OK

il OK Valves OK

Quick Connects OK

ters OK

est Meter

ometers OK

s OK

rical Check - Amphenol OK

c OK

m Gauge OK CF

Check at 27" hg. - OK

ks

ial each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. S 1563 P_b 29.9

n ice	CF_w	CF_d	T_w	IT_d	OT_d	T_d Avg.	Time t
.5	5	5.15	67	85	75	80	12.23
.0	5	5.06	67	85.5	77.6	81.5	90.12
.0	10	10.16	68	88.8	79.5	84.1	13.2
.0	10	10.03	68	89.0	79.6	84.3	93.06
6.0	10	10.05	68	92.8	80.3	86.5	7.67
8.0	10						

culate Y & $H_@$ at man. 2.0

Y =

$$Y = \frac{CF_w\, P_b\, (T_d\ avg. + 460)}{CF_d\, (P_b + 0.147(T_w + 460))}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)(\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)} \left(\frac{(T_w + 460)}{CF_w} \right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)} \left((\quad + 460)t \right)^2$$

Tolerances

Y = 0.99 - 1.00 - 1.0

$\Delta H_@$ = 1.6 - 1.84 - 2.1

Calibration Calculations Meter and Pump Box
Date 11/5/73 Box No. 51563

$$\Delta H_@ = \frac{0.317 \text{ (Man. Orifice)}}{P_b\ (OT_d + 460)} \left(\frac{(T_w + 460)t}{CF_w} \right)^2$$

ΔH@ calculation	Man.	H@
$\Delta H_@ = \frac{0.01585}{29.9\,(75 + 460)} \left(\frac{(67 + 460)}{5} \right)^2$ 12.7	.5	1.78
$\Delta H_@ = \frac{0.0317}{29.9\,(77.6 + 460)} \left(\frac{(67 + 460)}{5} \right)^2$ 90.12	1.0	1.77
$\Delta H_@ = \frac{0.0634}{29.9\,(79.5 + 460)} \left(\frac{(68 + 460)}{10} \right)^2$ 13.2	2.0	1.90
$\Delta H_@ = \frac{0.1268}{29.9\,(79.6 + 460)} \left(\frac{(68 + 460)}{10} \right)^2$ 93.06	4.0	1.89
$\Delta H_@ = \frac{0.1902}{29.9\,(80.3 + 460)} \left(\frac{(68 + 460)}{10} \right)^2$ 7.67	6.0	1.93
$\Delta H_@ = \frac{0.2536}{\quad} \left(\frac{(\_\_ + 460)}{\quad} \right)^2$	8.0	

$$Y = \frac{CF_w\ P_b\ (T_d \text{ avg.} + 460)}{CFd\ P_b + \frac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$$

Y calculation	Man.	Y
$Y = \frac{5 \times 29.9\,(80 + 460)}{5.15\,(29.9 + 0.0368)\,(67 + 460)}$	.5	.993
$Y = \frac{5 \times 29.9\,(81.5 + 460)}{5.06\,(29.9 + 0.0737)\,(67 + 460)}$	1.0	1.01
$Y = \frac{10 \times 29.9\,(84.1 + 460)}{10.16\,(29.9 + 0.147)\,(68 + 460)}$	2.0	1.0
$Y = \frac{10 \times 29.9\,(84.3 + 460)}{10.03\,(29.9 + 0.294)\,(68 + 460)}$ 29.9	4.0	1.0
$Y = \frac{10 \times 29.9\,(86.5 + 460)}{10.05\,(29.9 + 0.431)\,(68 + 460)}$ 29.9 .431	6.0	1.0
$Y = \frac{\_\_ \times \_\_\,(\_\_ + 460)}{\_\_\,(\_\_ + 0.588)\,(\_\_ + 460)}$	8.0	

REPORT NO. Y-8278-3

FIELD DATA

PLANT VT Harbor Station
DATE 12/11/73
SAMPLING LOCATION Stack Unit 2
SAMPLE TYPE Particulate
RUN NUMBER 1
OPERATOR BJL
AMBIENT TEMPERATURE 35
BAROMETRIC PRESSURE 29.93
STATIC PRESSURE, (P_s) -.6
FILTER NUMBER (s) 72-345

50 ml H_2O net

PROBE LENGTH AND TYPE
NOZZLE I.D. 3/16
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER 5-1063
METER $\Delta H_@$ 1.20
C FACTOR .86
PROBE HEATER SETTING [illegible]
HEATER BOX SETTING [illegible]
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT
READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\ in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\ out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
			95.845									
W 1		1010	102.30	1.4	1.38	1.38	350	55	55	7		
2		1015	104.92	1.3	1.32	1.37	350	54	56	6		
3		1020	106.983	.45	.46	.46	350	52	56	3		
END		1025	106.983									
S 1		1027	110.40	1.5	1.48	1.48	350	53	53	8		
2		1032	113.84	1.5	1.48	1.48	350	54	53	8		
3		1037	116.858	1.3	1.24	1.24	350	53	53	8		
END		1042	116.858									
E 1		1047	120.00	1.4	1.38	1.28	350	50	48	8		
2		1052	123.26	1.4	1.38	1.28	350	48	51	8		
3		1057	126.336	1.3	1.24	1.24	350	48	50	7		
END		1102	126.336									
N 1		1104	129.48	1.4	1.38	1.35	350	46	48	7		
2		1109	132.91	1.4	1.35	1.38	350	46	48	7		
3		1114	136.500	1.3	1.16	1.16	350	42	42	6		
END		1119										

COMMENTS:

ES-041

REPORT NO. Y-8278-3

FIELD DATA

PLANT UI Harbor station
DATE 12/11/83
SAMPLING LOCATION Stack Outlet
SAMPLE TYPE Particulate
RUN NUMBER 2
OPERATOR DTL
AMBIENT TEMPERATURE 35
BAROMETRIC PRESSURE 29.85
STATIC PRESSURE, (P_s) 1
FILTER NUMBER (s) EL-405

65 ml H_2O net

PROBE LENGTH AND TYPE
NOZZLE I.D. 3/16
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER 5-1563
METER $\Delta H_@$ 1.80
C FACTOR .96
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
N 1	1208	31.517	1.5	1.45	1.48	350	43	46	5		
2	1213	37.64	1.5	1.45	1.48	350	44	46	5		
3	1218	43.00	1.4	1.38	1.38	350	47	47	5		
END	1223	45.963									
E 1	1226	45.963	1.4	1.35	1.35	350	45	45	5		
2	1231	47.15	1.4	1.38	1.38	350	46	45	5		
3	1236	53.40	1.3	1.35	1.35	350	46	46	5		
END	1241	55.348									
S 1	1247	55.348	1.5	1.48	1.48	350	46	46	5		
2	1252	58.74	1.5	1.48	1.48	350	46	46	5		
3	1257	62.15	1.5	1.48	1.48	350	46	46	5		
END	1302	65.340									
W 1	1305	65.340	1.5	1.48	1.48	350	47	45	5		
2	1310	68.70	1.5	1.48	1.48	350	47	46	5		
3	1315	71.48	1.5	1.48	1.48	350	47	46	5		
END	1320	75.341									

ES-041

COMMENTS:

FIELD DATA

PLANT UT Harbor Station
DATE 12/11/73
SAMPLING LOCATION Stack Unit 2
SAMPLE TYPE particulate
RUN NUMBER 2
OPERATOR ETL
AMBIENT TEMPERATURE 35
BAROMETRIC PRESSURE 29.87
STATIC PRESSURE, (P_s) .6
FILTER NUMBER (s)

5.5 ml H_2O net

PROBE LENGTH AND TYPE
NOZZLE I.D. 3/16
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER 3-1563
METER $\Delta H_@$ 1.90
C FACTOR .76
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp

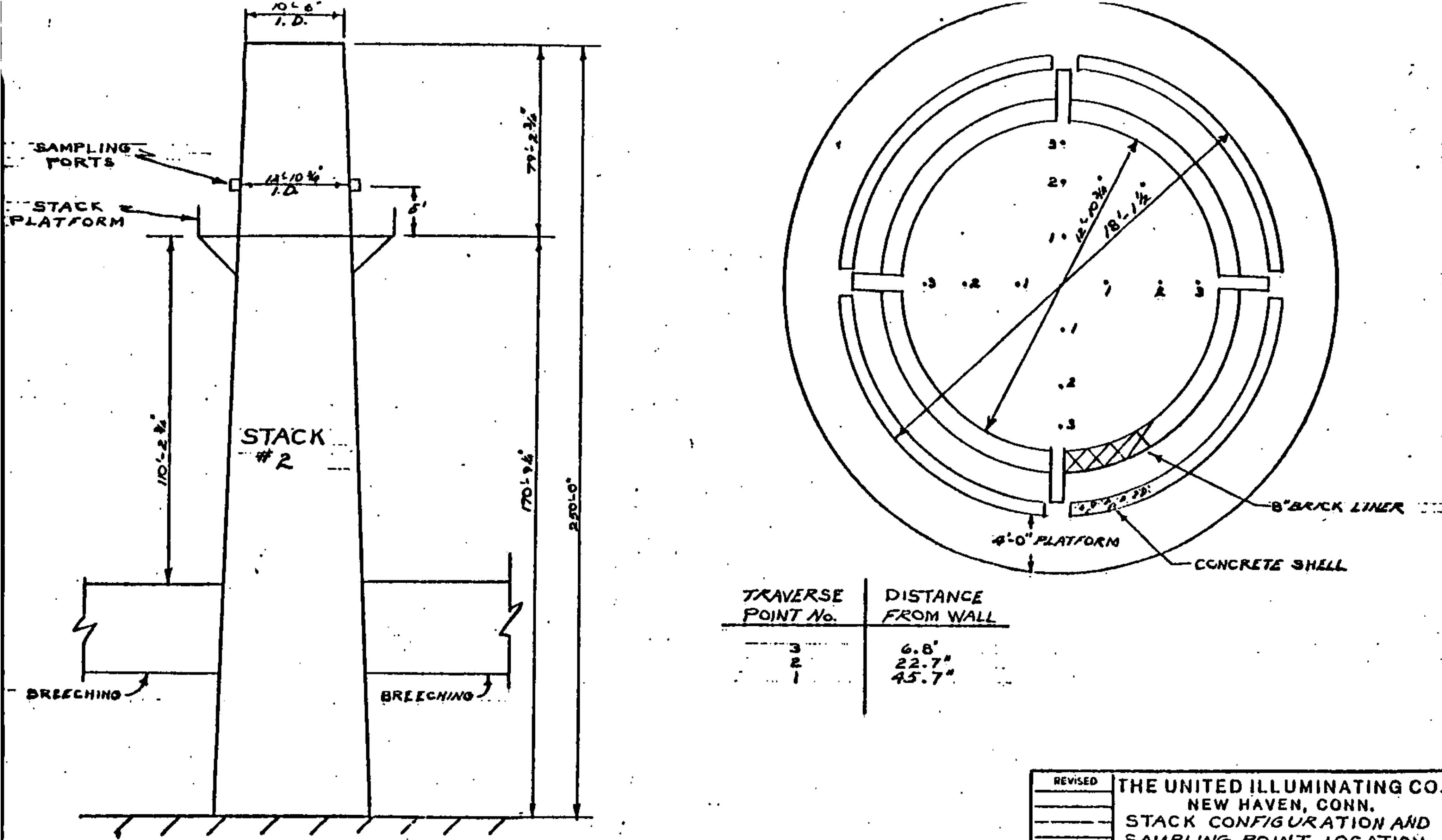
SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
W 1	1343	75.351	1.5	1.48	1.48	250	42	44	6		
2	1348	75.78	1.5	1.48	1.48	250	44	44	6		
3	1353	83.22	1.4	1.38	1.38	250	44	45	7		
END	1358	85.330									
C 1	1400	85.330	1.5	1.48	1.48	250	48	44	6		
2	1405	88.81	1.5	1.48	1.48	250	48	45	6		
3	1410	91.54	1.3	1.28	1.28	250	42	45	6		
END	1415	91.491									
E 1	1416	95.491	1.5	1.48	1.48	250	46	44	6		
2	1421	98.50	1.3	1.38	1.38	250	46	45	6		
3	1426	101.92	1.3	1.38	1.38	250	48	46	6		
END	1431	104.915									
N 1	1433	104.918	1.5	1.48	1.48	250	48	44	6		
2	1437	108.10	1.4	1.38	1.35	250	47	45	7		
3	1443	111.35	1.3	1.38	1.35	250	47	46	6		
END	1447	114.360									

COMMENTS:

ES-041



TRAVERSE POINT No.	DISTANCE FROM WALL
3	6.8"
2	22.7"
1	45.7"

REVISED	
	THE UNITED ILLUMINATING CO. NEW HAVEN, CONN.
	STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK #2
	BRIDGEPORT HARBOR STATION
	DRAWN BY P.L.O. DATE 4-2-74
	TRACED BY DATE
	APPROVED BY J.W.H. DATE 4-2-74
	SCALE NONE DRAWING NO. 41272-7

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 2 Date DEC. 11, 1973

Boiler Number 2 Time 11:15

Plant Location Bpt Harbor Sta

Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	11.95	11.84	11.95		11.91	44/100	5.24
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O2, % Vol (dry)	6.55	6.62	6.55		6.57	32/100	+ 2.10
N2, % Vol (dry)	81.50	81.54	81.50		81.51	28/100	+ 22.83

Avg. molecular wt. of dry stack gas = 30.17

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 2

Boiler Number 2

Plant Location Bpt Harbor

Sampling Point Location STACK

Date DEC. 11, 1973

Time 1:20 pm

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	11.70	11.80	11.80		11.77	44/100	5.18
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O2, % Vol (dry)	6.67	6.69	6.64		6.66	32/100	+ 2.13
N2, % Vol (dry)	81.63	81.51	81.56		81.57	28/100	+ 22.84
					Avg. molecular wt. of dry stack gas =		30.15

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 2 | Date DEC 11, 1973

Boiler Number 2 | Time 2:45 PM

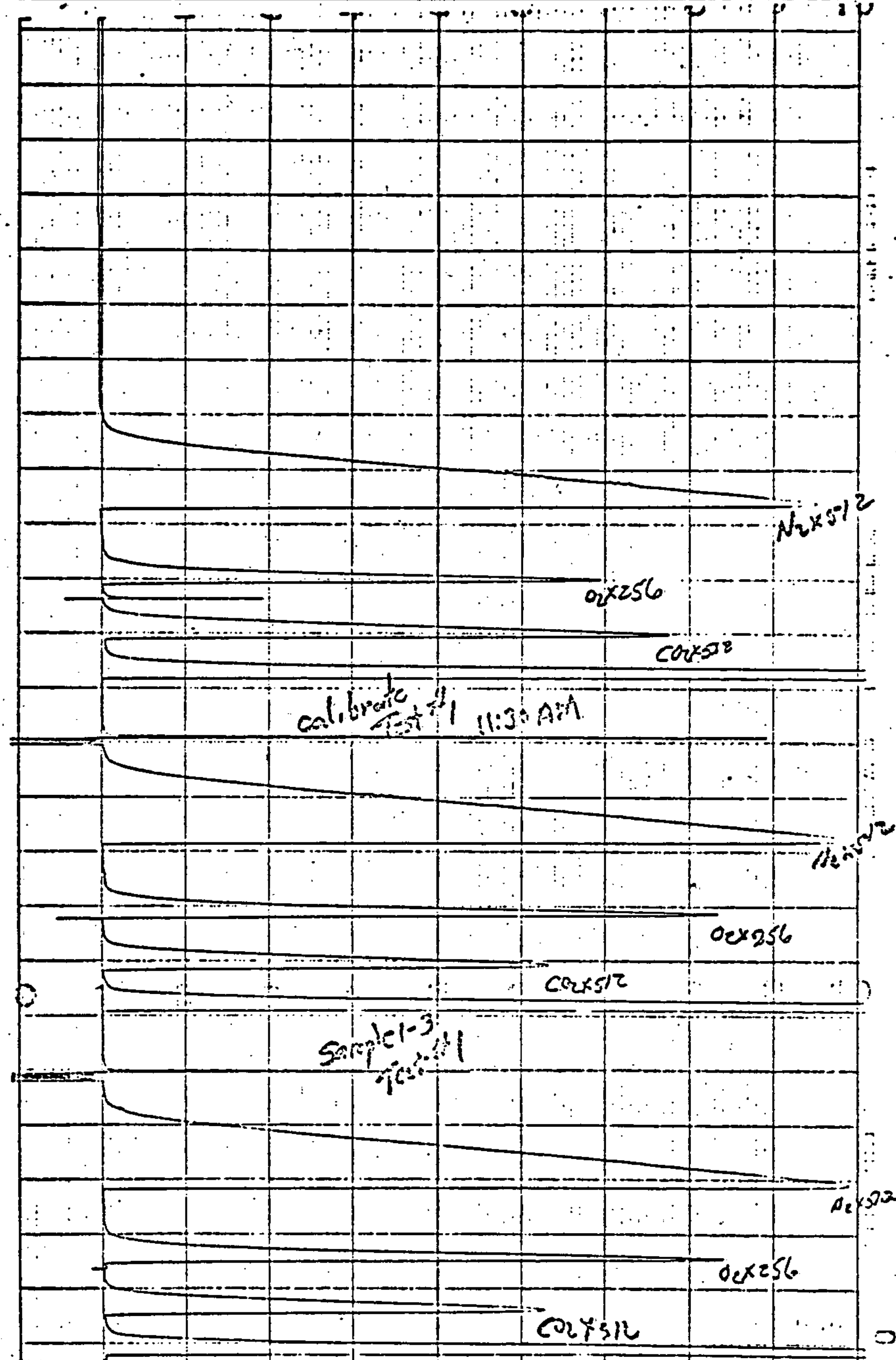
Plant Location Bpt Harbor

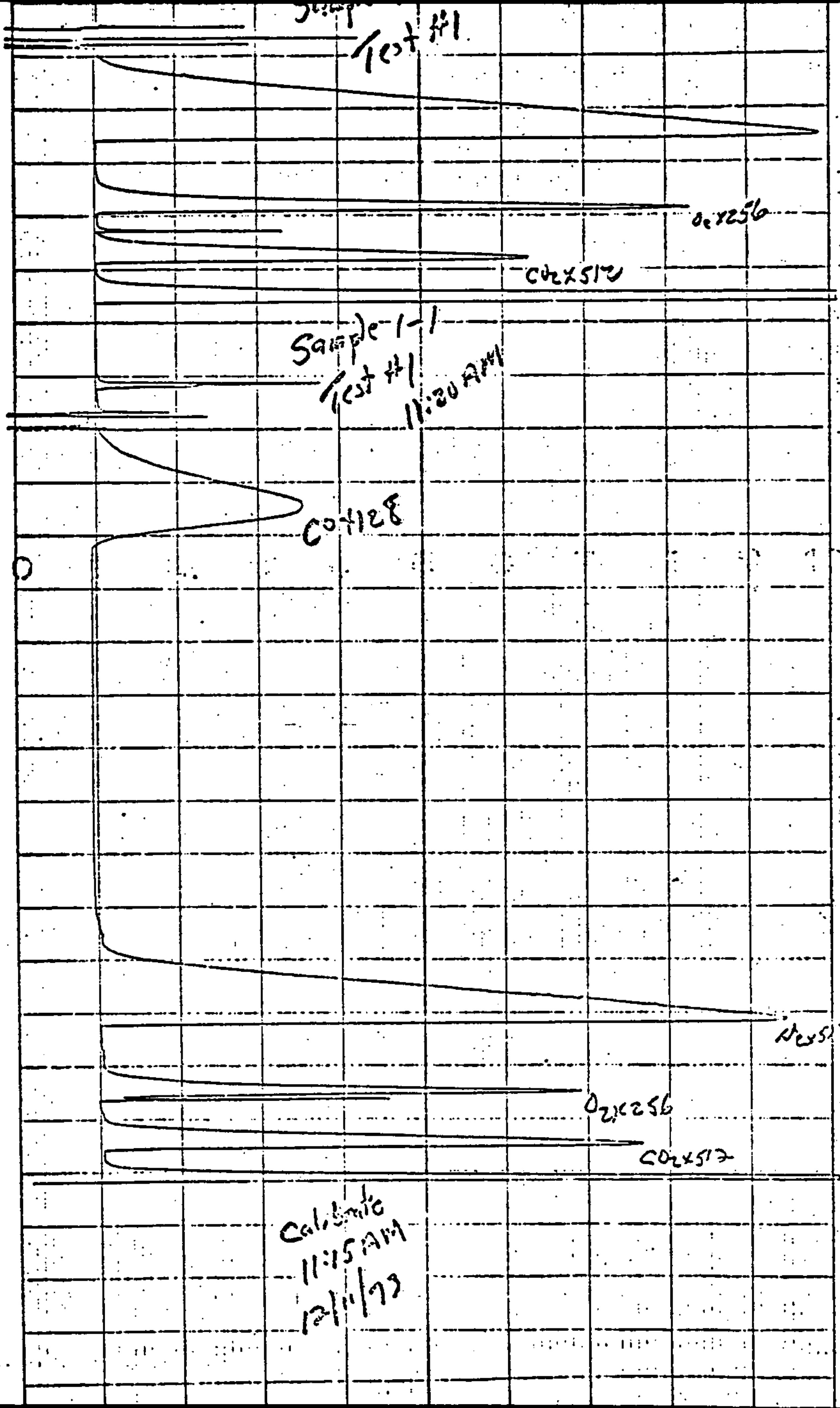
Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	11.6[illegible]	11.75	11.75		11.71	44/100	5.15
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O2, % Vol (dry)	[illegible]	[illegible]	[illegible]		6.69	32/100	+ 2.14
N2, % Vol (dry)	81.60	81.[illegible]0	81.60		81.60	28/100	+ 22.85

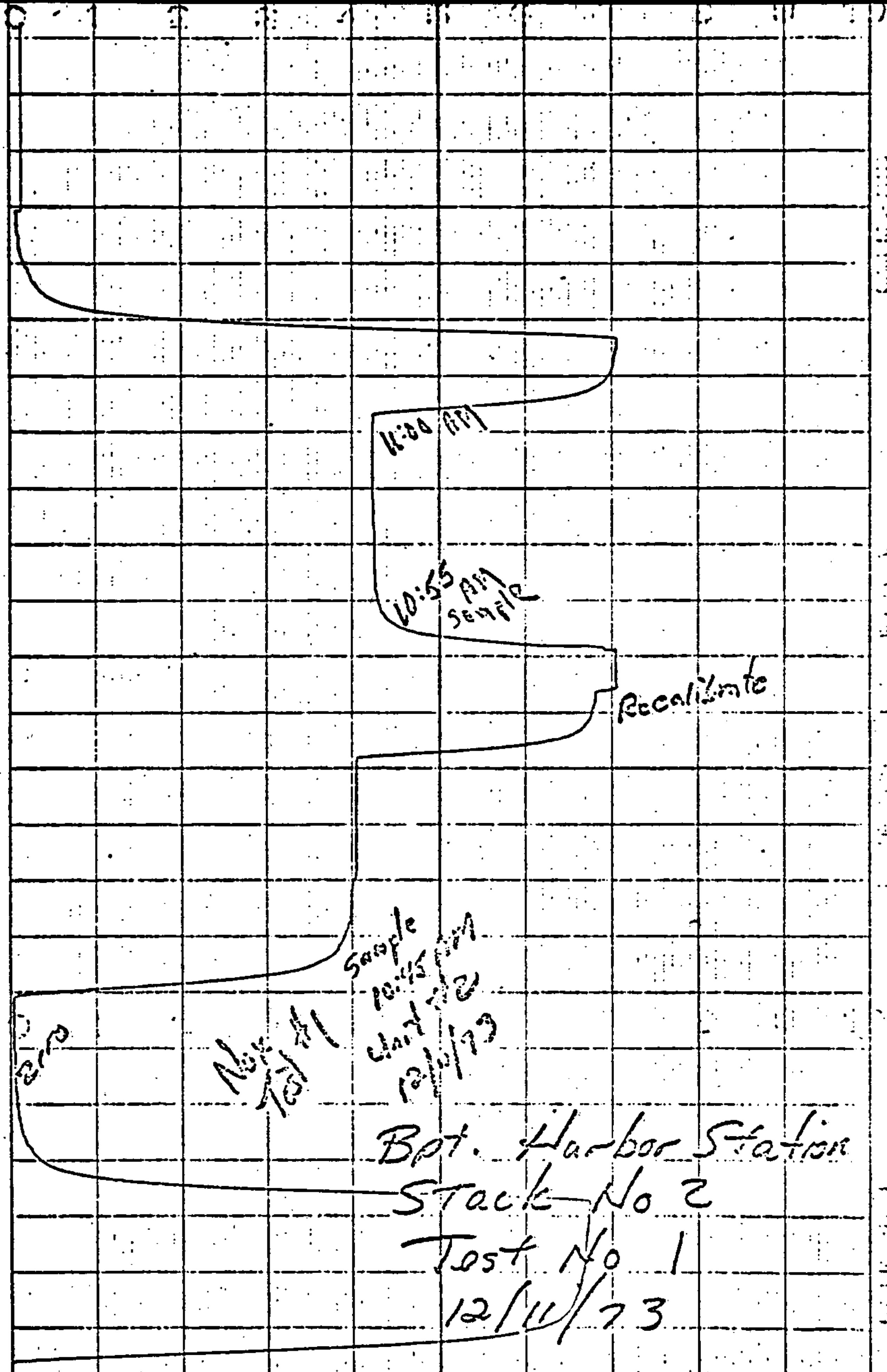
Avg. molecular wt. of dry stack gas = 30.14

TEST NO. 1

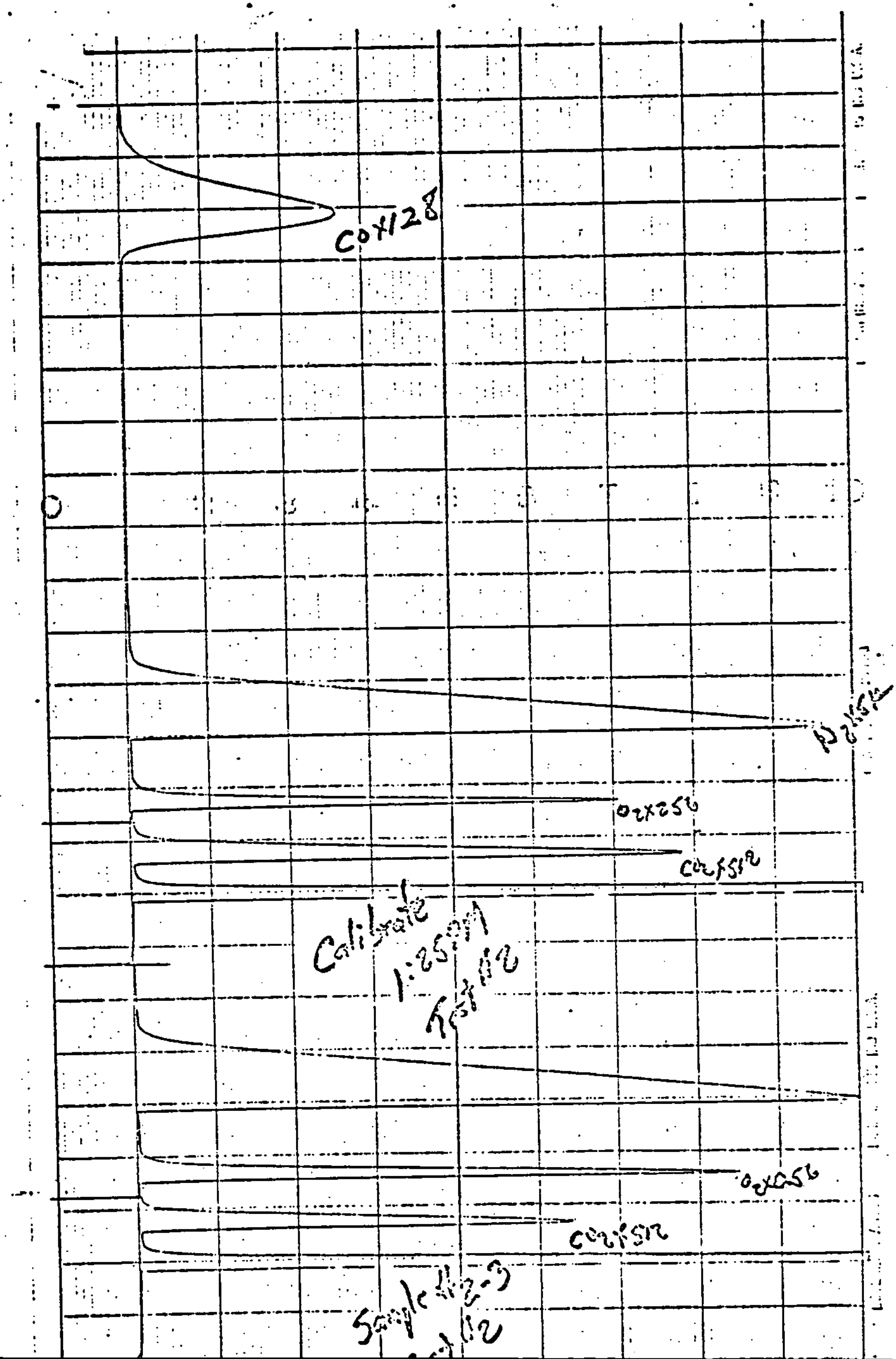

N2x512
O2x256
CO2x512
calibrate Test #1 11:30 AM
O2x256
CO2x512
Sample 1-3 Test #1
O2x256
CO2x512

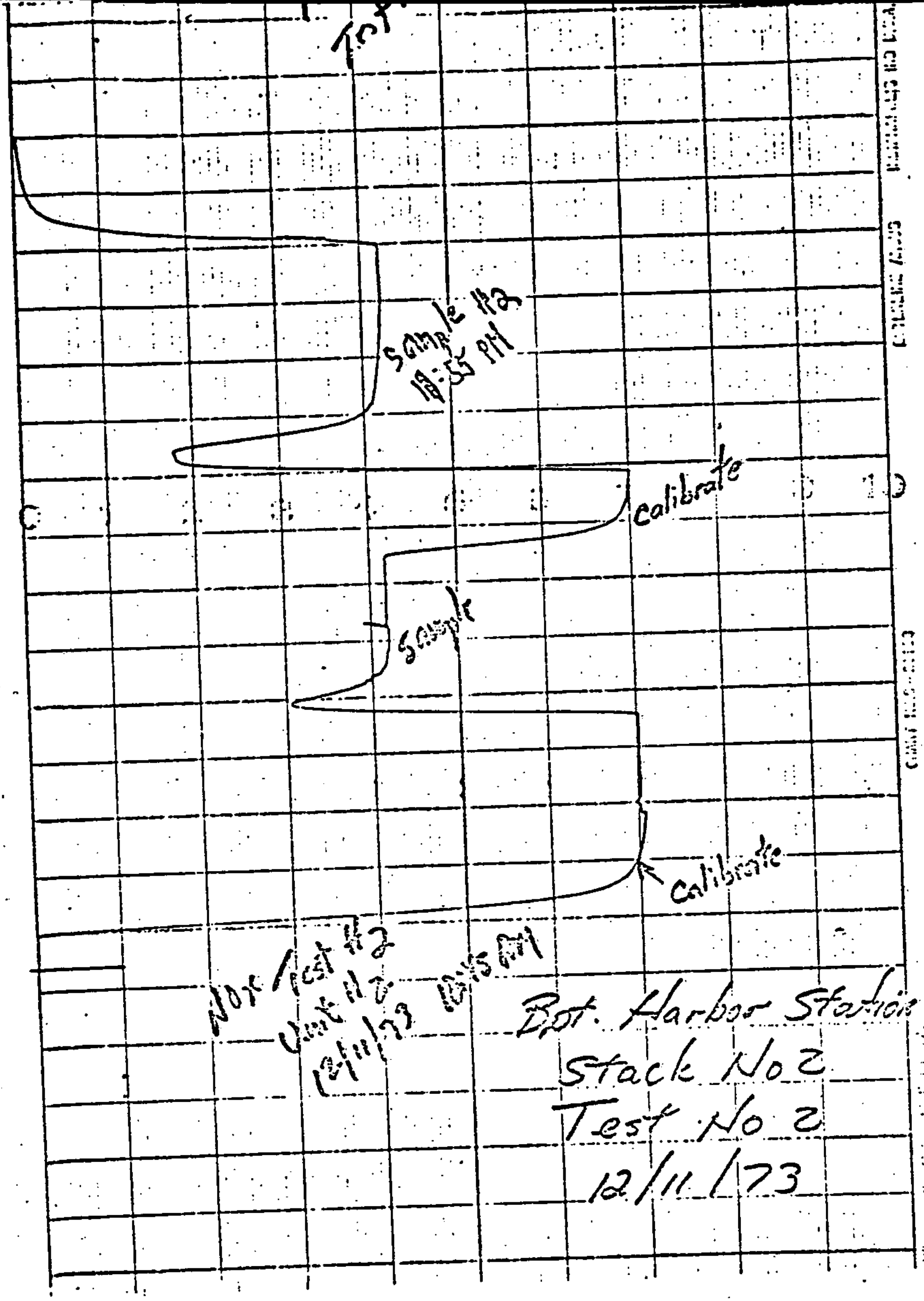


Test #1
O2x256
CO2x512
Sample 1-1
Test #1
11:20 AM
CO x128
N2x512
O2x256
CO2x512
Calibratio
11:15 AM

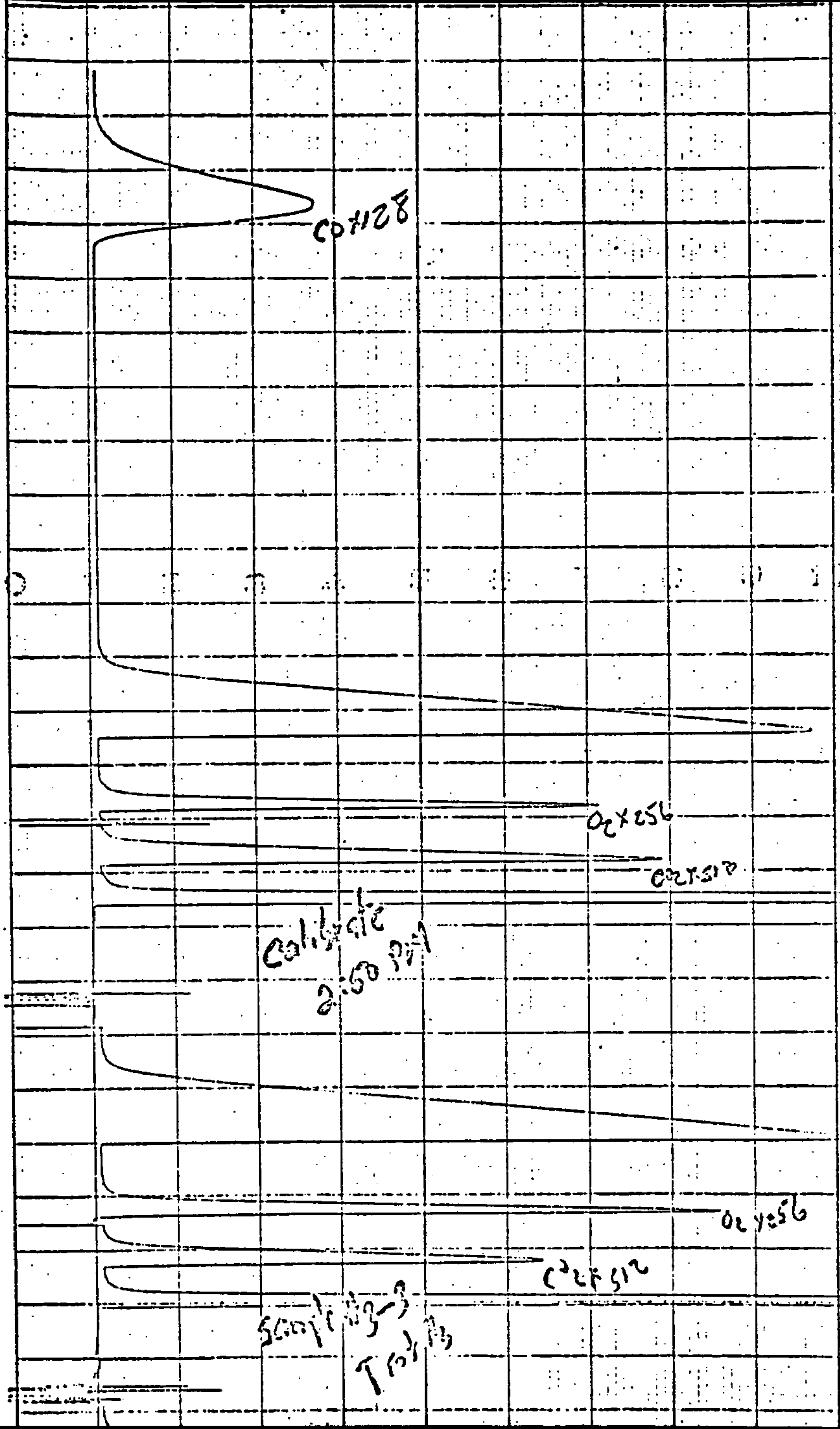

11:00 AM
10:55 AM sample
Recalibrate
Sample 10:45 AM
Bpt. Harbor Station
Stack No 2
Test No 1
12/11/73

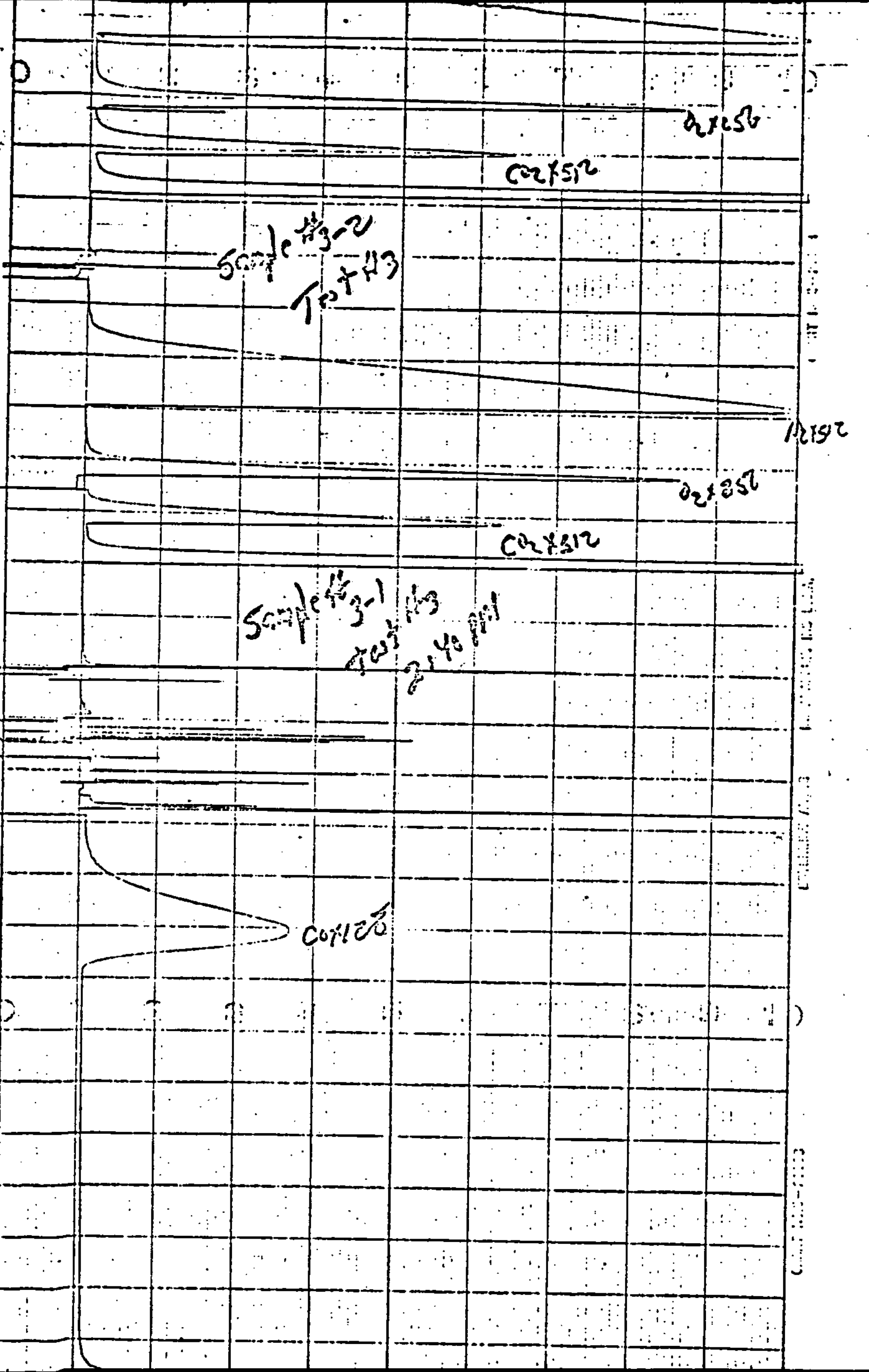
TEST NO. 2


COx128
O2x256
CO2x512
Calibrate
O2x256
CO2x512
Sample

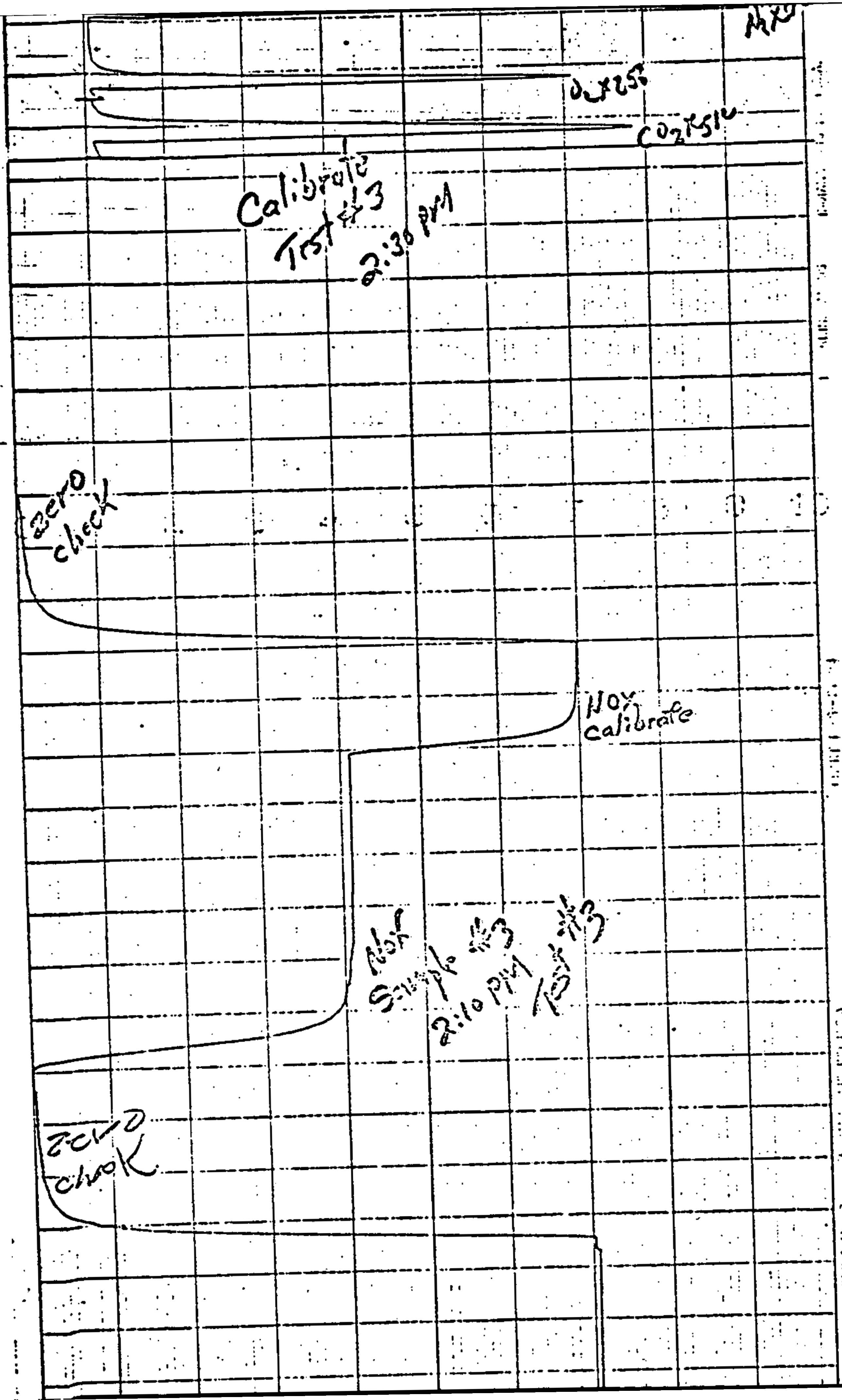

Test
Sample #2
12:55 PM
Calibrate
Sample
Calibrate
NOx Test #2
Unit #2
12/11/73 12:15 PM
Bpt. Harbor Station
Stack No 2
Test No 2
12/11/73

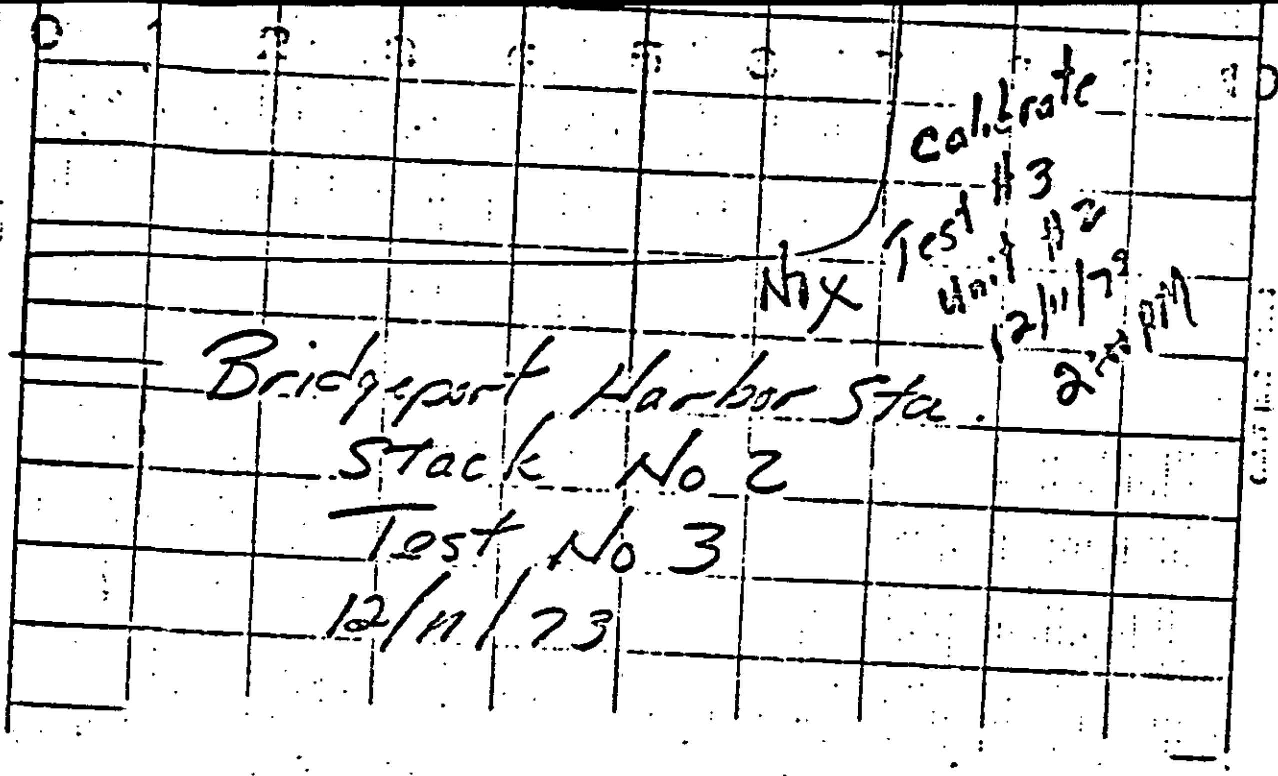
TEST NO. 3


CO×128
O2×256
Calibrate
O2×256



CO2x512
Sample #3-2
Test #3
CO2x512
Sample #3-1


Calibrate
Test #3
2:30 pm
zero
check
NOx
calibrate
NOx
Sample #3
2:10 pm
Test #3
zero
check


Calibrate
Test #3
Unit #2
12/11/73
NOx
Bridgeport Harbor Sta.
Stack No 2
Test No 3
12/11/73

APPENDIX C

BOILER OPERATING DATA

BOILER OPERATING CONDITIONS

C-1

Stack Identification Number BHS 2 Date DEC 11, 1973

Boiler Number 2 Test 1

Plant Location Bri Hr [illegible]

Parameters	0907	1038	1125				
Gross Load (MW)	182	182	182				
Net Load (MW)							
Fuel Flow (gal/hr) [illegible]	8,742,454	8,766,250	8,775,841				
Steam Flow (lb/hr)	1,325,000	1,325,000	1,325,000				
~~Feed Water Flow (lb/hr)~~	1,260,000	1,250,000	1,250,000				
Air Flow [illegible]	1,150,000	1,175,000	1,175,000				
Excess Air (%)	—	—	—				
Excess 02 (%) ECON OUTLET [illegible]	1.9	2.0	2.0				
Soot Blowing	—	—	—				
Boiler Inlet Feed Water Temp (°F) ([illegible])	510	512	514				
Boiler Exit Steam Press. (psig)	20[illegible]	[illegible]	2050				
Boiler Exit Steam Temp (°F)	970/970	[illegible]	970/970				
Reheat Inlet Steam Press. (psig)	440	[illegible]	505				
Reheat Inlet Steam Temp (°F)	—	—					
Reheat Exit Steam Press. (psig)	430	475	465				
Reheat Exit Steam Temp (°F)	980	990	970				
Condenser Pressure (in-Hg) [illegible]	1.4	1.4	1.4				

Parameters	0901	1030	1125				
~~oling-Water Temp (°F)~~	51	51	[illegible]				
iler Air Inlet mp (°F) Air Htr [illegible]	565	561	563				
iler Flue Gas Exit mp (°F)	275/315	[illegible]	[illegible]				
D. Fan Pressure Rise n H2O)	40	36	36				
D. Fan Current (amps)	320/320	315/320	315/305				
D. Fan Voltage (V)	—	—	—				
Fan Pressure Rise (in H2O)	—	—	—				
Fan Current (amps)	—	—	—				
Fan Voltage (V)	—	—	—				
rced Draft Inlet r Temp (°F)	37	39	41				
bient Air Relative midity	—	—	—				
rometric Pressire (in Hg)	27.91	29.93	29.92				
bient Air Temp (°F)	37	39	41				
iler Heat Rate TU/KW-hr)	—	—					
rner Tilt	—	—					
let Temp (°F)	275/245	275/250	275/250				
tlet Temp (°F)							
let Pressure (in H2O)	2.5	2.3	2.2				
pping Cycle Period (min)							
ark Rate (sparks/min)							
erating Voltage (KV)							
erating Amps							

BOILER OPERATING CONDITIONS

Date DEC 11, 1973

Stack Identification Number

Boiler Number 2

Plant Location [illegible]

TEST 2

Parameters	1203	1335					
Gross Load (MW)	182	182					
Net Load (MW)							
Fuel Flow (gal/hr)	[illegible]	8,5[illegible]					
Steam Flow (lb/hr)	1,3[illegible]	1,25[illegible]					
Feed Water Flow (lb/hr)	1,250[illegible]	1,250,000					
Air Flow	1,175[illegible]	1,175[illegible]					
Excess Air (%)	—	[illegible]					
Excess O2 (%) Econ [illegible]	1.9	1.9					
Soot Blowing	—	"					
Boiler Inlet Feed Water Temp (°F)	512	[illegible]					
Boiler Exit Steam Press. (psig)	[illegible]	[illegible]					
Boiler Exit Steam Temp (°F)	[illegible]	[illegible]					
Reheat Inlet Steam Press. (psig)	505	505					
Reheat Inlet Steam Temp (°F)	—						
Reheat Exit Steam Press. (psig)	[illegible]	470					
Reheat Exit Steam Temp (°F)	970	[illegible]					

Parameters	1323	1335						
~~Cooling Water Temp (°F)~~	51	51						
Boiler Air Inlet Temp (°F) [illegible]	[illegible]	56[illegible]				/		
Boiler Flue Gas Exit Temp (°F)	275/[illegible]	279/[illegible]				/		
F.D. Fan Pressure Rise (in H2O)	3/6	36				/		
F.D. Fan Current (amps)	310/[illegible]	[illegible]				/		
F.D. Fan Voltage (V)	—					/		
ID Fan Pressure Rise (in H2O)	—							
ID Fan Current (amps)	—							
ID Fan Voltage (V)	—							
Forced Draft Inlet Air Temp (°F)	45	45	—					
Ambient Air Relative Humidity	—							
Barometric Pressure (in Hg)	29.85	29.85						
Ambient Air Temp (°F)	—							
Boiler Heat Rate (BTU/KW-hr)	—							
Burner Tilt	—					PRECIP		
Inlet Temp (°F)	275/52	[illegible]				A	B	
Outlet Temp (°F)						100	0	IN
Inlet Pressure (in H2O)	2.2	2.2				320	0-300 [illegible]	[illegible]
Rapping Cycle Period (min)						.255	0	OUT
Spark Rate (sparks/min)	0	0				.13	0	IN
Operating Voltage (KV)						.43	.25-.35 [illegible]	[illegible]
Operating Amps						120	0	[illegible]

Capacity

BOILER OPERATING CONDITIONS

ack Identification Number

Date DEC 11, 1973

iler Number 2

ant Location B[illegible] 11[illegible]

TEST 3

Parameters	1346	1455					
Gross Load (MW)	18[illegible]	181					
Net Load (MW)							
Fuel Flow (gal/hr) [illegible]	[illegible]	8,818.[illegible]					
Steam Flow (lb/hr)	[illegible]	[illegible]					
~~Feed Water Flow (lb/hr)~~	[illegible]	[illegible]					
Air Flow Rel[illegible]	[illegible]	[illegible]					
Excess Air (%)	—	[illegible]					
Excess 02 (%) [illegible]	1.6	1.7					
Soot Blowing	—	[illegible]					
Boiler Inlet Feed Water Temp (oF)	57[illegible]	510					
Boiler Exit Steam Press. (psig)	2055	[illegible]					
Boiler Exit Steam Temp (°F)	[illegible]	9[illegible]					
Reheat Inlet Steam Press. (psig)	505	505					
Reheat Inlet Steam Temp (°F)	—						
Reheat Exit Steam Press. (psig)	[illegible]	[illegible]					
Reheat Exit Steam Temp (°F)	975	970					

Parameters	13[illegible]	1455						
~~ooling Water Temp (°F)~~	51	51						
oiler Air Inlet emp (°F) Air in [illegible]	562	565						
oiler Flue Gas Exit emp (°F)	[illegible]/255	277/[illegible]				/		
.D. Fan Pressure Rise in H20)	35	36				/		
.D. Fan Current (amps)	315/[illegible]	310/[illegible]				/		
.D. Fan Voltage (V)	—					/		
D Fan Pressure Rise (in H20)	—							
D Fan Current (amps)	—							
D Fan Voltage (V)	—							
orced Draft Inlet ir Temp (°F)			—					
mbient Air Relative umidity	—							
arometric Pressire (in Hg)	29.87				T-REC II			
mbient Air Temp (°F)	42						—	
oiler Heat Rate BTU/KW-hr)	—				A		B	
urner Tilt	—				100		0	IN
nlet Temp (°F)	280/355	277/350			340		erratic	C VOLT
utlet Temp (°F)					255		0	OUT
nlet Pressure (in H20)	9.2	9.2						
apping Cycle Period (min)					.11		0	IN DC
park Rate (sparks/min)	10				.41		erratic	C
perating Voltage (KV)	—	—			.31		0	OUT
perating Amps	—	—						

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative ot Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^oR}{in.Hg}\right) \quad Vm \left(\frac{Pbar + \frac{\overline{\Delta H}}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^oR}{in.Hg.}\right) \quad 37.605\ ft^3 \left(\frac{29.92\ in.Hg. + \frac{1.279\ In.\ H_2O}{13.6}}{511.4\ ^oR}\right)$$

$$= 39.087\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{ft^3}{M}\right) \quad Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{ft^3}{M}\right) \quad 60.2\ ml$$

$$= 2.853\ ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

$$= \frac{2.853\ ft^3}{2.853\ ft^3 + 39.087\ ft^3}$$

$$= 0.068 \times 100\% = 6.8\%$$

4. Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (11.91) + 0.32\ (6.57) + 0.28\ (81.52) + 0.28\ (0.00)$$

$$= 30.17\ \text{lb/lb-mole}$$

5. Molecular Weight (wet)

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 30.17\ (1-.068) + 18\ (.068)$$

$$= 29.34\ \text{lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}}\ \left(\frac{Ts}{Ps \times Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.86)\ (1.129)\ \left(\frac{710}{29.88 \times 29.34}\right)^{1/2}$$

$$= 74.70\ \text{F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A_s \times 60\ \text{sec/min}$$

$$= 74.70 \times 130.5\ \text{ft}^2 \times 60\ \text{sec/min}$$

$$= 584{,}901\ \text{ACFM}$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ A_s \left(\frac{Tstd}{Ts}\right)\left(\frac{Ps}{Pstd}\right) \qquad \text{ea. 2-3}$$

$$= 60\ (1-.068)\ (74.70)\ (130.5)\ \left(\frac{530}{710}\right)\left(\frac{29.88}{29.92}\right)$$

$$= 406{,}382\ \text{SCFM}$$

9. Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60\ \text{min}}{\text{hr}} \times \frac{Md}{386\ ft^3}$$

$$= 406{,}382\ \text{SCFM} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{30.17\ \text{lb/lb-mole}}{386\ ft^3}$$

$$= 1{,}905{,}784\ \text{lb/hr}$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154\ \frac{gr}{mg}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154\ \frac{gr}{mg}\right) \frac{76.4\ mg}{39.087\ ft^3}$$

$$= 0.030\ \text{gr/SCF}$$

11. Particulate Concentrations, lb/ft^3

$$Cs = \frac{\left(\frac{1}{453600}\ \frac{lb}{mg}\right) Mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600}\ \frac{lb}{mg}\right) 76.4\ mg}{39.087\ ft^3}$$

$$= 4.30 \times 10^{-6}\ \text{lb/SCF}$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60\ \text{min}}{\text{hr}}$$

$$= (4.30 \times 10^{-6}\ \text{lb/SCF})\ (406{,}382\ \text{SCFM})\ \frac{60\ \text{min}}{\text{hr}}$$

$$= 104.85\ \text{lb/hr}$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{104.85 \text{ lb/hr}}{1805.3 \times 10^6 \text{ BTU/hr}}$$

$$= 0.058 \text{ lb/MBTU}$$

14. % Isokinetic Sampling

$$I = \frac{\overline{Ts}\ (1.667\ \frac{\text{min}}{\text{sec}}) \left((0.00267)\ Vlc + \frac{Vm}{Tm} \left(Pbar + \frac{\overline{\Delta H}}{13.6} \right) \right)}{\Theta \quad Vs \quad Ps \quad An}$$

eq. 5-6

$$I = \frac{710\ (1.667) \left((0.00267)\ (60.2) + \frac{37.605}{511.4} \left(29.92 + \frac{1.279}{13.6} \right) \right)}{(60)\ (74.70)\ (29.88)\ (0.0001916)}$$

$$= 109.2\%$$

15. NO_x Concentrations, lb/hr

$$\text{lb/hr} = PPM \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{255}{10^6} \times \frac{46 \text{ lb/lb-mole}}{30.17 \text{ lb/lb-mole}} \times 1,905,784 \frac{\text{lb}}{\text{hr}}$$

$$= 741.0 \text{ lb/hr}$$

16. NO_x Concentrations, lb/MBTU

$$\text{lb/MBTU} = \frac{\text{lb/hr}}{\text{Heat Input}}$$

$$= \frac{741.0 \text{ lb/hr}}{1805.3 \times 10^6 \text{ BTU/hr}}$$

$$\text{lb/MBTU} = \frac{0.410 \text{ lb}}{10^6 \text{ BTU}}$$

17. Stack Pressure (Absolute) in.Hg.

$$Ps = Pb + \frac{Pd}{13.6} = 29.92 + \frac{(-0.6)}{13.6} = 29.88 \text{ in.Hg}$$

18. Nozzle Area (ft^2)

$$An = \pi D^2/4 = 0.785 \quad (0.1875/12)^2 = 1.916 \times 10^{-4} \ ft^2$$

19. Stack Area (ft^2)

$$As = \pi D^2/4 = 0.785 \ (154.75/12)^2 = 130.5 \ ft^2$$

20. Heat Input, MBTU

Sp. Gr. x 8.33 lb/gal x BTU/lb x gal/hr

0.909 x 8.33 x 19.452 x 12.257 = 1805.3 MBTU/hr

21. Gas Density, lb/ft^3

$$\text{Gas Density} = \frac{\text{Mol wt gas}}{386 \ ft^3} \text{(md)} \times \frac{Tstd}{Ts} \times \frac{Pbar}{Pstd}$$

$$= \frac{30.17}{386} \times \frac{530 \ ^{\circ}R}{710} \times \frac{29.92}{29.92} = 0.058 \ lb/ft^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

est No. Bridgeport Harbor Stack #2 No. Runs 3

ame of Firm The United Illuminating Company

ocation of Plant 10 Henry Street, Bridgeport, Connecticut

ype of Plant Steam Generating Station

ontrol Equipment Electrostatic Precipitator

ampling Point Locations Stack

ollutants Sampled Particulates, Nitrogen Oxides

ime of Particulate Test:

un No. 1	Date 12/11/73	Begin 10:10	End 11:19
un No. 2	Date 12/11/73	Begin 12:08	End 13:20
un No. 3	Date 12/11/73	Begin 13:43	End 14:47

PARTICULATE EMISSION DATA

n No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-^{o}R}\right)^{\frac{1}{2}}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.86	0.86	0.86	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	1.129	1.207	1.190	
$\overline{Ts}$ = Average stack temp., ^{o}R	710	710	710	
Pb = Barometric pressure, "Hg Abs.	29.92	29.85	29.87	
Pd = Gas duct pressure, "H_2O	-0.6	-0.6	-0.6	
Ps = Absolute stack gas pressure, inches Hg	29.88	29.81	29.83	
Bws = % moisture in stack gas, by volume	6.8	8.4	7.1	
Md = Molecular weight of stack gas, dry	30.17	30.15	30.14	
Ms = Molecular weight of stack gas	29.34	29.13	29.28	

un NO.	1	2	3	Average
Vs = Stack gas velocity, F.P.S.	74.70	80.23	78.87	
% CO_2	11.91	11.77	11.71	
% O_2	6.57	6.66	6.69	
% CO	0.00	0.00	0.00	
% N_2	81.52	81.57	81.60	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	60.2	78.9	66.5	
Vm = Volume of dry gas sampled at meter conditions, FT^3	37.605	38.724	39.009	
Vstd = Volume of dry gas sampled at STP, FT^3	39.087	40.616	40.946	
Tm = Average dry gas meter temp., ^oR	511.4	505.8	505.7	
$\overline{\Delta H}$ = Average pressure drop across orifice, inches H_2O	1.279	1.438	1.397	
θ = Total Sampling Time, min.	60	60	60	
Dn = Nozzle dia., inches	0.1875	0.1875	0.1875	
An = Nozzle area, FT^2 x 10^{-4}	1.916	1.916	1.916	
I = % of isokinetic sampling	109.2	107.8	108.9	
Qs = Stack gas volume at STP (SCFM)	406,382	427,969	426,971	420,441
Qa = Stack gas volume at stack conditions (ACFM)	584,901	628,201	617,552	610,218
Ws = Stack gas mass flow lbs/hr	1905784	2005689	2000348	1970607
Mp = Particulate-probe, washings, mg	-	-	-	
Mf = Particulate-filter (mg)	-	-	-	
Mn = Particulate-total (mg)	76.4	51.6	59.5	
C's = Particulate Concentrations gr/scf	0.030	0.020	0.022	0.024
Cw = Particulate total emission lb/hr	104.85	71.90	81.98	86.24
Er = Particulate emission rate, lb/106 BTU	0.058	0.040	0.045	0.05
C = NO, concentrations, PPM	255	252	246	251
Cn = NO, lb/10^6BTU	0.410	0.426	0.416	0.42

#46

OAQPS-78-1
7615-II-I 264

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref 21

Emission Test Report

English Station Stack No. 3

Steam Generator Nos. 7, 9, 11

9

~~1953~~ - 19?? 1941 1941

The United Illuminating Company
English Station
510 Grand Avenue
New Haven, Connecticut
06505

Approved by:

E. W. Somerville

Vice President, Engineering and Planning

Submitted by:

M. R. McCraven

Director of Environmental Engineering

Emission Test Report

English Station Stack No. 3
Steam Generator Nos. 7, 9, 11
(Ref. "Intent to Test" Form Number 720052)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis
M. Collins

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Larkin
J. Kittrell

Prepared by:

J. S. Sombati ______________________
Development & Test Laboratory Supervisor

J. W. Hotchkiss John W. Hotchkiss
Assistant Mechanical Engineer

Checked by:

J. F. Crowe ______________________
Chief Mechanical Engineer

<u>Test Results</u>

English Station Steam Generator
Nos. 7, 9, 11

Test Conducted on
December 26, 27, 1973.

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company English Station Steam Generator Nos. 7, 9 and 11, stack No. 3 located in New Haven, Connecticut. Testing was conducted on December 26 and 27, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII, and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new <u>Source Test Guidelines and Procedures,</u> (received April 3, 1973).

1. Sampling Train Information
(Ref. Item VIII, "Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_x: Dynascience Model P-101 NO_x Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. NO_x: Stainless steel tube

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube.

d. Probe Cleaning Method

See Appendix A

2. Field Data Sheets
(Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. Description of Operation
(Ref. Item X, "Intent To Test" Form)

The operation tested was English Station steam generator numbers 7, 9, and 11, stack 3, Registration Number E.S. 7, 9, and 11, stack 3, having a total BTU/hr rating of 381.8 MBTU (averaged over test period), burning No. 6 residual fuel oil at an average rate of 2585 gal/hr and having a gas flow of 159,264 ACFM average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission Sampling was performed in the stack 135 feet above the stack foundation (7 stack diameters above the breeching inlet and 2 stack diameters down from the top). Emission sampling was performed using four 4" diameter sampling ports spaced 90° apart on the stack circumference. A total of twenty sampling points (5 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 14'-7-1/4" I.D.

a. Stack Configuration:

See Appendix A

b. Sampling Port Location:

See Appendix A

c. Sampling Point Position:

See Appendix A

5. Stack and Vent Description
(Ref. Item XII, "Intent To Test" Form)

Three Babcock and Wilcox cross drum inclined tube boilers discharge flue gas into two ducts which enter the base of the stack 180° apart on the stack circumference. These boilers do not have any precipitators or other stack cleaning apparatus connected to the flue gas ducts.

6. Operational Parameters
(Ref. Item XIII, "Intent To Test" Form)

Electric utility steam generator burning No. 6 residual fuel oil having rated capacities as registered.

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATORS 7, 9, 11

STACK NO. 3

nt	Sampling Duration Minutes per point	Sampling Duration Total Test Time	Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
		15 min.	3	0.23 lb/10^6 BTU	Dynascience Model P-101
ticu- ate	5	100 min.	3	0.03 lb/10^6 BTU	Method 5*
sture	5	100 min.	3	8.7%	Method 4*
lysis		15 min.	3	39% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
ocity	1/2	15 min.	3	0.03" to 0.07" H_2O **	Method 2*

*Federal Register, Volume 36, No. 247, December 23, 1971

** Range of S-Type Pitot-Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATORS 7, 9, 11

STACK NO. 3

Test	1	2	3	Average
Date	12/26/73	12/27/73	12/27/73	
Stack Flow, ACFM	154,878	164,621	158,293	159,264
Stack Flow, SCFM	82,588	87,963	84,277	84,943
Stack Flow, lb/hr	385,284	409,780	391,823	395,629
% Excess O_2 at Test Point	7.51	7.78	8.09	7.79
Particulate Emissions				
gr/SCF	0.014	0.013	0.015	0.014
lb/hr	9.81	9.87	10.57	10.08
lb/MBTU	0.02	0.03	0.03	0.03
Nitrogen Oxide Emission				
ppm	138	138	150	142
lb/hr	81.5	86.8	90.4	86.2
lb/MBTU	0.20	0.23	0.25	0.23

NOx

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATORS 7, 9, 11

STACK 3

Test	1	2	3
Date	12/26/73	12/27/73	12/27/73
Steam Flow (avg. total) lb/hr	291,660	273,300	258,300
Oil Flow (avg. total) gal/hr	2754	2562	2440
Heat Input (avg. total) MBTU/hr	406.0	378.6	360.7
Stack Gas Temperature $^{\circ}F$	450	450	450
Gas Density, lb/ft^3	0.046	0.045	0.045

FUEL OIL ANALYSIS

STEAM GENERATORS 7, 9, 11

STACK NO. 3

Test	1	2	3
Date	12/26/73	12/27/73	12/27/73
	Composition (% by Weight)		
Carbon	86.40	86.37	86.37
Hydrogen	12.30	12.35	12.35
Nitrogen	<0.1	<0.1	<0.1
Ash	0.022	0.017	0.017
Sulfur	0.378	0.366	0.366
Specific Gravity	0.910	0.912	0.912
BTU/lb	19,447	19,451	19,451
BTU/gal	147,414	147,768	147,768

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

All test ports are located in the stack and the number of points sampled were calculated on the guidelines in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature, and velocity over the cross-sectional area of each stack. (See Figures 2,4,6 and 8.)

2. Velocity and Temperature

Velocity was determined by pitot tube in accordance with Western Precipitation Company Bulletin "WP-50". An S-type Pitot Tube (2) and thermocouple (3) are rigidly attached to the sampling probe (See Figure 9). A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques.

