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

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

# Emission Testing at a By-Product Coke Plant (Battery D Stack)

C.F. & I. Steel Corporation
Pueblo, Colorado

Prepared for the
U.S. Environmental Protection Agency
Emission Measurement Branch
Research Triangle Park, North Carolina 27711

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EMB REPORT NO. 79-CKO-16

Work Assignment 16

Contract No. 68-02-2817

# FOREWARD

Two firms prepared this report under contract to the U.S. Environmental Protection Agency; therefore, it is presented in two sections.

Section I was prepared by Clayton Environmental Consultants, Inc., Southfield, Michigan, and includes test results for particulate, sulfate, and chloroform/ether extractables; $NO_x$ (Method 7); continuous monitoring of CO, $O_2$, and $NO_x$; $O_2$, CO, $CO_2$ (Method 3); and, visible emission data for the Battery D stack exhaust.

Section II was prepared by TRW Energy Systems Group, Redondo Beach, California, and contains the benzo(a)pyrene (B(a)P) sampling data and summary, which immediately follows Appendix H of Section I.

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# 1.0 INTRODUCTION

The U.S. Environmental Protection Agency retained Clayton Environmental Consultants, Inc., to determine particulate and various gaseous emissions from the battery stack of Coke Oven Battery D at C.F. & I. Steel Corporation in Pueblo, Colorado. The results of this study will be used in research and development efforts for supporting New Source Performance Standards for coke oven battery stacks in the iron and steel industry. This study was commissioned as EMB Project No. 79-CKO-16, Contract No. 68-02-2817, Work Assignment 16.

The testing program included the following:

(1) Triplicate samples to be analyzed for particulate, sulfate and chloroform/ether extractables (of the impinger solution);

(2) Integrated bag samples for Orsat analyses;

(3) Continuous monitoring of carbon monoxide, nitrogen oxides and oxygen during the particulate runs;

(4) Grab samples for nitrogen oxides;

(5) Visible emission observations for the duration of each particulate sample run.

Auxiliary data included exhaust gas temperatures and flowrates, as determined from the traverses.

The study was conducted on August 7, 8, and 9, 1979 by Clayton Environmental Consultants, Inc. with the continuous nitrogen oxides and oxygen monitoring efforts subcontracted to York Research Corporation of Denver, Colorado. Project participants are listed in Appendix A.

## 2.0 SUMMARY AND DISCUSSION OF RESULTS

Results of the emission study are presented in Tables 2.1 through 2.5. Tables 2.1 and 2.2 present the filterable and total concentrations and emission rates of particulate and sulfate, respectively. The filterable fraction (front half) includes the particulate from the probe, front portion of the filter holder and the filter. Total particulate includes the filterable fraction plus the particulate in the rear half of the filter holder, the impingers, and connecting glassware up to the silica gel impinger. Concentrations are expressed as grains per dry standard cubic foot (gr/dscf) and milligrams per dry standard cubic meter (mg/dscm). Emission rates are expressed as pounds per hour (lb/hr) and kilograms per hour (kg/hr).

Table 2.3 presents sulfate expressed as a percent of particulate by weight. Sulfates are expressed as sulfuric acid (including sulfur trioxide). Nitrogen oxides concentrations and emission rates are presented in Table 2.4. Concentrations are expressed as parts of nitrogen dioxide per million parts of air (ppm) and the corresponding emission rates as lb/hr and kg/hr. Table 2.5 presents the results of the exhaust gas composition (Orsat) analyses.

All field data sheets and continuous monitoring data are included in Appendices B and C, respectively. Appendix D presents an example of calculations used to interpret the data collected.

PARTICULATE RESULTS

The measured filterable concentrations of particulate from Battery D, shown in Table 2.1, ranged from 0.035 to 0.045 gr/dscf (80.4 to 104 mg/dscm) and averaged 0.039 gr/dscf (89.9 mg/dscm). Concentrations of total particulate ranged from 0.043 to 0.064 gr/dscf (98.7 to 147 mg/dscm), and averaged 0.051 gr/dscf (118 mg/dscm).

Emission rates of filterable particulate ranged from 6.76 to 7.21 lb/hr (3.07 to 3.27 kg/hr) and averaged 6.93 lb/hr (3.15 kg/hr). Total particulate emission rates ranged from 8.38 to 9.54 lb/hr (3.80 to 4.33 kg/hr), and averaged 9.02 lb/hr (4.09 kg/hr). Generally, the data reflect good reproducibility (within 10 and 25-percent of the mean, based on concentration).

Run 1 results show a higher concentration of filterable and total particulate than Runs 2 and 3. The emission rates of filterable and total particulate, however, show lower filterable emissions and higher total particulate emissions than Runs 2 and 3. The flowrate during Run 1 was approximately 23-percent lower than during Runs 2 and 3, which contributes to

TABLE 2.1. PARTICULATE CONCENTRATIONS AND EMISSION RATES

| Sample Number | Date 1979 | Stack Gas Parameters | | Concentration | | | | Emission Rate | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flowrate | Temp | Filterable | | Total | | Filterable | | Total | |
| | | dscfm | F | gr/dscf | mg/dscm | gr/dscf | mg/dscm | lb/hr | kg/hr | lb/hr | kg/hr |
| 1 | 8-7 | 17,400 | 440 | 0.045 | 104 | 0.064 | 147 | 6.76 | 3.07 | 9.54 | 4.33 |
| 2 | 8-8 | 22,600 | 430 | 0.037 | 85.2 | 0.047 | 108 | 7.21 | 3.27 | 9.13 | 4.14 |
| 3 | 8-9 | 22,700 | 420 | 0.035 | 80.4 | 0.043 | 98.7 | 6.83 | 3.10 | 8.38 | 3.80 |
| Average | | 20,900 | 430 | 0.039 | 89.9 | 0.051 | 118 | 6.93 | 3.15 | 9.02 | 4.09 |

the differences in the calculated emission rates between these runs.

SULFATE RESULTS

Table 2.2 presents the measured filterable concentrations of sulfate, which was 0.012 gr/dscf for all three runs (ranging from 26.5 to 28.5 mg/dscm and averaging 27.2 mg/dscm). Concentrations of total sulfate ranged from 0.021 to 0.050 gr/dscf (47.6 to 115 mg/dscm), and averaged 0.032 gr/dscf (72.3 mg/dscm).

Emission rates of filterable sulfate ranged from 1.85 to 2.26 lb/hr (0.841 to 1.03 kg/hr), and averaged 2.12 lb/hr (0.964 kg/hr). Total sulfate emission rates ranged from 4.02 to 7.49 lb/hr (1.83 to 3.40 kg/hr), and averaged 5.37 lb/hr (2.44 kg/hr).

Sulfate, as a percent of the filterable particulate by weight (Table 2.3), ranged from 27.4 to 33.1-percent and averaged 30.5-percent. The total fractions ranged from 44.1 to 78.5-percent and averaged 59.2-percent.

Filterable sulfate concentrations are very reproducible over the three sample runs (0-percent variation about the mean). The emission rates of filterable sulfate are higher in Runs 2 and 3 than in Run 1 despite the similarity in sulfate concentrations, due to the higher flowrates which were measured in these runs. Total sulfate concentrations also

TABLE 2.2. SULFATE CONCENTRATIONS AND EMISSION RATES

| Sample Number | Date 1979 | Stack Gas Parameters | | Concentration | | | | Emission Rate | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flowrate | Temp | Filterable | | Total | | Filterable | | Total | |
| | | dscfm | F | gr/dscf | mg/dscm | gr/dscf | mg/dscm | lb/hr | kg/hr | lb/hr | kg/hr |
| 1 | 8-7 | 17,400 | 440 | 0.012 | 28.5 | 0.050 | 115 | 1.85 | 0.841 | 7.49 | 3.40 |
| 2 | 8-8 | 22,600 | 430 | 0.012 | 26.5 | 0.021 | 47.6 | 2.24 | 1.02 | 4.02 | 1.83 |
| 3 | 8-9 | 22,700 | 420 | 0.012 | 26.6 | 0.024 | 54.3 | 2.26 | 1.03 | 4.61 | 2.09 |
| Average | | 20,900 | 430 | 0.012 | 27.2 | 0.032 | 72.3 | 2.12 | 0.964 | 5.37 | 2.44 |

TABLE 2.3. SULFATE AS A PERCENT OF PARTICULATE (BY WEIGHT)

| Sample Number | Filterable | Total |
|---|---|---|
| 1 | 27.4 | 78.5 |
| 2 | 31.1 | 44.1 |
| 3 | 33.1 | 55.1 |
| AVERAGE | 30.5 | 59.2 |

show reproducibility for Runs 2 and 3 (with a 12-percent variation), but Run 1 shows twice as much total sulfate as Runs 2 and 3. A similar relationship exists in terms of total sulfate emission rates.

Total sulfate, as a percent of total particulate by weight, is 58-percent higher in Run 1 than the average of Runs 2 and 3. This fact, coupled with the higher total particulate concentrations and emission rates encountered in Run 1 versus Runs 2 and 3, and the differences in measured flowrates in these sets of data, suggests a possible difference in the process operating conditions between Run 1 and Runs 2 and 3.

NITROGEN OXIDES RESULTS

Nitrogen oxides concentrations for the Method 7 flask grab samples (Table 2.4) ranged from less than 7.66 to 81.9 ppm, and averaged 43.9 ppm. Emission rates ranged from less than 0.954 to 13.3 lb/hr (less than 0.433 to 6.04 kg/hr), and averaged 7.06 lb/hr (3.21 kg/hr). These averages do not include the "less than" values.

These grab sample results do not closely agree with the continuously monitored measurements of nitrogen oxides which are shown in Figures 2.1, 2.2, and 2.3. These measurements all fall within a range between 80 ppm, which occurred during Run 3 and 130 ppm, which occurred during Run 2. Grab Sample 2 does fall within this range, but Samples 1, 3, and 4 are all much lower

TABLE 2.4. NITROGEN OXIDES CONCENTRATIONS AND EMISSION RATES[a]

| Sample Number | Date 1979 | Concentrations | Emission Rate | |
|---|---|---|---|---|
| | | ppm | lb/hr | kg/hr |
| 1 | 8-7 | < 7.66 | <0.954 | <0.433 |
| 2 | 8-8 | 81.9 | 13.3 | 6.04 |
| 3 | 8-8 | 35.8 | 5.59 | 2.54 |
| 4 | 8-9 | 14.0 | 2.28 | 1.04 |
| | Average[b] | 43.9 | 7.06 | 3.21 |

[a]Method 7 flask grab samples (as nitrogen dioxide).
[b]Average based on Samples 2, 3, and 4.

Figure 2.1. Graphic display of continuously monitored data.

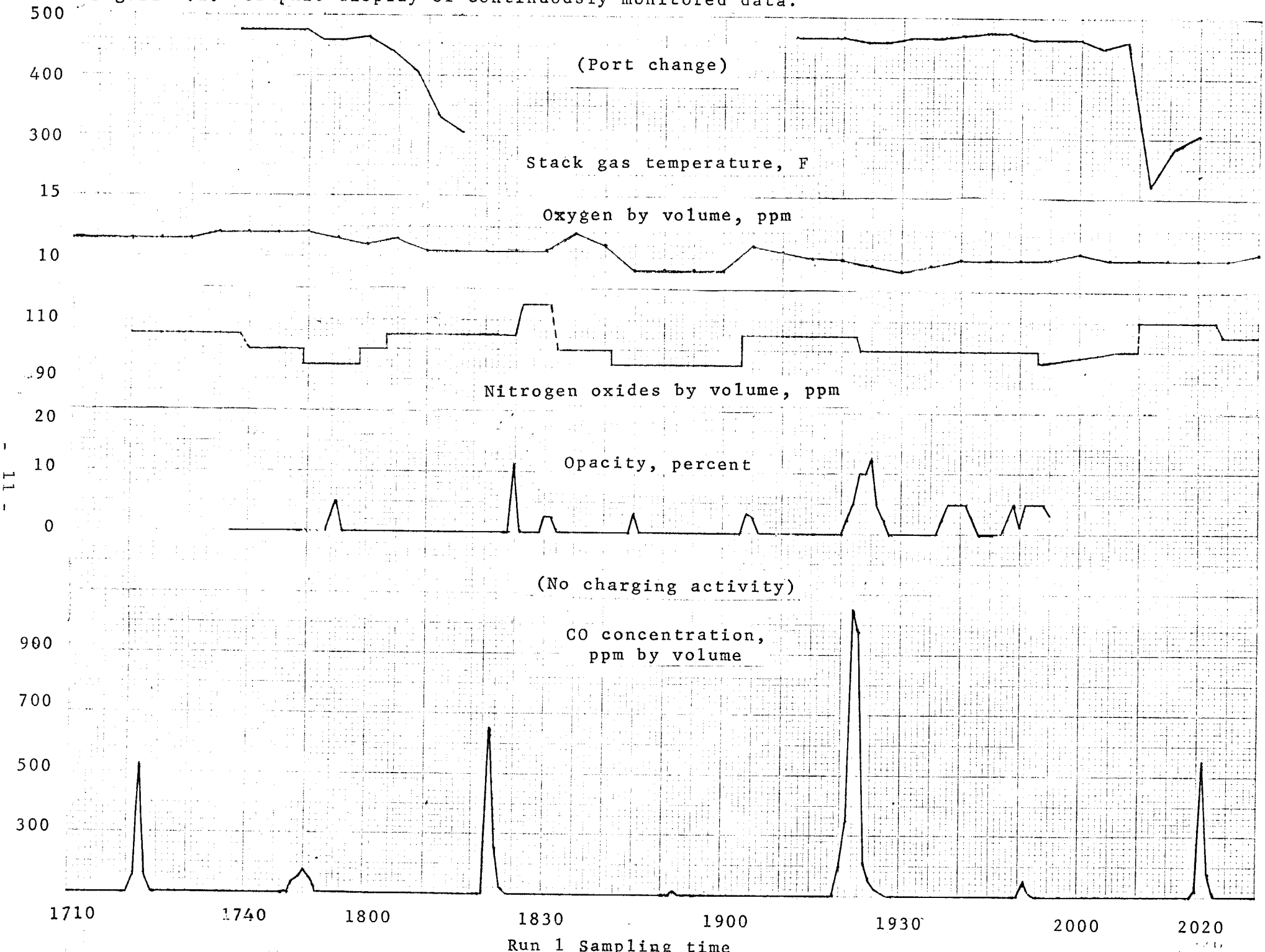


Figure 2.2. Graphic display of continuously monitored data.

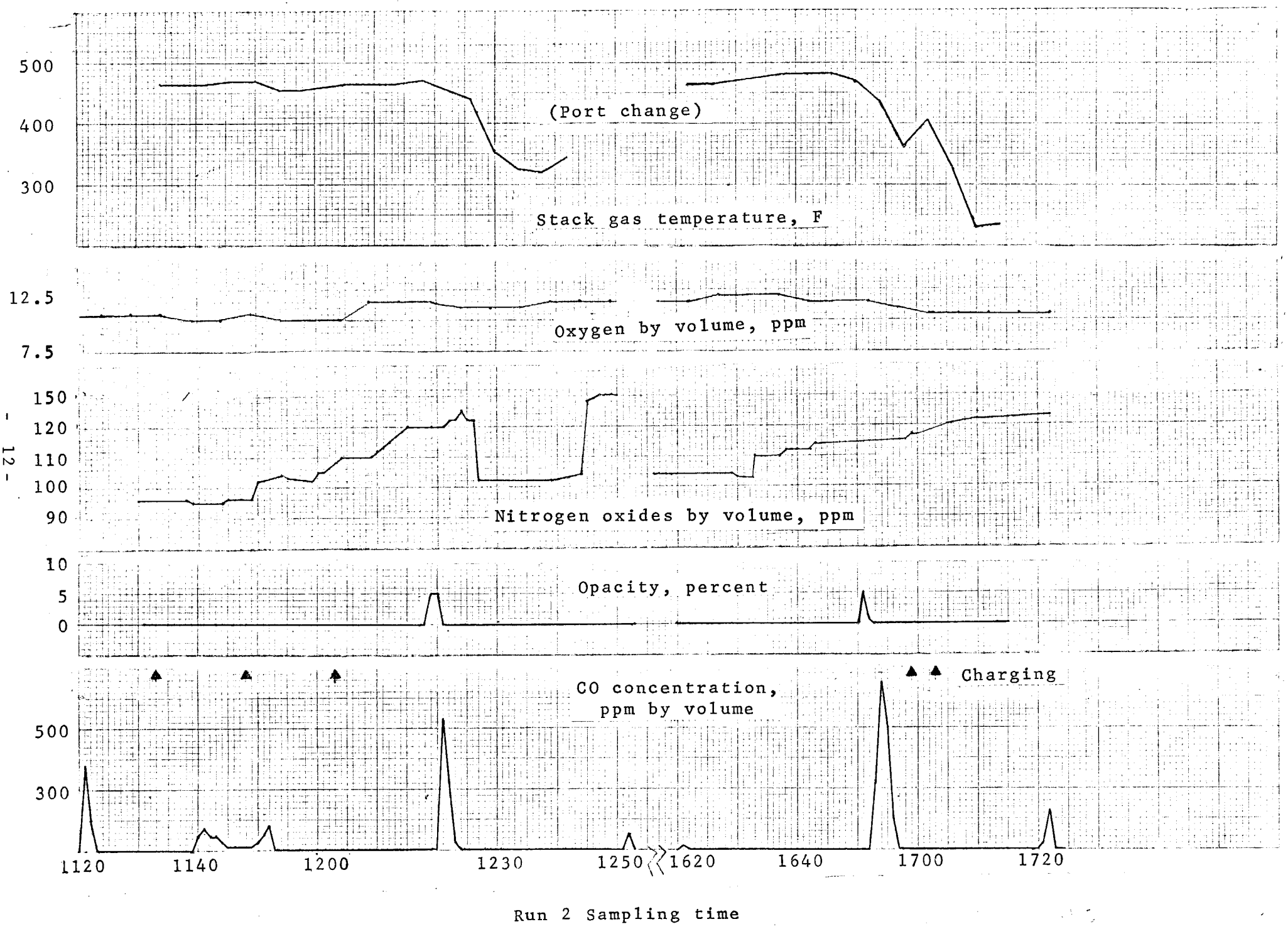
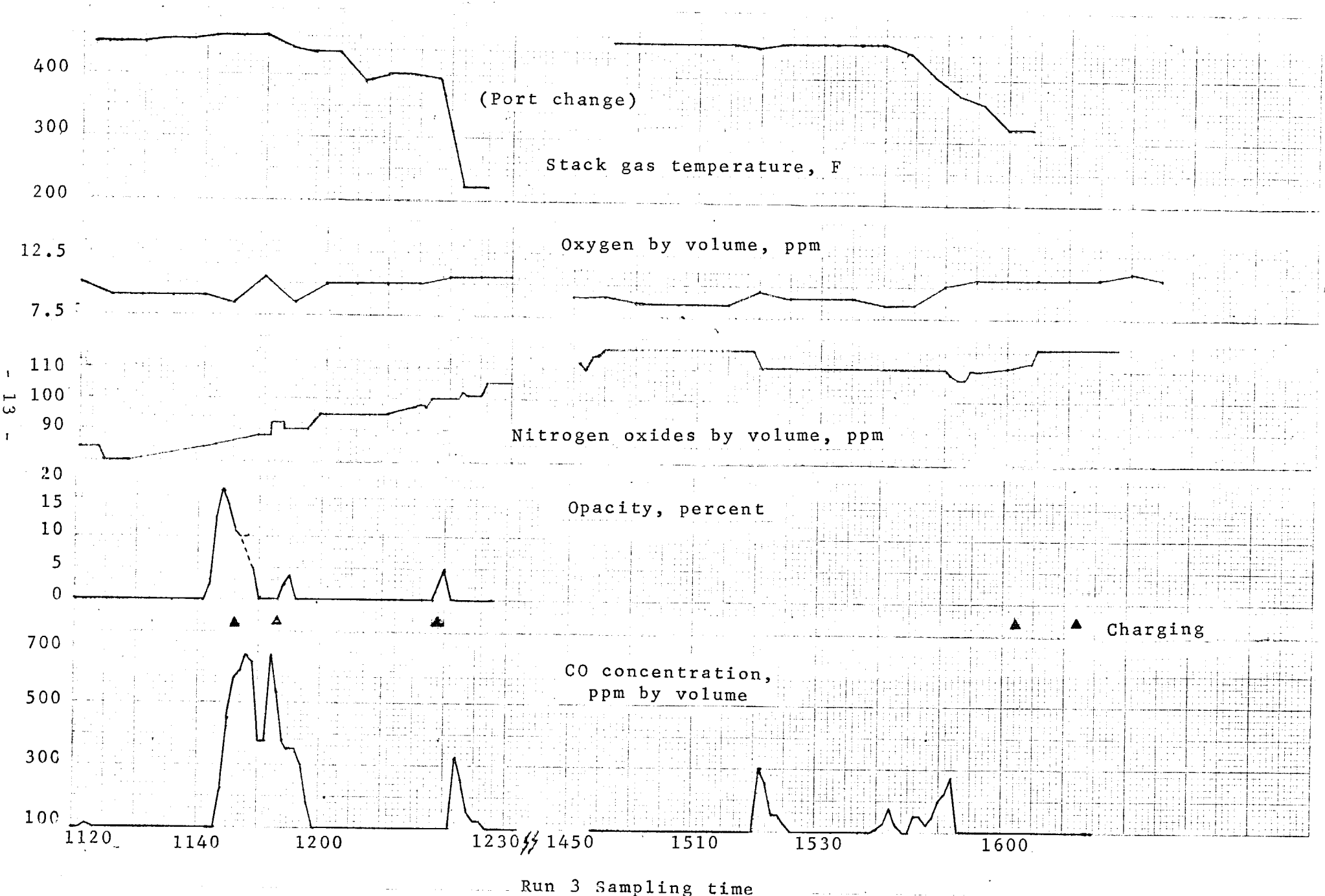


Figure 2.3. Graphic display of continuously monitored data.



than the continuous monitor recordings. The number of grab samples taken was not sufficient to determine if a true difference or apparent trend existed between the continuous monitor and the grab sample results.

## CONTINUOUS NITROGEN OXIDES MONITORING

Nitrogen oxides concentrations, as measured by the continuous chemiluminescence method, ranged from a low of 80 ppm during Run 3 to a high of 130 ppm during Run 2 (Figures 2.1, 2.2, and 2.3). These concentrations appear to fluctuate independently of temperature, oxygen, carbon monoxide, and opacity.

## CONTINUOUS OXYGEN MONITORING

The oxygen concentrations recorded by the continuous monitoring method ranged from a low of 8.5-percent during Run 3 to a high of 12.0-percent during Runs 1 and 2. These data correspond favorably to the oxygen levels measured by the Orsat method.

Oxygen levels remained relatively stable and appear to fluctuate independently of carbon monoxide, nitrogen oxides, opacity, and stack temperature fluctuations. Figures 2.1, 2.2, and 2.3 also display the recorded fluctuations of the oxygen levels.

## CONTINUOUS CARBON MONOXIDE MONITORING

With the exception of spiking, which coincided with the regularly-occurring coke oven gas reversals, carbon monoxide measurements were generally below 300

ppm, and usually remained near zero. Carbon monoxide concentrations are graphically displayed in Figures 2.1, 2.2, and 2.3 for Runs 1, 2, and 3, respectively.

The two-way radios used by the C.F. & I. coke oven battery workers caused occasional "radio interference" problems with the NDIR analyzer, which limited the precision attainable from the strip chart recordings, especially in the concentration range encountered.

There seems to be no relative correlation between carbon monoxide and nitrogen oxides, oxygen, and temperature data. Stack gas opacity, however, seems to correspond with and closely track carbon monoxide fluctuations, thus a linear regression and correlation analyses were performed on the data.

Statistical Analysis of Data

The time-concentration curves (Figures 2.1, 2.2, and 2.3) were reduced in the following manner: The carbon monoxide strip chart continuous readings were reduced to 15-second point readings to correspond with discrete 15-second opacity readings. The CO readings were rounded to the nearest 100 ppm and those less than 100 ppm were interpreted to be less than the limit of detection. A data file was then created using corresponding opacity and CO readings at a given point in time. One such data file was created for each sample run.

Since subjective observations indicated that CO concentration peaks were generally preceded within a few minutes by a rise in opacity, a computer program was devised which would accommodate and adjust the data set pairings for any given lag time. The lag time indicates the time, in minutes, before and after (negative or positive) an opacity reading to the associated CO reading. Each data file was then run through a linear regression program and correlation routine to determine if a significant relationship existed between the data for a given lag time. Different lag times were used to determine the optimum (maximum) correlation coefficient (r), beginning at whole minute intervals then reducing to quarter of a minute intervals. This usually required five to ten runs per sample.

Several problems necessitated altering the data inputs to accommodate a more realistic analysis. For example, steam exiting the quench tower occasionally obscured the battery stack emissions. Therefore, for these points in time, there would be CO readings but no associated opacity readings. Thus, these data could not be counted as a valid data set. The number of complete pairs of data available for correlation then, i.e., the number of data sets used, was less than the total number of pairs first described (above). Therefore, a new data file was created

based on the optimum time lag (defined by the maximum "r") and only complete data sets were utilized in the statistical analysis.

Results

Table 2.5 presents the results of the correlation analyses. A different time lag produced the optimum correlation coefficient (r) for each run (variation: -3.5 to 3 minutes). The results for each sample yielded a r-value of about 0.7. During the second half of Run 2, the CO readings were suspect due to very low readings, thus a second program iteration was made using only the first half of the test. This resulted in the much higher coefficient of 0.86. Appendix E presents the distribution of data pairs for each run.

Although continuous nitrogen oxide and oxygen data was available, the resolution of overall magnitude of oxygen concentrations was not sufficient to resolve the data over as many points as was needed. From the graphic summaries, however, no apparent trends seemed to exist. Therefore, this was the extent of the statistical analyses performed on this data.

Comparison with Previously Collected Data

The data from the C.F. & I. study was quite different than that previously collected at another battery stack location. Concentrations of carbon monoxide measured during

TABLE 2.5. SUMMARY OF CORRELATION RESULTS

| Sample Number | No. of Data Sets | % of Data Used | Correlation Coefficient (r) | Linear Regression Equation | Lag Time, Minutes[a] |
|---|---|---|---|---|---|
| 1 | 160 | 100 | 0.6802 | CO = 29.6 op + 69.8 | -3.5 |
| 2 | 271 | 100 | 0.6958 | CO = 57.2 op + 121 | 2 |
| | 173[b] | 100 | 0.8638 | CO = 42.7 op + 114 | |
| 3 | 81 | 100 | 0.7403 | CO = 24.4 op + 201 | 3 |

[a] Minutes from opacity reading to the carbon monoxide reading.
[b] Run using only the first half of the sample.

the earlier study ranged from 100 to 1500 ppm, while at C.F. & I. the greatest recorded concentration was 1100 ppm. Similarly, the maximum opacity at the other facility was 50-percent while at C.F. & I. the maximum was 20-percent, with most of the readings at 0-percent. As may be seen from the distribution of data pairs (Appendix E) for all runs, the majority of the readings at C.F. & I. were less than 150 ppm and either 0 or 5-percent opacity. This did not offer the wide variation in paired data sets as was present in the earlier study, thus outlying data sets did not suggest the need for elimination. Since no charge times were available as additional input, this relationship could not be explored for C.F. & I.

## EXHAUST GAS COMPOSITION

Table 2.6 displays the results of the exhaust gas composition analysis using Method 3. Determinations of carbon dioxide, oxygen, and carbon monoxide content were made for each of the three sample runs. Moisture content is also presented and shows an average of 13.9-percent.

## VISIBLE EMISSIONS

Visible emissions from the Battery D stack were recorded for the duration of each particulate sample run, with two exceptions. Readings were terminated

TABLE 2.6. EXHAUST GAS COMPOSITION ANALYSIS

| Sample Number | Moisture Content percent | Exhaust Gas Composition, Dry Basis percent | | | |
|---|---|---|---|---|---|
| | | Carbon Dioxide | Oxygen | Carbon Monoxide | Nitrogen and Inerts |
| 1 | 13.8 | 4.2 | 9.1 | <0.1 | 86.7 |
| 2 | 13.7 | 5.2 | 9.5 | <0.1 | 85.3 |
| 3 | 14.2 | 4.9 | 10.7 | <0.1 | 84.4 |
| Average | 13.9 | 4.8 | 9.8 | <0.1 | 85.5 |

within minutes of the completion of Run 2 due to insufficient sunlight. Overcast conditions permitted about 1-hour of observation during Run 3.

The opacities recorded during these runs were consistently low, with the exception of occasional peaks and regularly occurring peaks which coincided with rises in carbon monoxide concentrations and with the coke oven gas reversals in Battery D. These reversals occurred every half-hour at approximately 20 and 50 minutes past the hour. The peaks in opacity occurred approximately four minutes following carbon monoxide peaks during Run 1 and three minutes prior to carbon monoxide peaks in Runs 2 and 3. Figures 2.1, 2.2, and 2.3 graphically depict the fluctuations in opacity during each run.

## 3.0 PROCESS DESCRIPTION AND OPERATION

To be supplied by EPA.

## Process Description

EPA has been conducting a test program directed toward the development of national emission standards for air pollutants emitted from coke oven battery stacks. This is comprised of emissions tests on various well-controlled sources. The battery stack serving Battery D at CF&I Steel Corporation's Pueblo, Colorado, facility was selected for emissions sampling because of the plant's use of good operating and maintenance techniques. Most plants employ some operating and maintenance procedures that help reduce battery stack emissions, but the CF&I plant seemed to use very rigorous techniques. This facility was one of the few plants that utilized portable $O_2$ and combustible gas monitors to identify those oven flues that are contributing to the stack emissions. Furthermore, this plant uses a continuous $O_2$ analyzer to help minimize $O_2$ levels in the flues and thus conserve energy by avoiding high excess air levels.

There are three batteries at CF&I (B, C, and D). Both B and C are relatively new, being built in 1972 and 1974, respectively. Battery D was originally built in 1929, but was completely rebuilt from the pad up in 1960. This situation provided an opportunity to test and assess the effectiveness of the systematic operating and maintenance procedures on an older rebuilt battery (D). Since the battery stack serving Battery D is the only one with available test ports and sampling platforms, this battery was selected to carry out emissions testing. Test data for this battery should represent what can be achieved through the use of systematic operating and maintenance practices.

Battery D is a 31-oven Koppers gun-flue battery, fired with undesulfurized coke oven gas from the by-product plant. The D battery started operating in 1929, was completely rebuilt in 1960, and was rehabilitated in 1975. The coke side repairs included door jambs, buckstays, fuel gas guns, regenerator bricks, and the replacement of door jamb bricks. Plant design and operational data for Battery D are presented in Table 1.

Systematic maintenance techniques used on the battery include spray patching, nozzle and gun block repairs, and cleaning collecting mains, steam jet ejectors, and standpipes. In addition, the portable $O_2$ and combustible gas monitors are used, along with observation of emissions from the stack, to identify ovens or flues that may cause an increase in emissions. When these have been identified, the cause of the problem is investigated and necessary corrective action taken.

A hand-held slurry spraying gun is used to patch the end flues, door jambs, and cracks in the end flues (walls). Leakage through the first three or four flues (end flues) are considered to be the major cause of stack emissions. This routine maintenance procedure is employed twice as frequently to the coke side of the oven than to the pusher side because more wear occurs on that side. Each oven is spray patched this way every five weeks.

Normally, small cracks in the walls or roof are prevented from leaking by carbon buildup. Roof carbon is removed after each push by drawing air in through the charging ports via steam jet ejectors in the standpipes. If such leaks are found to be a problem, the oven decarbonization is decreased in order to increase the carbon buildup.

TABLE 1: PLANT DESIGN AND OPERATION RECORD

Date August 9, 1979

Plant Name CF&I Steel Corporation - Coke Plant
Location Pueblo, Colorado
Battery No. "D" Battery
Name of Plant Contact John C. Winkley

Type of Ovens and Designer Koppers - Gun Flue
Date Built Rebuilt in 1960
Date of Last Rehabilitation 1975
Type of Last Rehabilitation Coke side Jambs, Buckstays, Gas Guns, Regenerator Brick Repair, Replace Jamb Brick

Number of Ovens Total 31 In Service 31
Size of Ovens Height 13' Width 18-1/4" Length 40'-6 1/2"

Type of Coke Produced Furnace coke
Normal coking time (hr) 18 hrs.
Coal charged per oven (tons) 18.49
Reversal period (min) 30 min.

Nozzle decarbonization method Carbon caps
Is flue gas recirculated? No

Type of fuel gas Coke gas Heating value 510 Btu/scf
Is fuel gas desulfurized? No
Note use of stage charging, preheated coal, etc. Sequentially staged charging
Stack height and top diameter 250 ft., 9 ft. exit diameter
Test location (stack or waste heat canal) Stack

Control method used Systematic operation and maintenance !

| Fuel gas analysis | | Coal analysis | |
|---|---|---|---|
| Component | Vol.% | Component | Vol.% |
| $CO_2$ | 2.10 | Ash | 9.5 |
| Ill. | 4.87 | S | .46 |
| $O_2$ | .20 | $H_2O$ | 8 |
| CO | 7.53 | VM | 32.25 |
| $H_2$ | 52.74 | | |
| $CH_4$ | 28.11 | | |
| $N_2$ | 4.45 | | |
| $H_2S$ | 40 gr./100 ft.$^3$ | | |

In gun flue batteries, like those at CF&I, each fuel gas nozzle fits into a hole in the nozzle gun block. If the seal around the nozzle or the gun block develops a crack, additional fuel escapes into the flue which represents a fuel-rich condition which may cause an increase in the battery stack emissions. Visual and/or instrument flue inspection techniques are used to identify causes of emissions. If a nozzle leak is found to be the cause of the problem, sealant is placed around the nozzle to prevent leakage. If the same flue continues to cause emissions, patching material is swabbed on both the inside and outside of the gun block which would prevent any additional fuel leakage. Another maintenance practice uses a wire brush which fits inside a gun flue nozzle to brush away any carbon buildup which may restrict fuel gas flow. Other routinely performed maintenance procedures involve removal of tar buildup in collecting mains and in the steam jet ejectors and standpipes .

During each test period, process operating data were recorded at approximately 1-hr intervals. A log was kept of the time each oven was pushed and charged. The process operating logs and flow charts plus the oven's push and charge log sheets are included in Appendix A.

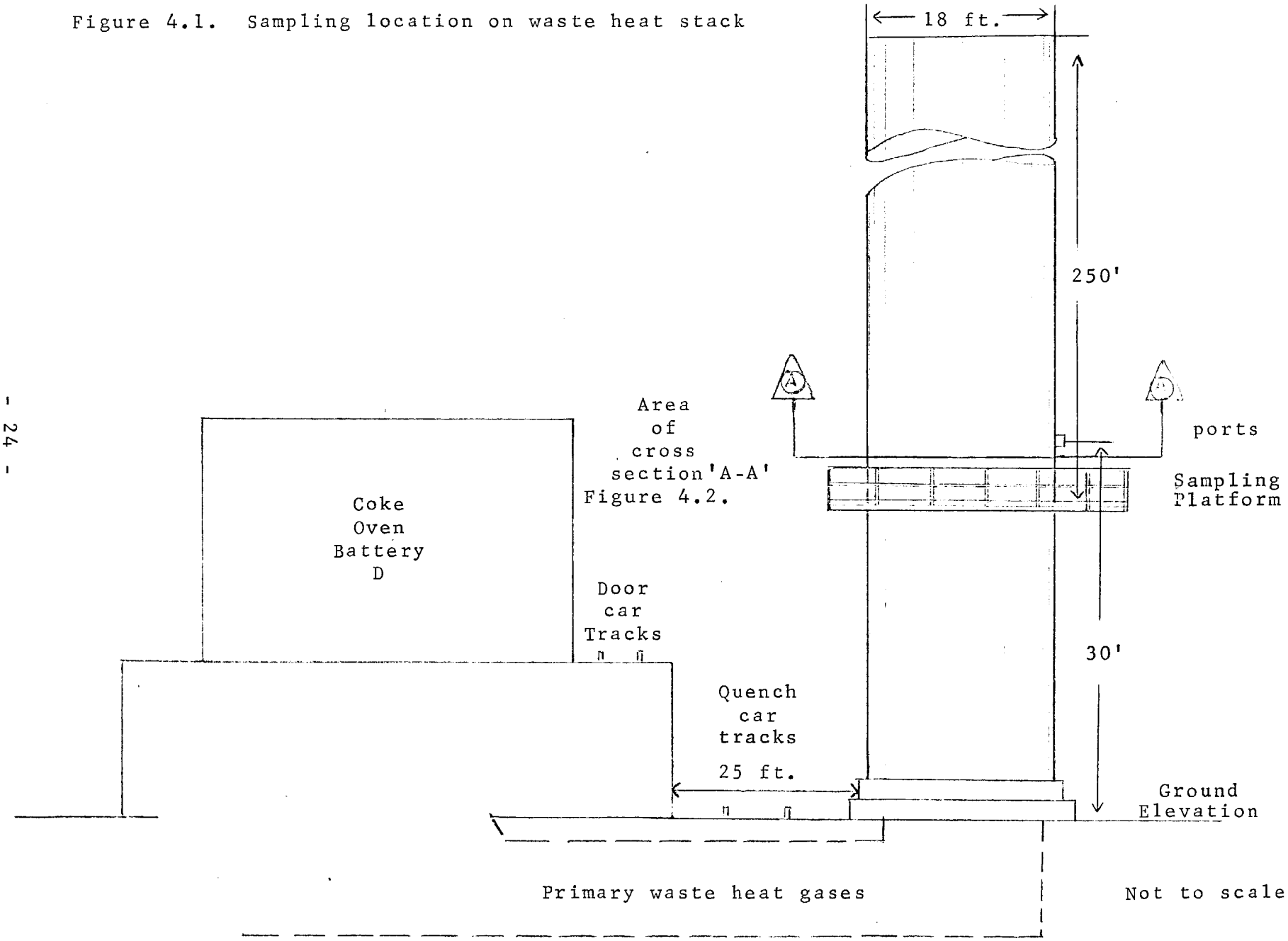
CF&I's personnel cooperated with the test team during the testing, and appreciation is expressed for the help provided by Mr. John Winkley and Mr. Dave Shilton.

## 4.0 LOCATION OF SAMPLING POINTS

At the sampling location elevation, access to the 10.2-foot I.D. waste heat battery stack was obtained through two of three sampling ports positioned approximately five stack diameters downstream from the underground, primary underfire flue duct and about 25 diameters upstream from the stack outlet. Two of the three ports had been previously installed through the four foot thick stack wall, at a 180-degree angle about the stack circumference, while the third port was installed perpendicular to these ports specifically for this testing program. Figure 4.1. characterizes the sampling location relative to the Coke Oven Battery D and stack. A total traverse of thirty-six sampling points, equally divided between two sampling ports spaced at 90 degrees, was employed during the testing program. Figure 4.2 depicts the location of each sampling point with respect to the inner stack wall.

The number of sampling and traverse points chosen afforded suitable velocity traverse data, considering the very low (natural draft) flowrates. The four outermost traverse points' sampling times were incorporated into the next inwardmost points due to their

Figure 4.1. Sampling location on waste heat stack



| Point Number | Distance from wall | |
|---|---|---|
| | inches | cm |
| 1 | 1.7 | 4.4 |
| 2 | 5.4 | 13.7 |
| 3 | 9.2 | 23.3 |
| 4 | 13.3 | 33.9 |
| 5 | 17.9 | 45.5 |
| 6 | 23.0 | 58.4 |
| 7 | 28.9 | 73.4 |
| 8 | 36.2 | 92.0 |
| 9 | 46.8 | 118.8 |
| 10 | 75.6 | 192.1 |
| 11 | 86.2 | 218.9 |
| 12 | 93.5 | 237.5 |
| 13 | 99.4 | 252.5 |
| 14 | 104.5 | 265.4 |
| 15 | 109.1 | 277.0 |
| 16 | 113.2 | 287.6 |
| 17 | 117.0 | 297.2 |
| 18 | 120.7 | 306.5 |

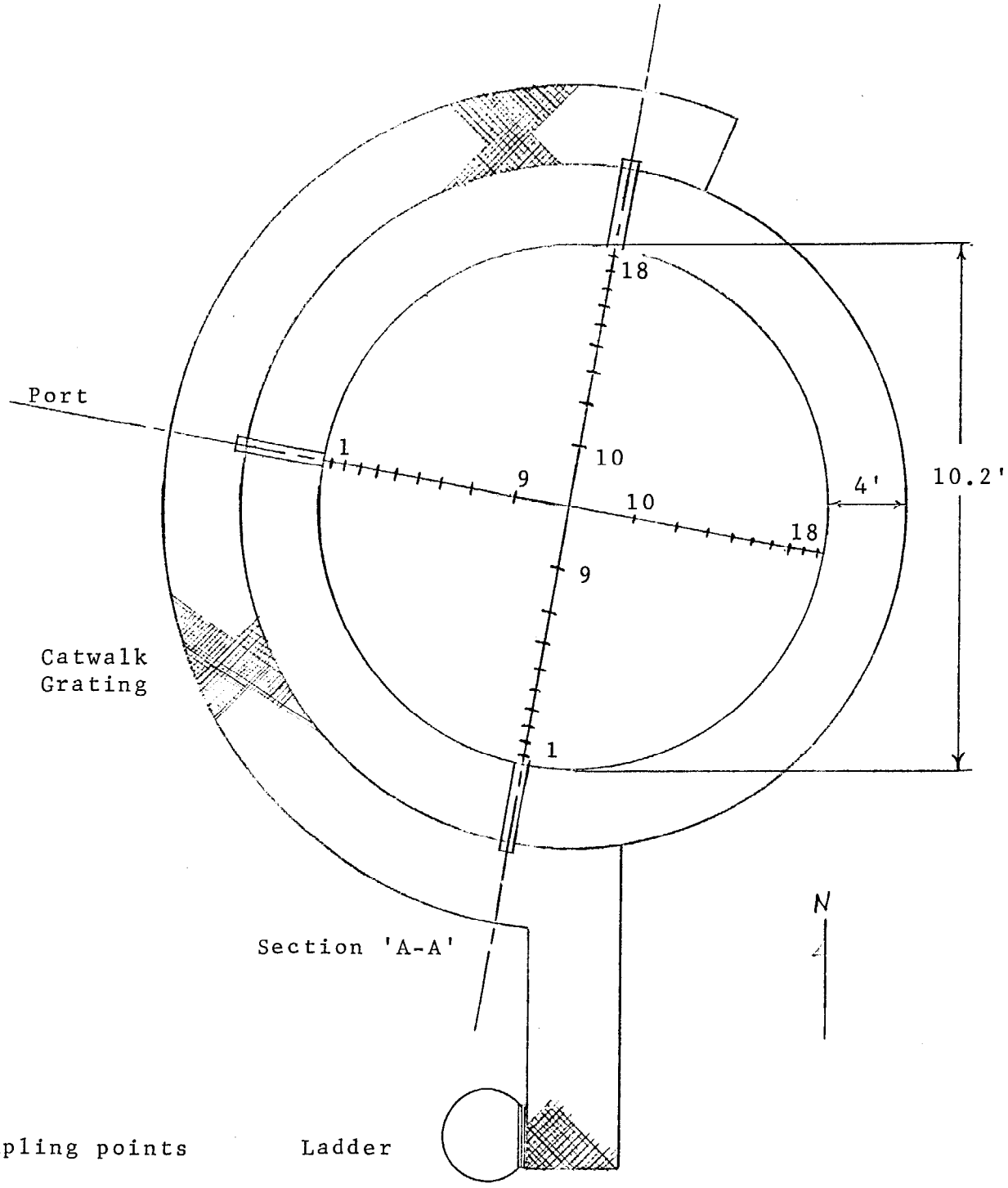



Figure 4.2. Location of sampling points

being positioned too close to the stack port liners to obtain representative velocity pressures. These port liners were not flush with the stack inner wall.

Throughout the testing program, difficulty was encountered when changing ports and with the support of the 16-ft probe. When the probe was largely outside of the stack, its weight placed considerable pressure on the front part of the probe, forcing the total length of the probe to bow. This bowing eventually caused the nozzle to catch the inside of the stack wall, making the probe intractable unless first disassembled. This problem precipitated the modification of the sampling nozzle after completion of the first test. With the approval of the EPA Technical Manager, a portion of the "elbow" type nozzle tip was removed and re-tapered. This allowed removal of the probe from the port without disassembly.

## 5.0 SAMPLING AND ANALYTICAL PROCEDURES

A detailed summary of sampling and analytical procedures is presented in Appendix F. Calibration data is included in Appendix G.

### PARTICULATE SAMPLING

Prior to particulate sampling of the waste heat exhaust stack, preliminary determinations were made to select a sampling nozzle of proper size to maintain isokinetic sampling rates throughout the sampling study. During these preliminary determinations the following were executed:

(1) The establishment of a minimum number of sampling points for the sampling site, calculated according to Method 1;

(2) The measurements of the stack static pressure, stack velocity pressure profile and temperatures at each sampling point, per Method 2 procedures;

(3) Determination of the stack gas dry molecular weight as described in Method 3; and,

(4) the approximate stack gas moisture content using Method 4.

While conducting the moisture test, the metering system (i.e., the vacuum pump vanes) malfunctioned

and was unable to maintain a steady flowrate for the remainder of the test. This preliminary test resulted in a moisture value of 3-percent, which was 10-percent lower than the average moisture value from a previous testing program for this source. The approximate moisture content thus determined was deduced to be suspect. Therefore, the average moisture value (13-percent) from previous battery stack emission studies was used for the preliminary determination of the isokinetic sampling rate. This assumed moisture value turned out to be 0.9-percent below the average actual percent moisture data for this emission study.

Triplicate 144-minute particulate samples were extracted isokinetically for 4-minutes at each of 32 of the 36 sampling points in the waste heat stack. Points 1 and 18 on each traverse diameter were judged to be too close to the sampling port liners, which were not flush with the stack wall, so points 2 and 17 were sampled for twice the normal duration, thus deleting four sampling points.

As it would have been difficult to support and move an impinger box at the end of a 16-foot probe it was necessary to modify an EPA Method 5 particulate sampling train. The heated filter was placed at the end of the probe and connected to the impingers with a flexible Teflon® line (Figure 5.1.). The sampling train consisted

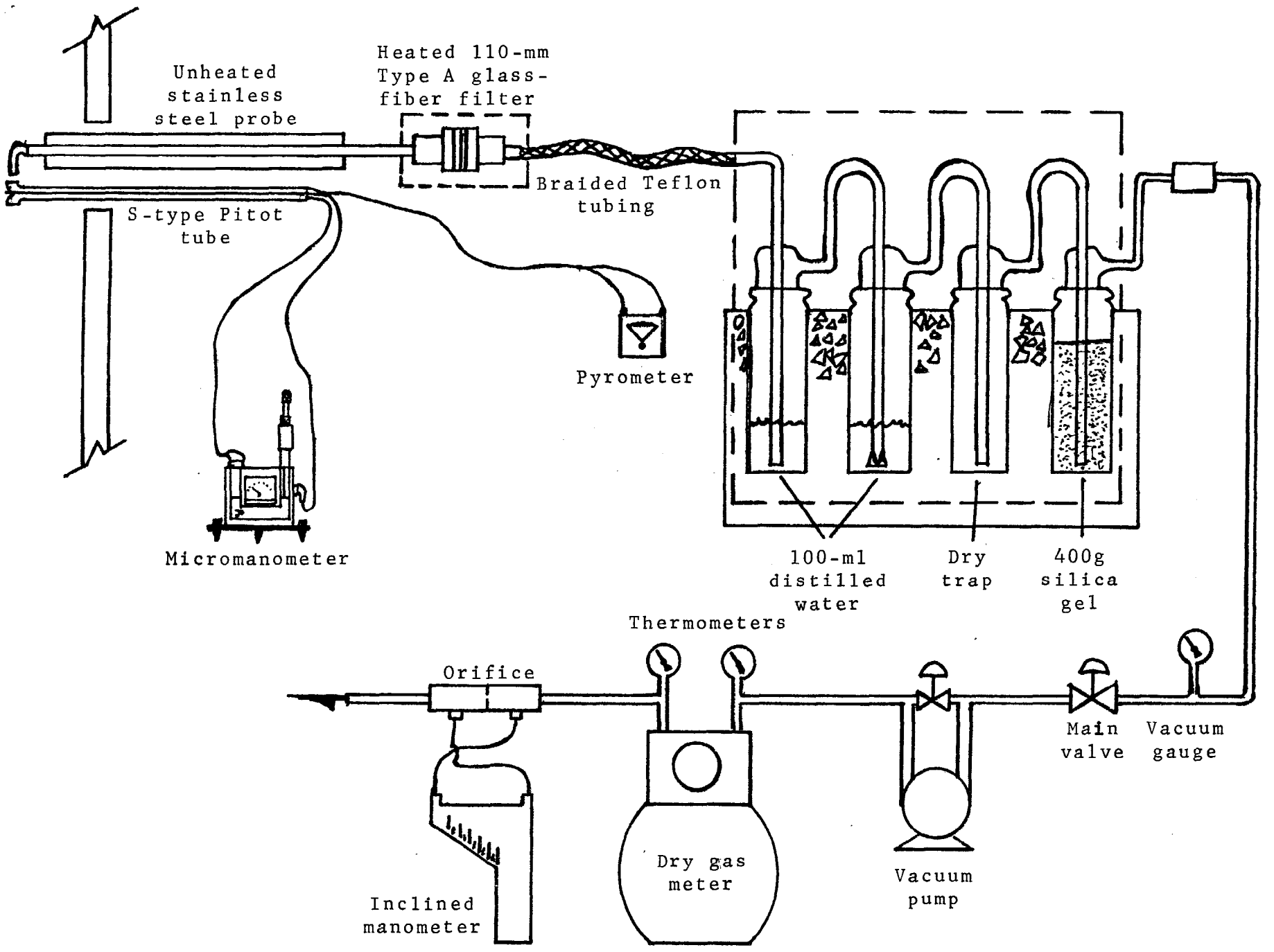



Figure 5.1. Particulate sampling train.

of (in sequential order of sampled gas flow): a sharp, tapered, stainless steel (SS) sampling nozzle; a 16-foot SS probe assembly (instead of a glass probe, due to the obvious probability of breakage during testing); a heated, pre-weighed 110- millimeter (mm) Type-A glass-fiber filter; flexible Teflon® tubing leading to two Greenburg-Smith impingers, the first modified, the second standard, each containing 100-milliliters (mls) of distilled water; an empty modified Greenburg-Smith impinger; a modified Greenburg-Smith impinger containing approximately 400 grams of silica gel; a leakless pump with vacuum gauge; a calibrated dry-gas meter equipped with bimetallic inlet and outlet thermometers; and, a calibrated orifice-type flowmeter connected to a zero to ten-inch range inclined (water gauge) manometer.

The impinger train was immersed in an ice bath to maintain the temperature in the last impinger at 70F or less. A calibrated S-type Pitot tube was connected to the sampling probe and velocity pressures were read on a zero to two-inch micro-manometer. An iron-constantan (I/C) thermocouple, attached to the Pitot-probe assembly, was connected to a calibrated pyrometer. During the course of testing,

the probe and filter temperatures were kept above the dew point of the exhaust gases sampled.

The sampling train was checked for leaks before and after each sample run in accordance with the requirement that the initial leak rate shall not exceed 0.02 cfm at 15-inches of mercury vacuum and the final leak rate shall not exceed 0.02 cfm at the greatest vacuum which occurred during the test.

During each test, the probe, Pitot tube and thermocouple assembly were moved to each sampling point, the velocity pressure and temperature of the exhaust gas were measured, and isokinetic sampling flowrates were adjusted accordingly, using an orifice-type meter to indicate instantaneous flowrates.

Following the leak check at the end of each 144-minute sample run, the sampling train was transferred to a sheltered clean-up area. The volumes of the impinger contents were measured and volume increases recorded. The solutions were placed in glass sample bottles and sealed with Teflon®-lined caps. The silica gel was weighed to determine the weight gain (as condensate). The probe and nozzle assembly was initially rinsed and brushed with water and then with acetone.

The two rinsings were collected in separate glass sample bottles with Teflon®-lined caps. The impinger assembly was thoroughly rinsed with water, and these water rinsings were placed with the impinger solutions. Following the water wash of the impingers, the entire impinger assembly was then rinsed with acetone and these rinsings were placed in separate glass sample bottles and sealed with Teflon®-lined caps. The glass-fiber filter was carefully returned to its original petri dish and sealed for transport. The front half of the filter holder was rinsed and brushed with water and acetone and these rinsings were added to the probe rinses. The back half of the filter holder and the Teflon® flexline were rinsed and brushed with water and acetone, and these rinsings were added to the contents and rinsings of the impingers. Thus, five fractions were collected from each sample run:

(1) water washings of nozzle, probe and front half of filter holder;

(2) acetone washings of nozzle, probe and front half of filter holder;

(3) 110-mm Type-A glass-fiber filter;

(4) impinger contents and distilled water rinsings of back half of filter holder, Teflon® flexline and impingers; and,

(5) acetone rinsings of back half of filter holder, Teflon® flexline and impingers.

In the laboratory, all liquid fractions were observed for leakage, then each measured volumetrically and the values recorded.

PARTICULATE EMISSIONS

A 50-ml aliquot was removed from Fractions 1 and 4 prior to the particulate analyses for sulfate analysis. The Fraction 1 samples were then transferred to tared beakers and evaporated to dryness at 105C. The dried residues were desiccated for at least 24 hours before determining constant weights. (A constant weight is determined by redesiccating the sample for at least 6-hours and then reweighing it. A difference between these weights less than 0.5 milligram, or 1-percent of the total weight, constitutes a constant weight.) The acetone volumes of Fractions 2 and 5 were transferred to tared beakers, evaporated to a residue at ambient conditions, then desiccated for 24-hours before constant weights were determined. The 110-mm Type A filters were desiccated at ambient conditions for more than 24 hours to determine constant weights.

The particulate and sulfate weights by fraction are presented in Appendix H.

Chloroform/Ether Extraction

After sulfate aliquots (50-ml) were removed, Fraction 4 water samples were extracted three times with equal volumes (30-ml) of chloroform and ethyl ether (C/E). The organic phases (C/E extractables) of each sample were collected and combined in separate tared beakers, evaporated to dryness at ambient conditions, and desiccated for 24 hours before constant weights were determined. The remaining water phase of Fraction 4 samples were evaporated to dryness at 105C, desiccated 24 hours and measured to constant weights. The sum of the C/E extractable organic weight and the aqueous phase weight (inorganic fraction) is the total weight of Fraction 4.

Sulfate Analysis

The 110-mm filters (Fraction 3) were leached of sulfates by liquefying each filter with 80-percent isopropanol (IPA) in a blender, scrubbing the amalgamated solutions in an ultrasonic bath, punctually followed by filtering the solutions and diluting the filtrate to 150 mls with 80-percent IPA. The residues from Fractions 2 and 5 were leached of sulfates by scrubbing the residue with 80-percent IPA in an ultrasonic bath then bringing to 100-ml volume with 80-percent IPA. Five-ml portions

of 50-ml aliquots of Fractions 1 and 4 were brought to 25-ml volumes with 100-percent isopropanol to form 80-percent solutions.

Each of the above solutions was adjusted for acidity with perchloric acid to a pH between 2.5 and 4.0. Three to five drops of thorin indicator were added to each solution before titrating with standardized barium perchlorate to a pink endpoint. The results are reported as sulfuric acid (including sulfur trioxide) and as a percent of the particulate weight for the individual fractions.

Exhaust Gas Composition

An integrated gaseous sample was withdrawn simultaneously with each particulate sample from the south port of the waste heat stack. The Orsat sampling train utilized during the first two sample runs consisted of a SS probe; a particulate/condensate trap; a leakless diaphragm pump; a pressure release connection; a needle valve coupled with a rotameter; and a 96-liter Saran® sample bag. All intermediate connections were made with lengths of polyvinylchloride (PVC) tubing. See Figure 5.2 for a graphic display of the sampling train used in gaseous sampling.

The Orsat sampling train was modified for Run 3, in that the carbon monoxide (CO) sampling

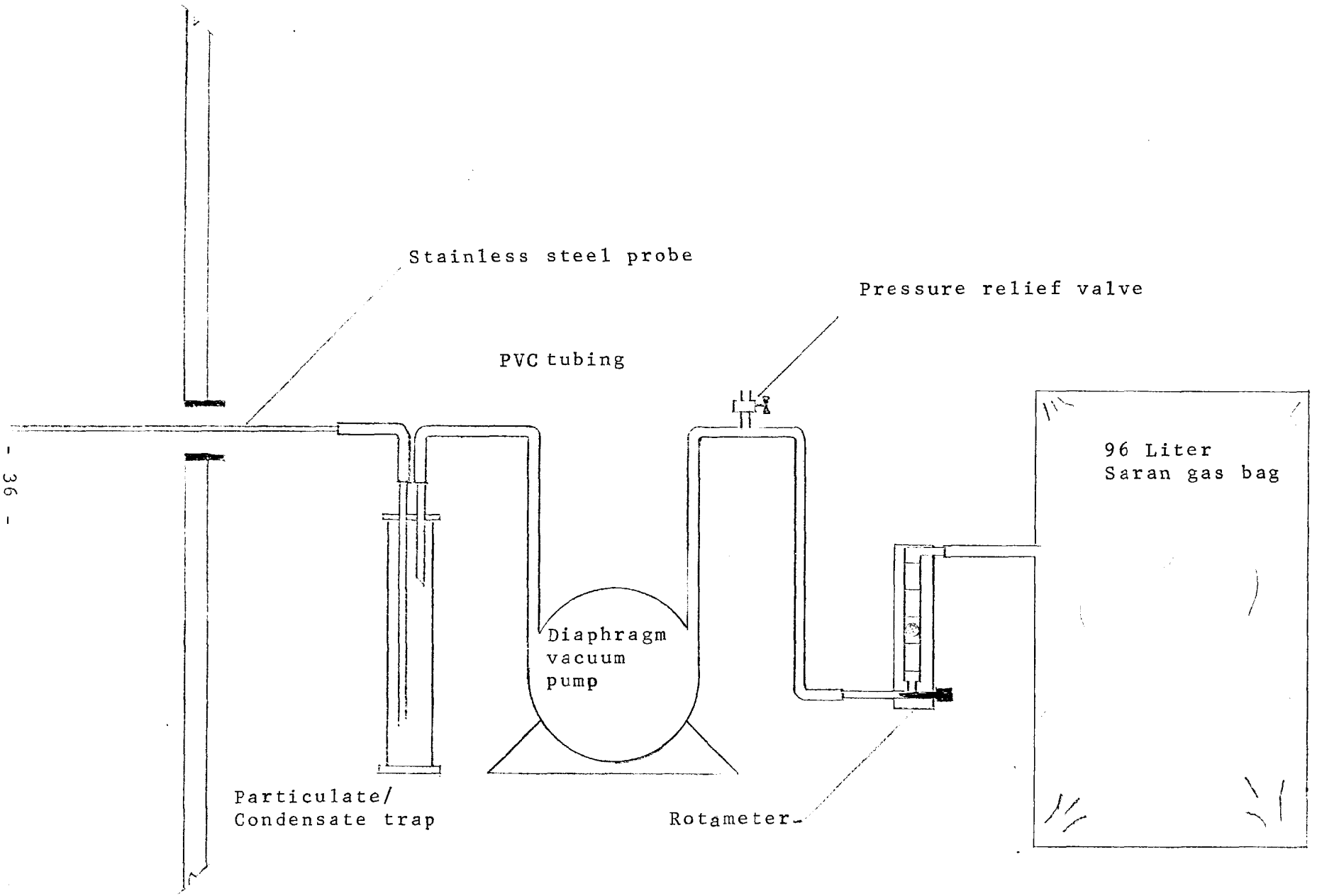



Figure 5.2, Orsat gas sampling train.

probe, particulate/condensate trap, and intermediate Teflon® tubing replaced their counterparts from the previous Orsat train. In addition, a 3-way brass valve was inserted after the particulate/condensate trap to split the gaseous sample for both continuous CO monitoring and integrated bag sample collection.

Each integrated bag sample was analyzed by the Orsat method for carbon dioxide, oxygen and carbon monoxide concentrations as specified in EPA Method 3. The results were used to calculate the molecular weight of the waste heat exhaust gas in the Battery D stack.

CARBON MONOXIDE SAMPLING

A sample of flue gas was drawn through a SS probe, Teflon® tubing and a particulate/condensate trap containing glass wool, to a pair of modified Greenburg-Smith impingers. The first impinger contained approximately 250 grams of silica gel and the second approximately 500 grams of Ascarite® to remove moisture and carbon dioxide, respectively. Finally, a leak-free diaphragm pump forced the sample through a needle valve and rotameter to a Beckman, Model 865, NDIR Analyzer.

The sampling probe was positioned in the west port of the stack for the first and second particulate runs but was moved to the south port for Run 3.

The sampling train was modified for the third sample run to accommodate the simultaneous collection of an integrated bag sample for the determination of exhaust gas composition by the Orsat method. The modification consisted of inserting a 3-way brass valve after the particulate/condensate trap, which was used to divide the gas sample into two streams, one for the Beckman NDIR Analyzer and the other for the Orsat integrated gas sample.

At the sample interface to the Beckman NDIR Analyzer, an approximate flowrate and delivery pressure of 1.5 cfh and 10 psig respectively, were maintained for the duration of continuous sampling. An analog strip chart recorder was used to record all instrument outputs. This sampling system is depicted in Figure 5.3.

The daily calibration sequence included passing a certified standard zero gas (dry nitrogen) and a certified standard span gas concentration (carbon monoxide in nitrogen) through the analyzer. The instrument output was calibrated for the anticipated range of 0 to 10,000 ppm carbon monoxide by adjustment of the zero and gain levels to the appropriate signal, as indicated on a calibration curve. Following the analyzer calibration, the strip chart recorder pen response was increased by a factor of ten by changing its input range.

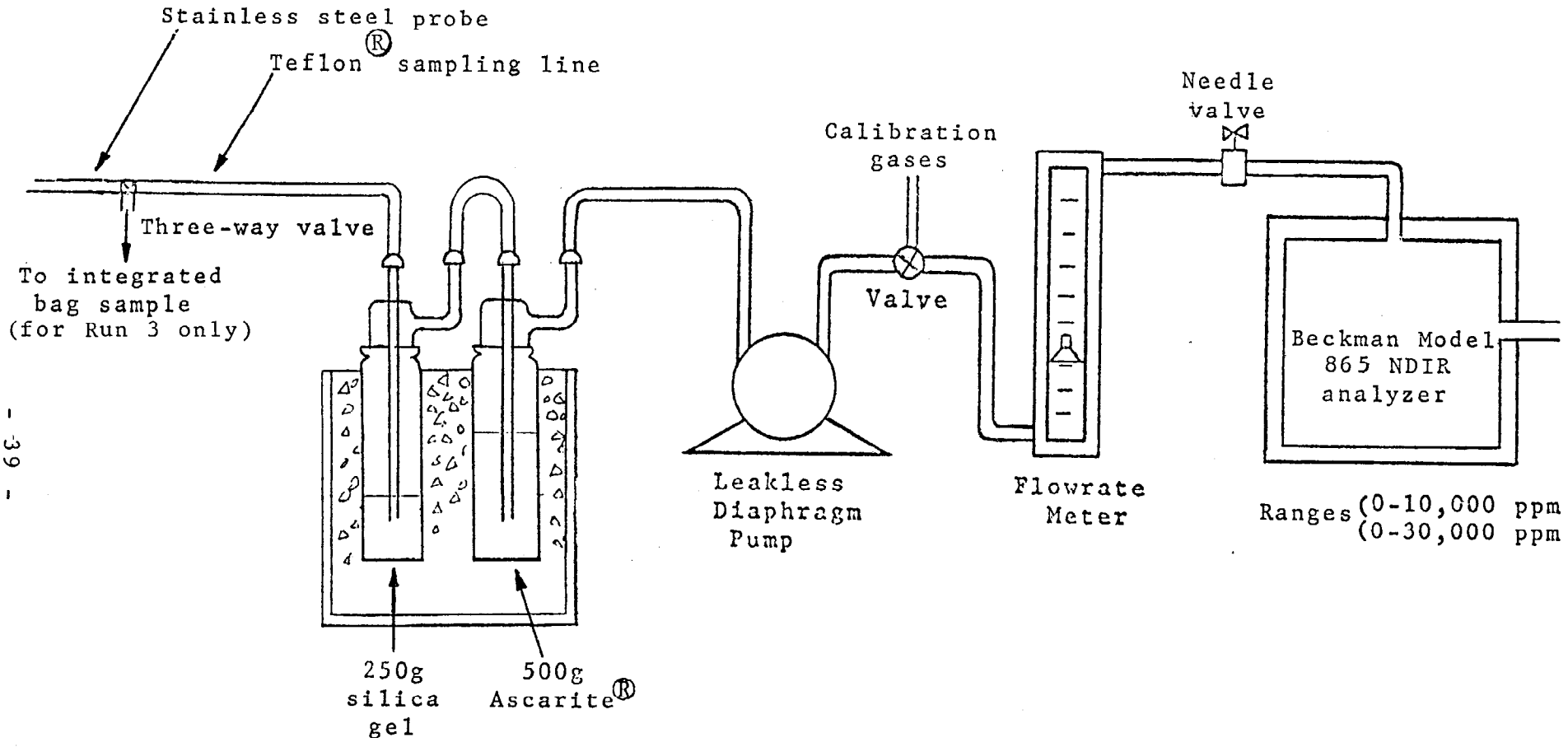



Figure 5.3. Sampling train for continuous monitoring of carbon monoxide.

The Beckman NDIR analyzer, which operates by the Luft principle specified by Reference Method 10, was equipped with a four-position valve to allow the introduction of sample gas or any of the required standard calibration gases, as depicted in Figure 5.3.

The actual measured concentrations of carbon monoxide were determined by adjusting the recorded strip chart values with the factory calibration curve for the 16-mm cell, which had been adjusted to the standard gas concentrations used in the field.

COMBINATION SAMPLE EXTRACTION SYSTEM FOR NITROGEN OXIDES AND OXYGEN

An in-stack stainless steel (SS) alundum thimble holder, packed with glass wool, was positioned in the North port of the D Battery stack throughout the complete testing study. The intermediate connections between components were accomplished using lengths of Teflon® tubing. A three-way SS valve was incorporated in-line after the probe to branch off to a leakless diaphragm pump. The 3-way valve facilitated sampling system leak checks and back purging of the probe assembly. Subsequently, the sampled gas flowed into an ice-cooled condenser and through a leakless diaphragm pump.

A SS control valve maintained the gas flow at 2 $\pm$ 0.5 scfh at the outlet of the rotameter downstream of both analyzers. A pair of SS "tee" connectors allowed aliquots of gases to be bled off to the analyzers. See Figure 5.4 for the schematic of the continuous extraction system and $NO_x$-$O_2$ analyzers.

A leak check of the system was performed prior to each day's testing by closing the 3-way valve following the probe assembly and observing the deflection of a rotameter at the outlet of the sampling system. Any noticeable deflection after a 2-minute time period indicated a leak in the sampling system.

CONTINUOUS NITROGEN OXIDES MONITORING

An aliquot of exhaust gases was withdrawn from the "tee" connector through a 3-way SS valve to a Thermo-Electron $NO_x$ Analyzer. The sampled gas flow through the $NO_x$ analyzer was monitored and maintained at 2.5 scfh by means of a flow meter mounted on the panel of the analyzer. Ambient air (dried) was employed as an oxygen source for the ozone generator within the analyzer. The vacuum pressure to the reaction chamber was monitored by a gauge connected with the chamber unit. The analyzer output signal was connected to a linear strip chart recorder which was set at a chart speed of 0.5 centimeters/minute (cm/min).

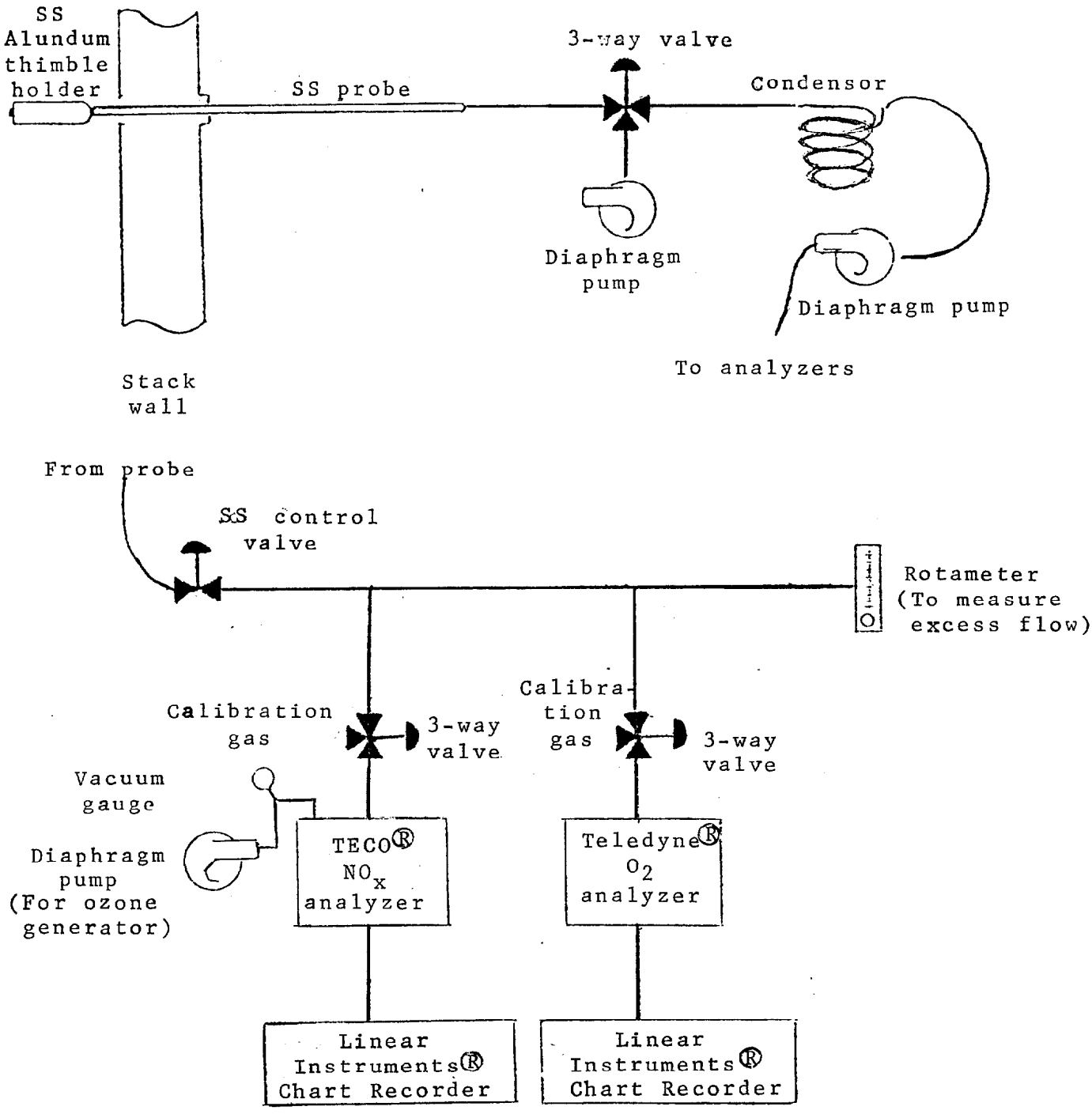



Figure 5.4. Combination sampling trains for continuous monitoring of nitrogen oxides and oxygen.

Calibration checks were performed prior to the start-up of each run, at selected times during testing, and at the completion of each day's testing.

CONTINUOUS OXYGEN MONITORING

A separate aliquot of the exhaust gases was withdrawn from the "tee" connector through a 3-way SS valve to a Teledyne Model 326A Oxygen Analyzer. The flowrate was continually maintained at 2 to 2.5 scfh throughout the testing program. The analyzer output signal was connected to a linear strip chart recorder with a chart speed of one-inch per hour. Calibration checks were routinely performed.

NITROGEN OXIDES GRAB SAMPLES

Daily "grab samples" were acquired from the waste heat stack for nitrogen oxides analysis, according to EPA Method 7. The nitrogen oxides sampling train apparatus is depicted in Figure 5.5. The field data for each sample is included in Appendix B-3.

After evacuating each flask containing dilute sulfuric acid/hydrogen peroxide absorbing solution to the appropriate vacuum pressure and leak checking, the SS probe and glass stopcock were purged with stack gas for approximately one minute. The stop-cock was then returned to the sampling position for

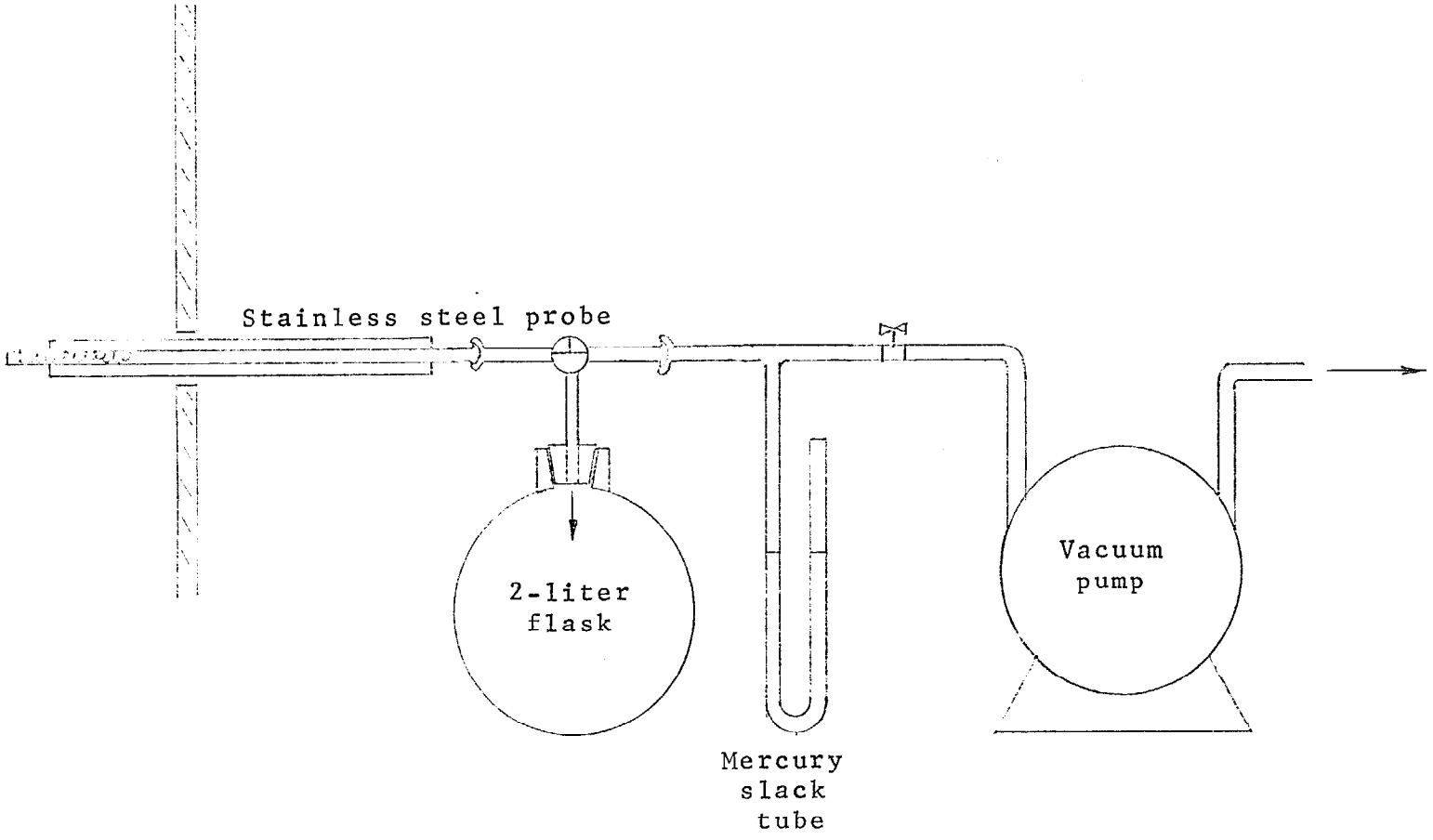



Figure 5.5. Sampling train for nitrogen oxides grab samples.

a period of approximately thirty seconds to insure equal pressurization between the sampling system and stack gases. Immediately following sample collection, each flask was shaken for five minutes and stored for at least 16 hours away from sunlight.

Prior to sample recovery, each flask was shaken for two minutes, followed by the measuring and recording of the internal pressure and temperature of the flask. The contents of each flask were transferred to leak-free polyethylene bottles along with two 5-ml water rinses. The pH of each solution was adjusted to a range of 9 to 12 with 1.0 N. sodium hydroxide before the bottles were marked, labelled and sealed for transport to the laboratory.

In the laboratory, the sample bottles were examined for leakage before transferring their contents to tared beakers along with sample bottle water rinsings. The samples were evaporated to dryness and treated successively with solutions of phenol disulfonic acid, distilled water, and sulfuric acid. The resulting solution was made basic with ammonium hydroxide, transferred to a volumetric flask, and diluted to volume with distilled water. The standard wavelength absorbance at 410 nanometers was measured and recorded as nitrogen dioxide in the samples and potassium nitrate standards.

