GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. A-3162 DATE 3/2/82

Project Director: W. M. Ewing ~~XXXXX~~ School/Lab EDL/SHS

Sponsor: Georgia Pacific Corporation

Type Agreement: Purchase Order No. 1183

Award Period: From 2/5/82 To 2/18/82 (Performance) ______ (Reports)

Sponsor Amount: $1,001 Contracted through:

Cost Sharing: ______ GTRI/~~GIT~~ XXX

Title: Carbon Monoxide Decay Rate Measurement in Large Environmental Chamber

ADMINISTRATIVE DATA

OCA Contact Faith G. Costello

1) Sponsor Technical Contact:

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Georgia Pacific Corp.
Technical Center
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Decatur, GA 30035

2) Sponsor Admin/Contractual Matters:

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Decatur, GA 30035

Defense Priority Rating: N/A

Security Classification: N/A

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with sponsor; however, none proposed.

COMMENTS:

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
Research Property Management	Reports Coordinator (OCA)	Computer Input
Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other ______

FORM OCA 4:781

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 3/10/82

Project Title: Carbon Monoxide Decay Rate Measurement in Large Environmental Chamber

Project No: A-3162

Project Director: W. M. Ewing

Sponsor: Georgia Pacific Corporation

Effective Termination Date: 2/18/82

Clearance of Accounting Charges: 2/18/82

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other __________

Assigned to: EDL/SHS (~~School~~/Laboratory)

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
Research Property Management	Reports Coordinator (OCA)	Computer Input
Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other ______

FORM OCA 10:781

DETERMINATION OF THE AIR EXCHANGE RATE IN AN ENVIRONMENTAL TEST CHAMBER

for
GEORGIA-PACIFIC CORPORATION
Southeast Resin Development Laboratory
2883 Miller Road
Decatur, Georgia 30035

February 16, 1982

submitted by
GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Occupational Safety and Health Services
Atlanta, Georgia 30332

Project No. A-3162

DETERMINATION OF THE AIR EXCHANGE RATE
IN AN ENVIRONMENTAL TEST CHAMBER

for
GEORGIA-PACIFIC CORPORATION
Southeast Resin Development Laboratory
2883 Miller Road
Decatur, Georgia 30035

1.0 INTRODUCTION

The Georgia Tech Research Institute (GTRI) was retained by Mr. Larry R. Newton of the Georgia-Pacific Corporation to perform a determination of the air exchange rate in an environmental test chamber. The chamber is located at Georgia-Pacific's Southeast Resin Development Laboratory, 2883 Miller Road, Decatur, Georgia. Six determinations were performed on February 11, 1982, by Messers. William M. Ewing and William H. Spain of GTRI. This report summarizes the results of these determinations. The results of the carbon monoxide decay determinations have been compiled in Appendix A. The procedure for the determination of air exchange using carbon monoxide is included in Appendix B.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The air exchange rate for Georgia-Pacific's environmental test chamber was determined to be 0.61 air changes per hour. This value was determined as the mean value for three paired tests (total of six determinations). This value is slightly higher than that calculated by Georgia-Pacific personnel of 0.54 air changes per hour.

The results of test numbers I, III, and V, each taken at the same sampling location indicated the air exchange rate may have decreased from 0.68 to 0.54 during the course of the study. To determine if the rate is actually changing it would be necessary during future tests to record the dry gas meter readings at the start and stop of each test.

Simultaneous sampling performed at sampling locations one and two indicated a variation in the exchange rate of 4.4 and 1.7 percent of the two paired tests. However, simultaneous sampling performed at sampling points one and three (tests V and VI) indicated a difference of 11.5 percent. This may be due to some dilution of the carbon monoxide concentration at sampling point number three (exit port of the chamber). If this is the cause of this variation then a longer sampling probe at the exit port should alleviate the problem.

Observations of air flow within the chamber using a smoke tube indicated some channeling of the supply air may be caused by the mixing fan. Dead air spaces were not noted. To check for channeling a formaldehyde test should be run simultaneously at sampling locations two and three to see if higher concentrations of formaldehyde are found at sampling location three.

Future air exchange rate determinations using carbon monoxide should be conducted with the chamber "loaded" with samples and the air conditioner operating.

3.0 PRESENTATION AND DISCUSSION OF FINDINGS

3.1 Environmental Test Chamber

Figure 3.0-1 is a sketch of the environmental test chamber. The chamber, measured with a standard tape measure, was found to be 208 1/4 inches long, 87 3/4 inches wide, and 94 3/4 inches in height. All measurements reflect interior dimensions. Using these measurements the air volume of the chamber is 1002 cubic feet (ft^3). It was estimated by Mr. William Ewing that equipment inside the chamber occupies approximately 2 ft^3. Accordingly, the adjusted volume of the chamber for calculations used in this report is 1000 ft^3.