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by the UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 9. The stainless steel, button-hook type probe tip (1) was equipped with a 5/8 inch diameter fitting connected by a stainless steel coupling with asbestos packing to the probe. The probe consisted of 1/2 inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 300°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the ball-joint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (4) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (5) which is thermostatically maintained at a minimum temperature of 250-300°F to prevent water condensation. Attached to the heated box was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a 1/2 inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger (10) modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (Δ P in inches water)
5. Desired pressure drop across orifice (Δ H in inches water)
6. Actual pressure drop across orifice (Δ H in inches water)
7. Dry gas temperature (°F) gas meter inlet.
8. Dry gas temperature (°F) gas meter outlet.
9. Vacuum pump gauge reading (in. Hg).
10. Filter box temperature (°F)
11. Dry gas temperature (°F) at the discharge of last impinger.
12. Stack temperature (°F)

The relationship of Δ P reading with the Δ H reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δ P and Δ H could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. Basic Laboratory Procedure

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with and Infra-Red Heat Lamp and the beaker weighed

again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

7. Calibration

The equipment used on this assignment was calibrated one week prior to field testing and re-calibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

TEST TEAM

Robert J. Larkin
James R. Kittrell

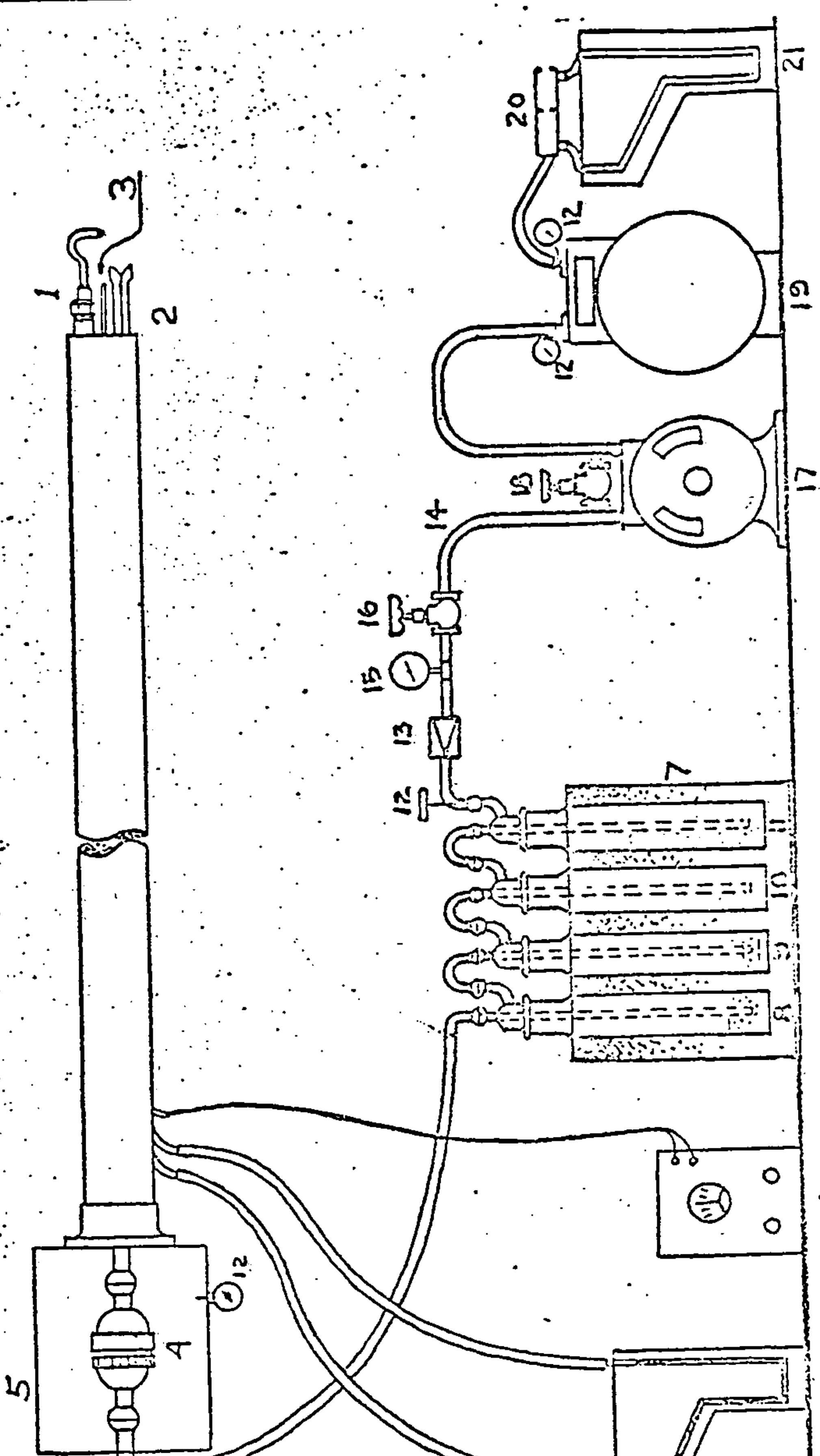
Prepared By: Robert J. Larkin
Robert J. Larkin
Test Engineer

Reviewed By: Robert S. Epstein
Robert S. Epstein
Project Director

Approved By: Roy S. Edgell
Roy S. Edgell
Manager-Engineering Services

SAMPLING TRAIN

Figure No. 9



York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.06	.08	.750	.866
.20	.28	.714	.845
.38	.53	.717	.847
.62	.91	.681	.825
.72	1.03	.699	.836

$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$

Pitot Tube # 14

F_s = .84

F_{std} = 1.00

Calibrated by [signature]

Date 12/13/73

oil ok

Quick Connects ok Valves ok

eters ok

est Meter

ometers ok

s ok

rical Check - Amphenol ok

e ok

n Gauge ok

Check at 27" hg. - ok CF.

ks

al each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. S 1563 P_b 29.9

ce	CF_w	CF_d	T_w	IT_d	OT_d	T_d Avg.	Time t
5	5	5.15	67	85	75	80	12.23
0	5	5.06	67	85.5	77.6	87.5	90.12
0	10	10.16	68	88.8	79.5	84.1	13.2
0	10	10.03	68	89.0	79.6	84.3	93.06
0	10	10.05	68	92.8	80.3	86.5	7.67
0	10						

late Y & $H_@$ at man. 2.0

$$Y =$$

$$Y = \frac{CF_w\, P_b\, (T_d \text{ avg.} + 460)}{CF_d\, (P_b + 0.147)(T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)(\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)}\left(\frac{(T_w + 460)t}{CF_w}\right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)}\left((\quad + 460)t\right)^2$$

Tolerances

Y = 0.99 - <u>1.00</u> - 1.01

$\Delta H_@$ = 1.6 - <u>1.84</u> - 2.1

$$\Delta H_@ = \frac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\frac{(T_w + 460)\,t}{CF_w} \right)^2$$

Man.	H@
.5	1.78
1.0	1.77
2.0	1.90
4.0	1.89
6.0	1.93
8.0	

$$\Delta H_@ = \frac{0.01585}{29.9\ (75 + 460)} \left(\frac{(67 + 460)\ \ 12.7}{5} \right)^2$$

$$\Delta H_@ = \frac{0.0317}{29.9\ (77.6 + 460)} \left(\frac{(67 + 460)\ \ 90.12}{5} \right)^2$$

$$\Delta H_@ = \frac{0.0634}{29.9\ (79.5 + 460)} \left(\frac{(68 + 460)\ \ 13.2}{10} \right)^2$$

$$\Delta H_@ = \frac{0.1268}{29.9\ (79.6 + 460)} \left(\frac{(68 + 460)\ \ 93.06}{10} \right)^2$$

$$\Delta H_@ = \frac{0.1902}{29.9\ (80.3 + 460)} \left(\frac{(68 + 460)\ \ 7.67}{10} \right)^2$$

$$0.2536 \quad \left(\frac{(\_\_ + 460)}{} \right)$$

Calibration Calculations Meter and Pump B

Date 11/5/73 Box No: 5 1 5

$$Y = \frac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ P_b + \frac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$$

Man.	Y
.5	$Y = \frac{5 \times 29.9\ (80 + 460)}{5.15\ (29.9 + 0.0368)\ (67 + 460)}$
1.0	$Y = \frac{5 \times 29.9\ (81.5 + 460)}{5.06\ (29.9 + 0.0737)\ (67 + 460)}$
2.0	$Y = \frac{10 \times 29.9\ (84.1 + 460)}{10.16\ (29.9 + 0.147)\ (68 + 460)}$
4.0	$Y = \frac{10 \times 29.9\ (84.3 + 460)}{10.03\ (29.9 + 0.294)\ (68 + 460)}$ 29.9 .64
6.0	$Y = \frac{10 \times 29.9\ (86.5 + 460)}{10.05\ (29.9 + 0.431)\ (68 + 460)}$ 29.9 .431 30.3
8.0	$Y = \frac{\_\_ \times \_\_\ (\_\_ + 460)}{\_\_\ (\_\_ + 0.588)\ (\_\_ + 460)}$

FIELD DATA

PLANT U.T. English STa.
DATE 12/26/73
SAMPLING LOCATION STack #3
SAMPLE TYPE Part.
RUN NUMBER 1
OPERATOR RWL + JRK
AMBIENT TEMPERATURE 50
BAROMETRIC PRESSURE 30.08
STATIC PRESSURE, (P_s) -.20
FILTER NUMBER (s) FL-183

50 ml H_2O net

PROBE LENGTH AND TYPE 9' SS.
NOZZLE I.D. 3/8" = .375
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER 5-1563
METER $\Delta H_@$ 1.90
C FACTOR 1.0
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
E 1	1355	55.930	.06	.72	.72	450	62	62	5.0	250-300	<70
A 2	1400	58.30	.06	.72	.72	450	63	71	5.0		
S 3	1405	60.51	.05	.60	.60	450	64	73	4.5		
T 4	1410	62.66	.03	.37	.37	450	66	74	3.5		
5	1415	64.40	.03	.37	.37	450	68	76	3.5		
End	1420	66.14									
W 1	1423	66.14	.06	.72	.72	450	66	72	5.0		
e 2	1428	68.50	.06	.72	.72	450	68	76	5.0		
S 3	1433	70.76	.04	.48	.48	450	64	78	4.6		
T 4	1438	72.66	.03	.37	.37	450	70	78	4.5		
5	1443	74.32	.03	.37	.37	450	72	75	3.5		
End	1448	75.92									
N 1	1451	75.92	.05	.60	.60	450	69	70	4.5		
o 2	1456	78.08	.05	.60	.60	450	70	72	4.5		
r 3	1501	80.14	.05	.60	.60	450	70	73	4.5		
T 4	1506	82.30	.04	.48	.48	450	72	75	4.0		
H 5	1511	84.18	.04	.48	.48	450	74	77	4.0		
End	1516	86.15									
S 1	1520	86.15	.06	.72	.72	450	70	71	5.0		
o 2	1525	88.55	.05	.60	.60	450	71	72	4.5		
u 3	1530	90.61	.05	.60	.60	450	71	74	4.5		
T 4	1535	92.70	.03	.37	.37	450	73	75	3.5		
H 5	1540	94.28	.03	.37	.37	450	73	77	3.5		
COMMENTS:	1545	95.94									

ES-041

REPORT NO. Y-8278-2

FIELD DATA

YORK RESEARCH CORPORATION — QUALITY CONTROLLED

PLANT U.T. (English STA.)
DATE 12/27/73
SAMPLING LOCATION STack #3
SAMPLE TYPE Part.
RUN NUMBER 2
OPERATOR TRR + RWL
AMBIENT TEMPERATURE 55
BAROMETRIC PRESSURE 30.01
STATIC PRESSURE, (P_s) -.20
FILTER NUMBER (s) FL-501

H_2O collected = 80 mL

PROBE LENGTH AND TYPE 9' S.S.
NOZZLE I.D. 3/8" = .375
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR 1.00
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET $(T_{m\,in})$, °F	OUTLET $(T_{m\,out})$, °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
E 1	1018	2.794	.07	.85	.85	450	63	63	4	250-300	<70
A 2	1023	5.74	.06	.72	.72	↓	64	68	↓		
S 3	1028	9.06	.05	.60	.60		64	69			
T 4	1033	10.10	.04	.48	.48		66	70			
5	1038	12.80	.03	.37	.37		66	69			
End	1043	13.735									
W 1	1047	13.735	.06	.72	.72	450	66	66			
E 2	1052	16.10	.07	.82	.82		67	66			
S 3	1057	18.58	.05	.60	.60	↓	70	68			
T 4	1102	20.49	.04	.48	.48		70	67			
5	1107	22.62	.03	.37	.37		68	67			
End	1112	24.350									
N 1	1118	24.350	.05	.60	.60	450	64	64			
O 2	1123	26.40	.07	.85	.85	↓	64	65			
R 3	1128	28.88	.06	.72	.72		71	69			
T 4	1133	31.16	.04	.48	.48		73	70			
H 5	1138	33.10	.03	.37	.37		73	70			
End	1143	34.775									
S 1	1144	34.775	.06	.72	.72	450	70	68			
O 2	1149	37.55	.07	.85	.85	↓	73	70			
U 3	1154	39.03	.06	.72	.72		74	70			
T 4	1159	41.85	.05	.60	.60		73	70			
H 5	1204	44.44	.03	.37	.37		73	70			
COMMENTS.	1209	46.210									

ES-041

REPORT NO. Y-8278-2

FIELD DATA

QUALITY CONTROLLED YORK RESEARCH CORPORATION

PLANT U.I. (English STa.)
DATE 12/27/73
SAMPLING LOCATION Stack #3
SAMPLE TYPE Part.
RUN NUMBER 3
OPERATOR RWL + TRK
AMBIENT TEMPERATURE 55
BAROMETRIC PRESSURE 30.00
STATIC PRESSURE, (P_s) -.20
FILTER NUMBER (s) FL-899

H_2O Collected
= 70 mL NET

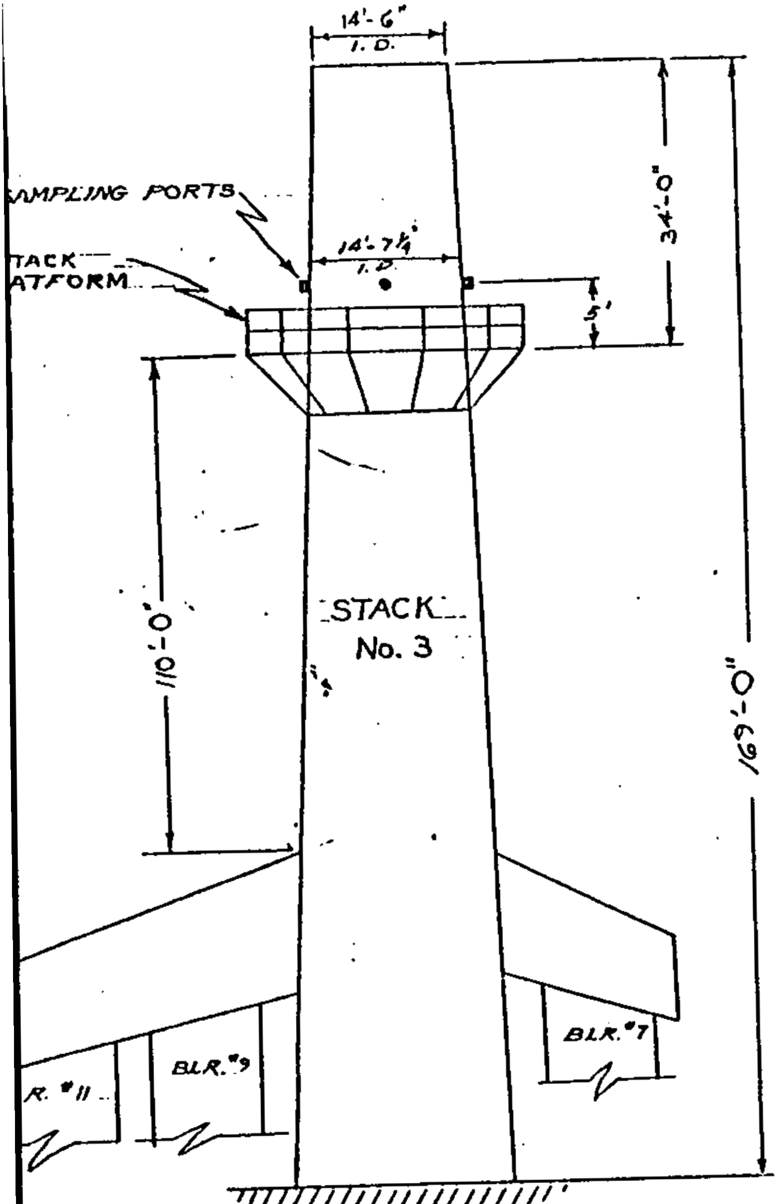
PROBE LENGTH AND TYPE 9' SS.
NOZZLE I.D. 3/8" = .375"
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR 1.00
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

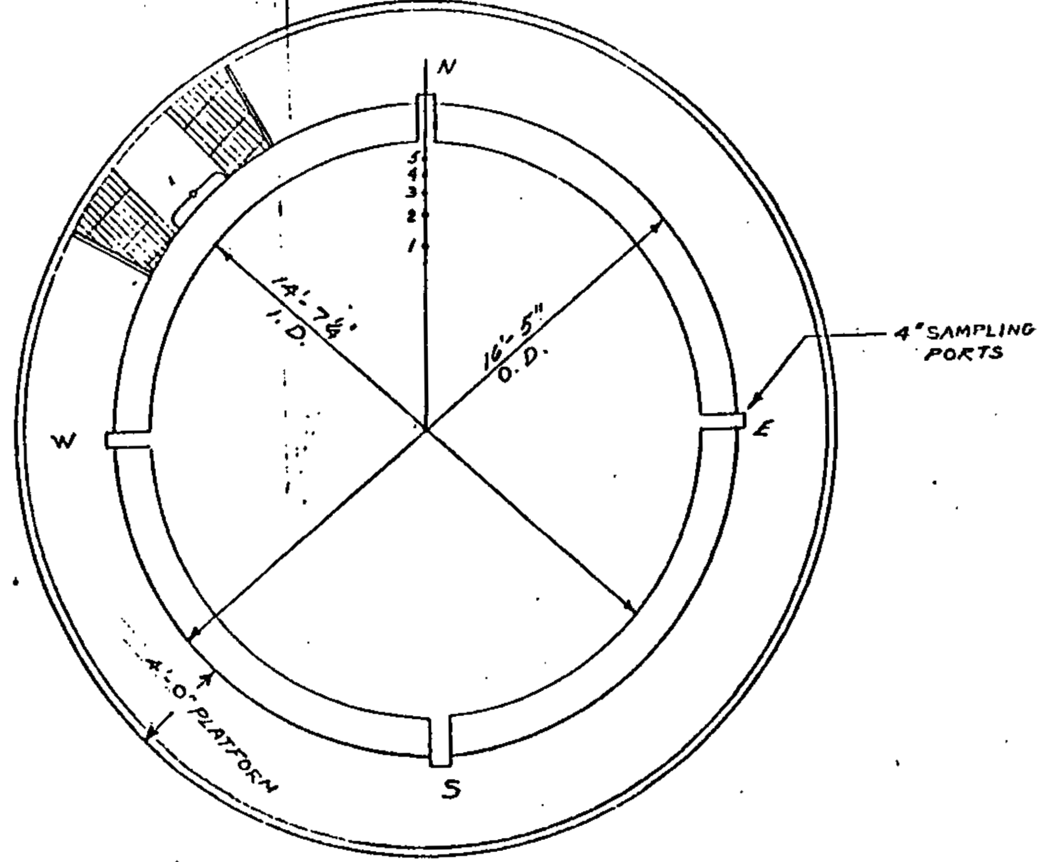
SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
W 1	1235	46.210	.06	.72	.72	450	64	64	5.0	250-300	<70
e 2	1240	48.50	.06	.72	.72		67	67			
S 3	1245	50.70	.05	.60	.60		70	68			
T 4	1250	52.73	.04	.48	.46		72	69			
5	1255	54.57	.03	.37	.37		73	70			
End	1300	56.455									
N 1	1302	56.455	.06	.72	.72	450	73	70			
o 2	1307	59.06	.06	.72	.72		74	71			
R 3	1312	61.06	.04	.48	.48		74	71			
T 4	1317	63.10	.04	.48	.48		74	70			
H 5.	1322	65.05	.03	.37	.37		74	70			
End	1327	66.688									
E 1	1331	66.688	.06	.72	.72	450	79	76			
A 2	1336	69.20	.06	.72	.72		79	77			
S 3	1341	71.34	.04	.48	.48		83	78			
T 4	1346	73.70	.03	.37	.37		85	78			
5	1351	75.64	.03	.37	.37		84	76			
End	1356	77.101									
S 1	1401	77.101	.06	.72	.72	450	76	76			
O 2	1406	79.55	.06	.72	.72		76	76			
U 3	1411	81.74	.04	.48	.48		76	75			
T 4	1416	83.90	.04	.48	.48		74	74			
H 5	1421	85.94	.04	.48	.48		74	73			
	1426	88.080									

COMMENTS:





TRAVERSE POINT No.	DISTANCE FROM WALL
5	4.4"
4	14.4"
3	25.6"
2	39.7"
1	60.0"

REVISED	
	THE UNITED ILLUMINATING CO. NEW HAVEN, CONN. STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK No. 3 ENGLISH STATION
	DRAWN BY P.L.O. DATE 3-21-74
	TRACED BY ______ DATE ______
	APPROVED BY J.W.H. DATE 4-1-74
	SCALE NONE DRAWING NO. 71212-73

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

k Identification Number STACK 3

er Number 7-9-11

t Location English

ling Point Location STACK

Date DEC 26, 1973

Time 1500

TEST 1

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
)2, % Vol (dry)	10.60	10.70	10.80		10.70	44/100	4.708
), % Vol (dry)	0	0	0		0.00	28/100	+0.00
2, % Vol (dry)	7.54	7.48	7.52		7.51	32/100	+2.403
2, % Vol (dry)	81.86	81.82	81.68		81.79	28/100	+22.901

Avg. molecular wt. of dry stack gas = 30.01

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

k Identification Number STACK 3 Date DEC. 27, 1973

er Number 7-9-11 Time 1150

t Location English

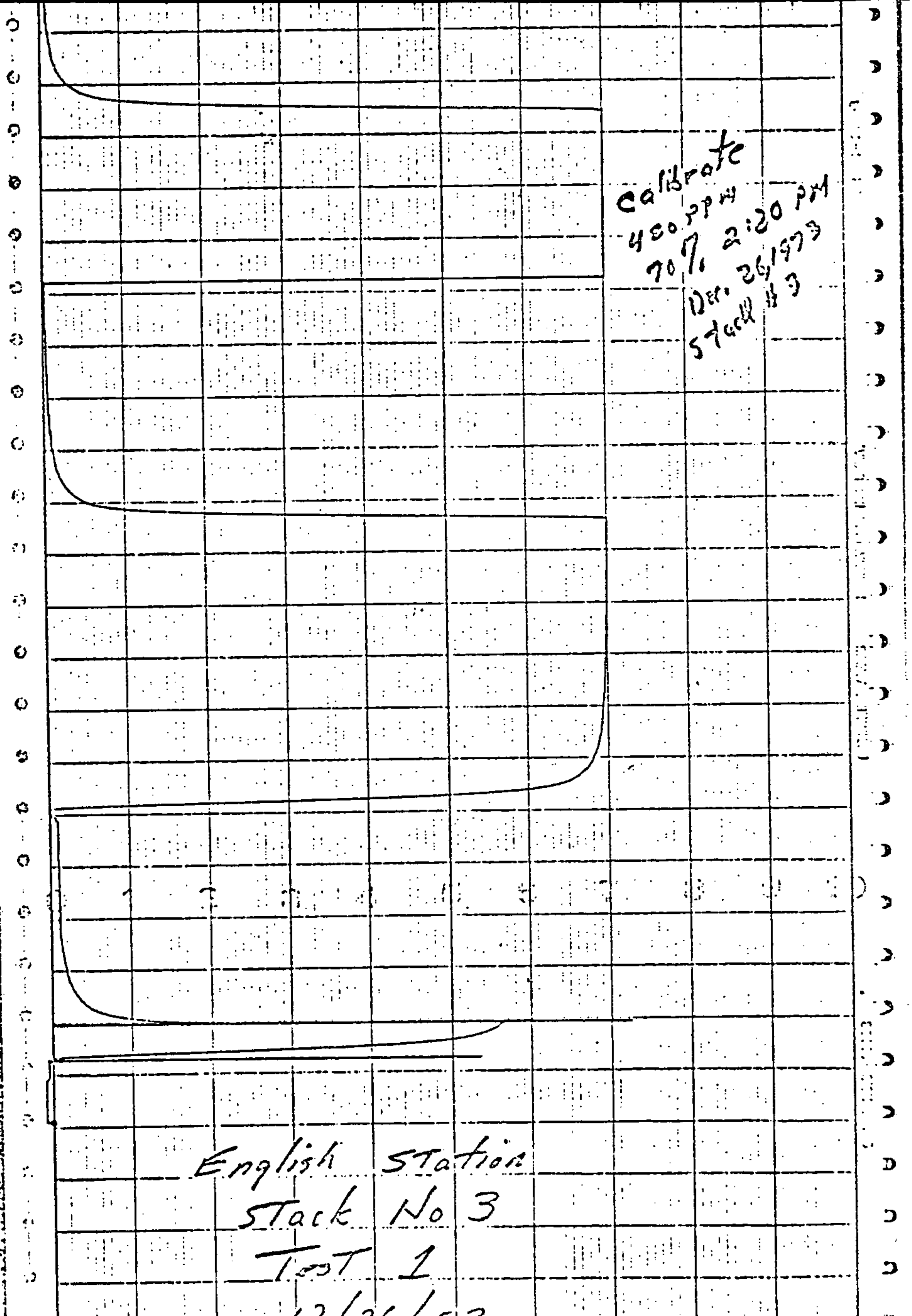
pling Point Location STACK

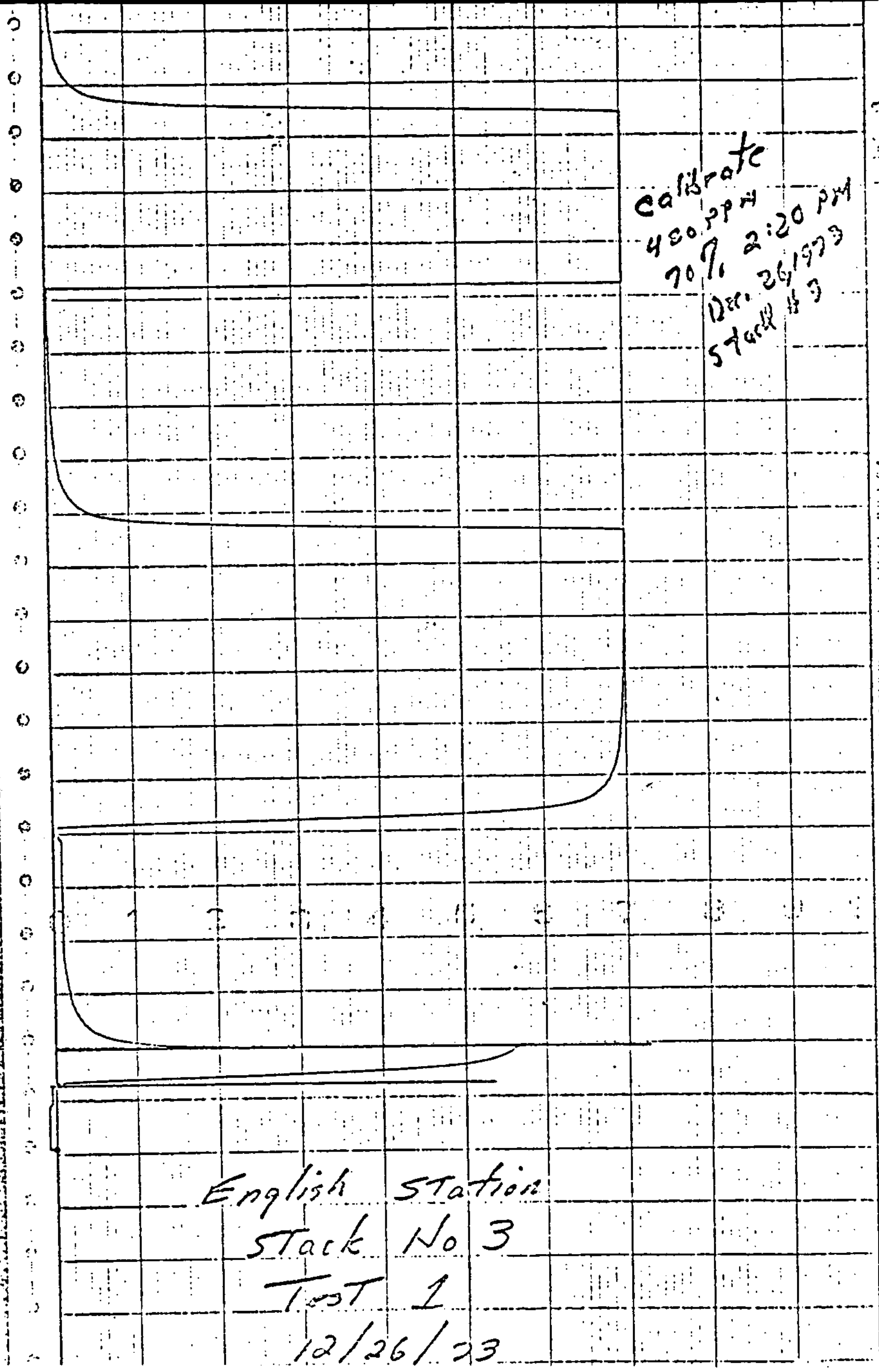
TEST 2

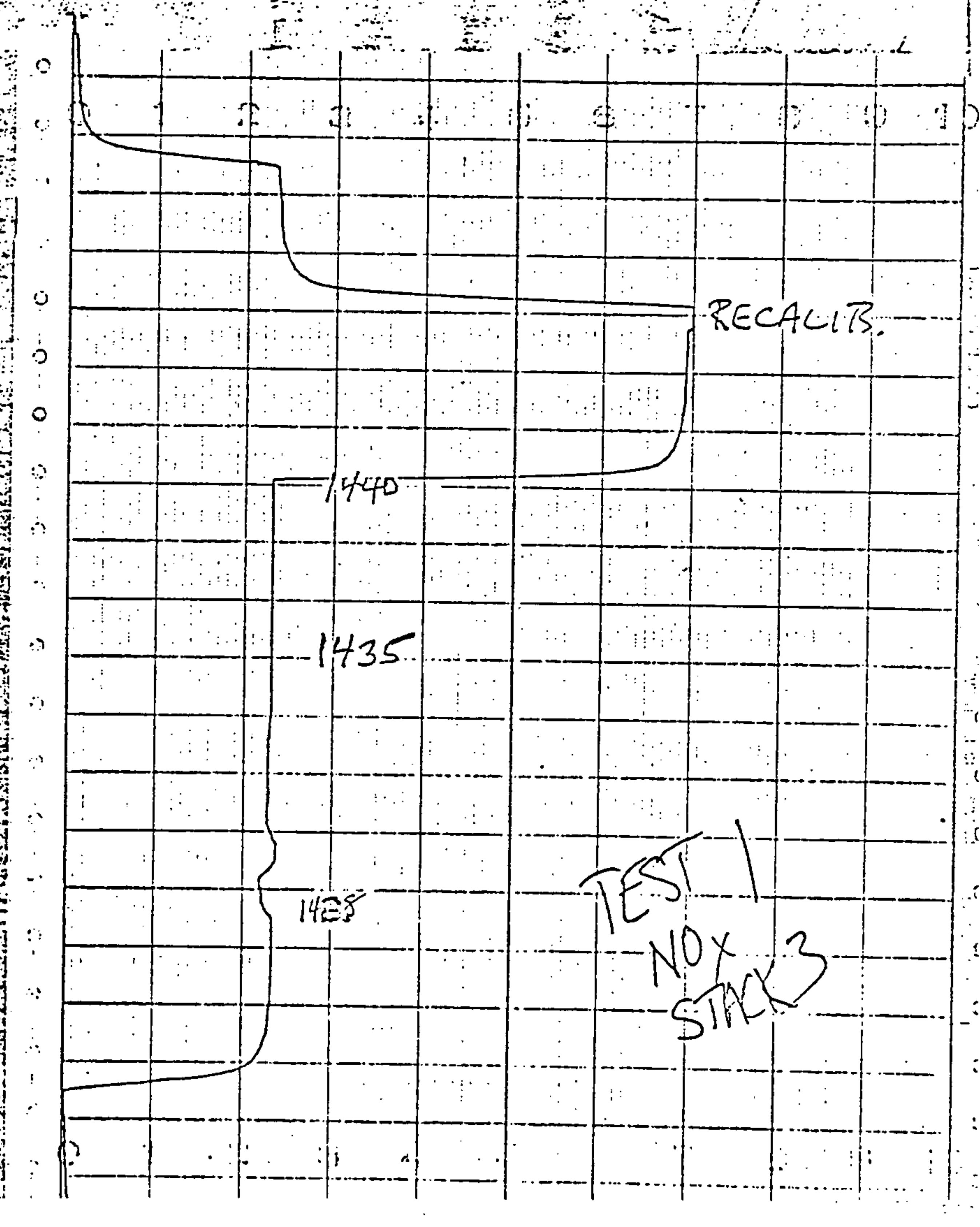
	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
2, % Vol (dry)	10.34	10.28	10.40		10.34	44/100	4.55
, % Vol (dry)	0	0	0			28/100	+
2, % Vol (dry)	7.88	7.72	7.75		7.78	32/100	+ 2.49
2, % Vol (dry)	81.78	82.00	81.85		81.88	28/100	+ 22.93

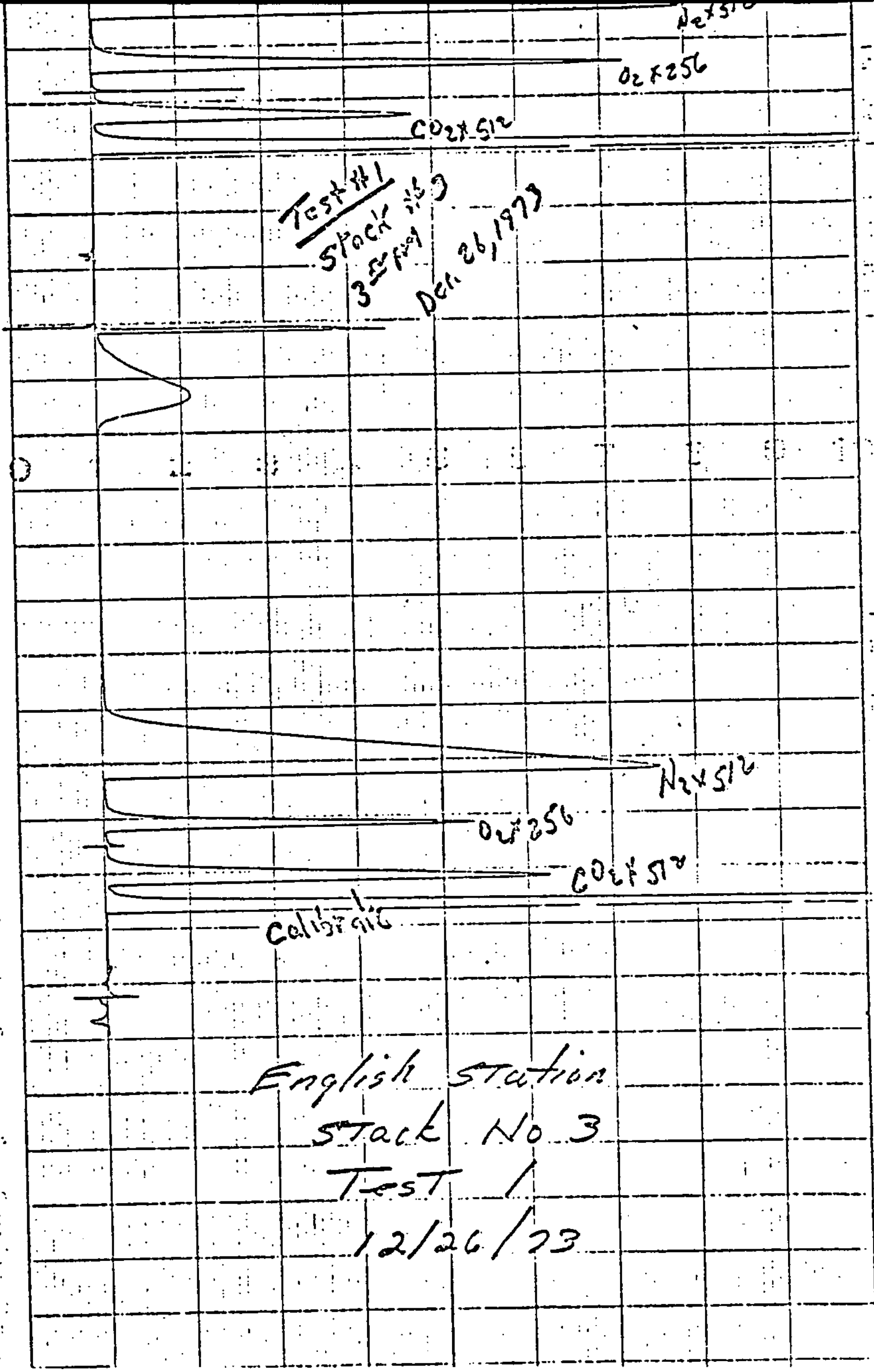
Avg. molecular wt. of dry stack gas = 29.97

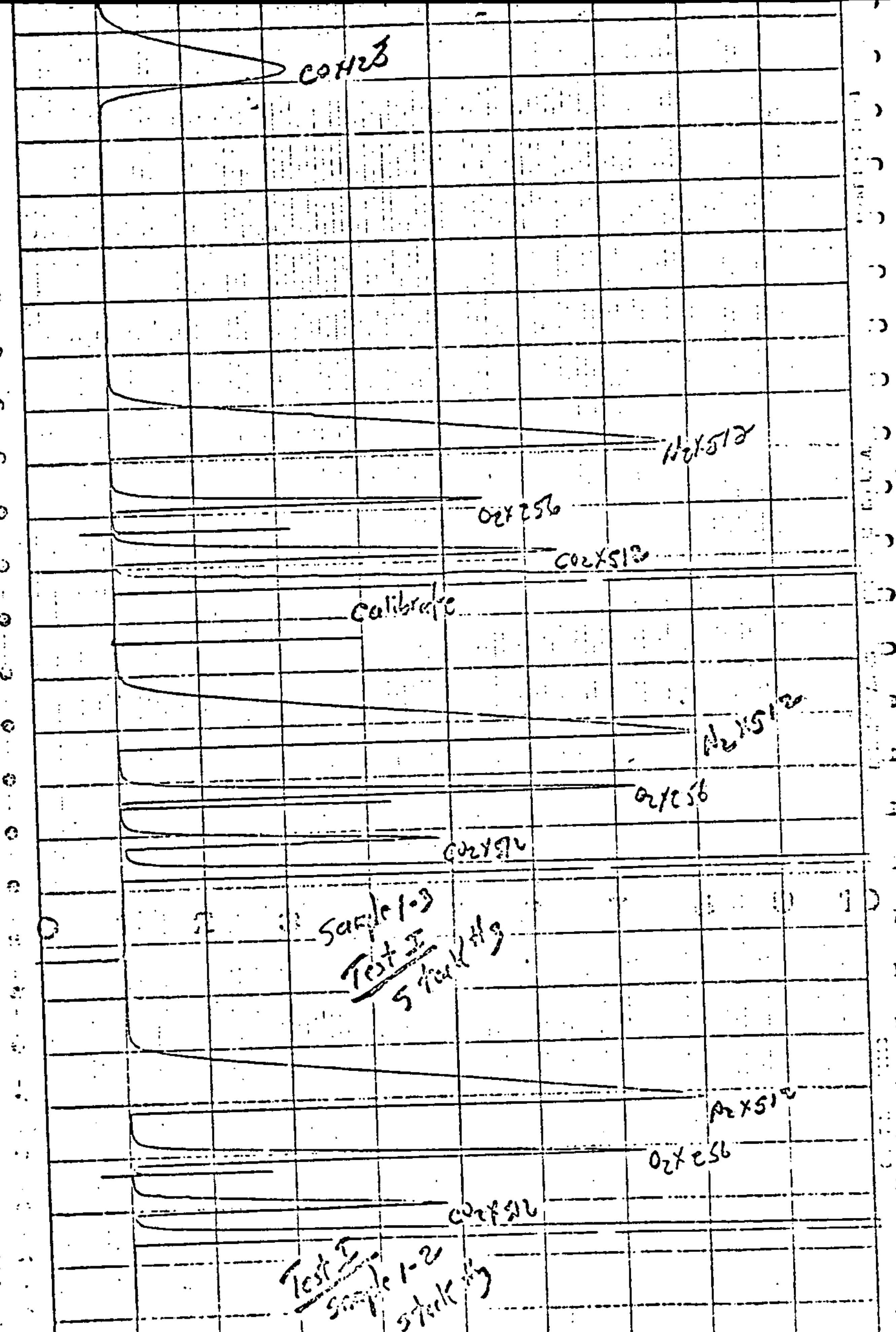
TEST NO. 1


Calibrate
480 PPM
70%, 2:20 PM
Dec. 26, 1973
Stack # 3
English Station
Stack No 3
Test 1
12/26/73

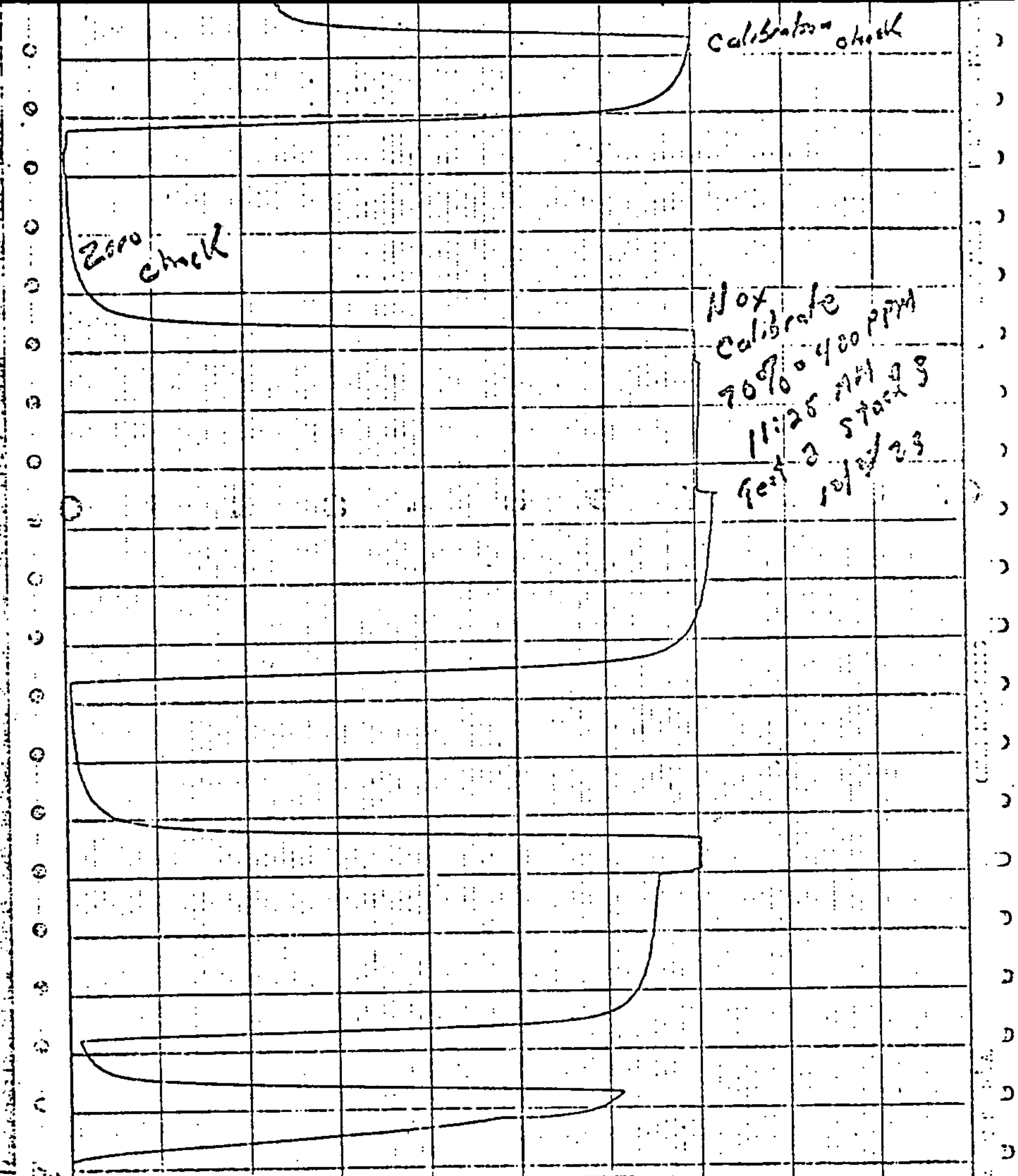

Calibrate
400 PPH
70% 2:20 PM
Dec. 26, 1973
Stack # 3
English Station
Stack No 3
Test 1
12/26/73


RECALIB.
1440
1435
1428
TEST 1
NOX
STACK 3

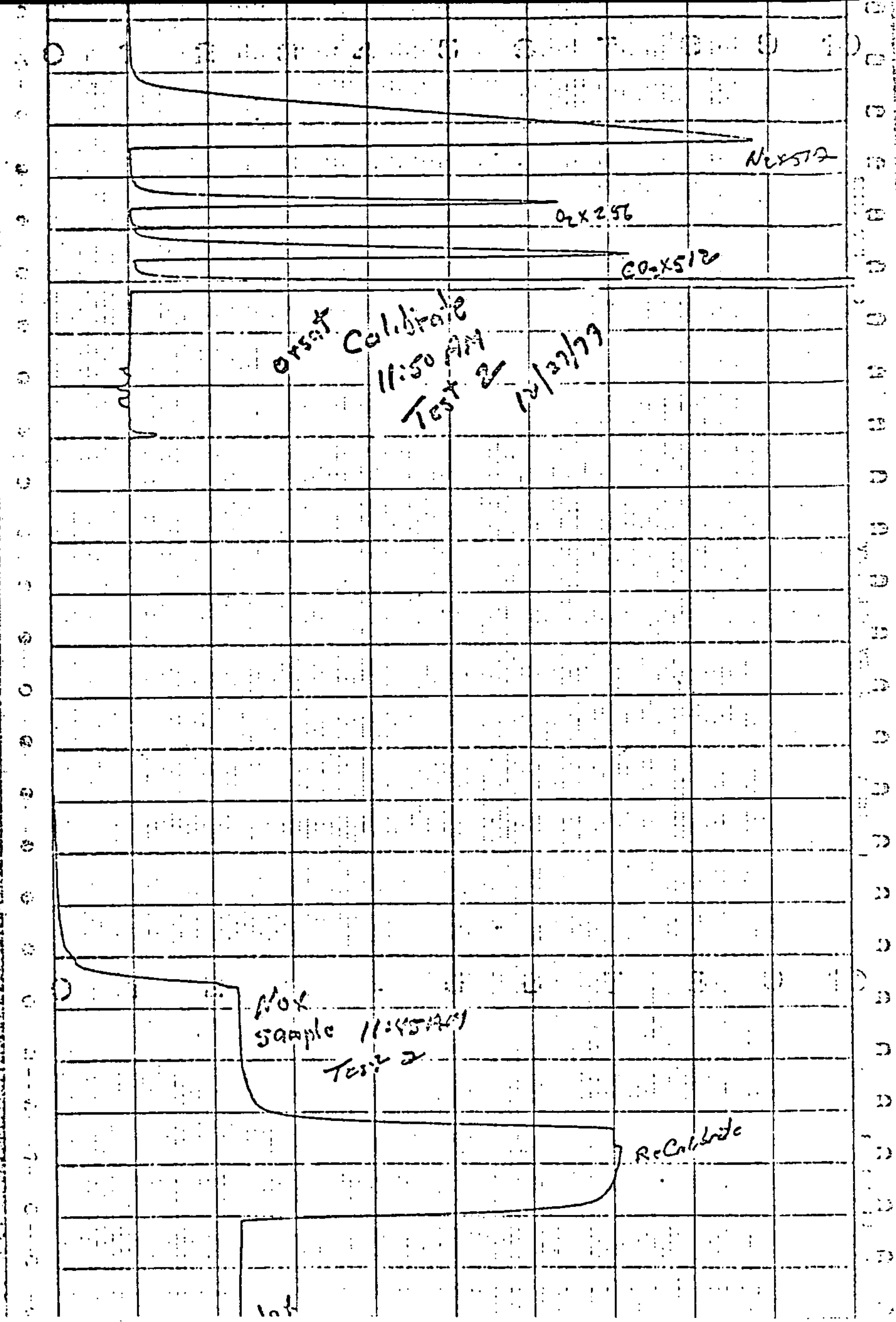

$O_2 \times 256$
$CO_2 \times 512$
Test #1
Stack #3
Dec 26, 1973
$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
English station
Stack No 3
Test 1
12/26/73


CO×128
N2×512
O2×256
CO2×512
calibrate
N2×512
O2×256
CO2×512
Sample 1-3
Test II
stack Hg
N2×512
O2×256
CO2×512
Test I
Sample 1-2
stack Hg

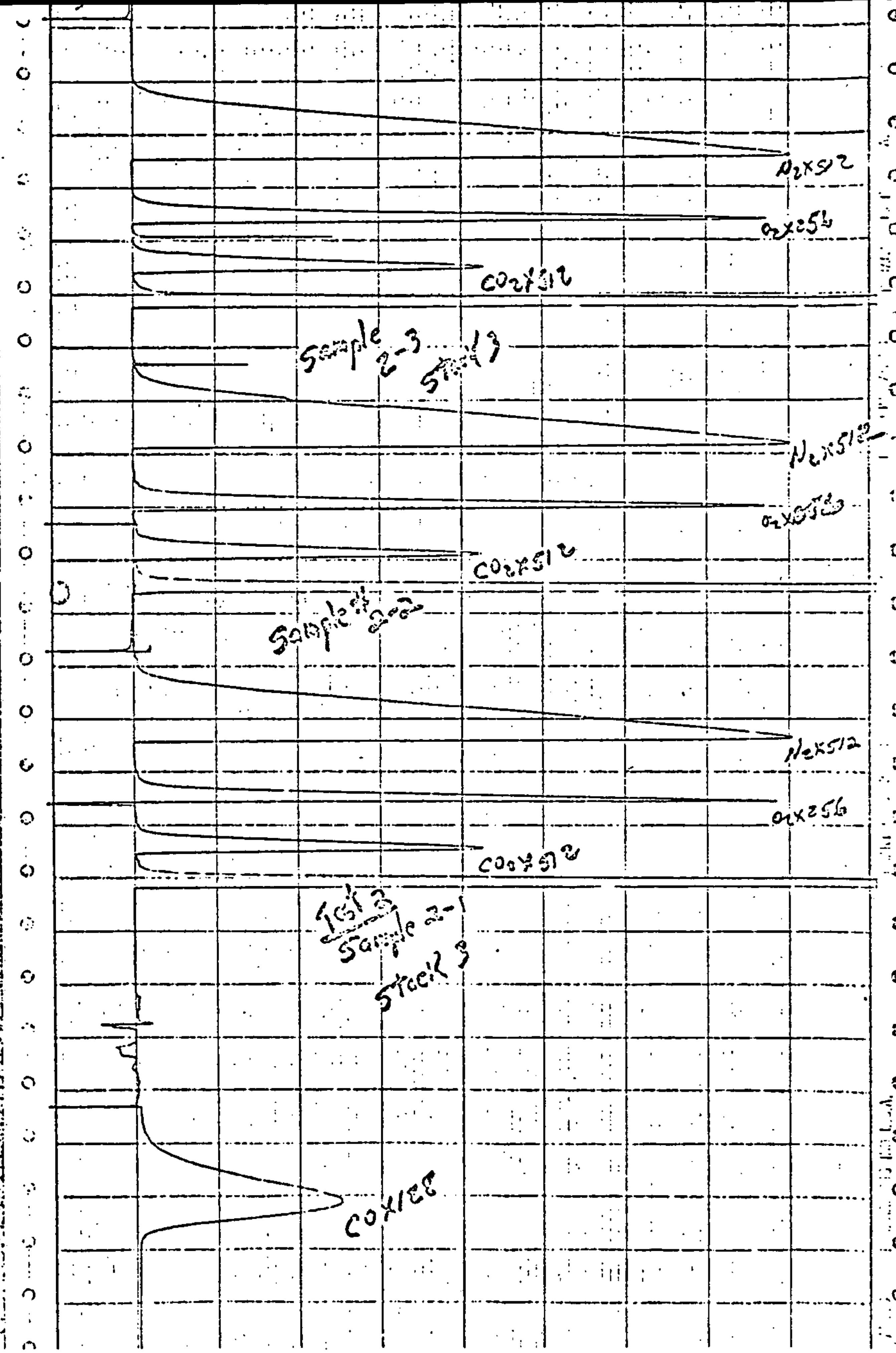
TEST NO. 2



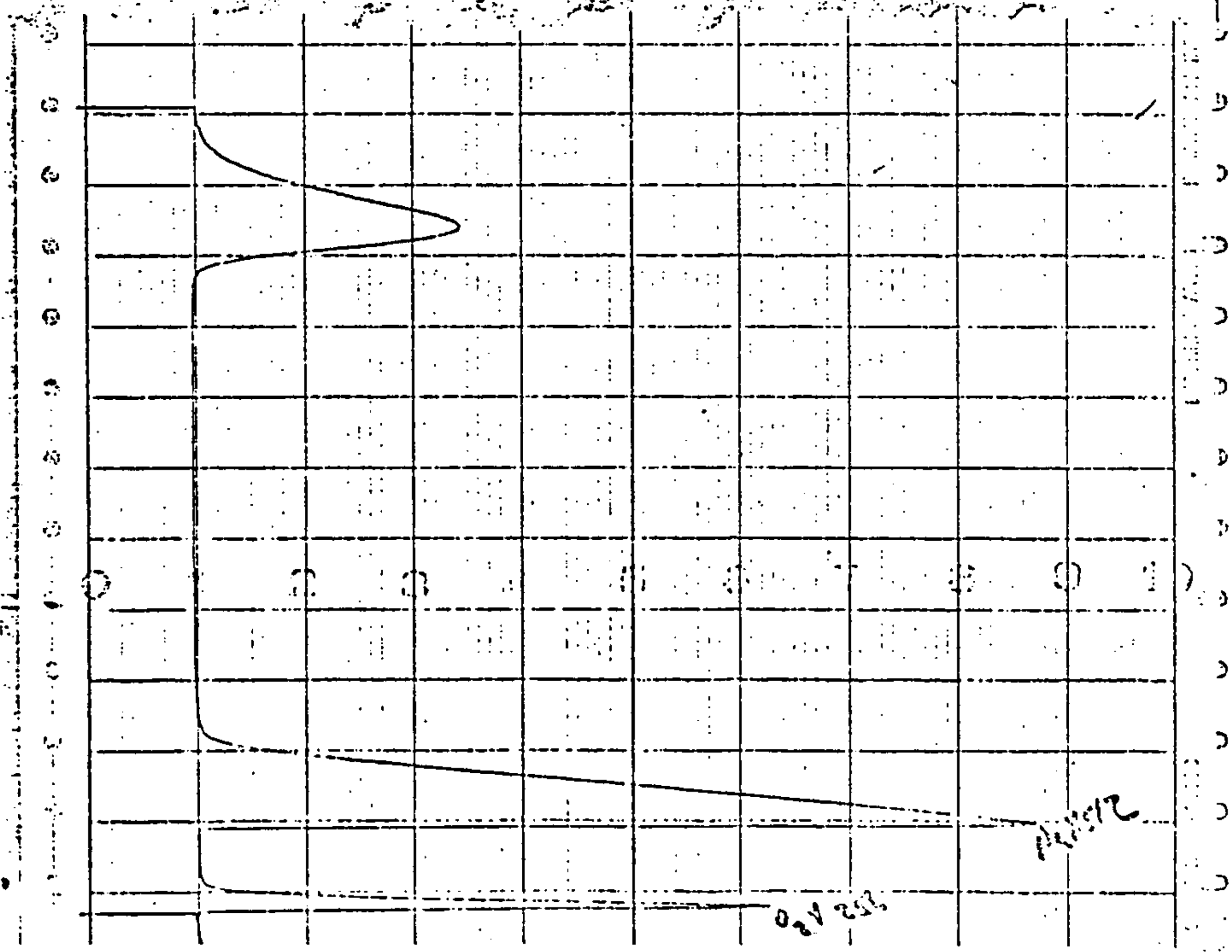
English station
stack No 3
Test 2
12/27/73



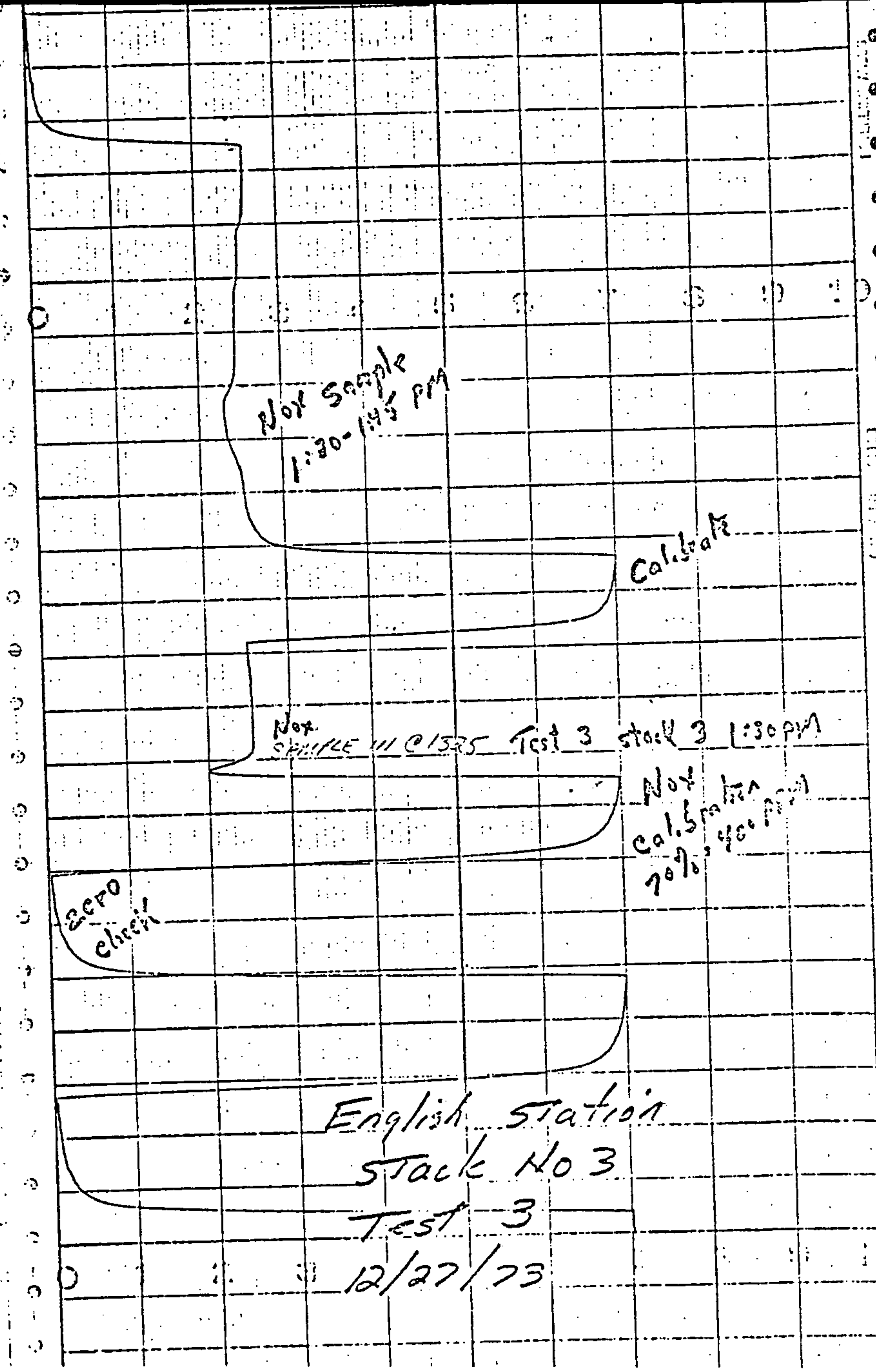
N2 x 512
O2 x 256
CO2 x 512
orsat Calibrate
11:50 AM
Test 2
12/27/79
NOx
sample 11:45 AM
Test 2
ReCalibrate



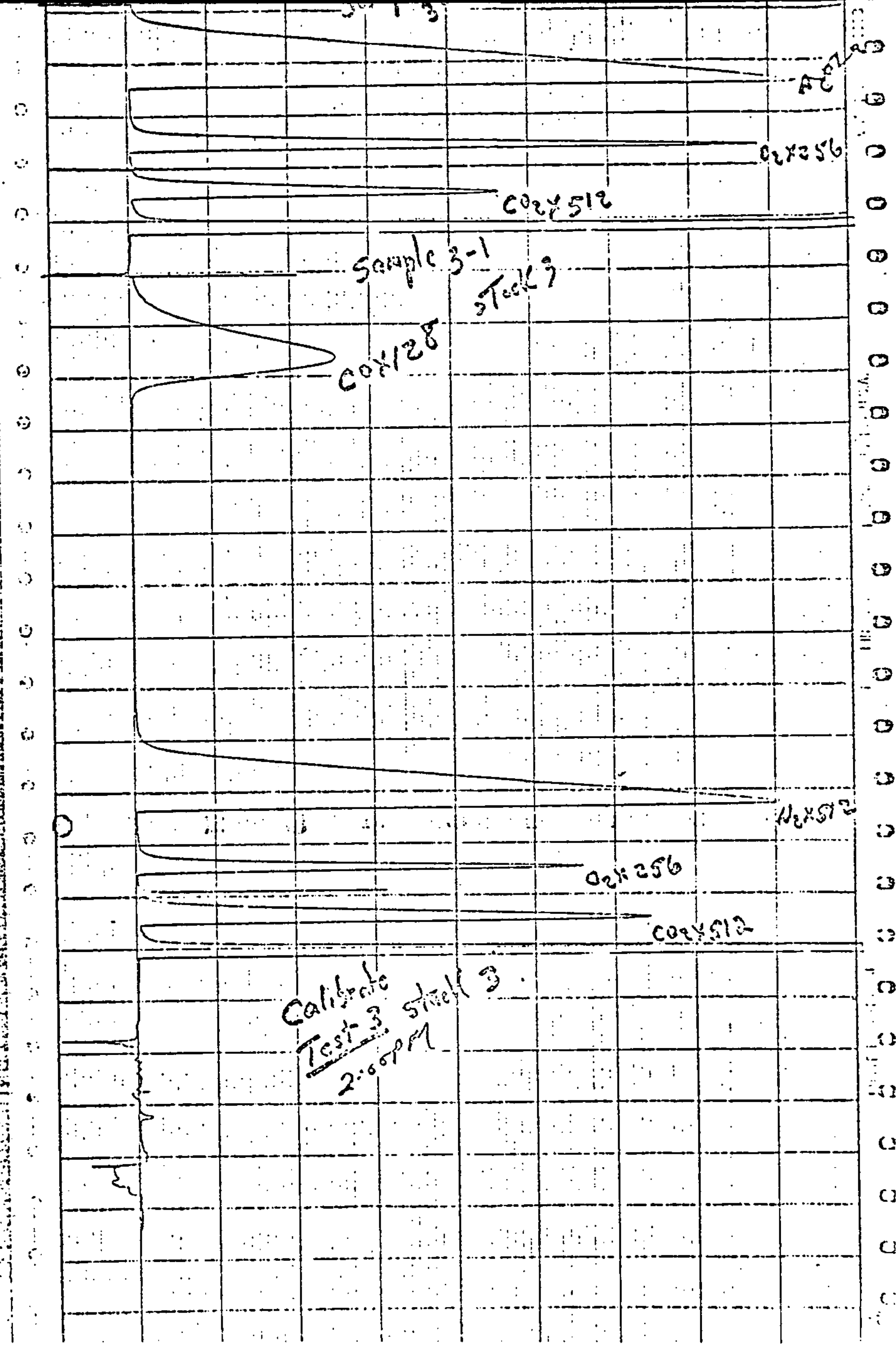
O2x512
O2x256
CO2x512
Sample 2-3
Stack 3
Nex512
CO2x512
Sample # 2-2
Nex512
O2x256
CO2x512
Test 3
Sample 2-1
Stack 3
COx128

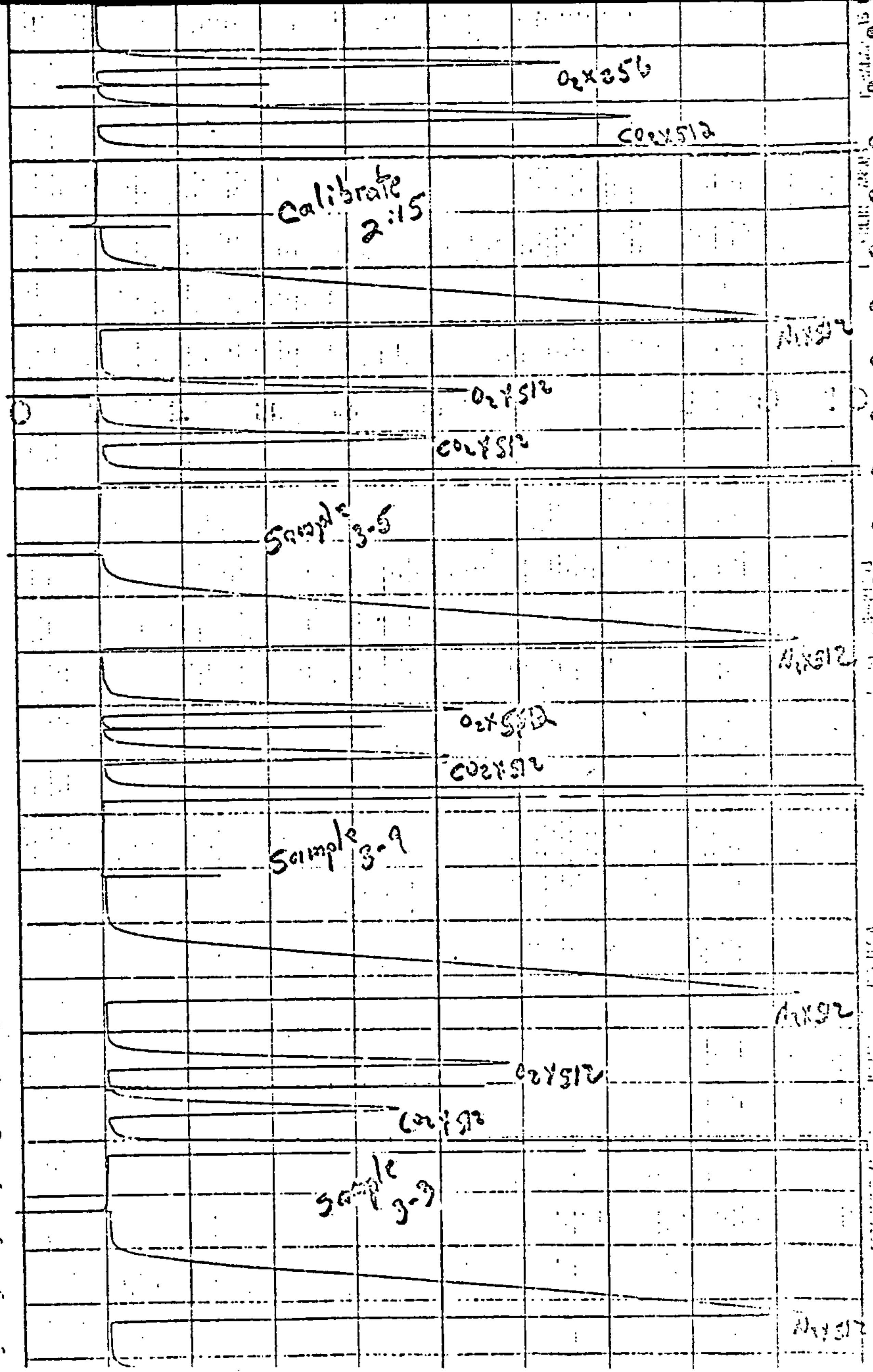


TEST NO. 3



Nox Sample
1:30-1:45 PM
Calibrate
Nox
SAMPLE III @1325 Test 3 stack 3 1:30 PM
Nox
calibration
70% 400 PPM
zero
check
English Station
Stack No 3
Test 3
12/27/73


O2x256
CO2x512
Sample 3-1
Stack 3
COx128
N2x512
O2x256
CO2x512
Calibrate
Test 3
Stack 3
2:00PM



O2x256
CO2x512
Calibrate 2:15
O2x512
CO2x512
Sample 3-5
O2x512
CO2x512
Sample 3-7
O2x512
CO2x512
Sample 3-9

APPENDIX C

BOILER OPERATING DATA

BOILER CONDITIONS

STACK ID NUMBER STACK 3

DATE DEC 26, 1973

BOILER NO. 7-9-11

TEST NO. 1

PLANT English Sta

PARAMETERS	1415	1523	1608				
METER (GAL) TOTAL	95901654	95906633	95910045				
STEAM HEADER PRESS.	[illegible]1	364	362				
FUEL OIL HEADER PRESS.	192	184	187				
BOILER # 7 WINDBOX PRESS "H₂O	1.7	2.0	2.0				
OIL FLOW %	68	68	72				
AIR FLOW %	70	71	71				
STEAM FLOW lb/hr	95,500	96,000	100,00				
Barometric	30.08	30.06	30.08				
BOILER # 9 WINDBOX PRESS "H₂O	2.9	2.7	3.0				
OIL FLOW %	75	70	78				
AIR FLOW %	77	78	78				
STEAM FLOW lb/hr	102,000	100,000	108,000				
[illegible]US RECIRC. OIL METER	86650839	86651636	86651401				
BOILER # 11 WINDBOX PRESS "H₂O	3.4	3.4	3.4				
OIL FLOW %	75	72	80				
AIR FLOW %	76	76	76				

STACK ID NUMBER SYN... 3

BOILER NO. 7-9-11

PLANT English

DATE DEC 22,19

TEST NO. 2

PARAMETERS	1009	1126	1223				
OIL METER (GAL)	7596.1926	7576.7568	9577.1.4?				
LP STEAM HEADER PRESS.	364	349	364				
LP FUEL OIL HEADER PRESS.	185	187	186				
LP BOILER # 7 WINDBOX PRESS "H_2O"	1.9	1.7	1.9				
OIL FLOW %	68	65	65				
AIR FLOW %	70	70	70				
STEAM FLOW lb/hr	87,000	90,000	87,000				
Recirc Meter	8609.2040	8009.4331	8109.1032				
LP BOILER # 9 WINDBOX PRESS "H_2O"	2.9	2.9	3.0				
OIL FLOW %	75	72	71				
AIR FLOW %	76	79	79				
STEAM FLOW lb/hr	104,000	102,000	98,100				
BAROMETER	30.01	30.00	29.96				
LP BOILER # 11 WINDBOX PRESS "H_2O"	3.1	3.1	3.2				
OIL FLOW %	72	69	72				
AIR FLOW %	74	75	75				

BOILER CONDITIONS

DATE DEC 27, 1973

TEST NO. 3

STACK ID NUMBER STACK 3

BOILER NO. 7-9-11

PLANT English

PARAMETERS	1223	1334	1433				
METER (GAL)	95971640	95976720	959[illegible]36				
STEAM HEADER PRESS.	364	370	358				
FUEL OIL HEADER PRESS.	186	187	187				
BOILER #7 WINDBOX PRESS. "H2O	1.9	1.9	2.6				
OIL FLOW %	65	64	48				
AIR FLOW %	70	70	60				
STEAM FLOW lb/hr	87,000	92,000	68,000				
Recirc Meter	86096032	86097971	86099742				
BOILER #9 WINDBOX PRESS "H2O	3.0	2.9	3.4				
OIL FLOW %	71	70	58				
AIR FLOW %	79	78	64				
STEAM FLOW lb/hr	98,000	105,000	75,000				
Barometer	29.96	30.00	30.00				
BOILER #11 WINDBOX PRESS "H2O	3.2	3.0	3.0				
OIL FLOW %	72	70	65				
%	75	75	70				

APPENDIX D

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{o}R}{in.\ Hg}\right) \quad Vm \quad \frac{\left(Pbar + \frac{\Delta H}{13.6}\right)}{Tm} \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{o}R}{in.\ Hg}\right) \quad 40.01\ ft^3 \quad \frac{\left(30.08\ in.Hg + \frac{0.540\ in.\ H_2O}{13.6}\right)}{531.3\ ^{o}R}$$

$$= 40.170\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{ft^3}{ml.}\right) \quad Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{ft^3}{ml.}\right) \quad 83.2\ ml.$$

$$= 3.944\ ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd} \qquad \text{eq. 5-3}$$

$$= \frac{3.944\ ft^3}{3.944\ ft^3 + 40.170\ ft^3}$$

$$= 0.089 \times 100\% = 8.9\%$$

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%\ N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (10.70) + 0.32\ (7.51) + 0.28\ (81.79) + 0.28\ (0.00)$$

$$= 30.01\ \text{lb/lb-mole}$$

5. Molecular Weight (wet)

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 30.01\ (1-.089) + 18\ (.089)$$

$$= 28.94\ \text{lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}} \left(\frac{\overline{Ts}}{Ps\ \ Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.84)\ (.210) \left(\frac{910}{30.07 \times 28.94}\right)^{1/2}$$

$$= 15.42\ \text{F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times As \times 60\ \text{sec/min}$$

$$= 15.42 \times 167.4\ ft^2 \times 60\ \text{sec/min}$$

$$= 154{,}878\ \text{ACFM}$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ As \left(\frac{Tstd}{\overline{Ts}}\right) \left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.089)\ (15.42)\ (167.4) \left(\frac{530}{910}\right) \left(\frac{30.07}{29.92}\right)$$

$$= 82{,}588\ \text{SCFM}$$

$$Ws = \frac{Qs \times 60\ min}{hr} \times \frac{Md}{386\ ft^3}$$

$$= 82{,}588\ SCFM \times \frac{60\ min}{hr} \times \frac{30.01\ lb/lb\text{-}mole}{386\ ft^3}$$

$$= 385{,}284\ lb/hr$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154\ \frac{gr.}{mg.}\right)\left(\frac{Mn}{Vmstd}\right) \qquad \text{eq. 5-4}$$

$$= \left(0.0154\ \frac{gr.}{mg.}\right)\frac{36.1\ mg.}{40.17\ ft^3}$$

$$= 0.0138\ gr/SCF$$

11. Particulate Concentrations, lb/ft^3

$$Cs = \frac{\left(\frac{1}{453600}\ \frac{lb.}{mg.}\right) Mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600}\ \frac{lb.}{mg.}\right) 36.1\ mg.}{40.17\ ft^3}$$

$$= 1.98 \times 10^{-6}\ lb/SCF$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60\ min}{hr}$$

$$= (1.98 \times 10^{-6}\ lb/SCF)\ (82{,}588\ SCFM)\ \frac{60\ min}{hr}$$

$$= 9.81\ lb/hr$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{9.81\ lb/hr}{406.0 \times 10^6\ BTU/hr}$$

$$= 0.024\ lb/MBTU$$

14. % Isokinetic Sampling

$$I = \frac{\overline{Ts}\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\overline{\Delta H}}{13.6}\right)\right)}{\Theta\ \ Vs\ \ Ps\ \ An}$$

eq. 5-6

$$I = \frac{910\ (1.667)\left((0.00267)\ (83.2) + \frac{40.01}{531.3}\left(30.08 + \frac{0.540}{13.6}\right)\right)}{(100)\ (15.42)\ (30.07)\ (7.666 \times 10^{-4})}$$

$$= 106.3\%$$

15. NOx Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{138}{10^6} \times \frac{46\ lb/lb\text{-}mole}{30.01\ lb/lb\text{-}mole} \times 385{,}284\ \frac{lb}{hr}$$

$$= 81.5\ lb/hr$$

16. NO_X Concentrations, lb/MBTU

$$lb/MBTU = \frac{lb/hr}{Heat\ Input}$$

$$= \frac{81.5\ lb/hr}{406.0 \times 10^6\ BTU/hr}$$

$$= \frac{0.201\ lb}{10^6\ BTU}$$

17. Stack Pressure (Absolute), in. Hg

$$Ps = Pb + \frac{Pd}{13.6} = 30.08 + \frac{(-0.20)}{13.6} = 30.07\ in.\ Hg.$$

18. Nozzle Area (Ft^2)

$$An = \pi D^2/4 = 0.785 \times (0.375/12)^2 = 7.666 \times 10^{-4}\ Ft.^2$$

19. Stack Area (ft^2)

$$As = \pi D^2/4 = 0.785 \; (175.25/12)^2 = 167.43 \text{ ft}^2$$

20. Heat Input MBTU

Sp. Gr. x 8.33 lb/gal x BTU/16 x gal/hr

0.910 x 8.33 x 19447 x 2754 406.0 x 10^6 BTU/hr.

21. Gas Density lb/ft^3

$$\text{Gas Density} = \frac{\text{Mol wt gas (md)}}{386 \text{ ft}^3} \times \frac{\text{Tstd}}{\text{Ts}} \times \frac{\text{Pbar}}{\text{Pstd}}$$

$$= \frac{30.01}{386} \times \frac{530^\circ R}{910} \times \frac{30.08}{29.92} = 0.046 \text{ lb/ft}^3$$

SOURCE TESTING CALCULATION FORMS

Test No. English Station #3 No. Runs 3

Name of Firm United Illuminating Company

Location of Plant 510 Grand Avenue, New Haven, Connecticut

Type of Plant Steam Generating Station

Control Equipment None

Sampling Point Locations Stack

Pollutants Sampled Particulates, Nitrogen Oxides

Time of Particulate Test:

Run No. 1	Date 12/26/73	Begin 1355	End 1545
Run No. 2	Date 12/27/73	Begin 1018	End 1209
Run No. 3	Date 12/27/73	Begin 1235	End 1426

PARTICULATE EMISSION DATA

Run No.	1	2	3	
$K_p = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-{}^{\circ}R}\right)^{1/2}$	85.48	85.48	85.48	
C_p = Pitot tube coefficient (calib.)	0.84	0.84	0.84	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.210	0.223	0.214	
$\overline{T_s}$ = Average stack temp., °R	910	910	910	
P_b = Barometric pressure, "Hg Abs.	30.08	30.01	30.00	
P_d = Gas duct pressure, "H_2O	-0.20	-0.20	-0.20	
P_s = Absolute stack gas pressure, inches Hg	30.07	30.00	29.99	
B_{ws} = % moisture in stack gas, by volume	8.9	8.5	8.8	
M_d = Molecular weight of stack gas, dry	30.01	29.97	29.91	
M_s = Molecular weight of stack gas	28.94	28.96	28.86	

OAQPS-78-1
76/5-II-I

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref 21

Emission Test Report

English Station Stack No. 1

Steam Generator Nos. 1, 3, 5

The United Illuminating Company
English Station
510 Grand Avenue
New Haven, Connecticut
06505

Approved by:

E. W. Somerville
Vice President, Engineering and Planning

Submitted by:

M. R. McCraven,
Director of Environmental Engineering

Emission Test Report

English Station Stack No. 1
Steam Generator Nos. 1, 3, 5
(Ref. "Intent to Test" Form Number 730060)

Test Conducted by
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis
M. Collins

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Larkin
J. Kittrell

Prepared by:

J. S. Sombati
Development & Test Laboratory Supervisor

J. W. Hotchkiss
Assistant Mechanical Engineer

Checked by:

J. F. Crowe
Chief Mechanical Engineer

Test Results

English Station Steam Generator
Nos. 1, 3, 5

Test Conducted on
December 13, 14, 1973.

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company English Station Steam Generator Nos. 1, 3, and 5, stack No. 1 located in New Haven, Connecticut. Testing was conducted on December 13 and 14, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII, and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new <u>Source Test Guidelines and Procedures</u>, (received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATORS 1, 3, 5

STACK NO. 1

Component	Sampling Duration		Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
	Minutes per point	Total Test Time			
1) NO_x		15 min.	3	0.30 lb/10^6 BTU	Dynascience Model P-101
2) Particulate	5	100 min.	3	0.03 lb/10^6 BTU	Method 5*
3) Moisture	5	100 min.	3	8.3%	Method 4*
4) Gas Analysis		15 min.	3	36% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	1/2	15 min.	3	0.03" to 0.12" H_2O **	Method 2*

*Federal Register, Volume 36, No. 247, December 23, 1971

** Range of S-Type Pitot-Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATORS 1, 3, 5

STACK NO. 1

Test	1	2	3	Average
Date	12/13/73	12/13/73	12/14/73	
Stack Flow, ACFM	196,242	217,800	200,976	205,006
Stack Flow, SCFM	105,819	116,594	106,997	109,803
Stack Flow, lb/hr	494,608	545,334	499,948	513,297
% Excess O_2 at Test Point	7.22	7.22	7.25	7.23
Particulate Emissions				
gr/SCF	0.013	0.013	0.015	0.014
lb/hr.	11.49	13.02	13.55	12.69
lb/MBTU	0.03	0.03	0.03	0.03
Nitrogen Oxide Emission				
ppm	165	165	171	167
lb/hr	125.1	137.6	130.8	131.2
lb/MBTU	0.30	0.30	0.30	0.30

Part: $\frac{12.7 \text{ lb/hr}}{2.95 \times 10^3 \text{ gal/hr}} = 4.3 \frac{\text{lb}}{10^3 \text{gal}}$

NO_x: $\frac{131 \text{ lb/hr}}{[illegible]}$ $45 \frac{\text{lb}}{10^3 \text{gal}}$

No controls

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATORS 1, 3, 5

STACK 1

Test	1	2	3
Date	12/13/73	12/13/73	12/14/73
Steam Flow (avg. total) lb/hr	331,650	337,660	331,330
Oil Flow (avg. total) gal/hr	2947	2957	2959 —
Heat Input (avg. total) MBTU/hr	440.0	441.5	441.5
Stack Gas temperature ^oF	443.8	446.5	443.5
Gas Density, lb/ft^3	0.0457	0.0456	0.0451

TABLE IV

FUEL OIL ANALYSIS

STEAM GENERATORS 1, 3, 5

STACK 1

Test	1	2	3
Date	12/13/73	12/13/73	12/14/73
	Composition (% by Weight)		
Carbon	86.73	86.73	86.65
Hydrogen	12.31	12.31	12.48
Nitrogen	<0.1	<0.1	<0.1
Ash	0.015	0.015	0.014
Sulfur	0.45	0.45	0.46
Specific Gravity	0.903	0.903	0.903
BTU/lb	19,847	19,847	19,835
BTU/gal.	149,289	149,289	149,199

1. Sampling Train Information
(Ref. Item VIII, "Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_X: Dynascience Model P-101 NO_X Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes :

1. NO_X: Stainless steel tube.

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube.

d. Probe Cleaning Method:

See Appendix A

2. Field Data Sheets
(Ref. Item IX, "Intent to Test" Form)

See Appendices A, B, C, D.

3. Description of Operation
(Ref. Item X, "Intent to Test" Form)

The operation tested was English Station steam generator numbers 1, 3, and 5, stack 1, Registration Number E.S. 1, 3 and 5, stack 1, having a total BTU/hr. rating of 441.0 MBTU (averaged over test period), burning No. 6 residual fuel oil at an average rate of 2954 gal/hr. for all three boilers, and having a gas flow of 205,006 ACFM average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent to Test" Form)

Emission sampling was performed in the stack 135 feet above the stack foundation (7 stack diameters above the breeching inlet and 2 stack diameters down from the top). Emission sampling was performed using four 4" diameter sampling ports spaced 90° apart on the stack circumference. A total of twenty sampling points (5 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 14'-7-1/2" I.D.

a. Stack Configuration

See Appendix A

b. Sampling Port Location

See Appendix A.

c. Sampling Point Position

See Appendix A.

5. Stack and Vent Descriptions
(Ref. Item XII, "Intent to Test" Form)

Three Babcock and Wilcox cross drum inclined tube boilers discharge flue gas into two ducts which enter the base of the stack 180° apart on the stack circumference. These boilers do not have any precipitators or other stack cleaning apparatus connected to the flue gas ducts.

6. Operational Parameters
(Ref. Item XIII, "Intent to Test" Form)

Electric utility steam generator burning No. 6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

TEST TEAM

Robert J. Larkin
James R. Kittrell

Prepared By: Robert J. Larkin
Test Engineer

Reviewed By: Robert S. Epstein
Project Director

Approved By: Roy S. Egdall
Manager-Engineering Services

V. SAMPLING METHODS

1. Port Location

All test ports are located in the stack and the number of points sampled were calculated on the guidelines in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature, and velocity over the cross-sectional area of each stack. (See Figures 2,4,6 and 8.)

2. Velocity and Temperature

Velocity was determined by pitot tube in accordance with Western Precipitation Company Bulletin "WP-50". An S-type Pitot Tube (2) and thermocouple (3) are rigidly attached to the sampling probe (See Figure 9). A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques.

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by the UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 9. The stainless steel, button-hook type probe tip (1) was equipped with a 5/8 inch diameter fitting connected by a stainless steel coupling with asbestos packing to the probe. The probe consisted of 1/2 inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 300°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the ball-joint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (4) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (5) which is thermostatically maintained at a minimum temperature of 250-300°F to prevent water condensation. Attached to the heated box was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a 1/2 inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger (10) modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (Δ P in inches water)
5. Desired pressure drop across orifice (Δ H in inches water)
6. Actual pressure drop across orifice (Δ H in inches water)
7. Dry gas temperature (°F) gas meter inlet.
8. Dry gas temperature (°F) gas meter outlet.
9. Vacuum pump gauge reading (in. Hg).
10. Filter box temperature (°F)
11. Dry gas temperature (°F) at the discharge of last impinger.
12. Stack temperature (°F)

The relationship of Δ P reading with the Δ H reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δ P and Δ H could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. Basic Laboratory Procedure

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with and Infra-Red Heat Lamp and the beaker weighed

again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

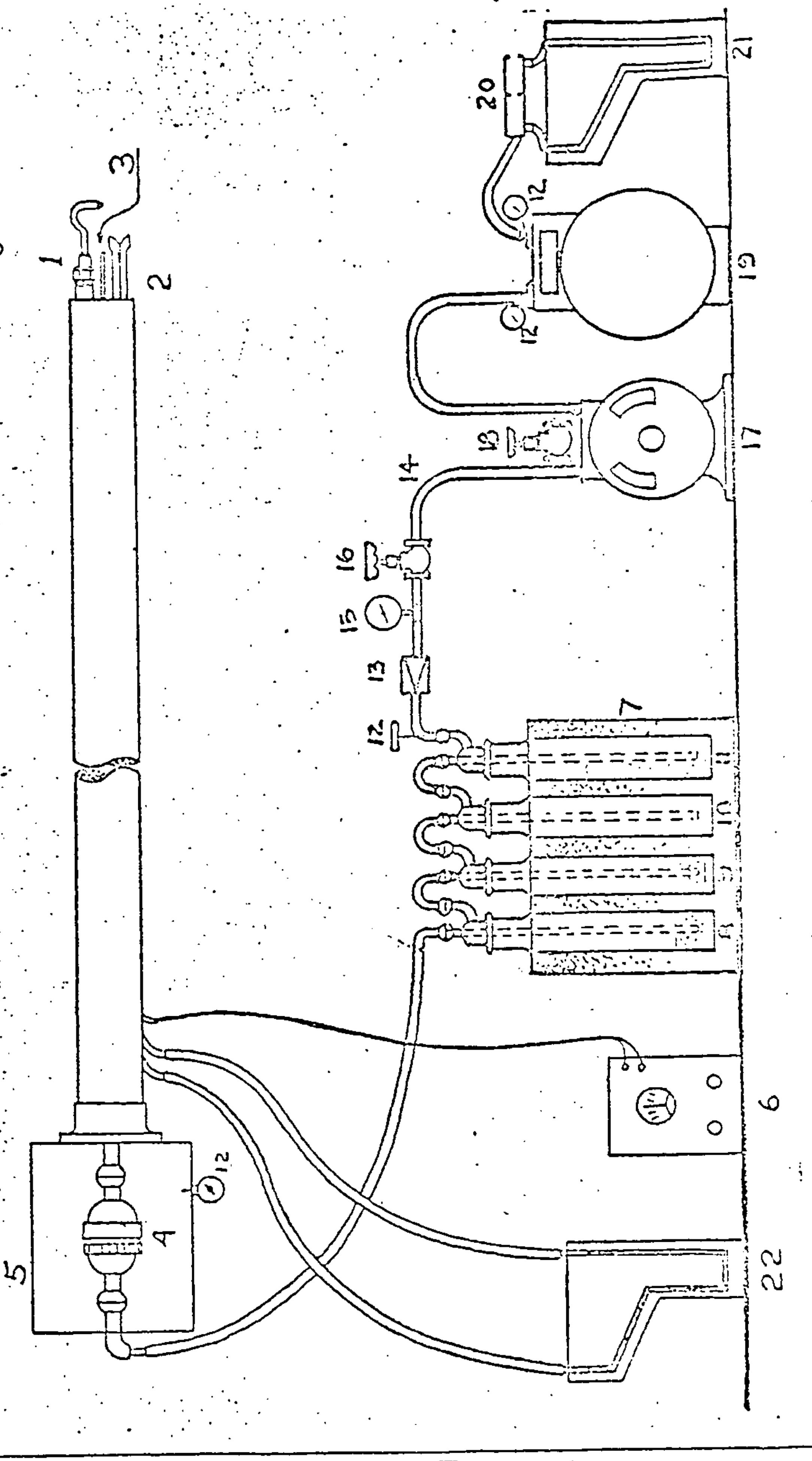
The impinger condensate is measured for moisture determination.