## VISIBLE EMISSIONS

Visible emissions from the D Battery stack exhaust were recorded for the duration of each sample run except for Run 3, for which visible emissions recording was abbreviated due to foul weather. The observations were performed in accordance with EPA Method 9 by a qualified visible emissions observer. A summary of the visible emission data is presented in Appendix B-4.

# APPENDIX A

# PROJECT PARTICIPANTS

# PROJECT PARTICIPANTS

## Clayton Environmental Consultants, Inc.

| | |
|---|---|
| N. Steve Walsh | Director<br>Air Resource Engineering |
| Timothy V. Mattson | Group Leader, Emission Measurement |
| Bruce G. Bird | Source Testing Specialist |
| Mary Fegan | Laboratory Technician |
| Randy M. Knutson | Source Testing Specialist |
| Dusanka Lazarevic | Environmental Data Specialist |
| Donna L. Opthoff | Environmental Data Specialist |
| Timothy J. Palmer | Environmental Control Specialist |
| George M. Santorilla | Technical Design Specialist |
| Daryl Strandberg | Laboratory Technician |

## York Research Corporation

Kurt R. Parker

## U.S. Environmental Protection Agency

Frank Clay

## C.F. & I. Steel

David Shilton

J.C. Winkley

## Midwest Research Institute

Pat Reider

## PROJECT PARTICIPANTS (CONTINUED)

TRW Energy Systems Group

Tom Rooney

Bart Wessel

Ed Torres

# APPENDIX B

## FIELD DATA SHEETS

B-1. Particulate Test Data Sheets

B-2. Sampling Summary Data

B-3. Visible Emission Data Sheets

B-4. Summary of Visible Emissions

B-5. Nitrogen Oxides Data Sheets

B-6. Process Operating Logs and Charts

# APPENDIX B-1

# PARTICULATE TEST DATA SHEETS

SAMPLING TRAIN DATA

COMPANY: CF&I Steel (US EPA) Pueblo, Colorado
SOURCE DESIGNATION: D Battery stack
REGULATING AUTHORITY: US EPA
DATE: 8-7-79
TEST NUMBER: P-1
Field Person(s): TVM TJP RMK GMS
Filter Number: A-159-16
Barometric Pressure ("Hg): 25.27
Stack Static Pressure ("$H_2O$): -.96
Stack Dimensions: 122.4" ID
Ambient Temperature (°F): 95
Record all Data Every 4 Minutes

Nozzle (Dia-in): .765 .758 .763 (Avg): .762
Pitot Tube No. 35, Corr. Factor: .8235
Meter Box No. R-1, Corr. Factor: 0.9795
Meter Isokinetic Factor: 1679
Assumed Moisture (%): 13
Condensate Volume (ml): 286
Silica Gel Weight Gain (g): 36.8
Actual Moisture (%):
Leak Rate: Initial: .008 CFM at 15 "Hg; Final: 0.008 CFM at 10 "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp. (°F) Inlet | Dry Gas Meter: Temp. (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-17 | 0 | 15:22 | 4.712 ~~.024~~ | ~~465~~ | 363.820 | 108 | 106 | 4.22 | | | 16.5 |
| | 3 | 15:25 | 2.019 stop to check lines | 465 | 366.586 | 108.5 | 106 | | | | |
| | | | Couldn't reach required orifice pressure, change silica gel. Leak checked in a dead stop | | | | | | | | |
| | | 15:53 | 2.151 .005 | ~~465~~ | 367.084 | 106 | 106 | .88 | | | 0 |
| S-17 | 4 | 15:54 | 2.151 .005 | 465 | 367.79 | 106 | 106 | .88 | 230 | 100 | 0 |
| S-16 | 8 | 15:58 | 1.360 .002 | 465 | 370.06 | 109 | 106 | .35 | 225 | 97 | 0 |
| S-15 | 12 | 16:02 | 0.962 .001 | 465 | 371.75 | 111 | 106 | .18 | 225 | 89 | 0 |
| S-14 | 16 | 16:06 | 1.364 .002 | 470 | 372.90 | 112 | 107 | .35 | 235 | 81 | 0 |
| S-13 | 20 | 16:10 | 1.675 .003 | 475 | 374.35 | 114 | 108 | .53 | 235 | 78 | 0 |
| S-12 | 24 | 16:14 | 0.967 .001 | 475 | 376.19 | 115 | 109 | .18 | 240 | 76 | 0 |
| S-11 | 28 | 16:18 | 0.967 .001 | ~~475~~ | 377.39 | 116 | 110 | .18 | 240 | 76 | 0 |
| ~~S-10~~ | 30:35 ~~32~~ | Lost power ~~16:22~~ | 1.0 .005 | 475 | 378.066 | | 105.6 | | | | |
| | | 17:38 | 3.358 .012 | 475 | 378.066 | 106 | 106 | 2.08 | 280 | 80 | 0 |
| S-10 | 32 | 17:40 | 2.735 .008 | 475 | 379.58 | 106 | 106 | 1.39 | 265 | 74 | 0 |
| S-9 | 36 | 17:44 | 1.367 .002 | 475 | 382.46 | 110 | 106 | .35 | 225 | 75 | 0 |
| S-8 | 40 | 17:48 | 2.901 .009 | 475 | 384.16 | 110 | 106 | 1.57 | 205 | 73 | 0 |
| S-7 | 44 | 17:52 | 1.918 .004 | 460 | 387.04 | 115 | 108 | .71 | 205 | 68 | 0 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

6.80 1544 1496 13.35

# SAMPLING TRAIN DATA

Company: CF&I Steel U.S EPA
Source Designation: Battery D stack
Date: 8-7-79
Test Number: P-1
Field Person: TVM TJP RMK GMS
Filter Number: A-159-16
Barometric Pressure ("Hg):
Stack Static Pressure ("$H_2O$):
Stack Dimensions:
Plume Appearance:
Ambient Temperature (°F):
Record all Data Every _____ Minutes

Filter Heater Setting:
Probe Heater Setting:
Nozzle Number: ____, Dia. (in.):
Pitot Tube No. ____, Corr. Factor:
Meter Box No. ____, Corr. Factor:
Meter Isokinetic Factor:
Assumed Moisture (%):
Condensate Volume (ml):
Silica Gel Weight Gain (g):
Leak Rate _____ CFM at _____ "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-6 | 48 | 17:56 | 2.349 .006 | 460 | 389.35 | 115 | 109 | 1.07 | 195 | 70 | 0 |
| S-5 | 52 | 18:00 | 2.151 .005 | 465 | 391.83 | 117 | 109 | .88 | 205 | 70 | 0 |
| S-4 | 56 | 18:04 | 2.183 .008 | 440 | 394.19 | 119 | 110 | 1.47 | 205 | 70 | 0 |
| S-3 | 60 | 18:08 | 2.790 .009 | 405 | 397.11 | 122 | 112 | 1.72 | 210 | 69 | 0 |
| S-2 | 64 | 18:12 | 2.352 .007 | 330 | 400.25 | 123 | 113 | 1.47 | 210 | 65 | 0 |
| S-2 | 68 | 18:16 | 2.142 .006 | 305 | 403.38 | 125 | 114 | 1.31 | | | 0 |
| | 72 | 18:20 | | | 406.255 | | | | | | |
| W-17 | — | 19:12 | 4.612 .023 | 465 | 406.516 | 107 | 107 | 4.05 | 225 | 85 | 3 |
| W17 | 76 | 19:16 | 5.009 .028 | 465 | 411.40 | 112 | 108 | 4.95 | 265 | 74 | 4 |
| W16 | 80 | 19:20 | 4.511 .022 | 465 | 416.53 | 118 | 108 | 3.91 | 270 | 67 | 3 |
| W-15 | 84 | 19:24 | 4.069 .018 | 460 | 421.23 | 122 | 109 | 3.23 | 275 | 68 | 3 |
| W14 | 88 | 19:28 | 4.395 .021 | 460 | 425.65 | 123 | 110 | 3.78 | 255 | 70 | 3 |
| W13 | 92 | 19:32 | 4.612 .023 | 465 | 430.34 | 126 | 112 | 4.13 | 245 | 70 | 3 |
| W12 | 96 | 19:36 | 4.904 .026 | 465 | 435.12 | 128 | 113 | 4.69 | 230 | 70 | 4 |
| W11 | 100 | 19:40 | 4.722 .025 | 470 | 440.26 | 130 | 114 | 4.49 | 215 | 70 | 4 |
| W10 | 104 | 19:44 | 4.324 .02 | 475 | 445.25 | 132 | 116 | 3.59 | 235 | 74 | 3 |
| W9 | 108 | 19:48 | 4.533 .022 | 475 | 449.94 | 132 | 116 | 3.95 | 235 | 74 | 3 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

13650 3495 3276 43.54

# SAMPLING TRAIN DATA

Company: CF&I Steel EPA

Source Designation: Battery D stack

Date: 8-7-79

Test Number: P-1

Field Person: TVM TJP RMK GMS

Filter Number: A-159-16

Barometric Pressure ("Hg):

Stack Static Pressure ("$H_2O$):

Stack Dimensions:

Plume Appearance:

Ambient Temperature(°F):

Record all Data Every _____ Minutes

Filter Heater Setting:

Probe Heater Setting:

Nozzle Number: ____, Dia.(in.):

Pitot Tube No. ____, Corr.Factor:

Meter Box No. ____, Corr.Factor:

Meter Isokinetic Factor:

Assumed Moisture(%):

Condensate Volume(ml):

Silica Gel Weight Gain(g):

Leak Rate _____ CFM at _____ "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W8 | 112 | 19:52 | 3.847 .016 | 465 | 454.74 | 133 | 118 | 2.91 | 265 | 78 | 2 |
| W7 | 116 | 19:56 | 3.965 .017 | 465 | 459.68 | 132 | 118 | 3.09 | 275 | 78 | 3 |
| W6 | 120 | 20:00 | 3.599 .014 | 465 | 463.4 | 132 | 120 | 2.55 | | | 3 |
| W5 | 124 | 20:04 | 3.305 .012 | 460 | 467.28 | 132 | 120 | 2.22 | 255 | 78 | 3 |
| W4 | 128 | 20:08 | 3.589 .014 | 460 | 471.0 | 130 | 120 | 2.55 | | | 3 |
| W3 | 132 | 20:12 | 3.869 .022 | 220 | 474.85 | 129 | 120 | 5.68 | 240 | 80 | 5 |
| W2 | 136 | 20:16 | ~~[illegible]~~ 2.561 .009 | 285 | 480.5 | 132 | 122 | 2.03 | | | 2 |
| W2 | 140 | 20:20 | 3.111 .018 | 305 | 484.20 | 130 | 119 | 3.51 | | | |
| | 144 | 20:24 | | | 488.164 | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 0.008 | | | | | | | | | | | |
| | | | | | | | | | | | |
| final leak check from filter on - probe could not be removed from stack due to bowing & had to be taken apart. at 10" = 0.008 | | | | | | | | | | | |
| | | | | 441.2 | 124.085 | | 115.5 | | | | |
| | | | | ~~465.7~~ | 123.837 | 119.6 | 111.4 | 2.29 | | | |
| AVERAGE (TOTAL) | | | | 441.2 | (121.541) | 119 | 111.4 | 2.23 | | | |

16765 4545 4233

Clayton Environmental Consultants, Inc.

# DRY MOLECULAR WEIGHT DETERMINATION ($M_d$)

P-1

Plant: C. F. & I. Steel
Date: 8/7/79
Sampling Time (24-hour Clock): 1845-2000
Sampling Location:: Stack

Sample Type (bag, integrated, continuous) _____
Analytical Method: ORSAT
Ambient Temperature: 85
Operator: TJP

Comments:

| Gas \ Run | 1 | | 2 | | 3 | | Average Net Volume | Multiplier | Molecular Weight Of Stack Gas (dry basis) $M_d$, lb/lb-mole |
|---|---|---|---|---|---|---|---|---|---|
| | Actual Reading | Net | Actual Reading | Net | Actual Reading | Net | | | |
| $CO_2$ | 4.3 | 4.3 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 44/100 | 1.848 |
| $O_2$ (Net is actual $O_2$ reading minus actual $CO_2$ reading) | 13.3 | 9.0 | 13.2 | 9.0 | 13.4 | 9.2 | 9.1 | 32/100 | 2.912 |
| CO (net is actual CO reading minus actual $O_2$ reading) | 13.3 | <0.1 | 13.2 | <0.1 | 13.4 | <0.1 | – | 28/100 | |
| $N_2$ (Net is 100 minus actual CO reading) | | | | | | | 86.4 | 28/100 | 24.2016 |
| | | | | | | | | Total | 28.964 = $M_d$ |

# WET MOLECULAR WEIGHT DETERMINATION ($M_s$)

$B_{wo}$ = Proportion by volume of water vapor in the gas stream

$M_s$ = Molecular weight of stack gas (wet basis), lb/lb-mole = $M_d(1-B_{wo}) + 18(B_{wo})$

$M_s$ = ( 28.04 )(1- .138 ) + 18( .138 ) = 24.716

$G_m = \frac{M_d}{28.96} = \frac{28.96}{28.96} = 1.00$ , $G_s = \frac{M_s}{28.96} = \frac{24.716}{28.96} = 0.853$ , $\frac{G_m}{G_s} = \frac{1.00}{0.853} = 1.05$

Clayton Environmental Consultants, Inc.

280.5 $\frac{T_m}{T_s}$ H

# SAMPLING TRAIN DATA

COMPANY: CF & I Steel (US EPA) Pueblo, Colorado

SOURCE DESIGNATION: Battery D stack .750 .164

REGULATING AUTHORITY: US EPA

DATE: 8-8-79

TEST NUMBER: P-2

Field Person(s): TVM TJP RMK GMS

Filter Number: A-159-15

Barometric Pressure ("Hg): 25.30

Stack Static Pressure ("$H_2O$): -.96

Stack Dimensions: 122.4" ID

Ambient Temperature (°F): 90

Record all Data Every 4 Minutes

Nozzle (Dia-in): .784 .725 .734 (Avg): .751

Pitot Tube No. 35, Corr. Factor: 0.8205

Meter Box No. R-1, Corr. Factor: 0.9795

Meter Isokinetic Factor: 1679

Assumed Moisture (%): ~~15.0~~ 13.6

Condensate Volume (ml): 373 → 403

Silica Gel Weight Gain (g): 36.4

Actual Moisture (%):

Leak Rate: Initial: 0.009 CFM at 16 "Hg; Final: _____ CFM at ____ "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp. (°F) Inlet | Dry Gas Meter: Temp. (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W 17 | 0 | 11:34 | 4.997 .027 | 465 | 490.002 | 94 | 93 | 4.53 | 260 | 70 | 7 |
| W 17 | 4 | 11:38 | 5.089 .028 | 465 | 494.96 | 100 | 93 | 4.73 | 265 | 66 | 7 |
| W 16 | 8 | 11:42 | 4.997 .027 | 465 | 500.04 | 108 | 94 | 4.59 | 270 | 62 | 7 |
| W 15 | 12 | 11:46 | 5.282 .03 | 470 | 505.12 | 114 | 96 | 5.11 | 265 | 72 | 8.5 |
| W 14 | 16 | 11:50 | 5.282 .03 | 470 | 510.44 | 120 | 99 | 5.15 | 235 | 72 | 9 |
| W 13 | 20 | 11:54 | 5.062 .028 | 455 | 515.81 | 124 | 102 | 4.92 | 225 | 76 | 8 |
| W 12 | 24 | 11:58 | 5.151 .029 | 455 | 521.11 | 129 | 105 | 5.13 | 230 | 71 | 8.5 |
| W 11 | 28 | 12:02 | 5.165 .029 | 460 | 526.51 | 130 | 106 | 5.11 | | | 8.5 |
| W 10 | 32 | 12:06 | 5.089 .028 | 465 | 531.91 | 133 | 109 | 4.93 | 235 | 65 | 8.5 |
| W 9 | 36 | 12:10 | 4.511 .022 | 465 | 537.5 | 134 | 110 | 3.88 | | | 6 |
| W 8 | 40 | 12:14 | 4.030 .018 | 465 | 542.23 | 135 | 112 | 3.19 | 260 | 66 | 5.5 |
| W 7 | 44 | 12:18 | 4.091 .018 | 470 | 546.62 | 134 | 114 | 2.90 | 260 | 62 | 5 |
| W 6 | 48 | 12:22 | 4.180 .019 | 455 | 550.95 | 132 | 114 | 3.40 | 250 | 60 | 6 |
| W 5 | 52 | 12:26 | 4.035 .018 | 440 | 555.16 | 132 | 116 | 3.28 | 250 | 61 | 6 |
| W 4 | 56 | 12:30 | 3.732 .017 | 355 | 559.58 | 133 | 116 | 3.42 | 250 | 62 | 6 |
| W 3 | 60 | 12:34 | 3.862 .019 | 325 | 564.07 | 134 | 117 | 3.98 | 245 | 61 | 7 |
| W 2 | 64 | 12:38 | 1.766 .004 | 320 | 568.87 | 136 | 118 | .84 | 245 | 61 | 2 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

# SAMPLING TRAIN DATA

Company: C F & I Steel - US EPA
Source Designation: Battery D stack
Date: 8-8-79
Test Number: P-2
Field Person: TVM TJP RMK GMS
Filter Number: A-159-15
Barometric Pressure ("Hg):
Stack Static Pressure ("$H_2O$):
Stack Dimensions:
Plume Appearance:
Ambient Temperature (°F):
Record all Data Every _____ Minutes

Filter Heater Setting:
Probe Heater Setting:
Nozzle Number: ____, Dia. (in.):
Pitot Tube No. ____, Corr. Factor:
Meter Box No. ____, Corr. Factor:
Meter Isokinetic Factor:
Assumed Moisture (%):
Condensate Volume (ml):
Silica Gel Weight Gain (g):
Leak Rate _____ CFM at _____ "Hg
halfway point 0.01 @ 14"

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 68 | 12:42 | 0.897 .001 | 345 | 571.97 | 133 | 118 | .20 | 245 | 62 | 0 |
| | 72 | 12:46 | leak check | | 573.387 | | | | | | |
| S-17 | – | 16:06 | 3.559 .014 | 465 | 573.814 | 105 | 104 | 2.40 | 250 | | 4 |
| S-17 | 76 | 16:10 | 4.091 .018 | 470 | 577.66 | 108 | 104 | 3.07 | 265 | 70 | 5 |
| S-16 | 80 | 16:14 | 3.618 .014 | 475 | 581.83 | 110 | 105 | 2.38 | 265 | 68 | 4 |
| S-15 | 84 | 16:18 | 3.987 .017 | 475 | 585.66 | 118 | 106 | 2.92 | 265 | 66 | 5 |
| S-14 | 88 | 16:22 | 3.965 .017 | 465 | 589.76 | 122 | 108 | 2.96 | 260 | 64 | 5 |
| S-13 | 92 | 16:26 | 3.847 .016 | 465 | 593.95 | 125 | 108 | 2.80 | 240 | 64 | 5 |
| S-12 | 96 | 16:30 | 4.204 .019 | 470 | 597.96 | 129 | 110 | 3.32 | 225 | 64 | 6 |
| S-11 | 100 | 16:34 | 4.324 .02 | 475 | 602.31 | 131 | 112 | 3.49 | 210 | 64 | 6 |
| S-10 | 104 | 16:38 | 4.443 .021 | 480 | 606.77 | 134 | 114 | 3.66 | 240 | 65 | 6 |
| S-9 | 108 | 16:42 | 4.113 .018 | 480 | 611.36 | 136 | 116 | 3.15 | 240 | 65 | 5.5 |
| S-8 | 112 | 16:46 | 4.548 .022 | 480 | 615.70 | 136 | 118 | 3.85 | 245 | 64 | 6.5 |
| S-7 | 116 | 16:50 | 3.477 .013 | 470 | 620.42 | 140 | 120 | 2.30 | 245 | 64 | 6 |
| S-6 | 120 | 16:54 | 3.540 .014 | 435 | 624.91 | 140 | 121 | 2.96 | 245 | 64 | 5 |
| S-5 | 124 | 16:58 | 3.842 .018 | 360 | 629.14 | 140 | 122 | 3.64 | 245 | 64 | 5 |
| S-4 | 128 | 17:02 | 3.353 .013 | 405 | 633.7 | 140 | 122 | 2.49 | 250 | 64 | 5 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

Clayton Environmental Consultants, Inc.

# SAMPLING TRAIN DATA

Company: CF&I - EPA
Source Designation: Battery D stack
Date: 8-8-79
Test Number: P-2
Field Person: TVM TJP RMK GMS
Filter Number: A-159-15
Barometric Pressure ("Hg):
Stack Static Pressure ("$H_2O$):
Stack Dimensions:
Plume Appearance:
Ambient Temperature (°F):
Record all Data Every _____ Minutes

Filter Heater Setting:
Probe Heater Setting:
Nozzle Number: ____, Dia. (in.):
Pitot Tube No. ____, Corr. Factor:
Meter Box No. ____, Corr. Factor:
Meter Isokinetic Factor:
Assumed Moisture (%):
Condensate Volume (ml):
Silica Gel Weight Gain (g):
Leak Rate .005 CFM at 10 "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-3 | 132 | 17:06 | 2.948 .011 | 330 | 637.41 | 140 | 124 | 2.31 | 255 | 64 | 4 |
| S-2 | 136 | 17:10 | 2.877 .012 | 440 230 | 641.19 | 140 | 124 | 2.89 | 255 | 64 | 5 |
| S-2 | 140 | 17:14 | 2.889 .012 | 235 | 645.40 | 140 | 124 | 2.89 | | | 5 |
| | 144 | 17:18 | | | 649.460 | | | | | | |
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| | | | | | | | 119.2 | | | | |
| | | | | 429.9 | 157.441 | 127.5 | 110.9 | 3.41 | | | |
| AVERAGE (TOTAL) | | | | 429.9 | (155.991) | 127.5 | 110.9 | 3.41 | | | |

Clayton Environmental Consultants, Inc.

DRY MOLECULAR WEIGHT DETERMINATION ($M_d$)

Plant: C. F. & I Steel
Date: 8/8/79
Sampling Time (24-hour Clock): 1745
Sampling Location:: Stack from coke battery "D"

Sample Type (grab, bag, integrated, continuous)
Analytical Method: ORSAT
Ambient Temperature: 95
Operator: TVP

Comments:

| Gas \ Run | 1 | | 2 | | 3 | | Average Net Volume | Multiplier | Molecular Weight Of Stack Gas (dry basis) $M_d$, lb/lb-mole |
|---|---|---|---|---|---|---|---|---|---|
| | Actual Reading | Net | Actual Reading | Net | Actual Reading | Net | | | |
| $CO_2$ | 5.3 | | 5.2 | | 5.2 | | 5.2 | 44/100 | 2.288 |
| $O_2$ (Net is actual $O_2$ reading minus actual $CO_2$ reading) | 14.8 | 9.5 | 14.6 | 9.4 | 14.7 | 9.5 | 9.5 | 32/100 | 3.040 |
| CO (net is actual CO reading minus actual $O_2$ reading) | 14.8 | | 14.6 | | 14.7 | | — | 28/100 | — |
| $N_2$ (Net is 100 minus actual CO reading) | | | | | | | 85.3 | 28/100 | 23.884 |
| | | | | | | | | Total | 29.212 = $M_d$ |

25.239

WET MOLECULAR WEIGHT DETERMINATION ($M_s$)

$B_{wo}$ = Proportion by volume of water vapor in the gas stream

$M_s$ = Molecular weight of stack gas (wet basis), lb/lb-mole = $M_d(1-B_{wo}) + 18(B_{wo})$

$M_s$ = ( )(1- ) + 18( ) = 27.687

$G_m = \frac{M_d}{28.96} = \frac{\quad}{28.96} =$ , $G_s = \frac{M_s}{28.96} = \frac{\quad}{28.96} = 0.956$ , $\frac{G_m}{G_s} = \frac{\quad}{\quad} =$

Clayton Environmental Consultants, Inc.

280.5 $\frac{T_m}{T_s}$ H

# SAMPLING TRAIN DATA

COMPANY: CF & I Steel (US EPA) Pueblo, Colorado
SOURCE DESIGNATION: Battery D Stack
REGULATING AUTHORITY: US EPA
DATE: 8-9-79
TEST NUMBER: P-3
Field Person(s): TVM
Filter Number: A-159-18
Barometric Pressure ("Hg): 25.32
Stack Static Pressure ("$H_2O$): -.96
Stack Dimensions: 122.4" ID
Ambient Temperature (°F): 90
Record all Data Every 4 Minutes

Nozzle (Dia-in): ___ ___ ___ (Avg): .751
Pitot Tube No. 35, Corr. Factor: 0.8285
Meter Box No. R-1, Corr. Factor: 0.9795
Meter Isokinetic Factor: 1679
Assumed Moisture (%): 13.6
Condensate Volume (ml): 343
Silica Gel Weight Gain (g): 35.7 / 1.25
Actual Moisture (%): ___
Leak Rate: Initial: 0 CFM at 15 "Hg; Final: ___ CFM at ___ "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp. (°F) Inlet | Dry Gas Meter: Temp. (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P-17 | 0 | 11:18 | 4.383 | 455 | 656.882 | 90 | 88 | 3.53 | 265 | 74 | 5 |
| P-17 | 4 | 11:22 | 4.371 .021 | 450 | 661.41 | 94 | 88 | 3.57 | 265 | 68 | 5 |
| P-16 | 8 | 11:26 | 4.575 .023 | 450 | 665.91 | 100 | 89 | 3.93 | 265 | 68 | 6 |
| P-15 | 12 | 11:30 | 4.575 .023 | 450 | 670.52 | 108 | 91 | 3.96 | 270 | 69 | 6 |
| P-14 | 16 | 11:34 | 4.383 .021 | 455 | 675.23 | 112 | 93 | 3.62 | 260 | 67 | 5.5 |
| P-13 | 20 | 11:38 | 4.180 .019 | 455 | 679.80 | 115 | 95 | 3.29 | 255 | 75 | 5 |
| P-12 | 24 | 11:42 | 4.181 .019 | 460 | 684.20 | 118 | 97 | 3.29 | 250 | 72 | 5 |
| P-11 | 28 | 11:46 | 4.449 .022 | 460 | 688.46 | 120 | 99 | 3.82 | 225 | 68 | 5.5 |
| P-10 | 32 | 11:50 | 4.181 .019 | 460 | 693.05 | 122 | 101 | 3.31 | 240 | 68 | 5 |
| P-9 | 36 | 11:54 | 4.147 .019 | 445 | 697.47 | 124 | 103 | 3.38 | 240 | 68 | 5 |
| P-8 | 40 | 11:58 | 4.437 .022 | 435 | 701.85 | 124 | 105 | 3.96 | 240 | 68 | 5.5 |
| P-7 | 44 | 12:02 | 4.124 .019 | 435 | 706.94 | 124 | 105 | 3.42 | 240 | 66 | 5 |
| P-6 | 48 | 12:06 | 3.801 .017 | 390 | 711.2 | 124 | 106 | 3.23 | 240 | 66 | 5 |
| P-5 | 52 | 12:10 | 3.709 .016 | 400 | 715.41 | 125 | 107 | 3.01 | 235 | 66 | 5 |
| P-4 | 56 | 12:14 | 3.709 .016 | 400 | 719.66 | 126 | 108 | 3.01 | 250 | 68 | 4.5 |
| P-3 | 60 | 12:18 | 3.812 .017 | 395 | 723.85 | 126 | 108 | 3.22 | 250 | 68 | 4.5 |
| P-2 | 64 | 12:22 | 2.857 .012 | 220 | 728.15 | 126 | 110 | 2.84 | 250 | 68 | 4 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

# SAMPLING TRAIN DATA

Company: CF&I
Source Designation: Battery D stack
Date: 8-9-79
Test Number: P-3
Field Person: TVM TJP RMK GMS
Filter Number: A-159-18
Barometric Pressure ("Hg):
Stack Static Pressure ("$H_2O$):
Stack Dimensions:
Plume Appearance:
Ambient Temperature (°F):
Record all Data Every _____ Minutes 19.79

Filter Heater Setting:
Probe Heater Setting:
Nozzle Number: ____, Dia. (in.):
Pitot Tube No. ____, Corr. Factor:
Meter Box No. ____, Corr. Factor:
Meter Isokinetic Factor:
Assumed Moisture (%):
Condensate Volume (ml):
Silica Gel Weight Gain (g):
Leak Rate 0 CFM at 10 "Hg
midpoint leak check

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-2 | 68 | 12:26 | 3.085 .014 | 220 | 732.29 | 127 | 110 | 3.34 | | | 5 |
| | 72 | 12:30 | | | 736.672 | | | | | | |
| W-17 | – | 14:56 | 5.326 .031 | 455 | 737.071 | 91 | 91 | 5.24 | 260 | 68 | 8 |
| W-17 | 76 | 15:00 | 5.151 .029 | 455 | 742.36 | 98 | 91 | 4.93 | 280 | 62 | 8 |
| W16 | 80 | 15:04 | 5.067 .028 | 455 | 747.62 | 108 | 92 | 4.81 | 270 | 62 | 7.5 |
| W15 | 84 | 15:08 | 4.686 .024 | 455 | 752.99 | 112 | 93 | 4.14 | 255 | 63 | 6.5 |
| W14 | 88 | 15:12 | 4.970 .027 | 455 | 757.66 | 117 | 96 | 4.69 | 245 | 64 | 7.0 |
| W13 | 92 | 15:16 | 4.686 .024 | 455 | 762.86 | 118 | 98 | 4.18 | 240 | 65 | 6.5 |
| W12 | 96 | 15:20 | 4.864 .026 | 450 | 767.64 | 120 | 99 | 4.56 | 230 | 65 | 7 |
| W11 | 100 | 15:24 | 4.383 .021 | 455 | 772.63 | 122 | 100 | 3.68 | 225 | 65 | 6 |
| W10 | 104 | 15:28 | 3.035 .01 | 455 | 777.25 | 124 | 102 | 1.76 | 220 | 66 | 3.5 |
| W9 | 108 | 15:32 | 3.035 .01 | 455 | 780.72 | 123 | 103 | 1.76 | 240 | 68 | 3.0 |
| W8 | 112 | 15:36 | 3.035 .01 | 455 | 783.97 | 123 | 104 | 1.76 | 240 | 67 | 3.0 |
| W7 | 116 | 15:40 | 3.173 .011 | 455 | 787.22 | 121 | 104 | 1.93 | 240 | 66 | 3.0 |
| W6 | 120 | 15:44 | 3.146 .011 | 440 | 790.62 | 121 | 105 | 1.96 | 240 | 66 | 3 |
| W5 | 124 | 15:48 | 2.740 .009 | 405 | 794.18 | 122 | 106 | 1.68 | 245 | 67 | 3 |
| W4 | 128 | 15:52 | 4.087 .02 | 375 | 797.30 | 121 | 106 | 3.85 | | | 6.5 |
| AVERAGE (TOTAL) | | | | | ( ) | | | | | | |

Clayton Environmental Consultants, Inc.

# SAMPLING TRAIN DATA

Company: CF&I Steel
Source Designation: Battery D Stack
Date: 8-8-79
Test Number: P-3
Field Person: TVM TJP RMK GMS
Filter Number: A-159-18
Barometric Pressure ("Hg):
Stack Static Pressure ("$H_2O$):
Stack Dimensions:
Plume Appearance:
Ambient Temperature (°F):
Record all Data Every _____ Minutes

Filter Heater Setting:
Probe Heater Setting:
Nozzle Number: ____, Dia. (in.):
Pitot Tube No. ____, Corr. Factor:
Meter Box No. ____, Corr. Factor:
Meter Isokinetic Factor:
Assumed Moisture (%):
Condensate Volume (ml):
Silica Gel Weight Gain (g):
Leak Rate .006 CFM at 12 "Hg

| Traverse Point No. | Time: Sampling (min) | Time: Clock | Velocity Pressure ("$H_2O$) | Stack Temp (°F) | Dry Gas Meter: Volume ($ft^3$) | Dry Gas Meter: Temp (°F) Inlet | Dry Gas Meter: Temp (°F) Outlet | Orifice Pressure Differential ("$H_2O$) | Filter Box Temp (°F) | Last Imp. Gas Temp (°F) | Sampling Train Static Pressure ("Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W3 | 132 | 15:56 | 4.436 .024 | 360 | 801.63 | 123 | 107 | 4.72 | 220 | 68 | 8 |
| W2 | 136 | 16:00 | 3.059 .012 | 320 | 806.65 | 125 | 107 | 2.49 | 225 | 67 | 5 |
| W2 | 140 | 16:04 | 2.450 .009 | 320 | 810.81 | 124 | 107 | 1.86 | 230 | 66 | 3.5 |
| | 144 | 16:08 | | | 814.199 | | | | | | |
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| | | | | | | | 108.8 | | | | |
| | | | | 419.7 | 155.349 | 117.2 | 100.4 | 3.38 | | | |
| AVERAGE (TOTAL) | | | | 419.7 | (153.701) | 117.2 | 100.4 | 3.38 | | | |

Clayton Environmental Consultants, Inc.

## DRY MOLECULAR WEIGHT DETERMINATION ($M_d$)

Plant: C.F.&I Steel
Date: 8/9/79
Sampling Time (24-hour Clock): 1118 1200
Sampling Location:: Stack (S. port) always
Comments:

Sample Type (bag, integrated, continuous)
Analytical Method: ORSAT
Ambient Temperature: 89
Operator: TJP

| Gas \ Run | 1 Actual Reading | 1 Net | 2 Actual Reading | 2 Net | 3 Actual Reading | 3 Net | Average Net Volume | Multiplier | Molecular Weight Of Stack Gas (dry basis) $M_d$, lb/lb-mole |
|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 4.8 | 4.8 | 4.9 | 4.9 | 5.0 | 5.0 | 4.9 | 44/100 | 2.156 |
| $O_2$ (Net is actual $O_2$ reading minus actual $CO_2$ reading) | 15.6 | 10.8 | 15.5 | 10.6 | 15.6 | 10.6 | 10.7 | 32/100 | 3.424 |
| CO (net is actual CO reading minus actual $O_2$ reading) | 15.6 | 0.0 | 15.6 | 0.1 | 15.6 | 0.0 | — | 28/100 | — |
| $N_2$ (Net is 100 minus actual CO reading) | | | | | | | 84.4 | 28/100 | 23.632 |
| | | | | | | | 25.093 | Total | 29.212 = $M_d$ |

## WET MOLECULAR WEIGHT DETERMINATION ($M_s$)

$B_{wo}$ = Proportion by volume of water vapor in the gas stream

$M_s$ = Molecular weight of stack gas (wet basis), lb/lb-mole = $M_d(1-B_{wo}) + 18(B_{wo})$

$M_s$ = ( )(1- ) + 18( ) = 27.631

$G_m = \frac{M_d}{28.96} = \frac{\quad}{28.96} =$ , $G_s = \frac{M_s}{28.96} = \frac{\quad}{28.96} = 0.954$ , $\frac{G_m}{G_s} = \frac{\quad}{\quad} =$

# APPENDIX B-2

# SAMPLING SUMMARY DATA

# SAMPLING SUMMARY SHEET

Plant C.F. & I. Steel Location Pueblo, Colorado

Sampled Source Battery D Stack

| Run | Date | $N_p$ | $P_m$ | $P_b$ | $V_m$ | $T_m$ | $V_{m_{std}}$ | $V_w$ | $V_{w_{gas}}$ | %M | $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8/7/79 | 36 | 2.33 | 25.27 | 121.541 | 116.0 | 94.751 | 322.8 | 15.204 | 13.8 | 0.862 |
| 2 | 8/8/79 | 36 | 3.41 | 25.30 | 155.771 | 119.2 | 121.285 | 409.4 | 19.283 | 13.7 | 0.863 |
| 3 | 8/9/79 | 36 | 3.38 | 25.32 | 153.701 | 108.8 | 121.946 | 428.7 | 20.192 | 14.2 | 0.858 |
| | | | | | | | | | | | |

| Run | $MW_d$ | MW | $P_{st}$ | $P_s$ | $C_p$ | $\sqrt{\Delta P_s X (T_s+460)}$ [c] | $V_s$ | $T_s$ | $T_t$ | $D_n$ | %I |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29.04 | 27.51 | -0.071 | 25.20 | 0.8205 | 3.127 | 499.0 | 439.6 | 144 | 0.762 | 97.1 |
| 2 | 29.21 | 27.67 | -0.071 | 25.23 | 0.8205 | 4.025 | 640.0 | 429.9 | 144 | 0.751 | 98.4 |
| 3 | 29.21 | 27.62 | -0.071 | 25.25 | 0.8205 | 4.015 | 638.8 | 419.7 | 144 | 0.751 | 98.5 |
| | | | | | | | | | | | |

$$V_{m_{std}} = \frac{17.65 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)}$$

$$\% M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}}$$

$$V_{w_{gas}} = 0.0471 \times V_w$$

$$M_d = \frac{100 - \% M}{100}$$

$$MW_d = (\% CO_2 \times \tfrac{44}{100}) + (\% O_2 \times \tfrac{32}{100}) + (\% CO + \% N_2) \times \tfrac{28}{100}$$

$$MW = MW_d \times M_d + 18 (1 - M_d)$$

$$P_s = P_b \pm P_{st}$$

$$V_s = 5120.8 \times Cp \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\% I = \frac{1,032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2}$$

$N_p$ Total No. of Sampling Points

$P_m$ Average Orifice Pressure Drop, in. $H_2O$

$P_b$ Barometric Pressure, in. Hg. Absolute

$V_m$ Volume of Dry Gas at Meter Conditions, DCF

$T_m$ Average Meter Temperature, °F

$V_{m_{std}}$ Volume of Dry Gas at STP, DSCF[a]

$V_w$ Total $H_2O$ Collected in Impingers and Silica Gel, g

$V_{w_{gas}}$ Volume of Water Vapor Collected at STP, SCF[b]

% M % Moisture by Volume

$M_d$ Mole Fraction of Dry Gas

% $CO_2$ Volume % Dry

% $O_2$ Volume % Dry

% CO Volume % Dry

% $N_2$ Volume % Dry

$MW_d$ Molecular Weight of Stack Gas, Dry Basis

MW Molecular Weight of Stack Gas, Wet Basis

$P_{st}$ Static Pressure of Stack Gas, in. Hg

$P_s$ Stack Gas Pressure, in. Hg Absolute

$C_p$ Pitot Tube Coefficient

$V_s$ Stack Gas Velocity at Stack Conditions, fpm.

$T_s$ Average Stack Temperature °F

$T_t$ Net Time of Test, Min.

$D_n$ Sampling Nozzle Diameter, f

% I Percent Isokinetic

[a] Dry standard cubic feet at 68°F, 29.92 in. Hg.

[b] Standard conditions at 68°F, 29.92 in. Hg.

[c] $\sqrt{\Delta P_s \times (T_s + 460)}$ is determined by averaging the square root of the product of the velocity head ($\Delta Ps$) and the absolute stack temperature from each sampling point.

TABLE B-2.1. STACK GAS PARAMETERS

| Sample Number | Date 1979 | Temperature | | Flowrate | | | |
|---|---|---|---|---|---|---|---|
| | | F | C | dscfm | acfm | $\frac{dsm^3}{min}$ | $\frac{am^3}{min}$ |
| 1 | 8-7 | 440 | 227 | 17,400 | 40,800 | 492 | 1,150 |
| 2 | 8-8 | 430 | 221 | 22,600 | 52,300 | 639 | 1,480 |
| 3 | 8-9 | 420 | 216 | 22,700 | 52,200 | 642 | 1,480 |
| Average | | 430 | 221 | 20,900 | 48,400 | 591 | 1,370 |

# APPENDIX B-3

# VISIBLE EMISSIONS DATA SHEETS

SUMMARY
RECORD OF VISIBLE EMISSIONS

Type of Plant ~~foundry~~ Coke Plant

Date Aug. 7, 1979

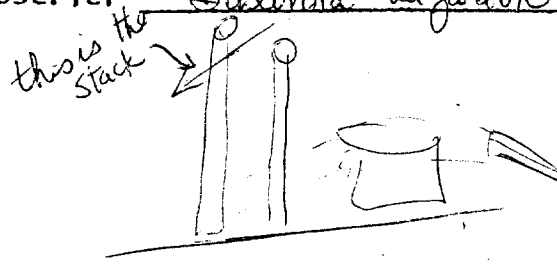
Company Name C.F. & I

Hours of Observation

Plant Address

Observer Dusanka Lazarevic

Type of Discharge (STACK) OTHER




Discharge Location Battery "D"

Height of Point of Discharge 250'

Observer's Location:

Distance to Discharge Point 350'

Height of Observation Point ground level

Direction from Discharge Point ~~south~~ west

Background Description Bright blue sky

Weather: (Clear) Overcast Partly Cloudy Other Color

Wind Direction from the southeast Wind Velocity 0-5 mi/hr

Plume Description:

Detached: Yes (No)

Color: Black White Other when visible reddish/brown

Plume Dispersion Behavior: Looping Coning Fanning

Lofting Fumigating Other

Estimated Distance Plume Visible

Summary of Observations:

| Opacity | Aggregate Time @ Opacity | | Opacity | Aggregate Time @ Opacity |
|---|---|---|---|---|
| 0 | min. | sec. | 55 | |
| 5 | | | 60 | |
| 10 | | | 65 | |
| 15 | | | 70 | |
| 20 | | | 75 | |
| 25 | | | 80 | |
| 30 | | | 85 | |
| 35 | | | 90 | |
| 40 | | | 95 | |
| 45 | | | 100 | |
| 50 | | | | |

RECORD OF VISIBLE EMISSIONS

Company Name C.F.&I Date Aug. 7, 1979

Plant Address Observer D. Lazarevic

Stack Location Battery "D" Observer's Location ground level - west of stack

Weather Conditions Beautiful, clear, hot!!!

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 00 | | | | | Particulate Test # 1 Pg. 1 |
| | 01 | | | | | |
| | 02 | | | | | 95° in the shade! |
| | 03 | | | | | |
| | 04 | | | | | |
| | 05 | | | | | |
| | 06 | | | | | |
| | 07 | | | | | |
| | 08 | | | | | |
| | 09 | | | | | |
| | 10 | | | | | |
| | 11 | | | | | |
| | 12 | | | | | |
| | 13 | | | | | |
| | 14 | | | | | "—" denotes interference |
| | 15 | | | | | |
| | 16 | | | | | |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| 15: | 21 | 0 | 0 | 0 | 0 | Start |
| | 22 | 0 | 0 | 0 | 0 | |
| | 23 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | — | — | 0 | a billow of black smoke interfered |
| | 25 | 0 | 0 | 0 | 0 | with my reading (bad puff?) |
| 15: | 26 | 0 | 0 | 0 | 0 | |
| 15: | 27 | 0 | 0 | 0 | 0 | these trains are going to drive me buggy!! |
| | 28 | 0 | 0 | 0 | 0 | |
| | 29 | 0 | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS Test #1 page 2 |
|---|---|---|---|---|---|---|
| | 30 | 0 | 0 | 0 | 0 | 0 test has stopped due to high vacuum |
| | 31 | 0 | 0 | 0 | 0 | I'll still continue my readings |
| 15: | 32 | 0 | 0 | 0 | 0 | |
| 15: | 33 | 0 | 0 | 0 | 0 | |
| | 34 | 0 | 0 | 0 | 0 | |
| | 35 | 0 | 0 | 0 | 0 | 0 |
| | 36 | 0 | 0 | 0 | 0 | |
| | 37 | 0 | 0 | 0 | 0 | |
| 15: | 38 | 0 | 0 | 0 | 0 | |
| 15: | 39 | 0 | 0 | 0 | 0 | |
| | 40 | 0 | 0 | 0 | 0 | |
| | 41 | 0 | 0 | 0 | 0 | 0 |
| | 42 | 0 | 0 | 0 | 0 | |
| | 43 | 0 | 0 | 0 | 0 | |
| 15: | 44 | 0 | 0 | 0 | 0 | |
| 15: | 45 | 0 | 0 | 0 | 0 | |
| | 46 | 0 | 0 | 0 | 0 | |
| | 47 | 0 | 0 | 0 | 0 | Started testing again |
| | 48 | 0 | 0 | 0 | 0 | |
| | 49 | 0 | 0 | 5 | 5 | |
| 15: | 50 | 5 | 0 | 0 | 0 | |
| 15: | 51 | 0 | 0 | 0 | 0 | |
| | 52 | 0 | 0 | 0 | 0 | |
| | 53 | 0 | 0 | 0 | 0 | 0 |
| | 54 | — | — | 0 | 0 | another bad puff (black smoke) |
| | 55 | 0 | 0 | 0 | 0 | |
| 15: | 56 | 0 | 0 | 0 | 0 | |
| 15: | 57 | 0 | 0 | 0 | 0 | |
| | 58 | 0 | 0 | 0 | 0 | |
| | 59 | 0 | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 page 3

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| 16: | 00 | 0 | 0 | 0 | 0 | |
| | 01 | 0 | 0 | 0 | 0 | 0 |
| 16: | 02 | 0 | 0 | 0 | 0 | |
| 16: | 03 | 0 | 0 | 0 | 0 | |
| | 04 | 0 | 0 | 0 | 0 | |
| | 05 | 0 | 0 | 0 | 0 | 0 |
| | 06 | 0 | 0 | 0 | 0 | |
| | 07 | 0 | 0 | 0 | 0 | |
| 16: | 08 | 0 | 0 | 0 | 0 | |
| 16: | 09 | 0 | 0 | 0 | 0 | |
| | 10 | 0 | 0 | 0 | 0 | |
| | 11 | 0 | 0 | 0 | 0 | 0 |
| | 12 | 0 | 0 | 0 | 0 | |
| | 13 | 0 | 0 | 0 | 0 | |
| 16: | 14 | 0 | 0 | 0 | 0 | |
| 16: | 15 | 0 | 0 | 0 | 0 | |
| | 16 | 0 | 0 | 0 | 0 | |
| | 17 | 0 | 0 | 0 | 0 | |
| | 18 | 0 | 0 | 0 | 0 | 0 |
| | 19 | 0 | 0 | 0 | 0 | |
| 16: | 20 | 0 | 0 | 0 | 0 | |
| 16: | 21 | 0 | 0 | 0 | 0 | |
| | 22 | 0 | 0 | 0 | 0 | |
| | 23 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | |
| | 25 | 0 | 0 | 0 | 0 | |
| 16: | 26 | 0 | 0 | 0 | 0 | |
| 16: | 27 | 0 | 0 | 0 | 0 | |
| | 28 | 0 | 0 | 0 | 0 | |
| | 29 | 0 | 0 | 0 | 0 | |

# RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 Page 4

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 30 | 0 | 0 | 0 | 0 | |
| | 31 | 0 | 0 | 0 | 0 | 0 |
| 16: | 32 | 0 | 0 | 0 | 0 | |
| 16: | 33 | 0 | 0 | 0 | 0 | |
| | 34 | 0 | 0 | 0 | 0 | |
| | 35 | 0 | 0 | 0 | 0 | |
| | 36 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 0 | 0 | 0 | 0 | |
| 16: | 38 | 0 | 0 | 0 | 0 | stopped testing - lost electricity - |
| | 39 | | | | | electricians have gone home. |
| | 40 | | | | | Will resume readings when test starts |
| 17:37 | 41 | 0 | 0 | 0 | 0 | up (if it does) test resumed. |
| | 42 | 0 | 0 | 0 | 0 | |
| | 43 | 0 | 0 | 0 | 0 | 0 |
| | 44 | 0 | 0 | 0 | 0 | |
| | 45 | 0 | – | – | 0 | black smoke from push |
| 17:42 | 46 | 0 | 0 | 0 | 0 | |
| 17:43 | 47 | 0 | 0 | 0 | 0 | |
| | 48 | 0 | 0 | 0 | 0 | |
| | 49 | 0 | 0 | 0 | 0 | 0 the other stack is emitting about |
| | 50 | 0 | 0 | 0 | 0 | 5% but isn't interfering. |
| | 51 | 0 | 0 | 0 | 0 | |
| 17:48 | 52 | 0 | – | – | – | cloud of red/brown smoke interfering all over |
| 17:49 | 53 | – | 0 | – | – | the place |
| | 54 | – | – | – | – | |
| | 55 | – | – | – | – | 2/5 |
| | 56 | – | – | – | – | |
| | 57 | – | – | – | 0 | |
| 17:54 | 58 | 0 | 0 | 5 | 5 | Cleared up |
| 17:55 | 59 | 5 | 5 | 5 | – | interference (black smoke) |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 Page 5

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| | 00 | – | 0 | 0 | 0 | |
| | 01 | 0 | 0 | 0 | 0 | 1/22 |
| | 02 | 0 | 0 | 0 | 0 | |
| | 03 | 0 | 0 | 0 | 0 | |
| 1800 | 04 | 0 | 0 | 0 | 0 | about 10% from other stack |
| 1801 | 05 | 0 | 0 | 0 | 0 | |
| | 06 | 0 | 0 | 0 | 0 | |
| | 07 | 0 | 0 | 0 | 0 | |
| | 08 | 0 | 0 | 0 | 0 | 0 |
| | 09 | 0 | 0 | 0 | 0 | |
| 1806 | 10 | 0 | – | – | 0 | |
| 1807 | 11 | 0 | 0 | 0 | 0 | |
| | 12 | 0 | 0 | 0 | 0 | |
| | 13 | 0 | 0 | 0 | 0 | 0 |
| | 14 | 0 | 0 | 0 | 0 | |
| | 15 | 0 | 0 | 0 | 0 | |
| 1812 | 16 | 0 | 0 | 0 | 0 | |
| 1813 | 17 | 0 | 0 | – | – | other stack steam 10-15%. |
| | 18 | 0 | 0 | 0 | 0 | |
| | 19 | 0 | 0 | 0 | 0 | 0 |
| | 20 | 0 | 0 | 0 | 0 | |
| | 21 | 0 | 0 | 0 | 0 | |
| 1818 | 22 | 0 | 0 | 0 | 0 | |
| 1819 | 23 | 0 | 0 | 0 | 0 | |
| | 24 | 0 | 0 | 0 | 0 | |
| | 25 | 0 | 0 | 0 | 0 | 0 |
| | 26 | 0 | 0 | 0 | 0 | |
| | 27 | 0 | 0 | 0 | 0 | |
| 1824 | 28 | 0 | 0 | 0 | 0 | |
| 1825 | 29 | 15 | 15 | 10 | 5 | |

# RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 Page 6

| HR | MIN | TIME SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 30 | 0 | 0 | 0 | 0 | |
| | 31 | 0 | 0 | 0 | 0 | 2/23 |
| | 32 | 0 | 0 | 0 | 0 | |
| | 33 | 0 | — | 0 | 0 | interference from trees |
| 1830 | 34 | 0 | 0 | 5 | 5 | |
| 1831 | 35 | 5 | 5 | 0 | 0 | |
| | 36 | 0 | 0 | 0 | 0 | |
| | 37 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 0 | 0 | 0 | 0 | |
| | 39 | 0 | 0 | 0 | 0 | |
| 1836 | 40 | 0 | 0 | 0 | 0 | |
| 1837 | 41 | 0 | 0 | 0 | 0 | |
| | 42 | 0 | 0 | 0 | 0 | |
| | 43 | 0 | 0 | 0 | 0 | 0 |
| | 44 | 0 | 0 | 0 | 0 | |
| | 45 | 0 | 0 | 0 | 0 | |
| 1842 | 46 | 0 | 0 | 0 | 0 | |
| 1843 | 47 | 0 | 0 | 0 | 0 | |
| | 48 | 0 | — | 0 | 0 | |
| | 49 | 5 | 5 | 5 | 0 | 1/23 |
| | 50 | 0 | 0 | 0 | 0 | |
| | 51 | 0 | 0 | 0 | 0 | |
| 1848 | 52 | 0 | 0 | 0 | 0 | |
| 1849 | 53 | 0 | 0 | 0 | 0 | |
| | 54 | 0 | 0 | 0 | 0 | |
| | 55 | 0 | 0 | 0 | 0 | |
| | 56 | 0 | 0 | 0 | 0 | 0 |
| | 57 | 0 | 0 | 0 | 0 | |
| 1854 | 58 | 0 | 0 | 0 | 0 | |
| 1855 | 59 | 0 | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 Page 7

| HR | MIN | TIME SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 00 | 0 | 0 | 0 | 0 | |
| | 01 | 0 | 0 | 0 | 0 | |
| | 02 | 0 | 0 | 0 | 0 | 0 |
| | 03 | 0 | 0 | 0 | 0 | |
| 1900 | 04 | 0 | 0 | 0 | 0 | |
| 1901 | 05 | 0 | 0 | 0 | 0 | it's cooling down to a mere 90°. (at 7pm) |
| | 06 | 0 | 0 | 0 | 0 | |
| | 07 | 0 | 0 | 0 | 0 | |
| | 08 | 0 | 5 | 5 | 5 | |
| | 09 | 5 | 5 | 0 | 0 | |
| 1906 | 10 | 0 | 0 | 0 | 0 | |
| 1907 | 11 | 0 | 0 | 0 | 0 | |
| | 12 | 0 | 0 | 0 | 0 | starting up the second ½ of test! |
| | 13 | — | — | — | — | 0 area a little hazy - fugitive emissions |
| | 14 | 0 | 0 | 0 | 0 | |
| | 15 | — | — | — | — | |
| 1912 | 16 | — | — | — | 0 | |
| 1913 | 17 | 0 | 0 | 0 | 0 | |
| | 18 | 0 | 0 | 0 | 0 | area clear of fugitive emissions |
| | 19 | 0 | 0 | 0 | 0 | 0 |
| | 20 | 0 | 0 | 0 | 0 | |
| | 21 | 0 | 0 | 0 | 0 | |
| 1918 | 22 | 0 | 0 | 0 | 0 | |
| 1919 | 23 | 0 | 0 | 0 | 0 | |
| | 24 | 0 | 0 | 0 | 0 | |
| | 25 | 0 | 0 | 5 | 5 | 5 |
| | 26 | 5 | 5 | 5 | 5 | |
| | 27 | 10 | 10 | 10 | 10 | |
| 1924 | 28 | 10 | 10 | 10 | 10 | |
| 1925 | 29 | 20 | 15 | 10 | 5 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 7, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #1 Page 8

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 30 | 5 | 5 | 5 | 5 | |
| | 31 | 0 | 5 | 5 | 0 | |
| | 32 | 0 | 0 | 0 | 0 | 3 |
| | 33 | 0 | 0 | 0 | 0 | |
| 1930 | 34 | 0 | 0 | 0 | 0 | |
| 1931 | 35 | 0 | 0 | 0 | 0 | |
| | 36 | 0 | 0 | 0 | 0 | |
| | 37 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 0 | 0 | 0 | 0 | |
| | 39 | 0 | 0 | 0 | 0 | |
| 1936 | 40 | 0 | 0 | 0 | 0 | |
| 1937 | 41 | 0 | 0 | 5 | 5 | |
| | 42 | 5 | 5 | 5 | – | |
| | 43 | – | 5 | 5 | 5 | 4 |
| | 44 | 5 | 5 | 5 | 5 | |
| | 45 | 5 | 5 | 5 | 5 | |
| 1942 | 46 | 5 | 5 | 0 | 0 | 89° getting cooler!! |
| 1943 | 47 | 0 | 0 | 0 | 0 | |
| | 48 | 0 | 0 | 0 | 0 | |
| | 49 | 0 | 0 | 0 | 0 | 1 |
| | 50 | 0 | 0 | 0 | – | another bad puff? black billowing smoke |
| | 51 | – | – | – | – | still hazy |
| 1948 | 52 | 0 | 0 | 5 | 5 | sun going down – lighting is easier on |
| 1949 | 53 | 5 | 5 | 5 | 5 | the eyes, makes reading easier |
| | 54 | 5 | 0 | 0 | 0 | |
| | 55 | 5 | 5 | 5 | 5 | 4 can read 5's now where as before couldn't |
| | 56 | 5 | 5 | 5 | 5 | very easily due to the very bright sunlight. |
| | 57 | 5 | 5 | 5 | 5 | |
| 1954 | 58 | 5 | 5 | 5 | 5 | |
| 0752 | 59 | 5 | 5 | 5 | 0 | stopped reading – sun going down |

SUMMARY
RECORD OF VISIBLE EMISSIONS

Type of Plant Coke Plant

Date Aug 8

Company Name

Hours of Observation

Plant Address

Observer

Type of Discharge STACK OTHER

Discharge Location

Height of Point of Discharge

Battery overs

Observer's Location:

Distance to Discharge Point 225'

Height of Observation Point ground level

Direction from Discharge Point X

Background Description blue sky

Weather: Clear Overcast Partly Cloudy Other Color

Wind Direction Wind Velocity 5-10 mi/hr

Plume Description:

Detached: Yes No

Color: Black White Other

Plume Dispersion Behavior: Looping Coning Fanning

Lofting Fumigating Other

Estimated Distance Plume Visible

Summary of Observations:

| Opacity | Aggregate Time @ Opacity | | Opacity | Aggregate Time @ Opacity |
|---|---|---|---|---|
| 0 | min. | sec. | 55 | |
| 5 | | | 60 | |
| 10 | | | 65 | |
| 15 | | | 70 | |
| 20 | | | 75 | |
| 25 | | | 80 | |
| 30 | | | 85 | |
| 35 | | | 90 | |
| 40 | | | 95 | |
| 45 | | | 100 | |
| 50 | | | | |

RECORD OF VISIBLE EMISSIONS

Company Name C.F.&I.

Date Aug 8, 1979

Plant Address

Observer D. Lazarevic

Stack Location

Observer's Location

Weather Conditions HOT - HOT - HOT !!!

| HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 30 | | | | | Part. test # 2 page 1 |
| 11: | 31 | 0 | 0 | 0 | 0 | started testing |
| | 32 | 0 | 0 | 0 | 0 | the sun is very very bright & HOT |
| | 33 | 0 | 0 | 0 | 0 | 0 There's not a speck of shade in sight |
| | 34 | 0 | 0 | 0 | 0 | |
| | 35 | 0 | 0 | 0 | 0 | |
| 11: | 36 | 0 | 0 | 0 | 0 | |
| 11: | 37 | 0 | 0 | 0 | 0 | |
| | 38 | 0 | 0 | 0 | 0 | |
| | 39 | 0 | 0 | 0 | 0 | |
| | 40 | 0 | 0 | 0 | 0 | 0 |
| | 41 | 0 | 0 | 0 | 0 | |
| 11: | 42 | 0 | 0 | 0 | 0 | |
| 11: | 43 | 0 | 0 | 0 | 0 | |
| | 44 | 0 | 0 | 0 | 0 | |
| | 45 | 0 | 0 | 0 | 0 | |
| | 46 | 0 | 0 | 0 | 0 | 0 |
| | 47 | 0 | 0 | 0 | 0 | |
| 11: | 48 | 0 | 0 | 0 | 0 | |
| 11: | 49 | 0 | 0 | 0 | 0 | |
| | 50 | 0 | 0 | 0 | 0 | |
| | 51 | 0 | 0 | 0 | 0 | |
| | 52 | 0 | 0 | 0 | 0 | 0 |
| | 53 | 0 | 0 | 0 | 0 | |
| 11: | 54 | 0 | 0 | 0 | 0 | |
| 11: | 55 | 0 | 0 | 0 | 0 | |
| | 56 | 0 | 0 | 0 | 0 | |
| | 57 | 0 | 0 | 0 | 0 | |
| | 58 | 0 | 0 | 0 | 0 | 0 |
| | 59 | 0 | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date _____

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test # 2 Page 2

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| 12: | 00 | 0 | 0 | 0 | 0 | |
| 12: | 01 | 0 | 0 | 0 | 0 | |
| | 02 | 0 | 0 | 0 | 0 | |
| | 03 | 0 | 0 | 0 | 0 | |
| | 04 | 0 | 0 | 0 | 0 | 0 |
| | 05 | 0 | 0 | 0 | 0 | |
| 12: | 06 | 0 | 0 | 0 | 0 | |
| 12: | 07 | 0 | 0 | 0 | 0 | |
| | 08 | 0 | 0 | 0 | 0 | |
| | 09 | 0 | 0 | 0 | 0 | |
| | 10 | 0 | 0 | 0 | 0 | 0 |
| | 11 | 0 | 0 | 0 | 0 | |
| 12: | 12 | 0 | 0 | 0 | 0 | |
| 12: | 13 | 0 | 0 | 0 | – | |
| | 14 | 0 | 0 | 0 | 0 | |
| | 15 | 0 | 0 | 0 | 0 | |
| | 16 | 0 | 0 | 0 | 0 | 0 |
| | 17 | 0 | 0 | 0 | 0 | |
| 12: | 18 | 0 | 0 | 0 | 0 | |
| 12: | 19 | 0 | 0 | 10 | 10 | |
| | 20 | 10 | 5 | 5 | 0 | |
| | 21 | 0 | 0 | 0 | 0 | |
| | 22 | 0 | 0 | 0 | 0 | 0 |
| | 23 | 0 | 0 | 0 | 0 | |
| 12: | 24 | 0 | 0 | 0 | 0 | |
| 12: | 25 | 0 | 0 | 0 | 0 | |
| | 26 | 0 | 0 | 0 | 0 | |
| | 27 | 0 | 0 | 0 | 0 | |
| | 28 | 0 | 0 | 0 | 0 | 0 |
| | 29 | 0 | 0 | 0 | 0 | |

# RECORD OF VISIBLE EMISSIONS

Company Name _____ Date _____

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test # 2 Page 3

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| 12: | 30 | 0 | 0 | 0 | 0 | |
| 12: | 31 | 0 | 0 | 0 | 0 | |
| | 32 | 0 | 0 | 0 | 0 | |
| | 33 | 0 | 0 | 0 | 0 | |
| | 34 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | |
| 12: | 36 | 0 | 0 | 0 | 0 | |
| 12: | 37 | 0 | 0 | 0 | 0 | |
| | 38 | 0 | 0 | 0 | 0 | |
| | 39 | 0 | 0 | 0 | 0 | |
| | 40 | 0 | 0 | 0 | 0 | 0 |
| | 41 | 0 | 0 | 0 | 0 | |
| 12: | 42 | 0 | 0 | 0 | 0 | |
| 12: | 43 | 0 | 0 | 0 | 0 | |
| | 44 | 0 | 0 | 0 | 0 | end of first port!!! Yahoo!!! |
| | 45 | | | | | |
| | 46 | | | | | |
| | 47 | | | | | |
| | 48 | | | | | |
| | 49 | | | | | |
| | 50 | | | | | reading position for the 2nd ½ of this |
| | 51 | | | | | test is the same as for TEST #1. |
| | 52 | | | | | |
| | 53 | | | | | it's 93° in the shade - getting cloudy |
| | 54 | | | | | looks like we might get some rain. |
| | 55 | | | | | |
| | 56 | | | | | |
| | 57 | | | | | |
| | 58 | | | | | |
| | 59 | | | | | |

TO HERE. D.S 8-8-79

# RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 8, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #2 page 4

| HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| | 00 | | | | | |
| | 01 | | | | | |
| | 02 | | | | | |
| 16: | 03 | 0 | 0 | 0 | 5 | Test start |
| | 04 | 5 | 5 | 5 | 5 | when the sun goes behind the clouds & |
| | 05 | 0 | 0 | 0 | 0 | it's intensity is reduced or a cloud passes behind the stack |
| | 06 | 0 | 0 | 0 | 0 | easier to read & the readings are mostly 5's. But |
| | 07 | 0 | 0 | 0 | 0 | when the sun is full strength, creates |
| 16: | 08 | 0 | 0 | 0 | 0 | quite alot of glare & makes reading |
| 16: | 09 | 0 | 0 | 5 | 5 | difficult, can't see much then. |
| | 10 | 5 | 5 | 5 | 0 | could be heat waves |
| | 11 | 5 | 0 | 0 | 0 | wind is really picking up |
| | 12 | 0 | 0 | 0 | 0 | |
| | 13 | 0 | 0 | 0 | 0 | |
| 16: | 14 | 0 | 0 | 0 | 0 | |
| 16: | 15 | 0 | 0 | 0 | 0 | |
| | 16 | 0 | 0 | 0 | 0 | |
| | 17 | 0 | 0 | 0 | 0 | 0 |
| | 18 | 0 | 0 | 0 | 0 | |
| | 19 | 0 | 0 | 0 | 0 | |
| 16: | 20 | 0 | 0 | 0 | 0 | |
| 16: | 21 | 0 | 0 | 0 | 0 | |
| | 22 | 0 | 0 | 0 | 0 | |
| | 23 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | |
| | 25 | 0 | 0 | 0 | 0 | |
| 16: | 26 | 0 | 0 | 0 | 0 | |
| 16: | 27 | 0 | 0 | 0 | 0 | |
| | 28 | 0 | 0 | 0 | 0 | |
| | 29 | 0 | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 8, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #2 Page 5

| HR | MIN | TIME SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| | 30 | 0 | 0 | 0 | 0 | |
| | 31 | 0 | 0 | 0 | 0 | 0 |
| 16: | 32 | 0 | 0 | 0 | 0 | |
| 16: | 33 | 0 | 0 | 0 | 0 | |
| | 34 | 0 | 0 | 0 | 0 | |
| | 35 | 0 | 0 | 0 | 0 | |
| | 36 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 0 | 0 | 0 | 0 | |
| 16: | 38 | 0 | 0 | 0 | 0 | |
| 16: | 39 | 0 | 0 | 0 | 0 | |
| | 40 | 0 | 0 | 0 | 0 | |
| | 41 | 0 | 0 | 0 | 0 | |
| | 42 | 0 | 0 | 0 | 0 | 0 |
| | 43 | 0 | 0 | 0 | 0 | |
| 16: | 44 | 0 | 0 | 0 | 0 | |
| 16: | 45 | 0 | 0 | 0 | 0 | |
| | 46 | 0 | 0 | 0 | 0 | |
| | 47 | 0 | 0 | 0 | 0 | |
| | 48 | 0 | 0 | 0 | 0 | 0 |
| | 49 | 0 | 0 | 0 | 0 | |
| 16: | 50 | 0 | 0 | 0 | 0 | |
| 16: | 51 | 5 | 5 | 5 | 5 | |
| | 52 | 5 | 0 | 0 | 0 | |
| | 53 | 0 | 0 | 0 | 0 | |
| | 54 | 0 | 0 | 0 | 0 | |
| | 55 | 0 | 0 | 0 | 0 | |
| 16: | 56 | 0 | 0 | 0 | 0 | |
| 16: | 57 | 0 | 0 | 0 | 0 | |
| | 58 | 0 | 0 | 0 | 0 | |
| | 59 | 0 | 0 | 0 | 0 | 0 |

# RECORD OF VISIBLE EMISSIONS

TO HERE. D.S. 8-9-79

Company Name _____ Date Aug 8, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #2 Page 6

| HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| | 00 | 0 | 0 | 0 | 0 | |
| | 01 | 0 | 0 | 0 | 0 | |
| 17 | 02 | 0 | 0 | 0 | 0 | |
| 17 | 03 | 0 | 0 | 0 | 0 | |
| | 04 | 0 | 0 | 0 | 0 | |
| | 05 | 0 | 0 | 0 | 0 | 0 |
| | 06 | 0 | 0 | 0 | 0 | |
| | 07 | 0 | 0 | 0 | 0 | |
| 17 | 08 | 0 | 0 | 0 | 0 | |
| 17 | 09 | 0 | 0 | 0 | 0 | |
| | 10 | 0 | 0 | 0 | 0 | |
| | 11 | 0 | 0 | 0 | 0 | |
| | 12 | 0 | 0 | 0 | 0 | 0 |
| | 13 | 0 | 0 | 0 | 0 | |
| 17 | 14 | 0 | – | – | 0 | interference red smoke all over! |
| 17 | 15 | 0 | 0 | 0 | 0 | |
| | 16 | | | | | all done !!! |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |
| | 26 | | | | | |
| | 27 | | | | | |
| | 28 | | | | | |
| | 29 | | | | | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug 9, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location S east of stack

Weather Conditions blue sky w/a scatter of clouds & HOT HOT HOT HOT

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| | 00 | | | | | Test # 3 page 1 |
| | 01 | | | | | |
| | 02 | | | | | same position as for the first ½ of test #2 |
| | 03 | | | | | |
| | 04 | | | | | |
| | 05 | | | | | Boy — is it HOT !!!! |
| | 06 | | | | | |
| | 07 | | | | | |
| | 08 | | | | | |
| | 09 | | | | | |
| | 10 | | | | | |
| | 11 | | | | | |
| | 12 | | | | | |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| | 16 | | | | | |
| | 17 | | | | | |
| 11 | 18 | | | | | test started at 11:18 |
| 11: | 19 | 0 | 0 | 0 | 5 | |
| | 20 | 0 | 0 | 0 | 0 | |
| | 21 | 0 | 0 | 0 | 0 | |
| | 22 | 0 | 0 | 0 | 0 | 0 |
| | 23 | 0 | 0 | 0 | 0 | |
| 11: | 24 | 0 | 0 | 0 | 0 | |
| 11: | 25 | 0 | 0 | 0 | 0 | |
| | 26 | 0 | 0 | 0 | 0 | |
| | 27 | 0 | 0 | 0 | 0 | 0 |
| | 28 | 0 | 0 | 0 | — | interference from quenching |
| | 29 | — | 0 | 0 | 0 | |

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug. 9, 1979

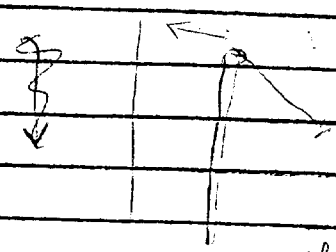
Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #3 Page 2

| HR | MIN | TIME SECONDS 00 | 15 | 30 | 45 | COMMENTS |
|---|---|---|---|---|---|---|
| 11: | 30 | 0 | 0 | 0 | 0 | |
| 11. | 31 | 0 | 0 | 0 | 0 | |
| | 32 | 0 | 0 | 0 | 0 | |
| | 33 | 0 | 0 | 0 | 0 | |
| | 34 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | |
| 11: | 36 | 0 | 0 | 0 | 0 | |
| 11: | 37 | 0 | 0 | 0 | 0 | |
| | 38 | 0 | 0 | 0 | 0 | |
| | 39 | — | — | — | — | black smoke |
| | 40 | 0 | 0 | 0 | 0 | 0 |
| | 41 | 0 | 0 | 0 | 0 | |
| 11: | 42 | 0 | 0 | 5 | 5 | |
| 11: | 43 | 10 | 10 | 10 | 20 | |
| | 44 | 20 | 20 | 15 | 15 | 14 |
| | 45 | 15 | 15 | 15 | 15 | 15 |
| | 46 | 15 | 10 | 10 | 10 | 0 / 15 |
| | 47 | 10 | 10 | — | — | interferenna "GREEN" smoke |
| 11: | 48 | — | — | — | — | |
| 11: | 49 | — | — | — | 5 | |
| | 50 | 5 | 5 | 5 | 5 | |
| | 51 | 0 | 0 | 0 | 0 | |
| | 52 | 0 | 0 | 0 | 0 | 7/19 |
| | 53 | 0 | 0 | 0 | 0 | |
| 11. | 54 | 0 | 5 | — | — | |
| 11. | 55 | 5 | 0 | 5 | 5 | |
| | 56 | 0 | 0 | 0 | 0 | |
| | 57 | 0 | 0 | 0 | 0 | 1/23 |
| | 58 | — | 0 | 0 | 0 | |
| | 59 | 0 | 0 | 0 | 0 | |



the wind is constant shifting

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug 9, 1979

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

COMMENTS Test #3 Page 3

| TIME HR | MIN | SECONDS 00 | 15 | 30 | 45 | |
|---|---|---|---|---|---|---|
| 12 | 00 | 0 | 0 | 0 | 0 | |
| 12: | 01 | 0 | 0 | 0 | 0 | |
| | 02 | 0 | 0 | 0 | 0 | |
| | 03 | 0 | 0 | 0 | 0 | 0 |
| | 04 | 0 | 0 | 0 | 0 | |
| | 05 | 0 | 0 | — | — | |
| 12: | 06 | 0 | 0 | — | — | |
| 12: | 07 | 0 | 0 | 0 | 0 | |
| | 08 | 0 | 0 | 0 | 0 | |
| | 09 | 0 | 0 | 0 | 0 | |
| | 10 | 0 | 0 | 0 | 0 | 0 |
| | 11 | 0 | 0 | 0 | 0 | |
| 12: | 12 | 0 | 0 | 0 | 0 | |
| 12: | 13 | 0 | 0 | 0 | — | |
| | 14 | — | — | — | 0 | |
| | 15 | 0 | 0 | 0 | 0 | |
| | 16 | 0 | 0 | 0 | 0 | 0 |
| | 17 | 0 | 0 | 0 | 0 | |
| 12: | 18 | 0 | 0 | 0 | 0 | |
| 12: | 19 | 0 | 0 | 0 | 10 | |
| | 20 | 5 | 5 | 5 | 5 | |
| | 21 | 0 | 0 | 0 | 0 | |
| | 22 | 0 | 0 | 0 | 0 | |
| | 23 | 0 | 0 | 0 | 0 | |
| 12: | 24 | 0 | 0 | 0 | 0 | |
| 12 | 25 | 0 | 0 | 0 | 0 | |
| | 26 | 0 | 0 | 0 | 0 | 0 |
| | 27 | 0 | 0 | 0 | 0 | |
| | 28 | 0 | | | | |
| | 29 | | | | | |

thunderheads are building up in the distance HUGE ONES!

Cloud passing behind stack - all I see is heat waves test done first ½.

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date Aug 9, 1977

Plant Address _____ Observer _____

Stack Location _____ Observer's Location _____

Weather Conditions _____

| HR | MIN | SECONDS 00 | 15 | 30 | 45 | COMMENTS Test # 3 page 4 |
|---|---|---|---|---|---|---|
| | 30 | | | | | Overcast skies - raining intermittently |
| | 31 | | | | | it may be difficult to read. Grayish/ |
| | 32 | | | | | black background. During the morning |
| | 33 | | | | | readings the smoke was reddish/brown, it |
| | 34 | | | | | Only 83° !!! could be read against the |
| | 35 | | | | | white sky. If smoke is white won't be able to |
| | 36 | | | | | see anything. |
| | 37 | | | | | |
| | 38 | | | | | |
| | 39 | | | | | |
| | 40 | | | | | |
| | 41 | | | | | |
| | 42 | | | | | |
| | 43 | | | | | |
| | 44 | | | | | |
| | 45 | | | | | |
| | 46 | | | | | |
| | 47 | | | | | |
| | 48 | | | | | |
| | 49 | | | | | |
| | 50 | | | | | |
| | 51 | | | | | |
| | 52 | | | | | |
| 14. | 53 | 0 | 0 | 0 | 0 | test started second 1/2 |
| 14 | 54 | 0 | 0 | 0 | 0 | |
| | 55 | 0 | | | | stopped reading opacities - can't see |
| | 56 | | | | | anything against the overcast sky |
| | 57 | | | | | |
| | 58 | | | | | |
| | 59 | | | | | |

# APPENDIX B-4

# SUMMARY OF VISIBLE EMISSIONS

# SUMMARY OF VISIBLE EMISSIONS
Test No. 1

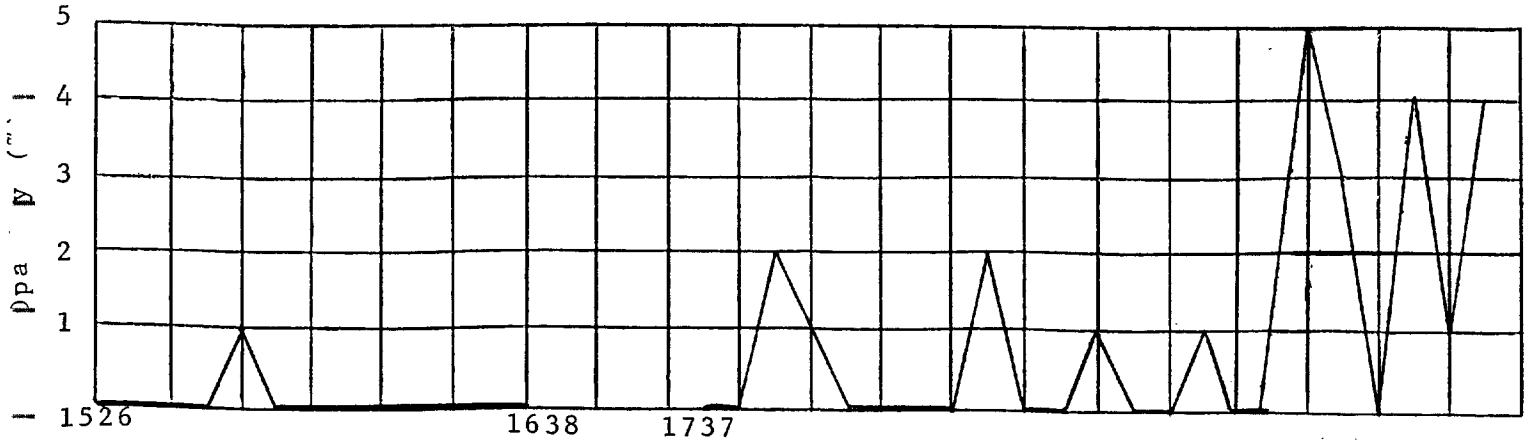
Date: 8/7/79
Type of Discharge: Stack
Height of Point of Discharge: 250'
Wind Direction: Southeast
Color of Plume: White to reddish brown
Observer's Name: D. Lazarevic
Type of Plant: Coke Plant
Location of Discharge: Battery stack D
Description of Sky: Blue
Wind Velocity: 0-5 mph
Detached Plume: No
Duration of Observation: 3 hr 34 min
Distance from Observer to Discharge Point: 350'
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level
Description of Background: sky

SUMMARY OF AVERAGE OPACITY

| Set Number | Time | | Opacity | | Set Number | Time | | Opacity | |
|---|---|---|---|---|---|---|---|---|---|
| | Start | End | Sum | Average | | Start | End | Sum | Average |
| 1 | 1521 | 1526 | 0 | 0 | 21 | 1819 | 1824 | 0 | 0 |
| 2 | 1527 | 1532 | 0 | 0 | 22 | 1825 | 1830 | 55 | 2/23 |
| 3 | 1533 | 1538 | 0 | 0 | 23 | 1831 | 1836 | 10 | 0 |
| 4 | 1539 | 1544 | 0 | 0 | 24 | 1837 | 1842 | 0 | 0 |
| 5 | 1545 | 1550 | 15 | 1 | 25 | 1843 | 1848 | 15 | 1/23 |
| 6 | 1551 | 1556 | 0 | 0 | 26 | 1849 | 1854 | 0 | 0 |
| 7 | 1557 | 1602 | 0 | 0 | 27 | 1855 | 1900 | 0 | 0 |
| 8 | 1603 | 1608 | 0 | 0 | 28 | 1901 | 1906 | 25 | 1 |
| 9 | 1609 | 1614 | 0 | 0 | 29 | 1907 | 1912 | 0 | 0 |
| 10 | 1615 | 1620 | 0 | 0 | 30 | 1913 | 1918 | 0 | 0 |
| 11 | 1621 | 1626 | 0 | 0 | 31 | 1919 | 1924 | 110 | 5 |
| 12 | 1627 | 1632 | 0 | 0 | 32 | 1925 | 1930 | 80 | 3 |
| 13 | 1633 | 1638 | 0 | 0 | 33 | 1931 | 1936 | 0 | 0 |
| 14 | 1737 | 1742 | 0 | 0 | 34 | 1937 | 1942 | 90 | 4/22 |
| 15 | 1743 | 1748 | 0 | 0 | 35 | 1943 | 1948 | 10 | 1/19 |
| 16 | 1749 | 1754 | 10 | 2/6 | 36 | 1949 | 1954 | 105 | 4 |
| 17 | 1755 | 1800 | 15 | 1/22 | 37 | | | | |
| 18 | 1801 | 1806 | 0 | 0 | 38 | | | | |
| 19 | 1807 | 1812 | 0 | 0 | 39 | | | | |
| 20 | 1813 | 1818 | 0 | 0 | 40 | | | | |

Readings were discontinued due to insufficient sunlight.