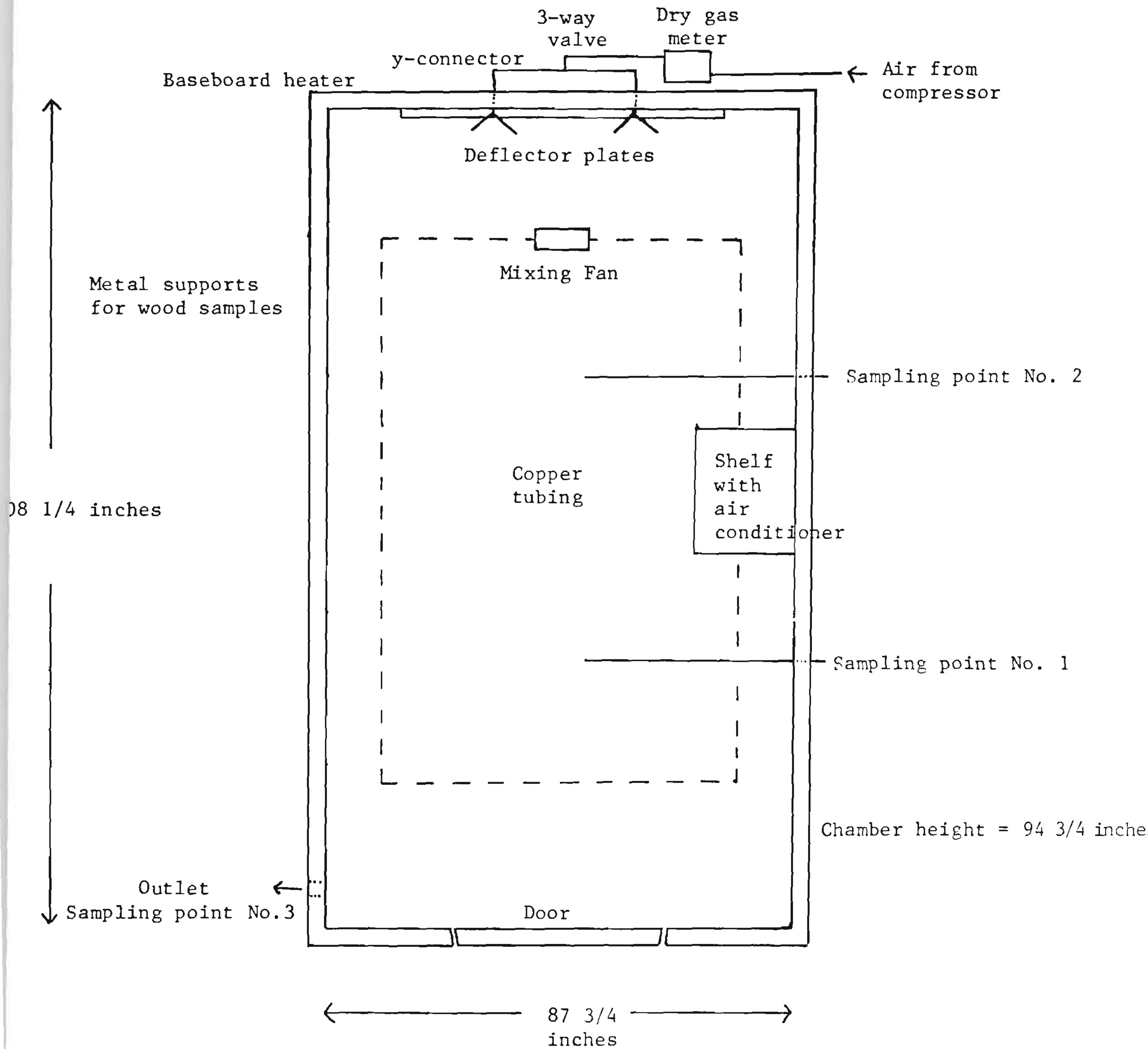
The chamber contains a metal structure used to support wood samples for off-gasing tests. A fan is located near one end of the chamber at a height of 4 feet for mixing of the air. Additionally, an air conditioner is situated on a shelf at a height of 6 feet. An electric baseboard heater is located at one end of the chamber. Two sampling probes extend from one wall for the purpose of collecting air samples. These probes are constructed of 1/4-inch copper tubing. A single door is located at one end of the chamber. Photographs (Figures 3.0-2 and 3.0-3) depict the exterior and interior of the chamber as it appeared during these tests.

The air supply for the chamber is from a recipricating air compressor located in a partially enclosed shed at the rear of the building. Air from the compressor, after passing an oil trap enters a dry gas meter located outside the rear of the chamber. From the meter, air passes a three-way valve to a Y-connector which splits the incoming air into two streams. The two streams of air are fed into the chamber through two ducts (approximately 1/2-inch diameter) located at a height of 4 feet. Deflector plates are attached at the end of each duct to reduce channeling of the incoming air. The chamber contains one outlet port (approximately 2 inches in diameter) as indicated on Figure 3.0-1. It should be noted that during the test the mixing fan was on and the air conditioner was off. Wood samples were not in the chamber during testing.

Georgia-Pacific personnel recorded the dry gas meter readings at 805 and 1542. These readings were 689,100 and 693,200, respectively. The dry gas meter indicated 4100 ft^3 of air was introduced to the chamber during a 7.62 hour period. This results in an infiltration rate of 538 ft^3 per hour. Assuming a constant volume of 1000 ft^3 for the chamber the calculated air exchange rate is 0.54 air changes per hour.

3.2 Carbon Monoxide Decay Determinations

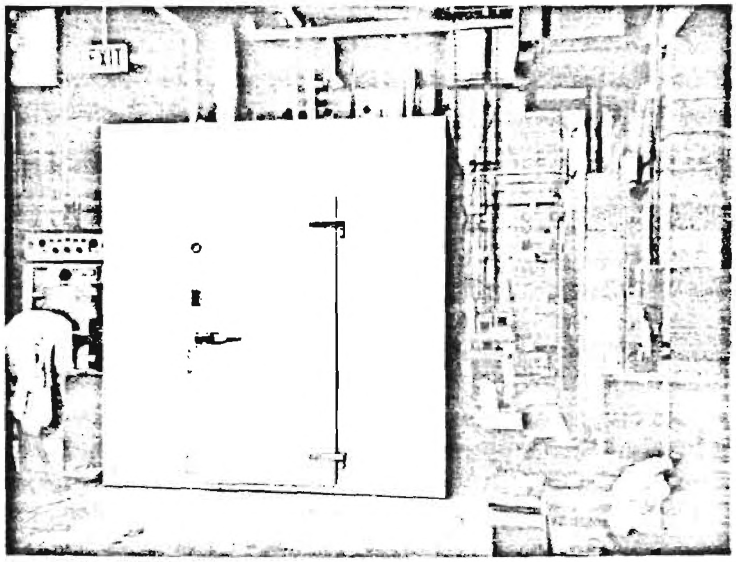
Six carbon monoxide decay determinations were made using the procedures outlined in Appendix B. The 4% carbon monoxide source was introduced to the chamber through the three-way valve located immediately downstream of the dry gas meter. Figures 3.0-4 and 3.0-5 illustrate the connections used to supply the



ENVIRONMENTAL TEST CHAMBER
(Not to Scale)

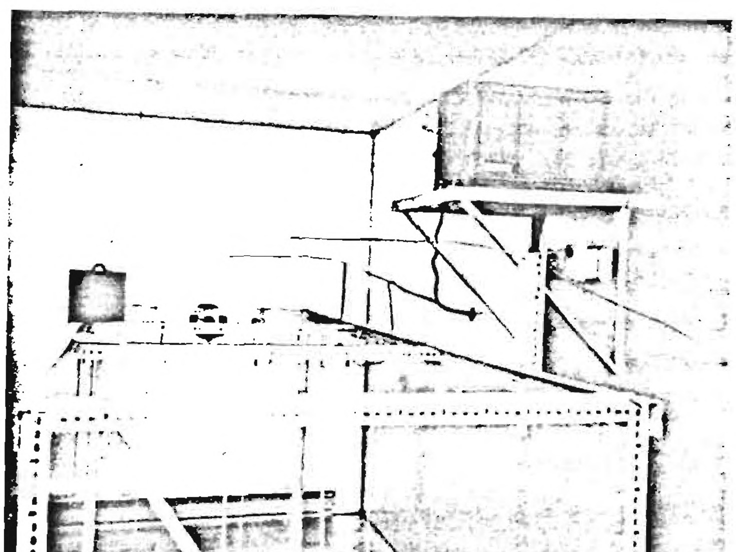
Georgia-Pacific Corporation
Southeast Resin Development Laboratory
Decatur, Georgia