7. Calibration

The equipment used on this assignment was calibrated one week prior to field testing and re-calibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

SAMPLING TRAIN

Figure No. 9



York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.06	.08	.750	.866
.20	.28	.714	.845
.38	.53	.717	.847
.62	.91	.681	.825
.72	1.03	.699	.836

$$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$$

Pitot Tube # 14

F_s = .84

F_{std} = 1.00

Calibrated by [signature]

Date 12/13/73

Oil O/K

Quick Connects O/K Valves O/K

eters O/K

est Meter

ometers O/K

s O/K

rical Check - Amphenol O/K

ic O/K

um Gauge O/K

Check at 27" hg. - O/K CI

rks

ial each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. 51563 P_b 29.9

n ice	CF_w	CF_d	T_W	IT_d	OT_d	T_d Avg.	Time t
.5	5	5.15	67	85	75	80	12.73
.0	5	5.06	67	85.5	77.6	81.55	90.12
.0	10	10.16	68	88.8	79.5	84.1	13.2
.0	10	10.03	68	89.0	79.6	84.3	93.06
.0	10	10.05	68	92.8	80.3	86.5	7.67
.0	10						

ulate Y & $H_@$ at man. 2.0

Y =

$$Y = \frac{CF_w\, P_b\, (T_d\ \text{avg.} + 460)}{CF_d\, (P_b + 0.147(\,T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)\ (\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)} \left(\frac{(T_w + 460)t}{CF_w}\right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)} \left((\quad + 460)t\right)^2$$

Tolerances

Y = 0.99 - 1.00 - 1.0

$\Delta H_@$ = 1.6 - 1.84 - 2.1

	Man.	H@
$\Delta H_@ = \dfrac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\dfrac{(T_w + 460)\,t}{CF_w} \right)^2$		
$\Delta H_@ = \dfrac{0.01585}{29.9\ (75 + 460)} \left(\dfrac{(67 + 460)\ 12.7}{5} \right)^2$	.5	1.78
$\Delta H_@ = \dfrac{0.0317}{29.9\ (77.6 + 460)} \left(\dfrac{(67 + 460)\ 90.12}{5} \right)^2$	1.0	1.77
$\Delta H_@ = \dfrac{0.0634}{29.9\ (79.5 + 460)} \left(\dfrac{(68 + 460)\ 13.2}{10} \right)^2$	2.0	1.90
$\Delta H_@ = \dfrac{0.1268}{29.9\ (79.6 + 460)} \left(\dfrac{(68 + 460)\ 93.06}{10} \right)^2$	4.0	1.89
$\Delta H_@ = \dfrac{0.1902}{29.9\ (80.3 + 460)} \left(\dfrac{(68 + 460)\ 7.67}{10} \right)^2$	6.0	1.93
$\Delta H_@ = 0.2536\ \left((\_\_\_ + 460) \right)$		

Calibration Calculations Meter and Pump Box

Date 11/5/73 Box No. S 156[illegible]

	Man.	Y
$Y = \dfrac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ P_b + \dfrac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$		
$Y = \dfrac{5 \times 29.9\ (80 + 460)}{5.15\ (29.9 + 0.0368)\ (67 + 460)}$	.5	.9
$Y = \dfrac{5 \times 29.9\ (81.5 + 460)}{5.06\ (29.9 + 0.0737)\ (67 + 460)}$	1.0	1.
$Y = \dfrac{10 \times 29.9\ (84.1 + 460)}{10.16\ (29.9 + 0.147)\ (68 + 460)}$	2.0	1.
$Y = \dfrac{10 \times 29.9\ (84.3 + 460)}{10.03\ (29.9 + 0.294)\ (68 + 460)}$	4.0	1.
$Y = \dfrac{10 \times 29.9\ (86.5 + 460)}{10.05\ (29.9 + 0.431)\ (68 + 460)}$	6.0	1.
$Y = \dfrac{\_\_\_ \times \_\_\_\ (\_\_\_ + 460)}{(\_\_\_ + 0.588)\ (\_\_\_ + 460)}$	8.0	

REPORT NO. Y-8278-2

FIELD DATA

PLANT UI English st.
DATE 12/13/73
SAMPLING LOCATION Stack 1
SAMPLE TYPE Particulate
RUN NUMBER 1
OPERATOR JKS
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.99
STATIC PRESSURE, (P_s) -.22
FILTER NUMBER (s) FL-305

86ml H_2O net

PROBE LENGTH AND TYPE 9' SS
NOZZLE I.D. 3/8" = .375
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .94
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
S 1	1109	85.258	.10	1.20	1.20	450	43	42	5	250-300	<70
2	1114	87.48	.10	1.20	1.20	450	43	50	5	"	"
3	1119	89.82	.10	1.20	1.20	450	43	53	5	"	"
4	1124	94.95	.09	1.05	1.05	450	43	53	4.5	"	"
5	1129	97.20	.06	.72	.72	440	43	49	4	—	—
END	1134	99.56	—	—	—	—	—	—	—	"	"
W 1	1137	99.56	.11	1.30	1.30	445	44	42	5	"	"
2	1142	102.82	.10	1.20	1.20	445	47	42	5	"	"
3	1147	105.54	.09	1.05	1.05	445	47	43	4.5	"	"
4	1152	108.23	.06	.72	.72	445	47	43	4	"	"
5	1157	110.49	.03	.36	.36	445	47	43	2.5	—	—
END	1202	112.15	—	—	—	—	—	—	—	"	"
N 1	1210	112.15	.08	.96	.96	445	42	42	4	"	"
2	1215	114.62	.07	.84	.84	445	47	43	4	"	"
3	1220	117.02	.05	.59	.59	445	45	43	3.5	"	"
4	1225	119.05	.04	.47	.47	420	42	43	3.5	"	"
5	1230	120.59	.03	.36	.36	430	42	43	2.5	—	—
END	1235	122.50	—	—	—	—	—	—	—		"
E 1	1235	122.50	.10	1.20	1.20	445	43	43	5	"	"
2	1243	125.35	.09	1.05	1.05	445	45	43	4.5	"	"
3	1248	128.10	.07	.84	.84	445	45	43	4	"	"
4	1253	130.50	.06	.72	.72	445	44	43	4	"	"
5	1258	132.71	.04	.42	.42	425	44	43	3	"	"
COMMENTS/ND	1303	134.525	—	—	—	—	—	—	—	—	—

REPORT NO. Y-8278-2

FIELD DATA

PLANT UT English St.
DATE 12/13/73
SAMPLING LOCATION Stack 1
SAMPLE TYPE Particulate
RUN NUMBER 2
OPERATOR JKK
AMBIENT TEMPERATURE 30
BAROMETRIC PRESSURE 29.96
STATIC PRESSURE, (P_s) -.27
FILTER NUMBER (s) EI-409

92 ml H_2O net

PROBE LENGTH AND TYPE 9'-SS
NOZZLE I.D. 3/8" = .375
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.70
C FACTOR .74
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
E 1	1347	34.535	.10	1.30	1.30	450	40	40	5	250-300	< 70
2	1352	37.82	.10	1.30	1.30	445	42	43	5	"	"
3	1357	40.25	.10	1.30	1.30	445	48	45	5	"	"
4	1402	43.17	.08	.96	.96	445	53	42	4.5	"	"
5	1407	45.74	.06	.72	.72	435	53	42	4	"	"
END	1412	48.01	—	—	—	—	—	—	—	—	—
N 1	1415	48.01	.11	1.30	1.30	450	45	42	5.5	"	"
2	1430	50.99	.10	1.30	1.30	445	46	52	5.5	"	"
3	1425	52.84	.08	.96	.96	445	46	52	5	"	"
4	1420	56.64	.07	.84	.84	445	46	52	4.5	"	"
5	1435	58.23	.05	.59	.59	445	46	53	4	"	"
END	1440	60.99	—	—	—	—	—	—	—	—	—
S 1	1445	60.99	.12	1.45	1.45	455	46	48	6	"	"
2	1450	64.63	.11	1.30	1.30	450	46	53	6	"	"
3	1455	67.35	.10	1.30	1.30	450	46	52	6	"	"
4	1500	70.68	.08	.96	.96	450	47	51	5.5	"	"
5	1505	73.20	.06	.72	.72	445	47	52	4.5	"	"
END	1510	75.49	—	—	—	—	—	—	—	—	—
W 1	1515	75.49	.12	1.45	1.45	450	43	43	6.5	"	"
2	1520	78.61	.12	1.45	1.45	450	42	52	6.5	"	"
3	1525	81.31	.09	1.15	1.15	445	42	52	5.5	"	"
4	1530	83.92	.07	.84	.84	445	42	53	5	"	"
5	1535	86.28	.05	.59	.59	440	41	52	4.5	"	"
END	1540	88.352	—	—	—	—	—	—	—	—	—

COMMENTS

ES-041

REPORT NO. Y-8278-2

FIELD DATA

PLANT UI English St.
DATE 12/14/73
SAMPLING LOCATION Stack 1
SAMPLE TYPE Particulate
RUN NUMBER 3
OPERATOR JRK
AMBIENT TEMPERATURE 45
BAROMETRIC PRESSURE 29.60
STATIC PRESSURE, (P_s) -.86
FILTER NUMBER (s) FI-609

87 ml H_2O net

PROBE LENGTH AND TYPE 9'-SS
NOZZLE I.D. 3/8" = .375
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER —
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .94
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp .15

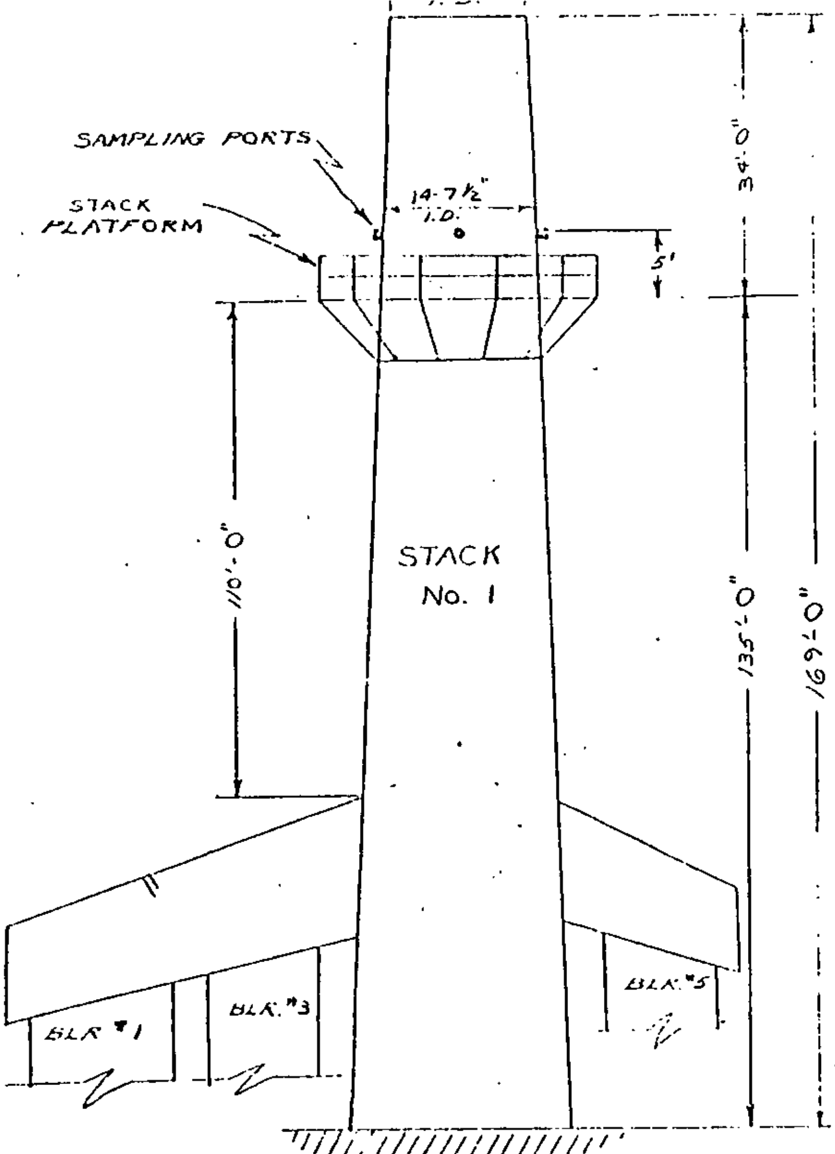
SCHEMATIC OF TRAVERSE POINT LAYOUT

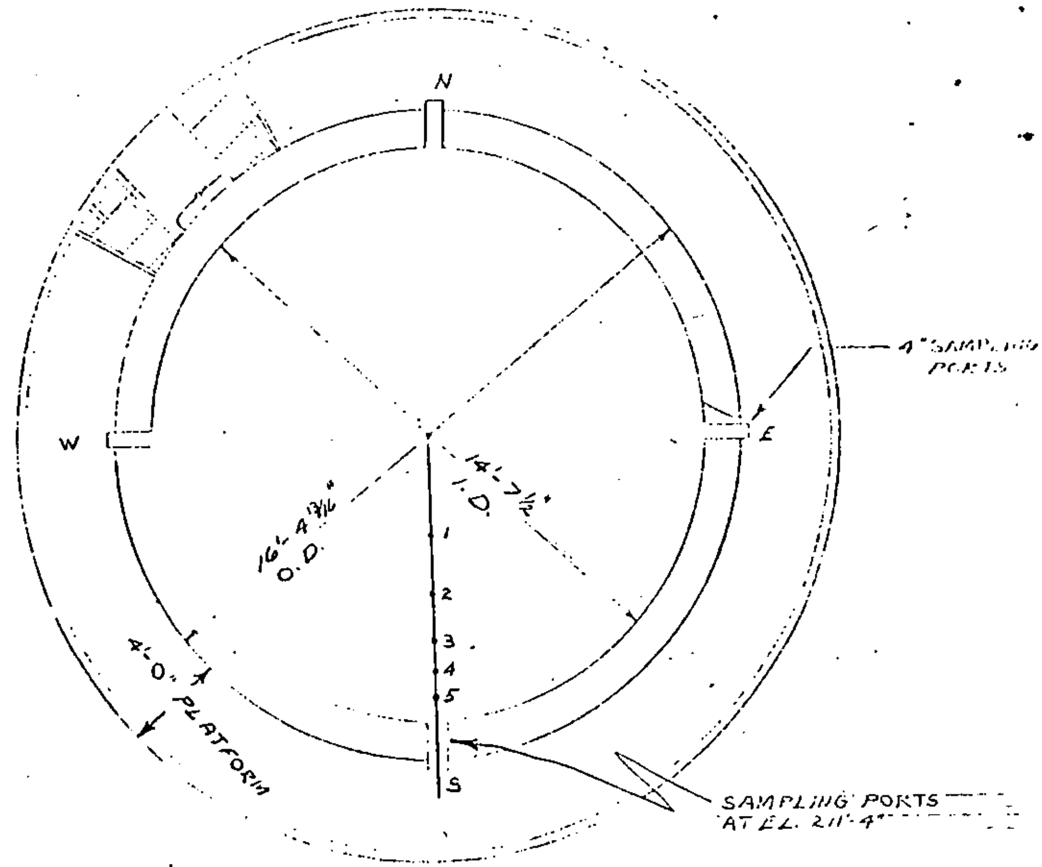
READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
S 1	0942	88.330	.12	1.45	1.45	445	55	60	5.5	250-300	<70
2	0947	92.53	.10	1.20	1.20	445	57	65	5	"	"
3	0952	95.50	.08	.96	.96	445	60	72	4	"	"
4	0957	98.11	.07	.84	.84	445	60	72	4	"	"
5	1002	100.55	.04	.47	.47	435	60	73	3		
END	1007	103.44	—	—	—	—	—	—	—	—	—
W 1	1010	103.44	.11	1.30	1.30	450	60	65	5	"	"
2	1015	105.42	.10	1.30	1.20	445	62	75	5	"	"
3	1020	108.53	.09	1.05	1.05	445	64	72	4.5	"	"
4	1025	110.12	.07	.84	.84	445	65	72	4	"	"
5	1030	113.63	.05	.57	.57	445	65	72	3.5	"	"
END	1035	115.732	—	—	—	—	—	—	—	—	—
N 1	1037	115.737	.09	1.05	1.05	450	64	64	4.5	"	"
2	1042	118.51	.07	.84	.84	445	64	67	4.5	"	"
3	1047	120.96	.05	.57	.57	445	64	67	4.0	"	"
4	1052	123.09	.05	.57	.57	445	64	67	4.0	"	"
5	1057	125.19	.04	.47	.47	435	63	65	3.5	"	"
END	1102	127.13	—	—	—	—	—	—	—	—	—
E 1	1105	127.13	.10	1.20	1.20	445	63	62	5	"	"
2	1110	130.05	.09	1.05	1.05	445	63	67	5	"	"
3	1115	132.79	.08	.96	.96	445	63	68	5	"	"
4	1120	135.91	.06	.72	.72	445	63	67	4.5	"	"
5	1125	137.65	.05	.57	.57	445	63	67	4	"	"

COMMENTS: END 1130 139.510 — — — — — — — — — —

ES-041





TRAVERSE POINT No.	DISTANCE FROM WALL
5	4.4"
4	14.4"
3	25.6"
2	39.7"
1	60.0"

REVISED	THE UNITED ILLUMINATING CO. NEW HAVEN, CONN. STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK No. 1 ENGLISH STATION
	DRAWN BY [illegible] DATE [illegible]
	TRACED BY DATE
	APPROVED BY J.W.H. DATE 4-1-74
	SCALE None DRAWING NO. 11272-18

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number STK 1 Date DEC 13, 1973

Boiler Number 1-3-5 Time

Plant Location English Sta

Sampling Point Location Stack

TEST 1

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	11.15	11.15	11.05		11.116	44/100	4.89
CO, % Vol (dry)	0	0	0			28/100	+
O_2, % Vol (dry)	7.17	7.17	7.32		7.220	32/100	+ 2.31
N_2, % Vol (dry)	81.68	81.68	81.63		81.663	28/100	+ 22.87

Avg. molecular wt. of dry stack gas = 30.07

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number STACK 1

Boiler Number 1-3-5

Plant Location English Sta

Sampling Point Location STACK

Date DEC 13, 1973

Time 1445

TEST 2

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	11.29	11.29	11.18		11.253	44/100	4.95
CO, % Vol (dry)	0	0	0			28/100	+
O_2, % Vol (dry)	7.23	7.23	7.21		7.223	32/100	+ 2.31
N_2, % Vol (dry)	81.48	81.48	81.61		81.523	28/100	+ 22.83
					Avg. molecular wt. of dry stack gas =		30.09

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number STACK 1

Boiler Number 1-3-5

Plant Location ENGLISH

Sampling Point Location STACK

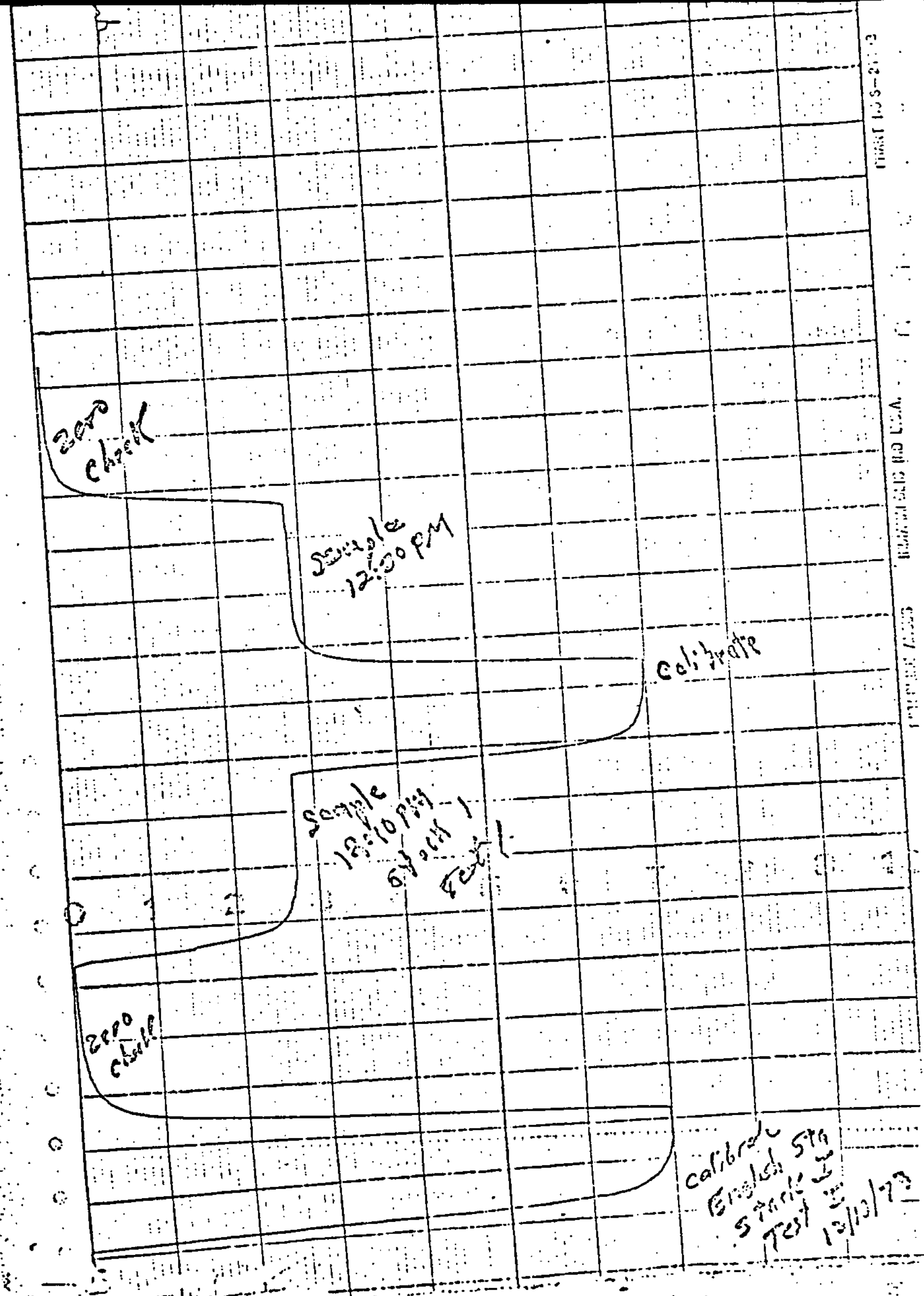
Date DEC 14, 1973

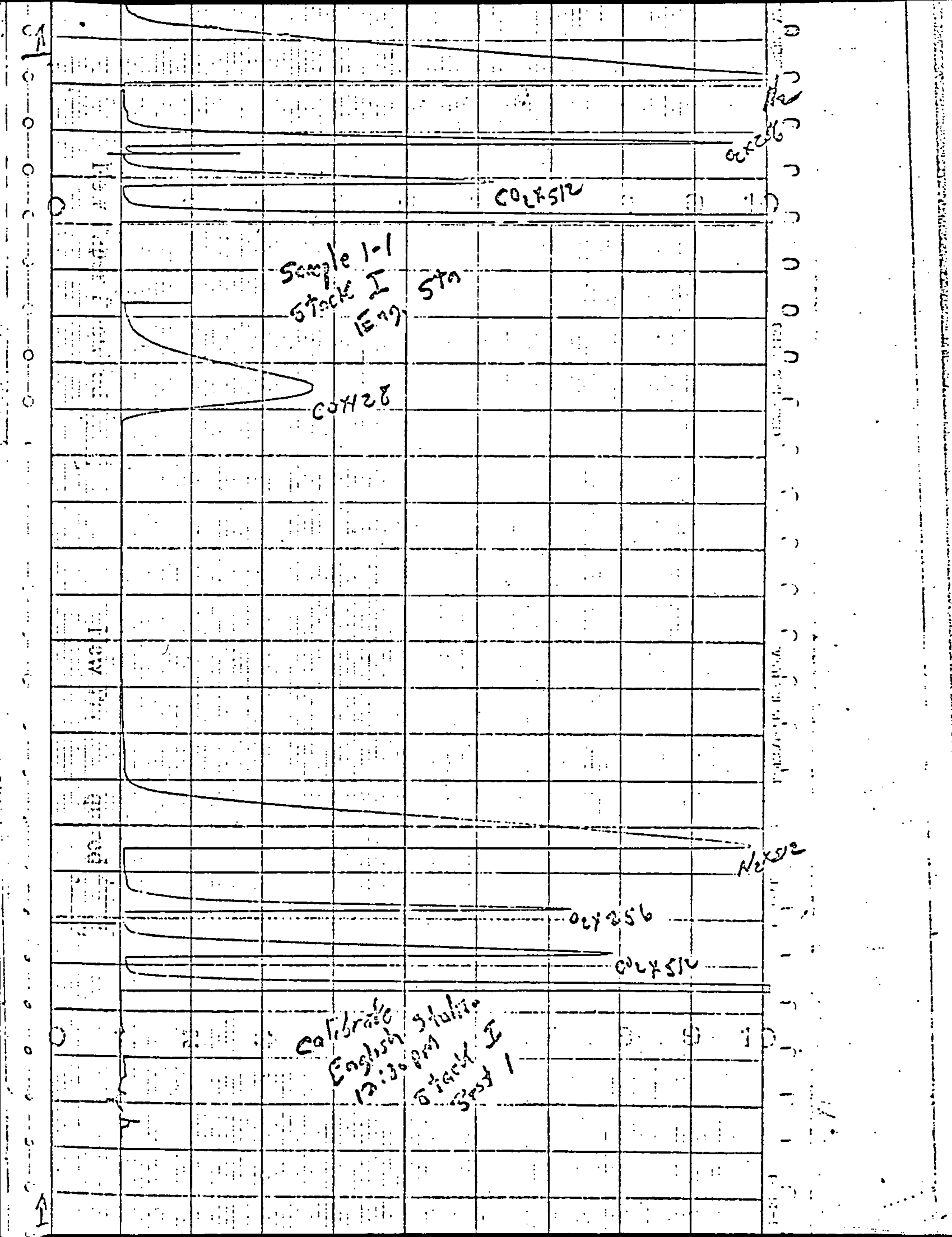
Time 1145

Test 3

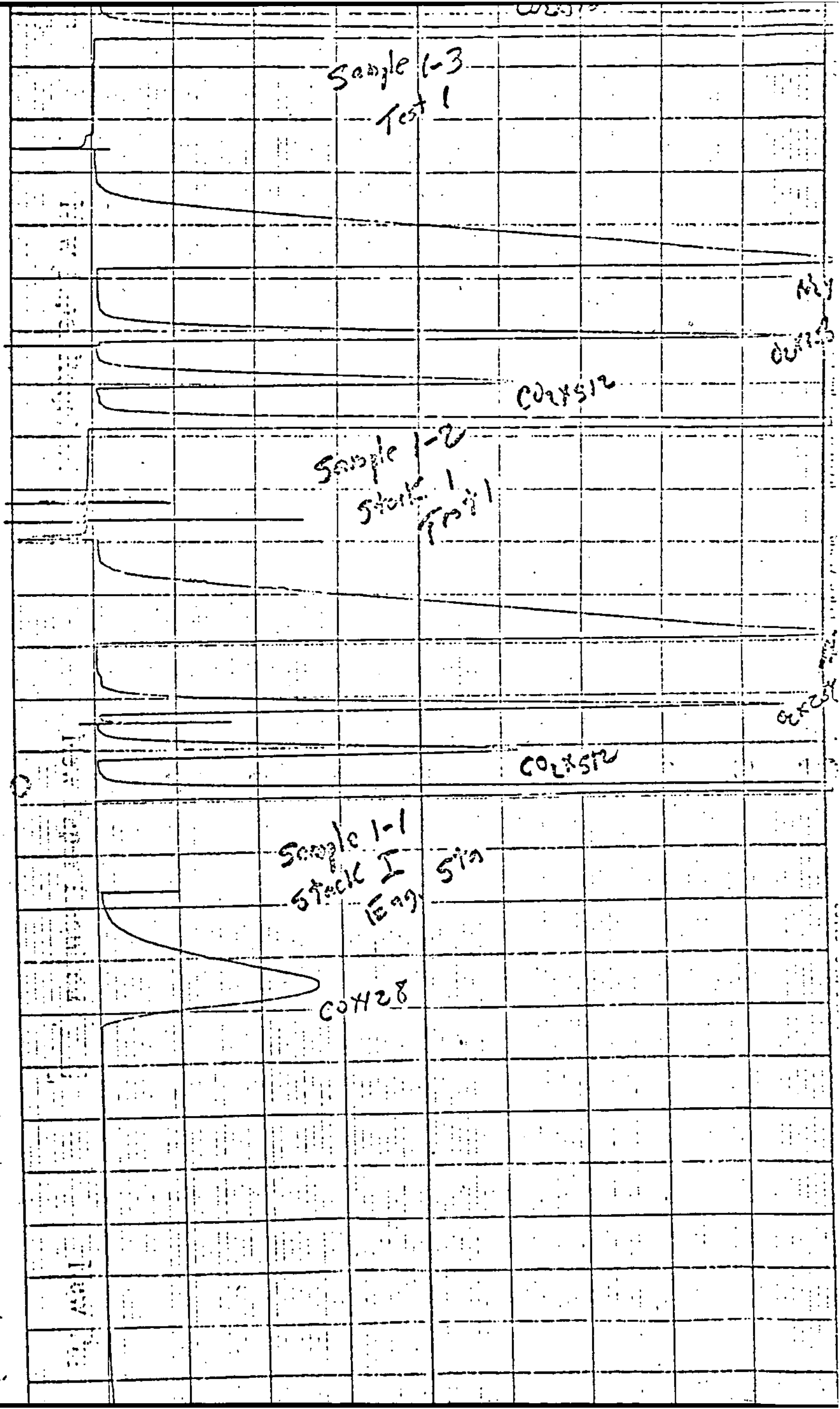
	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/molc. (dry)
CO_2, % Vol (dry)	11.12	11.05	11.00		11.057	44/100	4.87
CO, % Vol (dry)	0	0	0			28/100	+
O_2, % Vol (dry)	7.20	7.22	7.34		7.253	32/100	+ 2.32
N_2, % Vol (dry)	81.68	81.73	81.66		81.690	28/100	+ 22.87
					Avg. molecular wt. of dry stack gas =		30.06

TEST NO. 1

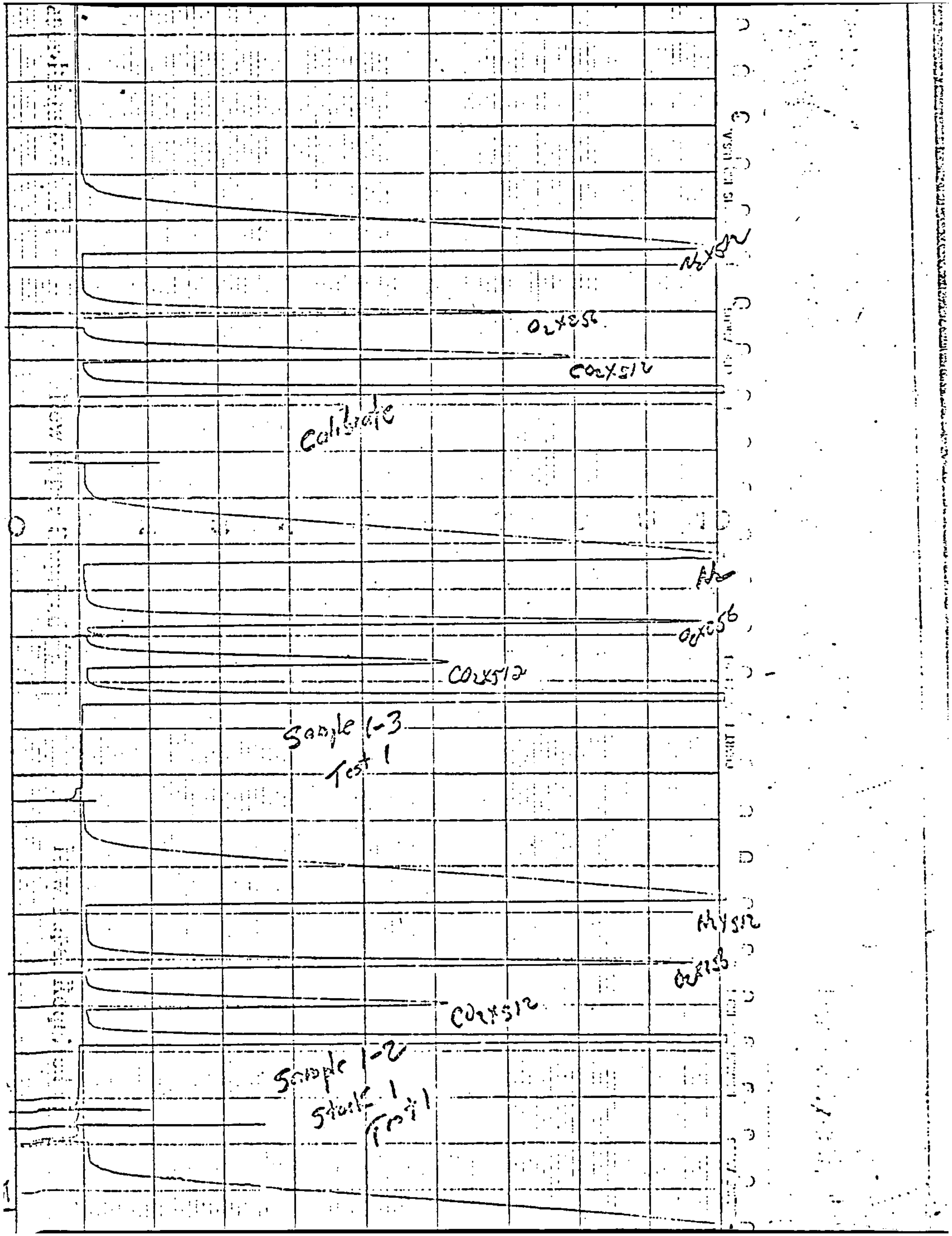

zero check
Sample 12:00 PM
calibrate
Sample 12:10 pm stack 1 Test I
zero check
calibrate English Stn stack I Test I 12/10/73



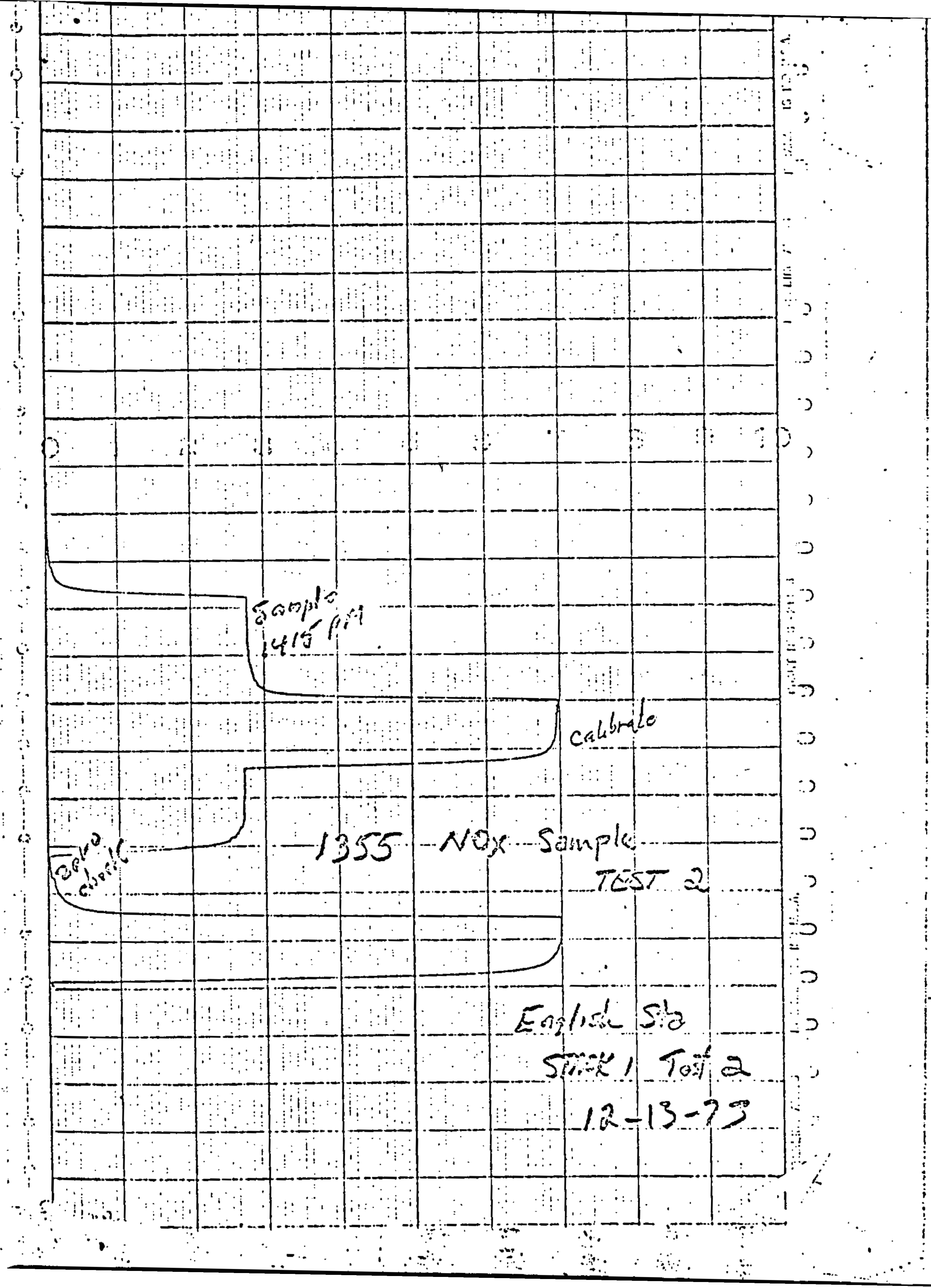
Air
O2x256
CO2x512
Sample 1-1
Stack I
Eng. Stn
COx128
N2x512
O2x256
CO2x512
Calibrate station
English
12:30pm
Stack I
Test 1

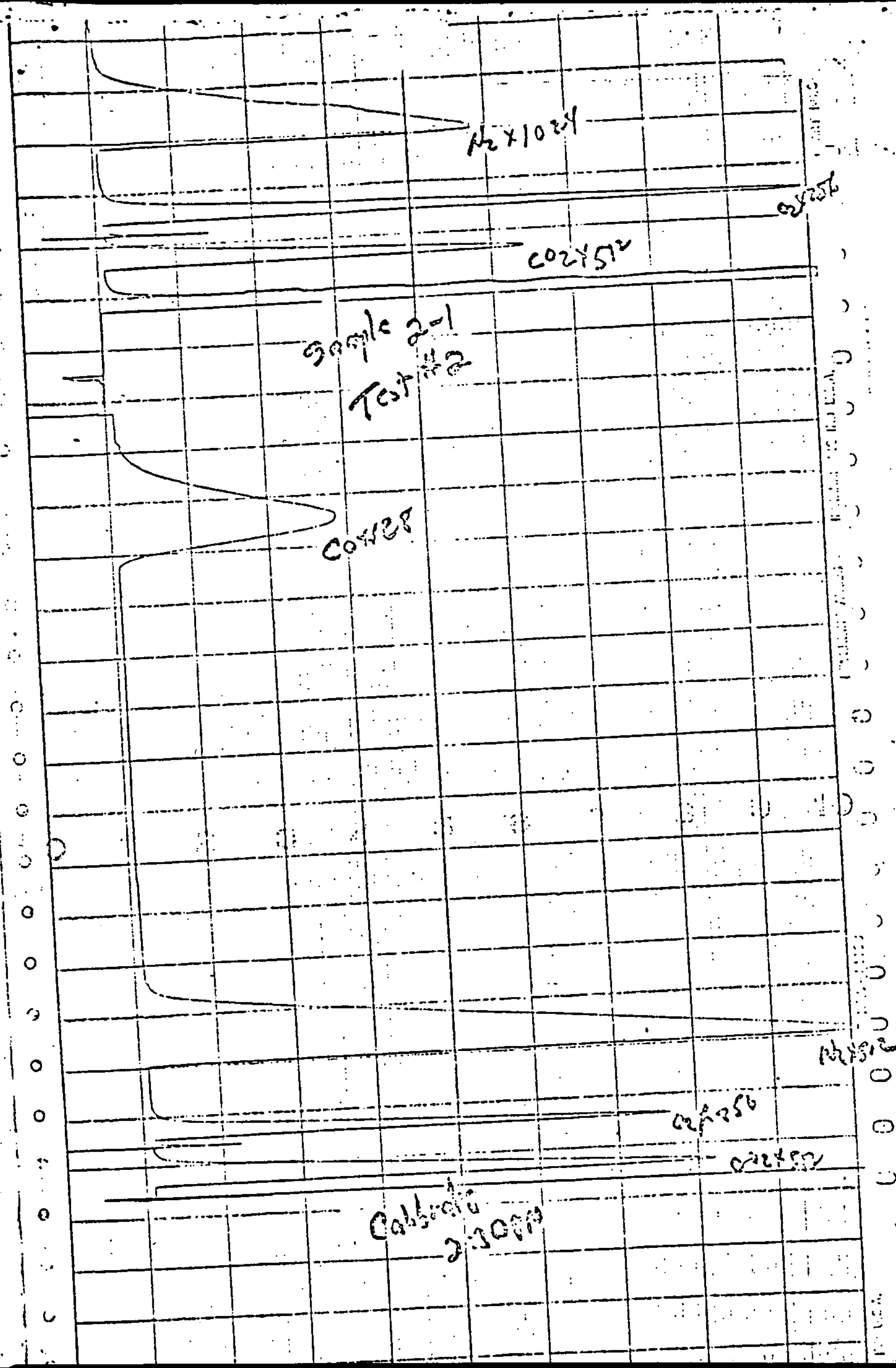


Sample 1-3
Test 1
CO2x512
Sample 1-2
Stack 1
CO2x512
Sample 1-1
Stack I

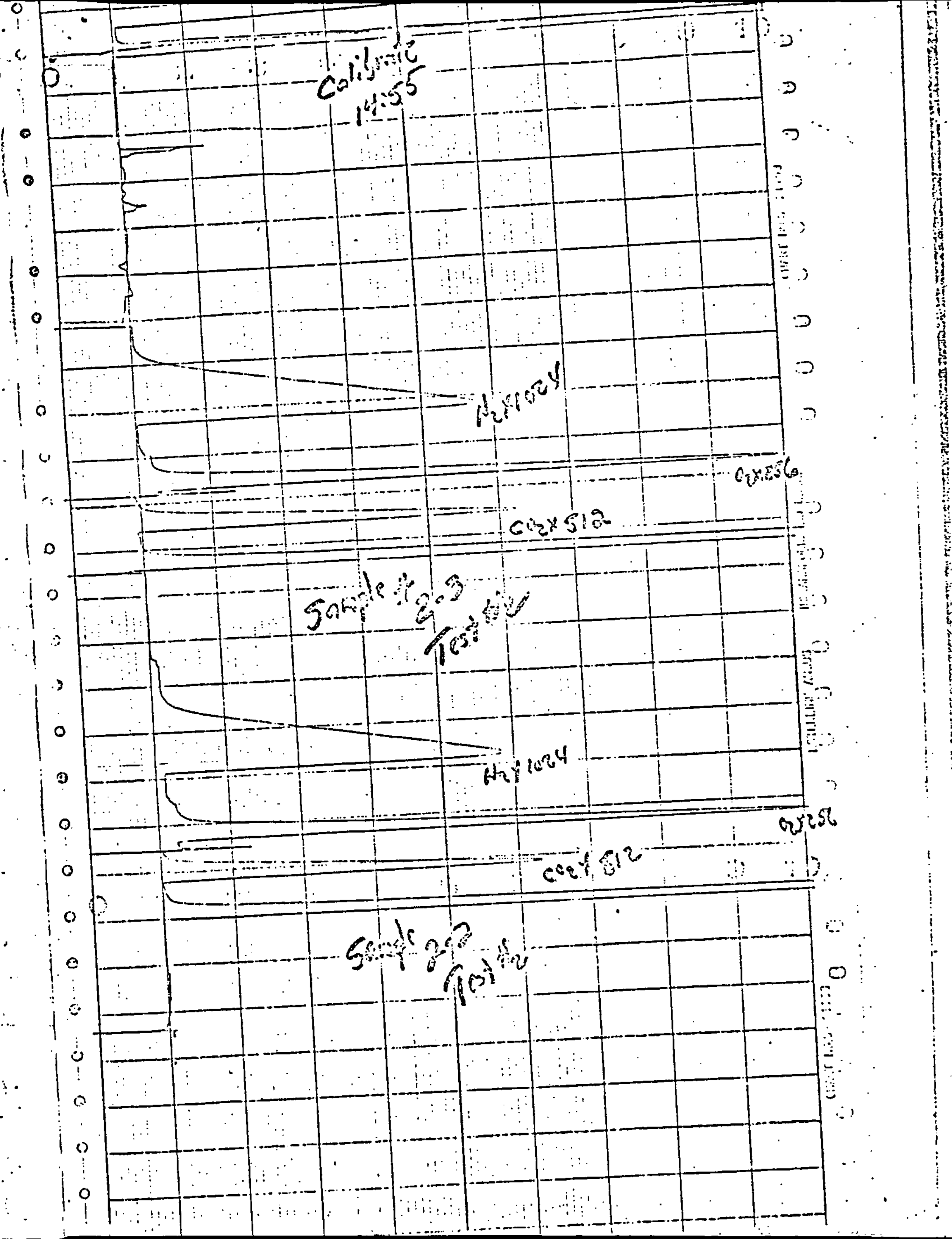

$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
Calibrate
N_2
$O_2 \times 256$
$CO_2 \times 512$
Sample 1-3
Test 1
$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
Sample 1-2
Stack 1
Test 1

TEST NO. 2

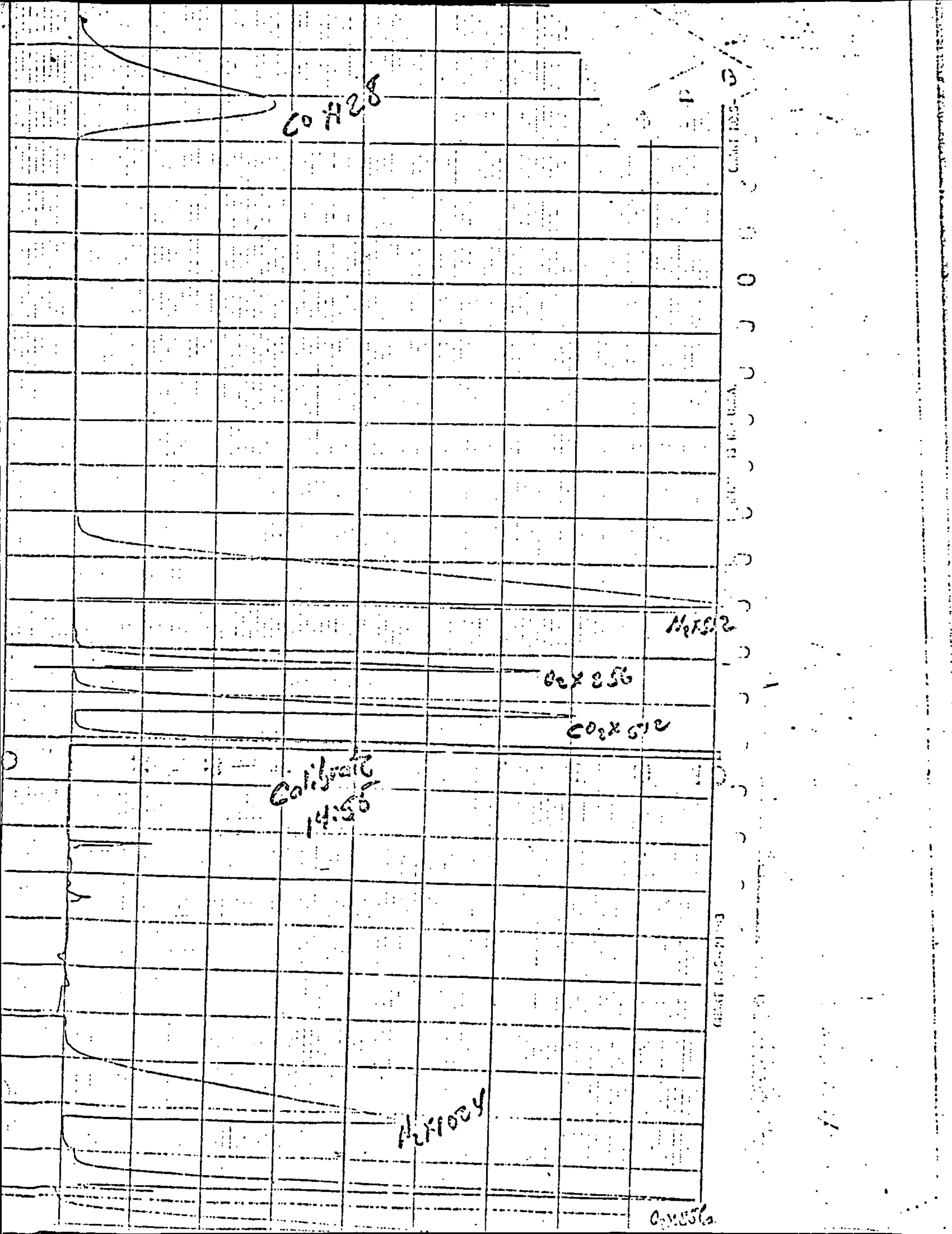

Sample 1415 PM
calibrate
zero check
1355 NOx Sample
TEST 2
English Sta
Stack 1 Test 2
12-13-73



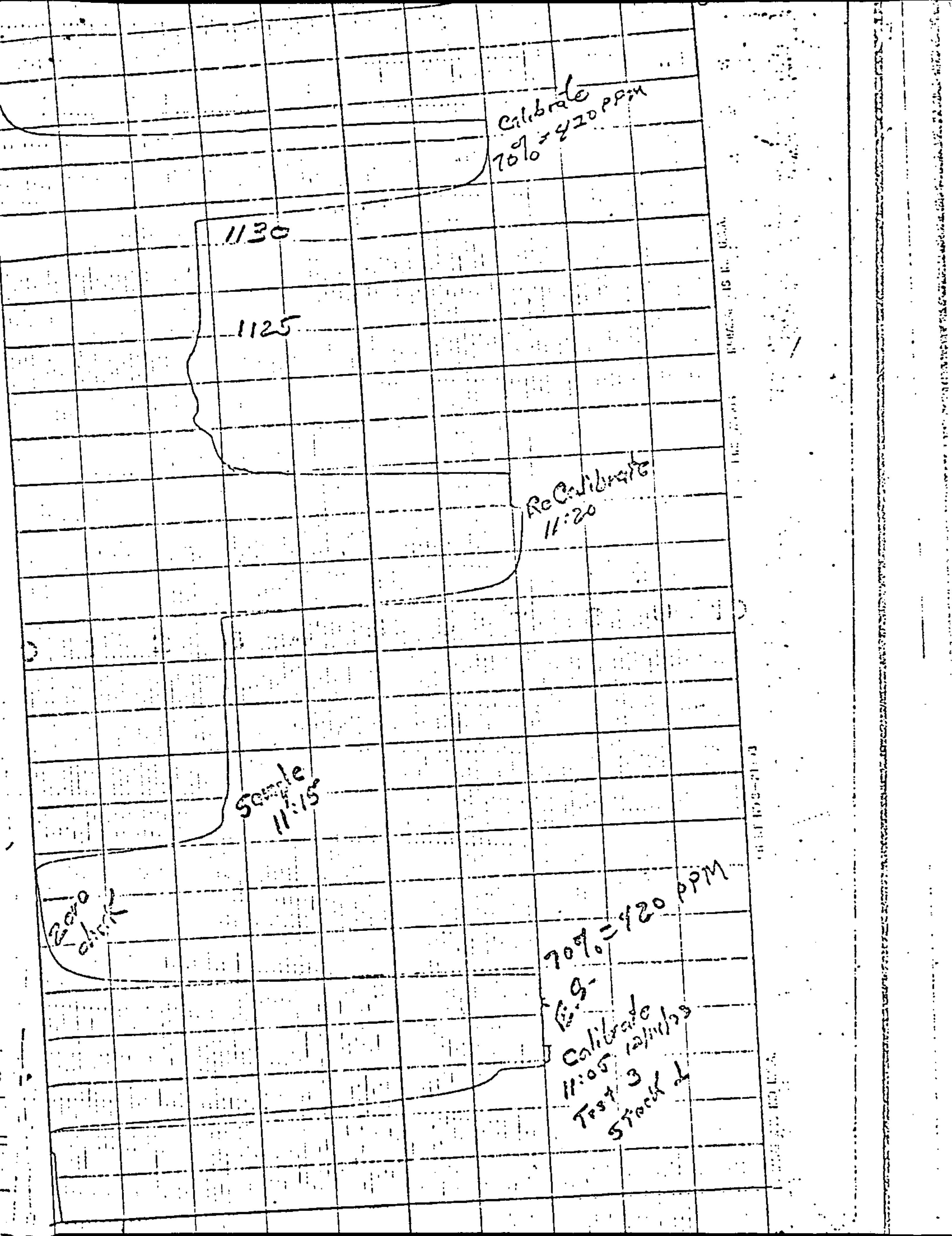
N2 x1024
O2 x256
CO2 x 512
Sample 2-1
Test #2
CO x 128
N2 x512
O2 x 256
CO2 x 512



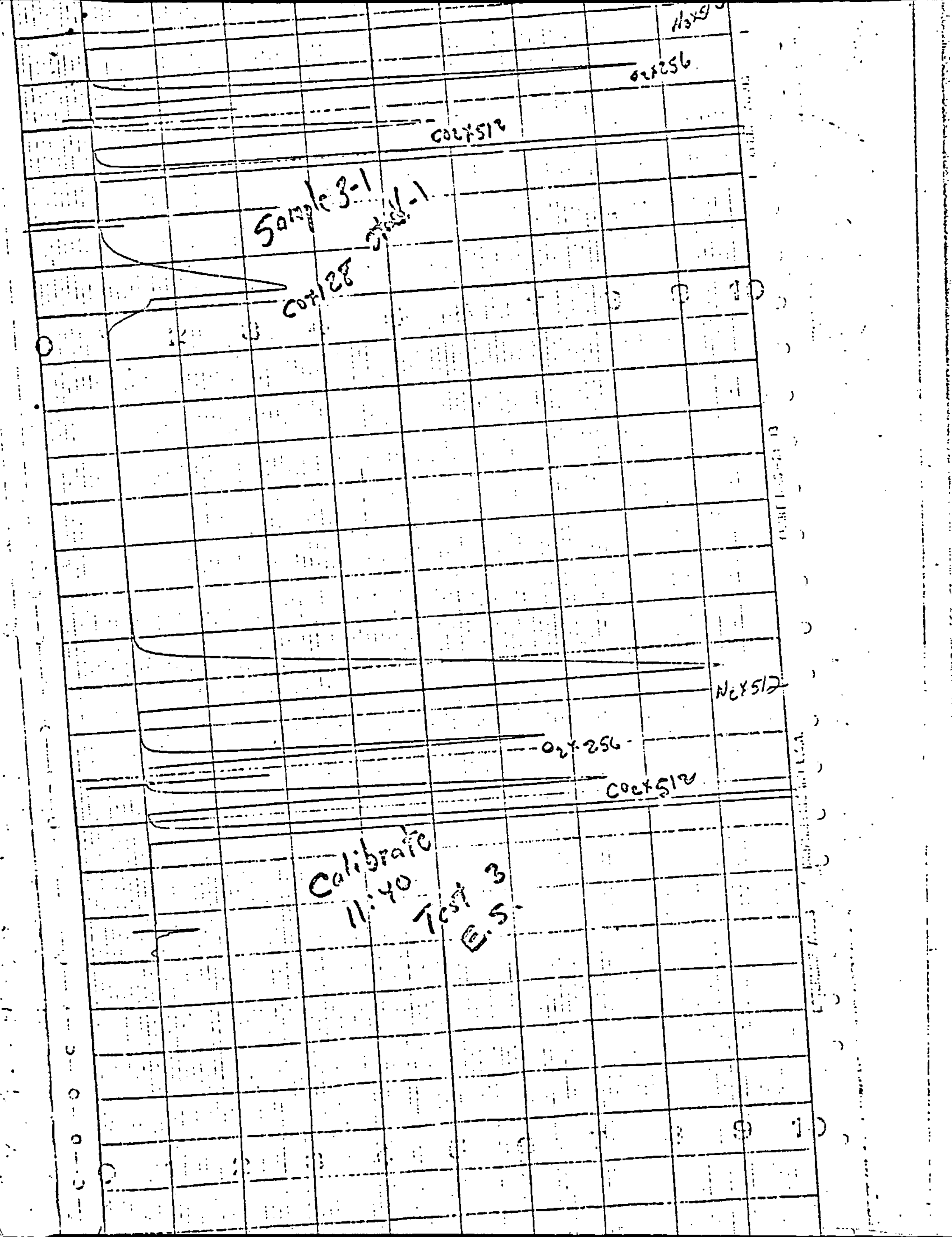
Calibrate
14:55
H2 X1024
CO2 X256
CO2 X512
Sample # 2-3
Test #2
H2 X1024
CO2 X256
CO2 X512
Sample 2-3
Test #2


Calibrate
14:50

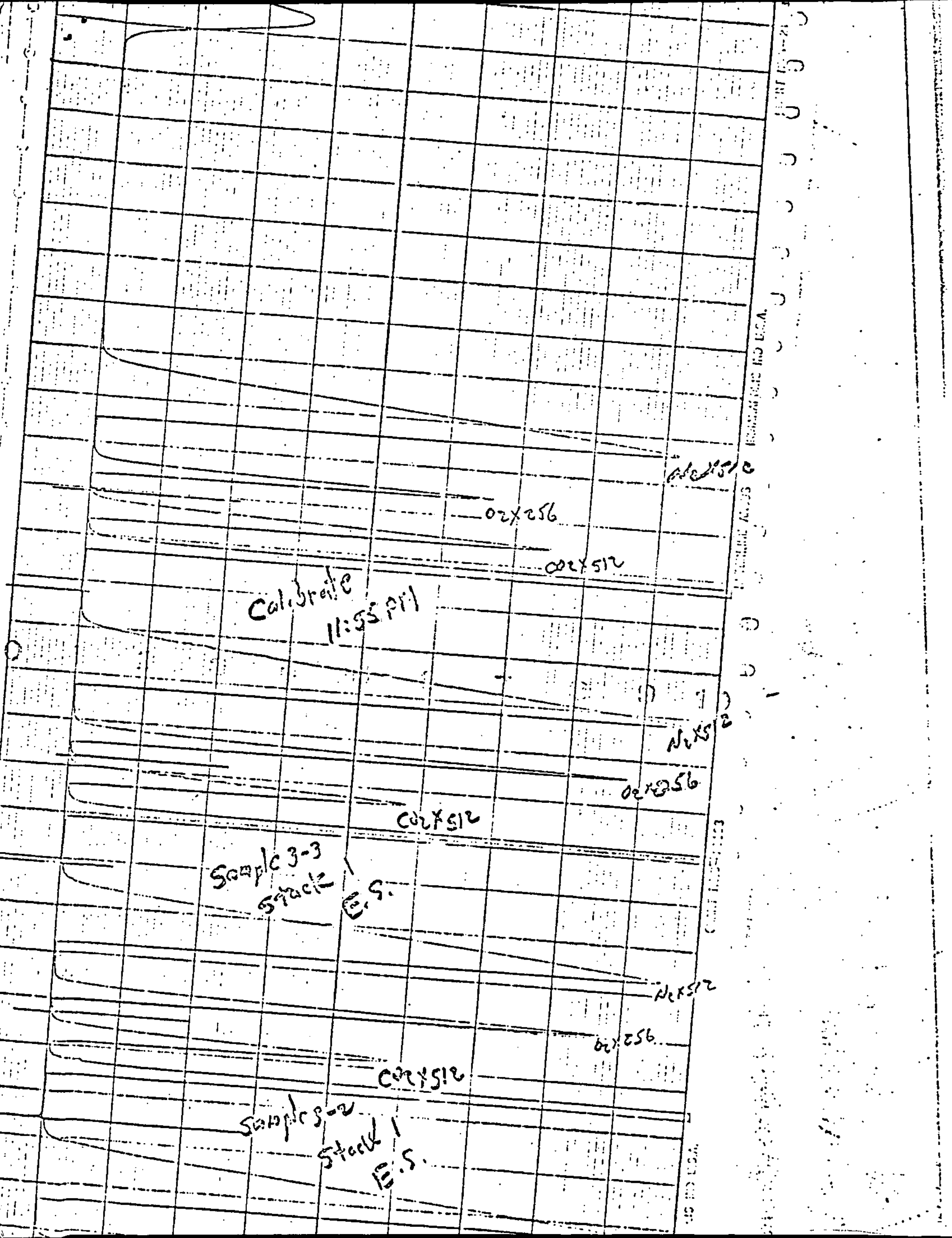
<u>TEST NO. 3</u>



Calibrate
70% = 420 ppm
1130
1125
ReCalibrate
11:20
Sample
11:15
Zero check
70% = 420 PPM
Calibrate
11:05 12/11/09
Test 3
Stack 1



O2x256
CO2x512
Sample 3-1
CO2x128
N2x512
O2x256
CO2x512
Calibrate
11:40
Test 3
E.S.


02x256
CO2X512
Calibrate
11:55 PM
NeX512
02x256
CO2X512
Sample 3-3
Stack 1
E.S.
NeX512
02x256
CO2X512
Sample 3-2
Stack 1
E.S.

APPENDIX C

BOILER OPERATING DATA

STACK ID NUMBER STACK 1

BOILER NO. 1-3-5

PLANT ENGLISH STA

DATE: DEC 13, 1973

TEST NO. 1

PARAMETERS	1116	1223	1300				
OIL METER (GAL)	8000	11300	13108				
LP STEAM HEADER PRESS.	367	364	364				
LP FUEL OIL HEADER PRESS.	188	185	185				
LP BOILER # 1 WINDBOX Press "H₂O	3.6	3.5	3.6				
OIL FLOW %	85	82	82				
AIR FLOW %	72	72	72				
STEAM FLOW lb/hr	105,000	105,000	105,000				
BAROMETER "Hg	30.01	29.99	29.98				
LP BOILER # 3 WINDBOX Press "H₂O	3.8	3.8	3.8				
OIL FLOW %	90	89	88				
AIR FLOW %	82	82	82				
STEAM FLOW lb/hr	115,000	110,000	110,000				
LP BOILER # 5 WINDBOX Press "H₂O	3.2	3.1	3.4				
OIL FLOW %	87	86	85				
AIR FLOW %	91	94	94				
STEAM FLOW lb/hr	115,000	115,000	115,000				

STACK ID NUMBER STACK #1

BOILER NO. 1-3-5

PLANT English Sta

DATE DEC. 13, 1973

TEST NO. 2

PARAMETERS	1300	1417	1529				
OIL METER (GAL)	13108	16870	20450				
LP STEAM HEADER PRESS.	364	358	362				
LP FUEL OIL HEADER PRESS.	185	185	186				
LP BOILER #1 WINDBOX PRESS. "H2O	3.6	3.6	3.0				
OIL FLOW %	82	80	80				
AIR FLOW %	72	72	70				
STEAM FLOW lb/hr	105,000	102,000	103,000				
BAROMETER	29.98	29.95	29.96				
LP BOILER #3 WINDBOX PRESS "H2O	3.8	3.7	3.8				
OIL FLOW %	88	88	90				
AIR FLOW %	82	82	82				
STEAM FLOW lb/hr	110,000	115,000	115,000				
LP BOILER #5 WINDBOX PRESS "H2O	3.4	3.6	3.4				
OIL FLOW %	85	87	90				
AIR FLOW %	94	95	95				
lb/...	115,000	123,000	125,000				

STACK ID NUMBER STACK 1

BOILER NO. 1-3-5

PLANT English Sta

DATE DEC. 14, 1973

TEST NO. 3

PARAMETERS	0956	1103	1206				
OIL METER (GAL)	03294	06645	09704				
LP STEAM HEADER PRESS.	362	368	358				
LP FUEL OIL HEADER PRESS.	190	190	188				
LP BOILER #1 WINDBOX PRESS. "H₂O	3.4	3.2	3.4				
OIL FLOW %	81	79	81				
AIR FLOW %	69	69	70				
STEAM FLOW lb/hr	100,000	98,000	103,000				
Barometer	29.62	29.59	29.58				
LP BOILER #3 WINDBOX PRESS "H₂O	3.7	3.7	3.7				
OIL FLOW %	89	88	88				
AIR FLOW %	80	80	80				
STEAM FLOW lb/hr	112,000	108,000	113,000				
LP BOILER #5 WINDBOX PRESS "H₂O	3.7	3.6	3.5				
OIL FLOW %	91	90	91				
AIR FLOW %	92	92	92				
STEAM FLOW lb/hr	119,000	118,000	123,000				

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{o}R}{in.\ Hg}\right) \quad Vm \quad \left(\frac{Pbar + \frac{\overline{\Delta H}}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{o}R}{in.\ Hg}\right) \left(49.27\ ft^3\right) \left(\frac{29.99\ in.Hg + \frac{0.875\ in\ H_2O}{13.6}}{504.9\ ^{o}R}\right)$$

$$= 51.94\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(\frac{0.0474\ ft^3}{ml.}\right) \left(Vlc\right) \qquad \text{eq.5-2}$$

$$= \left(\frac{0.0474\ ft^3}{ml.}\right) \left(97.7\ ml.\right)$$

$$= 4.63\ ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd} \qquad \text{eq.5-3}$$

$$= \frac{4.63\ ft^3}{4.63\ ft^3 + 51.94\ ft^3}$$

$$= 0.0818 \times 100\% = 8.2\%$$

4. Molecular Weight (dry)

$$Md = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2) + 0.28\ (\%CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (11.12) + 0.32\ (7.22) + 0.28\ (81.66) + 0.28\ (0.00)$$

$$= 30.07 \text{ lb/lb-mole}$$

5. Molecular Weight (wet)

$$Ms = Md\ (1\text{-}Bws) + 18\ Bws$$

$$= 30.07\ (1-.082) + 18\ (.082)$$

$$= 29.08 \text{ lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\Delta P}\ \left(\frac{Ts}{Ps\ Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.84)\ (.266)\ \left(\frac{903.8}{29.97 \times 29.08}\right)^{1/2}$$

$$= 19.48 \text{ F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A_s \times 60 \text{ sec/min}$$

$$= 19.48 \times 167.9 \text{ ft}^2 \times 60 \text{ sec/min}$$

$$= 196{,}242 \text{ ACFM}$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1\text{-}Bws)\ (Vs)\ (A_s) \left(\frac{Tstd}{Ts}\right) \left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.082)\ (19.48)\ (167.9) \left(\frac{530}{903.8}\right) \left(\frac{29.97}{29.92}\right)$$

$$= 105{,}819 \text{ SCFM}$$

9. Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60 \text{ min}}{\text{hr}} \times \frac{Md}{386 \text{ ft}^3}$$

$$= 105{,}819 \text{ SCFM} \times \frac{60 \text{ min}}{\text{hr.}} \times \frac{30.07 \text{ lb/lb-mole}}{386 \text{ ft}^3}$$

$$= 494{,}608 \text{ lb/hr.}$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154 \frac{\text{gr.}}{\text{mg.}}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154 \frac{\text{gr.}}{\text{mg.}}\right) \frac{42.8 \text{ mg}}{51.94 \text{ ft}^3}$$

$$= 0.013 \text{ gr/SCF}$$

11. Particulate Concentrations, lb/ft³

$$Cs = \frac{\left(\frac{1}{453600} \frac{\text{lb.}}{\text{mg.}}\right) Mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600} \frac{\text{lb}}{\text{mg.}}\right) 42.8 \text{ mg.}}{51.94 \text{ ft}^3}$$

$$= 1.81 \times 10^{-6} \text{ lb/SCF}$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\, Qs \times \frac{60 \text{ min}}{\text{hr}}$$

$$= (1.81 \times 10^{-6} \text{ lb/SCF}) \quad (105{,}819 \text{ SCFM}) \times \frac{60 \text{ Min}}{\text{hr}}$$

$$= 11.49 \text{ lb/hr}$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{11.49 \text{ lb/hr}}{440.0 \times 10^6 \text{ BTU/hr}}$$

$$= 0.026 \text{ lb/MBTU}$$

14. % Isokinetic Sampling

$$I = \frac{\overline{T}s\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\Delta H}{13.6}\right)\right)}{\Theta\ Vs\ Ps\ An}$$

eq. 5-6

$$I = \frac{903.8\ (1.667)\left((0.00267)\ (97.7)\ + \frac{49.27}{504.9}\left(29.99 + \frac{.875}{13.6}\right)\right)}{(100)\ (1948)\ (29.97)\ (7.67 \times 10^{-4})}$$

$$= 107.5\%$$

15. NO_X Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{165}{10^6} \times \frac{46\ lb/lb\text{-}mole}{30.07\ lb/lb\text{-}mole} \times 494{,}608\ \frac{lb}{hr}$$

$$= 124.8\ lb/hr$$

16. NO_X Concentrations, lb/MBTU

$$lb/MBTU \equiv \frac{lb/hr}{Heat\ Input}$$

$$= \frac{124.8\ lb/hr}{440.0 \times 10^6\ BTU/hr}$$

$$lb/MBTU = \frac{0.284\ lb}{10^6\ BTU}$$

17. Stack Pressure (Absolute), in. Hg

$$Ps = Pb + \frac{Pd}{13.6} = 29.99 + \frac{(-0.27)}{13.6} = 29.97 \text{ in. Hg.}$$

18. Nozzle Area (Ft^2)

$$An = \frac{\pi D^2}{4} = 0.785 \times \left(\frac{0.375}{12}\right)^2 = 7.67 \times 10^{-4}\ ft.^2$$

19. Stack Area (ft^2)

$$A_s = \frac{\pi D^2}{4} = 0.785 \times \left(\frac{175.5}{12}\right)^2 = 167.9 \text{ ft}^2$$

20. Heat Input, 10^6 BTU

Sp. Gr. x 8.33 #/gal. x BTU/lb. x gal/hr

0.903 x 8.33 #/gal x 19,847 BTU/lb x 2947 gal/hr =

440.0×10^6 BTU hr.

21. Gas Density (lb/ft^3)

$$\text{Gas Density} = \frac{\text{Mol wt gas}}{386 \text{ ft}^3} \times \frac{T_{std}}{T_s} \times \frac{P_{bar}}{P_{std}}$$

$$= \frac{30.07}{386} \times \frac{530}{903.8} \times \frac{29.99}{29.92} =$$

$$= 0.0457 \text{ lb/ft}^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

est No. English Station Stack 1 No. Runs 3

ame of Firm The United Illuminating Company

ocation of Plant 510 Grand Avenue, New Haven, Connecticut

ype of Plant Steam Generating Station

ontrol Equipment None

ampling Point Locations Stack

ollutants Sampled Particulates, Nitrogen Oxides

ime of Particulate Test:

un No. 1	Date 12/13/73	Begin 11:09	End 13:03
un No. 2	Date 12/13/73	Begin 13:47	End 15:40
un No. 3	Date 12/14/73	Begin 9:42	End 11:30

PARTICULATE EMISSION DATA

n No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-{}^{o}R}\right)^{1/2}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.84	0.84	0.84	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.266	0.295	0.271	
$\overline{Ts}$ = Average stack temp., ^{o}R	903.8	906.5	903.5	
Pb = Barometric pressure, "Hg Abs.	29.99	29.96	29.60	
Pd = Gas duct pressure, "H_2O	-0.27	-0.27	-0.26	
Ps = Absolute stack gas pressure, inches Hg	29.97	29.94	29.58	
Bws = % moisture in stack gas, by volume	8.2	8.5	8.2	
Md = Molecular weight of stack gas, dry	30.07	30.09	30.06	
Ms = Molecular weight of stack gas	29.08	29.06	29.07	

Vs = Stack gas velocity, F.P.S.	19.48	21.62	19.95	
% CO_2	11.12	11.25	11.06	
% O_2	7.22	7.22	7.25	
% CO	0.00	0.00	0.00	
% N_2	81.66	81.53	81.69	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	97.7	111.14	95.0	
Vm = Volume of dry gas sampled at meter conditions, FT^3	49.27	53.817	50.490	
std = Volume of dry gas sampled at STP, FT^3	51.94	56.37	50.46	
Tm = Average dry gas meter temp., $^{\circ}R$	504.9	507.9	525.7	
ΔH = Average pressure drop across orifice, inches H_2O	0.875	1.059	0.898	
θ = Total Sampling Time, min.	100	100	100	
Dn = Nozzle dia., inches	0.375	0.375	0.375	
An = Nozzle area, FT^2	7.67×10^{-4}	7.67×10^{-4}	7.67×10^{-4}	
I = % of isokinetic sampling	105.2	105.9	103.2	
Qs = Stack gas volume at STP (SCFM)	105,819	116,594	106,997	109,803
Qa = Stack gas volume at stack conditions (ACFM)	196,242	217,800	200,976	205,006
Ws = Stack gas mass flow lbs/hr	494,608	545,334	499,948	513,297
Mp = Particulate-probe, washings, mg	-	-	-	
Mf = Particulate-filter (mg)	-	-	-	
Mn = Particulate-total (mg)	42.8	47.7	48.4	
C's = Particulate Concentrations gr/scf	0.013	0.013	0.015	0.014
Cw = Particulate total emission lb/hr	11.49	13.02	13.55	12.69
Er = Particulate emission rate, lb/106 BTU	0.026	0.029	0.031	0.03
C = NO, concentrations, PPM	165	165	171	
Cn = NO, lb/10^6BTU	0.284	0.312	0.296	0.30

EMISSION TEST REPORT
(Ref. Intent to Test Form
Numbers 720045 and 720047)

OAQPS - 78-1
II-I-257

FUEL OIL
COMBUSTION
AP-42 Section 1.3
Reference Number
24
4/93 Ref 24

The United Illuminating Company
Steel Point Station
43 East Main Street
Bridgeport, Connecticut
06608

Stack No. S.P. 7
Steam Generator Nos. 25, 26, 27

1950

Test Conducted By
The United Illuminating Company
Test and Development Laboratory
80 Temple Street
New Haven, Connecticut
06506

Prepared by:

J.S. Sombati
Development & Testing Laboratory Supervisor

J.W. Hotchkiss
Assistant Mechanical Engineer

Approved by:

D.W. Hoskinson
Chief Mechanical Engineer

Submitted by:

M.R. McCraven
Director of Environmental Engineering

2/9/73

General Introduction

Emission tests were conducted on The United Illuminating Company Steel Point Station Steam Generators 25, 26 and 27. All three steam generators discharge emissions into a common stack, Stack #7. Steam Generators 25 and 27 are connected to a common flue gas duct which discharges into the base of Stack #7. The flue gas duct of Steam Generator 26 is connected to Stack 7 approximately 20 feet from the top of the stack. Due to this unique stack configuration, it became necessary to sample each flue gas duct for emissions.

Emission tests for Particulates and Nitrogen Oxides were conducted on each flue gas duct. The weighted averages of Particulates and Nitrogen Oxide emissions are summarized on the following page.

Summary of Test Results*
Stack Number S.P. 7
Steam Generator Nos. 25, 26, 27

Component	Sampling Duration: minutes per point	Sampling Duration: total test time	Number of tests (Minimum of 3)	Measured Concentrations Weighted Average	Method Employed to Determine Concentration i.e., material balance, emission factor, reference, (specify) etc
NOx	-	-	6	0.15 lb/MBTU	Dynascience Model NX-130
Particulates	-	-	5	0.05 lb/MBTU	Method 5**

*Weighted average of individual boiler tests
(Ref: Intent to Test Form Nos. 720045 and 720047.)
**Federal Register, Vol. 36, No. 247, December 23, 1971.

TEST RESULTS

Steam Generator No. 26
(Ref. Intent to Test Form No. 720047)

Test Conducted On
December 18, 19, 20, 21, 28, 1972

Introduction

Emission tests for Particulates and Nitrogen Oxides were conducted as required by Connecticut State Law on United Illuminating Company Steel Point Station Steam Generator 26, located in Bridgeport, Connecticut. Testing was conducted on December 18-21 and on December 28, 1972.

Source Sampling was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. These tests were conducted on the flue gas duct downstream of the precipitator outlet and upstream of the stack inlet. This site location was chosen due to the impracticality of source sampling in the stack due to stack configuration. It should be noted at this time that this stack #7 also handles the emissions produced by Steam Generators 25 and 27, which have been previously tested on December 5, 6, and 7, 1972 (Report No. 720045). A copy of that test report was forwarded to the State Department of Environmental Protection on December 26, 1972.

The primary contaminants tested for were Particulates and Nitrogen Oxides. Tests were also conducted to determine stack gas velocity and volumetric flow rates, flue gas analysis and molecular weight and moisture content of the flue gas. The procedures used in determining these various parameters, except for nitrogen oxides, are those found in the above mentioned Federal Register. Nitrogen Oxide emissions were found by using a Dynascience Model NX-130 NO_x Analyzer instead of using the phenoldisulfonic acid procedure as stated in Method 7 of the above mentioned Federal Register.

Two tests for determination of particulate emissions are reported. Results of these tests comply with the State Law on emission rates. Due to an operational malfunction of the electrostatic precipitator, the results from one test were disregarded as not being representative of normal emissions from the source. After mechanical and electrical maintenance was performed, the unit was tested with the results shown as Test 3B.

This test report includes the information required for Items III, IV, V, VI, VII, IX, X, XI and XII from the Department of Environmental Protection's "Intent to Test" form in compliance with the DEP's Source Test Guidelines and Procedures.

Source Test Form #2 was not available at the time of the writing of this report.

1. <u>Sampling Train Information</u>
(Ref. Item VII "Intent to Test" Form)

   a.) Schematic diagram of sampling train: See Fig. 1. Sampling Train used: RAC Stack-samplr Model 2343, purchased April 4, 1972.

   b.) Media type used to determine gas stream components. NO_x: DynaScience Model NX-130 NO_x Analyzer. Particulates: Reeve Angel 900 AF, 11 cm diameter glass fiber filter.

   c.) Sampling tube: Stainless steel for particulates, glass probe for NO_x, moisture, and orsat analysis.

   d.) Probe cleaning method: Wash probe with acetone and store in sealed container.