Sketch Showing How Opacity Varied With Time:

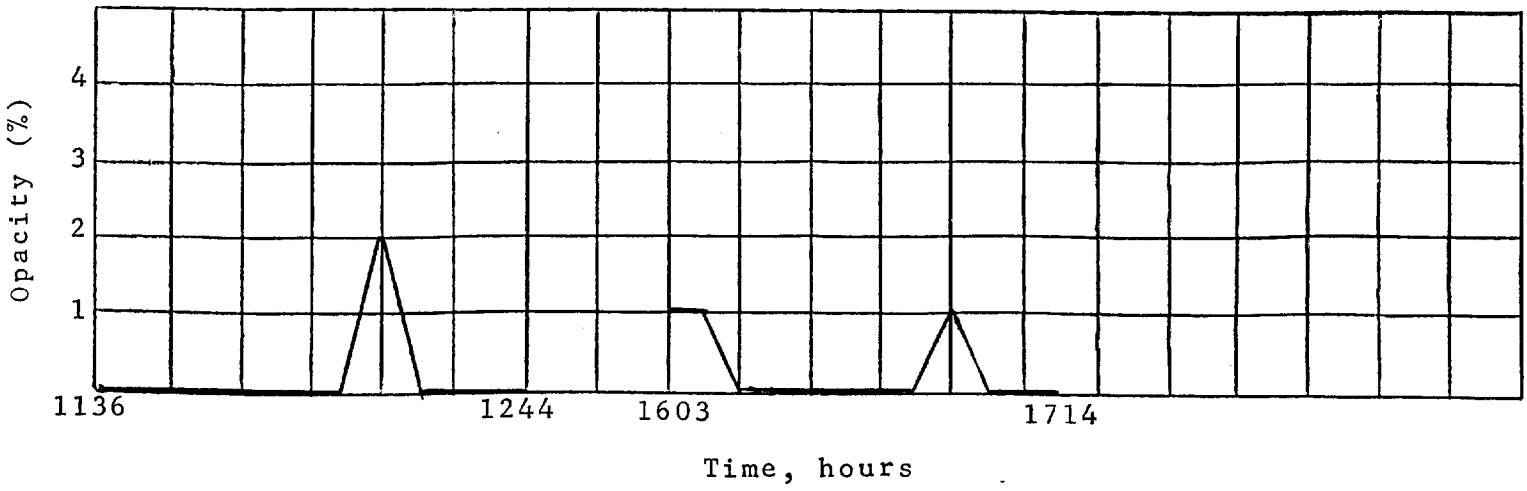


# SUMMARY OF VISIBLE EMISSIONS
Test No. 2

Date: 8/8/79
Type of Plant: Coke Plant
Type of Discharge: Stack
Location of Discharge: Battery Stack D
Height of Point of Discharge: 250'
Description of Sky: Blue
Wind Direction: Northwest
Wind Velocity: 5-10 mph
Color of Plume: White
Detached Plume: No
Observer's Name: D.Lazarevic
Duration of Observation: 2 hr 24 min
Distance from Observer to Discharge Point: 225'.During second half of test 350
Direction of Observer from Discharge Point: SE. During second half of test - W
Height of Observation Point: Ground level
Description of Background: sky

| SUMMARY OF AVERAGE OPACITY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Set Number | Time | | Opacity | | Set Number | Time | | Opacity | |
| | Start | End | Sum | Average | | Start | End | Sum | Average |
| 1 | 1131 | 1136 | 0 | 0 | 21 | 1645 | 1650 | 0 | 0 |
| 2 | 1137 | 1142 | 0 | 0 | 22 | 1651 | 1656 | 25 | 1 |
| 3 | 1143 | 1148 | 0 | 0 | 23 | 1657 | 1702 | 0 | 0 |
| 4 | 1149 | 1154 | 0 | 0 | 24 | 1703 | 1708 | 0 | 0 |
| 5 | 1155 | 1200 | 0 | 0 | 25 | 1709 | 1714 | 0 | 0 |
| 6 | 1201 | 1206 | 0 | 0 | 26 | | | | |
| 7 | 1207 | 1212 | 0 | 0 | 27 | | | | |
| 8 | 1213 | 1218 | 0 | 0 | 28 | | | | |
| 9 | 1219 | 1224 | 40 | 2 | 29 | | | | |
| 10 | 1225 | 1230 | 0 | 0 | 30 | | | | |
| 11 | 1231 | 1236 | 0 | 0 | 31 | | | | |
| 12 | 1237 | 1242 | 0 | 0 | 32 | | | | |
| 13 | 1243 | 1244 | 0 | 0 | 33 | | | | |
| 14 | 1603 | 1608 | 25 | 1 | 34 | | | | |
| 15 | 1609 | 1614 | 30 | 1 | 35 | | | | |
| 16 | 1615 | 1620 | 0 | 0 | 36 | | | | |
| 17 | 1621 | 1626 | 0 | 0 | 37 | | | | |
| 18 | 1627 | 1632 | 0 | 0 | 38 | | | | |
| 19 | 1633 | 1638 | 0 | 0 | 39 | | | | |
| 20 | 1639 | 1644 | 0 | 0 | 40 | | | | |

Sketch Showing How Opacity Varied With Time:



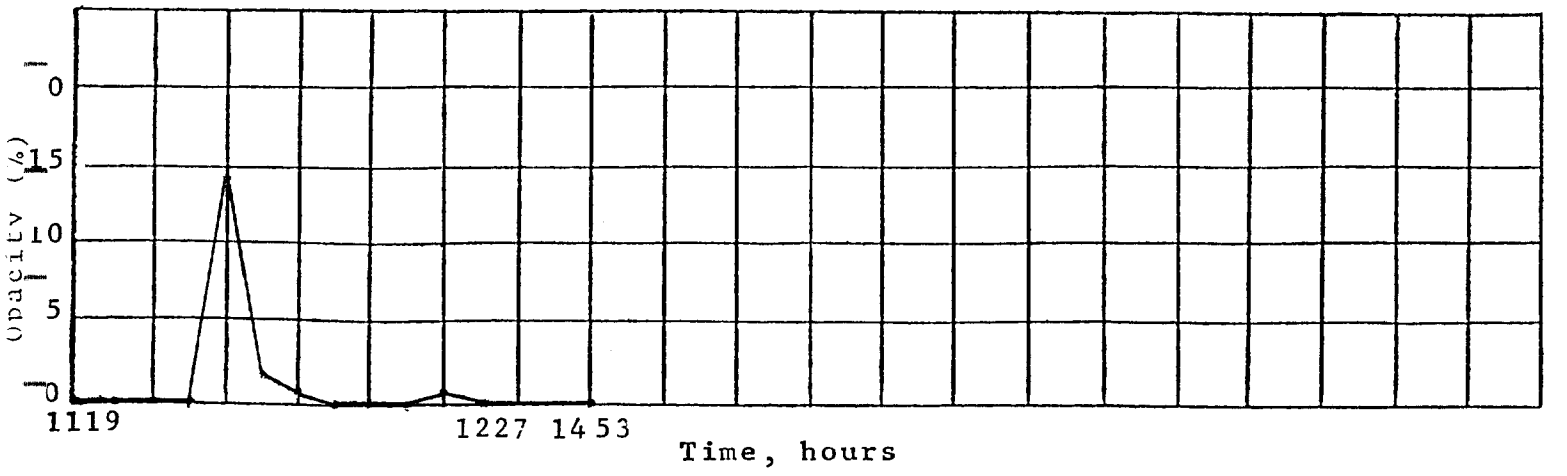
SUMMARY OF VISIBLE EMISSIONS
Test No. 3

Date: 8/9/79
Type of Plant: Coke Plant
Type of Discharge: Stack
Location of Discharge: Battery Stack D
Height of Point of Discharge: 250'
Description of Sky: Partly sunny
Wind Direction: Southeast
Wind Velocity: 5-10 mph
Color of Plume: White to reddish brown
Detached Plume: No
Observer's Name: D.Lazarevic
Duration of Observation: 1 hr 10 min
Distance from Observer to Discharge Point: 250'. During second half 350'
Direction of Observer from Discharge Point: SW. During second half-W.
Height of Observation Point: ground level
Description of Background: Partly sunny to cloudy by afternoon

SUMMARY OF AVERAGE OPACITY

| Set Number | Time | | Opacity | | Set Number | Time | | Opacity | |
|---|---|---|---|---|---|---|---|---|---|
| | Start | End | Sum | Average | | Start | End | Sum | Average |
| 1 | 1119 | 1124 | 5 | 0 | 21 | | | | |
| 2 | 1125 | 1130 | 0 | 0 | 22 | | | | |
| 3 | 1131 | 1136 | 0 | 0 | 23 | | | | |
| 4 | 1137 | 1142 | 10 | 0 | 24 | | | | |
| 5 | 1143 | 1148 | 245 | 14/18 | 25 | | | | |
| 6 | 1149 | 1154 | 30 | 2/19 | 26 | | | | |
| 7 | 1155 | 1200 | 15 | 1/23 | 27 | | | | |
| 8 | 1201 | 1206 | 0 | 0 | 28 | | | | |
| 9 | 1207 | 1212 | 0 | 0 | 29 | | | | |
| 10 | 1213 | 1218 | 0 | 0 | 30 | | | | |
| 11 | 1219 | 1224 | 30 | 1 | 31 | | | | |
| 12 | 1225 | 1227 | 0 | 0 | 32 | | | | |
| 13 | 1453 | 1455 | 0 | 0 | 33 | | | | |
| 14 | | | | | 34 | | | | |
| 15 | | | | | 35 | | | | |
| 16 | Readings were discontinued due to inclement weather. | | | | 36 | | | | |
| 17 | | | | | 37 | | | | |
| 18 | | | | | 38 | | | | |
| 19 | | | | | 39 | | | | |
| 20 | | | | | 40 | | | | |

Sketch Showing How Opacity Varied With Time:



# APPENDIX B-5

## NITROGEN OXIDE DATA SHEET

GEORGE D. CLAYTON & ASSOCIATES

$NO_x$ DATA SHEET (PHENOLDISULFONIC ACID METHOD)

Project: C.F.&I Field Man: TJP - TVM

| Sampling Station | Test Number | Flask Number & Volume | | Date | Time | Barometric Pressure | Flask Pressure (±) | Temperature (°F) | Final Volume (liters) |
|---|---|---|---|---|---|---|---|---|---|
| Battery "D" Stack | NOx-1 | 024 (2.029 l) | Initial | 8/7/79 | 21:10 | 25.27 | -23.0 | 90° | 1.50 |
| | | | Final | 8/9/79 | 17:30 | 25.32 | 0 | 85 | |
| " | NOx-2 | 051 2.072 l | Initial | 8-8-79 | 17:35 | 25.30 | -22.5 ~~-23.0~~ | 95° F | 1.50 |
| | | | Final | 8-9-79 | 17:35 | 25.32 | 0 | 85 | |
| | NOx-3 | 100 2.069 l | Initial | 8-8-79 | 17:35 | 25.30 | -22.5 | 95° F | 1.49 |
| | | | Final | 8-9-79 | 17:45 | 25.32 | 0 | 85 | |
| | NOx-4 | 053 2.066 l | Initial | 8-9-79 | 17:05 | 25.32 | -22.5 | 85 | 1.52 ~~1.51~~ |
| | | | Final | 8-10-79 | 10:00 | 25.56 | -4 (w.c.) | 75° | |
| | | | Initial | | | | | | |
| | | | Final | | | | | | |
| | | | Initial | | | | | | |
| | | | Final | | | | | | |
| | | | Initial | | | | | | |
| | | | Final | | | | | | |
| | | | Initial | | | | | | |
| | | | Final | | | | | | |

Called the NH lowered [illegible] is
Re-bis and obtained the [illegible]

# APPENDIX B-6

## PROCESS OPERATING LOGS AND CHARTS
(supplied by MRI)

TEST DAY 1

8/7/79

Run #1



Date 8/7/79
Plant Name CF+I Steel
Location Pueblo, CO
Battery No. D
JPR

COKE OVEN BATTERY LOG SHEET

| Oven Pushing Data | | | Oven Charging Data | | |
|---|---|---|---|---|---|
| Oven No. | Time Pushed | Push Greenness* | Oven No. | Time Leveled | Comments |
| 31 | 3:42 PM | 1 | 29 ~~29~~ | 3:47 | I may have missed Port #26 |
| | | | 31 | 4:01 | |
| | | | | | |
| 2 | 4:07 PM | 1 | 2 | 4:21 | 4:20 Stopped sampling |
| 4 | 4:20 PM | 4 | 4 | 4:30 | |
| 6 | 4:28 | 2 | 6 | 4:38 | |
| 8 | 4:35 | 1 | 8 | 4:49 | |
| 10 | 4:46 | 2 | | | |
| | | | | | 5:38 Restarted |
| 12 | 8:00 PM | 1 | 12 | Not charged. | 6:20 Port Change |
| | | | | | 7:12 Restarted |
| | | | | | 8:22 Stopped Sampling |
| | | | | | ~~[illegible]~~ |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

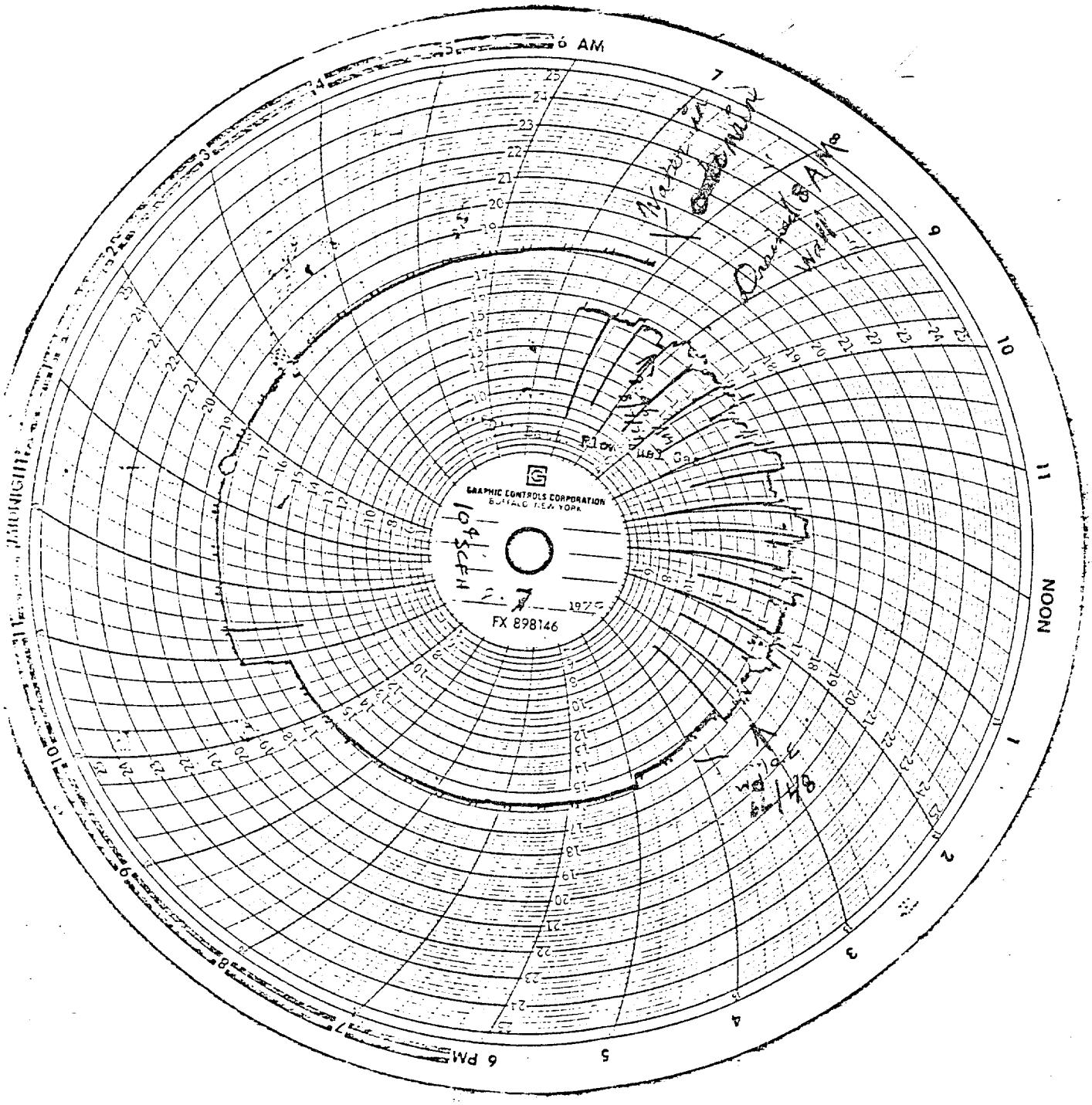
* Coke Greenness Rating: 1 - denotes coke is not green;
5 - denotes very green coke pushed.

8/7/79 Kwnt

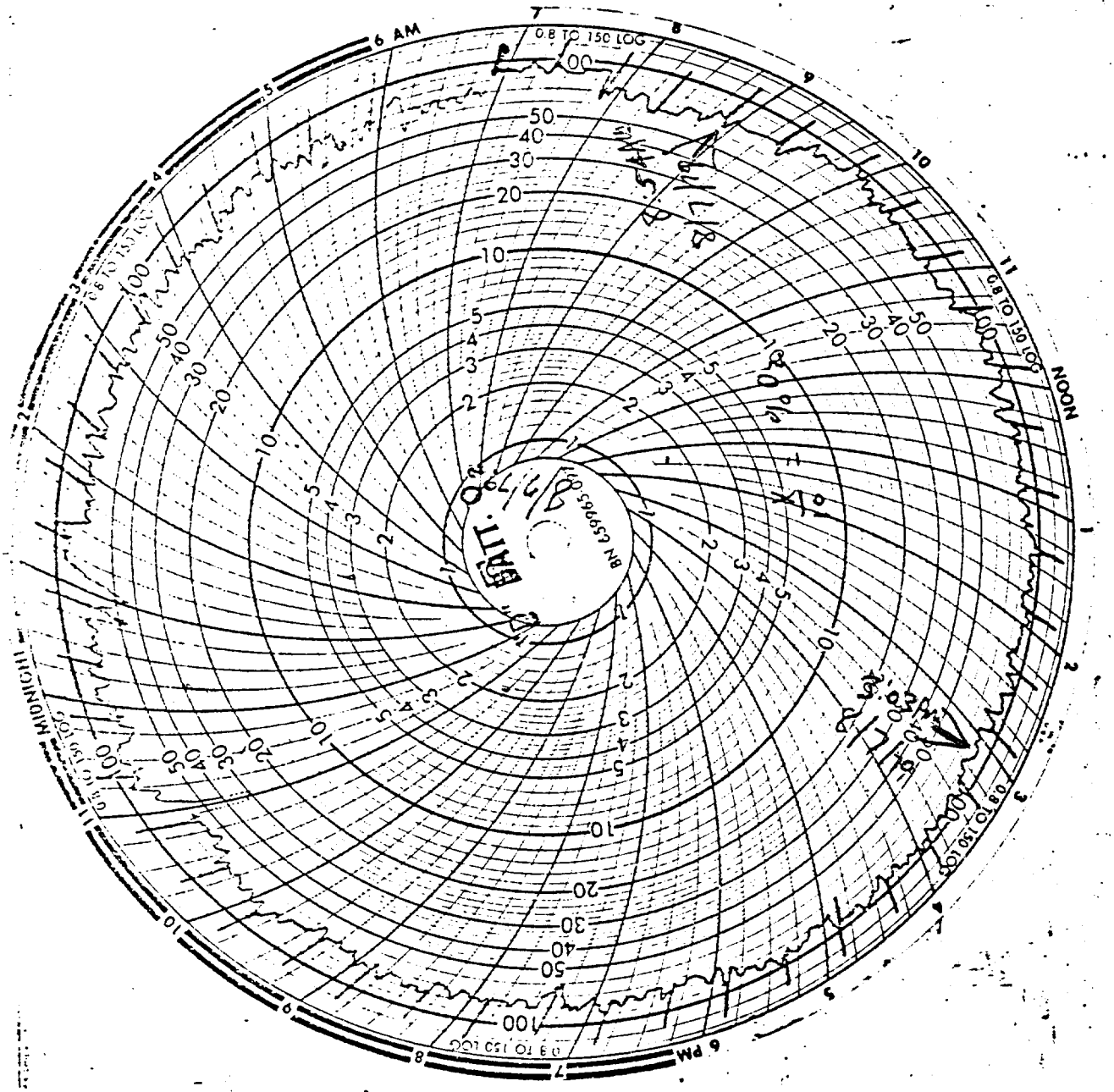
| ~~Time~~ Units | Fuel Gas Flow Rate $10^4$ SCFH | Fuel Gas Heater Temperature Before °C | Fuel Gas Heater Temperature After °C | Fuel Gas Pressure CS mm $H_2O$ | Fuel Gas Pressure PS mm $H_2O$ | Stack draft mm $H_2O$ | Stack $O_2$ % | Waste Heat Flue Pressure CS mm $H_2O$ | Waste Heat Flue Pressure PS mm $H_2O$ | Waste Heat Temperature °C | Crossover Main Pressure Crossover mm $H_2O$ | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time 3:28 PM | 15.2 | 47 | 67 | 113 | 111 | 28.5 | 8.5 | 8.5 | 12.2 | 290 | 6.0 | [illegible] |
| ~~[illegible]~~ | | | | ~~[illegible]~~ | | | | | | | | |
| 5:25 | 15.7 | 47 | 67 | 112 | 114 | 28.0 | 9.0 | 8.0 | 12.0 | 292 | 8.5 | 5 |
| 6:23 | 15.7 | 46 | 66 | 112 | 110 | 26.2 | 7.5 | 8.0 | 12.4 | 292 | 9.0 | 4.[illegible] |
| 7:31 | 15.7 | 45.5 | 66.0 | 112 | 112 | 26.0 | 7.5 | 7.8 | 11.2 | 290 | 9.0 | 6.5 |
| 8:43 PM | 15.8 | 40.5 | 65.0 | 112 | 103 | 25.2 | 8.0 | 7.8 | 11.0 | 298 | 8.0 | 4.2 |

8:45 Askinana not working properly on Pusher Side – off take – Manual operation necessa[illegible]

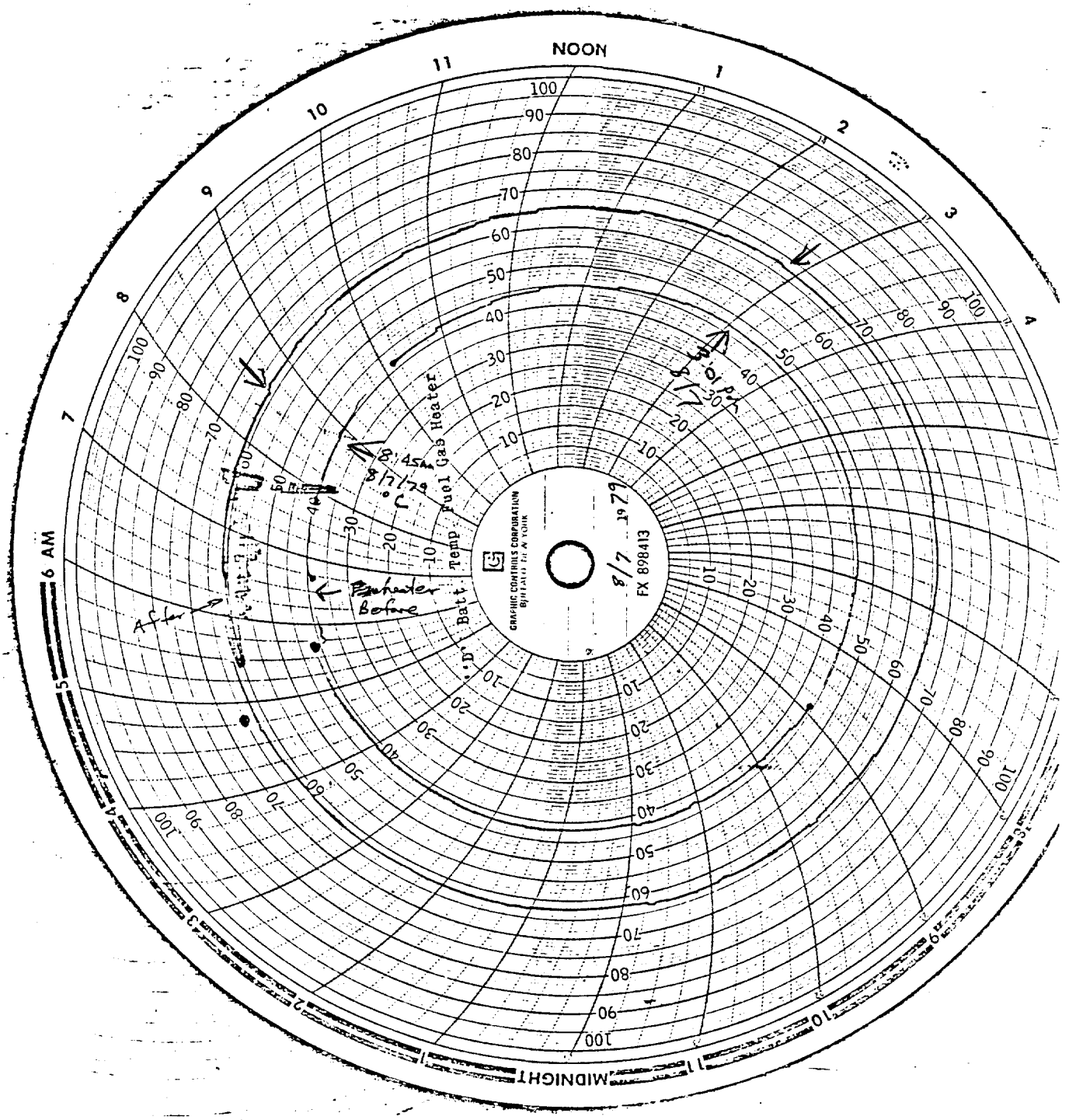
Bag filter – light gray loading.
#5 " – dark black loading, evenly distributed.



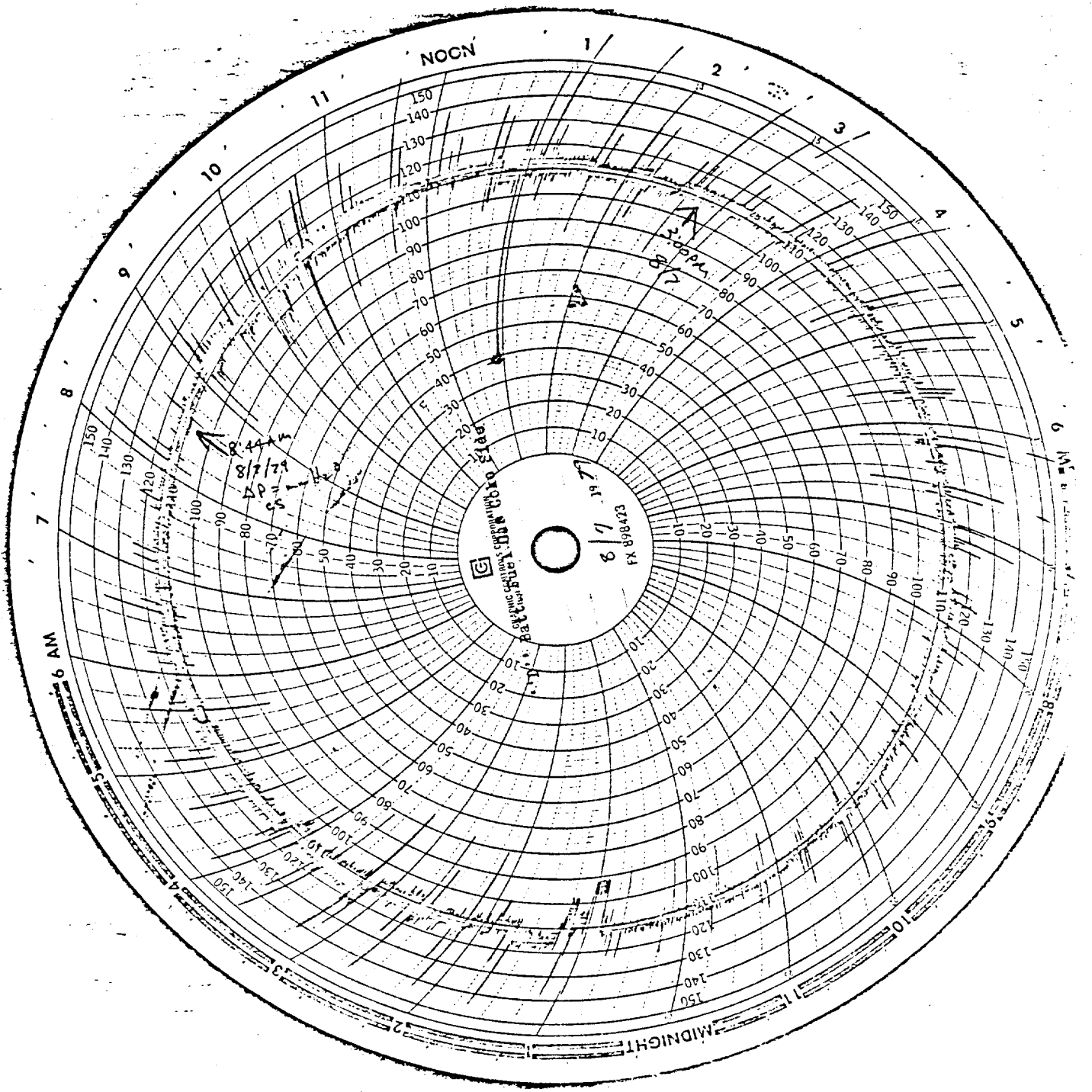

Fuel Gas Flow Rate ($10^4$ SCFH) - 8/7/79.



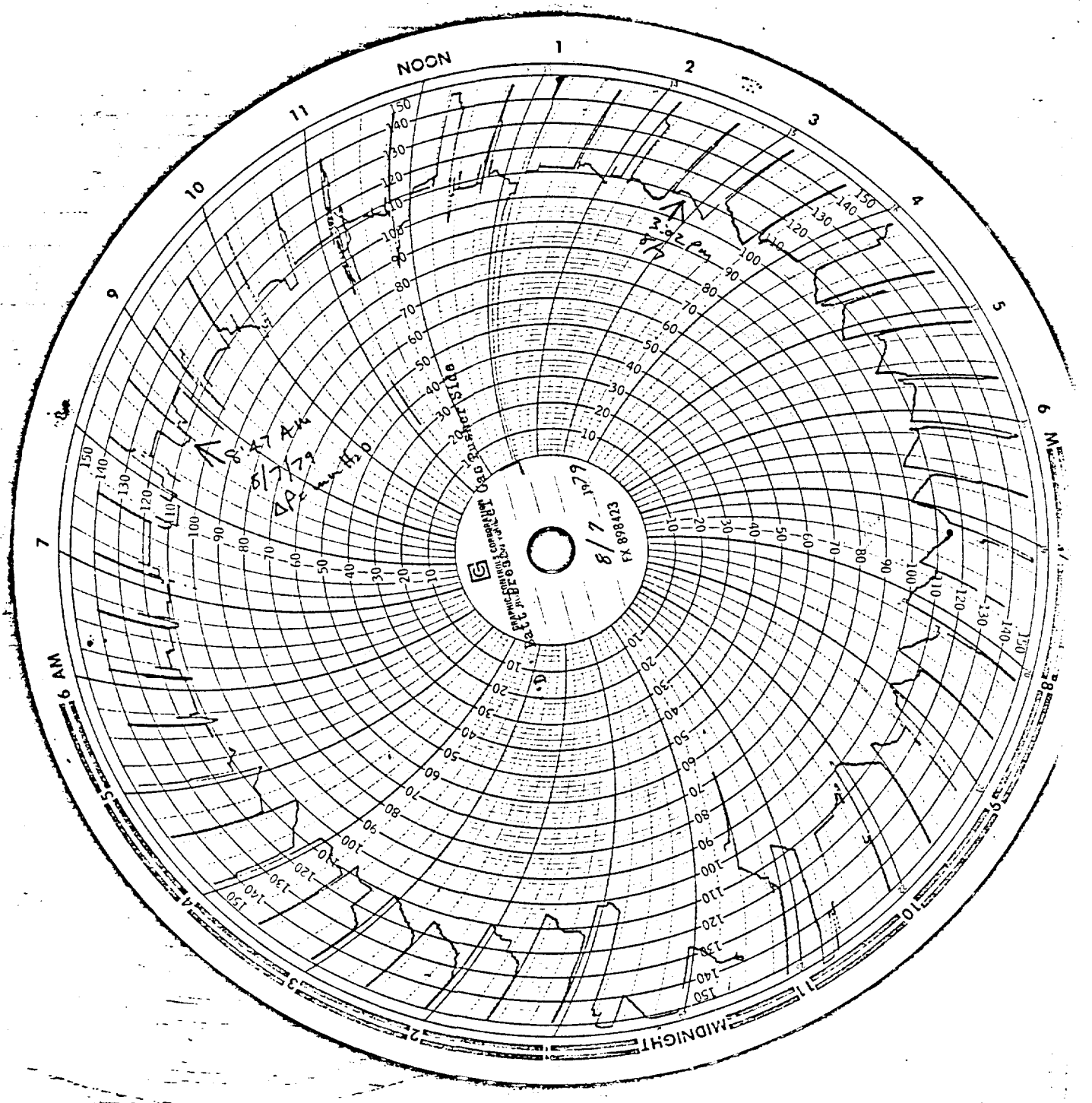

Continuous $O_2$ Monitor Chart ($\frac{x}{10}$ = % $O_2$) - 8/7/79



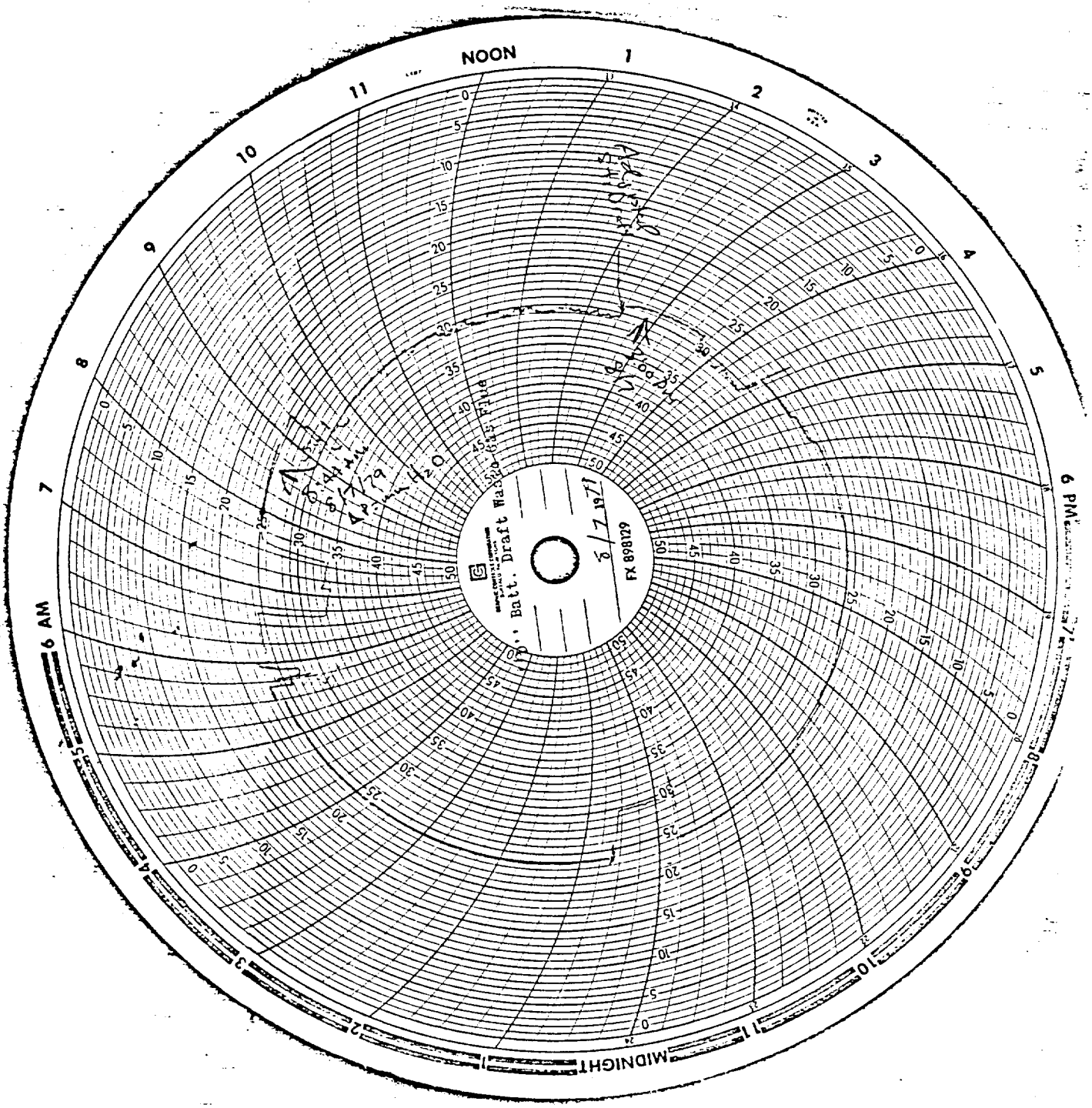

Fuel Gas Heater Inlet and Outlet Temperatures (°C) - 8/7/79



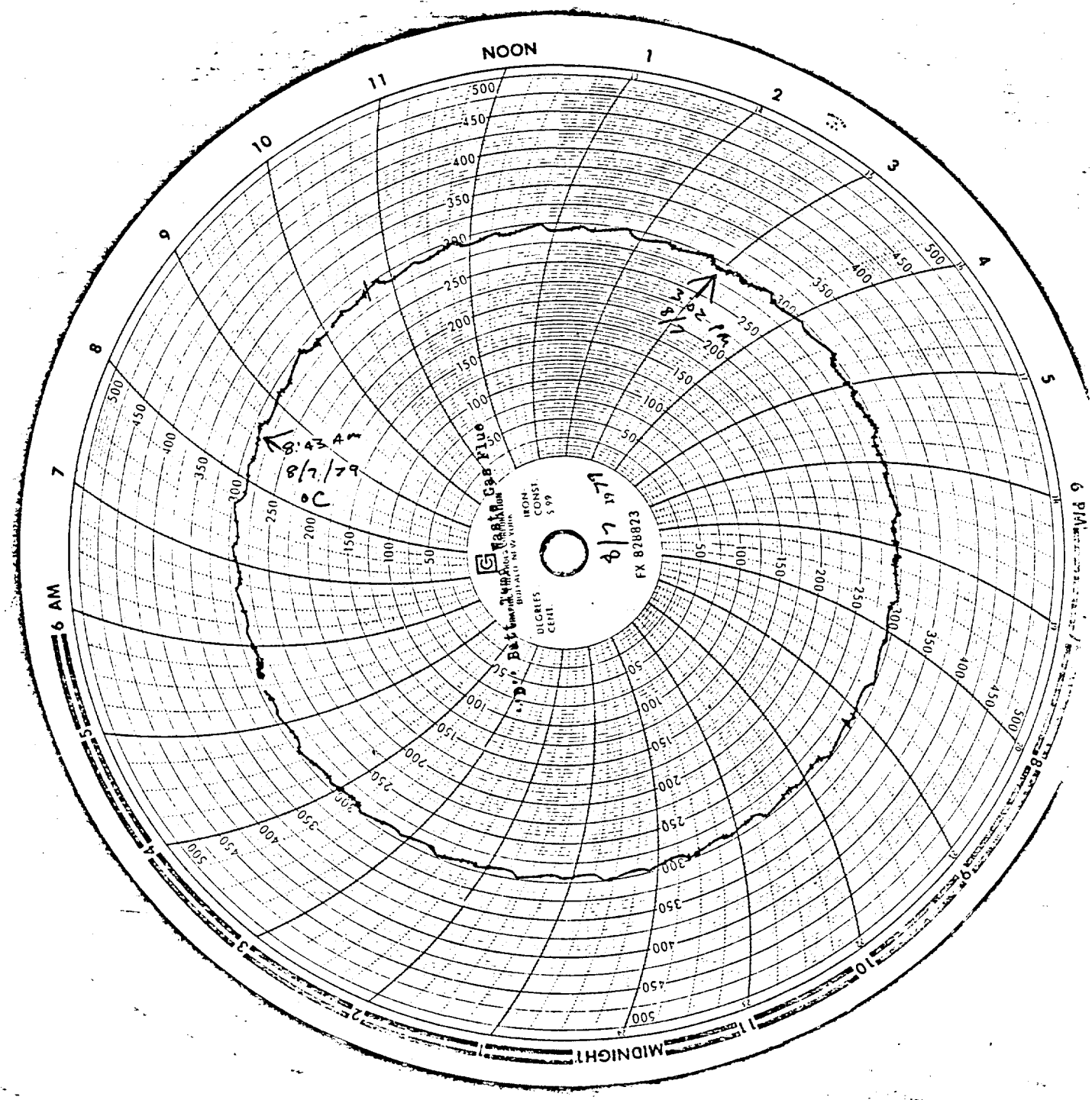

Coke Side Fuel Gas Pressure (mm $H_2O$) - 8/7/79



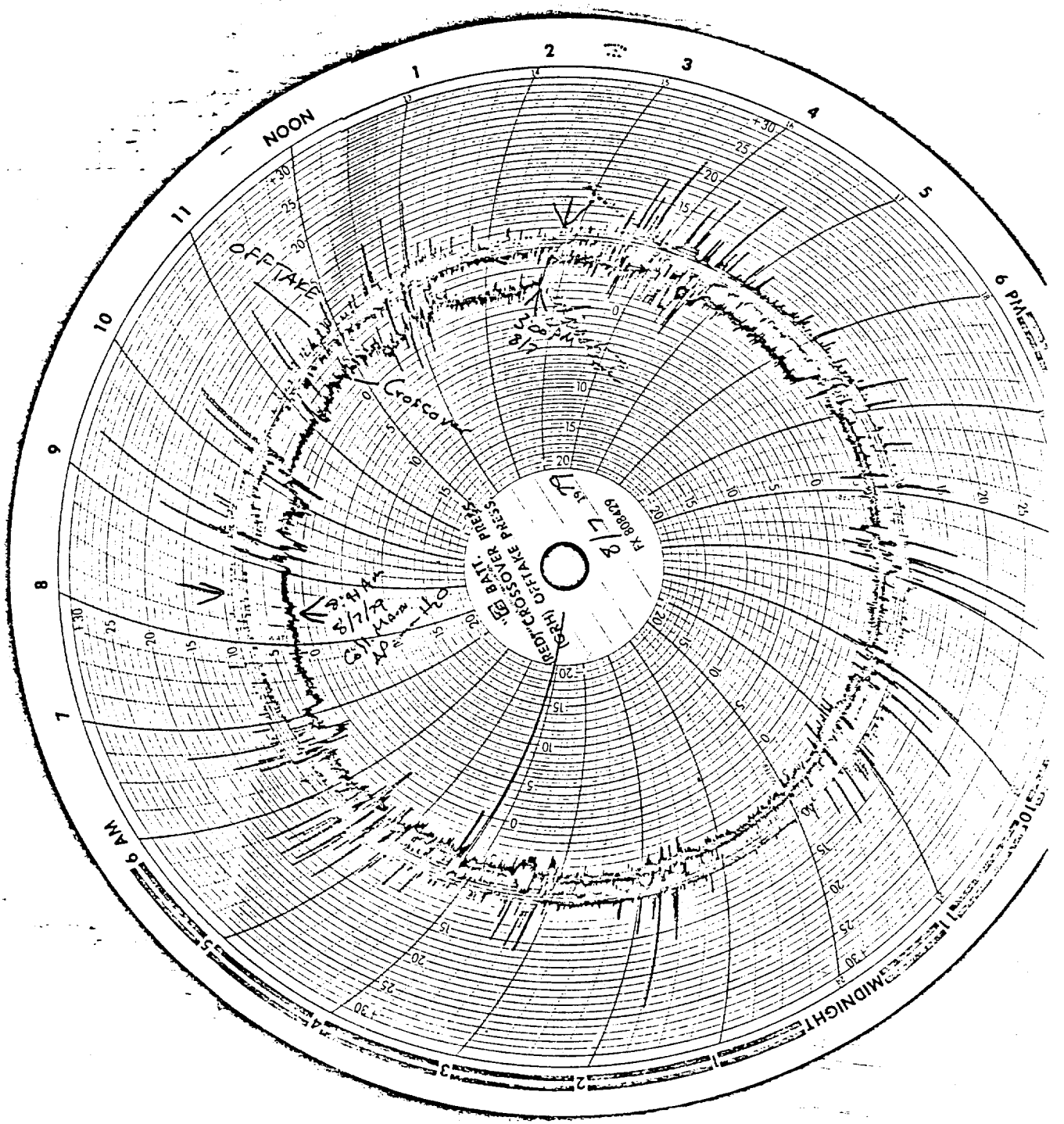

Pusher Side Fuel Gas Pressure (mm $H_2O$) - 8/7/79



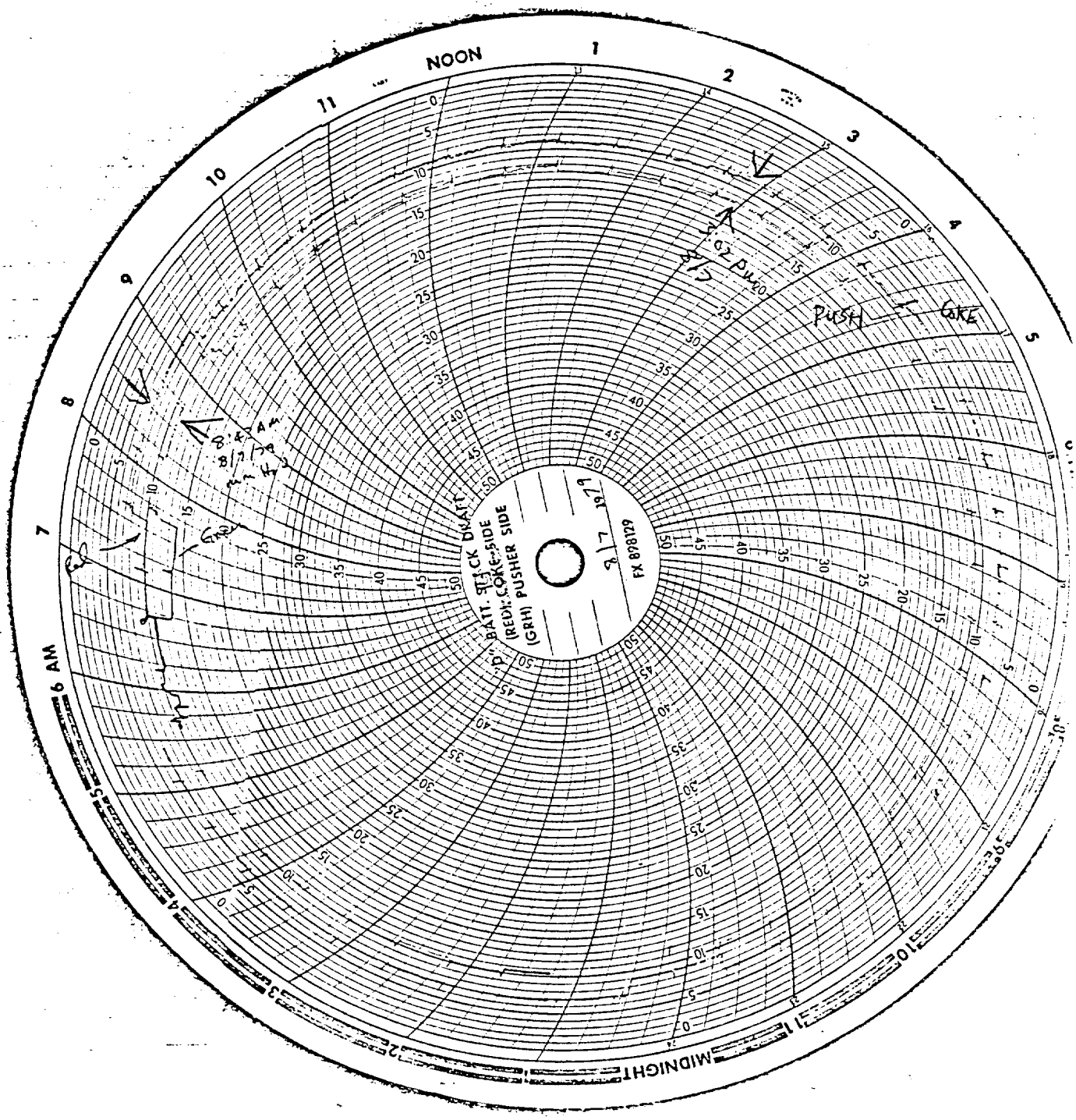

Flue Gas Stack Draft (-mm $H_2O$) - 8/7/79



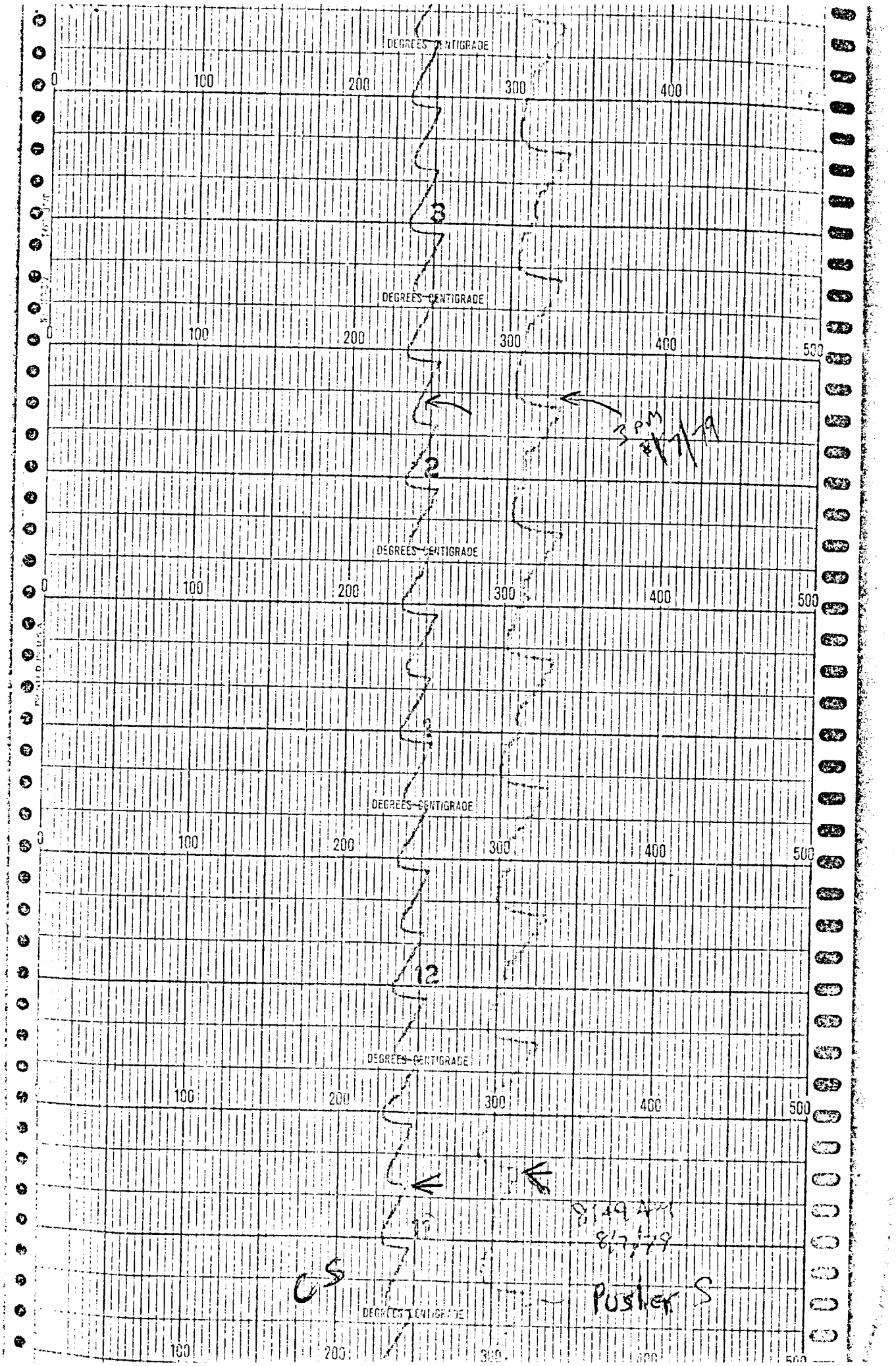

Waste Flue Gas Temperature (°C) - 8/7/79




Crossover (CS) and Offtake (PS) Collecting Main Pressures (mm $H_2O$) - 8/7/79




Coke Side and Pusher Side Waste Heat
Flue Pressures (-mm $H_2O$) - 8/7/79




Waste Heat Canal Temperatures (°C) - 8/7/79

TEST DAY 2

8/8/79

Run #2

Date 8/8/79
Plant Name CF+I Steel
Location Pueblo, CO
Battery No. D
JPR

COKE OVEN BATTERY LOG SHEET

| Oven Pushing Data | | | Oven Charging Data | | |
|---|---|---|---|---|---|
| Oven No. | Time Pushed | Push Greenness* | Oven No. | Time ~~Leveled~~ Charged | Comments |
| 23 | 11:31 AM | 1 | 21 | 11:33 | 11:31 Sampling Started Both Tra |
| 25 | 11:42 | 2 | 23 | 11:48 | Stack looks real clean. |
| | | | 25 | 12:03 | 12:45 #5 Finished 1 Port. |
| | | | | | |
| 27 | 1:18 | 2 | 27 | 1:25 | |
| 29 | 1:33 | 1 | 29 | 1:36 | 1:34 BAP Stopped |
| 31 | 1:43 | N.R. | 31 | 1:48 | |
| | | | | | |
| 2 | 3:32 | 1 | 2 | ~3:37 | |
| 4 | 3:40 | 1 | 4 | 4:39 | |
| 6 | 4:53 | 2 | 6 | 5:03 | |
| 8 | 5:01 | 2 | | | |
| | | | | | |
| 10 | 5:59 | 1 | 8 | 6:07 | |
| 12 | 6:12 | 1 | 10 | 6:22 | BAP Finished 7:04 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

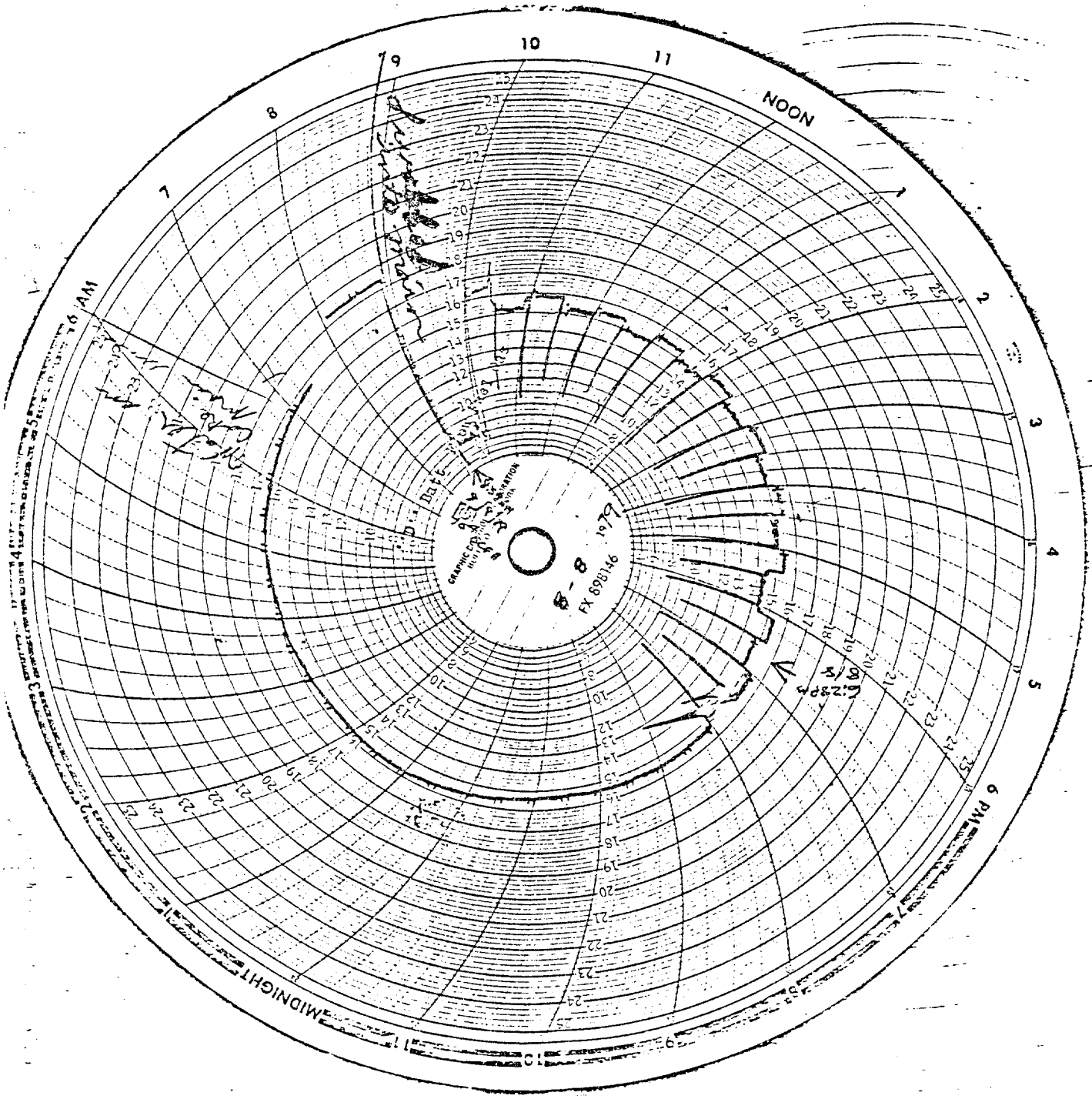
* Coke Greenness Rating: 1 - denotes coke is not green;
5 - denotes very green coke pushed.

N.R. -

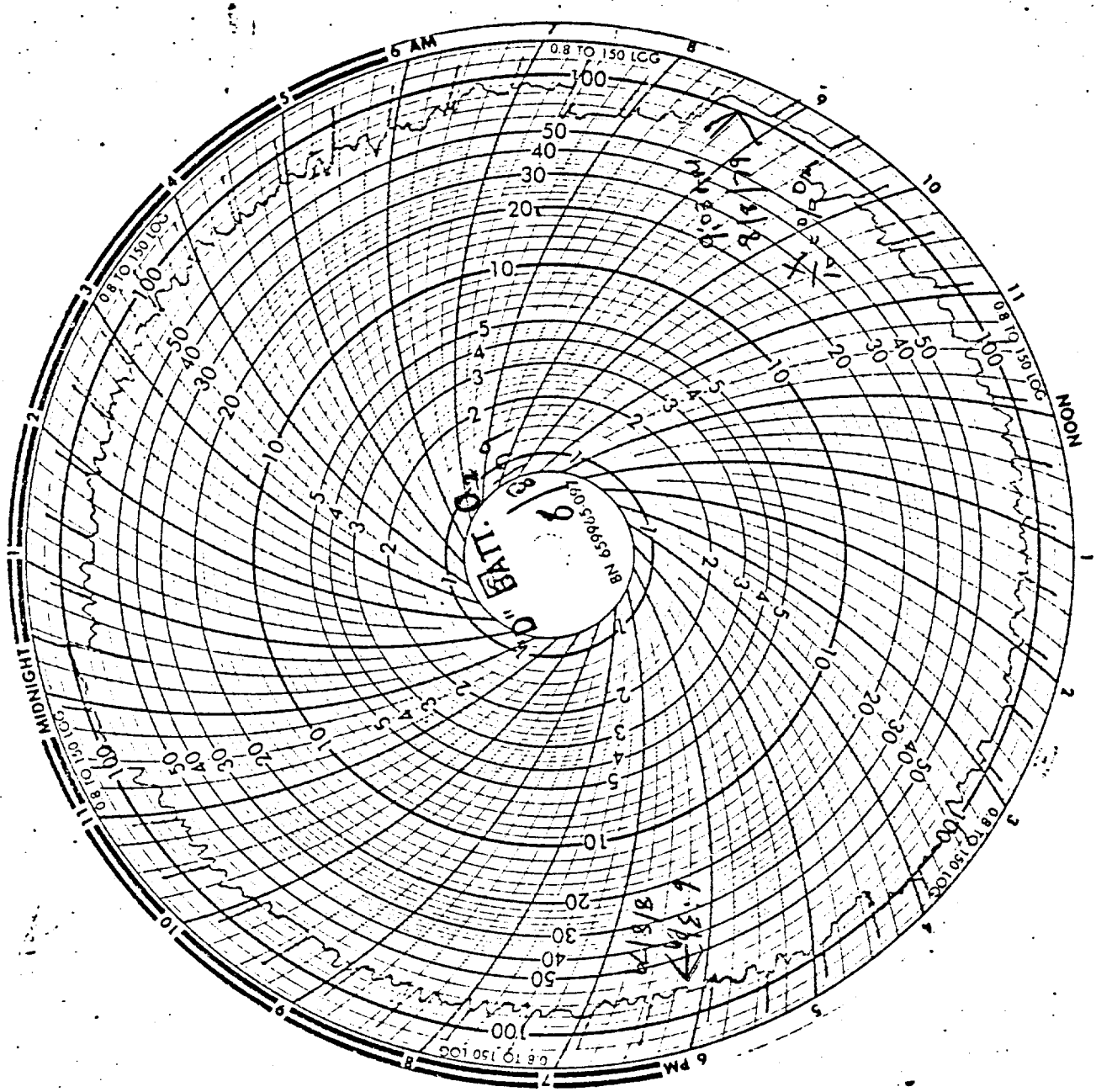
8/8/79 RUN # 2

| Time | Fuel Gas Flow Rate $\times 10^4$ SCFH | Preheater Temperature Before °C | Preheater Temperature After °C | Fuel Gas Pressure CS mm $H_2O$ | Fuel Gas Pressure PS mm $H_2O$ | STACK DRAFT mm $H_2O$ | WASTE HEAT Temp. °C | WASTE HEAT FLUES PRESSURES CS mm $H_2O$ | WASTE HEAT FLUES PRESSURES PS mm $H_2O$ | Collecting MAIN Pressures CS mm $H_2O$ | Collecting MAIN Pressures PS mm $H_2O$ | $O_2$ Level % | CANAL TEMP. WASTE HEAT CS °C | CANAL TEMP. WASTE HEAT PS °C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AM 1:00 | 15.9 | 44 | 64 | 111 | 72 | 25.5 | 285 | 7.7 | 11 | 8.5 | 4.5 | 7.2 | 300 | 245 |
| 1222 | 15.0 | 45 | 66 | 111 | 114 | 25.5 | 292 | 6.5 | 9 | 9.5 | 4.0 | 8.0 | 310 | 235 |
| 1:50pm | 15.4 | 46 | 67 | 110 | 112 | 25.7 | 300 | 6.2 | 9.5 | 9.0 | 4.5 | 9.0 | 315 | 240 |
| 3:49 | 15.0 | 47.5 | 68 | 110 | 114 | 25.7 | 300 | 6.2 | 9.0 | 9.0 | 5.0 | 10.0 | 310 | 245 |
| 4:44 | 15.0 | 47 | 67 | 111 | 112 | 31 | 300 | 8.0 | 10.0 | 8.5 | 6.0 | 10.0 | 330 | 255 |
| 5:31 | 14.8 | 46 | 66 | 112 | 112 | 23.4 | 295 | 5.8 | 9.2 | 8.8 | 6.4 | 7.0 | 320 | 240 |
| 6:23 | 14.8 | 45 | 65 | 114 | 112 | 23.2 | 295 | 5.5 | 8.2 | 9.5 | 6.2 | 8.0 | 316 | 260 |

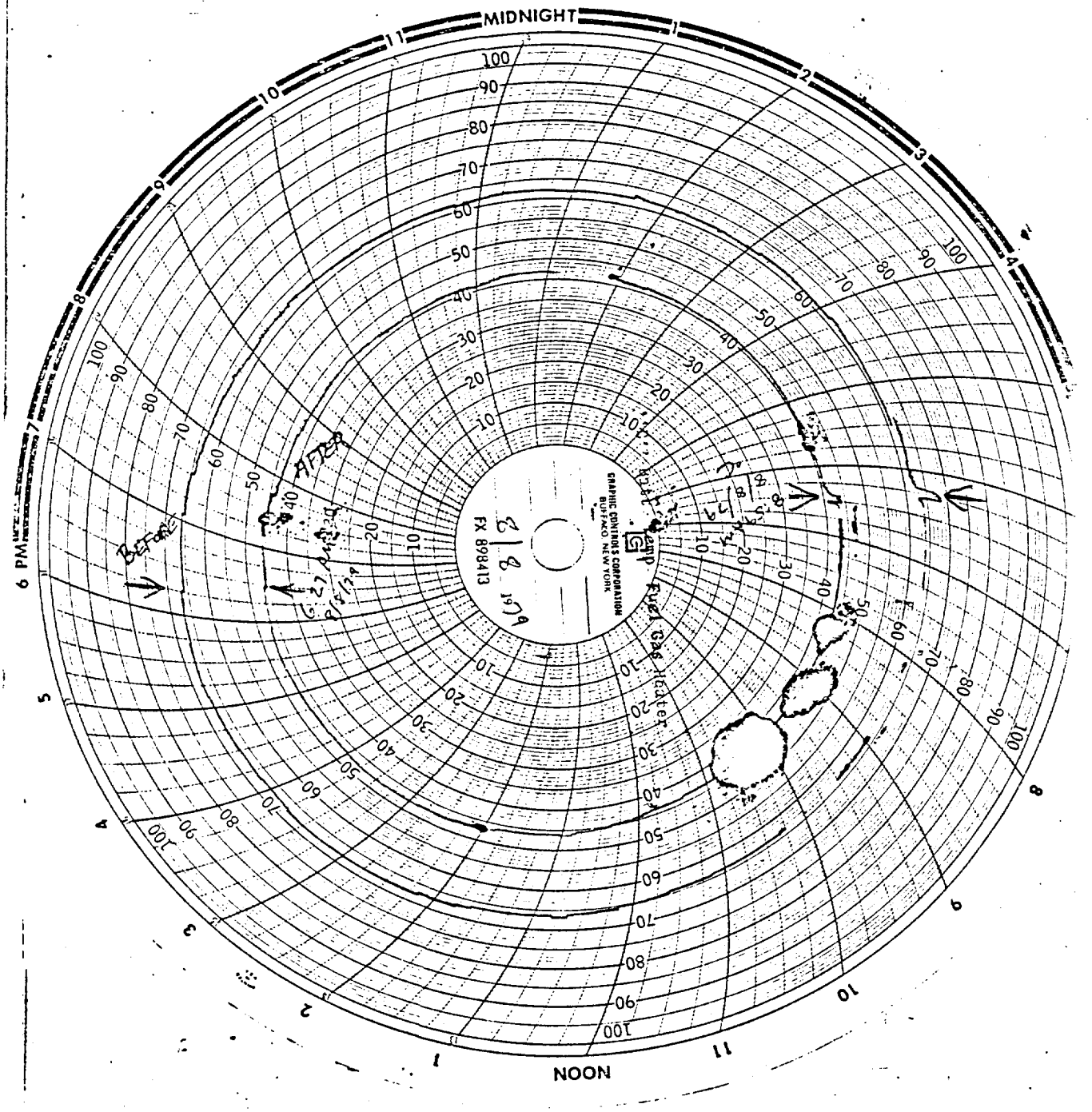
RAP filter – dark gray loading
#5 " – light loading, more gray color