Figure 3.0-1



ENVIRONMENTAL TEST CHAMBER
(Outside View)

Figure 3.0-2

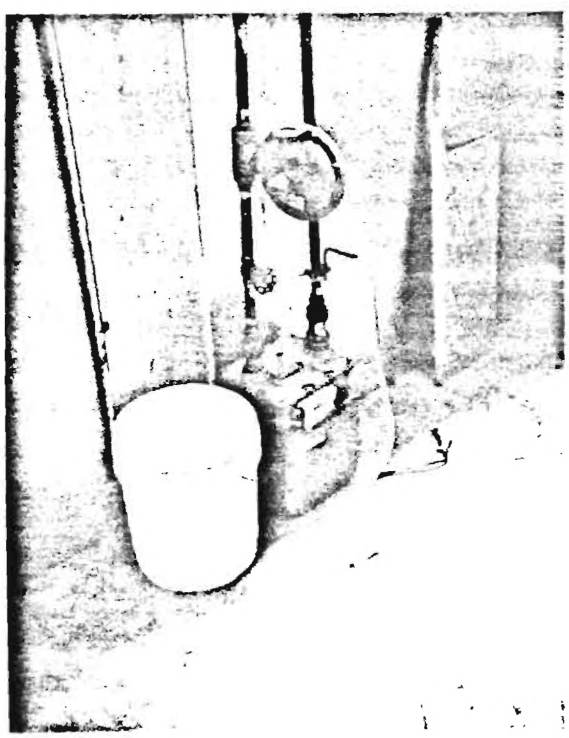


ENVIRONMENTAL TEST CHAMBER
(Inside View)

Figure 3.0-3

CARBON MONOXIDE SOURCE
4% CO, two-stage regulator,
3/8-inch Tygon tubing

Figure 3.0-4



DRY GAS METER
CO gas introduced at 3-way valve downstream of meter,
3/8-inch Tygon tubing,
1/4-inch copper tubing

Figure 3.0-5

chamber with dilute carbon monoxide gas. The cylidner (1650 psi) was fitted with a two-stage regulator. The regulator was then fitted with a nipple to attach 3/8-inch Tygon tubing. Dilute carbon monoxide gas was introduced at a pressure (regulator) of 10 psi until the cylinder pressure had dropped approximately 50 psi. This resulted in a chamber concentration of about 70-80 parts per million (ppm) carbon monoxide in air. After introduction of the gas, the regulator, three-way, and cylinder valves were closed during the test. It should be noted that the concentration of carbon monoxide inside the chamber was 2-3 ppm prior to the carbon monoxide decay test. This is a normal ambient level for carbon monoxide.

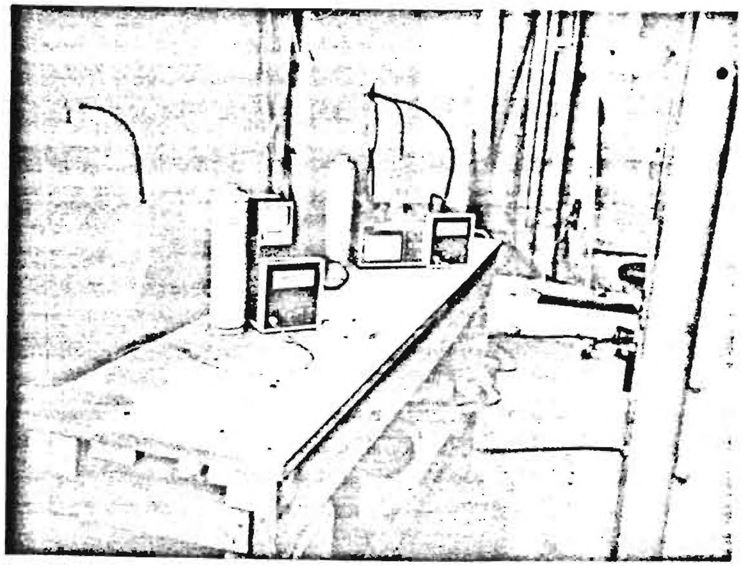
Three pairs of carbon monoxide decay determinations were conducted. Test numbers I and II were conducted simultaneously at sample points one and two, respectively. Test numbers III and IV were conducted simultaneously at sampling points one and two as well. The difference between the first pair of tests and the second is the latter pair evaluated the chamber using lower (10-20 ppm) concentrations of carbon monoxide gas. The third pair of tests (numbers V and VI) were conducted simultaneously at sampling points one and three, respectively. Photographs indicating each sampling point and the instrumentation used are depicted in Figures 3.0-6 and 3.0-7. The results of each test is detailed in Appendix A. The following is a summary of the six tests.

Test Number	Sampling Point	CO Concentration (ppm) Initial (C_i)	Final(C_f)	Air Exchange Rate (I)
I	1	64.5	46.0	0.68
II	2	70.0	50.5	0.65
III	1	46.0	34.5	0.58
IV	2	50.5	38.0	0.57
V	1	66.0	50.5	0.54
VI	3	67.0	49.5	0.61

SUMMARY OF CARBON MONOXIDE DECAY DETERMINATIONS

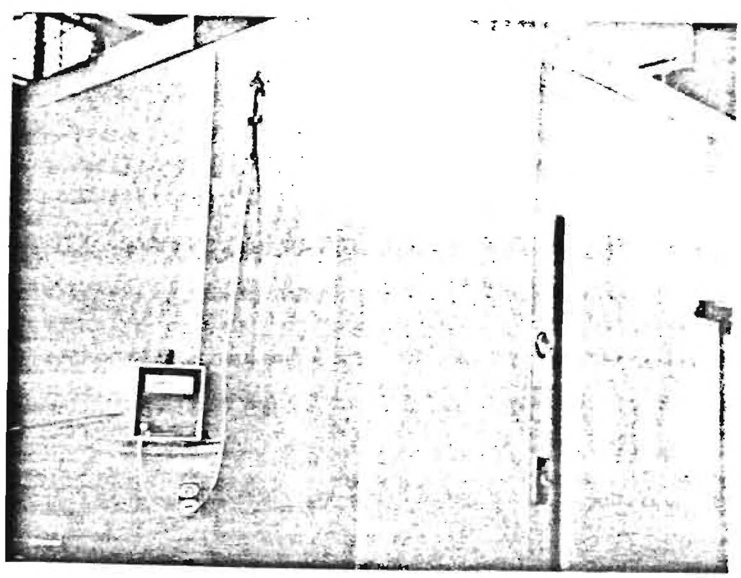
TABLE 3.0-1

From the above data the calculated mean ($\bar{x}$) for all six determinations is 0.61 air changes per hour. The standard deviation (Sx) is 0.052. The upper and lower limits (95% degree of confidence) are 0.55 and 0.66 air changes per hour, respectively.