2. <u>Description of Operations</u>
(Ref. Item IX "Intent to Test" Form)

The operation tested was Steel Point Station Steam Generator #26, Registration Number S.P. 26, Stack 7, having a capacity of 420.4×10^6 BTU/hr, burning #6 fuel oil at a rate of 2888 gal/hr., and having a gas flow of 158328 ACFM. See Table IV for fuel oil analysis.

3. <u>Sampling Area Description</u>
(Ref. Item X "Intent to Test" Form)

This flue gas discharges into Stack 7. Also discharging into this stack are Steam Generators 25 and 27. Due to stack configuration, it is necessary to sample Boiler 26 in this proposed location. (Intent to Test Forms for Steel Point Station Steam Generators 25 and 27 were mailed on October 30, 1972. Included were prints showing Boilers 25 and 27 flue gas duct configuration at Stack 7).

   a.) Stack Configuration

      (See Westcott and Mapes drawing Number 2022A Project Number 47001.)

   b.) Sampling Port Locations

      (See drawing referenced above.)

   c.) Sampling Point Positions for Each Port

      (See drawing referenced above.)

4. Stack and Vent Descriptions
(Ref. Item XI "Intent to Test" Form)

Connected to this boiler is a Research-Cottrell electrostatic precipitator having an estimated collection efficiency of approximately 60% when burning residual fuel oil. The outlet of the precipitator discharges through a flue gas duct into Stack #7. Emission sampling was conducted in sampling ports installed in the flue gas duct located between the precipitator outlet and the stack. (See Westcott and Mapes drawing Number 2022A referenced above.)

5. Operational Parameters
(Ref. Item XII "Intent to Test" Form)

Electric utility steam generator burning No. 6 residual fuel oil, having rated capacity as registered.

Table I

Summary of Test Results

Steam Generator No. 26

Component	Sampling Duration minutes per point	Sampling Duration total test time	Number of tests (Minimum of 3)	Measured Concentrations	Method Employed to Determine Concentration i.e., material balance, emission factor, reference, (specify) etc.
NO_x		15 min.	3	0.13 lb/10^6 BTU	DYNASCIENCE MODEL NX-130
Particulates	5	220 min.	3	0.05 lb/10^6 BTU**	METHOD 5*
Moisture		220 min.	3	10.3%	CONDENSER METHOD
Gas Analysis		30 min.	3	37% Excess Air	METHOD 3 (ORSAT)*
Velocity	½	25 min.	3	0.02" to 1.1" H_2O	METHOD 2*

*Federal Register, Vol. 36, No. 247, December 23, 1971
**Average of two tests

#25, 27 10.8% O_2 — 7.5% CO_2

#26

TABLE II

Summary of Results
Steam Generator No. 26

	Test 1	Test 2	Test 3A	Test 3B	Average
Date	12/19/72	12/20/72	12/21/72	12/28/72	
Stack Flow, ACFM	159192	153174	158378	162568	158328
Stack Flow, SCFM	95623	92188	97986	100293	96523
Stack Flow, lb/hr	443978	429032	456471	466597	449020
% Excess O_2 @ Test Point	7.15	7.72	7.4	N.A.	7.42
Particulate Emissions					
gr/SCF	0.026	*	-	0.019	0.023**
lb/hr	21.17	*	-	16.13	18.65**
lb/MBTU	0.05	*	-	0.04	0.05
Nitrogen Oxide Emissions					
ppm	118.65	107.79	114.65	-	113.7
lb/MBTU	0.13	0.11	0.13	-	0.13

Control:
electrostatic
precipitator
(estimate efficiency
60%)

$\frac{6.5 \text{ lb}}{10^3 \text{ gal}}$

$\frac{19 \text{ lb}}{10^3 \text{ gal}}$

*Not calculated
**Average of Test 1 and Test 3

TABLE III

Average Boiler Operating Data for Test Periods

	Test 1	Test 2	Test 3A	Test 3B
Date	12/19/72	12/20/72	12/21/72	12/28/72
Gross Load, MW	33.5	N.A.	N.A.	33.8
Steam Flow, lb/hr	316,000	314,000	320,000	320,000
Oil Flow, gal/hr	2,846	2,800	2,848	2,888
Air Flow, lb/hr	345,000	344,000	360,000	360,000
Excess O2 (%)	3.8	3.5	4.0	4.0
Soot Blowing	None	None	None	None
Additive Rate ("CHESCO")	2000:1	2000:1	2000:1	2000:1
Stack Gas Temperature °F	326.6	326.3	325.9	311.7
Gas Density lb/ft.^{3}	0.052	0.052	0.052	0.053

TABLE IV

Ultimate Analysis Of
Representative Fuel Oil Sample

FUEL ENGINEERING COMPANY

January 12, 1973
DATE

FUEL TESTING DEPARTMENT
TEST REPORT

254139
REPORT NUMBER

Your P.O. No

On Sample Marked Steel Point #26 Special Test

Sample Taken by You Us

Received from United Illuminating Co.
80 Temple Street
New Haven, Conn 06506
Attn: Mr. J. Sombati

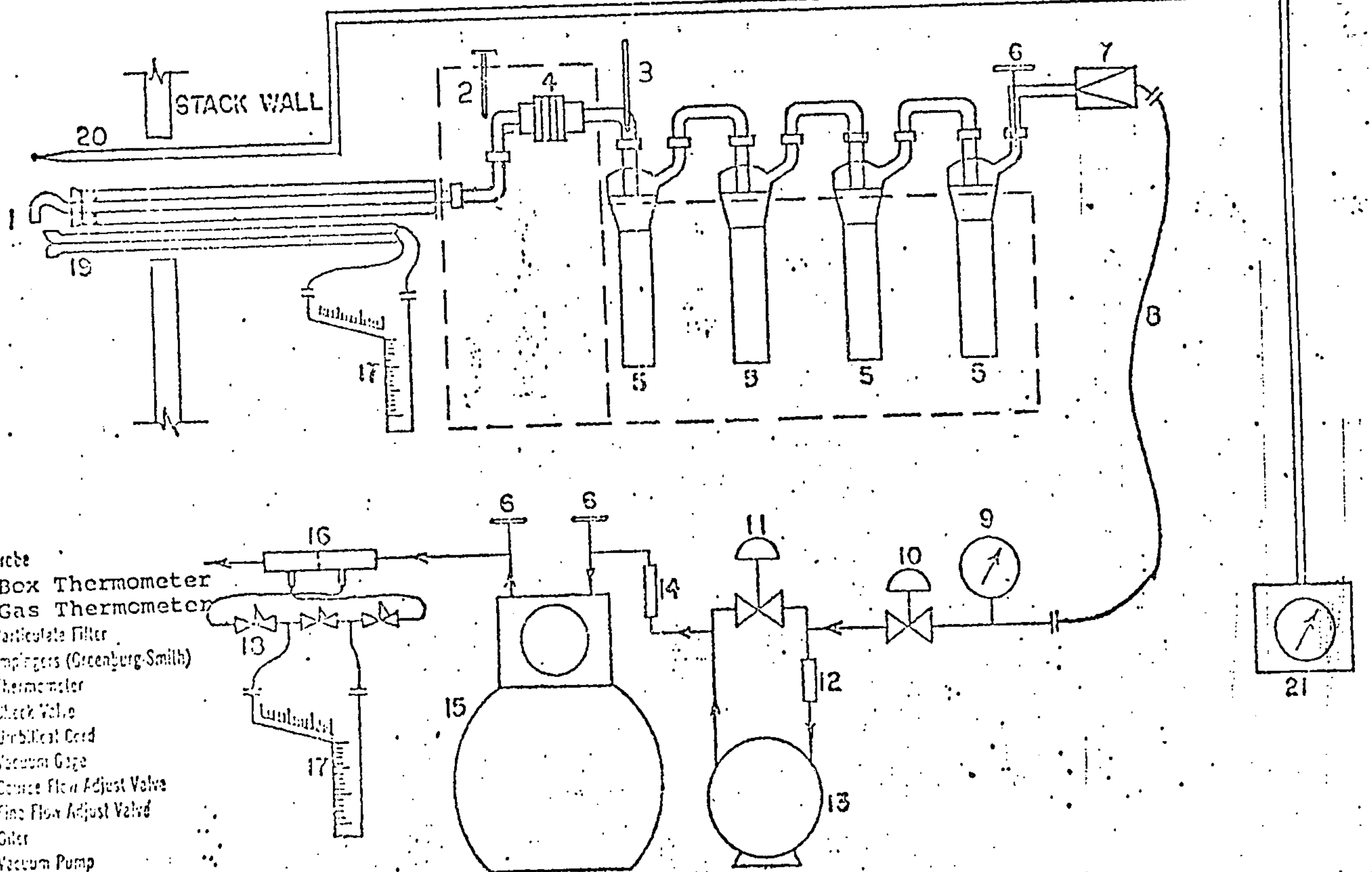
Ultimate Analysis

Carbon	=	85.37%
Hydrogen	=	12.24%
Sulfur	=	0.41%
Nitrogen	=	0.27%
Oxygen	=	1.71%
API @60°F	=	23.6
Specific Gravity	=	0.9123
BTU per pound	=	19,159
BTU per gallon	=	145,551

Fuel Engineering Company of New York

by: [signature]

RAC "STAKSAMPLR" SAMPLING TRAIN SCHEMATIC



1) Probe
2) Box Thermometer
3) Gas Thermometer
4) Particulate Filter
5) Impingers (Greenburg-Smith)
6) Thermometer
7) Check Valve
8) Umbilical Cord
9) Vacuum Gage
10) Course Flow Adjust Valve
11) Fine Flow Adjust Valve
12) Oiler
13) Vacuum Pump
14) Filter
15) Dry Gas Meter
16) Orifice Tube
17) Incline Manometer
18) Solenoid Valves
19) Pitot
20) Thermocouple
21) Leeds & Northrup 8695-2 I.C. Temperature Potentiometer

THE UNITED ILLUMINATING COMPANY
TYPICAL SAMPLING TRAIN
FIGURE 1

Moisture Determination

Moisture determination in stack gas is used in the calculation of isokinetic conditions. The amount of moisture in the stack gas was found by using the following procedure.

The gas sample is aspirated through a pyrex glass probe which is electrically heated and encased in a stainless steel tube. The probe is inserted into the flue gas duct and heated electrically using a variable transformer. The gas sample is drawn through the probe, and through a glass pre-weighed tube filled with silica gel. From the silica gel tube the gas passes through a rotometer, through the aspirating pump, and through a dry gas meter, and passes into the atmosphere. The rotometer is used to control the flow rate of the gas. By averaging the temperature of the gas through the dry gas meter, and recording the volume of gas passed through the meter, the amount of moisture can be determined.

The volume of water absorbed by the silica gel tube is converted to the vapor state by using the ideal gas law equation:

$$Vwt = \frac{MaRTm}{Pm\ Mw}$$

where Ma = mass or weight of water absorbed, grams

R = gas law constant, 21.83 $\frac{\text{in Hg - FT}^3}{\text{lb mol - }^{\circ}\text{R}}$

Tm = average outlet temperature of the dry gas meter, $^{\circ}$R

Pm = barometric pressure, in Hg

Mw = 18 lb/lb mol

The proportion by volume of the stack gas that is water vapor (Bws) is found by using the equation:

$$Bws = \frac{\text{Amount of water absorbed in the silica gel tube}}{\text{Amount of water absorbed + Amount of metered gas}}$$

Orsat Analysis

A Burrell Gas Analyzer was used to determine O_2, CO_2, CO, and N_2 concentrations of the flue gas. The gas sample was aspirated through a stainless steel probe, packed with glass wool at the inlet of the probe. Teflon tubing connected the stainless steel probe to the orsat analyzer. After a sufficient sample was drawn through the probe, tubing, and orsat manifold, a sample of gas was analyzed.

Velocity Traverse

A preliminary velocity traverse was made of the flue gas duct in order to determine a correct nozzle size used in determining particulate concentrations with the RAC Staksampler. It was noted that four traverse points had a negative delta "P". These four areas, located at port 1, points 7 and 8 and at port 6, points 7 and 8 were not used in the test for particulates. Instead of using 48 traverse and sampling points, only 44 sampling points were used.

Since these traverse points indicated negative delta "P," the total cross-sectional area of the flue gas duct was also reduced by the amount of the area occupied by these four sampling areas. The cross-sectional area of the duct was, therefore, reduced from $49.9 Ft^2$ to $45.8 Ft^2$.

Particulate Determination

The apparatus used in determining particulate emissions was a RAC Staksampler Model 2343-5, Serial No. 1399. The procedure followed in this test is Method 5 of the Federal Register, Vol. 36, No. 247, December 23, 1971.

Used in this test was a 10 foot stainless steel probe and pitot tube, recalibrated by the Research Corporation of New England. The pitot tube coefficient obtained from the calibration of this pitot tube was 0.817.

Two modifications were made to the RAC Staksampler by the UI Co. The heated box housing the four-inch fiber filter was fitted with a 0^{o}-$300^{o}F$ indicating thermometer. This enabled the equipment operator to be aware of the exact box temperature during the sampling period.

Also modified was the glass elbow from the filter to the first impinger. This was fitted with a tee connection into which a thermometer with a glass ground joint was inserted. This enabled the operator to check the gas temperature leaving the filter and make any corrections if need be in the probe heating transformer.

After running one test for particulate concentrations, it was found that the amount of silica gel in the fourth impinger had nearly been spent. To insure in future runs of this test that the effectiveness of the silica gel would not be depleted, 300 grams instead of 200 grams was used. This was found to give a greater margin of safety in making sure that there was no moisture carry-over into the dry gas meter.

NO_x Determination

Nitrogen oxides were determined by using a Dynascience NO_x Analyzer, Model NX-130, Serial No. 418. A stainless steel probe, packed with glass wool at the inlet, was inserted approximately 3 feet into the center of the flue gas duct. After calibrating the instrument with a known concentration of NO gas, the flue gas sample was drawn through the instrument which gave a direct read-out on the meter scale. The instrument was operated for fifteen minutes for each test, with readings taken every minute. At the conclusion of the test, the NO_x concentrations in PPM were averaged, and used in the final NO_x calculations.

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1) Dry Gas Volume

$$V_{mstd} = \left(17.71 \frac{^{\circ}R}{inHg}\right) V_m \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right) \quad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{\circ}R}{inHg}\right) 162.055\ ft^3 \left(\frac{29.93\ in\ Hg + \frac{2.066\ in\ H_2O}{13.6}}{553.6\ ^{\circ}R}\right)$$

$$= 155.84\ ft^3$$

2) Volume of Water Vapor

$$V_{wstd} = \left(0.0474 \frac{FT^3}{M}\right) V_{lc} \quad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{FT^3}{M}\right) 389.4\ ml$$

$$= 18.46\ FT^3$$

3) Moisture Content

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

$$= \frac{18.46\ FT^3}{18.46\ FT^3 + 155.84\ FT^3}$$

$$= 0.106 \times 100\% = 10.6\%$$

4) Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%\ N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (10.0) + 0.32\ (7.15) + 0.28\ (82.85) + 0.28\ (0)$$

$$= 29.87\ \text{lb/lb-mole}$$

5) Molecular Weight (wet)

$$MS = Md\ (1-Bws) + 18\ Bws$$

$$= 29.87\ (1-.106) + 18\ (.106)$$

$$= 28.61\ \text{lb/lb-mole}$$

6) Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}}\ \left(\frac{Ts}{Ps\ \ Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.817)\ (.864)\ \left(\frac{786.56}{29.835 \times 28.61}\right)^{1/2}$$

$$= 57.93\ \text{F.P.S.}$$

7) Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A \times 60\ \text{sec/min}$$

$$= 57.93 \times 45.8\ FT^2 \times 60\ \text{sec/min}$$

$$= 159{,}192\ \text{ACFM}$$

8) Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ A\ \left(\frac{Tstd}{Ts}\right)\left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.106)\ (57.93)\ (45.8)\ \left(\frac{530}{786.56}\right)\left(\frac{29.835}{29.92}\right)$$

$$= 95{,}623\ \text{SCFM}$$

9) Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60 \text{ min}}{\text{hr}} \times \frac{Md}{386 \text{ FT}^3}$$

$$= 95{,}623 \text{ SCFM} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{29.87 \text{ lb/lb-mole}}{386 \text{ FT}^3}$$

$$= 443{,}978 \text{ lb/hr}$$

10) Particulate Concentrations, gr/SCF

$$C's = \left(0.0154 \frac{\text{gr}}{\text{mg}}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154 \frac{\text{gr}}{\text{mg}}\right) \frac{261.2 \text{ mg}}{155.84 \text{ FT}^3}$$

$$= 0.026 \text{ gr/SCF}$$

11) Particulate Concentrations, lb/FT^3

$$Cs = \frac{\left(\frac{1}{453600} \frac{\text{lb}}{\text{mg}}\right) mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600} \frac{\text{lb}}{\text{mg}}\right) 261.2 \text{ mg}}{155.84 \text{ FT}^3}$$

$$= 3.69 \times 10^{-6} \text{ lb/SCF}$$

12) Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60 \text{ min}}{\text{hr}}$$

$$= (3.69 \times 10^{-6} \text{ lb/SCF})(95{,}623 \text{ SCFM}) \frac{60 \text{ min}}{\text{hr}}$$

$$= 21.17 \text{ lb/hr}$$

13) Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{21.17 \text{ lb/hr}}{414.2 \times 10^6 \text{ BTU/hr}}$$

$$= 0.051 \text{ lb/MBTU}$$

14) % Isokinetic Sampling

$$I = \frac{Ts\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\overline{\Delta}H}{13.6}\right)\right)}{\theta\ Vs\quad Ps\quad An}$$

eq. 5-6

$$I = \frac{786.56\ (1.667)\left((0.00267)\ (389.4) + \frac{162,055}{553.6}\left(29.93 + \frac{2.066}{13.6}\right)\right)}{(220)\ (57.93)\ (29.835)\ (0.00034)}$$

$$= 99.84\%$$

15) NO_x Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ (NO)}{Md} \times Ws$$

$$= \frac{118.65}{10^6} \times \frac{30\ lb/lb\text{-}mole}{29.87\ lb/lb\text{-}mole} \times 443,978\ \frac{lb}{hr}$$

$$= 52.9\ lb/hr$$

16) NO_x Concentrations, lb/MBTU

$$lb/MBTU = \frac{lb/hr}{Heat\ Input}$$

$$= \frac{52.9\ lb/hr}{414.2 \times 10^6\ BTU/hr}$$

$$lb/MBTU = \frac{0.128\ lb}{10^6\ BTU}$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

Test No. St. Pt. 26, Stack 7 No. Runs 3

Name of Firm The United Illuminating Company

Location of Plant Steel Point Station

Type of Plant Steam Generation

Control Equipment Electrostatic Precipitator

Sampling Point Locations Stack Entry Duct

Pollutants Sampled Particulates, Nitrogen Oxides

Time of Particulate Test:

Run No. 1	Date 12-19-72	Begin 1425	End 1830
Run No. 2	Date 12-20-72	Begin 1457	End 1920
Run No. 3A	Date 12-21-72	Begin	End
Run No. 3B	Date 12-28-72	Begin 1403	End 1756

PARTICULATE EMISSION DATA

Run No.	1	2	3A	3B
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-{}^oR}\right)^{\frac{1}{2}}$	85.48	85.48	85.48	85.48
Cp = Pitot tube coefficient (calib.)	.817	.817	.817	.817
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	.864	.834	.830	.894
$\overline{Ts}$ = Average stack temp., ^oR	786.56	786.27	785.91	771.72
Pb = Barometric pressure, "Hg Abs.	29.93	29.97	30.06	29.94
Pd = Gas duct pressure, "H_2O	-1.3"	-1.2"	-1.3"	-1.25"
Ps = Absolute stack gas pressure, inches Hg	29.835	29.882	29.965	29.849
Bws = % moisture in stack gas, by volume	10.6	10.6	8.4*	9.9
Md = Molecular weight of stack gas, dry	29.87	29.94	29.97	29.93 (avg.)
Ms = Molecular weight of stack gas	28.61	28.67	28.96	28.75 (avg.)

*Silica gel tube method

Run No.	I	[illegible]	[illegible]	[illegible]
Vs = Stack gas velocity, F.P.S.	57.93	55.74	55.12	59.12
% CO_2	10.0	10.3	10.45	10.25*
% O_2	7.15	7.72	7.4	7.42*
% CO	0.00	0.12	0.03	0.05*
% N_2	82.85	81.85	82.13	82.28*
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	389.4	373.2	-	373.8
Vm = Volume of dry gas sampled at meter conditions, FT^3	162.055	151.941	-	161.903
Vstd = Volume of dry gas sampled at STP, FT^3	155.84	149.61	-	161.43
Tm = Average dry gas meter temp., ^oR	553.6	541.1	-	533.7
ΔH = Average pressure drop across orifice, inches H_2O	2.066	1.31	-	2.102
θ = Total Sampling Time, min.	220	220	-	220
Dn = Nozzle dia., inches	.25	.25	-	.25
An = Nozzle area, FT^2	.00034	.00034	-	.00034
I = % of isokinetic sampling	99.84	99.40	-	98.70
Qs = Stack gas volume at STP (SCFM)	95,623	92,188	97,986	100,293
Qa = Stack gas volume at stack conditions (ACFM)	159,192	153,174	158,378	162,568
Ws = Stack gas mass flow lbs/hr	443,978	429,032	456,471	466,597
Mp = Particulate-probe, washings, mg	100.9		-	70.7
Mf = Particulate-filter (mg)	160.3		-	126.0
Mn = Particulate-total (mg)	261.2		-	196.7
C's = Particulate Concentrations gr/scf	0.026		-	0.019
Cw = Particulate total emission lb/hr	21.17		-	16.13
Er = Particulate emission rate, lb/106 BTU	0.05		-	0.04
C = NO, concentrations, PPM	118.65	107.79	114.65	
Cn = NO, $lb/10^6 BTU$	0.13	0.11	0.13	0.12

TEST RESULTS

Steam Generator Nos. 25 and 27
(Ref. Intent to Test Form No. 720045)

Test Conducted On
December 4, 5, 6, 7, 1972

Introduction

Emission tests for Particulates and Nitrogen Oxides were conducted as required by Connecticut State Law on United Illuminating Company Steel Point Station Steam Generators 25 and 27, located in Bridgeport, Connecticut. Testing was conducted on December 4-7, 1972.

Source Sampling was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. These tests were conducted on the flue gas duct downstream of the precipitator outlet and upstream of the stack inlet. This site location was chosen due to the impracticality of source sampling in the stack due to stack configuration. This Stack #7 also handles the emissions produced by Steam Generator 26, which was tested on December 18-21 and on December 28, 1972. A copy of that report is enclosed.

The primary contaminants tested for were Particulates and Nitrogen Oxides. Tests were also conducted to determine stack gas velocity and volumetric flow rates, flue gas analysis and molecular weight and moisture content of the flue gas. The procedures used in determining these various parameters, except for nitrogen oxides, are those found in the above mentioned Federal Register. Nitrogen Oxide emissions were found by using a Dynascience Model NX-130 NO_x Analyzer instead of using the phenoldisulfonic acid procedure as stated in Method 7 of the above mentioned Federal Register.

This test report includes the information required for Items III, IV, V, VI, VII, IX, X, XI and XII from the Department of Environmental Protection's "Intent to Test" form in compliance with the DEP's Source Test Guidelines and Procedures.

Source Test Form #2 was not available at the time of the writing of this report.

1. Sampling Train Information
(Ref. Item VII "Intent to Test" Form)

a.) Schematic diagram of sampling train: See Fig. 1. Sampling Train used: RAC Stack-samplr Model 2343, purchased April 4, 1972.

b.) Media type used to determine gas stream components. NO_x: DynaScience Model NX-130 NO_x Analyzer. Particulates: Reeve Angel 900 AF, 11 cm diameter glass fiber filter.

c.) Sampling tube: Stainless steel for particulates, glass probe for NO_x, moisture, and orsat analysis.

d.) Probe cleaning method: Wash probe with acetone and store in sealed container.

2. Description of Operations
(Ref. Item IX "Intent to Test" Form)

The operation tested was Steel Point Station Steam Generators 25, 27, Registration Number S.P. 25, 27, Stack 7, having a total capacity of 392.7×10^6 BTU/hr, burning #6 fuel oil at a rate of 2725 gal/hr for both boilers, and having a total gas flow of 217,350 ACFM. See Table IV for fuel oil analysis.

3. Sampling Area Description
(Ref. Item X "Intent to Test" Form)

This flue gas discharges into Stack 7. Also discharging into this stack is Steam Generator 26. Due to stack configuration, it is necessary to sample these boilers in the flue gas duct upstream of the stack inlet.

a.) Stack Configuration

(See Westcott and Mapes drawing Number 200-A, Project Number 41013.)

b.) Sampling Port Locations

(See drawing referenced above.)

c.) Sampling Point Positions for Each Port

(See drawing referenced above.)

4. Stack and Vent Descriptions
(Ref. Item XI "Intent to Test" Form).

Connected to each boiler is a Research Cottrell electrostatic precipitator having an estimated collection efficiency of approximately 60% when burning residual fuel oil. The precipitator outlet ducts merge together into a common duct, which is connected to the base of No. 7 stack. Emission sampling was conducted in sampling ports installed in the common flue gas duct joining the precipitator outlets to the stack. (See Westcott and Mapes drawing Number 200-A referenced above.)

5. Operational Parameters
(Ref. Item XII "Intent to Test" Form)

Electric utility steam generators burning No. 6 residual fuel oil and having rated capacities as registered.

Table I

Summary of Test Results

Steam Generator Nos. 25, 27

Component	Sampling Duration minutes per point	Sampling Duration total test time	Number of tests (Minimum of 3)	Measured Concentrations	Method Employed to Determine Concentration i.e., material balance, emiss factor, reference, (specify) et
NO_x		15 min.	3	0.18 lb/10^6 BTU	Dynascience Model NX-130
Particulates	5	235 min.	3	0.06 lb/10^6 BTU	Method 5*
Moisture		235 min.	3	7.8%	Condenser Method
Gas Analysis		30 min.	3	53% Excess Air	Method 3 (ORSAT)*
Velocity	½	25 min.	3	0.05" to 1.3" H_2O	Method 2*

TABLE II

Summary of Results
Steam Generator Nos. 25, 27

	Test 1	Test 2	Test 3	Average
Date	12/5/72	12/7/72	12/7/72	
Stack Flow, ACFM	227,482	211,751	212,818	217,350
Stack Flow, SCFM	134,816	125,426	126,902	129,048
Stack Flow, lb/hr	620,084	577,477	584,867	594,143
% Excess O_2 @ Test Point	10.92	10.50	10.50	10.64
Particulate Emissions				
gr/SCF	0.024	0.020	0.025	0.023
lb/hr	27.4	22.0	27.0	25.5
lb/MBTU	0.07	0.05	0.07	0.06
Nitrogen Oxide Emissions				
ppm	*60	119	123.8	
lb/MBTU	*0.10	0.17	0.19	0.18

*Invalid Data

TABLE III

Average Boiler Operating Data for Test Periods

Steam Generator Nos. 25, 27

	Test 1	Test 2	Test 3
Date	12/5/72	12/7/72	12/7/72
Gross Load, MW	7.0	7.7	7.2
Steam Flow, lb/hr, 25 blr.	129,000	126,800	125,200
27 blr.	132,800	142,300	140,000
Oil Flow, gal/hr, 25 blr.	1336	1353	1296
27 blr.	1337	1462	1390
Excess O_2 (%)	10.9	10.5	10.5
Soot Blowing	None	None	None
Additive Rate ("CHESCO")	2000:1	2000:1	2000:1
Stack Gas Temperature ^{o}F	371.6	376.3	375.7
Gas Density lb/ft.^{3}	0.049	0.049	0.049

TABLE IV (a)

Ultimate Analysis Of Representative Fuel Oil Samples

FUEL ENGINEERING COMPANY

January 3, 1973
DATE

FUEL TESTING DEPARTMENT

254021
REPORT NUMBER

FUEL OIL TEST REPORT

Your P.O. No.

Degrees A.P.I., 60°F	25.4
Specific Gravity, 60°F	0.9018
Flash Point °F OVER	230
Bottom Sediment (incl. water)	0.60
Sulphur % D-1552	0.46
B.T.U. Per Pound D-240	19062
B.T.U. Per Gallon	143156
Viscosity @ 122°F SSF	56.3
Ash	.029

On Sample Marked Oil - Steel Point Special Test

Sample Taken by You / Us

Sampling Date 12-5-72

Supplier's Name

Received from United Illuminating Company
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. A Henricksen

Ultimate:			
	Carbon	=	85.81%
	Hydrogen	=	12.83%
	Nitrogen	=	0.24%
	Oxygen	=	0.66%

Vanadium = 4 PPM
Sodium = 47 PPM

Fuel Engineering Company of New York

by: G. Gould

TABLE IV (b)

Analysis Of
Representative Fuel Oil Samples

FUEL ENGINEERING COMPANY

254022
REPORT NUMBER

Dec 22, 1972
DATE

FUEL TESTING DEPARTMENT

CORRECTED REPORT

FUEL OIL TEST REPORT

Your P.O. No.

Degrees A.P.I., 60°F	
Specific Gravity, 60°F	
Flash Point °F	
Bottom Sediment (incl. water)	
Sulphur %	0.35
B.T.U. Per Pound	19220
B.T.U. Per Gallon	
Viscosity @	

On Sample Marked Oil - Steel Point Special Test

Sample Taken by You / Us

Sampling Date 12-6-72

#25-#27

Supplier's Name

Received from United Illuminating Company
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. A. Henricksen

Fuel Engineering Company of New York

by: [signature]

TABLE IV (c)

Analysis Of
Representative Fuel Oil Samples

FUEL ENGINEERING COMPANY 254023

Dec 22 1972
DATE

FUEL TESTING DEPARTMENT

REPORT NUMBER

FUEL OIL TEST REPORT

Your P.O. No.

Degrees A P I, 60 F		
Specific Gravity, 60 F		
Flash Point F		
Bottom Sediment (incl. water)		
Sulphur %	D-1550	0.50
B T U. Per Pound		19280
B.T U. Per Gallon		
Viscosity @		

On Sample Marked Oil - Steel Point Special Test

Sample Taken by You Us

Sampling Date 12-7-72

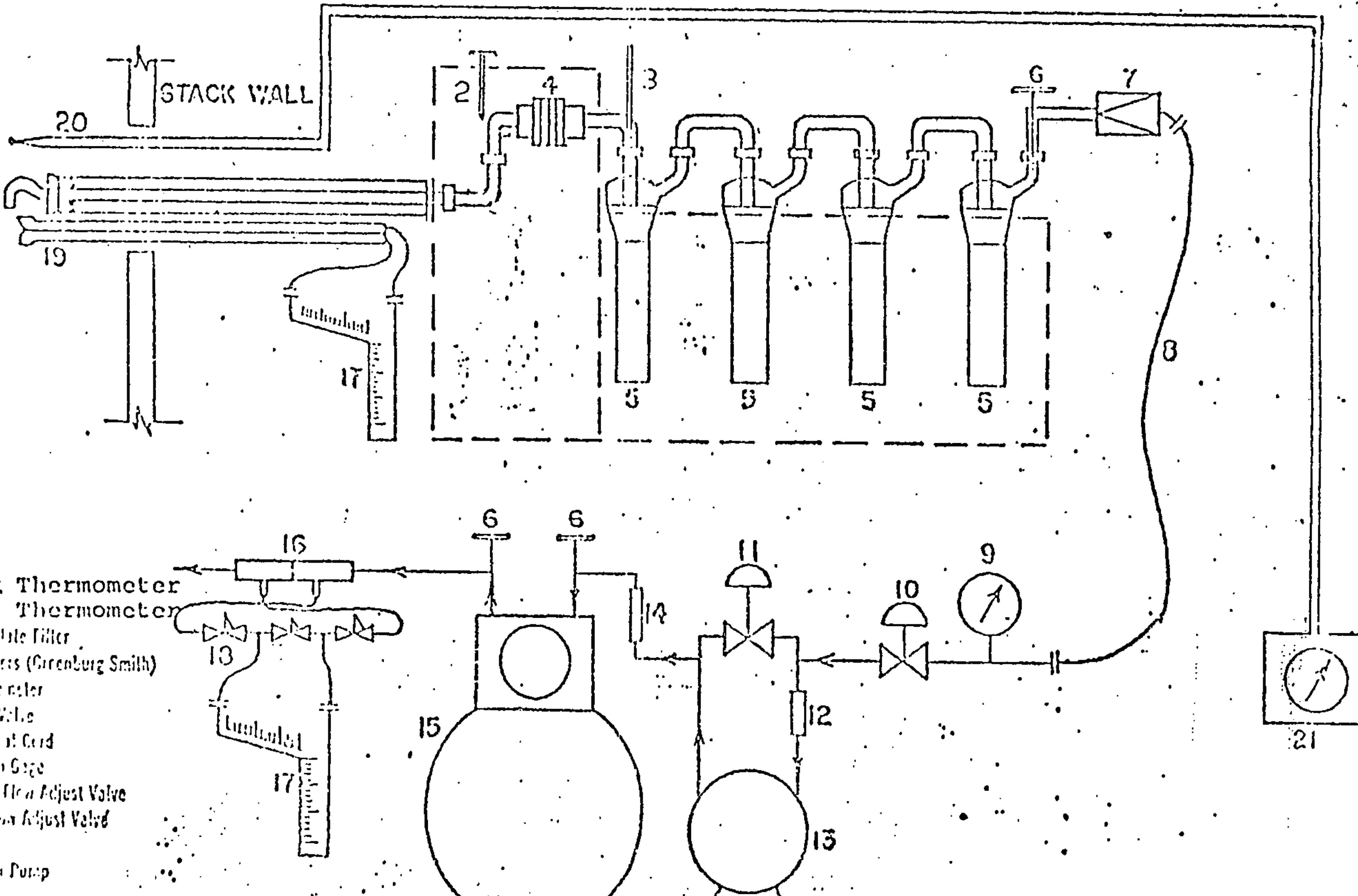
#25 - #27

Supplier's Name

Received from United Illuminating Company
80 Temple Street
New Haven, Connecticut 06506
Attn: Mr. A. Henricksen

Fuel Engineering Company of New York

by: [signature]



1) Probe
2) Box Thermometer
3) Gas Thermometer
4) Particulate Filter
5) Impingers (Greenburg Smith)
6) Thermometer
7) Check Valve
8) Umbilical Cord
9) Vacuum Gage
10) Coarse Flow Adjust Valve
11) Fine Flow Adjust Valve
12) Oiler
13) Vacuum Pump
14) Filter
15) Dry Gas Meter
16) Orifice Tube
17) Incline Manometer
18) Solenoid Valves
19) Pitot
20) Thermocouple
21) Leeds & Northrup 8695-2 I.C. Temperature Potentiometer

THE UNITED ILLUMINATING COMPANY
TYPICAL SAMPLING TRAIN
FIGURE 1

Moisture Determination

Moisture determination in stack gas is used in the calculation of isokinetic conditions. The amount of moisture in the stack gas was found by using the following procedure.

The gas sample is aspirated through a pyrex glass probe which is electrically heated and encased in a stainless steel tube. The probe is inserted into the flue gas duct and heated electrically using a variable transformer. The gas sample is drawn through the probe, and through a glass pre-weighed tube filled with silica gel. From the silica gel tube the gas passes through a rotometer, through the aspirating pump, and through a dry gas meter, and passes into the atmosphere. The rotometer is used to control the flow rate of the gas. By averaging the temperature of the gas through the dry gas meter, and recording the volume of gas passed through the meter, the amount of moisture can be determined.

The volume of water absorbed by the silica gel tube is converted to the vapor state by using the ideal gas law equation:

$$Vwt = \frac{MaRTm}{Pm\ Mw}$$

where Ma = mass or weight of water absorbed, grams

R = gas law constant, 21.83 $\frac{\text{in Hg} - FT^3}{\text{lb mol} - {}^{O}R}$

Tm = average outlet temperature of the dry gas meter, ^{O}R

Pm = barometric pressure, in Hg

Mw = 18 lb/lb mol

The proportion by volume of the stack gas that is water vapor (Bws) is found by using the equation:

$$Bws = \frac{\text{Amount of water absorbed in the silica gel tube}}{\text{Amount of water absorbed + Amount of metered gas}}$$

Orsat Analysis

A Burrell Gas Analyzer was used to determine O_2, CO_2, CO, and N_2 concentrations of the flue gas. The gas sample was aspirated through a stainless steel probe, packed with glass wool at the inlet of the probe. Teflon tubing connected the stainless steel probe to the orsat analyzer. After a sufficient sample was drawn through the probe, tubing, and orsat manifold, a sample of gas was analyzed.

Velocity Traverse

A preliminary velocity traverse was made of the flue gas duct in order to determine a correct nozzle size used in determining particulate concentrations with the RAC Staksamplr. It was noted that three traverse points had a negative delta "P". These three areas, located at port 1, point 1, and at port 5, points 1 and 2, were not used in the test for particulates. Instead of using 50 traverse and sampling points, only 47 sampling points were used.

Since three traverse points indicated negative delta "P", the total cross-sectional area of the flue gas duct was also reduced by the amount of the area occupied by these three sampling areas. The cross-sectional area of the duct was therefore reduced from $64.9 Ft^2$ to $61.0 Ft^2$.

Particulate Determination

The apparatus used in determining particulate emissions was a RAC Staksamplr Model 2343-5, Serial No. 1399. The procedure followed in this test is Method 5 of the Federal Register, Vol. 36, No. 247, December 23, 1971.

Used in this test was a 10 foot stainless steel probe and pitot tube, calibrated by The Research Corporation of New England. The pitot tube coefficient obtained from the calibration of this pitot tube was 0.819.

Two modifications were made to the RAC Staksamplr by the United Illuminating Company. The heated box housing the four-inch fiber filter was fitted with a 0^{o}-$300^{o}F$ indicating thermometer. This enabled the equipment operator to be aware of the exact box temperature during the sampling period.

Also modified was the glass elbow from the filter to the first impinger. This was fitted with a tee connection into which a thermometer with a glass ground joint was inserted. This enabled the operator to check the gas temperature leaving the filter and make any corrections if need be in the probe heating transformer.

After running one test for particulate concentrations, it was found that the amount of silica gel in the fourth impinger had nearly been spent. To insure in future runs of this test that the effectiveness of the silica gel would not be depleted, 300 grams instead of 200 grams was used. This was found to give a greater margin of safety in making sure that there was no moisture carryover into the dry gas meter.

NO_x Determination

Nitrogen oxides were determined by using a Dynascience NO_x Analyzer, Model NX-130, Serial No. 418. A stainless steel probe, packed with glass wool at the inlet, was inserted approximately three feet into the center of the flue gas duct. After calibrating the instrument with a known concentration of NO gas, the flue gas sample was drawn through the instrument which gave a direct readout on the meter scale. The instrument was operated for fifteen minutes for each test, with readings taken every minute. At the conclusion of the test, the NO_x concentrations in PPM were averaged, and used in the final NO_x calculations.

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

Test No. S.P. 25, 27 No. Runs 3

Name of Firm The United Illuminating Company

Location of Plant Steel Point Station, Bridgeport

Type of Plant Steam Generating Station

Control Equipment Electrostatic Precipitators

Sampling Point Locations Flue Gas Duct After Precipitators

Pollutants Sampled Particulates, Nitrogen Oxides

Time of Particulate Test:

Run No. 1	Date 12/5/72	Begin 1517	End 1939
Run No. 2	Date 12/7/72	Begin 1051	End 1522
Run No. 3	Date 12/7/72	Begin 1656	End 2113

PARTICULATE EMISSION DATA

Run No.	1	2	3	
$K_p = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole\text{-}^{o}R}\right)^{1/2}$	85.48	85.48	85.48	
C_p = Pitot tube coefficient (calib.)	0.819	0.819	0.819	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.905	0.845	0.851	
$\overline{T_s}$ = Average stack temp., ^{o}R	831.6	836.3	835.7	
P_b = Barometric pressure, "Hg Abs.	30.13	30.54	30.58	
P_d = Gas duct pressure, "H_2O	-1.4	-1.04	-0.97	
P_s = Absolute stack gas pressure, inches Hg	30.08	30.46	30.51	
B_{ws} = % moisture in stack gas, by volume	7.5	8.2	7.8	
M_d = Molecular weight of stack gas, dry	29.59	29.62	29.65	
M_s = Molecular weight of stack gas	28.72	28.67	28.74	

Run No.	1	2	3	
Vs = Stack gas velocity, F.P.S.	62.15	57.86	58.15	
% CO_2	7.23	7.50	7.70	
% O_2	10.92	10.50	10.50	
% CO	0.00	0.02	0.07	
% N_2	81.85	81.97	81.72	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	303	308.6	293.7	
Vm = Volume of dry gas sampled at meter conditions, FT^3	174.79	169.14	158.83	
Vstd = Volume of dry gas sampled at STP, FT^3	176.73	164.24	164.65	
Tm = Average dry gas meter temp., ^oR	531.4	559.7	558.1	
ΔH = Average pressure drop across orifice, inches H_2O	2.15	2.01	2.00	
θ = Total Sampling Time, min.	235	235	235	
Dn = Nozzle dia., inches	0.250	0.250	0.250	
An = Nozzle area, FT^2	0.00034	0.00034	0.00034	
I = % of isokinetic sampling	100.16	99.97	99.10	
Qs = Stack gas volume at STP (SCFM)	134,616	125,426	126,902	
Qa = Stack gas volume at stack conditions (ACFM)	227,482	211,751	212,613	
Ws = Stack gas mass flow lbs/hr	620,084	577,477	584,367	
Mp = Particulate-probe, washings, mg	210.8	162.9	211.2	
Mf = Particulate-filter (mg)	61.3	55.6	53.5	
Mn = Particulate-total (mg)	272.1	218.5	264.7	
C's = Particulate Concentrations gr/scf	0.024	0.020	0.025	
Cw = Particulate total emission lb/hr	27.4	22.0	27.0	
Er = Particulate emission rate, lb/106 BTU	0.07	0.05	0.07	
C = NO, concentrations, PPM	*60	119.0	123.9	
Cn = NO, $lb/10^6 BTU$	*0.10	0.17	0.19	

The United Illuminating Company
Steel Point Station
Boiler Numbers 25, 27
ITT No. 0.20045
April 9, 1993

APPENDIX A

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number ______ Date Dec. 5, 1972

Boiler Number 25-27 Time 11:00

Plant Location Steel Point

Sampling Point Location ______

Cummulative readings

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	6.8	7.5	7.2	7.4	7.225	44/100	3.179
CO, % Vol (dry)	18.0	18.4	18.0	18.2	0	28/100	+ 0
O2, % Vol (dry)	18.6	18.4	18.0	18.2	10.925	32/100	+ 3.496
N2, % Vol (dry)	82.0	81.6	82.0	81.8	81.85	28/100	+ 22.918
O2	11.2	10.9	10.8	10.8	10.9		

11.2 10.9 10.8 10.8

Avg. molecular wt. of dry stack gas = 29.593

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number______ Date Dec. 6, 1972

Boiler Number 25-27 Time 11:00 AM

Plant Location Steel Point

Sampling Point Location Port 3 - 3 feet in

Cummulative readings

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry) CO_2	7.5	7.4	7.6	7.5	7.50	44/100	3.30
CO, % Vol (dry) CO	17.8	18.1	18.0	18.2	.02	28/100	+ 0
O_2, % Vol (dry) O_2	17.8	18.0	18.0	18.2	10.50	32/100	+ 3.36
N_2, % Vol (dry) N_2	82.2	81.9	82.0	81.8	81.97	28/100	+ 22.95
O_2	10.30	10.60	10.40	10.7	10.5		

Avg. molecular wt. of dry stack gas = 29.613

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number ____ Date Dec. 6, 1972

Boiler Number 25-27 Time 2:50 PM oil

Plant Location Steel Point

Sampling Point Location stack inlet duct - Port 3, 3 ft in

Cummulative readings

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	7.7	7.6	8.0	7.5	7.7	44/100	3.38
CO, % Vol (dry)	18.2	18.0	18.4	18.5	.07	28/100	+ .01
O2, % Vol (dry)	18.0	18.0	18.3	18.5	10.5	32/100	+ 3.36
N2, % Vol (dry)	81.8	83.0	81.6	81.5	81.72	28/100	+ 27.88
O2	10.3	10.4	10.3	11.0	10.5		

Avg. molecular wt. of dry stack gas = 29.63

Preliminary Moisture

THE UNITED ILLUMINATING COMPANY
MOISTURE DETERMINATION
SILICA GEL METHOD

Stack Identification Number S.P. 25/27 Date Dec. 4, 1972

Boiler Number 25-27 [illegible] Operator

Plant Steel Point Amb. Temp. (°F) 40

Location Bar. Press. "Hg [illegible]

	Analysis 1 A	Analysis 2 B	Analysis 3
Time	13 min [illegible]	[illegible] 5:08 ½ 13 min	
Tube	A	[illegible]	
Final Wt. Tube grams	426.7	422.0	
Initial Wt. Tube grams	418.7	414.4	
Wt. Collected Moisture grams	8.0	7.6	
D GM Final FT³	101.5	106.3	
D GM Initial FT³	096.3	101.5	
Volume of Gas (Vm) FT³	5.2	4.8	
Meter Inlet Temp (°F) Avg.	44.9	42.4	
Meter Outlet Temp (°F) Avg.	47.6	46.9	
Vol. of H_2O Absorbed (Vwt)	.357	.338	
Water Vapor (%) of Gas (Bws)	6.4	6.5	

Blrs 25/27
NOx RUN #1
12-5-72

etermination by Portable DynaScience
NOx Monitor

10:55 Am max NOx Reading = 12%
scale calibration = 100% = 500 ppm

$\therefore \frac{12}{100} = \frac{x}{500}$ $100\overline{)6000}^{\,60}$

$x = 60$ ppm

Sample out temp to inst = 77°F.

11:00 AM NOx Reading = 11%
$\therefore$ X = 55 ppm

60 ppm NOx = Max observed.

ole: Probe inserted into Port #3
Distance in 2½ feet.

Disregard due to air leak
in sample line

NOx 2

BLRS 25, 27.
DEC 6, 1972.

NOx, RUN 2

INSERTION POINT: PORT 3, 3 FT IN.

RECALIBRATED DYNASCIENCE @ FIELD CONDITIONS
ZERO = 4.87 SPAN = 4.7
SCALE: 0-100% = 0-500 PPM

TIME	READINGS		
11:45	24%	=	120 PPM
11:46	24%	=	120 PPM
11:47	23.75%	=	118 PPM
11:48	24%	=	120 PPM
11:49	24%	=	120 PPM
11:50	24%	=	120 PPM
11:51	24%	=	120 PPM
11:52	23.75%	=	118 PPM
11:53	23.75%	=	118 PPM
11:54	23.5%	=	117.5 PPM
11:55	23.75%	=	118 PPM
11:56	23.75%	=	118 PPM
11:57	23.75%	=	118 PPM
11:58	24%	=	120 PPM
11:59	24%	=	120 PPM

AVG = 119 PPM

NOx RUN #3
Dec 6, 1972 3:25 PM

Port #3 - 3 ft insertion

	0-100%	=	0-500 ppm
3:25	24%	=	120 ppm
3:26	24%	=	120 ppm
3:27	24%	=	120 ppm
3:28	24.2%	=	121 ppm
3:29	24%	=	120 ppm
3:30	24.5%	=	122 ppm
3:31	25%	=	125 ppm
3:32	25%	=	125 ppm
3:33	25%	=	125 ppm
3:34	25%	=	125 ppm
3:35	25%	=	125 ppm
3:36	25%	=	125 ppm
3:37	25.5%	=	127 ppm
3:38	25.3%	=	126 ppm
3:39	25.5%	=	127 ppm
3:40	25.7%	=	128 ppm
	AVG	=	123.81 ppm

Blrs. 25/27

12-5-72

12:30 - 1:00 PM

INITIAL VELOCITY TRAVERSE

PORT	DISTANCE	TRAVERSE POINT	ΔP	$\sqrt{\Delta P}$
1	14"	1.	NEG	
	25"	2	.25	
	36"	3	.43	
	47"	4	.48	
	58"	5	.54	
	69"	6	.66	
	80"	7	.62	
	91"	8	.50	
	102"	9	.37	
	113"	10	.32	
	14"	1	.62	
	25"	2	.70	
	36"	3	.59	
	47"	4	.63	
	58"	5	.89	
	69"	6	.87	
	80"	7	.93	
	91"	8	.56	
	102"	9	.45	
	113"	10	.52	

PORT	DISTANCE	TRAVERSE POINT	ΔP	√ΔP	TEMP
3	14	1	.55		
	25	2	.75		
	36	3	.82		
	47	4	1.1		
	58	5	1.2		379°F
	69	6	1.1		
	80	7	1.2		
	91	8	1.1		
	102	9	.92		
	113	10	.56		
	14	1	.14		
	25	2	.25		
	36	3	.94		
	47	4	1.2		
	58	5	1.2		
	69	6	1.1		
	80	7	1.3		
	91	8	1.2		
	102	9	1.1		
	113	10	.5		

PORT	DISTANCE	TRAVERSE POINT	ΔP	√ΔP
5	14	1	NEG	
	25	2	NEG	
	36	3	.05	
	47	4	.78	
	58	5	.65	
	69	6	.70	
	80	7	.85	
	91	8	1.1	
	102	9	.93	
	113	10	.05	

duct pressure −1.4" H_2O
barometer 30.20

Stack Identification Number 25/27

Boiler Number 25-27

Plant Steel Plant

Run No. 1

Location Steel Point Stack Duct

Date 12-5-72

Operator JSS

Meter $\Delta H_{@}$ 1.89

C Factor .94) .91) .94) .98)

[illegible] T_m=55° 50° 100

Ambient Temp °F 46

Bar. Press. "Hg 30.18 - 30.73 (30.30)

Assumed Moisture % 6.5

Heater Box Setting, °F 275

Probe Tip Dia., In. .25

Probe Length 10'

Probe Heater Setting 50%

Avg $\sqrt{\Delta P}$ 0.905 Avg. ΔH 2.15

STACK PRESSURE: -1.4 in H_2O

$\bar{I}$ = ~~[illegible]~~ 100.21

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$ ~~Stack Press in. Hg~~	Stack Temp °F
B 1	3:17	235.995	.52	1.3	1.3	[illegible]	[illegible]	4	235	[illegible]	.72	[illegible]
2	3:22	[illegible]	[illegible]	2.1	2.1	70	[illegible]	5	[illegible]	55	.92	[illegible]
3	[illegible]	242.15	1.1	2.8	2.8	[illegible]	60	7	270	55	1.05	[illegible]
4	3:32	247.2	1.2	[illegible]	[illegible]	[illegible]	[illegible]	7.5	[illegible]	80	1.09	360
5	[illegible]	251.75	1.3	3.25	[illegible]	98	64	6	[illegible]	75	1.14	[illegible]
6	3:42	256.35	1.15	3.0	3.0	100	66	7	[illegible]	73	1.07	[illegible]
7	[illegible]	260.10	1.35	3.4	3.4	[illegible]	[illegible]	8	260	75	1.16	[illegible]
8	[illegible]	265.6	1.1	2.65	2.65	[illegible]	[illegible]	[illegible]	[illegible]	75	1.05	[illegible]
9	[illegible]	[illegible]	1.05	2.6	[illegible]	99	71	6.0	[illegible]	[illegible]	1.02	[illegible]
10	4:08	274.17	.67	1.75	1.75	96	71	4.5	[illegible]	[illegible]	0.83	[illegible]
	[illegible]	277.7										
4 1	4:16	277.5	.20	.50	.50	[illegible]	[illegible]	2	[illegible]	50	[illegible]	[illegible]
2	4:21	[illegible]	[illegible]	.545	.545	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	2.6	76	64	6.2	270	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	1.35	[illegible]	[illegible]	[illegible]	64	9.0	275	60	1.16	[illegible]
5	4:36	290.34	1.5	3.6	3.6	91	66	5.5	270	55	1.22	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δp	Orifice ΔH in H_2O Desired	Actual	Dry Gas Temp. °F Inlet	Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	H_2O ~~Stack Press in. Hg~~	Stack Temp °F
6	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.18	[illegible]
7	[illegible]	300.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.24	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66	[illegible]	[illegible]	[illegible]	1.22	[illegible]
[illegible]	[illegible]	[illegible]	1.8	[illegible]	[illegible]	95	66	2.5	[illegible]	[illegible]	1.19	[illegible]
10	[illegible]	[illegible]	.6	1.5	1.5	84	66	4	[illegible]	[illegible]	0.775	[illegible]
		[illegible]										
1	8:16	—	[illegible]	—	—							
[illegible]			[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	.5	.5	[illegible]	[illegible]	3	[illegible]	50	0.442	330
[illegible]	[illegible]	[illegible]	1.05	2.35	2.35	[illegible]	[illegible]	6.5	[illegible]	[illegible]	1.02	353
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	272	52	1.22	355
[illegible]	[illegible]	[illegible]	1.1	2.2	2.2	[illegible]	[illegible]	6.1	274	[illegible]	1.15	[illegible]
[illegible]	[illegible]	[illegible]	1.65	[illegible]	[illegible]	[illegible]	[illegible]	4.2	[illegible]	[illegible]	1.28	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88	63	[illegible]	[illegible]	[illegible]	1.28	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88	64	7.9	[illegible]	[illegible]	1.14	373
10	[illegible]	[illegible]	.78	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	0.884	387
[illegible]	[illegible]	[illegible]										
1	[illegible]	[illegible]	[illegible]	1.07	1.07	[illegible]	60	4.2	[illegible]	[illegible]	0.755	[illegible]
2	[illegible]	[illegible]	.77	1.0	1.0	70	60	5	[illegible]	50	0.877	[illegible]
3	[illegible]	[illegible]	.77	[illegible]	[illegible]	74	58	11	[illegible]	56	0.755	[illegible]
4	[illegible]	[illegible]	[illegible]	1.1	1.1	74	61	11.5	272	50	0.725	[illegible]
5	[illegible]	[illegible]	.87	2.17	2.17	74	60	5.5	252	55	0.945	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	58	6.5	[illegible]	[illegible]	[illegible]	[illegible]
7	6:23	331.9	.91	[illegible]	[illegible]	74	57	6.0	[illegible]	55	[illegible]	[illegible]
8	6:33	[illegible]	.64	1.58	1.58	80	58	4.8	272	55	0.8	[illegible]
9	[illegible]	[illegible]	.47	1.22	1.22	76	[illegible]	3.8	255	55	0.7	[illegible]
10	[illegible]	[illegible]	.51	1.25	1.25	72	58	4.0	254	52	0.715	371
[illegible]	[illegible]	[illegible]										
1			[illegible]									
2	[illegible]	[illegible]	.38	.75	.75	65	56	2	[illegible]	[illegible]	0.545	[illegible]
3	[illegible]	[illegible]	.51	1.37	1.27	66	57	3.9	256	[illegible]	0.775	[illegible]
4	[illegible]	[illegible]	[illegible]	1.48	1.33	70	57	4.0	265	56	[illegible]	[illegible]
5	[illegible]	[illegible]	.56	1.43	1.05	71	[illegible]	4.2	266	55	0.784	415
6	[illegible]	[illegible]	.58	1.54	1.38	78	58	4.5	241	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	.61	1.52	1.32	72	[illegible]	4.2	[illegible]	[illegible]	0.75	[illegible]
8	[illegible]	[illegible]	.52	1.2	1.2	74	[illegible]	4.0	266	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	.35	.88	.88	74	58	[illegible]	[illegible]	[illegible]	0.64	[illegible]
10	[illegible]	[illegible]	.28	.70	.70	72	58	[illegible]	[illegible]	60	0.53	[illegible]
											[illegible]	[illegible]
[illegible]	[illegible]	[illegible]								64	[illegible]	[illegible]
					2.14							

TEST 1

WEIGHT OF PARTICULATE COLLECTED mg

Filter Paper: Reeve Angel 900AF, 11cm., Glass fiber

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
Filter	.6592 grams	.5979 grams	.0613 grams
Washings	65.5000 grams	65.2892 grams	.2108
TOTAL	66.1592 grams	65.8871 grams	.2721 grams

VOLUME OF LIQUID WATER COLLECTED, ml

IMPINGER	1	2	3	4
FINAL VOL	277ml	182ml	14 ml	230
INITIAL VOL	100ml	100ml	0	200 g
LIQUID COLLECTED	177ml	82ml	14ml	30g 33 ml

Stack Identification Number

Boiler Number

Plant Steel Point

Run No. 2

Location Blrs 25/27

Date 12-7-72

Operator JSS

Meter Δ H 1.96

C Factor .92, .94, 1.0, 1.03

Ambient Temp °F 50

Bar. Press. "Hg 30.54

Assumed Moisture % 7.5

Heater Box Setting, °F 275

Probe Tip Dia., In. .25

Probe Length 10' S.S.

Probe Heater Setting 550

Avg $\sqrt{\Delta P}$ 0.845 Avg. Δ H 2.01

Stack press -1.04" H_2O

I = 99.90 %

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta p}$ ~~Stack Press in. Hg~~	Stack Temp °F
1	—	—	N/A									
2	10:51	411.455	.27	.83	.83	55	55	2.	270	50	.518	327
3	10:56	413.72	.50	1.45	1.45	68	55	2.5	290	50	.707	310
[illegible]	11:01	416.72	.50	1.45	1.45	76	56	2.5	255	[illegible]	[illegible]	[illegible]
[illegible]	11:06	419.30	.52	1.50	1.50	86	60	2.8	283	50	.720	302
[illegible]	11:11	422.95	.55	1.58	1.58	93	64	2.9	262	50	.742	[illegible]
[illegible]	11:16	424.20	.57	1.64	1.64	98	68	2.9	260	50	.755	310
8	11:21	429.55	.50	1.45	1.45	100	70	2.8	268	50	.707	305
9	11:26	432.72	.37	1.08	1.08	102	72	2.0	278	50	.608	[illegible]
[illegible]	11:31	435.50	.35	1.0	1.0	98	75	2.1	[illegible]	50	.591	293
[illegible]	11:36	[illegible]										
1	11:42	438.016	.59	1.7	1.7	97	76	3.1	260	50	.768	305
2	11:47	441.48	.76	2.16	2.18	104	79	3.5	247	50	.872	[illegible]
3	11:52	445.36	.57	1.68	1.68	110	81	3.0	272	50	.757	[illegible]
4	11:57	448.37	.64	1.6	1.6	110	83	2.6	250	50	[illegible]	[illegible]
5	12:02	452.19	.92	2.3	2.3	112	86	3.5	260	50	.9[illegible]	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta p}$	Stack Temp °F
				2.58	2.58	114	86	3.8	280	50	1.01	[illegible]
6	1207	456.11	1.03	2.50	2.50	118	88	3.6	[illegible]	50	1.00	395
7	1212	460.25	1.00	1.57	1.57	118	90	2.8	258	50	.787	377
8	1217	463.39	.62	1.20	1.20	114	90	2.1	250	50	.686	365
9	1222	467.75	.47	1.18	1.18	112	91	2.1	278	50	.678	361
10	1227	470.61	.46									
[illegible]	1232	473.[illegible]								50	.547	355
1	1250	472.572	.3	.76	.76	92	87	2.0	258	50	.937	357
2	1255	475.66	.87	2.2	2.2	92	87	3.5	[illegible]	50	1.01	352
3	1300	477.63	1.02	2.54	2.54	111	88	4.0	278	50	1.09	365
4	1305	483.81	1.2	3.0	3.0	118	90	4.5	234	50	1.14	[illegible]
5	1310	488.31	1.3	3.25	3.25	125	93	4.9	[illegible]	50	1.07	375
6	1315	[illegible]	1.2	3.0	3.0	130	95	[illegible]	[illegible]	55	1.11	372
7	1320	497.73	1.3	3.4	3.4	132	98	5.0	270	50	1.12	372
8	1325	502.52	1.25	3.25	3.25	134	100	5.0	250	50	1.05	370
9	1330	507.31	1.1	2.86	2.86	132	100	4.2	267	55	.825	370
10	1335	511.83	.68	1.81	1.81	130	100	3.2	[illegible]			
[illegible]3	1340	515.557					98	1.8	[illegible]	[illegible]	.38	[illegible]
1	1347	515.557	.15	.42	.42	113	98	1.8	240	[illegible]	[illegible]	355
2	1349	517.33	.15	.42	.42	110	97	4.0	247	55	.97	357
3	1354	519.12	.88	2.4	2.4	115	98	5.2	246	50	1.22	359
4	1359	523.10	1.5	3.9	3.9	122	98	5.5	242	50	1.24	367
5	1404	528.07	1.55	3.95	3.95	126	98	5.0	256	50	1.18	[illegible]
6	1409	533.18	1.4	3.45	3.45	122	99	5.5	263	50	1.20	372
7	1414	538.07	1.5	3.7	3.7	128	100	5.2	255	50	1.20	400
8	1419	543.16	1.45	3.65	3.65	130	102	5.0	250	50	1.14	400
9	1424	548.15	1.3	3.3	3.3	130	102	3.2	270	50	.793	380
10	1427	552.77	.63	1.62	1.62	128						
[illegible]	1432	5[illegible]										
1			N/C									
2			[illegible]					0	278	50	.200	[illegible]
3	1452	555.47	.04	.12	.12	102	97	4	262	50	.960	357
4	1457	556.74	.92	2.3	2.3	103	97	3.2	270	50	.787	[illegible]
5	1502	560.57	.61	1.52	1.52	118	98	2.2	270	50	.781	373
6	1507	563.[illegible]	[illegible]	.76	.76	120	98	[illegible]	[illegible]	50	.625	370
7	1512	[illegible]	.77	1.32	1.32	116	[illegible]	3.7	253	50	.855	[illegible]
8	1517	569.62	.73	1.82	1.82	118	100	4.5	257	50	1.05	377
9	1522	573.28	1.1	2.72	2.72	120	99	2.8	253	55	[illegible]	[illegible]
10	[illegible]	577.63	.4	1.03	1.03	122	98					
[illegible]	1532	580.518			94.58	111.34	88.08				.845	[illegible]
					2.01		99.77					

TEST 2

WEIGHT OF PARTICULATE COLLECTED mg.

Filter Paper: Reeve Angel 900 AF, 11 cm Glass Fiber

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
Filter	.6705 grams	.6149 grams	.0556 grams
Washings	65.2710 grams	65.1081 grams	.1629 grams
TOTAL	65.9415 grams	65.7230 grams	.2185 grams

VOLUME OF LIQUID WATER COLLECTED, ml

IMPINGER	1	2	3	4
FINAL VOL.	273	180 ml.	13 ml.	342.6
INITIAL VOL	100 ml	100 ml	0 ml	300.0 g
LIQUID COLLECTED	173	80 ml	13 ml	42.6 g 30.6 ml

Stack Identification Number

Boiler Number 25-27

Plant Steel Point

Run No. 3

Location Stack Inlet duct

Date 12-7-72

Operator Soubati

Meter Δ H 1.92

C Factor .96

Ambient Temp °F 60

Bar. Press. "Hg 30.58

Assumed Moisture % 8

Heater Box Setting, °F 275°

Probe Tip Dia., In. .25"

Probe Length 10'

Probe Heater Setting 55%

Avg $\sqrt{\Delta P}$ .851 Avg. Δ H 2.00

duct press = -.97" H_2O

I = 98.888%

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta p}$ ~~Stack Press In. Hg~~	Stack Temp °F
1	—	580.824	N.G.									
2	—	"	N.G.									
3	1156	580.824	.05	.13	.13	74	74	22	282	55	[illegible]	[illegible]
4	1701	581.53	.72	1.82	1.82	73	74	3	290	50	.848	[illegible]
5	1706	585.26	.46	1.2	1.2	94	76	2.5	250	50	.677	[illegible]
6	1711	[illegible]	.70	1.8	1.8	101	78	3.1	[illegible]	50	[illegible]	[illegible]
7	1716	591.23	.46	1.2	1.2	108	81	2.5	[illegible]	50	.678	[illegible]
8	1721	594.89	1.15	2.9	2.9	110	[illegible]	4.5	[illegible]	50	1.07	[illegible]
9	1726	599.24	1.2	3.05	3.05	116	86	4.8	250	50	1.09	[illegible]
10	1731	[illegible]	.12	.315	.315	[illegible]	[illegible]	1.5	265	50	.346	[illegible]
[illegible]	1736	[illegible]	—	—	—	—	—			—		
1	1746	[illegible]	.17	.45	.45	105	[illegible]	1.5	[illegible]	50	.412	[illegible]
2	[illegible]	[illegible]	[illegible]	.72	.72	101	[illegible]	2.0	[illegible]	50	[illegible]	[illegible]
3	[illegible]	[illegible]	1.05	2.6	2.6	108	89	4.0	[illegible]	50	[illegible]	[illegible]
4	[illegible]	613.81	1.5	3.8	3.8	121	92	5.3	[illegible]	50	1.22	[illegible]
5	1800	618.83	1.6	4.0	4.0	127	94	5.8	[illegible]	50	[illegible]	[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	ΔP Stack Press in. Hg	Stack Temp °F
6	1805	[illegible]	1.55	3.[illegible]	[illegible]	124	[illegible]	[illegible]	[illegible]	[illegible]	1.18	302
7	[illegible]	[illegible]3.14	1.6	4.0	4.0	126	[illegible]	5.5	[illegible]	50	1.27	305
8	[illegible]	[illegible]	1.5	3.6	3.6	126	96	[illegible]	[illegible]	50	1.22	4[illegible]
9	[illegible]	[illegible]	1.3	3.3	3.3	122	[illegible]	4.1	20[illegible]	[illegible]	1.14	410
10	[illegible]	[illegible]29	.70	1.8	1.8	118	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]007										
1	1832	[illegible]	.32	.83	.83	108	92	2.1	[illegible]	50	.555	[illegible]
2	1837	650.47	.82	2.2	2.2	108	[illegible]	[illegible]	252	50	.137	355
3	[illegible]	658.[illegible]	1.0	[illegible]	[illegible]	110	90	11.5	262	50	1.62	35[illegible]
4	1847	[illegible].61	1.15	3.18	3.18	114	92	5.0	245	50	1.12	310
5	1852	[illegible]	1.6	3.5	3.5	119	90	5.2	256	50	1.12	3[illegible]
6	[illegible]	[illegible]29	1.2	3.0	3.0	121	91	4.8	[illegible]	50	1.01	3[illegible]
7	1902	[illegible]	1.25	3.2	3.2	121	92	4.7	270	50	1.12	325
8	1907	672.65	1.2	3.0	3.0	121	92	[illegible]	[illegible]	[illegible]	1.07	[illegible]
9	1912	[illegible]	.82	2.1	2.1	117	92	3.7	250	50	[illegible]	322
10	1917	[illegible]5.05	.70	1.78	1.78	116	92	3.5	255	50	[illegible]	3[illegible]
[illegible]	[illegible]	[illegible]										
1	[illegible]	689.[illegible]	.66	1.8	1.8	92	85	3.2	255	50	.913	357
2	[illegible]	693.26	.86	2.1	2.1	102	86	3.5	260	50	.915	360
3	[illegible]	[illegible]	.62	1.64	1.64	[illegible]	85	3.0	265	50	.850	362
4	[illegible]	700.51	.65	1.66	1.66	110	86	3.1	252	50	.508	3[illegible]
5	1955	70[illegible]	.98	2.45	2.45	112	86	4.0	[illegible]	50	.970	3[illegible]
6	2000	705.07	1.05	2.65	2.65	115	86	4.0	256	50	1.02	3[illegible]
7	2005	712.39	1.02	2.6	2.6	118	88	4.2	[illegible]	50	1.01	325
8	2010	716.39	.65	1.67	1.67	115	88	[illegible].1	268	50	.808	351
9	2015	720.11	.63	1.7	1.7	115	88	2.5	290	50	.727	344
10	2020	723.21	.47	1.2	1.2	108	88	2.5	[illegible]	50	.655	348
[illegible]	[illegible]	724.245										
1			[illegible]									
2	[illegible]	726.245	.17	.45	.45	93	86	1.2	260	50	.462	[illegible]
3	[illegible]	728.07	.47	1.2	1.2	98	86	2.5	[illegible]	[illegible]	.655	[illegible]
4	2038	730.97	.46	1.19	1.19	100	84	2.5	255	50	.627	[illegible]
5	2043	733.76	.49	1.27	1.27	100	84	2.6	255	50	.700	375
6	2048	[illegible]	.47	1.32	1.32	102	82	2.5	275	50	.672	3[illegible]
7	2053	7[illegible].97	.50	1.28	1.28	102	83	2.5	2[illegible]	50	[illegible]	3[illegible]
8	[illegible]	7[illegible].98	.43	1.1	1.1	102	84	[illegible]	260	50	[illegible]	3[illegible]
9	2103	74[illegible]	.27	.70	.70	102	84	2.0	270	50	[illegible]	[illegible]
10	2108	745.20	.1	.27	.27	98	84	1.5	210	50	[illegible]	3[illegible]
[illegible]	2113	74[illegible]			[illegible] 2.00	[illegible]	[illegible]				.851	3[illegible]

TEST 3

WEIGHT OF PARTICULATE COLLECTED mg.

Filter Paper: Reeve Angel 900AF, 11cm Glass Fiber

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1 Filter	.6512 grams	.5977 grams	.0535 grams
2 Washings	63.3098 grams	63.0986 grams	.2112 grams
TOTAL	63.9610	63.6963 grams	.2647 grams

VOLUME OF LIQUID WATER COLLECTED, ml

IMPINGER	1	2	3	4.
FINAL VOL.	266 ml	172 ml	13 ml	342.7
INITIAL VOL	100 ml	100 ml	0 ml	300.0 g
LIQUID COLLECTED	166 ml	72 ml.	13 ml.	42.7 g 293.7 ml

OIL FLOW CALCULATIONS

TEST # 1 #25: 1336 gal/hr
#27: 1337.5 gal/hr
2673.5 gal/hr x 143,156 BTU/gal
= 382.7 x 10^6 BTU/hr

TEST 2 #25 1353.25 gal/hr
#27 1462.25 gal/hr
2815.5 X 144,342 BTU/gal
= 406.4 X 10^6 BTU/hr

TEST 3 #25 1296 gal/hr
#27 1390 gal/hr
2686 X 144793 BTU/gal
= 388.9 X 10^6 BTU/hr

Stack Identification Number BLR 25, 27 STACK 7 Date 12-5-72

Boiler Number

Plant Location STEEL POINT 3:00 TO 8:00

Parameters	#25 10:00	#27 10:	#25 11:00	#27	25 12:00	27	25 1:15	27
Gross Load (MW)	7.1		7.5		7.5		7.4	
Net Load (MW)	10:12	10:10			12:12	12:10	1:12	1:10
Fuel Flow (gal/hr)	7554596	9806320			7557265	9809180	7558630	9810[illegible]
Steam Flow (lb/hr)	128,000	139,000	129,000	139,00[illegible]	129,000	138,000	129,000	138,0[illegible]
Feed Water Flow (lb/hr)								
Air Flow	168,000	151,000	170,000	151,000	170000	151000	170,000	151,0[illegible]
Excess Air (%)	43	38.5	43	38.5	43.25	38.5	43.0	43.[illegible]
Excess O2 (%)	8.6%	7.7%	8.6	7.7	8.65	7.7	8.60	7.8[illegible]
Soot Blowing								
Boiler Inlet Feed Water ~~Temp (°F)~~ PRESS. 16	975	975	975	950	975	980	975	970
Boiler Exit Steam Press. (psig)	640		640		638		632	
Boiler Exit Steam Temp (°F)								
Reheat Inlet Steam Press. ~~(psig)~~								
Reheat Inlet Steam Temp (°F)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp. (°F)								
Condenser Pressure (in Hg)								

Parameters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cooling Water Temp (^{o}F)								
Boiler Air Inlet Temp (^{o}F)								
Boiler Flue Gas Exit Temp (^{o}F)								
F.D. Fan Pressure-~~Rise~~ (in H20)	9.0	6.3	9.0	6.8	9.0	6.8	9.0	6.8
F.D. Fan Current (amps)								
F.D. Fan Voltage (V)								
ID Fan Pressure Rise (in H20)								
ID Fan Current (amps)								
ID Fan Voltage (V)								
Forced Draft Inlet Air Temp (^{o}F)								
Ambient Air Relative Humidity								
Barometric Pressire (in Hg)	30.22	—	30.12				30.19	
Ambient Air Temp (^{o}F)								
Boiler Heat Rate (BTU/KW-hr)								
Burner Tilt								
Inlet Temp (^{o}F)								
Outlet Temp (^{o}F)								
Inlet Pressure (in H20)								
Rapping Cycle Period (min)								
Spark Rate (sparks/min)								
Operating Voltage (KV)								
Operating Amps								
[illegible]	5%	5%	5%	2%	5%	2.5%	5%	2.9%

Stack Identification Number BL&P [illegible] Stack 7 Date 12-5-72

Boiler Number

Plant Location [illegible] PT.

Parameters	200		300		400		500	
	25	27	25	27	25	27	25	27
Gross Load (MW)	7.2		7.1		7.1		7.1	
Net Load (MW)	2:12	2:10	3:12	3:10	4:12	4:10	5:12	5:10
Fuel Flow (gal/hr)	7559954	9811773	7561337	9813351	7567681	9814711	7564017	9816055
Steam Flow (lb/hr)	128,000	137000	128,000	135,000	129000	135,000	129,000	134,000
~~Feed Water Flow (lb/hr)~~								
Air Flow	170,000	151,000	170,000	151,000	170,000	151000	170,000	151,000
Excess Air (%)	43.5	40.0	43.5	40.5	44.0	41.0	44.5	41.5
Excess O2 (%)	8.7	8.0	8.7	8.1	8.8	8.2	8.9	8.3
Soot Blowing								
Boiler Inlet Feed Water ~~Temp (°F)~~ Press, lb	975	975	950	975	990	1000	1000	1000
Boiler Exit Steam Press. (psig)	622		620		620		610	
Boiler Exit Steam Temp (°F)								
Reheat Inlet Steam Press. (psig)								
Reheat Inlet Steam Temp (°F)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp (°F)								
Condenser Pressure (in Hg)								

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~Cooling-Water-Temp (°F)~~								
Boiler Air Inlet Temp (°F)								
Boiler Flue Gas Exit Temp (°F)								
F.D. Fan Pressure Rise (in H2O)	9.0	6.8	9.0	6.8	9.0	6.8	9.1	68
F.D. Fan Current (amps)								
F.D. Fan Voltage (V)								
ID Fan Pressure Rise (in H2O)								
ID Fan Current (amps)								
ID Fan Voltage (V)								
Forced Draft Inlet Air Temp (°F)			-					
Ambient Air Relative Humidity								
Barometric Pressure (in Hg)	30.19		30.19		30.20		30.2	
Ambient Air Temp (°F)	-							
Boiler Heat Rate (BTU/KW-hr)								
Burner Tilt								
Inlet Temp (°F)								
Outlet Temp (°F)								
Inlet Pressure (in H2O)	|							
Rapping Cycle Period (min)	|							
Spark Rate (sparks/min)								
Operating Voltage (KV)								
Operating Amps								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

tack Identification Number BLRS 25 & 27 STACK #7 Date 12-5-72

oiler Number

lant Location STEEL PT.

Parameters	#25	#27	25	27	25	27	
	600		700		800		
Gross Load (MW)	70		69				
~~Net Load (MW)~~	6:42	6:40	7:22	7:10	8:32	8:33	
Fuel Flow (gal/hr)	7565353	9817390	7566681	9818701	[illegible]	9820489	
Steam Flow (lb/hr)	130,000	132,000	129,000	132,000	127,000	127,000	
~~Feed Water Flow (lb/hr)~~							
Air Flow	170,000	151,000	[illegible]	151,000	170,000	151,000	
Excess Air (%)	44.0	40.5	45.0	45.5	45.5	44.0	
Excess O2 (%)	8.8	8.5	9.0	8.7	9.1	8.8	
~~Soot Blowing~~							
Boiler Inlet Feed Water Temp (°F) [illegible] PSI	1,000	1,000	1,000	1,025	1000	1020	
Boiler Exit Steam Press. (psig)	610		600		600		
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Cooling ~~Water Temp (°F)~~							
Boiler Air Inlet Temp (°F)							
Boiler Flue Gas Exit Temp (°F)							
F.D. Fan Pressure Rise (in H2O)	9.1	6.8	9.0	6.8	9.0	6.8	
F.D. Fan Current (amps)							
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H2O)							
ID Fan Current (amps)							
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)	30.24		30.26				
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H2O)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Stack Identification Number #7   Date 12-6-72

Boiler Number 25 & 27

Plant Location Steel Pt

Parameters	11^00 25	27	12^00 25	27	1^00 25	27	2^00 25	27
Gross Load (MW)	7.6		7.3		7.8	-	7.8	
Net Load (MW)	11^12	11^10	12^12	12^10	1^12	1^10	2^12	2^10
Fuel Flow (gal/hr)	7578134	8307.49	7579477	8321.78	7580860	783365	[illegible]	7835110
Steam Flow (lb/hr)	125,000	141000	125,000	138,000	128,000	[illegible]	128,000	141,000
~~Feed Water Flow (lb/hr)~~								
Air Flow	168,000	149,000	168,000	149,000	164,000	149,000	167,000	149,000
Excess Air (%)	42.0	38.0	41.5	38.75	46.75	35.5	40.0	37.0
Excess O2 (%)	8.4	7.6	8.3	7.75	8.15	7.1	8.0	7.4
~~Soot Blowing~~								
~~Boiler Inlet Feed Water Temp (°F)~~ pressures psi	975	1000	950	980	950	960	975	1000
Boiler Exit Steam Press. (psig)	648		630		650		648	
Boiler Exit Steam Temp (°F)								
Reheat Inlet Steam Press. (psig)								
Reheat Inlet Steam Temp (°F)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp (°F)								
Condenser Pressure (in Hg)								

Parameters	25	27	25	27	25	27	25	[illegible]
~~Cooling Water Temp (°F)~~								
Boiler Air Inlet Temp (°F)								
Boiler Flue Gas Exit Temp (°F)								
F.D. Fan Pressure Rise (in H2O)	8.9	6.8	8.8	6.8	8.8	6.8		6.8
F.D. Fan Current (amps)								
F.D. Fan Voltage (V)								
ID Fan Pressure Rise (in H2O)								
ID Fan Current (amps)								
ID Fan Voltage (V)								
Forced Draft Inlet Air Temp (°F)								
Ambient Air Relative Humidity								
Barometric Pressure (in Hg)	30.0[illegible]	—	29.96		29.96	—	29.90	—
Ambient Air Temp (°F)								
Boiler Heat Rate (BTU/KW-hr)								
Burner Tilt								
Inlet Temp (°F)								
Outlet Temp (°F)								
Inlet Pressure (in H2O)								
Rapping Cycle Period (min)								
Spark Rate (sparks/min)								
Operating Voltage (KV)								
Operating Amps		[illegible]				[illegible]	[illegible]	[illegible]

Stack Identification Number #7 Date 12-6-72

Boiler Number 25 & 27

Plant Location 37th St.