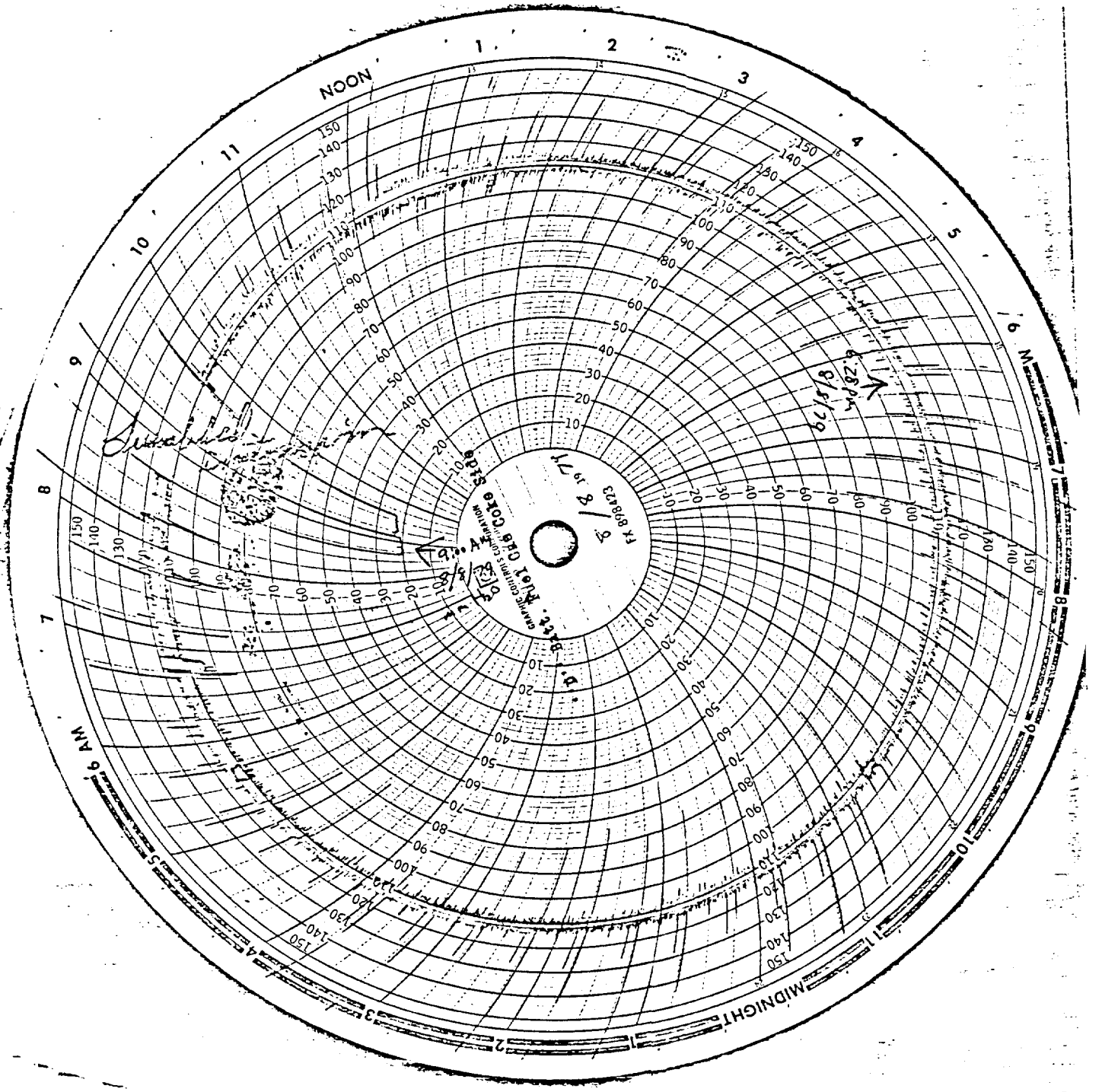

Fuel Gas Flow Rate ($10^4$ SCFH) - 8/8/79



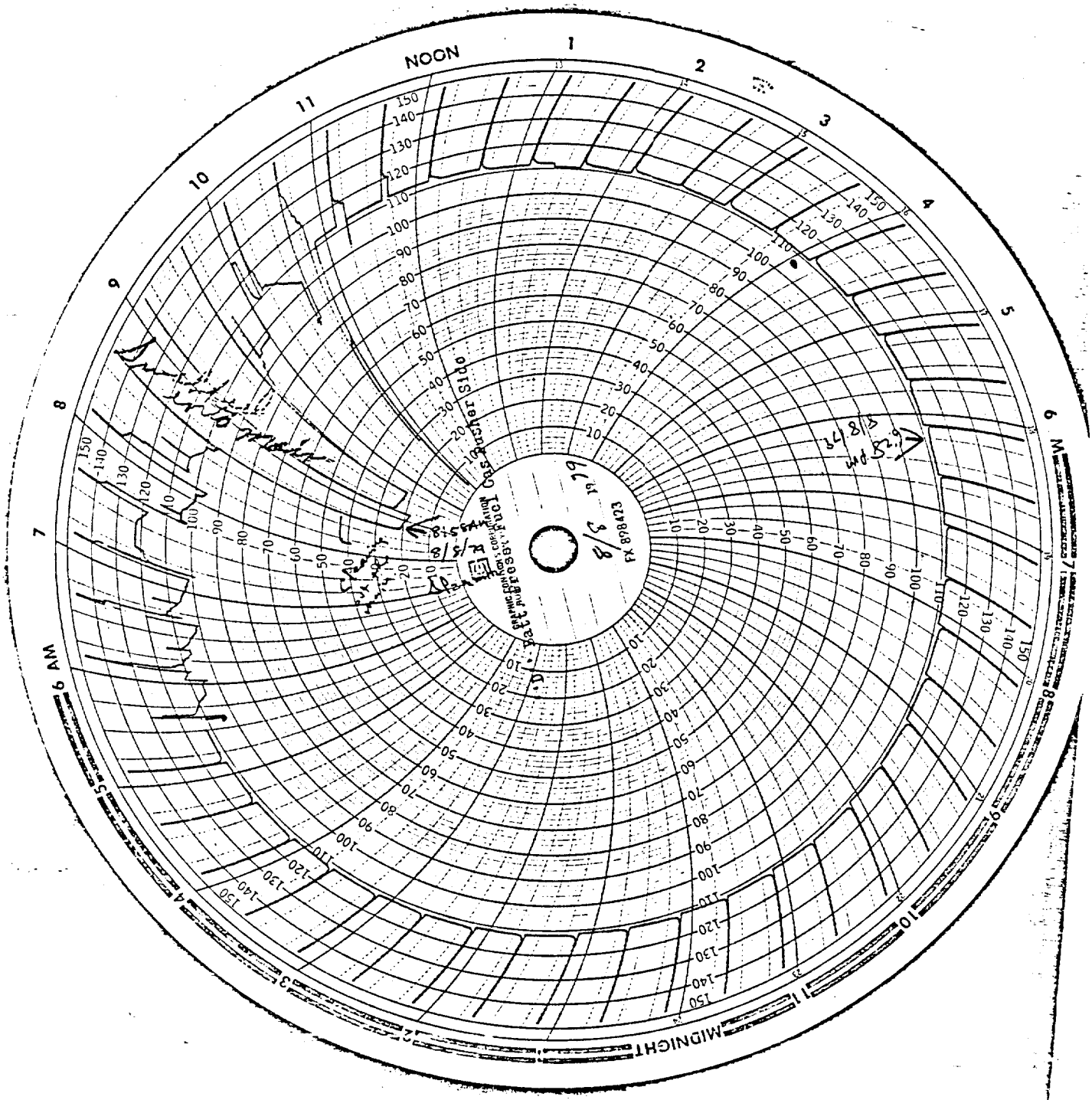

Continuous $O_2$ Monitor Chart ($\frac{x}{10}$ = % $O_2$) - 8/8/79



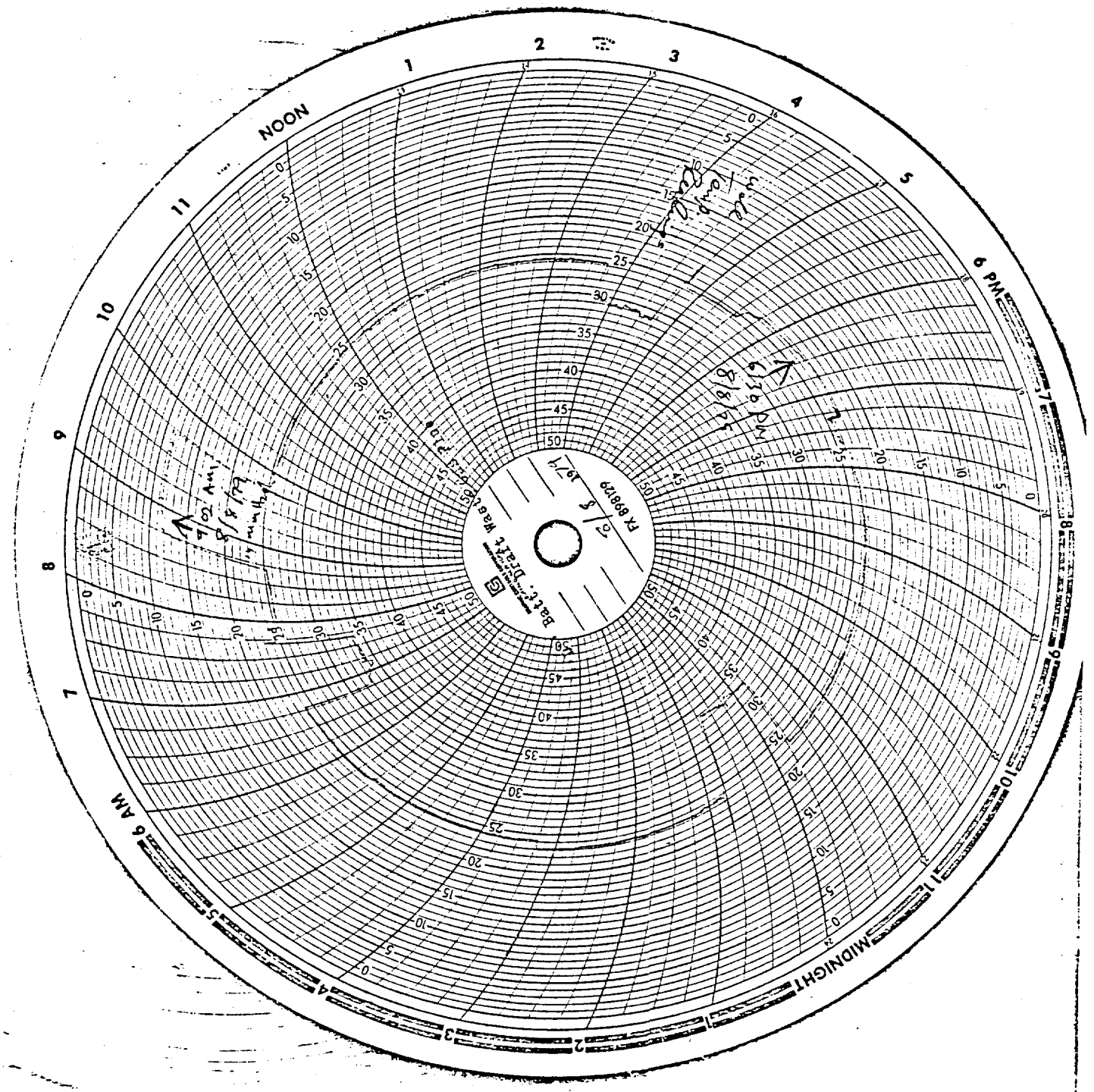

Fuel Gas Heater Inlet and Outlet Temperatures (°C) - 8/8/79



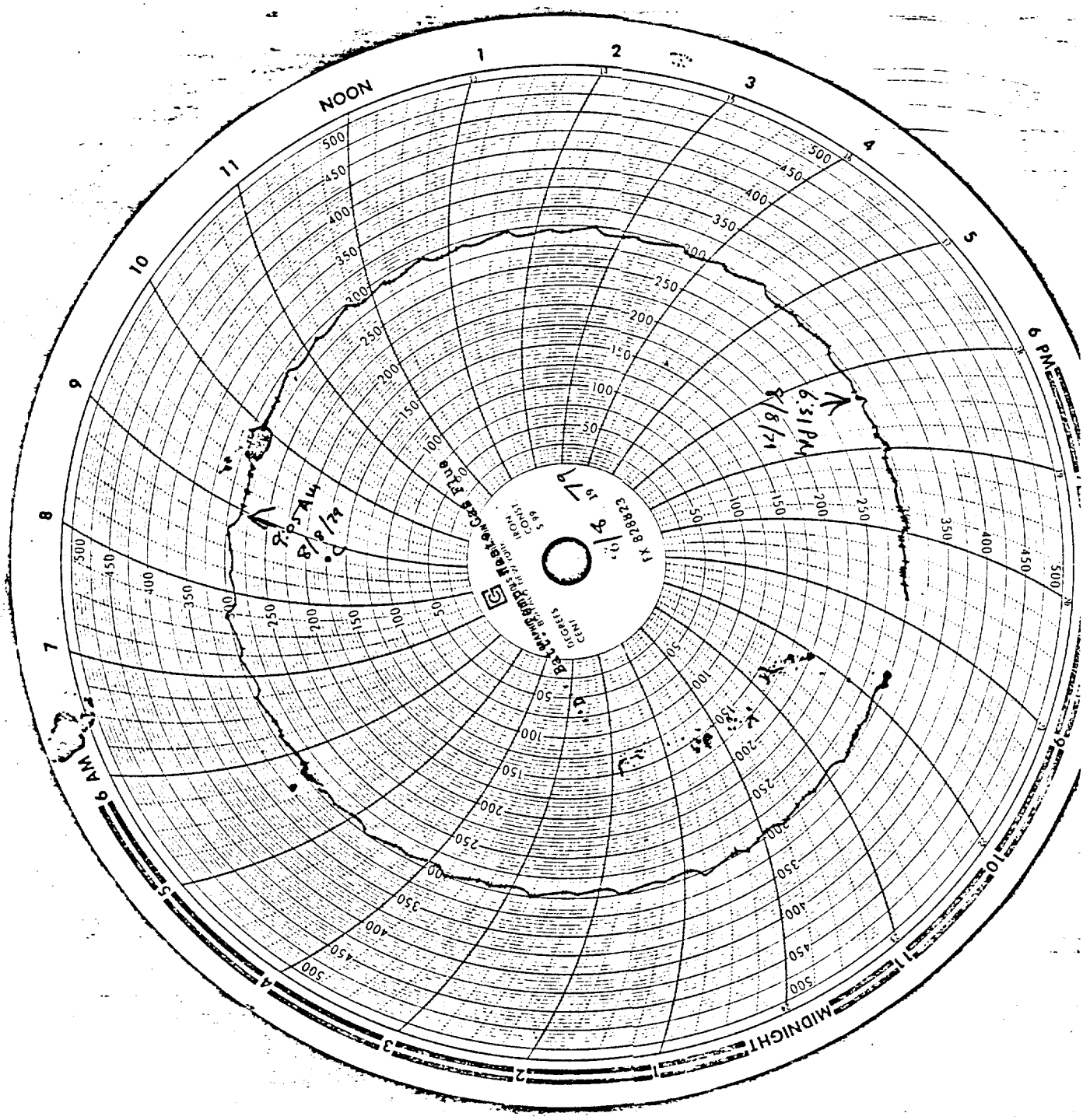

Coke Side Fuel Gas Pressure (mm $H_2O$) - 8/8/79



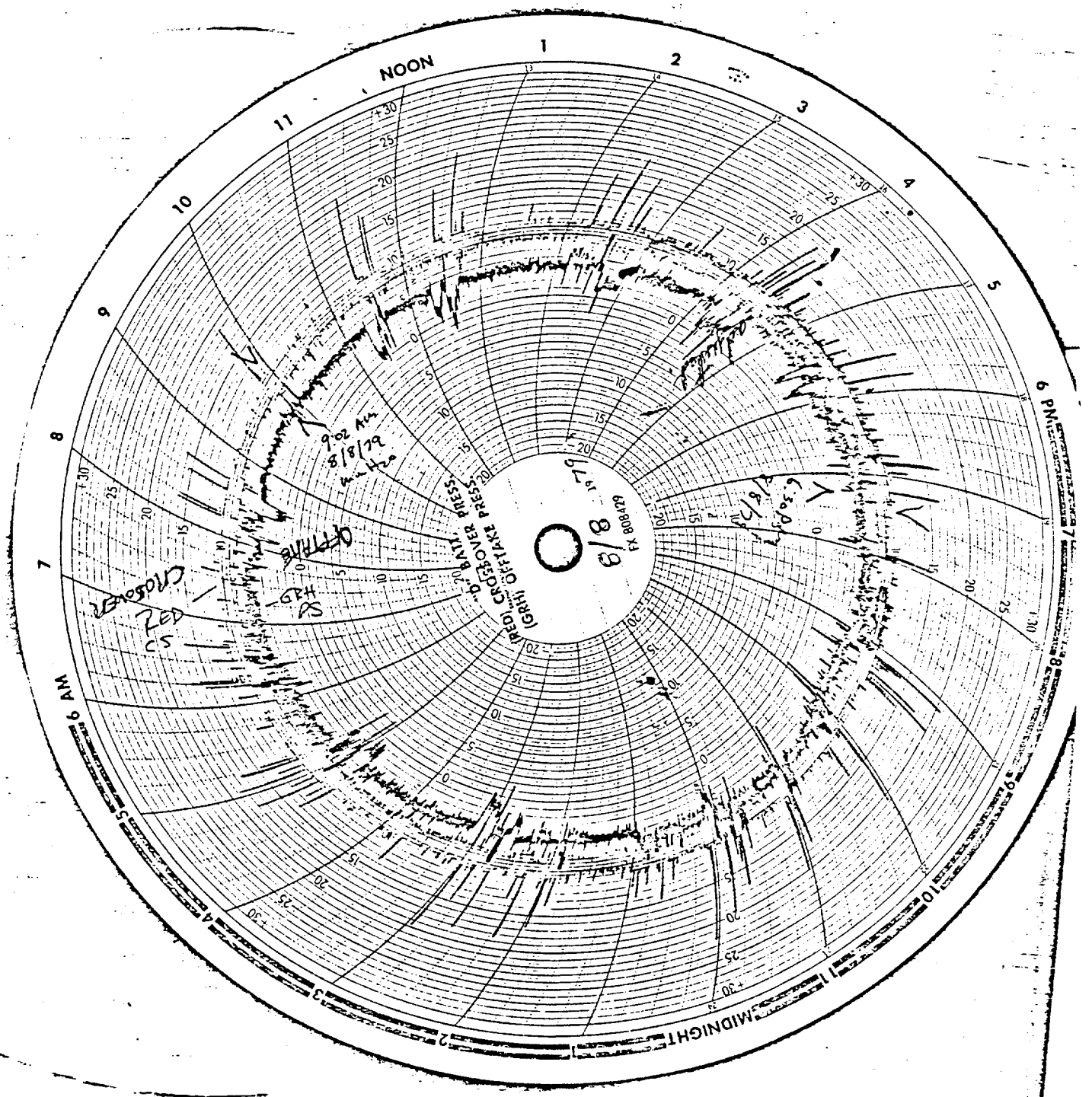

Pusher Side Fuel Gas Pressure (mm $H_2O$) - 8/8/79



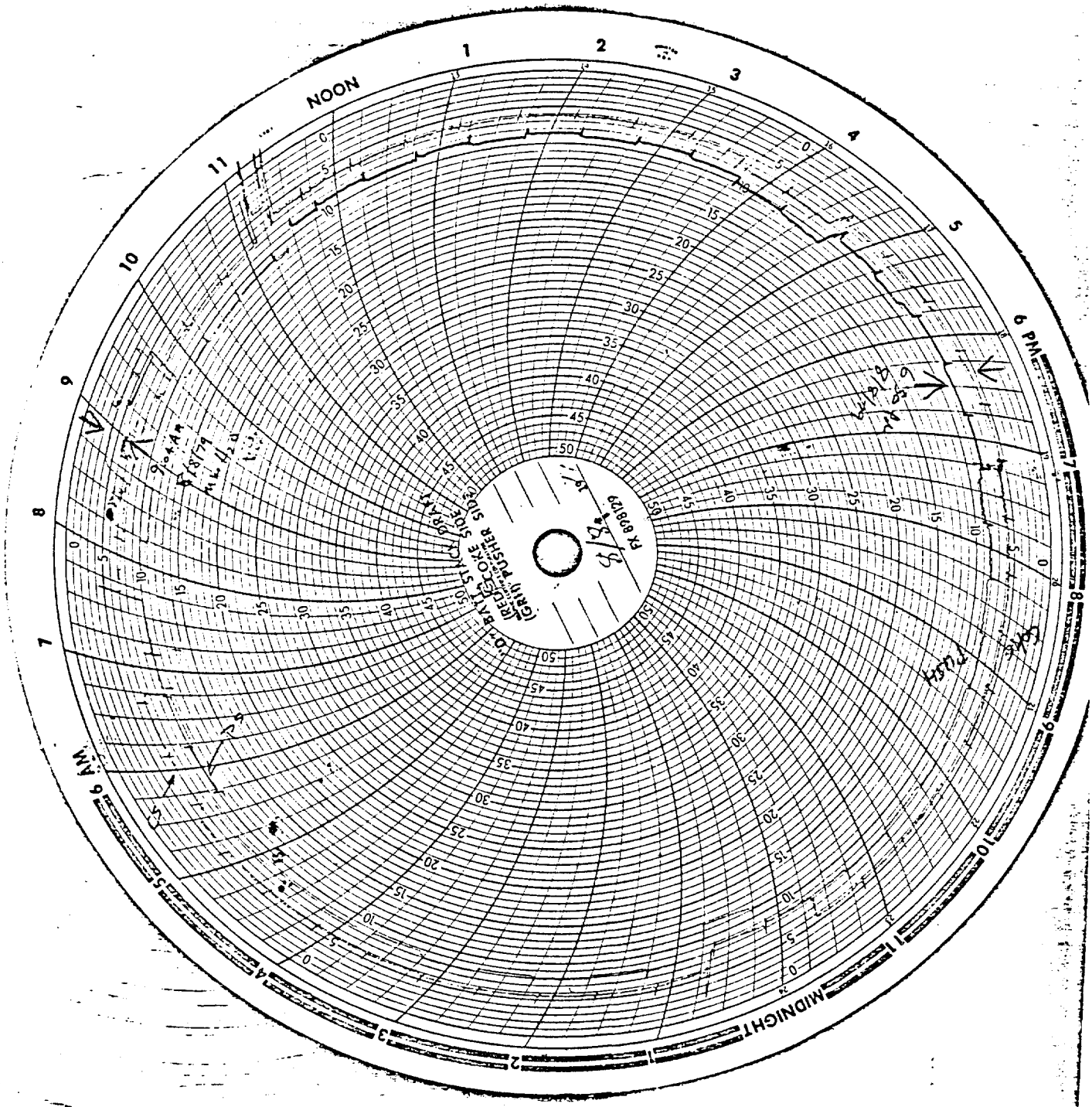

Flue Gas STack Draft (-mm $H_2O$) - 8/8/79



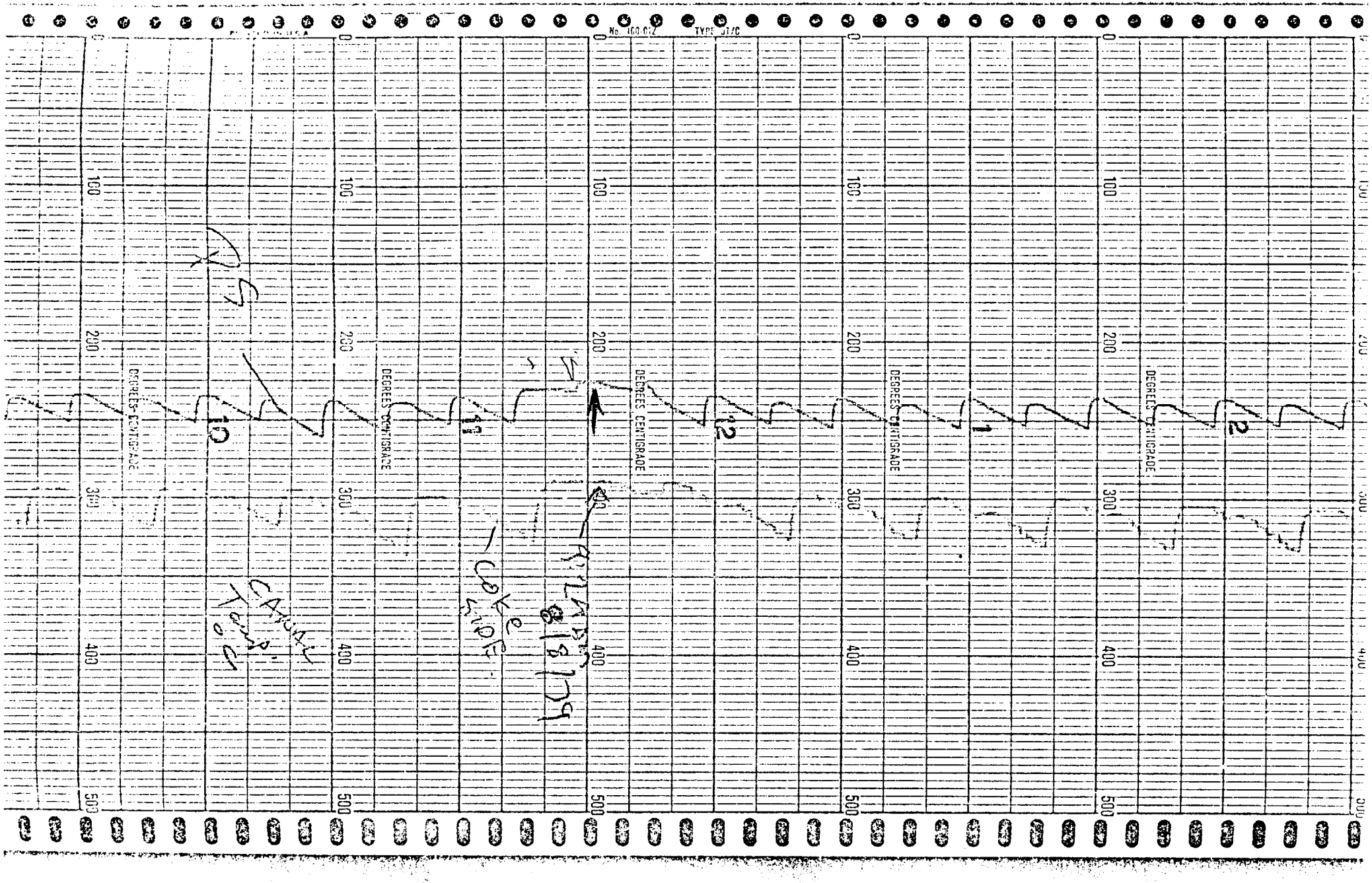

Waste Flue Gas Temperature (°C) - 8/8/79



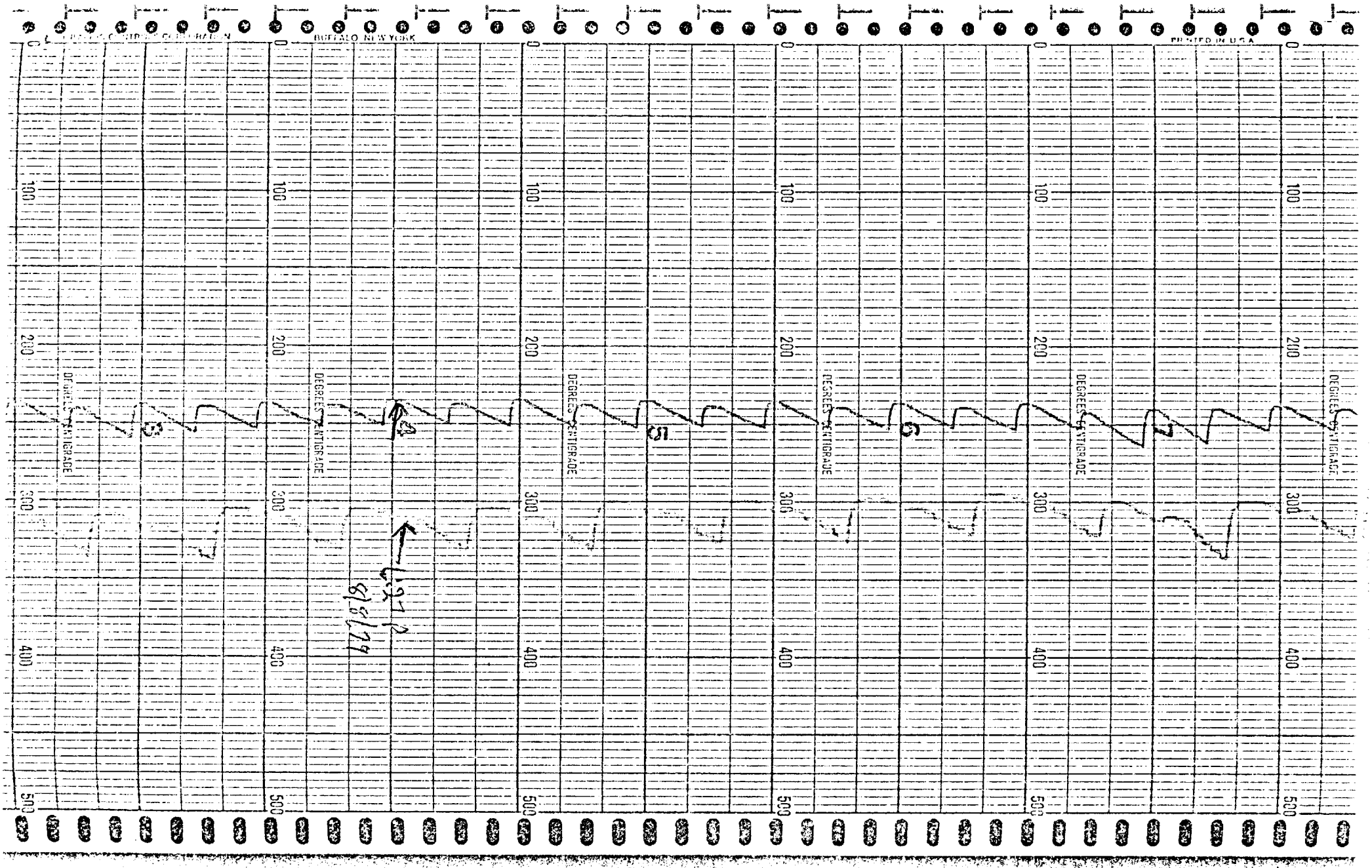

Crossover (CS) and Offtake (PS) Collecting Main Pressures (mm $H_2O$) - 8/8/79




Coke Side and Pusher Side Waste Heat
Flue Pressures (-mm $H_2O$) - 8/8/79




Waste Heat Canal Temperatures (°C) - 8/8/79




Waste Heat Canal Temperatures (°C) - 8/8/79 (Continued)

TEST DAY 3

8/9/79

Run # 3

Date 8/9/79
Plant Name CF+I Steel
Location Pueblo, Colorado
Battery No. D
JPR

COKE OVEN BATTERY LOG SHEET

| Oven Pushing Data | | | Oven Charging Data | | |
|---|---|---|---|---|---|
| Oven No. | Time Pushed | Push Greenness* | Oven No. | Time Leveled | Comments |
| 25 | 11:39 AM | 3 | 23 | 11:46 | 11:18 Start of Sampling |
| 27 | 11:51 | 2 | 25 | 11:53 | |
| 29 | 12:14 | 1 | 27 | ~~11:56~~ 12:19 | 12:28 #5 Part 1 Finished |
| | | | | | |
| 31 | 2:05 PM | 1 | 29 | 2:08 | |
| | | | | | |
| | | | | | I think I missed |
| | | | 4 | 4:02 | #2, 4 ovens pushed. Charging schedule is behind. |
| 6 | 3:58 | N.R | 6 | 4:12 | |
| 8 | 4:05 | 1 | 8 | 5:07 | 4:18 #5 - Finished BAP Still Running |
| 10 | 5:09 | 4 | 10 | [redacted] | Not Charged |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | 5:28 BAP Finished |
| | | | | | |
| | | | | | |
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| | | | | | |

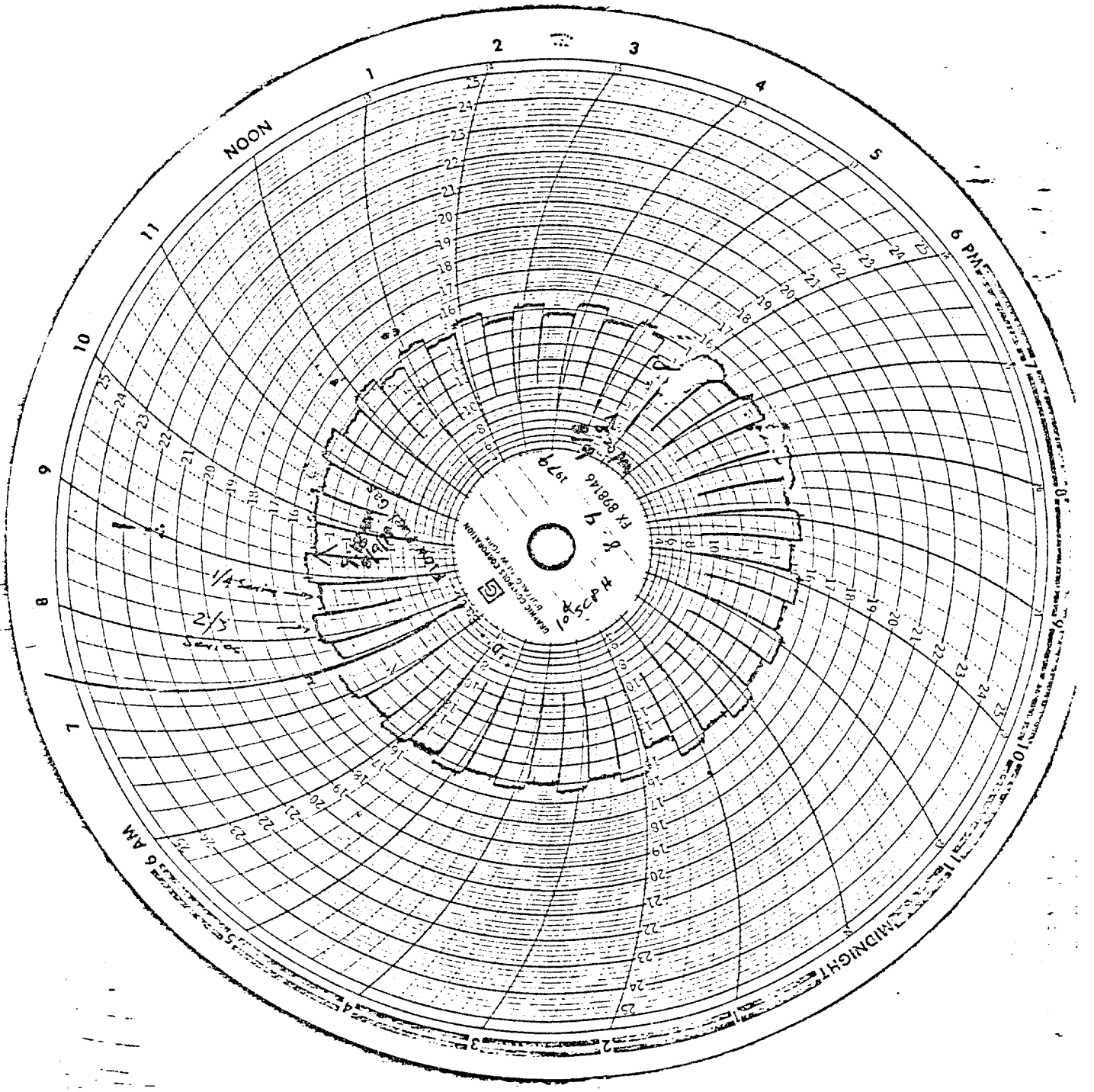
* Coke Greenness Rating: 1 - denotes coke is not green;
5 - denotes very green coke pushed.

# Run #3

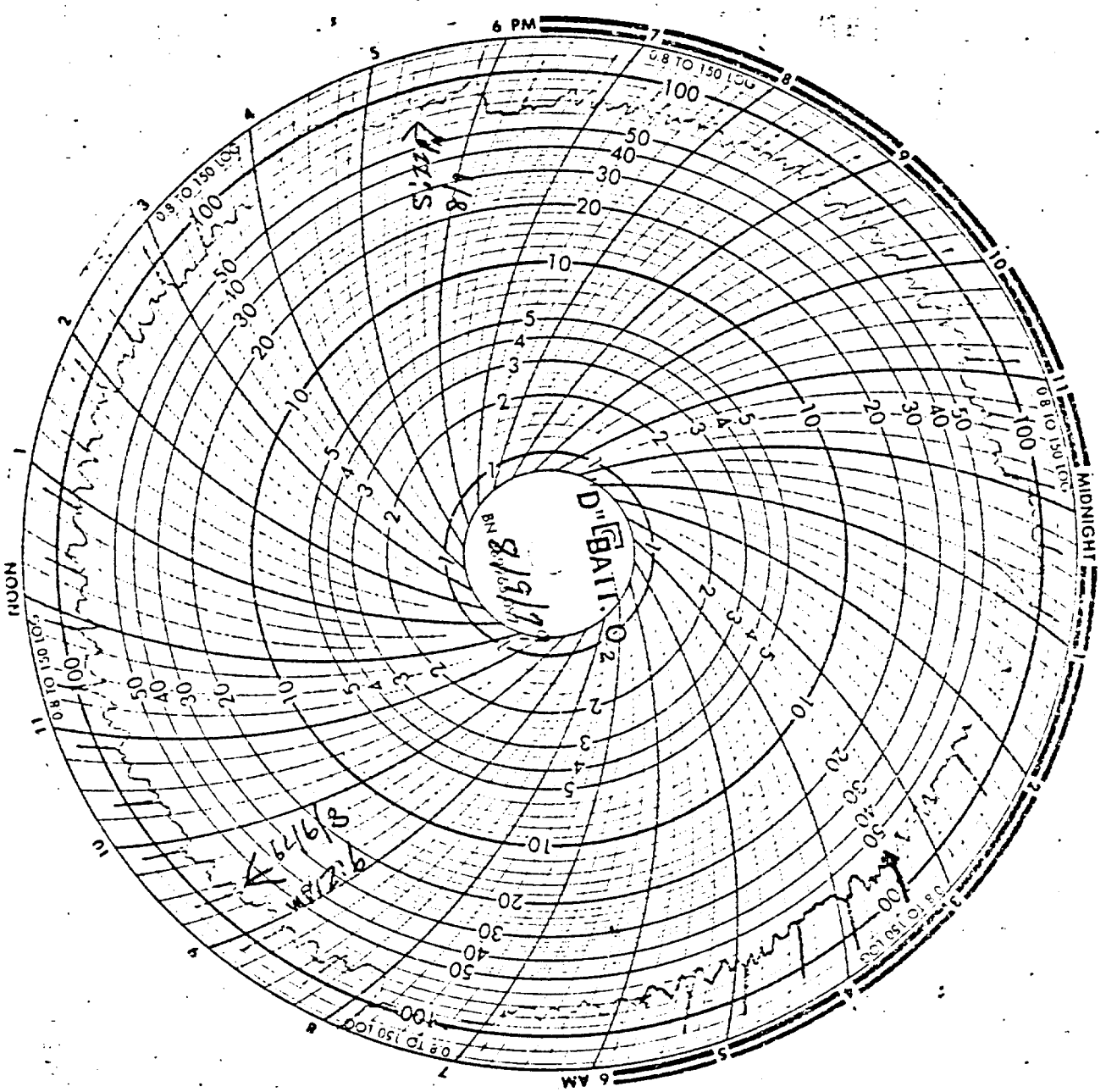
SBK

| Time | Fuel Gas Flow Rate | Reheater Temperature | | Fuel Gas Pressure | | Shift Draft | Waste Heat Temp. | Waste Heat Flues Pressures | | Collecting Main Pressures | | $O_2$ Level | Tunnel Temp. | Tunnel Draft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\times 10^4$ scfH | Bef. °C | Aft. °C | CS mm $H_2O$ | PS mm $H_2O$ | mm $H_2O$ | °C | CS mm $H_2O$ | PS mm $H_2O$ | CS mm $H_2O$ | PS mm $H_2O$ | % | CS mm $H_2O$ | PS mm $H_2O$ |
| Am 9:25 | 14.8 | 41 | 62 | 112 | 112 | 23.5 | 295 | 5.8 | 8.5 | 8.0 | 6.5 | 8.2 | 305 | 2 |
| 11:03 | 15.3 | 42 | 63 | 112 | 112 | 23.2 | 290 | 5.6 | 8.0 | 8.0 | 6.0 | 7.8 | 295 | 2 |
| 12:53 | 15.2 | 44 | 65 | 111 | 112 | 23.1 | 292 | 5.6 | 8.0 | 8.7 | 6.0 | 8.2 | 300 | 2 |
| 1:59 | 15.3 | 44 | 65 | 111 | 112 | 23.0 | 290 | 5.6 | 8.0 | 9.0 | 5.5 | 7.0 | 300 | 24 |
| 2:53 | 15.3 | 42 | 63 | 111 | 112 | 23.0 | 295 | 5.8 | 8.1 | 8.5 | 5.5 | 7.2 | 298 | 24 |
| 3:48 | 15.2 | 42 | 63 | 109 | 112 | 23.0 | 300 | 5.7 | 8.5 | 8.5 | 5.2 | 7.1 | 300 | 24 |
| 4:32 | 14.8 | 42 | 62 | 111 | 112 | 33.0 | ? Wall Temp. Reading 300 | 9.0 | 12.0 | 9.0 | 5.0 | 10.0 | 320 | 20 |
| 5:25 | 13.8 | 39 | 60 | 112 | 112 | 24.0 | 295 | 6.0 | 9.0 | 8.5 | 5.2 | 8.1 | 315 | 2 |

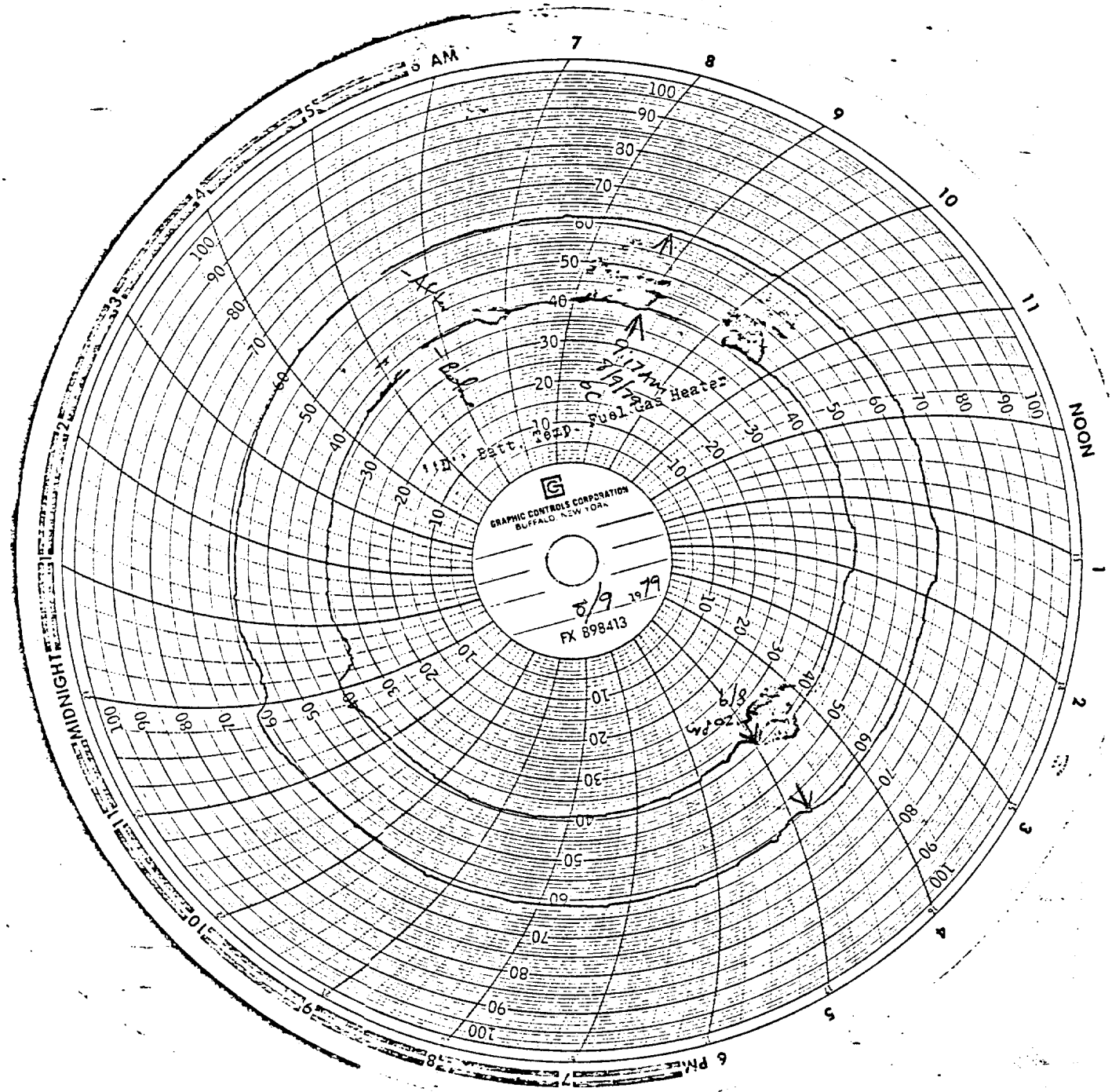
#5 Filter - Black, Moist. + Appears Evenly coated
Post " - Gray coating



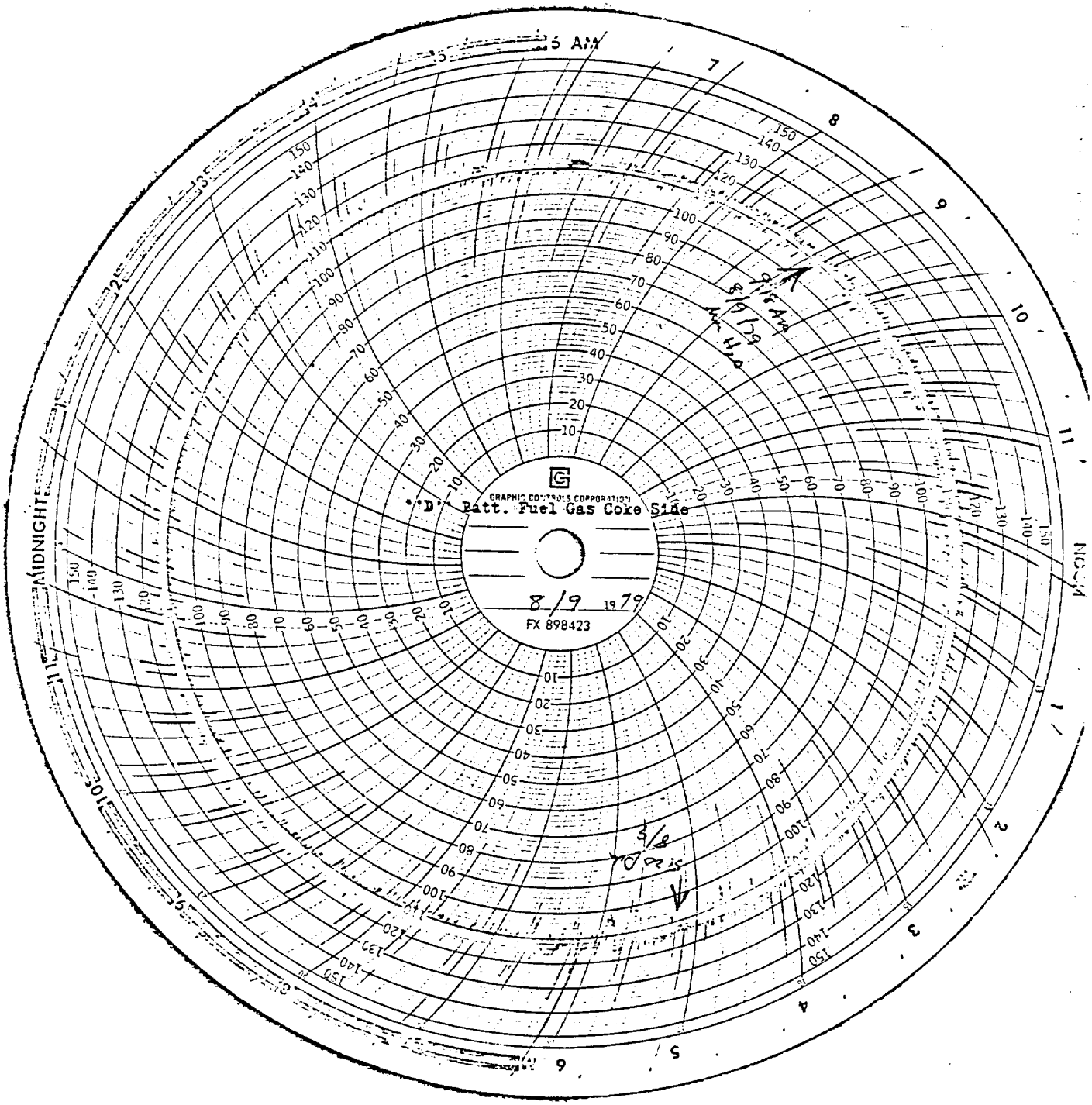

Fuel Gas Flow Rate ($10^4$ SCFH) - 8/9/79



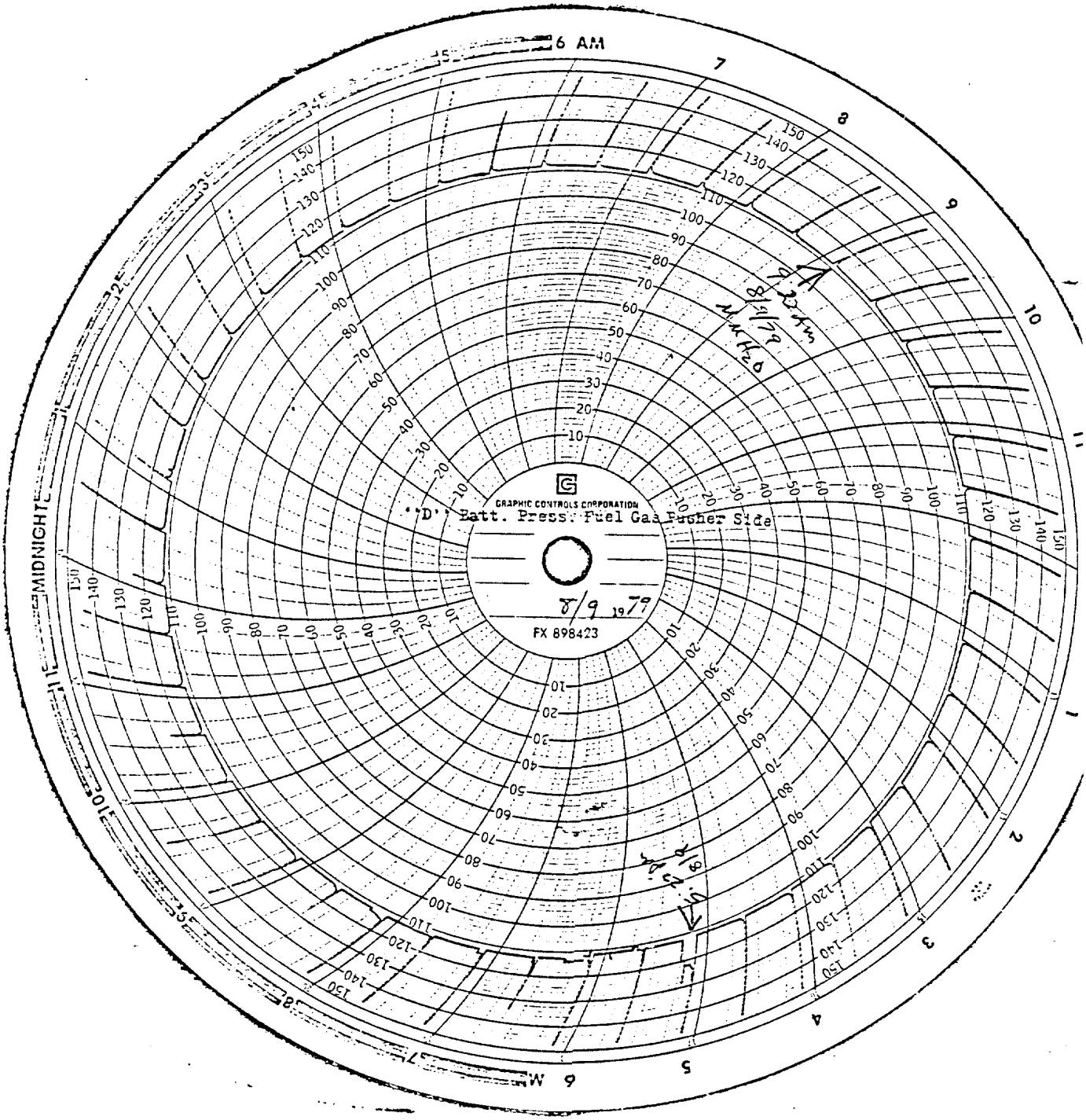

Continuous $O_2$ Monitor Chart ($\frac{x}{10} = \%\ O_2$) - 8/9/79



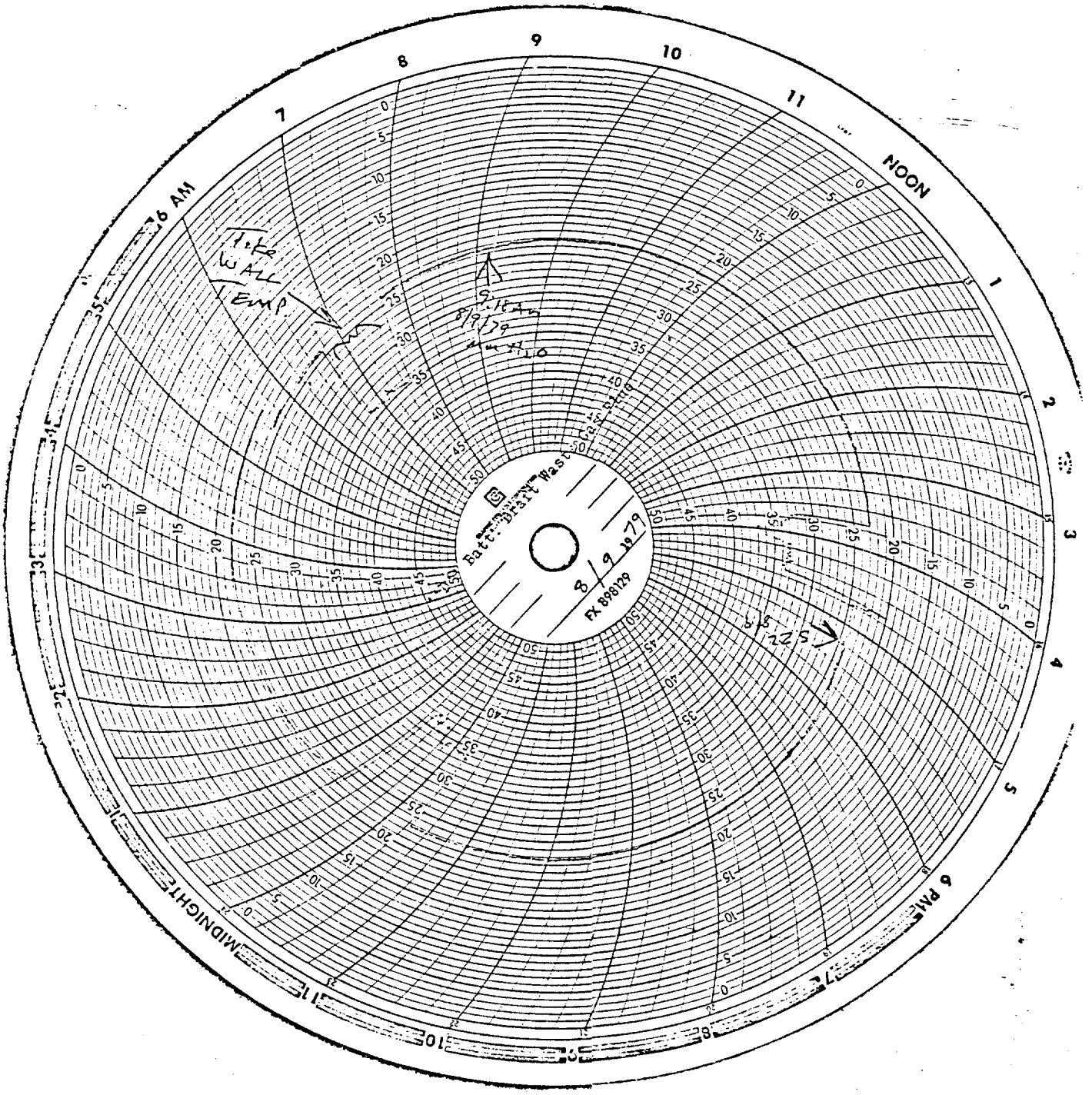

Fuel Gas Heater Inlet and Outlet Temperatures (°C) - 8/9/79



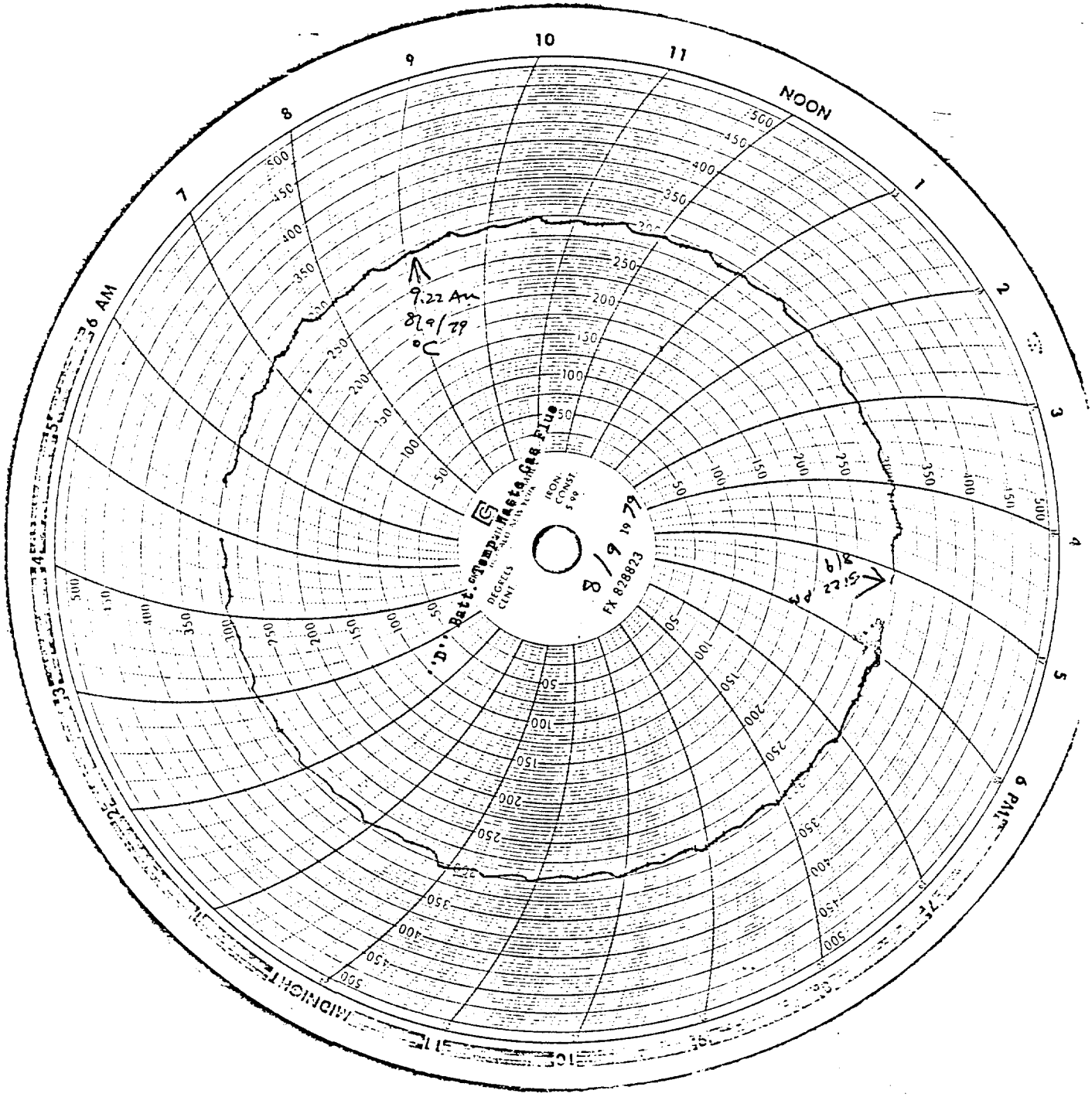

Coke Side Fuel Gas Pressure (mm $H_2O$) - 8/9/79



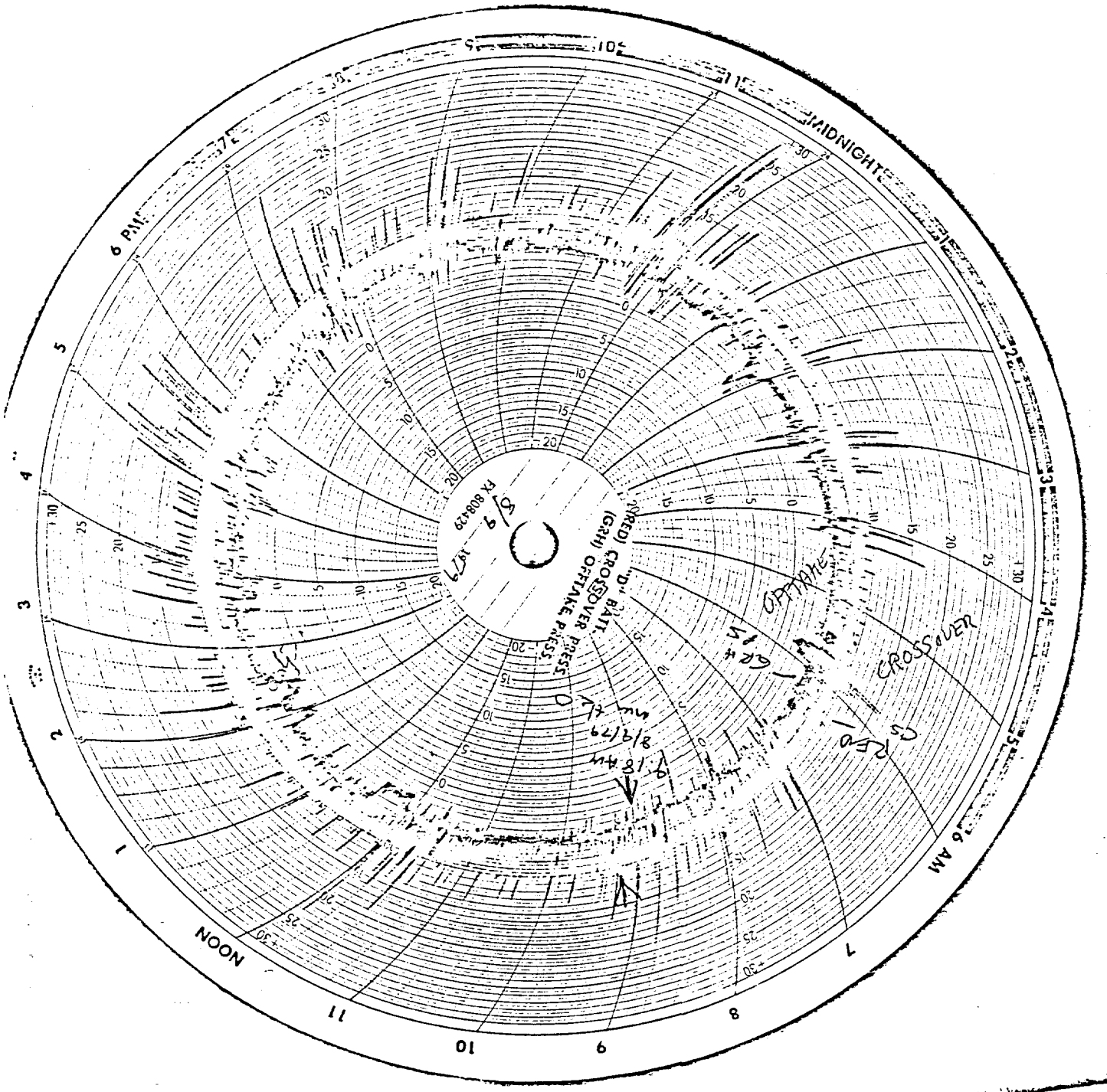

Pusher Side Fuel Gas Pressure (mm $H_2O$) - 8/9/79



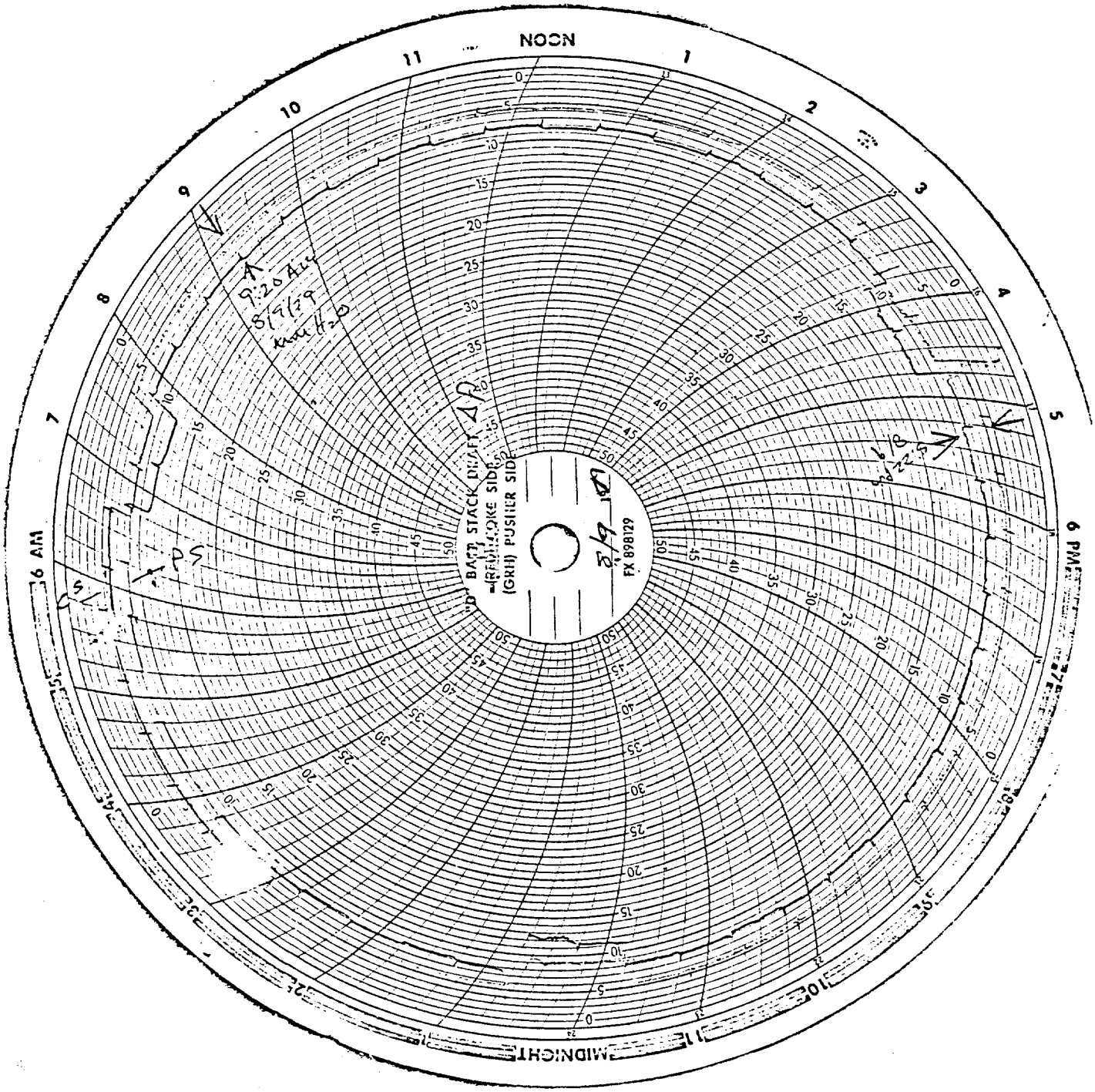

Flue Gas Stack Draft (-mm $H_2O$) - 8/9/79



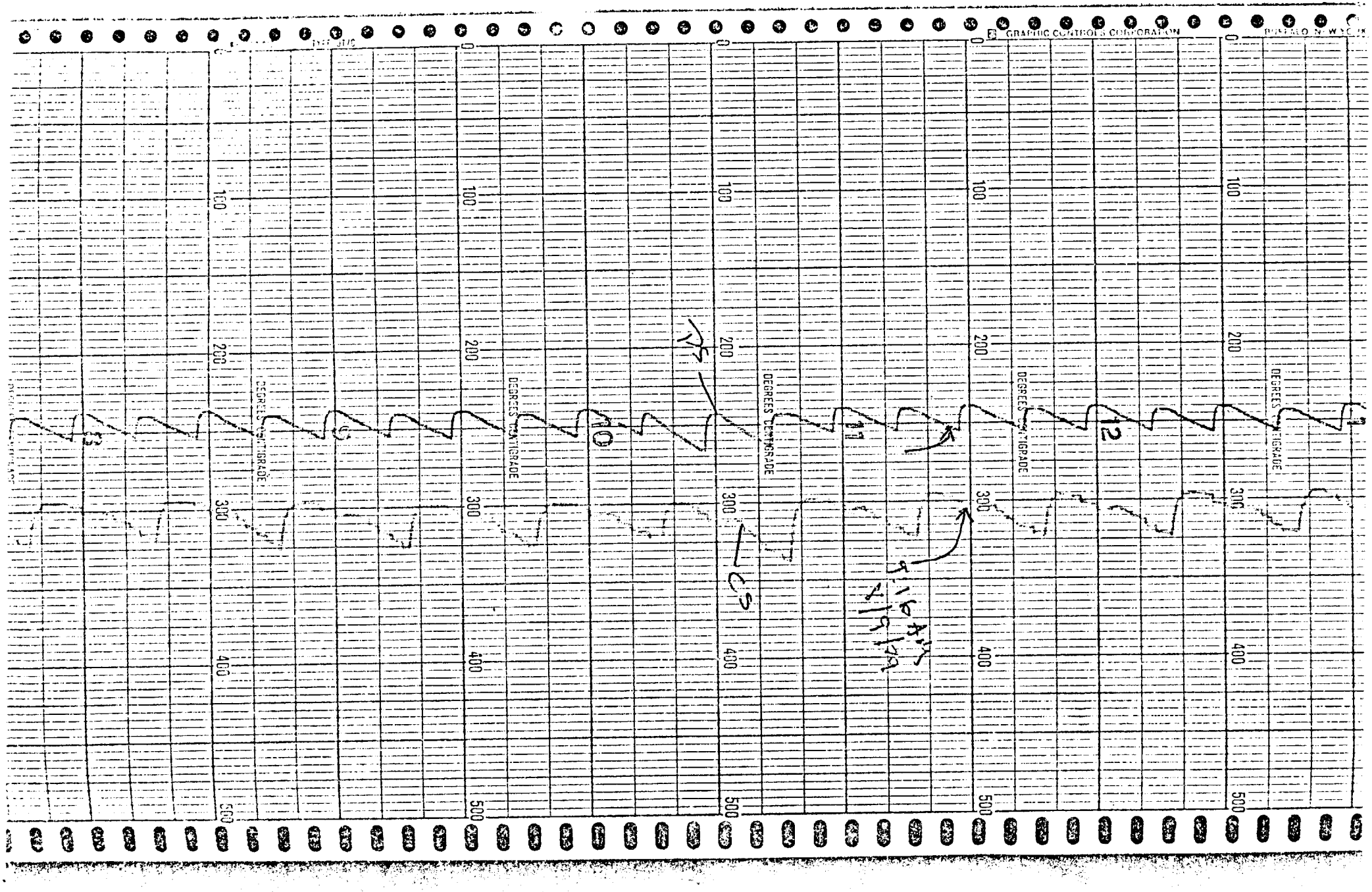

Waste Flue Gas Temperatures (°C) - 8/9/79



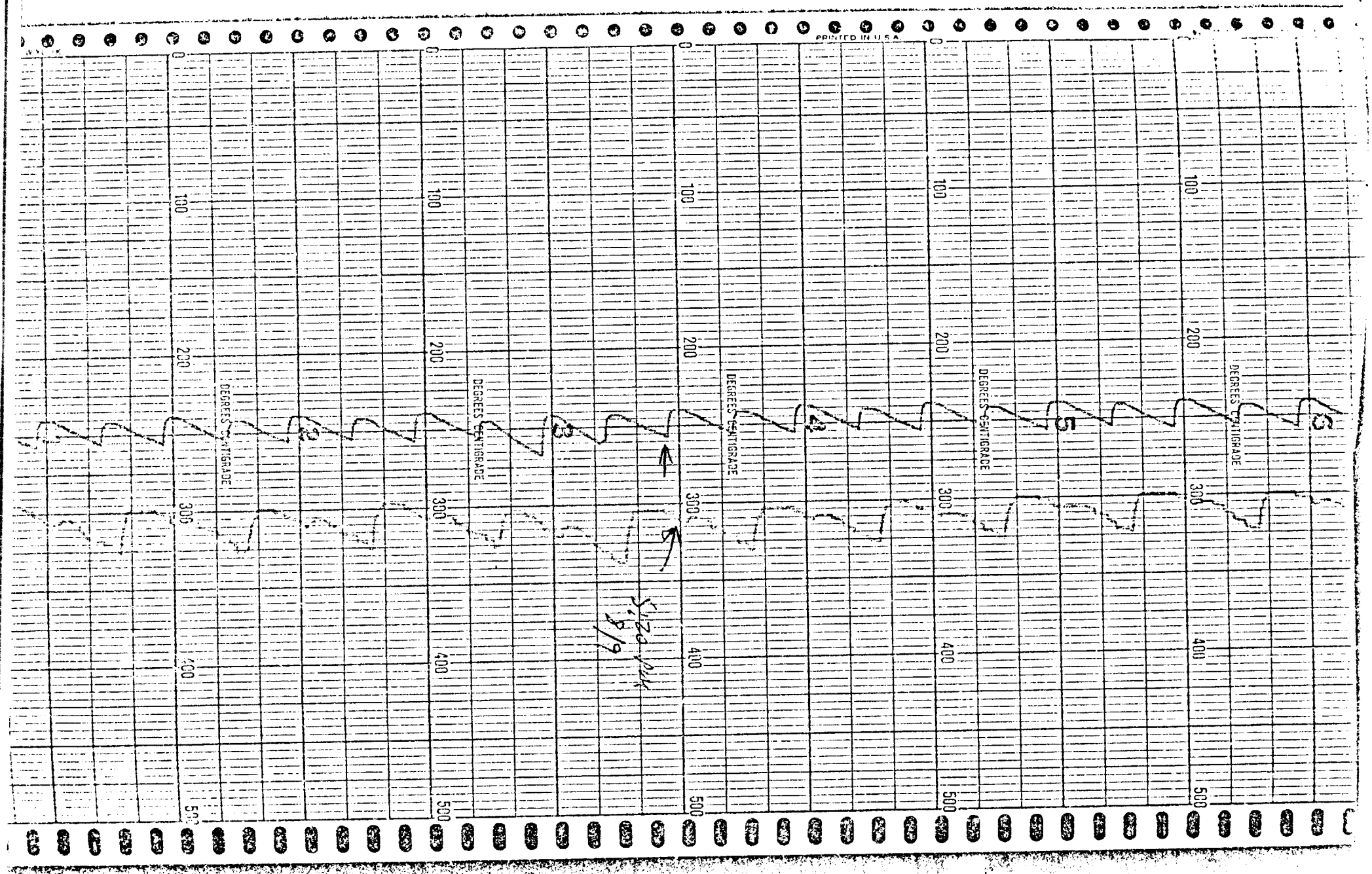

Crossover (CS) and Offtake (PS) Collecting Main Pressures (mm $H_2O$) - 8/9/79




Coke Side and Pusher Side Waste Heat
Flue Pressures (-mm $H_2O$) - 8/9/79




Waste Heat Canal Temperatures (°C) - 8/9/79




Waste Heat Canal Temperatures (°C) - 8/9/79 (Continued)