SAMPLING POINTS NO. 1 (left) AND NO. 2 (right)

Figure 3.0-6



SAMPLING POINT NO. 3

Figure 3.0-7

The paired tests indicated slight differences in the concentrations of carbon monoxide at different sampling points. It appears from pre and post-determination calibrations of the carbon monoxide measuring instruments that these variations in the actual carbon monoxide concentration may be due to differences in instrument responses. It should be noted, however, that the change in concentration over time was very close for the first two paired tests (less than 0.03 air changes/hour). The third paired tests indicated a difference between the two sampling points of 0.07 air changes per hour with the higher rate occuring at the exit port of the chamber. This may be due to some dilution at the exit port or to experimental error. It should also be noted that all carbon monoxide concentrations were recorded manually each minute of each test to reduce error that might occur when retrieving data from a strip chart.

This report prepared by:

William M. Ewing
Industrial Hygienist

Reviewed by:

William H. Spain, C.I.H.
Industrial Hygienist

Approved by:

James L. Burson, C.I.H.
Program Manager
Occupational Safety and Health Branch

APPENDIX A

RESULTS OF CARBON MONOXIDE DECAY DETERMINATIONS

TEST I

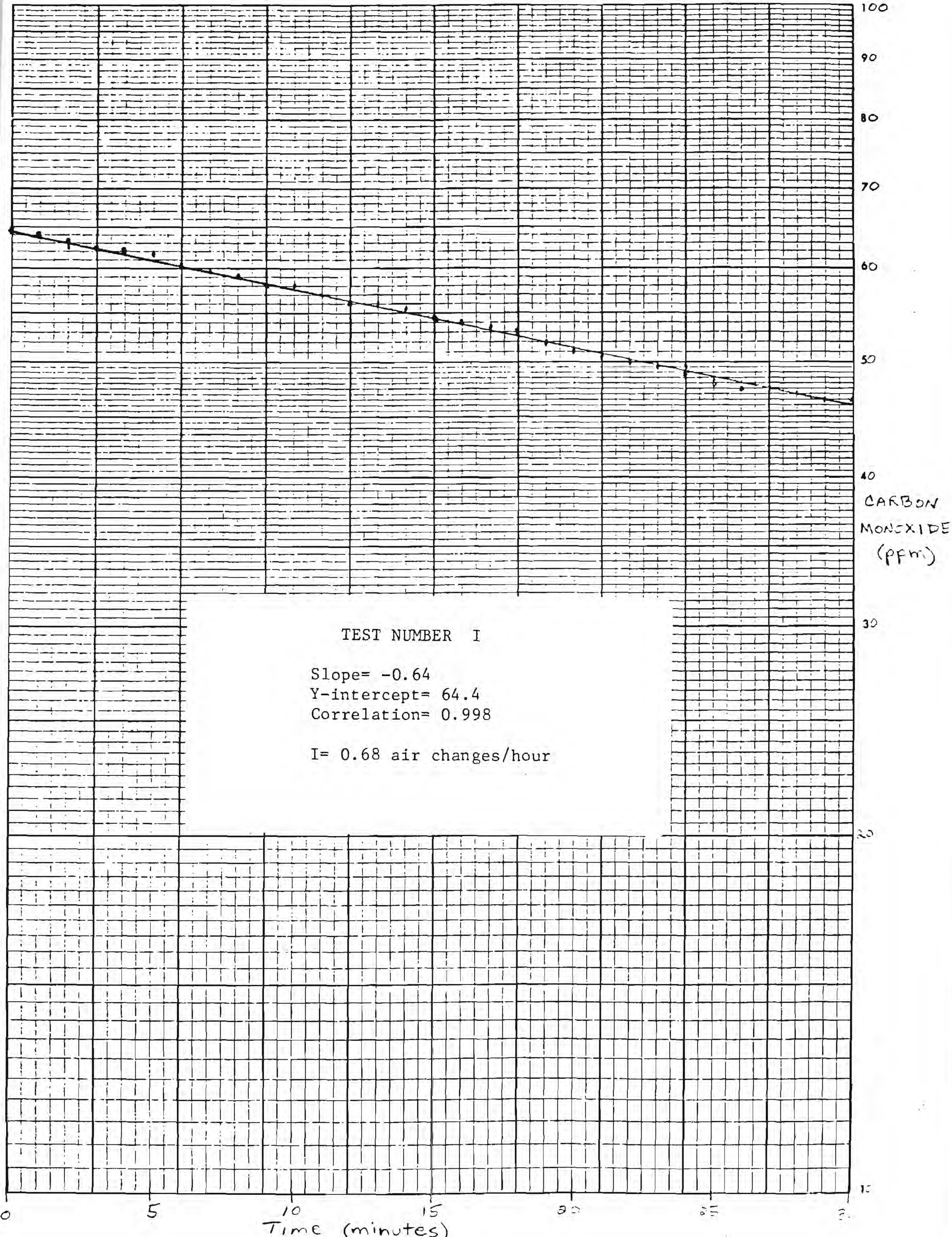
Test Location: Sampling point No. 1 Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23491)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1135	64.5	1150	54.5
36	64.0	51	54.0
37	63.5	52	53.5
38	62.5	53	53.0
39	62.0	54	52.0
1140	61.5	1155	51.0
41	60.5	56	50.5
42	59.5	57	50.0
43	59.0	58	49.5
44	58.0	59	49.0
1145	58.0	1200	48.0
46	57.0	01	47.5
47	56.0	02	47.5
48	56.0	03	47.0
49	55.5	04	46.0
		1205	46.0

$$\text{Air exchange rate (I)} = -\ln\left[\frac{C_f}{C_i}\right]\frac{1}{\Delta t}$$