Parameters	25	27	25	27	25	27	
	3:00		4:00		5:00		
Gross Load (MW)	7.7		7.7		7.7		
Net Load (MW)	3:12	3:10	4:12	4:10	5:12	5:10	
Fuel Flow (gal/hr)	7583471	9836560	7584926	9837911	7586281	9839137	
Steam Flow (lb/hr)	125,000	141,000	128,000	141,000	129,000	141,000	
~~Feed Water Flow (lb/hr)~~							
Air Flow	157,000	148000	167,000	148,000	167,000	148,000	
Excess Air (%)	44.0	36.75	39.5	36.0	40.0	36.0	
Excess O2 (%)	8.0	7.35	7.9	7.2	8.0	7.2	
Soot Blowing —							
Boiler Inlet Feed Water Temp (°F) [illegible] PSI	975	1000	975	990	975	1000	
Boiler Exit Steam Press. (psig)		648		645		645	
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
~~Cooling Water Temp (°F)~~							
Boiler Air Inlet Temp (°F)							
Boiler Flue Gas Exit Temp (°F)							
I.D. Fan Pressure Rise (in H2O)	8.8	6.8	8.8	6.8	8.7	6.8	
I.D. Fan Current (amps)							
I.D. Fan Voltage (V)							
FD Fan Pressure Rise (in H2O)							
FD Fan Current (amps)							
FD Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressure (in Hg)	29.88	—	29.86	—	29.83	—	
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H2O)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
[illegible]	5?%	5?%	57%	47%	57%	47%	

Stack Identification Number #7 Date 12-7-72

Boiler Number 25 & 27

Plant Location Steel Pit

11^00 12^00 1^00 2^00

Parameters	25	27	25	27	25	27	25	27
Gross Load (MW)	5.7		7.8		7.8	—	5.8	
Net Load (MW)	11^12	11^10	12^12	12^10	1^12	1^10	2^12	2^10
Fuel Flow (gal/hr)	1598466	9552513	[illegible]	1853960	[illegible]	9855396	7602537	9856906
Steam Flow (lb/hr)	128,000	[illegible]	118,000	111,000	127,000	144,000	126,000	142,000
~~Feed Water Flow (lb/hr)~~								
Air Flow	168,000	152,000	148,000	152,000	148,000	152,000	162,000	152,000
Excess Air (%)	43.0	39.0	40.75	39.0	43.5	39.5	44.0	39.0
Excess O2 (%)	8.6	7.8	8.55	7.8	8.7	7.7	8.8	7.8
~~Soot Blowing~~								
Boiler Inlet Feed Water Temp (°F)	975	1025	975	1025	975	1000	990	1025
Boiler Exit Steam Press. (psig)	650		644		650		640	
Boiler Exit Steam Temp (°F)								
Reheat Inlet Steam Press. (psig)								
Reheat Inlet Steam Temp (°F)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp (°F)								
Condenser Pressure (in Hg)								

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~oling Water Temp (°F)~~								
iler Air Inlet mp (°F)								
iler Flue Gas Exit mp (°F)							/	
D. Fan Pressure Rise n H2O)	92	6.8	9.2	6.8	9.2	6.8	9.2	6.8
D. Fan Current (amps)							/	
D. Fan Voltage (V)							/	
Fan Pressure Rise (in H2O)								
Fan Current (amps)								
Fan Voltage (V)								
rced Draft Inlet r Temp (°F)			—					
bient Air Relative midity								
rometric Pressire (in Hg)	30.55	—	30.54	—			30.56	—
bient Air Temp (°F)								
iler Heat Rate TU/KW-hr)								
rner Tilt								
let Temp (°F)								
tlet Temp (°F)								
let Pressure (in H2O)								
pping Cycle Period (min)								
ark Rate (sparks/min)								
erating Voltage (KV)								
erating Amps								
[illegible]	5%	2%	5%	2%	[illegible]	[illegible]	5%	[illegible]

tack Identification Number #7

Date 12/7/72

oiler Number 25 & 27

lant Location STEEL PT

Parameters	25	27	25	27	25	27	25	27
	3^{00}		4^{00}		5^{00}		6^{00}	
Gross Load (MW)	7.5		7.4		7.4		7.3	
Net Load (MW)	3^{00}	3^{00}	4^{00}	4^{10}	5^{00}	5^{00}	6^{12}	6^{20}
Fuel Flow (gal/hr)	7603877	9858362	7605215	9859816	7606545	9861276	7607734	9862612
Steam Flow (lb/hr)	126,000	142,000	126,000	142,000	126,000	141,000	126,000	140,000
~~Feed Water Flow (lb/hr)~~								
Air Flow	168,000	153,000	168,000	153,000	168,000	153,000	168,000	152,000
Excess Air (%)	44.0	39.0	44.5	39.0	45.0	39.5	45.0	40.0
Excess O2 (%)	8.8	7.8	8.9	7.8	9.0	7.9	9.0	8.0
~~Soot Blowing~~								
Boiler Inlet Feed Water ~~Temp (°F)~~ Pressure	980	1025	980	1025	980	1025	985	
Boiler Exit Steam Press. (psig)	640		636		632		630	
Boiler Exit Steam Temp (°F)								
Reheat Inlet Steam Press. (psig)								
Reheat Inlet Steam Temp (°F)								
Reheat Exit Steam Press. (psig)								
Reheat Exit Steam Temp (°F)								
Condenser Pressure (in Hg)								

~~ooling Water Temp (°F)~~								
oiler Air Inlet emp (°F)								
oiler Flue Gas Exit emp (°F)								
.D. Fan Pressure Rise in H2O)	9.2	6.8	9.2	6.8	9.2	6.8	9.2	6.9
.D. Fan Current (amps)								
.D. Fan Voltage (V)								
D Fan Pressure Rise (in H2O)								
D Fan Current (amps)								
D Fan Voltage (V)								
orced Draft Inlet ir Temp (°F)								
mbient Air Relative umidity								
arometric Pressire (in Hg)			30.58	—	30.62	—		
mbient Air Temp (°F)								
oiler Heat Rate BTU/KW-hr)								
urner Tilt								
nlet Temp (°F)								
utlet Temp (°F)								
nlet Pressure (in H2O)								
apping Cycle Period (min)								
park Rate (sparks/min)								
perating Voltage (KV)								
perating Amps								
acity	5%	2%	5	2	5	2	6	2

ack Identification Number #7 Date 12-7-72

iler Number 25 & 27

ant Location STEEL #1

7:00 8:00 9:45 9:47 9:48

Parameters	25	27	25	27	25	27	
Gross Load (MW)	7.3		7.2		7.0		
Net Load (MW)	7:12	7:10	8:16	8:15	9:47	9:48	
Fuel Flow (gal/hr)	7609222	9868162	7610510	9865560	7612485	9867716	
Steam Flow (lb/hr)	126,000	140,000	124,000	140,000	124,000	139,000	
~~Feed Water Flow (lb/hr)~~							
Air Flow	168,000	153,000	169,000	153,000	170,000	153,000	
Excess Air (%)	45.0	40.0	45.5	41.0	46.5	41.5	
Excess O2 (%)	9.0	8.0	9.1	8.2	9.3	8.3	
~~Soot Blowing~~							
Boiler Inlet Feed Water Temp (°F) 215 °F	975	1025	1000	1020	1000	1030	
Boiler Exit Steam Press. (psig)	620		625		620		
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

~~oling Water Temp (°F)~~							
oiler Air Inlet mp (°F)							
oiler Flue Gas Exit mp (°F)							
D. Fan Pressure Rise n H2O)		6.8	9.2	6.9	9.2	6.9	
D. Fan Current (amps)							
D. Fan Voltage (V)							
Fan Pressure Rise (in H2O)							
Fan Current (amps)							
Fan Voltage (V)							
orced Draft Inlet r Temp (°F)							
mbient Air Relative midity							
rometric Pressire (in Hg)			30.70				
mbient Air Temp (°F)							
oiler Heat Rate TU/KW-hr)							
urner Tilt							
nlet Temp (°F)							
utlet Temp (°F)							
nlet Pressure (in H2O)							
apping Cycle Period (min)							
park Rate (sparks/min)							
perating Voltage (KV)							
perating Amps	5	2	6	2	6	2	

The United Illuminating Company
Steel Point Station
Boiler No. 26
ITr No. 720047
April 9, 1973

PRELIMINARY.

APPENDIX B

THE UNITED ILLUMINATING COMPANY
MOISTURE DETERMINATION
SILICA GEL METHOD

Stack Identification Number 7

Boiler Number 26

Plant Steel Point Station

Location Stack Entry Duct

Date 12-18-72

Operator JTM

Amb. Temp. (°F) 45

Bar. Press. "Hg Test 1 30.18 → 30.1[illegible]
Test 2 30.16 → 30.1[illegible]

	Analysis 1	Analysis 2	Analysis 3
Time Start	3:44	4:20	
Tube	A	B	
Final Wt. Tube, grams	315.0	315.5	
Initial Wt. Tube, grams	308.1	309.1	
Wt. Collected Moisture, (Ma), grams	6.9	6.4	
D GM Final, $Ft.^3$	125.7	128.7	
D GM Initial, $Ft.^3$	122.7	125.7	
Volume of Gas (Vm), $Ft.^3$	3.0	3.0	
Avg. Meter Temp. °R	508.5	509	
Vol. of H2O Absorbed (Vwt)	.310	.288	Ave.
Water Vapor (%) of Gas (Bws)	9.3%	8.7%	9.0%

TEST 1 RUN A

MOISTURE DETERMINATION

$$V_{wt} = \frac{\left[(6.9\ gr)\frac{1\ lb}{454\ gr}\right]\left[\frac{21.83\ in\ Hg - ft^3}{lb\ mol - °R}\right](508.5\ °R)}{(30.17\ in\ Hg)\left[\frac{18\ lb}{lb\text{-}mol}\right]} = .310$$

$$B_{ws} = \frac{V_{wt}}{V_{wt} + V_m} = .093 = 9.3\%$$

TIME	INLET TEMP	OUTLET TEMP
3:44	48	50
3:54	47	50
4:12	47	50
4:18	47	50
	47	50 = 48.5 + 460 = 508.5 R

RUN #2

4:20	47	50	
4:28	47	49	.07
4:36	48	49	43/3.00
4:45	48	50	3.01
4:50	48	50	
end 5:02	48	50	
	48	50	= 49 + 460 = 509°R

Test 1. Run 5.

MOISTURE DETERMINATION

$$Vwt = \frac{\left[(6.4\ gr) \frac{1\ lb}{454\ gr} \right] \left[\frac{21.83\ in\ Hg - ft^3}{lb\ mol - °R} \right] (509\ °R)}{(30.15\ in\ Hg) \left[\frac{18\ lb}{lb\text{-}mol} \right]} = .288$$

$$Bws = \frac{Vwt}{Vwt + Vm} = .087 = 8.7\%$$

E INLET TEMP OUTLET TEMP

See other sheet

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 7 Date 12-19-72

Boiler Number 26 Time 12:30

Plant Location Steel Point

Sampling Point Location Stack Entry Duct

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	9.8	9.8	10.2	10.2	10.0	44/100	4.40
CO, % Vol (dry)	17.0	16.8	17.2	17.6	0	28/100	+ 0
O_2, % Vol (dry)	17.0	16.8	17.2	17.6	7.15	32/100	+ 2.28
N_2, % Vol (dry)	83.0	83.2	82.8	82.4	82.85	28/100	+ 23.19
Actual O_2	7.20	7.00	7.00	7.40			

Avg. molecular wt. of dry stack gas = 29.87

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

TEST 2

Stack Identification Number ______ Date 12-20-77

Boiler Number 26 Time 10:10 AM - 10:45 AM

Plant Location Steel Point

Sampling Point Location Stack Entry Duct

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	11.2	10.4	9.6	10.0	10.30	44/100	4.53
CO, % Vol (dry)	18.4	18.0	18.2	18.0	.12	28/100	+ .03
O_2, % Vol (dry)	18.1	17.8	18.2	18.0	7.72	32/100	+ 2.47
N_2, % Vol (dry)	81.6	82	81.8	82	81.85	28/100	+ 22.91
O_2	6.90	7.40	8.60	8.0			

Avg. molecular wt. of dry stack gas = 29.94

TEST 3

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number__________ Date Dec 21, 1972

Boiler Number ~~2~~ 26 Time 3:15 PM

Plant Location Steel Point

Sampling Point Location Stack Entry Duct

Cummulative readings

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	10.6	10.7	9.6	10.9	10.45	44/100	4.598
CO, % Vol (dry)	18.2	18.2	17.0	18.0	0.025	28/100	+ 0.007
O2, % Vol (dry) O2	18.2	18.3	17.0	18.1	7.4	32/100	+ 2.368
N2, % Vol (dry)	81.8	81.8	83.0	81.9	82.125	28/100	+ 22.995
	7.6	7.5	7.4	7.1			

Avg. molecular wt. of dry stack gas = 29.968

TEST 1

IR #26 NOx RUN #1

12-19-72

instrument calibrated at field conditions with standard NO gas of 420 ppm = 84%

0-500 ppm = 0-100% scale.

= 4.9 turns sample out temp 76°

= 4.15 turns

	Time	% scale	ppm NOx	sample temp
UP	10:26	21.75%	109	78
	10:27	22%	110	78
	10:28	23%	115	79
	10:29	23%	115	80
	10:30	23%	115	80
	10:31	23.8%	119	82
	10:32	23.9%	119.5	82
	10:33	24%	120	83
	10:34	24%	120	84
	10:35	24%	120	84
	10:36	24%	120	85
	10:37	24%	120	86
	10:38	24%	120	87
	10:39	23.9%	119.5	87
	10:40	23.9%	119.5	87

AVG = 118.653

#26 NOx Test #2

12-20-72

J. Sorbati

Science Calib — 0-100% scale = 0-500 ppm NOx

Std Calib gas = 420 ppm = 84% full scale.

Zero = 1.85 Span = 4.16

TIME	% scale	ppm NOx	sample Temp
1149	20	100	76
1150	20.5	103.5	75
1151	21	105	75
1152	20.75	103.8	75
1153	21	105	75
1154	21.5	107.5	75
1155	21	105	75
1156	21.5	107.5	76
1157	22	110	76
1158	21.8	109	76
1159	21.8	109	77
1200	21.8	109	77
1201	21.9	109.5	78
1202	21.8	109	78
1203	21.8	109	78
1204	21.8	109	79
1205	21.9	109.5	79

AVG = 107.73

PLR#26

12-21-72

NOX Test

DynaScience NOx Analyzer
0-100% scale = 0-500 ppm NOx

Calibrated Unit @ Field Conditions
420 ppm NO = 84% scale

10 = 4.95
11 = 4.20

	% Scale	PPM	Sample
1351	21%	105	70
1352	21.5	107.5	70
1353	22 %	110	70
1354	22.8	114	70
1355	23.2	116	70
1356	23.5	117.5	70
1357	23.7	118.5	70
1358	23.8	119	70
1359	23.8	119	70
1400	23.7	118.5	70
1401	23.0	115	71
1402	23.0	115	71
1403	23.0	115	71
1404	23.0	115	72
1405	23.0	115	72
1406	23.0	115	72
1407	23.0	115	72
1408	23.0	115	72
1409	22.8	114	72
1410	22.8	114	72

AVG = 114.65

Stack Identification Number 7

Boiler Number 26

Plant STEEL POINT STATION

Run No. Preliminary Velocity Traverse

Location Stack Entry Port

Date 12-18-72

Operator JSS

Meter Δ H —

C Factor —

Ambient Temp °F

Bar. Press. "Hg —

Assumed Moisture % —

Heater Box Setting, °F —

Probe Tip Dia., In. —

Probe Length 10'

Probe Heater Setting —

Avg. Δ P

Avg. Δ H

Stack Pressure

% Isokinetic

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P (Port 1)	Orifice Δ H in H_2O Desired (Port 2)	Orifice Δ H in H_2O Actual (Port 3)	Dry Gas Temp. °F Inlet (Port 4)	Dry Gas Temp. °F Outlet (Port 5)	Pump Vacuum In. Hg Gauge (Port 6)	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
1			1.1	1.10	1.25	1.15	.85	.76				
2			.78	.92	1.05	.85	.78	[illegible]				
3			.83	.90	1.05	.93	[illegible]	.58				
4			.40	1.1	1.10	1.05	.84	.12				
5			.55	1.1	1.10	1.08	.90	.05				
6			.15	1.1	1.10	1.15	.65	NEG				
7			.03	.92	.59	.54	.10	NEG				
8			.18	.15	.28	.58	.05	[illegible]				

Stack Identification Number

Boiler Number 26

Plant Steel Point Station

Run No. 1

Location Stack Entry Duct

Date 12-19-72

Operator [illegible]

Meter ΔH 1.89

C Factor .90

Ambient Temp °F 64

Bar. Press. "Hg 29.94, 29.92, 29.92

Assumed Moisture % 9

Heater Box Setting, °F 275

Probe Tip Dia., In. .25

Probe Length 10'

Probe Heater Setting [illegible]

Avg. ΔP .864 Avg. ΔH 2.066

Stack Pressure $-1.3"H_2O$

% Isokinetic 99.84

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
6-1	1025	7[illegible].10	.80	2.1	2.1	72	74	3.6	255	[illegible]	.897	[illegible]
6-2	1030	7[illegible].63	.78	2.03	2.03	8[illegible]	74	3.[illegible]	[illegible]	[illegible]	.887	[illegible]
6-3	[illegible]	75[illegible]	.70	1.[illegible]	1.82	[illegible]	75	[illegible]	[illegible]	[illegible]	.8[illegible]2	[illegible]
[illegible]	[illegible]	760.57	.5[illegible]	1.32	1.32	100	76	3.[illegible]	260	[illegible]	[illegible]	[illegible]
[illegible]	1045	7[illegible]1.03	.21	.78	.78	102	78	3.1	2[illegible]	58	[illegible]	3[illegible]
[illegible]	1050	764.[illegible]	.17	.46	.46	97	79	2.8	[illegible]	[illegible]	.413	[illegible]
[illegible]	[illegible]	766.32	NL[illegible]									
[illegible]			[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	2.3	2.3	[illegible]	[illegible]	4.0	[illegible]	[illegible]	.9[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.79	2.6	[illegible]	10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	776.[illegible]	[illegible]	2.5	[illegible]	[illegible]	[illegible]	11.1	265	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]10	[illegible]	[illegible]	[illegible].1	[illegible].1	110	87	11.0	[illegible]	[illegible]	.9[illegible]	[illegible]
[illegible]	1515	[illegible].12	.85	2.[illegible]	2.[illegible]	110	[illegible]	4.0	[illegible]	58	[illegible]	[illegible]
[illegible]	15[illegible]	[illegible]	[illegible]	1.11	1.11	11[illegible]	[illegible]	11.0	[illegible]	[illegible]	.7[illegible]	[illegible]
[illegible]	15[illegible]	7[illegible]	[illegible]									
[illegible]	1537		[illegible]									

PORT

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δp	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Sta[illegible]
[illegible]	[illegible]	[illegible]	1.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.02	[illegible]
[illegible]	[illegible]	[illegible]	1.00	[illegible]	[illegible]	106	[illegible]	[illegible]	[illegible]	[illegible]	1.00	3
[illegible]	1509	[illegible]	1.05	[illegible]	[illegible]	107	[illegible]	[illegible]	[illegible]	[illegible]	1.02	[illegible]
[illegible]	[illegible]	860.45	1.13	2.9	[illegible]	109	86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.15	[illegible]	[illegible]	110	87	5.0	[illegible]	58	1.07	3
[illegible]	[illegible]	[illegible]	1.15	2.83	2.83	111	87	[illegible]	[illegible]	52	1.07	3
[illegible]	1529	[illegible]	1.03	2.64	2.64	112	88	[illegible]	[illegible]	50	1.01	3
[illegible]	[illegible]	[illegible]	.95	[illegible]	[illegible]	110	88	3.0	235	45	.97	3
[illegible]	1614	[illegible]	—			107	87					
3-1	[illegible]	[illegible]	1.25	3.15	3.15	98	86	4.9	250	50	1.12	[illegible]
3-2	[illegible]	[illegible]	1.15	2.9	[illegible]	104	86	5.0	250	50	1.07	[illegible]
[illegible]	[illegible]	884.96	1.15	2.9	[illegible]	106	86	5.0	[illegible]	45	1.07	[illegible]
[illegible]	[illegible]	[illegible]	1.15	2.9	2.9	107	86	5.2	270	50	1.07	[illegible]
[illegible]	[illegible]	[illegible]	1.15	2.9	[illegible]	103	86	5.2	272	[illegible]	1.07	[illegible]
[illegible]	[illegible]	897.72	1.20	3.0	3.0	[illegible]	86	5.4	[illegible]	50	1.1	[illegible]
[illegible]	[illegible]	[illegible]	.94	2.37	2.37	[illegible]	87	[illegible]	282	50	.97	3
[illegible]	[illegible]	[illegible]	.99	2.50	[illegible]	105	86	7.0	[illegible]	50	[illegible]	[illegible]
[illegible]	1700	[illegible]	—	—	—	105	87					
2-1	[illegible]	[illegible]	1.12	[illegible]	[illegible]	98	87	5.5	[illegible]	[illegible]	[illegible]	[illegible]
2-2	1710	[illegible]	1.03	2.62	2.62	[illegible]	86	5.1	245	50	1.01	3
[illegible]	1715	[illegible]	.97	2.44	2.44	106	86	5.0	250	50	.99	[illegible]
[illegible]	1720	[illegible]	1.1	2.8	2.8	107	86	5.1	268	50	1.05	3
[illegible]	[illegible]	[illegible]	1.15	2.9	2.9	106	86	5.0	270	50	1.07	[illegible]
[illegible]	[illegible]	[illegible]	1.07	2.67	2.67	110	87	5.1	275	50	[illegible]	3
[illegible]	[illegible]	[illegible]	.44	1.11	1.11	101	88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.32	.81	.81	[illegible]	86	3.2	[illegible]	50	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	—	—	—	102	86	—	—	—	—	
1-1	[illegible]	[illegible]	1.25	3.15	3.15	[illegible]	[illegible]	6.0	290	50	1.12	[illegible]
1-2	[illegible]	[illegible]	.91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.95	[illegible]
1-3	[illegible]	[illegible]	.46	1.15	[illegible]	106	85	[illegible]	[illegible]	50	.68	[illegible]
1-4	[illegible]	[illegible]	[illegible]	1.5	1.5	103	86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.55	1.41	[illegible]	102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.15	.41	.41	103	86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	245	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]				[illegible]	[illegible]					

TEST 1 BH 26

12-19-72

WEIGHT OF PARTICULATE COLLECTED

mg

FILTER USED: REEVE ANGEL 900AF 11 cm

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
Filter	.7610 g	.6007 g	160.3 mg
Washings	100.9 mg		100.9 mg
TOTAL			261.2 mg

VOLUME OF LIQUID WATER COLLECTED, ml

IMPINGER	1	2	3	4
FINAL VOL.	334	196	13	346.4
INITIAL VOL	100	100	0	300 g
LIQUID COLLECTED	234	96	13	46.4 g 46.4 ml
Total	389.4 ml			

Stack Identification Number

Boiler Number 26

Plant Steel Point

Run No. ! 2

Location Stack Entry Duct

Date 12-26-72

Operator Smith

Meter Δ H 1.89

C Factor .89, .80

Ambient Temp °F [illegible]

Bar. Press. "Hg 29.94 - 30.02

Assumed Moisture % 8.8

Heater Box Setting, °F 250

Probe Tip Dia., In. .25

Probe Length 10'

Probe Heater Setting 250

Avg $\sqrt{\Delta P}$ .834 Avg. Δ H 1.81

Stack Pressure −1.2" H_2O

% Isokinetic 99.74

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δ P	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
6-1	1427	911.515	.75	1.9	1.9	[illegible]	[illegible]	[illegible]	235	55	[illegible]	[illegible]
[illegible]	[illegible]	913.44	.7	1.75	1.75	[illegible]	[illegible]	[illegible]	[illegible]	50	[illegible]	[illegible]
[illegible]	1437	[illegible]	.61	1.45	1.45	7?	[illegible]	[illegible]	262	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.0	1.0	67	48	2.5	277	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.25	.6	[illegible]	67	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.12	.32	.32	[illegible]	[illegible]	22	270	55	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.16									
[illegible]			[illegible]									
[illegible]	[illegible]	[illegible]	.76	1.85	1.85	74	50	[illegible]	290	[illegible]	.873	[illegible]
[illegible]	[illegible]	[illegible]	.7	1.7	1.7	74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2.0	2.0	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60	5.0	280	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.12	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1457	[illegible]	.65	1.6	1.6	80	[illegible]	[illegible]	[illegible]	50	[illegible]	5

[illegible] [illegible] 956.[illegible]

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
4-1	[illegible]	[illegible].25	[illegible]	2.3	2.3	78	66	[illegible]	[illegible]	50	[illegible]	[illegible]
[illegible]	[illegible]	960.27	.82	2.0	[illegible]	[illegible]	67	5.0	[illegible]	[illegible]	.917	[illegible]
[illegible]	[illegible]	[illegible].42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.7	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	.92	2.85	2.88	[illegible]	[illegible]	[illegible]	272	[illegible]	1.0	32[illegible]
[illegible]	[illegible]	971.15	1.0	2.7	2.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.05	2.5	2.5	96	[illegible]	4.8	265	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	975.57	.92	2.3	2.3	[illegible]	[illegible]	5.2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71	4.0	260	50	[illegible]	325
[illegible]	[illegible]	983.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]										
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	72	6.8	[illegible]	[illegible]	[illegible]	308
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]	[illegible]	50	1.0[illegible]	[illegible]
[illegible]	[illegible]	990.[illegible]	1.0	2.4	2.4	[illegible]	72	7.0	[illegible]	50	1.0[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.05	2.55	2.55	[illegible]	72	7.5	[illegible]	50	[illegible]	[illegible]
[illegible]	[illegible]	[illegible].31	1.1	2.78	2.78	102	73	8.5	25[illegible]	50	1.05	328
[illegible]	[illegible]	998.97	1.1	2.78	2.78	102	74	9.2	25[illegible]	55	1.02	[illegible]
[illegible]	1737	1007.72	1.15	2.9	2.9	104	74	[illegible]	[illegible]	55	1.05	[illegible]
[illegible]	[illegible]	10[illegible].31	1.1	[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1011.57	.92	2.3	2.3	112	78	9.2	[illegible]	55	.945	[illegible]
[illegible]	[illegible]	1015.72	.14	.37	.37	1[illegible]	82	3.8	[illegible]	[illegible]	.374	[illegible]
[illegible]	1757	1017.232										
[illegible]	1802	1017.232	1.05	2.65	2.65	[illegible]	81	10.7	260	60	1.02	[illegible]
2-1	[illegible]	1019.837	1.03	2.65	2.65	[illegible]	82	9.1	[illegible]	55	[illegible]	[illegible]
2-2	1813	—	[illegible]	[illegible]	[illegible]	107	84	9.1	249	55	.9[illegible]	[illegible]
2-3	[illegible]	1023.75	.82	2.15	2.15	111	[illegible]	10.7	[illegible]	[illegible]	1.0	[illegible]
2-4	1828	10[illegible]	1.0	2.58	2.58	113	[illegible]	11.0	[illegible]	65	.98	[illegible]
2-5	[illegible]	[illegible]	.92	2.30	2.37	113	[illegible]	11.0	[illegible]	60	.959	[illegible]
2-6	[illegible]	1032.77	.86	2.1	2.1	110	88	10.5	258	60	.927	[illegible]
2-7	[illegible]	1041.69	.42	1.02	1.02	112	88	7.2	260	65	.648	[illegible]
[illegible]	[illegible]	1044.32	.24	.5	.5	[illegible]	[illegible]	5.6	[illegible]	[illegible]	.49	[illegible]
[illegible]	[illegible]	10[illegible].315										
[illegible]	[illegible]	[illegible]	[illegible]	2.5	2.5	109	[illegible]	12.0	[illegible]	[illegible]	1.0[illegible]	[illegible]
1-1	1852	1046.315	1.03	2.5	2.5	109	[illegible]	12.5	[illegible]	65	[illegible]	332
1-2	[illegible]	1050.[illegible]	[illegible]	2.0	2.0	111	85	12.5	[illegible]	[illegible]	.89	[illegible]
1-3	[illegible]	1054.38	.[illegible]	1.05	1.05	112	88	[illegible]	[illegible]	[illegible]	.65	[illegible]
1-4	[illegible]	[illegible]	[illegible]	1.12	1.12	108	88	[illegible]	[illegible]	[illegible]	.6[illegible]	[illegible]
[illegible]	[illegible]	10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.964	[illegible]
[illegible]	[illegible]	1061.11	[illegible]	.34	.34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.582	[illegible]
[illegible]	[illegible]	1063.[illegible]	[illegible]	.[illegible]	.2	10[illegible]	[illegible]	4.0	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]		[illegible]									
		1[illegible]										

Date 12-20-72

Test

WEIGHT OF PARTICULATE COLLECTED

mg

FILTER USED: REEVE ANGEL 900AF 11CM

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
Filter	1.9216 g	.6151 g	1306.5 mg
Washings	57.5 mg		57.5 mg
TOTAL			1364.0 mg

VOLUME OF LIQUID WATER COLLECTED, ml

IMPINGER	1	2	3	4
FINAL VOL	348	162.5	1	356.7
INITIAL VOL	100	100	0	300 g
LIQUID COLLECTED	248	67.5	1	56.7 g 56.7 ml
TOTAL				373.2 ml

248
67.5
1
56.7

373.2 ml

Stack Identification Number

Boiler Number 76

Plant

Run No.

Location

Date 12-20-72

Operator

Meter Δ H

C Factor

Ambient Temp °F

Bar. Press. "Hg 30.06

Assumed Moisture %

Heater Box Setting, °F

Probe Tip Dia., In.

Probe Length

Probe Heater Setting

Avg. Δ P

Avg. Δ H

Stack Pressure $-1.3"H_2O$

% Isokinetic

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
1-1			1.15								1.070	[illegible]
1-2			.91								.954	277
1-3			.49								.700	[illegible]
[illegible]			.51								.714	[illegible]
[illegible]			.68								[illegible]	[illegible]
[illegible]			.81								.875	[illegible]
[illegible]			.91								.900	[illegible]
1-7			.93								[illegible]	[illegible]
[illegible]			1.15								1.072	[illegible]
[illegible]			[illegible]								.975	[illegible]
[illegible]			1.10								[illegible]	[illegible]
[illegible]			[illegible]								[illegible]	[illegible]
[illegible]			1.25								[illegible]	[illegible]
[illegible]			1.15								1.072	[illegible]
[illegible]			.97								.979	
[illegible]			.30								.548	

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O Δp	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
[illegible]			1.3	[illegible]							1.140	
[illegible]			1.25	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							1.070	
[illegible]				[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			1.08	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							1.035	
[illegible]			[illegible]	[illegible]							1.100	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			1.12	[illegible]							[illegible]	
[illegible]			1.25	[illegible]							[illegible]	
[illegible]			1.16	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			1.1	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]							[illegible]	
[illegible]			[illegible]	[illegible]								
[illegible]			[illegible]	[illegible]								
[illegible]			[illegible]									
			[illegible]	[illegible]								

Ambient Temp °F [illegible]

Stack Identification Number

Boiler Number 26

Plant Steel Point

Run No. 3

Location Stack Entry Duct

Date 12-28-72

Operator Smith

Meter Δ H 1.89

C Factor .86

Bar. Press. "Hg 29.85 [illegible]

Assumed Moisture % 9

Heater Box Setting, °F 275

Probe Tip Dia., In. .25

Probe Length 10'

Probe Heater Setting 70%

Avg $\sqrt{\Delta P}$ .894 Avg. Δ H 2.10

Stack Pressure $-1.25"$ H_2O

% Isokinetic

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice Δ H in H_2O Desired	Orifice Δ H in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp °F	$\sqrt{\Delta P}$	Stack Temp °F
6-1	1403	064.048	.85	2.1	2.1	56	56	3.6	240	.50	.922	310
6-2	1408	067.73	.83	2.05	2.05	65	56	3.5	[illegible]	50	.912	312
6-3	1413	071.45	.67	1.65	1.65	72	57	3.2	244	[illegible]	.819	312
6-4	1418	074.[illegible]	.42	1.05	1.05	72	57	3.5	245	[illegible]	.648	312
[illegible]	1423	077.42	.25	.64	.64	72	56	3.0	280	50	.500	307
[illegible]	1428	079.[illegible]	.11	.28	.28	75	57	2.2	[illegible]	[illegible]	.332	[illegible]
[illegible]	[illegible]	081.28	[illegible]									
[illegible]	[illegible]		[illegible]									
5-1	[illegible]	081.[illegible]	.96	2.1	2.1	[illegible]	57	3.9	225	.50	.980	304
5-2	[illegible]	[illegible]	.85	2.1	2.1	[illegible]	58	3.0	[illegible]	50	.923	[illegible]
5-3	[illegible]	[illegible]	.88	[illegible]	[illegible]	76	58	4.2	275	[illegible]	[illegible]	312
5-4	[illegible]	[illegible]	.98	2.39	[illegible]	80	62	4.2	275	50	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2.55	2.55	84	62	4.4	245	50	1.02	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2.55	[illegible]	86	62	4.4	290	50	1.02	[illegible]
[illegible]	[illegible]	100.[illegible]	.65	[illegible]	[illegible]	85	64	3.5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	103.[illegible]	.42	1.05	1.05	74	[illegible]	2.2	263	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	107.95	.1	.75	.25							

Point	Clock Time	Dry Gas Meter, CF	Pitot in H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum In. Hg Gauge	Box Temp. °F	Impinger Temp. °F	$\sqrt{\Delta P}$	Stack Temp. °F
-1	1517	109.4[illegible]	[illegible]	2.9	[illegible]	70	62	[illegible]	[illegible]	[illegible]	1.09	31[illegible]
-2	1522	113.75	[illegible]	2.55	2.55	84	[illegible]	[illegible]	242	[illegible]	1.02	312
[illegible]	1527	117.[illegible]	1.1	2.65	2.65	86	61	[illegible]	[illegible]	[illegible]	1.05	312
[illegible]	1532	122.13	1.15	2.75	2.75	8[illegible]	61	4.9	2[illegible]	72	1.07	312
-4	[illegible]	126.95	1.[illegible]	2.75	[illegible]	84	64	[illegible]	2[illegible]	[illegible]	1.07	312
[illegible]	[illegible]	130.[illegible]	1.2	2.0	2.0	86	[illegible]	[illegible]	[illegible]	[illegible]	1.09	3[illegible]
[illegible]	[illegible]	13[illegible]	1.2	2.0	[illegible]	85	64	4.8	238	55	1.05	312
-7	1607	135.19	1.1	2.65	2.65	85	64	[illegible]	242	65	.965	312
-8	1612	13[illegible]	[illegible]	1.7	1.7	8[illegible]	[illegible]	[illegible]	2[illegible]	65	[illegible]	[illegible]
			1.35	3.3	3.3	78	66	5.5	2[illegible]	65	1.16	312
-1	1622	142.91	1.2	2.9	2.9	88	68	5.0	[illegible]	70	1.21	312
-2	1627	147.[illegible]	1.15	2.85	[illegible]	91	69	5.0	[illegible]	[illegible]	1.07	314
-3	1612	152.0	1.15	2.85	2.85	94	70	5.1	248	65	1.07	314
-4	1617	156.39	1.15	2.85	[illegible]	98	72	5.1	2[illegible]	65	1.105	315
-5	1622	160.89	1.22	3.05	3.05	98	74	5.4	2[illegible]	65	1.10	316
-6	1627	165.[illegible]	1.21	3.0	3.0	98	74	4.6	[illegible]	65	1.01	310
-7	1632	1[illegible].31	1.05	2.6	2.6	99	74	3.1	[illegible]	55	.934	309
-8	1637	174.58	.77	1.5	1.5	99	72	3.1	[illegible]	55		
						78	68	5.2	250	50	1.10	312
2-1	1657	177.137	1.21	3.0	3.0	75	68	4.8	[illegible]	55	1.0	315
2-2	1702	182.[illegible]	1.0	2.45	2.45	[illegible]	68	4.8	[illegible]	55	.925	315
2-3	1707	186.56	.85	2.35	2.35	85	68	4.5	2[illegible]	55	1.0[illegible]	315
2-4	1712	1[illegible].[illegible]	1.15	2.85	2.85	88	67	[illegible]	[illegible]	50	1.05	314
2-5	1717	19[illegible].[illegible]	1.1	2.7	2.7	88	[illegible]	[illegible]	[illegible]	50	1.018	313
2-6	1722	197.06	1.02	2.55	2.55	86	66	[illegible]	2[illegible]	50	.955	312
2-7	1727	201.[illegible]	.97	2.41	2.41	86	66	4.8	250	50	.872	311
2-8	1732	20[illegible].31	.45	1.15	1.15	88	67	3.2	2[illegible]	50		
1-1	17[illegible]	208.[illegible]	1.25	3.1	3.1	88	68	5.5	27[illegible]	50	1.115	31[illegible]
1-2	17[illegible]	212.[illegible]	.93	2.3	2.3	92	70	4.8	2[illegible]	[illegible]	.965	314
1-3	17[illegible]	21[illegible].[illegible]	.83	1.1	1.1	92	70	3.2	2[illegible]	[illegible]	.[illegible]	315
1-4	17[illegible]	2[illegible].71	.[illegible]	.65	.65	87	70	3.1	[illegible]	50	.580	315
1-5	17[illegible]	221.[illegible]	.34	.85	.85	85	70	3.0	240	50	.584	314
1-6	17[illegible]	22[illegible]	.31	[illegible]	.76	82	70	3.1	[illegible]	50	.552	314
1-7	17[illegible]	2[illegible]	.[illegible]									
1-8	1[illegible]	2[illegible].[illegible]51	[illegible]									
1-[illegible]	[illegible]		[illegible]	[illegible]								311.76
						[illegible]	61					
		[illegible]	[illegible]		[illegible]	[illegible]	50[illegible]					
		[illegible]	[illegible]									

OAQPS - 78-1

II-I-258

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref 21

Emission Test Report

English Station Stack No. 5

Steam Generator No. 13

1978

The United Illuminating Company
English Station
510 Grand Avenue
New Haven, Connecticut
06505

Approved by:

E. W. Somerville
Vice President, Engineering and Planning

Submitted by:

M. R. McCraven
Director of Environmental Engineering

Emission Test Report

English Station Stack No. 5
Steam Generator No. 13
(Ref. "Intent to Test" Form Number 720051)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis
M. Collins

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Larkin
J. Kittrell

Prepared by:

J. S. Sombati [signature]
Development & Test Laboratory Supervisor

J. W. Hotchkiss [signature]
Assistant Mechanical Engineer

Checked by:

J. F. Crowe James F. Crowe
Chief Mechanical Engineer

Test Results

English Station Steam Generator
No. 13

Test Conducted on
December 28, 1973

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company English Station Steam Generator No. 13, stack No. 5, located in New Haven, Connecticut. Testing was conducted on December 28, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII, and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new Source Test Guidelines and Procedures, (received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATOR NO. 13

STACK NO. 5

Component	Sampling Duration		Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
	Minutes per point	Total Test Time			
1) NO_X		15 min.	3	0.20 lb/10^6 BTU	Dynascience Model P-101 NO_X Analyzer
2) Particulate	5	60 min.	3	0.03 lb/10^6 BTU	Method 5*
3) Moisture	5	60 min.	3	9.6%	Method 4*
4) Gas Analysis		15 min.	3	35% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	1/2	15 min.	3	0.21" H_2O to 0.48" H_2O **	Method 2*

*Federal Register, Volume 36, No. 247, December 23, 1971

** Range of S-Type Pitot-Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATOR NO. 13

STACK NO. 5

Test	1	2	3	Average
Date	12/28/73	12/28/73	12/28/73	
Stack Flow, ACFM	162,430	165,179	173,179	166,929
Stack Flow, SCFM	104,260	103,566	104,008	103,945
Stack Flow, lb/hr	488,131	484,882	486,628	486,547
% Excess O_2 at Test Point	7.0	7.0	7.1	7.0
Particulate Emissions				
gr/SCF	0.020	0.008	0.017	0.015
lb/hr	18.02	6.90	14.85	13.26
lb/MBTU	0.05	0.02	0.04	0.03
Nitrogen Oxide Emission				
ppm	109	108	108	108
lb/hr	80.0	81.3	80.3	80.5
lb/MBTU	0.20	0.20	0.20	0.20

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATOR NO. 13

STACK NO. 5

Test	1	2	3
Date	12/28/73	12/28/73	12/28/73
Gross Load, mw	34	33.5	33
Steam Flow, lb/hr	310,000	305,000	305,000
Feed Water Flow, lb/hr	340,000	335,000	345,000
Oil Flow, gal/hr	2725	2725	2725
Heat Input, MBTU/hr	401.1	401.1	401.1
Stack Gas Temperature, ^{o}F	306	307	310
Gas Density, lb/ft^3	0.054	0.054	0.054

TABLE IV

FUEL OIL ANALYSIS

STEAM GENERATOR NO. 13

STACK NO. 5

Test	1	2	3
Date	12/28/73	12/28/73	12/28/73
	(Composition (% by Weight)		
Carbon	86.46	86.46	86.46
Hydrogen	12.20	12.20	12.20
Nitrogen	<0.1	<0.1	<0.1
Ash	0.022	0.022	0.022
Sulfur	0.335	0.335	0.335
Specific Gravity	0.909	0.909	0.909
BTU/lb	19,438	19,438	19,438
BTU/gal	147,184	147,184	147,184

1. Sampling Train Information
(Ref. Item VIII, "Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_X: Dynascience Model P-101 NO_X Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. NO_X: Stainless steel tube

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube.

d. Probe Cleaning Method:

See Appendix A

2. Field Data Sheets
(Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. Description of Operation
(Ref. Item X, "Intent To Test" Form)

The operation tested was English Station steam generator number 13, stack 5, Registration Number E.S. 13, stack 5, having a total BTU/hr rating of 401.1 MBTU (averaged over test period) burning No. 6 residual fuel oil at an average rate of 2725 gal/hr, and having a gas flow of 166,929 ACFM average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission sampling was performed in the stack 106 feet above the stack foundation (8 stack diameters above the breeching inlet and 3 stack diameters down from the top). Emission sampling was performed using four - 4" diameter sampling ports spaced 90° apart on the stack circumference. A total of twelve sampling points (3 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location is 9'-4" I.D.

a. Stack Configuration:

See Appendix A

b. Sampling Port Location:

See Appendix A

c. Sampling Point Position:

See Appendix A

5. Stack and Vent Description
(Ref. Item XII, "Intent To Test" Form)

One Babcock and Wilcox Radiant Type Top-Fired Balanced Draft boiler discharges flue gas through a Research-Cottrell Electrostatic Precipitator to the stack breeching. The stack height is 135' with the breeching inlet located 103 feet down from the top of the stack.

6. Operational Parameters
(Ref. Item XIII, "Intent To Test" Form)

Electric utility steam generator burning No. 6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

All test ports are located in the stack and the number of points sampled were calculated on the guidelines in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature, and velocity over the cross-sectional area of each stack. (See Figures 2, 4, 6 and 8.)

2. Velocity and Temperature

Velocity was determined by pitot tube in accordance with Western Precipitation Company Bulletin "WP-50". An S-type Pitot Tube (2) and thermocouple (3) are rigidly attached to the sampling probe (See Figure 9). A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques.

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by the UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 9. The stainless steel, button-hook type probe tip (1) was equipped with a 5/8 inch diameter fitting connected by a stainless steel coupling with asbestos packing to the probe. The probe consisted of 1/2 inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 300°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the ball-joint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (4) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (5) which is thermostatically maintained at a minimum temperature of 250-300°F to prevent water condensation. Attached to the heated box was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a 1/2 inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger (10) modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (Δ P in inches water)
5. Desired pressure drop across orifice (Δ H in inches water)
6. Actual pressure drop across orifice (Δ H in inches water)
7. Dry gas temperature (°F) gas meter inlet.
8. Dry gas temperature (°F) gas meter outlet.
9. Vacuum pump gauge reading (in. Hg).
10. Filter box temperature (°F)
11. Dry gas temperature (°F) at the discharge of last impinger.
12. Stack temperature (°F)

The relationship of Δ P reading with the Δ H reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to baromet[illegible] ssure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δ P and Δ H could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. Basic Laboratory Procedure

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with and Infra-Red Heat Lamp and the beaker weighed

again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

7. Calibration

The equipment used on this assignment was calibrated one week prior to field testing and re-calibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

TEST TEAM

Robert J. Larkin
James R. Kittrell

Prepared By:

Robert J. Larkin
Test Engineer

Reviewed By:

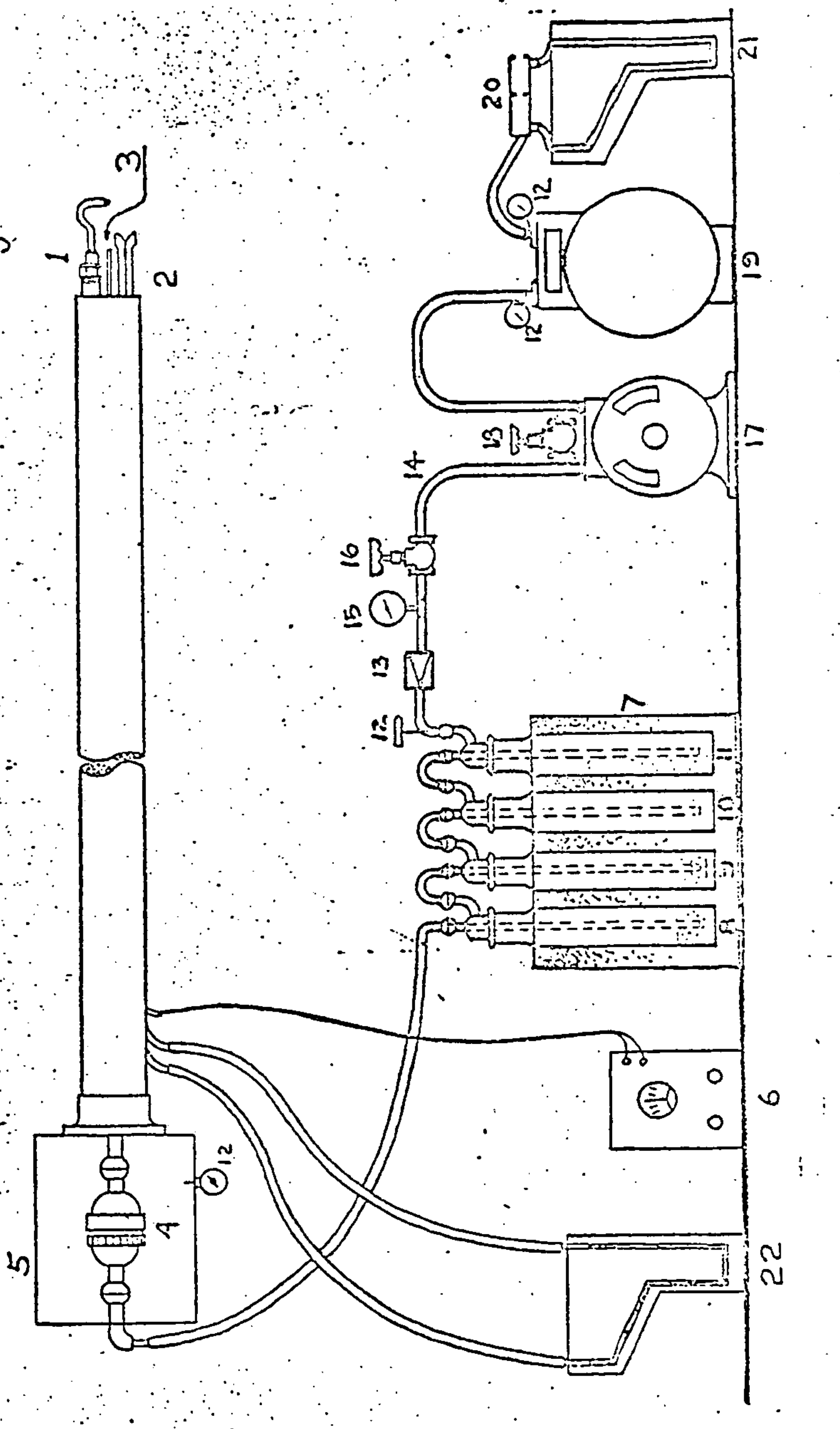
Robert S. Epstein
Project Director

Approved By:

Roy S. Egdall
Manager-Engineering Services

SAMPLING TRAIN

Figure No. 9



York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.06	.08	.750	.866
.20	.28	.714	.845
.38	.53	.717	.847
.62	.91	.681	.825
.72	1.03	.699	.836

$$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$$

Pitot Tube # 14

F_s = .84

F_{std} = 1.00

Calibrated by [signature]

Date 12/12/73

il O/K

Quick Connects Ok Valves O/K

ters OK

st Meter

meters OK

O/K

ical Check - Amphenol O/K

O/K

Gauge OK

heck at 27" hg. - O/K CF

s

l each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. S 1563 P_b 29.9

ce	CF_w	CF_d	T_W	IT_d	OT_d	T_d Avg.	Time t
5	5	5.15	67	85	75	80	12.73
0	5	5.06	67	85.5	77.6	87.5	90.12
0	10	10.16	68	88.8	79.5	84.1	13.2
0	10	10.03	68	89.0	79.6	84.3	93.06
0	10	10.05	68	92.8	80.3	86.5	7.67
0	10						

late Y & $H_@$ at man. 2.0

$$Y =$$

$$Y = \frac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ (P_b + 0.147(\ \overline{T_w} + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)\ (\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b (OT_d + 460)} \left(\frac{(T_w + 460)t}{CF_w} \right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)} \left((\quad + 460)t \right)^2$$

Tolerances

Y = 0.99 - 1.00 - 1.01

$\Delta H_@$ = 1.6 - 1.84 - 2.1

$\Delta H_@$	Man.	H@
$\Delta H_@ = \dfrac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\dfrac{(T_w + 460)t}{CF_w}\right)^2$		
$\Delta H_@ = \dfrac{0.01585}{29.9(75 + 460)} \left(\dfrac{(67 + 460)\ 12.7}{5}\right)^2$	.5	1.78
$\Delta H_@ = \dfrac{0.0317}{29.9\ (77.6 + 460)} \left(\dfrac{(67 + 460)\ 90.12}{5}\right)^2$	1.0	1.77
$\Delta H_@ = \dfrac{0.0634}{29.9\ (79.5 + 460)} \left(\dfrac{(68 + 460)\ 13.2}{10}\right)^2$	2.0	1.90
$\Delta H_@ = \dfrac{0.1268}{29.9\ (77.6 + 460)} \left(\dfrac{(68 + 460)\ 93.06}{10}\right)^2$	4.0	1.89
$\Delta H_@ = \dfrac{0.1902}{29.9\ (80.3 + 460)} \left(\dfrac{(68 + 460)\ 7.67}{10}\right)^2$	6.0	1.93
0.2536 $\left(\dfrac{(\_\_\_ + 460)}{}\right)$	8.0	

Calibration Calculations Meter and Pump Box

Date 11/5/73 Box No. 51563

Y	Man.	Y
$Y = \dfrac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ P_b + \dfrac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$	Man.	Y
$Y = \dfrac{5 \times 29.9\ (80 + 460)}{5.15\ (29.9 + 0.0368)(67 + 460)}$	.5	.9[illegible]
$Y = \dfrac{5 \times 29.9\ (81.5 + 460)}{5.06\ (29.9 + 0.0737)(67 + 460)}$	1.0	1.[illegible]
$Y = \dfrac{10 \times 29.9\ (84.1 + 460)}{10.16(29.9 + 0.147)(68 + 460)}$	2.0	1.[illegible]
$Y = \dfrac{10 \times 29.9\ (84.3 + 460)}{10.03(29.9 + 0.294)(68 + 460)}$ 29.9 .4	4.0	1.[illegible]
$Y = \dfrac{10 \times 29.9\ (86.5 + 460)}{10.05(29.9 + 0.431)(68 + 460)}$	6.0	1.[illegible]
$Y = \dfrac{\_\_ \times \_\_\ (\_\_ + 460)}{\_\_(\_\_ + 0.588)(\_\_ + 460)}$	8.0	

REPORT NO. Y-8278-2

FIELD DATA

PLANT U.I. (English)
DATE 12/28/73
SAMPLING LOCATION Stack #5
SAMPLE TYPE Part.
RUN NUMBER 1
OPERATOR TRK
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.89
STATIC PRESSURE, (P_s) -.31
FILTER NUMBER (s) FL-202

H_2O Collected

26 mL

PROBE LENGTH AND TYPE 9' S.S.
NOZZLE I.D. 3/16" = .1875"
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 100%
HEATER BOX SETTING 100%
REFERENCE Δp 2.00

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
1	1350	93.537	.36	.33	.33	305	64	62	2.0	250-300	<70
2	1355	95.19	.32	.24	.24	305	70	63	2.0		
3	1400	96.71	.21	.14	.19	305	72	64	1.5		
End	1405	97.99									
1	1410	97.99	.40	.37	.37	305	67	65	2.0		
2	1415	99.64	.39	.36	.36	305	67	65	2.0		
3	1420	101.09	.26	.24	.24	305	65	64	1.5		
End	1425	102.69									
1	1430	102.69	.45	.42	.42	310	65	64	2.0		
2	1435	104.54	.42	.39	.39	310	62	63	2.0		
3	1440	106.29	.24	.22	.22	300	67	63	1.5		
End	1445	107.615									
1	1449	102.615	.44	.41	.41	310	69	65	2.0		
2	1454	109.39	.41	.37	.37	305	71	66	1.5		
3	1459	111.17	.32	.30	.30	305	68	66	1.0		
End	1504	112.709									

COMMENTS:

ES-041

REPORT NO. [illegible]

FIELD DATA

YORK RESEARCH CORPORATION — QUALITY CONTROLLED

PLANT U.I. (English)
DATE 12/29/83
SAMPLING LOCATION Stack #5
SAMPLE TYPE Part
RUN NUMBER 2
OPERATOR TRK
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.89
STATIC PRESSURE, (P_s) −.30
FILTER NUMBER (s) FL-660

H_2O Collected = 53 mL NET

PROBE LENGTH AND TYPE 9' S.S.
NOZZLE I.D. 1/4" .250"
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 130 %
HEATER BOX SETTING 130 %
REFERENCE Δp .65

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
W 1	1535	12.820	.42	1.20	1.20	310	64	62	5.0	280-300	<70
2	1540	16.32	.40	1.15	1.15	310	70	63	4.5		
3	1545	18.58	.26	.73	.73	305	72	64	3.5		
End	1550	20.92									
S 1	1553	20.92	.43	1.25	1.25	310	70	64	5.0		
2	1558	23.28	.39	1.10	1.10	310	74	65	4.5		
3	1603	26.04	.24	.69	.68	300	76	67	3.5		
End	1603	28.29									
E 1	1610	28.29	.40	1.15	1.15	305	72	66	5.0		
2	1615	31.23	.34	1.05	1.05	310	76	69	4.5		
3	1620	33.93	.27	.75	.75	305	77	69	4.0		
End	1625	36.30									
N 1	1630	36.30	.44	1.25	1.25	310	74	69	5.0		
2	1635	39.21	.41	1.15	1.15	305	80	70	5.0		
3	1640	42.09	.27	.75	.75	305	80	70	4.0		
End	1645	44.495									

COMMENTS:

ES-041

FIELD DATA

PLANT U.I. (English)
DATE 12/28/73
SAMPLING LOCATION Stack #5
SAMPLE TYPE Part.
RUN NUMBER 3
OPERATOR JAK
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.40
STATIC PRESSURE, (P_s) -.35
FILTER NUMBER (s) FL-30?

H_2O Collected = 82 ml NET

PROBE LENGTH AND TYPE 9' S.S.
NOZZLE I.D. 1/4" = .250
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .99
PROBE HEATER SETTING 40 %
HEATER BOX SETTING 90 %
REFERENCE Δp .45

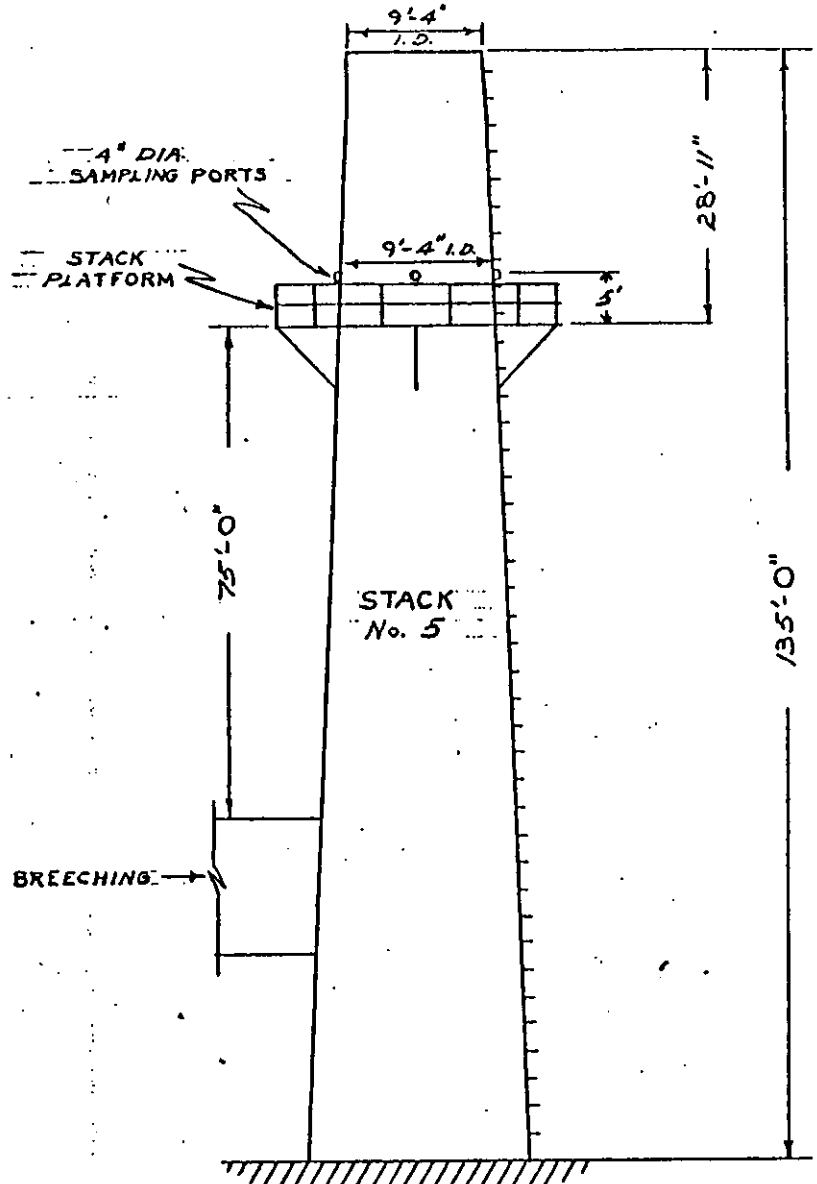
SCHEMATIC OF TRAVERSE POINT LAYOUT

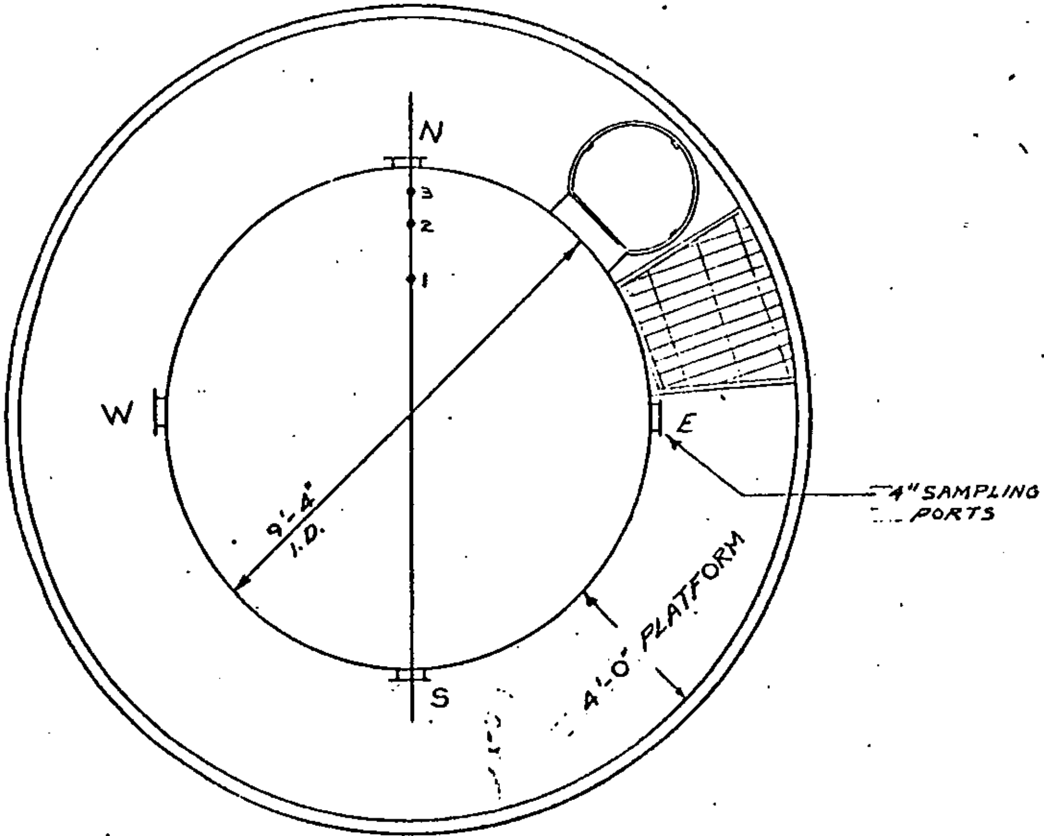
READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
N 1		1714	44.50	.48	1.35	1.35	310	65	64	5.5		
2		1719	47.73	.40	1.15	1.15	310	72	65	5.0		
3		1724	50.44	.29	.29	.29	310	70	67	4.0		
End		1729	52.55									
E 1		1733	52.55	.46	1.30	1.30	310	68	68	5.0		
2		1738	55.92	.42	1.20	1.20	310	70	69	5.0		
3		1743	58.97	.30	.85	.85	310	69	69	4.5		
End		1748	61.43									
S 1		1750	61.43	.47	1.35	1.35	310	70	63	5.5		
2		1755	64.45	.43	1.20	1.20	310	69	63	5.0		
3		1800	67.41	.25	.71	.71	310	65	62	4.0		
End		1805	69.71									
W 1		1809	69.71	.46	1.30	1.30	310	58	55	5.5		
2		1813	72.91	.41	1.15	1.15	310	63	57	5.0		
3		1819	75.64	.32	.92	.92	310	64	60	4.5		
End		1823	75.137									

COMMENTS:

ES-041





TRAVERSE POINT No.	DISTANCE FROM WALL
3	4.9"
2	16.5"
1	33.0"

REVISED	
	THE UNITED ILLUMINATING C NEW HAVEN, CONN. STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK No. 5 ENGLISH STATION
	DRAWN BY P.L.O. DATE 3-29-74
	TRACED BY DATE
	APPROVED BY J.W.H. DATE 4-1-74
	SCALE NONE DRAWING NO. 11212-1

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 5

Boiler Number 13

Plant Location ENGLISH

Sampling Point Location STACK

Date DEC. 28, 1973

Time 1500

TEST 1

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	11.58	11.52	11.48		11.53	44/100	5.07
CO, % Vol (dry)	0.	0	0		0.00	28/100	+ 0.00
O_2, % Vol (dry)	6.96	6.98	7.00		6.98	32/100	+ 2.23
N_2, % Vol (dry)	81.46	81.50	81.52		81.49	28/100	+ 22.82
						Avg. molecular wt. of dry stack gas =	30.12

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 5

Boiler Number 13

Plant Location ENGLISH

Sampling Point Location STACK

Date DEC. 28, 1973

Time 1615

TEST 2.

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	11.50	11.50	11.52		11.51	44/100	5.0644
CO, % Vol (dry)	0	0	0		0.00	28/100	+.000
O_2, % Vol (dry)	7.01	6.98	6.96		6.98	32/100	+2.2336
N_2, % Vol (dry)	81.49	81.52	81.52		81.51	28/100	+22.8228
						Avg. molecular wt. of dry stack gas =	30.12

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number 5

Boiler Number 13

Plant Location ENGLISH

Sampling Point Location STACK

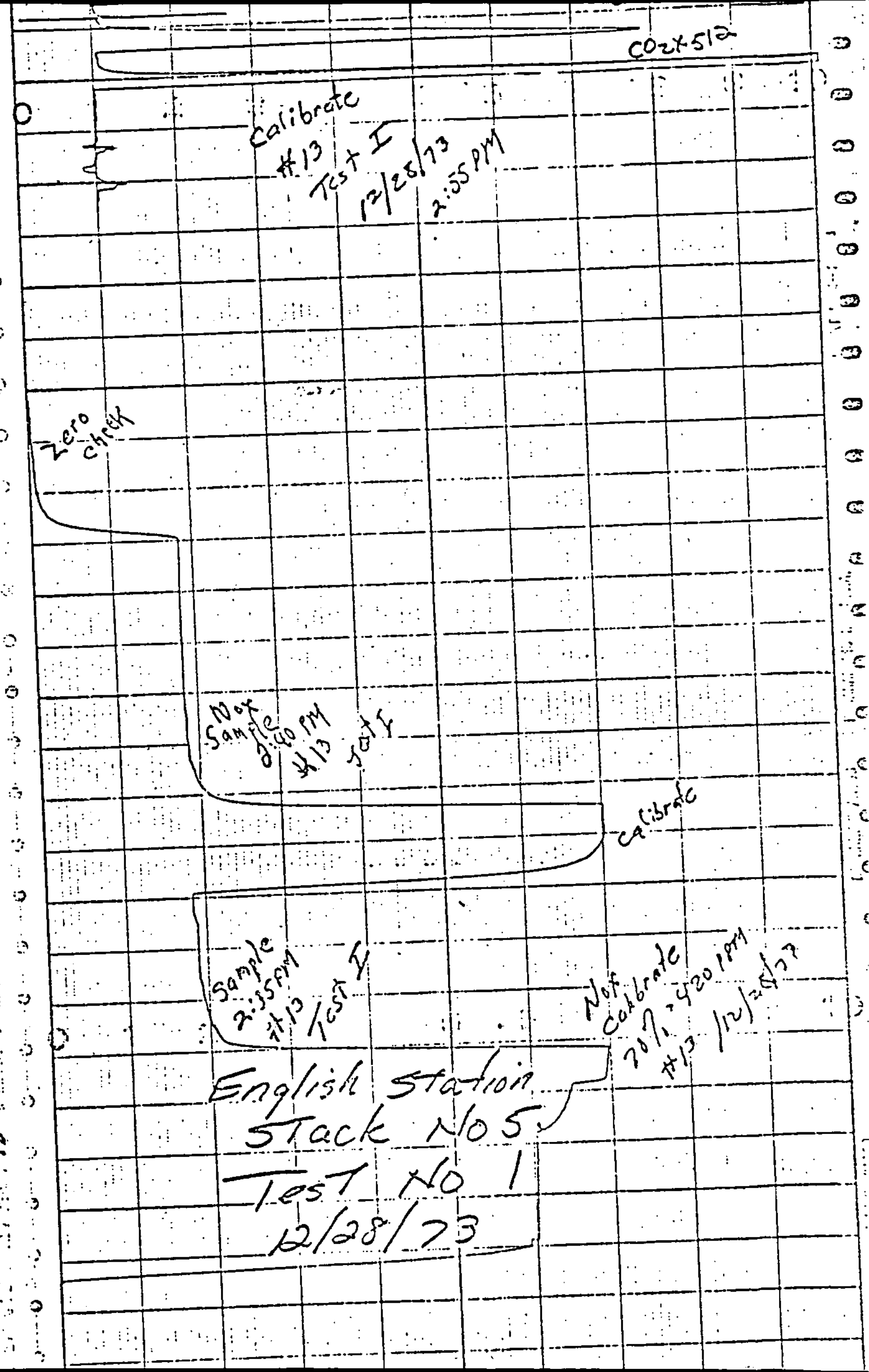
Date DEC. 28, 1973

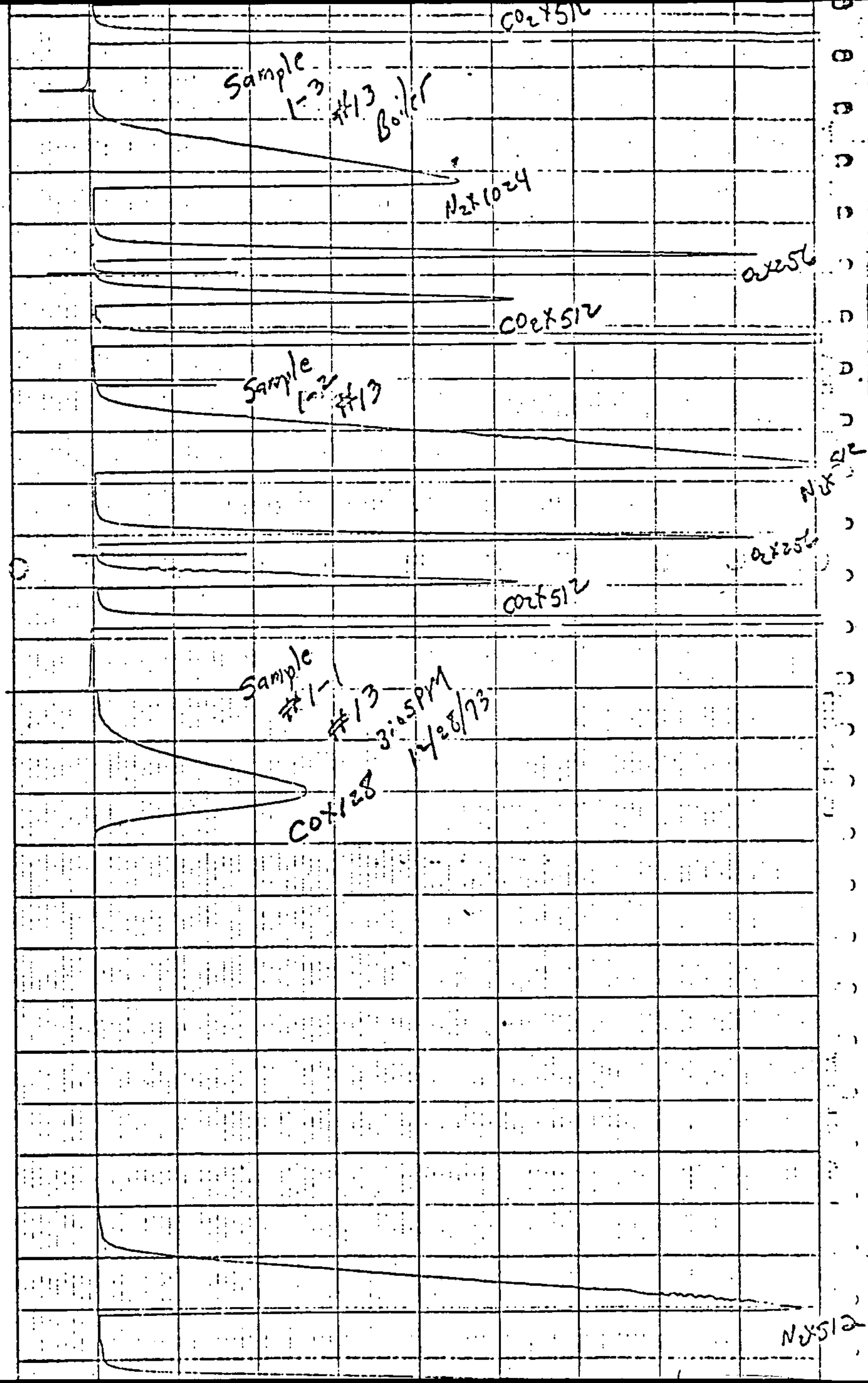
Time 1800

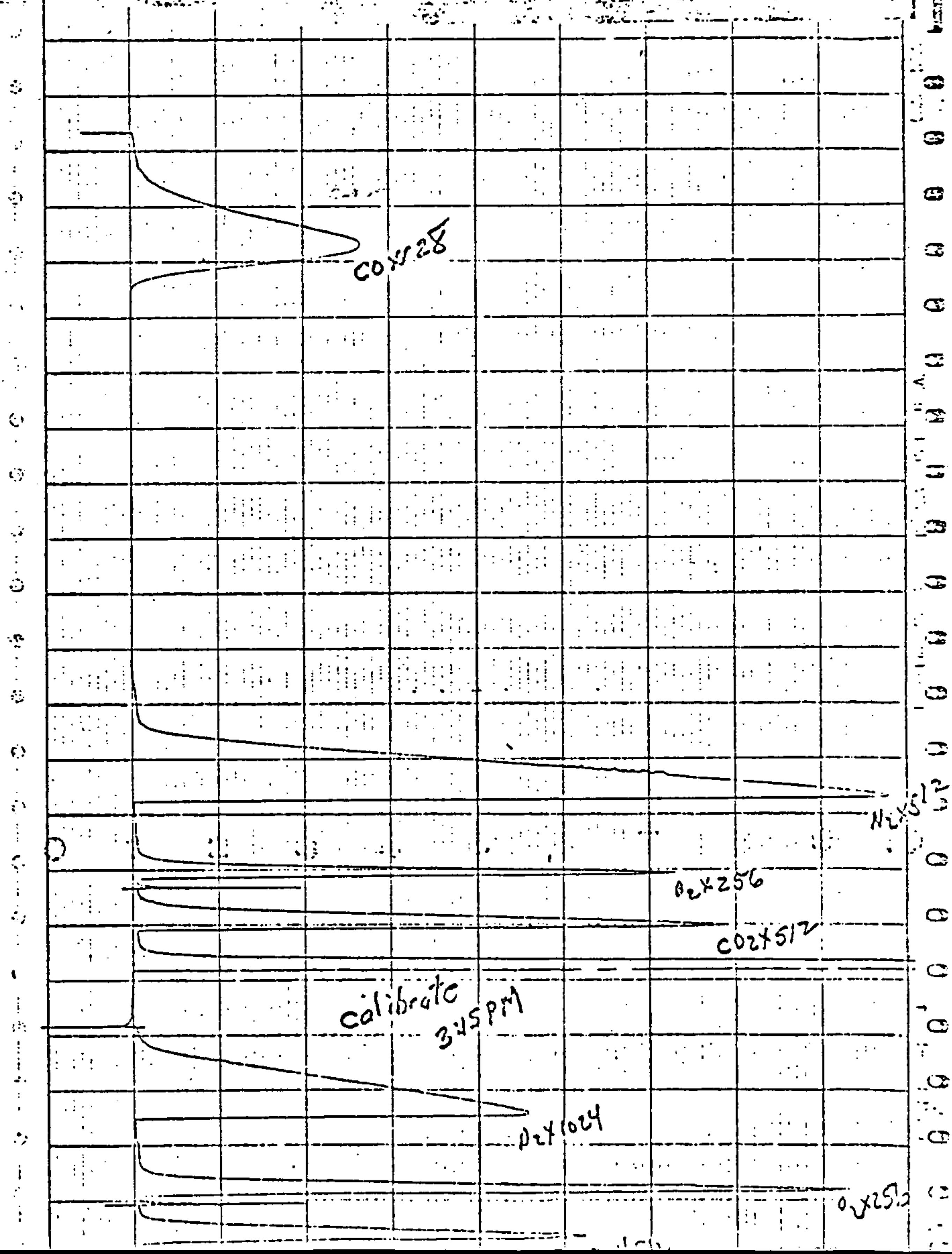
TEST 3

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/molc. (dry)
CO_2, % Vol (dry)	11.31	11.42	11.31		11.35	44/100	4.99
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O_2, % Vol (dry)	7.06	7.10	7.17		7.11	32/100	+ 2.28
N_2, % Vol (dry)	81.63	81.48	81.52		81.54	28/100	+ 22.83
					Avg. molecular wt. of dry stack gas =		30.10

TEST NO. 1

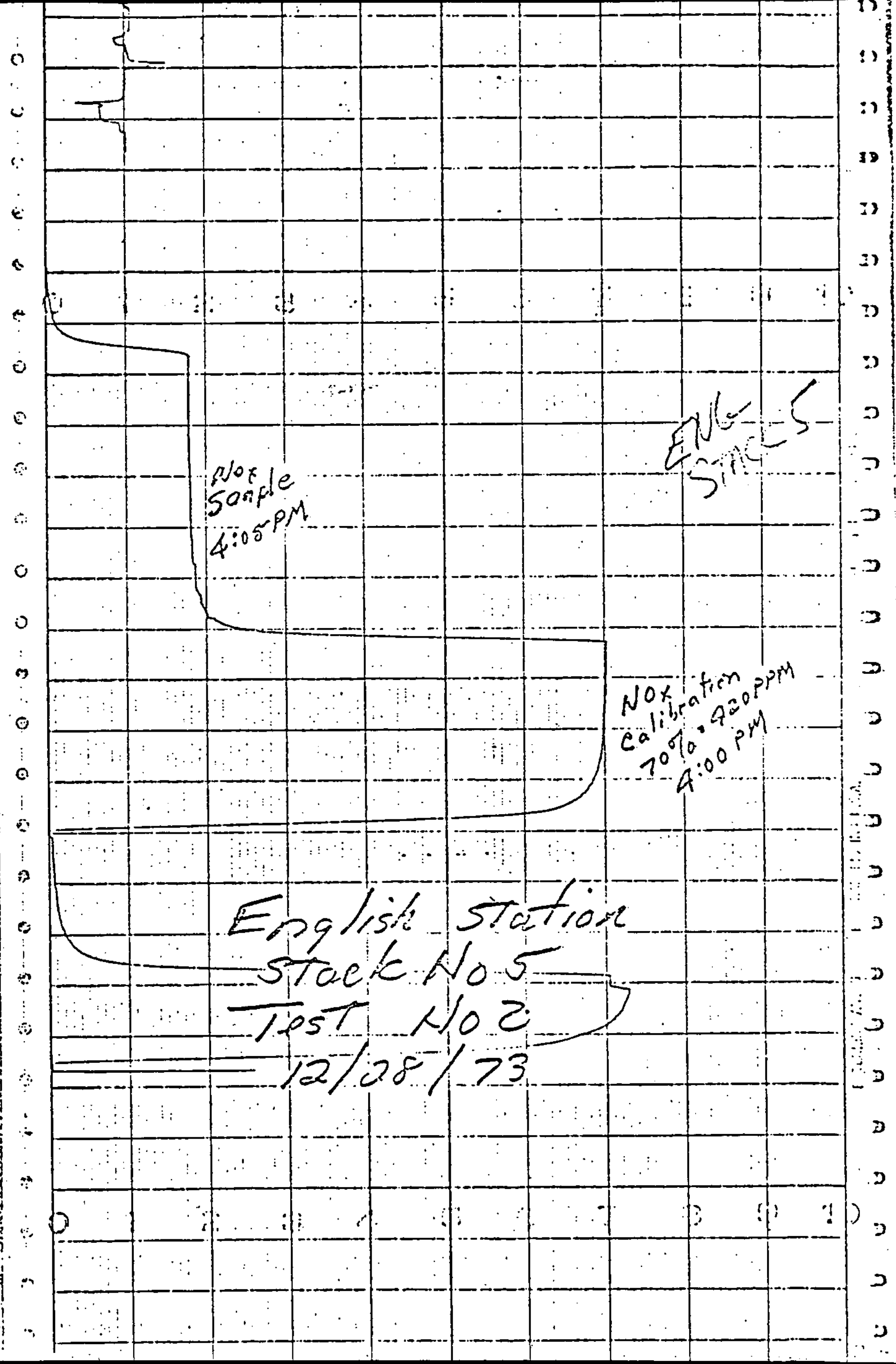

CO2x512
Calibrate
#13
Test I
12/28/73
2:55 PM
zero check
Nox
Sample
2:40 PM
#13
Test I
Calibrate
Sample
2:55 PM
#13
Test I
Nox
Calibrate
70% 4:20 PM
#13 12/28/73
English Station
Stack No 5
Test No 1
12/28/73

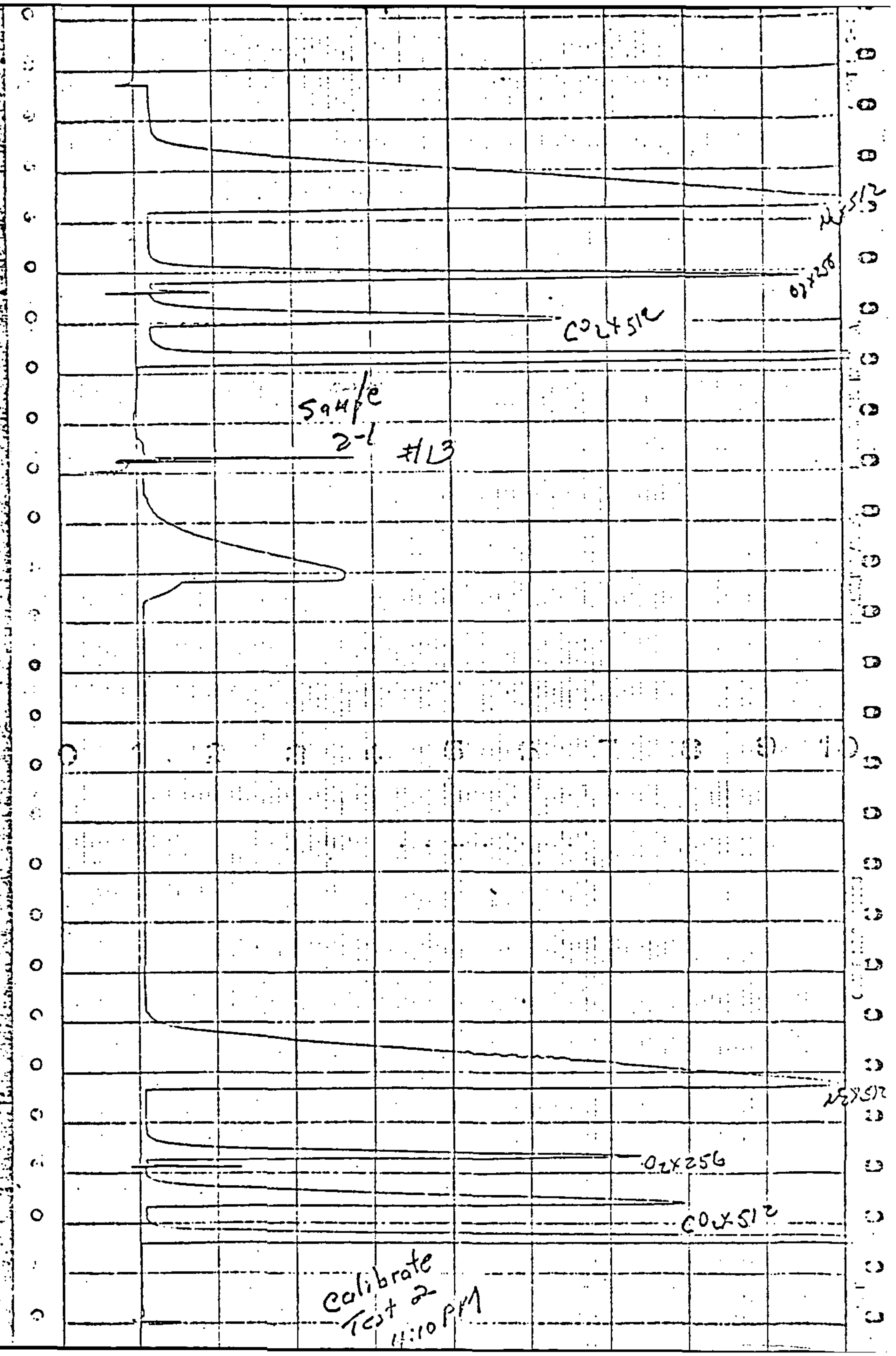

$CO_2 \times 512$
Sample 1-3 #13 Boiler
$N_2 \times 1024$
$O_2 \times 256$
$CO_2 \times 512$
Sample 1-2 #13
$N_2 \times 512$
$O_2 \times 256$
$CO_2 \times 512$
Sample #1-1 #13 3:05PM 12/28/73
$CO \times 128$
$N_2 \times 512$



N2×512
O2×256
CO2×512
calibrate
3:45 PM
O2×1024

TEST NO. 2


NOx Sample 4:05 PM
NOx calibration 70% - 420 PPM 4:00 PM
English Station
Stack No 5
Test No 2
12/28/73



N2x512
O2x256
CO2x512
Sample
2-1
#L3
N2x512
O2x256
COx512
Calibrate
Test 2
11:10 PM

TEST 3, BCR 26 10-28-72

WEIGHT OF PARTICULATE COLLECTED
mg

CONTAINER NUMBER	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
Filter	.7428 g	.6168 g	126.0 mg
Washings	70.7 mg		70.7 mg
TOTAL			196.7 mg

VOLUME OF LIQUID WATER
COLLECTED, ml

IMPINGER	1	2	3	4
FINAL VOL.	325	190	2	
INITIAL VOL.	100	100	0	
LIQUID COLLECTED	225	90	2.	5.6 g ml
TOTAL				323.? ml.