# APPENDIX C

## CONTINUOUS MONITORING DATA

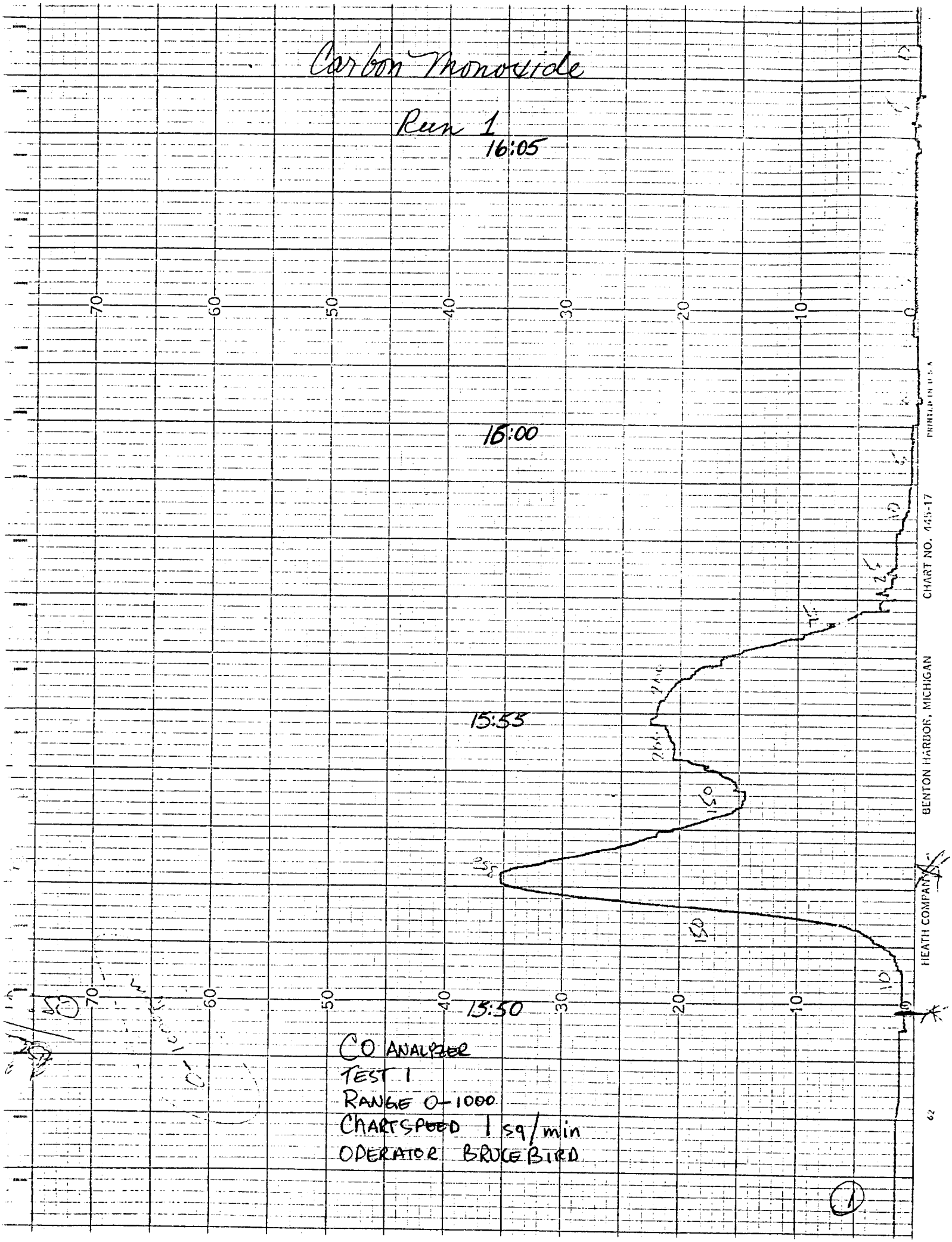
C-1. Carbon Monoxide

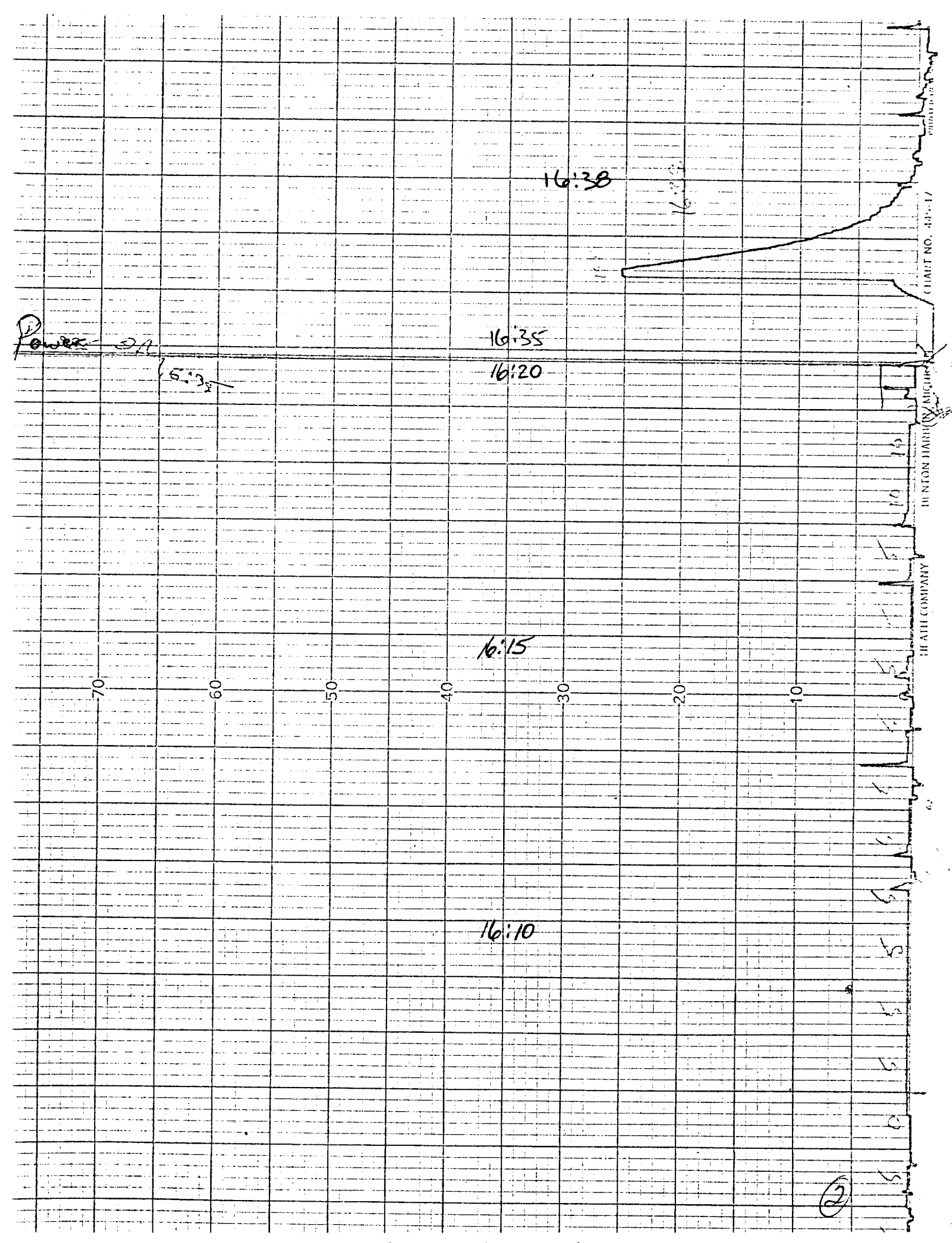
C-2. Nitrogen Oxides

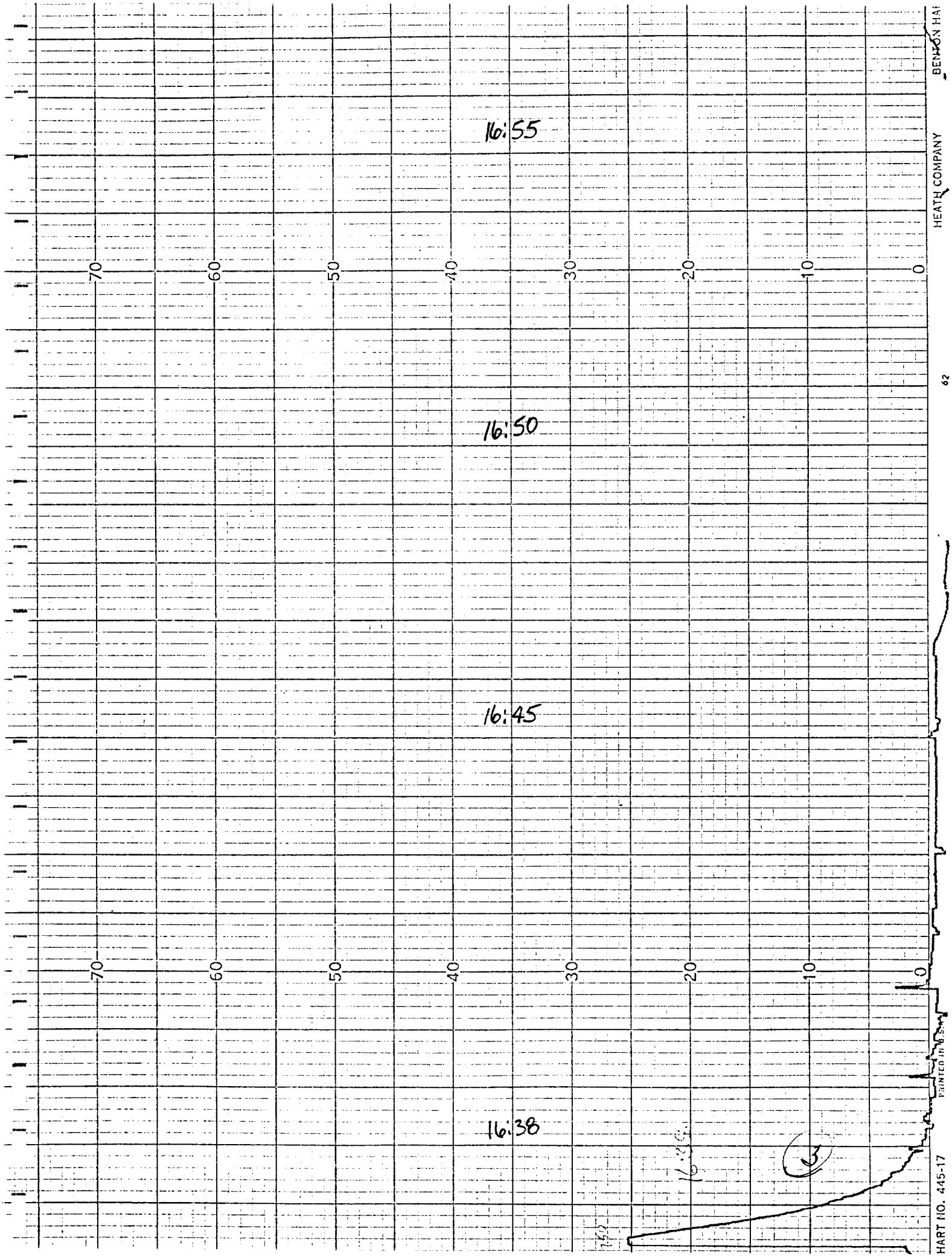
C-3. Oxygen

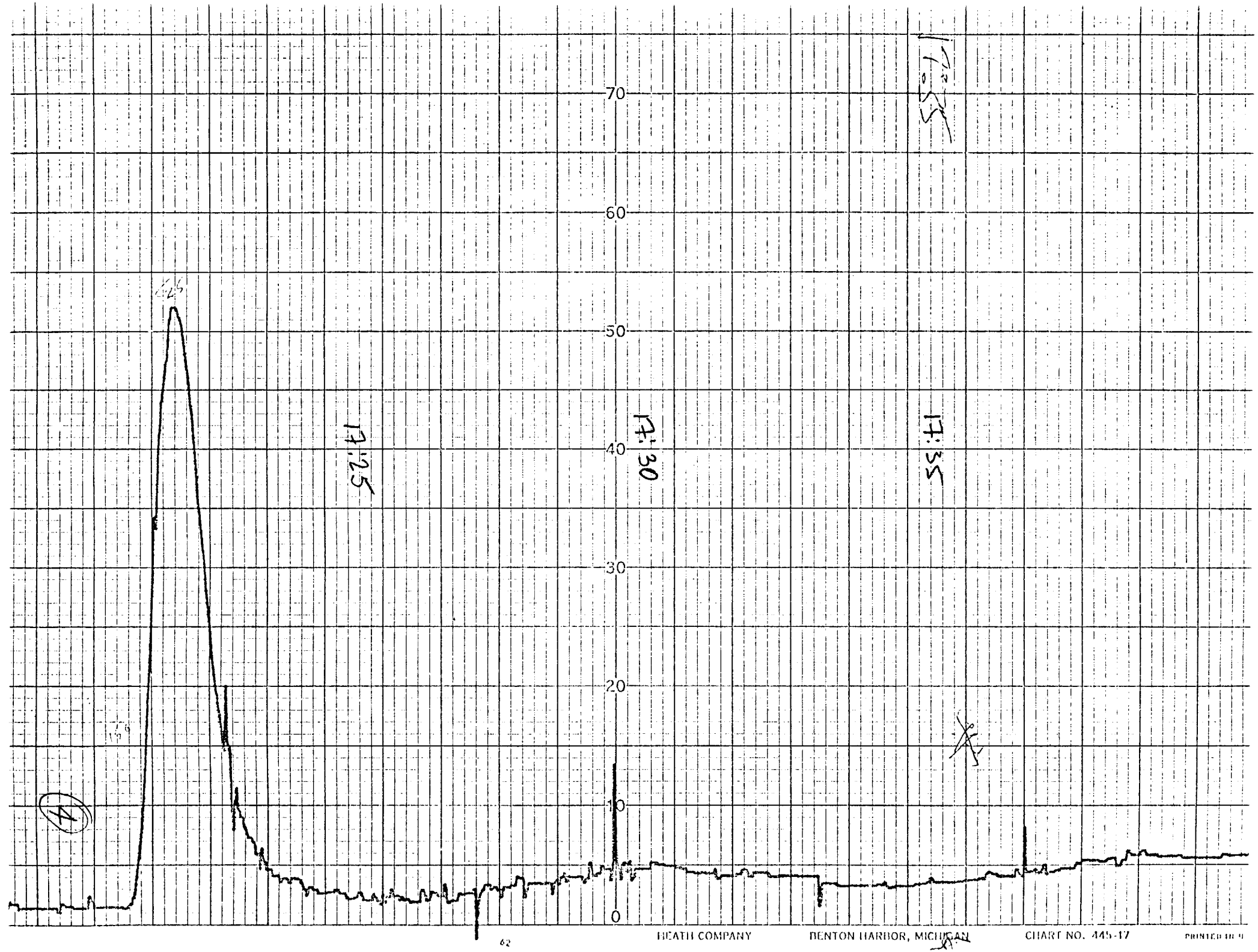
# APPENDIX C-1

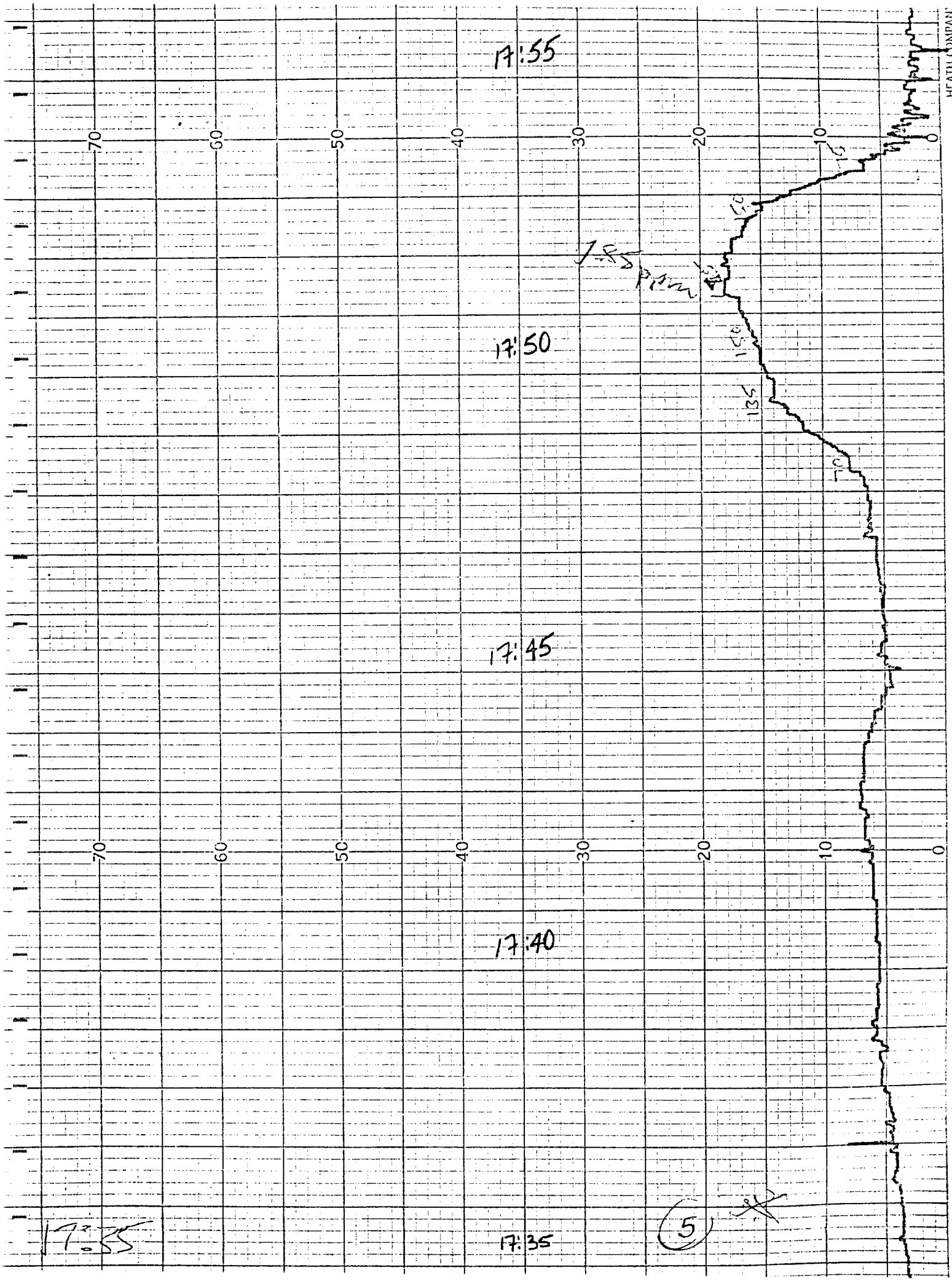
# CARBON MONOXIDE

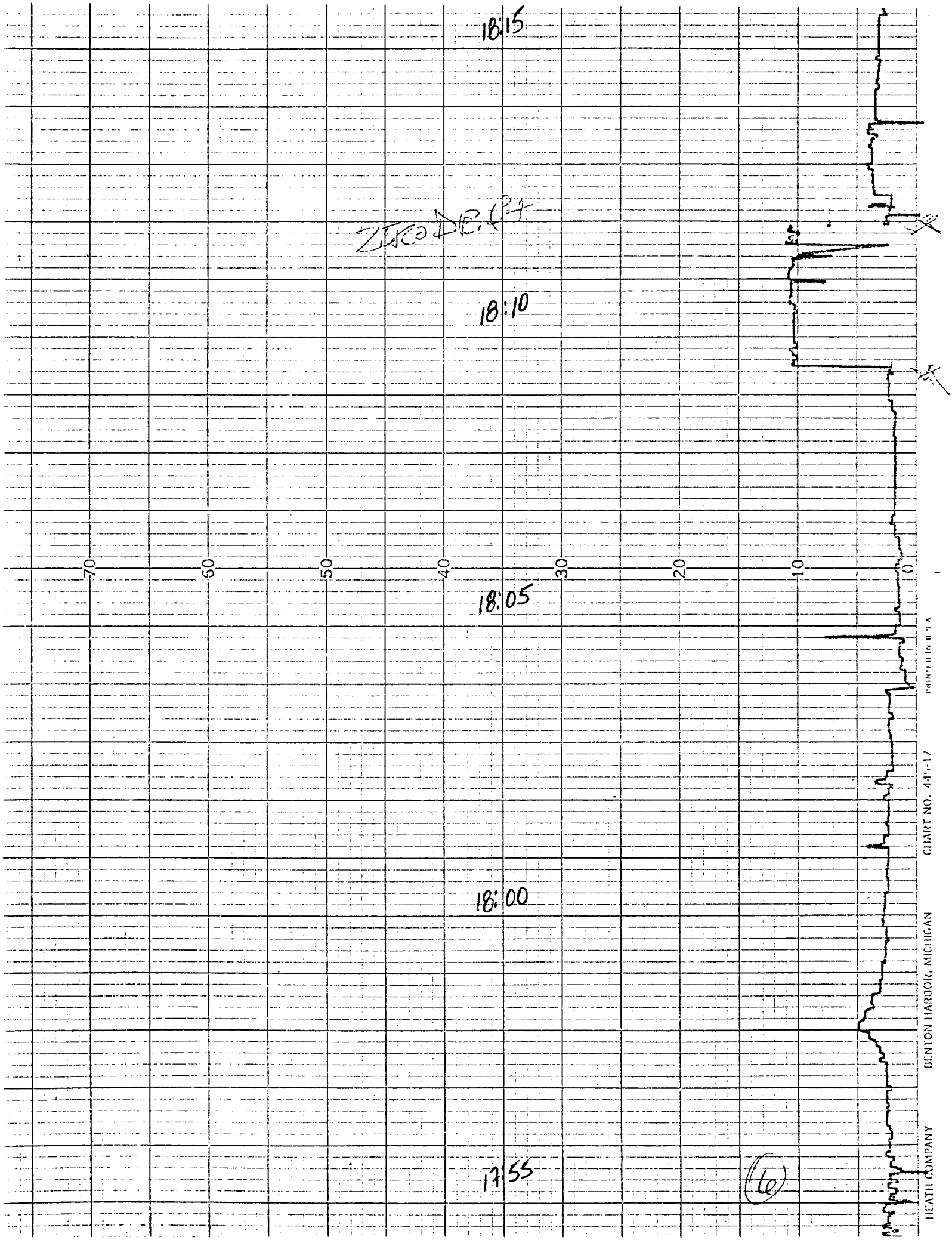

Carbon Monoxide
Run 1
16:05
16:00
15:55
15:50
70
60
50
40
30
20
10
0
CO ANALYZER
TEST 1
RANGE 0-1000
CHARTSPEED 1 sq/min
OPERATOR BRUCE BIRD
1
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 665-17
PRINTED IN U.S.A.


16:38
Power ON
16:35
16:20
16:15
16:10
70
60
50
40
30
20
10
CHART NO. 4-5-17
PRINTED IN U.S.A.
HEATH COMPANY
2


16:55
70
60
50
40
30
20
10
0
16:50
16:45
70
60
50
40
30
20
10
0
16:38
3
BENSON HA
HEATH COMPANY
62
PRINTED IN U.S.A.
HART NO. 445-17


70
60
50
40
30
20
10
0
14:25
14:30
14:35
4
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 445-17

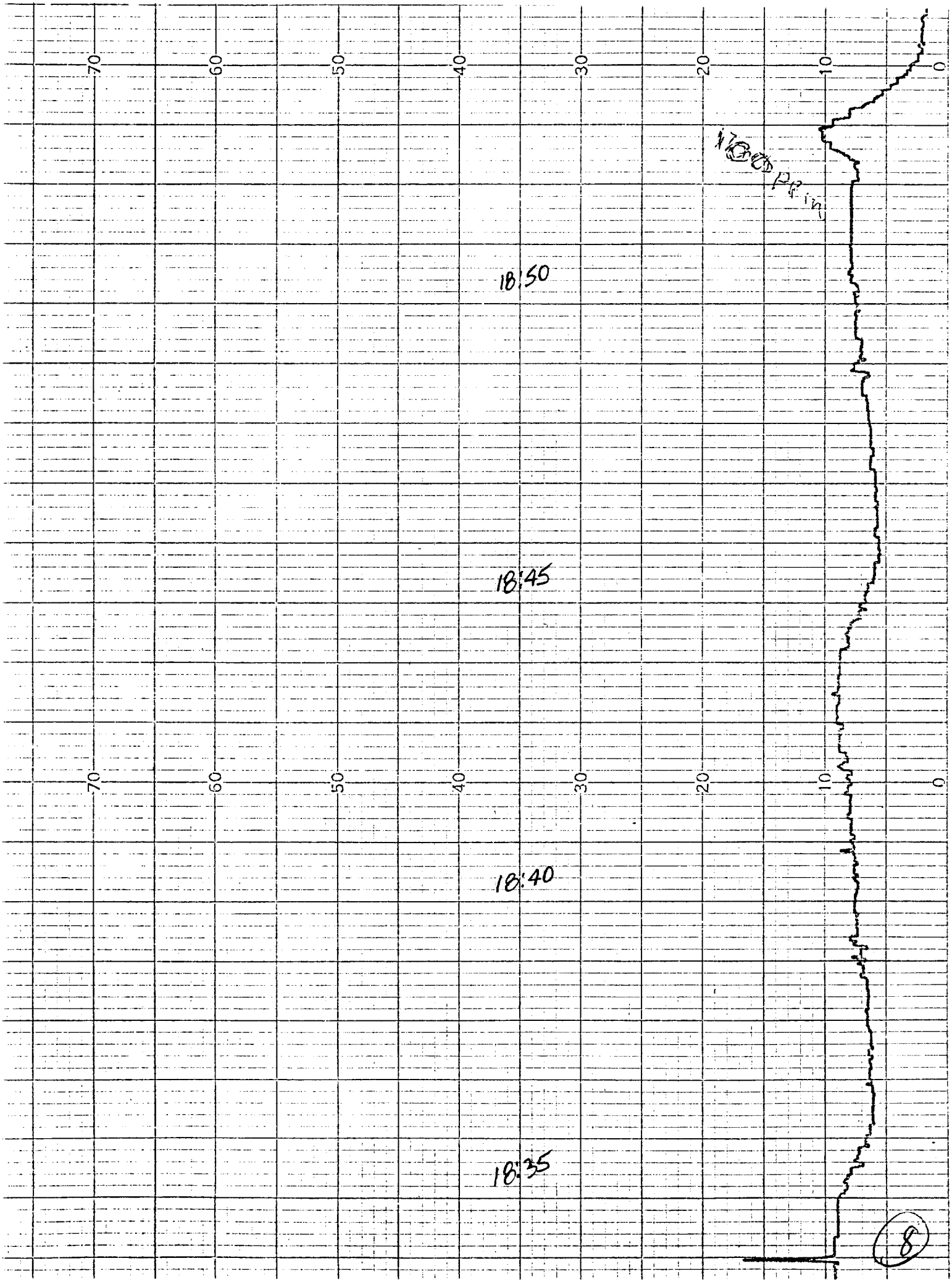

17:55
17:50
17:45
17:40
17:35
70
60
50
40
30
20
10
0
145 Pitch
150
135
70
5


18:15
18:10
18:05
18:00
17:55
70
60
50
40
30
20
10
0
(6)
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 44-17

7



HEATH COMPANY BENTON HARBOR, MICHIGAN CHART NO. 445-17 PRINTED IN U.S.A.


70
60
50
40
30
20
10
0
100 psig
18:50
18:45
18:40
18:35
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 445-17
PRINTED IN U.S.A.
8

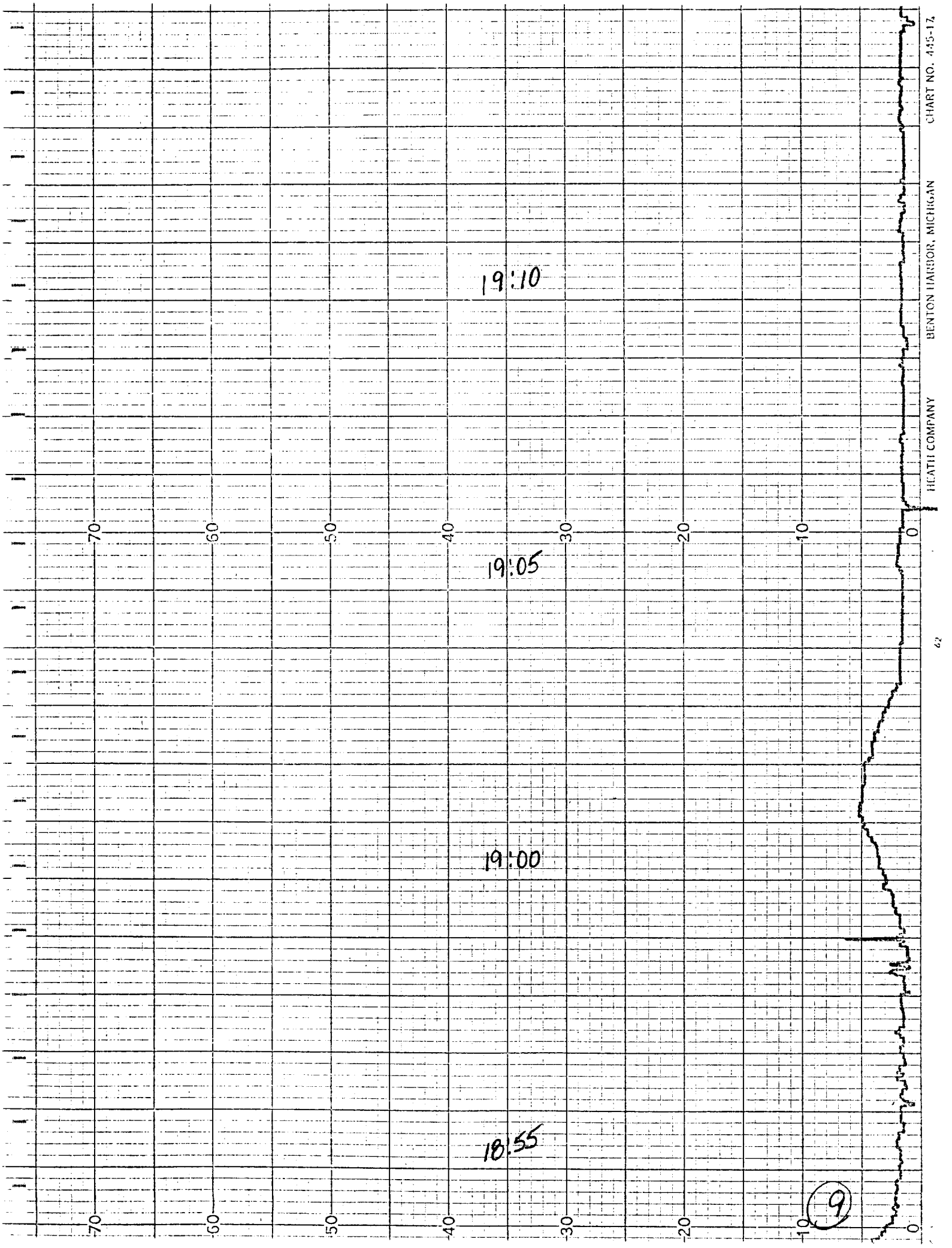
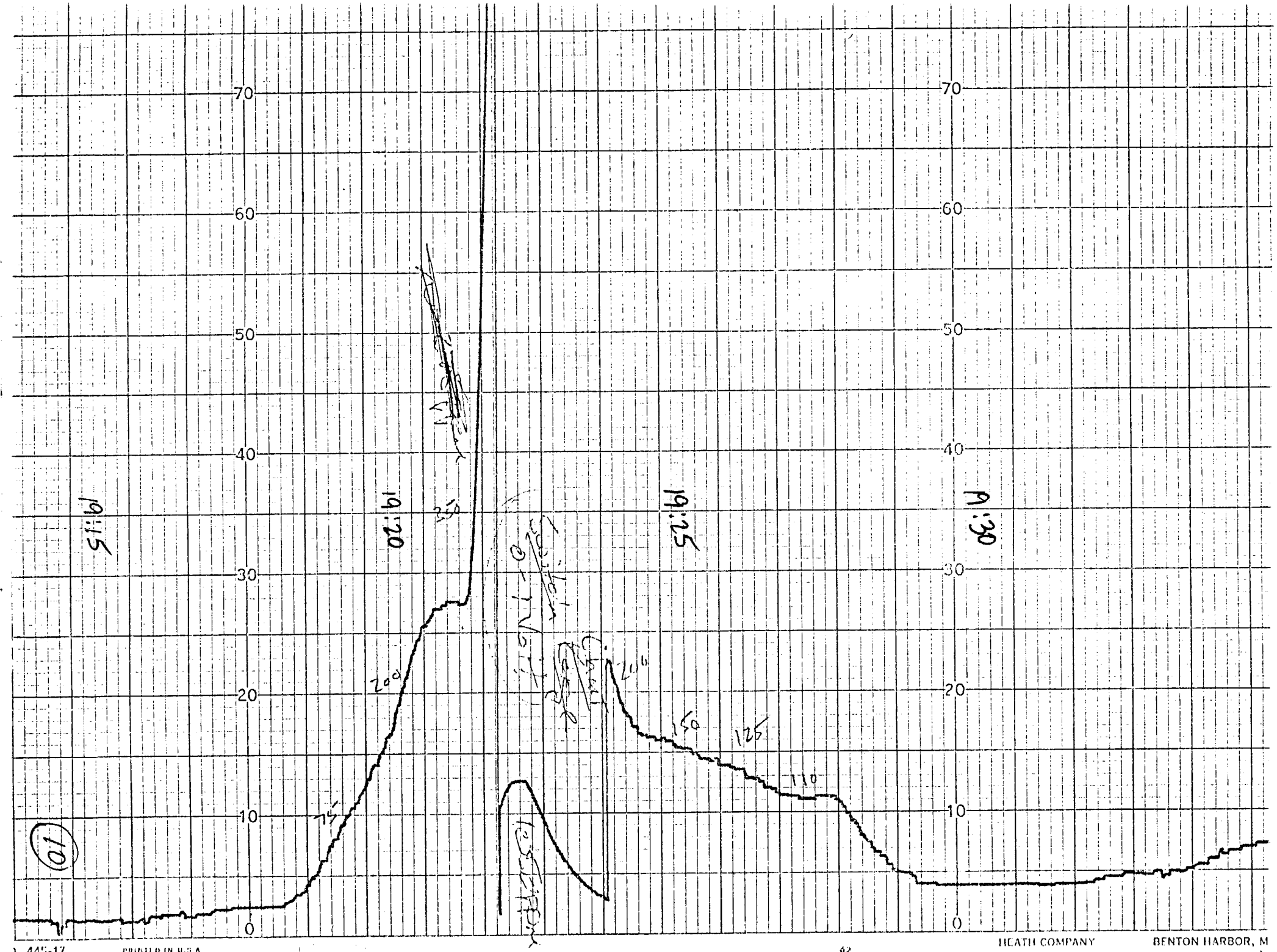
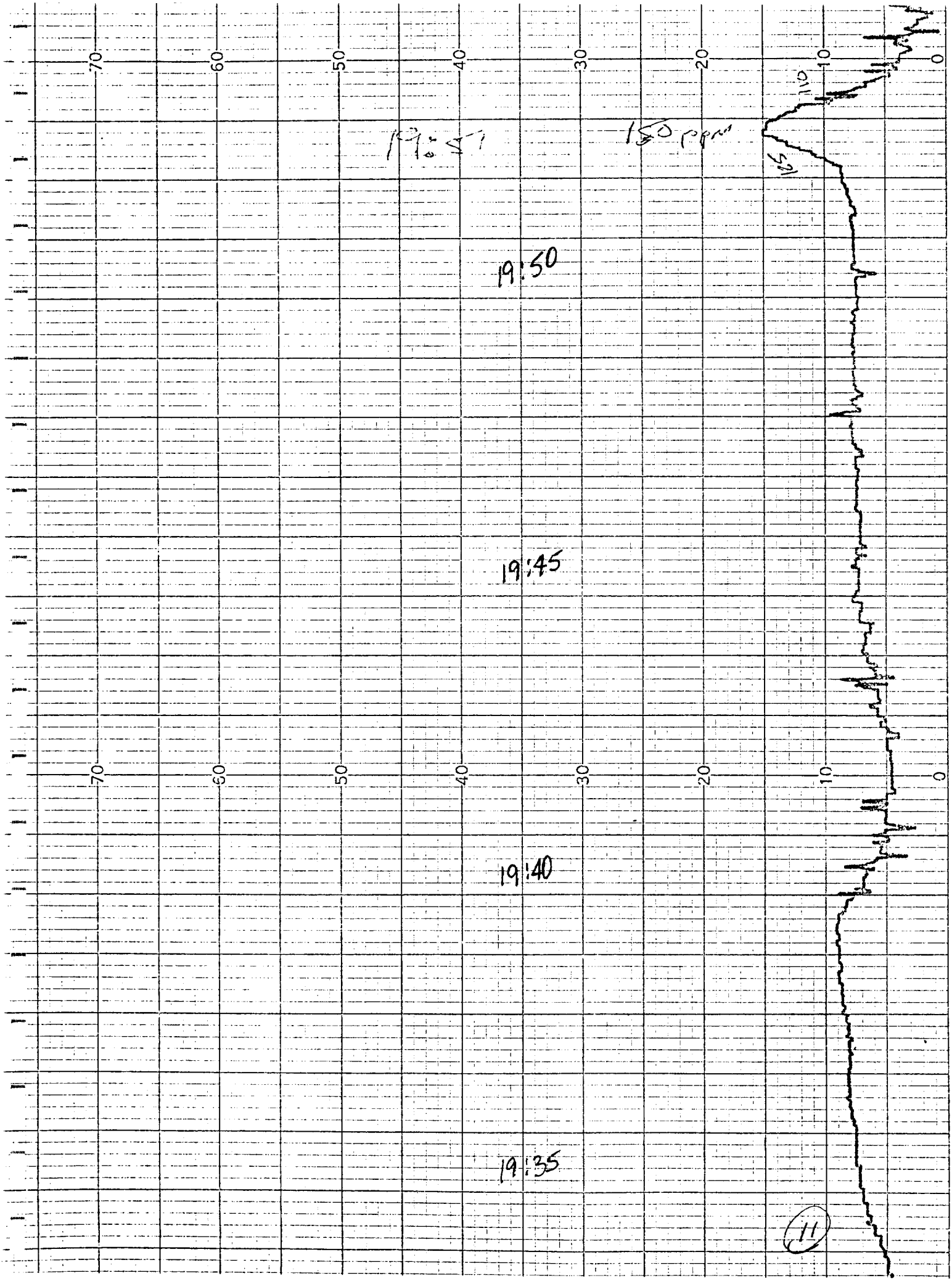
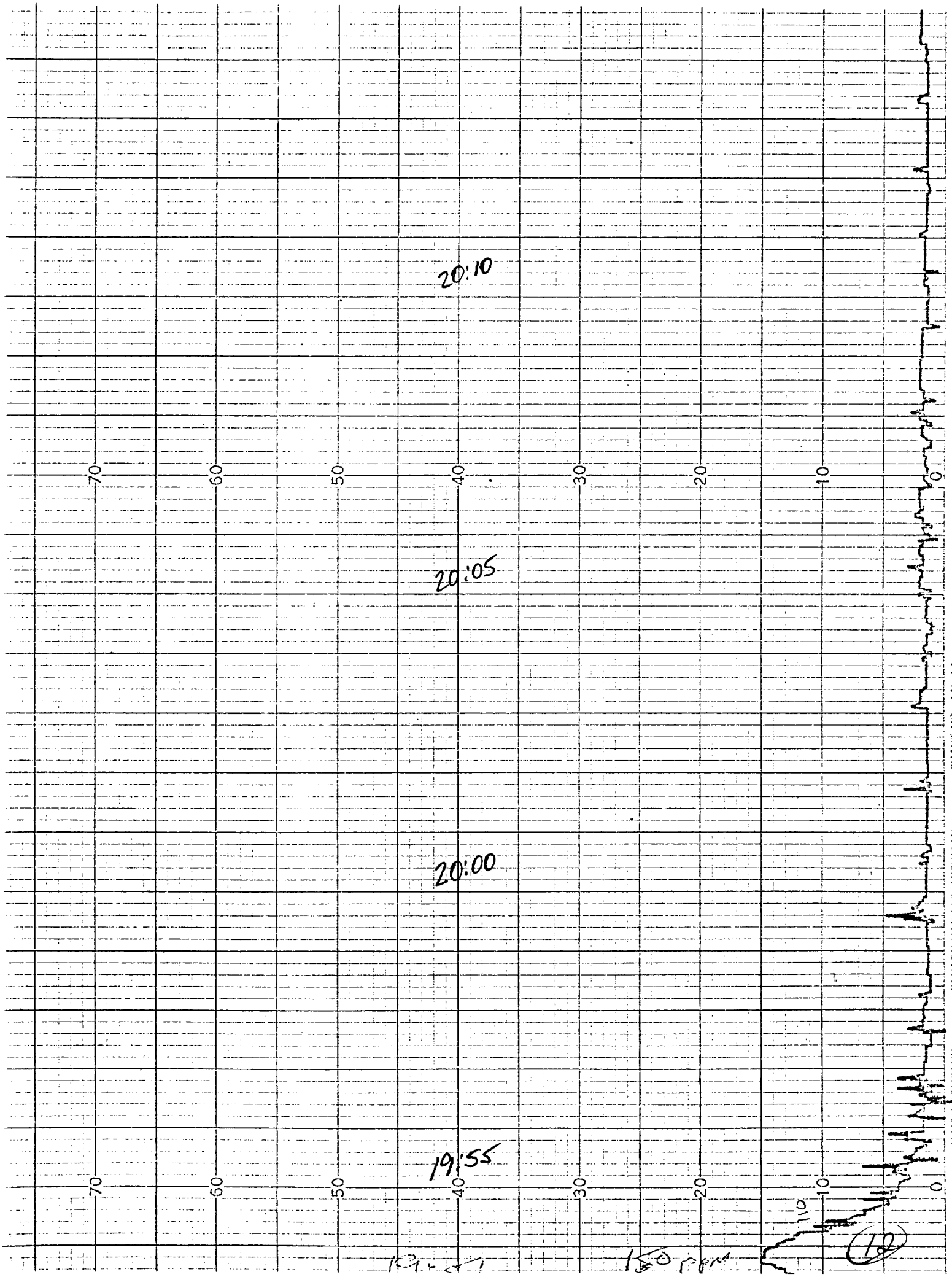


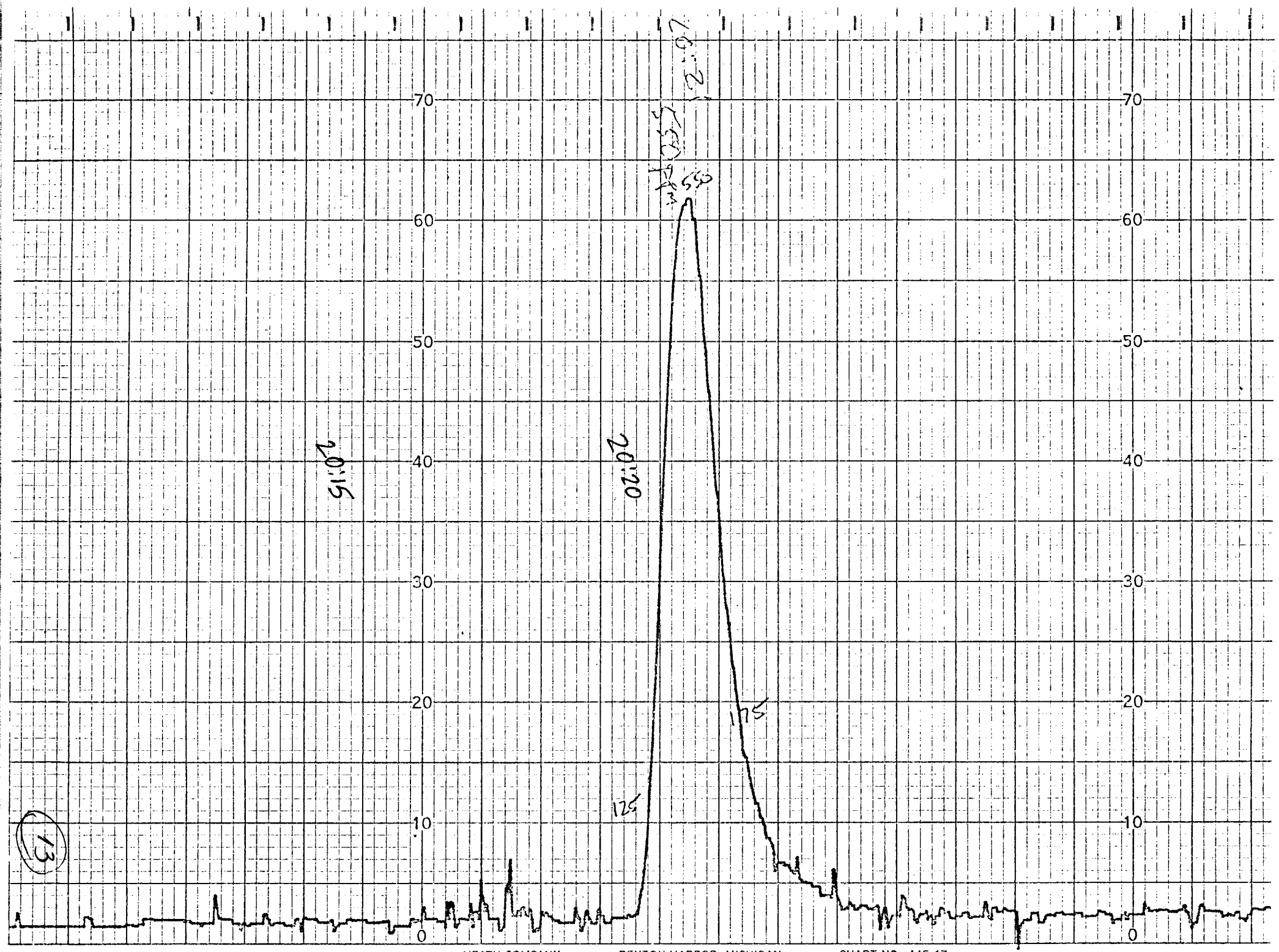
CHART NO. 445-17
BENTON HARBOR, MICHIGAN
HEATH COMPANY
19:10
19:05
19:00
18:55
70
60
50
40
30
20
10
0
9


70
60
50
40
30
20
10
0
10:15
10:20
10:25
10:30
75
200
350
200
150
125
110
01



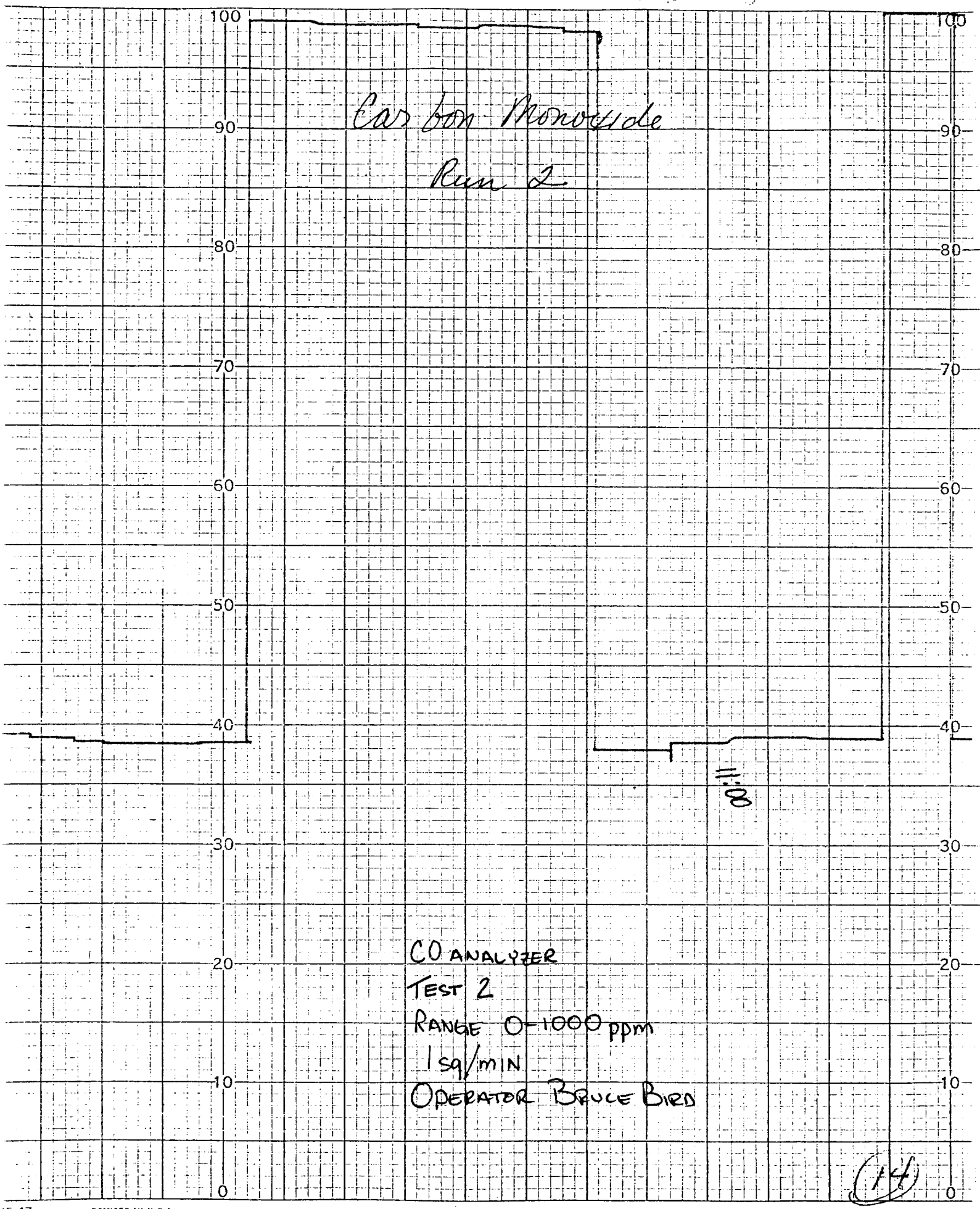

NTON HARBOR, MICHIGAN
CHART NO. 445-17
PRINTED IN U.S.A.

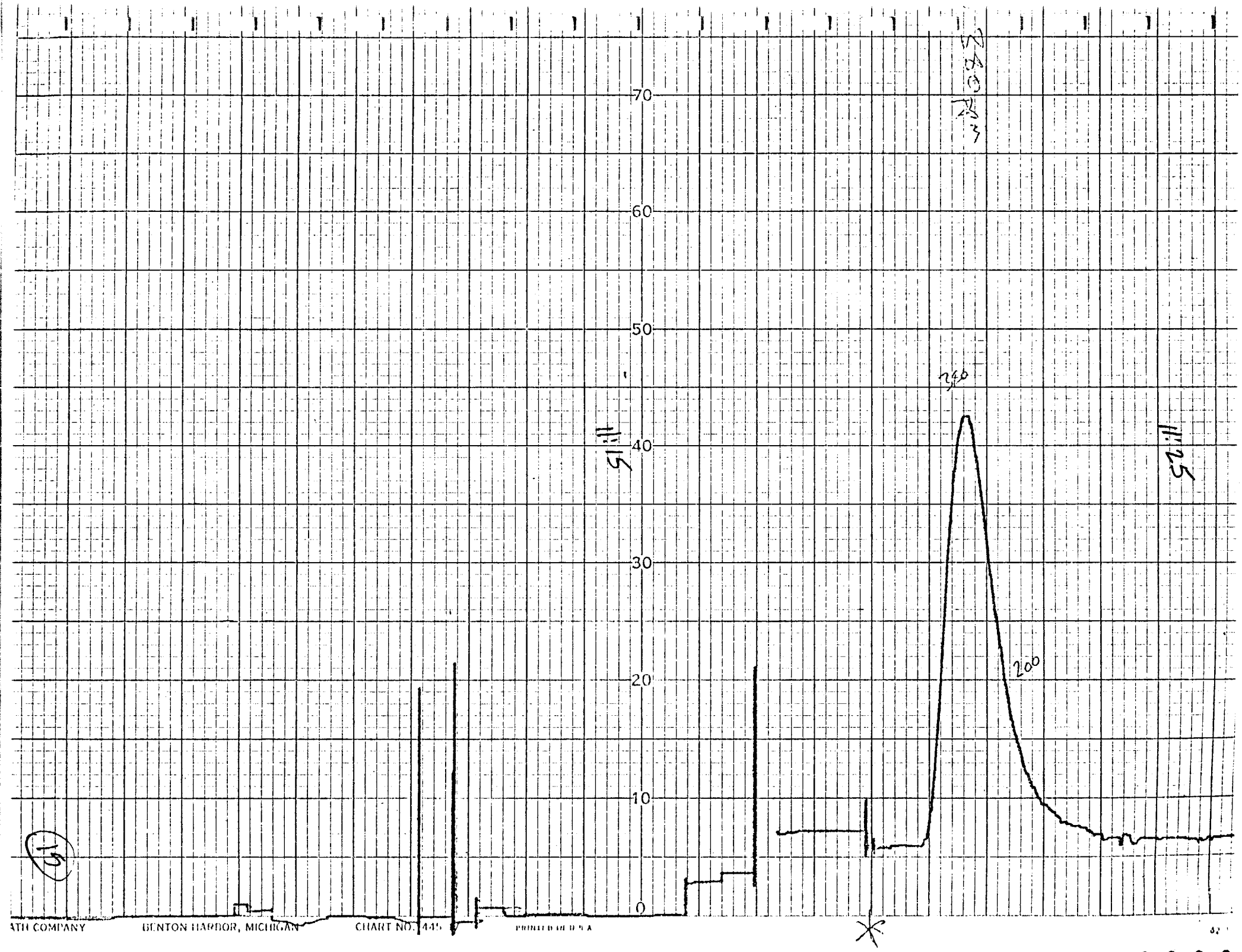

20:10
20:05
20:00
19:55
70
60
50
40
30
20
10
0
150 ppm
(12)
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 445-17
PRINTED IN U.S.A.

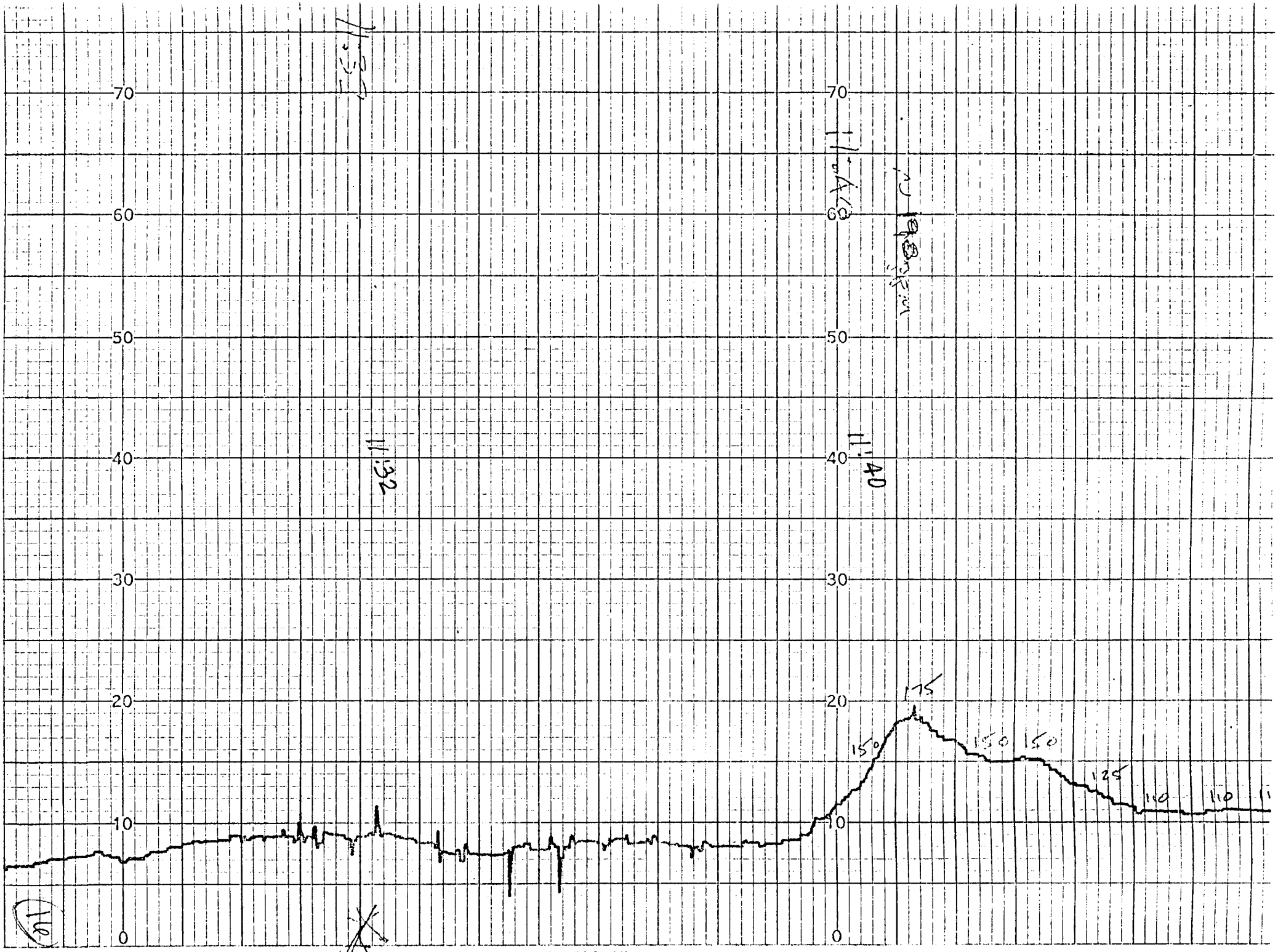


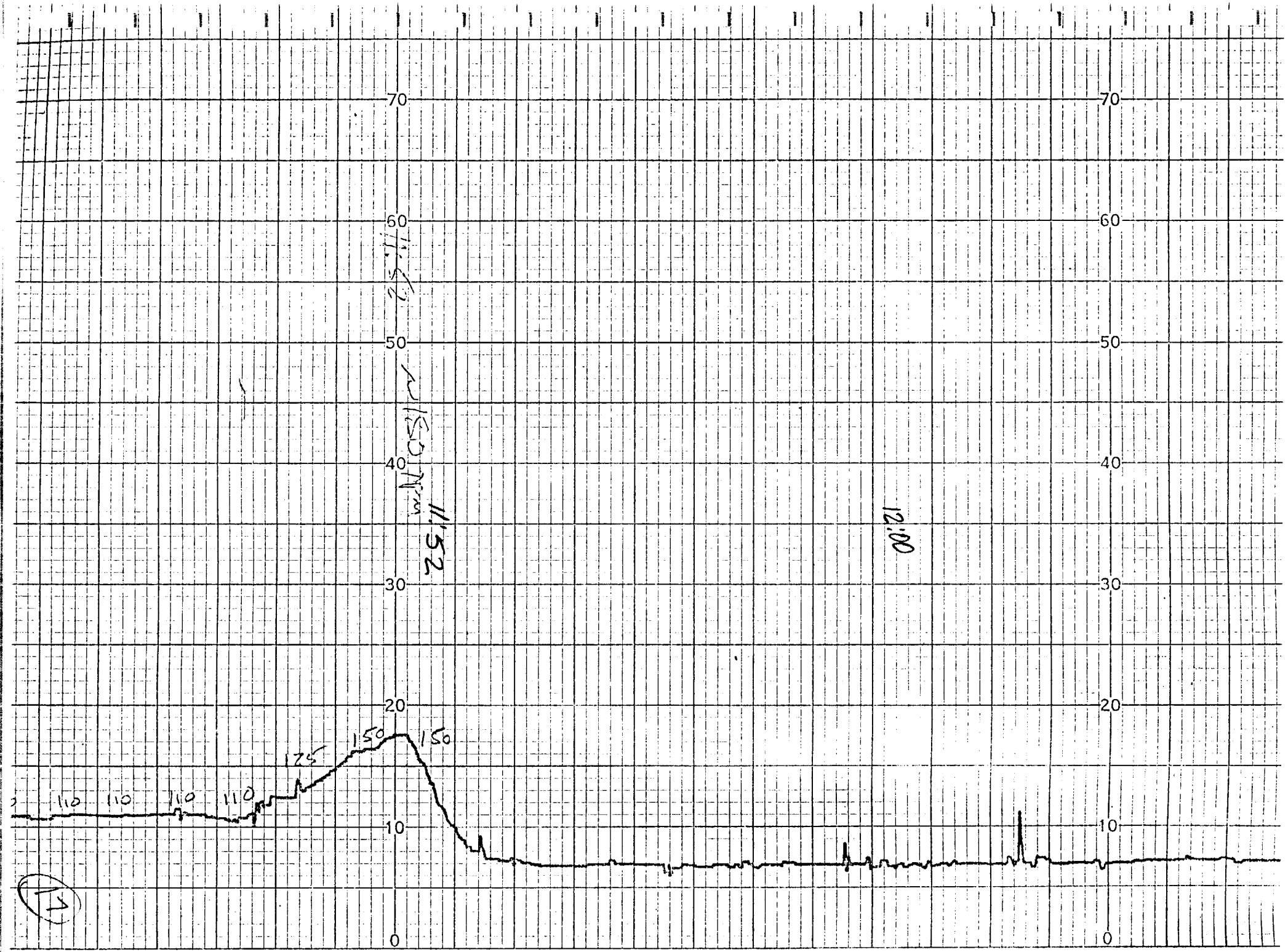



HEATH COMPANY BENTON HARBOR, MICHIGAN CHART NO. 445-17 PRINTED IN U.S.A.


Carbon Monoxide
Run 2
100
90
80
70
60
50
40
30
20
10
0
CO ANALYZER
TEST 2
RANGE 0-1000 ppm
1 sq/min
OPERATOR BRUCE BIRD
(14)

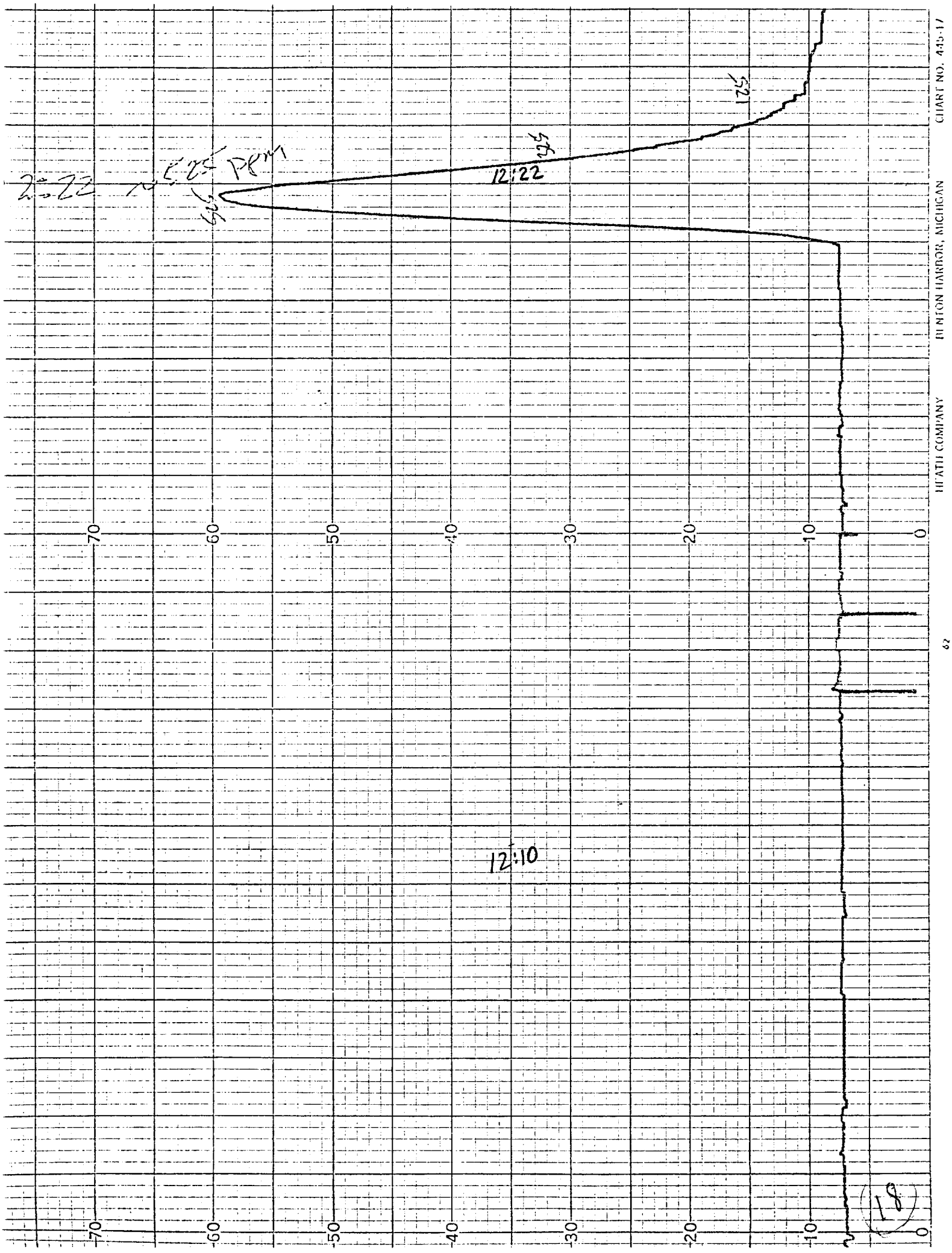

70
60
50
40
30
20
10
0
340
200
11:15
11:25
ATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 445

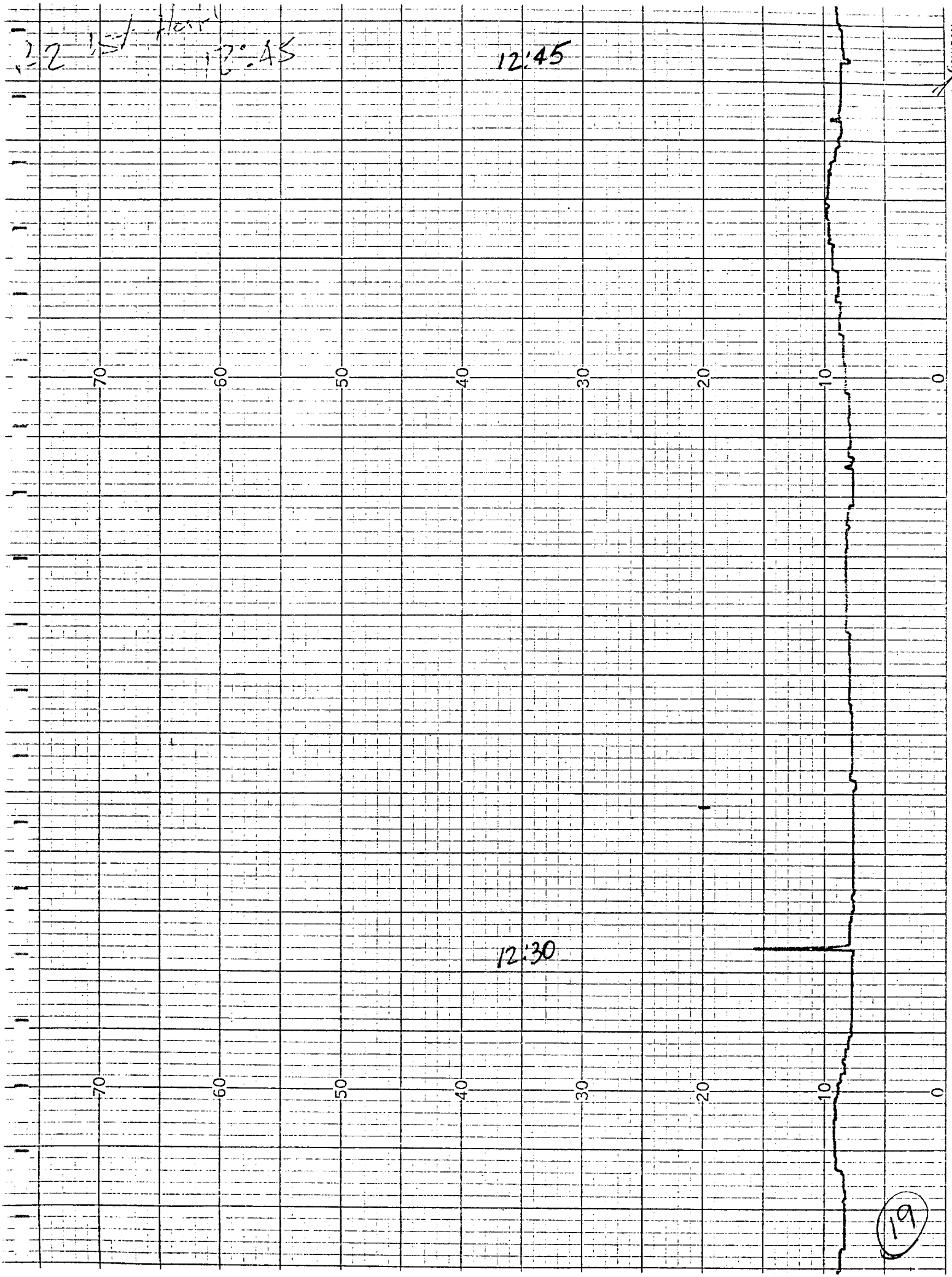

70
60
50
40
30
20
10
0
11:32
11:40
175
150
150
150
125
110
110






HEATH COMPANY BENTON HARBOR, MICHIGAN CHART NO. 445-17 PRINTED IN U.S.A.


2:22 N 625 PPM
12:22
12:10
70
60
50
40
30
20
10
0
CHART NO. 445-17
BENTON HARBOR, MICHIGAN
HEATH COMPANY


12 1st floor 12:45
12:45
12:30
70
60
50
40
30
20
10
0
70
60
50
40
30
20
10
0
BENTON HARBOR, MICHIGAN
HEATH COMPANY
62
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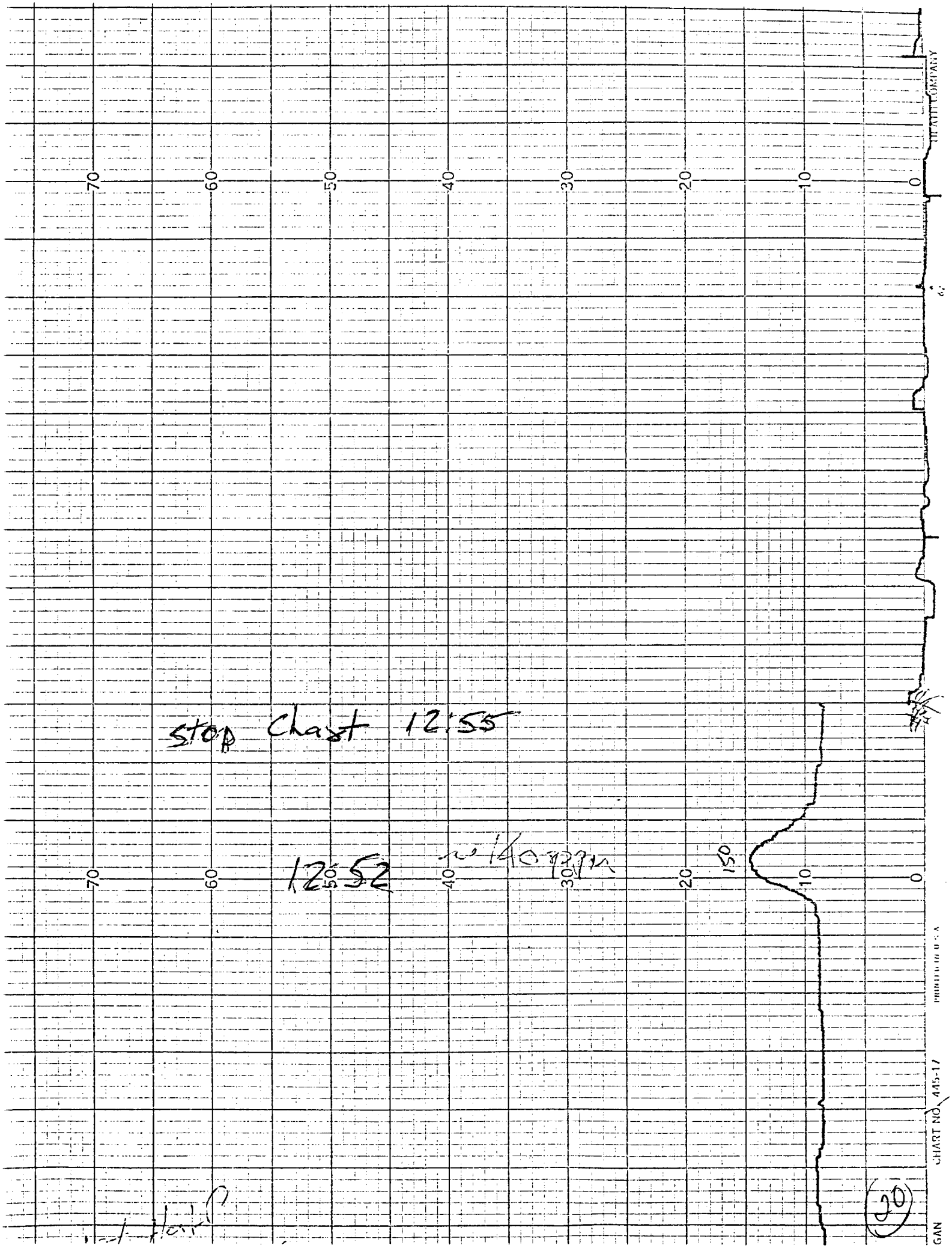
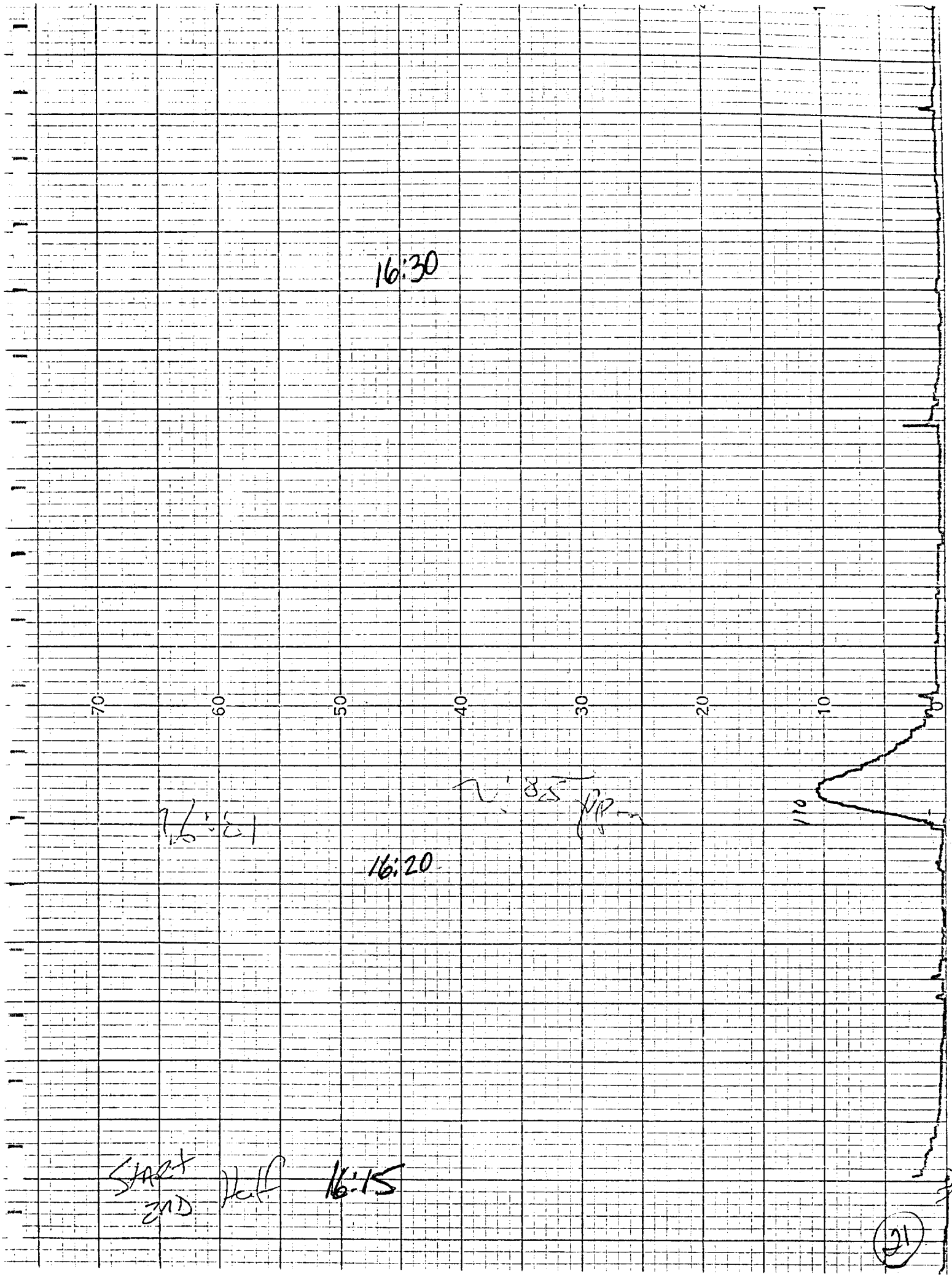
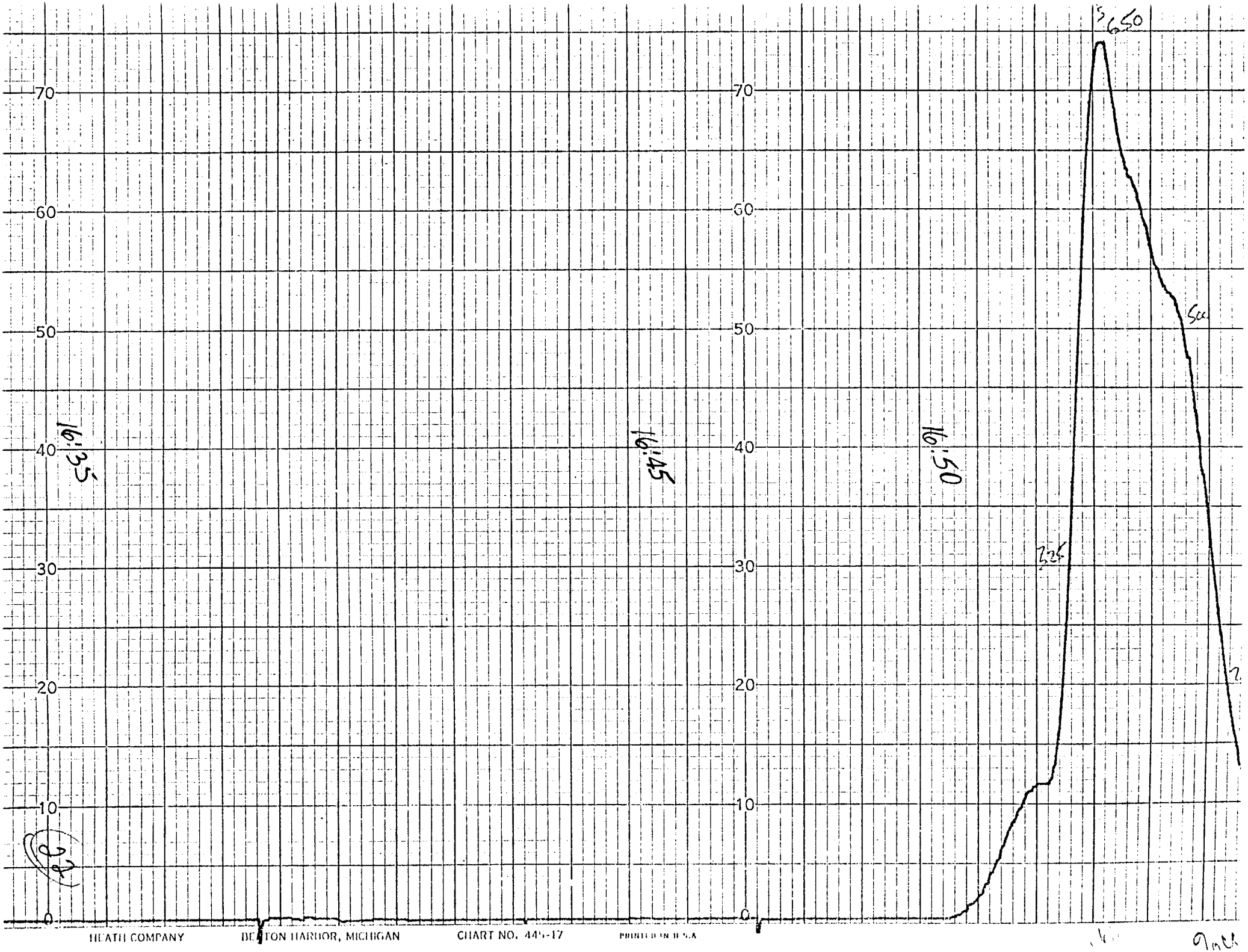
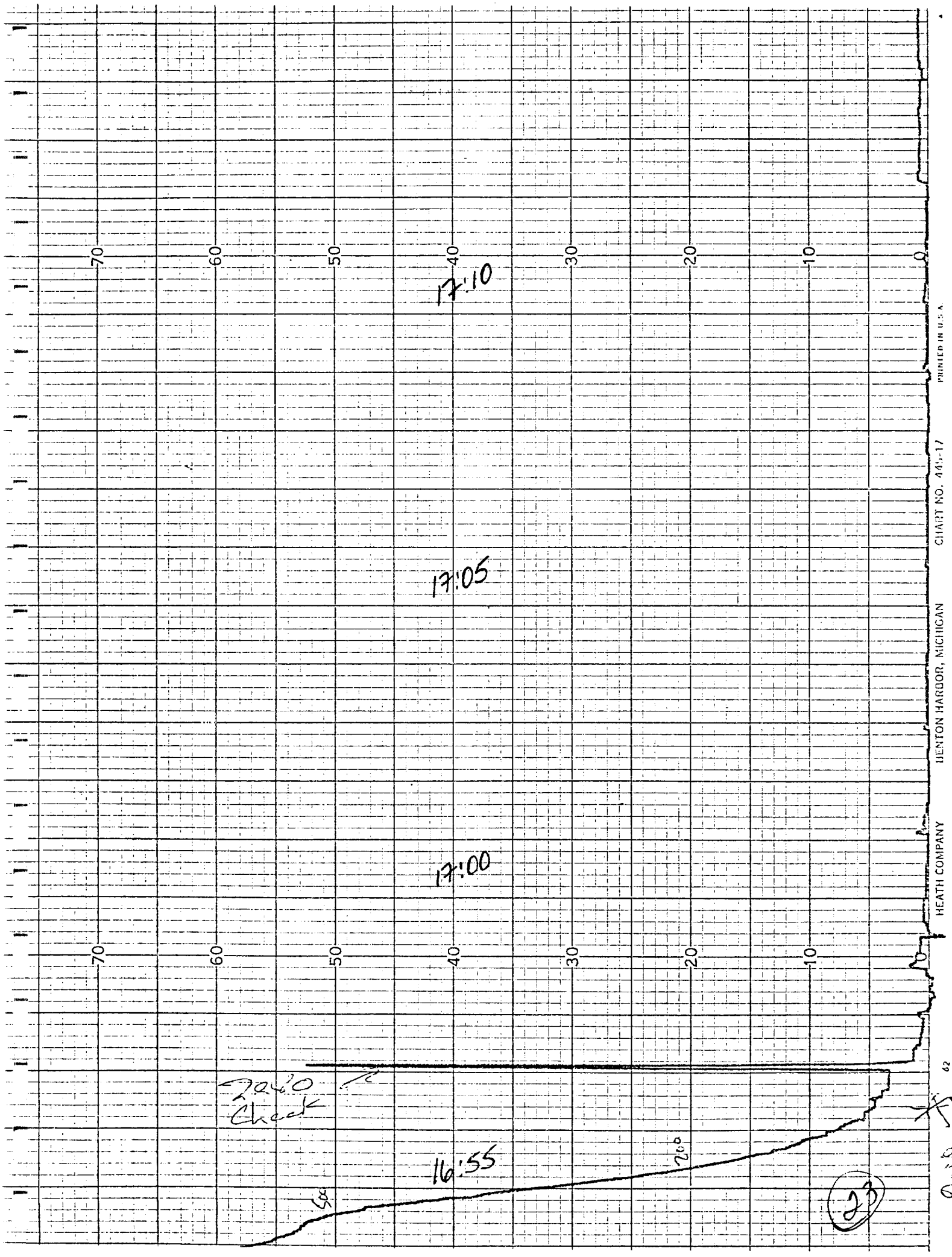
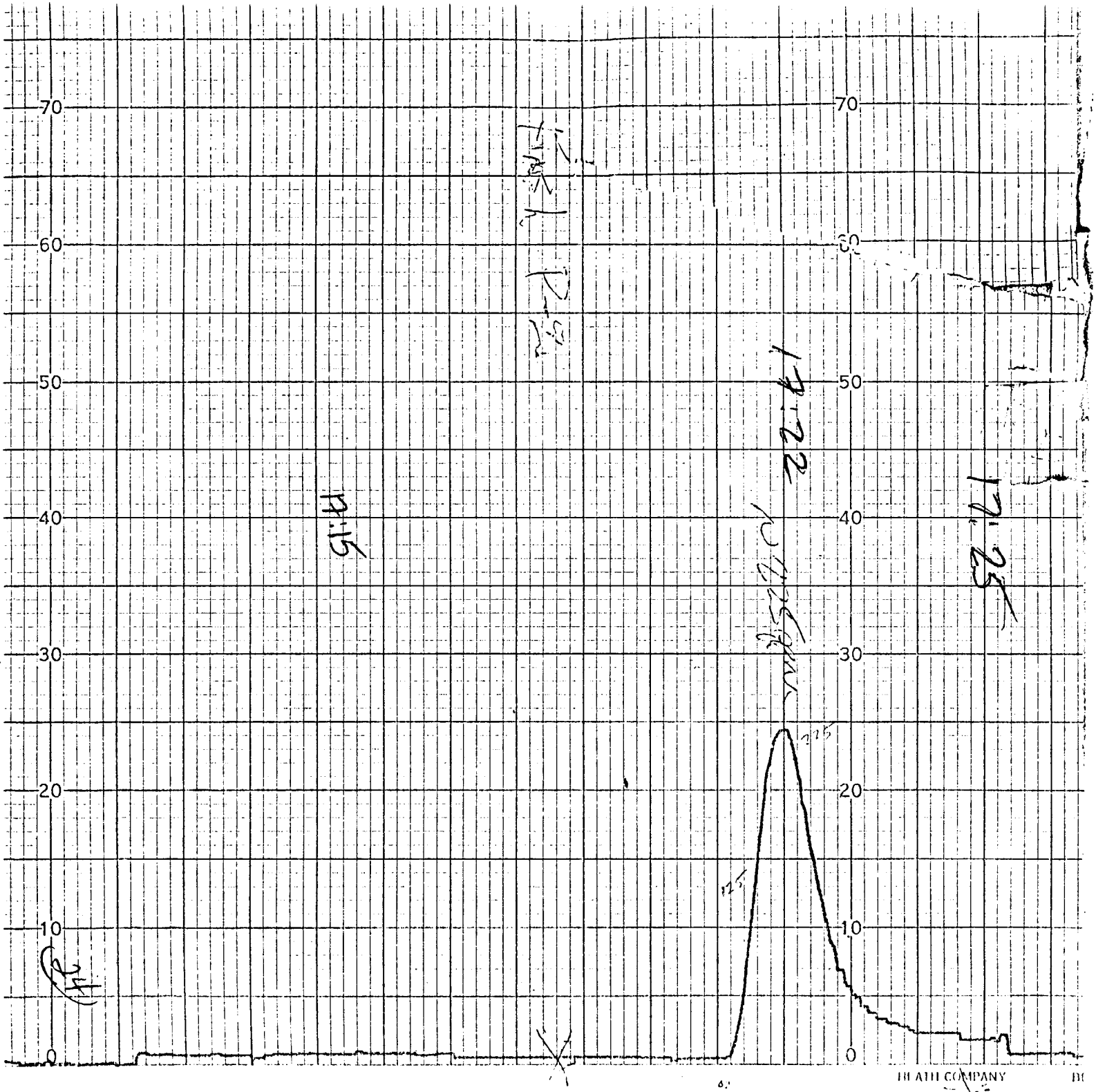
19


70
60
50
40
30
20
10
0
Stop Chart 12:55
12:52
150
CHART NO. 445-17
(20)

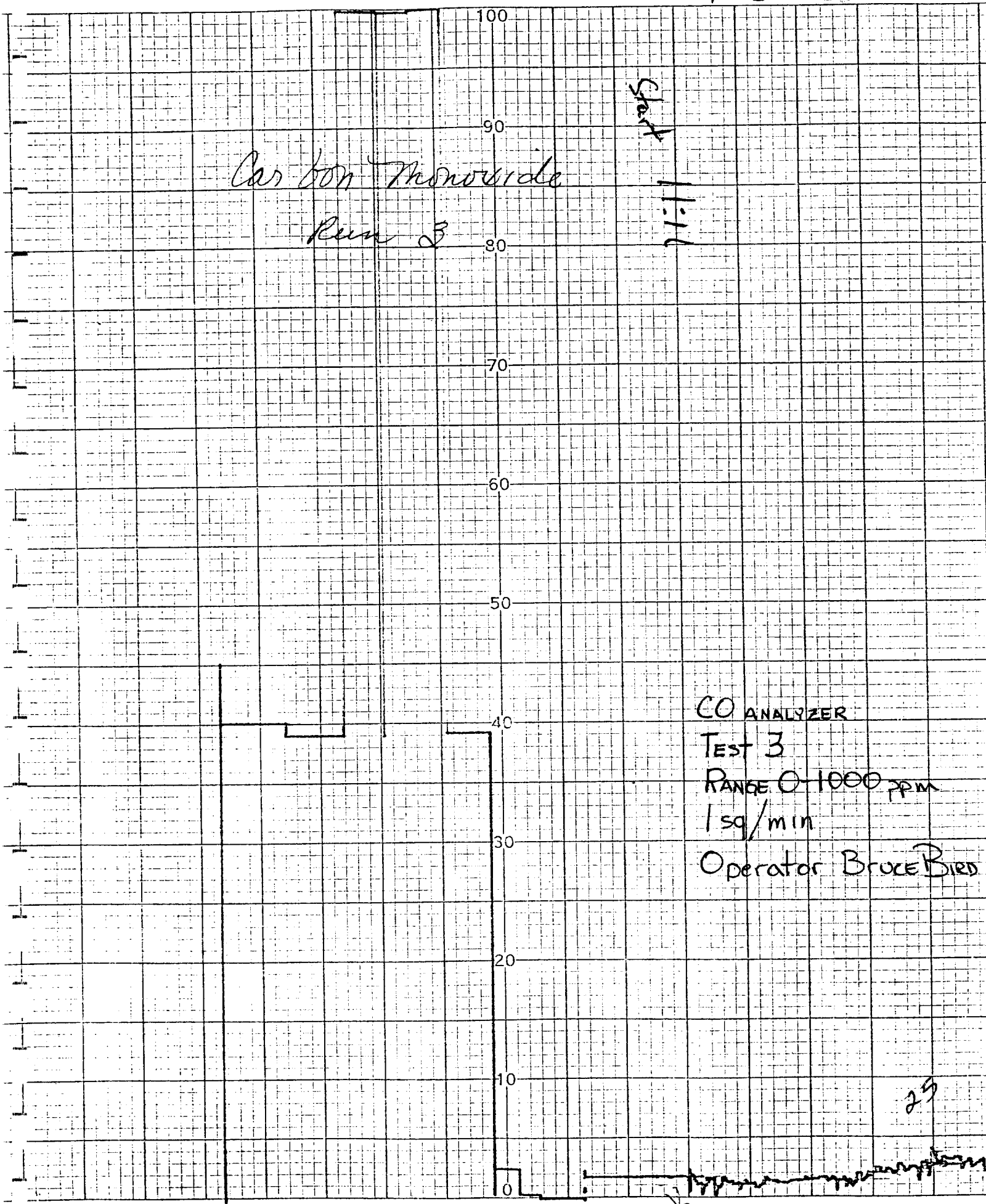

70
60
50
40
30
20
10
0
16:30
16:25
16:20
16:15
START 2ND Half
110
CHART NO. 445-17
BENTON HARBOR, MICHIGAN
PRINTED IN U.S.A.
62
21

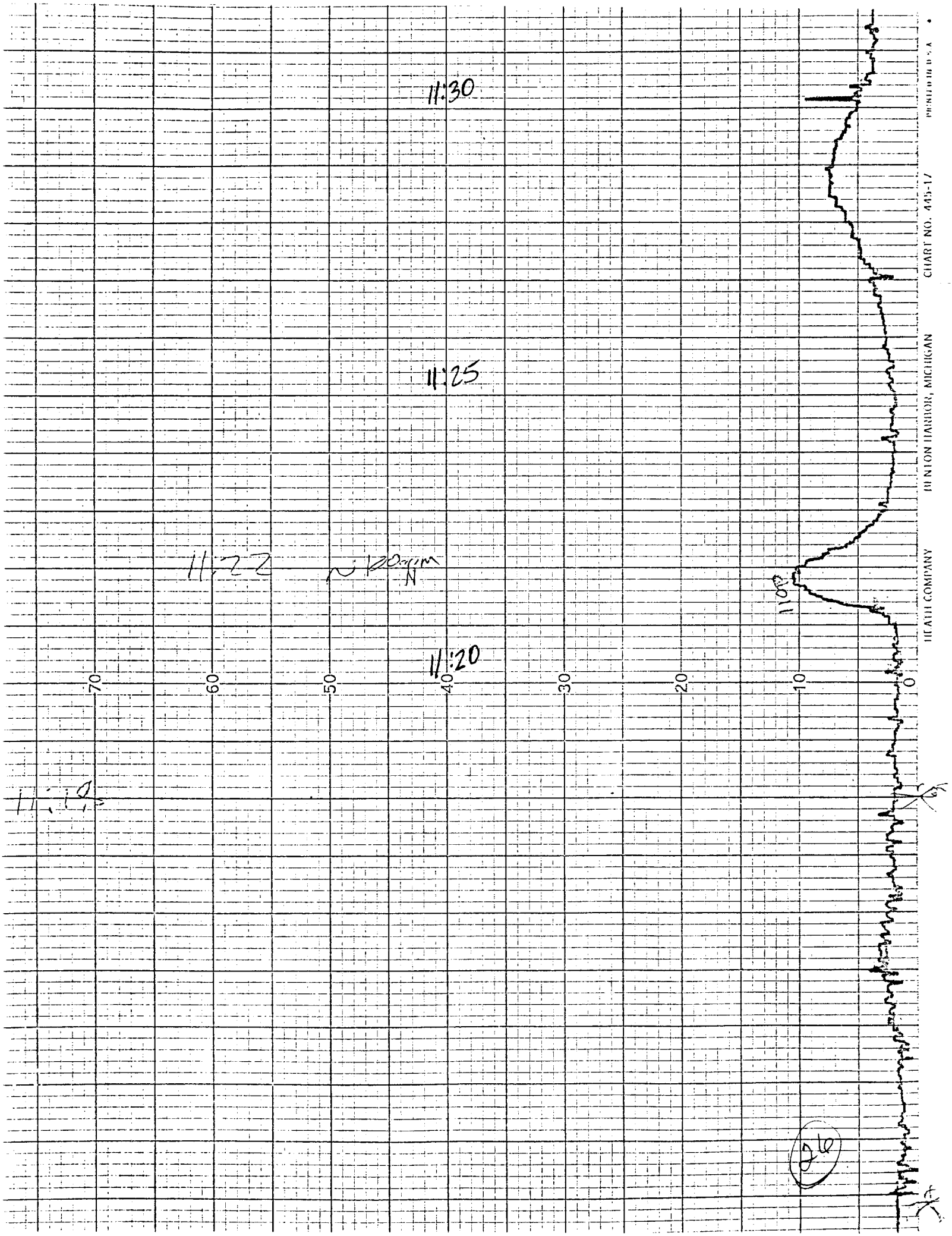

70
60
50
40
30
20
10
0
16:35
16:45
16:50
5:650
5:4
7:24
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 44[illegible]-17
PRINTED IN U.S.A.