$$I = -\ln\left[\frac{46.0}{64.5}\right]\frac{1}{0.5}$$

$$I = 0.68 \text{ air changes/hour}$$



TEST NUMBER I

Slope= -0.64
Y-intercept= 64.4
Correlation= 0.998

I= 0.68 air changes/hour

TEST II

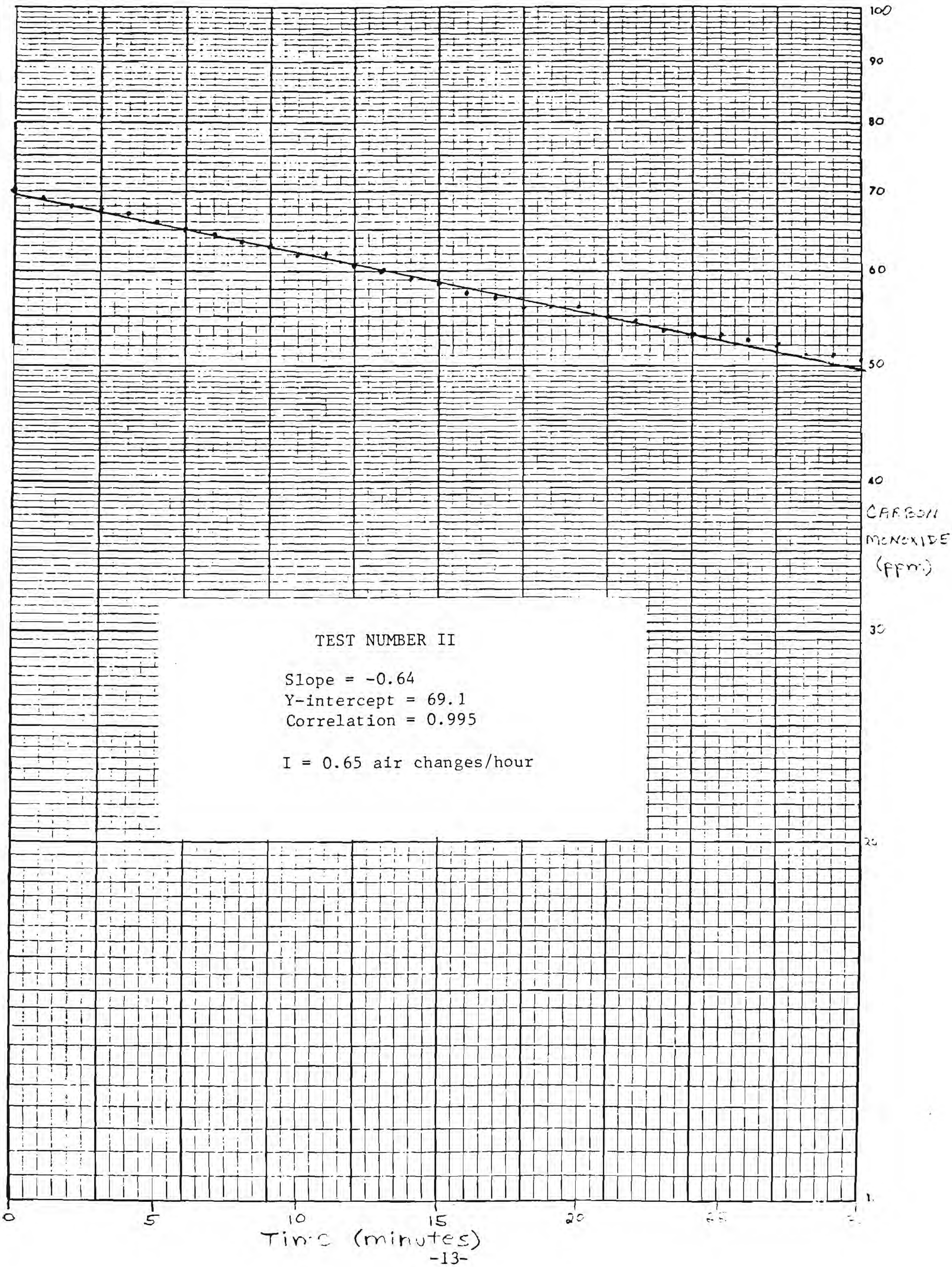
Test Location: Sampling point No. 2 Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23490)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1135	70.0	1150	58.5
36	69.0	51	57.5
37	68.0	52	57.0
38	67.5	53	56.0
39	67.0	54	56.0
1140	66.0	1155	56.0
41	65.0	56	55.0
42	64.5	57	54.5
43	63.5	58	53.5
44	63.0	59	53.0
1145	62.0	1200	53.0
46	62.0	01	52.5
47	60.5	02	52.0
48	60.0	03	51.0
49	59.0	04	51.0
		1205	50.5

$$\text{Air exchange rate } (I) = -\ln \left[\frac{C_f}{C_i}\right] \frac{1}{\Delta t}$$

$$I = -\ln \left[\frac{50.5}{70.0}\right] \frac{1}{0.5}$$

I = 0.65 air changes/hour


TEST NUMBER II
Slope = -0.64
Y-intercept = 69.1
Correlation = 0.995
I = 0.65 air changes/hour
CARBON MONOXIDE (ppm)
100
90
80
70
60
50
40
0
5
10
15
20
Time (minutes)

TEST III

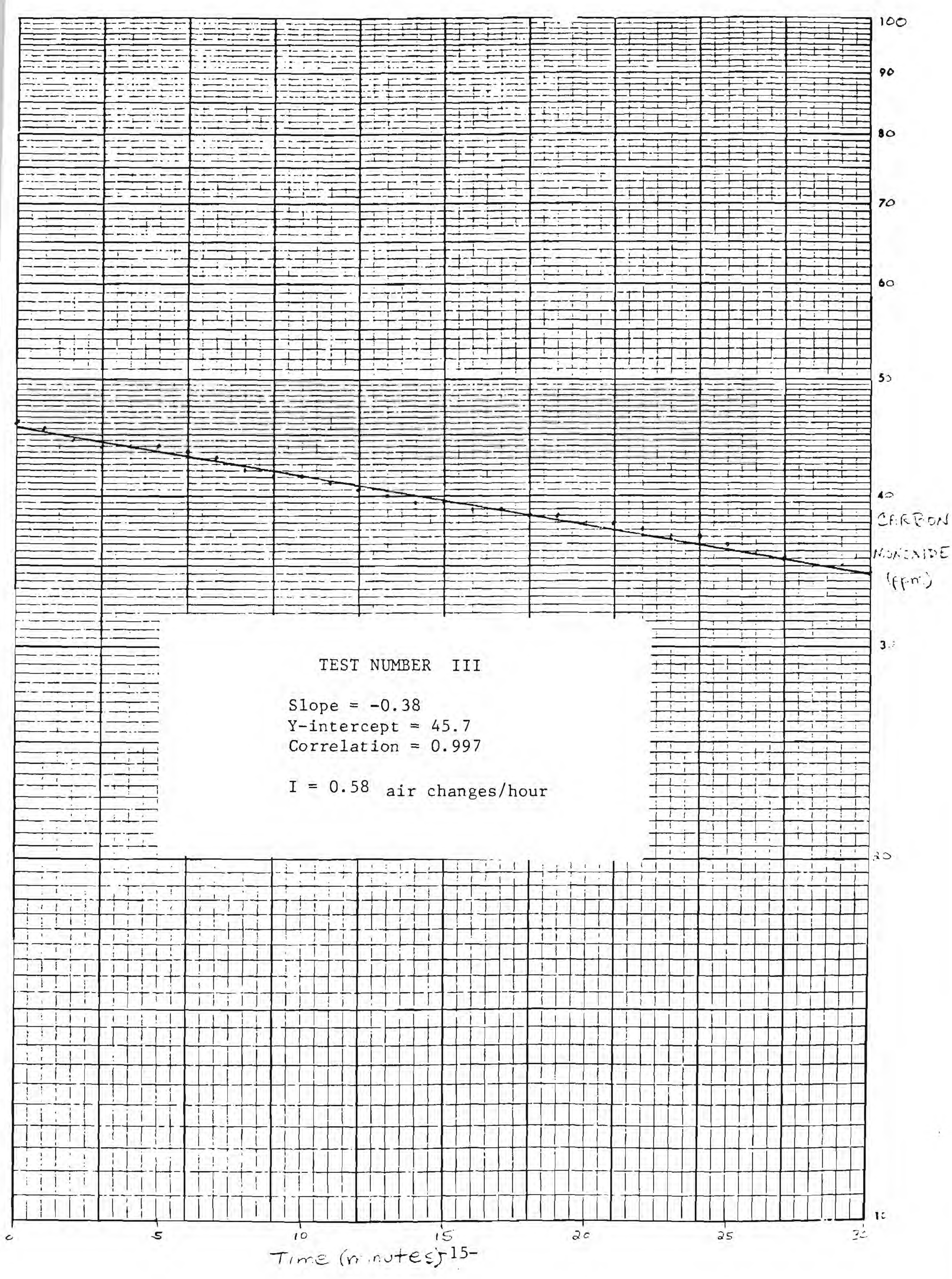
Test Location: Sampling point No. 1 Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23491)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1205	46.0	1220	39.5
06	45.5	21	39.0
07	44.5	22	39.0
08	44.0	23	38.5
09	44.0	24	38.5
1210	44.0	1225	38.0
11	43.5	26	38.0
12	43.0	27	37.5
13	42.0	28	37.0
14	41.5	29	37.0
1215	41.5	1230	36.5
16	41.0	31	36.0
17	40.5	32	35.5
18	40.0	33	35.0
19	39.5	34	35.0
		1235	34.5