Weight of particulates in washings

Test #3 ; 12/20/72 #26 Boiler, Stack 7
(steel plant)

Dish #1	(after)	65.3316	
	(before)	65.2900	
	wgt. of part.:	0.0416	0.0416
Dish #3	(after)	63.1297	
	(before)	63.0998	
		0.0299	0.0299
Dish (X's Sr.)	(after)	60.9796	
	(before)	60.9738	
		0.0058	0.0058
filter paper + part (wash)		0.7995	
		0.7941	
		0.0054	0.0054
			0.0827
* wgt. of residue (blank); 0.0040,			− 0.0120
			0.0707

Total weight of wash: 0.0707 g

wgt. of particulate on filter: 0.1260 g

Total particulate wgt.: 0.1967 g

OIL FLOW

TEST 1: 9:00 PM 0474876

12:00 N 0449264

$\frac{25{,}612 \text{ gal}}{9 \text{ hr}} = 2846 \text{ gal/hr}$

DURING TEST

7:00 PM 0469168

2:00 PM 0454954

$\frac{14{,}214 \text{ gal}}{5 \text{ hr}} = 2842 \text{ gal/hr}$

TEST 2 7:00 PM 0518856

3-8 10:00 AM 0493651

$\frac{25{,}205 \text{ gal}}{9 \text{ hr}} = 2800 \text{ gal/hr}$

DURING TEST

7:00 PM 0518856

3:00 PM 0507800

$\frac{11{,}056}{4 \text{ hr}} = 2764 \text{ gal/hr}$

TEST 3 B.

6:20 PM 0823000

1:20 0808558

$\frac{14{,}442 \text{ gal}}{5 \text{ hr}} = 2888 \frac{\text{gal}}{\text{hr}}$

Avg FUEL CONSUMED DURING TEST = 2831 gal/hr.

TEST 3 A. 0566630

0556661

9969 gal/3.5 hr

= 2848 gal/hr

Fuel Calculations

BTU/lb from Saybolt: 11/5/73
19,159 BTU/lb
145,551 BTU/gal

OMIT

From 25, 27 analysis
Specific gravity = ~~0.9078~~

8.33 lb/gal for H_2O x 0.9018 = 7.52 lb/gal

BTU/gal = 19636 BTU/lb x 7.52 lb/gal

= 147,503 BTU/gal

TEST 1 2846 gal/hr x 145,551 BTU/gal

= 414.2 x10^6 BTU/hr

TEST 2 = 2800 gal x 145,551 BTU/gal

= 407.6 x10^6 BTU/hr

TEST 3B: 2888 gal/hr x 145,551 BTU/gal

= 420.4 x10^6 BTU/hr

TEST 3A 2848 gal/hr x 145551 BTU/gal

= 414.5 x10^6 BTU/hr

AVE. 414.2

Stack Identification Number 7 TEST 1 Date 12-19-77

Boiler Number S.P. 26.

Plant Location STEEL POINT STATION [illegible]

Parameters	10:00	11:05	12:00	1:02	2:00	3:06	4:01
Gross Load (MW)	34	34.	33.	33.	33.5	33.5	33.5
Net Load (MW)							
Fuel Flow (gal/hr)		0444458	449264	4452.264	[illegible]954	[illegible]9225	[illegible]
Steam Flow (lb/hr)	315,000	315,000	315,000	318,000	315,000	315000	315,00[illegible]
Feed Water Flow (lb/hr)	320,[illegible]	320,000	320,000	320,000	320,000	320,[illegible]	[illegible]
Air Flow	345,000	345,000	345,000	345,000	345,000	345,000	[illegible]
Excess Air (%)	19.5	19.5	19.5	19.0	18.75	18.5	18.5
Excess O2 (%)	3.9	3.9	3.9	3.8	3.75	3.7	3.7
Soot Blowing	NO	NO.	NO.	NO.	N.O.	NO.	NO
Boiler Inlet Feed Water Temp. (°F) PRESS. psig	1160	1160	1160	1160	1160	1160	1160
Boiler Exit Steam Press. (psig)	900	900	900	900	900	900	900
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

[illegible]	10:00	11:00	12:00	1:00	[illegible]	[illegible]	[illegible]
Cooling Water Temp (°F)							
Boiler Air Inlet to A.H Temp (°F) [illegible]	110	105	110	110	110	110	112
Boiler ~~Flue Gas~~ Exit from A.H Temp (°F), °F	605	605	610	610	612	612	615
F.D. Fan Pressure Rise ~~(in H2O)~~ [illegible] A.H	700	700	705	705	708	710	710
~~F.D. Fan Current (amps)~~ gas out A.H	335	335	340	340	344	345	345
F.D. Fan Voltage (V)							
ID Fan Pressure ~~Rise~~ suction (in H20)	6.2	6.2	6.1	6.2	6.2	6.2	6.1
ID Fan ~~Current (amps)~~ discharge [illegible]	0.5"	0.5"	0.5	0.5	0.5	0.5	0.5
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hq)							
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
Capacity	[illegible]		24%	24%	24%	24% [?]	23% [?]

Stack Identification Number 7.

Boiler Number STEEL POINT 26

Plant Location STEEL POINT STATION BPT

Date 12-19-76

ALL RECTIFIER LIGHTS ON PRECIPITATOR [illegible]

F.O. TEMP: 125°F

Parameters	5:00	6:00	7:00	9:00			AVG.
Gross Load (MW)	33.5	33.5	33.5	33.5			
Net Load (MW)							
Fuel Flow (gal/hr)	0463778	0466363	[illegible]	0474876			
Steam Flow (lb/hr)	315,000	315,000	318,000	318,000			316
Feed Water Flow (lb/hr)	320,000	320,000	320,000	320,000			320,000
Air Flow lb/hr	345,000	345,000	345,000	345,000			345,000
Excess Air (%)	19.0	18.75	18.0	18.0			[illegible]
Excess O2 (%)	3.8	3.7	3.6	3.6			
Soot Blowing	NO	NO	NO	NO			
Boiler Inlet Feed Water Temp (°F) [illegible]	116.0	116.0	116.0	116.0			
Boiler Exit Steam Press. (psig)	900	900	900	900			
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

Parameter	5:00	6:00	7:00	9:00			
Cooling Water Temp (°F)							
Boiler Air Inlet TO M.H. Temp (°F)	115	110	110	110			
Boiler Flue-Gas Exit FROM M.H. Temp (°F)	618	618	620	623			
~~F.D. Fan Pressure Rise (in H20)~~ — GAS INTO A.H.	715	715	718	722			
GAS OUT A.H. ~~F.D. Fan Current (amps)~~	348	350	350	355			
F.D. Fan Voltage (V)							
ID Fan Pressure ~~Rise~~ SUCTION (in H20)	6.2	6.2	6.2	6.2			
ID Fan ~~Current (amps)~~ DISCHARGE	0.5	0.5	0.5	0.5			
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							

Stack Identification Number 7 Date 12-20-72

Boiler Number 26

Plant Location STH. [illegible] [illegible] BPT

Parameters	12:00	12:[illegible]	1:10	2:10	3:00	4:00	5:00
Gross Load (MW)							
Net Load (MW)							
Fuel Flow (gal/hr)	0493651	0492[illegible]	0502668	0505468	0507800	0510555	0513314
Steam Flow (lb/hr)	325,000	310,000	310,000	310,000	310,000	320,000	32[illegible]
Feed Water Flow (lb/hr)	32[illegible]	318,000	321,000	321,000	321,000	31[illegible]	31[illegible]
Air Flow	3[illegible]	360,000	350,000	345,000	340,000	34[illegible]	34[illegible]
Excess Air (%)	20.0	22.5	18.5	17.5	16.0	17.30	16.0
Excess O2 (%)	4.0	4.5	3.7	3.5	3.2	3.46	3.2
Soot Blowing	NO						
Boiler Inlet Feed Water ~~Temp (°F)~~ PRESS. PSIG	1150	1160	1150	1160	1160	1160	1170
Boiler Exit Steam Press. (psig)	900	900	900	900	900	900	900
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

	10:00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cooling Water Temp (°F)							
Boiler Air Inlet Temp (°F)	115	112	110	110	110	114	11?
Boiler Flue Gas Exit Temp (°F)	570	605	600	590	600	605	60?
F.D. Fan Pressure Rise (in H20)	690	705	700	695	700	710	71?
F.D. Fan Current (amps)	340.	345	340	342	345	350	347
F.D. Fan Voltage (V)							
ID Fan Pressure Suction ~~Rise (in H20)~~	6.7	6.6	6.4	6.2	6.1	6.2	6.2
ID Fan Current ~~(amps)~~	0.5	-0.5	0.5	0.5	0.5	0.5	0.5
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
[illegible]pacity	[illegible]						

Stack Identification Number 7 Date 12-?-72

Boiler Number 26

Plant Location [illegible]

Parameters	6:00 PM	7:00 PM					
Gross Load (MW)							
Net Load (MW)							
Fuel Flow (gal/hr)	0516088	0518856					
Steam Flow (lb/hr)	310,000	310,000					
Feed Water Flow (lb/hr)	315,000	312,000					
Air Flow	302,000	312,000					
Excess Air (%)	15.5	15.75					
Excess O2 (%)	3.1	3.15					
Soot Blowing							
Boiler Inlet Feed Water Temp (°F) [illegible]	1170	1170					
Boiler Exit Steam Press. (psig)	900	900					
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

Cooling Water Temp (°F)							
Boiler Air Inlet Temp (°F)	114	[illegible]					
Boiler Flue Gas Exit Temp (°F)	605	608					
F.D. Fan Pressure Rise (in H20)	714	713					
F.D. Fan Current (amps)	350	351					
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H20)	6.2	6.2					
ID Fan Current (amps)	0.5	0.5					
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressire (in Hg)							
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
Opacity							

Stack Identification Number #7

Boiler Number #16

Plant Location STEEL Pt

Date 12/21/72

Parameters	1:15 PM	2:45 PM	3:45	4:45			
Gross Load (MW)							
Net Load (MW)	(1 20)	(2 20)	(3 50)	4 50			
Fuel Flow (gal/hr)	2555661	[illegible]	2563786	2566630			
Steam Flow (lb/hr)	320,000	318,000	[illegible]	320,000			
Feed Water Flow (lb/hr)	320,000	320,000	318,000	320,000			
Air Flow	[illegible]	[illegible]	[illegible]	360,000			
Excess Air (%)	21.5	19.5	19.5	19.5			
Excess O2 (%)	4.3	3.9	3.9	39			
Soot Blowing							
Boiler Inlet Feed Water Temp (°F) Press.	1150	1150	1160	1150			
Boiler Exit Steam Press. (psig)	900	900	900	900			
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

Cooling Water Temp (°F)							
Boiler Air Inlet Temp (°F)	95	100	95	100			
Boiler Flue Gas Exit Temp (°F)	600	600	615	605			
F.D. Fan Pressure Rise (in H20)	714	715	728	720			
F.D. Fan Current (amps)	345	345	348	350			
F.D. Fan Voltage (V)							
ID Fan Pressure Rise (in H20)	6.6	6.7	6.8	6.7			
ID Fan Current (amps)	0.5	0.6	0.5	0.5			
ID Fan Voltage (V)							
Forced Draft Inlet Air Temp (°F)							
Ambient Air Relative Humidity							
Barometric Pressure (in Hg)	30.10	30.08	30.08	30.08			
Ambient Air Temp (°F)							
Boiler Heat Rate (BTU/KW-hr)							
Burner Tilt							
Inlet Temp (°F)							
Outlet Temp (°F)							
Inlet Pressure (in H20)							
Rapping Cycle Period (min)							
Spark Rate (sparks/min)							
Operating Voltage (KV)							
Operating Amps							
Capacity							

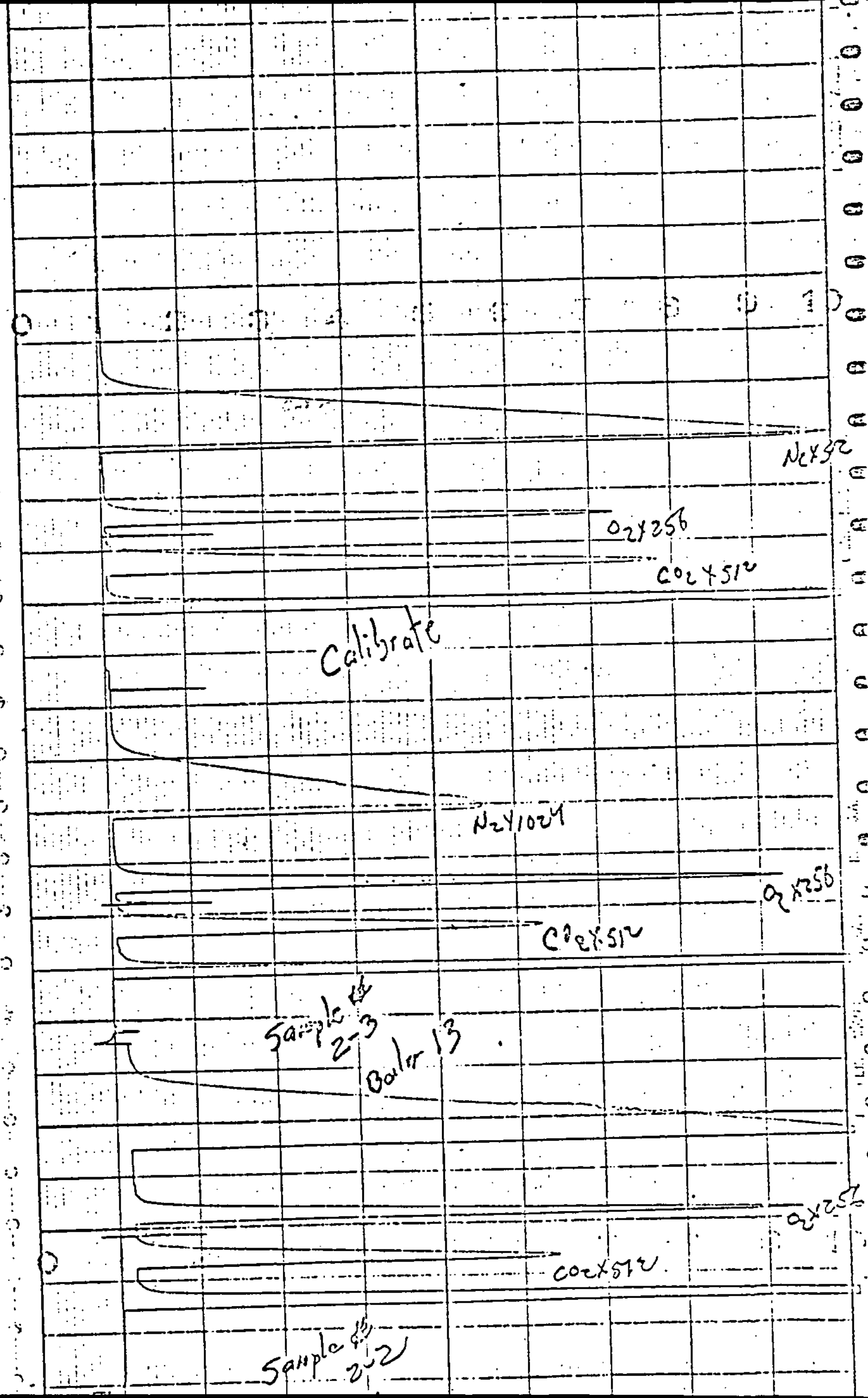
Stack Identification Number #7 Date 12-28-72

Boiler Number #26

Plant Location ST. PT.

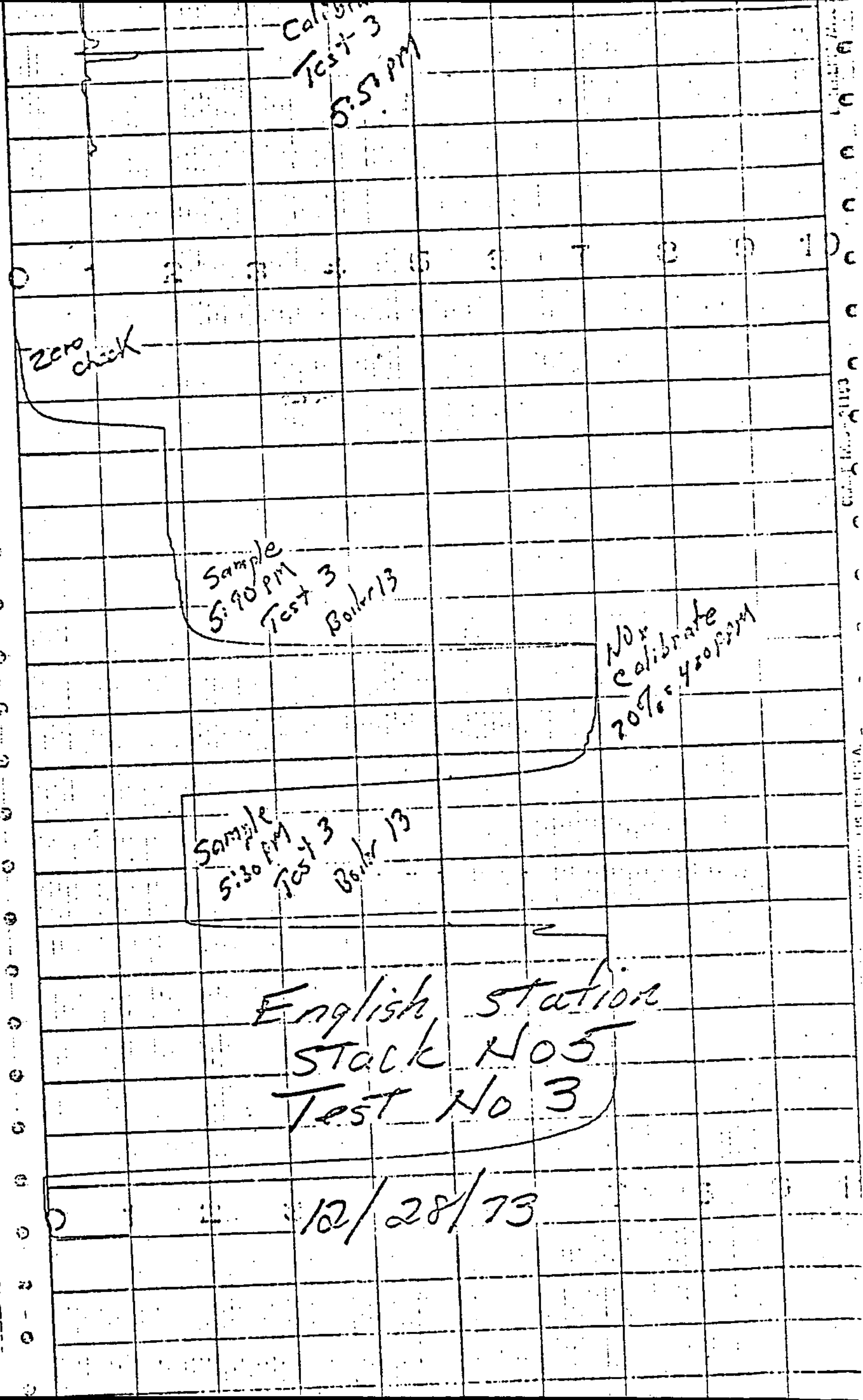
Parameters	1 20	2 30	3 20	4 20	5 20	6 20	
Gross Load (MW)	33.6	33.8	33.8	34.0	34.0		
Net Load (MW)	[illegible]	[illegible]	[illegible]	[illegible]	5 15	6 10	
Fuel Flow (gal/hr)	0808552	0811406	0814259	[illegible]57	0819962	0823050	
Steam Flow (lb/hr)	320,000	320,000	320,000	320,000	310,000	32[illegible]	
Feed Water Flow (lb/hr)	325,000	32[illegible]	32[illegible]	[illegible]	325,000	[illegible]	
Air Flow	360,000	360,000	358,000	358,000	360,000	360,000	
Excess Air (%)	20.25	20.25	20.25	20.0	[illegible]	20.0	
Excess O2 (%)	4.05	[illegible]	4.05	4.0	4.0	4.0	
~~Soot Blowing~~							
~~Boiler Inlet Feed Water Temp (°F)~~ PRESSURE	1140	1140	1140	[illegible]	1140	1140	
Boiler Exit Steam Press. (psig)	900	900	900	905	9[illegible]	900	
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig)							
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							
Condenser Pressure (in Hg)							

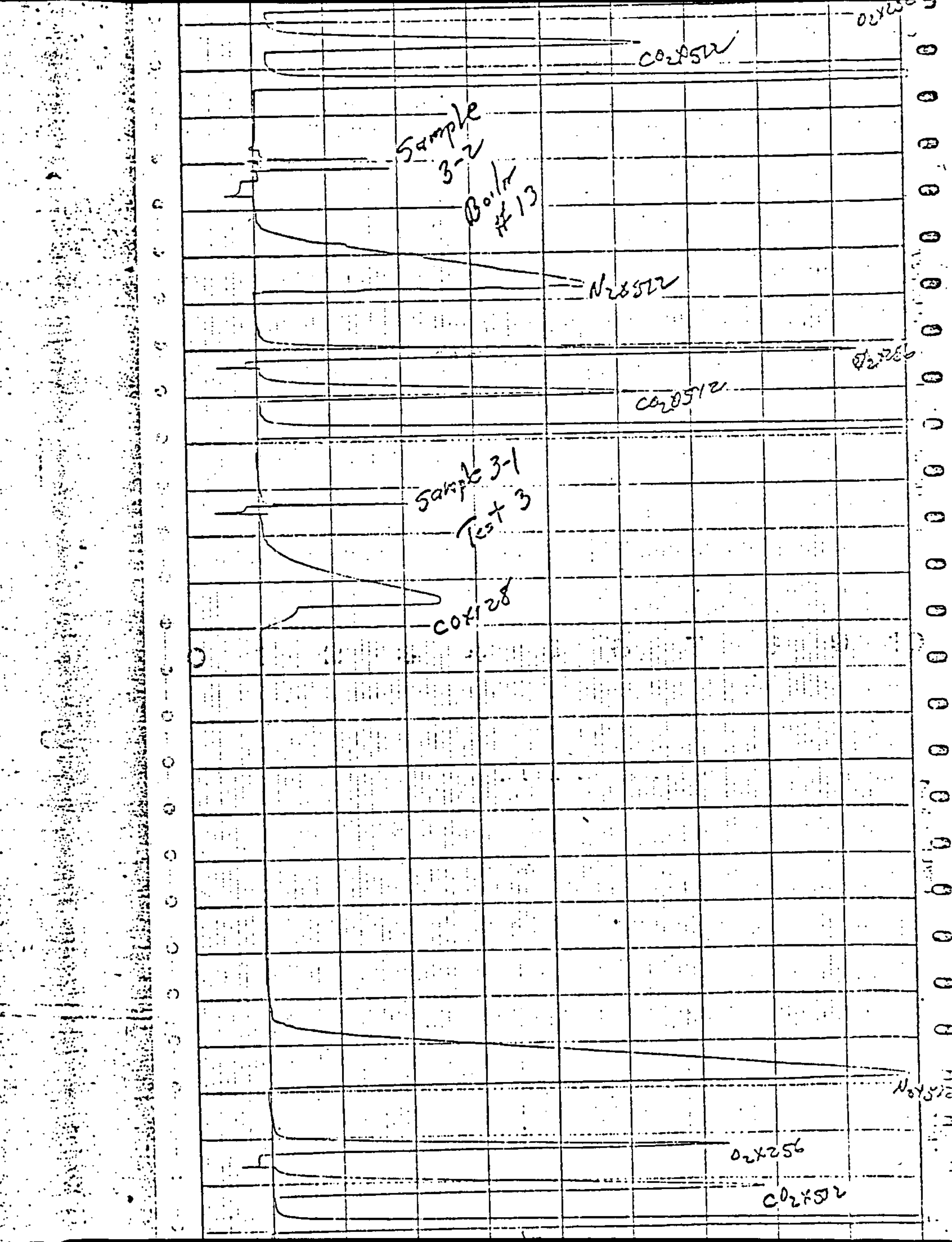
Air Inlet Temp (°F)	100	95	97	100	100	105		
Boiler Flue Gas Exit Temp (°F)	600	600	[illegible]	[illegible]	610	[illegible]		
F.D. Fan Pressure Rise (in H2O)	675	710	700	[illegible]	708	710		
F.D. Fan Current (amps)	330	325	328	332	346	342		
F.D. Fan Voltage (V)								
ID Fan Pressure Rise (in H2O) Suction	6.5	6.4	6.4	6.4	6.5	6.5		
ID Fan Current ~~(amps)~~ Discharge	.60	.60	.60	.50	.60	.60		
ID Fan Voltage (V)								
Forced Draft Inlet Air Temp (°F)								
Ambient Air Relative Humidity								
Barometric Pressire (in Hg)			29.94		30.02			
Ambient Air Temp (°F)								
Boiler Heat Rate (BTU/KW-hr)								
Burner Tilt								
Inlet Temp (°F)								
Outlet Temp (°F)								
Inlet Pressure (in H2O)								
Rapping Cycle Period (min)								
Spark Rate (sparks/min)								
Operating Voltage (KV)								
Operating Amps								
Opacity								



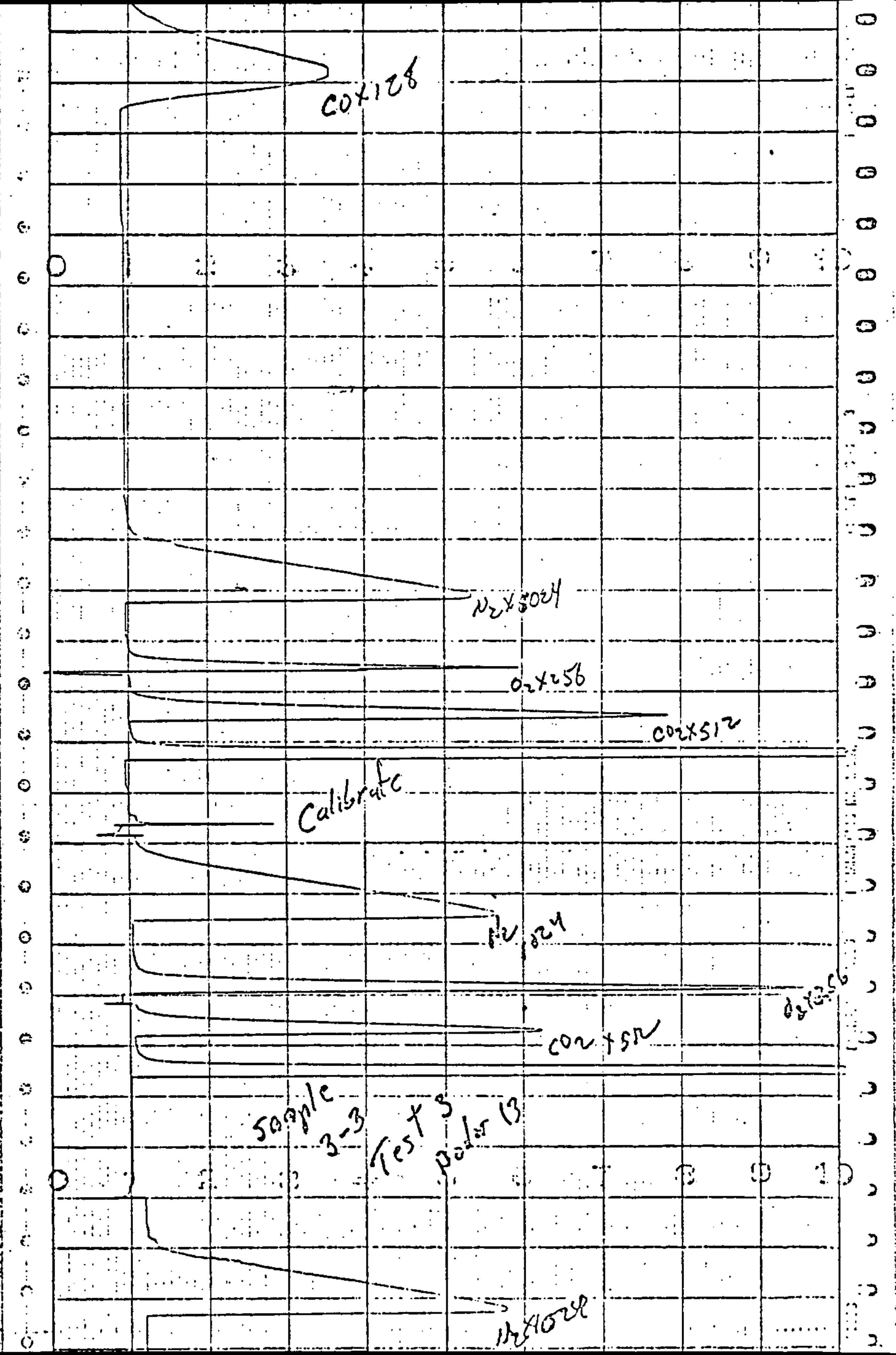
N2 X 512
O2 X 256
CO2 X 512
Calibrate
N2 X 1024
O2 X 256
CO2 X 512
Sample # 2-3
Boiler 13
O2 X 256
CO2 X 512
Sample # 2-2

TEST NO. 3


Calibr
Test 3
5:57 PM
zero check
Sample
5:40 PM
Test 3
Boiler 13
NOx
calibrate
70% 480 PPM
Sample
5:30 PM
Test 3
Boiler 13
English Station
Stack No 5
Test No 3
12/28/73



CO2x512
Sample 3-2
Boiler #13
N2x512
O2x256
CO2x512
Sample 3-1
Test 3
COx128
O2x256
CO2x512


COx128
N2x1024
O2x256
CO2x512
Calibrate
N2 1024
O2x256
CO2x512
Sample
3-3
Test 3
N2x1024

APPENDIX C

BOILER OPERATING DATA

BOILER OPERATING CONDITIONS

Date DEC 28, 1973.

Stack Identification Number 5

Boiler Number 13

Plant Location English Sta

Parameters	1340	1450	1607	1803			
Gross Load (MW)	34	33.5	33.5	33			
Net Load (MW)	—	—	—				
Fuel Flow (gal/~~hr~~) Meter	593681	576912	600405	625624			
Steam Flow (lb/hr)	310,000	305,000	305,000	305,000			
Feed Water Flow (lb/hr)	340,000	330,000	335,000	315,000			
Air Flow	325,000	330,000	310,000	310,000			
Excess Air (%)	—	—	—	—			
Excess O2 (%)	3.8	3.9	3.8	3.8			
Soot Blowing	—	—	—	—			
Boiler Inlet Feed Water Temp (°F)	380	380	380	350			
Boiler Exit Steam Press. (psig)	860	870	870	870			
Boiler Exit Steam Temp (°F)	870	870	870	870			
Reheat Inlet Steam Press. (psig)	—						
Reheat Inlet Steam Temp (°F)	—						
Reheat Exit Steam Press. (psig)	—						
Reheat Exit Steam Temp (°F)	—						
Condenser Pressure (in Hg)	29.30	29.35	29.35	29.35			

Parameters	[illegible]	1450	1607	1803			
Cooling Water Temp (^{o}F)	43/43	43/43	[illegible]	44/44			
Boiler Air Inlet Temp (^{o}F) Air Heater Inlet	105	105	115	110			
Boiler Flue Gas Exit Temp (^{o}F) Air Htr Outlet	320	320	315	320			
F.D. Fan Pressure Rise (in H20)	6.9	6.9	6.5	6.5			
F.D. Fan Current (amps)	230	228	230	232			
F.D. Fan Voltage (V)	—	—	—	—			
ID Fan Pressure ~~Rise~~ DISC PRESS. (in H20)	-.35	-.35	-.35	-.35			
ID Fan Current (amps)	350	350	345	345			
ID Fan Voltage (V)	—	—	—	—			
Forced Draft Inlet Air Temp (^{o}F)	50	50	50				
Ambient Air Relative Humidity	—	—	—	—			
Barometric Pressire (in Hg)	29.89	29.89	29.89	29.90			
Ambient Air Temp (^{o}F)	50	50.	50				
Boiler Heat Rate (BTU/KW-hr)	—	—	—	—			
Burner Tilt	—	—	—	—			
~~Inlet~~ [illegible] Temp (^{o}F)	320	320	315	320			
Outlet Temp (^{o}F)	—	—					
Inlet Pressure (in H20)	-1.9"	-1.8"	-1.7"	-1.8"			
Rapping Cycle Period (min)							
Spark Rate (sparks/min)	0/0/0						
Operating Voltage (KV) Primary	330/[illegible]/375						
Operating Amps Primary	58/55/6.2						

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{\circ}R}{in.\ Hg.}\right) \quad Vm \left(\frac{Pbar + \frac{\Delta H}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{\circ}R}{in.\ Hg.}\right) \quad 19.172\ ft^3 \left(\frac{29.89\ in.hg + \frac{0.324\ in\ H_2O}{13.6}}{525.9\ ^{\circ}R}\right)$$

$$= 19.313\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{Ft^3}{ml.}\right) \quad Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{Ft^3}{ml.}\right) \quad 31.1\ ml.$$

$$= 1.474\ Ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd} \qquad \text{eq. 5-3}$$

$$= \frac{1.474\ Ft^3}{1.474\ Ft^3 + 19.313\ Ft^3}$$

$$= 0.0709 \times 100\% = 7.1\%$$

4. Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (11.53) + 0.32\ (6.98) + 0.28\ (81.49) + 0.28\ (0.00)$$

$$= 30.12\ \text{lb/lb-mole}$$

5. Molecular Weight (wet)

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 30.12\ (1-.071) + 18\ (.071)$$

$$= 29.26\ \text{lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}} \left(\frac{Ts}{Ps \times Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.84)\ (.589) \left(\frac{765.8}{29.87 \times 29.26}\right)^{1/2}$$

$$= 39.59\ \text{F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A_s \times 60\ \text{sec/min}$$

$$= 39.59 \times 68.38\ Ft^2 \times 60\ \text{sec/min}$$

$$= 162{,}430\ ACFM$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1-Bws)\ Vs\ A_s \left(\frac{Tstd}{Ts}\right) \left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.071)\ (39.59)\ (68.38) \left(\frac{530}{765.8}\right) \left(\frac{29.87}{29.92}\right)$$

$$= 104{,}260\ SCFM$$

9. Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60\ \text{min}}{\text{hr}} \times \frac{Md}{386\ \text{Ft}^3}$$

$$= 104{,}260\ \text{SCFM} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{30.12\ \text{lb/lb-mole}}{386\ \text{Ft}^3}$$

$$= 488{,}131\ \text{lb/hr}$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154\ \frac{\text{gr.}}{\text{mg.}}\right) \frac{Mn}{Vmstd} \qquad \text{eq. 5-4}$$

$$= \left(0.0154\ \frac{\text{gr.}}{\text{mg.}}\right) \frac{25.3\ \text{mg.}}{19.313\ \text{Ft}^3}$$

$$= 0.0201\ \text{gr/SCF}$$

11. Particulate Concentrations, lb/Ft^3

$$Cs = \frac{\left(\frac{1}{453600}\ \frac{\text{lb}}{\text{mg}}\right) Mn}{Vmstd} \qquad \text{eq. 5-5}$$

$$= \frac{\left(\frac{1}{453600}\ \frac{\text{lb}}{\text{mg}}\right) 25.3\ \text{mg.}}{19.313\ \text{Ft}^3}$$

$$= 2.88 \times 10^{-6}\ \text{lb/SCF}$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60\ \text{min}}{\text{hr}}$$

$$= (2.88 \times 10^{-6}\ \text{lb/SCF})\ (104{,}260\ \text{SCFM})\ \frac{60\ \text{min}}{\text{hr}}$$

$$= 18.02\ \text{lb/hr}$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{18.02\ \text{lb/hr}}{401.1 \times 10^6\ \text{BTU/hr}}$$

$$= 0.045\ \text{lb/MBTU}$$

14. % Isokinetic Sampling

$$I = \frac{\overline{Ts}\ (1.667\ \frac{min}{sec}) \left((0.00267)\ Vlc + \frac{VM}{Tm} \left(Pbar + \frac{\overline{\Delta H}}{13.6} \right) \right)}{\Theta\ \ Vs\ \ Ps\ \ An}$$

eq. 5-6

$$I = \frac{765.8\ (1.667) \left((0.00267)\ (31.1) + \frac{19.172}{525.9}\ \ 29.89 + \left(\frac{0.324}{13.6} \right) \right)}{(60).\ (39.59)\ (29.87)\ (1.916 \times 10^{-4})}$$

$$= 110.2\%$$

15. NO_x Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{109}{10^6} \times \frac{46\ lb/lb\text{-}mole}{30.12\ lb/lb\text{-}mole} \times 488{,}131\ \frac{lb}{hr}$$

$$= 81.3\ lb/hr$$

16. NO_x Concentrations, lb/MBTU

$$lb/MBTU = \frac{lb/hr}{Heat\ Input}$$

$$= \frac{81.3\ lb/hr}{401.1 \times 10^6\ BTU/hr}$$

$$= \frac{0.203\ lb}{10^6\ BTU}$$

17. Stack Pressure (Absolute) in. Hg.

$$Ps = Pb + \frac{Pd}{13.6} = 29.89 + \frac{(-0.31)}{13.6} = 29.87\ in.\ Hg.$$

18. Nozzle Area (Ft^2)

$$An = \pi D^2/4 = 0.785\ (0.1875/12)^2 = 1.916 \times 10^{-4}\ Ft^2$$

19. Stack Area (Ft^2)

$$As = \pi D^2/4 = 0.785 \quad (112/12)^2 = 68.38 \text{ Ft}^2$$

20. Heat Input, MBTU

Sp. Gr. x 8.33 lb/gal X BTU/16 x gal/hr

$$0.909 \times 8.33 \times 19{,}438 \times 2725 = 401.1 \times 10^6 \text{ BTU}$$

21. Gas Density, lb/Ft^3

$$\text{Gas Density} = \frac{\text{mol wt gas}}{386 \text{ Ft}^3} (\text{md}) \times \frac{T_{std}}{T_s} \times \frac{P_{bar}}{P_{std}}$$

$$= \frac{30.12}{386} \times \frac{530\ ^\circ R}{765.8} \times \frac{29.89}{29.92} = 0.054 \text{ lb/Ft}^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

ɘst No. English Station #5 No. Runs 3

ɪme of Firm United Illuminating Company

ɔcation of Plant 510 Grand Avenue, New Haven, Connecticut

ʏpe of Plant Steam Generating Station

ɔntrol Equipment Electrostatic Precipitator

ɜmpling Point Locations Stack

ɔllutants Sampled Particulates, Nitrogen Oxides

ime of Particulate Test:

ɪn No. 1	Date 12/28/73	Begin 1350	End 1504
ɪn No. 2	Date 12/28/73	Begin 1535	End 1645
ɪn No. 3	Date 12/28/73	Begin 1714	End 1823

PARTICULATE EMISSION DATA

n No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb.\ mole-{}^{o}R}\right)^{\frac{1}{2}}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.84	0.84	0.84	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.589	0.596	0.619	
$\overline{Ts}$ = Average stack temp., ^{o}R	765.8	767.1	770.0	
Pb = Barometric pressure, "Hg Abs.	29.89	29.89	29.90	
Pd = Gas duct pressure, "H_2O	-0.31	-0.30	-0.35	
Ps = Absolute stack gas pressure, inches Hg	29.87	29.87	29.87	
Bws = % moisture in stack gas, by volume	7.1	9.1	12.6	
Md = Molecular weight of stack gas, dry	30.12	30.12	30.10	
Ms = Molecular weight of stack gas	29.26	29.02	28.58	

Vs = Stack gas velocity, F.P.S.	39.59	40.26	42.21	
% CO_2	11.53	11.51	11.35	
% O_2	6.98	6.98	7.11	
% CO	0.00	0.00	0.00	
% N_2	81.49	81.51	81.54	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	31.1	67.1	103.3	
Vm = Volume of dry gas sampled at meter conditions, FT^3	19.172	31.675	33.637	
std = Volume of dry gas sampled at STP, FT^3	19.313	31.710	34.051	
Tm = Average dry gas meter temp., °R	525.9	530.2	524.5	
ΔH = Average pressure drop across orifice, inches H_2O	0.324	1.018	1.098	
θ = Total Sampling Time, min.	60	60	60	
Dn = Nozzle dia., inches	0.1875	0.250	0.250	
An = Nozzle area, FT^2 ($x\ 10^{-4}$)	1.916	3.407	3.407	
I = % of isokinetic sampling	110.2	102.4	109.5	
Qs = Stack gas volume at STP (SCFM)	104,260	103,566	104,008	103,945
Qa = Stack gas volume at stack conditions (ACFM)	162,430	165,179	173,179	166,929
Ws = Stack gas mass flow lbs/hr	488,131	484,882	486,628	486,547
Mp = Particulate-probe, washings, mg	-	-	-	
Mf = Particulate-filter (mg)	-	-	-	
Mn = Particulate-total (mg)	25.3	16.1	36.9	
C's = Particulate Concentrations gr/scf	0.020	0.008	0.017	0.015
Cw = Particulate total emission lb/hr	18.02	6.90	14.85	13.26
Er = Particulate emission rate, lb/106 BTU	0.045	0.017	0.037	0.03
C = NO, concentrations, PPM	109	108	108	
Cn = NO, lb/10^6BTU	0.203	0.200	0.200	0.20

3

OAQPS - 78-1
II-I-259

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24
4/93 Ref 21

Emission Test Report

Bridgeport Harbor Station Stack No. 3

Steam Generator No. 3

1968

The United Illuminating Company
Bridgeport Harbor Station
10 Henry Street
Bridgeport, Connecticut
06604

Approved by:

R.J. Grossi
Vice President, Engineering and Planning

Submitted by:

M.R. McCraven
Director of Environmental Engineering

Emission Test Report

Bridgeport Harbor Station Stack No. 3
Steam Generator No. 3
(Ref. "Intent to Test" Form Number 720055)

Test Conducted by
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Hotchkiss
J. Macknis
M. Collins

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Larkin
J. Kittrell

Prepared by:

J.S. Sombati ____________________
Development & Test Laboratory Supervisor

J.W. Hotchkiss ____________________
Assistant Mechanical Engineer

Checked by:

J.F. Crowe ____________________
Chief Mechanical Engineer

Test Results

Bridgeport Harbor Station
Steam Generator No. 3

Test Conducted on
February 21, 22, 1974

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company Bridgeport Harbor Station Steam Generator No. 3, Stack No. 3, located in Bridgeport, Connecticut. Testing was conducted on February 21 and 22, 1974.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_x Analyzer. It is to be noted that the Nitrogen Oxide Test Results for test No. 1 indicate the unit to be in violation. However, averaging all three test results show the unit to comply with the allowable emission rate of 0.30 lb./MBTU. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the abovementioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new <u>Source Test Guidelines and Procedures,</u> (Received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATOR NO. 3

STACK NO. 3

Component	Sampling Minutes per point	Duration Total Test Time	Number of Tests	Measured Concentrations	Method Employed to Determine Concentration
1) NO_x		15 min.	3	0.30 lb/10^6 BTU	Dynascience Model P-101 NO_x Analyzer
2) Particulate	5	60 min.	3	0.02 lb/10^6 BTU	Method 5*
3) Moisture	5	60 min.	3	8.6%	Method 4*
4) Gas Analysis		15 min.	3	33% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	½	15 min.	3	1.1" H_2O to 1.5" H_2O**	Method 2*

* Federal Register, Volume 36, No. 247, December 23, 1971

** Range of S-Type Pitot Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATORS NO.3

STACK NO. 3

Test	1	2	3	Average
Date	2/21/74	2/21/74	2/22/74	
Stack Flow, ACFM	1,299,007	1,274,732	1,287,362	1,287,034
Stack Flow, SCFM	836,782	820,046	825,816	827,548
Stack Flow, lb/hr	3,905,994	3,832,971	3,880,479	3,873,148
% Excess O_2 at Test Point	7.88	6.32	5.57	6.59
Particulate Emissions				
gr/SCF	0.0124	0.0106	0.0089	.0106
lb/hr	89.37	75.28	63.42	76.02
lb/MBTU	.0222	.0193	.0162	.0192
Nitrogen Oxide Emission				
ppm	210	189	198	199
lb/hr	1256.3	1104.5	1169.1	1176.6
lb/MBTU	0.313	0.284	0.299	0.298

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATOR NO.3

STACK NO. 3

Test	1	2	3
Date	2/21/74	2/21/74	2/22/74
Steam Flow lb/hr	764 2,512,743	2,449,000	2,449,800
Oil Flow gal/hr	27,942	27,000	27,140
Heat Input, MBTU/hr	4011.4	3889.5	3910.0
Stack Gas Temp. ^{o}F	290	290	290
Gas Density, lb/ft^3	.055	.056	.054

TABLE IV

SUMMARY OF RESULTS

STEAM GENERATOR NO.3

STACK NO.3

Test	1	2	3
Date	2/21/74	2/21/74	2/22/74
Composition (% by Weight)			
Carbon	85.70	85.59	86.74
Hydrogen	13.07	12.68	12.99
Nitrogen	0.1	0.1	0.1
Ash	0.018	0.019	0.018
Sulfur	0.34	0.37	0.34
Specific Gravity	0.90	0.90	0.90
BTU/lb	19,149	19,215	19,217

1. <u>Sampling Train Information</u>
(Rev. Item VIII, " Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_x: Dynascience Model P-101 NO_x Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. Nitrogen Oxides: Stainless steel tube

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube.

d. Probe Cleaning Method:

See Appendix A

2. <u>Field Data Sheets</u>
Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. <u>Description of Operation</u>
Ref. Item X, "Intent To Test" Form)

The operation tested was Bridgeport Harbor Station steam generator No. 3, stack No. 3, Registration Number BHS 3, stack 3, having a total BTU/hr rating of 3937 MBTU/hr (averaged over the test period), burning No. 6 risdual fuel oil at an average rate of 27,360 gal/hr, and having a gas flow of 1,287,034 ACFM, average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission sampling was performed in the stack 243 feet above the stack foundation (approximately 10 stack diameters above the breeching inlets and approximately 15 stack diameters down from the top). Emission sampling was performed using four 4" diameter sampling ports, spaced 90° apart on the stack circumference. A total of twelve sampling points (3 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 18'-7 7/8"

a. Stack Configuration:

See Appendix A

b. Sampling Port Location:

See Appendix A

c. Sampling Point Position:

See Appendix A

5. Stack and Vent Description
Ref. Item XII, "Intent To Test" Form)

One Combustion Engineering tangentially-Fired Radient Reheat Boiler discharges flue gas through two breechings into the stack. Attached to the outlet of the boiler is a Research-Cottrell electrostatic precipitator, having an estimated collection efficiency of 75% when burning No.6 residual fuel oil.

6. Operational Parameters
Ref. Item XIII, " Intent To Test" Form)

Electric utility steam generator burning No.6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

The test port locations and the number of points sampled were calculated from guidelines in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature, and velocity over the cross-sectional area of each stack (See Figures 1-4).

2. Velocity and Temperature

Velocity was determined in accordance with Guidelines in Method 2 of the Federal Register. A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques (See Figure #6).

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe on Unit 2 and a fifteen (15) foot probe on Unit 3, heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 5. The stainless steel, button-hook type sampling nozzle (1), Type "S" pitot tube (2), and thermocouple (3), extended from the sampling end of the probe, which consisted of ½ inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 250°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the ball-joint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (5) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (4) which is thermostatically maintained at a minimum temperature of 250°F to prevent water condensation. Attached to the heated box with tygon tubing was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a ½ inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger (10) modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (ΔP in inches water)
5. Desired pressure drop across orifice (ΔH inches water)
6. Actual pressure drop across orifice (ΔH in inches water)
7. Dry gas temperature (°F) gas meter inlet
8. Dry gas temperature (°F) gas meter outlet.
9. Vacuum pump gauge reading (in. Hg).

10. Filter box temperature (°F)
11. Dry gas temperature (°F) at the discharge of last impinger
12. Stack temperature (°F)

The relationship of ΔP reading with the ΔH reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between ΔP and ΔH could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. BASIC LABORATORY PROCEDURE

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III and VI of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with an Infra-Red Heat Lamp and the beaker weighed again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

CALIBRATION

The equipment used on this assignment was calibrated one week prior to field testing and re-calibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

REPORT NO. Y-8278-3

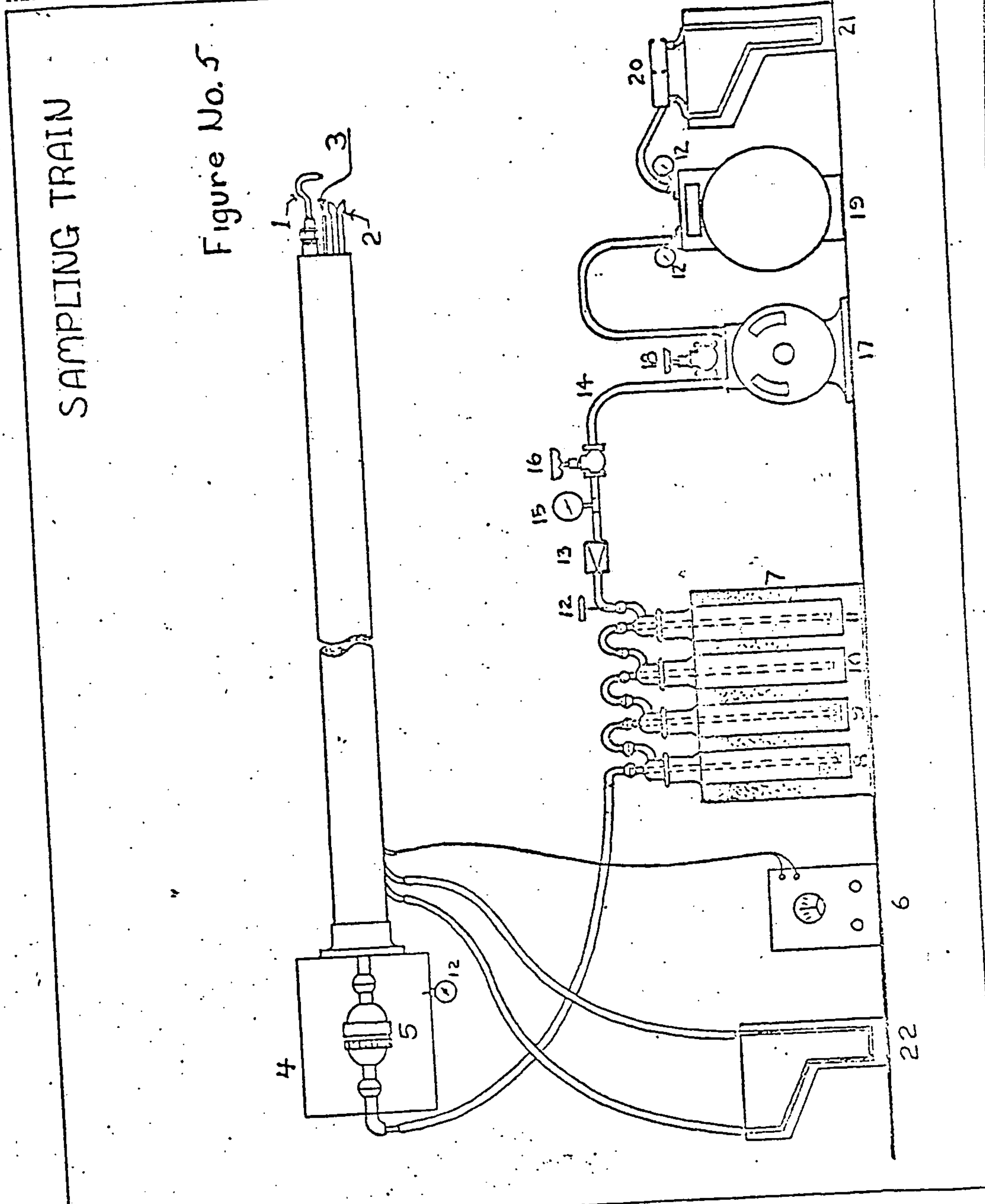
TEST TEAM

Robert J. Larkin
James R. Kittrell

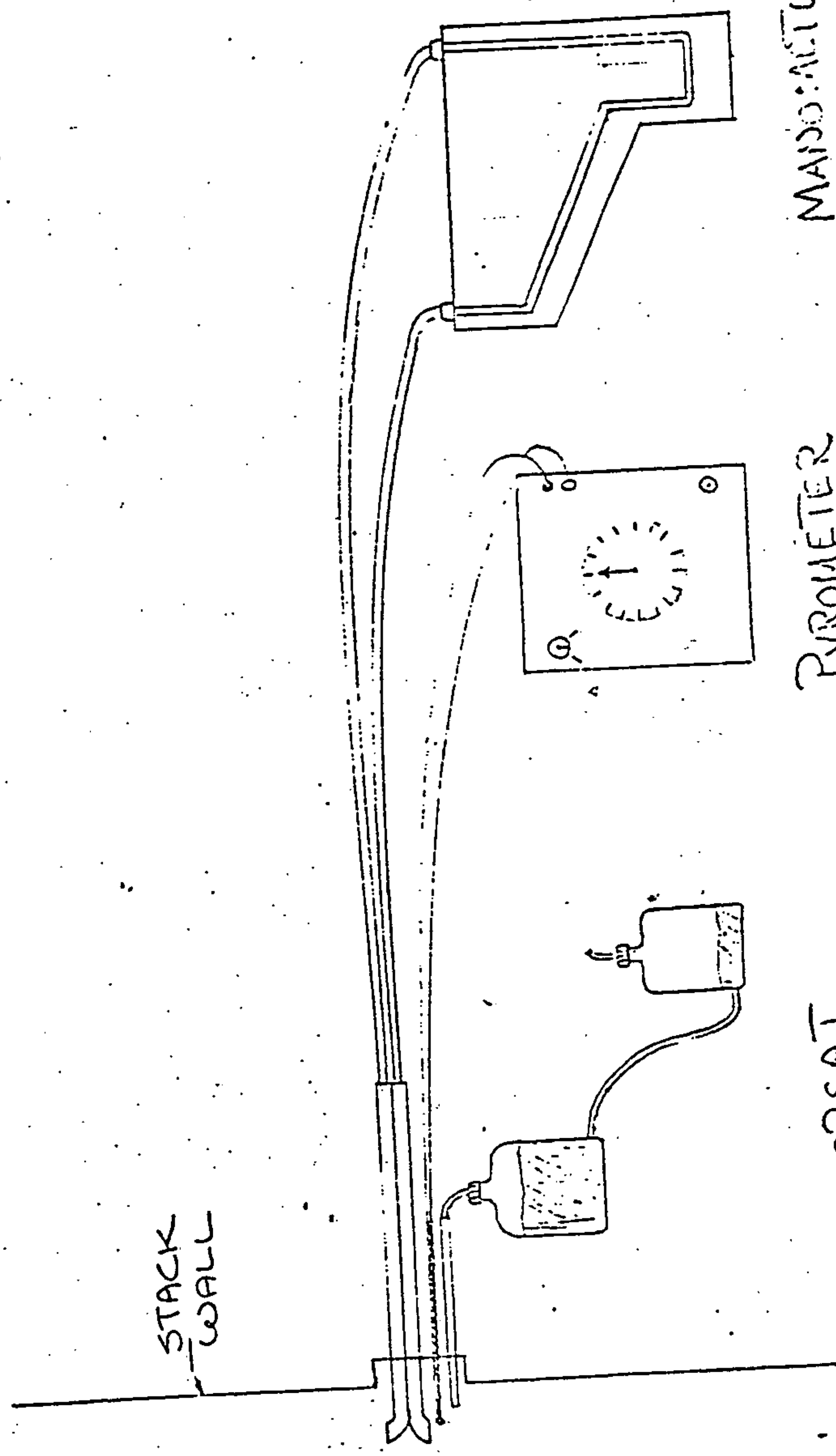
Prepared By: Robert J. Larkin
Robert J. Larkin
Test Engineer

Reviewed By: Robert S. Epstein
Robert S. Epstein
Project Director

Approved By: Roy S. Egdall
Roy S. Egdall
Manager Engineering Services


SAMPLING TRAIN
Figure No. 5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

VELOCITY MEASUREMENT APPARATUS
FIGURE # 6



FIELD DATA

PLANT: WE Harbor St.
DATE: 2/21/74
SAMPLING LOCATION: Stack 3
SAMPLE TYPE: Particulate
RUN NUMBER: 1
OPERATOR: RTL
AMBIENT TEMPERATURE: 40
BAROMETRIC PRESSURE: 30.25
STATIC PRESSURE, (P_s): -.5
FILTER NUMBER (s): FL-668

69 ml H_2O collected

PROBE LENGTH AND TYPE: ≈15' S.S.
NOZZLE I.D.: 3/16
ASSUMED MOISTURE, %: 10
SAMPLE BOX NUMBER: -
METER BOX NUMBER: 1578
METER $\Delta H_@$: 1.88
C FACTOR: .94
PROBE HEATER SETTING: -
HEATER BOX SETTING: -
REFERENCE Δp: 2.1

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET $(T_{m\,in})$, °F	DRY GAS METER TEMPERATURE OUTLET $(T_{m\,out})$, °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
E 1	1220	2.048	1.45	1.30	1.30	240	60	60	3	300	70
2	1225	5.10	1.35	1.31	1.31	240	64	64	↓	↓	↓
3	1230	8.00	1.15	1.03	1.03	240	72	64			
END	1235	10.648									
S 1	1243	10.648	1.50	1.34	1.34	240	60	60			
2	1248	13.20	1.25	1.12	1.12	240	61	60			
3	1253	16.04	1.20	1.05	1.08	240	70	62			
END	1255	19.000									
W 1	1311	19.000	1.50	1.34	1.34	240	60	60			
2	1316	22.20	1.45	1.30	1.30	240	55	50			
3	1321	24.91	1.15	1.03	1.02	240	60	55			
END	1324	27.500									
N 1	1349	27.500	1.50	1.34	1.34	240	43	42			
2	1354	30.44	1.50	1.34	1.34	240	46	44			
3	1359	33.51	1.30	1.15	1.15	240	48	43			
END	1404	36.564									

COMMENTS:

ES-041

REPORT NO. Y-8278-3

FIELD DATA

PLANT UT Harbor St.
DATE 3/21/74
SAMPLING LOCATION stack 3
SAMPLE TYPE Particulate
RUN NUMBER 2
OPERATOR RSL
AMBIENT TEMPERATURE ° 45
BAROMETRIC PRESSURE
STATIC PRESSURE, (P_s) -.5
FILTER NUMBER (s) EE-669

70 ml H_2O collected

PROBE LENGTH AND TYPE x15' S.S.
NOZZLE I.D. 3/16
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER -
METER BOX NUMBER 1578
METER $\Delta H_@$ 1.88
C FACTOR .74
PROBE HEATER SETTING -
HEATER BOX SETTING -
REFERENCE Δp .21

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr CLOCK) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
E 1	1517	6.565	1.50	1.34	1.34	290	40	39	3	100	70
2	1522	9.44	1.45	1.30	1.30	290	50	43			
3	1527	12.66	1.20	1.08	1.08	290	57	54			
END	1532	15.811									
N 1	1539	15.811	1.50	1.34	1.34	290	50	52			
2	1544	18.78	1.40	1.24	1.24	290	52	47			
3	1549	21.74	1.20	1.08	1.08	290	54	46			
END	1554	24.372									
W 1	1604	24.372	1.35	1.12	1.12	290	45	45			
2	1609	27.81	1.40	1.24	1.24	290	57	46			
3	1614	30.42	1.10	.99	.99	290	53	46			
END	1619	33.248									
S 1	1628	33.248	1.40	1.24	1.24	290	46	44			
2	1633	35.96	1.25	1.12	1.12	290	50	46			
3	1638	39.18	1.10	.99	.99	290	53	47			
END	1643	41.912									

ES-041

COMMENTS:

FIELD DATA

PLANT *WI, Hecker St.*
DATE *2/22/74*
SAMPLING LOCATION *Stack 3*
SAMPLE TYPE *Particulate*
RUN NUMBER *3*
OPERATOR *RSL*
AMBIENT TEMPERATURE *45*
BAROMETRIC PRESSURE *29.60*
STATIC PRESSURE, (P_s) *-5*
FILTER NUMBER (s) *EL-673*

50 ml H_2O collected

PROBE LENGTH AND TYPE *≈15' S.S.*
NOZZLE I.D. *3/16*
ASSUMED MOISTURE, % *10*
SAMPLE BOX NUMBER *-*
METER BOX NUMBER *1578*
METER $\Delta H_@$ *1.88*
C FACTOR *.94*
PROBE HEATER SETTING *-*
HEATER BOX SETTING *-*
REFERENCE Δp *2.1*

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY *5* MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
S1	0918	22.220	1.50	1.34	1.34	240	50	50	3	300	20
2	0923	25.36	1.30	1.18	1.18	240	55	50			
3	0928	28.14.	1.25	1.13	1.13	240	56	51			
END	0933	31.000									
W1	0940	31.000	1.45	1.30	1.30	240	51	50			
2	0945	34.16	1.30	1.18	1.18	240	58	52			
3	0950	37.30	1.25	1.13	1.13	240	58	51			
END	0955	40.048									
N1	1005	40.048	1.45	1.30	1.30	240	54	52			
2	1010	43.25	1.30	1.08	2.08	240	56	52			
3	1015	46.00	1.15	1.03	1.03	240	55	53			
END	1020	48.261									
E1	1031	48.261	1.40	1.24	1.24	240	53	50			
2	1036	52.20	1.25	1.13	1.13	240	55	51			
3	1041	55.00	1.20	1.08	1.08	240	57	53			
END	1046	57.842									

COMMENTS:

York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.37	.50	.731	.860
.55	.75	.733	.856
.74	1.00	.740	.860
.92	1.25	.736	.858
1.12	1.50	.747	.864

$$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$$

Pitot Tube # 15F

F_s = .860

F_{std} = 1.00

Calibrated by CMEl[illegible]

Date 12/4/73

ick Connects OK Valves OK

ers OK

t Meter OK

eters OK

OK

cal Check - Amphenol OK

OK

Gauge OK

eck at 27" hg. - 0 CFM

s

l each item when checked and write in any remarks.

Calibration - Orifice and Meter

2-15-74 Box No. S-1578 P_b 30.42

e	CF_w	CF_d	T_W	IT_d	OT_d	T_d Avg.	Time t
	5	5.27	58	89	78	84	13.12
	5	5.29	59	93	78	85	9.48
	10	10.62	58	97	77	87	13.92
	10	10.48	57	98	74	86	9.62
	10	10.55	57	97	71	84	7.87
	10						

late Y & $H_@$ at man. 2.0

$$Y = \frac{CF_w\, P_b\, (T_d \text{ avg.} + 460)}{CF_d\, (P_b + 0.147)(T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)(\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)}\left(\frac{(T_w + 460)t}{CF_w}\right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)}\left((\quad + 460)t\right)^2$$

Tolerances

Y = 0.99 - 1.00 - 1.01

$\Delta H_@$ = 1.6 - 1.84 - 2.1

REPORT NO.