70
60
50
40
30
20
10
0
17:10
17:05
17:00
70
60
50
40
30
20
10
0
2010
Check
16:55
50
200
23
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 44-17
PRINTED IN U.S.A.

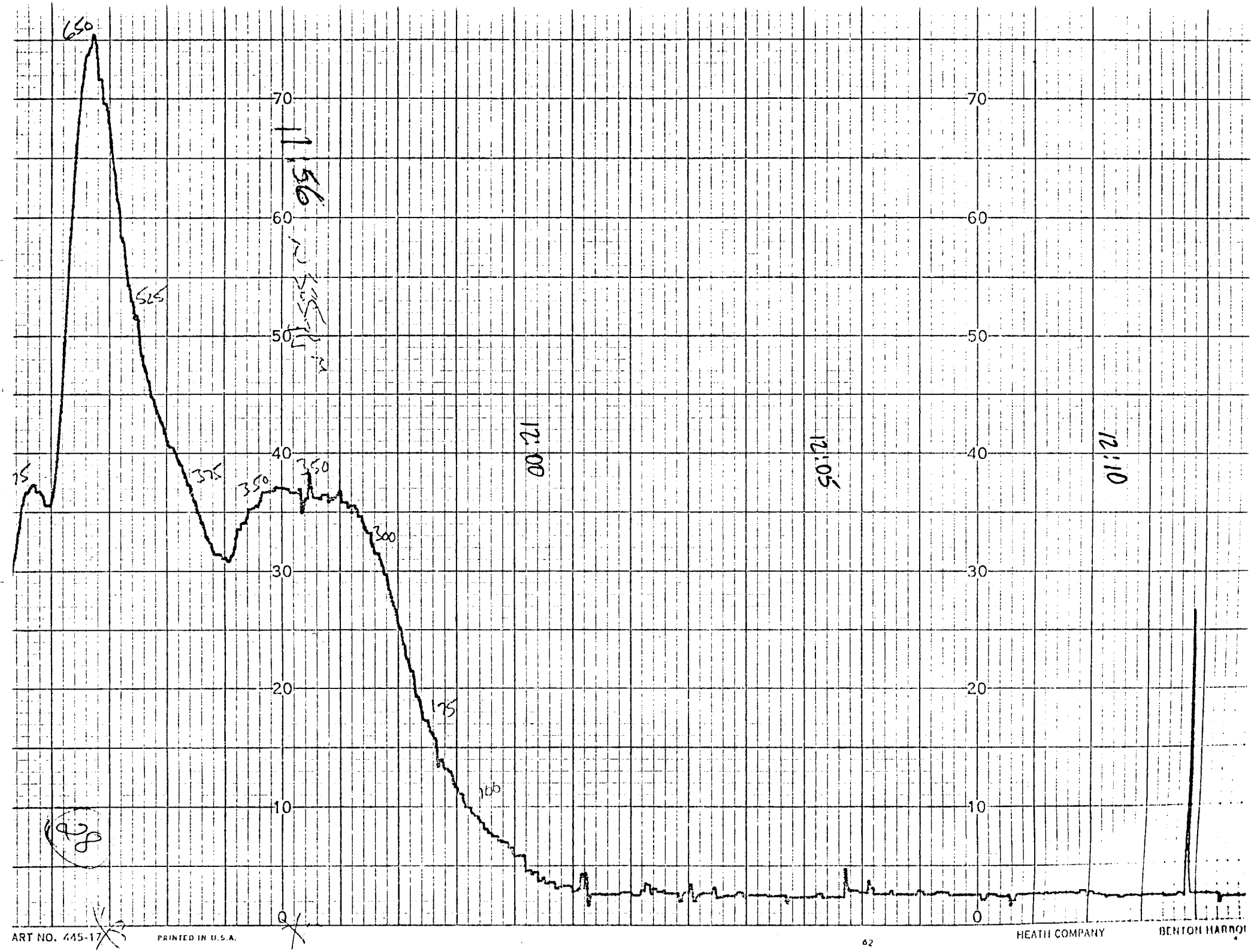

70
60
50
40
30
20
10
0
4:15
14:22
14:25
HEATH COMPANY

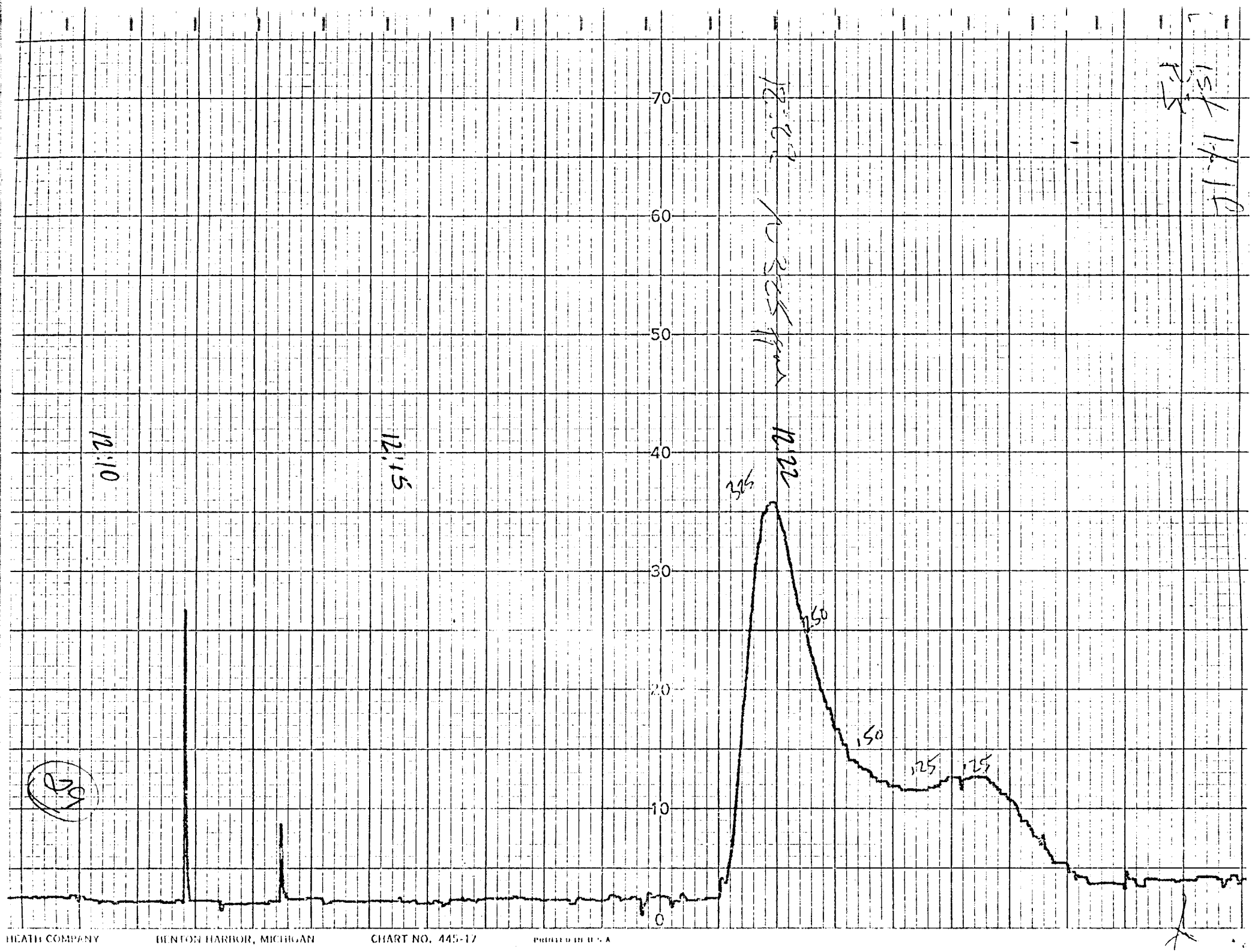
P-3 CO

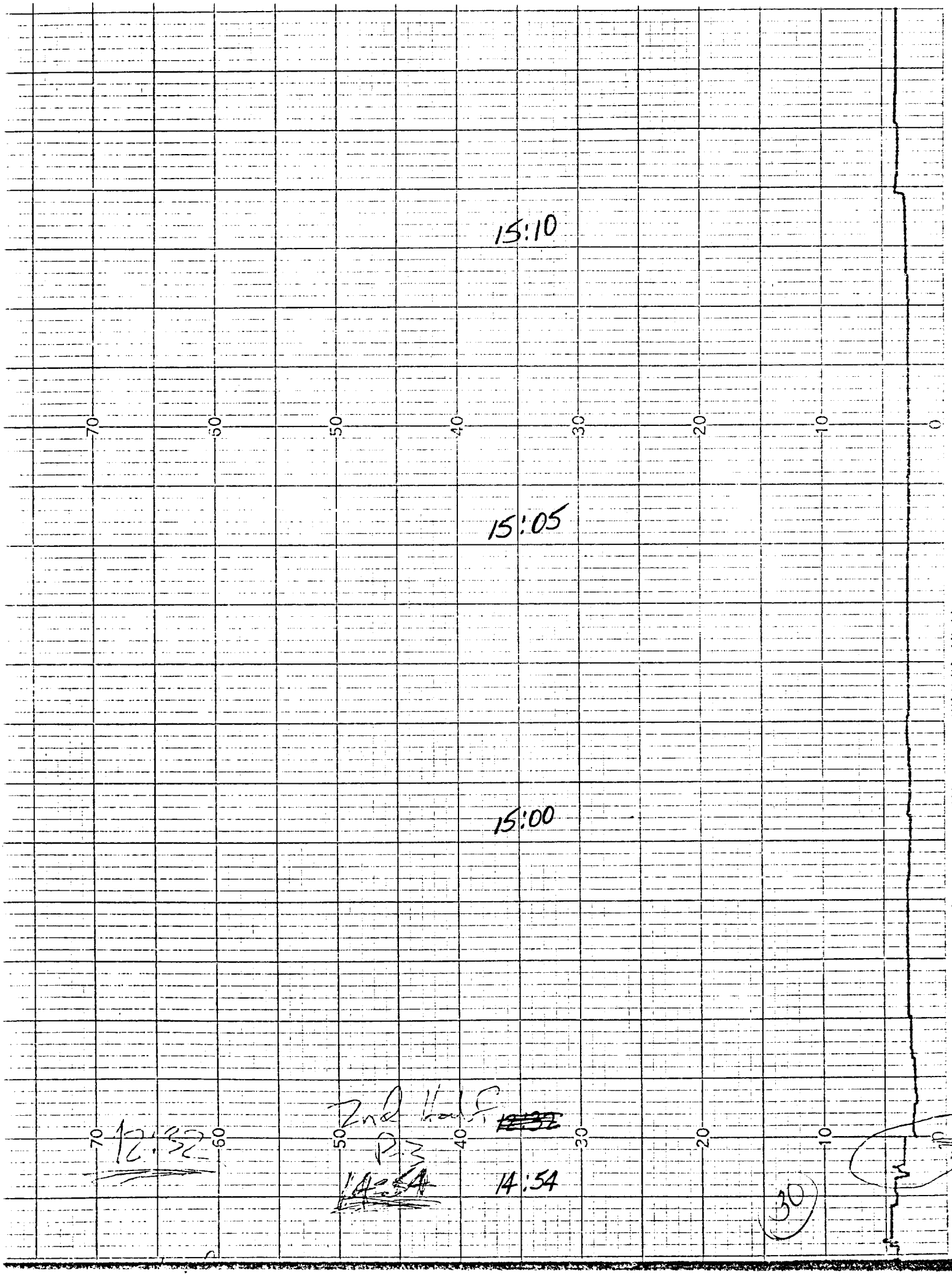

100
90
80
70
60
50
40
30
20
10
0
Carbon Monoxide
Run 3
Start 2:11
CO ANALYZER
TEST 3
RANGE 0-1000 ppm
1 sq/min
Operator Bruce Bird
25

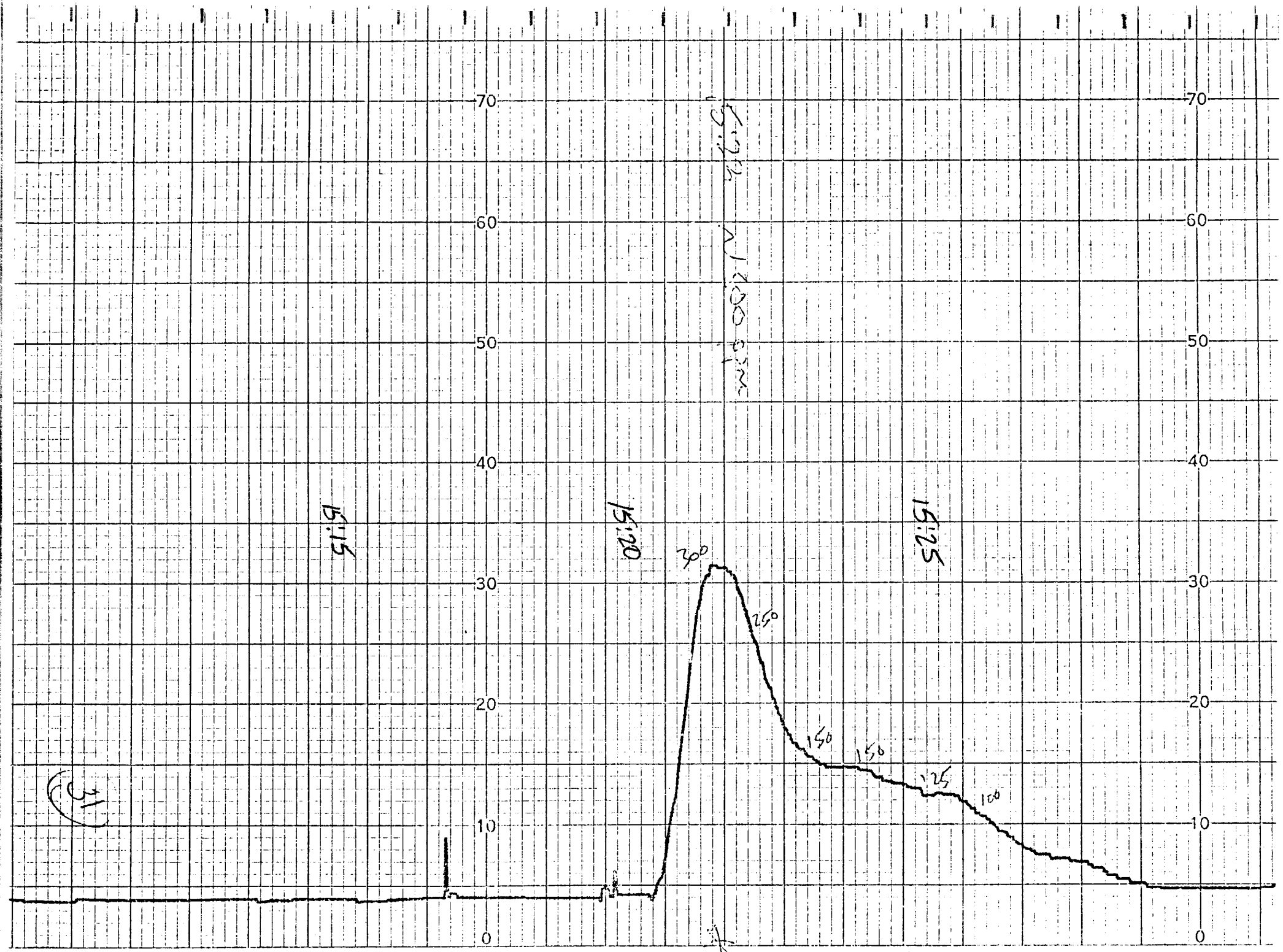

11:30
11:25
11:22
11:20
11:10
70
60
50
40
30
20
10
0
26
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 445-17

70
60
50
40
30
20
10
0
11:35
11:40
11:45
225
450
575
600
650
625
375
375


70
60
50
40
30
20
10
0
650
525
375
350
350
300
175
100
12:00
12:05
12:10
11:56
HEATH COMPANY
BENTON HARBOR
PRINTED IN U.S.A.
62

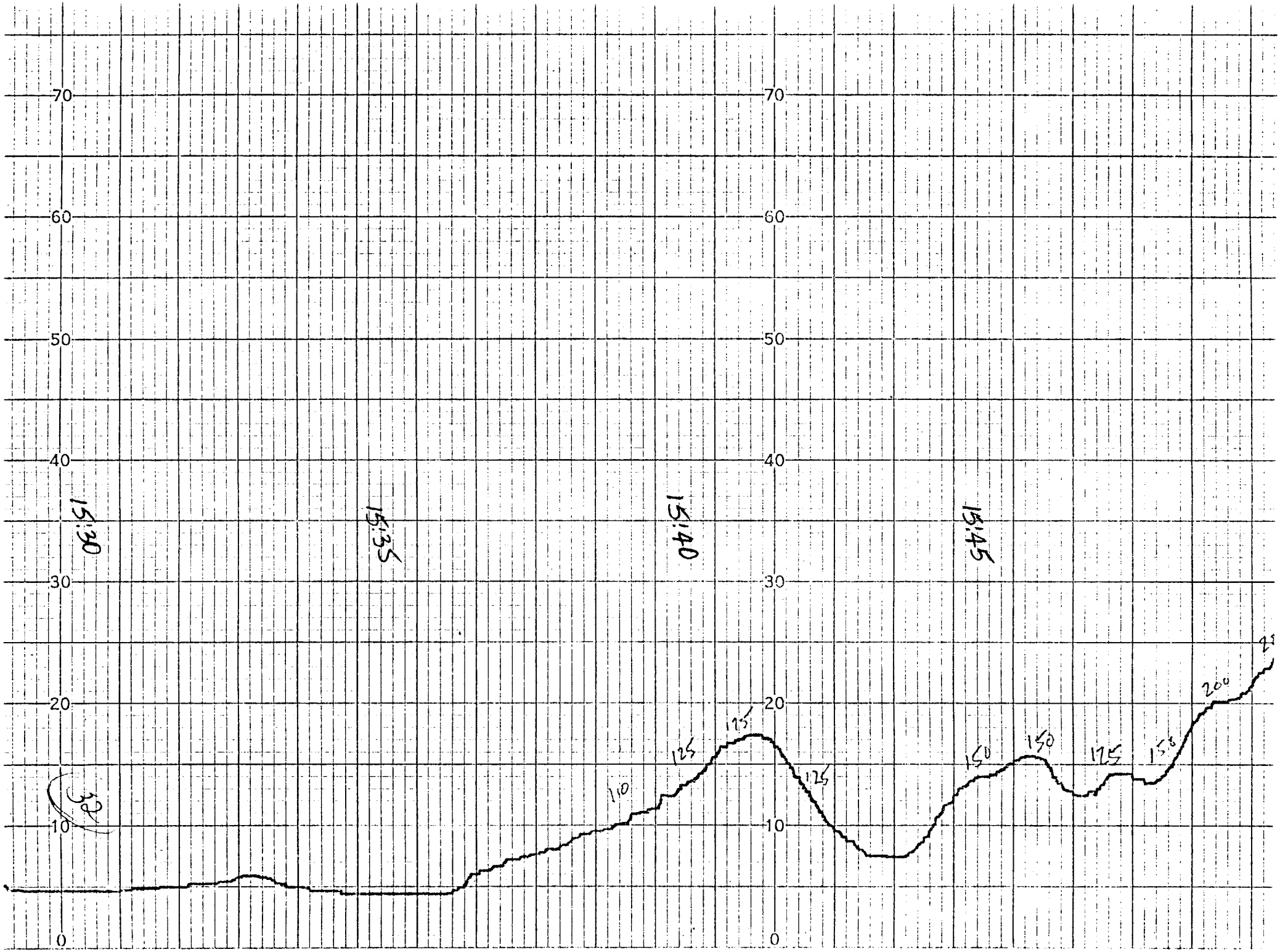

70
60
50
40
30
20
10
0
12:10
12:15
12:22
325
250
150
125
125

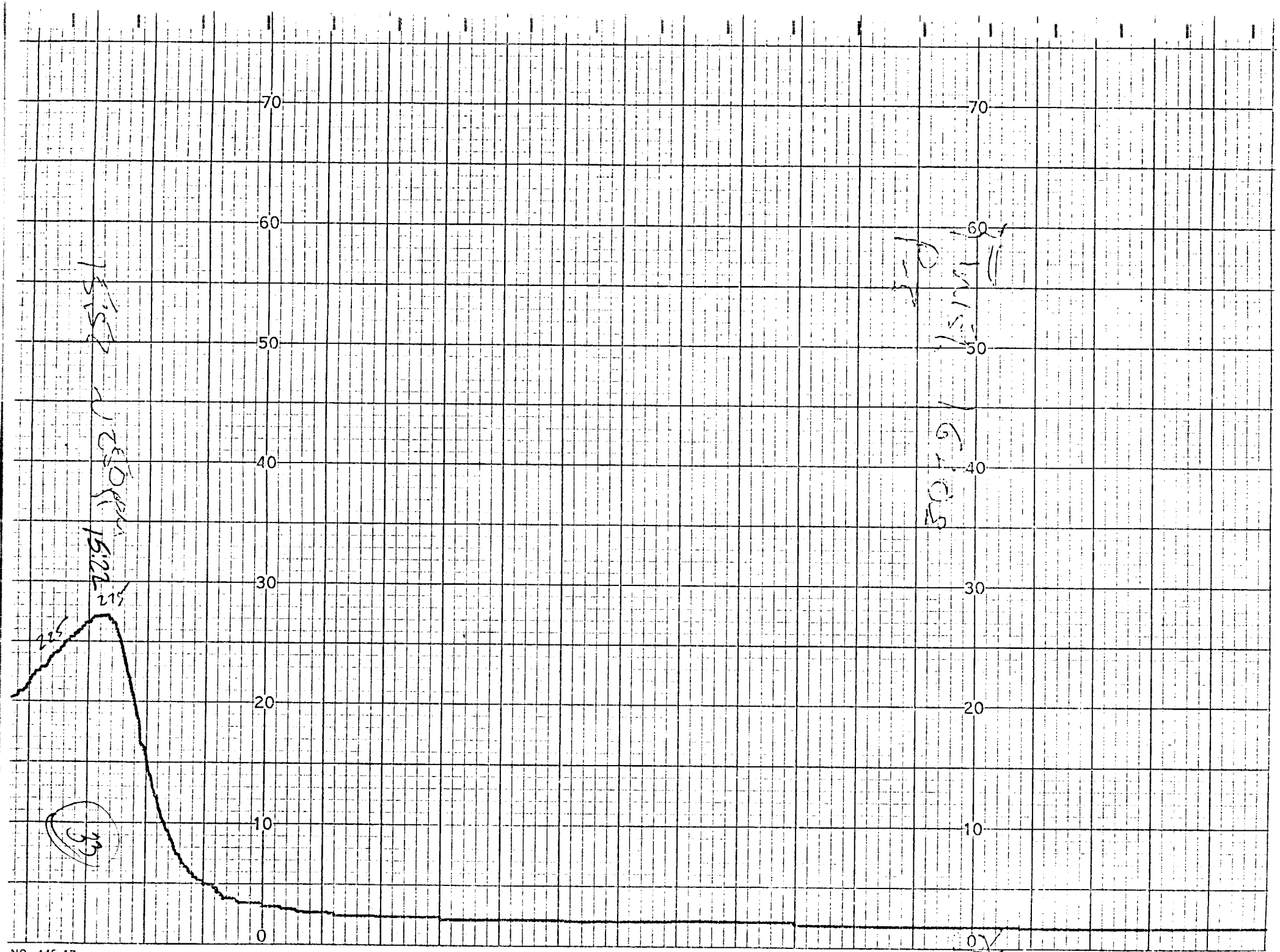

15:10
15:05
15:00
14:54
70
60
50
40
30
20
10
0
2nd half
PM
30
HEATH COMPANY
BENTON HARBOR, MICHIGAN
CHART NO. 44-17






HEATH COMPANY BENTON HARBOR, MICHIGAN CHART NO. 445-17 PRINTED IN U.S.A.


70
60
50
40
30
20
10
0
15:30
15:35
15:40
15:45
32
110
125
175
125
150
150
175
175
200



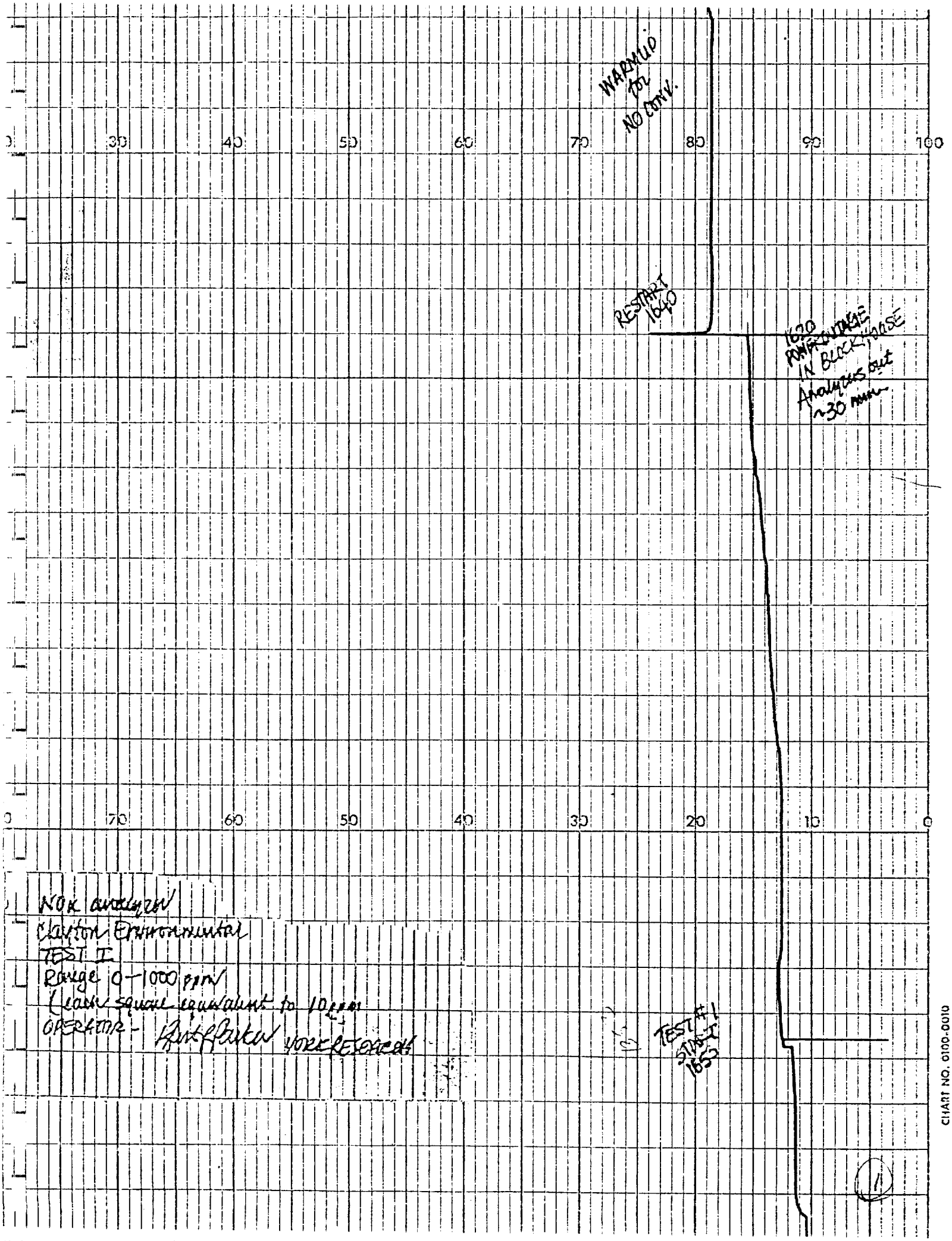

NO. 445-17 PRINTED IN U.S.A.

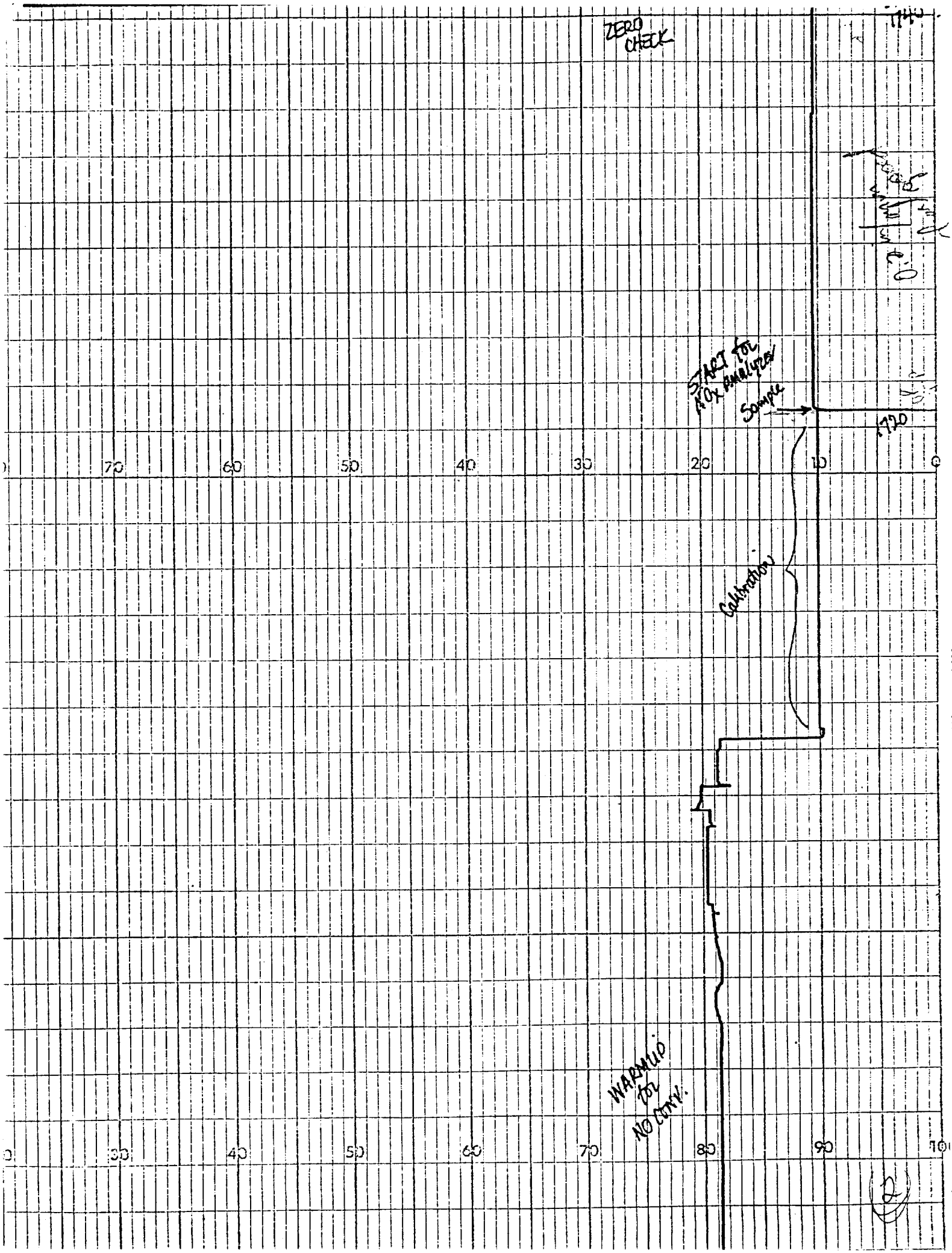


HEATH COMPANY BENTON HARBOR,

# APPENDIX C-2

# NITROGEN OXIDES


WARMUP FOR NO CONV.
RESTART 1640
1620 PARTIALLY IN BLOCKHOUSE
ANOMALOUS OUT ~30 min
TEST #1 START 1652
NOx analyzer
Clayton Environmental
TEST I
Range 0-1000 ppm
(leak squal equivalent to 10 ppm
OPERATOR - Kirk Baker YORK RESEARCH
CHART NO. 0100-0010


ZERO CHECK
START FOR NOx ANALYZER
Sample
Calibration
WARMUP FOR NO CONV.
70
60
50
40
30
20
10
0
30
40
50
60
70
80
90
100

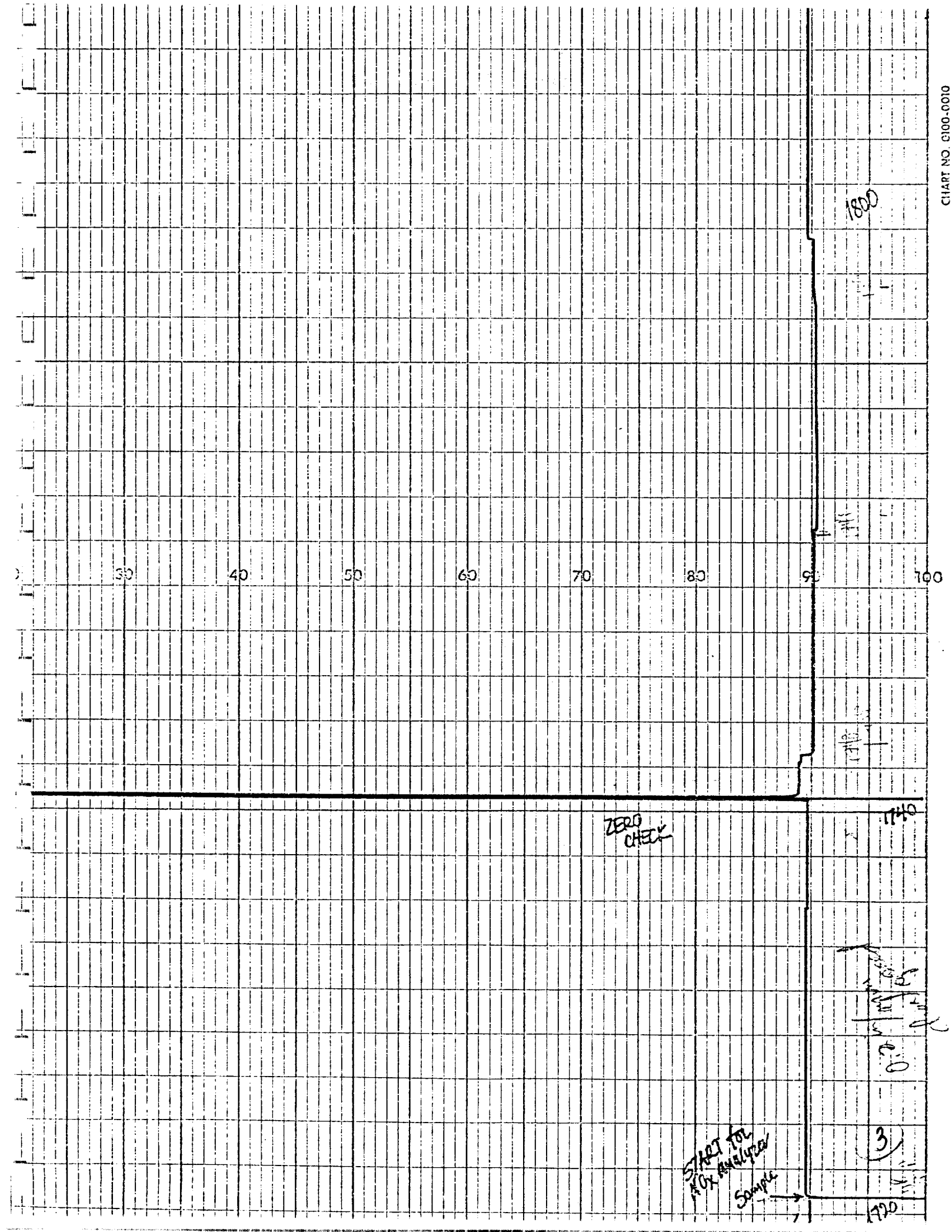
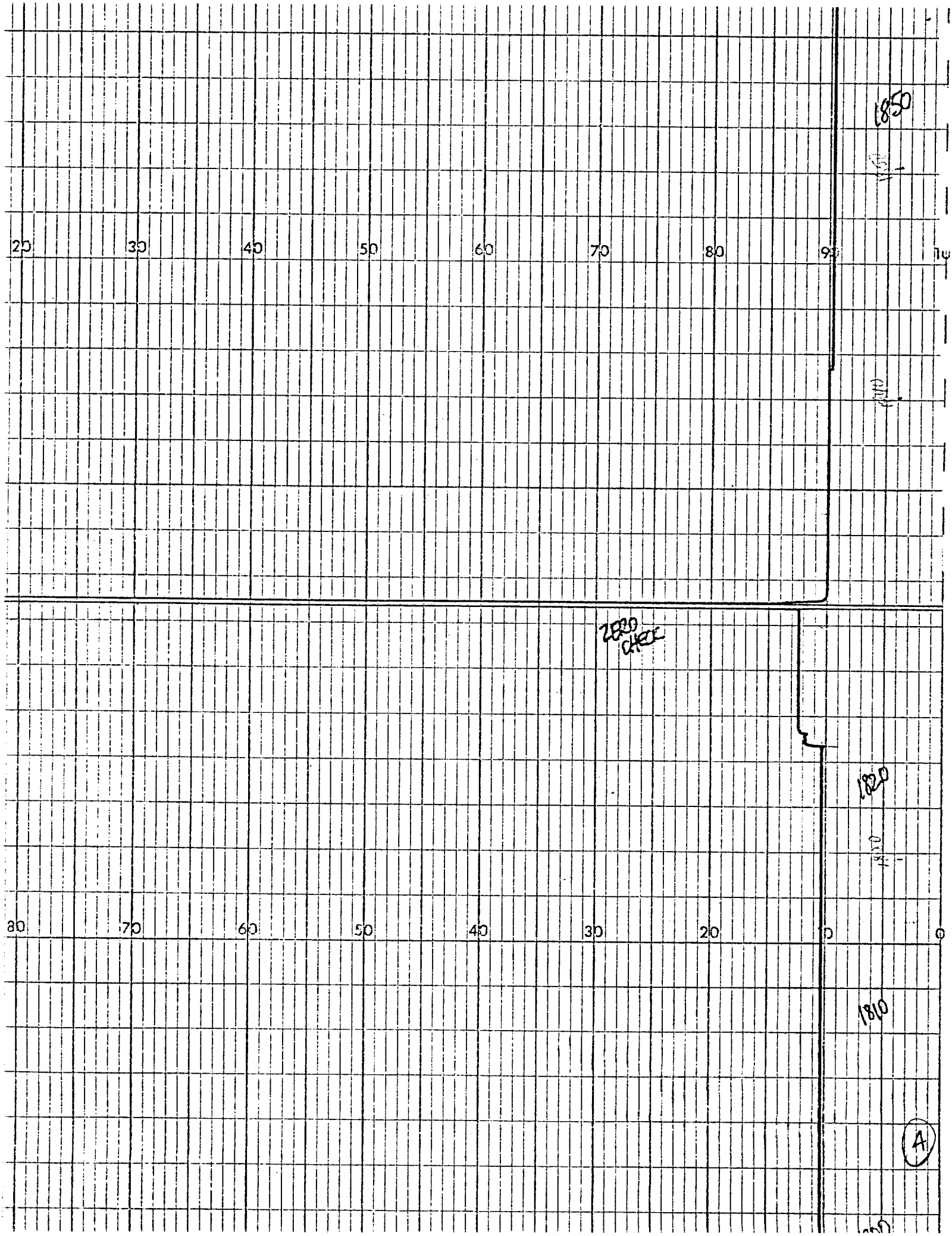
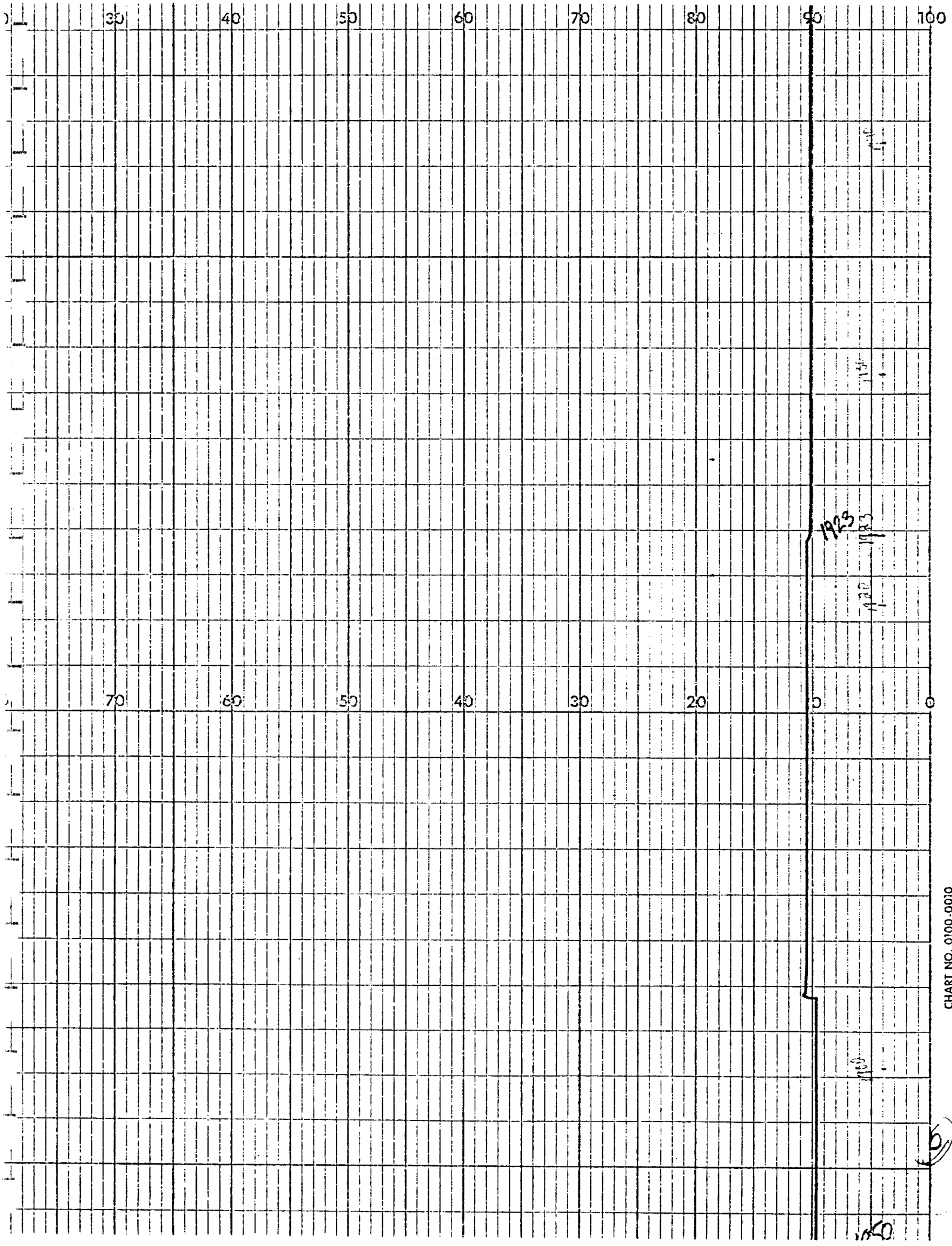
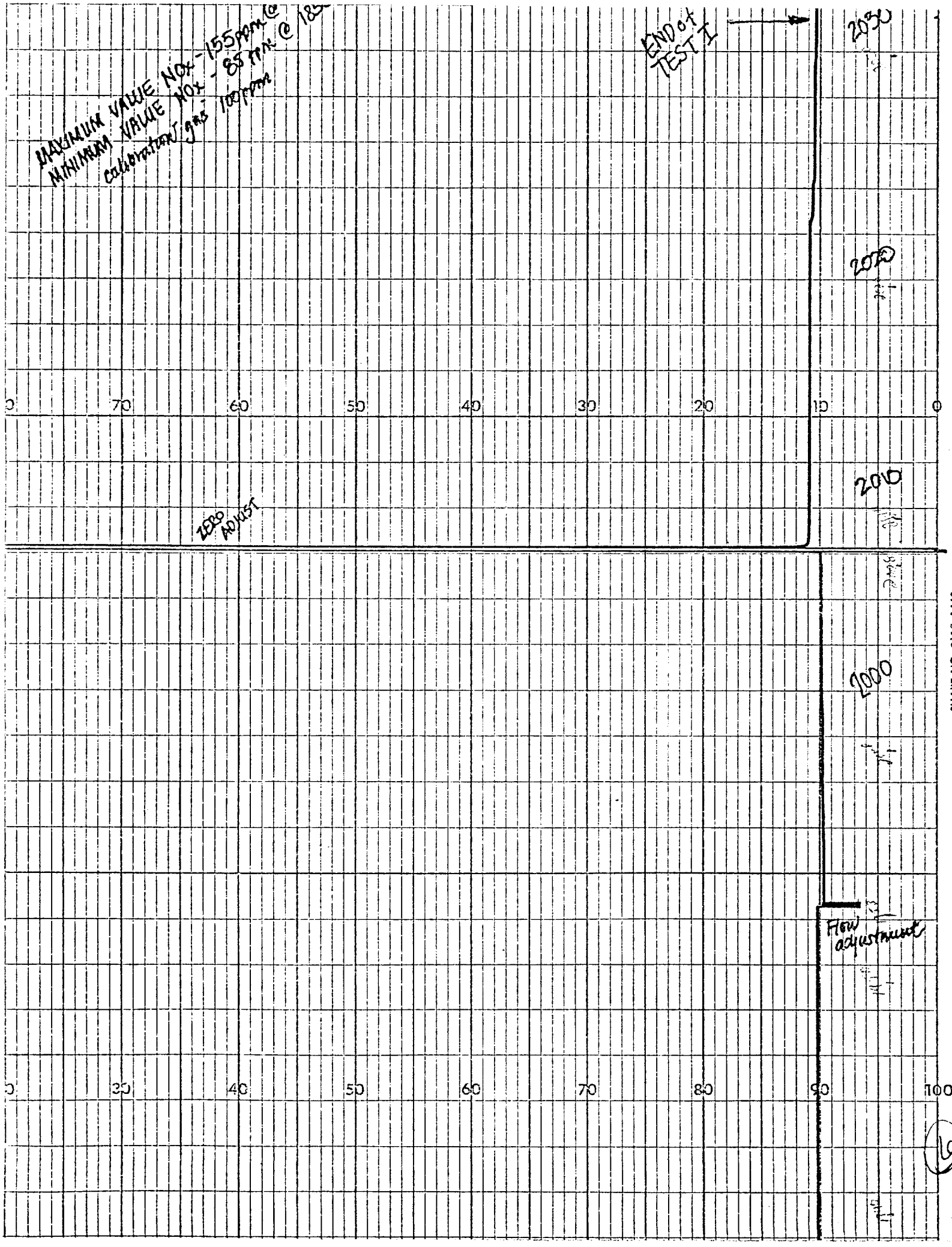
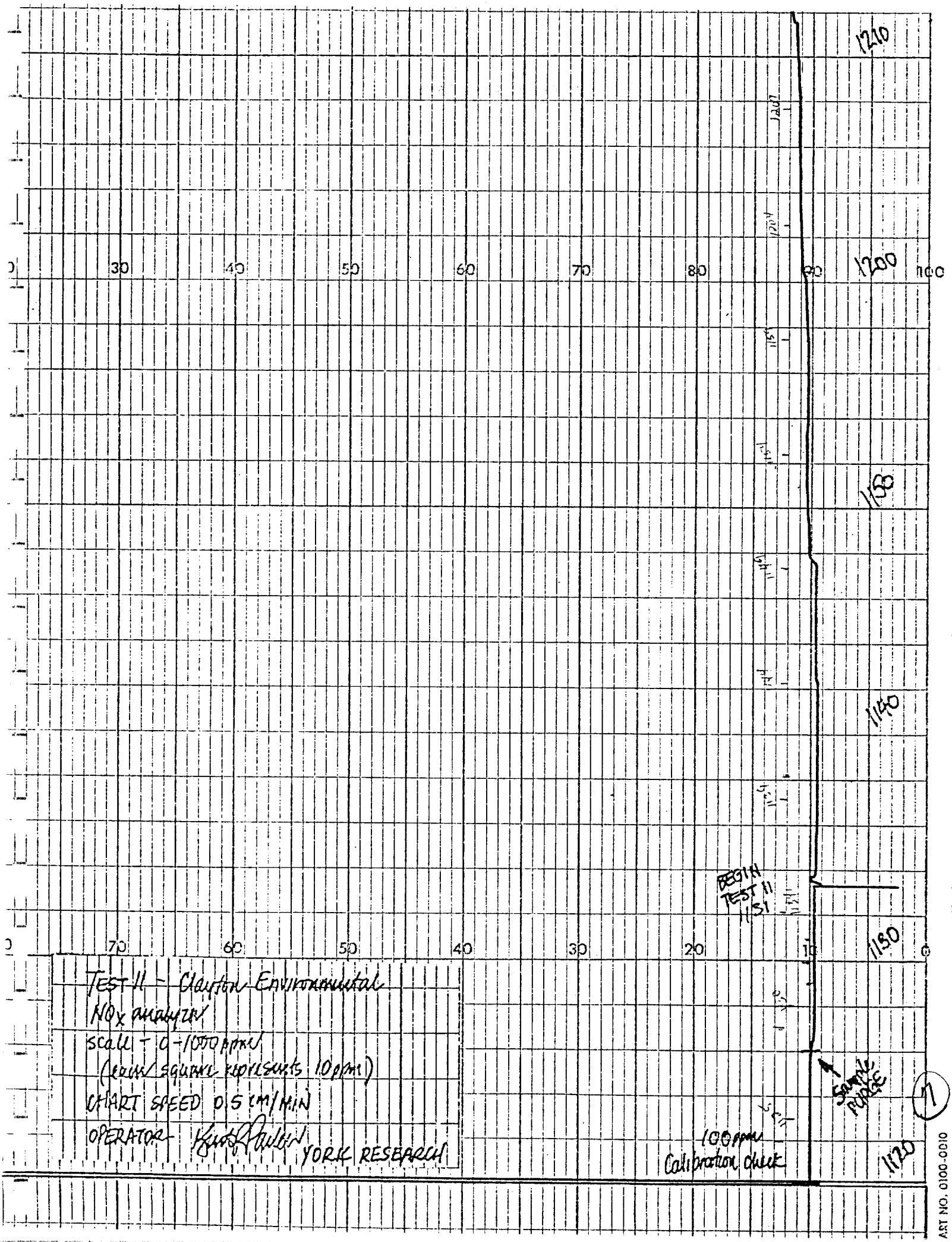


CHART NO. 6100-0010
30
40
50
60
70
80
90
100
1800
1740
ZERO CHECK
START FOR NOx ANALYZER
Sample
1720
3


20
30
40
50
60
70
80
90
1850
2020 check
1820
80
70
60
50
40
30
20
10
0
1810
A

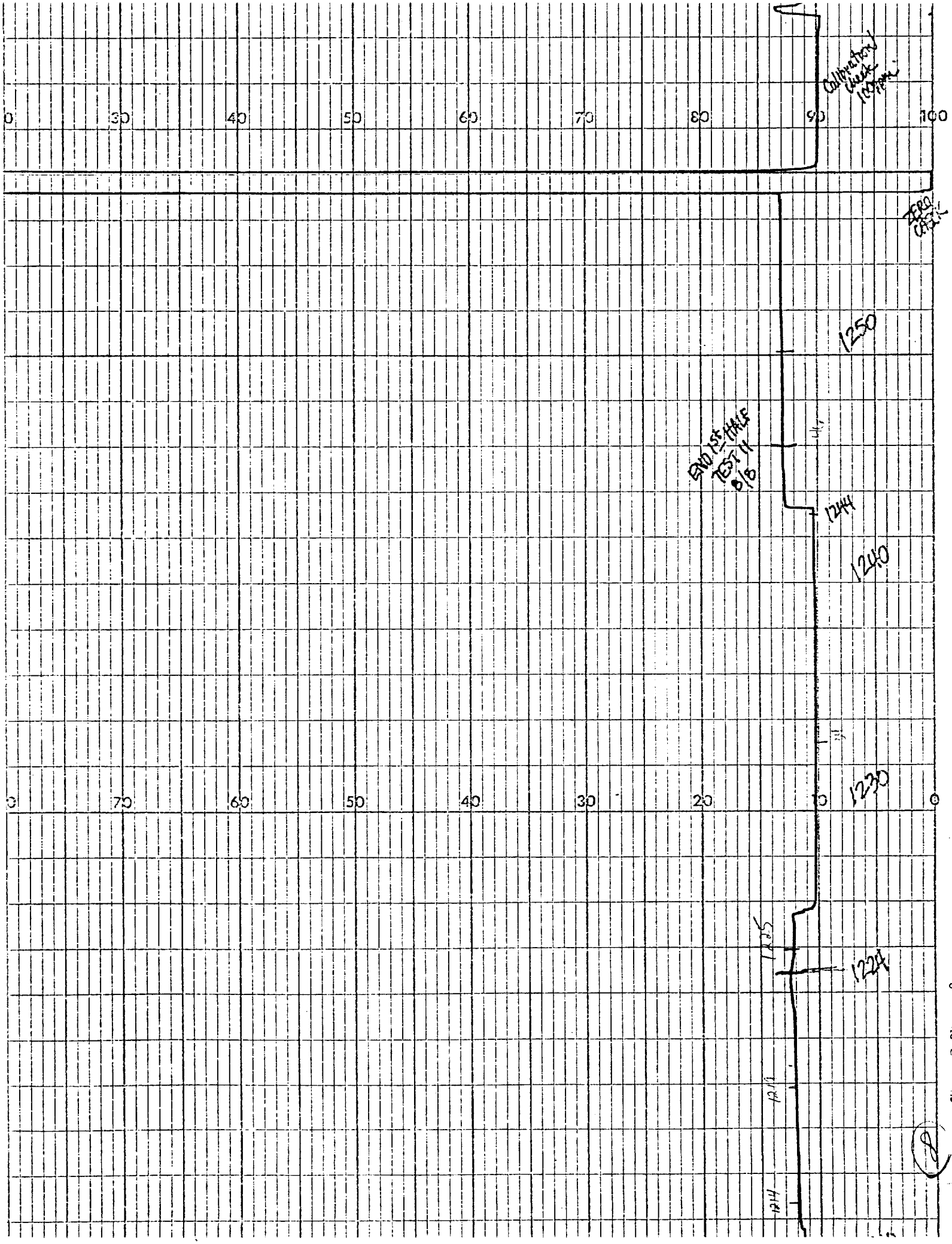

30
40
50
60
70
80
90
100
1923
70
60
50
40
30
20
10
0
CHART NO. 0100-0010

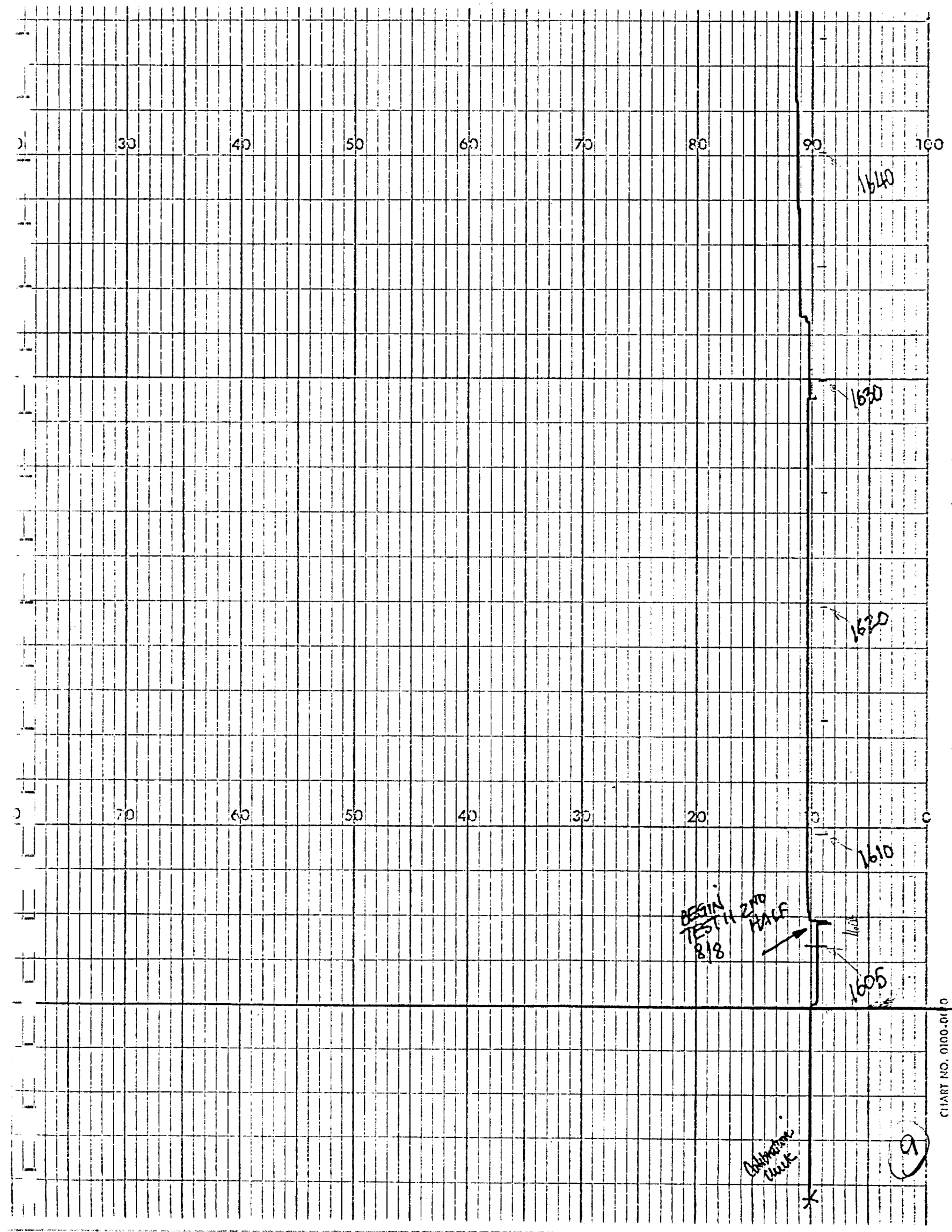

MAXIMUM VALUE NOx - 155ppm @
MINIMUM VALUE NOx - 85 ppm @ 18
calibration gas 100ppm
END of TEST I
2030
2020
2010
2000
70
60
50
40
30
20
10
0
ZERO ADJUST
Flow adjustment
40
50
60
70
80
90
100

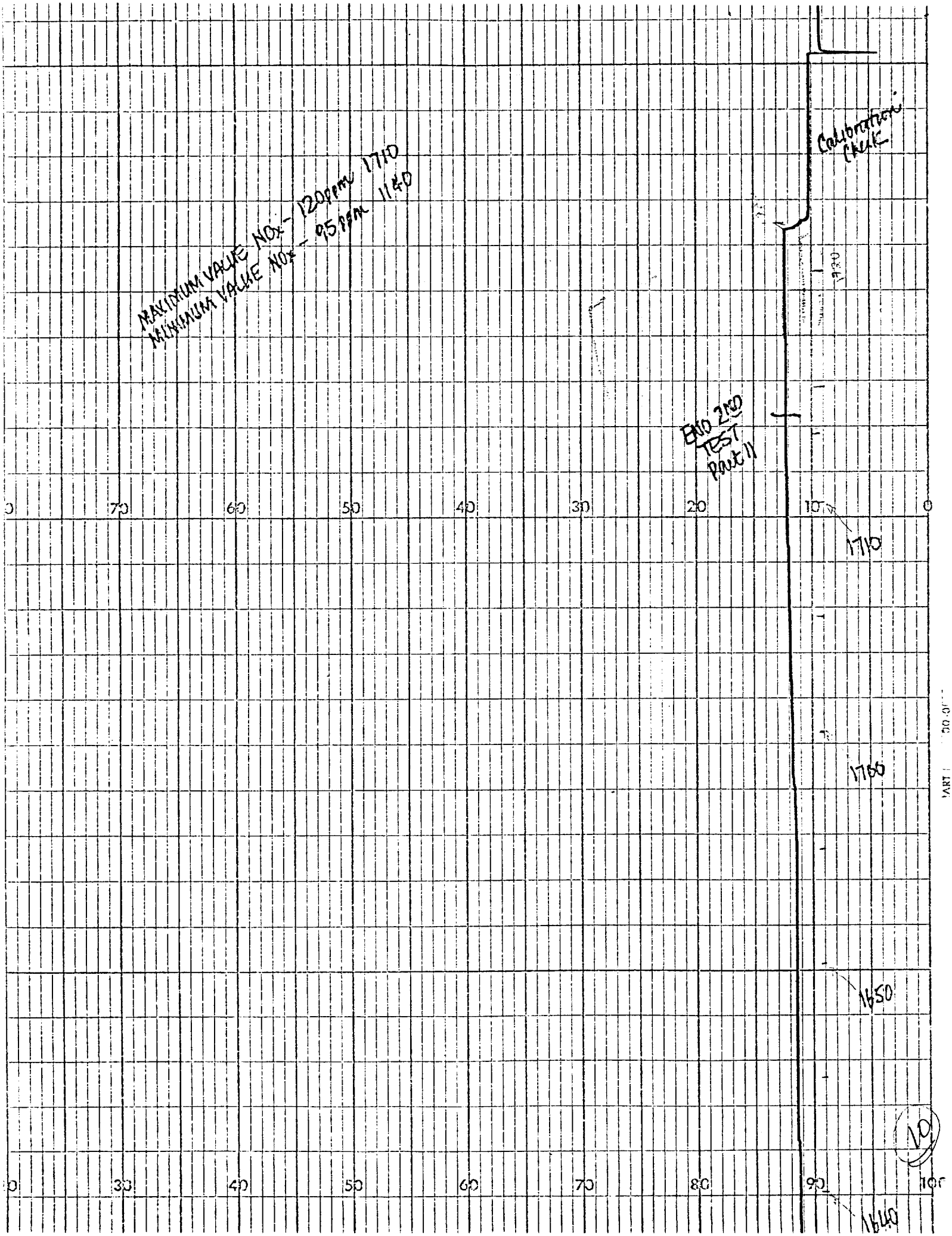


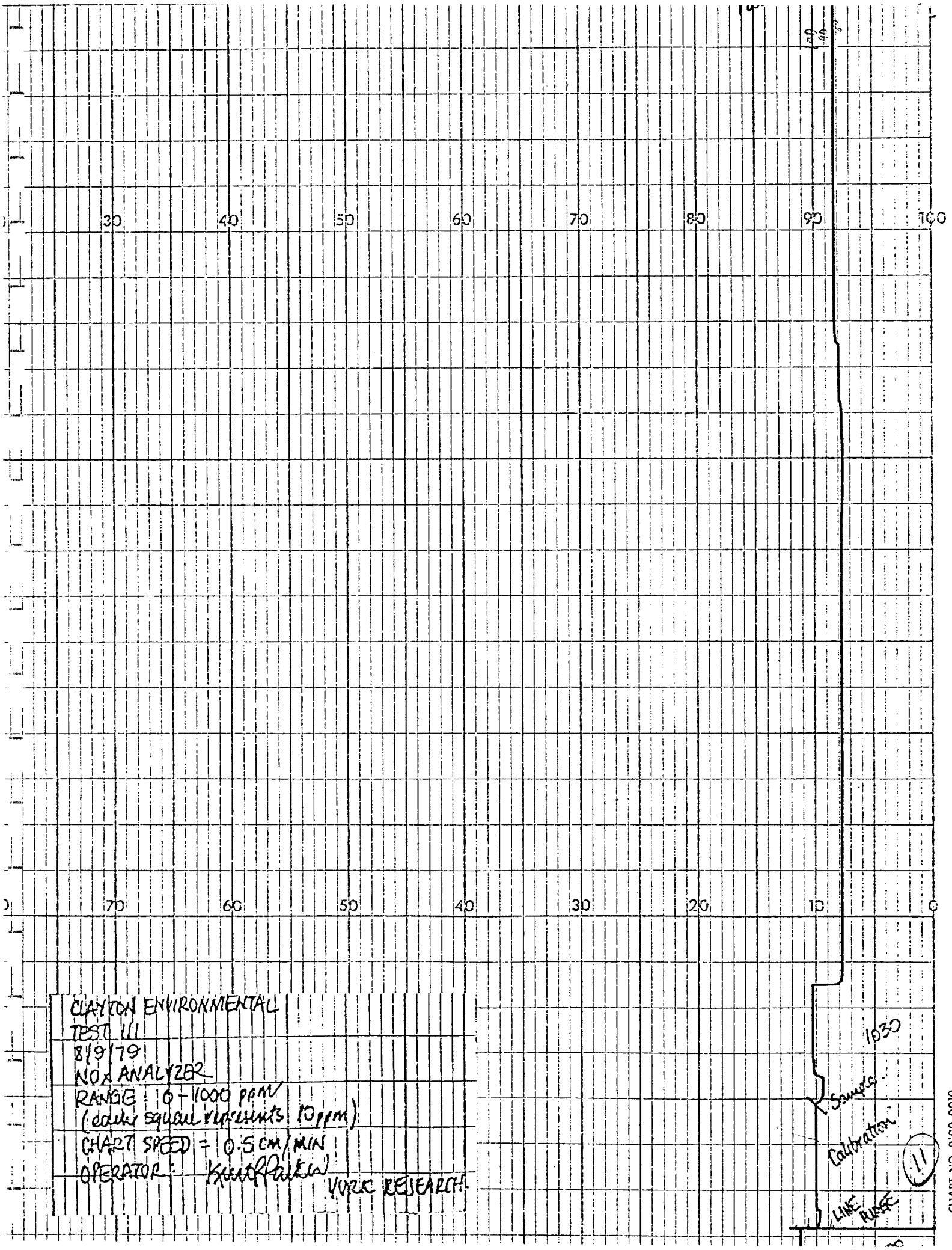

7

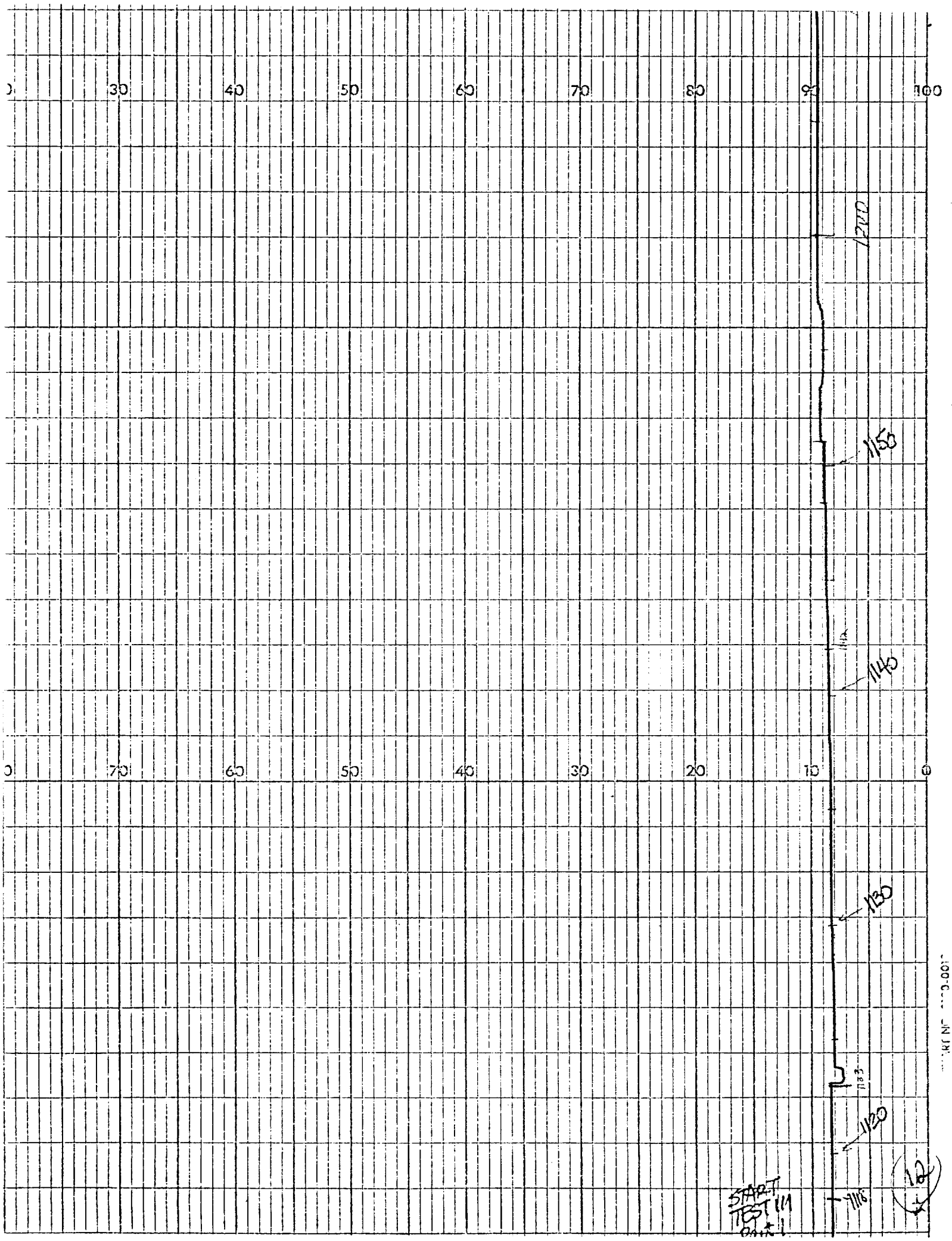
ART NO. 000-0010

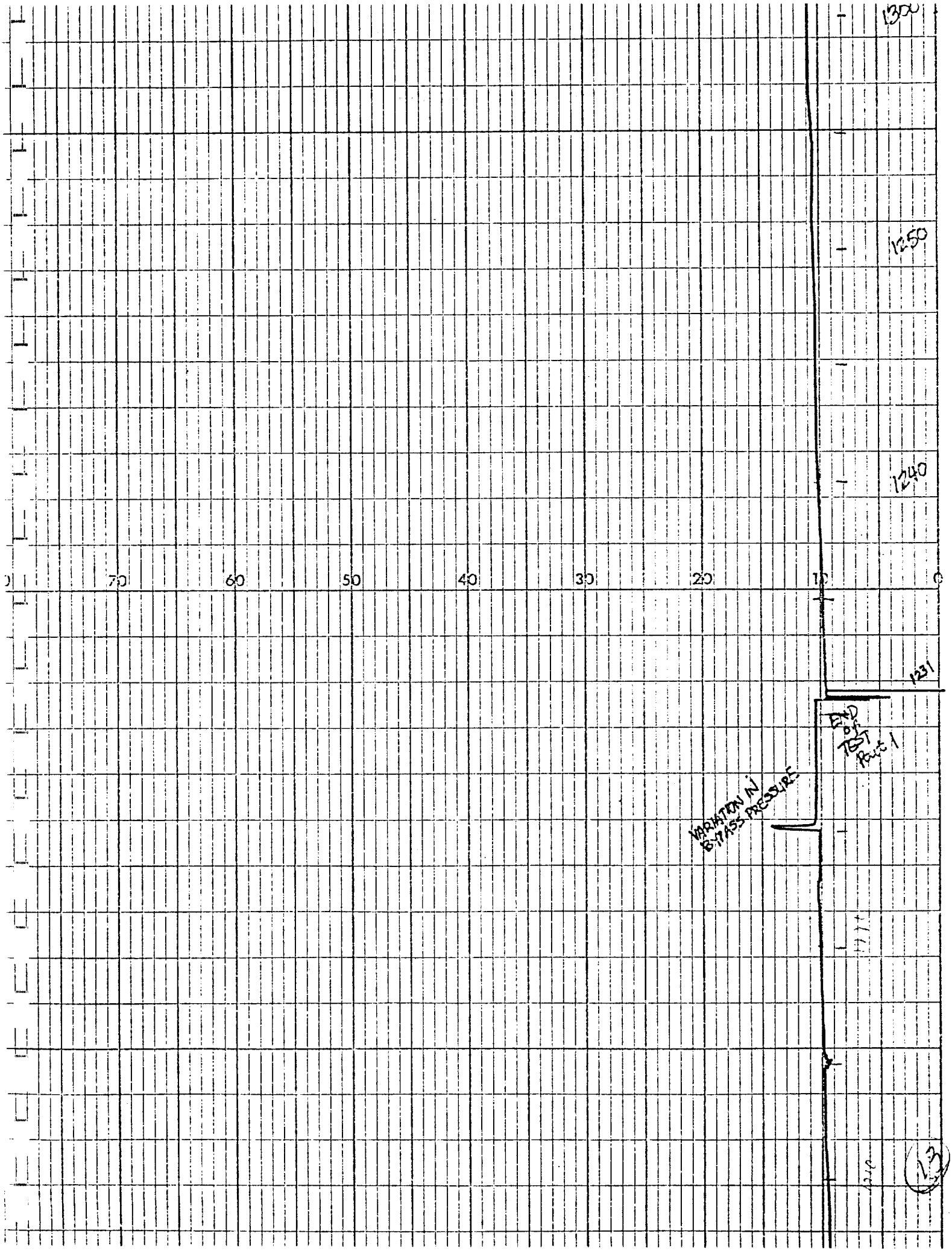

0
30
40
50
60
70
80
90
100
Calibration check 100 ppm
ZERO CHECK
1250
END 1ST HALF TEST 11 8/6
1244
1240
1230
0
70
60
50
40
30
20
10
0
1225
1224