$$\text{Air exchange rate (I)} = -\ln\left[\frac{C_f}{C_i}\right]\frac{1}{\Delta t}$$

$$I = -\ln\left[\frac{34.5}{46.0}\right]\frac{1}{0.5}$$

$$I = 0.58 \text{ air changes/hour}$$


TEST NUMBER III
Slope = -0.38
Y-intercept = 45.7
Correlation = 0.997
I = 0.58 air changes/hour
100
90
80
70
60
50
40
30
20
10
CARBON MONOXIDE (ppm)
0
5
10
15
20
25
30
Time (minutes)

TEST IV

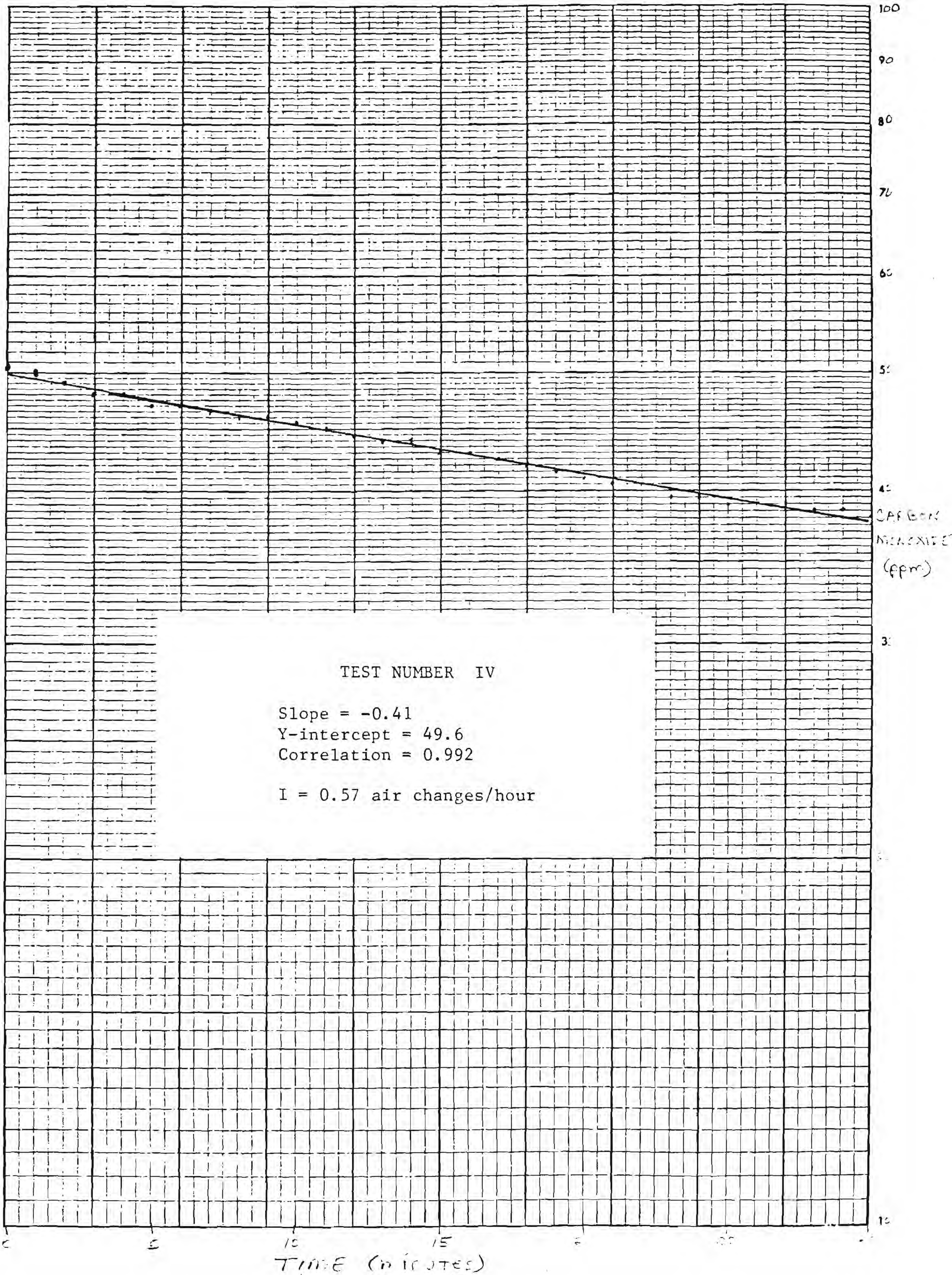
Test Location: Sampling point No. 2 Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23490)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1205	50.5	1220	43.0
06	50.0	21	43.0
07	49.0	22	42.5
08	48.0	23	42.0
09	48.0	24	41.5
1210	47.0	1225	41.0
11	47.0	26	41.0
12	46.5	27	40.5
13	46.0	28	40.5
14	46.0	29	39.5
1215	45.5	1230	39.5
16	45.0	31	39.0
17	44.5	32	39.0
18	44.0	33	39.0
19	44.0	34	38.5
		1235	38.0

$$\text{Air exchange rate } (I) = -\ln \left[\frac{C_f}{C_i}\right] \frac{1}{\Delta t}$$

$$I = -\ln \left[\frac{38.0}{50.5}\right] \frac{1}{0.5}$$

$$I = 0.57 \text{ air changes/hour}$$


TEST NUMBER IV
Slope = -0.41
Y-intercept = 49.6
Correlation = 0.992
I = 0.57 air changes/hour
100
90
80
(ppm)
15
TIME