Calibration Calculations   Box No. [illegible]

Date 2-15-74

$$\Delta H_@ = \frac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\frac{(T_w + 460)\, t}{CF_w} \right)^2$$

$$Y = \frac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CFd\left(P_b + \frac{\text{Man. Orifice}}{13.6}\right)(T_w + 460)}$$

Man.	H@
.5	1.79
1.0	1.87
2.0	1.88
4.0	1.93
6.0	1.96
8.0	

$$\Delta H_@ = \frac{0.01585}{30.42\,(79 + 460)} \left(\frac{(58 + 460)\,\text{[illegible]}}{5} \right)^2$$

$$\Delta H_@ = \frac{0.0317}{30.42\,(78 + 460)} \left(\frac{(58 + 460)\,\text{[illegible]}}{5} \right)^2$$

$$\Delta H_@ = \frac{0.0634}{30.42\,(77 + 460)} \left(\frac{(58 + 460)\,13.42}{10} \right)^2$$

$$\Delta H_@ = \frac{0.1268}{30.42\,(74 + 460)} \left(\frac{(57 + 460)\,\text{[illegible]}}{10} \right)^2$$

$$\Delta H_@ = \frac{0.1902}{30.42\,(71 + 460)} \left(\frac{(57 + 460)\,\text{[illegible]}}{10} \right)^2$$

$$\Delta H_@ = \frac{0.2536}{\_\_\_} \left(\frac{(\_\_\_ + 460)}{\_\_\_} \right)^2$$

Man.	Y
.5	
1.0	
2.0	
4.0	
6.0	
8.0	

$$Y = \frac{5 \times 30.42\,(\text{[illegible]} + 460)}{5.27\,(30.42 + 0.0368)(58 + 460)}$$

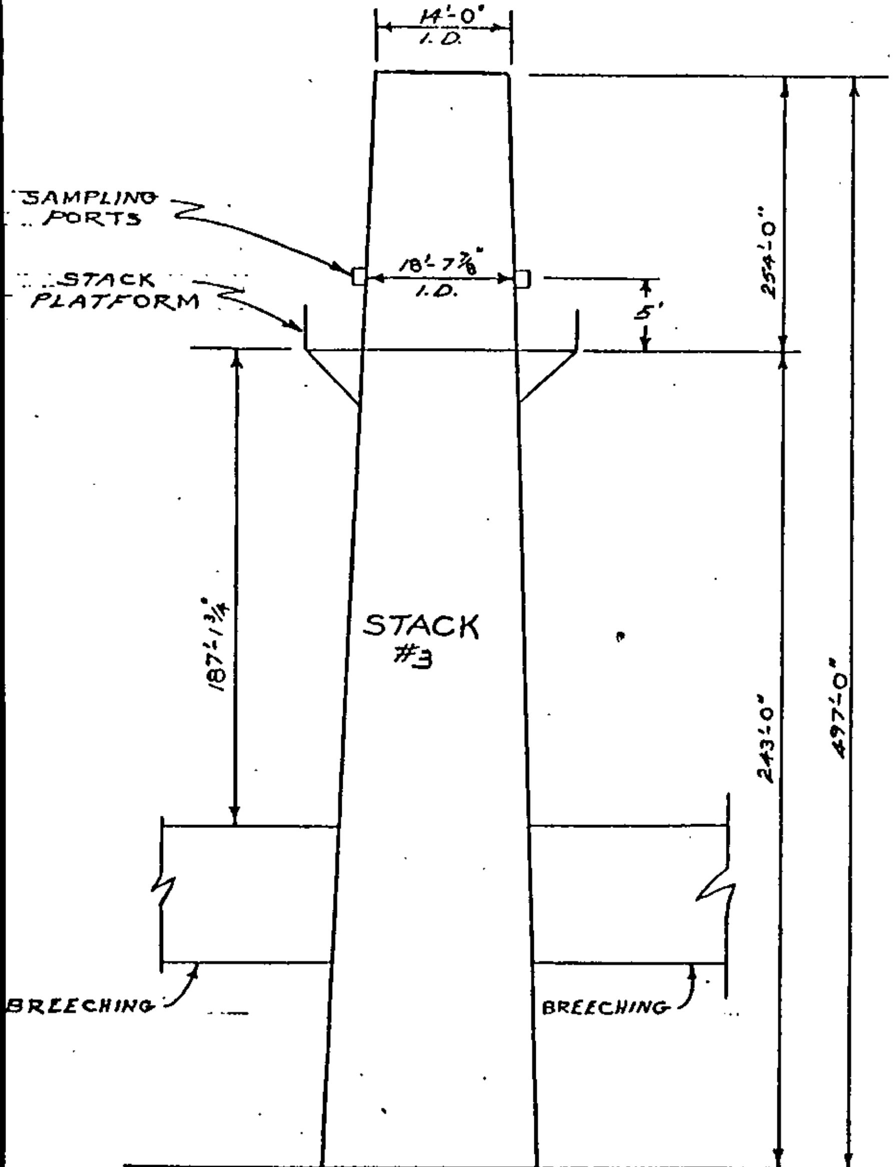
$$Y = \frac{5 \times 30.42\,(85 + 460)}{5.24\,(30.42 + 0.0737)(58 + 460)}$$

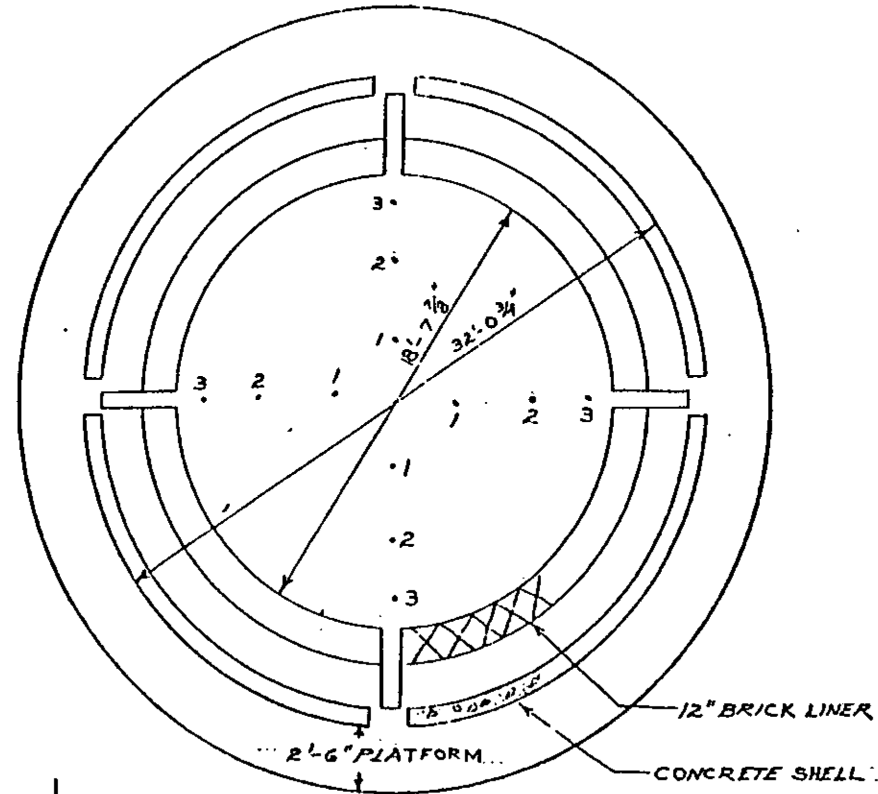
$$Y = \frac{10 \times 30.42\,(87 + 460)}{10.62\,(30.42 + 0.147)(58 + 460)}$$

$$Y = \frac{10 \times 30.42\,(86 + 460)}{10.48\,(30.42 + 0.294)(57 + 460)}$$

$$Y = \frac{10 \times 30.42\,(84 + 460)}{10.55\,(30.42 + 0.431)(57 + 460)}$$

$$Y = \frac{\_\_\_ \times \_\_\_\,(\_\_\_ + 460)}{\_\_\_\,(\_\_\_ + 0.588)(\_\_\_ + 460)}$$





TRAVERSE POINT No.	DISTANCE FROM WALL
3	9.9"
2	32.9"
1	66.0"

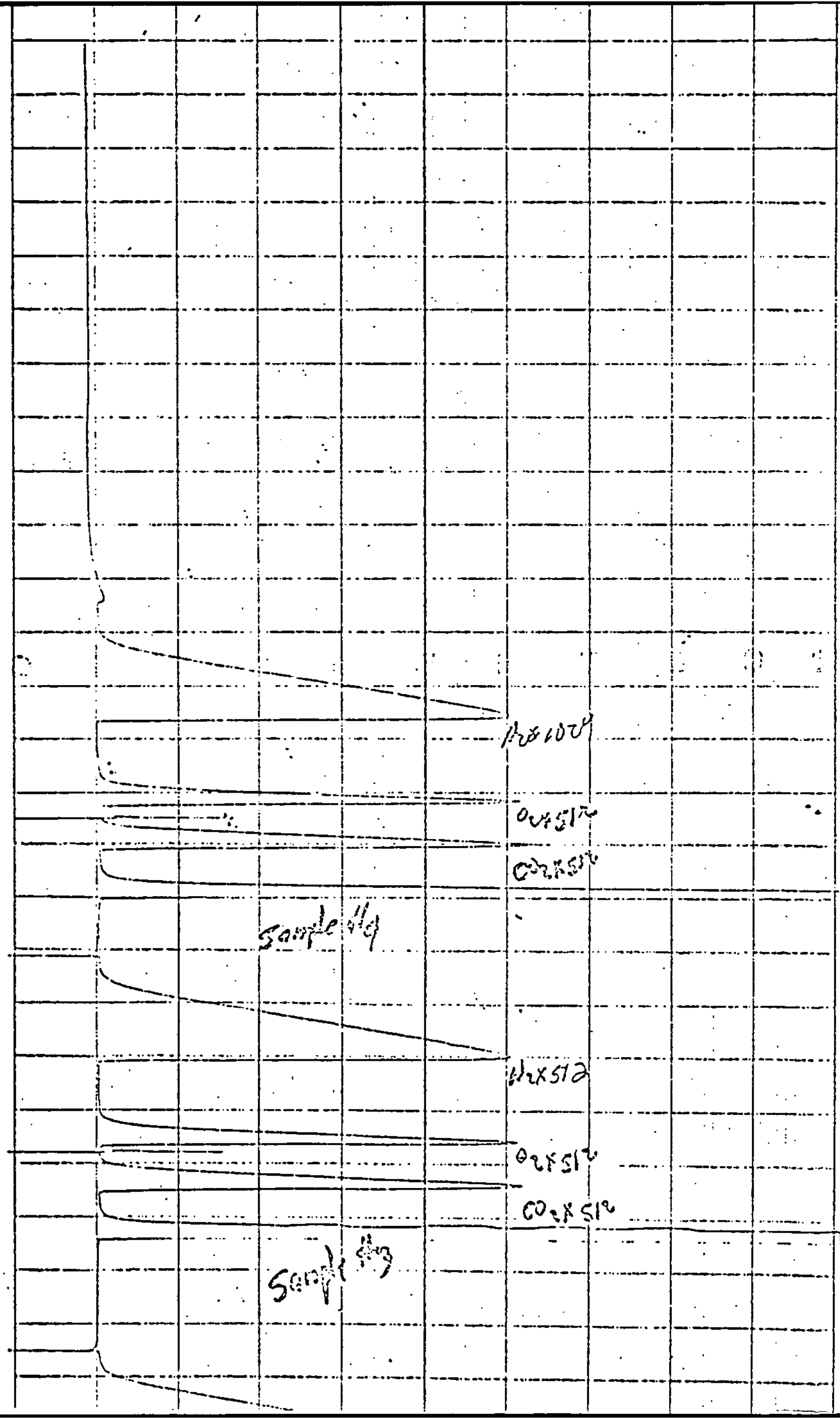
REVISED	THE UNITED ILLUMINATING CO. NEW HAVEN, CONN. STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK No. 3 BRIDGEPORT HARBOR STATION
	DRAWN BY P.L.O. DATE 4-2-74
	TRACED BY DATE
	APPROVED BY DATE
	SCALE NONE DRAWING NO. 47212-8

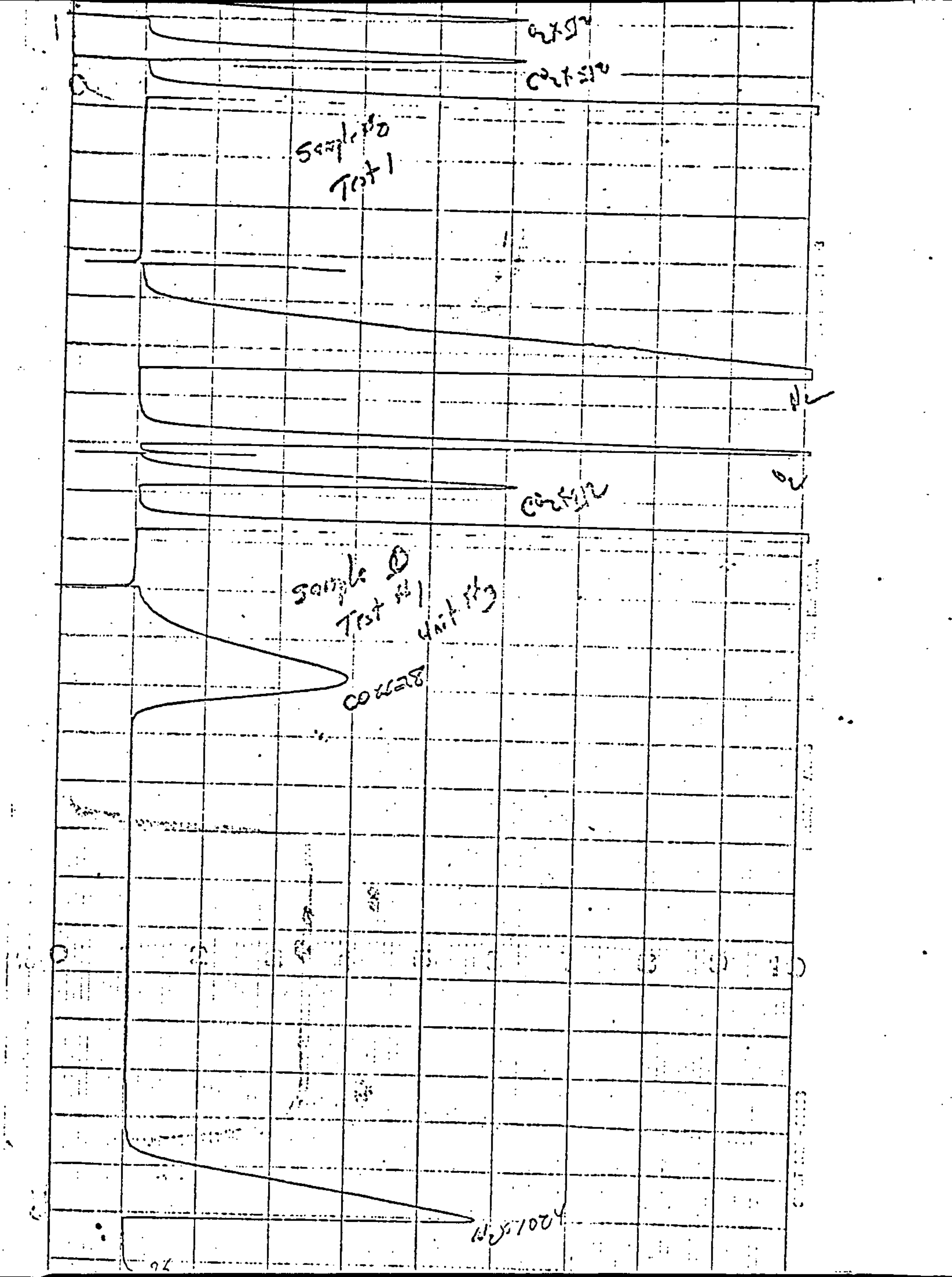
APPENDIX B

NITROGEN OXIDE TEST

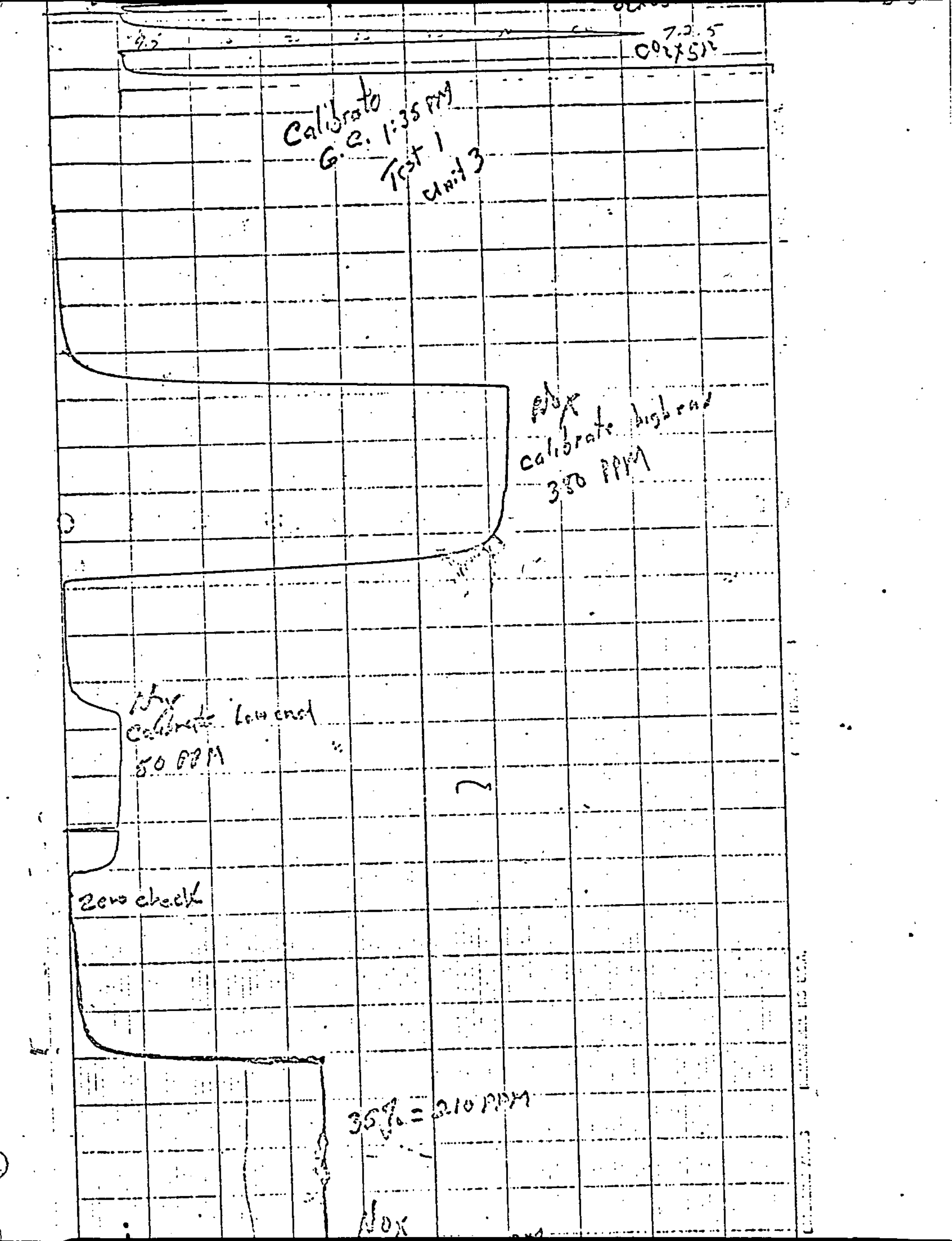
FLUE GAS ANALYSIS

TEST NO. 1

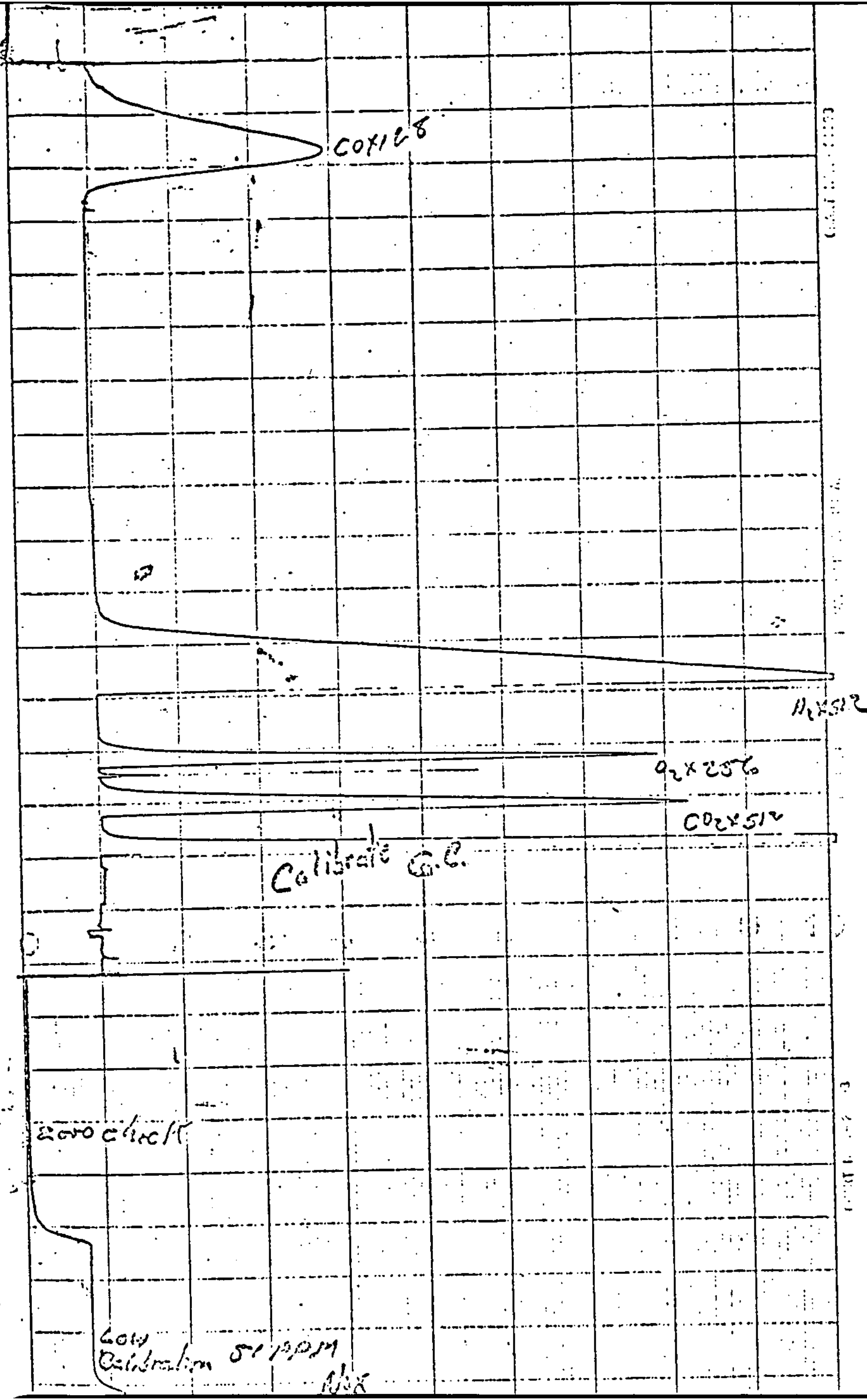

H2x1024
O2x512
CO2x512
Sample #4
H2x512
O2x512
CO2x512
Sample #3

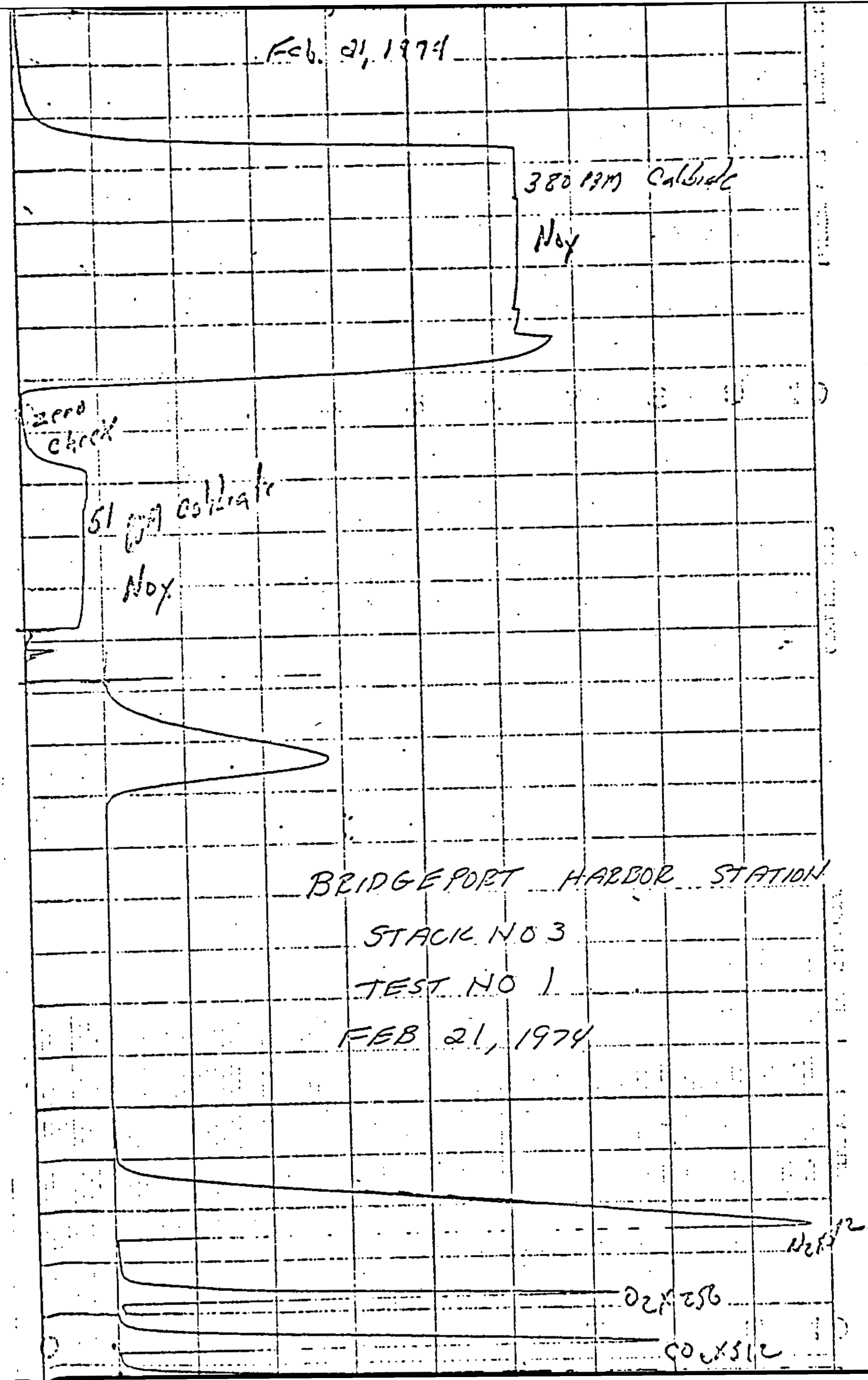


Sample
Test 1
Sample
Test #1

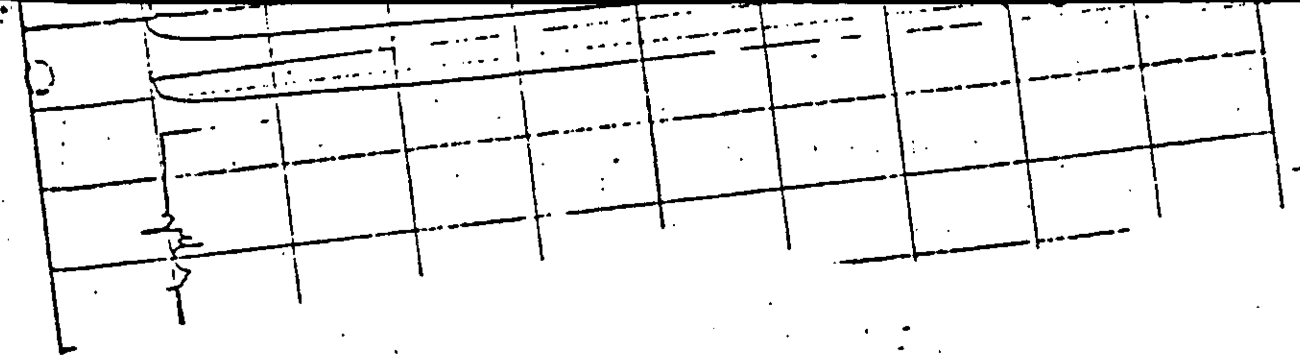


7.2.5
CO2 X 5%
Calibrate G.C. 1:35 PM Test 1 Unit 3
ЛОх calibrate high end 350 PPM
ЛУх Calibrate low end 50 PPM
zero check
35% = 210 PPM
Лох


CO x 128
N_2 x 512
O_2 x 256
CO_2 x 512
Calibrate G.C.
Zero check
Low Calibration 5 PPM



Feb. 21, 1974
380 PPM Calibrate
NOx
Zero check
51 ppm calibrate
NOx
BRIDGEPORT HARBOR STATION
STACK NO 3
TEST NO 1
FEB 21, 1974



THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number #3 [illegible] Date 2/21/74

Boiler Number #3 Time 12:5[illegible] PM

Plant Location Harbor [illegible]

Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	10.65%	10.76%	[illegible]		10.[illegible]%	44/100	[illegible]
CO, % Vol (dry)	[illegible]	[illegible]			[illegible]	28/100	+ [illegible]
O2, % Vol (dry)	[illegible]	[illegible]	[illegible]		[illegible]	32/100	+ [illegible]
N2, % Vol (dry)	[illegible]	81.3[illegible]	81.[illegible]%		[illegible]	28/100	+ [illegible]

Avg. molecular wt. of dry stack gas = [illegible]3

TEST NO. 2

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number #3 [illegible]　　Date [illegible]

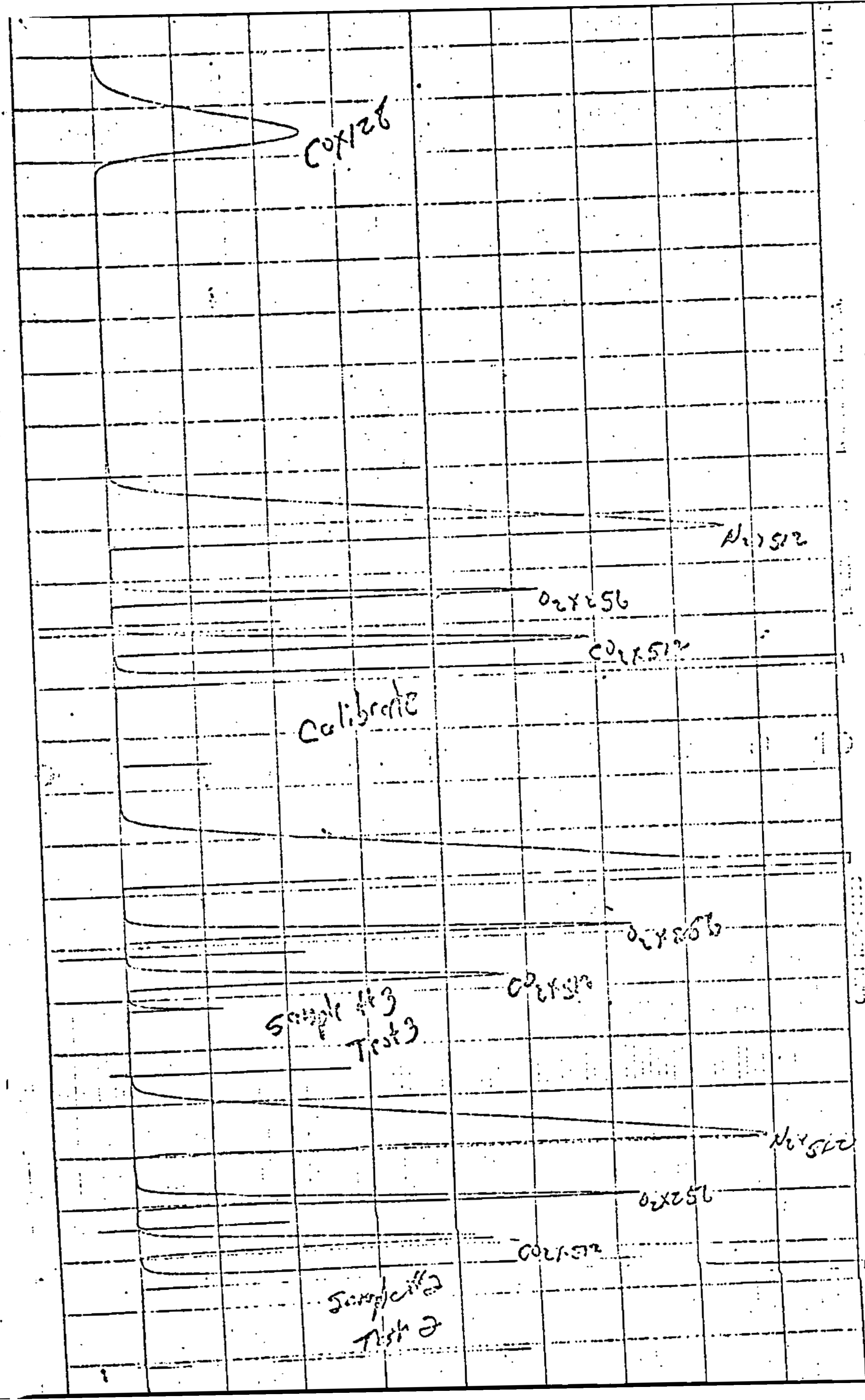
Boiler Number #3　　Time 3:45 PM

Plant Location Harbor [illegible]

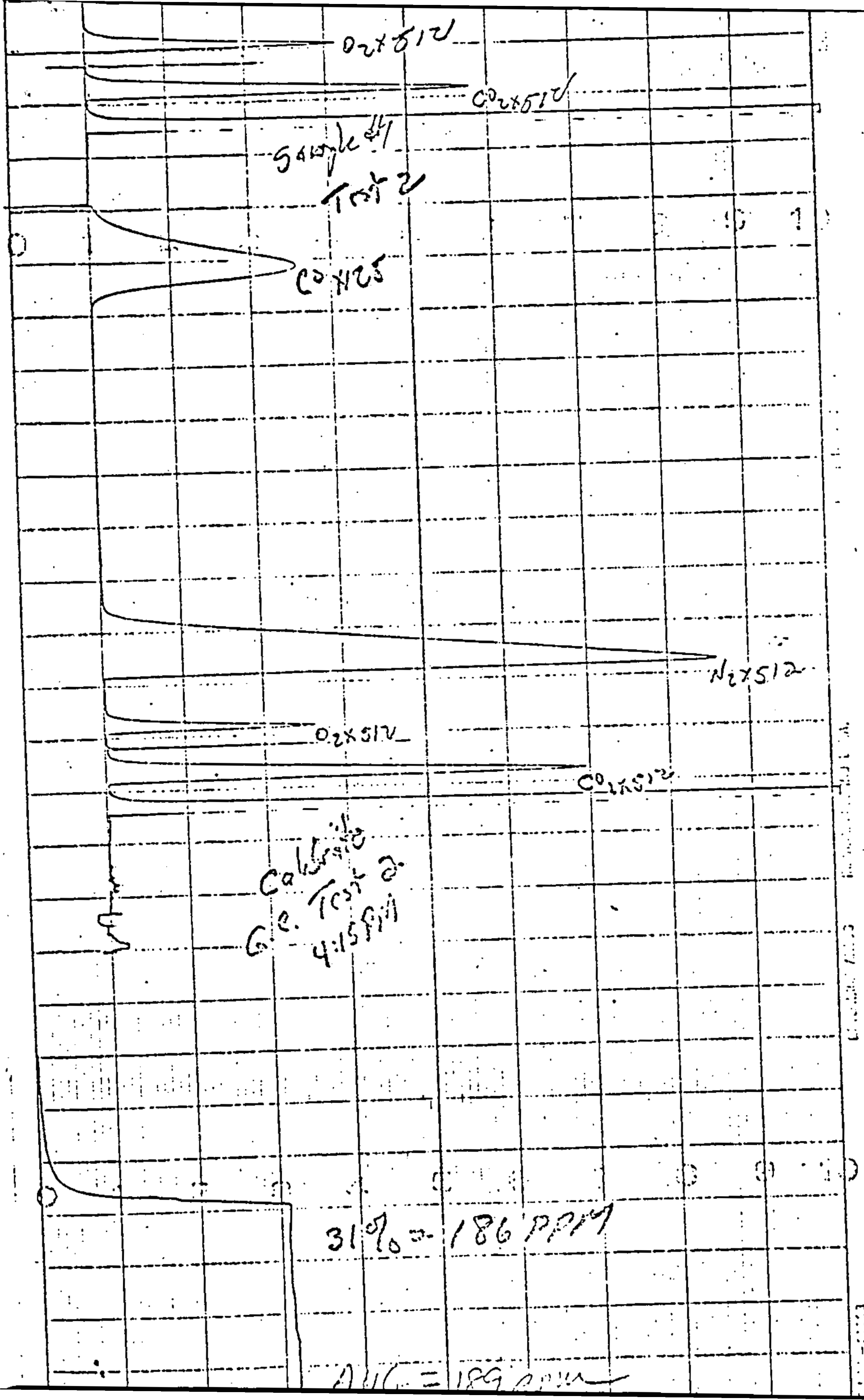
Sampling Point Location [illegible]

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	[illegible]	[illegible]	[illegible]		[illegible]	44/100	[illegible]
CO, % Vol (dry)	[illegible]				[illegible]	28/100	+ [illegible]
O_2, % Vol (dry)	[illegible]	6.32	[illegible]		6.33	32/100	+ [illegible]
N_2, % Vol (dry)	71.61	[illegible]	[illegible]		[illegible]	28/100	+ [illegible]

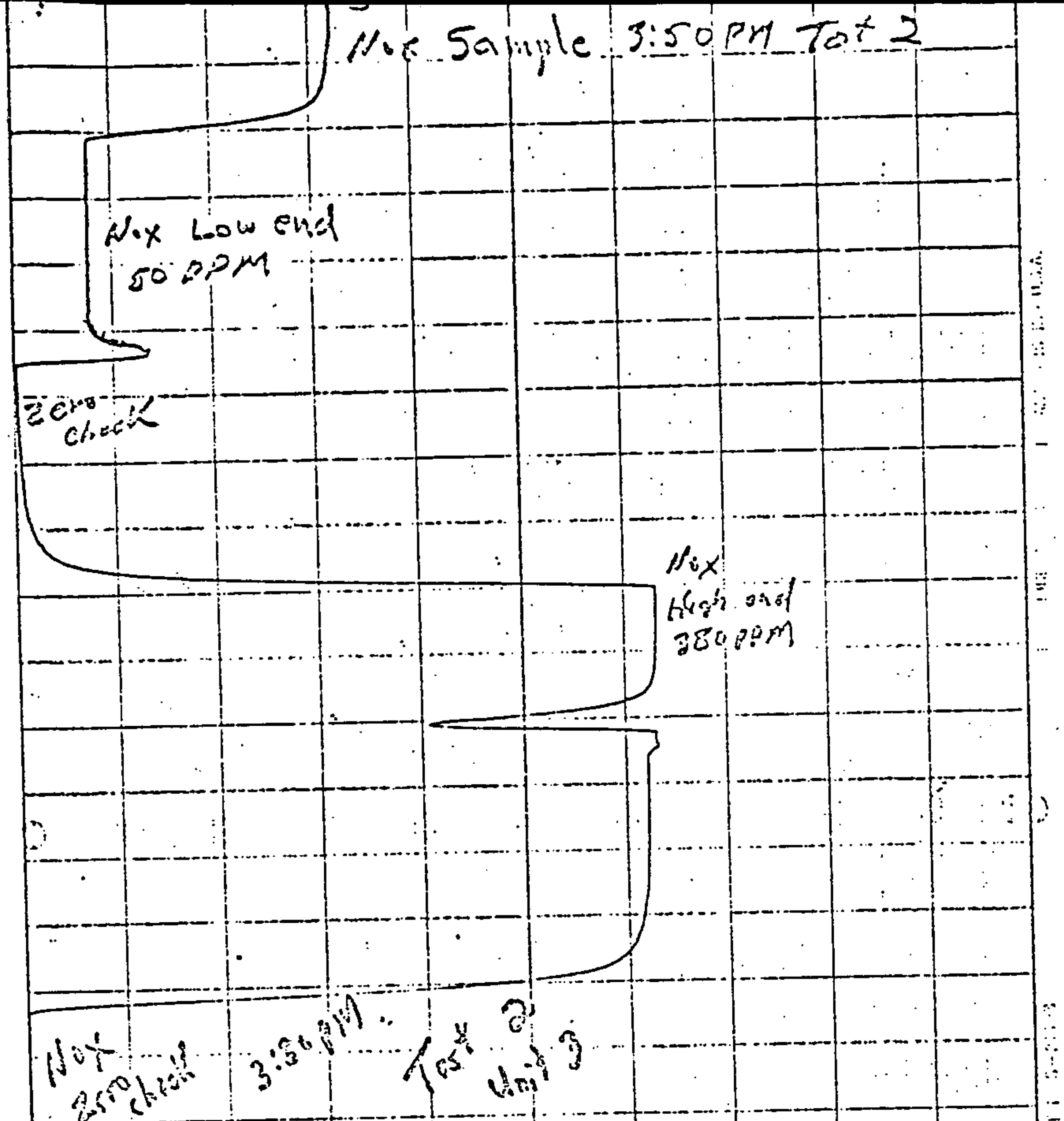
Avg. molecular wt. of dry stack gas = [illegible]



CO x128
N2 x512
O2 x256
CO2 x512
Calibrate
O2 x256
CO2 x512
Sample #3
Test 3
N2 x512
O2 x256
CO2 x512
Sample #2
Test 2



$O_2 \times 512$
$CO_2 \times 512$
Sample #4
Test 2
$CO_2 \times 25$
$N_2 \times 512$
$O_2 \times 512$
$CO_2 \times 512$
Calibrate
G.C. Test 2
4:15PM
31% = 186 PPM
AVG = 189 ppm



BRIDGEPORT HARBOR STATION
STACK NO 3
TEST NO 2
FEB 21, 1974

TEST NO. 3

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number #3 Test #3

Date 2/20/74

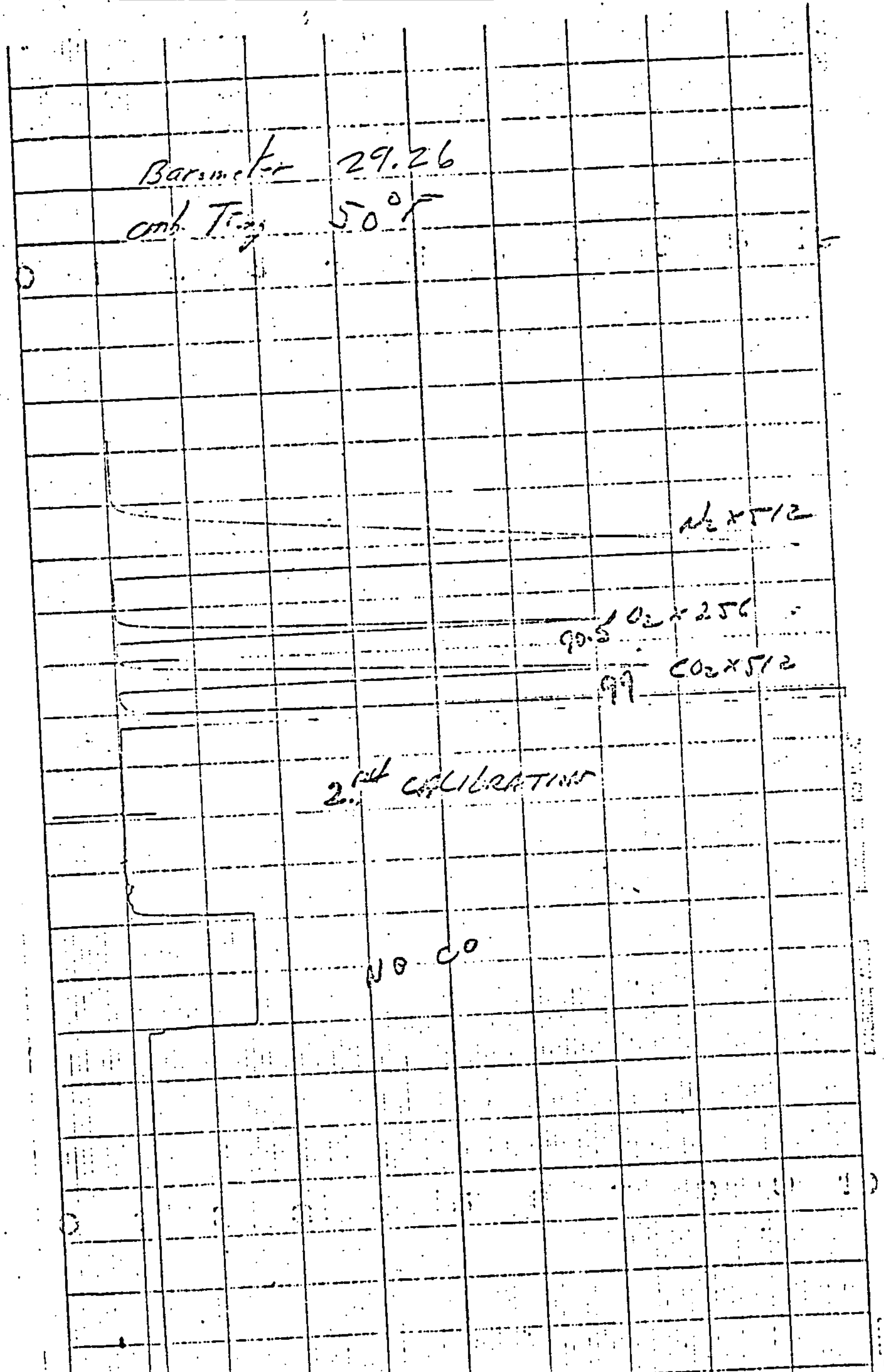
Boiler Number # 3

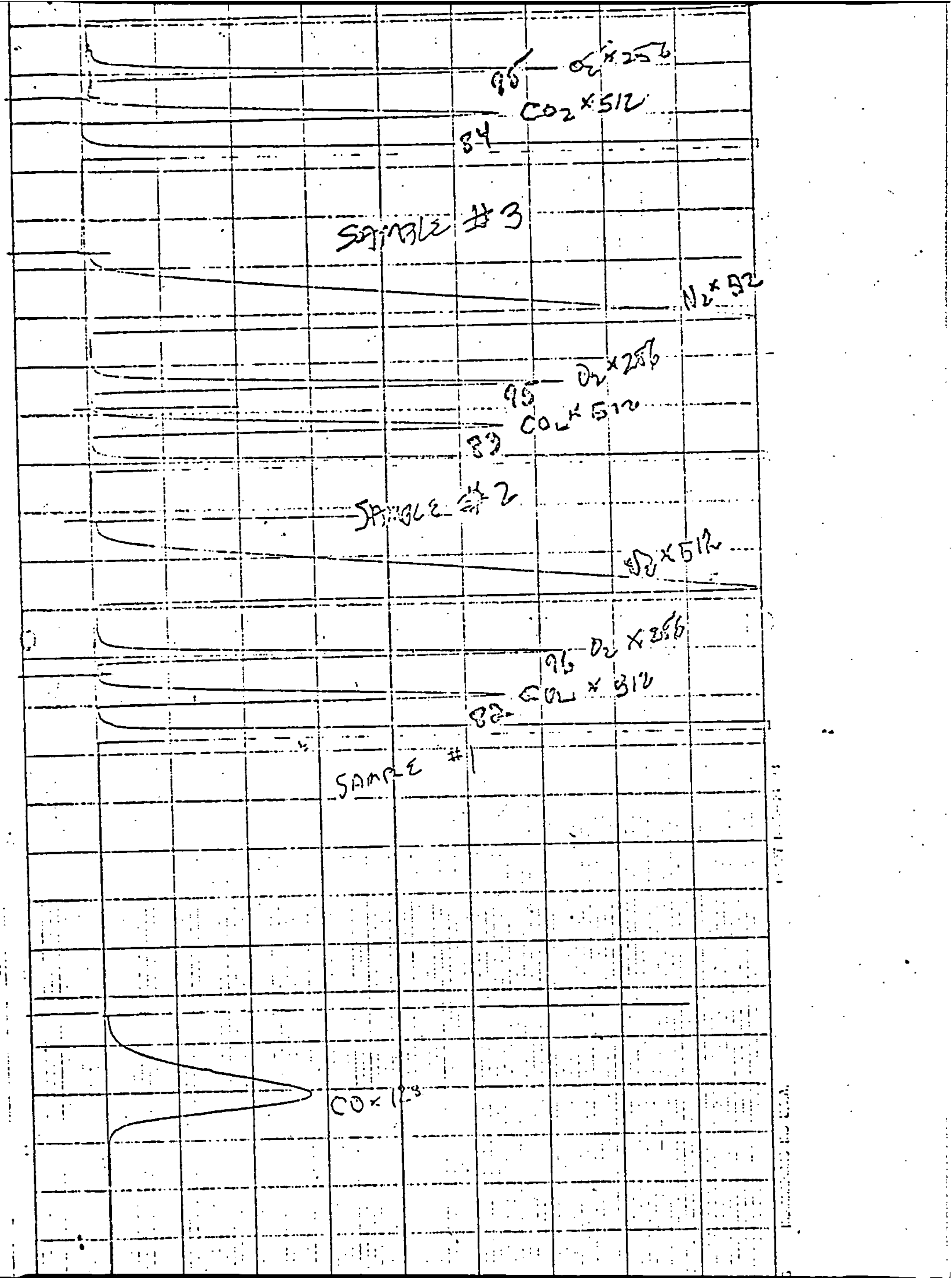
Time 10 AM

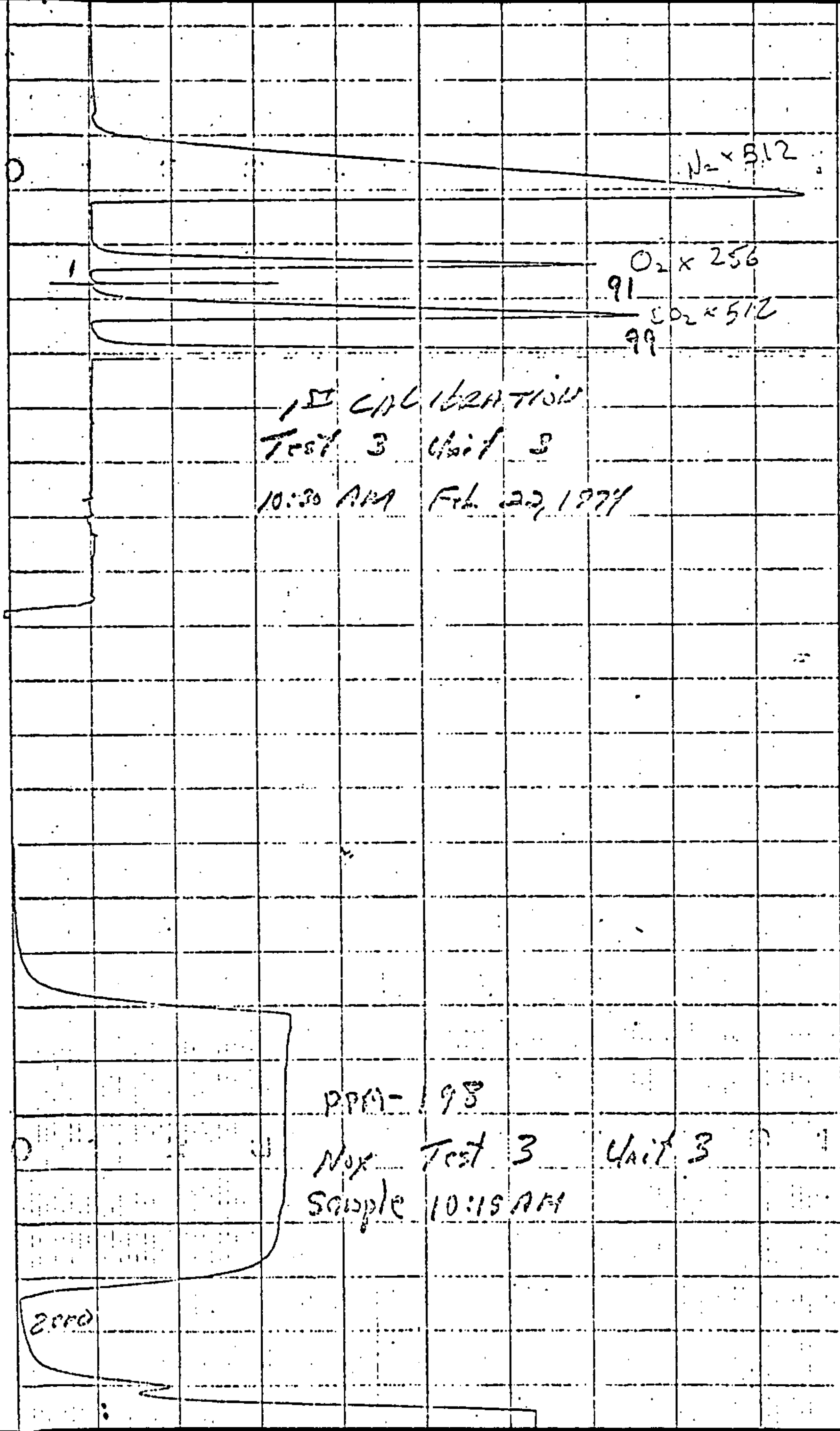
Plant Location Harbor Station.

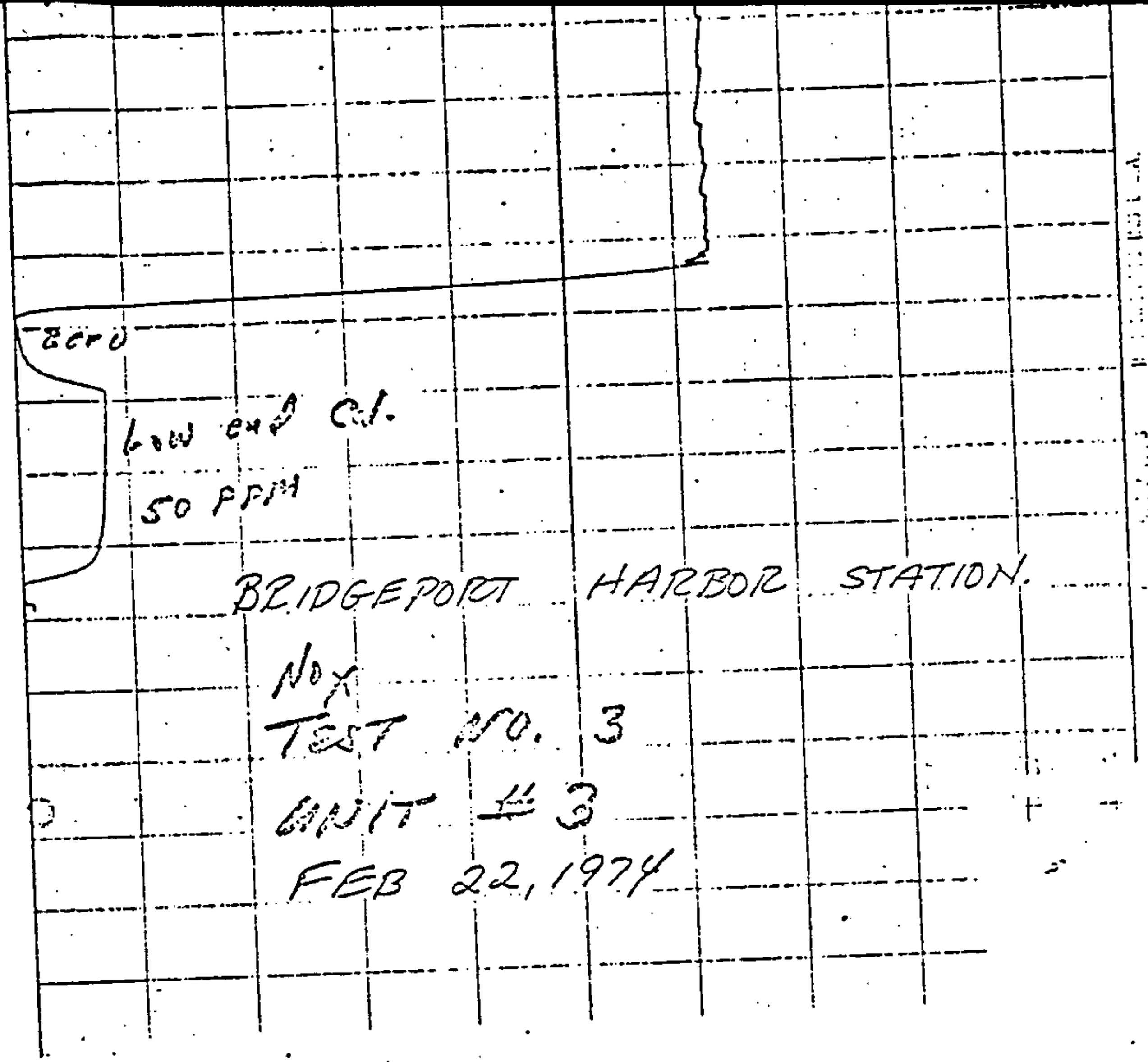
Sampling Point Location Stack

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	12.42%	12.52%	12.77%		12.57%	44/100	5.530
CO, % Vol (dry)	0.00%	0.00%	0.00%		0.00	28/100	+ 0.000
O_2, % Vol (dry)	5.66%	5.55%	5.55%		5.57	32/100	+ 1.782
N_2, % Vol (dry)	81.95%	81.93%	81.55%		81.86	28/100	+ 22.920
						Avg. molecular wt. of dry stack gas =	30.23


Barometer 29.26
amb. Temp 50°F
N_2 x 512
O_2 x 256
99.5
CO_2 x 512
99
2nd CALIBRATION
NO CO


95 O2 x 256
CO2 x 512
84
SAMPLE #3
95 O2 x 256
CO2 x 512
83
SAMPLE #2
96 O2 x 256
CO2 x 512
82
SAMPLE #1
CO x 128


$N_2 \times 512$
$O_2 \times 256$
91
$CO_2 \times 512$
99
1st CALIBRATION
Test 3 Unit 3
10:30 AM Feb. 22, 1977
PPM - 198
Nox Test 3 Unit 3
Sample 10:15 AM
zero


Zero
Low end Cal.
50 PPM
BRIDGEPORT HARBOR STATION.
NOx
TEST NO. 3
UNIT #3
FEB 22, 1974

APPENDIX C

BOILER OPERATING DATA

Unit #3
Bridgeport Harbor Station Test #1
Fuel flow readings corrected to 60° F

Time	1329	1335	1350	1405
Gross load	376.4 MW	376.4 MW	376.4 MW	375.7 MW
Net load (Accum)	171.8 MW	208.9 MW	367.6 MW	24.4 MW
Fuel flow (Accum)	12,490 Gal/hr	15,160 Gal/hr	22,270 Gal/hr	17,500 ~~[illegible]~~ Gal/hr
F.W. Temp	458° F	459° F	459° F	459° F
F.W. Flow	2,619,000 lb/hr	2,600,800 lb/hr	2,600,000 lb/hr	2,595,700 lb/hr
Excess O_2	2.93 %	2.94 %	2.99 %	2.87 %
Boiler Steam Press.	2370 PSIG	2365 PSIG	2374 PSIG	2366 PSIG
Steam Temp.	994° F	993° F	994° F	991° F
Condenser Cooling in A	38.6° F	38.1° F	37.9° F	38.8° F
cooling out A	38.6° F	38.1° F	37.9° F	38.6° F
cooling in B	74.5° F	74.5° F	73.6° F	74.5° F
cooling out B	73.2° F	72.9° F	72.7° F	73.4° F
F.D. Disc A	60° F	60° F	59° F	61° F
F.D. Disc B	—	—	—	—
A.H. in A	105° F	105° F	103° F	105° F
" " B	118° F	118° F	118° F	118° F
A.H. out A	594° F	594° F	594° F	594° F
" " B	601° F	601° F	601° F	601° F
Gas in A	687° F	688° F	688° F	687° F
" " B	695° F	696° F	695° F	695° F
Gas out A	296° F	297° F	296° F	297° F
" " B	331° F	330° F	331° F	331° F
Cond. Flow	881,500 lb/hr	1,064,700 lb/hr	1,577,200 lb/hr	1,257,000 lb/hr
Throttle Steam Flow	1,122,200 lb/hr	1,363,500 lb/hr	2,001,600 lb/hr	1,603,000 lb/hr
Main S.H. Spray Flow		76,730 ~~[illegible]~~ lb/hr	77,[illegible]40 ~~[illegible]~~ lb/hr	77,[illegible]20 ~~[illegible]~~ lb/hr
RH S.H. Spray Flow		108,410 ~~[illegible]~~ lb/hr	108,520 ~~1,665,200~~ lb/hr	108,600 ~~[illegible]~~ lb/hr
Hotwell A		89° F	88° F	90° F
Hotwell B		88° F	88° F	89° F
Barometer	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'
Temp. Amb.	44° F	44° F	44° F	44° F
R.H. Press	490 PSIG	490 PSIG	490 PSIG	489 PSIG
R.H. Temp.	979° F	979° F	980° F	978° F

Unit #3
Bridgeport Harbor Station Test #1

Time	1420	1435	1450	1505
Gross load	373.5 MW	301.2 MW	293.3 MW	381.8 MW
Net load	122.0 MW	194.1 MW	270.9 MW	24.4 MW
Fuel flow	8,870 Gal/hr	13,900 Gal/hr	19,360 Gal/hr	1,800 Gal/hr
F.W. Temp	458°F	437°F	434°F	460°F
F.W. Flow	2,602,600 lb/hr	1,996,500 lb/hr	1,941,900 lb/hr	2,571,200 lb/hr
Excess O_2	2.95%	3.07%	3.12%	3.24%
Boiler Steam Press.	2351 PSIG	2244 PSIG	2197 PSIG	2394 PSIG
Steam Temp.	996°F	1039°F	1014°F	996°F
Condenser Cooling in A	39.3°F	39.9°F	41.9°F	42.6°F
Cooling out A	39.3°F	39.7°F	41.7°F	42.6°F
Cooling in B	75.0°F	68.8°F	70.1°F	77.4°F
Cooling out B	74.1°F	68.2°F	69.4°F	77.4°F
F.D. Disc A	61°F	63°F	64°F	68.4°F
F.D. Disc B	—	—	—	—
A.H. in A	105°F	113°F	114°F	104°F
" " B	119°F	126°F	126°F	130°F
A.H. out A	593°F	560°F	546°F	582°F
" " B	600°F	565°F	551°F	587°F
Gas in A	687°F	628°F	615°F	688°F
" " B	694°F	633°F	620°F	680°F
Gas out A	296°F	282°F	273°F	288°F
" " B	331°F	316°F	305°F	325°F
Cond. Flow	627,960 lb/hr	104,470 lb/hr	1,424,900 lb/hr	119,900 lb/hr
Throttle Steam Flow	800,900 lb/hr	125,420 lb/hr	1,714,200 lb/hr	1,458,800 lb/hr
L.H.S.H. Spray Flow	77,210 ~~[illegible]~~ lb/hr			
RH S.H. Spray Flow	108,580 ~~[illegible]~~ lb/hr	128,400 ~~[illegible]~~ lb/hr	46,272 ~~[illegible]~~ lb/hr	119,840 ~~[illegible]~~ lb/hr
Hotwell A	91°	80°F	81°F	92°F
Hotwell B	89°		81°F	92°F
Barometer	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'
Temp. Amb.	44°F	45°F	45°F	45°F
R.H. Press.	484 PSIG	373 PSIG	368 PSIG	496 PSIG
R.H. Temp	976°F	973°F	972°F	989°F

Bridgeport Harbor Station Test #2

Time	1520	1535	1550	1605
Gross load	382.4 MW	379.5 MW	378.9 MW	375.4 MW
Net load	124.0 MW	211.9 MW	310.5 MW	25.4 MW
Fuel flow	9,010 Gal/hr	15,300 Gal/hr	22,510 Gal/hr	1,780 Gal/hr
F.W. Temp	460°F	459°F	459°F	458°F
F.W. Flow	2,622,900 lb/hr	2,645,400 lb/hr	2,631,600 lb/hr	2,595,800 lb/hr
Excess O_2	3.24%	3.24%	3.24%	3.24%
Boiler Steam Press	2415 PSI	2394 PSI	2393 PSI	2869 PSI
Steam Temp	1000°F	991°F	996°F	993°F
Condenser Cooling in A	42.6 ~~105~~ °F	43.1 ~~106~~ °F	43 ~~108~~ °F	45.1 ~~109~~ °F
Cooling out A	42.8°F	43.1°F	43.2°F	45.3°F
Cooling in B	78.7°F	80.2°F	80.1°F	81.1°F
Cooling out B	78.7°F	80.2°F	80.3°F	81.5°F
F.D. Disc A	61°F	61°F	64°F	63°F
F.D. Disc B	—	—	—	—
A.H. in A	105°F	106°F	108°F	107°F
" " B	121°F	122°F	122°F	120°F
A.H. out A	591°F	594°F	595°F	593°F
" " B	598°F	602°F	602°F	600°F
Gas in A	686°F	688°F	688°F	684°F
" " B	696°F	698°F	698°F	694°F
Gas out A	296°F	298°F	300°F	298°F
" " B	336°F	334°F	334°F	331°F
Cond. Flow	612,400 lb/hr	1,049,700 lb/hr	1,551,900 lb/hr	125,188
Throttle Steam Flow	809,700 lb/hr	1,381,100 lb/hr	2,034,200 lb/hr	162,088 lb/hr
L.H.S.H. Spray Flow			55,090 lb/hr	80,250 lb/hr
Rt S.H. Spray Flow			95,740 lb/hr	94,900 lb/hr
Hotwell A	93°F	94°F	94°F	95°F
Hotwell B	93°F	94°F	94°F	94°F
Barometer	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'	30.12 @ 243'
Temp. Amb.	45°F	45°F	45°F	45°F
R.H. Press	499 PSI	495 PSI	495 PSI	490 PSI
R.H. Temp	979°F	975°F	972°F	975°F

Unit #3
Bridgeport Harbor Station Test #2
Feb 21, 1974

Time	1620	1635	1650
Gross load	373.8 MW	374.4 MW	370.9 MW
Net load	123.0 MW	208.9 MW	305.6 MW
Fuel flow	8,880 Gal	15,090 Gal	22,130 Gal
F.W. Temp	458°F	458°F	457°F
F.W. Flow	2,595,200 lb/hr	2,573,000 lb/hr	2,563,000 lb/hr
Excess O_2	3.24%	3.24%	3.24%
Boiler Steam Press.	2362 PSI	2362 PSI	2344 PSI
Steam Temp.	994°F	995°F	997°F
Condenser Cooling in A	45.6°F	46.8°F	46.0°F
cooling out A	46.1°F	47.0°F	46.2°F
cooling in B	81.1°F	82.1°F	81.8°F
cooling out B	81.5°F	82.7°F	82.8°F
F.D. Disc A	64°F	64°F	61°F
F.D. Disc B	—	—	—
A.H. in A	108°F	108°F	109°F
" " B	121°F	121°F	122°F
A.H. out A	592°F	593°F	592°F
" " B	600°F	600°F	600°F
Gas in A	685°F	685°F	684°F
" " B	694°F	694°F	693°F
Gas out A	298°F	298°F	298°F
" " B	331°F	331°F	332°F
Cond. Flow	623,300 lb/hr	1,057,800 lb/hr	1,551,100 lb
Throttle Steam Flow	799,700 lb	1,357,800 lb	1,989,800 lb
L.H.S.H. Spray Flow	64,510 lb	71,260 lb	64,300 lb
Rt S.H. Spray Flow	94,700 lb	94,810 lb	94,370 lb
Hotwell A	96°F	96°F	96°F
Hotwell B	96°F	96°F	96°F
Barometer	30.12 @ 243	30.12 @ 243	30.12 @ 243
Temp Amb.	45°F	45°F	45°F
R.H. Press	488 PSI	488 PSI	484 PSI
R.H. Temp.	976°F	977°F	979°F

Unit #3
Bridgeport Harbor Station Test #3
Feb 22, 1974

Time	0924	0939	0954	1009
Gross load	378.9 MW	380.2 MW	380.2 MW	380.5 MW
Net load	149.3 MW	236.2 MW	335.8 MW	49.8 MW
Fuel flow	10,850 Gal	17,180 Gal	24,410 Gal	3,630 Gal
F.W. Temp	460° F	460° F	460° F	460° F
F.W. Flow	2,664,200 lb	2,666,200 lb	2,661,700 lb	2,651,200 lb
Excess O_2	3.24 %	3.24 %	3.24 %	3.24 %
Boiler Steam Press	2397 PSI	2405 PSI	2401 PSI	2407 PSI
Steam Temp.	996° F	989° F	988° F	996° F
Condenser Cooling in A	39.9° F	40.1° F	39.8° F	40.1° F
cooling out A	39.9° F	39.8° F	39.6° F	39.8° F
cooling in B	77.3° F	77.1° F	76.9° F	77.4° F
cooling out B	76.6° F	76.5° F	76.0° F	76.5° F
F.D. Disc A	69° F	70° F	70° F	70° F
F.D. Disc B	—	—	—	—
A.H. in A	111° F	112° F	112° F	112° F
" " B	127° F	127° F	128° F	128° F
A.H. out A	604° F	604° F	603° F	603° F
" " B	608° F	608° F	606° F	607° F
Gas in A	700° F	700° F	699° F	699° F
" " B	706° F	706° F	704° F	705° F
Gas out A	306° F	306° F	306° F	306° F
" " B	338° F	341° F	344° F	340° F
Cond. Flow	757,700 lb	1,208,400 lb	1,723,600 lb	256,900 lb
Throttle Steam Flow	97,610 lb	1,547,400 lb	2,201,200 lb	326,100 lb
L.M. S.H. Spray flow	—	87,290 lb	87,300 lb	86,970 lb
RH S.H. Spray Flow	—	110,720 lb	110,810 lb	110,470 lb
Hotwell A	91° F	91° F	91° F	91° F
Hotwell B	90° F	90° F	90° F	90° F
Barometer	29.26 @ 243'	29.26 @ 243'	29.26 @ 243	29.26 @ 243'
Temp Amb.	50° F	50° F	50° F	50° F
R.H. Press	497 PSI	498 PSI	498 PSI	498 PSI
R.H. Temp.	974° F	973° F	971° F	972° F

Unit #3
Bridgeport Harbor Station Test #3
Feb 24, 1974

Time	1024	1039	1054	1109
Gross load	379.5 MW	380.2 MW	381.1 MW	380.5 MW
Net load	149.3 MW	236.2 MW	335.7 MW	49.8 MW
Fuel flow	10,860 Gal	17,190 Gal	24,430 Gal	3,630 Gal
F.W. Temp	460°F	460°F	460°F	458°F
F.W. Flow	2,659,100 lb	2,660,300 lb	2,663,400 lb	2,655,800 lb
Excess O_2	3.24 %	3.24 %	3.24 %	3.24 %
Boiler Steam Press	2396 PSI	2400 PSI	2404 PSI	2401 PSI
Steam Temp.	989°F	989°F	988°F	988°F
Condenser Cooling in A	41.5°F	41.5°F	40.3°F	40.1°F
cooling out A	40.6°F	40.6°F	40.1°F	40.3°F
cooling in B	77.7°F	80.6°F	76.9°F	76.9°F
cooling out B	77.7°F	76.8°F	76.2°F	76.2°F
F.D. Disc A	71°F	71°F	71°F	72°F
F.D. Disc B	—	—	—	—
A.H. in A	112°F	109°F	112°F	113°F
" " B	128°F	125°F	128°F	129°F
A.H. out A	603°F	603°F	602°F	602°F
" " B	607°F	607°F	606°F	606°F
Gas in A	699°F	698°F	697°F	697°F
" " B	705°F	704°F	703°F	703°F
Gas out A	306°F	302°F	306°F	307°F
" " B	339°F	343°F	344°F	341°F
Cond. Flow	768,400 lb	1,215,900 lb	1,728,000 lb	258,100 lb
Throttle Steam Flow	980,200 lb	1,551,300 lb	2,205,100 lb	326,700 lb
L.H.S.H. Spray Flow	86,900 lbs	86,940 lbs	87,100 lb	87,020 lbs
RH S.H. Spray Flow	109,980 lb	110,470 lbs	110,540 lbs	110,470 lbs
Hotwell A	92°F	92°F	90°F	91°F
Hotwell B	91°F	90°F	90°F	90°F
Barometer	29.26 @ 243'	29.26 @ 243'	29.26 @ 243'	29.26 @ 243'
Temp. Amb.	50°F	50°F	50°F	50°F
R.H. Press	497 PSI	497 PSI	498 PSI	497 PSI
R.H. Temp.	972°F	972°F	972°F	972°F

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1) Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{\circ}R}{inHg}\right) Vm \left(\frac{Pbar + \frac{\Delta H}{13.6}}{Tm}\right) \qquad eg.5\text{-}1$$

$$= \left(17.71 \frac{^{\circ}R}{inHg}\right) 34.52\ ft^3 \left(\frac{30.12\ in\ Hg + \frac{1.217\ in\ H_2O}{13.6}}{517.8\ R}\right)$$

$$= 35.46\ ft^3$$

2) Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{FT^3}{M}\right) Vlc \qquad eg.5\text{-}2$$

$$= \left(0.0474 \frac{FT^3}{M}\right) 77.6\ ml$$

$$= 3.68\ FT^3$$

3) Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

$$= \frac{3.68\ FT^3}{3.68\ FT^3 + 35.67\ FT^3}$$

$$= .0934 \times 100\% = 9.34\%$$

4) <u>Molecular Weight (dry)</u>

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%\ N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (10.72) + 0.32\ (7.88) + 0.28\ (81.40) + 0.28\ (0.00)$$

$$= 30.03 \text{ lb/lb-mole}$$

5) <u>Molecular Weight (wet)</u>

$$Ms = Md\ (1-Bws) + 18\ Bws$$

$$= 30.03\ (1-.0934) + 18\ (.0934)$$

$$= 28.91 \text{ lb/lb-mole}$$

6) Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}} \left(\frac{Ts}{Ps\ \ Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (.86)\ (1.161) \left(\frac{750}{30.08 \times 28.9}\right)^{1/2}$$

$$= 79.2 \text{ F.P.S.}$$

7) <u>Gas Volumetric Flow Rate, ACFM</u>

$$ACFM = Vs \times A_S \times 60 \text{ sec/min}$$
$$= 79.2 \times 273.36\ FT^2 \times 60 \text{sec/min}$$
$$= 1,299,007 \text{ ACFM}$$

8) <u>Gas Volumetric Flow Rate, SCFM</u>

$$Qs = 60\ (1-Bws)\ Vs\ A_S \left(\frac{Tstd}{Ts}\right)\left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.0934)\ (79.2)\ (273.36) \left(\frac{530}{750}\right)\left(\frac{30.08}{29.92}\right)$$

$$= 836,782 \text{ SCFM}$$

9) Gas Volumetric Flow Rate, lb/hr

$$W_s = Q_s \times \frac{60 \text{ min}}{\text{hr}} \times \frac{Md}{386 FT^3}$$

$$= 836{,}782 \text{ SCFM} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{30.03 \text{ lb/lb-mole}}{386 \quad FT^3}$$

$$= 3{,}905{,}994 \text{ lb/hr}$$

10) Particulate Concentrations, gr/SCF

$$C's = \left(0.0154 \frac{gr}{mg}\right) \frac{Mn}{Vmstd} \qquad \text{eg. 5-4}$$

$$= \left(0.0154 \frac{gr}{mg}\right) \frac{28.8 \text{ mg}}{35.46 \text{ FT}^3}$$

$$= .0124 \quad \text{gr/SCF}$$

11) Particulate Concentrations, lb/FT^3

$$Cs = \frac{\left(\frac{1}{453600} \cdot \frac{lb}{mg}\right) \quad Mn}{Vmstd} \qquad \text{eg.5-5}$$

$$= \frac{\left(\frac{1}{453600} \quad \frac{lb}{mg}\right) \quad 28.8 \text{ mg}}{35.46 \quad FT^3}$$

$$= 1.78 \times 10^{-6} \quad \text{lb/SCF}$$

12) Particulate Concentrations, lb/hr

$$Cw = Cs \; Qs \times \frac{60 \text{ min}}{\text{hr}}$$

$$= (1.78 \times 10^{-6} \text{ lb/SCF}) \quad (836{,}782 \text{ SCFM}) \quad \frac{60 \text{ min}}{\text{hr}}$$

$$= 89.37 \text{ lb/hr}$$

13) Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{89.37 \text{ lb/hr}}{4011.4 \times 10^6 \quad \text{BTU/hr}}$$

$$= .022 \text{ lb/MBTU}$$

14) % Isokinetic Sampling

$$I = \frac{Ts\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\Delta H}{13.6}\right)\right)}{\theta\ Vs\ Ps\ An}$$

eg. 5-6

$$I = \frac{750\ (1.667)\left((0.00267)\ (77.6) + \frac{34.52}{517.8}\left(30.12 + \frac{1.217}{13.6}\right)\right)}{60\ (79.20)\ (30.08)\ (.00192)}$$

$= 101.18\%$

15) NO_x Concentrations, lb/hr

$$lb/hr = PPM \times \frac{Mw\ NO_2}{Md} \times Ws$$

$$= \frac{210}{10^6} \times \frac{46 lb/lb\text{-}mole}{30.03\ lb/lb\text{-}mole} \times 3,905,994\ \frac{lb}{hr}$$

$= 1256\ lb/hr$

16) NO_x Concentrations, lb/MBTU

$$lb/MBTU = \frac{lb/hr}{Heat\ Input}$$

$$= \frac{1256\ lb/hr}{4011.4 \times 10^6\ BTU/hr}$$

$$lb/MBTU = \frac{.313\ lb}{10^6\ BTU}$$

17) Stack Pressure (Absolute), in Hg

$$Ps = Pb + \frac{Pd}{13.6} = 30.12 + \frac{(-.5)}{13.6} = 30.08\ in\ Hg$$

18) Nozzle Area (FT^2)

$$An = \pi D^2/4 = 0.785\ (.1875/12)^2 = 1.92 \times 10^{-4}\ Ft^2$$

19) Stack Area (FT^2)

$$As = \pi D^2/4 = 0.785\ (18.6562/12)^2 = 273.36\ FT^2$$

20) Heat Input, MBTU

SP. Gr x 8.33 lb/gal x BTU/gal x gal /hr

$0.90 \times 8.33 \times 19,149 \times 27,942 = 4011.4 \times 10^6$ BTU/hr

21) Gas Density, lb/ft^3

$$Gas\ Density = \frac{Mol\ wt\ gas\ (md)}{386\ FT^3} \times \frac{Tstd}{Ts} \times \frac{Pbar}{Pstd}$$

$$= \frac{30.03}{386} \times \frac{530^oR}{750} \times \frac{30.12}{29.92} = .055\ lb/Ft^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

Test No. BHS 3 No. Runs 3

Name of Firm The United Illuminating Comapny

Location of Plant 10 Henry Street, Bridgeport, Connecticut

Type of Plant Steam Electric Generating Station

Control Equipment Electrostatic Precipitator

Sampling Point Locations Stack

Pollutants Sampled Particulates, Nitrogen Oxide

Time of Particulate Test:

Run No. 1 Date 2/21/74 Begin 1220 End 1404

Run No. 2 Date 2/21/74 Begin 1517 End 1643

Run No. 3 Date 2/22/74 Begin 0918 End 1046

PARTICULATE EMISSION DATA

Run No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-{}^{\circ}R}\right)^{\frac{1}{2}}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.860	0.860	0.860	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	1.161	1.143	1.142	
$\overline{Ts}$ = Average stack temp., $^{\circ}R$	750	750	750	
Pb = Barometric pressure, "Hg Abs.	30.12	30.12	29.26	
Pd = Gas duct pressure, "H_2O	-0.5	-0.5	-0.5	
Ps = Absolute stack gas pressure, inches Hg	30.08	30.08	29.22	
Bws = % moisture in stack gas, by volume	9.34	9.45	7.05	
Md = Molecular weight of stack gas, dry	30.03	30.17	30.23	
Ms = Molecular weight of stack gas	28.91	29.02	29.37	

Vs = Stack gas velocity, F.P.S.	79.20	77.72	78.49	
% CO_2	10.72	12.05	12.57	
% O_2	7.88	6.32	5.57	
% CO	0.00	0.00	0.00	
% N_2	81.40	81.63	81.86	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	77.6	82.0	57.8	
Vm = Volume of dry gas sampled at meter conditions, FT^3	34.52	35.35	35.62	
std = Volume of dry gas sampled at STP, FT^3	35.46	37.24	36.08	
Tm = Average dry gas meter temp., °R	517.8	507.8	513.1	
$\overline{\Delta H}$ = Average pressure drop across orifice, inches H2O	1.217	1.173	1.174	
θ = Total Sampling Time, min.	60	60	60	
Dn = Nozzle dia., inches	.1875	.1875	.1875	
An = Nozzle area, FT^2	.000192	.000192	.000192	
I = % of isokinetic sampling	101.18	107.78	103.70	
Qs = Stack gas volume at STP (SCFM)	836,782	820,046	825,816	827,548
Qa = Stack gas volume at stack conditions (ACFM)	1,299,007	1,274,732	1,287,362	1,287,034
Ws = Stack gas mass flow lbs/hr	3,905,994	3,832,971	3,880,479	3,873,148
Mp = Particulate-probe, washings, mg	-	-	-	-
Mf = Particulate-filter (mg)	-	-	-	
Mn = Particulate-total (mg)	28.8	25.8	21.0	
C's = Particulate Concentrations gr/scf	0.0124	0.0106	0.0089	0.0106
Cw = Particulate total emission lb/hr	89.37	75.28	63.42	76.02
Er = Particulate emission rate, lb/106 BTU	0.0222	0.0193	0.0162	0.0192
C = NO, concentrations, PPM	210	189	198	199
Cn = NO, lb/10^6BTU	0.313	0.284	0.299	0.298

OAQPS-78-1
76/5-II-I 260

FUEL
OIL COMBUSTION
AP-42 Section 1.3
Reference Number
24

4/93 Ref21

Emission Test Report

Steel Point Station Stack No. 4

Steam Generator Nos. 19, 20, 21, 22

1981

The United Illuminating Company
Steel Point Station
43 East Main Street
Bridgeport, Connecticut
06608

Approved by:

E. W. Somerville
Vice President, Engineering and Planning

Submitted by:

M. R. McCraven
Director of Environmental Engineering

Emission Test Report

Steel Point Station Stack No. 4
Steam Generator Nos. 19, 20, 21, 22
(Ref. "Intent to Test" Form Number 730058)

Test Conducted By
The United Illuminating Company
Development and Test Laboratory
80 Temple Street
New Haven, Connecticut
06506

United Illuminating Company Personnel Present
J. Sombati
J. Hotchkiss
J. Macknis

and by
York Research Corporation
One Research Drive
Stamford, Connecticut
06906

York Research Corporation Personnel Present
R. Epstein
J. Jasko

Prepared by:

J. S. Sombati ______
Development & Test Laboratory Supervisor

J. W. Hotchkiss ______
Assistant Mechanical Engineer

Checked by:

J. F. Crowe ______
Chief Mechanical Engineer

Test Results

Steel Point Station Steam Generator
Nos. 19, 20, 21, 22

Test Conducted on
November 16 and 17, 1973

[illegible]

Introduction

Emission tests for particulates and nitrogen oxides were conducted as required by Connecticut State Law on The United Illuminating Company Steel Point Station Steam Generator Nos. 19, 20, 21, 22, stack No. 4, located in Bridgeport, Connecticut. Testing was conducted on November 16 and 17, 1973.

Particulate testing was performed in accordance with test methods and procedures as prescribed in the Federal Register, Vol. 36, No. 247, dated December 23, 1971. Testing was performed by York Research Corporation of Stamford, Connecticut, using a sampling train as described in Appendix A.

Nitrogen oxide emission testing was performed by the United Illuminating Company Development and Test Laboratory using a Dynascience Model P-101 NO_X Analyzer. Field data is included in Appendix B.

Tests were also conducted to determine stack gas velocity, moisture content, and flue-gas analysis. The procedures used in determining these various parameters, except for flue gas analysis, are those found in the above mentioned Federal Register. The stack flue gas was analyzed by using an Analytical Instrument Development Model 512 Portable Gas Chromatograph.

York Research Corporation was retained to perform particulate tests, together with a preliminary velocity traverse, moisture determination, and fuel oil analysis. The United Illuminating Company was responsible for the flue gas analysis, nitrogen oxide analysis, and for accumulating boiler operating data.

This test report includes the information required for Item Nos. III, IV, V, VI, VII, VIII, IX, X, XI, XII and XIII from the Department of Environmental Protection's Intent to Test form in compliance with the Department of Environmental Protection's new Source Test Guidelines and Procedures, (received April 3, 1973).

TABLE I

SUMMARY OF TEST RESULTS

STEAM GENERATOR NOS. 19, 20, 21, 22

STACK NO. 4

Component	Sampling Duration		Number of Tests	Measured Concentrations	Method Employed to Determine Concentrations
	Minutes per point	Total Test Time			
1) NO_X		15 min.	3	0.25 $lb/10^6$ BTU	Dynascience Model P-101 NO_X Analyzer
2) Particulate	5	140 min.	3	0.11 $lb/10^6$ BTU	Method 5*
3) Moisture	5	140 min.	3	5.2%	Method 4*
4) Gas Analysis		15 min.	3	47% Excess Air	A.I.D. Model 512 Portable Gas Chromatograph
5) Velocity	1/2	15 min.	3	0.01" H_2O to 0.08" H_2O**	Method 2*

*Federal Register, Volume 36, No. 247, December 23, 1971
**Range of S-type Pitot - Tube Differential

TABLE II

SUMMARY OF RESULTS

STEAM GENERATOR NOS. 19, 20, 21, 22

STACK NO. 4

Test	1	2	3	Average
Date	11/16/73	11/17/73	11/17/73	
Stack Flow, ACFM	174,456	176,814	196,317	182,529
Stack Flow, SCFM	86,151	89,819	98,570	91,513
Stack Flow, lb/hr	398,526	413,121	455,363	422,337
% Excess O_2 at Test Point	8.92	9.76	9.42	9.37
Particulate Emissions				
gr/SCF	0.027	0.018	0.052	0.032
lb/hr	20.0	14.0	44.3	26.1
lb/MBTU	0.07	0.06	0.19	0.11
Nitrogen Oxide Emission				
ppm	106.5	90	93	96.5
lb/hr	65.6	57.8	65.5	63.0
lb/MBTU	0.23	0.24	0.28	0.25

particulate 26.1 lb/hr = 15.4 lb/10^3 gal

7.6 lb/10^3 gal

TABLE III

AVERAGE BOILER OPERATING DATA FOR TEST PERIODS

STEAM GENERATOR NOS. 19, 20, 21, 22

STACK 4

Test	1	2	3
Date	11/16/73	11/17/73	11/17/73
Oil Flow (Total) gal/hr	1833	1642	1644
Heat Input (Total), MBTU/hr	290.8	237.1	237.4
Stack Gas Temperature ^{o}F	534.6	535.2	543.7
Gas Density, lb/ft^3	0.040	0.041	0.041

TABLE IV

FUEL OIL ANALYSIS

STEAM GENERATOR NOS. 19, 20, 21, 22

STACK NO. 4

Test	1	2	3
Date	11/16/73	11/17/73	11/17/73
	Composition (% by Weight)		
Carbon	85.43	85.86	85.86
Hydrogen	12.70	12.66	12.66
Nitrogen	<0.1	<0.1	<0.1
Ash	0.016	0.021	0.021
Sulfur	0.360	0.401	0.401
Specific Gravity	0.895	0.897	0.897
BTU/lb	21,276	19,328	19,328
BTU/gal	158,620	144,419	144,419

1. Sampling Train Information
(Rev. Item VIII, "Intent To Test" Form)

a. Schematic Diagram and description of sampling train:

See Appendix A.

b. Media type used to determine gas stream components:

1. NO_X: Dynascience Model P-101 NO_X Analyzer

2. Particulates: Tared glass fiber filter.

3. Flue Gas Analysis: Analytical Instrument Development Model 512 Portable Gas Chromatograph

c. Sampling Probes:

1. Nitrogen Oxides: Stainless steel tube

2. Particulates: See Appendix A

3. Flue Gas Analysis: Stainless steel tube.

d. Probe Cleaning Method:

See Appendix A

2. Field Data Sheets
(Ref. Item IX, "Intent To Test" Form)

See Appendices A, B, C, D.

3. Description of Operation
(Ref. Item X, "Intent To Test" Form)

The operation tested was Steel Point Station steam generator numbers 19, 20, 21, and 22, stack number 4, Registration Number St. Pt., 19-22, stack 4, having a total BTU/hr rating of 255.1 MBTU/hr (averaged over test period), burning No. 6 residual fuel oil at an average rate of 1706 gal/hr for all four boilers and having a gas flow of 182,589 ACFM average for the test period. See Table IV for fuel oil analysis.

4. Sampling Area Description
(Ref. Item XI, "Intent To Test" Form)

Emission sampling was performed in the stack 100 feet above the stack foundation (5 stack diameters above the breeching inlet and 2 stack diameters down from the top). Emission sampling was performed using four - 4" diameter sampling ports, spaced 90° apart on the stack circumference. A total of twenty eight sampling points (7 per sampling port) were used in the test for particulates. The inside diameter of the stack at the sampling location was found to be 15'-1" I.D.

a. Stack Configuration:

See Appendix A.

b. Sampling Port Location:

See Appendix A.

c. Sampling Point Position:

See Appendix A.

5. Stack and Vent Description
(Ref. Item XII, "Intent To Test" Form)

Four Babcock and Wilcox Three Drum Sterling Boilers discharge flue gas into a common breeching which enters the stack approximately 20 feet above the stack foundation. These boilers do not have any precipitators connected to the flue gas ducts.

6. Operational Parameters
(Ref. Item XIII, "Intent To Test" Form)

Electric utility steam generators burning No. 6 residual fuel oil having rated capacities as registered.

APPENDIX A

PARTICULATE TEST

V. SAMPLING METHODS

1. Port Location

The test port locations and the number of points samples were calculated from the guidelines in the Federal Register, Volume 36, Number 247, December 23, 1971. Enough points were used to assure accurate measurement of particulate emissions, temperature and velocity over the cross-sectional area of each stack. (See Figures 1 to 4.)

2. Velocity and Temperature

Velocity was determined by pitot tube in accordance with EPA Method 2. An "S"-Type Pitot Tube (2) and thermocouple (3) are rigidly attached to the sampling probe (See Figure 5). A preliminary velocity traverse was made to establish isokinetic sampling rates using EPA Method 5 sampling techniques.