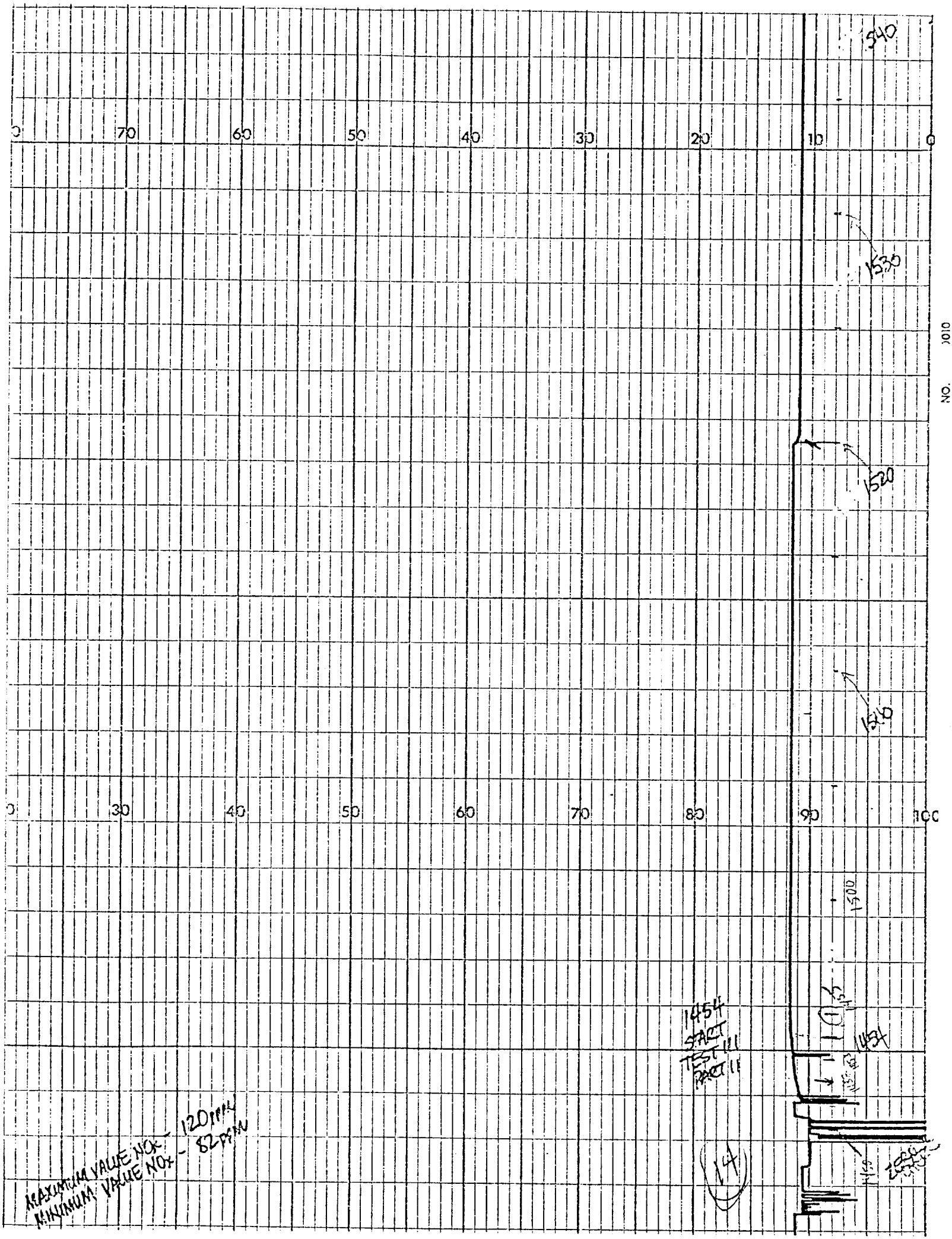

30
40
50
60
70
80
90
100
1640
1630
1620
70
60
50
40
30
20
10
0
1610
BEGIN TEST II 2ND HALF
8/8
1605
Calibration check
9
CHART NO. 0100-010

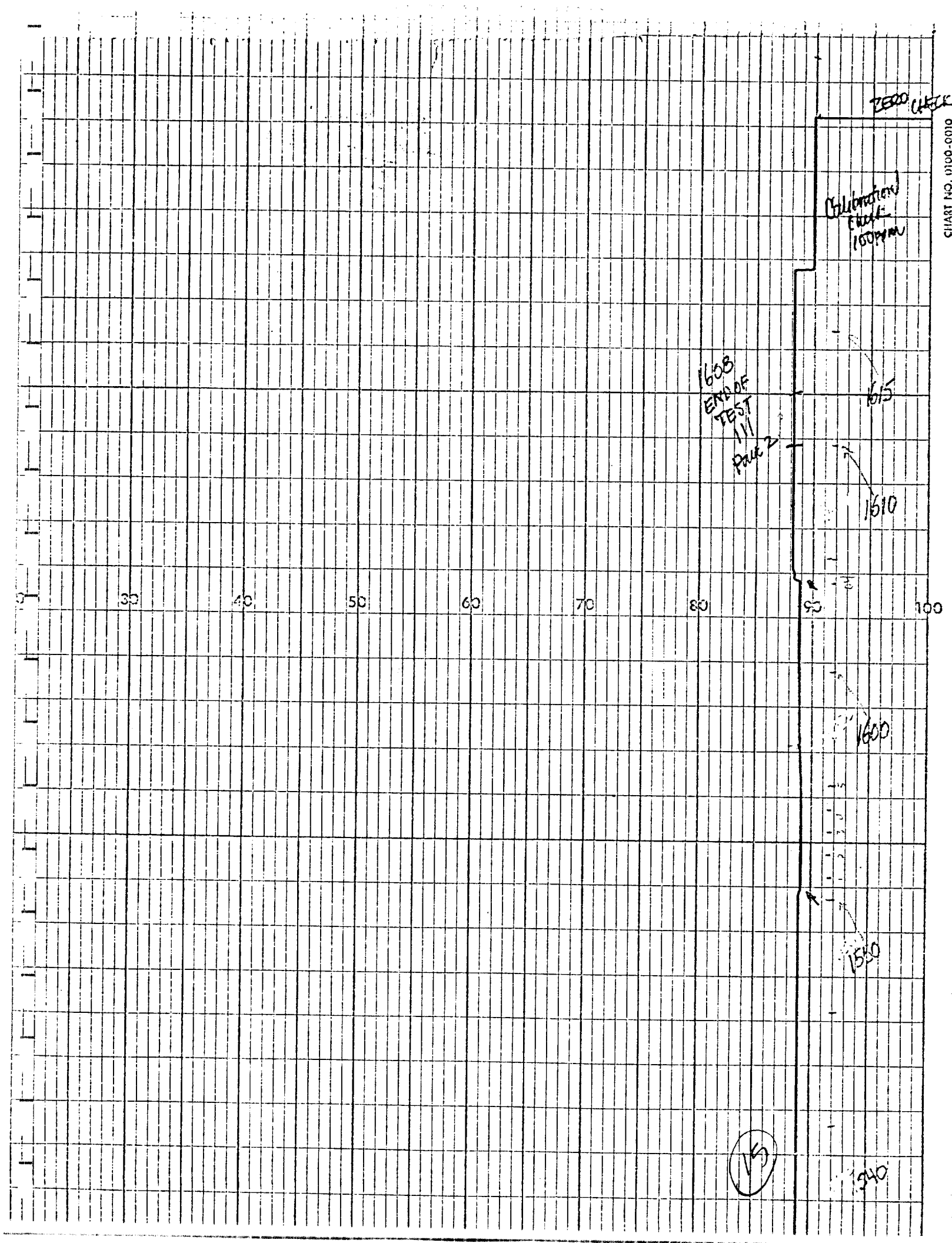

MAXIMUM VALUE NOx - 120ppm 1710
MINIMUM VALUE NOx - 95ppm 1140
Calibration Check
END 2ND TEST Part II
70
60
50
40
30
20
10
0
1710
1700
1650
1640
30
40
50
60
70
80
90
100
10


30
40
50
60
70
80
90
100
70
60
50
40
30
20
10
0
1030
Samples
Calibration
LINE RUNS
CLAYTON ENVIRONMENTAL
TEST 111
8/9/79
NOx ANALYZER
RANGE: 0-1000 ppm
(each square represents 10 ppm)
CHART SPEED = 0.5 CM/MIN
OPERATOR: KWOPaulew
YORK RESEARCH
11
CHART NO. 0100-0010


30
40
50
60
70
80
90
100
1200
1150
1140
70
60
50
40
30
20
10
0
1130
1120
START
TEST 14
Part 1
12

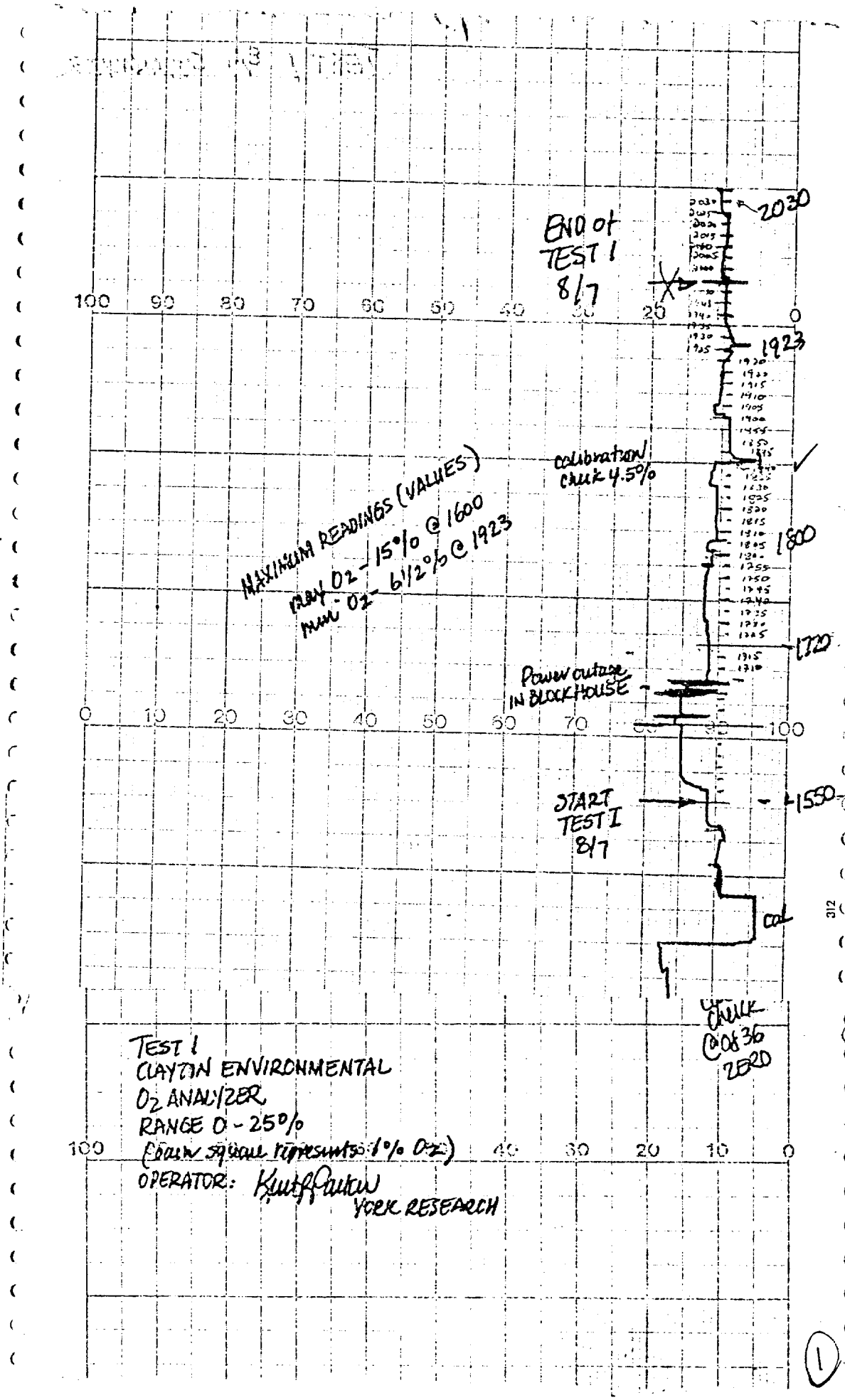

1300
1250
1240
70
60
50
40
30
20
10
0
1231
END OF TEST PART 1
VARIATION IN BYPASS PRESSURE
CHART NO. 0100-0010


70
60
50
40
30
20
10
0
1540
1530
1520
1510
30
40
50
60
70
80
90
100
1500
1454
START
TEST III
PART II
1454
MAXIMUM VALUE NOx - 120 PPM
MINIMUM VALUE NOx - 82 PPM
14

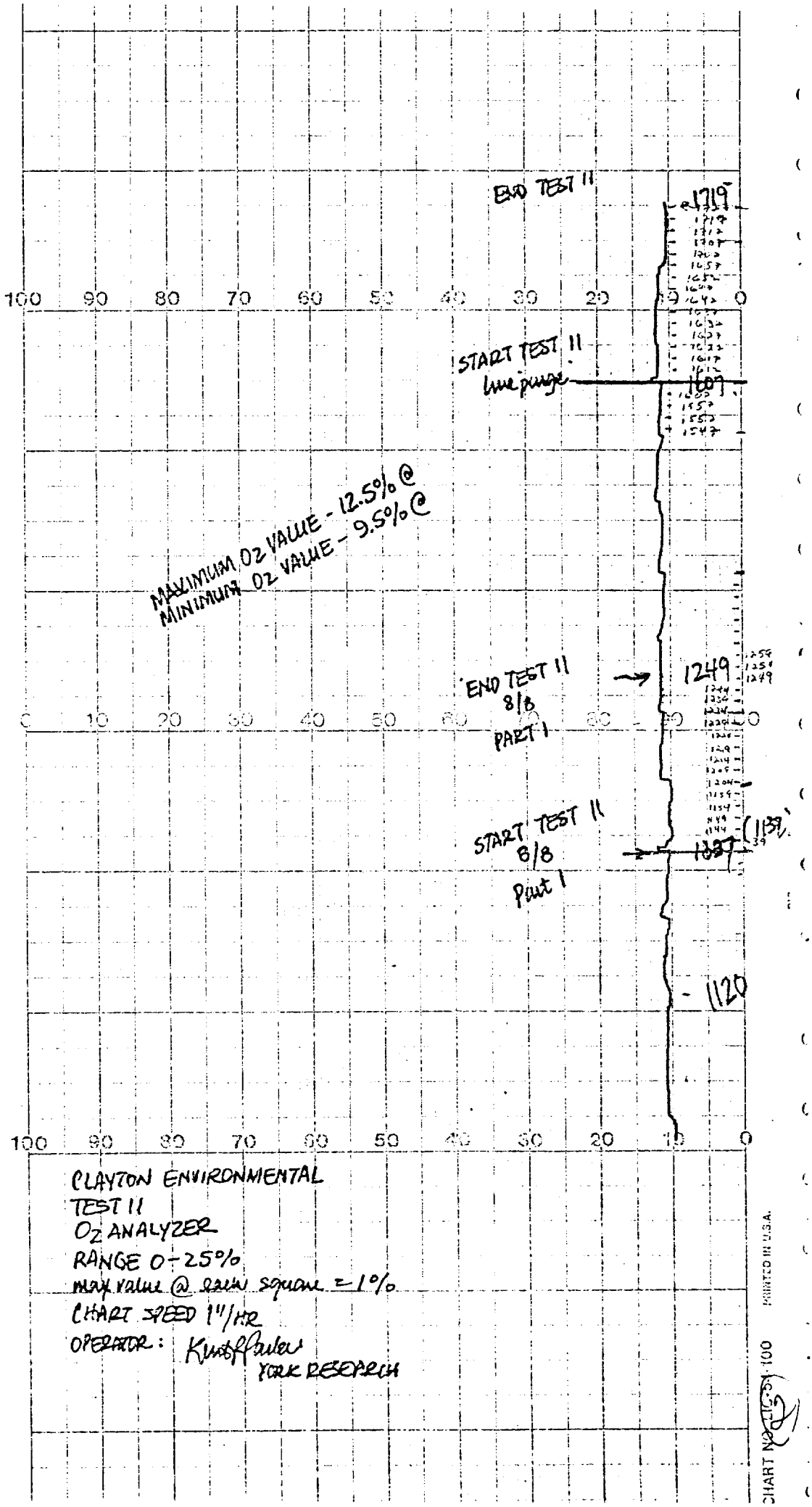

ZERO CHECK
Calibration Check 100PPM
1608 END OF TEST 111 PAGE 2
1615
1610
1600
1550
1540
30
40
50
60
70
80
90
100
15
CHART NO. 0100-0010

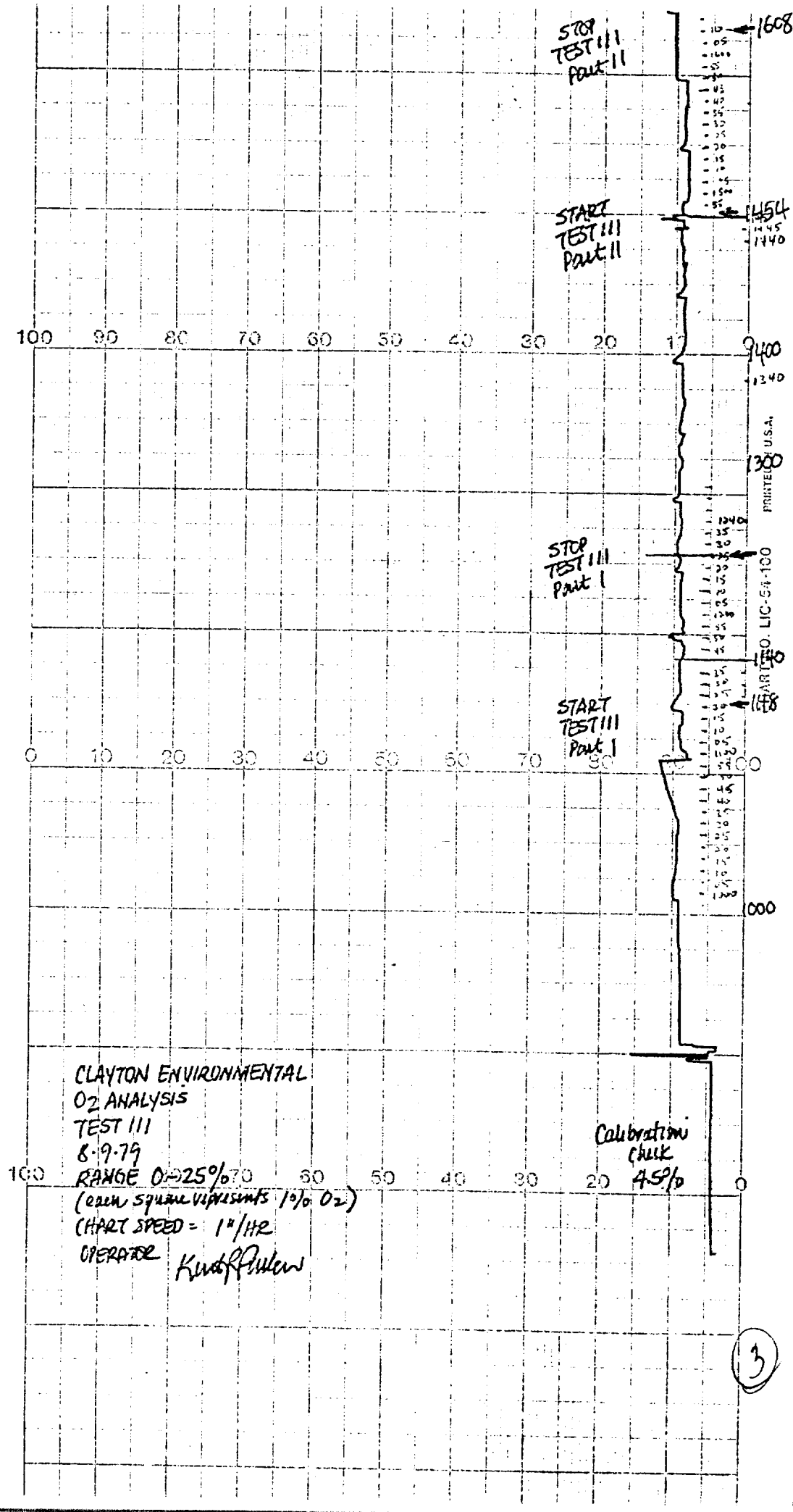
# APPENDIX C-3

# OXYGEN


END of TEST 1 8/7
2030
1923
1800
1720
1550
calibration check 4.5%
MAXIMUM READINGS (VALUES)
max O2 - 15% @ 1600
min O2 - 6 1/2% @ 1923
Power outage IN BLOCKHOUSE
START TEST I 8/7
cal
CHECK @0836 ZERO
100 90 80 70 60 50 40 30 20 0
0 10 20 30 40 50 60 70 80 90 100
TEST 1
CLAYTON ENVIRONMENTAL
O2 ANALYZER
RANGE 0 - 25%
(each square represents 1% O2)
OPERATOR: Kurt Parker
YORK RESEARCH

1


END TEST 11
1719
100 90 80 70 60 50 40 30 20 10 0
START TEST 11
line purge
1607
MAXIMUM O2 VALUE - 12.5% @
MINIMUM O2 VALUE - 9.5% @
END TEST 11
8/8
PART 1
1249
0 10 20 30 40 50 60 70 80 90 0
START TEST 11
8/8
Part 1
1137
1120
100 90 80 70 60 50 40 30 20 10 0
CLAYTON ENVIRONMENTAL
TEST 11
O2 ANALYZER
RANGE 0-25%
max value @ 2min square = 1%
CHART SPEED 1"/HR
OPERATOR: Kurt Parker
YORK RESEARCH
PRINTED IN U.S.A.
CHART NO. 100


STOP TEST III Part II
START TEST III Part II
STOP TEST III Part I
START TEST III Part I
1608
1454
1445
1440
1400
1340
1300
1240
1235
1230
1140
1108
1000
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
CLAYTON ENVIRONMENTAL
O2 ANALYSIS
TEST III
8-9-79
RANGE 0-25%
(each square represents 1% O2)
CHART SPEED = 1"/HR
OPERATOR
Calibration check 4.5%
PRINTED IN U.S.A.
HARTED, LIC-54-100
3

# APPENDIX D

# EXAMPLE CALCULATIONS

## Nomenclature

$A_s$ = Stack area, inches$^2$

$C_f$ = Concentration (filterable), gr/dscf

$C_n$ = Concentration (nitrogen oxides), ppm

$C_p$ = Pitot tube correction factor, dimensionless

$C_t$ = Concentration (total), gr/dscf

$CM_f$ = Concentration (filterable), mg/dscm

$CM_t$ = Concentration (total), mg/dscm

$D_n$ = Sampling nozzle diameter, inches

$ER_f$ = Emission rate (filterable), lb/hr

$ER_n$ = Emission Rate ($NO_x$), lb/hr

$ER_t$ = Emission rate (total), lb/hr

$ERM_f$ = Emission rate (filterable),kg/hr

$ERM_t$ = Emission rate (total), kg/hr

$M_d$ = Mole fraction of dry gas, g/g-mole

MW = Molecular weight of wet stack gas

$MW_d$ = Molecular weight of dry stack gas

$MW_g$ = Molecular weight of sampled gas

$P_b$ = Barometric pressure, inches mercury

$P_f$ = Final pressure of flask, inches mercury

$P_i$ = Initial pressure of flask, inches mercury

$P_m$ = Average orifice pressure drop, inches water

$P_s$ = Absolute stack gas pressure, inches mercury

$P_{st}$ = Static pressure of stack gas, inches mercury

$Q_a$ = Actual stack gas flowrate at stack conditions, acfm

$Q_{am}$ = Actual stack gas flowrate at stack conditions, acm/min

$Q_m$ = Dry stack gas flowrate at standard conditions, dscm/min

$Q_s$ = Dry stack gas flowrate at standard conditions, dscfm

$SW_f$ = Filterable sample weight, mg

$SW_t$ = Total sample weight, mg

$T_f$ = Final temperature, F

$T_i$ = Initial temperature, F

$T_m$ = Average meter temperature, F

$T_s$ = Stack temperature, F

$T_t$ = Net time of test, minutes

$V_a$ = Volume of absorbing solution, ml

$V_f$ = Volume of flask, ml

$V_m$ = Volume of dry gas at meter conditions, cf

$V_{m_{std}}$ = Volume of dry gas at standard conditions, dscf

$V_{no}$ = Volume of gas (nitrogen oxides), l

$V_s$ = Stack gas velocity at stack conditions, fpm

$V_w$ = Total condensate collected in sampling train, ml

$V_{w_{gas}}$ = Volume of water vapor at standard conditions, scf

$\triangle P_s$ = Velocity pressure, inches water

%I = Percent of isokinetic variation, dimensionless

%M = Percent moisture, dimensionless

## Calculation of Particulate Emissions

The dry volume of sampled gas corrected to standard conditions of 68 F and 29.92 in. Hg is calculated as follows:

$$V_{m_{std}} = \frac{17.65 * V_m * \left[P_b + \left(\frac{P_m}{13.6}\right)\right]}{T_m + 460}$$

The dry stack gas flowrate corrected to standard conditions is

calculated using the following set of equations sequentially:

$$V_{w_{gas}} = 0.0471 * V_w$$

$$\%M = \frac{100 * V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$MW_d = (\%CO_2 * 44/100) + (\%O_2 * 32/100) + \left[(\%CO + \%N_2)*28/100\right]$$

$$MW = (MW_d * M_d) + 18(1 - M_d)$$

$$P_s = P_b + P_{st}$$

$$V_s = 5120.8 * C_p * \sqrt{\Delta P_s * (T_s + 460)} * \sqrt{\frac{1}{P_s * MW}}$$

$$Q_s = \frac{0.1225 * V_s * A_s * M_d * P_s}{T_s + 460}$$

Stack gas flowrate may be expressed metrically as dry standard cubic meters per minute (dscm/min), in terms of actual cubic feet per minute (acfm), and metrically as actual cubic meters per minute (acm /min) with use of the following equations:

$$Q_m = Qs * 0.02832$$

$$Qa = \frac{0.05667 * Qs * (T_s + 460)}{P_s * M_d}$$

$$Qam = Qa * 0.02832.$$

The equation employed to determine percent of isokinetic variation is:

$$\%I = \frac{1032 * (T_s + 460) * V_{m_{std}}}{V_s * T_t * P_s * M_d * (D_n)^2}$$

To determine the concentration of particulate matter in grains per dry standard cubic foot (gr/dscf), one of the following equations is used:

$$C_f = 0.01543 * \frac{SW_f}{V_{m_{std}}} \quad \text{and}$$

$$C_t = 0.01543 * \frac{SW_t}{V_{m_{std}}} \quad .$$

When metric units are desired, the concentration is calculated in milligrams per dry standard cubic meter (mg/dscm)) as follows:

$$CM_f = \frac{SW_f}{(0.02832)(V_{m_{std}})} \quad \text{and}$$

$$CM_t = \frac{SW_t}{(0.02832)(V_{m_{std}})} \quad .$$

Filterable particulate concentrations are obtained by summing the weight of particulate matter collected on the filter and all portions of the train preceding it. Total particulate concentration includes, in addition, any particulate matter collected in the impingers.

The emission rate of particulate matter can be calculated from the filterable or total particulate concentration using one of the following equations:

$$ER_f = 0.00857 * C_f * Q_s \quad \text{and}$$

$$ER_t = 0.00857 * C_t * Q_s \quad .$$

When metric units are desired, the emission rates are calculated as kilograms per hour.

$$ERM_f = ER_f * 0.4536$$

$$ERM_t = ER_t * 0.4536$$

To avoid rounding errors it is preferable to carry out the calculation of concentration and emission rate in one operation.

Concentrations and emission rates for sulfuric acid including sulfur trioxide were determined utilizing the same formulae as for particulate using the weights in milligrams as determined in the laboratory.

The volume of nitrogen oxide sampled in liters (l) at standard conditions can be calculated using the following equation:

$$V_{no} = \frac{528}{1000 * 29.92}(V_f - V_a) \left(\frac{P_f}{T_f + 460} - \frac{P_i}{T_i + 460}\right)$$

The following equations are used to calculate the concentration in parts per million (ppm) and emission rate in pounds per hour (lb/hr) of nitrogen oxide compounds:

$$C_n = \frac{24040 * SW_t}{V_{no} * MW_g}$$

$$ER_n = \frac{60 * 0.07523 * 10^{-6}}{28.95} * C_n * Q_s * MW_g$$

Example Calculation

Using the data from Run 1, the sample volume is calculated using the formula on page 2.

Given:

$V_m$ = 121.541

$P_b$ = 25.27

$P_m$ = 2.33 in $H_2O$

$T_m$ = 116F

then:

$V_{m_{std}}$ = 94.751 dscf

Percent moisture in the stack during the test is then determined from the measured condensate volume.

Given:

$V_w$ = 322.8 ml

then:

$V_{w_{gas}}$ = 15.204 scf

%M = 13.8

$M_d$ = 0.862

Using the data from the Orsat analyses conducted during this run, the molecular weight of the stack gas can be determined.

Given:

$\%CO_2$ = 4.2

$\%O_2$ = 9.1

%CO = <0.1

$\%N_2$ = 86.7

then:

$MW_d$ = 29.04

MW = 27.51

The flowrate in dry standard cubic feet can then be calculated using the formulae on page 3.

Given:

$P_{st}$ = -0.071 in $H_2O$

$C_p$ = 0.8205

$\sqrt{\Delta P_s * (T_s + 460)}$ = 3.127

$A_s$ = 11,767 $in^2$

$T_s$ = 439.6 F

then:

$P_s$ = 25.20 in Hg

$V_s$ = 499.0 fpm

$Q_s$ = 17,370 dscfm

$Q_m$ = 492 dscm/min

$Q_a$ = 40,800 acfm

$Q_{am}$ = 1,150 acm/min

Utilizing the sampled volume and the flowrate, the percent of isokinetic variation can be calculated.

Given:

$T_t$ = 144 min

$D_n$ = 0.762 in

then:

%I = 97.1

Given the analytical data, the concentrations and emission rates may be calculated for both particulate and sulfate.

Given for particulate:

$SW_f$ = 279.1 mg

$SW_t$ = 393.7 mg

then:

$C_f$ = 0.045 gr/dscf

$C_t$ = 0.064 gr/dscf

$CM_f$ = 104 mg/dscm

$CM_t$ = 147 mg/dscm

$ER_f$ = 6.76 lb/hr

$ER_t$ = 9.54 lb/hr

$ERM_f$ = 3.07 kg/hr

$ERM_t$ = 4.33 kg/hr

Given similarily for sulfates:

$SW_f$ = 76.5 mg

$SW_t$ = 309.1 mg

then:

$C_f$ = 0.012 gr/dscf

$C_t$ = 0.050 gr/dscf

$CM_f$ = 28.5 mg/dscm

$CM_t$ = 115 mg/dscm

$ER_f$ = 1.85 lb/hr

$ER_t$ = 7.49 lb/hr

$ERM_f$ = 0.841 kg/hr

$ERM_t$ = 3.40 kg/hr

Using the first $NO_x$ test as an example, the sampled volume of nitrogen dioxide can be determined as follows:

Given:

$V_f$ = 2029 ml

$V_a$ = 25 ml

$T_i$ = 90 F

$T_f$ = 85 F

$P_i$ = 2.27 in Hg

$P_f$ = 25.32 in Hg

Then, using the equation for $V_{no}$ the volume in liters (1) is:

$V_{no}$ = 1.50 1

The concentration and emission rate for nitrogen dioxide can then be calculated as follows:

Given:

$SW_t$ = <0.022 mg

$MW_g$ = 46.005

Then using the associated equations, concentration in parts per million (ppm) and the emission rates in pounds per hour (lb/hr) and kilogram are as follows:

$C_n$ = <7.66 ppm

$ER_n$ = <0.954 lb/hr

$ERM_t$ = <0.433 kg/hr

# APPENDIX E

# OPACITY AND CARBON MONOXIDE CORRELATION DATA

Sample 1

Desired lag time from opacity reading to co reading -3.5
Based on 100.00 percent of 160 usable data sets (from a total of 564); for a total of 160 data points
The Coefficient of Correlation is ~~.4697~~ 0.6802
The Linear Regression Coefficients: CO = 29.634 Opacity + 69.825

DISTRIBUTION OF READINGS

| | Opacities | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50< |
| <150 | 80 | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <250 | 4 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <350 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <450 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <550 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <650 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <750 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO ppm <850 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1050 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1150 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1350 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1450< | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample 2

Desired lag time from opacity reading to co reading 2

Based on 100.00 percent of 271 usable data sets (from a total of 588); for a total of 271 data points

The Coefficient of Correlation is ~~.4941~~ 0.6958

The Linear Regression Coefficients: CO = 57.161 Opacity + 121.293

DISTRIBUTION OF READINGS

| | Opacities | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50< |
| <150 | 228 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <250 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <350 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <450 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <550 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <650 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <750 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO ppm <850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1350 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1450< | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample 2

Desired lag time from opacity reading to co reading 2

Based on 100.00 percent of 173 usable data sets (from a total of 296); for a total of 173 data points

The Coefficient of Correlation is ~~.7462~~ 0.8638

The Linear Regression Coefficients: CO = 42.706 Opacity + 113.825

DISTRIBUTION OF READINGS

| | Opacities | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50< |
| <150 | 145 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <250 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <350 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <450 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <550 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <650 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <750 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO ppm <850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1350 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1450< | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Sample 3

Desired lag time from opacity reading to co reading 3
Based on 100.00 percent of 31 usable data sets (from a total of 277); for a total of 31 data points
The Coefficient of Correlation is ~~.5491~~ 0.7403
The Linear Regression Coefficients: CO = 24.439 Opacity + 201.394

DISTRIBUTION OF READINGS

| | Opacities | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50< |
| <150 | 24 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <250 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <350 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <450 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <550 | 0 | 4 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <650 | 0 | 1 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| <750 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO ppm <850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1050 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1350 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1450< | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

stop
sru's:3.1

# APPENDIX F

## DETAILED SUMMARY OF SAMPLING AND ANALYTICAL PROCEDURES

F-1. Non Dispersive Infrared (Continuous Carbon Monoxide)

F-2. Continuous Nitrogen Oxides

F-3. Continuous Oxygen

# APPENDIX F-1

## NON DISPERSIVE INFRARED
## (CONTINUOUS CARBON MONOXIDE)

## METHOD 10—DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability.*

1.1 *Principle.* An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a Luft-type nondispersive infrared analyzer (NDIR) or equivalent.

1.2 *Applicability.* This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

2. *Range and sensitivity.*

2.1 *Range.* 0 to 1,000 ppm.

2.2 *Sensitivity.* Minimum detectable concentration is 20 ppm for a 0 to 1,000 ppm span.

3. *Interferences.* Any substance having a strong absorption of infrared energy will interfere to some extent. For example, discrimination ratios for water ($H_2O$) and carbon dioxide ($CO_2$) are 3.5 percent $H_2O$ per 7 ppm CO and 10 percent $CO_2$ per 10 ppm CO, respectively, for devices measuring in the 1,500 to 3,000 ppm range. For devices measuring in the 0 to 100 ppm range, interference ratios can be as high as 3.5 percent $H_2O$ per 25 ppm CO and 10 percent $CO_2$ per 50 ppm CO. The use of silica gel and ascarite traps will alleviate the major interference problems. The measured gas volume must be corrected if these traps are used.

4. *Precision and accuracy.*

4.1 *Precision.* The precision of most NDIR analyzers is approximately ±2 percent of span.

4.2 *Accuracy.* The accuracy of most NDIR analyzers is approximately ±5 percent of span after calibration.

5. *Apparatus.*

5.1 *Continuous sample* (Figure 10–1).

5.1.1 *Probe.* Stainless steel or sheathed Pyrex[1] glass, equipped with a filter to remove particulate matter.

5.1.2 *Air-cooled condenser or equivalent.* To remove any excess moisture.

5.2 *Integrated sample* (Figure 10–2).

5.2.1 *Probe.* Stainless steel or sheathed Pyrex glass, equipped with a filter to remove particulate matter.

5.2.2 *Air-cooled condenser or equivalent.* To remove any excess moisture.

5.2.3 *Valve.* Needle valve, or equivalent, to to adjust flow rate.

5.2.4 *Pump.* Leak-free diaphragm type, or equivalent, to transport gas.

5.2.5 *Rate meter.* Rotameter, or equivalent, to measure a flow range from 0 to 1.0 liter per min. (0.035 cfm).

5.2.6 *Flexible bag.* Tedlar, or equivalent, with a capacity of 60 to 90 liters (2 to 3 $ft^3$). Leak-test the bag in the laboratory before using by evacuating bag with a pump followed by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

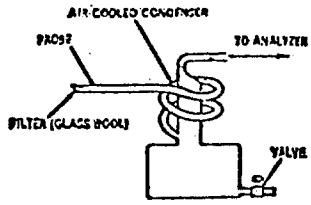



Figure 10-1. Continuous sampling train.

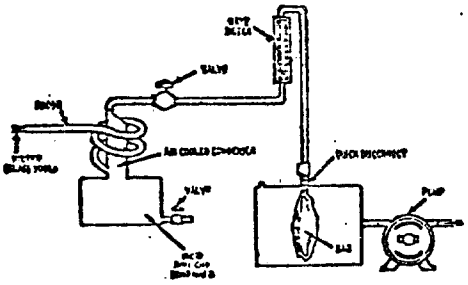



Figure 10-2. Integrated gas-sampling train.

5.2.7 *Pitot tube.* Type S, or equivalent, attached to the probe so that the sampling rate can be regulated proportional to the stack gas velocity when velocity is varying with the time or a sample traverse is conducted.

5.3 *Analysis* (Figure 10–3).

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

5.3.1 *Carbon monoxide analyzer.* Nondispersive infrared spectrometer, or equivalent. This instrument should be demonstrated, preferably by the manufacturer, to meet or exceed manufacturer's specifications and those described in this method.

5.3.2 *Drying tube.* To contain approximately 200 g of silica gel.

5.3.3 *Calibration gas.* Refer to paragraph 6.1.

5.3.4 *Filter.* As recommended by NDIR manufacturer.

5.3.5 *$CO_2$ removal tube.* To contain approximately 500 g of ascarite.

5.3.6 *Ice water bath.* For ascarite and silica gel tubes.

5.3.7 *Valve.* Needle valve, or equivalent, to adjust flow rate

5.3.8 *Rate meter.* Rotameter or equivalent to measure gas flow rate of 0 to 1.0 liter per min. (0.035 cfm) through NDIR.

5.3.9 *Recorder (optional).* To provide permanent record of NDIR readings.

6. *Reagents.*

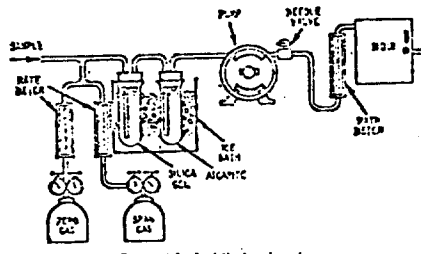



Figure 10-3. Analytical equipment.

6.1 *Calibration gases.* Known concentration of CO in nitrogen ($N_2$) for instrument span, prepurified grade of $N_2$ for zero, and two additional concentrations corresponding approximately to 60 percent and 30 percent span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within ±2 percent of the specified concentration.

6.2 *Silica gel.* Indicating type, 6 to 16 mesh, dried at 175° C (347° F) for 2 hours.

6.3 *Ascarite.* Commercially available.

7. *Procedure.*

7.1 *Sampling.*

7.1.1 *Continuous sampling.* Set up the equipment as shown in Figure 10–1 making sure all connections are leak free. Place the probe in the stack at a sampling point and purge the sampling line. Connect the analyzer and begin drawing sample into the analyzer. Allow 5 minutes for the system to stabilize, then record the analyzer reading as required by the test procedure. (See § 7.2 and 8). $CO_2$ content of the gas may be determined by using the Method 3 integrated sample procedure (36 FR 24886), or by weighing the ascarite $CO_2$ removal tube and computing $CO_2$ concentration from the gas volume sampled and the weight gain of the tube.

7.1.2 *Integrated sampling.* Evacuate the flexible bag. Set up the equipment as shown in Figure 10–2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are leak free. Sample at a rate proportional to the stack velocity. $CO_2$ content of the gas may be determined by using the Method 3 integrated sample procedures (36 FR 24886), or by weighing the ascarite $CO_2$ removal tube and computing $CO_2$ concentration from the gas volume sampled and the weight gain of the tube.

7.2 *CO Analysis.* Assemble the apparatus as shown in Figure 10–3, calibrate the instrument, and perform other required operations as described in paragraph 8. Purge analyzer with $N_2$ prior to introduction of each sample. Direct the sample stream through the instrument for the test period, recording the readings. Check the zero and span again after the test to assure that any drift or malfunction is detected. Record the sample data on Table 10–1.

8. *Calibration.* Assemble the apparatus according to Figure 10–3. Generally an instrument requires a warm-up period before stability is obtained. Follow the manufacturer's instructions for specific procedure. Allow a minimum time of one hour for warm-up. During this time check the sample conditioning apparatus, i.e., filter, condenser, drying tube, and $CO_2$ removal tube, to ensure that each component is in good operating condition. Zero and calibrate the instrument according to the manufacturer's procedures using, respectively, nitrogen and the calibration gases.

TABLE 10-1.—*Field data*

| | |
|---|---|
| Location | Comments: |
| Test | |
| Date | |
| Operator | |

| *Clock time* | *Rotameter setting, liters per minute (cubic feet per minute)* |
|---|---|
| | |

9. *Calculation—Concentration of carbon monoxide.* Calculate the concentration of carbon monoxide in the stack using equation 10-1.

$$C_{CO_{stack}} = C_{CO_{NDIR}}(1 - F_{CO_2}) \qquad \text{equation 10-1}$$

where:

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

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

$F_{CO_2}$ = volume fraction of $CO_2$ in sample, i.e., percent $CO_2$ from Orsat analysis divided by 100.

[39 FR 13776, April 17, 1974]

10. *Bibliography.*

10.1 McElroy, Frank, The Intertech NDIR-CO Analyzer, Presented at 11th Methods Conference on Air Pollution, University of California, Berkeley, Calif., April 1, 1970.

10.2 Jacobs, M. B., et al., Continuous Determination of Carbon Monoxide and Hydrocarbons in Air by a Modified Infrared Analyzer, J. Air Pollution Control Association, 9(2):110-114, August 1959.

10.3 MSA LIRA Infrared Gas and Liquid Analyzer Instruction Book, Mine Safety Appliances Co., Technical Products Division, Pittsburgh, Pa.

10.4 Models 215A, 315A, and 415A Infrared Analyzers, Beckman Instruments, Inc., Beckman Instructions 1635-B, Fullerton, Calif., October 1967.

10.5 Continuous CO Monitoring System, Model A5611, Intertech Corp., Princeton, N.J.

10.6 UNOR Infrared Gas Analyzers, Bendix Corp., Ronceverte, West Virginia.

ADDENDA

*A. Performance Specifications for NDIR Carbon Monoxide Analyzers.*

| | |
|---|---|
| Range (minimum) | 0-1000ppm. |
| Output (minimum) | 0-10mV. |
| Minimum detectable sensitivity | 20 ppm. |
| Rise time, 90 percent (maximum) | 30 seconds. |
| Fall time, 90 percent (maximum) | 30 seconds. |
| Zero drift (maximum) | 10% in 8 hours. |
| Span drift (maximum) | 10% in 8 hours. |
| Precision (minimum) | ± 2% of full scale. |
| Noise (maximum) | ± 1% of full scale. |
| Linearity (maximum deviation) | 2% of full scale. |
| Interference rejection ratio | $CO_2$—1000 to 1, $H_2O$—500 to 1. |

B. *Definitions of Performance Specifications.*

*Range*—The minimum and maximum measurement limits.

*Output*—Electrical signal which is proportional to the measurement; intended for connection to readout or data processing devices. Usually expressed as millivolts or milliamps full scale at a given impedance.

*Full scale*—The maximum measuring limit for a given range.

*Minimum detectable sensitivity*—The smallest amount of input concentration that can be detected as the concentration approaches zero.

*Accuracy*—The degree of agreement between a measured value and the true value; usually expressed as ± percent of full scale.

*Time to 90 percent response*—The time interval from a step change in the input concentration at the instrument inlet to a reading of 90 percent of the ultimate recorded concentration.

*Rise Time (90 percent)*—The interval between initial response time and time to 90 percent response after a step increase in the inlet concentration.

*Fall Time (90 percent)*—The interval between initial response time and time to 90 percent response after a step decrease in the inlet concentration.

*Zero Drift*—The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is zero; usually expressed as percent full scale.

*Span Drift*—The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is a stated upscale value; usually expressed as percent full scale.

*Precision*—The degree of agreement between repeated measurements of the same concentration, expressed as the average deviation of the single results from the mean.

*Noise*—Spontaneous deviations from a mean output not caused by input concentration changes.

*Linearity*—The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

METHOD 11—DETERMINATION OF HYDROGEN SULFIDE CONTENT OF FUEL GAS STREAMS IN PETROLEUM REFINERIES

1. *Principle and applicability.* 1.1 *Principle.* Hydrogen sulfide ($H_2S$) is collected from a source in a series of midget impingers and absorbed in pH 3.0 cadmium sulfate ($CdSO_4$) solution to form cadmium sulfide (CdS). The latter compound is then measured iodometrically. An impinger containing hydrogen peroxide is included to remove $SO_2$ as an interfering species. This method is a revision of the $H_2S$ method originally published in the FEDERAL REGISTER, Volume 39, No. 47, dated Friday, March 8, 1974.

1.2 *Applicability.* This method is applicable for the determination of the hydrogen sulfide content of fuel gas streams at petroleum refineries.

2. *Range and sensitivity.* The lower limit of detection is approximately 8 mg/m³ (6

[Appendix A, Method 11]

# APPENDIX F-2

# CONTINUOUS NITROGEN OXIDES

*Performance Specification 2—Specifications and Test Procedures for $SO_2$ and $NO_x$ Continuous Monitoring Systems in Stationary Sources*

1. Applicability and Principle

1.1 Applicability. This Specification contains (a) installation requirements, (b) instrument performance and equipment specifications, and (c) test procedures and data reduction procedures for evaluating the acceptability of $SO_2$ and $NO_x$ continuous monitoring systems, which may include, for certain stationary sources, diluent monitors. The test procedures in item (c), above, are not applicable to single-pass, in-situ continuous monitoring systems; these systems will be evaluated on a case-by-case basis upon written request to the Administrator and alternative test procedures will be issued separately.

1.2 Principle. Any $SO_2$ or $NO_x$ continuous monitoring system that is expected to meet this Specification is installed, calibrated, and operated for a specified length of time. During this specified time period, the continuous monitoring system is evaluated to determine conformance with the Specification.

2. Definitions

2.1 Continuous Monitoring System. The total equipment required for the determination of a gas concentration or a gas emission rate. The system consists of the following major sub-systems:

2.1.1 Sample Interface. That portion of a system that is used for one or more of the following: sample acquisition, sample transportation, sample conditioning, or protection of the monitor from the effects of the stack effluent.

2.1.2. Pollutant Analyzer. That portion of the system that senses the pollutant gas and generates an output that is proportional to the gas concentration.

2.1.3. Diluent Analyzer (if applicable). That portion of the system that senses the diluent gas (e.g., $CO_2$ or $O_2$) and generates an output that is proportional to the gas concentration.

2.1.4 Data Recorder. That portion of the monitoring system that provides a permanent record of the analyzer output. The data recorder may include automatic data reduction capabilities.

2.2 Types of Monitors. Continuous monitors are categorized as "extractive" or "in-situ," which are further categorized as "point," "multipoint," "limited-path," and "path" type monitors or as "single-pass" or "double-pass" type monitors.

2.2.1 Extractive Monitor. One that withdraws a gas sample from the stack and transports the sample to the analyzer.

2.2.2 In-situ Monitor. One that senses the gas concentration in the stack environment and does not extract a sample for analysis.

2.2.3 Point Monitor. One that measures the gas concentration either at a single point or along a path which is less than 10 percent of the length of a specified measurement line.

2.2.4 Multipoint Monitor. One that measures the gas concentration at 2 or more points.

2.2.5 Limited-Path Monitor. One that measures the gas concentration along a path, which is 10 to 90 percent of the length of a specified measurement line.

2.2.6 Path Monitor. One that measures the gas concentration along a path, which is greater than 90 percent of the length of a specified measurement line.

2.2.7 Single-Pass Monitor. One that has the transmitter and the detector on opposite sides of the stack or duct.

2.2.8 Double-Pass Monitor. One that has the transmitter and the detector on the same side of the stack or duct.

2.3 Span Value. The upper limit of a gas concentration measurement range which is specified for affected source categories in the applicable subpart of the regulations.

2.4 Calibration Gases. A known concentration of a gas in an appropriate diluent gas.

2.5 Calibration Gas Cells or Filters. A device which, when inserted between the transmitter and detector of the analyzer, produces the desired output level on the data recorder.

2.6 Relative Accuracy. The degree of correctness including analytical variations of the gas concentration or emission rate determined by the continuous monitoring system, relative to the value determined by the reference method(s).

2.7 Calibration Error. The difference between the gas concentration indicated by the continuous monitoring system and the known concentration of the calibration gas, gas cell, or filter.

2.8 Zero Drift. The difference in the continuous monitoring system output readings before and after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place and when the pollutant concentration at the time of the measurements was zero (i.e., zero gas, or zero gas cell or filter).

2.9 Calibration Drift. The difference in the continuous monitoring system output readings before and after a stated period of operation during which no unscheduled maintenance, repair or adjustment took place and when the pollutant concentration at the time of the measurements was a high-level value (i.e., calibration gas, gas cell or filter).

2.10 Response Time. The amount of time it takes the continuous monitoring system to display on the data recorder 95 percent of a step change in pollutant concentration.

2.11 Conditioning Period. A minimum period of time over which the continuous monitoring system is expected to operate with no unscheduled maintenance, repair, or adjustments prior to initiation of the operational test period.

2.12 Operational Test Period. A minimum period of time over which the continuous monitoring system is expected to operate within the established performance specifications with no unscheduled maintenance, repair or adjustment.

3. Installation Specifications

Install the continuous monitoring system at a location where the pollutant concentration measurements are representative of the total emissions from the affected facility and are representative of the concentration over the cross section. Both requirements can be met as follows:

3.1 Measurement Location. Select an accessible measurement location in the stack or ductwork that is at least 2 equivalent diameters downstream from the nearest control device or other point at which a change in the pollutant concentration may occur and at least 0.5 equivalent diameters upstream from the effluent exhaust. Individual subparts of the regulations may contain additional requirements. For example, for steam generating facilities, the location must be downstream of the air preheater.

3.2 Measurement Points or Paths. There are two alternatives. The tester may choose either (a) to conduct the stratification check procedure given in Section 3.3 to select the point, points, or path of average gas concentration, or (b) to use the options listed below without a stratification check.

Note.—For the purpose of this section, the "centroidal area" is defined as a concentric area that is geometrically similar to the stack cross section and is no greater than 1 percent of the stack cross-sectional area.

3.2.1 $SO_2$ and $NO_x$ Path Monitoring Systems. The tester may choose to centrally locate the sample interface (path) of the monitoring system on a measurement line that passes through the "centroidal area" of the cross section.

3.2.2 $SO_2$ and $NO_x$ Multipoint Monitoring Systems. The tester may choose to space 3 measurement points along a measurement line that passes through the "centroidal area" of the stack cross section, at distances of 16.7, 50.0, and 83.3 percent of the way across it (see Figure 2-1).

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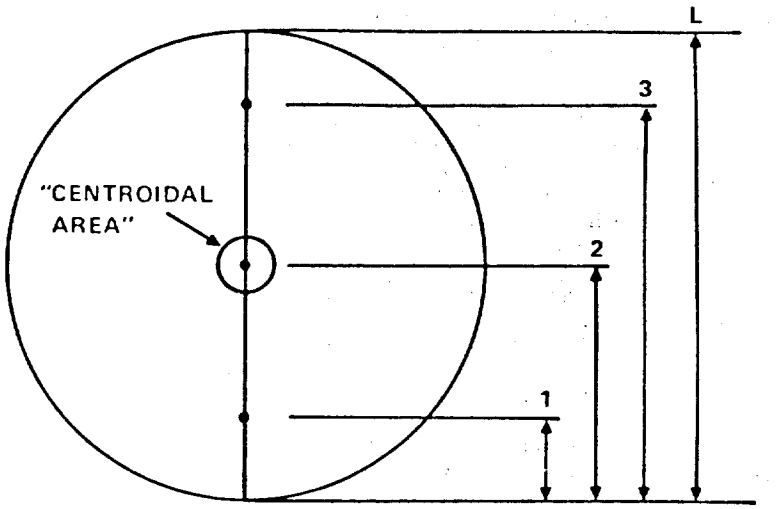


| POINT NO. | DISTANCE (% OF L) |
|---|---|
| 1 | 16.7 |
| 2 | 50.0 |
| 3 | 83.3 |

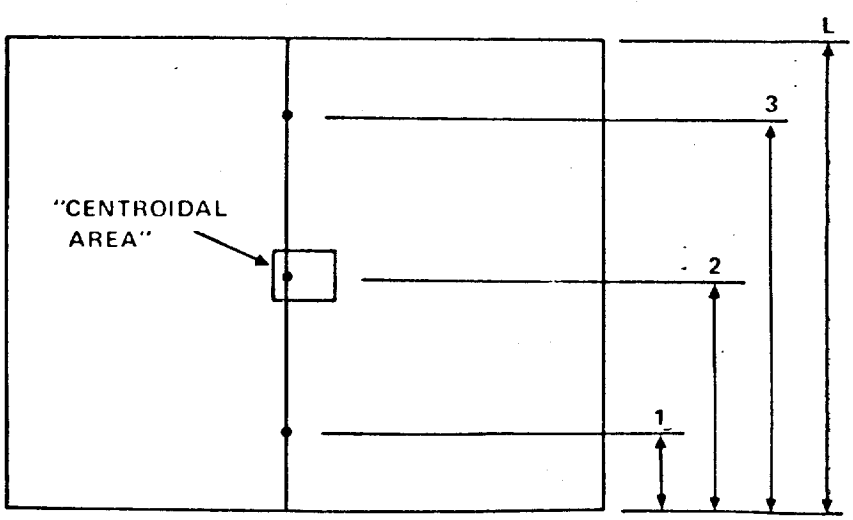


Figure 2-1. Location of an example measurement line (L) and measurement points.

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The following sampling strategies, or equivalent, for measuring the concentrations at the 3 points are acceptable: (a) The use of a 3-probe or a 3-hole single probe arrangment, provided that the sampling rate in each of the 3 probes or holes is maintained within 10 percent of their average rate (This option requires a procedure, subject to the approval of the Administrator, to demonstrate that the proper sampling rate is maintained); or (b) the use of a traversing probe arrangement, provided that a measurement at each point is made at least once every 15 minutes and all 3 points are traversed and sampled for equal lengths of time within 15 minutes.

3.2.3 $SO_2$ Single-Point and Limited-Path Monitoring Systems. Provided that (a) no "dissimilar" gas streams (i.e., having greater than 10 percent difference in pollutant concentration from the average) are combined upstream of the measurement location, and (b) for steam generating facilities, a $CO_2$ or $O_2$ cotinuous monitor is installed in addition to the $SO_2$ monitor, according to the guidelines given in Section 3.1 or 3.2 of Performance Specification 3, the tester may choose to monitor $SO_2$ at a single point or over a limited path. Locate the point in or centrally locate the limited path over the "centroidal area." Any other location within the inner 50 percent of the stack cross-sectional area that has been demonstrated (see Section 3.4) to have a concentration within 5 percent of the concentration at a point within the "centroidal area" may be used.

3.2.4 $NO_x$ Single-Point and Limited-Path Monitoring Systems. For $NO_x$ monitors, the tester may choose the single-point or limited-path option described in Section 3.2.3 only in coal-burning steam generators (does not include oil and gas-fired units) and nitric acid plants, which have no dissimilar gas streams combining upstream of the measurement location.

3.3 Stratification Check Procedure. Unless specifically approved in Section 3.2., conduct a stratification check and select the measurement point, points, or path as follows:

3.3.1 Locate 9 sample points, as shown in Figure 2–2, a or b. The tester may choose to use more than 9 points, provided that the sample points are located in a similar fashion as in Fgure 2–2.

3.3.2 Measure at least twice the pollutant and, if applicable (as in the case of steam generators), $CO_2$ or $O_2$ concentrations at each of the sample points. Moisture need not be determined for this step. The following methods are acceptable for the measurements: (a) Reference Methods 3 (grab-sample), 6 or 7 of this part; (b) appropriate instrumental methods which give relative responses to the pollutant (i.e., the methods need not be absolutely correct), subject to the approval of the Administrator; or (c) alternative methods subject to the approval of the Administrator. Express all measurements, if applicable, in the units of the applicable standard.

3.3.3 Calculate the mean value and select a point, points, limited-path, or path which gives an equivalent value to the mean. The point or points must be within, and the limited-path or path must pass through, the inner 50 percent of the stack cross-sectional area. All other locations must be approved by the Administrator.

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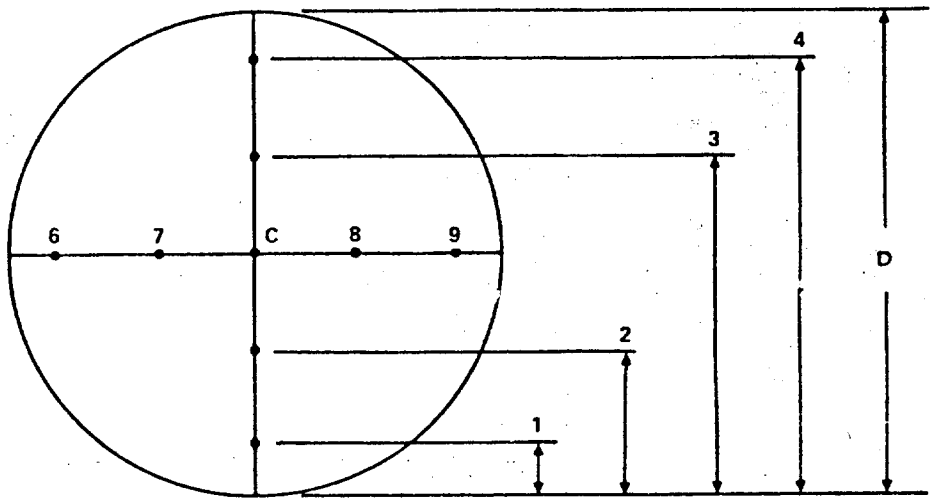
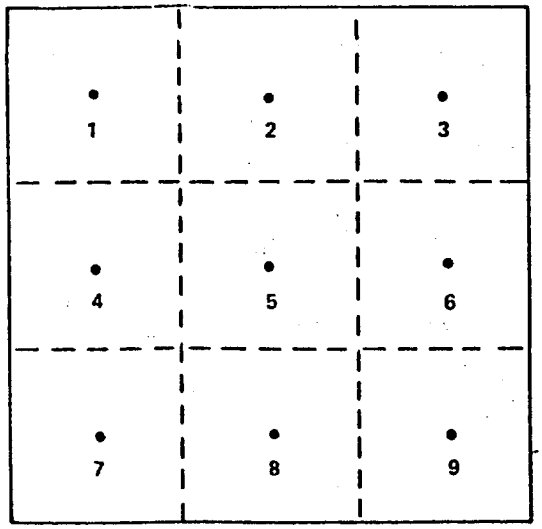
| POINT NO. | DISTANCE (% OF D) |
|---|---|
| 1, 9 | 10.0 |
| 2, 8 | 30.0 |
| C | 50.0 |
| 3, 7 | 70.0 |
| 4, 6 | 90.0 |




(a)




(b)

Figure 2-2. Location of 9 sampling points for stratification check.

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3.4 Acceptability of Single Point or Limited Path Alternative Location. Any of the applicable measurement methods mentioned in Section 3.3.2, above, may be used. Measure the pollutant and, if applicable, $CO_2$ or $O_2$ concentrations at both the centroidal area and the alternative locations. Moisture need not be measured for this test. Collect a 21-minute integrated sample or 3 grab-samples, either at evenly spaced (7 ± 2 min.) intervals over 21 minutes or all within 3 minutes, at each location. Run the comparative tests either concurrently or within 10 minutes of each other. Average the results of the 3 grab-samples.

Repeat the measurements until a minimum of 3 paired measurements spanning a minimum of 1 hour of process operation are obtained. Determine the average pollutant concentrations at the centroidal area and the alternative locations. If applicable, convert the data in terms of the standard for each paired set before taking the average. The alternative sampling location is acceptable if each alternative location value is within ± 10 percent of the corresponding centroidal area value and if the average at the alternative location is within 5 percent of the average of the centroidal area.

4. Performance and Equipment Specifications

The continuous monitoring system performance and equipment specifications are listed in Table 2-1. To be considered acceptable, the continuous monitoring system must demonstrate compliance with these specifications using the test procedures of Section 6.

5. Apparatus

5.1 Continuous Monitoring System. Use any continuous monitoring system of $SO_2$ or $NO_x$ which is expected to meet the specifications in Table 2-1. For sources which are required to convert the pollutant concentrations to other emission units using diluent gas measurements, the diluent gas continuous monitor, as described in Performance Specification 3 of this Appendix, is considered part of the continuous monitoring system. The data recorder may be an analog strip chart recorder type or other suitable device with an input signal range compatible with the analyzer output.

5.2 Calibration Gases. For continuous monitoring systems that allow the introduction of calibration gases to the analyzer, the calibration gases may be $SO_2$ in air or $N_2$, NO in $N_2$, and $NO_2$ in air or $N_2$. Two or more calibration gases may be combined in the same gas cylinder, except do not combine the NO and air. For $NO_x$ monitoring systems that oxidize NO to $NO_2$, the calibration gases must be in the form of NO. Use three calibration gas mixtures as specified below:

5.2.1 High-Level Gas. A gas concentration that is equivalent to 80 to 90 percent of the span value.

**Table 2-1.**—*Continuous Monitoring System Performance and Equipment Specifications*

| Parameter | Specification |
|---|---|
| 1. Conditioning period [a]. | ≥168 hours. |
| 2. Operational test period [a]. | ≥168 hours. |
| 3. Calibration error [b]. | ≤5 pct of each mid-level and high-level calibration value. |
| 4. Response time..... | ≤15 minutes (5 minutes for 3-point traversing probe arrangement). |
| 5. Zero drift (2-hour) [b,c]. | ≤2 pct of span value. |
| 6. Zero drift (24-hour) [b,c]. | ≤2 pct of span value. |
| 7. Calibration drift (2-hour) [b]. | ≤2 pct of span value. |
| 8. Calibration drift (24-hour) [b]. | ≤2.5 pct of span value. |
| 9. Relative accuracy [b]. | ≤20 pct of the mean value of reference method(s) test data in terms of emission standard or 10 percent of the applicable standard, whichever is greater. |
| 10. Calibration gas cells or filters. | Must provide a check of all analyzer internal mirrors and lenses and all electronic circuitry including the radiation source and detector assembly which are normally use in sampling and analysis. |
| 11. Data recorder chart resolution. | Chart scales must be readable to within ≤0.50 pct of full-scale. |
| 12. Extractive systems with diluent monitors. | Must use the same sample interface to sample both the pollutant and diluent gases. Place in series (diluent after pollutant analyzer) or use a "T." [a] During the conditioning and operational test periods, the continuous monitoring system shall not require any corrective maintenance, repair, replacement, or adjustment other than that clearly specified as routine and required in the operation and maintenance manuals. [b] Expressed as the sum of the absolute mean value plus the 95 percent confidence interval of a series of tests divided by a reference value. [c] A low-level (5-15 percent of span value) drift test may be substituted for the zero Drift tests. |

5.2.2 Mid-Level Gas. A gas concentration that is equivalent to 45 to 55 percent of the span value.

5.2.3 Zero Gas. A gas concentration of less than 0.25 percent of the span value. Ambient air may be used for the zero gas.

5.3 Calibration Gas Cells or Filters. For continuous monitoring systems which use calibration gas cells or filters, use three certified calibration gas cells or filters as specified below:

5.3.1 High-Level Gas Cell or Filter. One that produces an output equivalent to 80 to 90 percent of the span value.

5.3.2 Mid-Level Gas Cell or Filter. One that produces an output equivalent to 45 to 55 percent of the span value.

5.3.3 Zero Gas Cell or Filter. One that produces an output equivalent to zero. Alternatively, an analyzer may produce a zero value check by mechanical means, such as a movable mirror.

5.4 Calibration Gas—Gas Cell or Filter Combination. Combinations of the above may be used.

6. Performance Specification Test Procedures.

6.1 Pretest Preparation.

6.1.1 Calibration Gas Certification. The tester may select one of the following alternatives: (a) The tester may use calibration gases prepared according to the protocol defined in Citation 10.5, i.e. These gases may be used as received without reference method analysis (obtain a statement from the gas cylinder supplier certifying that the calibration gases have been prepared according to the protocol); or (b) the tester may use calibration gases not prepared according to the protocol. In case (b), he must perform triplicate analyses of each calibration gas (mid-level and high-level, only) within 2 weeks prior to the operational test period using the appropriate reference methods. Acceptable procedures are described in Citations 10.6 and 10.7. Record the results on a data sheet (example is shown in Figure 2-3). Each of the individual analytical results must be within 10 percent (or 15 ppm, whichever is greater) of the average; otherwise, discard the entire set and repeat the triplicate analyses. If the average of the triplicate reference method test results is within 5 percent of the calibration gas manufacturer's tag value, use the tag value; otherwise, conduct at least 3 additional reference method test analyses until the results of 6 individual runs (the 3 original plus 3 additional) agree within 10 percent or 15 ppm, whichever is greater, of the average. Then use this average for the cylinder value.

Figure 2-3. Analysis of Calibration Gases[a]

Date_____(Must be within 2 weeks prior to the operational test period)

Reference Method Used_____

| Sample Run | Mid-level[b] ppm | High-level[c] ppm |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| Average | | |
| Maximum % Deviation[d] | | |

[a] Not necessary if the protocol in Citation 10.5 is used to prepare the gas cylinders.

[b] Average must be 45 to 55 percent of span value.

[c] Average must be 80 to 90 percent of span value.

[d] Must be $\leq \pm$ 10 percent of applicable average or 15 ppm, whichever is greater.

6.1.2 Calibration Gas Cell or Filter Certification. Obtain (a) a statement from the manufacturer certifying that the calibration gas cells or filters (zero, mid-level, and high-level) will produce the stated instrument responses for the continuous monitoring system, and (b) a description of the test procedure and equipment used to calibrate the cells or filters. At a minimum, the manufacturer must have calibrated the gas cells or filters against a simulated source of known concentration.

6.2 Conditioning Period. Prepare the monitoring system for operation according to the manufacturer's written instructions. At the outset of the conditioning period, zero and span the system. Use the mid-level calibration gas (or gas cell or filter) to set the span at 50 percent of recorder full-scale. If necessary to determine negative zero drift, offset the scale by 10 percent. (Do not forget to account for this when using the calibration curve.) If a zero offset is not possible or is impractical, a low-level drift may be substituted for the zero drift, by using a low-level (5 to 15 percent of span value) calibration gas (or gas cell or filter). This low-level calibration gas (or gas cell or filter) need not be certified. Operate the continuous monitoring system for an initial 168-hour period in the manner specified by the manufacturer. Except during times of instrument zero, calibration checks, and system backpurges, the continuous monitoring system shall collect and condition the effluent gas sample (if applicable), analyze the sample for the appropriate gas constituents, and produce a permanent record of the system output. Conduct daily zero and mid-level calibration checks and, when drift exceeds the daily operating limits, make adjustments. The data recorder shall reflect these checks and adjustments. Keep a record of any instrument failure during this time. If the conditioning period is interrupted because of source breakdown (record the dates and times of process shutdown), continue the 168-hour period following resumption of source operation. If the conditioning period is interrupted because of monitor failure, restart the 168-hour conditioning period when the monitor becomes functional.

6.3 Operational Test Period. Operate the continuous monitoring system for an additional 168-hour period. The continuous monitoring system shall monitor the effluent, except during periods when the system calibration and response time are checked or during system backpurges; however, the system shall produce a permanent record of all operations. Record any system failure during this time on the data recorder output sheet.

It is not necessary that the 168-hour operational test period immediately follow the 168-hour conditioning period. During the operational test period, perform the following test procedures:

6.3.1 Calibration Error Determination. Make a total of 15 nonconsecutive zero, mid-level, and high-level measurements (e.g., zero, mid-level, zero, high-level, mid-range, etc.). This will result in a set of 5 each of zero, mid-level, and high-level measurements. Convert the data output to concentration units, if necessary, and record the results on a data sheet (example is shown in Figure 2–4). Calculate the differences between the reference calibration gas concentrations and the measurement system reading. Then calculate the mean, confidence interval, and calibration errors separately for the mid-level and high-level concentrations using Equations 2–1, 2–2, and 2–3. In Equation 2–3, use each respective calibration gas concentration for R.V.

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Figure 2-4. Calibration Error Determination

| Run no. | Calibration gas concentration[a] ppm | Measurement system reading ppm | Arithmetic differences ppm | |
|---|---|---|---|---|
| | A | B | A-B | |
| | | | Mid | High |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| Arithmetic Mean (Eq. 2-1) = | | | | |
| Confidence Interval (Eq. 2-2) = | | | | |
| Calibration Error (Eq. 2-3)[b] = | | | | |

[a] Calibration Data from Section 6.1.1 or 6.1.2

Mid-level: C = _____ppm

High-level: D = _____ppm

[b] Use C or D as R.V. in Eq. 2-3

Figure 2-5. Response Time

Date_____ High-level = _____ ppm

| Test Run | Upscale min. | Downscale min. |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| Average | A = | B = |

System Response Time (slower of A and B) = _____ min.

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6.3.2 Response Time Test Procedure. At a minimum, each response time test shall provide a check of the entire sample transport line (if applicable), any sample conditioning equipment (if applicable), the pollutant analyzer, and the data recorder. For in-situ systems, perform the response time check by introducing the calibration gases at the sample interface (if applicable), or by introducing the calibration gas cells or filters at an appropriate location in the pollutant analyzer. For extractive monitors, introduce the calibration gas at the sample probe inlet in the stack or at the point of connection between the rigid sample probe and the sample transport line. If an extractive analyzer is used to monitor the effluent from more than one source, perform the response time test for each sample interface.