TEST V

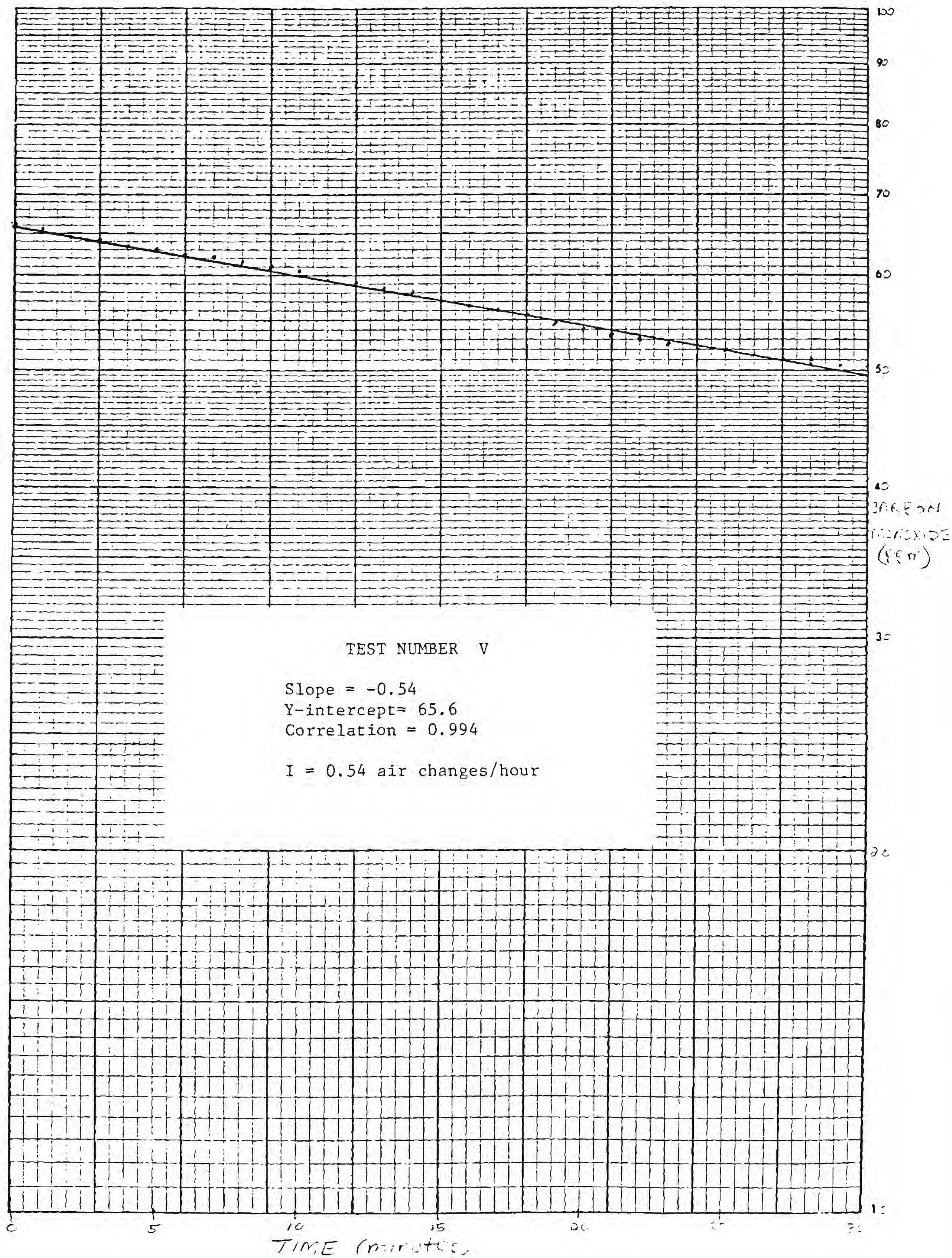
Test Location: Sampling point No. 1 — Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) — Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23491)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1433	66.0	1448	57.0
34	65.5	49	56.5
1435	64.5	1450	56.0
36	64.0	51	55.5
37	63.5	52	54.5
38	63.0	53	54.0
39	62.5	54	53.5
1440	62.0	1455	53.0
41	61.5	56	52.5
42	61.0	57	52.0
43	60.5	58	52.0
44	59.5	59	51.5
1445	59.0	1500	51.0
46	58.5	01	51.0
47	58.0	02	50.5
		03	50.5

$$\text{Air exchange rate } (I) = -\ln\left[\frac{C_f}{\bar{C}_i}\right]\frac{1}{\Delta t}$$

$$I = -\ln\left[\frac{50.5}{66.0}\right]\frac{1}{0.5}$$

$$I = 0.54 \text{ air changes/hour}$$


TEST NUMBER V
Slope = -0.54
Y-intercept= 65.6
Correlation = 0.994
I = 0.54 air changes/hour
TIME (minutes)