3. Flue Gas Analysis

Gas analysis for CO_2 and O_2 was conducted by UI using an Orsat apparatus. Readings for each test are reported in the Summary of Results.

4. Particulate Sampling Methods - EPA Method 5

The sampling apparatus consisted of a nine (9) foot probe heated filter, four impingers, dry gas meter, vacuum pump, and calibrated orifice as shown in Figure 5. The stainless steel, button-hook type probe tip (1) was equipped with a 5/8 inch diameter fitting connected by a stainless steel coupling (2) with asbestos packing to the probe. The probe (3) consisted of 1/2 inch inside diameter medium-wall stainless steel tube with a ground steel joint on one end. The probe was logarithmically wound from the entrance end with 26-gauge nickel-chromium wire. During sampling, the wire was connected to a variable transformer to maintain a gas temperature of 300°F in the probe. The wire wound tube was wrapped with fiber glass tape and encased in a 1-inch-OD stainless steel tube for protection. The end of the steel tube that does not have the balljoint protruding has a nut welded to it for connection to the stainless steel coupling used to attach the nozzle. The probe connects to a very coarse fritted glass filter holder (4) which holds a tared glass fiber filter. The filter holder was contained in an electrically heated enclosed box (5) which is thermostatically maintained at 250-300°F to prevent water condensation. Attached to the heated box was an ice bath (7) containing four impingers connected in series with vacuum hose. The first impinger (8) receives the gas stream from the filter. This impinger is of the Greenburg-Smith design modified by replacing the tip with a 1/2 inch ID glass tube extending to 0.5 inch from the bottom of the flask. This impinger was initially filled with 100 milliliters of distilled water. The second impinger (9) is a Greenburg-Smith impinger with tip, and also filled with 100 milliliters of distilled water. The third impinger modified like the first, with no water. The fourth impinger (11) is also a Greenburg-Smith type modified like the first and contained 300 grams of dry indicating silica gel.

From the fourth impinger (11) the effluent stream flows through a dial thermometer (12), a check valve (13); flexible rubber vacuum tubing (14); vacuum gauge (15); a valve (16); a leakless vacuum pump (17), rated at 4 cubic feet per minute at 0 inches of mercury gauge pressure and 0 cubic feet per minute at 26 inches of mercury gauge pressure, and connected in parallel with a bypass needle valve (18); and a dry gas meter rated at .1 cubic foot per revolution (19). A calibrated orifice (20) completes the train and was used to measure instantaneous meter flow rates. The three thermometers (12) are dial type with a range of 25° to 125°F. A fourth thermometer in the heated portion of the box has a range up to 500°F. The dual manometer (21) across the calibrated orifice is an inclined-vertical type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

5. Test Procedure

Prior to the start of a test series for each stack, the pressure, temperature, and range of velocity pressures were determined during preliminary pitot tube and temperature traverse.

During each test the following readings were taken at each point:

1. Point Designation
2. Clock Time
3. Dry gas meter reading (CF)
4. Velocity head (ΔP in inches water)
5. Desired pressure drop across orifice (ΔH in inches of water)
6. Actual pressure drop across orifice (ΔH in inches of water)
7. Dry gas temperature (°F) gas meter inlet
8. Dry gas temperature (°F) gas meter outlet
9. Vacuum pump gauge reading (in. Hg)
10. Filter box temperature (°F).
11. Dry gas temperature (°F) at the discharge of last impinger.
12. Stack temperature (°F)

The relationship of Δ P reading with the Δ H reading is a function of the following variables:

1. Orifice calibration factor
2. Gas meter temperature
3. % moisture in the flue gas
4. Ratio of flue gas pressure to barometric pressure
5. Stack temperature
6. Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δ P and Δ H could be determined by the sampler within fifteen seconds and isokinetic conditions maintained throughout the test.

6. Basic Laboratory Procedure

The following paragraph briefly describes the methods used in the laboratory to obtain the raw data used in the calculations of our results as reported in Section III of this report.

The clean up is done in the field according to EPA test procedure. The filters were previously tare weighed and recorded at the laboratory. Upon return they are dried, cooled in a dessicator, then weighed on an analytical balance and the amount of particulate collected is the difference in the two weights. The particulate wash solution (taken from the train in front of the filter) is placed in a tared beaker, the wash solution is evaporated with an Infra-Red Heat Lamp and the beaker weighed again. The difference in weight is the weight of the particulate in the wash. This is combined with the filter catch as the weight of the sample.

The impinger condensate is measured for moisture determination.

7. Calibration of Sampling Equipment

The equipment used on this assignment was calibrated one week prior to field testing and recalibrated upon equipment return after testing. York Research calibration is traceable to the National Bureau of Standards.

TEST TEAM

Robert S. Epstein
John Jasko

Prepared By:

Robert J. Larkin
Test Engineer

Reviewed By:

Robert S. Epstein
Project Director

Approved By:

Roy S. Egdall
Manager-Engineering Services

York Research Corporation

Pitot Tube Calibration

ΔP_{std}	ΔP_s	$\frac{\Delta P_{std}}{\Delta P_s}$	F_s
.08	.11	.727	.853
.19	.27	.704	.839
.45	.66	.682	.826
.64	.91	.703	.839
.72	1.01	.713	.844

$$F_s = \sqrt{\frac{\Delta P_{std}}{\Delta P_s}}$$

Pitot Tube # 14

F_s = .84

F_{std} = 1.00

Calibrated by [signature]

Date 11/5/73

il O/K

Quick Connects Ok Valves O/K

ters O/K

st Meter

meters O/K

O/K

ical Check - Amphenol O/K

O/K

Gauge OK

Check at 27" hg. - O/K CF

ks

al each item when checked and write in any remarks.

Calibration - Orifice and Meter

11/5/73 Box No. S 1563 P_b 29.9

ce	CF_w	CF_d	T_W	IT_d	OT_d	T_d Avg.	Time t
5	5	5.15	67	85	75	80	12.73
0	5	5.06	67	85.5	77.6	87.15	90.12
0	10	10.16	68	88.8	79.5	84.1	13.2
0	10	10.63	68	89.0	79.6	84.3	93.06
0	10	10.05	68	92.8	80.3	86.5	7.67
.0	10						

ulate Y & $H_@$ at man. 2.0

$$Y =$$

$$Y = \frac{CF_w\ P_b\ (T_d \text{ avg.} + 460)}{CF_d\ (P_b + 0.147)(T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)(\quad + 460)}$$

$$\Delta H_@ = \frac{0.0634}{P_b(OT_d + 460)}\left(\frac{(T_w + 460)}{CF_w}\right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)}\left((\quad + 460)t\right)^2$$

Tolerances

$Y = 0.99 - \underline{1.00} - 1.01$

$\Delta H_@ = 1.6 - \underline{1.84} - 2.1$

Calibration Calculations Meter and Pump Box

Date 11/5/73 Box No. 5 1 5 6 3

Equation	Man.	H@
$H_@ = \dfrac{0.317\ (\text{Man. Orifice})}{P_b\ (OT_d + 460)} \left(\dfrac{(T'_w + 460)\,t}{CF_w} \right)^2$	Man.	H@
$H_@ = \dfrac{0.01585}{29.9\,(75 + 460)} \left(\dfrac{(67 + 460)}{5} \right)^2$ 12.7	.5	1.78
$H_@ = \dfrac{0.0317}{29.9\,(77.6 + 460)} \left(\dfrac{(67 + 460)}{5} \right)^2$ 90.12	1.0	1.77
$H_@ = \dfrac{0.0634}{29.9\,(79.5 + 460)} \left(\dfrac{(68 + 460)}{10} \right)^2$ 13.2	2.0	1.90
$\Delta H_@ = \dfrac{0.1268}{29.9\,(79.6 + 460)} \left(\dfrac{(68 + 460)}{10} \right)^2$ 93.06	4.0	1.89
$\Delta H_@ = \dfrac{0.1902}{29.9\,(80.3 + 460)} \left(\dfrac{(68 + 460)}{10} \right)^2$ 7.67	6.0	1.93
$\dfrac{0.2536}{} \left(\dfrac{(\_\_ + 460)}{} \right)$	8.0	

Equation	Man.	Y
$Y = \dfrac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\ P_b + \dfrac{\text{Man. Orifice}}{13.6}\ (T_w + 460)}$	Man.	Y
$Y = \dfrac{5 \times 29.9\,(80 + 460)}{5.15\,(29.9 + 0.0368)\,(67 + 460)}$	.5	.99
$Y = \dfrac{5 \times 29.9\,(81.5 + 460)}{5.06\,(29.9 + 0.0737)\,(67 + 460)}$	1.0	1.0
$Y = \dfrac{10 \times 29.9\,(84.1 + 460)}{10.16\,(29.9 + 0.147)\,(68 + 460)}$	2.0	1.0
$Y = \dfrac{10 \times 29.9\,(84.3 + 460)}{10.03\,(29.9 + 0.294)\,(68 + 460)}$ 29.9 .6	4.0	1.0
$Y = \dfrac{10 \times 29.9\,(86.5 + 460)}{10.05\,(29.9 + 0.431)\,(68 + 460)}$ 29.9	6.0	1.0
$Y = \dfrac{\_\_ \times \_\_\,(\_\_ + 460)}{\_\_\,(\_\_ + 0.588)\,(\_\_ + 460)}$	8.0	

FIELD DATA

YORK RESEARCH CORPORATION — QUALITY CONTROLLED

PLANT: UNITED ILLUMINATING - STEEL POINT
DATE: 11-16-73
SAMPLING LOCATION: STACK #4
SAMPLE TYPE: PARTICULATE
RUN NUMBER: 1
OPERATOR: JJ / RJE
AMBIENT TEMPERATURE: 60
BAROMETRIC PRESSURE: 29.31
STATIC PRESSURE, (P_s): -.01
FILTER NUMBER (s): FL 228

PROBE LENGTH AND TYPE: 100" SS
NOZZLE I.D.: .500
ASSUMED MOISTURE, %: 10.0
SAMPLE BOX NUMBER: —
METER BOX NUMBER: S-1563
METER $\Delta H_@$: 1.90
C FACTOR: .93
PROBE HEATER SETTING: 250-300
HEATER BOX SETTING: 250-300
REFERENCE Δp: .054

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	1107	532.933									
A1	5	1112	537.97	.07	2.15	2.15	535	65	64	5	300	<70
2	10	1117	540.89	.03	1.05	1.05	540	73	65	4		
3	15	1122	543.98	.04	1.37	1.37	535	77	67	4		
4	20	1127	547.42	.05	1.70	1.70	530	82	69	5		
5	25	1132	550.34	.03	1.05	1.05	530	86	72	4		
6	30	1137	552.59	.02	0.70	0.70	530	87	77	3		
7	35	1142	554.410	.01	0.35	0.35	480	87	75	1.5		
B1	40	1206	558.24	.06	2.05	2.05	550	68	70	4.5	300	<70
2	45	1211	562.12	.06	2.05	2.05	545	75	70	4.5		
3	50	1216	566.09	.05	1.70	1.70	545	80	70	4.5		
4	55	1221	561.56	.07	2.15	2.15	540	81	73	5.5		
5	60	1226	573.13	.05	1.70	1.70	540	82	73	5		
6	65	1231	575.55	.02	0.70	0.70	540	82	73	3.5		
7	70	1236	577.226	.01	0.35	0.35	545	76	74	2.5		
C1	75	1305	582.03	.08	2.50	2.50	545	60	65	5.5	300	<70
2	80	1310	585.12	.08	2.50	2.50	545	69	65	6		
3	85	1315	590.10	.06	2.06	2.06	545	75	65	5.5		
4	90	1320	593.95	.06	2.06	2.06	[illegible]	77	66	5.5		
5	95	1325	597.25	.04	1.37	1.37	[illegible]	75	67	5		
6	100	1330	600.73	.04	1.37	1.37	535	73	67	4.5		
7	105	1335	603.122	.02	0.70	0.70	530	[illegible]	[illegible]	3.5		

COMMENTS:

ES-041

Y-8278-1 TEST #1, STACK T

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	105	1300	603.122									
D1	110	1305	607.02	.06	2.05	2.05	540	55	60	5	300	<70
2	115	1400	610.58	.05	1.70	1.70	540	65	60	5		
3	120	1405	614.73	.07	2.45	2.45	540	70	70	6		
4	125	1410	618.45	.05	1.70	1.70	530	73	73	5		
5	130	1415	621.67	.04	1.37	1.37	530	72	72	4.5		
6	135	1420	624.854	.04	1.37	1.37	530	72	72	4.5		
7	125	1421	624.854	<.01	—	—	—	—	—	—	—	—

FIELD DATA

PLANT United Illum. - Steel Point
DATE 11-17-73
SAMPLING LOCATION Stack #7
SAMPLE TYPE [illegible]
RUN NUMBER 2
OPERATOR [illegible]
AMBIENT TEMPERATURE 45°
BAROMETRIC PRESSURE 30.01
STATIC PRESSURE, (P_s) -.01
FILTER NUMBER (s) FL-245

PROBE LENGTH AND TYPE 100" SS
NOZZLE I.D. .500
ASSUMED MOISTURE, % 10.0
SAMPLE BOX NUMBER
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .73
PROBE HEATER SETTING 250-300
HEATER BOX SETTING 250-300
REFERENCE Δp .037

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	0855	27.201	.06	2.05	2.05	510	43	55	5.0	250°	<70°
D 1	5	0901	31.07	.03	1.05	1.05	510	53	58	3.5		
2	10	0906	33.77	.03	1.05	1.05	510	54	62	3.5		
3	15	0911	36.70	.03	1.05	1.05	505	55	64	3.5		
4	20	0916	37.[illegible]	.02	0.70	0.70	505	57	65	2.5		
5	25	0921	41.70	.02	0.70	0.70	505	55	65	2.5		
6	30	0926	44.85	.02	0.70	0.70	505	58	66	2.5		
7	35	0931	46.543									
				.08	2.80	2.80	510	[illegible]	56	6.5	250°	<70°
C 1	40	0944	50.08	.08	2.80	2.80	[illegible]	57	61	6.5		
2	45	0949	54.33	.08	2.80	2.80	[illegible]	[illegible]	[illegible]	6.5		
3	50	0954	58.[illegible]	.07	2.45	2.80	[illegible]	[illegible]	70	[illegible]		
4	55	0959	62.31	.04	1.35	1.35	[illegible]	[illegible]	[illegible]	4.0		
5	60	1004	65.[illegible]	.02	0.70	[illegible]	[illegible]	[illegible]	71	3.0		
6	65	1009	[illegible]	.01	0.35	0.35	[illegible]	[illegible]	[illegible]	2.0		
7	70	1014	70.070									
				.06	2.05	2.05	[illegible]	57	58	4.5	250°	<70°
[illegible] 1	75	1033	73.78	.07	2.45	[illegible]	[illegible]	57	63	5.5		
2	80	1038	77.10	.08	2.80	2.80	[illegible]	60	[illegible]	[illegible]		
3	85	1043	82.55	.08	2.80	2.80	[illegible]	60	71	6.5		
4	90	1048	87.17	.06	2.05	2.05	[illegible]	62	72	[illegible]		
5	95	1053	91.17	.04	1.35	1.35	[illegible]	63	72	4.5		
6	100	1058	94.[illegible]	.02	0.70	0.70	[illegible]	63	70	3.0		
7	105	1103	97.[illegible]03									

COMMENTS:

ES-041

Y-8278-1 TEST #2, STACK #4

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
		1106	97.403						[illegible]	6.0	250°	<70°
	:05	1111	100.36	.08	2.30	[illegible]	510	59	66	6.5		
A 1	:10	1116	105.62	.08	2.30	[illegible]	500	60	68	5.5		
2	:15	1121	[illegible]	.06	2.05	[illegible]	500	60	70	5.5		
3	:20	1126	[illegible]	.06	2.00	2.05	500	61	71	4.5		
4	:25	1131	117.43	.04	1.35	1.35	500	62	72	5.0		
5	:30	1136	120.66	.03	1.70	1.70	500	62	69	3.5		
6	:35	1141	123.179	.02	0.70	0.70	480	62				
7	:40											

FIELD DATA

PLANT UNITED Illum - STEEL POINT
DATE 11-17-73
SAMPLING LOCATION STACK [illegible]
SAMPLE TYPE PARTICULATE
RUN NUMBER 3
OPERATOR [illegible]
AMBIENT TEMPERATURE [illegible]
BAROMETRIC PRESSURE 30.01
STATIC PRESSURE, (P_s) -.01
FILTER NUMBER (s) FL-554

PROBE LENGTH AND TYPE 100" SS.
NOZZLE I.D. .500
ASSUMED MOISTURE, % 10.0
SAMPLE BOX NUMBER
METER BOX NUMBER S-1563
METER $\Delta H_@$ 1.90
C FACTOR .78
PROBE HEATER SETTING 250-300
HEATER BOX SETTING 250-300
REFERENCE Δp .054

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

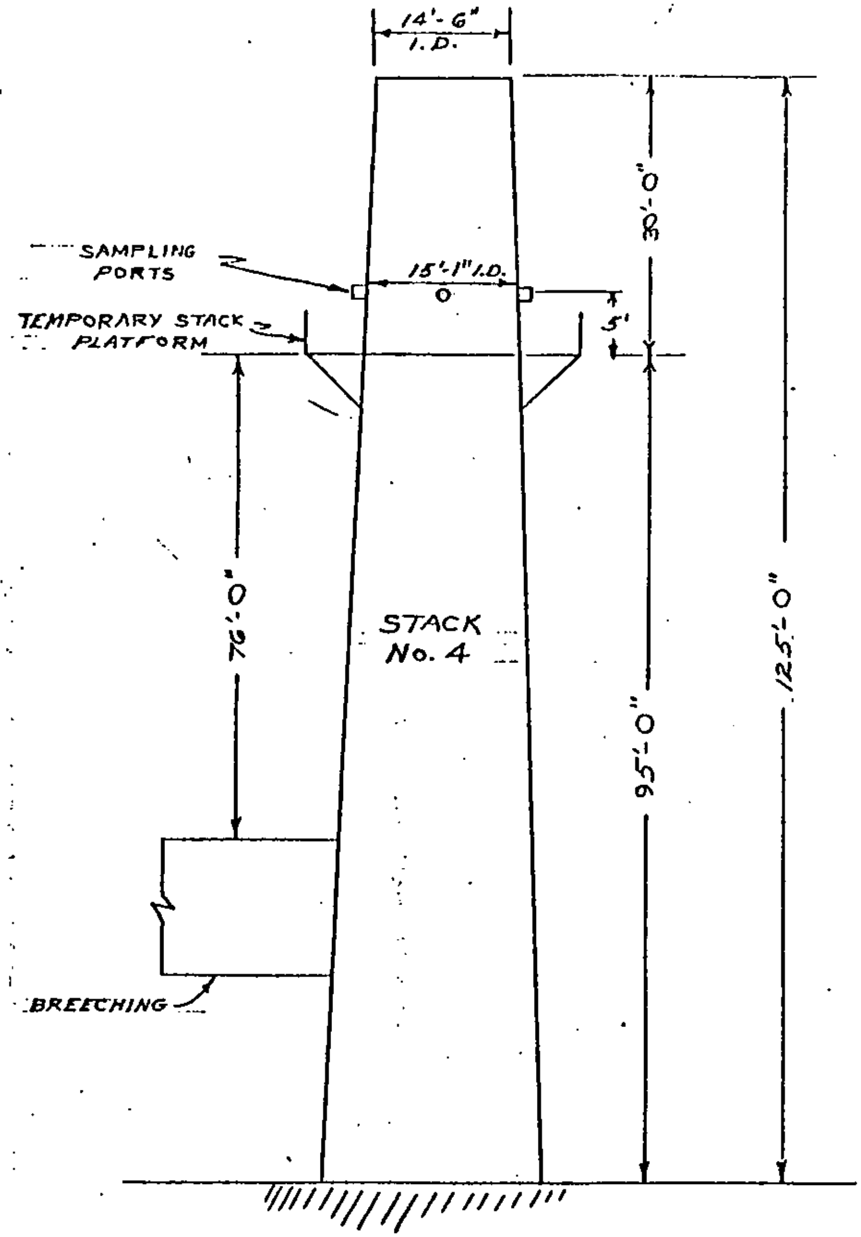
TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	0	1211	23.1[illegible]									
A 1	5	[illegible]	25.6[illegible]	.07	2.15	[illegible]	540	50	50	8.5	250°	<70°
2	10	[illegible]	32.00	.07	2.15	[illegible]	540	51	54	8.5		
3	15	[illegible]	35.33	.06	2.05	2.05	540	53	44	8.5		
4	20	[illegible]	39.13	.04	1.35	1.35	540	55	66	6.5		
5	25	1241	42.32	.04	1.35	1.35	540	56	66	6.5		
6	30	1246	45.36	.03	1.05	1.05	540	57	68	6.0		
7	35	1251	[illegible]	.03								
B 1	35	1306	47.85	.03	2.80	2.80	530	51	53	8.0	250°	<70°
2	40	1311	54.25	.03	2.80	2.80	[illegible]	55	57	8.5		
3	45	1316	58.81	.03	2.80	[illegible]	[illegible]	55	66	9.5		
4	50	1321	63.6[illegible]	[illegible]	2.80	[illegible]	[illegible]	56	70	9.5		
5	55	1326	67.33	.06	2.05	[illegible]	545	57	72	8.5		
6	60	1331	[illegible]	.04	1.35	1.35	545	58	71	6.0		
7	65	1336	72.107	.02	0.97	0.97	[illegible]	59	72	3.5		
C 1	70	1341	77.38	.08	2.80	2.80	540	52	53	9.0	250°	<70°
2	75	1346	81.64	.08	2.80	[illegible]	545	54	56	8.5		
3	80	1351	85.[illegible]	.07	[illegible]	[illegible]	545	55	65	9.0		
4	85	[illegible]	[illegible]	.07	2.15	2.45	[illegible]	56	68	9.0		
5	90	1401	91.32	[illegible]	2.05	[illegible]	[illegible]	64	70	7.5		
6	95	[illegible]	[illegible]	[illegible]	2.05	2.05	[illegible]	58	71	7.5		
7	100	1411	101.[illegible]11	[illegible]	1.[illegible]0	1.[illegible]0	[illegible]	58	72	7.0		

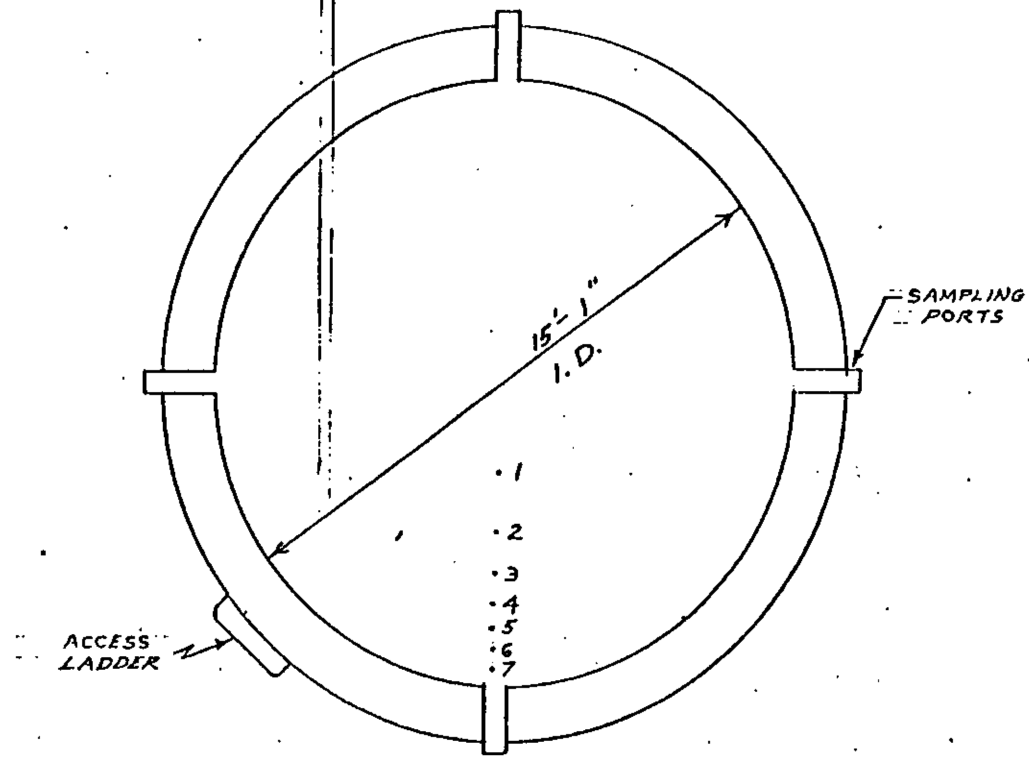
COMMENTS:

ES-041

Y-8278-1 TEST # 3, STACK # 4

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	100	1430	101.711								250°	< 70°
D 1	105	1435	105.42	.07	2.45	2.45	550	54	[illegible]	7.5		
2	110	1440	108.40	.06	2.05	2.05	550	56	62	8.5		
3	115	1445	112.13	.08	2.80	2.80	515	56	65	10.0		
4	120	1450	116.02	.05	1.70	1.70	515	57	70	7.0		
5	125	1455	117.67	[illegible]	1.35	1.35	515	58	71	6.0		
6	130	1500	123.16	.04	1.35	1.35	520	57	72	6.0		
7	135	1505	125.512	.02	0.70	0.70	520	57	69	4.5		





TRAVERSE POINT No.	DISTANCE FROM WALL
7	3.3"
6	10.4"
5	18.1"
4	26.7"
3	36.8"
2	49.2"
1	67.0"

REVISED	THE UNITED ILLUMINATING CO. NEW HAVEN, CONN. STACK CONFIGURATION AND SAMPLING POINT LOCATION STACK No. 4 STEEL POINT STATION
	DRAWN BY P.L.D. DATE 3-20-74
	TRACED BY ______ DATE ______
	APPROVED BY J.W.H. DATE 4-1-74
	SCALE NONE DRAWING NO. 2/212-7

APPENDIX B

NITROGEN OXIDE TEST

FLUE GAS ANALYSIS

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number STACK #4

Date NOV 16, 1973

Boiler Number 19-20-21-22

Time 1245

Plant Location STEEL POINT

Sampling Point Location STACK

TEST 1

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	8.76	8.76	8.76		8.76	44/100	3.8544
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O2, % Vol (dry)	8.82	8.92	9.01		8.92	32/100	+ 2.8544
N2, % Vol (dry)	82.42	82.32	82.23		82.32	28/100	+ 23.0496
						Avg. molecular wt. of dry stack gas =	29.76

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number STACK 4

Date NOV. 17, 1973

Time 11:00 AM

Boiler Number 19-20-21-22

Plant Location STEEL POINT

Sampling Point Location STACK

TEST 2

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO_2, % Vol (dry)	7.75	7.00	7.75		7.50	44/100	3.3000
CO, % Vol (dry)	0	0	0		0.00	28/100	+ 0.00
O_2, % Vol (dry)	9.68	9.82	9.78		9.76	32/100	+ 3.1232
N_2, % Vol (dry)	82.57	83.18	82.47		82.74	28/100	+ 23.1672
						Avg. molecular wt. of dry stack gas =	29.59

THE UNITED ILLUMINATING COMPANY

ORSAT DATA & CALCULATION SHEET

Stack Identification Number Stack 4

Boiler Number 19-20-21-22

Plant Location Steel Point

Sampling Point Location Stack

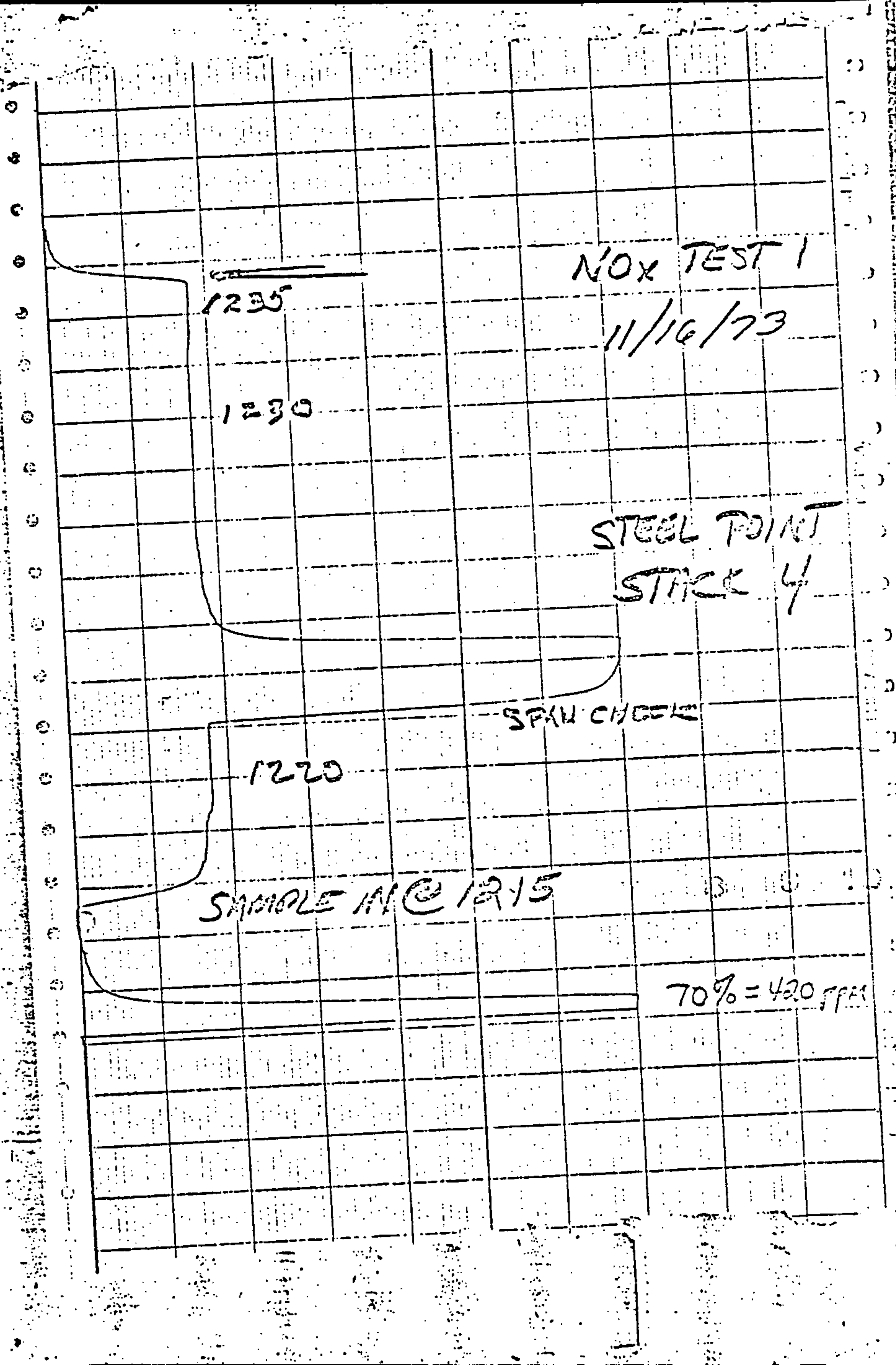
Date NOV. 17, 1973

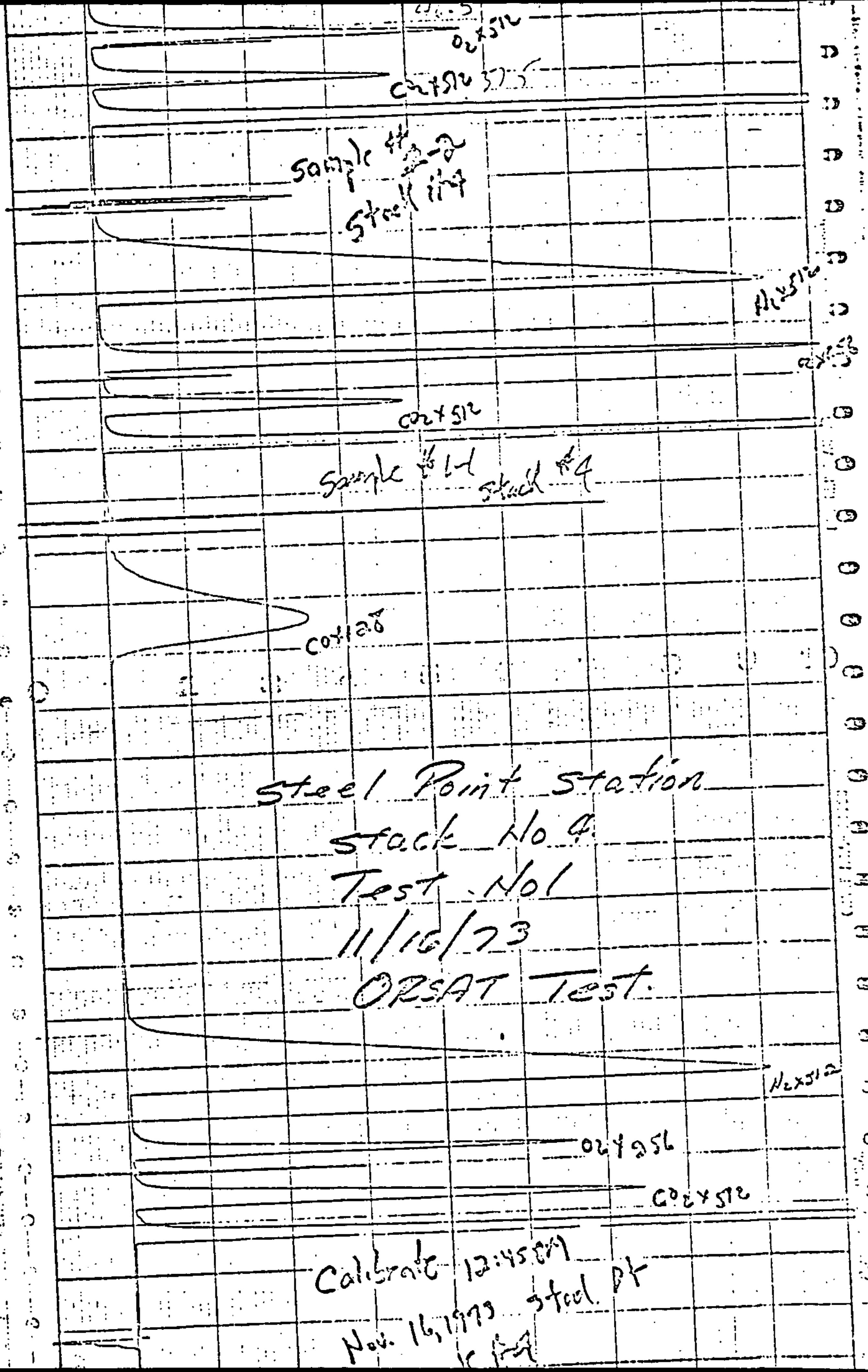
Time 2:30pm

TEST 3

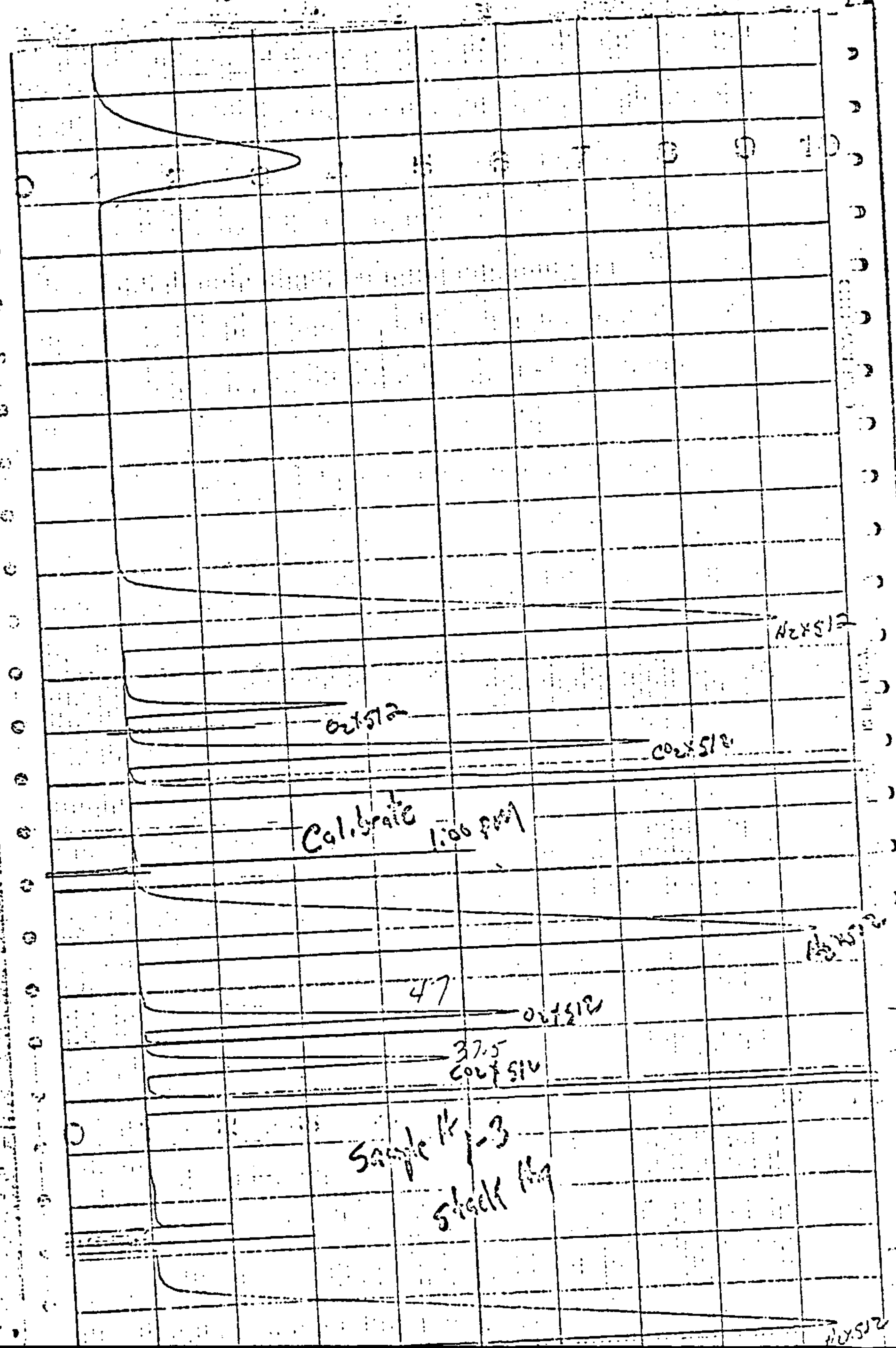
	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Average	X mole wt	wt/mole. (dry)
CO2, % Vol (dry)	8.43	8.39	8.43		8.42	44/100	3.7048
CO, % Vol (dry)	0	0	0		0.00	28/100	+0.00
O2, % Vol (dry)	9.47	9.42	9.36		9.42	32/100	+3.0144
N2, % Vol (dry)	82.10	82.19	82.19		82.16	28/100	+23.0048
						Avg. molecular wt. of dry stack gas =	29.72

TEST NO. 1

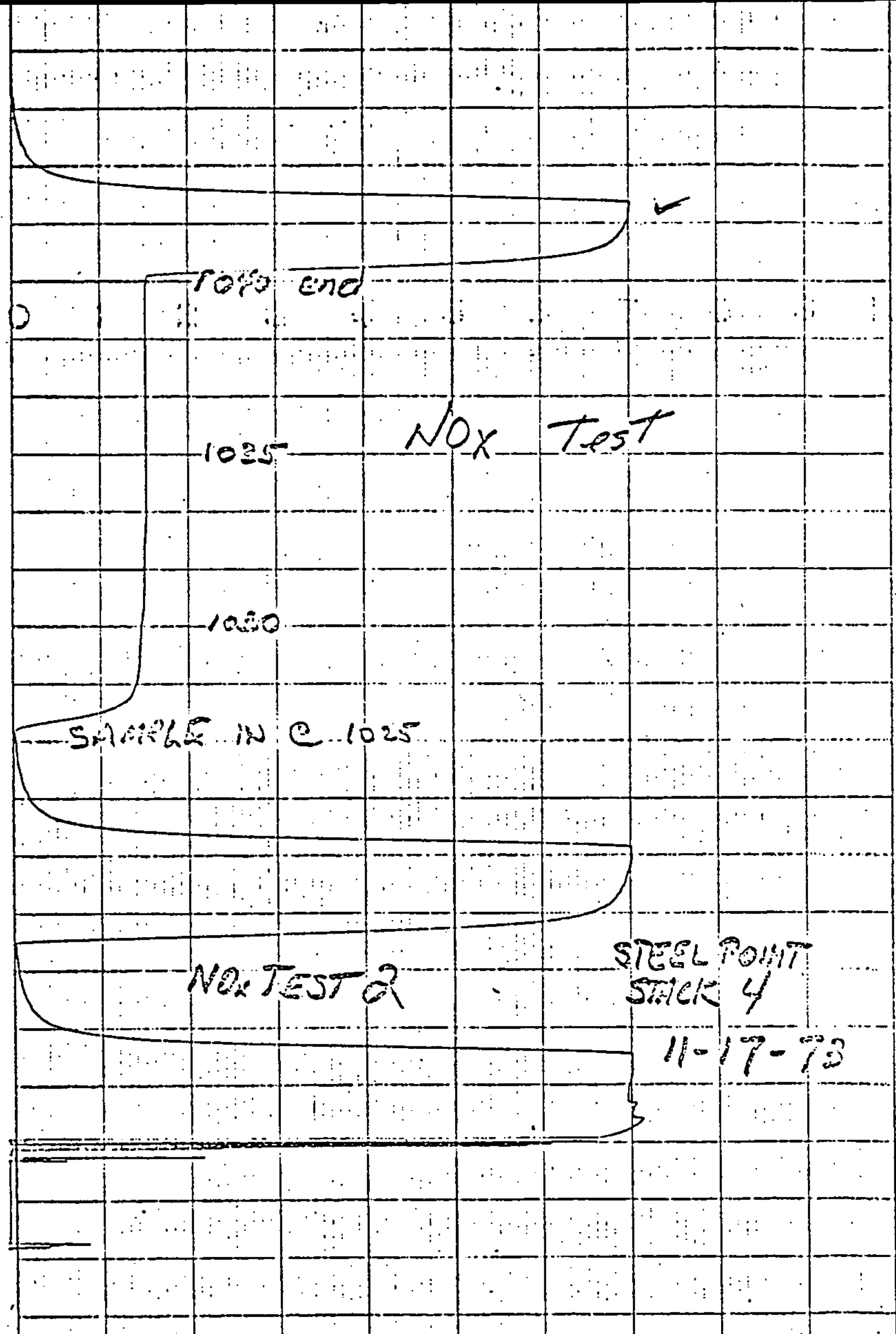

NOx TEST 1
11/16/73
1235
1230
STEEL POINT
STACK 4
SPAN CHECK
1220
SAMPLE IN @ 1215
70% = 420 ppm



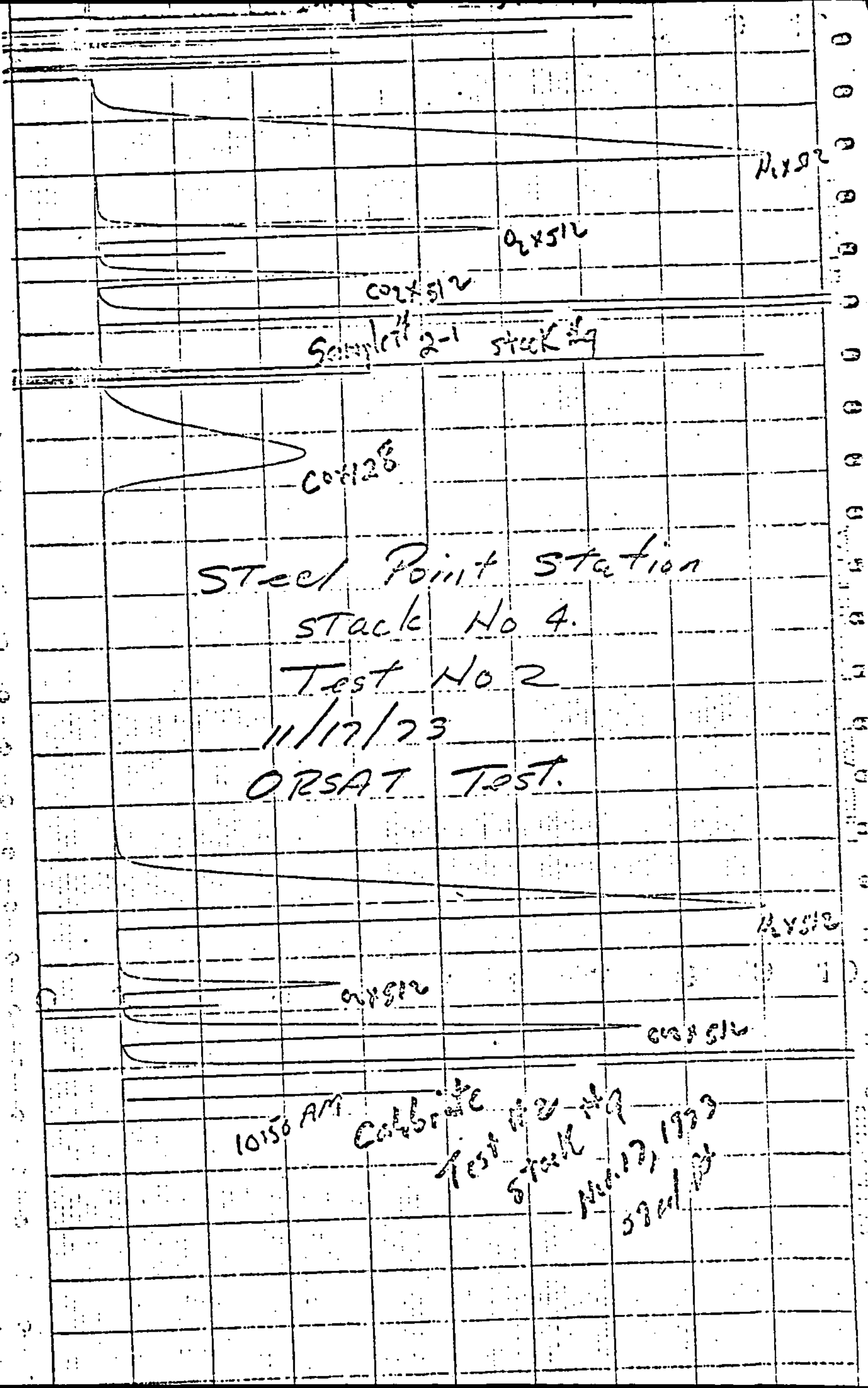
O_2 x 512
Sample
N_2 x 512
CO_2 x 512
Sample #14 stack #4
CO x 128
Steel Point Station
Stack No 4
Test No 1
11/16/73
ORSAT Test
N_2 x 512
O_2 x 256
CO_2 x 512
Calibrate 12:45 PM
Nov. 16, 1973 Steel Pt

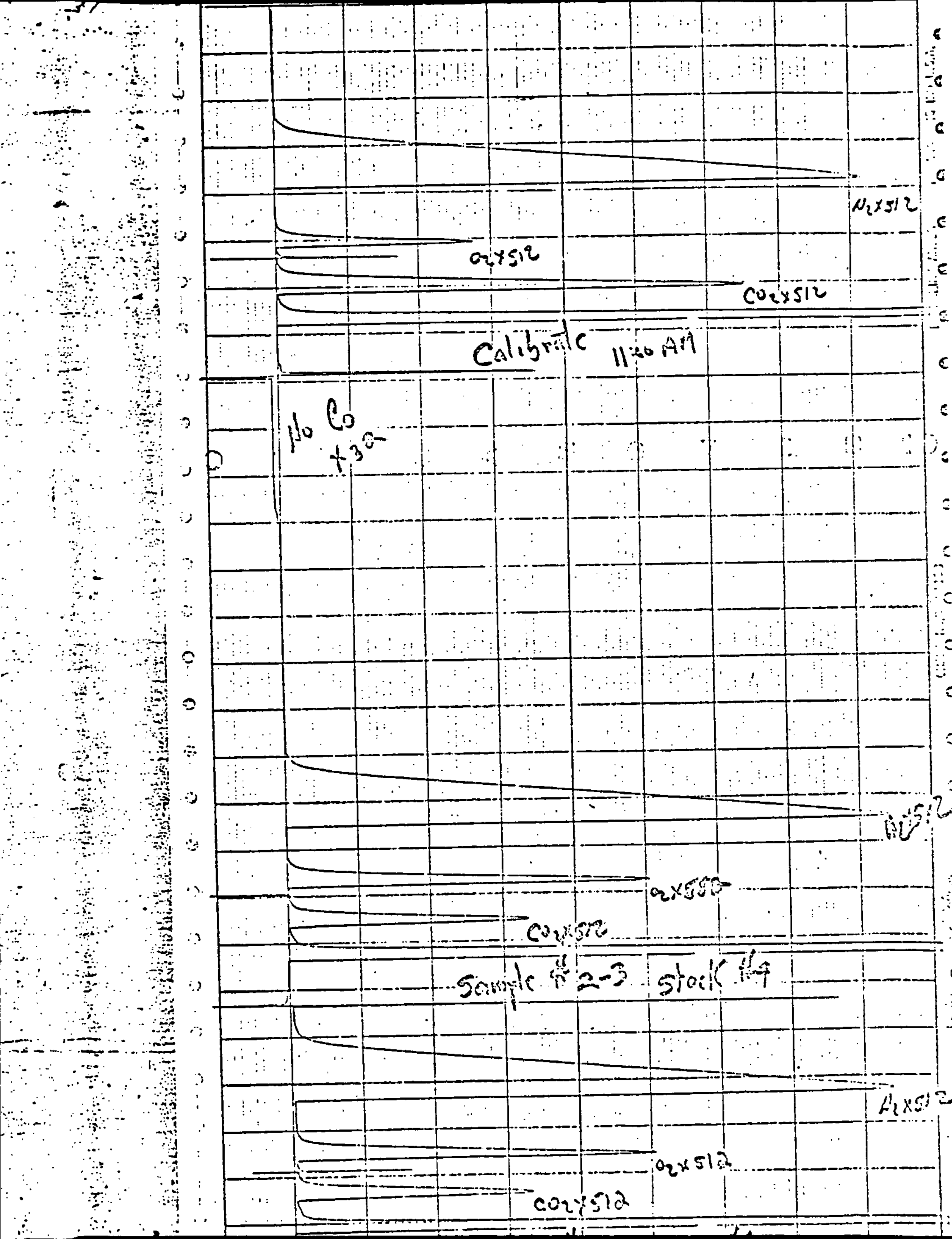

N2x512
O2x512
CO2x512
Calibrate 1:00 PM
N2x512
47
O2x512
37.5
CO2x512
Sample # 1-3
N2x512

TEST NO. 2

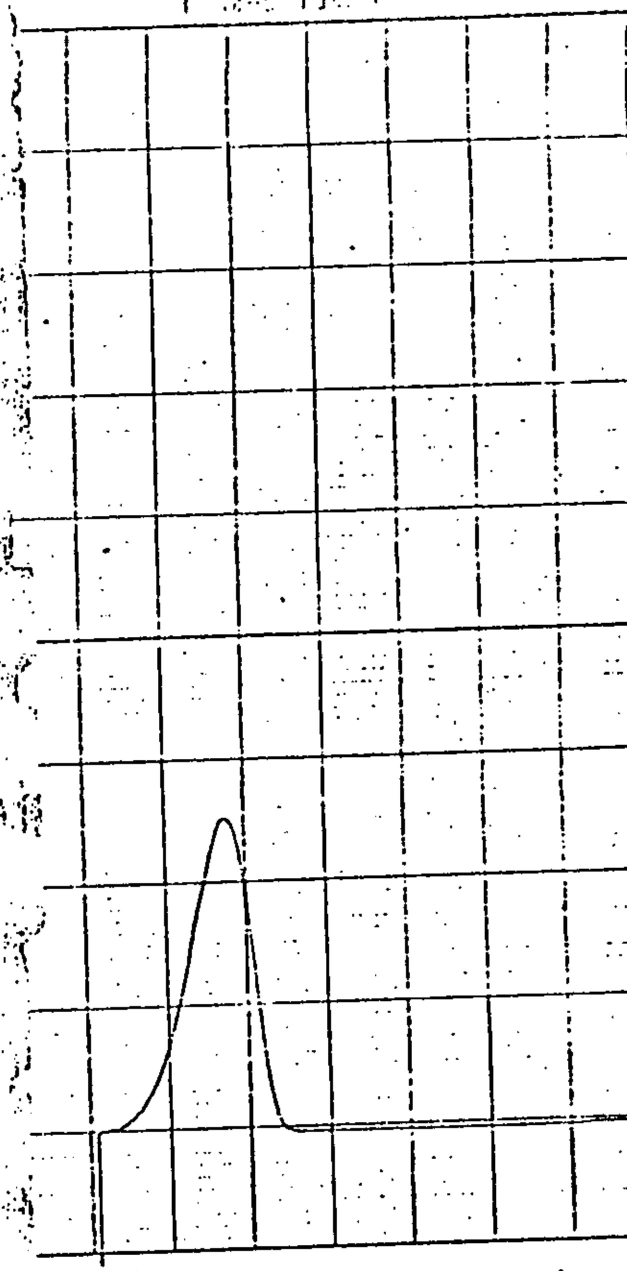


1030 end
NOx Test
1025
1020
SAMPLE IN @ 1025
NOx TEST 2
STEEL POINT
STACK 4
11-17-73

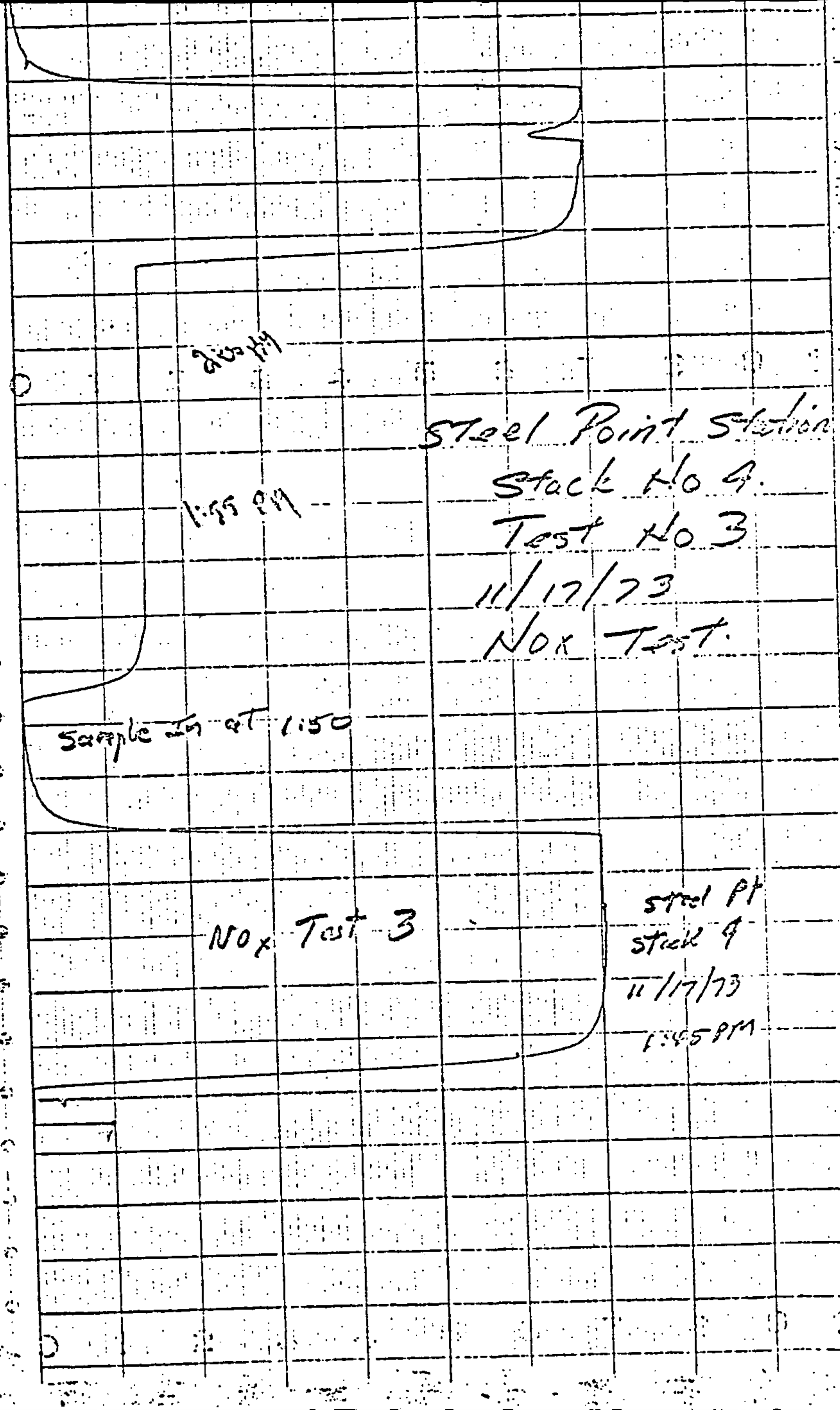

N2x512
O2x512
CO2x512
Sample #2-1 stack #4
COx128
Steel Point Station
Stack No 4.
Test No 2
11/17/73
ORSAT Test.
N2x512
O2x512
CO2x512
10:50 AM Calibrate
Test #2
Stack #4
Nov. 17, 1973

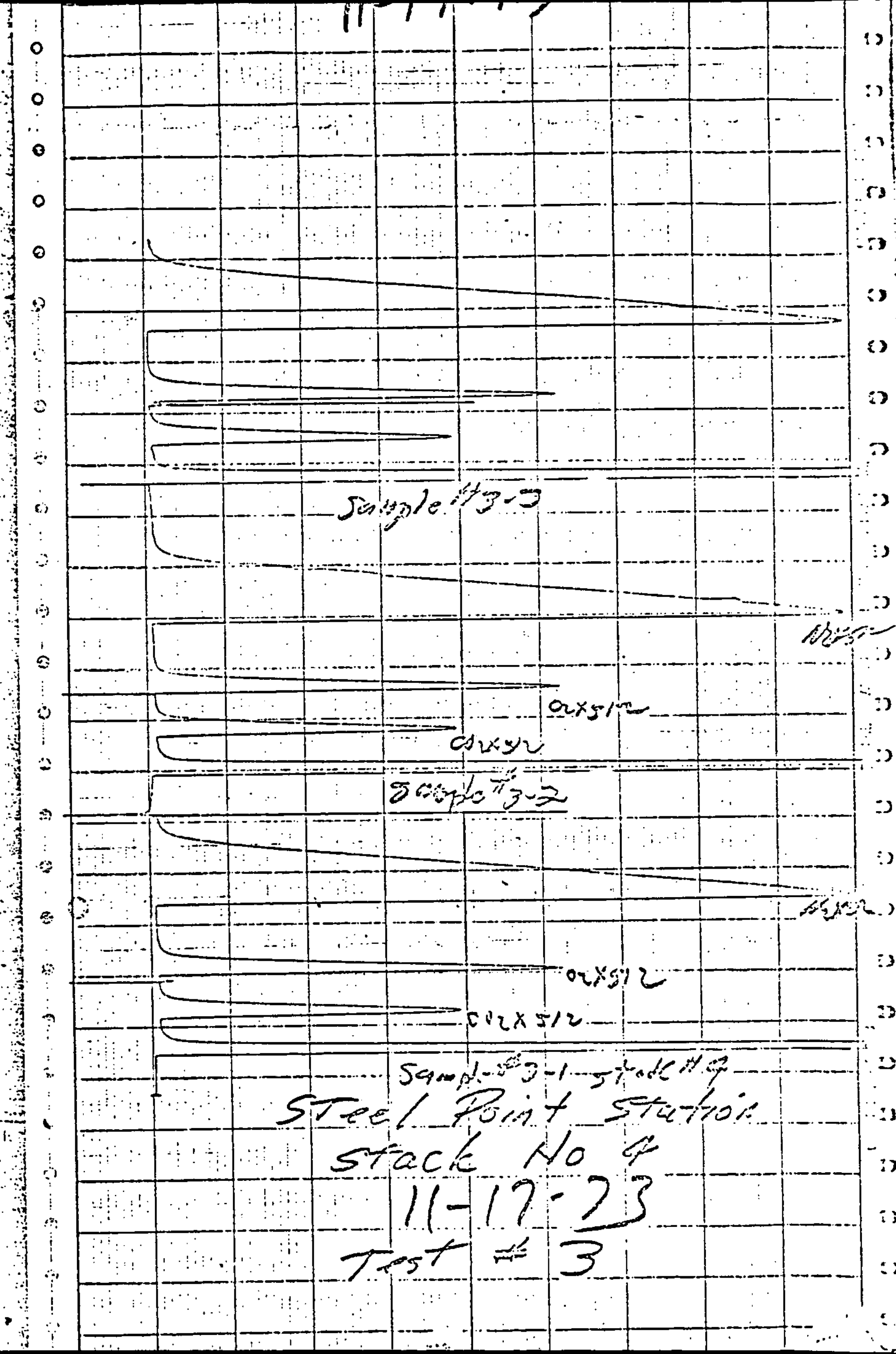


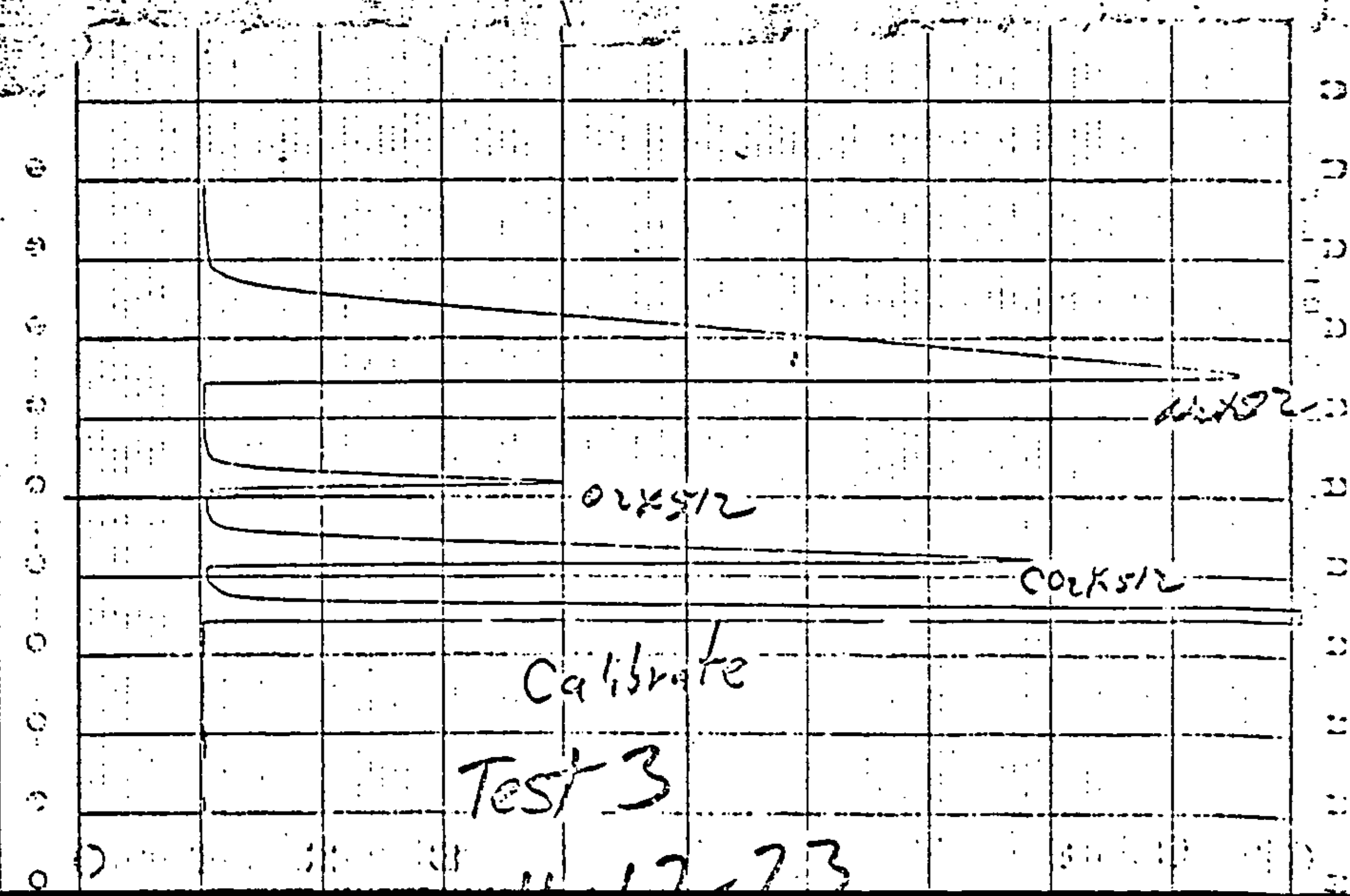
N2x512
O2x512
CO2x512
Calibrate 11:20 AM
No Co
x30
O2x512
CO2x512
Sample #2-3 stock #4
N2x512
O2x512
CO2x512



TEST NO. 3


Steel Point Station
Stack No 4.
Test No 3
11/17/73
Nox Test.
1:55 PM
Sample In at 1:50
Nox Test 3
Steel Pt
Stack 4
11/17/73
1:45 PM


Sample #3-3
Sample #3-2
Sample #3-1 stack #4
Steel Point Station
stack No 4
11-17-73
Test #3


O2 K5/2
CO2 K5/2
Calibrate
Test 3

APPENDIX C

BOILER OPERATING DATA

BOILER OPERATING CONDITIONS

Stack Identification Number STR [illegible] Date Nov. 16 1973

Boiler Number 19-22

Plant Location St[illegible] TEST #1

Parameters	0937	1057	1242	1357	1503		
Gross Load (MW)							
Net Load (MW)							
MCRP Fuel Flow (gal/~~hr~~)	33218	41928	45162	[illegible]	[illegible]		
Steam Flow (lb/hr)							
~~Feed Water Flow (lb/hr)~~							
~~Air-Flow~~ Fuel Flow gph #19	440	[illegible]	440	[illegible]	440		
~~Excess Air (%)~~ #20	450	[illegible]	470	470	470		
~~Excess O2 (%)~~ #21	375	370	370	370	365		
~~Soot-Blowing~~ #22	345	350	355	355	355		
Boiler Inlet Feed Water Temp (°F)							
Boiler Exit Steam Press. (psig)	205	205	215	210	210		
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam LP FAN DUCT Press. (psig)	6.1	6.1	6.2	6.2	6.2		
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							

Stack Identification Number Stack 4

Boiler Number 19-20-21-22

Plant Location Steel Point [illegible]

Date May 17, 19[illegible] TEST 2

Parameters	0900	0945	1147				
Gross Load (MW)							
Net Load (MW)							
Fuel Flow (gal/hr) [illegible]	78222	74851	76546				
Steam Flow (lb/hr)							
~~Feed Water Flow (lb/hr)~~							
Air Flow 19	310	400	400				
Excess Air (%) 20	425	445	435				
Excess O2 (%) 21	440	450	455				
Soot Blowing 22	215	310	315				
Boiler Inlet Feed Water Temp (°F)							
Boiler Exit Steam Press. (psig)	205	215	210				
Boiler Exit Steam Temp (°F)							
Reheat Inlet Steam Press. (psig) LP Air Duct Press	7.3	7.3	7.1				
Reheat Inlet Steam Temp (°F)							
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (°F)							

Pressure (In-Hg)

BOILER

Stack Identification Number

Boiler Number 19-20-21-22

Plant Location STEEL PoinT

BALANCE 29.9

Date 11/17/1975

TEST 3

Parameters	1226	1343	1519				
Gross Load (MW)							
Net Load (MW)							
Fuel Flow (gal/hr)	77611	79708	82350				
Steam Flow (lb/hr)							
~~Feed Water Flow (lb/hr)~~							
Air Flow Oil flow #19	490	410	405				
Excess Air (%) #20	430	415	420				
Excess O2 (%) #21	455	455	450				
Soot Blowing #22	315	345	315				
Boiler Inlet Feed Water Temp (OF)							
Boiler Exit Steam Press. (psig)	210	210	210				
Boiler Exit Steam Temp (OF)							
Reheat Inlet Steam Press. (psig)							
~~Reheat Inlet Steam Temp (OF)~~ LP AIR DUCT PRESS	7.1	7.2	7.1				
Reheat Exit Steam Press. (psig)							
Reheat Exit Steam Temp (OF)							

APPENDIX D

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

NOTE: All equations used in these calculations are found in the Federal Register, Vol. 36, No. 247, dated December 23, 1971.

Calculations representative of Test #1.

1. Dry Gas Volume

$$Vmstd = \left(17.71 \frac{^{o}R}{in.Hg.}\right) Vm \left(\frac{Pbar + \frac{\overline{\Delta H}}{13.6}}{Tm}\right) \qquad \text{eq. 5-1}$$

$$= \left(17.71 \frac{^{o}R}{in.Hg.}\right) 90.921\ ft^3 \left(\frac{29.31\ In.Hg. + \frac{1.609\ in.\ H_2O}{13.6}}{531.5\ ^{o}R}\right)$$

$$= 89.155\ ft^3$$

2. Volume of Water Vapor

$$Vwstd = \left(0.0474 \frac{ft^3}{M}\right) Vlc \qquad \text{eq. 5-2}$$

$$= \left(0.0474 \frac{ft^3}{M}\right) 106.5\ ml$$

$$= 5.048\ ft^3$$

3. Moisture Content

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

$$= \frac{5.048\ ft^3}{5.048\ ft^3 + 89.155\ ft^3}$$

$$= 0.0535 \times 100\% = 5.4\%$$

4. Molecular Weight (dry)

$$Md = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%\ N_2) + 0.28\ (\%\ CO) \qquad \text{eq. 3-2}$$

$$= 0.44\ (8.76) + 0.32\ (8.92) + 0.28\ (82.32) + 0.28\ (0.00)$$

$$= 29.76\ \text{lb/lb-mole}$$

5. Moelcular Weight (wet)

$$Ms = Md\ (1\text{-}Bws) + 18\ Bws$$

$$= 29.76\ (1-.054) + 18\ (.054)$$

$$= 29.12\ \text{lb/lb-mole}$$

6. Stack Gas Velocity

$$Vs = Kp\ Cp\ \sqrt{\overline{\Delta P}} \left(\frac{Ts}{Ps \times Ms}\right)^{1/2} \qquad \text{eq. 2-2}$$

$$= (85.48)\ (0.84)\ (0.210) \left(\frac{994.6}{29.31 \times 29.12}\right)^{1/2}$$

$$= 16.28\ \text{F.P.S.}$$

7. Gas Volumetric Flow Rate, ACFM

$$ACFM = Vs \times A_s \times 60\ \text{sec/min}$$

$$= 16.28 \times 178.6\ \text{ft}^2 \times 60\ \text{sec/min}$$

$$= 174{,}456\ \text{ACFM}$$

8. Gas Volumetric Flow Rate, SCFM

$$Qs = 60\ (1\text{-}Bws)\ Vs\ A_s \left(\frac{Tstd}{Ts}\right)\left(\frac{Ps}{Pstd}\right) \qquad \text{eq. 2-3}$$

$$= 60\ (1-.054)\ (16.28)\ (178.6) \left(\frac{530}{994.6}\right) \left(\frac{29.31}{29.92}\right)$$

$$= 86{,}151\ \text{SCFM}$$

9. Gas Volumetric Flow Rate, lb/hr

$$Ws = Qs \times \frac{60 \text{ min}}{\text{hr}} \times \frac{Md}{386 \text{ ft}^3}$$

$$= 86{,}151 \text{ SCFM} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{29.76 \text{ lb/lb-mole}}{386 \text{ ft}^3}$$

$$= 398{,}526 \text{ lb/hr}$$

10. Particulate Concentrations, gr/SCF

$$C's = \left(0.0154 \frac{gr}{mg}\right) \frac{Mn}{Vmstd}$$ eq. 5-4

$$= \left(0.0154 \frac{gr}{mg}\right) \frac{156.7 \text{ mg}}{89.155 \text{ ft}^3}$$

$$= 0.027 \text{ gr/SCF}$$

11. Particulate Concentrations, lb/ft^3

$$Cs = \frac{\left(\frac{1}{453600} \frac{lb}{mg}\right) Mn}{Vmstd}$$ eq. 5-5

$$= \frac{\left(\frac{1}{453600} \frac{lb}{mg}\right) 156.7 \text{ mg}}{89.155 \text{ ft}^3}$$

$$= 3.87 \times 10^{-6} \text{ lb/SCF}$$

12. Particulate Concentrations, lb/hr

$$Cw = Cs\ Qs \times \frac{60 \text{ min}}{\text{hr}}$$

$$= (3.87 \times 10^{-6} \text{ lb/SCF})\ (86{,}151 \text{ SCFM})\ \frac{60 \text{ min}}{\text{hr}}$$

$$= 20.00 \text{ lb/hr}$$

13. Particulate Concentrations, lb/MBTU

$$Er = \frac{Cw}{\text{Heat Input}}$$

$$= \frac{20.00 \text{ lb/hr}}{290.8 \times 10^6 \text{ BTU/hr}}$$

$$= 0.069 \text{ lb/MBTU}$$

14. % Isokinetic Sampling

$$I = \frac{\overline{Ts}\ (1.667\ \frac{min}{sec})\left((0.00267)\ Vlc + \frac{Vm}{Tm}\left(Pbar + \frac{\overline{\Delta H}}{13.6}\right)\right)}{\Theta\ \ Vs\ \ Ps\ \ An}$$

eq. 5-6

$$= \frac{994.6\ (1.667)\left((0.00267)\ (106.5) + \frac{90.921}{531.5}\left(29.31 + \frac{1.609}{13.6}\right)\right)}{(135)\ (16.28)\ (29.31)\ (0.001363)}$$

$$= 100.4\%$$

15. NO_X Concentrations, lb/hr

$$\text{lb/hr} = \text{ppm} \times \frac{Mw\ (NO_2)}{Md} \times Ws$$

$$= \frac{106.5}{10^6} \times \frac{46 \text{ lb/lb-mole}}{29.76 \text{ lb/lb-mole}} \times 398{,}526\ \frac{lb}{hr}$$

$$= 65.6 \text{ lb/hr}$$

16. NO_X Concentrations, lb/MBTU

$$\text{lb/MBTU} = \frac{\text{lb/hr}}{\text{Heat Input}}$$

$$= \frac{65.6 \text{ lb/hr}}{290.8 \times 10^6 \text{ BTU/hr}}$$

$$\text{lb/MBTU} = \frac{0.226 \text{ lb}}{10^6 \text{ BTU}}$$

17. Stack Pressure (Absolute), in.Hg.

$$P_s = P_b + \frac{P_d}{13.6} = 29.31 + \frac{(-0.01)}{13.6} = 29.31 \text{ in.Hg.}$$

18. Nozzle Area (ft^2)

$$A_n = \pi D^2/4 = 0.785 \ (0.500/12)^2 = 13.63 \times 10^{-4} \ ft^2$$

19. Stack Area (ft^2)

$$A_s = \pi D^2/4 = 0.785 \ (181/12)^2 = 178.6 \ ft^2$$

20. Heat Input, MBTU

Sp. Gr. x 8.33 lb/gal x BTU/lb x gal/hr

0.895 x 8.33 x 21,276 x 1833 gal/hr = 290.8 MBTU

21. Gas Density, lb/ft^3

$$\text{Gas Density} = \frac{\text{mol wt gas}}{386 \ ft^3} (\text{md}) \times \frac{T_{std}}{T_s} \times \frac{P_{bar}}{P_{std}}$$

$$= \frac{29.76}{386} \times \frac{530^\circ R}{994.6} \times \frac{29.31}{29.92} = 0.040 \ lb/ft^3$$

THE UNITED ILLUMINATING COMPANY

SOURCE TESTING CALCULATION FORMS

est No. Steel Point #4 No. Runs 3

ame of Firm The United Illuminating Company

ocation of Plant 43 East Main Street, Bridgeport, Connecticut

ype of Plant Steam Generating Station

ontrol Equipment None

ampling Point Locations Stack

ollutants Sampled Particulates, Nitrogen Oxides

ime of Particulate Test:

un No. 1	Date 11/16/73	Begin 11:07	End 14:21
un No. 2	Date 11/17/73	Begin 8:56	End 11:41
un No. 3	Date 11/17/73	Begin 12:19	End 15:05

PARTICULATE EMISSION DATA

un No.	1	2	3	
$Kp = 85.48 \frac{ft}{sec} \left(\frac{lb.}{lb\ mole-{}^{o}R}\right)^{\frac{1}{2}}$	85.48	85.48	85.48	
Cp = Pitot tube coefficient (calib.)	0.84	0.84	0.84	
$\overline{\sqrt{\Delta P}}$ = Average velocity head of stack gas, inches H_2O	0.210	0.215	0.238	
$\bar{Ts}$ = Average stack temp., ^{o}R	994.6	995.2	1003.7	
Pb = Barometric pressure, "Hg Abs.	29.31	30.01	30.01	
Pd = Gas duct pressure, "H_2O	-0.01	-0.01	-0.01	
Ps = Absolute stack gas pressure, inches Hg	29.31	30.01	30.01	
Bws = % moisture in stack gas, by volume	5.4	4.9	5.2	
Md = Molecular weight of stack gas, dry	29.76	29.59	29.72	
Ms = Molecular weight of stack gas	29.12	29.02	29.11	

Run NO.				
Vs = Stack gas velocity, F.P.S.	16.28	16.50	18.32	
% CO_2	8.76	7.50	8.42	
% O_2	8.92	9.76	9.42	
% CO	0.00	0.00	0.00	
% N_2	82.32	82.74	82.16	
Vlc = Total volume of liquid collected in impingers and silica gel, ml.	106.5	106.0	121.5	
Vm = Volume of dry gas sampled at meter conditions, FT^3	90.921	95.978	101.812	
Vstd = Volume of dry gas sampled at STP, FT^3	89.155	98.095	104.535	
Tm = Average dry gas meter temp., °R	531.5	522.2	520.2	
$\overline{\Delta H}$ = Average pressure drop across orifice, inches H_2O	1.609	1.721	2.026	
θ = Total Sampling Time, min.	135	140	135	
Dn = Nozzle dia., inches	0.500	0.500	0.500	
An = Nozzle area, FT^2	13.63	13.63	13.63	
I = % of isokinetic sampling	100.4	102.2	103.0	
Qs = Stack gas volume at STP (SCFM)	86,151	89,819	98,570	91,513
Qa = Stack gas volume at stack conditions (ACFM)	174,456	176,814	196,317	182,529
Ws = Stack gas mass flow lbs/hr	398,526	413,121	455,363	422,337
Mp = Particulate-probe, washings, mg	-	-	-	
Mf = Particulate-filter (mg)	-	-	-	
Mn = Particulate-total (mg)	156.7	115.4	355.6	
C's = Particulate Concentrations gr/scf	0.027	0.018	0.052	
Cw = Particulate total emission lb/hr	20.00	13.96	44.30	26.09
Er = Particulate emission rate, lb/106 BTU	0.069	0.059	0.187	0.105
C = NO, concentrations, PPM	106.5	90	93	96.5
Cn = NO, $lb/10^6 BTU$	0.226	0.244	0.276	0.249