To begin the response time test, introduce zero gas (or zero cell or filter) into the continuous monitor. When the system output has stabilized, switch to monitor the stack effluent and wait until a "stable value" has been reached. Record the upscale response time. Then, introduce the high-level calibration gas (or gas cell or filter). Once the system has stabilized at the high-level concentration, switch to monitor the stack effluent and wait until a "stable value" is reached. Record the downscale response time. A "stable value" is equivalent to a change of less than 1 percent of span value for 30 seconds or 5 percent of measured average concentration for 2 minutes. Repeat the entire procedure three times. Record the results of each test on a data sheet (example is shown in Figure 2–5). Determine the means of the upscale and downscale response times using Equation 2–1. Report the slower time as the system response time.

6.3.3 Field Test for Zero Drift and Calibration Drift. Perform the zero and calibration drift tests for each pollutant analyzer and data recorder in the continuous monitoring system.

6.3.3.1 Two-hour Drift. Introduce consecutively zero gas (or zero cell or filter) and high-level calibration gas (or gas cell or filter) at 2-hour intervals until 15 sets (before and after) of data are obtained. Do not make any zero or calibration adjustments during this time unless otherwise prescribed by the manufacturer. Determine and record the amount that the output had drifted from the recorder zero and high-level value on a data sheet (example is shown in Figure 2–6). The 2-hour periods over which the measurements are conducted need not be consecutive, but must not overlap. Calculate the zero and calibration drifts for each set. Then calculate the mean, confidence interval, and zero and calibration drifts (2-hour) using Equations 2–1, 2–2, and 2–3. In Equation 2–3, use the span value for R.V.

6.3.3.2 Twenty-Four Hour Drift. In addition to the 2-hour drift tests, perform a series of seven 24-hour drift tests as follows: At the beginning of each 24-hour period, calibrate the monitor, using mid-level value. Then introduce the high-level calibration gas (or gas cell or filter) to obtain the initial reference value. At the end of the 24-hour period, introduce consecutively zero gas (or gas cell or filter) and high-level calibration gas (or gas cell or filter); do not make any adjustments at this time. Determine and record the amount of drift from the recorder zero and high-level value on a data sheet (example is shown in Figure 2–7). Calculate the zero and calibration drifts for each set. Then calculate the mean, confidence interval, and zero and calibration drifts (24-hour) using Equations 2–1, 2–2, and 2–3. In Equation 2–3, use the span value for R.V.

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| Data set no. | Date | Time | | Zero Rdg | | Zero drift | Hi-level Rdg | | Span drift | Calib. drift |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Begin | End | Init. A | Fin. B | C=B-A | Init. D | Fin. E | F=E-D | G=F-C |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| Arithmetic Mean (Eq. 2-1) | | | | | | | | | | |
| Confidence Interval (Eq. 2-2) | | | | | | | | | | |
| Zero Drift[a] | | | | | | | Calibration drift[a] | | | |

[a] Use Equation 2-3, with span value for R. V.

Figure 2-6. Zero and Calibration Drift (2 hour)

BILLING CODE 6560-01-C

| Data set no. | Date | Time | | Zero Rdg | | Zero drift | Hi-level Rdg | | Span drift | Calib. drift |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Begin | End | Init. A | Fin. B | C=B-A | Init. D | Fin. E | F=E-D | G=F-C |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| Arithmetic Mean (Eq. 2-1) | | | | | | | | | | |
| Confidence Interval (Eq. 2-2) | | | | | | | | | | |
| Zero drift | | | | | | | Calibration drift[a] | | | |

[a] Use Equation 2-3, with the span value for R. V.

Figure 2-7. Zero and Calibration Drift (24-hour)

Note.—Automatic zero and calibration adjustments made by the monitoring system without operator intervention or initiation are allowable at any time. Manual adjustments, however, are allowable only at 24-hour intervals, unless a shorter time is specified by the manufacturer.

6.4 System Relative Accuracy. Unless otherwise specified in an applicable subpart of the regulations, the reference methods for $SO_2$, $NO_x$, diluent ($O_2$ or $CO_2$), and moisture are Reference Methods 6, 7, 3, and 4, respectively. Moisture may be determined along with $SO_2$ using Method 6. See Citation 10.8. Reference Method 4 is necessary only if moisture content is needed to enable comparison between the Reference Method and monitor values. Perform the accuracy test using the following guidelines:

6.4.1 Location of Pollutant Reference Method Sample Points. The following specifies the location of the Reference Method sample points which are on the same cross-sectional plane as the monitor's. However, any cross-sectional plane within 2 equivalent diameter of straight runs may be used, by using the projected image of the monitor on the selected plane in the following criteria.

6.4.1.1 For point monitors, locate the Reference Method sample point no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from the pollutant monitor sample point.

6.4.1.2 For multipoint monitors, locate each Reference Method sample traverse point no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from each corresponding pollutant monitor sample point.

6.4.1.3 For limited-path and path monitors, locate 3 sample points on a line parallel to the monitor path and no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from the centerline of the monitor path. The three points of the Reference Method shall correspond to points in the monitor path at 16.7, 50.0, and 83.3 percent of the effective length of the monitor path.

6.4.2 Location of Diluent and Moisture Reference Method Sample Points.

6.4.2.1 For sources which require diluent monitors in addition to pollutant monitors, locate each of the sample points for the diluent Reference Method measurements within 3 cm of the corresponding pollutant Reference Method sample point as defined in Sections 6.4.1.1, 6.4.1.2, or 6.4.1.3. In addition, locate each pair of diluent and pollutant Reference Method sample points no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from *both* the diluent and pollutant continuous monitor sample points or paths.

6.4.2.2 If it is necessary to convert pollutant and/or diluent monitor concentrations to a dry basis for comparison with the Reference data, locate each moisture Reference Method sample point within 3 cm of the corresponding pollutant or diluent Reference Method sample point as defined in Sections 6.4.1.1, 6.4.1.2, 6.4.1.3, or 6.4.2.1.

6.4.3 Number of Reference Method Tests.

6.4.3.1 For $NO_x$ monitors, make a minimum of 27 $NO_x$ Reference Method measurements, divided into 9 sets.

6.4.3.2 For $SO_2$ monitors, make a minimum of 9 $SO_2$ Reference Method tests.

6.4.3.3 For diluent monitors, perform one diluent Reference Method test for each $SO_2$ and/or $NO_x$ Reference Method test(s).

6.4.3.4 For moisture determinations, perform one moisture Reference Method test for each or each set of pollutant(s) and diluent (if applicable) Reference Method tests.

Note.—The tester may choose to perform more than 9 sets of $NO_x$ measurements or more than 9 $SO_2$ reference method diluent, or moisture tests. If this option is chosen, the tester may, at his discretion, reject up to 3 of the set or test results, so long as the total number of set or test results used to determine the relative accuracy is greater than or equal to 9. Report all data including rejected data.

6.4.4 Sampling Strategy for Reference Method Tests. Schedule the Reference Method tests so that they will not be in progress when zero drift, calibration drift, and response time data are being taken. Within any 1-hour period, conduct the following tests: (a) one set, consisting of 3 individual measurements, of $NO_x$ and/or one $SO_2$; (b) one diluent, if applicable; and (c) one moisture (if needed). Whenever two or more reference tests (pollutant, diluent, and moisture) are conducted, the tester may choose to run all these reference tests within a 1-hour period. However, it is recommended that the tests be run concurrently or consecutively within a 4-minute interval if two reference tests employ grab sampling techniques. Also whenever an integrated reference test is run together with grab sample reference tests, it is recommended that the integrated sample be started one-sixth the test period before the first grab sample is collected.

In order to properly correlate the continuous monitoring system and Reference Method data, mark the beginning and end of each Reference Method test period (including the exact time of day) on the pollutant and diluent (if applicable) chart recordings. Use one of the following strategies for the Reference Method tests:

6.4.4.1 Single Point Monitors. For single point sampling, the tester may: (a) take a 21-minute integrated sample (e.g. Method 6, Method 4, or the integrated bag sample technique of Method 3); (b) take 3 grab samples (e.g. Method 7 or the grab sample technique of Method 3), equally spaced at 7-minute (±2 min) intervals (or one-third the test period); or (c) take 3 grab samples over a 3-minute test period.

6.4.4.2 Multipoint or Path Monitors. For multipoint sampling, the tester may either: (a) make a 21-minute integrated sample traverse, sampling for 7 minutes (±2 min) (or one-third the test period) at each point; or (b) take grab samples at each traverse point, scheduling the grab samples to that they are an equal interval (7±2 minutes) of time apart (or one-third the test period).

Note.—If the number of sample points is greater than 3, make appropriate adjustments to the individual sampling time intervals. At times NSPS performance test data may be used as part of the data base of the continuous monitoring relative accuracy tests. In these cases, other test periods as specified in the applicable subparts of the regulations may be used.

6.4.5 Correlation of Reference Method and Continuous Monitoring System Data. Correlate the continuous monitoring system data with the Reference Method test data, as to the time and duration of the Reference Method tests. To accomplish this, first determine from the continuous monitoring system chart recordings, the integrated average pollutant and diluent (if applicable) concentration(s) for each Reference Method test period. Be sure to consider system response time. Then, compare each integrated average concentration against the corresponding average concentration obtained by the Reference Method; use the following guidelines to make these comparisons:

6.4.5.1 If the Reference Method is an integrated sampling technique (e.g., Method 6), make a direct comparison of the Reference Method results and the continuous monitoring system integrated average concentration.

6.4.5.2 If the Reference Method is a grab-sampling technique (e.g., Method 7), first average the results from all grab-samples taken during the test period, and then compare this average value against the integrated value obtained from the continuous monitoring system chart recording.

6.5 Data Summary for Relative Accuracy Tests. Summarize the results on a data sheet; example is shown in figure 2–8. Calculate the arithmetic differences between the reference method and the continuous monitoring output sets. Then calculate the mean, confidence interval, and system relative accuracy, using Equation 2–1, 2–2, and 2–3. In Equation 2–3, use the average of the reference method test results for R.V.

7. Equations

7.1 Arithmetic Mean. Calculate the mean of a data set as follows:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \qquad \text{Equation 1-2}$$

Where:

$x$ = arithmetic mean.
$n$ = number of data points.
$\Sigma x_i$ = algebraic sum of the individual values, $x_i$.

When the mean of the differences of pairs of data is calculated, be sure to correct the data for moisture.

7.2 Confidence Interval. Calculate the 95 percent confidence interval (two-sided) as follows:

$$C.I._{95} = \frac{t_{.975}}{n\sqrt{n-1}} \sqrt{n\Sigma x_i^2 - (\Sigma x_i)^2} \qquad \text{Equation 1-3}$$

Where:

$C.I._{95}$ = 95 percent confidence interval estimate of mean value.
$t_{.975} = t_{(1-\alpha/2)}$ (see Table 2–2)

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**Table 2-2.—*t* = *Values***

| n[a] | $t_{.975}$ | n[a] | $t_{.975}$ | n[a] | $t_{.975}$ |
|---|---|---|---|---|---|
| 2 | 12.706 | 7 | 2.447 | 12 | 2.201 |
| 3 | 4.303 | 8 | 2.365 | 13 | 2.179 |
| 4 | 3.182 | 9 | 2.306 | 14 | 2.160 |
| 5 | 2.776 | 10 | 2.262 | 15 | 2.145 |
| 6 | 2.571 | 11 | 2.228 | 16 | 2.131 |

[a] The values in this table are already corrected for n-1 degrees of freedom. Use *n* equal to the number of individual values.

| Run no. | Date and time | $SO_2$ | | | $NO_x$[b] | | | $CO_2$ or $O_2$[a] | | $SO_2$[a] | | | $NO_x$[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RM | M | Diff | RM | M | Diff | RM | M | RM | M | Diff | RM | M | Diff |
| | | ppm[d] | | | ppm[d] | | | %[d] | %[d] | mass/GCV | | | mass/GCV | | |
| 1 | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | |
| Average | | | | | | | | | | | | | | | |
| Confidence Interval | | | | | | | | | | | | | | | |
| Accuracy[c] | | | | | | | | | | | | | | | |

[a] For steam generators [b] Average of 3 samples [c] Use average of reference method test results for R.V

[d] Make sure that RM and M data are on a consistent basis, either wet or dry

Figure 2-8. Relative accuracy determination

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7.3 Relative Accuracy. Calculate the relative accuracy of a set of data as follows:

$$R.A. = \frac{|\bar{x}| + |C.I._{95}|}{R.V.} \times 100 \quad \text{Equation 2-3}$$

Where: R. A. = relative accuracy

$|\bar{x}|$ = absolute value of the arithmetic mean (from Equation 2-1).

$|C.I._{95}|$ = absolute value of the 95 percent confidence interval (from Equation 2-2).

R.V. = reference value, as defined in Sections 6.3.1, 6.3.3.1, 6.3.3.2, and 6.5.

8. Reporting

At a minimum (check with regional offices for additional requirements, if any) summarize the following results in tabular form: calibration error for mid-level and high-level concentrations, the slower of the upscale and downscale response times, the 2-hour and 24-hour zero and calibration drifts, and the system relative accuracy. In addition, provide, for the conditioning and operational test periods, a statement to the effect that the continuous monitoring system operated continuously for a minimum of 168 hours each, except during times of instrument zero, calibration checks, system backpurges, and source breakdown, and that no corrective maintenance, repair, replacement, or adjustment other than that clearly specified as routine and required in the operation and maintenance manuals were made. Also include the manufacturer's certification statement (if applicable) for the calibration gas, gas cells, or filters. Include all data sheets and calculations and charts (data outputs), which are necessary to substantiate that the system met the performance specifications.

9. Retest

If the continuous monitoring system operates within the specified performance parameters of Table 2-1, the operational test period will be successfully concluded. If the continuous monitoring system fails to meet any of the specifications, repeat that portion of the testing which is related to the failed specification.

10. Bibliography


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10.3 "Experimental Statistics." Department of Commerce, Handbook 91, 1963, pp. 3–31, paragraphs 3–3.1.4.

10.4 "Performance Specifications for Stationary-Source Monitoring Systems for Gases and Visible Emissions." Environmental Protection Agency, Research Triangle Park, N.C., EPA–650/2–74–013, January 1974.

10.5 Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors (Protocol No. 1). June 15, 1978. Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. EPA, Research Triangle Park, N.C. 27711.

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10.8 Stanley, Jon and P. R. Westlin. An Alternative Method for Stack Gas Moisture Determination. Emission Measurement Branch, Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, N.C., August 1978.

# APPENDIX F-3

# CONTINUOUS OXYGEN

*Performance Specification 3—Specifications and Test Procedures for $CO_2$ and $O_2$ Continuous Monitors in Stationary Sources*

1. Applicability and Principle

1.1 Applicability. This Specification contains (a) installation requirements, (b) instrument performance and equipment specifications, and (c) test procedures and data reduction procedures for evaluating the acceptability of continuous $CO_2$ and $O_2$ monitors that are used as diluent monitors. The test procedures are primarily designed for systems that introduce calibration gases directly into the analyzer; other types of monitors (e.g., single-pass monitors, as described in Section 2.2.7 of Performance Specification 2 of this Appendix) will be evaluated on a case-by-case basis upon written request to the Administrator, and alternative procedures will be issued separately.

1.2 Principle. Any $CO_2$ or $O_2$ continuous monitor, which is expected to meet this Specification, is operated for a specified length of time. During this specified time period, the continuous monitor is evaluated to determine conformance with the Specification.

2. Definitions

The definitions are the same as those listed in Section 2 of Performance Specification 2.

3. Installation Specifications

3.1 Measurement Location and Measurement Points or Paths. Select and install the continuous monitor at the same sampling location used for the pollutant monitor(s). Locate the measurement points or paths as shown in Figure 3–1 or 3–2.

3.2 Alternative Measurement Location and Measurement Points or Paths. The diluent monitor may be installed at a different location from that of the pollutant monitor, provided that the diluent gas concentrations at both locations differ by no more than 5 percent from that of the pollutant monitor location for $CO_2$ or the quantity 20.9-percent $O_2$, for $O_2$. See Section 3.4 of Performance Specification 2 for the demonstration procedure.

4. Continuous Monitor Performance and Equipment Specifications

The continuous monitor performance and equipment specifications are listed in Table 3–1. To be considered acceptable, the continuous monitor must demonstrate compliance with these specifications, using the test procedures in Section 6.

5. Apparatus

5.1 $CO_2$ or $O_2$ Continuous Monitor. Use any continuous monitor, which is expected to meet this Specification. The data recorder may either be an analog strip-chart recorder or other suitable device having an input voltage range compatible with the analyzer output.

5.2 Calibration Gases. Diluent gases shall be air or $N_2$ for $CO_2$ mixtures, and shall be $N_2$ for $O_2$ mixtures. Use three calibration gases as specified below:

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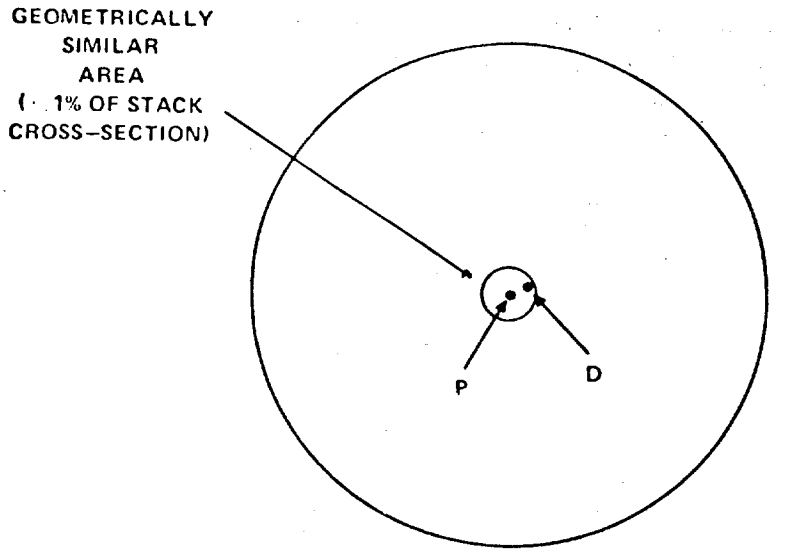
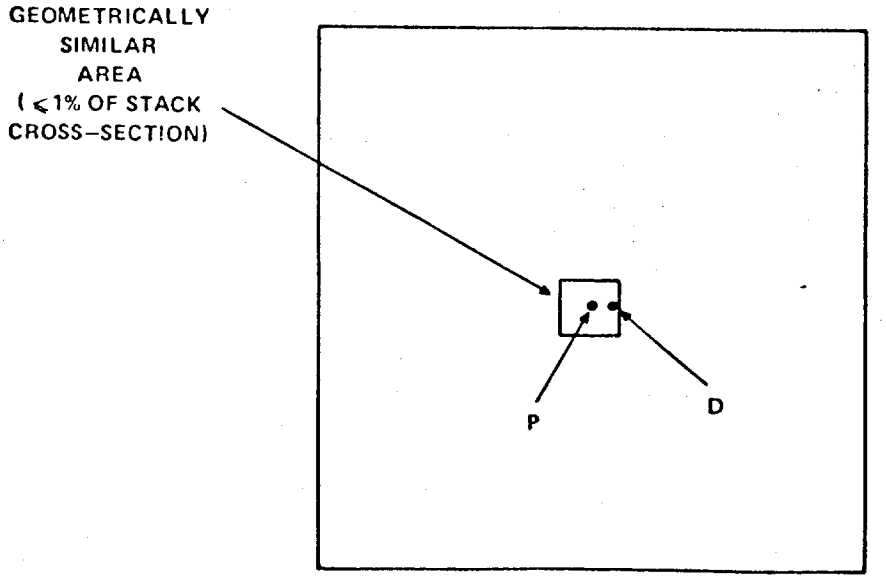
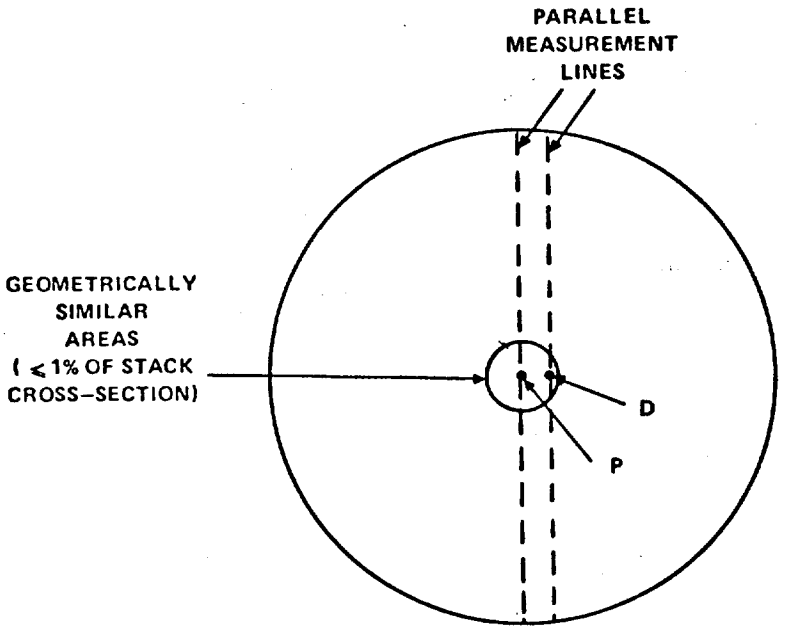



(a)

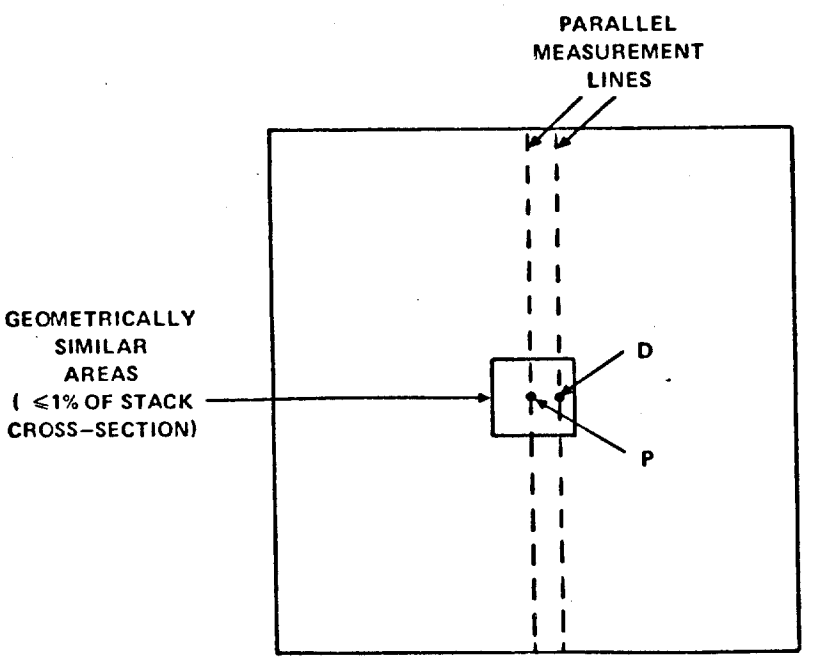



(b)

Figure 3-1. Relative locations of pollutant (P) and diluent (D) measurement points in (a) circular and (b) rectangular ducts. P is located at the centroid of the geometrically similar area. Note: The geometrically similar area need not be concentric.




(a)




(b)

Figure 3-2. Relative locations of pollutant (P) and diluent (D) measurement paths for (a) circular and (b) rectangular ducts. P is located at the centroid of both the geometrically similar areas and the pollutant monitor path cross-sectional areas. D is located at the centroid of the diluent monitor path cross-sectional area.

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**Table 3-1.**—*Performance and Equipment Specifications*

| Parameter | Specification |
|---|---|
| 1. Conditioning period [a]. | ≥ 168 hours. |
| 2. Operational test period [a]. | ≥ 168 hours. |
| 3. Calibration error [b] ... | ≤ 5 pct. of each (mid-range and high-range, only) calibration gas value. |
| 4. Reponse time ..... | ≤ 15 minutes. |
| 5. Zero drift (2-hour) [b, c]. | ≤ 0.4 pct. $CO_2$ or $O_2$. |
| 6. Zero drift (24-hour) [b, c]. | ≤ 10.5 pct. $CO_2$ or $O_2$. |
| 7. Calibration drift (2-hour) [b]. | ≤ 0.4 pct. $CO_2$ or $O_2$ |
| 8. Calibration drift (24-hour) [b]. | ≤ 0.5 pct. $CO_2$ or $O_2$. |
| 9. Data recorder chart resolution. | Chart scales must be readable to within ≤ 0.50 pct. of full-scale. |
| 10. Extractive monitors | Must use the same interface as the pollutant monitor. Place in a series (diluent after pollutant analyzer) or use a "T." |

[a] During the conditioning and operational test periods, the continuous monitor shall not require any corrective maintenance, repair, replacement, or adjustment other than that clearly specified as routine and required in the operation and maintenance manuals.

[b] Expressed as the sum of the absolute mean value plus the 95 percent confidence interval of a series of tests.

[c] A low-level (5–15 percent of span value) drift tests may be substituted for the zero drift tests.

5.2.1 High-Level Gas. A $CO_2$ or $O_2$ concentration of 20.0 to 22.5 percent. For $O_2$ analyzers, ambient air (20.9 percent $O_2$) may be used as the high-range calibration gas; lower high-level $O_2$ concentration may be used, subject to the approval of the Administrator.

5.2.2 Mid-Level Gas. A $CO_2$ or $O_2$ concentration of 11.0 to 14.0 percent; for $O_2$ analyzers, concentrations in the operational range may be used.

5.2.3 Zero Gas. A $CO_2$ or $O_2$ concentration of less than 0.05 percent. For $CO_2$ monitors, ambient air (0.03 percent $CO_2$) may be used as the zero gas.

6. Performance Specification Test Procedures.

6.1 Calibration Gas Certification. Follow the procedure as outlined in Section 6.1.2 of Performance Specification 2, except use 0.5 percent $CO_2$ or $O_2$ instead of the 15 ppm. Figure 3–3 is provided as an example data sheet.

6.2 Conditioning Period. Follow the same procedure outlined in Section 6.2 of Performance Specification 2.

6.3 Operational Test Period. Follow the same procedures outlined in Section 6.3 of Performance Specification 2, to evaluate the calibration error, response time, and the 2-hour and 24-hour zero and calibration drifts. See example data sheets (Figures 3–4 through 3–7).

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Figure 3-3. Analysis of Calibration Gases[a]

Date_____ (Must be within 2 weeks prior to the operational test period)

Reference Method Used_____

| Sample run | Mid-range[c] ppm | High-range[d] ppm |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| Average | | |
| Maximum % deviation[e] | | |

[a] Not necessary if the protocol in Citation 10.5 of Performance Specification 2 is used to prepare the gas cylinders.

[c] Average must be 11.0 to 14.0 percent; for $O_2$, see Section 5.2.2.

[d] Average must be 20.0 to 22.5 percent; for $O_2$, see Section 5.2.1.

[e] Must be $\leq \pm$ 10 percent of applicable average or 0.5 percent, whichever is greater.

Figure 3-4. Calibration Error Determination

| Run No. | Calibration Gas Concentration[a] ppm | Measurement System Reading ppm | Arithmetic Differences ppm | |
|---|---|---|---|---|
| | A | B | A-B | |
| | | | Mid | High |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| Arithmetic Mean (Eq. 2-1)[b] = | | | | |
| Confidence Interval (Eq. 2-2)[b] = | | | | |
| Calibration Error (Eq. 2-3)[b,c] = | | | | |

[a]Calibration Data from Section 6.1

Mid-level: C = _____ ppm

High-level: D = _____ ppm

[b] See Performance Specification 2

[c] Use C or D as R. V.

Figure 3-5. Response Time

Date _____ High-Range = _____ ppm

| Test Run | Upscale min | Downscale min |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| Average | A = | B = |

System Response Time (slower of A and B) = _____ min.

| Data set no | Date | Time | | Zero Rd. | | Zero drift | Hi-Range Rdg. | | Span drift | Calib. drift |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Begin | End | Init. | Fin. | | Init. | Fin. | | |
| | | | | A | B | C=B-A | D | E | F=E-D | G=F-C |
| | | | | | | | | | | |
| | | | | | | | | | | |
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| | | | | | | | | | | |
| | | | | | | | | | | |
| Arithmetic Mean (Eq. 2-1)[a] | | | | | | | | | | |
| Confidence Interval (Eq. 2-2)[a] | | | | | | | | | | |
| Zero drift[b] | | | | | | | Calibration drift[b] | | | |

[a] From Performance Specification 2.

[b] Use Equation 2-3 of Performance Specification 2 and 1.0 for R. V.

Figure 3-6. Zero and Calibration Drift (2 hour)

| Data set no. | Date | Time | | Zero Rdg | | Zero drift | Hi-Range Rdg | | Span drift | Calib. drift |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Begin | End | Init. | Fin. | | Init. | Fin. | | |
| | | | | A | B | C=B-A | D | E | F=E-D | G=F-C |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Arithmetic Mean (Eq. 2-1)[a] | | | | | | | | | | |
| Confidence Interval (Eq. 2-2)[a] | | | | | | | | | | |
| Zero drift [b] | | | | | | | Calibration drift [b] | | | |

[a] From Performance Specification 2.

[b] Use Equation 2-3 of Performance Specification 2, with 1.0 for R. V.

Figure 3-7. Zero and Calibration Drift (24-hour)

BILLING CODE 6560-01-C

6.4 System Relative Accuracy. (Note: The relative accuracy is not determined separately for the diluent monitor, but is determined for the pollutant-diluent system.) Unless otherwise specified in an applicable subpart of the regulations, the Reference Methods for the diluent concentration determination shall be Reference Method 3 for $CO_2$ or $O_2$. For this test, Fyrite analyses may be used for $CO_2$ and $O_2$ determinations. Perform the measurements using the guidelines below (an example data sheet is shown in Figure 2-8 of Performance Specification 2):

6.4.1 Location of Reference Method 3 Sampling Points. Locate the diluent Reference Method sampling points according to the guidelines given in Section 6.4.2.1 of Performance Specification 2.

6.4.2 Number of Reference Method Tests. Perform one Reference Method 3 test according to the guideline in Performance Specification 2.

6.4.3 Sampling Strategy for Reference Method Tests. Use the basic Reference Method sampling strategy outlined in Section 6.4.4 (and related sub-sections) of Performance Specification 2.

6.4.4 Correlation of Reference Method and Continuous Monitor Data. Use the guidelines given in Section 6.4.5 of Performance Specification 2.

7. Equations, Reporting, Retest, and Bibliography. The procedure and citations are the same as in Sections 7 through 10 of Performance Specification 2.

[FR Doc. 79-31033 Filed 10-9-79; 8:45 am]
BILLING CODE 6560-01-M

# APPENDIX G

# CALIBRATION DATA

# METER AND ORIFICE CALIBRATION

Date 7/30/79 Client U.S. EPA. Meter Box Number RAC-1

Barometric Pressure Pb ("Hg) 29.39 Calibrator TJP Gas Meter Number

| - | Orifice Manometer Setting, Δm (in. $H_2O$) | Gas Volume Wet Test Meter $V_w$ ($ft^3$) | Gas Volume Dry Gas Meter $V_d$ ($ft^3$) | Temperature: Wet Test Meter $t_w$ (°F) | Temperature: Dry Gas Meter Inlet $t_{di}$ (°F) | Temperature: Dry Gas Meter Outlet $t_{do}$ (°F) | Temperature: Dry Gas Meter Average $t_d$ (°F) | Vacuum Wet Test Meter $p_w$ (in. $H_2O$) | Time θ (min) | γ | $K_m$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stop | 0.5 | 810.320 | 336.607 | 74.3 | 102 | 94 | | | | | |
| Start | | 804.410 | 330.306 | 74.2 | 101 | 94 | | <0.025 | 15.0 | | |
| Average | 29.43 | (5) 591 | 6.301 | 74.3 | | | 97.8 | 29.39 | 15.0 | 0.978 | 0.131 |
| Stop | 1.0 | 804.037 | 329.908 | 74.1 | 104 | 94 | | | | | |
| Start | | 795.857 | 321.203 | 74.0 | 103 | 93 | | 0.025 | 15.0 | | |
| Average | 29.46 | (5) 8.180 | 8.705 | 74.1 | | | 98.5 | 29.39 | 15.0 | 0.980 | 0.128 |
| Stop | 2.0 | 795.625 | 320.956 | 74.0 | 106 | 93 | | | | | |
| Start | | 783.800 | 308.403 | 74.1 | 101 | 91 | | 0.05 | 15'30" | | |
| Average | 29.54 | (10) 11.825 | 12.553 | 74.1 | | | 97.8 | 29.39 | 15.5 | 0.979 | 0.127 |
| Stop | 3.0 | 783.388 | 307.968 | 74.0 | 106 | 90 | | | | | |
| Start | | 773.186 | 297.197 | 73.6 | 101 | 87 | | 0.05 | 11.0 | | |
| Average | 29.61 | (10) 10.202 | 10.771 | 73.8 | | | 96.0 | 29.39 | 11.0 | 0.979 | 0.126 |
| Stop | 4.0 | 771.318 | 295.232 | 73.5 | 104 | 88 | | | | | |
| Start | | 759.633 | 283.004 | 73.4 | 97 | 84 | | 0.075 | 11.0 | | |
| Average | 29.68 | (10) 11.685 | 12.228 | 73.5 | | | 93.3 | 29.38 | 11.0 | 0.981 | 0.125 |
| Stop | 5.0 | 759.227 | 282.587 | 73.4 | 101 | 84 | | | 12'30" | | |
| Start | | 744.484 | 267.310 | 73.8 | 90 | 80 | | 0.1 | | | |
| Average | 29.76 | (10) 14.743 | 15.277 | 73.6 | | | 88.8 | 29.38 | 12.5 | 0.980 | 0.124 |
| | | | | | | | | | AVERAGE | 0.980 | 0.127 |

$$P_w = P_b - \frac{p_w}{13.6} \qquad P_d = P_b + \frac{\Delta m}{13.6} \qquad K_m = \frac{V_w}{\theta}\sqrt{\frac{P_w}{T_w\,\Delta m}}$$

$$\gamma = \frac{V_w\,P_w\,(t_d + 460)}{V_d\,P_d\,(t_w + 460)}$$

Factor in isokinetic equation $= \frac{27.40}{(\overline{K_m})^2} = \frac{27.40}{(\quad)^2} =$ 1711

Clayton Environmental Consultants, Inc.

# METER AND ORIFICE CALIBRATION

Date 8-16-79 Client US EPA Meter Box Number 1

Barometric Pressure Pb ("Hg) 29.80 Calibrator RMK Gas Meter Number

| | Orifice Manometer Setting, $\Delta m$ (in. $H_2O$) | Gas Volume Wet Test Meter $V_w$ ($ft^3$) | Gas Volume Dry Gas Meter $V_d$ ($ft^3$) | Temperature: Wet Test Meter $t_w$ (°F) | Temperature: Dry Gas Meter Inlet $t_{di}$ (°F) | Temperature: Dry Gas Meter Outlet $t_{do}$ (°F) | Temperature: Dry Gas Meter Average $t_d$ (°F) | Vacuum Wet Test Meter $P_w$ (in. $H_2O$) | Time $\theta$ (min) | $\gamma$ | $K_m$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stop | 0.5 | 1050.000 | 826.958 | 70 | 80 | 70 | 75 | 0.15 | | | |
| Start | | 1045.000 | 821.817 | 70 | 74 | 68 | 72 | 0.05 | 12:33 | | |
| Average | 29.84 | (5) 5.0 | 5.141 | 70 | | | 73 | 29.79 | 12.55 | 0.977 | 0.134 |
| Stop | 1.0 | 1058.000 | 835.237 | 72 | 90 | 78 | 84 | 0.15 | | | |
| Start | | 1050.000 | 826.958 | 70 | 80 | 70 | 75 | 0.15 | 14:41 | | |
| Average | 29.87 | (5) 8.0 | 8.279 | 70.5 | | | 79.5 | 29.79 | 14.68 | 0.980 | 0.129 |
| Stop | 2.0 | 1068.000 | 845.656 | 71 | 96 | 80 | 88 | 0.15 | | | |
| Start | | 1058.000 | 835.237 | 72 | 90 | 78 | 84 | 0.15 | 13:12 | | |
| Average | 29.95 | (10) 10.0 | 10.419 | 71 | | | 86.0 | 29.79 | 13.20 | 0.982 | 0.127 |
| Stop | 3.0 | 1078.000 | 856.128 | 72 | 97 | 83 | | 0.15 | | | |
| Start | | 1068.000 | 845.656 | 71 | 96 | 80 | 88 | 0.15 | 10:55 | | |
| Average | 30.02 | (10) 10.0 | 10.472 | 71.5 | | | 89.0 | 29.79 | 10.92 | 0.979 | 0.125 |
| Stop | 4.0 | 1088.000 | 866.625 | ~~72~~ | 102 | 84 | | | | | |
| Start | | 1078.000 | 856.128 | 72 | 97 | 83 | | 0.15 | 9:32 | | |
| Average | 30.09 | (10) 10.0 | 10.497 | 71.8 | | | 91.5 | 29.79 | 9.53 | 0.978 | 0.124 |
| Stop | 5.0 | 1098.000 | 877.144 | 72 | 103 | 86 | 95 | 0.15 | | | |
| Start | | 1088.000 | 866.625 | 71.5 | 102 | 84 | 93 | 0.15 | 8:35 | | |
| Average | 30.17 | (10) 10.0 | 10.519 | 71.8 | | | 93.8 | 29.79 | 8.58 | 0.978 | 0.123 |
| | | | | | | | | | AVERAGE | 0.979 | 0.127 |

$$P_w = P_b - \frac{P_w}{13.6} \qquad P_d = P_b + \frac{\Delta m}{13.6} \qquad K_m = \frac{V_w}{\theta}\sqrt{\frac{P_w}{T_w\,\Delta m}}$$

$$\gamma = \frac{V_w\,P_w\,(t_d + 460)}{V_d\,P_d\,(t_w + 460)}$$

Factor in isokinetic equation $= \frac{27.40}{(\overline{K}_m)^2} = \frac{27.40}{(\quad)^2} = 1698$

'la n I .ro nt: Con tai , I

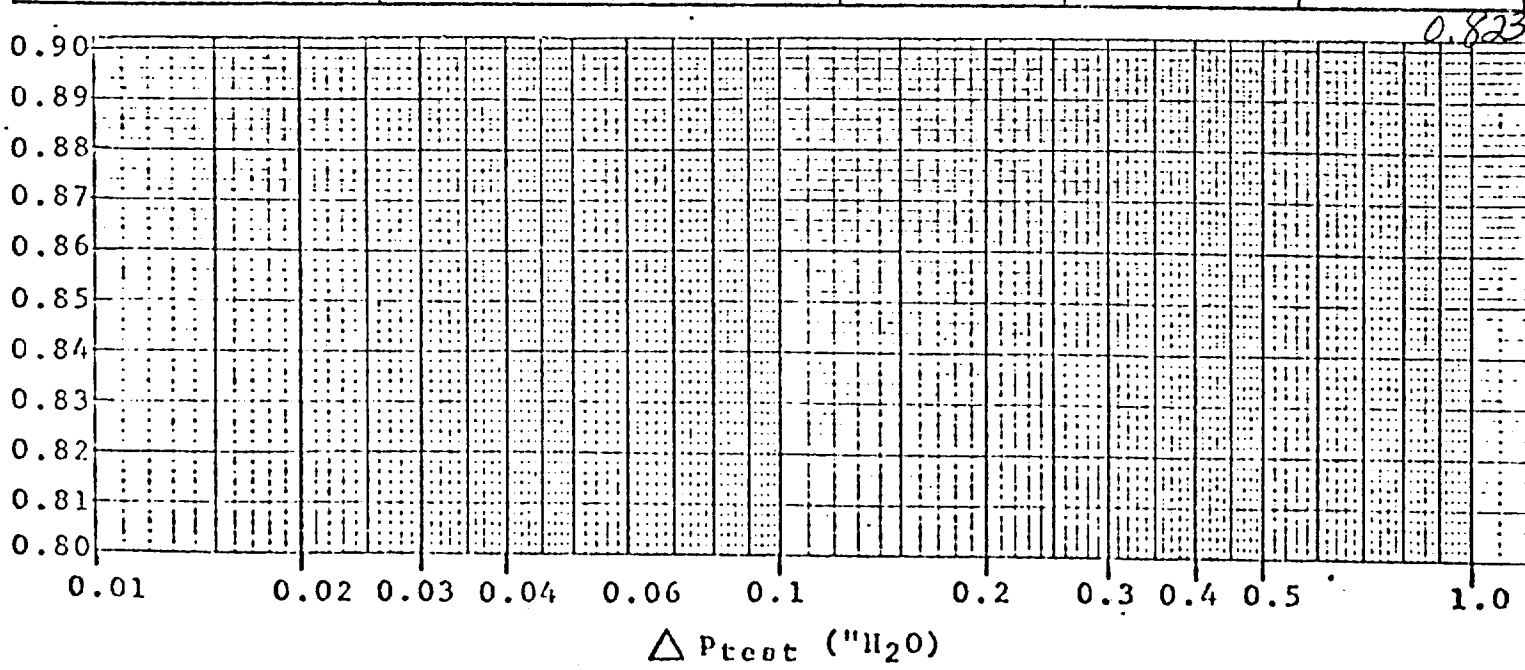
$$C_{Ptest} = 0.99\sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}}$$

Pitot Tube Type S Pitot Tube No. 35

Standard Pitot Tube No. _____

Calibrator: RMK Date: 6/28/79 Client: _____

| Anticipated $\Delta P_{std}$ | $\Delta P_{std}$ | A | | B | |
|---|---|---|---|---|---|
| | | $\Delta P_{test}$ | $\Delta C_{Ptest}$ | $\Delta P_{test}$ | $\Delta C_{Ptest}$ |
| 0.02 | 0. | 0. | 0. | 0. | 0. |
| 0.04 | 0.0980 | 0.144 | 0.825 | 0. | 0. |
| 0.06 | 0.0980 | 0.145 | 0.822 | 0. | 0. |
| 0.08 | 0.0960 | 0.144 | 0.816 | 0. | 0. |
| 0.10 | 0. | 0. | 0. | 0. | 0. |
| 0.12 | 0.0960 | 0. | 0. | 0.142 | 0.822 |
| 0.16 | 0.0960 | 0. | 0. | 0.141 | 0.825 |
| 0.20 | 0.0960 | 0. | 0. | 0.141 | 0.825 |
| 0.30 | 0. | 0. | 0. | 0. | 0. |
| 0.50 | 0. | 0. | 0. | 0. | 0. |
| 0.70 | 0. | 0. | 0. | 0. | 0. |
| 0.80 | 0. | 0. | 0. | 0. | 0. |



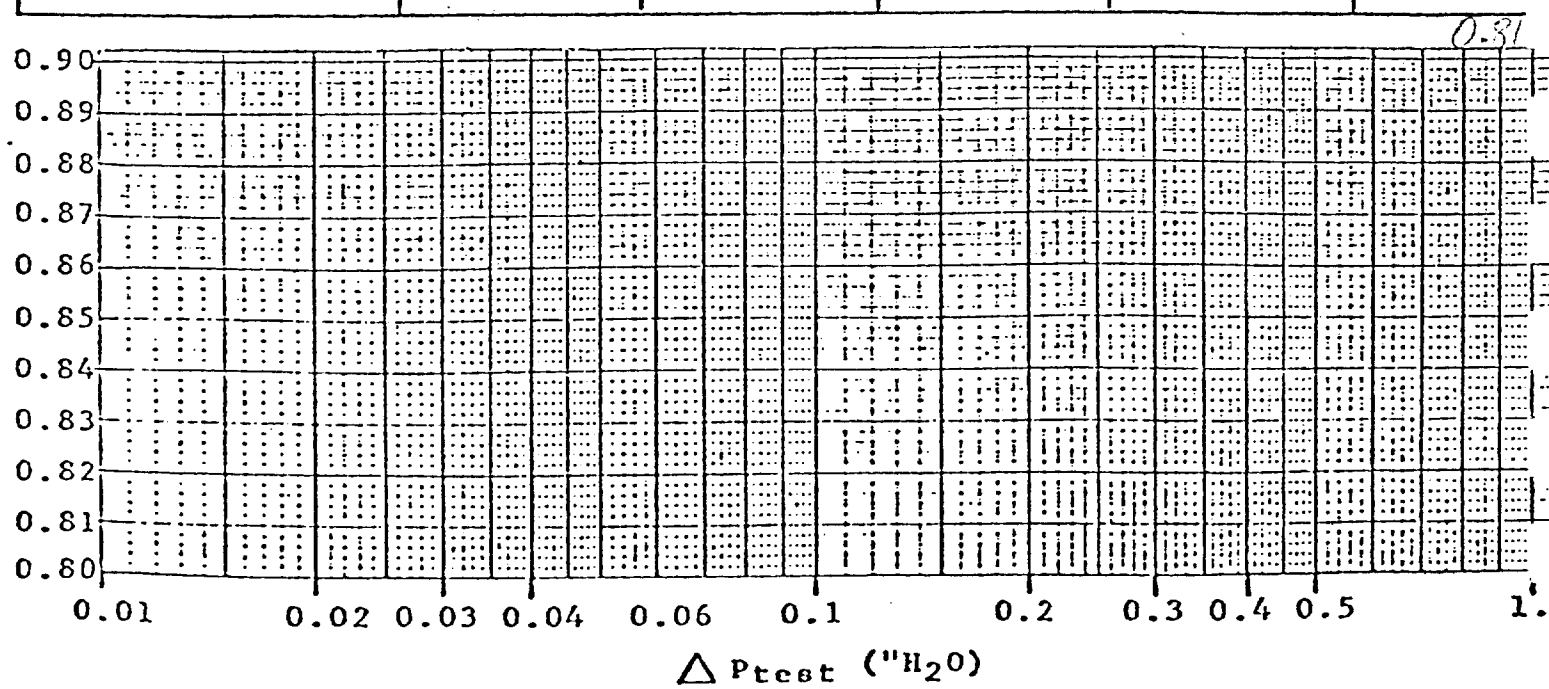
$$C_{ptest} = 0.99\sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}}$$

Pitot Tube Type S Pitot Tube No. S

Standard Pitot Tube No.

Calibrator: TJP JWB Date: 8/21/79 Client: C.F.+I.

| Anticipated $\Delta P_{std}$ | $\Delta P_{std}$ | A | | B | |
|---|---|---|---|---|---|
| | | $\Delta P_{test}$ | $\Delta C_{ptest}$ | $\Delta P_{test}$ | $\Delta C_{ptest}$ |
| 0.02 | 0. | 0. | 0. | 0. | 0. |
| 0.04 | 0. | 0. | 0. | 0. | 0. |
| 0.06 | 0. | 0. | 0. | 0. | 0. |
| 0.08 | 0. | 0. | 0. | 0. | 0. |
| 0.10 | 0.106 | 0.106 | 0.156 | 0.105 | 0.152 |
| 0.12 | 0. | 0.106 | 0.156 | 0.104 | 0.152 |
| 0.16 | 0. | 0.104 | 0.155 | 0.104 | 0.15 |
| 0.20 | 0. | 0. | 0.816 | 0.10 | 0.823 |
| 0.30 | 0. | 0. | 0.816 | 0. | 0.818 |
| 0.50 | 0. | 0. | 0.8[illegible] | 0. | 0.83 |
| 0.70 | 0. | 0. | 0. | 0. | 0. |
| 0.80 | 0. | 0. | 0. | 0. | 0. |



Beckman INSTRUMENTS, INC.
PROCESS INSTRUMENTS DIVISION
FULLERTON, CALIFORNIA • 92634

# INFRARED ANALYZER CALIBRATION & DATA SHEET

| | |
|---|---|
| CUSTOMER: | S.O. NO.: |
| ADDRESS: | P.O. NO.: |
| APPLICATION: CARBON MONOXIDE | MODEL NO.: |
| RANGES: 0-1% By VOLUME CALIBRATION PRESSURE | SERIAL NO.: |

| | ATMOSPHERIC ✓ | OTHER |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

| | |
|---|---|
| DETECTOR SER. NO.: | |
| DETECTOR PART NO.: | |
| TAG NO.: | |
| CONFIGURATION NO.: 12 | |

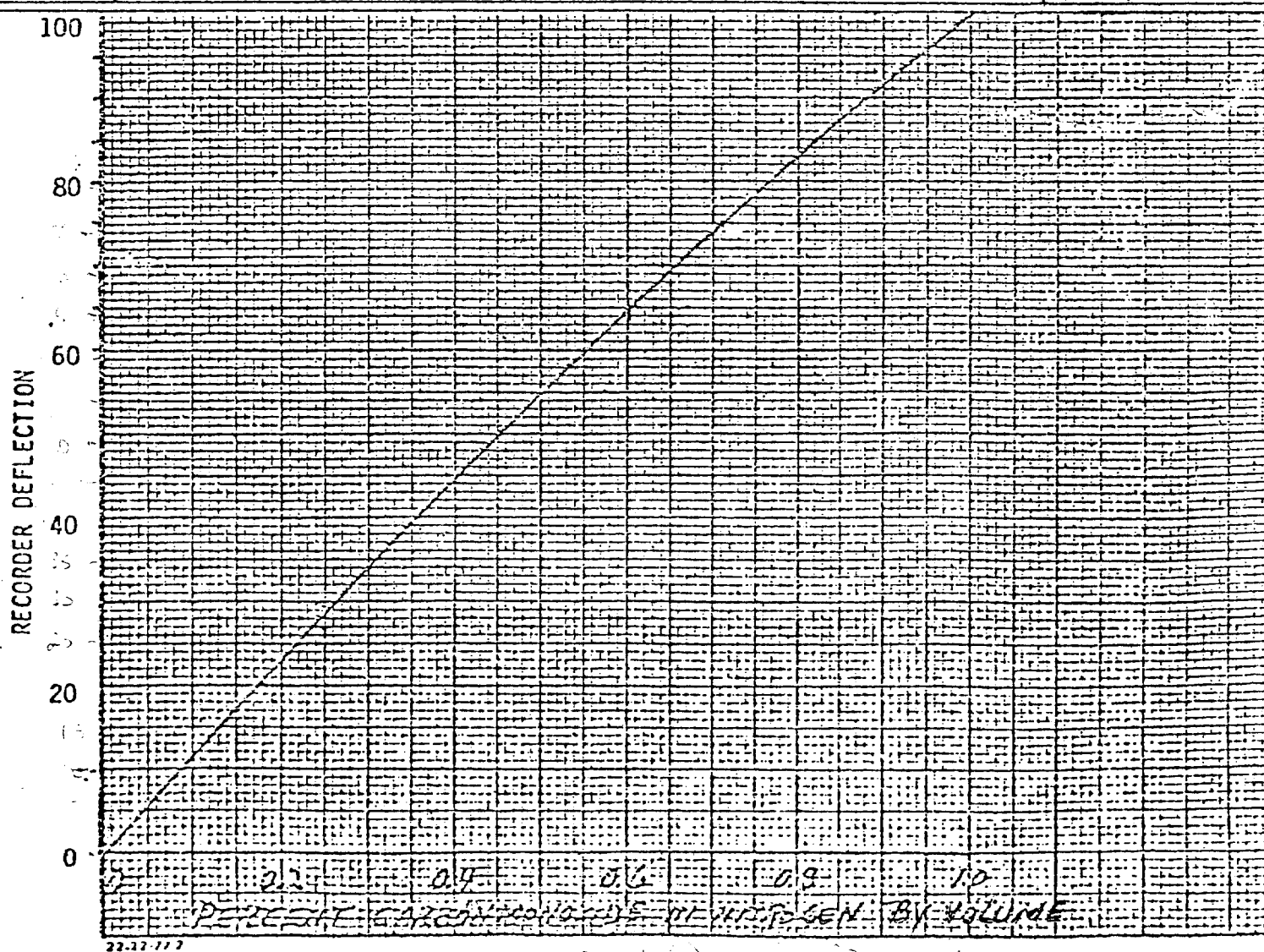
REPEATABILITY: (IN % OF F.S.)

| | |
|---|---|
| RANGE 1: | % RANGE 3: |
| RANGE 2: | % RANGE 4: |

MODIFICATIONS AND REMARKS:
TYPICAL CALIBRATION CURVE.

| INTERFERENCE GAS | MOL % | RESP. EQU |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

ENGINEER: HPH. DATE:




22-22-112

# APPENDIX H

## WEIGHTS BY FRACTION

TABLE H-1. PARTICULATE WEIGHT BY FRACTION, MILLIGRAMS

| Sample Number | Front Acetone Wash | Front Water Wash | 110-mm Type-A Glass-Fiber Filter | Filterable Particulate | Back Acetone Wash | Back Water Wash | | Total Particulate |
|---|---|---|---|---|---|---|---|---|
| | | | | | | C/E | Aqueous | |
| 1 | 53.2 | 78.8 | 147.1 | 279.1 | 62.1 | 4.9 | 47.6 | 393.7 |
| 2 | 39.2 | 112.3 | 141.3 | 292.8 | 41.5 | 4.8 | 32.0 | 371.1 |
| 3 | 49.0 | 116.3 | 112.3 | 277.6 | 33.7 | 4.4 | 24.9 | 340.6 |

TABLE H-2. SULFATE WEIGHT BY FRACTION, MILLIGRAMS

| Sample Number | Front Acetone Wash | Front Water Wash | 110-mm Type-A Glass-Fiber Filter | Filterable Sulfate | Back Acetone Wash | Back Water Wash | Total Sulfate |
|---|---|---|---|---|---|---|---|
| 1 | 0.3 | 25.8 | 50.4 | 76.5 | 0.2 | 232.4 | 309.1 |
| 2 | 1.0 | 34.8 | 55.3 | 91.1 | 0.1 | 72.3 | 163.5 |
| 3 | 0.5 | 49.2 | 42.2 | 91.9 | 2.0 | 93.7 | 187.6 |

# SECTION II

## BαP SAMPLING AND ANALYSIS

The sampling train used to collect BαP was identical to the particulate train except the BaP train contained an absorbent module between the filter and the first impinger.

The module was packed with a polymeric absorbent, XAD-2 (styrene divinyl benzene). The temperature of water circulating through the cooling jacket was maintained at 127$^{o}$F, therefore, the sampled gas would pass through the adsorbent material at a constant cooled temperature. The adsorbent module was covered with aluminum foil throughout the testing to prevent deterioration of the sample from exposure to ultraviolet light. The described operation of the absorbent module was the only variance of the BαP train from the particulate train.

The moisture content of the stack gas must take into account all the water collected in the BαP train. The water collected in the impingers and silica gel will not accurately reflect the true moisture content of the stack gas as the adsorbent module is located immediately behind the heated filter and water cooled to 127$^{o}$F; this temperature change will cause condensation of the stack gas in the middle before the impingers. Therefore, in operating a BαP train at a source with a high moisture content, either a moisture train or a Method 5 train should be operated during the run. This would provide an accurate moisture determination for the BαP run. This test utilized the moisture content from the Method 5 train as the source for BαP data reductions.

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 7:10 | 546.425 | | | | | | | | | |
| 1 | 05 | 7:15 | 547.88 | .003 | .26 | .26 | ~~[illegible]~~ | 104 | 104 | 9 | 250 | 80 |
| 2 | 10 | 7:20 | 549.42 | .003 | .26 | .26 | ~~[illegible]~~ | 104 | 104 | 9.5 | 250 | 80 |
| 3 | 15 | 7:25 | 550.07 | .003 | .26 | .26 | ~~[illegible]~~ | 105 | 104 | 10 | 250 | 80 |
| 4 | 20 | 7:30 | 552.51 | .003 | .26 | .26 | [illegible] | 110 | 105 | 10 | 250 | 78 |
| 5 | [illegible] | 7:35 | 553.33 | .003 | .26 | .26 | [illegible] | 113 | 106 | 10 | 250 | 78 |
| 6 | [illegible] | 7:40 | 555.31 | .003 | .26 | .26 | [illegible] | 115 | 106 | 9.5 | 250 | 78 |
| 7 | 35 | 7:45 | 556.70 | .003 | .26 | .26 | 451 | 116 | 106 | 9.5 | 250 | 78 |
| 8 | 40 | 7:50 | 558.28 | .003 | .26 | .26 | 450 | 118 | 108 | 10 | 250 | 78 |
| 9 | 45 | 7:55 | 559.87 | .003 | .26 | .26 | 452 | 120 | 110 | 12 | 250 | 76 |
| 10 | 50 | 8:00 | 561.52 | .003 | .26 | .26 | 454 | 121 | 110 | 15 | 250 | 76 |
| 11 | 55 | 8:05 | 563.13 | .003 | .26 | .26 | 457 | 121 | 111 | 15 | 250 | 76 |
| 12 | 60 | 8:10 | 564.78 | .003 | .26 | .26 | 460 | 120 | 112 | 16 | 250 | 76 |
| 13 | 65 | 8:15 | 566.41 | .003 | .26 | .26 | 463 | 120 | 112 | 16 | 250 | 76 |
| 14 | 70 | 8:20 | 568.06 | .003 | .26 | .26 | 466 | 119 | 111 | 16 | 250 | 76 |
| 15 | 75 | 8:25 | 569.70 | .003 | .26 | .26 | 457 | 118 | 111 | 16 | 250 | 76 |
| 16 | [illegible] | 8:30 | 571.34 | .003 | .26 | .26 | 459 | 118 | 110 | 16 | 250 | 76 |
| 17 | 85 | 8:35 | 572.98 | .003 | .26 | .26 | 463 | 118 | 110 | 17 | 250 | 76 |
| 18 | 90 | 8:40 | 574.610 | .003 | .26 | .26 | 465 | 118 | 110 | 17 | 250 | 76 |
| | | | | | | | 4466 | | | | | |
| | 180 | | 58.450 | .0030 | | .29 | 462 | 110 | 110 | .20 | | |

Run #2.

# FIELD DATA

PLANT: C.F.I.
DATE: 3-8-94
SAMPLING LOCATION: BATTERY B OUTLET
SAMPLE TYPE: BAR
RUN NUMBER: 2
OPERATOR: [illegible] & TORRES
AMBIENT TEMPERATURE: 114°
BAROMETRIC PRESSURE:
STATIC PRESSURE, ($P_s$): -1.0 " $H_2O$
FILTER NUMBER (s):

PROBE LENGTH AND TYPE: 15'
NOZZLE I.D.: .625
ASSUMED MOISTURE, %: 13%
SAMPLE BOX NUMBER:
METER BOX NUMBER: 2235
METER $\Delta H_@$:
C FACTOR:
PROBE HEATER SETTING:
HEATER BOX SETTING: 250
REFERENCE $\Delta p$: .022

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 10 MINUTES

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | 11:15 | 577.617 | | | | | | | | | |
| 1 | 10 | 11:25 | 580.47 | .003 | .26 | .26 | 470 | 108 | 100 | 21 | 250 | 76 |
| 2 | 20 | 11:35 | 583.58 | .003 | .26 | .26 | 470 | 108 | 100 | 21 | 250 | 76 |
| 3 | 30 | 11:45 | 586.71 | .003 | .26 | .26 | 470 | 112 | 104 | 21 | 250 | 76 |
| 4 | 40 | 11:55 | 589.82 | .003 | .26 | .26 | 470 | 117 | 108 | 21 | 250 | 76 |
| 5 | 50 | 12:05 | 592.93 | .003 | .26 | .26 | 470 | 118 | 112 | 21 | 250 | 78 |
| 6 | 60 | 12:15 | 596.05 | .003 | .26 | .26 | 470 | 120 | 114 | 21 | 250 | 80 |
| 7 | 70 | 12:25 | 599.14 | .003 | .26 | .26 | 470 | 120 | 116 | 21 | 250 | 82 |
| 8 | 80 | 12:35 | 602.21 | .003 | .26 | .26 | 470 | 118 | 116 | 21 | 250 | 83 |
| 9 | 90 | 12:45 | 605.33 | .003 | .26 | .26 | 470 | 120 | 116 | 21 | 250 | 84 |
| 10 | 100 | 12:55 | 608.4 | .003 | .26 | .26 | 470 | 120 | 116 | 21 | 250 | 86 |
| 11 | 110 | 1:05 | 611.5 | .002 | .22 | .22 | 465 | 118 | 118 | 21 | 250 | 86 |
| 12 | 120 | 1:15 | 614.6 | .002 | .22 | .22 | 461 | 120 | 118 | 21 | 250 | 88 |
| 13 | 130 | 1:25 | 617.30 | .002 | .22 | .22 | 467 | 120 | 115 | 21 | 250 | 90 |
| 14 | 136 | 1:31 | 618.790 | .002 | .22 | .22 | 465 | 120 | 118 | 21 | 250 | 92 |
| | | 2:54 | 630.10 | repaired pump and leak checked system | | | | | | | | |
| 15 | 150 | 3:08 | 634.63 | .002 | .22 | .22 | 465 | 118 | 114 | 20 | 250 | 95 |
| 16 | 160 | 3:18 | 637.39 | .002 | .22 | .22 | 465 | 117 | 114 | 20 | 250 | 90 |
| 17 | 170 | 3:28 | 640.10 | .002 | .22 | .22 | 465 | 118 | 116 | 20 | 250 | 89 |
| 18 | 180 | 3:38 | 642.77 | .002 | .22 | .22 | 465 | 118 | 116 | 20 | 250 | 90 |

COMMENTS:

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 3:54 | 642.525 | | | | | | | | | |
| 1 | 10 | 4:04 | 646.51 | .002 | .22 | .22 | 463 | 112 | 114 | 20 | 250 | 94 |
| 2 | 20 | 4:14 | 650.40 | .002 | .22 | .22 | 464 | 116 | 114 | 19.5 | 250 | 76 |
| 3 | 30 | 4:24 | 654.32 | .002 | .22 | .22 | 466 | 118 | 115 | 19.5 | 250 | 76 |
| 4 | 40 | 4:34 | 658.18 | .002 | .22 | .22 | 465 | 119 | 116 | 19.5 | 250 | 78 |
| 5 | 50 | 4:44 | 662.05 | .002 | .22 | .22 | 464 | 119 | 116 | 19.5 | 250 | 79 |
| 6 | 60 | 4:54 | 665.92 | .002 | .22 | .22 | 466 | 120 | 117 | 20 | 250 | 78 |
| 7 | 70 | 5:04 | 669.79 | .002 | .22 | .22 | 464 | 122 | 118 | 19.5 | 250 | 80 |
| 8 | 80 | 5:14 | 674.04 | .002 | .22 | .22 | 461 | 122 | 119 | 19.5 | 250 | 80 |
| 9 | 90 | 5:24 | 677.50 | .002 | .22 | .22 | 463 | 124 | 120 | 19.5 | 250 | 86 |
| 10 | 100 | 5:34 | 681.35 | .002 | .22 | .22 | 464 | 124 | 120 | 19.5 | 250 | 82 |
| 11 | 110 | 5:44 | 685.19 | .002 | .22 | .22 | 464 | 124 | 121 | 19.5 | 250 | 82 |
| 12 | 120 | 5:54 | 688.93 | .002 | .22 | .22 | 464 | 124 | 122 | 19.5 | 250 | 82 |
| [illegible] | 130 | [illegible] | 692.89 | .002 | .22 | .22 | 464 | 124 | 123 | 19.5 | 250 | 82 |
| [illegible] | 140 | [illegible] | 696.65 | .002 | .22 | .22 | 464 | 124 | 123 | 19.5 | 250 | 82 |
| [illegible] | [illegible] | [illegible] | 700.34 | .002 | .22 | .22 | 464 | 126 | 123 | 19.5 | 250 | 83 |
| [illegible] | [illegible] | [illegible] | 704.06 | .002 | .22 | .22 | 464 | 128 | 124 | 19.5 | 250 | 83 |
| [illegible] | [illegible] | [illegible] | 707.72 | .002 | .22 | .22 | 464 | 130 | 125 | 20 | 250 | 82 |
| [illegible] | [illegible] | [illegible] | 711.18 | .002 | .22 | .22 | 464 | 130 | 126 | 20 | 250 | 82 |
| | | | | | | | | 119.8 | 117.7 | | | |
| | | | | | | | | 119.88 | 116.38 | | | |
| | | | ~~723.508~~ | | | | | | 118.13 | | | |
| | 360 | | 723.198 | .0025 | | .231 | 465.8 | | 116.8 | | | |

EPA (Dur) 236

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [illegible] | 2:30 | 239.445 | | | | | | | | | |
| 1 | 10 | 2:48 | 243.50 | .002 | .26 | .26 | 464 | 94 | 94 | 6 | 250 | 74 |
| 2 | 20 | 2:58 | 246.1 | .003 | .26 | .26 | 462 | 100 | 98 | 6 | 250 | 74 |
| 3 | [illegible] | 3:08 | 248.9 | .003 | .26 | .26 | 467 | 100 | 98 | 45 | 250 | 74 |
| 4 | 40 | 3:18 | 251.6 | .003 | .26 | .26 | [illegible] | 106 | 99 | 5 | 250 | 70 |
| 5 | 50 | 3:28 | 254.1 | .003 | .26 | .26 | 462 | 106 | 98 | 5 | 250 | 69 |
| 6 | [illegible] | 3:38 | 256.6 | .003 | .26 | .26 | 465 | 104 | 100 | 5 | 250 | [illegible] |
| 8 | 70 | 3:48 | 259.60 | .003 | .26 | .26 | 460 | 104 | 100 | 5 | 250 | [illegible] |
| 9 | 80 | 3:58 | 262.30 | .003 | .26 | .26 | 458 | 106 | 100 | 5 | 250 | 68 |
| 10 | 90 | 4:08 | 265.1 | .003 | .26 | .26 | 460 | 106 | 100 | 5 | 250 | 70 |
| 11 | 100 | 4:18 | 268.2 | .003 | .26 | .26 | 464 | 102 | 100 | 6 | 250 | 70 |
| 12 | 110 | 4:28 | 270.9 | .003 | .26 | .26 | 465 | 102 | 100 | 6 | 250 | [illegible] |
| 13 | 120 | 4:38 | 273.55 | .003 | .26 | .26 | 460 | 107 | 100 | 7 | 250 | [illegible] |
| 14 | 140 | 4:48 | 276.80 | .003 | .26 | .26 | [illegible] | 104 | 96 | 11 | 250 | 66 |
| 15 | 150 | 4:58 | 279.74 | .003 | .26 | .26 | 464 | 108 | 98 | 11 | 250 | 66 |
| 16 | 160 | 5:08 | 282.46 | .003 | .26 | .26 | 464 | 110 | 100 | 10 | 250 | 66 |
| 17 | 170 | 5:18 | 285.11 | .003 | .26 | .26 | 464 | 106 | 100 | 11 | 250 | 66 |
| 18 | 180 | 5:28 | 287.81 | .003 | .26 | .26 | 462 | 106 | 100 | | 250 | 66 |
| | | | | | | | | 104.8 | 103.6 | | | |
| | | | 104.49 | | | | | | | | | |
| | 350 | | 103.7 | .0025 | | .26 | 463.7 | | 106.7 | | | |

? 130 (?)

EPA (Dur) 236
4 72

Run #1

# FIELD DATA

PLANT CF&I
DATE 8-2-79
SAMPLING LOCATION BATTERY 3 OUTLET
SAMPLE TYPE BAP
RUN NUMBER 1
OPERATOR ED TORRES & BART WEDSEL
AMBIENT TEMPERATURE 95°
BAROMETRIC PRESSURE 26.00
STATIC PRESSURE, ($P_s$) -4" H2O
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 15' STAINLESS
NOZZLE I.D. .625 00213
ASSUMED MOISTURE, % 10%
SAMPLE BOX NUMBER
METER BOX NUMBER 21.88
METER $\Delta H_@$
C FACTOR
PROBE HEATER SETTING 2
HEATER BOX SETTING 250°
REFERENCE $\Delta p$ .022

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 ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), 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 | 320 | 159.650 | | | | | | | | | |
| 1 | 05 | 325 | 161.600 | .005 | 2.8 | 2.85 | 230 | 104 | 101 | 19.0 | 250 | 68 |
| 2 | 10 | 330 | 163.4 | .005 | .71 | .71 | 230 | 108 | 104 | 19.0 | 250 | 70 |
| 3 | 15 | 335 | 165.10 | .005 | .52 | .71 | 442 | 110 | 104 | 20 | 250 | 70 |
| 4 | 20 | 340 | 166.829 | .003 | .52 | .52 | 470 | 112 | 106 | 20 | 250 | 70 |
| | 25 | 345 | 166.923 | | | | | | | | | |
| 5 | 30 | 350 | 168.5 | .003 | .30 | .30 | 494 | 110 | 106 | 20 | 250 | 70 |
| 6 | 35 | [illegible] | 170.[illegible] | [illegible] | .20 | .20 | 462 | 112 | 109 | 20 | 250 | 70 |
| 7 | 40 | [illegible] | 172.0 | .003 | .31 | .31 | 466 | 117 | 110 | 20 | 250 | 78 |
| 8 | 45 | [illegible] | 173.7 | .003 | .31 | .31 | 464 | 118 | 110 | 20 | 250 | 78 |
| 9 | 50 | 415 | 175.46 | .003 | .31 | .31 | 470 | 118 | 112 | 20 | 250 | 78 |
| 10 | 55 | 418 | 177.1 | .002 | .20 | .20 | 470 | 118 | 112 | 20 | 250 | 78 |
| 11 | 60 | 420 | 177.70 | .002 | .20 | .20 | 466 | 118 | 114 | 20 | 250 | 78 |
| | 65 | 540 | 534.21 | | | | | | | | | |
| 12 | 70 | 545 | 535.80 | .003 | .26 | .26 | 470 | 100 | 100 | 13 | 250 | 74 |
| 13 | 75 | 550 | 537.49 | .003 | .26 | .26 | 470 | 104 | 100 | 13 | 250 | 74 |
| 14 | 80 | 555 | 539.41 | .003 | .26 | .26 | 457 | 106 | 100 | 13 | 250 | 74 |
| 15 | 85 | 600 | 541.01 | .003 | .26 | .26 | 454 | 110 | 100 | 13 | 250 | 74 |
| 16 | 90 | 605 | 542.79 | .003 | .26 | .26 | 456 | 112 | 102 | 13 | 250 | 70 |
| 17 | | 610 | 544.57 | .003 | .26 | .26 | 458 | 117 | 104 | 19 | 250 | 70 |
| 18 | | 615 | 546.41 | .003 | .26 | .26 | 460 | 114 | 104 | 18 | 250 | 68 |

COMMENTS: 540 [illegible]

Run # 3

# FIELD DATA

PLANT CFEE
DATE 8-9-19
SAMPLING LOCATION [illegible] B
SAMPLE TYPE BAP
RUN NUMBER 3
OPERATOR [illegible]
AMBIENT TEMPERATURE 96°
BAROMETRIC PRESSURE 25.32
STATIC PRESSURE, ($P_s$) -.9" $H_2O$
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 15'
NOZZLE I.D. .625
ASSUMED MOISTURE, % 13%
SAMPLE BOX NUMBER
METER BOX NUMBER 2343
METER $\Delta H_@$ .26
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING 250°
REFERENCE $\Delta p$ .002

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 10 MINUTES PRE LEAK TEST 1.02 CFM

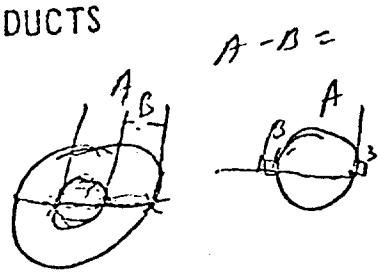
| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ ACTUAL | STACK TEMPERATURE ($T_s$), °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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | 1112 | 183.255 | | | | | | | | | |
| 1 | 10 | 1122 | 186.42 | .002 | .26 | .26 | 464 | 99 | 91 | 9 | 250 | 73 |
| 2 | 20 | 1132 | 189.54 | .002 | .26 | .26 | 464 | 104 | 94 | 9.5 | 250 | 74 |
| 3 | 30 | 1142 | 192.74 | .002 | .26 | .26 | 464 | 110 | 98 | 10 | 250 | 76 |
| 4 | 40 | 1152 | 195.22 | .002 | .26 | .26 | 464 | 112 | 102 | 10 | 250 | 76 |
| 5 | 50 | 1202 | 198.31 | .002 | .26 | .26 | 464 | 114 | 104 | 10 | 250 | 80 |
| 6 | 60 | 1212 | 201.46 | .002 | .26 | .26 | 464 | 115 | 106 | 5 | 250 | 78 |
| | | 1217 | 203.25 | | | | | | | | | |
| 7 | 70 | 1227 | 205.64 | .002 | .26 | .26 | 464 | 118 | 110 | 3 | 250 | 80 |
| 8 | 80 | 1237 | 208.82 | .002 | .26 | .26 | 464 | 119 | 111 | 3 | 250 | 80 |
| 9 | 90 | 1247 | 212.11 | .002 | .26 | .26 | 464 | 120 | 112 | 3 | 250 | 82 |
| 10 | 100 | 1257 | 215.22 | .002 | .26 | .26 | 464 | 120 | 119 | 3 | 250 | 78 |
| 11 | 110 | 1307 | 218.23 | .002 | .26 | .26 | 464 | 120 | 119 | 3 | 250 | 74 |
| 12 | 120 | 1317 | 221.25 | .002 | .26 | .26 | 464 | 119 | 114 | 3 | 250 | 72 |
| 13 | 130 | 1327 | 224.31 | .002 | .26 | .26 | 464 | 119 | 113 | 3 | 250 | 74 |
| 14 | 140 | 1337 | 227.18 | .002 | .26 | .26 | 464 | 119 | 113 | 3 | 250 | 74 |
| 15 | 150 | 1347 | 230.32 | .002 | .26 | .26 | 464 | 119 | 113 | 3 | 250 | 80 |
| 16 | 160 | 1357 | 233.45 | .002 | .26 | .26 | 464 | 123 | 114 | 3 | 250 | 80 |
| 17 | 170 | 2:07 | 236.52 | .002 | .26 | .26 | 464 | 120 | 114 | 3 | 250 | 76 |
| 18 | 180 | 2:17 | 239.38 | .002 | .26 | .26 | 464 | 116 | 114 | 3 | 250 | 74 |

COMMENTS: 12:12 → STOP DUE TO VACUUM DROP .. LEAK CHECK IS O.K. THROUGH THE TEST.

EPA (Dur) 235

# TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT CFI
DATE 8/4/76
SAMPLING LOCATION BATTERY 3 OUTLET
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A) 122.25"+47"
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B) 47"
STACK I.D., (DISTANCE A - DISTANCE B) 122.25"
NEAREST UPSTREAM DISTURBANCE
NEAREST DOWNSTREAM DISTURBANCE
CALCULATOR




SCHEMATIC OF SAMPLING LOCATION

| TRAVERSE POINT NUMBER | FRACTION OF STACK I.D. | STACK I.D. | PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH) | DISTANCE B | TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5) |
|---|---|---|---|---|---|
| 1 | 1.4 | | | | 48.72 |
| 2 | 4.4 | | | | 52.33 |
| 3 | 7.5 | | | | 56.18 |
| 4 | 10.9 | | | | 60.34 |
| 5 | 14.6 | | | | 64.90 |
| 6 | 18.8 | | | | 70.01 |
| 7 | 23.6 | | | | 75.91 |
| 8 | 29.6 | | | | 83.17 |
| 9 | 38.2 | | | | 93.72 |
| 10 | 61.8 | | | | 122.53 |
| 11 | 70.4 | | | | 133.08 |
| 12 | 76.4 | | | | 140.34 |
| 13 | 81.2 | | | | 146.24 |
| 14 | 85.4 | | | | 151.35 |
| 15 | 89.1 | | | | 155.91 |
| 16 | 92.5 | | | | 160.07 |
| 17 | 95.6 | | | | 163.92 |
| 18 | 98.6 | | | | 167.53 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## CF & I Battery Outlet

## BαP - Test Results

| RUN | 1 | 2 | 3 | Average |
|---|---|---|---|---|
| DATE | 8-7-79 | 8-8-79 | 8-9-79 | |
| Meter Volume (DSCF) | 46.26 | 95.34 | 81.92 | 74.51 |
| Meter Volume (DSCM) | 1.31 | 2.70 | 2.32 | 2.11 |
| Stack Volume (ACFM) | 22,060 | 19,280 | 19,976 | 20,438 |
| Stack Volume (DSCFM) | 10,032 | 8,460 | 8,820 | 9,104 |
| Stack Volume (DSCMM) | 284.1 | 239.6 | 249.8 | 257.8 |
| % Isokinetic | 104.0 | 125.1 | 108.8 | 112.6 |
| mg/Filter | 0.350 | 0.350 | 0.200 | 0.300 |
| mg/Rinse | 11.288 | 7.236 | 11.618 | 10.047 |
| mg/XAD-2 | 0.725 | 0.300 | 1.200 | 0.742 |
| mg/Total | 12.363 | 7.886 | 13.018 | 11.089 |
| mg/DSCM | 0.0094 | 0.0029 | 0.0056 | 0.0060 |
| kg/Hour | 0.0002 | 0.00004 | 0.00008 | 0.00009 |
| lbs/DSCF | $58.68 \times 10^{-11}$ | $18.10 \times 10^{-11}$ | $34.96 \times 10^{-11}$ | $37.45 \times 10^{-11}$ |
| lbs/Hour | $3.532 \times 10^{-4}$ | $9.188 \times 10^{-5}$ | $1.850 \times 10^{-4}$ | $2.046 \times 10^{-4}$ |
| lbs/24 Hour Day | $8.48 \times 10^{-3}$ | $2.20 \times 10^{-3}$ | $4.440 \times 10^{-3}$ | $4.910 \times 10^{-3}$ |
| lbs/365 Days | 3.10 | 0.80 | 1.62 | 1.79 |