TEST VI

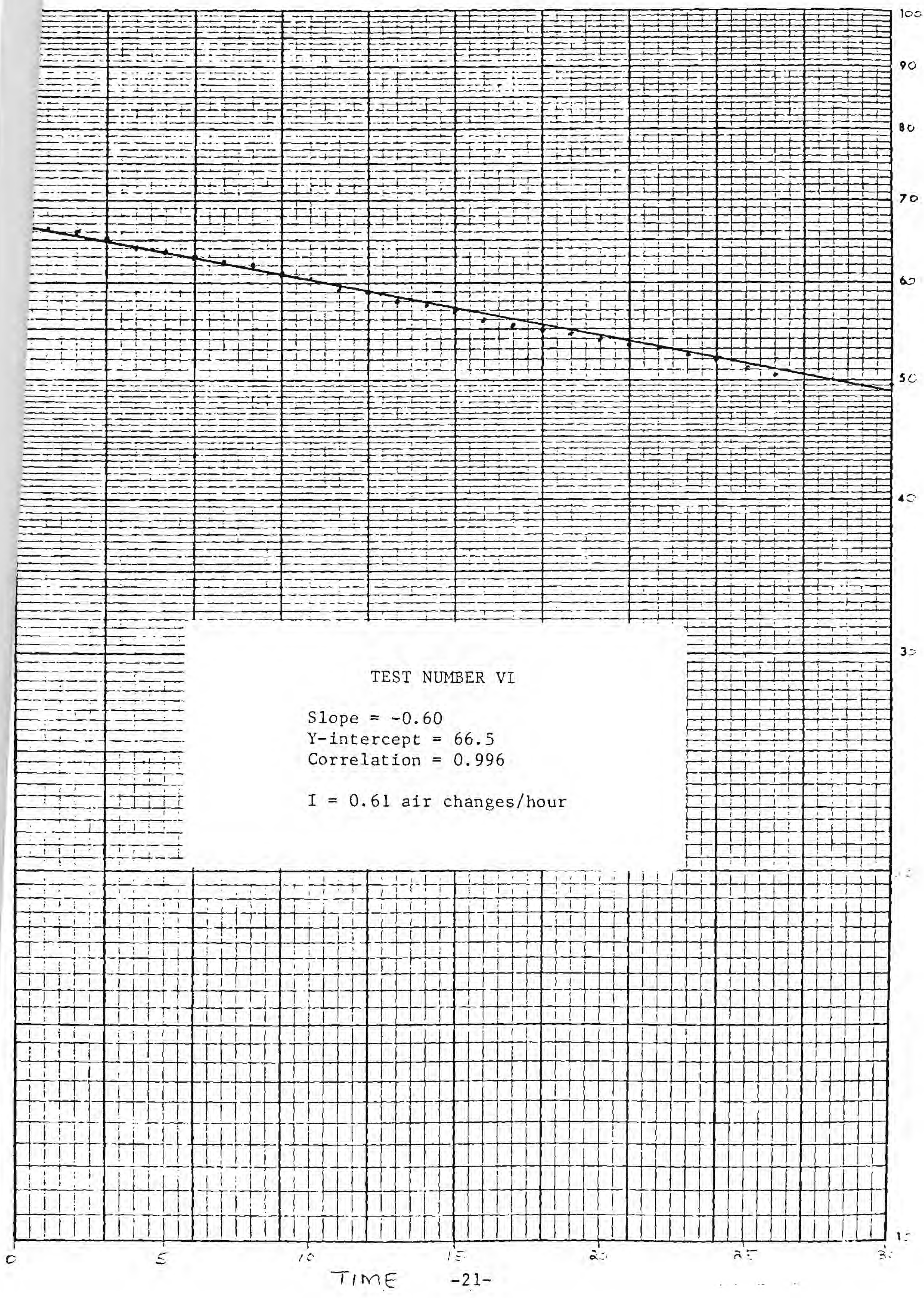
Test Location: Sampling point No. 3 Invetigators: Ewing/Spain
Test Duration: 30 minutes (0.5 hrs) Date: February 11, 1982
Instrument: Interscan CO detector (Model No. 1144, S/N 23490)

Time	Indicated CO Concentration (ppm)	Time	Indicated CO Concentration (ppm)
1433	67.0	1448	57.0
34	66.5	49	56.0
1435	66.0	1450	55.5
36	65.0	51	55.0
37	64.0	52	54.5
38	63.5	53	54.0
39	63.0	54	53.5
1440	62.5	1455	53.0
41	62.0	56	52.5
42	61.0	57	52.0
43	60.5	58	51.0
44	59.5	59	50.5
1445	59.0	1500	50.0
46	58.0	01	50.0
47	57.5	02	49.5
		03	49.5

$$\text{Air exchange rate } (I) = -\ln \left[\frac{C_f}{\bar{C}_i}\right] \frac{1}{\Delta t}$$

$$I = -\ln \left[\frac{49.5}{67.0}\right] \frac{1}{0.5}$$

$$I = 0.61 \text{ air changes/hour}$$


100
90
80
70
60
50
40
30
10
0
5
10
15
20
25
30
TIME
TEST NUMBER VI
Slope = -0.60
Y-intercept = 66.5
Correlation = 0.996
I = 0.61 air changes/hour

APPENDIX B

PROCEDURE FOR THE DETERMINATION OF AIR EXCHANGE USING CARBON MONOXIDE

PROCEDURE FOR THE DETERMINATION OF
AIR EXCHANGE RATE USING CARBON MONOXIDE

Principle of the Method: A known concentration of carbon monoxide (CO) is generated in the enclosure for which the air exchange rate (I) is to be determined. The concentration of carbon monoxide is then measured over time (t). The resultant value gives the air exchange rate in cubic feet per hour (CFH).

Apparatus:

1) Source of 4% (40,000 ppm) carbon monoxide. CAUTION - CO at this concentration is lethal.

2) Two-stage regulator equipped with a 1/4-inch nipple.

3) 50 feet of3/8" tygon tubing.

4) 2 carbon monoxide detectors, Interscan CO meter or equivalent.

5) 2 strip chart recorders.

6) Adjustable wrench.

Procedure:

1) Connect the two-stage regulator to the cylinder of 4% CO using the adjustable wrench. Be sure the regulator is turned off. Connect the nipple and a suitable length of tygon tubing to the regulator outlet.

2) Place one calibrated CO meter outside the enclosure and attach a strip chart to record the ambient level during the entire test. Record the time, chart speed, attenuation, range, and initial concentration.

3) Attach a suitable length of tygon tubing to a second calibrated CO meter which will collect air from within the enclosure. Attach a strip chart and record data as in procedure 2.

4) Introduce 4% CO to the structure until the CO meter monitoring inside the structure reads approximately 75 ppm*. Turn off CO gas. Mark time on strip chart. Continue reading CO concentration inside and outside structure for .5hours.

Calculations: The air exchange rate is calculated using the following formula.

$$I = -\ln \left[\frac{C_f}{C_i} \right] \frac{1}{\Delta t}$$

where: I = air exhange rate in CFH
C_i = initial CO concentration in ppm
C_f = final CO concentration in ppm
Δt = duration of test in hours

*For a 6600 ft^3 enclosure approximately 200 psi, 4% CO will be needed to attain 75 ppm.

For further information: See ASTM Special Technical Publication No. 719, Building Air Change Rate and Infiltration Measurement by Hunt, King, and Trechsel.

NOTE: The results may be presented graphically by plotting the gas concentration (y axis) versus time (x axis) on semilog paper (2 or 3 cycle).